CDO

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Uwe Schulzweida

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CHAPTER

ONE

INTRODUCTION

The Climate Data Operator (**CDO**) software is a collection of many operators for standard processing of climate and forecast model data. The operators include simple statistical and arithmetic functions, data selection and subsampling tools, and spatial interpolation.

CDO was developed to have the same set of processing functions for GRIB [GRIB] and NetCDF [NetCDF] datasets in one package.

The Climate Data Interface [CDI] is used for the fast and file format independent access to GRIB and NetCDF datasets. The local MPI-MET data formats SERVICE, EXTRA and IEG are also supported.

There are some limitations for GRIB and NetCDF datasets:

GRIB datasets have to be consistent, similar to NetCDF. That means all time steps need to have the same variables, and within a time step each variable may occur only once. Multiple fields in single GRIB2 messages are not supported!

NetCDF datasets are only supported for the classic data model and arrays up to 4 dimensions. These dimensions should only be used by the horizontal and vertical grid and the time. The NetCDF attributes should follow the GDT, COARDS or CF Conventions.

The main **CDO** features are:

- More than 700 operators available
- Modular design and easily extendable with new operators
- Very simple UNIX command line interface
- A dataset can be processed by several operators, without storing the interim results in files
- Most operators handle datasets with missing values
- Fast processing of large datasets
- Support of many different grid types
- Tested on many UNIX/Linux systems, Cygwin, and MacOS-X
- Free available and runs on all UNIX platforms.

Latest pdf documentation be found here.

1.1 Installation

CDO is supported in different operative systems such as Unix, macOS and Windows. This section describes how to install **CDO** in those platforms. More examples are found on the main website (https://code.mpimet.mpg.de/projects/cdo/wiki)

1.1.1 Unix

Prebuilt CDO packages

Prebuilt **CDO** versions are available in online Unix repositories, and you can install them by typing on the Unix terminal

> apt-get install cdo

Note that prebuilt libraries do not offer the most recent version, and their version might vary with the Unix system. It is recommended to build from the source or Conda environment for an updated version or a customised setting.

Building from sources

CDO uses the GNU configure and build system for compilation. The only requirement is a working ISO C++20 and C11 compiler.

First go to the download page (`https://code.mpimet.mpg.de/projects/cdo`) to get the latest distribution, if you do not have it yet.

To take full advantage of **CDO** features the following additional libraries should be installed:

- Unidata NetCDF library (`https://www.unidata.ucar.edu/software/netcdf`) version 4.3.3 or higher. This library is needed to process NetCDF [NetCDF] files with **CDO**.
- ECMWF ecCodes library (`https://software.ecmwf.int/wiki/display/ECC/ecCodes+Home`) version 2.3.0 or higher. This library is needed to process GRIB2 files with **CDO**.
- HDF5 szip library (`https://www.hdfgroup.org/doc\_resource/SZIP`) version 2.1 or higher. This library is needed to process szip compressed GRIB [GRIB] files with **CDO**.
- HDF5 library (`https://www.hdfgroup.org`) version 1.6 or higher. This library is needed to import CM-SAF [CM-SAF] HDF5 files with the **CDO** operator **import_cmsaf**.
- PROJ library (`https://proj.org`) version 5.0 or higher. This library is needed to convert Sinusoidal and Lambert Azimuthal Equal Area coordinates to geographic coordinates, for e.g. remapping.
- Magics library (`https://software.ecmwf.int/wiki/display/MAGP/Magics`) version 2.18 or higher. This library is needed to create contour, vector and graph plots with **CDO**.

Compilation

Compilation is done by performing the following steps:

1. Unpack the archive, if you haven't done that yet:

   ```
   gunzip cdo-$VERSION.tar.gz    # uncompress the archive
   tar xf cdo-$VERSION.tar       # unpack it
   cd cdo-$VERSION
   ```

2. Run the configure script:

   ```
   ./configure
   ```

   - Optionally with NetCDF [NetCDF] support:

     ```
     ./configure --with-netcdf=<NetCDF root directory>
     ```

   - and with ecCodes:

     ```
     ./configure --with-eccodes=<ecCodes root directory>
     ```

   For an overview of other configuration options use

   ```
   ./configure --help
   ```

3. Compile the program by running make:

```
make
```

The program should compile without problems and the binary (`cdo`) should be available in the `src` directory of the distribution.

Installation

After the compilation of the source code do a `make install`, possibly as root if the destination permissions require that.

```
make install
```

The binary is installed into the directory `<prefix>/bin`. `<prefix>` defaults to `/usr/local` but can be changed with the *–prefix* option of the configure script.

Alternatively, you can also copy the binary from the `src` directory manually to some `bin` directory in your search path.

Conda

Conda is an open-source package manager and environment management system for various languages (Python, R, etc.). Conda is installed via Anaconda or Miniconda. Unlike Anaconda, miniconda is a lightweight conda distribution. They can be dowloaded from the main conda Website (https://conda.io/projects/conda/en/latest/user-guide/install/linux.html) or on the terminal

```
wget https://repo.anaconda.com/archive/Anaconda3-2021.11-Linux-x86_64.sh
bash Anaconda3-2021.11-Linux-x86_64.sh
source ~/.bashrc
```

and

```
wget https://repo.continuum.io/miniconda/Miniconda3-latest-Linux-x86_64.sh
sh Miniconda3-latest-Linux-x86_64.sh
```

Upon setting your conda environment, you can install **CDO** using conda

```
conda install cdo
conda install python-cdo
```

1.1.2 MacOS

Among the MacOS package managers, **CDO** can be installed from Homebrew and Macports. The installation via Homebrew is straight forward process on the terminal

```
brew install cdo
```

Similarly, Macports

```
port install cdo
```

In contrast to Homebrew, Macport allows you to enable GRIB2, szip compression and Magics++ graphic in **CDO** installation.

```
port install cdo +grib_api +magicspp +szip
```

In addition, you could also set **CDO** via Conda as Unix. You can follow this tutorial to install anaconda or miniconda in your computer (https://conda.io/projects/conda/en/latest/user-guide/install/macos.html). Then, you can install cdo by

```
conda install -c conda-forge cdo
```

1.1.3 Windows

Currently, **CDO** is not supported in Windows system and the binary is not available in the windows conda repository. Therefore, **CDO** needs to be set in a virtual environment. Here, it covers the installation of **CDO** using Windows Subsystem Linux (WSL) and virtual machines.

WSL

WSL emulates Unix in your Windows system. Then, you can install Unix libraries and software such as **CDO** or the linux conda distribution in your computer. Also, it allows you to directly share your files between your Windows and the WSL environment. However, more complex functions that require a graphic interface are not allowed.

In Windows 10 or newer, WSL can be readily set in your cmd by typing

```
wsl --install
```

This command will install, by default, Ubuntu 20.04 in WSL2. You could also choose a different system from this list.

```
wsl -l -o
```

Then, you can install your WSL environment as

```
wsl --install -d NAME
```

Virtual machine

Virtual machines can emulate different operative systems in your computer. Virtual machines are guest computers mounted inside your host computer. You can set a Linux distribution in your Windows device in this particular case. The advantages of Virtual machines to WSL are the graphical interface and the fully operational Linux system. You can follow any tutorial on the internet such as this one https://ubuntu.com/tutorials/how-to-run-ubuntu-desktop-on-a-virtual-machine-using-virtualbox#1-overview

Finally, you can install **CDO** following any method listed in the section *Unix*.

1.2 Usage

This section describes how to use `CDO`. The syntax is:

cdo [*Options*] *Operator1* [-*Operator2* [-*OperatorN*]]

1.2.1 Options

All options have to be placed before the first operator. The following options are available for all operators:

`-a, --absolute_taxis`

Generate an absolute time axis.

`--async_read` `<true|false>`

Read input data asynchronously [default: false]. Available for the operators: *diff*, *info*, *trend*, *detrend*, *Timstat*

`-b` `<nbits>`

Set the number of bits for the output precision. The valid precisions depend on the file format:

format	nbits
`grb1`, `grb2`	P1 - P24
`nc1`, `nc2`, `nc4`, `nc4c`, `nc5`	I8/I16/I32/F32/F64
`nc4`, `nc4c`, `nc5`	U8/U16/U32
`grb2`, `srv`, `ext`, `ieg`	F32/F64

For `srv`, `ext` and `ieg` format the letter `L` or `B` can be added to set the byteorder to Little or Big endian.

`-C, --color`
Colorized output messages.

`-c, --check_data_range`
Enables checks for data overflow.

`--chunksize` `<size>`
NetCDF4 chunk size (x/y dimension).

`--chunkspec` `<chunkspec>`
NetCDF4 specify chunking for dimensions (x,y,z,t).

`--cmor`
CMOR conform NetCDF output.

`--copy_chunkspec`
Copy chunk specification.

`--double`
Uses double precision floats for reading data. This is the default for 64-bit float data.

`--eccodes`
Use [ecCodes] to decode/encode GRIB1 messages.

`-F, --filter` `<filterspec>`
NetCDF4 filter specification.

`-f` `<format>`
Set the output file format. The valid file formats are:

File format	format
GRIB version 1	`grb1/grb`
GRIB version 2	`grb2`
NetCDF	`nc1`
NetCDF version 2 (64-bit offset)	`nc2/nc`
NetCDF-4 (HDF5)	`nc4`
NetCDF-4 classic	`nc4c`
NetCDF version 5 (64-bit data)	`nc5`
SERVICE	`srv`
EXTRA	`ext`
IEG	`ieg`

GRIB2 is only available if **CDO** was compiled with ecCodes support and all NetCDF file types are only available if **CDO** was compiled with NetCDF support!

`--force`
Forcing a CDO process.

`-g` `<grid>`
Define the default grid description by name or from file (see *Grid description*). Available grid names are: `global_<DXY>`, `zonal_<DY>`, `r<NX>x<NY>`, `lon=<LON>/lat=<LAT>`, `F<N>`, `gme<NI>`, `hpr<ZOOM>`.

`-h, --help`
Help information for the operators.

`--nofile` `<num>`
Set maximum number of files that can be opened.

`--no_history`
: Do not append to NetCDF *history* global attribute.

`--netcdf_hdr_pad, --hdr_pad, --header_pad` `<nbr>`
: Pad NetCDF output header with *nbr* bytes.

`-k` `<chunktype>`
: NetCDF4 chunk type: auto, grid or lines.

`-m` `<missval>`
: Set the missing value of non NetCDF files (default: `-9e+33`).

`-O, --overwrite`
: Overwrite existing output file, if checked. Existing output file is checked only for: *Ensstat*, *merge*, *mergetime*

`--operators`
: List of all operators.

`-P` `<nthreads>`
: Set number of OpenMP threads (Only available if OpenMP support was compiled in).

`-p`
: Short for *`--async_read true`*

`--pedantic`
: Warnings count as errors.

`--percentile` `<method>`
: Methods: nrank, nist, rtype8, < NumPy method (linear | lower | higher | nearest | …) >

`--precision` `<float_digits[,double_digits]>`
: Precision to use in displaying floating-point data (default: 7,15).

`--query` `<name|cell|layer|step>`
: Pre-selects a subset of the data cube from a dataset. Available parameter:

Keyword	Description
name	Variable names (name=var1,var2,…)
cell	Cell index range (cell=first/to/last)
layer	Layer index range (layer=first/to/last)
step	Time step index range (step=first/to/last)

`--reduce_dim`
: Reduce NetCDF dimensions.

`-R, --regular`
: Convert GRIB1 data from global reduced to regular Gaussian grid (only with cgribex lib).

`-r, --relative_taxis`
: Generate a relative time axis.

`--remove_chunkspec`
: Remove chunk specification.

`-S, --diagnostic`
: Create a diagnostic output stream for the module *Timstat*. This stream contains the number of non missing values for each output period.

`-s, --silent`
: Silent mode.

`--shuffle`
Specify shuffling of variable data bytes before compression (NetCDF).

`--single`
Uses single precision floats for reading data. This is the default for 32-bit float data.

`--sortname`
Alphanumeric sorting of NetCDF parameter names.

`-t` `<partab>`
Set the GRIB1 (cgribex) default parameter table name or file (see *Parameter table*). Predefined tables are: `echam4` `echam5` `echam6` `mpiom1` `ecmwf` `remo`

`--timestat_date` `<srcdate>`
Target timestamp (temporal statistics): `first`, `middle`, `midhigh` or `last` source timestep.

`-V`, `--version`
Print the version number.

`-v`, `--verbose`
Print extra details for some operators.

`-w`
Disable warning messages.

`--worker` `<num>`
Number of worker to decode/decompress GRIB records.

`-z` `aec`
AEC compression of GRIB1 records.

`-z` `jpeg`
JPEG compression of GRIB2 records.

`-z` `zip[_1-9]`
Deflate compression of NetCDF4 variables.

`-z` `zstd[_1-19]`
Zstandard compression of NetCDF4 variables.

1.2.2 Environment Variables

There are some environment variables which influence the behavior of **CDO**. An incomplete list can be found in {*Appendix A*}.

Here is an example to set the environment variable `CDO_RESET_HISTORY` for different shells:

Bourne shell (sh):	`CDO_RESET_HISTORY=1 ; export CDO_RESET_HISTORY`
Korn shell (ksh):	`export CDO_RESET_HISTORY=1`
C shell (csh):	`setenv CDO_RESET_HISTORY 1`

1.2.3 Operators

There are more than 700 operators available. A detailed description of all operators can be found in the *Reference Manual* section.

1.2.4 Parallelized operators

Some of the CDO operators are shared memory parallelized with OpenMP. An OpenMP-enabled C compiler is needed to use this feature. Users may request a specific number of OpenMP threads `nthreads` with the '`-P`' switch.

Here is an example to distribute the bilinear interpolation on 8 OpenMP threads:

```
cdo -P 8  remapbil,targetgrid  infile  outfile
```

Many CDO operators are I/O-bound. This means most of the time is spend in reading and writing the data. Only compute intensive CDO operators are parallelized. An incomplete list of OpenMP parallelized operators can be found in *Appendix B*.

1.2.5 Operator parameter

Some operators need one or more parameter. A list of parameter is indicated by the seperator ','.

- STRING

  String parameters require quotes if the string contains blanks or other characters interpreted by the shell. The following command select variables with the name `pressure` and `tsurf`:

  ```
  cdo selvar,pressure,tsurf infile outfile
  ```

- FLOAT

  Floating point number in any representation. The following command sets the range between `0` and `273.15` of all fields to missing value:

  ```
  cdo setrtomiss,0,273.15 infile outfile
  ```

- BOOL

  Boolean parameter in the following representation TRUE/FALSE, T/F or 0/1. To disable the weighting by grid cell area in the calculation of a field mean, use:

  ```
  cdo fldmean,weights=FALSE infile outfile
  ```

- INTEGER

  A range of integer parameter can be specified by *first/last*[*/inc*]. To select the days 5, 6, 7, 8 and 9 use:

  ```
  cdo selday,5/9 infile outfile
  ```

  The result is the same as:

  ```
  cdo selday,5,6,7,8,9 infile outfile
  ```

1.2.6 Operator chaining

Operator chaining allows to combine two or more operators on the command line into a single **CDO** call. This allows the creation of complex operations out of more simple ones: reductions over several dimensions, file merges and all kinds of analysis processes. All operators with a fixed number of input streams and one output stream can pass the result directly to an other operator. For differentiation between files and operators all operators must be written with a prepended "–" when chaining.

```
cdo -monmean -add -mulc,2.0 infile1 -daymean infile2 outfile        (CDO example call)
```

Here `monmean` will have the output of `add` while `add` takes the output of `mulc,2.0` and `daymean`. `infile1` and `infile2` are inputs for their predecessor. When mixing operators with an arbitrary number of input streams extra care needs to be taken. The following examples illustrates why.

1. `cdo info -timavg infile1 infile2`
2. `cdo info -timavg infile?`

3.
   ```
   cdo timavg infile1 tmpfile
   cdo info tmpfile infile2
   rm tmpfile
   ```

All three examples produce identical results. The time average will be computed only on the first input file.

Note

In section *Argument Groups* we introduce argument groups which will make this a lot easier and less error prone.

Note

Operator chaining is implemented over POSIX Threads (pthreads). Therefore this **CDO** feature is not available on operating systems without POSIX Threads support!

1.2.7 Chaining Benefits

Combining operators can have several benefits. The most obvious is a performance increase through reducing disk I/O:

```
cdo sub -dayavg infile2 -timavg infile1 outfile
```

instead of

```
cdo timavg infile1 tmp1
cdo dayavg infile2 tmp2
cdo sub tmp2 tmp1 outfile
rm tmp1 tmp2
```

Especially with large input files the reading and writing of intermediate files can have a big influence on the overall performance.

A second aspect is the execution of operators: Limited by the algorithms potentially all operators of a chain can run in parallel.

1.3 Advanced Usage

In this section we will introduce advanced features of **CDO**. These include operator grouping which allows to write more complex **CDO** calls and the apply keyword which allows to shorten calls that need an operator to be executed on multiple files as well as wildcards which allow to search paths for file signatures. These features have several restrictions and follow rules that depend on the input/output properties. These required properties of operators can be investigated with the following commands which will output a list of operators that have selected properties:

```
cdo --attribs [arbitrary/filesOnly/onlyFirst/noOutput/obase]
```

- *arbitrary* describes all operators where the number of inputs is not defined.
- *filesOnly* are operators that can have other operators as input.
- *onlyFirst* shows which operators can only be at the most left position of the polish notation argument chain.
- *noOutput* are all operators that do not print to any file (e.g info).

- *obase* Here obase describes an operator that does not use the output argument as file but e.g as a file name base (output base). This is almost exclusively used for operators the split input files.

  ```
  cdo -splithour baseName_
  could result in: baseName_1 baseName_2 ... baseName_N
  ```

For checking a single or multiple operator directly the following usage of `-{}`-attribs can be used:

```
cdo --attribs operatorName
```

1.3.1 Wildcards

Wildcards are a standard feature of command line interpreters (shells) on many operating systems. They are placeholder characters used in file paths that are expanded by the interpreter into file lists. For further information the Advance Bash Scripting Guide is a valuable source of information. Handling of input is a central issue for **CDO** and in some circumstances it is not enough to use the wildcards from the shell. That's why **CDO** can handle them on its own.

all files	2020-2-01.txt 2020-2-11.txt 2020-2-15.txt 2020-3-01.txt 2020-3-02.txt 2020-3-12.txt 2020-3-13.txt 2020-3-15.txt 2021.grb 2022.grb
wildcard	**filelist results**
2020-3* and 2020-3-??.txt	2020-3-01.txt 2020-3-02.txt 2020-3-12.txt 2020-3-13.txt 2020-3-15.txt
2020-3-?1.txt	2020-3-01.txt
*.grb	2021.grb 2020.grb

Use single quotes if the input stream names matched to a single wildcard expression. In this case **CDO** will do the pattern matching and the output can be combined with other operators. Here is an example for this feature:

```
cdo timavg -select,name=temperature 'infile?' outfile
```

In earlier versions of **CDO** this was necessary to have the right files parsed to the right operator. Newer version support this with the argument grouping feature (see *Argument Groups*). We advice the use of the grouping mechanism instead of the single quoted wildcards since this feature could be deprecated in future versions.

Note

Wildcard expansion is not available on operating systems without the *glob()* function!

1.3.2 Argument Groups

In section *Operator chaining* we described that it is not possible to chain operators with an arbitrary number of inputs. In this section we want to show how this can be achieved through the use of *operator grouping* with angled brackets `[]`. Using these brackets **CDO** can assigned the inputs to their corresponding operators during the execution of the command line. The ability to write operator combination in a parentheses-free way is partly given up in favor of allowing operators with arbitrary number of inputs. This allows a much more compact way to handle large number of input files.

The following example shows an example which we will transform from a non-working solution to a working one.

```
cdo -infon -div -fldmean -cat infileA -mulc,2.0 infileB -fldmax infileC
```

This example will throw the following error:

```
cdo (Abort):
-infon -div -fldmean -cat infileA -mulc,2.0 infileB -fldmax infileC
                                      ^ Operator cannot be assigned.
       Reason:
         Multiple variable input operators used.
         Use subgroups via [ ] to clarify relations (help: --argument_groups).
```

The error is raised by the operator *div*. This operator needs two input streams and one output stream, but the *cat* operator has claimed all possible streams on its right hand side as input because it accepts an arbitrary number of inputs. Hence it didn't leave anything for the remaining input or output streams of *div*. For this we can declare a group which will be passed to the operator left of the group.

```
cdo -infon -div -fldmean -cat [ infileA -mulc,2.0 infileB ] -fldmax infileC
```

For full flexibility it is possible to have groups inside groups:

```
cdo -infon -div -fldmean -cat [ infileA infileB -merge [ infileC1 infileC2 ] ] -
↪fldmax infileD
```

1.3.3 Applying a operator or chain to multiple inputs

When working with medium or large number of similar files there is a common problem of a processing step (often a reduction) which needs to be performed on all of them before a more specific analysis can be applied. Usually this can be done in two ways: One option is to use a merge operator to glue everything together and chain the reduction step after it. The second option is to write a for-loop over all inputs which perform the basic processing on each of the files separately and call a merge operator one the results. Unfortunately both options have side-effects: The first one needs a lot of memory because all files are read in completely and reduced afterwards while the latter one creates a lot of temporary files. Both memory and disk IO can be bottlenecks and should be avoided. In **CDO** there exist two approaches to circumvent most drawbacks. The first is to use the more recent 'apply' feature using the [to_be_applied : applied_to] syntax, the second is an older approach and is only listed and documented for completeness sake. We highly recommend the more recent approach!

1.3.4 Apply with [:] notation

With the [to_be_applied : applied_to] syntax it is possible to prepend multiple inputs or chains with another chain. For example:

```
-mergetime [ -selname,tsurf : *.grb ]
```

would merge all grib files in the folder after selecting the variable *tsurf* from them.

In general the *to_be_applied* is applied in parallel to all related input streams (*applied_to*) before all streams are passed to operator next in the chain.

Usage and result of [:] notation

The following is an example with three input files:

```
cdo -mergetime [ -selname,tsurf : infile1 infile2 infile3 ] outfile
```

This would result in **CDO** executing as if the following was used:

```
cdo -mergetime -selname,tsurf infile1 -selname,tsurf infile2 -selname,tsurf␣
↪infile3 outfile
```

This notation is especially useful when combined with wildcards. The previous example can be shortened further.

```
cdo -mergetime  [ -selname,tsurf : infile? ] outfile
```

As shown this feature allows to simplify commands with medium amount of files and to move reductions further back. This can also have a positive impact on the performance.

Notation simplifies command and execution

An example where performance can take a hit.

```
cdo -yearmean -selname,tsurf -mergetime [ f1 ... f40 ]
```

An improved but ugly to write example.

```
cdo -yearmean -mergetime [ -selname,tsurf f1 -selname,tsurf f2 ... -selname,
↪tsurf f40 ]
```

Apply saves the day. And creates the call above with much less typing.

```
cdo -yearmean -mergetime [ -selname,tsurf :  f1 ... f40  ]
```

Further this notation allows to prepend full cdo chains with other operators:

```
cdo -info -mergetime [ -selname,tsurf : -addc,1 -mul f1 f2 -addc,4 f3 ]
```

Resolving internally to the following command:

```
info -mergetime -selname,tsurf [ -addc,1 -mul f1 f2 -selvar,tsurf -addc,4 f3 ]
```

1.3.5 Apply Keyword (LEGACY)

Originally the *apply* keyword was introduced for that purpose. We want to repeat that this is an older method and should not be used in newly written **CDO** commands! It can be used as an operator, but it needs at least one operator as a parameter, which is applied in parallel to all related input streams in a parallel way before all streams are passed to operator next in the chain.

Usage and result of apply keyword

The following is an example with three input files:

```
cdo -mergetime -apply,-selname,tsurf [ infile1 infile2 infile3 ] outfile
```

would result in:

```
cdo -mergetime -selname,tsurf infile1 -selname,tsurf infile2 -selname,tsurf␣
↪infile3 outfile
```

Apply is especially useful when combined with wildcards. The previous example can be shortened further:

```
cdo -mergetime -apply,-selname,tsurf [ infile? ] outfile
```

As shown this feature allows to simplify commands with medium amount of files and to move reductions further back. This can also have a positive impact on the performance.

Apply keyword simplifies command and execution

An example where performance can take a hit:

```
cdo -yearmean -selname,tsurf -mergetime [ f1 ... f40 ]
```

An improved but ugly to write example:

```
cdo -yearmean -mergetime [ -selname,tsurf f1 -selname,tsurf f2 ... -selname,
↪tsurf f40 ]
```

Apply saves the day. And creates the call above with much less typing:

```
cdo -yearmean -mergetime [ -apply,-selname,tsurf [ f1 ... f40 ] ]
```

In the example in figure *simpleApply* the resulting call will dramatically save process interaction as well as execution times since the reduction (selname,tsurf) is applied on the files first. That means that the mergetime operator will receive the reduced files and the operations for merging the whole data is saved. For other **CDO** calls further improvements can be made by adding more arguments to apply (*multiApply*)

Multi argument apply

A less performant example:

```
cdo -aReduction -anotherReduction -selname,tsurf -mergetime [ f1 ... f40 ]
```

```
cdo  -mergetime -apply,"-aReduction -anotherReduction -selname,tsurf" [ f1 .
↪.. f40 ]
```

Restrictions:

While the apply keyword can be extremely helpful it has several restrictions (for now!).

- Apply inputs can only be files, wildcards and operators that have 0 inputs and 1 output.
- Apply can not be used as the first **CDO** operator.
- Apply arguments can only be operators with 1 input and 1 output.
- Grouping inside the Apply argument or input is not allowed.

1.4 Memory Requirements

This section roughly describes the memory requirements of **CDO**. **CDO** tries to use as little memory as possible. The smallest unit that is read by all operators is a horizontal field. The required memory depends mainly on the used operators, the data format, the data type and the size of the fields.

The operators have partly very different memory requirements. Many **CDO** modules like *Fldstat* process one horizontal field at a time. Memory-intensive modules such as *Ensstat* and *Timstat* require all fields of a time step to be held in memory. Of course, the memory requirements of each operator add up when they are combined. Some operators are parallelized with OpenMP. In multi-threaded mode (see option *-P*) the memory requirement can increase for these operators. This increase grows with the number of threads used.

The data type determines the number of bytes per value. Single precision floating point data occupies 4 bytes per value. All other data types are read as double precision floats and thus occupy 8 bytes per value. With the **CDO** option *–single* all data is read as single precision floats. This can reduce the memory requirement by a factor of 2.

1.5 Horizontal grids

Physical quantities of climate models are typically stored on a horizontal grid. **CDO** supports structured grids like regular lon/lat or curvilinear grids and also unstructured grids.

1.5.1 Grid area weights

One single point of a horizontal grid represents the mean of a grid cell. These grid cells are typically of different sizes, because the grid points are of varying distance.

Area weights are individual weights for each grid cell. They are needed to compute the area weighted mean or variance of a set of grid cells (e.g. *fldmean* - the mean value of all grid cells). In **CDO** the area weights are derived from the grid cell area. If the cell area is not available then it will be computed from the geographical coordinates via spherical triangles. This is only possible if the geographical coordinates of the grid cell corners are available or derivable. Otherwise **CDO** gives a warning message and uses constant area weights for all grid cells.

The cell area is read automatically from a NetCDF input file if a variable has the corresponding `cell_measures` attribute, e.g.:

```
var:cell_measures = "area: cell_area" ;
```

If the computed cell area is not desired then the **CDO** operator *setgridarea* can be used to set or overwrite the grid cell area.

1.5.2 Grid description

In the following situations it is necessary to give a description of a horizontal grid:

- Changing the grid description (operator: *setgrid*)
- Horizontal interpolation (all remapping operators)
- Generating of variables (operator: *const*, *random*)

As now described, there are several possibilities to define a horizontal grid.

Predefined grids

Predefined grids are available for global regular, gaussian, HEALPix or icosahedral-hexagonal GME grids.

Global regular grid: `global_<DXY>`

`global_<DXY>` defines a global regular lon/lat grid. The grid increment `<DXY>` can be chosen arbitrarily. The longitudes start at `<DXY>`/2 - 180° and the latitudes start at `<DXY>`/2 - 90°.

Regional regular grid: `dcw:<CountryCode>[_<DXY>]`

`dcw:<CountryCode>[_<DXY>]` defines a regional regular lon/lat grid from the country code. The default value of the optional grid increment `<DXY>` is 0.1 degree. The ISO two-letter country codes can be found on https://en.wikipedia.org/wiki/ISO_3166-1_alpha-2. To define a state, append the state code to the country code, e.g. USAK for Alaska. For the coordinates of a country **CDO** uses the DCW (Digital Chart of the World) dataset from GMT. This dataset must be installed on the system and the environment variable `DIR_DCW` must point to it.

Zonal latitudes: `zonal_<DY>`

`zonal_<DY>` defines a grid with zonal latitudes only. The latitude increment `<DY>` can be chosen arbitrarily. The latitudes start at `<DY>`/2 - 90°. The boundaries of each latitude are also generated. The number of longitudes is 1. A grid description of this type is needed to calculate the zonal mean (*zonmean*) for data on an unstructured grid.

Global regular grid: `r<NX>x<NY>`

`r<NX>x<NY>` defines a global regular lon/lat grid. The number of the longitudes `<NX>` and the latitudes `<NY>` can be chosen arbitrarily. The longitudes start at 0° with an increment of (360/`<NX>`)°. The latitudes go from south to north with an increment of (180/`<NY>`)°.

One grid point: `lon=<LON>/lat=<LAT>`

`lon=<LON>/lat=<LAT>` defines a lon/lat grid with only one grid point.

Full regular Gaussian grid: `F<N>`

`F<N>` defines a global regular Gaussian grid. `N` specifies the number of latitudes lines between the Pole and the Equator. The total number of latitudes and longitudes is: $nlat = N * 2$; $nlon = nlat * 2$. The longitudes start at 0° with an increment of (360/nlon)°. The gaussian latitudes go from north to south.

Global icosahedral-hexagonal GME grid: `gme<NI>`

`gme<NI>` defines a global icosahedral-hexagonal GME grid. `NI` specifies the number of intervals on a main triangle side.

HEALPix grid: `hp<NSIDE>[_<ORDER>]`

HEALPix is an acronym for Hierarchical Equal Area isoLatitude Pixelization of a sphere. `hp<NSIDE>[_<ORDER>]` defines the parameter of a global HEALPix grid. The `NSIDE` parameter controls the resolution of the pixelization. It is the number of pixels on the side of each of the 12 top-level HEALPix pixels. The total number of grid pixels is `12*NSIDE*NSIDE`. `NSIDE=1` generates the 12 (H=4, K=3) equal sized top-level HEALPix pixels. `ORDER` sets the index ordering convention of the pixels, available are `nested` (default) or `ring` ordering. A shortcut for `hp<NSIDE>_nested` is `hpr<ZOOM>`. `ZOOM` is the refinement level and the relation to `NSIDE` is $zoom = log_2(nside)$.

If the geographical coordinates are required in **CDO**, they are calculated from the HEALPix parameters. For this calculation the astropy-healpix C library is used.

Grids from data files

You can use the grid description from an other datafile. The format of the datafile and the grid of the data field must be supported by **CDO**. Use the operator '*sinfo*' to get short informations about your variables and the grids. If there are more then one grid in the datafile the grid description of the first variable will be used. Add the extension :N to the name of the datafile to select grid number N.

SCRIP grids

SCRIP (Spherical Coordinate Remapping and Interpolation Package) uses a common grid description for curvilinear and unstructured grids. For more information about the convention see [SCRIP]. This grid description is stored in NetCDF. Therefor it is only available if **CDO** was compiled with NetCDF support!

SCRIP grid description example of a curvilinear MPIOM [MPIOM] GROB3 grid (only the NetCDF header):

```
netcdf grob3s {
dimensions:
        grid_size = 12120 ;
        grid_corners = 4 ;
        grid_rank = 2 ;
variables:
        int grid_dims(grid_rank) ;
        double grid_center_lat(grid_size) ;
                grid_center_lat:units = "degrees" ;
                grid_center_lat:bounds = "grid_corner_lat" ;
        double grid_center_lon(grid_size) ;
                grid_center_lon:units = "degrees" ;
                grid_center_lon:bounds = "grid_corner_lon" ;
        int grid_imask(grid_size) ;
                grid_imask:units = "unitless" ;
                grid_imask:coordinates = "grid_center_lon grid_center_lat" ;
        double grid_corner_lat(grid_size, grid_corners) ;
                grid_corner_lat:units = "degrees" ;
        double grid_corner_lon(grid_size, grid_corners) ;
                grid_corner_lon:units = "degrees" ;

// global attributes:
                :title = "grob3s" ;
}
```

CDO grids

All supported grids can also be described with the **CDO** grid description.

The following keywords can be used to describe a grid:

Keyword	Datatype	Description
gridtype	STRING	Type of the grid (gaussian, lonlat, curvilinear, unstructured).
gridsize	INTEGER	Size of the grid.
xsize	INTEGER	Size in x direction (number of longitudes).
ysize	INTEGER	Size in y direction (number of latitudes).
xvals	FLOAT ARRAY	X values of the grid cell center.
yvals	FLOAT ARRAY	Y values of the grid cell center.
nvertex	INTEGER	Number of the vertices for all grid cells.
xbounds	FLOAT ARRAY	X bounds of each gridbox.
ybounds	FLOAT ARRAY	Y bounds of each gridbox.
xfirst, xinc	FLOAT, FLOAT	Macros to define xvals with a constant increment, xfirst is the x value of the first grid cell center.
yfirst, yinc	FLOAT, FLOAT	Macros to define yvals with a constant increment, yfirst is the y value of the first grid cell center.
xunits	STRING	units of the x axis
yunits	STRING	units of the y axis

Which keywords are necessary depends on the gridtype. The following table gives an overview of the default values or the size with respect to the different grid types:

gridtype	lonlat	gaussian	projection	curvilinear	unstructured
gridsize	xsize*ysize	xsize*ysize	xsize*ysize	xsize*ysize	**ncell**
xsize	**nlon**	**nlon**	**nx**	**nlon**	**gridsize**
ysize	**nlat**	**nlat**	**ny**	**nlat**	**gridsize**
xvals	xsize	xsize	xsize	gridsize	gridsize
yvals	ysize	ysize	ysize	gridsize	gridsize
nvertex	2	2	2	4	**nv**
xbounds	2*xsize	2*xsize	2*xsize	4*gridsize	nv*gridsize
ybounds	2*ysize	2*ysize	2*xsize	4*gridsize	nv*gridsize
xunits	degrees	degrees	m	degrees	degrees
yunits	degrees	degrees	m	degrees	degrees

The keywords nvertex, xbounds and ybounds are optional if area weights are not needed. The grid cell corners xbounds and ybounds have to rotate counterclockwise.

CDO grid description example of a T21 gaussian grid:

```
gridtype = gaussian
xsize    = 64
ysize    = 32
xfirst   =  0
xinc     = 5.625
yvals    = 85.76  80.27  74.75  69.21  63.68  58.14  52.61  47.07
           41.53  36.00  30.46  24.92  19.38  13.84   8.31   2.77
           -2.77  -8.31 -13.84 -19.38 -24.92 -30.46 -36.00 -41.53
          -47.07 -52.61 -58.14 -63.68 -69.21 -74.75 -80.27 -85.76
```

CDO grid description example of a global regular grid with 60x30 points:

```
gridtype = lonlat
xsize    =   60
ysize    =   30
xfirst   = -177
xinc     =    6
yfirst   =  -87
yinc     =    6
```

The description for a projection is somewhat more complicated. Use the first section to describe the coordinates of the projection with the above keywords. Add the keyword **grid_mapping_name** to describe the mapping between the given coordinates and the true latitude and longitude coordinates. **grid_mapping_name** takes a string value that contains the name of the projection. A list of attributes can be added to define the mapping. The name of the attributes depend on the projection. The valid names of the projection and there attributes follow the NetCDF CF-Convention.

CDO supports the special grid mapping attribute **proj_params**. These parameter will be passed directly to the [PROJ] library to generate the geographic coordinates if needed.

The geographic coordinates of the following projections can be generated without the attribute **proj_params**, if all other attributes are available:

- **rotated_latitude_longitude**
- **lambert_conformal_conic**
- **lambert_azimuthal_equal_area**
- **sinusoidal**
- **polar_stereographic**

It is recommend to set the attribute **proj_params** also for the above projections to make sure all PROJ parameter are set correctly.

Here is an example of a **CDO** grid description using the attribute **proj_params** to define the PROJ parameter of a polar stereographic projection:

```
gridtype = projection
xsize     = 11
ysize     = 11
xunits   = "meter"
yunits   = "meter"
xfirst    = -638000
xinc      = 150
yfirst    = -3349350
yinc      = 150
grid_mapping = crs
grid_mapping_name = polar_stereographic
proj_params = "+proj=stere +lon_0=-45 +lat_ts=70 +lat_0=90 +x_0=0 +y_0=0"
```

The result is the same as using the CF conform Grid Mapping Attributes:

```
gridtype = projection
xsize     = 11
ysize     = 11
xunits   = "meter"
yunits   = "meter"
xfirst    = -638000
xinc      = 150
yfirst    = -3349350
```

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```
yinc      = 150
grid_mapping = crs
grid_mapping_name = polar_stereographic
straight_vertical_longitude_from_pole = -45.
standard_parallel = 70.
latitude_of_projection_origin = 90.
false_easting = 0.
false_northing = 0.
```

CDO grid description example of a regional rotated lon/lat grid:

```
gridtype = projection
xsize    = 81
ysize    = 91
xunits   = "degrees"
yunits   = "degrees"
xfirst   =  -19.5
xinc     =    0.5
yfirst   =  -25.0
yinc     =    0.5
grid_mapping_name = rotated_latitude_longitude
grid_north_pole_longitude = -170
grid_north_pole_latitude = 32.5
```

Example **CDO** descriptions of a curvilinear and an unstructured grid can be found in *Appendix D*.

1.5.3 ICON - Grid File Server

The geographic coordinates of the ICON model are located on an unstructured grid. This grid is stored in a separate grid file independent of the model data. The grid files are made available to the general public via a file server. Furthermore, these grid files are located at DKRZ under `/pool/data/ICON/grids`.

With the **CDO** function `setgrid,<gridfile>` this grid information can be added to the data if needed. Here is an example:

```
cdo sellonlatbox,-20,60,10,70 -setgrid,<path_to_gridfile> icondatafile result
```

ICON model data in NetCDF format contains the global attribute `grid_file_uri`. This attribute contains a link to the appropriate grid file on the ICON grid file server. If the global attribute `grid_file_uri` is present and valid, the grid information can be added automatically. The `setgrid` function is then no longer required. The environment variable *CDO_DOWNLOAD_PATH* can be used to select a directory for storing the grid file. If this environment variable is set, the grid file will be automatically downloaded from the grid file server to this directory if needed. If the grid file already exists in the current directory, the environment variable does not need to be set.

If the grid files are available locally, like at DKRZ, they do not need to be fetched from the grid file server. Use the environment variable *CDO_ICON_GRIDS* to set the root directory of the ICON grids. Here is an example for the ICON grids at DKRZ:

```
CDO_ICON_GRIDS=/pool/data/ICON
```

1.6 Z-axis description

Sometimes it is necessary to change the description of a z-axis. This can be done with the operator *setzaxis*. This operator needs an ASCII formatted file with the description of the z-axis. The following keywords can be used to describe a z-axis:

Keyword	Datatype	Description
zaxistype	STRING	type of the z-axis
size	INTEGER	number of levels
levels	FLOAT ARRAY	values of the levels
lbounds	FLOAT ARRAY	lower level bounds
ubounds	FLOAT ARRAY	upper level bounds
vctsize	INTEGER	number of vertical coordinate parameters
vct	FLOAT ARRAY	vertical coordinate table

The keywords **lbounds** and **ubounds** are optional. **vctsize** and **vct** are only necessary to define hybrid model levels.

Available z-axis types:

Z-axis type	Description	Units
surface	Surface	
pressure	Pressure level	pascal
hybrid	Hybrid model level	
height	Height above ground	meter
depth_below_sea	Depth below sea level	meter
depth_below_land	Depth below land surface	centimeter
isentropic	Isentropic (theta) level	kelvin

Z-axis description example for pressure levels 100, 200, 500, 850 and 1000 hPa:

```
zaxistype = pressure
size      = 5
levels    = 10000 20000 50000 85000 100000
```

Z-axis description example for ECHAM5 L19 hybrid model levels:

```
zaxistype = hybrid
size      = 19
levels    = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
vctsize   = 40
vct       = 0 2000 4000 6046.10938 8267.92578 10609.5117 12851.1016 14698.5
            15861.125 16116.2383 15356.9258 13621.4609 11101.5625 8127.14453
            5125.14062 2549.96875 783.195068 0 0 0
            0 0 0 0.000338993268 0.00335718691 0.0130700432 0.0340771675
            0.0706498027 0.12591666 0.201195419 0.295519829 0.405408859
            0.524931908 0.646107674 0.759697914 0.856437683 0.928747177
            0.972985268 0.992281914 1
```

Note that the vctsize is twice the number of levels plus two and the vertical coordinate table must be specified for the level interfaces.

1.7 Time axis

A time axis describes the time for every timestep. Two time axis types are available: absolute time and relative time axis. **CDO** tries to maintain the actual type of the time axis for all operators.

1.7.1 Absolute time

An absolute time axis has the current time to each time step. It can be used without knowledge of the calendar. This is preferably used by climate models. In NetCDF files the absolute time axis is represented by the unit of the time: “`day as %Y%m%d.%f`”.

1.7.2 Relative time

A relative time is the time relative to a fixed reference time. The current time results from the reference time and the elapsed interval. The result depends on the calendar used. **CDO** supports the standard Gregorian, proleptic Gregorian, 360 days, 365 days and 366 days calendars. The relative time axis is preferably used by numerical weather prediction models. In NetCDF files the relative time axis is represented by the unit of the time: "<*time-units*> `since` <*reference-time*>", e.g "`days since 1989-6-15 12:00`".

1.7.3 Conversion of the time

Some programs which work with NetCDF data can only process relative time axes. Therefore it may be necessary to convert from an absolute into a relative time axis. This conversion can be done for each operator with the **CDO** option '-r'. To convert a relative into an absolute time axis use the **CDO** option '-a'.

1.8 Parameter table

A parameter table is an ASCII formated file to convert code numbers to variable names. Each variable has one line with its code number, name and a description with optional units in a blank separated list. It can only be used for GRIB, SERVICE, EXTRA and IEG formated files. The **CDO** option '-t <partab>' sets the default parameter table for all input files. Use the operator 'setpartab' to set the parameter table for a specific file.

Example of a **CDO** parameter table:

```
134  aps      surface pressure [Pa]
141  sn       snow depth [m]
147  ahfl     latent heat flux [W/m**2]
172  slm      land sea mask
175  albedo   surface albedo
211  siced    ice depth [m]
```

1.9 Missing values

Missing values are data points that are missing or invalid. Such data points are treated in a different way than valid data. Most **CDO** operators can handle missing values in a smart way. But if the missing value is within the range of valid data, it can lead to incorrect results. This applies to all arithmetic operations, but especially to logical operations when the missing value is 0 or 1.

The default missing value for GRIB, SERVICE, EXTRA and IEG files is $-9.e^{33}$. The **CDO** option '-m <missval>' overwrites the default missing value. In NetCDF files the variable attribute '_FillValue' is used as a missing value. The operator *setmissval* can be used to set a new missing value.

The **CDO** use of the missing value is shown in the following tables, where one table is printed for each operation. The operations are applied to arbitrary numbers a, b, the special case 0, and the missing value $miss$.

For example the table named "addition" shows that the sum of an arbitrary number a and the missing value is the missing value, and the table named "multiplication" shows that 0 multiplied by missing value results in 0.

Table 1: Maximum

	b	miss
a	$max(a, b)$	a
miss	b	$miss$

Table 2: Minimum

	b	miss
a	$min(a, b)$	a
miss	b	$miss$

Table 3: Sum

	b	miss
a	$a + b$	a
miss	b	$miss$

Table 4: Addition

	b	miss
a	$a + b$	$miss$
miss	$miss$	$miss$

Table 5: Subtraction

	b	miss
a	$a - b$	$miss$
miss	$miss$	$miss$

Table 6: Multiplication

	b	miss	0
a	$a * b$	$miss$	0
miss	$miss$	$miss$	0
0	0	0	0

Table 7: Division

	b	miss	0
a	a/b	$miss$	$miss$
miss	$miss$	$miss$	$miss$
0	0	$miss$	$miss$

The handling of missing values by the operations "minimum" and "maximum" may be surprising, but the definition given here is more consistent with that expected in practice. Mathematical functions (e.g. log, $sqrt$, etc.) return the missing value if an argument is the missing value or an argument is out of range.

All statistical functions ignore missing values, treading them as not belonging to the sample, with the side-effect of a reduced sample size.

1.9.1 Mean and average

An artificial distinction is made between the notions mean and average. The mean is regarded as a statistical function, whereas the average is found simply by adding the sample members and dividing the result by the sample size. For example, the mean of 1, 2, $miss$ and 3 is $(1+2+3)/3 = 2$, whereas the average is $(1+2+miss+3)/4 = miss/4 = miss$. If there are no missing values in the sample, the average and mean are identical.

1.10 Percentile

There is no standard definition of percentile. All definitions yield to similar results when the number of values is very large. The following percentile methods are available in **CDO**:

Percentile method	Description
nrank	Nearest Rank method [default in]
nist	The primary method recommended by NIST
rtype8	R's type=8 method
inverted_cdf	NumPy with percentile method='inverted_cdf' (R type=1)
averaged_inverted_cdf	NumPy with percentile method='averaged_inverted_cdf' (R type=2)
closest_observation	NumPy with percentile method='closest_observation' (R type=3)
interpolated_inverted_cdf	NumPy with percentile method='interpolated_inverted_cdf' (R type=4)
hazen	NumPy with percentile method='hazen' (R type=5)
weibull	NumPy with percentile method='weibull' (R type=6)
linear	NumPy with percentile method='linear' (R type=7) [default in NumPy and R]
median_unbiased	NumPy with percentile method='median_unbiased' (R type=8)
normal_unbiased	NumPy with percentile method='normal_unbiased' (R type=9)
lower	NumPy with percentile method='lower'
higher	NumPy with percentile method='higher'
midpoint	NumPy with percentile method='midpoint'
nearest	NumPy with percentile method='nearest'

The percentile method can be selected with the **CDO** option `--percentile`. The Nearest Rank method is the default percentile method in **CDO**.

The different percentile methods can lead to different results, especially for small number of data values. Consider the ordered list {15, 20, 35, 40, 50, 55}, which contains six data values. Here is the result for the 30th, 40th, 50th, 75th and 100th percentiles of this list using the different percentile methods:

Percentile P	nrank	nist	rtype8	NumPy linear	NumPy lower	NumPy higher	NumPy nearest
30th	20	21.5	23.5	27.5	20	35	35
40th	35	32	33	35	35	35	35
50th	35	37.5	37.5	37.5	35	40	40
75th	50	51.25	50.42	47.5	40	50	50
100th	55	55	55	55	55	55	55

1.10.1 Percentile over timesteps

The amount of data for time series can be very large. All data values need to held in memory to calculate the percentile. The percentile over timesteps uses a histogram algorithm, to limit the amount of required memory. The default number of histogram bins is 101. That means the histogram algorithm is used, when the dataset has more than 101 time steps. The default can be overridden by setting the environment variable *`CDO_PCTL_NBINS`* to a different value. The histogram algorithm is implemented only for the Nearest Rank method.

1.11 Regions

The **CDO** operators *maskregion* and *selregion* can be used to mask and select regions. For this purpose, the region needs to be defined by the user. In **CDO** there are two possibilities to define regions.

One possibility is to define the regions with an ASCII file. Each region is defined by a polygon. Each line of the polygon contains the longitude and latitude coordinates of a point. A description file for regions can contain several polygons, these must be separated by a line with the character &.

Here is a simple example of a polygon for a box with longitudes from 120W to 90E and latitudes from 20N to 20S:

```
120  20
120 -20
270 -20
270  20
```

With the second option, predefined regions can be used via country codes. A country is specified with `dcw:<CountryCode>`. Country codes can be combined with the plus sign.

Here is an example to select the region Spain and Portugal:

```
cdo  selregion,dcw:ES+PT  infile  outfile
```

The ISO two-letter country codes can be found on https://en.wikipedia.org/wiki/ISO_3166-1_alpha-2. To define a state, append the state code to the country code, e.g. USAK for Alaska. For the coordinates of a country **CDO** uses the DCW (Digital Chart of the World) dataset from GMT. This dataset must be installed on the system and the environment variable `DIR_DCW` must point to it.

CHAPTER

TWO

REFERENCE MANUAL

This section gives a description of all operators. Related operators are grouped to modules. For easier description all single input files are named `infile` or `infile1`, `infile2`, etc., and an arbitrary number of input files are named `infiles`. All output files are named `outfile` or `outfile1`, `outfile2`, etc. Further the following notion is introduced:

$o(t,x)$
    Timestep t of `infile`

$i(t,x)$
    Element number x of the field at timestep t of `infile`

$o(t)$
    Timestep t of `outfile`

$o(t,x)$
    Element number x of the field at timestep t of `outfile`

2.1 Information

This section contains modules to print information about datasets. All operators print there results to standard output.

Here is a short overview of all operators in this section:

Info	*info*	Dataset information listed by identifier
	infon	Dataset information listed by name
	cinfo	Compact information listed by name
	map	Dataset information and simple map
Sinfo	*sinfo*	Short information listed by identifier
	sinfon	Short information listed by name
XSinfo	*xsinfo*	Extra short information listed by name
	xsinfop	Extra short information listed by identifier
Diff	*diff*	Compare two datasets listed by identifier
	diffn	Compare two datasets listed by name
Ninfo	*npar*	Number of parameters
	nlevel	Number of levels
	nyear	Number of years
	nmon	Number of months
	ndate	Number of dates
	ntime	Number of timesteps
	ngridpoints	Number of gridpoints
	ngrids	Number of horizontal grids
Showinfo	*showformat*	Show file format
	showcode	Show code numbers
	showname	Show variable names
	showstdname	Show standard names
	showlevel	Show levels
	showltype	Show GRIB level types
	showyear	Show years
	showmon	Show months
	showdate	Show date information
	showtime	Show time information
	showtimestamp	Show timestamp
	showchunkspec	Show chunk specification
	showfilter	Show filter specification
Showattribute	*showattribute*	Show attributes
Filedes	*partab*	Parameter table
	codetab	Parameter code table
	griddes	Grid description
	zaxisdes	Z-axis description
	vct	Vertical coordinate table

2.1.1 Info

Name

info, infon, cinfo, map - Information and simple statistics

Synopsis

cdo [options] <*operator*> *infiles*

Description

This module writes information about the structure and contents for each field of all input files to standard output. A field is a horizontal layer of a data variable. All input files need to have the same structure with the same variables on different timesteps. The information displayed depends on the chosen operator.

Operators

info

Dataset information listed by identifier

Prints information and simple statistics for each field of all input datasets. For each field the operator prints one line with the following elements:

- Date and Time
- Level, Gridsize and number of Missing values
- Minimum, Mean and Maximum
  The mean value is computed without the use of area weights!
- Parameter identifier

infon

Dataset information listed by name

The same as operator info but using the parameter name instead of the identifier to label the parameter.

cinfo

Compact information listed by name

cinfo is a compact version of **infon**. It prints the minimum, mean and maximum value for each variable across all layers and time steps.

map

Dataset information and simple map

Prints information, simple statistics and a map for each field of all input datasets. The map will be printed only for fields on a regular lon/lat grid.

Options

`-p`, `--async_read true` to read input data asynchronously.

Example

To print information and simple statistics for each field of a dataset use:

```
cdo [options] infon infile
```

This is an example result of a dataset with one 2D parameter over 12 timesteps:

```
-1 :       Date     Time Level  Size  Miss : Minimum    Mean Maximum : Name
 1 : 1987-01-31 12:00:00     0  2048  1361 :  232.77  266.65  305.31 : SST
 2 : 1987-02-28 12:00:00     0  2048  1361 :  233.64  267.11  307.15 : SST
 3 : 1987-03-31 12:00:00     0  2048  1361 :  225.31  267.52  307.67 : SST
 4 : 1987-04-30 12:00:00     0  2048  1361 :  215.68  268.65  310.47 : SST
 5 : 1987-05-31 12:00:00     0  2048  1361 :  215.78  271.53  312.49 : SST
 6 : 1987-06-30 12:00:00     0  2048  1361 :  212.89  272.80  314.18 : SST
 7 : 1987-07-31 12:00:00     0  2048  1361 :  209.52  274.29  316.34 : SST
 8 : 1987-08-31 12:00:00     0  2048  1361 :  210.48  274.41  315.83 : SST
 9 : 1987-09-30 12:00:00     0  2048  1361 :  210.48  272.37  312.86 : SST
10 : 1987-10-31 12:00:00     0  2048  1361 :  219.46  270.53  309.51 : SST
11 : 1987-11-30 12:00:00     0  2048  1361 :  230.98  269.85  308.61 : SST
12 : 1987-12-31 12:00:00     0  2048  1361 :  241.25  269.94  309.27 : SST
```

Author

Uwe Schulzweida

2.1.2 Sinfo

Name

sinfo, sinfon - Short information

Synopsis

cdo <*operator*> *infiles*

Description

This module writes short information about the structure of `infiles` to standard output. `infiles` is an arbitrary number of input files. All input files need to have the same structure with the same variables on different timesteps. The information displayed depends on the chosen operator.

Operators

sinfo
Short information listed by identifier

Prints short information of a dataset. The information is divided into 4 sections. Section 1 prints one line per parameter with the following information:

- institute and source
- time c=constant v=varying
- type of statistical processing
- number of levels and z-axis number
- horizontal grid size and number
- data type
- parameter identifier

Section 2 and 3 gives a short overview of all grid and vertical coordinates. And the last section contains short information of the time coordinate.

sinfon
Short information listed by name

The same as operator *sinfo* but using the name instead of the identifier to label the parameter.

Example

To print short information of a dataset use:

```
cdo sinfon infile
```

This is the result of an ECHAM5 dataset with 3 parameter over 12 timesteps:

```
   -1 : Institut Source  T Steptype Levels Num   Points Num Dtype : Name
    1 : MPIMET   ECHAM5  c instant       1   1     2048   1  F32  : GEOSP
    2 : MPIMET   ECHAM5  v instant       4   2     2048   1  F32  : T
    3 : MPIMET   ECHAM5  v instant       1   1     2048   1  F32  : TSURF
  Grid coordinates :
    1 : gaussian              : points=2048 (64x32)  F16
                    longitude : 0 to 354.375 by 5.625 degrees_east  circular
                     latitude : 85.7606 to -85.7606 degrees_north
  Vertical coordinates :
    1 : surface               : levels=1
    2 : pressure              : levels=4
```

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```
                        level : 92500 to 20000 Pa
  Time coordinate :
                         time : 12 steps
YYYY-MM-DD hh:mm:ss YYYY-MM-DD hh:mm:ss YYYY-MM-DD hh:mm:ss YYYY-MM-DD hh:mm:ss
1987-01-31 12:00:00 1987-02-28 12:00:00 1987-03-31 12:00:00 1987-04-30 12:00:00
1987-05-31 12:00:00 1987-06-30 12:00:00 1987-07-31 12:00:00 1987-08-31 12:00:00
1987-09-30 12:00:00 1987-10-31 12:00:00 1987-11-30 12:00:00 1987-12-31 12:00:00
```

Author

Uwe Schulzweida

2.1.3 XSinfo

Name

xsinfo, xsinfop - Extra short information

Synopsis

cdo <*operator*> *infiles*

Description

This module writes extra short information about the structure of `infiles` to standard output. `infiles` is an arbitrary number of input files. All input files need to have the same structure with the same variables on different timesteps. The information displayed depends on the chosen operator.

Operators

xsinfo
Extra short information listed by name

Prints extra short information of a dataset. The information is divided into 4 sections. Section 1 prints one line per parameter with the following information:

- institute and source
- time c=constant v=varying
- type of statistical processing
- number of levels and z-axis number
- horizontal grid size and number
- data type
- memory type (float or double)
- parameter name

Section 2 to 4 gives a extra short overview of all grid, vertical and time coordinates.

xsinfop
Extra short information listed by identifier

The same as operator *xsinfo* but using the identifier instead of the name to label the parameter.

Example

To print extra short information of a dataset use:

```
cdo xsinfo infile
```

This is the result of an ECHAM5 dataset with 3 parameter over 12 timesteps:

```
 -1 : Institut Source  T Steptype Levels Num   Points Num Dtype Mtype : Name
  1 : MPIMET   ECHAM5  c instant       1   1     2048   1  F32   F32 : GEOSP
  2 : MPIMET   ECHAM5  v instant       4   2     2048   1  F32   F32 : T
  3 : MPIMET   ECHAM5  v instant       1   1     2048   1  F32   F32 : TSURF
Grid coordinates :
  1 : gaussian         : points=2048 (64x32)  F16
              longitude: 0 to 354.375 by 5.625 degrees_east  circular
               latitude: 85.7606 to -85.7606 degrees_north
Vertical coordinates :
  1 : surface          : levels=1
  2 : pressure         : levels=4
```

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```
                  level: 92500 to 20000 Pa
Time coordinate :
                  steps: 12
                   time: 1987-01-31T18:00:00 to 1987-12-31T18:00:00 by 1 month
                  units: days since  1987-01-01T00:00:00
               calendar: proleptic_gregorian
```

Author

Uwe Schulzweida

2.1.4 Diff

Name

diff, diffn - Compare two datasets field by field

Synopsis

cdo [options] <*operator*>[,*parameters*] *infile1 infile2*

Description

Compares the contents of two datasets field by field. The input datasets need to have the same structure and its fields need to have the dimensions. Try the option names if the number of variables differ. Exit status is 0 if inputs are the same and 1 if they differ.

Operators

diff
Compare two datasets listed by identifier

Provides statistics on differences between two datasets. For each pair of fields the operator prints one line with the following information:

- Date and Time
- Level, Gridsize and number of Missing values
- Number of different values
- Occurrence of coefficient pairs with different signs (S)
- Occurrence of zero values (Z)
- Maxima of absolute difference of coefficient pairs
- Maxima of relative difference of non-zero coefficient pairs with equal signs
- Parameter identifier

diffn
Compare two datasets listed by name

The same as operator diff. Using the name instead of the identifier to label the parameter.

Parameters

maxcount
[INTEGER] Stop after maxcount different fields.

abslim
[FLOAT] Limit of the maximum absolute difference (default: 0).

rellim
[FLOAT] Limit of the maximum relative difference (default: 1).

names
[STRING] Consideration of the variable names of only one input file (left/right) or the intersection of both (intersect).

Options

`-p`, `--async_read true` to read input data asynchronously.

Example

To print the difference for each field of two datasets use:

```
cdo diffn infile1 infile2
```

This is an example result of two datasets with one 2D parameter over 12 timesteps:

```
           Date   Time Level Size Miss Diff : S Z Max_Absdiff Max_Reldiff : Name
 1 : 1987-01-31 12:00:00   0 2048 1361  273 : F F  0.00010681  4.1660e-07 : SST
 2 : 1987-02-28 12:00:00   0 2048 1361  309 : F F  6.1035e-05  2.3742e-07 : SST
 3 : 1987-03-31 12:00:00   0 2048 1361  292 : F F  7.6294e-05  3.3784e-07 : SST
 4 : 1987-04-30 12:00:00   0 2048 1361  183 : F F  7.6294e-05  3.5117e-07 : SST
 5 : 1987-05-31 12:00:00   0 2048 1361  207 : F F  0.00010681  4.0307e-07 : SST
 7 : 1987-07-31 12:00:00   0 2048 1361  317 : F F  9.1553e-05  3.5634e-07 : SST
 8 : 1987-08-31 12:00:00   0 2048 1361  219 : F F  7.6294e-05  2.8849e-07 : SST
 9 : 1987-09-30 12:00:00   0 2048 1361  188 : F F  7.6294e-05  3.6168e-07 : SST
10 : 1987-10-31 12:00:00   0 2048 1361  297 : F F  9.1553e-05  3.5001e-07 : SST
11 : 1987-11-30 12:00:00   0 2048 1361  234 : F F  6.1035e-05  2.3839e-07 : SST
12 : 1987-12-31 12:00:00   0 2048 1361  267 : F F  9.3553e-05  3.7624e-07 : SST
11 of 12 records differ
```

Author

Uwe Schulzweida, Karl-Hermann Wieners

2.1.5 Ninfo

Name

npar, nlevel, nyear, nmon, ndate, ntime, ngridpoints, ngrids - Print the number of parameters, levels or times

Synopsis

cdo <*operator*> *infile*

Description

This module prints the number of variables, levels or times of the input dataset.

Operators

npar
Number of parameters

Prints the number of parameters (variables).

nlevel
Number of levels

Prints the number of levels for each variable.

nyear
Number of years

Prints the number of different years.

nmon
Number of months

Prints the number of different combinations of years and months.

ndate
Number of dates

Prints the number of different dates.

ntime
Number of timesteps

Prints the number of timesteps.

ngridpoints
Number of gridpoints

Prints the number of gridpoints for each variable.

ngrids
Number of horizontal grids

Prints the number of horizontal grids.

Example

To print the number of parameters (variables) in a dataset use:

```
cdo npar infile
```

To print the number of months in a dataset use:

```
cdo nmon infile
```

Author

Uwe Schulzweida, Ralf Müller

2.1.6 Showinfo

Name

showformat, showcode, showname, showstdname, showlevel, showltype, showyear, showmon, showdate, showtime, showtimestamp, showchunkspec, showfilter - Show variable information

Synopsis

cdo <*operator*> *infile*

Description

This module prints meta-data information of all input variables. Depending on the chosen operator the name, level, date, time and other information is printed.

Operators

showformat
Show file format

Prints the file format of the input dataset.

showcode
Show code numbers

Prints the code number of all variables.

showname
Show variable names

Prints the name of all variables.

showstdname
Show standard names

Prints the standard name of all variables.

showlevel
Show levels

Prints all levels for each variable.

showltype
Show GRIB level types

Prints the GRIB level type for all z-axes.

showyear
Show years

Prints all years.

showmon
Show months

Prints all months.

showdate
Show date information

Prints date information of all timesteps (format YYYY-MM-DD).

showtime
Show time information

Prints time information of all timesteps (format hh:mm:ss).

showtimestamp
Show timestamp

Prints timestamp of all timesteps (format YYYY-MM-DDThh:mm:ss).

showchunkspec
Show chunk specification

Prints NetCDF4 chunk specification of all variables.

showfilter
Show filter specification

Prints NetCDF4 filter specification of all variables.

Example

To print the code number of all variables in a dataset use:

```
cdo showcode infile
```

This is an example result of a dataset with three variables:

```
129 130 139
```

To print all months in a dataset use:

```
cdo showmon infile
```

This is an examples result of a dataset with an annual cycle:

```
1 2 3 4 5 6 7 8 9 10 11 12
```

Author

Uwe Schulzweida

2.1.7 Showattribute

Name

showattribute - Show attributes

Synopsis

cdo showattribute[,attributes] *infile*

Description

This operator prints the attributes of the data variables of a dataset.

Each attribute has the following structure: [**var_nm**@][**att_nm**]

var_nm	Variable name (optional). Example: pressure
att_nm	Attribute name (optional). Example: units

The value of **var_nm** is the name of the variable containing the attribute (named **att_nm**) that you want to print. Use wildcards to print the attribute **att_nm** of more than one variable. A value of **var_nm** of '*' will print the attribute **att_nm** of all data variables. If **var_nm** is missing then **att_nm** refers to a global attribute.

The value of **att_nm** is the name of the attribute you want to print. Use wildcards to print more than one attribute. A value of **att_nm** of '*' will print all attributes.

Note

NetCDF attributes that are interpreted in **CDO** can't be displayed. Here is a incomplete list: formula_terms, cell_measures, coordinates, grid_mapping, valid_range, ...

Parameters

attributes
[STRING] Comma-separated list of attributes.

Author

Uwe Schulzweida

2.1.8 Filedes

Name

partab, codetab, griddes, zaxisdes, vct - Dataset description

Synopsis

cdo <*operator*> *infile*

Description

This module provides operators to print meta information about a dataset. The printed meta-data depends on the chosen operator.

Operators

partab
Parameter table

Prints all available meta information of the variables.

codetab
Parameter code table

Prints a code table with a description of all variables. For each variable the operator prints one line listing the code, name, description and units.

griddes
Grid description

Prints the description of all grids.

zaxisdes
Z-axis description

Prints the description of all z-axes.

vct
Vertical coordinate table

Prints the vertical coordinate table.

Parameters

genbounds
[BOOL] Generates cell bounds for regular LonLat grids.

Example

Assume all variables of the dataset are on a regular Gausssian F16 grid. To print the grid description of this dataset use:

```
cdo griddes infile
```

Result:

```
gridtype  : gaussian
gridsize  : 2048
xname     : lon
xlongname : longitude
xunits    : degrees_east
yname     : lat
ylongname : latitude
yunits    : degrees_north
```

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```
xsize     : 64
ysize     : 32
xfirst    : 0
xinc      : 5.625
yvals     : 85.76058 80.26877 74.74454 69.21297 63.67863 58.1429 52.6065
            47.06964 41.53246 35.99507 30.4575 24.91992 19.38223 13.84448
            8.306702 2.768903 -2.768903 -8.306702 -13.84448 -19.38223
            -24.91992 -30.4575 -35.99507 -41.53246 -47.06964 -52.6065
            -58.1429 -63.67863 -69.21297 -74.74454 -80.26877 -85.76058
```

Author

Uwe Schulzweida

2.2 File operation

This section contains modules to perform operations on files.

Here is a short overview of all operators in this section:

Copy	*copy*	Copy datasets
	clone	Clone datasets
	cat	Concatenate datasets
Tee	*tee*	Duplicate a data stream and write it to file
Pack	*pack*	Pack data
Unpack	*unpack*	Unpack data
Setchunkspec	*setchunkspec*	Specify chunking
Setfilter	*setfilter*	Specify filter
Bitrounding	*bitrounding*	Bit rounding
Replace	*replace*	Replace variables
Duplicate	*duplicate*	Duplicates a dataset
Mergegrid	*mergegrid*	Merge grid
Merge	*merge*	Merge datasets with different fields
	mergetime	Merge datasets sorted by date and time
Split	*splitcode*	Split code numbers
	splitparam	Split parameter identifiers
	splitname	Split variable names
	splitlevel	Split levels
	splitgrid	Split grids
	splitzaxis	Split z-axes
	splittabnum	Split parameter table numbers
	splitensemble	Split ensembles
Splittime	*splithour*	Split hours
	splitday	Split days
	splitseas	Split seasons
	splityear	Split years
	splityearmon	Split in years and months
	splitmon	Split months
Splitsel	*splitsel*	Split selected timesteps
Splitdate	*splitdate*	Splits a file into dates
Distgrid	*distgrid*	Distribute horizontal grid
Collgrid	*collgrid*	Collect horizontal grid

2.2.1 Copy

Name

copy, clone, cat - Copy datasets

Synopsis

cdo <*operator*> *infiles outfile*

Description

This module contains operators to copy, clone or concatenate datasets. `infiles` is an arbitrary number of input files. All input files need to have the same structure with the same variables on different timesteps.

Operators

copy
Copy datasets

Copies all input datasets to `outfile`.

clone
Clone datasets

Copies all input datasets to `outfile`. In contrast to the copy operator, clone tries not to change the input data. GRIB records are neither decoded nor decompressed.

cat
Concatenate datasets

Concatenates all input datasets and appends the result to the end of `outfile`. If `outfile` does not exist it will be created.

Example

To change the format of a dataset to NetCDF use:

```
cdo -f nc copy infile outfile.nc
```

Add the option '-r' to create a relative time axis, as is required for proper recognition by GrADS or Ferret:

```
cdo -r -f nc copy infile outfile.nc
```

To concatenate 3 datasets with different timesteps of the same variables use:

```
cdo copy infile1 infile2 infile3 outfile
```

If the output dataset already exists and you wish to extend it with more timesteps use:

```
cdo cat infile1 infile2 infile3 outfile
```

Author

Uwe Schulzweida

2.2.2 Tee

Name

tee - Duplicate a data stream and write it to file

Synopsis

cdo tee,*outfile2 infile outfile1*

Description

This operator copies the input dataset to `outfile1` and `outfile2`. The first output stream in `outfile1` can be further processed with other cdo operators. The second output `outfile2` is written to disk. It can be used to store intermediate results to a file.

Parameters

outfile2
[STRING] Destination filename for the copy of the input file

Example

To compute the daily and monthy average of a dataset use:

```
cdo monavg -tee,outfile_dayavg dayavg infile outfile_monavg
```

Author

Uwe Schulzweida

2.2.3 Pack

Name

pack - Pack data

Synopsis

cdo pack[,*parameter*] *infile outfile*

Description

Packing reduces the data volume by reducing the precision of the stored numbers. It is implemented using the NetCDF attributes `add_offset` and `scale_factor`. The operator **pack** calculates the attributes `add_offset` and `scale_factor` for all variables. The default data type for all variables is automatically changed to 16-bit integer. Use the **CDO** option -b to change the data type to a different integer precision, if needed. Missing values are automatically transformed to the current data type.

Alternatively, the pack parameters `add_offset` and `scale_factor` can be read from a file for each variable.

Parameters

printparam
: [BOOL] Print pack parameters to stdout for each variable

filename
: [STRING] Read pack parameters from file for each variable[format: name=<> add_offset=<> scale_factor=<>]

Author

Uwe Schulzweida

2.2.4 Unpack

Name

unpack - Unpack data

Synopsis

cdo unpack *infile outfile*

Description

Packing reduces the data volume by reducing the precision of the stored numbers. It is implemented using the NetCDF attributes `add_offset` and `scale_factor`. The operator **unpack** unpack all packed variables. The default data type for all variables is automatically changed to 32-bit floats. Use the **CDO** option -b F64 to change the data type to 64-bit floats, if needed.

Author

Uwe Schulzweida

2.2.5 Setchunkspec

Name

setchunkspec - Specify chunking

Synopsis

cdo setchunkspec,*parameter infile outfile*

Description

Specify chunking for selected variables in the output. Chunking is available for NetCDF4 and useful to specify the units of disk access and compression. The filename parameter is used to specify the file which contains the chunk specification for each variable. The chunkspec argument is a comma-separated string with the chunk size for the dimensions x,y,z,t. A chunkspec must name at least one dimension, e.g. t=<chunksize> to set the chunk size of the time dimension to <chunksize>.

Use the **CDO** option –chunkspec instead of setchunkspec if all variables require the same chunks.

Parameters

filename
[STRING] Name of the file containing the chunk specification per variable [format: varname=”<chunkspec>”]

Author

Uwe Schulzweida

2.2.6 Setfilter

Name

setfilter - Specify filter

Synopsis

cdo setfilter,*parameter infile outfile*

Description

Specify filter for selected variables in the output. Filters are available for NetCDF4 and mainly used to compress/decompress data. NetCDF4 uses the HDF5 plugins for filter support. To find the HDF5 plugins, the environment variable HDF5_PLUGIN_PATH must point to the directory with the installed plugins. The program may terminate unexpectedly if filters are used whose plugins are not found.

The filename parameter is used to specify the file which contains the filter specification for each variable. A filter specification consists of the filterId and the filter parameters. **CDO** supports multiple filters connected with '|'. Here is a filter specification for bzip2 (filterId: 307) combined with szip (filterId:4): "307,9|4,32,32".

Use the **CDO** option –filter instead of setfilter if all variables require the same filter. More information about NetCDF4 filters can be found in https://docs.unidata.ucar.edu/netcdf-c/current/filters.html.

Parameters

filename
[STRING] Name of the file containing the filter specification per variable [format: varname="<filterspec>"]

Author

Uwe Schulzweida

2.2.7 Bitrounding

Name

bitrounding - Bit rounding

Synopsis

cdo bitrounding[,*parameter*] *infile outfile*

Description

This operator calculates for each field the number of necessary mantissa bits to get a certain information level in the data. With this number of significant bits (`numbits`) a rounding of the data is performed. This allows the data to be compressed to a higher level.

The default value of the information level is 0.9999 and can be adjusted with the parameter `inflevel`. That means 99.99% of the information in the mantissa bits is preserved.

Alternatively, the number of significant bits can be set for all variables with the `numbits` parameter. Furthermore, `numbits` can be assigned for each variable via the filename parameter. In this case, `numbits` is still calculated for all variables if they are not present in the file.

The analysis of the bit information is based on the Julia library BitInformation.jl. The procedure to derive the number of significant mantissa bits was adapted from the Python library xbitinfo. Quantize to the number of mantissa bits is done with IEEE rounding using code from NetCDF 4.9.0.

Currently only 32-bit float data is rounded. Data with missing values are not yet supported for the calculation of significant bits.

Parameters

inflevel
    [FLOAT] Information level (0 - 1) [default: 0.9999]

addbits
    [INTEGER] Add bits to the number of significant bits [default: 0]

minbits
    [INTEGER] Minimum value of the number of bits [default: 1]

maxbits
    [INTEGER] Maximum value of the number of bits [default: 23]

numsteps
    [INTEGER] Set to 1 to run the calculation only in the first time step

numbits
    [INTEGER] Set number of significant bits

printbits
    [BOOL] Print max. numbits per variable of 1st timestep to stdout [format: name=numbits]

filename
    [STRING] Read number of significant bits per variable from file [format: name=numbits]

Example

Apply bit rounding to all 32-bit float fields, preserving 99.9% of the information, followed by compression and storage to NetCDF4:

```
cdo -f nc4 -z zip bitrounding,inflevel=0.999 infile outfile
```

Add the option `-v` to view used number of mantissa bits for each field:

```
cdo -v -f nc4 -z zip bitrounding,inflevel=0.999 infile outfile
```

Author

Uwe Schulzweida

2.2.8 Replace

Name

replace - Replace variables

Synopsis

cdo replace *infile1 infile2 outfile*

Description

This operator replaces variables in `infile1` by variables from `infile2` and write the result to `outfile`. Both input datasets need to have the same number of timesteps. All variable names may only occur once!

Example

Assume the first input dataset `infile1` has three variables with the names geosp, t and tslm1 and the second input dataset `infile2` has only the variable tslm1. To replace the variable tslm1 in `infile1` by tslm1 from `infile2` use:

```
cdo replace infile1 infile2 outfile
```

Author

Uwe Schulzweida

2.2.9 Duplicate

Name

duplicate - Duplicates a dataset

Synopsis

cdo duplicate[,*parameter*] *infile outfile*

Description

This operator duplicates the contents of `infile` and writes the result to `outfile`. The optional parameter sets the number of duplicates, the default is 2.

Parameters

ndup
[INTEGER] Number of duplicates, default is 2.

Author

Uwe Schulzweida

2.2.10 Mergegrid

Name

mergegrid - Merge grid

Synopsis

cdo mergegrid *infile1 infile2 outfile*

Description

Merges grid points of all variables from `infile2` to `infile1` and write the result to `outfile`. Only the non missing values of `infile2` will be used. The horizontal grid of `infile2` should be smaller or equal to the grid of `infile1` and the resolution must be the same. Only rectilinear grids are supported. Both input files need to have the same variables and the same number of timesteps.

Author

Uwe Schulzweida

2.2.11 Merge

Name

merge, mergetime - Merge datasets

Synopsis

cdo [options] merge *infiles outfile*

cdo [options] mergetime[,*parameters*] *infiles outfile*

Description

This module reads datasets from several input files, merges them and writes the resulting dataset to `outfile`.

Operators

merge
Merge datasets with different fields

Merges time series of different fields from several input datasets. The number of fields per timestep written to `outfile` is the sum of the field numbers per timestep in all input datasets. The time series on all input datasets are required to have different fields and the same number of timesteps. The fields in each different input file either have to be different variables or different levels of the same variable. A mixture of different variables on different levels in different input files is not allowed.

mergetime
Merge datasets sorted by date and time

Merges all timesteps of all input files sorted by date and time. All input files need to have the same structure with the same variables on different timesteps. After this operation every input timestep is in `outfile` and all timesteps are sorted by date and time.

Parameters

skip_same_time
[BOOL] Skips all consecutive timesteps with a double entry of the same timestamp.

names
[STRING] Fill missing variable names with missing values (union) or use the intersection (intersect).

Options

`-O`, `--overwrite` to overwrite existing output file.

Note

Operators of this module need to open all input files simultaneously. The maximum number of open files depends on the operating system!

Example

Assume three datasets with the same number of timesteps and different variables in each dataset. To merge these datasets to a new dataset use:

```
cdo merge infile1 infile2 infile3 outfile
```

Assume you split a 6 hourly dataset with *splithour*. This produces four datasets, one for each hour. The following command merges them together:

```
cdo mergetime infile1 infile2 infile3 infile4 outfile
```

Author

Uwe Schulzweida

2.2.12 Split

Name

splitcode, splitparam, splitname, splitlevel, splitgrid, splitzaxis, splittabnum, splitensemble - Split a dataset

Synopsis

cdo <*operator*>[,*parameters*] *infile obase*

Description

This module splits `infile` into pieces. The output files will be named `<obase><xxx><suffix>` where `suffix` is the filename extension derived from the file format. `xxx` and the contents of the output files depends on the chosen operator. params is a comma-separated list of processing parameters.

Operators

splitcode
Split code numbers

Splits a dataset into pieces, one for each different code number. `xxx` will have three digits with the code number.

splitparam
Split parameter identifiers

Splits a dataset into pieces, one for each different parameter identifier. `xxx` will be a string with the parameter identifier.

splitname
Split variable names

Splits a dataset into pieces, one for each variable name. `xxx` will be a string with the variable name.

splitlevel
Split levels

Splits a dataset into pieces, one for each different level. `xxx` will have six digits with the level.

splitgrid
Split grids

Splits a dataset into pieces, one for each different grid. `xxx` will have two digits with the grid number.

splitzaxis
Split z-axes

Splits a dataset into pieces, one for each different z-axis. `xxx` will have two digits with the z-axis number.

splittabnum
Split parameter table numbers

Splits a dataset into pieces, one for each GRIB1 parameter table number. `xxx` will have three digits with the GRIB1 parameter table number.

splitensemble
Split ensembles

Splits a dataset into pieces, one for each GRIB2 ensemble member. `xxx` will have five digits with the GRIB2 key perturbationNumber.

Parameters

swap
[STRING] Swap the position of obase and xxx in the output filename

uuid=<attname>
[STRING] Add a UUID as global attribute <attname> to each output file

Environment

CDO_FILE_SUFFIX sets the filename suffix.

Note

Operators of this module need to open all output files simultaneously. The maximum number of open files depends on the operating system!

Example

Assume an input GRIB1 dataset with three variables, e.g. code number 129, 130 and 139. To split this dataset into three pieces, one for each code number use:

```
cdo splitcode infile code
```

Result of `dir code*`:

```
code129.grb code130.grb code139.grb
```

Author

Uwe Schulzweida

2.2.13 Splittime

Name

splithour, splitday, splitseas, splityear, splityearmon, splitmon - Split timesteps of a dataset

Synopsis

cdo *<operator> infile obase*

Description

This module splits `infile` into timesteps pieces. The output files will be named `<obase><xxx><suffix>}` `where :file:`suffix` is the filename extension derived from the file format. `xxx` and the contents of the output files depends on the chosen operator.

Operators

splithour
: Split hours

  Splits a file into pieces, one for each different hour. `xxx` will have two digits with the hour.

splitday
: Split days

  Splits a file into pieces, one for each different day. `xxx` will have two digits with the day.

splitmon
: Split months

  Splits a file into pieces, one for each different month. `xxx` will have two digits with the month. Use the optional format parameter to change the format for the month.

splitseas
: Split seasons

  Splits a file into pieces, one for each different season. `xxx` will have three characters with the season.

splityearmon
: Split in years and months

  Splits a file into pieces, one for each different year and month. `xxx` will have six digits with the year and month (YYYYMM).

splityear
: Split years

  Splits a file into pieces, one for each different year. `xxx` will have four digits with the year (YYYY).

Parameters

format
: [STRING] C-style format for strftime() (e.g. %B for the full month name)

Environment

CDO_FILE_SUFFIX sets the filename suffix.

Note

Operators of this module need to open all output files simultaneously. The maximum number of open files depends on the operating system!

Example

Assume the input GRIB1 dataset has timesteps from January to December. To split each month with all variables into one separate file use:

```
cdo splitmon infile mon
```

Result of `dir mon*`:

```
mon01.grb  mon02.grb  mon03.grb  mon04.grb  mon05.grb  mon06.grb
mon07.grb  mon08.grb  mon09.grb  mon10.grb  mon11.grb  mon12.grb
```

Author

Uwe Schulzweida

2.2.14 Splitsel

Name

splitsel - Split selected timesteps

Synopsis

cdo splitsel,*parameters infile obase*

Description

This operator splits `infile` into pieces, one for each adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range. The output files will be named `<obase><nnnnnn><suffix>` where `nnnnnn` is the sequence number and `suffix` is the filename extension derived from the file format.

Parameters

nsets
[INTEGER] Number of input timesteps for each output file

noffset
[INTEGER] Number of input timesteps skipped before the first timestep range (optional)

nskip
[INTEGER] Number of input timesteps skipped between timestep ranges (optional)

Environment

CDO_FILE_SUFFIX sets the filename suffix.

Author

Etienne Tourigny

2.2.15 Splitdate

Name

splitdate - Splits a file into dates

Synopsis

cdo splitdate *infile obase*

Description

This operator splits `infile` into pieces, one for each different date. The output files will be named `<obase><YYYY-MM-DD><suffix>` where `YYYY-MM-DD` is the date and `suffix` is the filename extension derived from the file format.

Environment

`CDO_FILE_SUFFIX` sets the filename suffix.

Author

Uwe Schulzweida

2.2.16 Distgrid

Name

distgrid - Distribute horizontal grid

Synopsis

cdo distgrid,*parameters infile obase*

Description

This operator distributes a dataset into smaller pieces. Each output file contains a different region of the horizontal source grid. 2D Lon/Lat grids can be split into `nx*ny` pieces, where a target grid region contains a structured longitude/latitude box of the source grid. Data on an unstructured grid is split into `nx` pieces. The output files will be named `<obase><xxx><suffix>` where suffix is the filename extension derived from the file format. `xxx` will have five digits with the number of the target region.

Parameters

nx

[INTEGER] Number of regions in x direction, or number of pieces for unstructured grids

ny

[INTEGER] Number of regions in y direction [default: 1]

Note

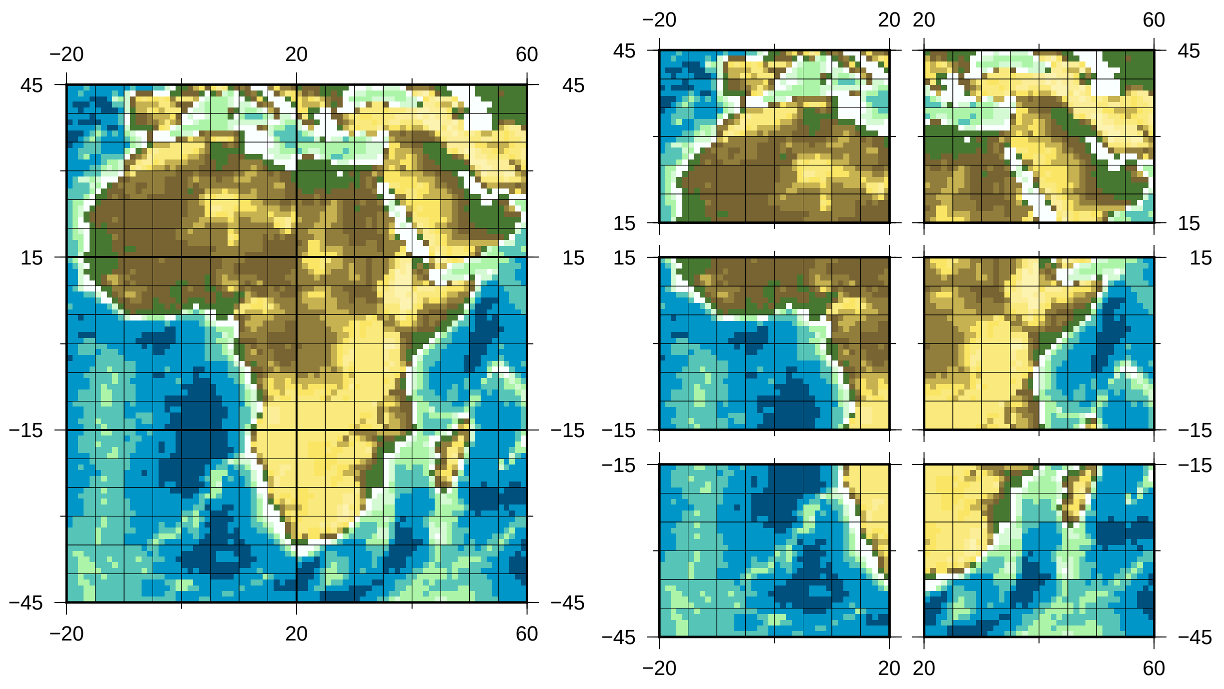
This operator needs to open all output files simultaneously. The maximum number of open files depends on the operating system!

Example

Distribute data on a 2D Lon/Lat grid into 6 smaller files, each output file receives one half of x and a third of y of the source grid:

```
cdo distgrid,2,3 infile.nc obase
```

Below is a schematic illustration of this example:



On the left side is the data of the input file and on the right side is the data of the six output files.

Author

Uwe Schulzweida

2.2.17 Collgrid

Name

collgrid - Collect horizontal grid

Synopsis

cdo collgrid,*parameters infiles obase*

Description

This operator collects the data of the input files to one output file. All input files need to have the same variables and the same number of timesteps on a different horizontal grid region. If the source regions are on a structured lon/lat grid, all regions together must result in a new structured lat/long grid box. Data on an unstructured grid are concatenated in the order of the input files. For ICON restart data, the array global_cell_indices is used for indexing if it is available. The parameter `nx` needs to be specified only for curvilinear grids.

Parameters

nx
: [INTEGER] Number of regions in x direction [default: number of input files]

name
: [STRING] Comma-separated list of variable names.

levidx
: [INTEGER] Comma-separated list or first/last[/inc] range of index of levels.

gridtype
: [STRING] For unstructured grids, set to unstructured.

Note

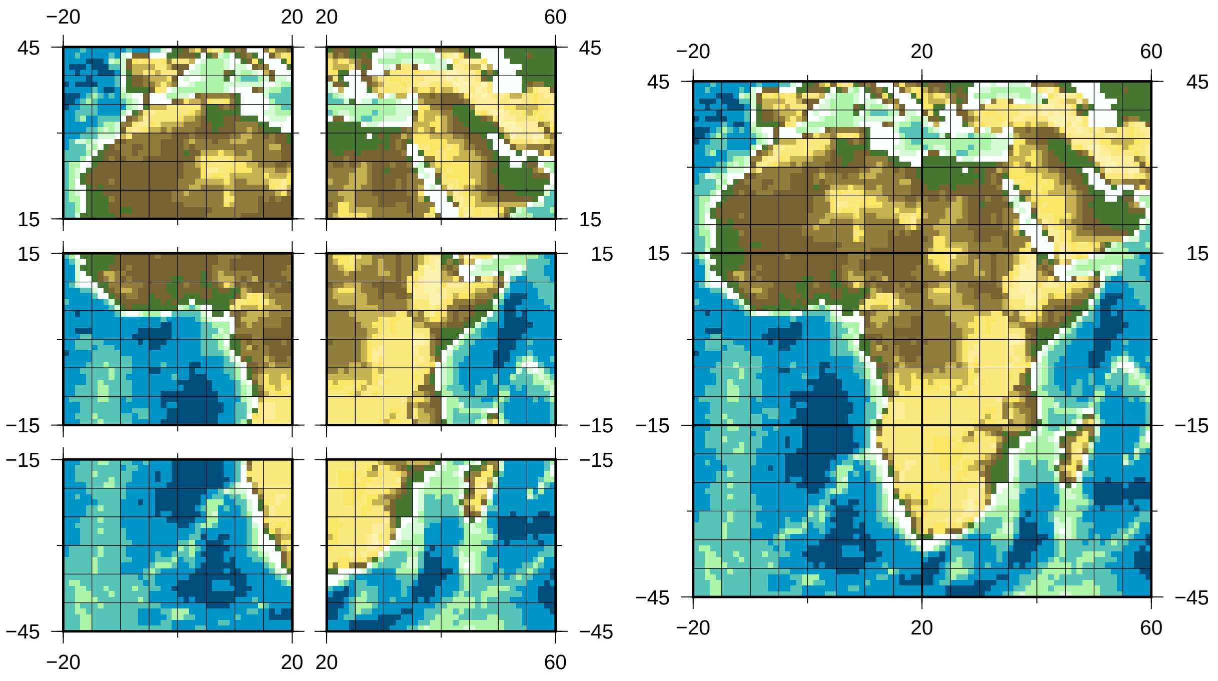
This operator needs to open all input files simultaneously. The maximum number of open files depends on the operating system!

Example

Collect the horizontal grid of 6 input files. Each input file contains a lon/lat region of the target grid:

```
cdo collgrid infile[1-6] outfile
```

Below is a schematic illustration of this example:



On the left side is the data of the six input files and on the right side is the collected data of the output file.

Author

Uwe Schulzweida

2.3 Selection

This section contains modules to select time steps, fields or a part of a field from a dataset.

Here is a short overview of all operators in this section:

Select	*select*	Select fields
	delete	Delete fields
Selmulti	*selmulti*	Select multiple fields
	delmulti	Delete multiple fields
	changemulti	Change identification of multiple fields
Selvar	*selparam*	Select parameters by identifier
	delparam	Delete parameters by identifier
	selcode	Select parameters by code number
	delcode	Delete parameters by code number
	selname	Select parameters by name
	delname	Delete parameters by name
	selstdname	Select parameters by standard name
	sellevel	Select levels
	sellevidx	Select levels by index
	selgrid	Select grids
	selzaxis	Select z-axes
	selzaxisname	Select z-axes by name
	selltype	Select GRIB level types
	seltabnum	Select parameter table numbers
Seltime	*seltimestep*	Select timesteps
	seltime	Select times
	selhour	Select hours
	selday	Select days
	selmonth	Select months
	selyear	Select years
	selseason	Select seasons
	seldate	Select dates
	selsmon	Select single month
Selbox	*sellonlatbox*	Select a longitude/latitude box
	selindexbox	Select an index box
Selregion	*selregion*	Select cells inside regions
	selcircle	Select cells inside a circle
Selgridcell	*selgridcell*	Select grid cells
	delgridcell	Delete grid cells
Samplegrid	*samplegrid*	Resample grid cells
Selyearidx	*selyearidx*	Select year by index
Seltimeidx	*seltimeidx*	Select timestep by index
Selsurface	*bottomvalue*	Extract bottom level
	topvalue	Extract top level
	isosurface	Extract isosurface

2.3.1 Select

Name

select, delete - Select fields

Synopsis

cdo *<operator>,parameters infiles outfile*

Description

This module selects some fields from `infiles` and writes them to `outfile`. `infiles` is an arbitrary number of input files. All input files need to have the same structure with the same variables on different timesteps. The fields selected depends on the chosen parameters. Parameter is a comma-separated list of "key=value" pairs. A range of integer values can be specified by first/last[/inc]. Wildcards are supported for string values.

Operators

select
Select fields

Selects all fields with parameters in a user given list.

delete
Delete fields

Deletes all fields with parameters in a user given list.

Parameters

name
[STRING] Comma-separated list of variable names.

param
[STRING] Comma-separated list of parameter identifiers.

code
[INTEGER] Comma-separated list or first/last[/inc] range of code numbers.

level
[FLOAT] Comma-separated list of vertical levels.

levrange
[FLOAT] First and last value of the level range.

levidx
[INTEGER] Comma-separated list or first/last[/inc] range of index of levels.

zaxisname
[STRING] Comma-separated list of zaxis names.

zaxisnum
[INTEGER] Comma-separated list or first/last[/inc] range of zaxis numbers.

ltype
[INTEGER] Comma-separated list or first/last[/inc] range of GRIB level types.

gridname
[STRING] Comma-separated list of grid names.

gridnum
[INTEGER] Comma-separated list or first/last[/inc] range of grid numbers.

steptype
[STRING] Comma-separated list of timestep types (constant|avg|accum|min|max|range|diff|sum)

date
[STRING] Comma-separated list of dates (format: YYYY-MM-DDThh:mm:ss).

startdate
[STRING] Start date (format: YYYY-MM-DDThh:mm:ss).

enddate
[STRING] End date (format: YYYY-MM-DDThh:mm:ss).

minute
[INTEGER] Comma-separated list or first/last[/inc] range of minutes.

hour
[INTEGER] Comma-separated list or first/last[/inc] range of hours.

day
[INTEGER] Comma-separated list or first/last[/inc] range of days.

month
[INTEGER] Comma-separated list or first/last[/inc] range of months.

season
[STRING] Comma-separated list of seasons (substring of DJFMAMJJASOND or ANN).

year
[INTEGER] Comma-separated list or first/last[/inc] range of years.

dom
[STRING] Comma-separated list of the day of month (e.g. 29feb).

timestep
[INTEGER] Comma-separated list or first/last[/inc] range of timesteps. Negative values select timesteps from the end (NetCDF only).

timestep_of_year
[INTEGER] Comma-separated list or first/last[/inc] range of timesteps of year.

timestepmask
[STRING] Read timesteps from a mask file.

Example

Assume you have 3 inputfiles. Each inputfile contains the same variables for a different time period. To select the variable T,U and V on the levels 200, 500 and 850 from all 3 input files, use:

```
cdo select,name=T,U,V,level=200,500,850 infile1 infile2 infile3 outfile
```

To remove the February 29th use:

```
cdo delete,dom=29feb infile outfile
```

Author

Uwe Schulzweida

2.3.2 Selmulti

Name

selmulti, delmulti, changemulti - Select multiple fields via GRIB1 parameters

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module selects multiple fields from `infile` and writes them to `outfile`. selection-specification is a filename or in-place string with the selection specification. Each selection-specification has the following compact notation format:

```
<type>(parameters; leveltype(s); levels)
```

type : sel for select or del for delete (optional)

parameters : GRIB1 parameter code number

leveltype : GRIB1 level type

levels : value of each level

Examples:

```
(1; 103; 0)
(33,34; 105; 10)
(11,17; 105; 2)
(71,73,74,75,61,62,65,117,67,122,121,11,131,66,84,111,112; 105; 0)
```

The following descriptive notation can also be used for selection specification from a file:

```
SELECT/DELETE, PARAMETER=parameters, LEVTYPE=leveltye(s), LEVEL=levels
```

Examples:

```
SELECT, PARAMETER=1, LEVTYPE=103, LEVEL=0
SELECT, PARAMETER=33/34, LEVTYPE=105, LEVEL=10
SELECT, PARAMETER=11/17, LEVTYPE=105, LEVEL=2
SELECT, PARAMETER=71/73/74/75/61/62/65/117/67/122, LEVTYPE=105, LEVEL=0
DELETE, PARAMETER=128, LEVTYPE=109, LEVEL=*
```

The following will convert Pressure from Pa into hPa; Temp from Kelvin to Celsius:

```
SELECT, PARAMETER=1, LEVTYPE= 103, LEVEL=0, SCALE=0.01
SELECT, PARAMETER=11, LEVTYPE=105, LEVEL=2, OFFSET=273.15
```

If SCALE and/or OFFSET are defined, then the data values are scaled as SCALE*(VALUE-OFFSET).

Operators

selmulti
: Select multiple fields

delmulti
: Delete multiple fields

changemulti
: Change identification of multiple fields

Example

Change ECMWF GRIB code of surface pressure to Hirlam notation:

```
cdo changemulti,'{(134;1;*|1;105;*)}' infile outfile
```

Author

Michal Koutek

2.3.3 Selvar

Name

selparam, delparam, selcode, delcode, selname, delname, selstdname, sellevel, sellevidx, selgrid, selzaxis, selzaxisname, selltype, seltabnum - Select fields

Synopsis

cdo <*operator*>,*parameters infile outfile*

Description

This module selects some fields from `infile` and writes them to `outfile`. The fields selected depends on the chosen operator and the parameters. A range of integer values can be specified by first/last[/inc].

Operators

selparam
: Select parameters by identifier

  Selects all fields with parameter identifiers in a user given list (Parameter: identifiers).

delparam
: Delete parameters by identifier

  Deletes all fields with parameter identifiers in a user given list (Parameter: identifiers).

selcode
: Select parameters by code number

  Selects all fields with code numbers in a user given list or range (Parameter: codes).

delcode
: Delete parameters by code number

  Deletes all fields with code numbers in a user given list or range (Parameter: codes).

selname
: Select parameters by name

  Selects all fields with parameter names in a user given list (Parameter: names).

delname
: Delete parameters by name

  Deletes all fields with parameter names in a user given list (Parameter: names).

selstdname
: Select parameters by standard name

  Selects all fields with standard names in a user given list (Parameter: stdnames).

sellevel
: Select levels

  Selects all fields with levels in a user given list (Parameter: levels).

sellevidx
: Select levels by index

  Selects all fields with index of levels in a user given list or range (Parameter: levidx).

selgrid
: Select grids

  Selects all fields with grids in a user given list (Parameter: grids).

selzaxis
Select z-axes

Selects all fields with z-axes in a user given list (Parameter: zaxes).

selzaxisname
Select z-axes by name

Selects all fields with z-axis names in a user given list (Parameter: zaxisnames).

selltype
Select GRIB level types

Selects all fields with GRIB level type in a user given list or range (Parameter: ltypes).

seltabnum
Select parameter table numbers

Selects all fields with parameter table numbers in a user given list or range (Parameter: tabnums).

Parameters

identifier
[STRING] Comma-separated list of parameter identifiers.

codes
[INTEGER] Comma-separated list or first/last[/inc] range of code numbers.

names
[STRING] Comma-separated list of variable names.

stdnames
[STRING] Comma-separated list of standard names.

levels
[FLOAT] Comma-separated list of vertical levels.

levidx
[INTEGER] Comma-separated list or first/last[/inc] range of index of levels.

ltypes
[INTEGER] Comma-separated list or first/last[/inc] range of GRIB level types.

grids
[STRING] Comma-separated list of grid names or numbers.

zaxes
[STRING] Comma-separated list of z-axis types or numbers.

zaxisnames
[STRING] Comma-separated list of z-axis names.

tabnums
[INTEGER] Comma-separated list or range of parameter table numbers.

Example

Assume an input dataset has three variables with the code numbers 129, 130 and 139. To select the variables with the code number 129 and 139 use:

```
cdo selcode,129,139 infile outfile
```

You can also select the code number 129 and 139 by deleting the code number 130 with:

```
cdo delcode,130 infile outfile
```

Author

Uwe Schulzweida

2.3.4 Seltime

Name

seltimestep, seltime, selhour, selday, selmonth, selyear, selseason, seldate, selsmon - Select timesteps

Synopsis

cdo <*operator*>,*parameters infile outfile*

Description

This module selects user specified timesteps from `infile` and writes them to `outfile`. The timesteps selected depends on the chosen operator and the parameters. A range of integer values can be specified by first/last[/inc].

Operators

seltimestep
Select timesteps

Selects all timesteps with a timestep in a user given list or range (Parameter: timesteps).

seltime
Select times

Selects all timesteps with a time in a user given list or range (Parameter: times).

selhour
Select hours

Selects all timesteps with a hour in a user given list or range (Parameter: hours).

selday
Select days

Selects all timesteps with a day in a user given list or range (Parameter: days).

selmonth
Select months

Selects all timesteps with a month in a user given list or range (Parameter: months).

selyear
Select years

Selects all timesteps with a year in a user given list or range (Parameter: years).

selseason
Select seasons

Selects all timesteps with a month of a season in a user given list (Parameter: seasons).

seldate
Select dates

Selects all timesteps with a date in a user given range (Parameter: startdate [enddate]).

selsmon
Select single month

Selects a month and optional an arbitrary number of timesteps before and after this month (Parameter: month [nts1] [nts2]).

Parameters

timesteps
[INTEGER] Comma-separated list or first/last[/inc] range of timesteps. Negative values select timesteps from the end (NetCDF only).

times
[STRING] Comma-separated list of times (format hh:mm:ss).

hours
[INTEGER] Comma-separated list or first/last[/inc] range of hours.

days
[INTEGER] Comma-separated list or first/last[/inc] range of days.

months
[INTEGER] Comma-separated list or first/last[/inc] range of months.

years
[INTEGER] Comma-separated list or first/last[/inc] range of years.

seasons
[STRING] Comma-separated list of seasons (substring of DJFMAMJJASOND or ANN).

startdate
[STRING] Start date (format: YYYY-MM-DDThh:mm:ss).

enddate
[STRING] End date (format: YYYY-MM-DDThh:mm:ss) [default: startdate].

nts1
[INTEGER] Number of timesteps before the selected month [default: 0].

nts2
[INTEGER] Number of timesteps after the selected month [default: nts1].

Author

Uwe Schulzweida

2.3.5 Selbox

Name

sellonlatbox, selindexbox - Select a box

Synopsis

cdo sellonlatbox,*lon1,lon2,lat1,lat2 infile outfile*

cdo selindexbox,*idx1,idx2,idy1,idy2 infile outfile*

Description

Selects grid cells inside a lon/lat or index box.

Operators

sellonlatbox
: Select a longitude/latitude box

  Selects grid cells inside a lon/lat box. The user must specify the longitude and latitude of the edges of the box. Only those grid cells are considered whose grid center lies within the lon/lat box. For rotated lon/lat grids the parameters must be specified in rotated coordinates.

selindexbox
: Select an index box

  Selects grid cells within an index box. The user must specify the indices of the edges of the box. The index of the left edge can be greater then the one of the right edge. Use negative indexing to start from the end. The input grid must be a regular lon/lat or a 2D curvilinear grid.

Parameters

lon1
: [FLOAT] Western longitude in degrees

lon2
: [FLOAT] Eastern longitude in degrees

lat1
: [FLOAT] Southern or northern latitude in degrees

lat2
: [FLOAT] Northern or southern latitude in degrees

idx1
: [INTEGER] Index of first longitude (1 - nlon)

idx2
: [INTEGER] Index of last longitude (1 - nlon)

idy1
: [INTEGER] Index of first latitude (1 - nlat)

idy2
: [INTEGER] Index of last latitude (1 - nlat)

Example

To select the region with the longitudes from 30W to 60E and latitudes from 30N to 80N from all input fields use:

```
cdo sellonlatbox,-30,60,30,80 infile outfile
```

If the input dataset has fields on a regular Gaussian F16 grid, the same box can be selected with *selindexbox* by:

```
cdo selindexbox,60,11,3,11 infile outfile
```

Author

Uwe Schulzweida

2.3.6 Selregion

Name

selregion, selcircle - Select horizontal regions

Synopsis

cdo selregion,*regions infile outfile*

cdo selcircle,*parameters infile outfile*

Description

Selects all grid cells with the center point inside user defined regions or a circle. The resulting grid is unstructured.

Operators

selregion
Select cells inside regions

Selects all grid cells with the center point inside the regions. Regions can be defined by the user via an ASCII file. Each region consists of the geographic coordinates of a polygon. Each line of a polygon description file contains the longitude and latitude of one point. Each polygon description file can contain one or more polygons separated by a line with the character &.

Predefined regions of countries can be specified via the country codes. A country is specified with dcw:<CountryCode>. Country codes can be combined with the plus sign.

selcircle
Select cells inside a circle

Selects all grid cells with the center point inside a circle. The circle is described by geographic coordinates of the center and the radius of the circle (Parameter: lon, lat, radius).

Parameters

regions
[STRING] Comma-separated list of ASCII formatted files with different regions

lon
[FLOAT] Longitude of the center of the circle in degrees, default lon=0.0

lat
[FLOAT] Latitude of the center of the circle in degrees, default lat=0.0

radius
[STRING] Radius of the circle, default radius=1deg (units: deg, rad, km, m)

Example

To select all grid cells of a country use the country code with data from the Digital Chart of the World. Here is an example for Spain with the country code ES:

```
cdo selregion,dcw:ES infile outfile
```

Author

Uwe Schulzweida

2.3.7 Selgridcell

Name

selgridcell, delgridcell - Select grid cells

Synopsis

cdo <*operator*>,*indices infile outfile*

Description

The operator selects grid cells of all fields from `infile`. The user must specify the index of each grid cell. The resulting grid in `outfile` is unstructured.

Operators

selgridcell
    Select grid cells

delgridcell
    Delete grid cells

Parameters

indices
    [INTEGER] Comma-separated list or first/last[/inc] range of indices

Author

Uwe Schulzweida

2.3.8 Samplegrid

Name

samplegrid - Resample grid cells

Synopsis

cdo samplegrid,*factor infile outfile*

Description

This is a special operator for resampling the horizontal grid. No interpolation takes place. Resample factor=2 means every second grid point is removed. Only rectilinear and curvilinear source grids are supported by this operator.

Parameters

factor
: [INTEGER] Resample factor, typically 2, which will half the resolution

Author

Michal Koutek

2.3.9 Selyearidx

Name

selyearidx - Select year by index

Synopsis

cdo selyearidx *infile1 infile2 outfile*

Description

Selects field elements from `infile2` according to a year index from `infile1`. The index of the year in `infile1` should be the result of corresponding *yearminidx* or *yearmaxidx* operations, respectively.

Author

Uwe Schulzweida

2.3.10 Seltimeidx

Name

seltimeidx - Select timestep by index

Synopsis

cdo seltimeidx *infile1 infile2 outfile*

Description

Selects field elements from `infile2` according to a timestep index from `infile1`. The index of the timestep in `infile1` should be the result of corresponding *timminidx* or *timmaxidx* operations, respectively.

Author

Uwe Schulzweida

2.3.11 Selsurface

Name

bottomvalue, topvalue, isosurface - Extract surface

Synopsis

cdo <*operator*> *infile outfile*

cdo isosurface,*isovalue infile outfile*

Description

This module computes a surface from all 3D variables. The result is a horizontal 2D field.

Operators

isosurface
Extract isosurface

This operator computes an isosurface. The value of the isosurfce is specified by the parameter isovalue. The isosurface is calculated by linear interpolation between two layers.

bottomvalue
Extract bottom level

This operator selects the valid values at the bottom level. The NetCDF CF compliant attribute positive is used to determine where top and bottom are. If this attribute is missing, low values are bottom and high values are top.

topvalue
Extract top level

This operator selects the valid values at the top level. The NetCDF CF compliant attribute positive is used to determine where top and bottom are. If this attribute is missing, low values are bottom and high values are top.

Parameters

isovalue
[FLOAT] Isosurface value

Author

Uwe Schulzweida

2.4 Conditional selection

This section contains modules to conditional select field elements. The fields in the first input file are handled as a mask. A value not equal to zero is treated as “true”, zero is treated as “false”.

Here is a short overview of all operators in this section:

Cond	*ifthen*	If then
	ifnotthen	If not then
Cond2	*ifthenelse*	Conditional selection
Condc	*ifthenc*	If then constant
	ifnotthenc	If not then constant
Mapreduce	*reducegrid*	Reduce fields to user-defined mask

2.4.1 Cond

Name

ifthen, ifnotthen - Conditional selection

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module selects field elements from `infile2` with respect to `infile1` and writes them to `outfile`. The fields in `infile1` are handled as a mask. A value not equal to zero is treated as "true", zero is treated as "false". The number of fields in `infile1` has either to be the same as in `infile2` or the same as in one timestep of `infile2` or only one. The fields in `outfile` inherit the meta data from `infile2`.

Operators

ifthen
If then

$$o(t,x) = \begin{cases} i_2(t,x) & \text{if } \; i_1(t,x) \neq 0 \quad \wedge \; i_1(t,x) \neq \text{miss} \\ \text{miss} & \text{if } \; i_1(t,x) = 0 \quad \vee \; i_1(t,x) = \text{miss} \end{cases}$$

ifnotthen
If not then

$$o(t,x) = \begin{cases} i_2(t,x) & \text{if } \; i_1(t,x) = 0 \quad \wedge \; i_1(t,x) \neq \text{miss} \\ \text{miss} & \text{if } \; i_1[t,x) \neq 0 \quad \vee \; i_1(t,x) = \text{miss} \end{cases}$$

Example

To select all field elements of `infile2` if the corresponding field element of `infile1` is greater than 0 use:

```
cdo ifthen infile1 infile2 outfile
```

Author

Uwe Schulzweida

2.4.2 Cond2

Name

ifthenelse - Conditional selection

Synopsis

cdo ifthenelse *infile1 infile2 infile3 outfile*

Description

This operator selects field elements from `infile2` or `infile3` with respect to `infile1` and writes them to `outfile`. The fields in `infile1` are handled as a mask. A value not equal to zero is treated as "true", zero is treated as "false". The number of fields in `infile1` has either to be the same as in `infile2` or the same as in one timestep of `infile2` or only one. `infile2` and `infile3` need to have the same number of fields. The fields in `outfile` inherit the meta data from `infile2`.

$$o(t,x) = \begin{cases} i_2(t,x) & \text{if } i_1(t,x) \neq 0 \quad \wedge \ i_1(t,x) \neq \text{miss} \\ i_3(t,x) & \text{if } i_1(t,x) = 0 \quad \wedge \ i_1(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} \end{cases}$$

Example

To select all field elements of `infile2` if the corresponding field element of `infile1` is greater than 0 and from `infile3` otherwise use:

```
cdo ifthenelse infile1 infile2 infile3 outfile
```

Author

Uwe Schulzweida

2.4.3 Condc

Name

ifthenc, ifnotthenc - Conditional selection

Synopsis

cdo <*operator*>,*c infile outfile*

Description

This module creates fields with a constant value or missing value. The fields in `infile` are handled as a mask. A value not equal to zero is treated as "true", zero is treated as "false".

Operators

ifthenc
If then constant

$$o(t,x) = \begin{cases} \text{c} & \text{if } \; i(t,x) \neq 0 \quad \wedge \; i(t,x) \neq \text{miss} \\ \text{miss} & \text{if } \; i(t,x) = 0 \quad \vee \; i(t,x) = \text{miss} \end{cases}$$

ifnotthenc
If not then constant

$$o(t,x) = \begin{cases} \text{c} & \text{if } \; i(t,x) = 0 \quad \wedge \; i(t,x) \neq \text{miss} \\ \text{miss} & \text{if } \; i(t,x) \neq 0 \quad \vee \; i(t,x) = \text{miss} \end{cases}$$

Parameters

c
[FLOAT] Constant

Example

To create fields with the constant value 7 if the corresponding field element of `infile` is greater than 0 use:

```
cdo ifthenc,7 infile outfile
```

Author

Uwe Schulzweida

2.4.4 Mapreduce

Name

reducegrid - Reduce fields to user-defined mask

Synopsis

cdo reducegrid,*parameters infile outfile*

Description

This module holds an operator for data reduction based on a user defined mask. The output grid is unstructured and includes coordinate bounds. Bounds can be avoided by using the additional 'nobounds' keyword. With 'nocoords' given, coordinates a completely suppressed.

Operators

reducegrid
Reduce fields to user-defined mask

Reduce input file variables to locations, where mask is non-zero. Horizontal grids of `mask` and `infile` must be identical.

Parameters

mask
[STRING] file which holds the mask field

limitCoordsOutput
[STRING] optional parameter to limit coordinates output: 'nobounds' disables coordinate bounds, 'nocoords' avoids all coordinate information

Example

To limit data fields to land values, a mask has to be created first with:

```
cdo -gtc,0 -topo,ni96 lsm_gme96.grb
```

Here a GME grid is used. Say `temp_gme96.grb` contains a global temperature field. The following command limits the global grid to landpoints:

```
cdo -f nc reducegrid,lsm_gme96.grb temp_gme96.grb tempOnLand_gme96.nc
```

Note that output file type is NetCDF, because unstructured grids cannot be stored in GRIB format.

Author

Ralf Müller

2.5 Comparison

This section contains modules to compare datasets. The resulting field is a mask containing 1 if the comparison is true and 0 if not.

Here is a short overview of all operators in this section:

Comp	*eq*	Equal
	ne	Not equal
	le	Less equal
	lt	Less than
	ge	Greater equal
	gt	Greater than
Compc	*eqc*	Equal constant
	nec	Not equal constant
	lec	Less equal constant
	ltc	Less than constant
	gec	Greater equal constant
	gtc	Greater than constant
Ymoncomp	*ymoneq*	Compare time series with Equal
	ymonne	Compare time series with NotEqual
	ymonle	Compare time series with LessEqual
	ymonlt	Compares if time series with LessThan
	ymonge	Compares if time series with GreaterEqual
	ymongt	Compares if time series with GreaterThan
Yseascomp	*yseaseq*	Compare time series with Equal
	yseasne	Compare time series with NotEqual
	yseasle	Compare time series with LessEqual
	yseaslt	Compares if time series with LessThan
	yseasge	Compares if time series with GreaterEqual
	yseasgt	Compares if time series with GreaterThan

2.5.1 Comp

Name

eq, ne, le, lt, ge, gt - Comparison of two fields

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module compares two datasets field by field. The resulting field is a mask containing 1 if the comparison is true and 0 if not. The number of fields in *infile1* should be the same as in *infile2*. One of the input files can contain only one timestep or one field. The fields in *outfile* inherit the meta data from *infile1* or *infile2*. The type of comparison depends on the chosen operator.

Operators

eq

Equal

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) = i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) \neq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

ne

Not equal

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) \neq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) = i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

le

Less equal

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) \leq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) > i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

lt

Less than

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) < i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) \geq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

ge

Greater equal

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) \geq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) < i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

gt

Greater than

$$o(t,x) = \begin{cases} 1 & \text{if } i_1(t,x) > i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ 0 & \text{if } i_1(t,x) \leq i_2(t,x) & \wedge \ i_1(t,x), i_2(t,x) \neq \text{miss} \\ \text{miss} & \text{if } i_1(t,x) = \text{miss} & \vee \ i_2(t,x) = \text{miss} \end{cases}$$

Example

To create a mask containing 1 if the elements of two fields are the same and 0 if the elements are different use:

```
cdo eq infile1 infile2 outfile
```

Author

Uwe Schulzweida

2.5.2 Compc

Name

eqc, nec, lec, ltc, gec, gtc - Comparison of a field with a constant

Synopsis

cdo <*operator*>,*c infile outfile*

Description

This module compares all fields of a dataset with a constant. The resulting field is a mask containing 1 if the comparison is true and 0 if not. The type of comparison depends on the chosen operator.

Operators

eqc

Equal constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) = \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) \neq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

nec

Not equal constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) \neq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) = \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

lec

Less equal constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) \leq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) > \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

ltc

Less than constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) < \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) \geq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

gec

Greater equal constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) \geq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) < \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

gtc

Greater than constant

$$o(t,x) = \begin{cases} 1 & \text{if } i(t,x) > \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ 0 & \text{if } i(t,x) \leq \text{c} & \wedge \; i(t,x), \text{c} \neq \text{miss} \\ \text{miss} & \text{if } i(t,x) = \text{miss} & \vee \; \text{c} = \text{miss} \end{cases}$$

Parameters

c

[FLOAT] Constant

Example

To create a mask containing 1 if the field element is greater than 273.15 and 0 if not use:

```
cdo gtc,273.15 infile outfile
```

Author

Uwe Schulzweida

2.5.3 Ymoncomp

Name

ymoneq, ymonne, ymonle, ymonlt, ymonge, ymongt - Multi-year monthly comparison

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs comparisons of a time series and one timestep with the same month of year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same month of year is used. The resulting field is a mask containing 1 if the comparison is true and 0 if not. The type of comparison depends on the chosen operator. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Ymonstat*.

Operators

ymoneq
: Compare time series with Equal

  Compares whether a time series is equal to a multi-year monthly time series.

ymonne
: Compare time series with NotEqual

  Compares whether a time series is not equal to a multi-year monthly time series.

ymonle
: Compare time series with LessEqual

  Compares whether a time series is less than or equal to a multi-year monthly time series.

ymonlt
: Compares if time series with LessThan

  Compares whether a time series is less than a multi-year monthly time series.

ymonge
: Compares if time series with GreaterEqual

  Compares whether a time series is greater than or equal to a multi-year monthly time series.

ymongt
: Compares if time series with GreaterThan

  Compares whether a time series is greater than a multi-year monthly time series.

Author

Uwe Schulzweida

2.5.4 Yseascomp

Name

yseaseq, yseasne, yseasle, yseaslt, yseasge, yseasgt - Multi-year seasonal comparison

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs comparisons of a time series and one timestep with the same season of year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same season of year is used. The resulting field is a mask containing 1 if the comparison is true and 0 if not. The type of comparison depends on the chosen operator. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module @mod{YseasSTAT}.

Operators

yseaseq
: Compare time series with Equal

  Compares whether a time series is equal to a multi-year seasonal time series.

yseasne
: Compare time series with NotEqual

  Compares whether a time series is not equal to a multi-year seasonal time series.

yseasle
: Compare time series with LessEqual

  Compares whether a time series is less than or equal to a multi-year seasonal time series.

yseaslt
: Compares if time series with LessThan

  Compares whether a time series is less than a multi-year seasonal time series.

yseasge
: Compares if time series with GreaterEqual

  Compares whether a time series is greater than or equal to a multi-year seasonal time series.

yseasgt
: Compares if time series with GreaterThan

  Compares whether a time series is greater than a multi-year seasonal time series.

Author

Uwe Schulzweida

2.6 Modification

This section contains modules to modify the metadata, fields or part of a field in a dataset.

Here is a short overview of all operators in this section:

Setattribute	*setattribute*	Set attributes
	delattribute	Delete attributes
Setpartab	*setpartabp*	Set parameter table
	setpartabn	Set parameter table
Set	*setcodetab*	Set parameter code table
	setcode	Set code number
	setparam	Set parameter identifier
	setname	Set variable name
	setstdname	Set standard name
	setunit	Set variable unit
	setlevel	Set level
	setltype	Set GRIB level type
	setmaxsteps	Set max timesteps
Settime	*setdate*	Set date
	settime	Set time of the day
	setday	Set day
	setmon	Set month
	setyear	Set year
	settunits	Set time units
	settaxis	Set time axis
	settbounds	Set time bounds
	setreftime	Set reference time
	setcalendar	Set calendar
	shifttime	Shift timesteps
Change	*chcode*	Change code number
	chparam	Change parameter identifier
	chname	Change variable or coordinate name
	chunit	Change variable unit
	chlevel	Change level
	chlevelc	Change level of one code
	chlevelv	Change level of one variable
Setgrid	*setgrid*	Set grid
	setgridtype	Set grid type
	setgridarea	Set grid cell area
	setgridmask	Set grid mask
	setprojparams	Set proj params
Setzaxis	*setzaxis*	Set z-axis
	genlevelbounds	Generate level bounds
Invert	*invertlat*	Invert latitudes
Invertlev	*invertlev*	Invert levels
Shiftxy	*shiftx*	Shift x
	shifty	Shift y
Maskregion	*maskregion*	Mask regions
Maskbox	*masklonlatbox*	Mask a longitude/latitude box
	maskindexbox	Mask an index box
Setbox	*setclonlatbox*	Set a longitude/latitude box to constant
	setcindexbox	Set an index box to constant
Enlarge	*enlarge*	Enlarge fields
Setmiss	*setmissval*	Set a new missing value
	setctomiss	Set constant to missing value
	setmisstoc	Set missing value to constant

continues on next page

Table 4 – continued from previous page

	setrtomiss	Set range to missing value
	setvrange	Set valid range
	setmisstonn	Set missing value to nearest neighbor
	setmisstodis	Set missing value to distance-weighted average
Vertfillmiss	*vertfillmiss*	Vertical filling of missing values
Timfillmiss	*timfillmiss*	Temporal filling of missing values
Setgridcell	*setgridcell*	Set the value of a grid cell

2.6.1 Setattribute

Name

setattribute, delattribute - Set attributes

Synopsis

cdo <*operator*>*,parameters infile outfile*

Description

This operator sets or deletes attributes of a dataset and writes the result to `outfile`. The new attributes are only available in `outfile` if the file format supports attributes.

Each attribute has the following structure:

[**var_nm**@]**att_nm**[:s|d|i]=[**att_val** | {[**var_nm**@]**att_nm**}]

var_nm	Variable name (optional). Example: pressure
att_nm	Attribute name. Example: units
att_val	Comma-separated list of attribute values. Example: pascal

The value of **var_nm** is the name of the variable containing the attribute (named **att_nm**) that you want to set. Use wildcards to set the attribute **att_nm** to more than one variable. A value of **var_nm** of '*' will set the attribute **att_nm** to all data variables. If **var_nm** is missing then **att_nm** refers to a global attribute.

The value of **att_nm** is the name of the attribute you want to set. For each attribute a string (att_nm:s), a double (att_nm:d) or an integer (att_nm:i) type can be defined. By default the native type is set.

The value of **att_val** is the contents of the attribute **att_nm**. **att_val** may be a single value or one-dimensional array of elements. The type and the number of elements of an attribute will be detected automatically from the contents of the values. An already existing attribute **att_nm** will be overwritten or it will be removed if **att_val** is omitted. Alternatively, the values of an existing attribute can be copied. This attribute must then be enclosed in curly brackets.

A special meaning has the attribute name **FILE**. If this is the 1st attribute then all attributes are read from a file specified in the value of **att_val**.

Some NetCDF attributes can't be deleted. Here is a incomplete list: missing_value, formula_terms, cell_measures, coordinates, grid_mapping, valid_range, …

Operators

setattribute
Set attributes

delattribute
Delete attributes

Parameters

attributes
[STRING] Comma-separated list of attributes.

Note

Attributes are evaluated by **CDO** when opening `infile`. Therefor the result of this operator is not available for other operators when this operator is used in chaining operators.

Example

To set the units of the variable pressure to pascal use:

```
cdo  setattribute,pressure@units=pascal  infile  outfile
```

To set the global text attribute “my_att” to “my contents”, use:

```
cdo  setattribute,my_att="my contents"  infile  outfile
```

Result of `ncdump -h outfile`:

```
netcdf outfile {
dimensions: ...

variables: ...

// global attributes:
                :my_att = "my contents" ;
}
```

Author

Uwe Schulzweida

2.6.2 Setpartab

Name

setpartabp, setpartabn - Set parameter table

Synopsis

cdo <*operator*>*,parameters infile outfile*

Description

This module transforms data and metadata of `infile` via a parameter table and writes the result to `outfile`. A parameter table is an ASCII formatted file with a set of parameter entries for each variable. Each new set have to start with "&parameter" and to end with "/".

The following parameter table entries are supported:

Entry	Type	Description
name	WORD	Name of the variable
out_name	WORD	New name of the variable
param	WORD	Parameter identifier (GRIB1: code[.tabnum]; GRIB2: num[.cat[.dis]])
out_param	WORD	New parameter identifier
type	WORD	Data type (real or double)
standard_name	WORD	As defined in the CF standard name table
long_name	STRING	Describing the variable
units	STRING	Specifying the units for the variable
comment	STRING	Information concerning the variable
cell_methods	STRING	Information concerning calculation of means or climatologies
cell_measures	STRING	Indicates the names of the variables containing cell areas and volumes
filterspec	STRING	NetCDF4 filter specification
missing_value	FLOAT	Specifying how missing data will be identified
valid_min	FLOAT	Minimum valid value
valid_max	FLOAT	Maximum valid value
ok_min_mean_abs	FLOAT	Minimum absolute mean
ok_max_mean_abs	FLOAT	Maximum absolute mean
factor	FLOAT	Scale factor
delete	INTEGER	Set to 1 to delete variable
convert	INTEGER	Set to 1 to convert the unit if necessary

Unsupported parameter table entries are stored as variable attributes. The search key for the variable depends on the operator. Use @oper{setpartabn} to search variables by the name. This is typically used for NetCDF datasets. The operator @oper{setpartabp} searches variables by the parameter ID.

Operators

setpartabp
Set parameter table

Search variables by the parameter identifier.

setpartabn
Set parameter table

Search variables by name.

Parameters

table
[STRING] Parameter table file or name

convert
[STRING] Converts the units if necessary

Example

Here is an example of a parameter table for one variable:

```
prompt> cat mypartab
&parameter
name            = t
out_name        = ta
standard_name   = air_temperature
units           = "K"
missing_value   = 1.0e+20
valid_min       = 157.1
valid_max       = 336.3
/
```

To apply this parameter table to a dataset use:

```
cdo setpartabn,mypartab,convert  infile  outfile
```

This command renames the variable **t** to **ta**. The standard name of this variable is set to **air_temperature** and the unit is set to [**K**] (converts the unit if necessary). The missing value will be set to **1.0e+20**. In addition it will be checked whether the values of the variable are in the range of **157.1** to **336.3**.

Author

Uwe Schulzweida

2.6.3 Set

Name

setcodetab, setcode, setparam, setname, setstdname, setunit, setlevel, setltype, setmaxsteps - Set field info

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module sets some field information. Depending on the chosen operator the parameter table, code number, parameter identifier, variable name or level is set.

Operators

setcodetab
Set parameter code table

Sets the parameter code table for all variables (Parameter: table).

setcode
Set code number

Sets the code number for all variables to the same given value (Parameter: code).

setparam
Set parameter identifier

Sets the parameter identifier of the first variable (Parameter: param).

setname
Set variable name

Sets the name of the first variable (Parameter: name).

setstdname
Set standard name

Sets the standard name of the first variable (Parameter: stdname).

setunit
Set variable unit

Sets the unit of the first variable (Parameter: unit).

setlevel
Set level

Sets the first level of all variables (Parameter: level).

setltype
Set GRIB level type

Sets the GRIB level type of all variables (Parameter: ltype).

setmaxsteps
Set max timesteps

Sets maximum number of timesteps (Parameter: maxsteps).

Parameters

table
[STRING] Parameter table file or name

code
[INTEGER] Code number

param
[STRING] Parameter identifier (GRIB1: code[.tabnum]; GRIB2: num[.cat[.dis]])

name
[STRING] Variable name

stdname
[STRING] Standard name

level
[FLOAT] New level

ltype
[INTEGER] GRIB level type

maxsteps
[INTEGER] Maximum number of timesteps

Author

Uwe Schulzweida

2.6.4 Settime

Name

setdate, settime, setday, setmon, setyear, settunits, settaxis, settbounds, setreftime, setcalendar, shifttime - Set time

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module sets the time axis or part of the time axis. Which part of the time axis is overwritten/created depends on the chosen operator. The number of time steps does not change.

Operators

setdate
Set date

Sets the date in every timestep to the same given value (Parameter: date).

settime
Set time of the day

Sets the time in every timestep to the same given value (Parameter: time).

setday
Set day

Sets the day in every timestep to the same given value (Parameter: day).

setmon
Set month

Sets the month in every timestep to the same given value (Parameter: month).

setyear
Set year

Sets the year in every timestep to the same given value (Parameter: year).

settunits
Set time units

Sets the base units of a relative time axis (Parameter: units).

settaxis
Set time axis

Sets the time axis (Parameter: date time [inc]).

settbounds
Set time bounds

Sets the time bounds (Parameter: frequency).

setreftime
Set reference time

Sets the reference time of a relative time axis (Parameter: date time [units]).

setcalendar
Set calendar

Sets the calendar attribute of a relative time axis (Parameter: calendar).

shifttime
Shift timesteps

Shifts all timesteps by the parameter shiftValue (Parameter: shiftValue).

Parameters

day
: [INTEGER] Value of the new day

month
: [INTEGER] Value of the new month

year
: [INTEGER] Value of the new year

units
: [STRING] Base units of the time axis (seconds|minutes|hours|days|months|years)

date
: [STRING] Date (format: YYYY-MM-DD)

time
: [STRING] Time (format: hh:mm:ss)

inc
: [STRING] Optional increment (seconds|minutes|hours|days|months|years) [default: 1hour]

frequency
: [STRING] Frequency of the time series (hour|day|month|year)

calendar
: [STRING] Calendar (standard|proleptic_gregorian|360_day|365_day|366_day)

shiftValue
: [STRING] Shift value (e.g. -3hour)

Example

To set the time axis to 1987-01-16 12:00:00 with an increment of one month for each timestep use:

```
cdo settaxis,1987-01-16,12:00:00,1mon infile outfile
```

Result of `cdo showdate outfile` for a dataset with 12 timesteps:

```
1987-01-16 1987-02-16 1987-03-16 1987-04-16 1987-05-16 1987-06-16 \
1987-07-16 1987-08-16 1987-09-16 1987-10-16 1987-11-16 1987-12-16
```

To shift this time axis by -15 days use:

```
cdo shifttime,-15days infile outfile
```

Result of `cdo showdate outfile`:

```
1987-01-01 1987-02-01 1987-03-01 1987-04-01 1987-05-01 1987-06-01 \
1987-07-01 1987-08-01 1987-09-01 1987-10-01 1987-11-01 1987-12-01
```

Author

Uwe Schulzweida

2.6.5 Change

Name

chcode, chparam, chname, chunit, chlevel, chlevelc, chlevelv - Change field header

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module reads fields from `infile`, changes some header values and writes the results to `outfile`. The kind of changes depends on the chosen operator.

Operators

chcode
: Change code number

  Changes some user given code numbers to new user given values (Parameter: oldcode newcode [. . .]).

chparam
: Change parameter identifier

  Changes some user given parameter identifiers to new user given values (Parameter: oldparam newparam . . .).

chname
: Change variable or coordinate name

  Changes some user given variable or coordinate names to new user given names (Parameter: oldname newname . . .).

chunit
: Change variable unit

  Changes some user given variable units to new user given units (Parameter: oldunit newunit . . .).

chlevel
: Change level

  Changes some user given levels to new user given values (Parameter: oldlev newlev . . .).

chlevelc
: Change level of one code

  Changes one level of a user given code number (Parameter: code oldlev newlev).

chlevelv
: Change level of one variable

  Changes one level of a user given variable name (Parameter: name oldlev newlev).

Parameters

code
: [INTEGER] Code number

oldcode,newcode,. . .
: [INTEGER] Pairs of old and new code numbers

oldparam,newparam,. . .
: [STRING] Pairs of old and new parameter identifiers

name
: [STRING] Variable name

oldname,newname,. . .
: [STRING] Pairs of old and new variable names

oldlev
: [FLOAT] Old level

newlev
: [FLOAT] New level

oldlev,newlev,. . .
: [FLOAT] Pairs of old and new levels

Example

To change the code number 98 to 179 and 99 to 211 use:

```
cdo chcode,98,179,99,211 infile outfile
```

Author

Uwe Schulzweida

2.6.6 Setgrid

Name

setgrid, setgridtype, setgridarea, setgridmask, setprojparams - Set grid information

Synopsis

cdo <*operator*>,*parameters infile outfile*

Description

This module modifies the metadata of the horizontal grid. Depending on the chosen operator a new grid description is set, the coordinates are converted or the grid cell area is added.

Operators

setgrid
Set grid

Sets a new grid description (Parameter: grid). The input fields need to have the same grid size as the size of the target grid description.

setgridtype
Set grid type

Sets the grid type of all input fields (Parameter: gridtype). The following grid types are available:

curvilinear	Converts a regular grid to a curvilinear grid
unstructured	Converts a regular or curvilinear grid to an unstructured grid
dereference	Dereference a reference to a grid
regular	Linear interpolation of a reduced Gaussian grid to a regular Gaussian grid
regularnn	Nearest neighbor interpolation of a reduced Gaussian grid to a regular Gaussian grid
lonlat	Converts a regular lonlat grid stored as a curvilinear grid back to a lonlat grid
projection	Removes the geographical coordinates if projection parameter available

setgridarea
Set grid cell area

Sets the grid cell area. The parameter *gridarea* is the path to a data file, the first field is used as grid cell area. The input fields need to have the same grid size as the grid cell area. The grid cell area is used to compute the weights of each grid cell if needed by an operator, e.g. for *fldmean*.

setgridmask
Set grid mask

Sets the grid mask. The parameter *gridmask* is the path to a data file, the first field is used as the grid mask. The input fields need to have the same grid size as the grid mask. The grid mask is used as the target grid mask for remapping, e.g. for *remapbil*.

setprojparams
Set proj params

Sets the *proj_params* attribute of a projection. This attribute is used to compute geographic coordinates of a projecton with the proj library (Parameter: projparams).

Parameters

grid
: [STRING] Grid description file or name

gridtype
: [STRING] Grid type (curvilinear, unstructured, regular, lonlat, projection or dereference)

gridarea
: [STRING] Data file, the first field is used as grid cell area

gridmask
: [STRING] Data file, the first field is used as grid mask

projparams
: [STRING] Proj library parameter (e.g.:+init=EPSG:3413)

Example

Assuming a dataset has fields on a grid with 2048 elements without or with wrong grid description. To set the grid description of all input fields to a regular Gaussian F32 grid (8192 gridpoints) use:

```
cdo setgrid,F32 infile outfile
```

Author

Uwe Schulzweida

2.6.7 Setzaxis

Name

setzaxis, genlevelbounds - Set z-axis information

Synopsis

cdo <*operator*>,*parameters infile outfile*

Description

This module modifies the metadata of the vertical grid.

Operators

setzaxis
Set z-axis

This operator sets the z-axis description of all variables with the same number of level as the new z-axis (Parameter: zaxis).

genlevelbounds
Generate level bounds

Generates the layer bounds of the z-axis (Parameter: zbot ztop).

Parameters

zaxis
[STRING] Z-axis description file or name of the target z-axis

zbot
[FLOAT] Specifying the bottom of the vertical column. Must have the same units as z-axis.

ztop
[FLOAT] Specifying the top of the vertical column. Must have the same units as z-axis.

Author

Uwe Schulzweida

2.6.8 Invert

Name

invertlat - Invert latitudes

Synopsis

cdo invertlat *infile outfile*

Description

This operator inverts the latitudes of all fields on a rectilinear grid.

Example

To invert the latitudes of a 2D field from N->S to S->N use:

```
cdo invertlat infile outfile
```

Author

Uwe Schulzweida

2.6.9 Invertlev

Name

invertlev - Invert levels

Synopsis

cdo invertlev *infile outfile*

Description

This operator inverts the levels of all 3D variables.

Author

Uwe Schulzweida

2.6.10 Shiftxy

Name

shiftx, shifty - Shift field

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module contains operators to shift all fields in x or y direction. All fields need to have the same horizontal rectilinear or curvilinear grid.

Operators

shiftx
: Shift x

  Shifts all fields in x direction.

shifty
: Shift y

  Shifts all fields in y direction.

Parameters

nshift
: [INTEGER] Number of grid cells to shift (default: 1)

cyclic
: [STRING] If set, cells are filled up cyclic (default: missing value)

coord
: [STRING] If set, coordinates are also shifted

Example

To shift all input fields in the x direction by +1 cells and fill the new cells with missing value, use:

```
cdo shiftx infile outfile
```

To shift all input fields in the x direction by +1 cells and fill the new cells cyclic, use:

```
cdo shiftx,1,cyclic infile outfile
```

Author

Uwe Schulzweida

2.6.11 Maskregion

Name

maskregion - Mask regions

Synopsis

cdo maskregion,*regions infile outfile*

Description

Masks different regions of the input fields. The grid cells inside a region are untouched, the cells outside are set to missing value. Considered are only those grid cells with the grid center inside the regions. All input fields must have the same horizontal grid.

Regions can be defined by the user via an ASCII file. Each region consists of the geographic coordinates of a polygon. Each line of a polygon description file contains the longitude and latitude of one point. Each polygon description file can contain one or more polygons separated by a line with the character &.

Predefined regions of countries can be specified via the country codes. A country is specified with dcw:<CountryCode>. Country codes can be combined with the plus sign.

Parameters

regions
[STRING] Comma-separated list of ASCII formatted files with different regions

Example

To mask the region with the longitudes from 120E to 90W and latitudes from 20N to 20S on all input fields use:

```
cdo maskregion,myregion infile outfile
```

For this example the description file of the region `myregion` should contain one polygon with the following four coordinates:

```
120  20
120 -20
270 -20
270  20
```

To mask the region of a country use the country code with data from the Digital Chart of the World. Here is an example for Spain with the country code ES:

```
cdo maskregion,dcw:ES infile outfile
```

Author

Uwe Schulzweida, Cedrick Ansorge

2.6.12 Maskbox

Name

masklonlatbox, maskindexbox - Mask a box

Synopsis

cdo masklonlatbox,*lon1,lon2,lat1,lat2 infile outfile*

cdo maskindexbox,*idx1,idx2,idy1,idy2 infile outfile*

Description

Masks grid cells inside a lon/lat or index box. The elements inside the box are untouched, the elements outside are set to missing value. All input fields need to have the same horizontal grid. Use *sellonlatbox* or *selindexbox* if only the data inside the box are needed.

Operators

masklonlatbox
Mask a longitude/latitude box

Masks grid cells inside a lon/lat box. The user must specify the longitude and latitude of the edges of the box. Only those grid cells are considered whose grid center lies within the lon/lat box. For rotated lon/lat grids the parameters must be specified in rotated coordinates.

maskindexbox
Mask an index box

Masks grid cells within an index box. The user must specify the indices of the edges of the box. The index of the left edge can be greater then the one of the right edge. Use negative indexing to start from the end. The input grid must be a regular lon/lat or a 2D curvilinear grid.

Parameters

lon1
[FLOAT] Western longitude in degrees

lon2
[FLOAT] Eastern longitude in degrees

lat1
[FLOAT] Southern or northern latitude in degrees

lat2
[FLOAT] Northern or southern latitude in degrees

idx1
[INTEGER] Index of first longitude (1 - nlon)

idx2
[INTEGER] Index of last longitude (1 - nlon)

idy1
[INTEGER] Index of first latitude (1 - nlat)

idy2
[INTEGER] Index of last latitude (1 - nlat)

Example

To mask the region with the longitudes from 120E to 90W and latitudes from 20N to 20S on all input fields use:

```
cdo masklonlatbox,120,-90,20,-20 infile outfile
```

If the input dataset has fields on a regular Gaussian F16 grid, the same box can be masked with *maskindexbox* by:

```
cdo maskindexbox,23,48,13,20 infile outfile
```

Author

Uwe Schulzweida

2.6.13 Setbox

Name

setclonlatbox, setcindexbox - Set a box to constant

Synopsis

cdo setclonlatbox,*c,lon1,lon2,lat1,lat2 infile outfile*

cdo setcindexbox,*c,idx1,idx2,idy1,idy2 infile outfile*

Description

Sets a box of the rectangularly understood field to a constant value. The elements outside the box are untouched, the elements inside are set to the given constant. All input fields need to have the same horizontal grid.

Operators

setclonlatbox
Set a longitude/latitude box to constant

Sets the values of a longitude/latitude box to a constant value. The user has to give the longitudes and latitudes of the edges of the box.

setcindexbox
Set an index box to constant

Sets the values of an index box to a constant value. The user has to give the indices of the edges of the box. The index of the left edge can be greater than the one of the right edge.

Parameters

c
[FLOAT] Constant

lon1
[FLOAT] Western longitude in degrees

lon2
[FLOAT] Eastern longitude in degrees

lat1
[FLOAT] Southern or northern latitude in degrees

lat2
[FLOAT] Northern or southern latitude in degrees

idx1
[INTEGER] Index of first longitude (1 - nlon)

idx2
[INTEGER] Index of last longitude (1 - nlon)

idy1
[INTEGER] Index of first latitude (1 - nlat)

idy2
[INTEGER] Index of last latitude (1 - nlat)

Example

To set all values in the region with the longitudes from 120E to 90W and latitudes from 20N to 20S to the constant value -1.23 use:

```
cdo setclonlatbox,-1.23,120,-90,20,-20 infile outfile
```

If the input dataset has fields on a regular Gaussian F16 grid, the same box can be set with *setcindexbox* by:

```
cdo setcindexbox,-1.23,23,48,13,20 infile outfile
```

Author

Etienne Tourigny

2.6.14 Enlarge

Name

enlarge - Enlarge fields

Synopsis

cdo enlarge,*grid infile outfile*

Description

Enlarge all fields of `infile` to a user given horizontal grid. Normally only the last field element is used for the enlargement. If however the input and output grid are regular lon/lat grids, a zonal or meridional enlargement is possible. Zonal enlargement takes place, if the xsize of the input field is 1 and the ysize of both grids are the same. For meridional enlargement the ysize have to be 1 and the xsize of both grids should have the same size.

Parameters

grid
[STRING] Target grid description file or name

Example

Assumed you want to add two datasets. The first dataset is a field on a global grid (n field elements) and the second dataset is a global mean (1 field element). Before you can add these two datasets the second dataset have to be enlarged to the grid size of the first dataset:

```
cdo enlarge,infile1 infile2 tmpfile
cdo add infile1 tmpfile outfile
```

Or shorter using operator piping:

```
cdo add infile1 -enlarge,infile1 infile2 outfile
```

Author

Uwe Schulzweida

2.6.15 Setmiss

Name

setmissval, setctomiss, setmisstoc, setrtomiss, setvrange, setmisstonn, setmisstodis - Set missing value

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module sets part of a field to missing value or missing values to a constant value. Which part of the field is set depends on the chosen operator.

Operators

setmissval
Set a new missing value

$$o(t,x) = \begin{cases} \text{newmiss} & \text{if } \ i(t,x) = \text{miss} \\ i(t,x) & \text{if } \ i(t,x) \neq \text{miss} \end{cases}$$

setctomiss
Set constant to missing value

$$o(t,x) = \begin{cases} \text{miss} & \text{if } \ i(t,x) = \text{c} \\ i(t,x) & \text{if } \ i(t,x) \neq \text{c} \end{cases}$$

setmisstoc
Set missing value to constant

$$o(t,x) = \begin{cases} \text{c} & \text{if } \ i(t,x) = \text{miss} \\ i(t,x) & \text{if } \ i(t,x) \neq \text{miss} \end{cases}$$

setrtomiss
Set range to missing value

$$o(t,x) = \begin{cases} \text{miss} & \text{if } \ i(t,x) \geq \text{rmin} \wedge i(t,x) \leq \text{rmax} \\ i(t,x) & \text{if } \ i(t,x) < \text{rmin} \vee i(t,x) > \text{rmax} \end{cases}$$

setvrange
Set valid range

$$o(t,x) = \begin{cases} \text{miss} & \text{if } \ i(t,x) < \text{rmin} \vee i(t,x) > \text{rmax} \\ i(t,x) & \text{if } \ i(t,x) \geq \text{rmin} \wedge i(t,x) \leq \text{rmax} \end{cases}$$

setmisstonn
Set missing value to nearest neighbor

Set all missing values to the nearest non missing value.

$$o(t,x) = \begin{cases} i(t,y) & \text{if } \ i(t,x) = \text{miss} \wedge i(t,y) \neq \text{miss} \\ i(t,x) & \text{if } \ i(t,x) \neq \text{miss} \end{cases}$$

setmisstodis
Set missing value to distance-weighted average

Set all missing values to the distance-weighted average of the nearest non missing values. The default number of nearest neighbors is 4.

Parameters

neighbors
: [INTEGER] Number of nearest neighbors

newmiss
: [FLOAT] New missing value

c
: [FLOAT] Constant

rmin
: [FLOAT] Lower bound

rmax
: [FLOAT] Upper bound

Example

setrtomiss

Assume an input dataset has one field with temperatures in the range from 246 to 304 Kelvin. To set all values below 273.15 Kelvin to missing value use:

```
cdo setrtomiss,0,273.15 infile outfile
```

Result of `cdo info infile`:

```
-1 :       Date  Time     Code Level  Size  Miss :  Minimum     Mean  Maximum
 1 : 1987-12-31 12:00:00 139      0  2048     0 :   246.27   276.75   303.71
```

Result of `cdo info outfile`:

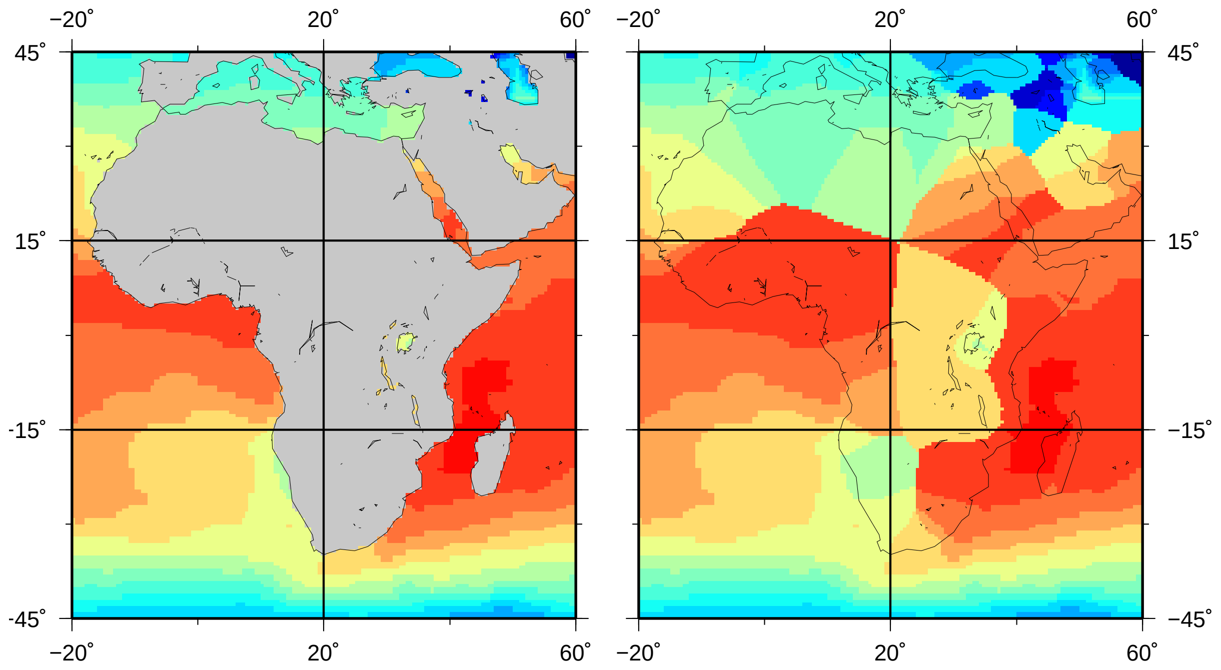
```
-1 :       Date  Time     Code Level  Size  Miss :  Minimum     Mean  Maximum
 1 : 1987-12-31 12:00:00 139      0  2048   871 :   273.16   287.08   303.71
```

setmisstonn

Set all missing values to the nearest non missing value:

```
cdo setmisstonn infile outfile
```

Below is a schematic illustration of this example:



On the left side is input data with missing values in grey and on the right side the result with the filled missing values.

Author

Uwe Schulzweida

2.6.16 Vertfillmiss

Name

vertfillmiss - Vertical filling of missing values

Synopsis

cdo vertfillmiss,*parameters infile outfile*

Description

This operator fills in vertical missing values. The *method* parameter can be used to select the filling method. The default *method=nearest* fills missing values with the nearest neighbor value. Other options are *forward* and *backward* to fill missing values by forward or backward propagation of values. Use the *limit* parameter to set the maximum number of consecutive missing values to fill and *max_gaps* to set the maximum number of gaps to fill.

Parameters

method
[STRING] Fill method [nearest|linear|forward|backward] (default: nearest)

limit
[INTEGER] The maximum number of consecutive missing values to fill (default: all)

max_gaps
[INTEGER] The maximum number of gaps to fill (default: all)

Author

Uwe Schulzweida

2.6.17 Timfillmiss

Name

timfillmiss - Temporal filling of missing values

Synopsis

cdo timfillmiss,*parameters infile outfile*

Description

This operator fills in temporally missing values. The *method* parameter can be used to select the filling method. The default *method=nearest* fills missing values with the nearest neighbor value. Other options are *forward* and *backward* to fill missing values by forward or backward propagation of values. Use the *limit* parameter to set the maximum number of consecutive missing values to fill and *max_gaps* to set the maximum number of gaps to fill.

Parameters

method
[STRING] Fill method [nearest|linear|forward|backward] (default: nearest)

limit
[INTEGER] The maximum number of consecutive missing values to fill (default: all)

max_gaps
[INTEGER] The maximum number of gaps to fill (default: all)

Author

Uwe Schulzweida

2.6.18 Setgridcell

Name

setgridcell - Set the value of a grid cell

Synopsis

cdo setgridcell,*parameters infile outfile*

Description

This operator sets the value of the selected grid cells. The grid cells can be selected by a comma-separated list of grid cell indices or a mask. The mask is read from a data file, which may contain only one field. If no grid cells are selected, all values are set.

Parameters

value
: [FLOAT] Value of the grid cell

cell
: [INTEGER] Comma-separated list of grid cell indices

mask
: [STRING] Name of the data file which contains the mask

Author

Uwe Schulzweida

2.7 Arithmetic

This section contains modules to arithmetically process datasets.

Here is a short overview of all operators in this section:

Expr	*expr*	Evaluate expressions
	exprf	Evaluate expressions script
	aexpr	Evaluate expressions and append results
	aexprf	Evaluate expression script and append results
Math	*abs*	Absolute value
	int	Integer value
	nint	Nearest integer value
	pow	Power
	sqr	Square
	sqrt	Square root
	exp	Exponential
	ln	Natural logarithm
	log10	Base 10 logarithm
	sin	Sine
	cos	Cosine
	tan	Tangent
	asin	Arc sine
	acos	Arc cosine
	atan	Arc tangent
	reci	Reciprocal value
	not	Logical NOT
Arithc	*addc*	Add a constant
	subc	Subtract a constant
	mulc	Multiply with a constant
	divc	Divide by a constant
	minc	Minimum of a field and a constant
	maxc	Maximum of a field and a constant
Arith	*add*	Add two fields
	sub	Subtract two fields
	mul	Multiply two fields
	div	Divide two fields
	min	Minimum of two fields
	max	Maximum of two fields
	atan2	Arc tangent of two fields
	setmiss	Set missing values
Dayarith	*dayadd*	Add daily time series
	daysub	Subtract daily time series
	daymul	Multiply daily time series
	daydiv	Divide daily time series
Monarith	*monadd*	Add monthly time series
	monsub	Subtract monthly time series
	monmul	Multiply monthly time series
	mondiv	Divide monthly time series
Yeararith	*yearadd*	Add yearly time series
	yearsub	Subtract yearly time series
	yearmul	Multiply yearly time series
	yeardiv	Divide yearly time series
Yhourarith	*yhouradd*	Add multi-year hourly time series
	yhoursub	Subtract multi-year hourly time series
	yhourmul	Multiply multi-year hourly time series
	yhourdiv	Divide multi-year hourly time series

continues on next page

Table 5 – continued from previous page

Ydayarith	*ydayadd*	Add multi-year daily time series
	ydaysub	Subtract multi-year daily time series
	ydaymul	Multiply multi-year daily time series
	ydaydiv	Divide multi-year daily time series
Ymonarith	*ymonadd*	Add multi-year monthly time series
	ymonsub	Subtract multi-year monthly time series
	ymonmul	Multiply multi-year monthly time series
	ymondiv	Divide multi-year monthly time series
Yseasarith	*yseasadd*	Add multi-year seasonal time series
	yseassub	Subtract multi-year seasonal time series
	yseasmul	Multiply multi-year seasonal time series
	yseasdiv	Divide multi-year seasonal time series
Arithdays	*muldpm*	Multiply with days per month
	divdpm	Divide by days per month
	muldpy	Multiply with days per year
	divdpy	Divide by days per year
Arithlat	*mulcoslat*	Multiply with the cosine of the latitude
	divcoslat	Divide by cosine of the latitude

2.7.1 Expr

Name

expr, exprf, aexpr, aexprf - Evaluate expressions

Synopsis

cdo <*operator*>,*parameters infile outfile*

Description

This module arithmetically processes every timestep of the input dataset. Each individual assignment statement have to end with a semi-colon. The special key _ALL_ is used as a template. A statement with a template is replaced for all variable names. Unlike regular variables, temporary variables are never written to the output stream. To define a temporary variable simply prefix the variable name with an underscore (e.g. _varname) when the variable is declared.

The following operators are supported:

Operator	Meaning	Example	Result
=	assignment	x = y	Assigns y to x
+	addition	x + y	Sum of x and y
-	subtraction	x - y	Difference of x and y
*	multiplication	x * y	Product of x and y
/	division	x / y	Quotient of x and y
exp	exponentiation	x exp y	Exponentiates x with y
==	equal to	x == y	1, if x equal to y; else 0
!=	not equal to	x != y	1, if x not equal to y; else 0
>	greater than	x > y	1, if x greater than y; else 0
<	less than	x < y	1, if x less than y; else 0
>=	greater equal	x >= y	1, if x greater equal y; else 0
<=	less equal	x <= y	1, if x less equal y; else 0
<=>	less equal greater	x <=> y	-1, if x less y; 1, if x greater y; else 0
and	logical AND	x and y	1, if x and y not equal 0; else 0
or	logical OR	x or y	1, if x or y not equal 0; else 0
!	logical NOT	!x	1, if x equal 0; else 0
?:	ternary conditional	x ? y : z	y, if x not equal 0, else z

The following functions are supported:

Math intrinsics:

abs(x)	Absolute value of x
floor(x)	Round to largest integral value not greater than x
ceil(x)	Round to smallest integral value not less than x
float(x)	32-bit float value of x
int(x)	Integer value of x
nint(x)	Nearest integer value of x
sqr(x)	Square of x
sqrt(x)	Square Root of x
exp(x)	Exponential of x
ln(x)	Natural logarithm of x
log10(x)	Base 10 logarithm of x
sin(x)	Sine of x, where x is specified in radians
cos(x)	Cosine of x, where x is specified in radians
tan(x)	Tangent of x, where x is specified in radians
asin(x)	Arc-sine of x, where x is specified in radians
acos(x)	Arc-cosine of x, where x is specified in radians
atan(x)	Arc-tangent of x, where x is specified in radians
sinh(x)	Hyperbolic sine of x, where x is specified in radians
cosh(x)	Hyperbolic cosine of x, where x is specified in radians
tanh(x)	Hyperbolic tangent of x, where x is specified in radians
asinh(x)	Inverse hyperbolic sine of x, where x is specified in radians
acosh(x)	Inverse hyperbolic cosine of x, where x is specified in radians
atanh(x)	Inverse hyperbolic tangent of x, where x is specified in radians
rad(x)	Convert x from degrees to radians
deg(x)	Convert x from radians to degrees
rand(x)	Replace x by pseudo-random numbers in the range of 0 to 1
isMissval(x)	Returns 1 where x is missing

mod(x,y)	Floating-point remainder of x/ y
min(x,y)	Minimum value of x and y
max(x,y)	Maximum value of x and y
pow(x,y)	Power function
hypot(x,y)	Euclidean distance function, sqrt(x*x + y*y)
atan2(x,y)	Arc tangent function of y/x, using signs to determine quadrants
trimrel(x,kb)	Trim relative precision to kb keep-bits. Max relative error to a value | result - x | / x < 2**(-1-kb) for any finite x. trimrel is a non-decreasing function of x. Loosely follows A5 of https://gmd.copernicus.org/articles/14/377/2021/
trimabs(x,err)	Trim absolute precision introducing given max. absolute error | result - x | < err, trimabs is a non-decreasing function of x. Loosely follows A6 of https://gmd.copernicus.org/articles/14/377/2021/

Coordinates:

clon(x)	Longitude coordinate of x (available only if x has geographical coordinates)
clat(x)	Latitude coordinate of x (available only if x has geographical coordinates)
gridarea(x)	Grid cell area of x (available only if x has geographical coordinates)
gridindex(x)	Grid cell indices of x
clev(x)	Level coordinate of x (0, if x is a 2D surface variable)
clevidx(x)	Level index of x (0, if x is a 2D surface variable)
cthickness(x)	Layer thickness, upper minus lower level bound of x (1, if level bounds are missing)
ctimestep()	Timestep number (1 to N)
cdate()	Verification date as YYYYMMDD
ctime()	Verification time as HHMMSS.millisecond
cdeltat()	Difference between current and last timestep in seconds
cday()	Day as DD
cmonth()	Month as MM
cyear()	Year as YYYY
csecond()	Second as SS.millisecond
cminute()	Minute as MM
chour()	Hour as HH

Constants:

ngp(x)	Number of horizontal grid points
nlev(x)	Number of vertical levels
size(x)	Total number of elements (ngp(x)*nlev(x))
missval(x)	Returns the missing value of variable x

Statistics over a field:

fldmin(x), *fldmax*(x), *fldrange*(x), *fldsum*(x), *fldmean*(x), *fldavg*(x), *fldstd*(x), *fldstd1*(x), *fldvar*(x), *fldvar1*(x), *fldskew*(x), *fldkurt*(x), *fldmedian*(x)

Zonal statistics for regular 2D grids:

zonmin(x), *zonmax*(x), *zonrange*(x), *zonsum*(x), *zonmean*(x), *zonavg*(x), *zonstd*(x), *zonstd1*(x), *zonvar*(x), *zonvar1*(x), *zonskew*(x), *zonkurt*(x), *zonmedian*(x)

Vertical statistics:

vertmin(x), *vertmax*(x), *vertrange*(x), *vertsum*(x), *vertmean*(x), *vertavg*(x), *vertstd*(x), *vertstd1*(x), *vertvar*(x), *vertvar1*(x)

Miscellaneous:

sellevel(x,k)	Select level k of variable x
sellevidx(x,k)	Select level index k of variable x
sellevelrange(x,k1,k2)	Select all levels of variable x in the range k1 to k2
sellevidxrange(x,k1,k2)	Select all level indices of variable x in the range k1 to k2
remove(x)	Remove variable x from output stream

Operators

expr
Evaluate expressions

The processing instructions are read from the *instr* parameter .

exprf
Evaluate expressions script

Contrary to *expr* the processing instructions are read from a file (Parameter: filename).

aexpr
Evaluate expressions and append results

Same as *expr*, but keep input variables and append results

aexprf
Evaluate expression script and append results

Same as *exprf*, but keep input variables and append results

Parameters

instr
[STRING] Processing instructions (need to be 'quoted' in most cases)

filename
[STRING] File with processing instructions

Note

If the input stream contains duplicate entries of the same variable name then the last one is used.

Example

Assume an input dataset contains at least the variables 'aprl', 'aprc' and 'ts'. To create a new variable 'var1' with the sum of 'aprl' and 'aprc' and a variable 'var2' which convert the temperature 'ts' from Kelvin to Celsius use:

```
cdo expr,'var1=aprl+aprc;var2=ts-273.15;' infile outfile
```

The same example, but the instructions are read from a file:

```
cdo exprf,myexpr infile outfile
```

The file `myexpr` contains:

```
var1 = aprl + aprc;
var2 = ts - 273.15;
```

Author

Uwe Schulzweida, Karl-Hermann Wieners

2.7.2 Math

Name

abs, int, nint, pow, sqr, sqrt, exp, ln, log10, sin, cos, tan, asin, acos, atan, reci, not - Mathematical functions

Synopsis

cdo *<operator> infile outfile*

Description

This module contains some standard mathematical functions. All trigonometric functions calculate with radians.

Operators

abs
: Absolute value

  $o(t,x) = \mathrm{abs}(i(t,x))$

int
: Integer value

  $o(t,x) = \mathrm{int}(i(t,x))$

nint
: Nearest integer value

  $o(t,x) = \mathrm{nint}(i(t,x))$

pow
: Power

  $o(t,x) = i(t,x)^y$

sqr
: Square

  $o(t,x) = i(t,x)^2$

sqrt
: Square root

  $o(t,x) = \sqrt{i(t,x)}$

exp
: Exponential

  $o(t,x) = \mathrm{e}^{i(t,x)}$

ln
: Natural logarithm

  $o(t,x) = \ln(i(t,x))$

log10
: Base 10 logarithm

  $o(t,x) = \log_{10}(i(t,x))$

sin
: Sine

  $o(t,x) = \sin(i(t,x))$

cos
: Cosine

  $o(t,x) = \cos(i(t,x))$

tan
Tangent

$o(t,x) = \tan(i(t,x))$

asin
Arc sine

$o(t,x) = \arcsin(i(t,x))$

acos
Arc cosine

$o(t,x) = \arccos(i(t,x))$

atan
Arc tangent

$o(t,x) = \arctan(i(t,x))$

reci
Reciprocal value

$o(t,x) = 1/i(t,x)$

not
Logical NOT

$o(t,x) = 1, \text{if } \ x \ \text{ equal } \ 0; \text{else } \ 0$

Example

To calculate the square root for all field elements use:

```
cdo sqrt infile outfile
```

Author

Uwe Schulzweida

2.7.3 Arithc

Name

addc, subc, mulc, divc, minc, maxc - Arithmetic with a constant

Synopsis

cdo <*operator*> *infile outfile*

Description

This module performs simple arithmetic with all field elements of a dataset and a constant. The fields in `outfile` inherit the meta data from `infile`.

Operators

addc
Add a constant

$o(t, x) = i(t, x) + c$

subc
Subtract a constant

$o(t, x) = i(t, x) - c$

mulc
Multiply with a constant

$o(t, x) = i(t, x) * c$

divc
Divide by a constant

$o(t, x) = i(t, x)/c$

minc
Minimum of a field and a constant

$o(t, x) = \min(i(t, x), c)$

maxc
Maximum of a field and a constant

$o(t, x) = \max(i(t, x), c)$

Parameters

c
[FLOAT] Constant

Example

To sum all input fields with the constant -273.15 use:

```
cdo addc,-273.15 infile outfile
```

Author

Uwe Schulzweida

2.7.4 Arith

Name

add, sub, mul, div, min, max, atan2, setmiss - Arithmetic on two datasets

Synopsis

cdo *<operator> infile1 infile2 outfile*

Description

This module performs simple arithmetic of two datasets. The number of fields in `infile1` should be the same as in `infile2`. The fields in `outfile` inherit the meta data from `infile1`. All operators in this module simply process one field after the other from the two input files. Neither the order of the variables nor the date is checked. One of the input files can contain only one timestep or one variable.

Operators

add

Add two fields

$o(t,x) = i_1(t,x) + i_2(t,x)$

sub

Subtract two fields

$o(t,x) = i_1(t,x) - i_2(t,x)$

mul

Multiply two fields

$o(t,x) = i_1(t,x) * i_2(t,x)$

div

Divide two fields

$o(t,x) = i_1(t,x)/i_2(t,x)$

min

Minimum of two fields

$o(t,x) = \text{min}(i_1(t,x), i_2(t,x))$

max

Maximum of two fields

$o(t,x) = \text{max}(i_1(t,x), i_2(t,x))$

atan2

Arc tangent of two fields

The $atan2$ operator calculates the arc tangent of two fields. The result is in radians, which is between -PI and PI (inclusive).

$o(t,x) = \text{atan2}(i_1(t,x), i_2(t,x))$

setmiss

Set missing values

Sets missing values of `infile1` to values from `infile2`.

Example

To sum all fields of the first input file with the corresponding fields of the second input file use:

```
cdo add infile1 infile2 outfile
```

Author

Uwe Schulzweida

2.7.5 Dayarith

Name

dayadd, daysub, daymul, daydiv - Daily arithmetic

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same day, month and year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same day, month and year is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Daystat*.

Operators

dayadd
: Add daily time series

  Adds a time series and a daily time series.

daysub
: Subtract daily time series

  Subtracts a time series and a daily time series.

daymul
: Multiply daily time series

  Multiplies a time series and a daily time series.

daydiv
: Divide daily time series

  Divides a time series and a daily time series.

Example

To subtract a daily time average from a time series use:

```
cdo daysub infile -dayavg infile outfile
```

Author

Uwe Schulzweida

2.7.6 Monarith

Name

monadd, monsub, monmul, mondiv - Monthly arithmetic

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same month and year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same month and year is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Monstat*.

Operators

monadd
Add monthly time series

Adds a time series and a monthly time series.

monsub
Subtract monthly time series

Subtracts a time series and a monthly time series.

monmul
Multiply monthly time series

Multiplies a time series and a monthly time series.

mondiv
Divide monthly time series

Divides a time series and a monthly time series.

Example

To subtract a monthly time average from a time series use:

```
cdo monsub infile -monavg infile outfile
```

Author

Uwe Schulzweida

2.7.7 Yeararith

Name

yearadd, yearsub, yearmul, yeardiv - Yearly arithmetic

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same year is used. The header information in `infile1` have to be the same as in `infile2`. Usually `infile2` is generated by an operator of the module *Yearstat*.

Operators

yearadd
: Add yearly time series

  Adds a time series and a yearly time series.

yearsub
: Subtract yearly time series

  Subtracts a time series and a yearly time series.

yearmul
: Multiply yearly time series

  Multiplies a time series and a yearly time series.

yeardiv
: Divide yearly time series

  Divides a time series and a yearly time series.

Example

To subtract a yearly time average from a time series use:

```
cdo yearsub infile -yearavg infile outfile
```

Author

Uwe Schulzweida

2.7.8 Yhourarith

Name

yhouradd, yhoursub, yhourmul, yhourdiv - Multi-year hourly arithmetic

Synopsis

cdo *<operator> infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same hour and day of year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same hour and day of year is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Yhourstat*.

Operators

yhouradd
Add multi-year hourly time series

Adds a time series and a multi-year hourly time series.

yhoursub
Subtract multi-year hourly time series

Subtracts a time series and a multi-year hourly time series.

yhourmul
Multiply multi-year hourly time series

Multiplies a time series and a multi-year hourly time series.

yhourdiv
Divide multi-year hourly time series

Divides a time series and a multi-year hourly time series.

Example

To subtract a multi-year hourly time average from a time series use:

```
cdo yhoursub infile -yhouravg infile outfile
```

Author

Uwe Schulzweida

2.7.9 Ydayarith

Name

ydayadd, ydaysub, ydaymul, ydaydiv - Multi-year daily arithmetic

Synopsis

cdo *<operator> infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same day of year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same day of year is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Ydaystat*.

Operators

ydayadd
Add multi-year daily time series

Adds a time series and a multi-year daily time series.

ydaysub
Subtract multi-year daily time series

Subtracts a time series and a multi-year daily time series.

ydaymul
Multiply multi-year daily time series

Multiplies a time series and a multi-year daily time series.

ydaydiv
Divide multi-year daily time series

Divides a time series and a multi-year daily time series.

Example

To subtract a multi-year daily time average from a time series use:

```
cdo ydaysub infile -ydayavg infile outfile
```

Author

Uwe Schulzweida

2.7.10 Ymonarith

Name

ymonadd, ymonsub, ymonmul, ymondiv - Multi-year monthly arithmetic

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same month of year. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same month of year is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Ymonstat*.

Operators

ymonadd
Add multi-year monthly time series

Adds a time series and a multi-year monthly time series.

ymonsub
Subtract multi-year monthly time series

Subtracts a time series and a multi-year monthly time series.

ymonmul
Multiply multi-year monthly time series

Multiplies a time series with a multi-year monthly time series.

ymondiv
Divide multi-year monthly time series

Divides a time series by a multi-year monthly time series.

Example

To subtract a multi-year monthly time average from a time series use:

```
cdo ymonsub infile -ymonavg infile outfile
```

Author

Uwe Schulzweida

2.7.11 Yseasarith

Name

yseasadd, yseassub, yseasmul, yseasdiv - Multi-year seasonal arithmetic

Synopsis

cdo <*operator*> *infile1 infile2 outfile*

Description

This module performs simple arithmetic of a time series and one timestep with the same season. For each field in `infile1` the corresponding field of the timestep in `infile2` with the same season is used. The input files need to have the same structure with the same variables. Usually `infile2` is generated by an operator of the module *Yseasstat*.

Operators

yseasadd
: Add multi-year seasonal time series

  Adds a time series and a multi-year seasonal time series.

yseassub
: Subtract multi-year seasonal time series

  Subtracts a time series and a multi-year seasonal time series.

yseasmul
: Multiply multi-year seasonal time series

  Multiplies a time series and a multi-year seasonal time series.

yseasdiv
: Divide multi-year seasonal time series

  Divides a time series and a multi-year seasonal time series.

Example

To subtract a multi-year seasonal time average from a time series use:

```
cdo yseassub infile -yseasavg infile outfile
```

Author

Uwe Schulzweida

2.7.12 Arithdays

Name

muldpm, divdpm, muldpy, divdpy - Arithmetic with days

Synopsis

cdo <*operator*> *infile outfile*

Description

This module multiplies or divides each timestep of a dataset with the corresponding days per month or days per year. The result of these functions depends on the used calendar of the input data.

Operators

muldpm
: Multiply with days per month

  $o(t, x) = i(t, x) * days\_per\_month$

divdpm
: Divide by days per month

  $o(t, x) = i(t, x)/days\_per\_month$

muldpy
: Multiply with days per year

  $o(t, x) = i(t, x) * days\_per\_year$

divdpy
: Divide by days per year

  $o(t, x) = i(t, x)/days\_per\_year$

Author

Uwe Schulzweida

2.7.13 Arithlat

Name

mulcoslat, divcoslat - Arithmetic with latitude

Synopsis

cdo <*operator*> *infile outfile*

Description

This module multiplies or divides each field element with the cosine of the latitude.

Operators

mulcoslat
Multiply with the cosine of the latitude

$o(t,x) = i(t,x) * cos(latitude(x))$

divcoslat
Divide by cosine of the latitude

$o(t,x) = i(t,x)/cos(latitude(x))$

Author

Uwe Schulzweida

2.8 Statistic

This section contains modules to compute statistical values of datasets. In this program there is the different notion of "mean" and "average" to distinguish two different kinds of treatment of missing values. While computing the mean, only the not missing values are considered to belong to the sample with the side effect of a probably reduced sample size. Computing the average is just adding the sample members and divide the result by the sample size. For example, the mean of 1, 2, miss and 3 is (1+2+3)/3 = 2, whereas the average is (1+2+miss+3)/4 = miss/4 = miss. If there are no missing values in the sample, the average and the mean are identical.

CDO is using the verification time to identify the time range for temporal statistics. The time bounds are never used!

In this section the abbreviations as in the following table are used:

$$\begin{aligned}
\textbf{sum} &= \sum_{i=1}^{n} x_i \\
\begin{matrix}\textbf{mean} \text{ resp. } \textbf{avg} \\ \overline{x}\end{matrix} &= n^{-1} \sum_{i=1}^{n} x_i \\
\begin{matrix}\textbf{mean} \text{ resp. } \textbf{avg} \\ \text{weightedby} \\ \{w_i, i = 1, ..., n\}\end{matrix} &= \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{i=1}^{n} w_i \, x_i \\
\begin{matrix}\text{Variance} \\ \textbf{var}\end{matrix} &= n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2 \\
\textbf{var1} &= (n-1)^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2 \\
\begin{matrix}\textbf{var} \text{ weighted by} \\ \{w_i, i = 1, ..., n\}\end{matrix} &= \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{i=1}^{n} w_i \left(x_i - \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{j=1}^{n} w_j \, x_j \right)^2 \\
\begin{matrix}\text{Standard deviation} \\ \textbf{std} \\ s\end{matrix} &= \sqrt{n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2} \\
\textbf{std1} &= \sqrt{(n-1)^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2} \\
\begin{matrix}\textbf{std} \text{ weighted by} \\ \{w_i, i = 1, ..., n\}\end{matrix} &= \sqrt{\left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{i=1}^{n} w_i \left(x_i - \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{j=1}^{n} w_j \, x_j \right)^2} \\
\textbf{median} &= \begin{cases} x_{\frac{n+1}{2}} & \text{if } n \text{ is odd} \\ \frac{1}{2}\left(x_{\frac{n}{2}} + x_{\frac{n}{2}+1} \right) & \text{if } n \text{ is even} \end{cases} \\
\begin{matrix}\text{Skewness} \\ \textbf{skew}\end{matrix} &= \frac{\sum_{i=1}^{n} (x_i - \overline{x})/n}{s^3} \\
\begin{matrix}\text{Kurtosis} \\ \textbf{kurt}\end{matrix} &= \frac{\sum_{i=1}^{n} (x_i - \overline{x})^4/n}{s^4} \\
\begin{matrix}\text{CumulativeRanked} \\ \text{ProbabilityScore} \\ \textbf{crps}\end{matrix} &= \int_{-\infty}^{\infty} \left[H(x_1) - cdf(\{x_2 \ldots x_n\})|_r \right]^2 dr
\end{aligned}$$

with $cdf(X)|_r$ being the cumulative distribution function of $\{x_i, i = 2 \ldots n\}$ at r and $H(x)$ the Heavyside function jumping at x.

Here is a short overview of all operators in this section:

Timcumsum	*timcumsum*	Cumulative sum over all timesteps
Consecstat	*consecsum*	Consecutive Sum
	consects	Consecutive Timesteps
Varsstat	*varsmin*	Variables minimum
	varsmax	Variables maximum
	varsrange	Variables range
	varssum	Variables sum
	varsmean	Variables mean
	varsavg	Variables average
	varsstd	Variables standard deviation
	varsstd1	Variables standard deviation (n-1)
	varsvar	Variables variance
	varsvar1	Variables variance (n-1)
	varsskew	Variables skewness
	varskurt	Variables kurtosis
	varsmedian	Variables median
	varspctl	Variables percentile
Ensstat	*ensmin*	Ensemble minimum
	ensmax	Ensemble maximum
	ensrange	Ensemble range
	enssum	Ensemble sum
	ensmean	Ensemble mean
	ensavg	Ensemble average
	ensstd	Ensemble standard deviation
	ensstd1	Ensemble standard deviation (n-1)
	ensvar	Ensemble variance
	ensvar1	Ensemble variance (n-1)
	ensskew	Ensemble skewness
	enskurt	Ensemble kurtosis
	ensmedian	Ensemble median
	enspctl	Ensemble percentile
Ensstat2	*ensrkhistspace*	Ranked Histogram averaged over space
	ensrkhisttime	Ranked Histogram averaged over time
	ensroc	Ensemble Receiver Operating characteristics
Ensval	*enscrps*	Ensemble CRPS and decomposition
	ensbrs	Ensemble Brier score
Fldstat	*fldmin*	Field minimum
	fldmax	Field maximum
	fldrange	Field range
	fldsum	Field sum
	fldint	Field integral
	fldmean	Field mean
	fldavg	Field average
	fldstd	Field standard deviation
	fldstd1	Field standard deviation (n-1)
	fldvar	Field variance
	fldvar1	Field variance (n-1)
	fldskew	Field skewness
	fldkurt	Field kurtosis
	fldmedian	Field median
	fldcount	Field count
	fldpctl	Field percentile
Zonstat	*zonmin*	Zonal minimum
	zonmax	Zonal maximum
	zonrange	Zonal range
	zonsum	Zonal sum

continues on next page

Table 6 – continued from previous page

	zonmean	Zonal mean
	zonavg	Zonal average
	zonstd	Zonal standard deviation
	zonstd1	Zonal standard deviation (n-1)
	zonvar	Zonal variance
	zonvar1	Zonal variance (n-1)
	zonskew	Zonal skewness
	zonkurt	Zonal kurtosis
	zonmedian	Zonal median
	zonpctl	Zonal percentile
Merstat	*mermin*	Meridional minimum
	mermax	Meridional maximum
	merrange	Meridional range
	mersum	Meridional sum
	mermean	Meridional mean
	meravg	Meridional average
	merstd	Meridional standard deviation
	merstd1	Meridional standard deviation (n-1)
	mervar	Meridional variance
	mervar1	Meridional variance (n-1)
	merskew	Meridional skewness
	merkurt	Meridional kurtosis
	mermedian	Meridional median
	merpctl	Meridional percentile
Gridboxstat	*gridboxmin*	Gridbox minimum
	gridboxmax	Gridbox maximum
	gridboxrange	Gridbox range
	gridboxsum	Gridbox sum
	gridboxmean	Gridbox mean
	gridboxavg	Gridbox average
	gridboxstd	Gridbox standard deviation
	gridboxstd1	Gridbox standard deviation (n-1)
	gridboxvar	Gridbox variance
	gridboxvar1	Gridbox variance (n-1)
	gridboxskew	Gridbox skewness
	gridboxkurt	Gridbox kurtosis
	gridboxmedian	Gridbox median
Remapstat	*remapmin*	Remap minimum
	remapmax	Remap maximum
	remaprange	Remap range
	remapsum	Remap sum
	remapmean	Remap mean
	remapavg	Remap average
	remapstd	Remap standard deviation
	remapstd1	Remap standard deviation (n-1)
	remapvar	Remap variance
	remapvar1	Remap variance (n-1)
	remapskew	Remap skewness
	remapkurt	Remap kurtosis
	remapmedian	Remap median
Vertstat	*vertmin*	Vertical minimum
	vertmax	Vertical maximum
	vertrange	Vertical range
	vertsum	Vertical sum
	vertmean	Vertical mean
	vertavg	Vertical average

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Table 6 – continued from previous page

	vertstd	Vertical standard deviation
	vertstd1	Vertical standard deviation (n-1)
	vertvar	Vertical variance
	vertvar1	Vertical variance (n-1)
Timselstat	*timselmin*	Time selection minimum
	timselmax	Time selection maximum
	timselrange	Time selection range
	timselsum	Time selection sum
	timselmean	Time selection mean
	timselavg	Time selection average
	timselstd	Time selection standard deviation
	timselstd1	Time selection standard deviation (n-1)
	timselvar	Time selection variance
	timselvar1	Time selection variance (n-1)
Timselpctl	*timselpctl*	Time range percentile
Runstat	*runmin*	Running minimum
	runmax	Running maximum
	runrange	Running range
	runsum	Running sum
	runmean	Running mean
	runavg	Running average
	runstd	Running standard deviation
	runstd1	Running standard deviation (n-1)
	runvar	Running variance
	runvar1	Running variance (n-1)
Runpctl	*runpctl*	Running percentile
Timstat	*timmin*	Time minimum
	timmax	Time maximum
	timminidx	Index of time minimum
	timmaxidx	Index of time maximum
	timrange	Time range
	timsum	Time sum
	timmean	Time mean
	timavg	Time average
	timstd	Time standard deviation
	timstd1	Time standard deviation (n-1)
	timvar	Time variance
	timvar1	Time variance (n-1)
Timpctl	*timpctl*	Temporal percentile
Hourstat	*hourmin*	Hourly minimum
	hourmax	Hourly maximum
	hourrange	Hourly range
	hoursum	Hourly sum
	hourmean	Hourly mean
	houravg	Hourly average
	hourstd	Hourly standard deviation
	hourstd1	Hourly standard deviation (n-1)
	hourvar	Hourly variance
	hourvar1	Hourly variance (n-1)
Hourpctl	*hourpctl*	Hourly percentile
Daystat	*daymin*	Daily minimum
	daymax	Daily maximum
	dayrange	Daily range
	daysum	Daily sum
	daymean	Daily mean
	dayavg	Daily average

continues on next page

Table 6 – continued from previous page

	daystd	Daily standard deviation
	daystd1	Daily standard deviation (n-1)
	dayvar	Daily variance
	dayvar1	Daily variance (n-1)
Daypctl	*daypctl*	Daily percentile
Monstat	*monmin*	Monthly minimum
	monmax	Monthly maximum
	monrange	Monthly range
	monsum	Monthly sum
	monmean	Monthly mean
	monavg	Monthly average
	monstd	Monthly standard deviation
	monstd1	Monthly standard deviation (n-1)
	monvar	Monthly variance
	monvar1	Monthly variance (n-1)
Monpctl	*monpctl*	Monthly percentile
Yearmonstat	*yearmonmean*	Yearly mean from monthly data
Yearstat	*yearmin*	Yearly minimum
	yearmax	Yearly maximum
	yearminidx	Index of yearly minimum
	yearmaxidx	Index of yearly maximum
	yearrange	Yearly range
	yearsum	Yearly sum
	yearmean	Yearly mean
	yearavg	Yearly average
	yearstd	Yearly standard deviation
	yearstd1	Yearly standard deviation (n-1)
	yearvar	Yearly variance
	yearvar1	Yearly variance (n-1)
Yearpctl	*yearpctl*	Yearly percentile
Seasstat	*seasmin*	Seasonal minimum
	seasmax	Seasonal maximum
	seasrange	Seasonal range
	seassum	Seasonal sum
	seasmean	Seasonal mean
	seasavg	Seasonal average
	seasstd	Seasonal standard deviation
	seasstd1	Seasonal standard deviation (n-1)
	seasvar	Seasonal variance
	seasvar1	Seasonal variance (n-1)
Seaspctl	*seaspctl*	Seasonal percentile
Yhourstat	*yhourmin*	Multi-year hourly minimum
	yhourmax	Multi-year hourly maximum
	yhourrange	Multi-year hourly range
	yhoursum	Multi-year hourly sum
	yhourmean	Multi-year hourly mean
	yhouravg	Multi-year hourly average
	yhourstd	Multi-year hourly standard deviation
	yhourstd1	Multi-year hourly standard deviation (n-1)
	yhourvar	Multi-year hourly variance
	yhourvar1	Multi-year hourly variance (n-1)
Dhourstat	*dhourmin*	Multi-day hourly minimum
	dhourmax	Multi-day hourly maximum
	dhourrange	Multi-day hourly range
	dhoursum	Multi-day hourly sum
	dhourmean	Multi-day hourly mean

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Table 6 – continued from previous page

	dhouravg	Multi-day hourly average
	dhourstd	Multi-day hourly standard deviation
	dhourstd1	Multi-day hourly standard deviation (n-1)
	dhourvar	Multi-day hourly variance
	dhourvar1	Multi-day hourly variance (n-1)
Dminutestat	*dminutemin*	Multi-day by the minute minimum
	dminutemax	Multi-day by the minute maximum
	dminuterange	Multi-day by the minute range
	dminutesum	Multi-day by the minute sum
	dminutemean	Multi-day by the minute mean
	dminuteavg	Multi-day by the minute average
	dminutestd	Multi-day by the minute standard deviation
	dminutestd1	Multi-day by the minute standard deviation (n-1)
	dminutevar	Multi-day by the minute variance
	dminutevar1	Multi-day by the minute variance (n-1)
Ydaystat	*ydaymin*	Multi-year daily minimum
	ydaymax	Multi-year daily maximum
	ydayrange	Multi-year daily range
	ydaysum	Multi-year daily sum
	ydaymean	Multi-year daily mean
	ydayavg	Multi-year daily average
	ydaystd	Multi-year daily standard deviation
	ydaystd1	Multi-year daily standard deviation (n-1)
	ydayvar	Multi-year daily variance
	ydayvar1	Multi-year daily variance (n-1)
Ydaypctl	*ydaypctl*	Multi-year daily percentile
Ymonstat	*ymonmin*	Multi-year monthly minimum
	ymonmax	Multi-year monthly maximum
	ymonrange	Multi-year monthly range
	ymonsum	Multi-year monthly sum
	ymonmean	Multi-year monthly mean
	ymonavg	Multi-year monthly average
	ymonstd	Multi-year monthly standard deviation
	ymonstd1	Multi-year monthly standard deviation (n-1)
	ymonvar	Multi-year monthly variance
	ymonvar1	Multi-year monthly variance (n-1)
Ymonpctl	*ymonpctl*	Multi-year monthly percentile
Yseasstat	*yseasmin*	Multi-year seasonal minimum
	yseasmax	Multi-year seasonal maximum
	yseasrange	Multi-year seasonal range
	yseassum	Multi-year seasonal sum
	yseasmean	Multi-year seasonal mean
	yseasavg	Multi-year seasonal average
	yseasstd	Multi-year seasonal standard deviation
	yseasstd1	Multi-year seasonal standard deviation (n-1)
	yseasvar	Multi-year seasonal variance
	yseasvar1	Multi-year seasonal variance (n-1)
Yseaspctl	*yseaspctl*	Multi-year seasonal percentile
Ydrunstat	*ydrunmin*	Multi-year daily running minimum
	ydrunmax	Multi-year daily running maximum
	ydrunsum	Multi-year daily running sum
	ydrunmean	Multi-year daily running mean
	ydrunavg	Multi-year daily running average
	ydrunstd	Multi-year daily running standard deviation
	ydrunstd1	Multi-year daily running standard deviation (n-1)
	ydrunvar	Multi-year daily running variance

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Table 6 – continued from previous page

	ydrunvar1	Multi-year daily running variance (n-1)
Ydrunpctl	*ydrunpctl*	Multi-year daily running percentile

2.8.1 Timcumsum

Name

timcumsum - Cumulative sum over all timesteps

Synopsis

cdo timcumsum *infile outfile*

Description

The timcumsum operator calculates the cumulative sum over all timesteps. Missing values are treated as numeric zero when summing.

$o(t, x) = \text{sum}\{i(t', x), 0 \leq t' \leq t\}$

Author

Uwe Schulzweida

2.8.2 Consecstat

Name

consecsum, consects - Consecute timestep periods

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes periods over all timesteps in `infile` where a certain property is valid. The property can be chosen by creating a mask from the original data, which is the expected input format for operators of this module. Depending on the operator full information about each period or just its length and ending date are computed.

Operators

consecsum
Consecutive Sum

This operator computes periods of consecutive timesteps similar to a *runsum*, but periods are finished, when the mask value is 0. That way multiple periods can be found. Timesteps from the input are preserved. Missing values are handled like 0, i.e. finish periods of consecutive timesteps.

consects
Consecutive Timesteps

In contrast to the operator above consects only computes the length of each period together with its last timestep. To be able to perform statistical analysis like min, max or mean, everything else is set to missing value.

Example

For a given time series of daily temperatures, the periods of summer days can be calculated with in-place masking the input field:

```
cdo consects -gtc,20.0 infile1 outfile
```

Author

Ralf Müller

2.8.3 Varsstat

Name

varsmin, varsmax, varsrange, varssum, varsmean, varsavg, varsstd, varsstd1, varsvar, varsvar1, varsskew, varskurt, varsmedian, varspctl - Statistical values over all variables

Synopsis

cdo <*operator*> *infile outfile*

cdo varspctl,*pn infile outfile*

Description

This module computes statistical values over all variables for each timestep. Depending on the chosen operator the minimum, maximum, range, sum, average, standard deviation, variance, skewness, kurtosis, median or a certain percentile is written to `outfile`. All input variables need to have the same gridsize and the same number of levels.

Operators

varsmin
Variables minimum

For every timestep the minimum over all variables is computed.

varsmax
Variables maximum

For every timestep the maximum over all variables is computed.

varsrange
Variables range

For every timestep the range over all variables is computed.

varssum
Variables sum

For every timestep the sum over all variables is computed.

varsmean
Variables mean

For every timestep the mean over all variables is computed.

varsavg
Variables average

For every timestep the average over all variables is computed.

varsstd
Variables standard deviation

For every timestep the standard deviation over all variables is computed. Normalize by n.

varsstd1
Variables standard deviation (n-1)

For every timestep the standard deviation over all variables is computed. Normalize by (n-1).

varsvar
Variables variance

For every timestep the variance over all variables is computed. Normalize by n.

varsvar1
Variables variance (n-1)

For every timestep the variance over all variables is computed. Normalize by (n-1).

varsskew
Variables skewness

For every timestep the skewness over all variables is computed.

varskurt
Variables kurtosis

For every timestep the kurtosis over all variables is computed.

varsmedian
Variables median

For every timestep the median over all variables is computed.

varspctl
Variables percentile

For every timestep the percentile over all variables is computed.

Parameters

pn
[FLOAT] Percentile number in $\{0, \ldots, 100\}$

Author

Uwe Schulzweida

2.8.4 Ensstat

Name

ensmin, ensmax, ensrange, enssum, ensmean, ensavg, ensstd, ensstd1, ensvar, ensvar1, ensskew, enskurt, ensmedian, enspctl - Ensemble statistics

Synopsis

cdo [options] <*operator*> *infiles outfile*

cdo [options] enspctl,*pn infiles outfile*

Description

This module computes statistical values over an ensemble of input files. Depending on the chosen operator, the minimum, maximum, range, sum, average, standard deviation, variance, skewness, kurtosis, median or a certain percentile over all input files is written to `outfile`. All input files need to have the same structure with the same variables. The date information of a timestep in `outfile` is the date of the first input file.

Operators

ensmin
Ensemble minimum

$o(t,x) = \mathbf{min}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensmax
Ensemble maximum

$o(t,x) = \mathbf{max}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensrange
Ensemble range

$o(t,x) = \mathbf{range}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

enssum
Ensemble sum

$o(t,x) = \mathbf{sum}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensmean
Ensemble mean

$o(t,x) = \mathbf{mean}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensavg
Ensemble average

$o(t,x) = \mathbf{avg}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensstd
Ensemble standard deviation

Normalize by n.

$o(t,x) = \mathbf{std}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensstd1
Ensemble standard deviation (n-1)

Normalize by (n-1).

$o(t,x) = \mathbf{std1}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensvar
Ensemble variance

Normalize by n.

$o(t,x) = \textbf{var}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensvar1
Ensemble variance (n-1)

Normalize by (n-1).

$o(t,x) = \textbf{var1}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensskew
Ensemble skewness

$o(t,x) = \textbf{skew}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

enskurt
Ensemble kurtosis

$o(t,x) = \textbf{kurt}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensmedian
Ensemble median

$o(t,x) = \textbf{median}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

enspctl
Ensemble percentile

$o(t,x) = \textbf{pth percentile}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

Options

`-O`, `--overwrite` to overwrite existing output file.

Note

Operators of this module need to open all input files simultaneously. The maximum number of open files depends on the operating system!

Example

To compute the ensemble mean over 6 input files use:

```
cdo ensmean infile1 infile2 infile3 infile4 infile5 infile6 outfile
```

Or shorter with filename substitution:

```
cdo ensmean infile[1-6] outfile
```

To compute the 50th percentile (median) over 6 input files use:

```
cdo enspctl,50 infile1 infile2 infile3 infile4 infile5 infile6 outfile
```

Author

Uwe Schulzweida

2.8.5 Ensstat2

Name

ensrkhistspace, ensrkhisttime, ensroc - Statistical values over an ensemble

Synopsis

cdo <*operator*> *obsfile ensfiles outfile*

Description

This module computes statistical values over the ensemble of `ensfiles` using `obsfile` as a reference. Depending on the operator a ranked Histogram or a roc-curve over all Ensembles `ensfiles` with reference to `obsfile` is written to `outfile`. The date and grid information of a timestep in `outfile` is the date of the first input file. Thus all input files are required to have the same structure in terms of the gridsize, variable definitions and number of timesteps.

All Operators in this module use `obsfile` as the reference (for instance an observation) whereas `ensfiles` are understood as an ensemble consisting of n (where n is the number of `ensfiles`) members.

The operators ensrkhistspace and ensrkhisttime compute Ranked Histograms. Therefor the vertical axis is utilized as the Histogram axis, which prohibits the use of files containing more than one level. The histogram axis has nensfiles+1 bins with level 0 containing for each grid point the number of observations being smaller as all ensembles and level nensfiles+1 indicating the number of observations being larger than all ensembles.

ensrkhisttime computes a ranked histogram at each timestep reducing each horizontal grid to a 1x1 grid and keeping the time axis as in `obsfile`. Contrary ensrkhistspace computes a histogram at each grid point keeping the horizontal grid for each variable and reducing the time-axis. The time information is that from the last timestep in `obsfile`.

Operators

ensrkhisttime
Ranked Histogram averaged over time

ensrkhistspace
Ranked Histogram averaged over space

ensroc
Ensemble Receiver Operating characteristics

Example

To compute a rank histogram over 5 input files `ensfile1`-`ensfile5` given an observation in `obsfile` use:

```
cdo ensrkhisttime obsfile ensfile1 ensfile2 ensfile3 ensfile4 ensfile5 outfile
```

Or shorter with filename substitution:

```
cdo ensrkhisttime obsfile ensfile[1-5] outfile
```

Author

Uwe Schulzweida

2.8.6 Ensval

Name

enscrps, ensbrs - Ensemble validation tools

Synopsis

cdo enscrps *rfile infiles outfilebase*

cdo ensbrs,*x rfile infiles outfilebase*

Description

This module computes ensemble validation scores and their decomposition such as the Brier and cumulative ranked probability score (CRPS). The first file is used as a reference it can be a climatology, observation or reanalysis against which the skill of the ensembles given in infiles is measured. Depending on the operator a number of output files is generated each containing the skill score and its decomposition corresponding to the operator. The output is averaged over horizontal fields using appropriate weights for each level and timestep in rfile.

All input files need to have the same structure with the same variables. The date information of a timestep in `outfile` is the date of the first input file. The output files are named as <`outfilebase`>.<`type`>.<`filesuffix`> where <`type`> depends on the operator and <`filesuffix`> is determined from the output file type. There are three output files for operator enscrps and four output files for operator ensbrs.

The CRPS and its decomposition into Reliability and the potential CRPS are calculated by an appropriate averaging over the field members (note, that the CRPS does *not* average linearly). In the three output files <`type`> has the following meaning: `crps` for the CRPS, `reli` for the reliability and `crpspot` for the potential crps. The relation $CRPS = CRPS_{pot} + RELI$ holds.

The Brier score of the Ensemble given by `infiles` with respect to the reference given in `rfile` and the threshold x is calculated. In the four output files <`type`> has the following meaning: `brs` for the Brier score wrt threshold x; `brsreli` for the Brier score reliability wrt threshold x; `brsreso` for the Brier score resolution wrt threshold x; `brsunct` for the Brier score uncertainty wrt threshold x. In analogy to the CRPS the following relation holds $BRS(x) = RELI(x) - RESO(x) + UNCT(x)$.

The implementation of the decomposition of the CRPS and Brier Score follows
Hans Hersbach (2000): Decomposition of the Continuous Ranked Probability Score for Ensemble Prediction Systems, in: Weather and Forecasting (15) pp. 559-570.

The CRPS code decomposition has been verified against the CRAN - ensemble validation package from R. Differences occur when grid-cell area is not uniform as the implementation in R does not account for that.

Operators

enscrps
Ensemble CRPS and decomposition

ensbrs
Ensemble Brier score

Parameters

x
[FLOAT] threshold

Example

To compute the field averaged Brier score at x=5 over an ensemble with 5 members `ensfile1-5` w.r.t. the reference `rfile` and write the results to files `obase.brs.<suff>`, `obase.brsreli<suff>`, `obase.brsreso<suff>`, `obase.brsunct<suff>` where <`suff`> is determined from the output file type, use

```
cdo ensbrs,5 rfile ensfile1 ensfile2 ensfile3 ensfile4 ensfile5 obase
```

or shorter using file name substitution:

```
cdo ensbrs,5 rfile ensfile[1-5] obase
```

Author

Cedrick Ansorge

2.8.7 Fldstat

Name

fldmin, fldmax, fldrange, fldsum, fldint, fldmean, fldavg, fldstd, fldstd1, fldvar, fldvar1, fldskew, fldkurt, fldmedian, fldcount, fldpctl - Statistical values over a field

Synopsis

cdo <*operator*>[,parameter] *infile outfile*

Description

This module computes statistical values of all input fields. A field is a horizontal layer of a data variable. Depending on the chosen operator, the minimum, maximum, range, sum, integral, average, standard deviation, variance, skewness, kurtosis, median or a certain percentile of the field is written to *outfile*.

Operators

fldmin
: Field minimum

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{min}\{i(t,x'), x_1 \leq x' \leq x_n\}$

fldmax
: Field maximum

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{max}\{i(t,x'), x_1 \leq x' \leq x_n\}$

fldrange
: Field range

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{range}\{i(t,x'), x_1 \leq x' \leq x_n\}$

fldsum
: Field sum

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{sum}\{i(t,x'), x_1 \leq x' \leq x_n\}$

fldint
: Field integral

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{sum}\{i(t,x') * cellarea(x'), x_1 \leq x' \leq x_n\}$

fldmean
: Field mean

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{mean}\{i(t,x'), x_1 \leq x' \leq x_n\}$

  weighted by area weights obtained by the input field.

fldavg
: Field average

  For every gridpoint $x_1, ..., x_n$ of the same field it is:

  $o(t,1) = \textbf{avg}\{i(t,x'), x_1 \leq x' \leq x_n\}$

  weighted by area weights obtained by the input field.

fldvar
Field variance

Normalize by n. For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{var}\{i(t, x'), x_1 \leq x' \leq x_n\}$

weighted by area weights obtained by the input field.

fldvar1
Field variance (n-1)

Normalize by (n-1). For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{var1}\{i(t, x'), x_1 \leq x' \leq x_n\}$

weighted by area weights obtained by the input field.

fldstd
Field standard deviation

Normalize by n. For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{std}\{i(t, x'), x_1 \leq x' \leq x_n\}$

weighted by area weights obtained by the input field.

fldstd1
Field standard deviation (n-1)

Normalize by (n-1). For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{std1}\{i(t, x'), x_1 \leq x' \leq x_n\}$

weighted by area weights obtained by the input field.

fldskew
Field skewness

For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{skew}\{i(t, x'), x_1 \leq x' \leq x_n\}$

fldkurt
Field kurtosis

For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{kurt}\{i(t, x'), x_1 \leq x' \leq x_n\}$

fldmedian
Field median

For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{median}\{i(t, x'), x_1 \leq x' \leq x_n\}$

fldcount
Field count

Number of non-missing values of the field.

fldpctl
Field percentile

For every gridpoint $x_1, ..., x_n$ of the same field it is:

$o(t, 1) = \textbf{pth percentile}\{i(t, x'), x_1 \leq x' \leq x_n\}$

Parameters

verbose
: [BOOL] print lon/lat coordinates of min/max values

weights
: [BOOL] weights=FALSE disables weighting by grid cell area [default: weights=TRUE]

pn
: [FLOAT] Percentile number in {0, …, 100}

Example

To compute the field mean of all input fields use:

```
cdo fldmean infile outfile
```

To compute the 90th percentile of all input fields use:

```
cdo fldpctl,pn=90 infile outfile
```

Author

Uwe Schulzweida

2.8.8 Zonstat

Name

zonmin, zonmax, zonrange, zonsum, zonmean, zonavg, zonstd, zonstd1, zonvar, zonvar1, zonskew, zonkurt, zonmedian, zonpctl - Zonal statistics

Synopsis

cdo <*operator*> *infile outfile*

cdo zonpctl,*pn infile outfile*

Description

This module computes zonal statistical values of the input fields. Depending on the chosen operator, the zonal minimum, maximum, range, sum, average, standard deviation, variance, skewness, kurtosis, median or a certain percentile of the field is written to `outfile`. Operators of this module require all variables on the same regular lon/lat grid. Only the zonal mean (zonmean) can be calculated for data on an unstructured grid if the latitude bins are defined with the optional parameter zonaldes.

Operators

zonmin
Zonal minimum

For every latitude the minimum over all longitudes is computed.

zonmax
Zonal maximum

For every latitude the maximum over all longitudes is computed.

zonrange
Zonal range

For every latitude the range over all longitudes is computed.

zonsum
Zonal sum

For every latitude the sum over all longitudes is computed.

zonmean
Zonal mean

For every latitude the mean over all longitudes is computed. Use the optional parameter zonaldes for data on an unstructured grid.

zonavg
Zonal average

For every latitude the average over all longitudes is computed.

zonvar
Zonal variance

For every latitude the variance over all longitudes is computed. Normalize by n.

zonvar1
Zonal variance (n-1)

For every latitude the variance over all longitudes is computed. Normalize by (n-1).

zonstd
Zonal standard deviation

For every latitude the standard deviation over all longitudes is computed. Normalize by n.

zonstd1
Zonal standard deviation (n-1)

For every latitude the standard deviation over all longitudes is computed. Normalize by (n-1).

zonskew
Zonal skewness

For every latitude the skewness over all longitudes is computed.

zonkurt
Zonal kurtosis

For every latitude the kurtosis over all longitudes is computed.

zonmedian
Zonal median

For every latitude the median over all longitudes is computed.

zonpctl
Zonal percentile

For every latitude the pth percentile over all longitudes is computed.

Parameters

pn
[FLOAT] Percentile number in $\{0, \ldots, 100\}$

zonaldes
[STRING] Description of the zonal latitude bins needed for data on an unstructured grid. A predefined zonal description is zonal_<DY>. DY is the increment of the latitudes in degrees.

Example

To compute the zonal mean of all input fields use:

```
cdo zonmean infile outfile
```

To compute the 50th meridional percentile (median) of all input fields use:

```
cdo zonpctl,50 infile outfile
```

Author

Uwe Schulzweida

2.8.9 Merstat

Name

mermin, mermax, merrange, mersum, mermean, meravg, merstd, merstd1, mervar, mervar1, merskew, merkurt, mermedian, merpctl - Meridional statistics

Synopsis

cdo <*operator*> *infile outfile*

cdo merpctl,*pn infile outfile*

Description

This module computes meridional statistical values of the input fields. Depending on the chosen operator, the meridional minimum, maximum, range, sum, average, standard deviation, variance, skewness, kurtosis, median or a certain percentile of the field is written to `outfile`. Operators of this module require all variables on the same regular lon/lat grid.

Operators

mermin
Meridional minimum

For every longitude the minimum over all latitudes is computed.

mermax
Meridional maximum

For every longitude the maximum over all latitudes is computed.

merrange
Meridional range

For every longitude the range over all latitudes is computed.

mersum
Meridional sum

For every longitude the sum over all latitudes is computed.

mermean
Meridional mean

For every longitude the area weighted mean over all latitudes is computed.

meravg
Meridional average

For every longitude the area weighted average over all latitudes is computed.

mervar
Meridional variance

For every longitude the variance over all latitudes is computed. Normalize by n.

mervar1
Meridional variance (n-1)

For every longitude the variance over all latitudes is computed. Normalize by (n-1).

merstd
Meridional standard deviation

For every longitude the standard deviation over all latitudes is computed. Normalize by n.

merstd1
Meridional standard deviation (n-1)

For every longitude the standard deviation over all latitudes is computed. Normalize by (n-1).

merskew
Meridional skewness

For every longitude the skewness over all latitudes is computed.

merkurt
Meridional kurtosis

For every longitude the kurtosis over all latitudes is computed.

mermedian
Meridional median

For every longitude the median over all latitudes is computed.

merpctl
Meridional percentile

For every longitude the pth percentile over all latitudes is computed.

Parameters

pn
[FLOAT] Percentile number in {0, ..., 100}

Example

To compute the meridional mean of all input fields use:

```
cdo mermean infile outfile
```

To compute the 50th meridional percentile (median) of all input fields use:

```
cdo merpctl,50 infile outfile
```

Author

Uwe Schulzweida

2.8.10 Gridboxstat

Name

gridboxmin, gridboxmax, gridboxrange, gridboxsum, gridboxmean, gridboxavg, gridboxstd, gridboxstd1, gridboxvar, gridboxvar1, gridboxskew, gridboxkurt, gridboxmedian - Statistical values over grid boxes

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module computes statistical values over surrounding grid boxes. Depending on the chosen operator, the minimum, maximum, range, sum, average, standard deviation, variance, skewness, kurtosis or median of the neighboring grid boxes is written to `outfile`. All gridbox operators only work on quadrilateral curvilinear grids.

Operators

gridboxmin
Gridbox minimum

Minimum value of the selected grid boxes.

gridboxmax
Gridbox maximum

Maximum value of the selected grid boxes.

gridboxrange
Gridbox range

Range (max-min value) of the selected grid boxes.

gridboxsum
Gridbox sum

Sum of the selected grid boxes.

gridboxmean
Gridbox mean

Mean of the selected grid boxes.

gridboxavg
Gridbox average

Average of the selected grid boxes.

gridboxvar
Gridbox variance

Variance of the selected grid boxes. Normalize by n.

gridboxvar1
Gridbox variance (n-1)

Variance of the selected grid boxes. Normalize by (n-1).

gridboxstd
Gridbox standard deviation

Standard deviation of the selected grid boxes. Normalize by n.

gridboxstd1
Gridbox standard deviation (n-1)

Standard deviation of the selected grid boxes. Normalize by (n-1).

gridboxskew
Gridbox skewness

Skewness of the selected grid boxes.

gridboxkurt
Gridbox kurtosis

Kurtosis of the selected grid boxes.

gridboxmedian
Gridbox median

Median of the selected grid boxes.

Parameters

nx
[INTEGER] Number of grid boxes in x direction

ny
[INTEGER] Number of grid boxes in y direction

Example

To compute the mean over 10x10 grid boxes of the input field use:

```
cdo gridboxmean,10,10 infile outfile
```

Author

Uwe Schulzweida

2.8.11 Remapstat

Name

remapmin, remapmax, remaprange, remapsum, remapmean, remapavg, remapstd, remapstd1, remapvar, remapvar1, remapskew, remapkurt, remapmedian - Remaps source points to target cells

Synopsis

cdo *<operator>,parameters infile outfile*

Description

This module maps source points to target cells by calculating a statistical value from the source points. Each target cell contains the statistical value from all source points within that target cell. If there are no source points within a target cell, it gets a missing value. Depending on the chosen operator the minimum, maximum, range, sum, average, variance, standard deviation, skewness, kurtosis or median of source points is computed.

Operators

remapmin
Remap minimum

Minimum value of the source points.

remapmax
Remap maximum

Maximum value of the source points.

remaprange
Remap range

Range (max-min value) of the source points.

remapsum
Remap sum

Sum of the source points.

remapmean
Remap mean

Mean of the source points.

remapavg
Remap average

Average of the source points.

remapvar
Remap variance

Variance of the source points. Normalize by n.

remapvar1
Remap variance (n-1)

Variance of the source points. Normalize by (n-1).

remapstd
Remap standard deviation

Standard deviation of the source points. Normalize by n.

remapstd1
Remap standard deviation (n-1)

Standard deviation of the source points. Normalize by (n-1).

remapskew
: Remap skewness

  Skewness of the source points.

remapkurt
: Remap kurtosis

  Kurtosis of the source points.

remapmedian
: Remap median

  Median of the source points.

Parameters

grid
: [STRING] Target grid description file or name

Example

To compute the mean over source points within the taget cells, use:

```
cdo remapmean,<targetgrid> infile outfile
```

If some of the target cells contain missing values, use the Operator *setmisstonn* to fill these missing values with the nearest neighbor cell:

```
cdo setmisstonn -remapmean,<targetgrid> infile outfile
```

Author

Uwe Schulzweida

2.8.12 Vertstat

Name

vertmin, vertmax, vertrange, vertsum, vertmean, vertavg, vertstd, vertstd1, vertvar, vertvar1 - Vertical statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values over all levels of the input variables. According to chosen operator the vertical minimum, maximum, range, sum, average, variance or standard deviation is written to `outfile`. Weighting based on layer thickness can be disabled with the parameter weights=FALSE.

Operators

vertmin
Vertical minimum

For every gridpoint the minimum over all levels is computed.

vertmax
Vertical maximum

For every gridpoint the maximum over all levels is computed.

vertrange
Vertical range

For every gridpoint the range over all levels is computed.

vertsum
Vertical sum

For every gridpoint the sum over all levels is computed.

vertmean
Vertical mean

For every gridpoint the weighted mean over all levels is computed.

vertavg
Vertical average

For every gridpoint the weighted average over all levels is computed.

vertvar
Vertical variance

For every gridpoint the weighted variance over all levels is computed. Normalize by n.

vertvar1
Vertical variance (n-1)

For every gridpoint the weighted variance over all levels is computed. Normalize by (n-1).

vertstd
Vertical standard deviation

For every gridpoint the weighted standard deviation over all levels is computed. Normalize by n.

vertstd1
Vertical standard deviation (n-1)

For every gridpoint the weighted standard deviation over all levels is computed. Normalize by (n-1).

Parameters

weights
[BOOL] weights=FALSE disables weighting with layer thickness [default: weights=TRUE]

Example

To compute the vertical sum of all input variables use:

```
cdo vertsum infile outfile
```

Author

Uwe Schulzweida

2.8.13 Timselstat

Name

timselmin, timselmax, timselrange, timselsum, timselmean, timselavg, timselstd, timselstd1, timselvar, timselvar1 - Time range statistics

Synopsis

cdo <*operator*>,*nsets*[,*noffset*[,*nskip*]] *infile outfile*

Description

This module computes statistical values for a selected number of timesteps. According to the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of the selected timesteps is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

timselmin
: Time selection minimum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{min}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselmax
: Time selection maximum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{max}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselrange
: Time selection range

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{range}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselsum
: Time selection sum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{sum}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselmean
: Time selection mean

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{mean}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselavg
: Time selection average

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{avg}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselvar
: Time selection variance

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

  $o(t, x) = \text{var}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselvar1

Time selection variance (n-1)

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

$o(t, x) = \text{var1}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselstd

Time selection standard deviation

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

$o(t, x) = \text{std}\{i(t', x), t_1 \leq t' \leq t_n\}$

timselstd1

Time selection standard deviation (n-1)

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same selected time range it is:

$o(t, x) = \text{std1}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

nsets

[INTEGER] Number of input timesteps for each output timestep

noffset

[INTEGER] Number of input timesteps skipped before the first timestep range (optional)

nskip

[INTEGER] Number of input timesteps skipped between timestep ranges (optional)

Example

Assume an input dataset has monthly means over several years. To compute seasonal means from monthly means the first two month have to be skipped:

```
cdo timselmean,3,2 infile outfile
```

Author

Uwe Schulzweida

2.8.14 Timselpctl

Name

timselpctl - Time range percentile

Synopsis

cdo timselpctl,*pn*,*nsets*[,*noffset*[,*nskip*]] *infile1 infile2 infile3 outfile*

Description

This operator computes percentile values over a selected number of timesteps in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by setting the environment variable *CDO_PCTL_NBINS* to a different value. The files `infile2` and `infile3` should be the result of corresponding *timselmin* and *timselmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence :$t_1, ..., t_n$ of timesteps of the same selected time range it is:

$o(t, x) = \text{pth percentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
: [FLOAT] Percentile number in {0, …, 100}

nsets
: [INTEGER] Number of input timesteps for each output timestep

noffset
: [INTEGER] Number of input timesteps skipped before the first timestep range (optional)

nskip
: [INTEGER] Number of input timesteps skipped between timestep ranges (optional)

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Author

Uwe Schulzweida

2.8.15 Runstat

Name

runmin, runmax, runrange, runsum, runmean, runavg, runstd, runstd1, runvar, runvar1 - Running statistics

Synopsis

cdo <*operator*>,*nts infile outfile*

Description

This module computes running statistical values over a selected number of timesteps. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of a selected number of consecutive timesteps read from `infile` is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

runmin
Running minimum

$o(t + (nts - 1)/2, x) = \text{min}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runmax
Running maximum

$o(t + (nts - 1)/2, x) = \text{max}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runrange
Running range

$o(t + (nts - 1)/2, x) = \text{range}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runsum
Running sum

$o(t + (nts - 1)/2, x) = \text{sum}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runmean
Running mean

$o(t + (nts - 1)/2, x) = \text{mean}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runavg
Running average

$o(t + (nts - 1)/2, x) = \text{avg}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runvar
Running variance

Normalize by n.

$o(t + (nts - 1)/2, x) = \text{var}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runvar1
Running variance (n-1)

Normalize by (n-1).

$o(t + (nts - 1)/2, x) = \text{var1}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runstd
Running standard deviation

Normalize by n.

$o(t + (nts - 1)/2, x) = \text{std}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runstd1
Running standard deviation (n-1)

Normalize by (n-1).

$o(t + (nts - 1)/2, x) = \text{std1}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

Parameters

nts
[INTEGER] Number of timesteps

Example

To compute the running mean over 9 timesteps use:

```
cdo runmean,9 infile outfile
```

Author

Uwe Schulzweida

2.8.16 Runpctl

Name

runpctl - Running percentile

Synopsis

cdo runpctl,*pn*,*nts infile outfile*

Description

This module computes running percentiles over a selected number of timesteps in `infile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

$o(t + (nts - 1)/2, x) = \text{pth percentile}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

nts
[INTEGER] Number of timesteps

Example

To compute the running 50th percentile (median) over 9 timesteps use:

```
cdo runpctl,50,9 infile outfile
```

Author

Uwe Schulzweida

2.8.17 Timstat

Name

timmin, timmax, timminidx, timmaxidx, timrange, timsum, timmean, timavg, timstd, timstd1, timvar, timvar1 - Statistical values over all timesteps

Synopsis

cdo [options] <*operator*> *infile outfile*

Description

This module computes statistical values over all timesteps in `infile`. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of all timesteps read from `infile` is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

timmin
Time minimum

$o(1,x) = \text{min}\{i(t',x), t_1 \leq t' \leq t_n\}$

timmax
Time maximum

$o(1,x) = \text{max}\{i(t',x), t_1 \leq t' \leq t_n\}$

timminidx
Index of time minimum

$o(1,x) = \text{minidx}\{i(t',x), t_1 \leq t' \leq t_n\}$

timmaxidx
Index of time maximum

$o(1,x) = \text{maxidx}\{i(t',x), t_1 \leq t' \leq t_n\}$

timrange
Time range

$o(1,x) = \text{range}\{i(t',x), t_1 \leq t' \leq t_n\}$

timsum
Time sum

$o(1,x) = \text{sum}\{i(t',x), t_1 \leq t' \leq t_n\}$

timmean
Time mean

$o(1,x) = \text{mean}\{i(t',x), t_1 \leq t' \leq t_n\}$

timavg
Time average

$o(1,x) = \text{avg}\{i(t',x), t_1 \leq t' \leq t_n\}$

timvar
Time variance

Normalize by n.

$o(1,x) = \text{var}\{i(t',x), t_1 \leq t' \leq t_n\}$

timvar1
Time variance (n-1)

Normalize by (n-1).

$o(1, x) = \text{var1}\{i(t', x), t_1 \le t' \le t_n\}$

timstd
Time standard deviation

Normalize by n.

$o(1, x) = \text{std}\{i(t', x), t_1 \le t' \le t_n\}$

timstd1
Time standard deviation (n-1)

Normalize by (n-1).

$o(1, x) = \text{std1}\{i(t', x), t_1 \le t' \le t_n\}$

Options

`-S`, `--diagnostic` to create a diagnostic output stream with the number of non missing values for each output period.

`-p`, `--async_read true` to read input data asynchronously.

Example

To compute the mean over all input timesteps use:

```
cdo timmean infile outfile
```

Author

Uwe Schulzweida

2.8.18 Timpctl

Name

timpctl - Temporal percentile

Synopsis

cdo timpctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable *CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *timmin* and *timmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

$o(1, x) = \text{pth percentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
[FLOAT] Percentile number in {0, ..., 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the 90th percentile over all input timesteps use:

```
cdo timmin infile minfile
cdo timmax infile maxfile
cdo timpctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo timpctl,90 infile -timmin infile -timmax infile outfile
```

Author

Uwe Schulzweida

2.8.19 Hourstat

Name

hourmin, hourmax, hourrange, hoursum, hourmean, houravg, hourstd, hourstd1, hourvar, hourvar1 - Hourly statistics

Synopsis

cdo [options] <*operator*> *infile outfile*

Description

This module computes statistical values over timesteps of the same hour. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of timesteps of the same hour is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

hourmin
Hourly minimum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{min}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourmax
Hourly maximum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{max}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourrange
Hourly range

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{range}\{i(t', x), t_1 \leq t' \leq t_n\}$

hoursum
Hourly sum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{sum}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourmean
Hourly mean

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{mean}\{i(t', x), t_1 \leq t' \leq t_n\}$

houravg
Hourly average

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{avg}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourvar
Hourly variance

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{var}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourvar1
Hourly variance (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{var1}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourstd
Hourly standard deviation

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{std}\{i(t', x), t_1 \leq t' \leq t_n\}$

hourstd1
Hourly standard deviation (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{std1}\{i(t', x), t_1 \leq t' \leq t_n\}$

Options

`-S`, `--diagnostic` to create a diagnostic output stream with the number of non missing values for each output period.

`-p`, `--async_read true` to read input data asynchronously.

Example

To compute the hourly mean of a time series use:

```
cdo hourmean infile outfile
```

Author

Uwe Schulzweida

2.8.20 Hourpctl

Name

hourpctl - Hourly percentile

Synopsis

cdo hourpctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps of the same hour in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable *CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *hourmin* and *hourmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same hour it is:

$o(t, x) = \text{pth percentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the hourly 90th percentile of a time series use:

```
cdo hourmin infile minfile
cdo hourmax infile maxfile
cdo hourpctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo hourpctl,90 infile -hourmin infile -hourmax infile outfile
```

Author

Uwe Schulzweida

2.8.21 Daystat

Name

daymin, daymax, dayrange, daysum, daymean, dayavg, daystd, daystd1, dayvar, dayvar1 - Daily statistics

Synopsis

cdo [options] <*operator*> *infile outfile*

Description

This module computes statistical values over timesteps of the same day. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of timesteps of the same day is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>. Set the parameter complete_only=TRUE to process the last day only when it is complete.

Operators

daymin
: Daily minimum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{min}\{i(t',x), t_1 \le t' \le t_n\}$

daymax
: Daily maximum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{max}\{i(t',x), t_1 \le t' \le t_n\}$

dayrange
: Daily range

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{range}\{i(t',x), t_1 \le t' \le t_n\}$

daysum
: Daily sum

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{sum}\{i(t',x), t_1 \le t' \le t_n\}$

daymean
: Daily mean

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{mean}\{i(t',x), t_1 \le t' \le t_n\}$

dayavg
: Daily average

  For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{avg}\{i(t',x), t_1 \le t' \le t_n\}$

dayvar
: Daily variance

  Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

  $o(t,x) = \text{var}\{i(t',x), t_1 \le t' \le t_n\}$

dayvar1
Daily variance (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

$o(t, x) = \text{var1}\{i(t', x), t_1 \leq t' \leq t_n\}$

daystd
Daily standard deviation

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

$o(t, x) = \text{std}\{i(t', x), t_1 \leq t' \leq t_n\}$

daystd1
Daily standard deviation (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

$o(t, x) = \text{std1}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

complete_only
[BOOL] Process the last day only when it is complete

Options

`-S`, `--diagnostic` to create a diagnostic output stream with the number of non missing values for each output period.

`-p`, `--async_read true` to read input data asynchronously.

Example

To compute the daily mean of a time series use:

```
cdo daymean infile outfile
```

Author

Uwe Schulzweida

2.8.22 Daypctl

Name

daypctl - Daily percentile

Synopsis

cdo daypctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps of the same day in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable :*CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *daymin* and *daymax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same day it is:

$o(t, x) = \text{pth percentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
: [FLOAT] Percentile number in {0, …, 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the daily 90th percentile of a time series use:

```
cdo daymin infile minfile
cdo daymax infile maxfile
cdo daypctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo daypctl,90 infile -daymin infile -daymax infile outfile
```

Author

Uwe Schulzweida

2.8.23 Monstat

Name

monmin, monmax, monrange, monsum, monmean, monavg, monstd, monstd1, monvar, monvar1 - Monthly statistics

Synopsis

cdo [options] <*operator*>[,*parameters*] *infile outfile*

Description

This module computes statistical values over timesteps of the same month. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of timesteps of the same month is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

monmin
Monthly minimum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{min}\{i(t', x), t_1 \leq t' \leq t_n\}$

monmax
Monthly maximum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{max}\{i(t', x), t_1 \leq t' \leq t_n\}$

monrange
Monthly range

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{range}\{i(t', x), t_1 \leq t' \leq t_n\}$

monsum
Monthly sum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{sum}\{i(t', x), t_1 \leq t' \leq t_n\}$

monmean
Monthly mean

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{mean}\{i(t', x), t_1 \leq t' \leq t_n\}$

monavg
Monthly average

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{avg}\{i(t', x), t_1 \leq t' \leq t_n\}$

monvar
Monthly variance

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{var}\{i(t', x), t_1 \leq t' \leq t_n\}$

monvar1
Monthly variance (n-1)

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t,x) = \mathbf{var1}\{i(t',x), t_1 \le t' \le t_n\}$

monstd
Monthly standard deviation

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t,x) = \mathbf{std}\{i(t',x), t_1 \le t' \le t_n\}$

monstd1
Monthly standard deviation (n-1)

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t,x) = \mathbf{std1}\{i(t',x), t_1 \le t' \le t_n\}$

Parameters

complete_only
[BOOL] Process the last month only if it is complete

Options

`-S`, `--diagnostic` to create a diagnostic output stream with the number of non missing values for each output period.

`-p`, `--async_read true` to read input data asynchronously.

Example

To compute the monthly mean of a time series use:

```
cdo monmean infile outfile
```

Author

Uwe Schulzweida

2.8.24 Monpctl

Name

monpctl - Monthly percentile

Synopsis

cdo monpctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps of the same month in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable *CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *monmin* and *monmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same month it is:

$o(t, x) = \mathbf{pthpercentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the monthly 90th percentile of a time series use:

```
cdo monmin infile minfile
cdo monmax infile maxfile
cdo monpctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo monpctl,90 infile -monmin infile -monmax infile outfile
```

Author

Uwe Schulzweida

2.8.25 Yearmonstat

Name

yearmonmean - Yearly mean from monthly data

Synopsis

cdo yearmonmean *infile outfile*

Description

This operator computes the yearly mean of a monthly time series. Each month is weighted with the number of days per month. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{mean}\{i(t', x), t_1 \leq t' \leq t_n\}$

Example

To compute the yearly mean of a monthly time series use:

```
cdo yearmonmean infile outfile
```

Author

Uwe Schulzweida

2.8.26 Yearstat

Name

yearmin, yearmax, yearminidx, yearmaxidx, yearrange, yearsum, yearmean, yearavg, yearstd, yearstd1, yearvar, yearvar1 - Yearly statistics

Synopsis

cdo [options] <*operator*> *infile outfile*

Description

This module computes statistical values over timesteps of the same year. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of timesteps of the same year is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>. Set the parameter complete_only=TRUE to process the last year only when it is complete.

Operators

yearmin
Yearly minimum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{min}\{i(t',x), t_1 \le t' \le t_n\}$

yearmax
Yearly maximum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{max}\{i(t',x), t_1 \le t' \le t_n\}$

yearminidx
Index of yearly minimum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{minidx}\{i(t',x), t_1 \le t' \le t_n\}$

yearmaxidx
Index of yearly maximum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{maxidx}\{i(t',x), t_1 \le t' \le t_n\}$

yearrange
Yearly range

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{range}\{i(t',x), t_1 \le t' \le t_n\}$

yearsum
Yearly sum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{sum}\{i(t',x), t_1 \le t' \le t_n\}$

yearmean
Yearly mean

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t,x) = \text{mean}\{i(t',x), t_1 \le t' \le t_n\}$

yearavg
Yearly average

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{avg}\{i(t', x), t_1 \leq t' \leq t_n\}$

yearvar
Yearly variance

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{var}\{i(t', x), t_1 \leq t' \leq t_n\}$

yearvar1
Yearly variance (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{var1}\{i(t', x), t_1 \leq t' \leq t_n\}$

yearstd
Yearly standard deviation

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{std}\{i(t', x), t_1 \leq t' \leq t_n\}$

yearstd1
Yearly standard deviation (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{std1}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

complete_only
[BOOL] Process the last year only when it is complete

Options

`-S`, `--diagnostic` to create a diagnostic output stream with the number of non missing values for each output period.

`-p`, `--async_read true` to read input data asynchronously.

Note

The operators yearmean and yearavg compute only arithmetical means!

Example

To compute the yearly mean of a time series use:

```
cdo yearmean infile outfile
```

To compute the yearly mean from the correct weighted monthly mean use:

```
cdo yearmonmean infile outfile
```

Author

Uwe Schulzweida

2.8.27 Yearpctl

Name

yearpctl - Yearly percentile

Synopsis

cdo yearpctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps of the same year in `infile1`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable *CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *yearmin* and *yearmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same year it is:

$o(t, x) = \text{pth percentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the yearly 90th percentile of a time series use:

```
cdo yearmin infile minfile
cdo yearmax infile maxfile
cdo yearpctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo yearpctl,90 infile -yearmin infile -yearmax infile outfile
```

Author

Uwe Schulzweida

2.8.28 Seasstat

Name

seasmin, seasmax, seasrange, seassum, seasmean, seasavg, seasstd, seasstd1, seasvar, seasvar1 - Seasonal statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values over timesteps of the same meteorological season. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of timesteps of the same season is written to `outfile`. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile`. This can be change with the **CDO** option –timestat_date <first|middle|last>. Be careful about the first and the last output timestep, they may be incorrect values if the seasons have incomplete timesteps.

Operators

seasmin
Seasonal minimum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{min}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasmax
Seasonal maximum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{max}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasrange
Seasonal range

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{range}\{i(t', x), t_1 \leq t' \leq t_n\}$

seassum
Seasonal sum

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{sum}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasmean
Seasonal mean

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{mean}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasavg
Seasonal average

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{avg}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasvar
Seasonal variance

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{var}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasvar1
Seasonal variance (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{var1}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasstd
Seasonal standard deviation

Normalize by n. For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{std}\{i(t', x), t_1 \leq t' \leq t_n\}$

seasstd1
Seasonal standard deviation (n-1)

Normalize by (n-1). For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \mathbf{std1}\{i(t', x), t_1 \leq t' \leq t_n\}$

Example

To compute the seasonal mean of a time series use:

```
cdo seasmean infile outfile
```

Author

Uwe Schulzweida

2.8.29 Seaspctl

Name

seaspctl - Seasonal percentile

Synopsis

cdo seaspctl,*pn infile1 infile2 infile3 outfile*

Description

This operator computes percentiles over all timesteps in `infile1` of the same season. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable *CDO_PCTL_NBINS*. The files `infile2` and `infile3` should be the result of corresponding *seasmin* and *seasmax* operations, respectively. The time of `outfile` is determined by the time in the middle of all contributing timesteps of `infile1`. This can be change with the **CDO** option –timestat_date <first|middle|last>. Be careful about the first and the last output timestep, they may be incorrect values if the seasons have incomplete timesteps.

For every adjacent sequence $t_1, ..., t_n$ of timesteps of the same season it is:

$o(t, x) = \textbf{pthpercentile}\{i(t', x), t_1 \leq t' \leq t_n\}$

Parameters

pn
[FLOAT] Percentile number in $\{0, \ldots, 100\}$

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the seasonal 90th percentile of a time series use:

```
cdo seasmin infile minfile
cdo seasmax infile maxfile
cdo seaspctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo seaspctl,90 infile -seasmin infile -seasmax infile outfile
```

Author

Uwe Schulzweida

2.8.30 Yhourstat

Name

yhourmin, yhourmax, yhourrange, yhoursum, yhourmean, yhouravg, yhourstd, yhourstd1, yhourvar, yhourvar1 - Multi-year hourly statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values of each hour and day of year. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each hour and day of year in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field.

Operators

yhourmin
: Multi-year hourly minimum

$$o(0001,x) = \mathbf{min}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{min}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhourmax
: Multi-year hourly maximum

$$o(0001,x) = \mathbf{max}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{max}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhourrange
: Multi-year hourly range

$$o(0001,x) = \mathbf{range}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{range}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhoursum
: Multi-year hourly sum

$$o(0001,x) = \mathbf{sum}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{sum}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhourmean
: Multi-year hourly mean

$$o(0001,x) = \mathbf{mean}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{mean}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhouravg
: Multi-year hourly average

$$o(0001,x) = \mathbf{avg}\{i(t,x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784,x) = \mathbf{avg}\{i(t,x), \text{day}(i(t)) = 8784\}$$

yhourvar
Multi-year hourly variance

Normalize by n.

$$o(0001, x) = \mathbf{var}\{i(t, x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{var}\{i(t, x), \text{day}(i(t)) = 8784\}$$

yhourvar1
Multi-year hourly variance (n-1)

Normalize by (n-1).

$$o(0001, x) = \mathbf{var1}\{i(t, x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{var1}\{i(t, x), \text{day}(i(t)) = 8784\}$$

yhourstd
Multi-year hourly standard deviation

Normalize by n.

$$o(0001, x) = \mathbf{std}\{i(t, x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{std}\{i(t, x), \text{day}(i(t)) = 8784\}$$

yhourstd1
Multi-year hourly standard deviation (n-1)

Normalize by (n-1).

$$o(0001, x) = \mathbf{std1}\{i(t, x), \text{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{std1}\{i(t, x), \text{day}(i(t)) = 8784\}$$

Example

To compute the hourly mean for all days over all input years use:

```
cdo yhourmean infile outfile
```

Author

Uwe Schulzweida

2.8.31 Dhourstat

Name

dhourmin, dhourmax, dhourrange, dhoursum, dhourmean, dhouravg, dhourstd, dhourstd1, dhourvar, dhourvar1 - Multi-day hourly statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values of each hour of day. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each hour of day in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field.

Operators

dhourmin
Multi-day hourly minimum

$$o(01, x) = \mathbf{min}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{min}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhourmax
Multi-day hourly maximum

$$o(01, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhourrange
Multi-day hourly range

$$o(01, x) = \mathbf{range}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{range}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhoursum
Multi-day hourly sum

$$o(01, x) = \mathbf{sum}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{sum}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhourmean
Multi-day hourly mean

$$o(01, x) = \mathbf{mean}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{mean}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhouravg
Multi-day hourly average

$$o(01, x) = \mathbf{avg}\{i(t, x), \mathrm{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(24, x) = \mathbf{avg}\{i(t, x), \mathrm{day}(i(t)) = 24\}$$

dhourvar

Multi-day hourly variance

Normalize by n.

$$\begin{aligned} o(01,x) &= \mathbf{var}\{i(t,x), \mathrm{day}(i(t)) = 01\} \\ &\vdots \\ o(24,x) &= \mathbf{var}\{i(t,x), \mathrm{day}(i(t)) = 24\} \end{aligned}$$

dhourvar1

Multi-day hourly variance (n-1)

Normalize by (n-1).

$$\begin{aligned} o(01,x) &= \mathbf{var1}\{i(t,x), \mathrm{day}(i(t)) = 01\} \\ &\vdots \\ o(24,x) &= \mathbf{var1}\{i(t,x), \mathrm{day}(i(t)) = 24\} \end{aligned}$$

dhourstd

Multi-day hourly standard deviation

Normalize by n.

$$\begin{aligned} o(01,x) &= \mathbf{std}\{i(t,x), \mathrm{day}(i(t)) = 01\} \\ &\vdots \\ o(24,x) &= \mathbf{std}\{i(t,x), \mathrm{day}(i(t)) = 24\} \end{aligned}$$

dhourstd1

Multi-day hourly standard deviation (n-1)

Normalize by (n-1).

$$\begin{aligned} o(01,x) &= \mathbf{std1}\{i(t,x), \mathrm{day}(i(t)) = 01\} \\ &\vdots \\ o(24,x) &= \mathbf{std1}\{i(t,x), \mathrm{day}(i(t)) = 24\} \end{aligned}$$

Author

Uwe Schulzweida

2.8.32 Dminutestat

Name

dminutemin, dminutemax, dminuterange, dminutesum, dminutemean, dminuteavg, dminutestd, dminutestd1, dminutevar, dminutevar1 - Multi-day by the minute statistics

Synopsis

cdo *<operator> infile outfile*

Description

This module computes statistical values of each minute of day. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each minute of day in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field.

Operators

dminutemin
Multi-day by the minute minimum

$$o(01,x) = \textbf{min}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{min}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutemax
Multi-day by the minute maximum

$$o(01,x) = \textbf{max}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{max}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminuterange
Multi-day by the minute range

$$o(01,x) = \textbf{range}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{range}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutesum
Multi-day by the minute sum

$$o(01,x) = \textbf{sum}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{sum}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutemean
Multi-day by the minute mean

$$o(01,x) = \textbf{mean}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{mean}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminuteavg
Multi-day by the minute average

$$o(01,x) = \textbf{avg}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \textbf{avg}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutevar

Multi-day by the minute variance

Normalize by n.

$$o(01,x) = \mathbf{var}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \mathbf{var}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutevar1

Multi-day by the minute variance (n-1)

Normalize by (n-1).

$$o(01,x) = \mathbf{var1}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \mathbf{var1}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutestd

Multi-day by the minute standard deviation

Normalize by n.

$$o(01,x) = \mathbf{std}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \mathbf{std}\{i(t,x), \text{day}(i(t)) = 1440\}$$

dminutestd1

Multi-day by the minute standard deviation (n-1)

Normalize by (n-1).

$$o(01,x) = \mathbf{std1}\{i(t,x), \text{day}(i(t)) = 01\}$$
$$\vdots$$
$$o(1440,x) = \mathbf{std1}\{i(t,x), \text{day}(i(t)) = 1440\}$$

Author

Uwe Schulzweida

2.8.33 Ydaystat

Name

ydaymin, ydaymax, ydayrange, ydaysum, ydaymean, ydayavg, ydaystd, ydaystd1, ydayvar, ydayvar1 - Multi-year daily statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values of each day of year. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each day of year in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field.

Operators

ydaymin
Multi-year daily minimum

$$o(001,x) = \mathbf{min}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{min}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydaymax
Multi-year daily maximum

$$o(001,x) = \mathbf{max}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{max}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydayrange
Multi-year daily range

$$o(001,x) = \mathbf{range}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{range}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydaysum
Multi-year daily sum

$$o(001,x) = \mathbf{sum}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{sum}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydaymean
Multi-year daily mean

$$o(001,x) = \mathbf{mean}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{mean}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydayavg
Multi-year daily average

$$o(001,x) = \mathbf{avg}\{i(t,x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{avg}\{i(t,x), \mathrm{day}(i(t)) = 366\}$$

ydayvar
: Multi-year daily variance

  Normalize by n.

$$o(001, x) = \textbf{var}\{i(t, x), \text{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{var}\{i(t, x), \text{day}(i(t)) = 366\}$$

ydayvar1
: Multi-year daily variance (n-1)

  Normalize by (n-1).

$$o(001, x) = \textbf{var1}\{i(t, x), \text{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{var1}\{i(t, x), \text{day}(i(t)) = 366\}$$

ydaystd
: Multi-year daily standard deviation

  Normalize by n.

$$o(001, x) = \textbf{std}\{i(t, x), \text{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{std}\{i(t, x), \text{day}(i(t)) = 366\}$$

ydaystd1
: Multi-year daily standard deviation (n-1)

  Normalize by (n-1).

$$o(001, x) = \textbf{std1}\{i(t, x), \text{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{std1}\{i(t, x), \text{day}(i(t)) = 366\}$$

Example

To compute the daily mean over all input years use:

```
cdo ydaymean infile outfile
```

Author

Uwe Schulzweida

2.8.34 Ydaypctl

Name

ydaypctl - Multi-year daily percentile

Synopsis

cdo ydaypctl,*pn infile1 infile2 infile3 outfile*

Description

This operator writes a certain percentile of each day of year in `infile1` to `outfile`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by setting the environment variable *CDO_PCTL_NBINS* to a different value. The files `infile2` and `infile3` should be the result of corresponding *ydaymin* and *ydaymax* operations, respectively. The date information in an output field is the date of the last contributing input field.

$$
\begin{aligned}
o(001, x) &= \text{pth percentile}\{i(t, x), \text{day}(i(t)) = 001\} \\
&\vdots \\
o(366, x) &= \text{pth percentile}\{i(t, x), \text{day}(i(t)) = 366\}
\end{aligned}
$$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the daily 90th percentile over all input years use:

```
cdo ydaymin infile minfile
cdo ydaymax infile maxfile
cdo ydaypctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo ydaypctl,90 infile -ydaymin infile -ydaymax infile outfile
```

Author

Uwe Schulzweida

2.8.35 Ymonstat

Name

ymonmin, ymonmax, ymonrange, ymonsum, ymonmean, ymonavg, ymonstd, ymonstd1, ymonvar, ymonvar1 - Multi-year monthly statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values of each month of year. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each month of year in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field. This can be change with the **CDO** option –timestat_date <first|middle|last>.

Operators

ymonmin
Multi-year monthly minimum

$$\begin{gathered} o(01,x) = \mathbf{min}\{i(t,x), \text{month}(i(t)) = 01\} \\ \vdots \\ o(12,x) = \mathbf{min}\{i(t,x), \text{month}(i(t)) = 12\} \end{gathered}$$

ymonmax
Multi-year monthly maximum

$$\begin{gathered} o(01,x) = \mathbf{max}\{i(t,x), \text{month}(i(t)) = 01\} \\ \vdots \\ o(12,x) = \mathbf{max}\{i(t,x), \text{month}(i(t)) = 12\} \end{gathered}$$

ymonrange
Multi-year monthly range

$$\begin{gathered} o(01,x) = \mathbf{range}\{i(t,x), \text{month}(i(t)) = 01\} \\ \vdots \\ o(12,x) = \mathbf{range}\{i(t,x), \text{month}(i(t)) = 12\} \end{gathered}$$

ymonsum
Multi-year monthly sum

$$\begin{gathered} o(01,x) = \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 01\} \\ \vdots \\ o(12,x) = \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 12\} \end{gathered}$$

ymonmean
Multi-year monthly mean

$$\begin{gathered} o(01,x) = \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 01\} \\ \vdots \\ o(12,x) = \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 12\} \end{gathered}$$

ymonavg
Multi-year monthly average

$$\begin{aligned} o(01,x) &= \mathbf{avg}\{i(t,x), \mathrm{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \mathbf{avg}\{i(t,x), \mathrm{month}(i(t)) = 12\} \end{aligned}$$

ymonvar
Multi-year monthly variance

Normalize by n.

$$\begin{aligned} o(01,x) &= \mathbf{var}\{i(t,x), \mathrm{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \mathbf{var}\{i(t,x), \mathrm{month}(i(t)) = 12\} \end{aligned}$$

ymonvar1
Multi-year monthly variance (n-1)

Normalize by (n-1).

$$\begin{aligned} o(01,x) &= \mathbf{var1}\{i(t,x), \mathrm{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \mathbf{var1}\{i(t,x), \mathrm{month}(i(t)) = 12\} \end{aligned}$$

ymonstd
Multi-year monthly standard deviation

Normalize by n.

$$\begin{aligned} o(01,x) &= \mathbf{std}\{i(t,x), \mathrm{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \mathbf{std}\{i(t,x), \mathrm{month}(i(t)) = 12\} \end{aligned}$$

ymonstd1
Multi-year monthly standard deviation (n-1)

Normalize by (n-1).

$$\begin{aligned} o(01,x) &= \mathbf{std1}\{i(t,x), \mathrm{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \mathbf{std1}\{i(t,x), \mathrm{month}(i(t)) = 12\} \end{aligned}$$

Example

To compute the monthly mean over all input years use:

```
cdo ymonmean infile outfile
```

Author

Uwe Schulzweida

2.8.36 Ymonpctl

Name

ymonpctl - Multi-year monthly percentile

Synopsis

cdo ymonpctl,*pn infile1 infile2 infile3 outfile*

Description

This operator writes a certain percentile of each month of year in `infile1` to `outfile`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by setting the environment variable *CDO_PCTL_NBINS* to a different value. The files `infile2` and `infile3` should be the result of corresponding *ymonmin* and *ymonmax* operations, respectively. The date information in an output field is the date of the last contributing input field.

$$\begin{aligned} o(01,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 01\} \\ &\vdots \\ o(12,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 12\} \end{aligned}$$

Parameters

pn
[FLOAT] Percentile number in {0, ..., 100}

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the monthly 90th percentile over all input years use:

```
cdo ymonmin infile minfile
cdo ymonmax infile maxfile
cdo ymonpctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo ymonpctl,90 infile -ymonmin infile -ymonmax infile outfile
```

Author

Uwe Schulzweida

2.8.37 Yseasstat

Name

yseasmin, yseasmax, yseasrange, yseassum, yseasmean, yseasavg, yseasstd, yseasstd1, yseasvar, yseasvar1 - Multi-year seasonal statistics

Synopsis

cdo <*operator*> *infile outfile*

Description

This module computes statistical values of each season. Depending on the chosen operator the minimum, maximum, range, sum, average, variance or standard deviation of each season in `infile` is written to `outfile`. The date information in an output field is the date of the last contributing input field.

Operators

yseasmin
: Multi-year seasonal minimum

$$\begin{aligned} o(1,x) &= \mathbf{min}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \mathbf{min}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \mathbf{min}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \mathbf{min}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasmax
: Multi-year seasonal maximum

$$\begin{aligned} o(1,x) &= \mathbf{max}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \mathbf{max}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \mathbf{max}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \mathbf{max}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasrange
: Multi-year seasonal range

$$\begin{aligned} o(1,x) &= \mathbf{range}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \mathbf{range}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \mathbf{range}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \mathbf{range}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseassum
: Multi-year seasonal sum

$$\begin{aligned} o(1,x) &= \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \mathbf{sum}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasmean
: Multi-year seasonal mean

$$\begin{aligned} o(1,x) &= \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \mathbf{mean}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasavg
Multi-year seasonal average

$$\begin{aligned} o(1,x) &= \textbf{avg}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \textbf{avg}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \textbf{avg}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \textbf{avg}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasvar
Multi-year seasonal variance

$$\begin{aligned} o(1,x) &= \textbf{var}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \textbf{var}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \textbf{var}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \textbf{var}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasvar1
Multi-year seasonal variance (n-1)

$$\begin{aligned} o(1,x) &= \textbf{var1}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \textbf{var1}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \textbf{var1}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \textbf{var1}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasstd
Multi-year seasonal standard deviation

$$\begin{aligned} o(1,x) &= \textbf{std}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \textbf{std}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \textbf{std}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \textbf{std}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

yseasstd1
Multi-year seasonal standard deviation (n-1)

$$\begin{aligned} o(1,x) &= \textbf{std1}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \textbf{std1}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \textbf{std1}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \textbf{std1}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

Example

To compute the seasonal mean over all input years use:

```
cdo yseasmean infile outfile
```

Author

Uwe Schulzweida

2.8.38 Yseaspctl

Name

yseaspctl - Multi-year seasonal percentile

Synopsis

cdo yseaspctl,*pn infile1 infile2 infile3 outfile*

Description

This operator writes a certain percentile of each season in `infile1` to `outfile`. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by setting the environment variable *CDO_PCTL_NBINS* to a different value. The files `infile2` and `infile3` should be the result of corresponding *yseasmin* and *yseasmax* operations, respectively. The date information in an output field is the date of the last contributing input field.

$$\begin{aligned} o(1,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 12, 01, 02\} \\ o(2,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 03, 04, 05\} \\ o(3,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 06, 07, 08\} \\ o(4,x) &= \text{pth percentile}\{i(t,x), \text{month}(i(t)) = 09, 10, 11\} \end{aligned}$$

Parameters

pn

[FLOAT] Percentile number in $\{0, \ldots, 100\}$

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

To compute the seasonal 90th percentile over all input years use:

```
cdo yseasmin infile minfile
cdo yseasmax infile maxfile
cdo yseaspctl,90 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo yseaspctl,90 infile -yseasmin infile -yseasmax infile outfile
```

Author

Uwe Schulzweida

2.8.39 Ydrunstat

Name

ydrunmin, ydrunmax, ydrunsum, ydrunmean, ydrunavg, ydrunstd, ydrunstd1, ydrunvar, ydrunvar1 - Multi-year daily running statistics

Synopsis

cdo <*operator*>,*nts*[,rm=c] *infile outfile*

Description

This module writes running statistical values for each day of year in `infile` to `outfile`. Depending on the chosen operator, the minimum, maximum, sum, average, variance or standard deviation of all timesteps in running windows of which the medium timestep corresponds to a certain day of year is computed. The date information in an output field is the date of the timestep in the middle of the last contributing running window. Note that the operator have to be applied to a continuous time series of daily measurements in order to yield physically meaningful results. Also note that the output time series begins (nts-1)/2 timesteps after the first timestep of the input time series and ends (nts-1)/2 timesteps before the last one. For input data which are complete but not continuous, such as time series of daily measurements for the same month or season within different years, the operator yields physically meaningful results only if the input time series does include the (nts-1)/2 days before and after each period of interest.

Operators

ydrunmin
Multi-year daily running minimum

$$o(001,x) = \mathbf{min}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{min}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunmax
Multi-year daily running maximum

$$o(001,x) = \mathbf{max}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{max}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunsum
Multi-year daily running sum

$$o(001,x) = \mathbf{sum}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{sum}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunmean
Multi-year daily running mean

$$o(001,x) = \mathbf{mean}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{mean}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunavg
Multi-year daily running average

$$o(001,x) = \mathbf{avg}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{avg}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunvar
: Multi-year daily running variance

  Normalize by n.

$$o(001,x) = \mathbf{var}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{var}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunvar1
: Multi-year daily running variance (n-1)

  Normalize by (n-1).

$$o(001,x) = \mathbf{var1}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{var1}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunstd
: Multi-year daily running standard deviation

  Normalize by n.

$$o(001,x) = \mathbf{std}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{std}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunstd1
: Multi-year daily running standard deviation (n-1)

  Normalize by (n-1).

$$o(001,x) = \mathbf{std1}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{std1}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

Parameters

nts
: [INTEGER] Number of timesteps

rm=c
: [STRING] Read method circular

Example

Assume the input data provide a continuous time series of daily measurements. To compute the running multi-year daily mean over all input timesteps for a running window of five days use:

```
cdo ydrunmean,5 infile outfile
```

Note that except for the standard deviation the results of the operators in this module are equivalent to a composition of corresponding operators from the *Ydaystat* and *Runstat* modules. For instance, the above command yields the same result as:

```
cdo ydaymean -runmean,5 infile outfile
```

Author

Ralf Quast, Uwe Schulzweida, Fabian Wachsmann

2.8.40 Ydrunpctl

Name

ydrunpctl - Multi-year daily running percentile

Synopsis

cdo ydrunpctl,*pn*,*nts*[,rm=c][,pm=r8] *infile1 infile2 infile3 outfile*

Description

This operator writes running percentile values for each day of year in `infile1` to `outfile`. A certain percentile is computed for all timesteps in running windows of which the medium timestep corresponds to a certain day of year. The algorithm uses histograms with minimum and maximum bounds given in `infile2` and `infile3`, respectively. The default number of histogram bins is 101. The default can be overridden by setting the environment variable *CDO_PCTL_NBINS* to a different value. The files `infile2` and `infile3` should be the result of corresponding *ydrunmin* and *ydrunmax* operations, respectively. The date information in an output field is the date of the timestep in the middle of the last contributing running window. Note that the operator have to be applied to a continuous time series of daily measurements in order to yield physically meaningful results. Also note that the output time series begins (nts-1)/2 timesteps after the first timestep of the input time series and ends (nts-1)/2 timesteps before the last. For input data which are complete but not continuous, such as time series of daily measurements for the same month or season within different years, the operator only yields physically meaningful results if the input time series does include the (nts-1)/2 days before and after each period of interest.

$$\begin{array}{c} o(001,x) = \text{pth percentile}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \text{day}[(i(t+(nts-1)/2)] = 001\} \\ \vdots \\ o(366,x) = \text{pth percentile}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \text{day}[(i(t+(nts-1)/2)] = 366\} \end{array}$$

Parameters

pn
[FLOAT] Percentile number in {0, …, 100}

nts
[INTEGER] Number of timesteps

rm=c
[STRING] Read method circular

pm=r8
[STRING] Percentile method rtype8

Environment

CDO_PCTL_NBINS sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`).

Example

Assume the input data provide a continuous time series of daily measurements. To compute the running multi-year daily 90th percentile over all input timesteps for a running window of five days use:

```
cdo ydrunmin,5 infile minfile
cdo ydrunmax,5 infile maxfile
cdo ydrunpctl,90,5 infile minfile maxfile outfile
```

Or shorter using operator piping:

```
cdo ydrunpctl,90,5 infile -ydrunmin infile -ydrunmax infile outfile
```

Author

Ralf Quast, Uwe Schulzweida, Fabian Wachsmann

2.9 Correlation

This sections contains modules for correlation and covariance in grid space and over time.
In this section the abbreviations as in the following table are used:

Covariance **covar**	$n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})(y_i - \overline{y})$
covar weighted by $\{w_i, i = 1, ..., n\}$	$\left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{i=1}^{n} w_i \left(x_i - \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{j=1}^{n} w_j \, x_j \right) \left(y_i - \left(\sum_{j=1}^{n} w_j \right)^{-1} \sum_{j=1}^{n} w_j \, y_j \right)$

Here is a short overview of all operators in this section:

Fldcor	*fldcor*	Correlation in grid space
Timcor	*timcor*	Correlation over time
Fldcovar	*fldcovar*	Covariance in grid space
Timcovar	*timcovar*	Covariance over time

2.9.1 Fldcor

Name

fldcor - Correlation in grid space

Synopsis

cdo fldcor *infile1 infile2 outfile*

Description

The correlation coefficient is a quantity that gives the quality of a least squares fitting to the original data. This operator correlates all gridpoints of two fields for each timestep. With

$$S(t) = \{x, i_1(t,x) \neq missval \wedge i_2(t,x) \neq missval\}$$

it is

$$o(t,1) = \frac{\sum\limits_{x \in S(t)} i_1(t,x) i_2(t,x) w(x) - \overline{i_1(t,x)}\ \overline{i_2(t,x)} \sum\limits_{x \in S(t)} w(x)}{\sqrt{\left(\sum\limits_{x \in S(t)} i_1(t,x)^2 w(x) - \overline{i_1(t,x)}^2 \sum\limits_{x \in S(t)} w(x)\right)\left(\sum\limits_{x \in S(t)} i_2(t,x)^2 w(x) - \overline{i_2(t,x)}^2 \sum\limits_{x \in S(t)} w(x)\right)}}$$

where $w(x)$ are the area weights obtained by the input streams. For every timestep t only those field elements x belong to the sample, which have $i_1(t,x) \neq missval$ and $i_2(t,x) \neq missval$.

Author

Uwe Schulzweida

2.9.2 Timcor

Name

timcor - Correlation over time

Synopsis

cdo timcor *infile1 infile2 outfile*

Description

The correlation coefficient is a quantity that gives the quality of a least squares fitting to the original data. This operator correlates each gridpoint of two fields over all timesteps. If there is only one input field, the p-value (probability value) is also written out. With

$$S(x) = \{t, i_1(t,x) \neq missval \wedge i_2(t,x) \neq missval\}$$

it is

$$o(1,x) = \frac{\sum\limits_{t\in S(x)} i_1(t,x) i_2(t,x) - n\,\overline{i_1(t,x)}\,\overline{i_2(t,x)}}{\sqrt{\left(\sum\limits_{t\in S(x)} i_1(t,x)^2 - n\,\overline{i_1(t,x)}^2\right)\left(\sum\limits_{t\in S(x)} i_2(t,x)^2 - n\,\overline{i_2(t,x)}^2\right)}}$$

For every gridpoint x only those timesteps t belong to the sample, which have $i_1(t,x) \neq missval$ and $i_2(t,x) \neq missval$.

Author

Uwe Schulzweida

2.9.3 Fldcovar

Name

fldcovar - Covariance in grid space

Synopsis

cdo fldcovar *infile1 infile2 outfile*

Description

This operator calculates the covariance of two fields over all gridpoints for each timestep. With

$$S(t) = \{x, i_1(t,x) \neq missval \wedge i_2(t,x) \neq missval\}$$

it is

$$o(t,1) = \left(\sum_{x \in S(t)} w(x) \right)^{-1} \sum_{x \in S(t)} w(x) \left(i_1(t,x) - \frac{\sum\limits_{x \in S(t)} w(x)\, i_1(t,x)}{\sum\limits_{x \in S(t)} w(x)} \right) \left(i_2(t,x) - \frac{\sum\limits_{x \in S(t)} w(x)\, i_2(t,x)}{\sum\limits_{x \in S(t)} w(x)} \right)$$

where $w(x)$ are the area weights obtained by the input streams. For every timestep t only those field elements x belong to the sample, which have $i_1(t,x) \neq missval$ and $i_2(t,x) \neq missval$.

Author

Uwe Schulzweida

2.9.4 Timcovar

Name

timcovar - Covariance over time

Synopsis

cdo timcovar *infile1 infile2 outfile*

Description

This operator calculates the covariance of two fields at each gridpoint over all timesteps. With

$$S(x) = \{t, i_1(t,x) \neq missval \wedge i_2(t,x) \neq missval\}$$

it is

$$o(1,x) = n^{-1} \sum_{t \in S(x)} \left(i_1(t,x) - \overline{i_1(t,x)} \right) \left(i_2(t,x) - \overline{i_2(t,x)} \right)$$

For every gridpoint x only those timesteps t belong to the sample, which have $i_1(t,x) \neq missval$ and $i_2(t,x) \neq missval$.

Author

Uwe Schulzweida

2.10 Regression

This sections contains modules for linear regression of time series.

Here is a short overview of all operators in this section:

Regres	*regres*	Regression
Detrend	*detrend*	Detrend time series
Trend	*trend*	Trend of time series
Trendarith	*addtrend*	Add trend
	subtrend	Subtract trend

2.10.1 Regres

Name

regres - Regression

Synopsis

cdo regres[,*equal*] *infile outfile*

Description

The values of the input file `infile` are assumed to be distributed as $N(a+bt,\sigma^2)$ with unknown a, b and σ^2. This operator estimates the parameter b. For every field element x only those timesteps t belong to the sample $S(x)$, which have $i(t,x) \neq \text{miss}$. It is

$$o(1,x) = \frac{\sum\limits_{t\in S(x)} \left(i(t,x) - \frac{1}{\#S(x)} \sum\limits_{t'\in S(x)} i(t',x) \right) \left(t - \frac{1}{\#S(x)} \sum\limits_{t'\in S(x)} t' \right)}{\sum\limits_{t\in S(x)} \left(t - \frac{1}{\#S(x)} \sum\limits_{t'\in S(x)} t' \right)^2}$$

It is assumed that all timesteps are equidistant, if this is not the case set the parameter equal=false.

Parameters

equal
: [BOOL] Set to false for unequal distributed timesteps (default: true)

Author

Uwe Schulzweida

2.10.2 Detrend

Name

detrend - Detrend time series

Synopsis

cdo [options] detrend[,*equal*] *infile outfile*

Description

Every time series in `infile` is linearly detrended. For every field element x only those timesteps t belong to the sample S, which have $i(t,x) \neq$ miss. It is assumed that all timesteps are equidistant, if this is not the case set the parameter equal=false. With

$$a(x) = \frac{1}{\#S(x)} \sum_{t \in S(x)} i(t,x) - b(x) \left(\frac{1}{\#S(x)} \sum_{t \in S(x)} t \right)$$

and

$$b(x) = \frac{\sum_{t \in S(x)} \left(i(t,x) - \frac{1}{\#S(x)} \sum_{t' \in S(x)} i(t',x) \right) \left(t - \frac{1}{\#S(x)} \sum_{t' \in S(x)} t' \right)}{\sum_{t \in S(x)} \left(t - \frac{1}{\#S(x)} \sum_{t' \in S(x)} t' \right)^2}$$

it is

$$o(t,x) = i(t,x) - (a(x) + b(x)t)$$

Parameters

equal
[BOOL] Set to false for unequal distributed timesteps (default: true)

Options

`-p`, `--async_read true` to read input data asynchronously.

Note

This operator has to keep the fields of all timesteps concurrently in the memory. If not enough memory is available use the operators *trend* and *subtrend*.

Example

To detrend the data in `infile` and to store the detrended data in `outfile` use:

```
cdo detrend infile outfile
```

Author

Uwe Schulzweida

2.10.3 Trend

Name

trend - Trend of time series

Synopsis

cdo [options] trend[,*equal*] *infile outfile1 outfile2*

Description

The values of the input file `infile` are assumed to be distributed as $N(a+bt, \sigma^2)$ with unknown a, b and σ^2. This operator estimates the parameter a and b. For every field element x only those timesteps t belong to the sample $S(x)$, which have $i(t,x) \neq \mathrm{miss}$. It is

$$o_1(1,x) = \frac{1}{\#S(x)} \sum_{t \in S(x)} i(t,x) - b(x) \left(\frac{1}{\#S(x)} \sum_{t \in S(x)} t \right)$$

and

$$o_2(1,x) = \frac{\sum_{t \in S(x)} \left(i(t,x) - \frac{1}{\#S(x)} \sum_{t' \in S(x)} i(t',x) \right) \left(t - \frac{1}{\#S(x)} \sum_{t' \in S(x)} t' \right)}{\sum_{t \in S(x)} \left(t - \frac{1}{\#S(x)} \sum_{t' \in S(x)} t' \right)^2}$$

Thus the estimation for a is stored in `outfile1` and that for b is stored in `outfile2`. To subtract the trend from the data see operator *subtrend*. It is assumed that all timesteps are equidistant, if this is not the case set the parameter equal=false.

Parameters

equal
[BOOL] Set to false for unequal distributed timesteps (default: true)

Options

`-p`, `--async_read true` to read input data asynchronously.

Author

Uwe Schulzweida

2.10.4 Trendarith

Name

addtrend, subtrend - Add or subtract a trend

Synopsis

cdo trend[,*equal*] *infile1 infile2 infile3 outfile*

Description

This module is for adding or subtracting a trend computed by the operator *trend*.

Operators

addtrend
Add trend

It is

$o(t,x) = i_1(t,x) + (i_2(1,x) + i_3(1,x) \cdot t)$

where t is the timesteps.

subtrend
Subtract trend

It is

$o(t,x) = i_1(t,x) - (i_2(1,x) + i_3(1,x) \cdot t)$

where t is the timesteps.

Parameters

equal
[BOOL] Set to false for unequal distributed timesteps (default: true)

Example

The typical call for detrending the data in `infile` and storing the detrended data in `outfile` is:

```
cdo trend infile afile bfile
cdo subtrend infile afile bfile outfile
```

The result is identical to a call of the operator *detrend*:

```
cdo detrend infile outfile
```

Author

Uwe Schulzweida

2.11 EOFs

This section contains modules to compute Empirical Orthogonal Functions and - once they are computed - their principal coefficients.

An introduction to the theory of principal component analysis as applied here can be found in:

Principal Component Analysis in Meteorology and Oceanography [Preisendorfer]

Details about calculation in the time- and spatial spaces are found in:

Statistical Analysis in Climate Research [vonStorch]

EOFs are defined as the eigen values of the scatter matrix (covariance matrix) of the data. For the sake of simplicity, samples are regarded as **time series of anomalies**

$$(z(t))\,, t \in \{1,\ldots,n\}$$

of (column-) vectors $z(t)$ with p entries (where p is the gridsize). Thus, using the fact, that $z_j(t)$ are anomalies, i.e.

$$\langle z_j \rangle = n^{-1}\sum_{i=1}^{n} z_j(i) = 0 \,\forall\, 1 \le j \le p$$

the scatter matrix $\mathbf{S}$ can be written as

$$\mathbf{S} = \sum_{t=1}^{n}\left[\sqrt{\mathbf{W}}z(t)\right]\left[\sqrt{\mathbf{W}}z(t)\right]^T$$

where $\mathbf{W}$ is the diagonal matrix containing the area weight of cell p_0 in z at $\mathbf{W}(x,x)$.

The matrix $\mathbf{S}$ has a set of orthonormal eigenvectors $e_j, j = 1,\ldots p$, which are called *empirical orthogonal functions (EOFs) of the sample* z. (Please note, that e_j is the eigenvector of $\mathbf{S}$ and not the weighted eigen-vector which would be $\mathbf{W}e_j$.) Let the corresponding eigenvalues be denoted λ_j. The vectors e_j are spatial patterns which explain a certain amount of variance of the time series $z(t)$ that is related linearly to λ_j. Thus, the spatial pattern defined by the first eigenvector (the one with the largest eigenvalue) is the pattern which explains a maximum possible amount of variance of the sample $z(t)$. The orthonormality of eigenvectors reads as

$$\sum_{x=1}^{p}\left[\sqrt{\mathbf{W}(x,x)}e_j(x)\right]\left[\sqrt{\mathbf{W}(x,x)}e_k(x)\right] = \sum_{x=1}^{p}\mathbf{W}(x,x)e_j(x)e_k(x) = \begin{cases} 0\, if\ j \neq k \\ 1\, if\ j = k \end{cases}$$

If all EOFs e_j with $\lambda_j \neq 0$ are calculated, the data can be reconstructed from

$$z(t,x) = \sum_{j=1}^{p}\mathbf{W}(x,x)a_j(t)e_j(x)$$

where a_j are called the *principal components* or *principal coefficients* or *EOF coefficients* of z. These coefficients - as readily seen from above - are calculated as the projection of an EOF e_j onto a time step of the data sample $z(t_0)$ as

$$a_j(t_0) = \sum_{x=1}^{p}\left[\sqrt{\mathbf{W}(x,x)}e_j(x)\right]\left[\sqrt{\mathbf{W}(x,x)}z(t_0,x)\right] = \left[\sqrt{\mathbf{W}}z(t_0)\right]^T\left[\sqrt{\mathbf{W}}e_j\right].$$

Here is a short overview of all operators in this section:

EOF	*eof*	Calculate EOFs in spatial or time space
	eoftime	Calculate EOFs in time space
	eofspatial	Calculate EOFs in spatial space
	eof3d	Calculate 3-Dimensional EOFs in time space
Eofcoeff	*eofcoeff*	Principal coefficients of EOFs

2.11.1 EOF

Name

eof, eoftime, eofspatial, eof3d - Empirical Orthogonal Functions

Synopsis

cdo *<operator>,neof infile outfile1 outfile2*

Description

This module calculates empirical orthogonal functions of the data in `infile` as the eigen values of the scatter matrix (covariance matrix) S of the data sample $z(t)$. A more detailed description can be found above.

Please note, that the input data are assumed to be anomalies.

If operator *eof* is chosen, the EOFs are computed in either time or spatial space, whichever is the fastest. If the user already knows, which computation is faster, the module can be forced to perform a computation in time- or gridspace by using the operators *eoftime* or *eofspatial*, respectively. This can enhance performance, especially for very long time series, where the number of timesteps is larger than the number of grid-points. Data in `infile` are assumed to be anomalies. If they are not, the behavior of this module is **not well defined**. After execution `outfile1` will contain all eigen-values and `outfile2` the eigenvectors e_j. All EOFs and eigen-values are computed. However, only the first $neof$ EOFs are written to `outfile2`. Nonetheless, `outfile1` contains all eigen-values.

Missing values are not fully supported. Support is only checked for non-changing masks of missing values in time. Although there still will be results, they are not trustworthy, and a warning will occur. In the latter case we suggest to replace missing values by 0 in `infile`.

Operators

eof
Calculate EOFs in spatial or time space

eof3d
Calculate 3-Dimensional EOFs in time space

eoftime
Calculate EOFs in time space

eofspatial
Calculate EOFs in spatial space

Parameters

neof
[INTEGER] Number of eigen functions

Environment

`CDO_SVD_MODE`
Is used to choose the algorithm for eigenvalue calculation. Options are 'jacobi' for a one-sided parallel jacobi-algorithm (only executed in parallel if -P flag is set) and 'danielson_lanczos' for a non-parallel d/l algorithm. The default setting is 'jacobi'.

`CDO_WEIGHT_MODE`
It is used to set the weight mode. The default is 'off'. Set it to 'on' for a weighted version.

`MAX_JACOBI_ITER`
Is the maximum integer number of annihilation sweeps that is executed if the jacobi-algorithm is used to compute the eigen values. The default value is 12.

`FNORM_PRECISION`
: Is the Frobenius norm of the matrix consisting of an annihilation pair of eigenvectors that is used to determine if the eigenvectors have reached a sufficient level of convergence. If all annihilation-pairs of vectors have a norm below this value, the computation is considered to have converged properly. Otherwise, a warning will occur. The default value 1e-12.

Example

To calculate the first 40 EOFs of a data-set containing anomalies use:

```
cdo eof,40 infile outfile1 outfile2
```

If the dataset does not contain anomalies, process them first, and use:

```
cdo sub infile1 -timmean infile1 anom_file
cdo eof,40 anom_file outfile1 outfile2
```

Author

Cedrick Ansorge

2.11.2 Eofcoeff

Name

eofcoeff - Principal coefficients of EOFs

Synopsis

cdo eofcoeff *infile1 infile2 obase*

Description

This module calculates the time series of the principal coefficients for given EOF (empirical orthogonal functions) and data. Time steps in `infile1` are assumed to be the EOFs, time steps in `infile2` are assumed to be the time series.

Note, that this operator calculates a non weighted dot product of the fields in `infile1` and `infile2`. For consistency set the environment variable *CDO_WEIGHT_MODE*=off when using *eof* or *eof3d*.

Given a set of EOFs e_j and a time series of data $z(t)$ with p entries for each timestep from which e_j have been calculated, this operator calculates the time series of the projections of data onto each EOF

$$o_j(t) = \sum_{x=1}^{p} z(t,x) e_j(x)$$

There will be a seperate file o_j for the principal coefficients of each EOF.

As the EOFs e_j are uncorrelated, so are their principal coefficients, i.e.

$$\sum_{t=1}^{n} o_j(t) o_k(t) = \left\{ \begin{array}{l} 0 \; if \; j \neq k \\ \lambda_j \; if \; j = k \end{array} \right. \; with \; \sum_{t=1}^{n} o_j(t) = 0 \forall j \in \{1, \ldots, p\}.$$

There will be a separate file containing a time series of principal coefficients with time information from `infile2` for each EOF in `infile1`. Output files will be numbered as `<obase><neof><suffix>` where `neof+1` is the number of the EOF (timestep) in `infile1` and `suffix` is the filename extension derived from the file format.

Environment

CDO_FILE_SUFFIX sets the filename suffix.

Example

To calculate principal coefficients of the first 40 EOFs of `anom_file`, and write them to files beginning with obase, use:

```
export CDO_WEIGHT_MODE=off
cdo eof,40 anom_file eval_file eof_file
cdo eofcoeff eof_file anom_file obase
```

The principal coefficients of the first EOF will be in the file `obase000000.nc` (and so forth for higher EOFs, nth EOF will be in `obase<n-1>`).

If the dataset `infile` does not containt anomalies, process them first, and use:

```
export CDO_WEIGHT_MODE=off
cdo sub infile -timmean infile anom_file
cdo eof,40 anom_file eval_file eof_file
cdo eofcoeff eof_file anom_file obase
```

Author

Cedrick Ansorge

2.12 Interpolation

This section contains modules to interpolate datasets. There are several operators to interpolate horizontal fields to a new grid. Some of those operators can handle only 2D fields on a regular rectangular grid. Vertical interpolation of 3D variables is possible from hybrid model levels to height or pressure levels. Interpolation in time is possible between time steps and years.

Here is a short overview of all operators in this section:

Remapbil	*remapbil*	Bilinear interpolation
	genbil	Generate bilinear interpolation weights
Remapbic	*remapbic*	Bicubic interpolation
	genbic	Generate bicubic interpolation weights
Remapknn	*remapknn*	k-nearest neighbor remapping
	remapnn	Nearest neighbor remapping
	remapdis	Distance weighted average remapping
	genknn	Generate k-nearest neighbor remap weights
	gennn	Generate nearest neighbor remap weights
	gendis	Generate distance weighted average remap weights
Remapnn	*remapnn*	Nearest neighbor remapping
	gennn	Generate nearest neighbor remap weights
Remapdis	*remapdis*	Distance weighted average remapping
	gendis	Generate distance weighted average remap weights
Remapcon	*remapcon*	First order conservative remapping
	gencon	Generate 1st order conservative remap weights
Remaplaf	*remaplaf*	Largest area fraction remapping
	genlaf	Generate largest area fraction remap weights
Remap	*remap*	Grid remapping
Remapeta	*remapeta*	Remap vertical hybrid levels
Vertintml	*ml2pl*	Model to pressure level interpolation
Vertintap	*ap2pl*	Vertical pressure interpolation
Vertintgh	*gh2hl*	Geometric height interpolation
Intlevel	*intlevel*	Linear level interpolation
Intlevel3d	*intlevel3d*	Linear level interpolation from/to 3D vertical coordinates
Inttime	*inttime*	Interpolation between timesteps
	intntime	Interpolation between timesteps
Intyear	*intyear*	Interpolation between two years

2.12.1 Remapbil

Name

remapbil, genbil - Bilinear interpolation

Synopsis

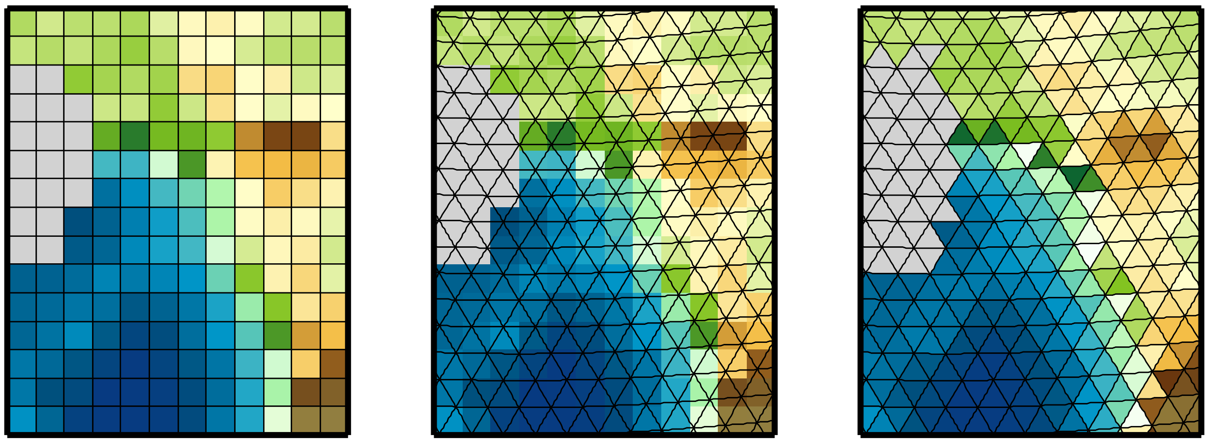
cdo remapbil,*targetgrid infile outfile*

cdo genbil,*targetgrid*[,*map3d*] *infile outfile*

Description

This module contains operators for a bilinear remapping of fields between grids in spherical coordinates. The interpolation is based on an adapted SCRIP library version. For a detailed description of the interpolation method see [SCRIP]. This interpolation method only works on quadrilateral curvilinear source grids.

Below is a schematic illustration of the bilinear remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapbil
Bilinear interpolation

Performs a bilinear interpolation on all input fields.

genbil
Generate bilinear interpolation weights

Generates bilinear interpolation weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

Parameters

targetgrid
[STRING] Target grid description file or name

map3d
[BOOL] Generate all mapfiles of the first 3D field

Environment

REMAP_EXTRAPOLATE is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for cyclic grids.

Example

Say `infile` contains fields on a quadrilateral curvilinear grid. To remap all fields bilinear to a regular Gaussian F32 grid, type:

```
cdo remapbil,F32 infile outfile
```

Author

Uwe Schulzweida

2.12.2 Remapbic

Name

remapbic, genbic - Bicubic interpolation

Synopsis

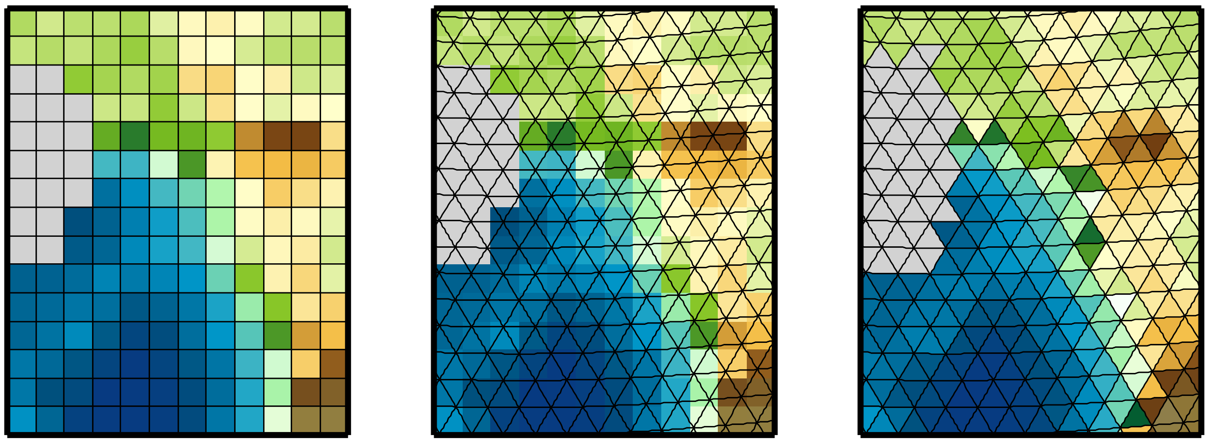
cdo remapbic,*targetgrid infile outfile*

cdo genbic,*targetgrid*[,*map3d*] *infile outfile*

Description

This module contains operators for a bicubic remapping of fields between grids in spherical coordinates. The interpolation is based on an adapted SCRIP library version. For a detailed description of the interpolation method see [SCRIP]. This interpolation method only works on quadrilateral curvilinear source grids.

Below is a schematic illustration of the bicubic remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapbic
Bicubic interpolation

Performs a bicubic interpolation on all input fields.

genbic
Generate bicubic interpolation weights

Generates bicubic interpolation weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

Parameters

targetgrid
[STRING] Target grid description file or name

map3d
[BOOL] Generate all mapfiles of the first 3D field

Environment

REMAP_EXTRAPOLATE is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for cyclic grids.

Example

Say `infile` contains fields on a quadrilateral curvilinear grid. To remap all fields bicubic to a regular Gaussian F32 grid, type:

```
cdo remapbic,F32 infile outfile
```

Author

Uwe Schulzweida

2.12.3 Remapknn

Name

remapknn, remapnn, remapdis, genknn, gennn, gendis - k-nearest neighbor remapping

Synopsis

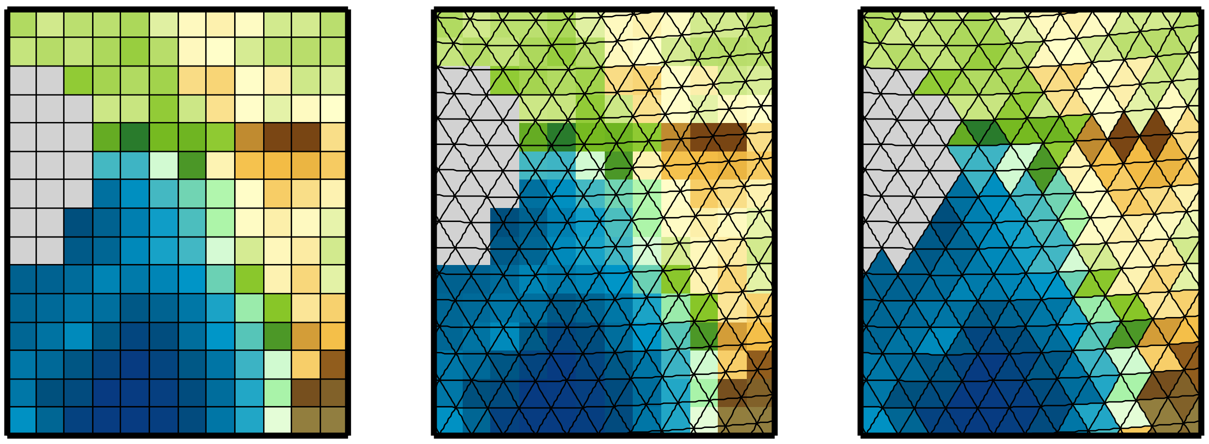
cdo <*operator*>,*parameter infile outfile*

Description

This module contains operators for a k-nearest neighbor remapping of fields between grids in spherical coordinates. The default number for k is 1. If k is greater than 1, the *weighted* parameter can be used to choose between different weighting methods. The default method is *weighted=dist*, for an inverse distance weighting. Here is a list of all available weighting methods.

dist	Inverse distance weighted
avg	Simple arithmetic average
gauss	Gaussian filter

Below is a schematic illustration of the nearest neighbor remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapknn
k-nearest neighbor remapping

Performs a k-nearest neighbor remapping on all input fields.

remapnn
Nearest neighbor remapping

remapnn,<targetgrid> corresponds to **remapknn**,grid=<targetgrid>,extrapolate=true

remapdis
Distance weighted average remapping

remapdis,<targetgrid> corresponds to **remapknn**,grid=<targetgrid>,k=4,kmin=1,weighted=dist,extrapolate=true

genknn
Generate k-nearest neighbor remap weights

Generates k-nearest neighbor remapping weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

gennn
Generate nearest neighbor remap weights

gennn,<targetgrid> corresponds to **genknn**,grid=<targetgrid>,extrapolate=true

gendis
Generate distance weighted average remap weights

gendis,<targetgrid> corresponds to **genknn**,grid=<targetgrid>,k=4,kmin=1,weighted=dist,extrapolate=true

Parameters

grid
[STRING] Target grid description file or name

k
[INTEGER] Number of nearest neighbors [default: 1]

kmin
[INTEGER] Minimum number of nearest neighbors [default: k]

weighted
[WORD] Weighting method (dist/avg/gauss) [default: dist]

gauss_scale
[FLOAT] Scaling factor for gauss weighting method [default: 0.1]

extrapolate
[BOOL] Extrapolate [default: false]

map3d
[BOOL] Generate all mapfiles of the first 3D field [default: false]

Environment

`REMAP_EXTRAPOLATE` is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for circular grids.

`CDO_GRIDSEARCH_RADIUS` sets the grid search radius in degree (default: `CDO_GRIDSEARCH_RADIUS=180`).

See Also

Remapbil, *Remapbic*, *Remapcon*

Author

Uwe Schulzweida

2.12.4 Remapnn

Name

remapnn, gennn - Nearest neighbor remapping

Synopsis

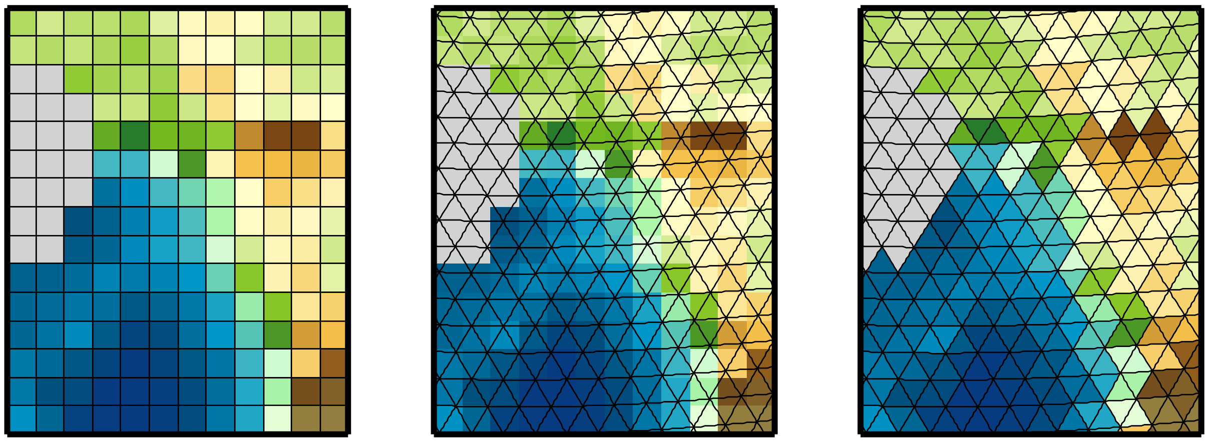
cdo remapnn,*targetgrid infile outfile*

cdo gennn,*targetgrid*[,*map3d*] *infile outfile*

Description

This module contains operators for a nearest neighbor remapping of fields between grids in spherical coordinates.

Below is a schematic illustration of the nearest neighbor remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapnn
Nearest neighbor remapping

Performs a nearest neighbor remapping on all input fields.

gennn
Generate nearest neighbor remap weights

Generates nearest neighbor remapping weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

Parameters

targetgrid
[STRING] Target grid description file or name

map3d
[BOOL] Generate all mapfiles of the first 3D field

Environment

REMAP_EXTRAPOLATE is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for cyclic grids.

CDO_GRIDSEARCH_RADIUS sets the grid search radius in degree (default: `CDO_GRIDSEARCH_RADIUS=180`).

Author

Uwe Schulzweida

2.12.5 Remapdis

Name

remapdis, gendis - Distance weighted average remapping

Synopsis

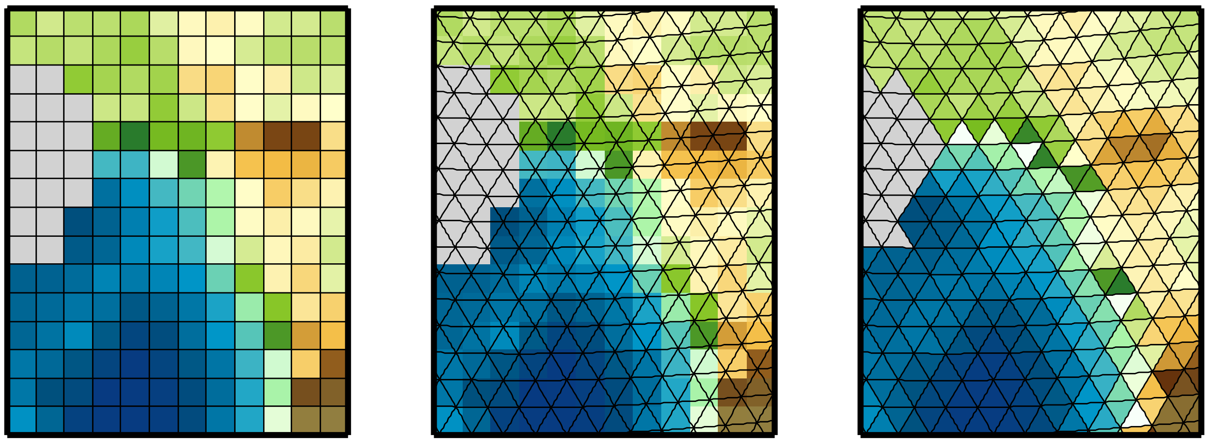
cdo remapdis,*targetgrid*[,*neighbors*] *infile outfile*

cdo gendis,*targetgrid*[,*neighbors*][,*map3d*] *infile outfile*

Description

This module contains operators for an inverse distance weighted average remapping of the four nearest neighbor values of fields between grids in spherical coordinates. The default number of 4 neighbors can be changed with the **neighbors** parameter.

Below is a schematic illustration of the distance weighted average remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapdis
Distance weighted average remapping

Performs an inverse distance weighted averaged remapping of the nearest neighbor values on all input fields.

gendis
Generate distance weighted average remap weights

Generates distance weighted averaged remapping weights of the nearest neighbor values for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

Parameters

targetgrid
[STRING] Target grid description file or name

neighbors
[INTEGER] Number of nearest neighbors [default: 4]

map3d
[BOOL] Generate all mapfiles of the first 3D field

Environment

REMAP_EXTRAPOLATE is used to switch the extrapolation feature ‘on’ or ‘off’. By default the extrapolation is enabled for circular grids.

CDO_GRIDSEARCH_RADIUS sets the grid search radius in degree (default: `CDO_GRIDSEARCH_RADIUS=180`).

Author

Uwe Schulzweida

2.12.6 Remapcon

Name

remapcon, gencon - First order conservative remapping

Synopsis

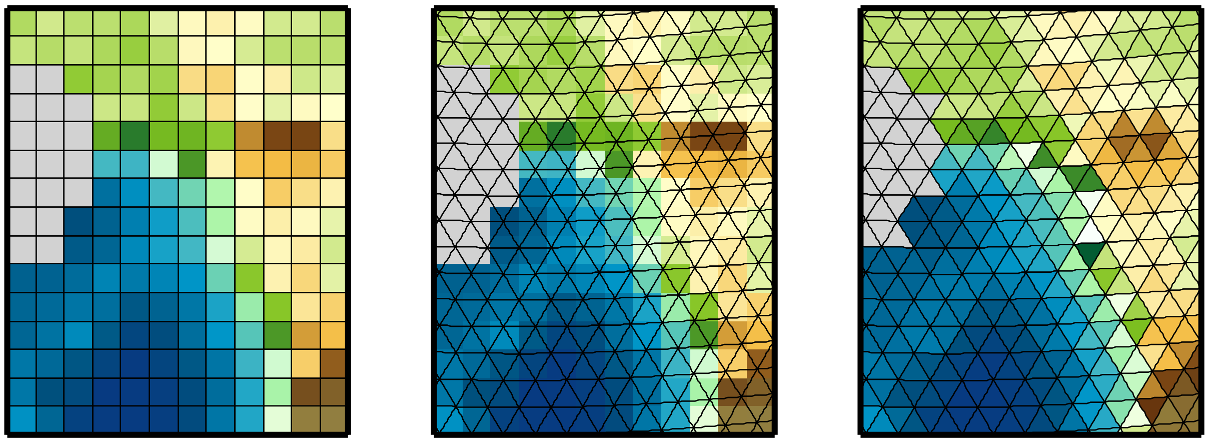
cdo remapcon,*targetgrid infile outfile*

cdo gencon,*targetgrid*[,*map3d*] *infile outfile*

Description

This module contains operators for a first order conservative remapping of fields between grids in spherical coordinates. The operators in this module uses code from the YAC software package to compute the conservative remapping weights. For a detailed description of the interpolation method see [YAC]. The interpolation method is completely general and can be used for any grid on a sphere. The search algorithm for the conservative remapping requires that no grid cell occurs more than once.

Below is a schematic illustration of the 1st order conservative remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remapcon
First order conservative remapping

Performs a first order conservative remapping on all input fields.

gencon
Generate 1st order conservative remap weights

Generates first order conservative remapping weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid. Set the parameter **map3d**=true to generate all mapfiles of the first 3D field with varying masks. In this case the mapfiles will be named `<outfile><xxx>.nc`. `xxx` will have five digits with the number of the mapfile.

Parameters

targetgrid
[STRING] Target grid description file or name

map3d
: [BOOL] Generate all mapfiles of the first 3D field

Environment

CDO_REMAP_NORM is used to choose the normalization of the conservative interpolation. By default `CDO_REMAP_NORM` is set to 'fracarea'. 'fracarea' uses the sum of the non-masked source cell intersected areas to normalize each target cell field value. This results in a reasonable flux value but the flux is not locally conserved. The option 'destarea' uses the total target cell area to normalize each target cell field value. Local flux conservation is ensured, but unreasonable flux values may result.

REMAP_AREA_MIN is used to set the minimum destination area fraction (default: `REMAP_AREA_MIN=0.0`).

Example

Say `infile` contains fields on a quadrilateral curvilinear grid. To remap all fields conservative to a regular Gaussian F32 grid, type:

```
cdo remapcon,F32 infile outfile
```

Author

Uwe Schulzweida

2.12.7 Remaplaf

Name

remaplaf, genlaf - Largest area fraction remapping

Synopsis

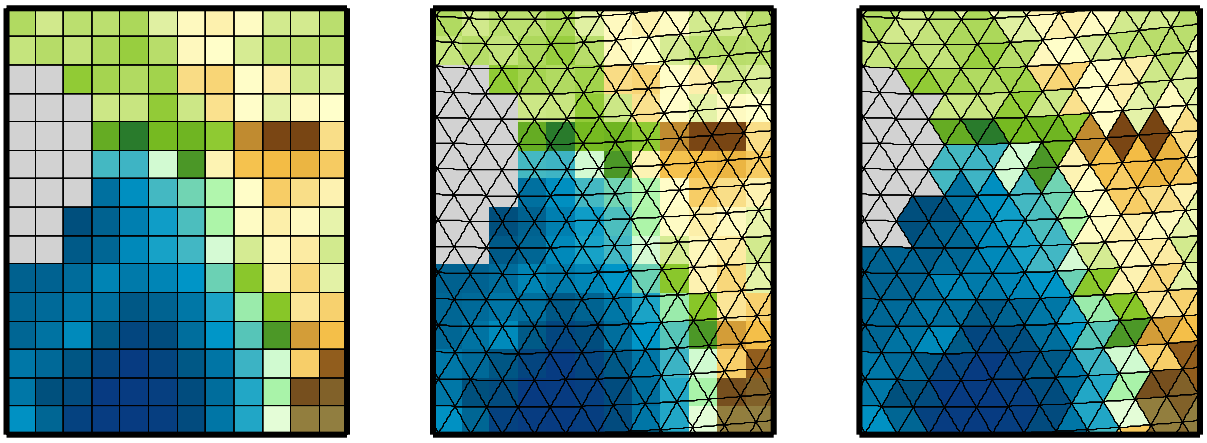
cdo remaplaf,*targetgrid infile outfile*

cdo genlaf,*targetgrid*[,*map3d*] *infile outfile*

Description

This module contains operators for a largest area fraction remapping of fields between grids in spherical coordinates. The operators in this module uses code from the YAC software package to compute the largest area fraction. For a detailed description of the interpolation method see [YAC]. The interpolation method is completely general and can be used for any grid on a sphere. The search algorithm for this remapping method requires that no grid cell occurs more than once.

Below is a schematic illustration of the largest area fraction conservative remapping:



The figure on the left side shows the input data on a regular lon/lat source grid and on the right side the remapped result on an unstructured triangular target grid. The figure in the middle shows the input data with the target grid. Grid cells with missing value are grey colored.

Operators

remaplaf
Largest area fraction remapping

Performs a largest area fraction remapping on all input fields.

genlaf
Generate largest area fraction remap weights

Generates largest area fraction remapping weights for the first input field and writes the result to a file. The format of this file is NetCDF following the SCRIP convention. Use the operator *remap* to apply this remapping weights to a data file with the same source grid.

Parameters

targetgrid
[STRING] Target grid description file or name

map3d
[BOOL] Generate all mapfiles of the first 3D field

Environment

REMAP_AREA_MIN is used to set the minimum destination area fraction (default: `REMAP_AREA_MIN=0.0`).

Author

Uwe Schulzweida

2.12.8 Remap

Name

remap - Grid remapping

Synopsis

cdo remap,*targetgrid*,*weights infile outfile*

Description

Interpolation between different horizontal grids can be a very time-consuming process. Especially if the data are on an unstructured and/or a large grid. In this case the interpolation process can be split into two parts. Firstly the generation of the interpolation weights, which is the most time-consuming part. These interpolation weights can be reused for every remapping process with the operator **remap**. This operator remaps all input fields to a new horizontal grid. The remap type and the interpolation weights of one input grid are read from a NetCDF file. More weights are computed if the input fields are on different grids. The NetCDF file with the weights should follow the [SCRIP] convention. Normally these weights come from a previous call to one of the genXXX operators (e.g. *genbil*) or were created by the original SCRIP package.

Parameters

targetgrid
[STRING] Target grid description file or name

weights
[STRING] Interpolation weights (SCRIP NetCDF file)

Environment

CDO_GRIDSEARCH_RADIUS sets the grid search radius in degree (default: `CDO_GRIDSEARCH_RADIUS=180`).

CDO_REMAP_NORM is used to choose the normalization of the conservative interpolation. By default `CDO_REMAP_NORM` is set to 'fracarea'. 'fracarea' uses the sum of the non-masked source cell intersected areas to normalize each target cell field value. This results in a reasonable flux value but the flux is not locally conserved. The option 'destarea' uses the total target cell area to normalize each target cell field value. Local flux conservation is ensured, but unreasonable flux values may result.

REMAP_AREA_MIN is used to set the minimum destination area fraction (default: `REMAP_AREA_MIN=0.0`).

REMAP_EXTRAPOLATE is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for circular grids.

Example

Say `infile` contains fields on a quadrilateral curvilinear grid. To remap all fields bilinear to a regular Gaussian F32 grid use:

```
cdo genbil,F32 infile remapweights.nc
cdo remap,F32,remapweights.nc infile outfile
```

The result will be the same as::
cdo remapbil,F32 infile outfile

Author

Uwe Schulzweida

2.12.9 Remapeta

Name

remapeta - Remap vertical hybrid levels

Synopsis

cdo remapeta,*vct*[,*oro*] *infile outfile*

Description

This operator interpolates between different vertical hybrid levels. This include the preparation of consistent data for the free atmosphere. The procedure for the vertical interpolation is based on the HIRLAM scheme and was adapted from [INTERA]. The vertical interpolation is based on the vertical integration of the hydrostatic equation with few adjustments. The basic tasks are the following one:

- at first integration of hydrostatic equation
- extrapolation of surface pressure
- Planetary Boundary-Layer (PBL) proutfile interpolation
- interpolation in free atmosphere
- merging of both proutfiles
- final surface pressure correction

The vertical interpolation corrects the surface pressure. This is simply a cut-off or an addition of air mass. This mass correction should not influence the geostrophic velocity field in the middle troposphere. Therefore the total mass above a given reference level is conserved. As reference level the geopotential height of the 400 hPa level is used. Near the surface the correction can affect the vertical structure of the PBL. Therefore the interpolation is done using the potential temperature. But in the free atmosphere above a certain n (n=0.8 defining the top of the PBL) the interpolation is done linearly. After the interpolation both proutfiles are merged. With the resulting temperature/pressure correction the hydrostatic equation is integrated again and adjusted to the reference level finding the final surface pressure correction. A more detailed description of the interpolation can be found in [INTERA]. This operator requires all variables on the same horizontal grid.

Parameters

vct
: [STRING] File name of an ASCII dataset with the vertical coordinate table

oro
: [STRING] File name with the orography (surf. geopotential) of the target dataset (optional)

Environment

`REMAPETA_PTOP`
: Sets the minimum pressure level for condensation. Above this level the humidity is set to the constant 1.E-6. The default value is 0 Pa.

Note

The code numbers or the variable names of the required parameter have to follow the [ECHAM] convention.

Use the *sinfo* command to test if your vertical coordinate system is recognized as hybrid system.

In case **remapeta** complains about not finding any data on hybrid model levels you may wish to use the *setzaxis* command to generate a zaxis description which conforms to the ECHAM convention. See section *Z-axis description* for an example how to define a hybrid Z-axis.

Example

To remap between different hybrid model level data use:

```
cdo remapeta,vct infile outfile
```

Here is an example vct file with 19 hybrid model level:

```
 0       0.00000000000000000       0.00000000000000000
 1    2000.00000000000000000       0.00000000000000000
 2    4000.00000000000000000       0.00000000000000000
 3    6046.10937500000000000       0.00033899326808751
 4    8267.92968750000000000       0.00335718691349030
 5   10609.51171875000000000       0.01307003945112228
 6   12851.10156250000000000       0.03407714888453484
 7   14698.50000000000000000       0.07064980268478394
 8   15861.12890625000000000       0.12591671943664551
 9   16116.23828125000000000       0.20119541883468628
10   15356.92187500000000000       0.29551959037780762
11   13621.46093750000000000       0.40540921688079834
12   11101.55859375000000000       0.52493220567703247
13    8127.14453125000000000       0.64610791206359863
14    5125.14062500000000000       0.75969839096069336
15    2549.96899414062500000       0.85643762350082397
16     783.19506835937500000       0.92874687910079956
17       0.00000000000000000       0.97298520803451538
18       0.00000000000000000       0.99228149652481079
19       0.00000000000000000       1.00000000000000000
```

Author

Uwe Schulzweida, Ingo Kirchner

2.12.10 Vertintml

Name

ml2pl - Model to pressure level interpolation

Synopsis

cdo ml2pl,*plevels infile outfile*

Description

Interpolates 3D variables on hybrid sigma pressure level to pressure levels. A basic linear method is used for interpolation. To calculate the pressure on model levels, the a and b coefficients defining the model levels and the surface pressure are required. The a and b coefficients are normally part of the model level data. If not available, the surface pressure can be derived from the logarithm of the surface pressure. To extrapolate the temperature, the surface geopotential is also needed. The geopotential height must be present at the hybrid layer interfaces (model half-layers)! All needed variables are identified by their GRIB1 code number or NetCDF CF standard name. Supported parameter tables are: WMO standard table number 2 and ECMWF local table number 128.

Name	Units	GRIB1 code	CF standard name
log surface pressure	Pa	152	
surface pressure	Pa	134	surface_air_pressure
air temperature	K	130	air_temperature
surface geopotential	m2 s-2	129	surface_geopotential
geopotential height	m	156	geopotential_height

Use the alias **ml2plx** to fill in missing values with the next available value of the same vertical column. Only the temperature is extrapolated in this case. The extrapolation method originates from the ECHAM postprocessing. This operator requires all variables on the same horizontal grid. Missing values in the input data are not supported.

Parameters

plevels
    [Float] Pressure levels in pascal

Note

This is a specific implementation for data from the ECHAM model, it may not work with data from other sources. The components of the hybrid coordinate must always be available at the hybrid layer interfaces even if the data is defined at the hybrid layer midpoints.

Example

To interpolate hybrid model level data to pressure levels of 925, 850, 500 and 200 hPa use:

```
cdo ml2pl,92500,85000,50000,20000 infile outfile
```

Author

Uwe Schulzweida

2.12.11 Vertintap

Name

ap2pl - Vertical pressure interpolation

Synopsis

cdo ap2pl,*levels infile outfile*

Description

Interpolate 3D variables on hybrid sigma height coordinates to pressure levels. A basic linear method is used for interpolation. The input file must contain the 3D air pressure in pascal. The air pressure is identified by the NetCDF CF standard name *air_pressure*. Use the alias **ap2plx** to fill in missing values with the next available value of the same vertical column. This operator requires all variables on the same horizontal grid. Missing values in the input data are not supported.

Parameters

levels
[Float] Comma-separated list of pressure levels in pascal

Note

This is a specific implementation for NetCDF files from the ICON model, it may not work with data from other sources.

Example

To interpolate 3D variables on hybrid sigma height level to pressure levels of 925, 850, 500 and 200 hPa use:

```
cdo ap2pl,92500,85000,50000,20000 infile outfile
```

Author

Uwe Schulzweida

2.12.12 Vertintgh

Name

gh2hl - Geometric height interpolation

Synopsis

cdo gh2hl,*levels infile outfile*

Description

Interpolate 3D variables on hybrid sigma height coordinates to height levels. A basic linear method is used for interpolation. The input file must contain the 3D geometric height in meter. The geometric height is identified by the NetCDF CF standard name *geometric_height_at_full_level_center*. Use the alias **gh2hlx** to fill in missing values with the next available value of the same vertical column. This operator requires all variables on the same horizontal grid. Missing values in the input data are not supported.

Parameters

levels
[Float] Comma-separated list of height levels in meter

Note

This is a specific implementation for NetCDF files from the ICON model, it may not work with data from other sources.

Example

To interpolate 3D variables on hybrid sigma height level to height levels of 20, 100, 500, 1000, 5000, 10000 and 20000 meter use:

```
cdo gh2hl,20,100,500,1000,5000,10000,20000 infile outfile
```

Author

Uwe Schulzweida

2.12.13 Intlevel

Name

intlevel - Linear level interpolation

Synopsis

cdo intlevel,*parameters infile outfile*

Description

This operator performs a linear vertical interpolation of 3D variables. The 1D target levels can be specified with the level parameter or read in via a Z-axis description file.

Parameters

level
: [FLOAT] Comma-separated list of target levels

zdescription
: [STRING] Path to a file containing a description of the Z-axis

zvarname
: [STRING] Use zvarname as the vertical 3D source coordinate instead of the 1D coordinate variable

extrapolate
: [BOOL] Fill target layers out of the source layer range with the nearest source layer

Example

To interpolate 3D variables on height levels to a new set of height levels use:

```
cdo intlevel,level=10,50,100,500,1000 infile outfile
```

Author

Uwe Schulzweida

2.12.14 Intlevel3d

Name

intlevel3d - Linear level interpolation from/to 3D vertical coordinates

Synopsis

cdo intlevel3d,*tgtcoordinate infile1 infile2 outfile*

Description

This operator performs a linear vertical interpolation of 3D variables fields with given 3D vertical coordinates. `infile1` contains the 3D data variables and `infile2` the 3D vertical source coordinate. The parameter `tgtcoordinate` is a datafile with the 3D vertical target coordinate. Use the alias **intlevel3dx** to fill in missing values with the next available value of the same vertical column.

Parameters

tgtcoordinate
[STRING] filename for 3D vertical target coordinates

Example

To interpolate 3D variables from one set of 3D height levels into another one where

- `infile2` contains a single 3D variable, which represents the source 3D vertical coordinate
- `infile1` contains the source data, which the vertical coordinate from `infile2` belongs to
- `tgtcoordinate` only contains the target 3D height levels

```
cdo intlevel3d,tgtcoordinate infile1 infile2 outfile
```

Author

Ralf Müller

2.12.15 Inttime

Name

inttime, intntime - Time interpolation

Synopsis

cdo inttime,*date*,*time*[,*inc*] *infile outfile*

cdo intntime,*n infile outfile*

Description

This module performs linear interpolation between timesteps. Interpolation is only performed if both values exist. If both values are missing values, the result is also a missing value. If only one value exists, it is taken if the time weighting is greater than or equal to 0.5. So no new value will be created at existing time steps, if the value is missing there.

Operators

inttime
: Interpolation between timesteps

  This operator creates a new dataset by linear interpolation between timesteps. The user has to define the start date/time with an optional increment.

intntime
: Interpolation between timesteps

  This operator performs linear interpolation between timesteps. The user has to define the number of timesteps from one timestep to the next.

Parameters

date
: [STRING] Start date (format YYYY-MM-DD)

time
: [STRING] Start time (format hh:mm:ss)

inc
: [STRING] Optional increment (seconds, minutes, hours, days, months, years) [default: 0hour]

n
: [INTEGER] Number of timesteps from one timestep to the next

Example

Assumed a 6 hourly dataset starts at 1987-01-01 12:00:00. To interpolate this time series to a one hourly dataset use:

```
cdo inttime,1987-01-01,12:00:00,1hour infile outfile
```

Author

Uwe Schulzweida

2.12.16 Intyear

Name

intyear - Interpolation between two years

Synopsis

cdo intntime,*years infile1 infile2 obase*

Description

This operator performs linear interpolation between two years, timestep by timestep. The input files need to have the same structure with the same variables. The output files will be named `<obase><yyyy><suffix>` where `yyyy` will be the year and `suffix` is the filename extension derived from the file format.

Parameters

years
[INTEGER] Comma-separated list or first/last[/inc] range of years

Environment

CDO_FILE_SUFFIX sets the filename suffix.

Note

This operator needs to open all output files simultaneously. The maximum number of open files depends on the operating system!

Example

Assume there are two monthly mean datasets over a year. The first dataset has 12 timesteps for the year 1985 and the second one for the year 1990. To interpolate the years between 1985 and 1990 month by month use:

```
cdo intyear,1986,1987,1988,1989 infile1 infile2 year
```

Example result of '*dir year**' for NetCDF datasets:

```
year1986.nc year1987.nc year1988.nc year1989.nc
```

Author

Uwe Schulzweida

2.13 Transformation

This section contains modules to perform spectral transformations.

Here is a short overview of all operators in this section:

Spectral	*sp2gp*	Spectral to gridpoint
	gp2sp	Gridpoint to spectral
Specconv	*sp2sp*	Spectral to spectral
Wind2	*dv2ps*	D and V to vel. potential and stream function
Wind	*dv2uv*	Divergence and vorticity to U and V wind
	uv2dv	U and V wind to divergence and vorticity
Fourier	*fourier*	Fourier transformation

2.13.1 Spectral

Name

sp2gp, gp2sp - Spectral transformation

Synopsis

cdo <*operator*>[,*parameters*] *infile outfile*

Description

This module transforms fields on a global regular Gaussian grid to spectral coefficients and vice versa. The transformation is achieved by applying Fast Fourier Transformation (FFT) first and direct Legendre Transformation afterwards in gp2sp. In sp2gp the inverse Legendre Transformation and inverse FFT are used. Missing values are not supported.

The relationship between the spectral resolution, governed by the truncation number T, and the grid resolution depends on the number of grid points at which the shortest wavelength field is represented. For a grid with 2N points between the poles (so 4N grid points in total around the globe) the relationship is:

**linear grid: the shortest wavelength is represented by 2 grid points $\rightarrow$ 4N $\simeq$ 2(TL + 1)
**quadratic grid: the shortest wavelength is represented by 3 grid points $\rightarrow$ 4N $\simeq$ 3(TQ + 1)
**cubic grid: the shortest wavelength is represented by 4 grid points $\rightarrow$ 4N $\simeq$ 4(TC + 1)

The quadratic grid is used by ECHAM and ERA15. ERA40 is using a linear Gaussian grid reflected by the TL notation.

The following table shows the calculation of the number of latitudes and the triangular truncation for the different grid types:

Gridtype	Number of latitudes: nlat	Triangular truncation: ntr
linear	NINT((ntr*2 + 1)/2)	(nlat*2 - 1) / 2
quadratic	NINT((ntr*3 + 1)/2)	(nlat*2 - 1) / 3
cubic	NINT((ntr*4 + 1)/2)	(nlat*2 - 1) / 4

Operators

sp2gp
Spectral to gridpoint

Convert all spectral fields to a global regular Gaussian grid. The optional parameter **trunc** must be greater than the input truncation.

gp2sp
Gridpoint to spectral

Convert all Gaussian gridpoint fields to spectral fields. The optional parameter **trunc** must be lower than the input truncation.

Parameters

type
[STRING] Type of the grid: quadratic, linear, cubic (default: type=quadratic)

trunc
[INTEGER] Triangular truncation

Note

To speed up the calculations, the Legendre polynoms are kept in memory. This requires a relatively large amount of memory. This is for example 12GB for T1279 data.

Example

To transform spectral coefficients from T106 to F80 regular Gaussian grid use:

```
cdo sp2gp infile outfile
```

To transform spectral coefficients from TL159 to F80 regular Gaussian grid use:

```
cdo sp2gp,type=linear infile outfile
```

Author

Uwe Schulzweida

2.13.2 Specconv

Name

sp2sp - Spectral to spectral

Synopsis

cdo sp2sp,*trunc infile outfile*

Description

Changed the triangular truncation of all spectral fields. This operator performs downward conversion by cutting the resolution. Upward conversions are achieved by filling in zeros.

Parameters

trunc
[INTEGER] New spectral resolution

Author

Uwe Schulzweida

2.13.3 Wind2

Name

dv2ps - D and V to vel. potential and stream function

Synopsis

cdo dv2ps *infile outfile*

Description

Calculate spherical harmonic coefficients of velocity potential and stream function from spherical harmonic coefficients of relative divergence and vorticity. The divergence and vorticity need to have the names sd and svo or code numbers 155 and 138.

2.13.4 Wind

Name

dv2uv, uv2dv - Wind transformation

Synopsis

cdo <*operator*>[,*gridtype*] *infile outfile*

Description

This module converts relative divergence and vorticity to U and V wind and vice versa. Divergence and vorticity are spherical harmonic coefficients in spectral space and U and V are on a global regular Gaussian grid. The Gaussian latitudes need to be ordered from north to south. Missing values are not supported.

The relationship between the spectral resolution, governed by the truncation number T, and the grid resolution depends on the number of grid points at which the shortest wavelength field is represented. For a grid with 2N points between the poles (so 4N grid points in total around the globe) the relationship is:

**linear grid: the shortest wavelength is represented by 2 grid points $\rightarrow$ 4N $\simeq$ 2(TL + 1)
**quadratic grid: the shortest wavelength is represented by 3 grid points $\rightarrow$ 4N $\simeq$ 3(TQ + 1)
**cubic grid: the shortest wavelength is represented by 4 grid points $\rightarrow$ 4N $\simeq$ 4(TC + 1)

The quadratic grid is used by ECHAM and ERA15. ERA40 is using a linear Gaussian grid reflected by the TL notation.

The following table shows the calculation of the number of latitudes and the triangular truncation for the different grid types:

Gridtype	Number of latitudes: nlat	Triangular truncation: ntr
linear	NINT((ntr*2 + 1)/2)	(nlat*2 - 1) / 2
quadratic	NINT((ntr*3 + 1)/2)	(nlat*2 - 1) / 3
cubic	NINT((ntr*4 + 1)/2)	(nlat*2 - 1) / 4

Operators

dv2uv
Divergence and vorticity to U and V wind

Calculate U and V wind on a Gaussian grid from spherical harmonic coefficients of relative divergence and vorticity. The divergence and vorticity need to have the names sd and svo or code numbers 155 and 138.

uv2dv
U and V wind to divergence and vorticity

Calculate spherical harmonic coefficients of relative divergence and vorticity from U and V wind. The U and V wind need to be on a Gaussian grid and need to have the names u and v or the code numbers 131 and 132.

Parameters

gridtype
[STRING] Type of the grid: quadratic, linear, cubic (default: quadratic)

Note

To speed up the calculations, the Legendre polynoms are kept in memory. This requires a relatively large amount of memory. This is for example 12GB for T1279 data.

Example

Assume a dataset has at least spherical harmonic coefficients of divergence and vorticity. To transform the spectral divergence and vorticity to U and V wind on a Gaussian grid use:

```
cdo dv2uv infile outfile
```

Author

Uwe Schulzweida

2.13.5 Fourier

Name

fourier - Fourier transformation

Synopsis

cdo fourier,*epsilon infile outfile*

Description

The fourier operator performs the fourier transformation or the inverse fourier transformation of all input fields. If the number of timesteps is a power of 2 then the algorithm of the Fast Fourier Transformation (FFT) is used.

It is

$$o(t,x) = \frac{1}{\sqrt{n}} \sum_{j=0}^{n-1} i(t,x) e^{\epsilon 2\pi ij}$$

where a user given $epsilon = -1$ leads to the forward transformation and a user given $epsilon = 1$ leads to the backward transformation.

If the input stream `infile` consists only of complex fields, then the fields of `outfile`, computed by

```
cdo -f ext fourier,1 -fourier,-1 infile outfile
```

are the same than that of `infile`. For real input files see function retocomplex.

Parameters

epsilon
[INTEGER] -1: forward transformation; 1: backward transformation

Note

Complex numbers can only be stored in NetCDF4 and EXTRA format.

Author

Uwe Schulzweida

2.14 Import/Export

This section contains modules to import and export data files which can not read or write directly with **CDO**.

Here is a short overview of all operators in this section:

Importbinary	*import_binary*	Import binary data sets
Importcmsaf	*import_cmsaf*	Import CM-SAF HDF5 files
Input	*input*	ASCII input
	inputsrv	SERVICE ASCII input
	inputext	EXTRA ASCII input
Output	*output*	ASCII output
	outputf	Formatted output
	outputint	Integer output
	outputsrv	SERVICE ASCII output
	outputext	EXTRA ASCII output
Outputtab	*outputtab*	Table output
Outputgmt	*gmtxyz*	GMT xyz format
	gmtcells	GMT multiple segment format

2.14.1 Importbinary

Name

import_binary - Import binary data sets

Synopsis

cdo import_binary *infile.ctl outfile*

Description

This operator imports gridded binary data sets via a GrADS data descriptor file. The GrADS data descriptor file contains a complete description of the binary data as well as instructions on where to find the data and how to read it. The descriptor file is an ASCII file that can be created easily with a text editor. The general contents of a gridded data descriptor file are as follows:

- Filename for the binary data
- Missing or undefined data value
- Mapping between grid coordinates and world coordinates
- Description of variables in the binary data set

A detailed description of the components of a GrADS data descriptor file can be found in [GrADS]. Here is a list of the supported components: BYTESWAPPED, CHSUB, DSET, ENDVARS, FILEHEADER, HEADERBYTES, OPTIONS, TDEF, TITLE, TRAILERBYTES, UNDEF, VARS, XDEF, XYHEADER, YDEF, ZDEF

Note

Only 32-bit IEEE floats are supported for standard binary files!

Example

To convert a binary data file to NetCDF use:

```
cdo -f nc import_binary infile.ctl outfile.nc
```

Here is an example of a GrADS data descriptor file:

```
DSET  ^infile.bin
OPTIONS sequential
UNDEF  -9e+33
XDEF 360 LINEAR -179.5 1
YDEF 180 LINEAR  -89.5 1
ZDEF   1 LINEAR 1 1
TDEF   1 LINEAR 00:00Z15jun1989 12hr
VARS   1
param  1  99  description of the variable
ENDVARS
```

The binary data file infile.bin contains one parameter on a global 1 degree lon/lat grid written with FORTRAN record length headers (sequential).

Author

Uwe Schulzweida

2.14.2 Importcmsaf

Name

import_cmsaf - Import CM-SAF HDF5 files

Synopsis

cdo import_cmsaf *infile outfile*

Description

This operator imports gridded CM-SAF (Satellite Application Facility on Climate Monitoring) HDF5 files. CM-SAF exploits data from polar-orbiting and geostationary satellites in order to provide climate monitoring products of the following parameters:

Cloud parameters:

cloud fraction (CFC), cloud type (CTY), cloud phase (CPH), cloud top height, pressure and temperature (CTH,CTP,CTT), cloud optical thickness (COT), cloud water path (CWP).

Surface radiation components:

Surface albedo (SAL); surface incoming (SIS) and net (SNS) shortwave radiation; surface downward (SDL) and outgoing (SOL) longwave radiation, surface net longwave radiation (SNL) and surface radiation budget (SRB).

Top-of-atmosphere radiation components:

Incoming (TIS) and reflected (TRS) solar radiative flux at top-of-atmosphere. Emitted thermal radiative flux at top-of-atmosphere (TET).

Water vapour:

Vertically integrated water vapour (HTW), layered vertically integrated water vapour and layer mean temperature and relative humidity for 5 layers (HLW), temperature and mixing ratio at 6 pressure levels.

Daily and monthly mean products can be ordered via the CM-SAF web page (www.cmsaf.eu). Products with higher spatial and temporal resolution, i.e. instantaneous swath-based products, are available on request (contact.cmsaf@dwd.de). All products are distributed free-of-charge. More information on the data is available on the CM-SAF homepage (www.cmsaf.eu).

Daily and monthly mean products are provided in equal-area projections. **CDO** reads the projection parameters from the metadata in the HDF5-headers in order to allow spatial operations like remapping. For spatial operations with instantaneous products on original satellite projection, additional files with arrays of latitudes and longitudes are needed. These can be obtained from CM-SAF together with the data.

Note

To use this operator, it is necessary to build **CDO** with [HDF5] support (version 1.6 or higher). The [PROJ] library (version 5.0 or higher) is needed for full support of the remapping functionality.

Example

A typical sequence of commands with this operator could look like this:

```
cdo -f nc remapbil,r360x180 -import_cmsaf cmsaf_product.hdf output.nc
```

(bilinear remapping to a predefined global grid with 1 deg resolution and conversion to NetCDF).

If you work with CM-SAF data on original satellite project, an additional file with information on geolocation is required, to perform such spatial operations:

```
cdo -f nc remapbil,r720x360 -setgrid,cmsaf_latlon.h5 -import_cmsaf cmsaf.hdf out.nc
```

Some CM-SAF data are stored as scaled integer values. For some operations, it could be desirable (or necessary) to increase the accuracy of the converted products:

```
cdo -b f32 -f nc fldmean -sellonlatbox,0,10,0,10 -remapbil,r720x360 \
                -import_cmsaf cmsaf_product.hdf output.nc
```

Author

Uwe Schulzweida, Frank Kaspar

2.14.3 Input

Name

input, inputsrv, inputext - Formatted input

Synopsis

cdo <*operator*> *outfile*

cdo input,*grid*[,*zaxis*] *outfile*

Description

This module reads time series of one 2D variable from standard input. All input fields need to have the same horizontal grid. The format of the input depends on the chosen operator.

Operators

input
ASCII input

Reads fields with ASCII numbers from standard input and stores them in `outfile`. The numbers read are exactly that ones which are written out by the *output* operator.

inputsrv
SERVICE ASCII input

Reads fields with ASCII numbers from standard input and stores them in `outfile`. Each field should have a header of 8 integers (SERVICE likely). The numbers that are read are exactly that ones which are written out by the *outputsrv* operator.

inputext
EXTRA ASCII input

Read fields with ASCII numbers from standard input and stores them in `outfile`. Each field should have header of 4 integers (EXTRA likely). The numbers read are exactly that ones which are written out by the *outputext* operator.

Parameters

grid
[STRING] Grid description file or name

****zaxis: STRING**
Z-axis description file

Example

Assume an ASCII dataset contains a field on a global regular grid with 32 longitudes and 16 latitudes (512 elements). To create a GRIB1 dataset from the ASCII dataset use:

```
cdo -f grb input,r32x16 outfile.grb < my_ascii_data
```

Author

Uwe Schulzweida

2.14.4 Output

Name

output, outputf, outputint, outputsrv, outputext - Formatted output

Synopsis

cdo <*operator*> *infiles*

cdo outputf[,*format*[,*nelem*]] *infiles*

Description

This module prints all values of all input datasets to standard output. All input fields need to have the same horizontal grid. All input files need to have the same structure with the same variables. The format of the output depends on the chosen operator.

Operators

output
ASCII output

Prints all values to standard output. Each row has 6 elements with the C-style format "%13.6g".

outputf
Formatted output

Prints all values to standard output. The format and number of elements for each row have to be specified by the parameters **format** and **nelem**. The default for **nelem** is 1.

outputint
Integer output

Prints all values rounded to the nearest integer to standard output.

outputsrv
SERVICE ASCII output

Prints all values to standard output. Each field with a header of 8 integers (SERVICE likely).

outputext
EXTRA ASCII output

Prints all values to standard output. Each field with a header of 4 integers (EXTRA likely).

Parameters

format
[STRING] C-style format for one element (e.g. %13.6g)

nelem
[INTEGER] Number of elements for each row (default: nelem = 1)

Example

To print all field elements of a dataset formatted with "%8.4g" and 8 values per line use:

```
cdo outputf,%8.4g,8 infile
```

Example result of a dataset with one field on 64 grid points:

```
261.7     262   257.8   252.5   248.8   247.7   246.3   246.1
250.6   252.6   253.9   254.8     252   246.6   249.7   257.9
273.4   266.2   259.8   261.6   257.2   253.4     251   263.7
267.5   267.4   272.2   266.7   259.6   255.2   272.9   277.1
```

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```
275.3   275.5   276.4   278.4     282   269.6   278.7   279.5
282.3   284.5   280.3   280.3     280   281.5   284.7   283.6
292.9   290.5   293.9   292.6   292.7   292.8   294.1   293.6
293.8   292.6   291.2   292.6   293.2   292.8     291   291.2
```

Author

Uwe Schulzweida

2.14.5 Outputtab

Name

outputtab - Table output

Synopsis

cdo outputtab,*parameters infiles*

Description

This operator prints a table of all input datasets to standard output. `infiles` is an arbitrary number of input files. All input files need to have the same structure with the same variables on different timesteps. All input fields need to have the same horizontal grid.

The contents of the table depends on the chosen parameters. The format of each table parameter is keyname[:len]. len is the optional length of a table entry. The number of significant digits of floating point parameters can be set with the **CDO** option –precision, the default is 7. Here is a list of all valid keynames:

Keyname	Type	Description
value	FLOAT	Value of the variable [len:8]
name	STRING	Name of the variable [len:8]
param	STRING	Parameter ID (GRIB1: code[.tabnum]; GRIB2: num[.cat[.dis]]) [len:11]
code	INTEGER	Code number [len:4]
x	FLOAT	X coordinate of the original grid [len:6]
y	FLOAT	Y coordinate of the original grid [len:6]
lon	FLOAT	Longitude coordinate in degrees [len:6]
lat	FLOAT	Latitude coordinate in degrees [len:6]
lev	FLOAT	Vertical level [len:6]
xind	INTEGER	Grid x index [len:4]
yind	INTEGER	Grid y index [len:4]
timestep	INTEGER	Timestep number [len:6]
date	STRING	Date (format YYYY-MM-DD) [len:10]
time	STRING	Time (format hh:mm:ss) [len:8]
year	INTEGER	Year [len:5]
month	INTEGER	Month [len:2]
day	INTEGER	Day [len:2]
nohead	INTEGER	Disable output of header line

Parameters

keynames
: [STRING] Comma-separated list of keynames, one for each column of the table

Example

To print a table with name, date, lon, lat and value information use:

```
cdo  outputtab,name,date,lon,lat,value  infile
```

Here is an example output of a time series with the yearly mean temperatur at lon=10/lat=53.5:

```
#   name       date    lon    lat    value
   tsurf  1991-12-31     10   53.5  8.83903
   tsurf  1992-12-31     10   53.5  8.17439
   tsurf  1993-12-31     10   53.5  7.90489
   tsurf  1994-12-31     10   53.5  10.0216
   tsurf  1995-12-31     10   53.5  9.07798
```

Author

Uwe Schulzweida

2.14.6 Outputgmt

Name

gmtxyz, gmtcells - GMT output

Synopsis

cdo <*operator*> *infile*

Description

This module prints the first field of the input dataset to standard output. The output can be used to generate 2D Lon/Lat plots with [GMT]. The format of the output depends on the chosen operator.

Operators

gmtxyz
GMT xyz format

The operator exports the first field to the GMT xyz ASCII format. The output can be used to create contour plots with the GMT module pscontour.

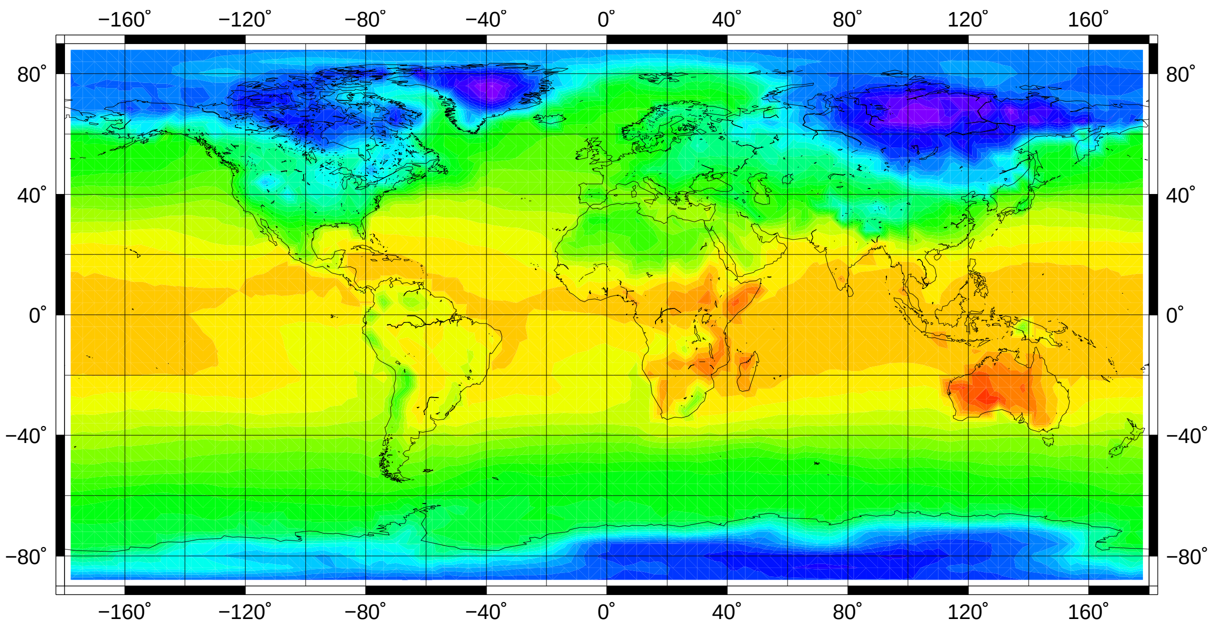
gmtcells
GMT multiple segment format

The operator exports the first field to the GMT multiple segment ASCII format. The output can be used to create shaded gridfill plots with the GMT module psxy.

Example

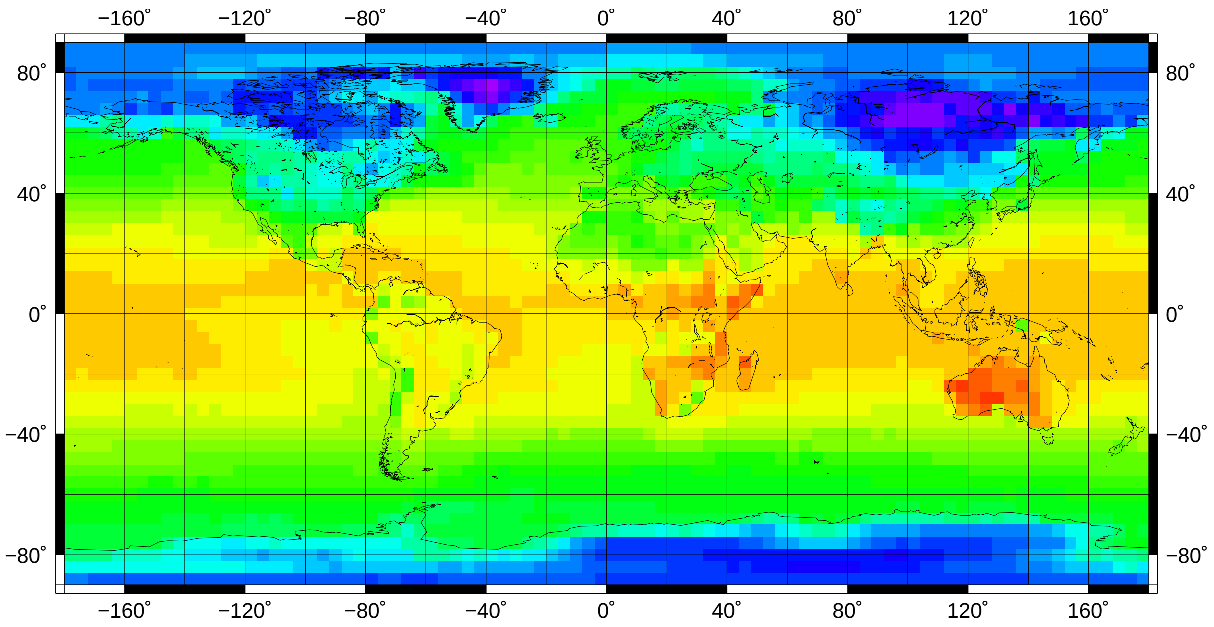
1) GMT shaded contour plot of a global temperature field with a resolution of 4 degree. The contour interval is 3 with a rainbow color table:

```
cdo gmtxyz temp > data.gmt
makecpt -T213/318/3  -Crainbow > gmt.cpt
pscontour -K -JQ0/10i -Rd -I -Cgmt.cpt data.gmt > gmtplot.ps
pscoast -O -J -R -Dc -W -B40g20 >> gmtplot.ps
```



2) GMT shaded gridfill plot of a global temperature field with a resolution of 4 degree. The contour interval is 3 with a rainbow color table:

```
cdo gmtcells temp > data.gmt
makecpt -T213/318/3  -Crainbow > gmt.cpt
psxy -K -JQ0/10i -Rd -L -Cgmt.cpt -m data.gmt > gmtplot.ps
pscoast -O -J -R -Dc -W -B40g20 >> gmtplot.ps
```



Author

Uwe Schulzweida

2.15 Graphic with Magics

Magics is the latest generation of the ECMWF's Meteorological plotting software MAGICS. Magics supports the plotting of contours, wind fields, observations, satellite images, symbols, text, axis and graphs (including box plots). Data fields to be plotted may be presented in various formats, for instance GRIB 1 and 2 code data, gaussian grid, regularly spaced grid and fitted data, BUFR and NetCDF format or retrieved from an ODB database. The produced meteorological plots can be saved in various formats, such as PostScript, EPS, PDF, GIF, PNG and SVG. [Magics]

In order to rapidly generate high quality pictures from the data obtained from the existing **CDO** operators, the **CDO** has been interfaced with the Magics library. As a first step, some **CDO** plotting operators are created to cater to the most essential/ frequently used plotting features viz., graph, contour, vector. These operators rely on the Magics and generate output files in the various formats supported by Magics. These operators can be used as terminal operators and chained with the existing operators.

Magics provides a vast number of parameters to control the attributes of various plotting features. Keeping in view, the usability of **CDO** users, currently only a few of these parameters are supported and accessible to the **CDO** users as command line arguments for the respective operators. The users are requested to refer to the Magics manual [Magics] for detailed description of the various parameters available for the various features. The description of the plotting operators and the various arguments that can be passed to these operators is provided in the subsequent sections.

This section gives a description of all **CDO** operators to generate plots with magics.

Here is a short overview of all operators in this section:

Magplot	*contour*	Contour plot
	shaded	Shaded contour plot
	grfill	Shaded gridfill plot
Magvector	*vector*	Lon/Lat vector plot
Maggraph	*graph*	Line graph plot

2.15.1 Magplot

Name

contour, shaded, grfill - Lon/Lat plot

Synopsis

cdo *<operator>,parameter infile obase*

Description

The operators in this module generates 2D Lon/Lat plots. The data for the plot is read from `infile`. Only data on rectilinear Lon/Lat grids are supported. The output file will be named <obase>_<param>.<device> where param is the parameter name and device is the device name. The default output file format is postscript, this can be changed with the device parameter. The type of the plot depends on the choosen operator.

Here is a list of all common plot parameters:

Keyname	Type	Description
device	STRING	Output device (ps, eps, pdf, png, gif, gif_animation, jpeg, svg, kml)
projection	STRING	Projection (cylindrical, polar_stereographic, robinson, mercator)
style	STRING	Contour line style (solid, dash, dot, chain_dash, chain_dot)
min	FLOAT	Minimum value
max	FLOAT	Maximum value
lon_max	FLOAT	Maximum longitude of the image
lon_min	FLOAT	Minimum longitude of the image
lat_max	FLOAT	Maximum latitude of the image
lat_min	FLOAT	Minimum latitude of the image
count	INTEGER	Number of Contour levels / Colour bands
interval	FLOAT	Interval in data units between two bands lines
list	INTEGER	List of levels to be plotted
RGB	STRING	TRUE or FALSE, to indicate, if the input colour is in RGB format
step_freq	INTEGER	Frequency of time steps to be considered for making the animation (device=gif_animation). Default value is "1" (all time steps). Will be ignored if input file has multiple variables.
file_split	STRING	TRUE or FALSE, to split the output file for each variable, if input has multiple variables. Default value is "FALSE". Valid only for "PS" format.

Operators

contour
Contour plot

The operator **contour** generates the discrete contour lines of the input field values. The following additional parameters are valid for contour operator, module in addition to the common plot parameters:

Keyname	Type	Description
colour	STRING	Colour for drawing the contours
thickness	FLOAT	Thickness of the contour line
style	STRING	Line Style can be "SOLID", "DASH", "DOT", "CHAIN_DASH", "CHAIN_DOT"

shaded
Shaded contour plot

The operator **shaded** generates the filled contours of the given input field values. The following additional parameters are valid for shaded contour and gridfill operator, in addition to the common plot parameters.

Keyname	Type	Description
colour_min	STRING	Colour for the Minimum colour band
colour_max	STRING	Colour for the Minimum colour band
colour_triad	STRING	Direction of colour sequencing for shading "CW" or "ACW", to denote "clockwise" and "anticlockwise" respectively. To be used in conjunction with "colour_min", "colour_max" options. Default is "ACW"
colour_table	STRING	File with user specified colours with the format as

Example file for 6 colours in RGB format:

```
6
RGB(0.0;0.0;1.0)
RGB(0.0;0.0;0.5)
RGB(0.0;0.5;0.5)
RGB(0.0;1.0;0.0)
RGB(0.5;0.5;0.0)
RGB(1.0;0.0;0.0)
```

grfill
Shaded gridfill plot

The operator **grfill** is similar to satellite imaging and shades each cell (pixel) according to the value of the field at that cell.

Parameters

parameter STRING
Comma-separated list of plot parameters

Note

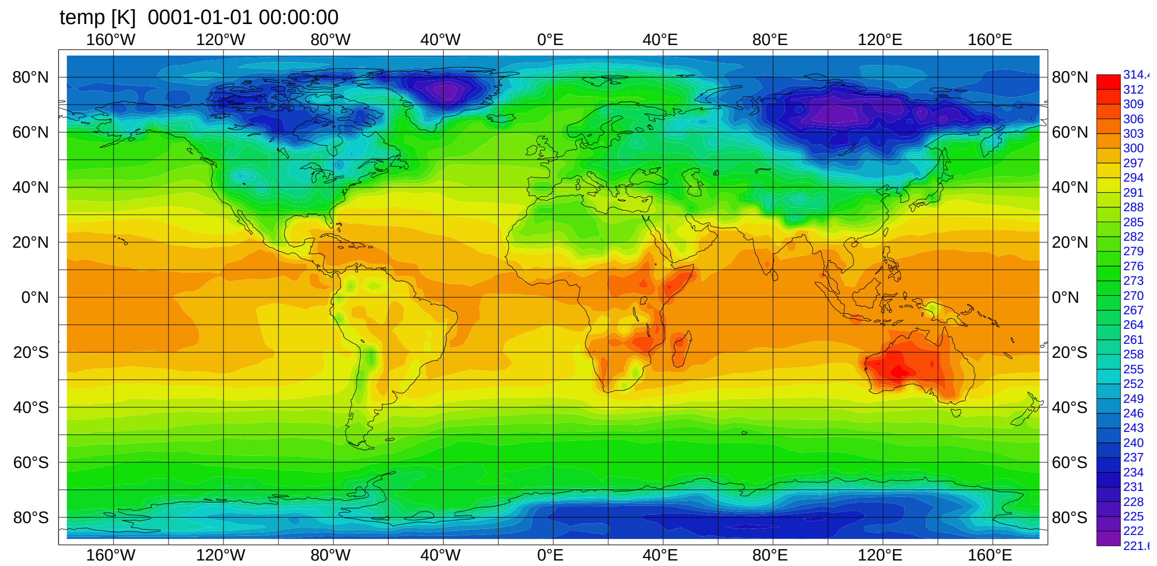
All colour parameter can be either standard name or in RGB format. The valid standard name strings for "colour" are:

"red", "green", "blue", "yellow", "cyan", "magenta", "black", "avocado", "beige", "brick", "brown", "burgundy", "charcoal", "chestnut", "coral", "cream", "evergreen", "gold", "grey", "khaki", "kellygreen", "lavender", "mustard", "navy", "ochre", "olive", "peach", "pink", "rose", "rust", "sky", "tan", "tangerine", "turquoise", "violet", "reddishpurple", "purplered", "purplishred", "orangishred", "redorange", "reddishorange", "orange", "yellowishorange", "orangeyellow", "orangishyellow", "greenishyellow", "yellowgreen", "yellowishgreen", "bluishgreen", "bluegreen", "greenishblue", "purplishblue", "bluepurple", "bluishpurple", "purple", "white"

Example

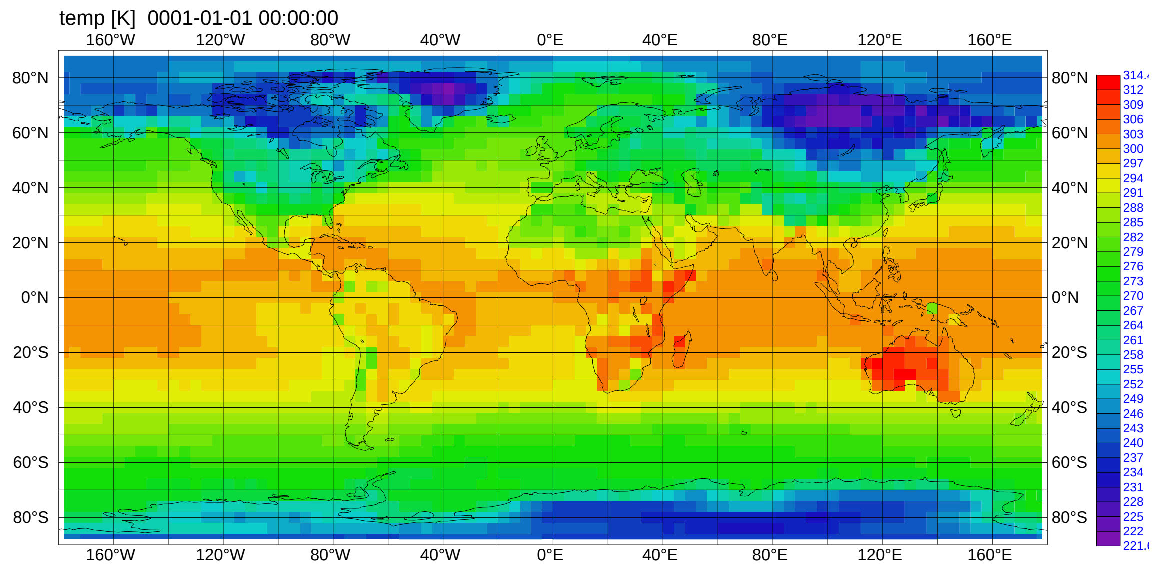
1) Shaded contour plot of a global temperature field with a resolution of 4 degree. The contour interval is 3 with a rainbow color table.

```
cdo shaded,interval=3,colour_min=violet,colour_max=red,colour_triad=cw temp plot
```



2) Shaded gridfill plot of a global temperature field with a resolution of 4 degree. The contour interval is 3 with a rainbow color table.

```
cdo grfill,interval=3,colour_min=violet,colour_max=red,colour_triad=cw temp plot
```



Author

Kameswarrao Modali

2.15.2 Magvector

Name

vector - Lon/Lat vector plot

Synopsis

cdo vector,*parameter infile obase*

Description

This operator generates 2D Lon/Lat vector plots. The data for the plot is read from `infile`. The input is expected to contain two velocity components. Only data on rectilinear Lon/Lat grids are supported. The output file will be named <obase>.<device> where device is the device name. The default output file format is postscript, this can be changed with the device parameter.

Here is a list of all vector plot parameters:

Keyname	Type	Description
device	STRING	Output device (ps, eps, pdf, png, gif, gif_animation, jpeg, svg, kml)
projection	STRING	Projection (cylindrical, polar_stereographic, robinson, mercator)
thin_fac	FLOAT	Controls the actual number of wind arrows or flags plotted (default 2).
unit_vec	FLOAT	Wind speed in m/s represented by a unit vector (1.0cm)
step_freq	INTEGER	Frequency of time steps to be considered for making the animation (device=gif_animation). Default value is “1” (all time steps). Will be ignored if input file has multiple variables.

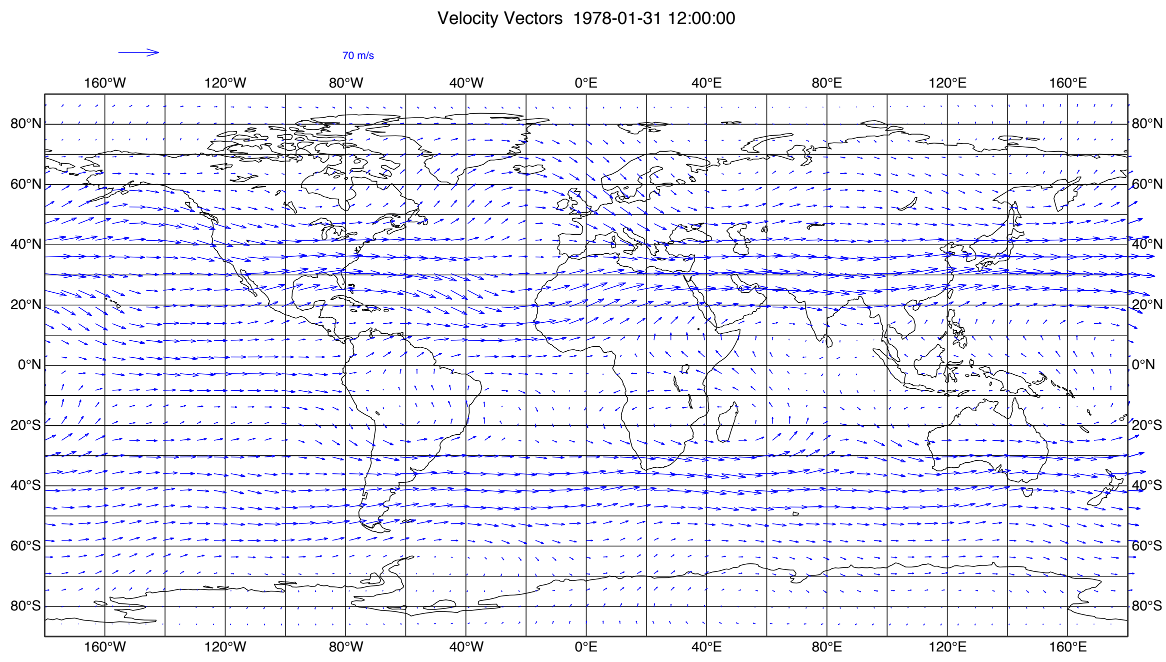
Parameters

parameter STRING
Comma-separated list of plot parameters

Example

Vector plot of global wind vectors with a resolution of 5 degree. The unit vector is set to 70 and all wind arrows are plotted.

```
cdo vector,thin_fac=1,unit_vec=70 uvdata plot
```



Author

Kameswarrao Modali

2.15.3 Maggraph

Name

graph - Line graph plot

Synopsis

cdo graph,*parameter infiles obase*

Description

This operator generates line graph plots. The data for the plot is read from `infiles`. The result is written to `outfile`. The default output file format is postscript, this can be changed with the device parameter.

Here is a list of all graph plot parameters:

Keyname	Type	Description
device	STRING	Output device (ps, eps, pdf, png, gif, gif_animation, jpeg, svg, kml)
ymin	FLOAT	Minimum value of the y-axis data
ymax	FLOAT	Maximum value of the y-axis data
linewidth	INT	Line width (default 8)
stat	STRING	"TRUE" or "FALSE", to switch on the mean computation. Default is "FALSE". Will be overridden to "FALSE", if input files have unequal number of time steps or different start/end times.
sigma	FLOAT	Standard deviation value for generating shaded back ground around the mean value. To be used in conjunction with 'stat="TRUE"'
obsv	STRING	To indicate if the input files have an observation data, by setting to "TRUE". Default value is "FALSE". The observation data should be the first file in the input file list. The observation data is always plotted in black colour.

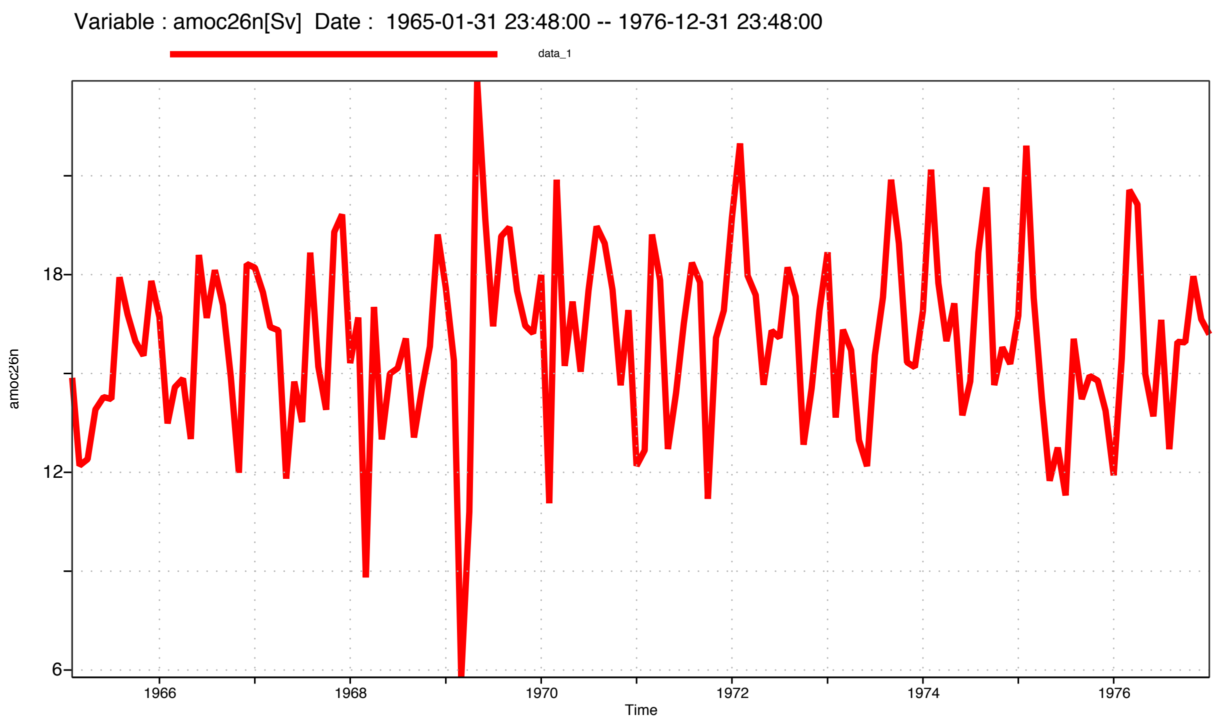
Parameters

parameter STRING
Comma-separated list of plot parameters

Example

Graph plot of an atlantic MOC time series from 1965 to 1976:

```
cdo graph amoc plot
```



Author

Kameswarrao Modali

2.16 Miscellaneous

This section contains miscellaneous modules which do not fit to the other sections before.

Here is a short overview of all operators in this section:

Gradsdes	*gradsdes*	GrADS data descriptor file
Afterburner	*after*	ECHAM standard post processor
Filter	*bandpass*	Bandpass filtering
	lowpass	Lowpass filtering
	highpass	Highpass filtering
Gridcell	*gridarea*	Grid cell area
	gridweights	Grid cell weights
Smooth	*smooth*	Smooth grid points
	smooth9	9 point smoothing
Deltat	*deltat*	Difference between timesteps
Replacevalues	*setvals*	Set list of old values to new values
	setrtoc	Set range to constant
	setrtoc2	Set range to constant others to constant2
Getgridcell	*gridcellindex*	Get grid cell index
Vargen	*const*	Create a constant field
	random	Create a field with random numbers
	topo	Create a field with topography
	seq	Create a time series
	stdatm	Create values for pressure and temperature for hydrostatic atmosphere
Timsort	*timsort*	Temporal sorting
WindTrans	*uvDestag*	Destaggering of u/v wind components
	rotuvNorth	Rotate u/v wind to North pole
	projuvLatLon	Cylindrical Equidistant projection
Rotuv	*rotuvb*	Backward wind rotation
Mrotuvb	*mrotuvb*	Backward rotation of MPIOM data
Mastrfu	*mastrfu*	Mass stream function
Pressure	*pressure_half*	Pressure on half-levels
	pressure	Pressure on full-levels
	delta_pressure	Pressure difference of half-levels
Derivepar	*sealevelpressure*	Sea level pressure
	gheight	Geopotential height on full-levels
	gheight_half	Geopotential height on half-levels
	air_density	Air density
Adisit	*adisit*	Potential temperature to in-situ temperature
	adipot	In-situ temperature to potential temperature
Rhopot	*rhopot*	Calculates potential density
Histogram	*histcount*	Histogram count
	histsum	Histogram sum
	histmean	Histogram mean
	histfreq	Histogram frequency
Sethalo	*sethalo*	Set the bounds of a field
Wct	*wct*	Windchill temperature
Fdns	*fdns*	Frost days where no snow index per time period
Strwin	*strwin*	Strong wind days index per time period
Strbre	*strbre*	Strong breeze days index per time period
Strgal	*strgal*	Strong gale days index per time period
Hurr	*hurr*	Hurricane days index per time period
CMORlite	*cmorlite*	CMOR lite
Verifygrid	*verifygrid*	Verify grid coordinates
Healpix	*hpdegrade*	Degrade healpix
	hpupgrade	Upgrade healpix

continues on next page

Table 7 – continued from previous page

Symmetrize	*symmetrize*	Mirrors data at the equator
NCL_wind	*uv2vr_cfd*	U and V wind to relative vorticity
	uv2dv_cfd	U and V wind to divergence

2.16.1 Gradsdes

Name

gradsdes - GrADS data descriptor file

Synopsis

cdo gradsdes[,*mapversion*] *infile*

Description

Creates a [GrADS] data descriptor file. Supported file formats are GRIB1, NetCDF, SERVICE, EXTRA and IEG. For GRIB1 files the GrADS map file is also generated. For SERVICE and EXTRA files the grid have to be specified with the **CDO** option '-g <grid>'. This module takes `infile` in order to create filenames for the descriptor (`infile.ctl`) and the map (`infile.gmp`) file.

Parameters

mapversion
: [INTEGER] Format version of the GrADS map file for GRIB1 datasets. Use 1 for a machine specific version 1 GrADS map file, 2 for a machine independent version 2 GrADS map file and 4 to support GRIB files >2GB.

  A version 2 map file can be used only with GrADS version 1.8 or newer.

  A version 4 map file can be used only with GrADS version 2.0 or newer.

  The default is 4 for files >2GB, otherwise 2.

Example

To create a GrADS data descriptor file from a GRIB1 dataset use:

```
cdo gradsdes infile.grb
```

This will create a descriptor file with the name `infile.ctl` and the map file `infile.gmp`.

Assumed the input GRIB1 dataset has 3 variables over 12 timesteps on a regular Gaussian F16 grid. The contents of the resulting GrADS data description file is approximately:

```
DSET  ^infile.grb
DTYPE  GRIB
INDEX  ^infile.gmp
XDEF 64 LINEAR 0.000000 5.625000
YDEF 32 LEVELS -85.761 -80.269 -74.745 -69.213 -63.679 -58.143
               -52.607 -47.070 -41.532 -35.995 -30.458 -24.920
               -19.382 -13.844  -8.307  -2.769   2.769   8.307
                13.844  19.382  24.920  30.458  35.995  41.532
                47.070  52.607  58.143  63.679  69.213  74.745
                80.269  85.761
ZDEF 4 LEVELS 925 850 500 200
TDEF 12 LINEAR 12:00Z1jan1987 1mo
TITLE  infile.grb  T21 grid
OPTIONS yrev
UNDEF  -9e+33
VARS  3
geosp    0  129,1,0  surface geopotential (orography)  [m^2/s^2]
t        4  130,99,0  temperature  [K]
tslm1    0  139,1,0  surface temperature of land  [K]
ENDVARS
```

Author

Uwe Schulzweida

2.16.2 Afterburner

Name

after - ECHAM standard post processor

Synopsis

cdo after[,*vct*] *infile outfile*

Description

The *afterburner* is the standard post processor for [ECHAM] GRIB and NetCDF data which provides the following operations:

- Extract specified variables and levels
- Compute derived variables
- Transform spectral data to Gaussian grid representation
- Vertical interpolation to pressure levels
- Compute temporal means

This operator reads selection parameters as namelist from stdin. Use the UNIX redirection "<namelistfile" to read the namelist from file.

The input files can't be combined with other **CDO** operators because of an optimized reader for this operator.

Namelist

Namelist parameter and there defaults:

```
TYPE=0, CODE=-1, LEVEL=-1, INTERVAL=0, MEAN=0, EXTRAPOLATE=1
```

`TYPE` controls the transformation and vertical interpolation. Transforming spectral data to Gaussian grid representation and vertical interpolation to pressure levels are performed in a chain of steps. The `TYPE` parameter may be used to stop the chain at a certain step. Valid values are:

```
TYPE  =  0 : Hybrid   level spectral coefficients
TYPE  = 10 : Hybrid   level fourier  coefficients
TYPE  = 11 : Hybrid   level zonal mean sections
TYPE  = 20 : Hybrid   level gauss grids
TYPE  = 30 : Pressure level gauss grids
TYPE  = 40 : Pressure level fourier  coefficients
TYPE  = 41 : Pressure level zonal mean sections
TYPE  = 50 : Pressure level spectral coefficients
TYPE  = 60 : Pressure level fourier  coefficients
TYPE  = 61 : Pressure level zonal mean sections
TYPE  = 70 : Pressure level gauss grids
```

Vorticity, divergence, streamfunction and velocity potential need special treatment in the vertical transformation. They are not available as types 30, 40 and 41. If you select one of these combinations, type is automatically switched to the equivalent types 70, 60 and 61. The type of all other variables will be switched too, because the type is a global parameter.

`CODE` selects the variables by the ECHAM GRIB1 code number (1-255). The default value `-1` processes all detected codes. Derived variables computed by the afterburner:

Code	Name	Longname	Units	Level	Needed Codes
34	low_cld	low cloud		single	223 on modellevel
35	mid_cld	mid cloud		single	223 on modellevel
36	hih_cld	high cloud		single	223 on modellevel
131	u	u-velocity	m/s	atm (ml+pl)	138, 155
132	v	v-velocity	m/s	atm (ml+pl)	138, 155
135	omega	vertical velocity	Pa/s	atm (ml+pl)	138, 152, 155
148	stream	streamfunction	m^2/s	atm (ml+pl)	131, 132
149	velopot	velocity potential	m^2/s	atm (ml+pl)	131, 132
151	slp	mean sea level pressure	Pa	surface	129, 130, 152
156	geopoth	geopotential height	m	atm (ml+pl)	129, 130, 133, 152
157	rhumidity	relative humidity		atm (ml+pl)	130, 133, 152
189	sclfs	surface solar cloud forcing		surface	176-185
190	tclfs	surface thermal cloud forcing		surface	177-186
191	sclf0	top solar cloud forcing		surface	178-187
192	tclf0	top thermal cloud forcing		surface	179-188
259	windspeed	windspeed	m/s	atm (ml+pl)	sqrt(u*u+v*v)
260	precip	total precipitation		surface	142+143

LEVEL selects the hybrid or pressure levels. The allowed values depends on the parameter TYPE. The default value -1 processes all detected levels.

INTERVAL selects the processing interval. The default value 0 process data on monthly intervals. INTERVAL=1 sets the interval to daily.

MEAN=1 compute and write monthly or daily mean fields. The default value 0 writes out all timesteps.

EXTRAPOLATE=0 switch of the extrapolation of missing values during the interpolation from model to pressure level (only available with MEAN=0 and TYPE=30). The default value 1 extrapolate missing values.

Possible combinations of TYPE, CODE and MEAN:

TYPE	CODE		MEAN
0/10/11	130	temperature	0
0/10/11	131	u-velocity	0
0/10/11	132	v-velocity	0
0/10/11	133	specific humidity	0
0/10/11	138	vorticity	0
0/10/11	148	streamfunction	0
0/10/11	149	velocity potential	0
0/10/11	152	LnPs	0
0/10/11	155	divergence	0
>11	all	codes	0/1

Parameters

vct
[STRING] File with VCT in ASCII format

Example

To interpolate ECHAM hybrid model level data to pressure levels of 925, 850, 500 and 200 hPa, use:

```
cdo after infile outfile << EON
   TYPE=30  LEVEL=92500,85000,50000,20000
EON
```

2.16.3 Filter

Name

bandpass, lowpass, highpass - Time series filtering

Synopsis

cdo bandpass,*fmin*,*fmax* *infile* *outfile*

cdo lowpass,*fmin* *infile* *outfile*

cdo highpass,*fmax* *infile* *outfile*

Description

This module takes the time series for each gridpoint in `infile` and (fast fourier) transforms it into the frequency domain. According to the particular operator and its parameters certain frequencies are filtered (set to zero) in the frequency domain and the spectrum is (inverse fast fourier) transformed back into the time domain. To determine the frequency the time-axis of `infile` is used. (Data should have a constant time increment since this assumption applies for transformation. However, the time increment has to be different from zero.) All frequencies given as parameter are interpreted per year. This is done by the assumption of a 365-day calendar. Consequently if you want to perform multiyear-filtering accurately you have to delete the 29th of February. If your `infile` has a 360 year calendar the frequency parameters **fmin** respectively **fmax** should be multiplied with a factor of 360/365 in order to obtain accurate results. For the set up of a frequency filter the frequency parameters have to be adjusted to a frequency in the data. Here **fmin** is rounded down and **fmax** is always rounded up. Consequently it is possible to use bandpass with **fmin=fmax** without getting a zero-field for `outfile`. Hints for efficient usage:

- to get reliable results the time-series has to be detrended (cdo detrend)
- the lowest frequency greater zero that can be contained in infile is 1/(N*dT),
- the greatest frequency is 1/(2dT) (Nyquist frequency),

with N the number of timesteps and dT the time increment of `infile` in years.

Missing value support for operators in this module is not implemented, yet!

Operators

bandpass
Bandpass filtering

Bandpass filtering (pass for frequencies between **fmin** and **fmax**). Suppresses all variability outside the frequency range specified by [**fmin**,**fmax**].

highpass
Highpass filtering

Highpass filtering (pass for frequencies greater than **fmin**). Suppresses all variability with frequencies lower than **fmin**.

lowpass
Lowpass filtering

Lowpass filtering (pass for frequencies lower than **fmax**). Suppresses all variability with frequencies greater than **fmax**.

Parameters

fmin
[FLOAT] Minimum frequency per year that passes the filter.

fmax
[FLOAT] Maximum frequency per year that passes the filter.

Note

For better performance of these operators use the **CDO** configure option –with-fftw3.

Example

Now assume your data are still hourly for a time period of 5 years but with a 365/366-day-calendar and you want to suppress the variability on timescales greater or equal to one year (we suggest here to use a number x bigger than one (e.g. x=1.5) since there will be dominant frequencies around the peak (if there is one) as well due to the issue that the time series is not of infinite length). Therefor you can use the following:

```
cdo highpass,x -del29feb infile outfile
```

Accordingly you might use the following to suppress variability on timescales shorter than one year:

```
cdo lowpass,1 -del29feb infile outfile
```

Finally you might be interested in 2-year variability. If you want to suppress the seasonal cycle as well as say the longer cycles in climate system you might use:

```
cdo bandpass,x,y -del29feb infile outfile
```

with x<=0.5 and y >=0.5.

Author

Cedrick Ansorge

2.16.4 Gridcell

Name

gridarea, gridweights - Grid cell quantities

Synopsis

cdo <*operator*>[,*parameters*] *infile outfile*

Description

This module reads the grid cell area of the first grid from the input stream. If the grid cell area is missing it will be computed from the grid coordinates. The area of a grid cell is calculated using spherical triangles from the coordinates of the center and the vertices. The base is a unit sphere which is scaled with the radius of the planet. The default planet radius is 6371000 meter. The parameter **radius** or the environment variable *PLANET_RADIUS* can be used to change the default. Depending on the chosen operator the grid cell area or weights are written to the output stream.

Operators

gridarea
Grid cell area

Writes the grid cell area to the output stream. If the grid cell area have to be computed it is scaled with the planet radius to square meters.

gridweights
Grid cell weights

Writes the grid cell area weights to the output stream.

Parameters

radius
[FLOAT] Planet radius in meter

Environment

`PLANET_RADIUS`
This variable is used to scale the computed grid cell areas to square meters. By default PLANET_RADIUS is set to an earth radius of 6371000 meter.

Author

Uwe Schulzweida

2.16.5 Smooth

Name

smooth, smooth9 - Smooth grid points

Synopsis

cdo smooth[,*parameters*] *infile outfile*

cdo smooth9 *infile outfile*

Description

Smooth all grid points of a horizontal grid.

Operators

smooth
: Smooth grid points

  Performs a N point smoothing on all input fields. The number of points used depend on the search radius (radius) and the maximum number of points (maxpoints). Per default all points within the search radius of 1degree are used. The weights for the points depend on the weighting method and the distance. The implemented weighting method is linear with constant default weights of 0.25 at distance 0 (weight0) and at the search radius (weightR).

smooth9
: 9 point smoothing

  Performs a 9 point smoothing on all fields with a quadrilateral curvilinear grid. The result at each grid point is a weighted average of the grid point plus the 8 surrounding points. The center point receives a weight of 1.0, the points at each side and above and below receive a weight of 0.5, and corner points receive a weight of 0.3. All 9 points are multiplied by their weights and summed, then divided by the total weight to obtain the smoothed value. Any missing data points are not included in the sum; points beyond the grid boundary are considered to be missing. Thus the final result may be the result of an averaging with less than 9 points.

Parameters

nsmooth
: [INTEGER] Number of times to smooth, default nsmooth=1

radius
: [STRING] Search radius, default radius=1deg (units: deg, rad, km, m)

maxpoints
: [INTEGER] Maximum number of points, default maxpoints=<gridsize>

weighted
: [STRING] Weighting method, default weighted=linear

weight0
: [FLOAT] Weight at distance 0, default weight0=0.25

weightR
: [FLOAT] Weight at the search radius, default weightR=0.25

Author

Uwe Schulzweida, Cedrick Ansorge

2.16.6 Deltat

Name

deltat - Difference between timesteps

Synopsis

cdo deltat *infile outfile*

Description

This operator computes the difference between each timestep.

Author

Uwe Schulzweida

2.16.7 Replacevalues

Name

setvals, setrtoc, setrtoc2 - Replace data values

Synopsis

cdo setvals,*oldval*,*newval* *infile* *outfile*

cdo setrtoc,*rmin*,*rmax*,*c* *infile* *outfile*

cdo setrtoc2,*rmin*,*rmax*,*c*,*c2* *infile* *outfile*

Description

This module replaces old variable values with new values, depending on the operator.

Operators

setvals
: Set list of old values to new values

  Supply a list of n pairs of old and new values.

setrtoc
: Set range to constant

$$o(t,x) = \begin{cases} \mathbf{c} & \text{if } \ i(t,x) \geq \mathbf{rmin} \wedge i(t,x) \leq \mathbf{rmax} \\ i(t,x) & \text{if } \ i(t,x) < \mathbf{rmin} \vee i(t,x) > \mathbf{rmax} \end{cases}$$

setrtoc2
: Set range to constant others to constant2

$$o(t,x) = \begin{cases} \mathbf{c} & \text{if } \ i(t,x) \geq \mathbf{rmin} \wedge i(t,x) \leq \mathbf{rmax} \\ \mathbf{c2} & \text{if } \ i(t,x) < \mathbf{rmin} \vee i(t,x) > \mathbf{rmax} \end{cases}$$

Parameters

oldval,newval,...
: [FLOAT] Pairs of old and new values

rmin
: [FLOAT] Lower bound

rmax
: [FLOAT] Upper bound

c
: [FLOAT] New value - inside range

c2
: [FLOAT] New value - outside range

Author

Etienne Tourigny

2.16.8 Getgridcell

Name

gridcellindex - Get grid cell index

Synopsis

cdo gridcellindex,*parameters infile*

Description

Get the grid cell index of one grid point selected by the parameter lon and lat.

Parameters

lon
: [FLOAT] Longitude of the grid cell in degree

lat
: [FLOAT] Latitude of the grid cell in degree

Example

The grid cell index of a data set on an F80 regular Gaussian grid at lon=10/lat=53.5 is 10250:

```
cdo gridcellindex,lon=10,lat=53.5 F80data
```

Author

Uwe Schulzweida

2.16.9 Vargen

Name

const, random, topo, seq, stdatm - Generate a field

Synopsis

cdo const,*const*,*grid outfile*

cdo random,*grid*[,*seed*] *outfile*

cdo topo,*grid outfile*

cdo seq,*start*,*end*[,*inc*] *outfile*

cdo stdatm,*levels outfile*

Description

Generates a dataset with one or more fields.

Operators

const
Create a constant field

Creates a constant field. All field elements of the grid have the same value.

random
Create a field with random numbers

Creates a field with rectangularly distributed random numbers in the interval [0,1].

topo
Create a field with topography

Creates a field with topography data, per default on a global half degree grid.

seq
Create a time series

Creates a time series with field size 1 and field elements beginning with a start value in time step 1 which is increased from one time step to the next.

stdatm
Create values for pressure and temperature for hydrostatic atmosphere

Creates pressure and temperature values for the given list of vertical levels. The formulas are:

$$P(z) = P_0 \exp\left(-\frac{g}{R}\frac{H}{T_0}\log\left(\frac{\exp\left(\frac{z}{H}\right)T_0 + \Delta T}{T_0 + \Delta T}\right)\right)$$

$$T(z) = T_0 + \Delta T \exp\left(-\frac{z}{H}\right)$$

with the following constants

$$\begin{aligned}
T_0 &= 213\text{K} : \text{offset to get a surface temperature of 288K}\\
\Delta T &= 75\text{K} : \text{Temperature lapse rate for 10Km}\\
P_0 &= 1013.25\text{hPa} : \text{surface pressure}\\
H &= 10000.0\text{m} : \text{scale height}\\
g &= 9.80665\frac{\text{m}}{\text{s}^2} : \text{earth gravity}\\
R &= 287.05\frac{\text{J}}{\text{kgK}} : \text{gas constant for air}
\end{aligned}$$

This is the solution for the hydrostatic equations and is only valid for the troposphere (constant positive lapse rate). The temperature increase in the stratosphere and other effects of the upper atmosphere are not taken into account.

Parameters

const
: [FLOAT] Constant

seed
: [INTEGER] The seed for a new sequence of pseudo-random numbers [default: 1]

grid
: [STRING] Target grid description file or name

start
: [FLOAT] Start value of the loop

end
: [FLOAT] End value of the loop

inc
: [FLOAT] Increment of the loop [default: 1]

levels
: [FLOAT] Target levels in metre above surface

Example

To create a standard atmosphere dataset on a given horizontal grid:

```
cdo enlarge,gridfile -stdatm,10000,8000,5000,3000,2000,1000,500,200,0 outfile
```

Author

Uwe Schulzweida, Ralf Müller

2.16.10 Timsort

Name

timsort - Temporal sorting

Synopsis

cdo timsort *infile outfile*

Description

Sorts the elements in ascending order over all timesteps for every field position. After sorting it is:

$o(t_1, x) <= o(t_2, x) \; \forall (t_1 < t_2), x$

Example

To sort all field elements of a dataset over all timesteps use:

```
cdo timsort infile outfile
```

Author

Uwe Schulzweida

2.16.11 WindTrans

Name

uvDestag, rotuvNorth, projuvLatLon - Wind transformation

Synopsis

cdo uvDestag,*u*,*v*[,-/+0.5,-/+0.5] *infile outfile*

cdo rotuvNorth,*u*,*v* *infile outfile*

cdo projuvLatLon,*u*,*v* *infile outfile*

Description

This module contains special operators for datsets with wind components on a rotated lon/lat grid, e.g. data from the regional model HIRLAM or [REMO].

Operators

uvDestag
Destaggering of u/v wind components

This is a special operator for destaggering of wind components. If the file contains a grid with temperature (name='t' or code=11) then grid_temp will be used for destaggered wind.

rotuvNorth
Rotate u/v wind to North pole

This is an operator for transformation of wind-vectors from grid-relative to north-pole relative for the whole file. (FAST implementation with JACOBIANS)

projuvLatLon
Cylindrical Equidistant projection

Thus is an operator for transformation of wind-vectors from the globe-spherical coordinate system into a flat Cylindrical Equidistant (lat-lon) projection. (FAST JACOBIAN implementation)

Parameters

u,v
[STRING] Pair of u,v wind components (use variable names or code numbers)

-/+0.5,-/+0.5
[STRING] Destaggered grid offsets are optional (default -0.5,-0.5)

Example

Typical operator sequence on HIRLAM NWP model output (LAMH_D11 files):

```
cdo uvDestag,33,34   inputfile inputfile_destag
cdo rotuvNorth,33,34 inputfile_destag inputfile_rotuvN
```

Author

Michal Koutek

2.16.12 Rotuv

Name

rotuvb - Backward wind rotation

Synopsis

cdo rotuvb,*u*,*v*[, . . .] *infile outfile*

Description

This is a special operator for datasets with wind components on a rotated grid, e.g. data from the regional model [REMO]. It performs a backward transformation of velocity components U and V from a rotated spherical system to a geographical system.

Parameters

u,v
[STRING] Pairs of zonal and meridional velocity components (use variable names or code numbers)

Note

This is a specific implementation for data from the REMO model, it may not work with data from other sources.

Example

To transform the u and v velocity of a dataset from a rotated spherical system to a geographical system use:

```
cdo rotuvb,u,v infile outfile
```

2.16.13 Mrotuvb

Name

mrotuvb - Backward rotation of MPIOM data

Synopsis

cdo mrotuvb *infile1 infile2 outfile*

Description

MPIOM data are on a rotated Arakawa C grid. The velocity components U and V are located on the edges of the cells and point in the direction of the grid lines and rows. With mrotuvb the velocity vector is rotated in latitudinal and longitudinal direction. Before the rotation, U and V are interpolated to the scalar points (cell center). U is located with the coordinates for U in infile1 and V in infile2. mrotuvb assumes a positive meridional flow for a flow from grid point(i,j) to grid point(i,j+1) and positive zonal flow for a flow from grid point(i+1,j) to point(i,j).

Note

This is a specific implementation for data from the MPIOM model, it may not work with data from other sources.

Author

Uwe Schulzweida

2.16.14 Mastrfu

Name

mastrfu - Mass stream function

Synopsis

cdo mastrfu *infile outfile*

Description

This is a special operator for the post processing of the atmospheric general circulation model [ECHAM]. It computes the mass stream function (code=272). The input dataset have to be a zonal mean of v-velocity [m/s] (code=132) on pressure levels.

Example

To compute the mass stream function from a zonal mean v-velocity dataset use:

```
cdo mastrfu infile outfile
```

2.16.15 Pressure

Name

pressure_half, pressure, delta_pressure - Pressure on model levels

Synopsis

cdo <*operator*> *infile outfile*

Description

This module contains operators to calculate the pressure on model levels. To calculate the pressure on model levels, the a and b coefficients defining the model levels and the surface pressure are required. The a and b coefficients are normally part of the model level data. If not available, the surface pressure can be derived from the logarithm of the surface pressure. The surface pressure is identified by the GRIB1 code number or NetCDF CF standard name.

Name	Units	GRIB1 code	CF standard name
log surface pressure	Pa	152	
surface pressure	Pa	134	surface_air_pressure

Operators

pressure_half
Pressure on half-levels

This operator computes the pressure on model half-levels in pascal. The model half-level pressure (p_half) is given by:

$p\_half = a + b * sp$

with:

a, b: coefficients defining the model levels

sp: surface pressure

pressure
Pressure on full-levels

This operator computes the pressure on model full-levels in pascal. The pressure on model full-levels (p_full) is in the middle of the layers defined by the model half-levels:

$p\_full = (p\_half\_above + p\_half\_below)/2$

delta_pressure
Pressure difference of half-levels

This operator computes the pressure difference between to model half-levels.

$delta\_p = p\_half\_below - p\_half\_above$

Author

Uwe Schulzweida

2.16.16 Derivepar

Name

sealevelpressure, gheight, gheight_half, air_density - Derived model parameters

Synopsis

cdo <*operator*> *infile outfile*

Description

This module contains operators that calculate derived model parameters. All necessary input variables are identified by their GRIB1 code number or the NetCDF CF standard name. Supported GRIB1 parameter tables are: WMO standard table number 2 and ECMWF local table number 128.

CF standard name	Units	GRIB 1 code
surface_air_pressure	Pa	134
air_temperature	K	130
specific_humidity	kg/kg	133
surface_geopotential	m2 s-2	129
geopotential_height	m	156

Operators

sealevelpressure
Sea level pressure

This operator computes the sea level pressure (air_pressure_at_sea_level). Required input fields are surface_air_pressure, surface_geopotential and air_temperature on full hybrid sigma pressure levels.

gheight
Geopotential height on full-levels

This operator computes the geopotential height (geopotential_height) on model full-levels in metres. Required input fields are surface_air_pressure, surface_geopotential, specific_humidity and air_temperature on full hybrid sigma pressure levels. Note, this procedure is an approximation, which doesn't take into account the effects of e.g. cloud ice and water, rain and snow.

gheight_half
Geopotential height on half-levels

This operator computes the geopotential height (geopotential_height) on model half-levels in metres. Required input fields are surface_air_pressure, surface_geopotential, specific_humidity and air_temperature on full hybrid sigma pressure levels. Note, this procedure is an approximation, which doesn't take into account the effects of e.g. cloud ice and water, rain and snow.

air_density
Air density

This operator computes the air density, it depends on pressure, humidity and temperature. Required input fields are surface_air_pressure, specific_humidity and air_temperature on full hybrid sigma pressure levels. The air density (rho) is calculated with the following formula:

$rho = P/Rs * Tv$

P: air pressure in Pascal

Tv: virtual temperature in Kelvin

Rs: specific gas constant for try air; 287.085 J/(kg*K)

$$Tv = T * [1 + a * q]$$

T: air temperature in Kelvin
q: specific humidity
a: gas constants of air and water vapor; 0.6078

Author

Uwe Schulzweida

2.16.17 Adisit

Name

adisit, adipot - Potential temperature to in-situ temperature and vice versa

Synopsis

cdo <*operator*>[,*pressure*] *infile outfile*

Operators

adisit
Potential temperature to in-situ temperature

This is a special operator for the post processing of the ocean and sea ice model [MPIOM]. It converts potential temperature adiabatically to in-situ temperature to(t, s, p). Required input fields are sea water potential temperature (name=tho; code=2) and sea water salinity (name=sao; code=5). Pressure is calculated from the level information or can be specified by the optional parameter. Output fields are sea water temperature (name=to; code=20) and sea water salinity (name=s; code=5).

adipot
In-situ temperature to potential temperature

This is a special operator for the post processing of the ocean and sea ice model [MPIOM]. It converts in-situ temperature to potential temperature tho(to, s, p). Required input fields are sea water in-situ temperature (name=t; code=2) and sea water salinity (name=sao,s; code=5). Pressure is calculated from the level information or can be specified by the optional parameter. Output fields are sea water temperature (name=tho; code=2) and sea water salinity (name=s; code=5).

Parameters

pressure
[FLOAT] Pressure in bar (constant value assigned to all levels)

Author

Uwe Schulzweida, Helmut Haak

2.16.18 Rhopot

Name

rhopot - Calculates potential density

Synopsis

cdo rhopot[,*pressure*] *infile outfile*

Description

This is a special operator for the post processing of the ocean and sea ice model [MPIOM]. It calculates the sea water potential density (name=rhopoto; code=18). Required input fields are sea water in-situ temperature (name=to; code=20) and sea water salinity (name=sao; code=5). Pressure is calculated from the level information or can be specified by the optional parameter.

Parameters

pressure
    [FLOAT] Pressure in bar (constant value assigned to all levels)

Example

To compute the sea water potential density from the potential temperature use this operator in combination with *adisit*:

```
cdo rhopot -adisit infile outfile
```

2.16.19 Histogram

Name

histcount, histsum, histmean, histfreq - Histogram

Synopsis

cdo <*operator*>,*bounds infile outfile*

Description

This module creates bins for a histogram of the input data. The bins have to be adjacent and have non-overlapping intervals. The user has to define the bounds of the bins. The first value is the lower bound and the second value the upper bound of the first bin. The bounds of the second bin are defined by the second and third value, aso. Only 2-dimensional input fields are allowed. The output file contains one vertical level for each of the bins requested.

Operators

histcount
Histogram count

Number of elements in the bin range.

histsum
Histogram sum

Sum of elements in the bin range.

histmean
Histogram mean

Mean of elements in the bin range.

histfreq
Histogram frequency

Relative frequency of elements in the bin range.

Parameters

bounds
[FLOAT] Comma-separated list of the bin bounds (-inf and inf valid)

Author

Ralf Quast

2.16.20 Sethalo

Name

sethalo - Set the bounds of a field

Synopsis

cdo sethalo,*parameter infile outfile*

Description

This operator sets the boundary in the east, west, south and north of the rectangular understood fields. Positive values of the parameters increase the boundary in the selected direction. Negative values decrease the field at the selected boundary. The new rows and columns are filled with the missing value. With the optional parameter value a different fill value can be used. Global cyclic fields are filled cyclically at the east and west borders, if the fill value is not set by the user. All input fields need to have the same horizontal grid.

Parameters

east
[INTEGER] East halo

west
[INTEGER] West halo

south
[INTEGER] South halo

north
[INTEGER] North halo

value
[FLOAT] Fill value (default is the missing value)

Author

Uwe Schulzweida

2.16.21 Wct

Name

wct - Windchill temperature

Synopsis

cdo wct *infile1 infile2 outfile*

Description

Let `infile1` and `infile2` be time series of temperature and wind speed fields, then a corresponding time series of resulting windchill temperatures is written to `outfile`. The wind chill temperature calculation is only valid for a temperature of T <= 33°C and a wind speed of v >= 1.39 m/s. Whenever these conditions are not satisfied, a missing value is written to `outfile`. Note that temperature and wind speed fields have to be given in units of °C and m/s, respectively.

Author

Ralf Quast

2.16.22 Fdns

Name

fdns - Frost days where no snow index per time period

Synopsis

cdo fdns *infile1 infile2 outfile*

Description

Let `infile1` be a time series of the daily minimum temperature TN and `infile2` be a corresponding series of daily surface snow amounts. Then the number of days where TN < 0°C and the surface snow amount is less than 1 cm is counted. The temperature TN have to be given in units of Kelvin. The date information of a timestep in `outfile` is the date of the last contributing timestep in `infile`.

2.16.23 Strwin

Name

strwin - Strong wind days index per time period

Synopsis

cdo strwin[,*v*] *infile outfile*

Description

Let `infile` be a time series of the daily maximum horizontal wind speed VX, then the number of days where VX > v is counted. The horizontal wind speed v is an optional parameter with default v = 10.5 m/s. A further output variable is the maximum number of consecutive days with maximum wind speed greater than or equal to v. Note that both VX and v have to be given in units of m/s. Also note that the horizontal wind speed is defined as the square root of the sum of squares of the zonal and meridional wind speeds. The date information of a timestep in `outfile` is the date of the last contributing timestep in `infile`.

Parameters

v

[FLOAT] Horizontal wind speed threshold (m/s, default v = 10.5 m/s)

2.16.24 Strbre

Name

strbre - Strong breeze days index per time period

Synopsis

cdo strbre[,*v*] *infile outfile*

Description

Let `infile` be a time series of the daily maximum horizontal wind speed VX, then the number of days where VX is greater than or equal to 10.5 m/s is counted. A further output variable is the maximum number of consecutive days with maximum wind speed greater than or equal to 10.5 m/s. Note that VX is defined as the square root of the sum of squares of the zonal and meridional wind speeds and have to be given in units of m/s. The date information of a timestep in `outfile` is the date of the last contributing timestep in `infile`.

2.16.25 Strgal

Name

strgal - Strong gale days index per time period

Synopsis

cdo strgal[,*v*] *infile outfile*

Description

Let `infile` be a time series of the daily maximum horizontal wind speed VX, then the number of days where VX is greater than or equal to 20.5 m/s is counted. A further output variable is the maximum number of consecutive days with maximum wind speed greater than or equal to 20.5 m/s. Note that VX is defined as the square root of the sum of square of the zonal and meridional wind speeds and have to be given in units of m/s. The date information of a timestep in `outfile` is the date of the last contributing timestep in `infile`.

2.16.26 Hurr

Name

hurr - Hurricane days index per time period

Synopsis

cdo hurr *infile outfile*

Description

Let `infile` be a time series of the daily maximum horizontal wind speed VX, then the number of days where VX is greater than or equal to 32.5 m/s is counted. A further output variable is the maximum number of consecutive days with maximum wind speed greater than or equal to 32.5 m/s. Note that VX is defined as the square root of the sum of squares of the zonal and meridional wind speeds and have to be given in units of m/s. The date information of a timestep in `outfile` is the date of the last contributing timestep in `infile`.

2.16.27 CMORlite

Name

cmorlite - CMOR lite

Synopsis

cdo cmorlite,*table*[,*convert*] *infile outfile*

Description

The [CMOR] (Climate Model Output Rewriter) library comprises a set of functions, that can be used to produce CF-compliant NetCDF files that fulfill the requirements of many of the climate community's standard model experiments. These experiments are collectively referred to as MIP's. Much of the metadata written to the output files is defined in MIP-specific tables, typically made available from each MIP's web site.

The **CDO** operator cmorlite process the header and variable section of such MIP tables and writes the result with the internal IO library [CDI]. In addition to the CMOR 2 and 3 table format, the **CDO** parameter table format is also supported. The following parameter table entries are available:

Entry	Type	Description
`name`	WORD	Name of the variable
`out_name`	WORD	New name of the variable
`type`	WORD	Data type (real or double)
`standard_name`	WORD	As defined in the CF standard name table
`long_name`	STRING	Describing the variable
`units`	STRING	Specifying the units for the variable
`comment`	STRING	Information concerning the variable
`cell_methods`	STRING	Information concerning calculation of means or climatologies
`cell_measures`	STRING	Indicates the names of the variables containing cell areas and volumes
`missing_value`	FLOAT	Specifying how missing data will be identified
`valid_min`	FLOAT	Minimum valid value
`valid_max`	FLOAT	Maximum valid value
`ok_min_mean_abs`	FLOAT	Minimum absolute mean
`ok_max_mean_abs`	FLOAT	Maximum absolute mean
`factor`	FLOAT	Scale factor
`delete`	INTEGER	Set to 1 to delete variable
`convert`	INTEGER	Set to 1 to convert the unit if necessary

Most of the above entries are stored as variables attributes, some of them are handled differently. The variable `name` is used as a search key for the parameter table. `valid_min`, `valid_max`, `ok_min_mean_abs` and `ok_max_mean_abs` are used to check the range of the data.

Parameters

table
: [STRING] Name of the CMOR table as specified from PCMDI

convert
: [STRING] Converts the units if necessary

Example

Here is an example of a parameter table for one variable:

```
prompt> cat mypartab
&parameter
name            = t
```

(continues on next page)

(continued from previous page)

```
out_name        = ta
standard_name   = air_temperature
units           = "K"
missing_value   = 1.0e+20
valid_min       = 157.1
valid_max       = 336.3
/
```

To apply this parameter table to a dataset use:

```
cdo -f nc cmorlite,mypartab,convert  infile  outfile
```

This command renames the variable `t` to `ta`. The standard name of this variable is set to `air_temperature` and the unit is set to [K] (converts the unit if necessary). The missing value will be set to `1.0e+20`. In addition it will be checked whether the values of the variable are in the range of `157.1` to `336.3`. The result will be stored in NetCDF.

Author

Uwe Schulzweida

2.16.28 Verifygrid

Name

verifygrid - Verify grid coordinates

Synopsis

cdo verifygrid *infile*

Description

This operator verifies the coordinates of all horizontal grids found in `infile`. Among other things, it searches for duplicate cells, non-convex cells, and whether the center is located outside the cell bounds. Use the **CDO** option -v to output the position of these cells. This information can be useful to avoid problems when interpolating the data.

2.16.29 Healpix

Name

hpdegrade, hpupgrade - Change healpix resolution

Synopsis

cdo [options] *<operator>,parameters infile outfile*

Description

Degrade or upgrade the resolution of a healpix grid.

Operators

hpdegrade
Degrade healpix

Degrade the resolution of a healpix grid. The value of the target pixel is the mean of the source pixels.

hpupgrade
Upgrade healpix

Upgrade the resolution of a healpix grid. The values of the target pixels are the value of the source pixel.

Parameters

nside
[INTEGER] The nside of the target healpix, must be a power of two [default: same as input].

zoom
[INTEGER] **zoom** is the refinement level and the relation to **nside** is: $nside = 2^{zoom}$.

order
[STRING] Pixel ordering of the target healpix ('nested' or 'ring').

power
[FLOAT] If non-zero, divide the result by (nside[in]/nside[out])**power. power=-2 keeps the sum of the map invariant.

Options

`-p`, `--async_read true` to read input data asynchronously.

Author

Uwe Schulzweida

2.16.30 Symmetrize

Name

symmetrize - Mirrors data at the equator

Synopsis

cdo symmetrize[,*parameters*] *infile outfile*

Description

This operator symmetrizes global fields relative to the equator. By default, data with positive latitudes are mirrored. With the parameter **lat**=negative, it is the data with negative latitudes. The result for fields on a global lon/lat or Gaussian grid is perfectly symmetrical. For fields on an unstructured grid, the result is the nearest neighbour of the other hemisphere. Use the **grid** parameter to specify the path to a grid description file if the unstructured data is available without grid coordinates.

Parameters

lat
: [STRING] lat=negative mirrors data with negative latitudes

grid
: [STRING] Grid description file or name

Author

Uwe Schulzweida, Bjorn Stevens

2.16.31 NCL_wind

Name

uv2vr_cfd, uv2dv_cfd - Wind transformation

Synopsis

cdo <*operator*>[,*u,v,boundOpt,outMode*] *infile outfile*

Description

This module contains **CDO** operators with an interface to NCL functions. The corresponding NCL functions have the same name. A more detailed description of those NCL function can be found on the NCL homepage https://www.ncl.ucar.edu.

Operators

uv2vr_cfd
: U and V wind to relative vorticity

  Computes relative vorticity for a latitude-longitude grid using centered finite differences. The grid need not be global and missing values are allowed.

uv2dv_cfd
: U and V wind to divergence

  Computes divergence for a latitude-longitude grid using centered finite differences. The grid need not be global and missing values are allowed.

Parameters

u STRING
: Name of variable u (default: u)

v STRING
: Name of variable v (default: v)

boundOpt INTEGER
: Boundary condition option (0-3) (default: 0/1 for cyclic grids)

outMode STRING
: Output mode new/append (default: new)

Author

Uwe Schulzweida

CHAPTER

THREE

CONTRIBUTORS

3.1 History

CDO was originally developed by Uwe Schulzweida at the Max Planck Institute for Meteorology (MPI-M). The first public release is available since 2003. The MPI-M, together with the DKRZ, has a long history in the development of tools for processing climate data. **CDO** was inspired by some of these tools, such as the [PINGO] package and the GRIB-Modules.

PINGO (Procedural INterface for GRIB formatted Objects) was developed by Jürgen Waszkewitz, Peter Lenzen, and Nathan Gillet in 1995 at the DKRZ, Hamburg (Germany). **CDO** has a similar user interface and uses some of the PINGO operators.

The GRIB-Modules was developed by Heiko Borgert and Wolfgang Welke in 1991 at the MPI-M. **CDO** is using a similar module structure and also some of the operators.

3.2 External sources

CDO has incorporated code from several sources:

afterburner
: is a postprocessing application for ECHAM data and ECMWF analysis data, originally developed by Edilbert Kirk, Michael Ponater and Arno Hellbach. The afterburner code was modified for the **CDO** operators *after*, *ml2pl*, *sp2gp*, *gp2sp*.

SCRIP
: is a software package used to generate interpolation weights for remapping fields from one grid to another in spherical geometry [SCRIP]. It was developed at the Los Alamos National Laboratory by Philip W. Jones. The SCRIP library was converted from Fortran to ANSI C and is used as the base for the remapping operators in **CDO**.

YAC
: (Yet Another Coupler) was jointly developed by DKRZ and MPI-M by Moritz Hanke and René Redler [YAC]. **CDO** is using the clipping and cell search routines for the conservative remapping with *remapcon*.

libkdtree
: a C99 implementation of the kd-tree algorithm developed by Jörg Dietrich.

CDO uses tools from the GNU project, including automake, and libtool.

3.3 Contributors

The primary contributors to the **CDO** development have been:

Uwe Schulzweida : Concept, design and implementation of **CDO**, project coordination, and releases.

Luis Kornblueh : He supports **CDO** from the beginning.
His main contributions are GRIB performance and compression, GME and unstructured grid support.

Luis also helps with design and planning.

Ralf Müller : He is working on **CDO** since 2009.
His main contributions are the implementation of the User Portal,
the ruby and python interface for all **CDO** operators, the building process and the Windows support.
The **CDO** User Portal was funded by the European Commission infracstructure project IS-ENES.
Ralf also helps a lot with the user support.
Implemented operators: *intlevel3d*, *consecsum*, *consects*, *ngrids*, *ngridpoints*, *reducegrid*

Oliver Heidmann : He is working on **CDO** since 2015.
His main contributions are refactoring to C++ and the new command line parser.

Karin Meier-Fleischer : She is working in the **CDO** user support since 2017.

Fabian Wachsmann : He is working on **CDO** for the CMIP6 project since 2016.
His main task is the implementation and support of the cmor operator.
He has also implemented the ETCCDI Indices of Daily Temperature and Precipitation Extremes.

Cedrick Ansorge : He worked on the software package **CDO** from 2007-2011.
Implemented operators: *eof*, *eof3d*, *enscrps*, *ensbrs*, *maskregion*, *bandpass*, *lowpass*, *highpass*, *smooth9*

Ralf Quast : He worked on **CDO** on behalf of the Service Gruppe Anpassung (SGA), DKRZ in 2006.
He implemented all ECA Indices of Daily Temperature and Precipitation Extremes,
all percentile operators, module *Ydrunstat* and *wct*.

Kameswarrao Modali : He worked on **CDO** from 2012-2013.
Implemented operators: contour, shaded, grfill, vector, graph.

Michal Koutek : Implemented operators: *selmulti*, *delmulti*, *changemulti*, *samplegrid*,
uvDestag, *rotuvNorth*, *projuvLatLon*.

Etienne Tourigny : Implemented operators: *setclonlatbox*, *setcindexbox*,
splitsel, *histfreq*, *setvals*, *setrtoc*, *setrtoc2*.

Karl-Hermann Wieners : Implemented operators: *aexpr*, *aexprf*, *selzaxisname*.

Asela Rajapakse : He worked on **CDO** from 2016-2017 as part of the EUDAT project.
Implemented operator: *verifygrid*

Estanislao Gavilan : Improved the **CDO** documentation for the installation section.

Many users have contributed to **CDO** by sending bug reports, patches and suggestions over time. Very helpful is also the active participation in the user forum of some users. Here is an incomplete list:

Jaison-Thomas Ambadan, Harald Anlauf, Andy Aschwanden, Stefan Bauer, Simon Blessing, Renate Brokopf, Michael Boettinger, Tim Brücher, Reinhard Budich, Martin Claus, Traute Crüger, Brendan de Tracey, Irene Fischer-Bruns, Chris Fletscher, Helmut Frank, Kristina Fröhlich, Oliver Fuhrer, Monika Esch, Pier Giuseppe Fogli, Beate Gayer, Veronika Gayler, Marco Giorgetta, David Gobbett, Holger Goettel, Helmut Haak, Stefan Hagemann, Angelika Heil, Barbara Hennemuth, Daniel Hernandez, Nathanael Huebbe, Thomas Jahns, Frank Kaspar, Daniel Klocke, Edi Kirk, Stefanie Legutke, Leonidas Linardakis, Stephan Lorenz, Frank Lunkeit, Uwe Mikolajewicz, Laura Niederdrenk, Dirk Notz, Hans-Jürgen Panitz, Ronny Petrik, Swantje Preuschmann, Florian Prill, Asela Rajapakse, Daniel Reinert, Hannes Reuter, Mathis Rosenhauer, Reiner Schnur, Martin Schultz, Dennis Shea, Kevin Sieck, Martin Stendel, Bjorn Stevens, Martina Stockhaus, Claas Teichmann, Adrian Tompkins, Jörg Trentmann, Álvaro M. Valdebenito, Geert Jan van Oldenborgh, Jin-Song von Storch, David Wang, Joerg Wegner, Heiner Widmann, Claudia Wunram, Klaus Wyser

Please let me know if your name was omitted!

CHAPTER

FOUR

ENVIRONMENT VARIABLES

The following environment variables affect the behavior of **CDO**:

CDO_DOWNLOAD_PATH

Path where **CDO** can store downloads.

CDO_FILE_SUFFIX

Sets the filename suffix. This suffix will be added to the output file name instead of the filename extension derived from the file format. `CDO_FILE_SUFFIX=NULL` will disable the adding of a file suffix. A filename suffix is used in **CDO** operators which generate file names (e.g. *Split*).

CDO_GRIDSEARCH_RADIUS

Sets the grid search radius in degree (default: `CDO_GRIDSEARCH_RADIUS=180`). Used by the operators *setmisstonn* and *remapknn*.

CDO_HISTORY_INFO

'false' don't write information to the global *history* attribute (default: `CDO_HISTORY_INFO=true`).

CDO_ICON_GRIDS

Root directory of the installed ICON grids (e.g. */pool/data/ICON*).

CDO_PCTL_NBINS

Sets the number of histogram bins (default: `CDO_PCTL_NBINS=101`). Histograms are used to calculate the percentile over time.

CDO_REMAP_NORM

This variable is used to choose the normalization of the conservative interpolation. By default `CDO_REMAP_NORM` is set to 'fracarea'. 'fracarea' uses the sum of the non-masked source cell intersected areas to normalize each target cell field value. This results in a reasonable flux value but the flux is not locally conserved. The option 'destarea' uses the total target cell area to normalize each target cell field value. Local flux conservation is ensured, but unreasonable flux values may result.

CDO_RESET_HISTORY

'true' resets the global *history* attribute (default: `CDO_RESET_HISTORY=false`).

CDO_VERSION_INFO

'false' disables the global NetCDF attribute **CDO** (default: `CDO_VERSION_INFO=true`).

REMAP_AREA_MIN

This variable is used to set the minimum destination area fraction (default: `REMAP_AREA_MIN=0.0`). Used by the operators *remapcon* and *remaplaf*.

REMAP_EXTRAPOLATE

This variable is used to switch the extrapolation feature 'on' or 'off'. Extrapolation is used in remapping.

CHAPTER

FIVE

PARALLELIZED OPERATORS

Some of the **CDO** operators are parallelized with OpenMP. To use **CDO** with multiple OpenMP threads, you have to set the number of threads with the option '-P'. Here is an example to distribute the bilinear interpolation on 8 OpenMP threads:

```
cdo -P 8  remapbil,targetgrid  infile  outfile
```

The following **CDO** operators are parallelized with OpenMP:

Module	Operator	Description
Afterburner	after	ECHAM standard post processor
Detrend	detrend	Detrend
EcaEtccdi	etccdi_tx90p	% of days when daily max temperature is > the 90th percentile
EcaEtccdi	etccdi_tx10p	% of days when daily max temperature is < the 10th percentile
EcaEtccdi	etccdi_tn90p	% of days when daily min temperature is > the 90th percentile
EcaEtccdi	etccdi_tn10p	% of days when daily min temperature is < the 10th percentile
EcaEtccdi	etccdi_r95p	Annual tot precip when daily precip exceeds the 95th percentile of Wet Day Precipitation
EcaEtccdi	etccdi_r99p	Annual tot precip when daily precip exceeds the 99th percentile of Wet Day Precipitation
Ensstat	ens<STAT>	Statistical values over an ensemble
EOF	eof	Empirical Orthogonal Functions
Fillmiss	setmisstonn	Set missing value to nearest neighbor
Fillmiss	setmisstodis	Set missing value to distance-weighted average
Filter	bandpass	Bandpass filtering
Filter	lowpass	Lowpass filtering
Filter	highpass	Highpass filtering
Fourier	fourier	Fourier transformation
Genweights	genbil	Generate bilinear interpolation weights
Genweights	genbic	Generate bicubic interpolation weights
Genweights	gendis	Generate distance-weighted average remap weights
Genweights	gennn	Generate nearest neighbor remap weights
Genweights	gencon	Generate 1st order conservative remap weights
Genweights	genlaf	Generate largest area fraction remap weights
Gridboxstat	gridbox<STAT>	Statistical values over grid boxes
Intlevel	intlevel	Linear level interpolation
Intlevel3d	intlevel3d	Linear level interpolation from/to 3D vertical coordinates
Remapeta	remapeta	Remap vertical hybrid level
Remap	remapbil	Bilinear interpolation
Remap	remapbic	Bicubic interpolation
Remap	remapdis	Distance-weighted average remapping
Remap	remapnn	Nearest neighbor remapping
Remap	remapcon	First order conservative remapping
Remap	remaplaf	Largest area fraction remapping
Smooth	smooth	Smooth grid points
Spectral	sp2gp, gp2sp	Spectral transformation

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Table 1 – continued from previous page

Module	Operator	Description
Vertintap	ap2pl, ap2hl	Vertical interpolation on hybrid sigma height coordinates
Vertintgh	gh2hl	Vertical height interpolation
Vertintml	ml2pl, ml2hl	Vertical interpolation on hybrid sigma pressure coordinates

CHAPTER

SIX

STANDARD NAME TABLE

The following CF standard names are supported by **CDO**.

CF standard name	Units	GRIB 1 code	variable name
surface_geopotential	m2 s-2	129	geosp
air_temperature	K	130	ta
specific_humidity	1	133	hus
surface_air_pressure	Pa	134	aps
air_pressure_at_sea_level	Pa	151	psl
geopotential_height	m	156	zg

CHAPTER

SEVEN

GRID DESCRIPTION EXAMPLES

7.1 Example of a curvilinear grid description

Here is an example for the **CDO** description of a curvilinear grid. xvals/yvals describe the positions of the 6x5 quadrilateral grid cells. The first 4 values of xbounds/ybounds are the corners of the first grid cell.

```
gridtype  = curvilinear
gridsize  = 30
xsize     = 6
ysize     = 5
xvals     =   -21  -11    0   11   21   30  -25  -13    0   13
               25   36  -31  -16    0   16   31   43  -38  -21
                0   21   38   52  -51  -30    0   30   51   64
xbounds   =   -23  -14  -17  -28       -14   -5   -6  -17        -5    5    6   -6
                5   14   17    6        14   23   28   17        23   32   38   28
              -28  -17  -21  -34       -17   -6   -7  -21        -6    6    7   -7
                6   17   21    7        17   28   34   21        28   38   44   34
              -34  -21  -27  -41       -21   -7   -9  -27        -7    7    9   -9
                7   21   27    9        21   34   41   27        34   44   52   41
              -41  -27  -35  -51       -27   -9  -13  -35        -9    9   13  -13
                9   27   35   13        27   41   51   35        41   52   63   51
              -51  -35  -51  -67       -35  -13  -21  -51       -13   13   21  -21
               13   35   51   21        35   51   67   51        51   63   77   67
yvals     =    29   32   32   32   29   26   39   42   42   42
               39   35   48   51   52   51   48   43   57   61
               62   61   57   51   65   70   72   70   65   58
ybounds   =    23   26   36   32        26   27   37   36        27   27   37   37
               27   26   36   37        26   23   32   36        23   19   28   32
               32   36   45   41        36   37   47   45        37   37   47   47
               37   36   45   47        36   32   41   45        32   28   36   41
               41   45   55   50        45   47   57   55        47   47   57   57
               47   45   55   57        45   41   50   55        41   36   44   50
               50   55   64   58        55   57   67   64        57   57   67   67
               57   55   64   67        55   50   58   64        50   44   51   58
               58   64   72   64        64   67   77   72        67   67   77   77
               67   64   72   77        64   58   64   72        58   51   56   64
```

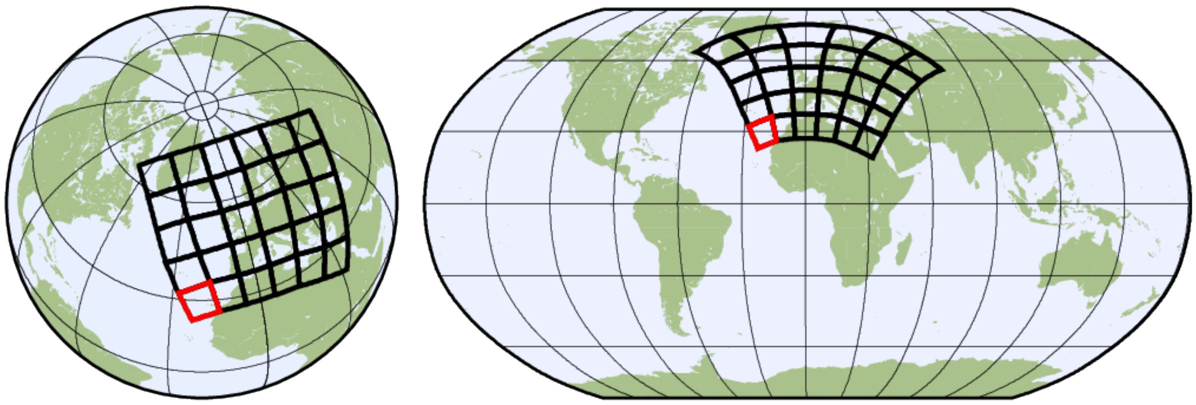

Fig. 1: Orthographic and Robinson projection of the curvilinear grid, the first grid cell is colored red

7.2 Example description for an unstructured grid

Here is an example of the **CDO** description for an unstructured grid. xvals/yvals describe the positions of 30 independent hexagonal grid cells. The first 6 values of xbounds/ybounds are the corners of the first grid cell. The grid cell corners have to rotate counterclockwise. The first grid cell is colored red.

```
gridtype  = unstructured
gridsize  = 30
nvertex   = 6
xvals     =  -36   36    0  -18   18  108   72   54   90  180  144  126  162 -108 -144
            -162 -126  -72  -90  -54    0   72   36  144  108 -144  180  -72 -108  -36
xbounds   =  339    0    0  288  288  309       21   51   72   72    0    0
               0   16   21    0  339  344      340    0   -0  344  324  324
              20   36   36   16    0    0       93  123  144  144   72   72
              72   88   93   72   51   56       52   72   72   56   36   36
              92  108  108   88   72   72      165  195  216  216  144  144
             144  160  165  144  123  128      124  144  144  128  108  108
             164  180  180  160  144  144      237  267  288  288  216  216
             216  232  237  216  195  200      196  216  216  200  180  180
             236  252  252  232  216  216      288  304  309  288  267  272
             268  288  288  272  252  252      308  324  324  304  288  288
             345  324  324   36   36   15       36   36  108  108   87   57
              20   15   36   57   52   36      108  108  180  180  159  129
              92   87  108  129  124  108      180  180  252  252  231  201
             164  159  180  201  196  180      252  252  324  324  303  273
             236  231  252  273  268  252      308  303  324  345  340  324
yvals     =   58   58   32    0    0   58   32    0    0   58   32    0    0   58   32
               0    0   32    0    0  -58  -58  -32  -58  -32  -58  -32  -58  -32  -32
ybounds   =   41   53   71   71   53   41       41   41   53   71   71   53
              11   19   41   53   41   19      -19   -7   11   19    7  -11
             -19  -11    7   19   11   -7       41   41   53   71   71   53
              11   19   41   53   41   19      -19   -7   11   19    7  -11
             -19  -11    7   19   11   -7       41   41   53   71   71   53
              11   19   41   53   41   19      -19   -7   11   19    7  -11
             -19  -11    7   19   11   -7       41   41   53   71   71   53
              11   19   41   53   41   19      -19   -7   11   19    7  -11
             -19  -11    7   19   11   -7       11   19   41   53   41   19
             -19   -7   11   19    7  -11      -19  -11    7   19   11   -7
             -41  -53  -71  -71  -53  -41      -53  -71  -71  -53  -41  -41
             -19  -41  -53  -41  -19  -11      -53  -71  -71  -53  -41  -41
             -19  -41  -53  -41  -19  -11      -53  -71  -71  -53  -41  -41
             -19  -41  -53  -41  -19  -11      -53  -71  -71  -53  -41  -41
             -19  -41  -53  -41  -19  -11      -19  -41  -53  -41  -19  -11
```

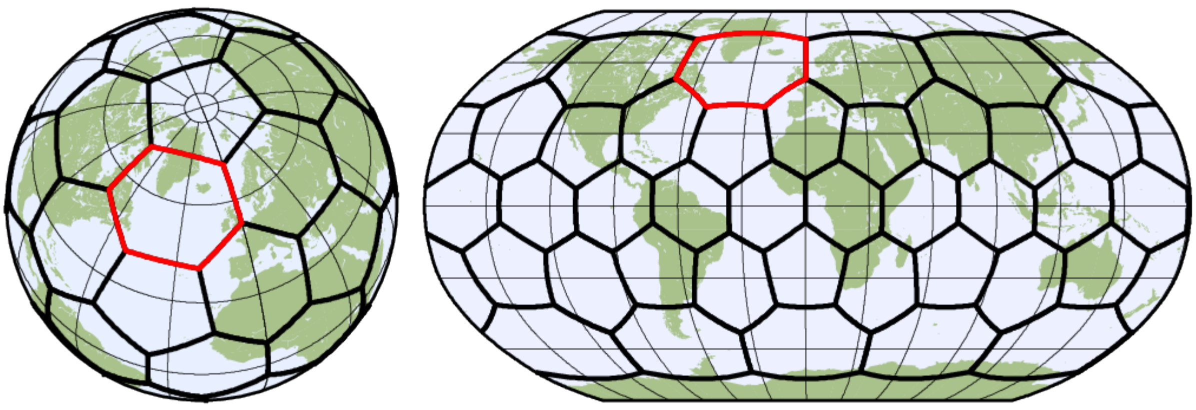

Fig. 2: Orthographic and Robinson projection of the unstructured grid

CHAPTER

EIGHT

ALPHABETIC LIST OF OPERATORS

abs	Absolute value
acos	Arc cosine
add	Add two fields
addc	Add a constant
addtrend	Add trend
adipot	In-situ temperature to potential temperature
adisit	Potential temperature to in-situ temperature
aexpr	Evaluate expressions and append results
aexprf	Evaluate expression script and append results
after	ECHAM standard post processor
air_density	Air density
ap2pl	Vertical pressure interpolation
asin	Arc sine
atan	Arc tangent
atan2	Arc tangent of two fields
bandpass	Bandpass filtering
bitrounding	Bit rounding
bottomvalue	Extract bottom level
cat	Concatenate datasets
changemulti	Change identification of multiple fields
chcode	Change code number
chlevel	Change level
chlevelc	Change level of one code
chlevelv	Change level of one variable
chname	Change variable or coordinate name
chparam	Change parameter identifier
chunit	Change variable unit
cinfo	Compact information listed by name
clone	Clone datasets
cmor	Climate Model Output Rewriting to produce CMIP-compliant data
cmorlite	CMOR lite
codetab	Parameter code table
collgrid	Collect horizontal grid
consecsum	Consecutive Sum
consects	Consecutive Timesteps
const	Create a constant field
contour	Contour plot
copy	Copy datasets
cos	Cosine
dayadd	Add daily time series
dayavg	Daily average
daydiv	Divide daily time series
daymax	Daily maximum

continues on next page

Table 1 – continued from previous page

daymean	Daily mean
daymin	Daily minimum
daymul	Multiply daily time series
daypctl	Daily percentile
dayrange	Daily range
daystd	Daily standard deviation
daystd1	Daily standard deviation (n-1)
daysub	Subtract daily time series
daysum	Daily sum
dayvar	Daily variance
dayvar1	Daily variance (n-1)
delattribute	Delete attributes
delcode	Delete parameters by code number
delete	Delete fields
delgridcell	Delete grid cells
delmulti	Delete multiple fields
delname	Delete parameters by name
delparam	Delete parameters by identifier
delta_pressure	Pressure difference of half-levels
deltat	Difference between timesteps
detrend	Detrend time series
dhouravg	Multi-day hourly average
dhourmax	Multi-day hourly maximum
dhourmean	Multi-day hourly mean
dhourmin	Multi-day hourly minimum
dhourrange	Multi-day hourly range
dhourstd	Multi-day hourly standard deviation
dhourstd1	Multi-day hourly standard deviation (n-1)
dhoursum	Multi-day hourly sum
dhourvar	Multi-day hourly variance
dhourvar1	Multi-day hourly variance (n-1)
diff	Compare two datasets listed by identifier
diffn	Compare two datasets listed by name
distgrid	Distribute horizontal grid
div	Divide two fields
divc	Divide by a constant
divcoslat	Divide by cosine of the latitude
divdpm	Divide by days per month
divdpy	Divide by days per year
dminuteavg	Multi-day by the minute average
dminutemax	Multi-day by the minute maximum
dminutemean	Multi-day by the minute mean
dminutemin	Multi-day by the minute minimum
dminuterange	Multi-day by the minute range
dminutestd	Multi-day by the minute standard deviation
dminutestd1	Multi-day by the minute standard deviation (n-1)
dminutesum	Multi-day by the minute sum
dminutevar	Multi-day by the minute variance
dminutevar1	Multi-day by the minute variance (n-1)
duplicate	Duplicates a dataset
dv2ps	D and V to vel. potential and stream function
dv2uv	Divergence and vorticity to U and V wind
eca_cdd	Consecutive dry days index per time period
eca_cfd	Consecutive frost days index per time period
eca_csu	Consecutive summer days index per time period
eca_cwd	Consecutive wet days index per time period

continues on next page

Table 1 – continued from previous page

eca_cwdi	Cold wave duration index wrt mean of reference period
eca_cwfi	Cold-spell days index wrt 10th percentile of reference period
eca_etr	Intra-period extreme temperature range
eca_fd	Frost days index per time period
eca_gsl	Thermal Growing season length index
eca_hd	Heating degree days per time period
eca_hwdi	Heat wave duration index wrt mean of reference period
eca_hwfi	Warm spell days index wrt 90th percentile of reference period
eca_id	Ice days index per time period
eca_pd	Precipitation days index per time period
eca_r10mm	Heavy precipitation days index per time period
eca_r20mm	Very heavy precipitation days index per time period
eca_r75p	Moderate wet days wrt 75th percentile of reference period
eca_r75ptot	Precipitation percent due to R75p days
eca_r90p	Wet days wrt 90th percentile of reference period
eca_r90ptot	Precipitation percent due to R90p days
eca_r95p	Very wet days wrt 95th percentile of reference period
eca_r95ptot	Precipitation percent due to R95p days
eca_r99p	Extremely wet days wrt 99th percentile of reference period
eca_r99ptot	Precipitation percent due to R99p days
eca_rr1	Wet days index per time period
eca_rx1day	Highest one day precipitation amount per time period
eca_rx5day	Highest five-day precipitation amount per time period
eca_sdii	Simple daily intensity index per time period
eca_su	Summer days index per time period
eca_tg10p	Cold days percent wrt 10th percentile of reference period
eca_tg90p	Warm days percent wrt 90th percentile of reference period
eca_tn10p	Cold nights percent wrt 10th percentile of reference period
eca_tn90p	Warm nights percent wrt 90th percentile of reference period
eca_tr	Tropical nights index per time period
eca_tx10p	Very cold days percent wrt 10th percentile of reference period
eca_tx90p	Very warm days percent wrt 90th percentile of reference period
enlarge	Enlarge fields
ensavg	Ensemble average
ensbrs	Ensemble Brier score
enscrps	Ensemble CRPS and decomposition
enskurt	Ensemble kurtosis
ensmax	Ensemble maximum
ensmean	Ensemble mean
ensmedian	Ensemble median
ensmin	Ensemble minimum
enspctl	Ensemble percentile
ensrange	Ensemble range
ensrkhistspace	Ranked Histogram averaged over space
ensrkhisttime	Ranked Histogram averaged over time
ensroc	Ensemble Receiver Operating characteristics
ensskew	Ensemble skewness
ensstd	Ensemble standard deviation
ensstd1	Ensemble standard deviation (n-1)
enssum	Ensemble sum
ensvar	Ensemble variance
ensvar1	Ensemble variance (n-1)
eof	Calculate EOFs in spatial or time space
eof3d	Calculate 3-Dimensional EOFs in time space
eofcoeff	Principal coefficients of EOFs
eofspatial	Calculate EOFs in spatial space

continues on next page

Table 1 – continued from previous page

eoftime	Calculate EOFs in time space
eq	Equal
eqc	Equal constant
etccdi_cdd	Consecutive dry days index per time period
etccdi_csdi	Cold-spell duration index
etccdi_cwd	Consecutive wet days index per time period
etccdi_fd	Frost days index per time period
etccdi_id	Ice days index per time period
etccdi_r1mm	Precipitation days index per time period
etccdi_r95p	Annual Total Precipitation when Daily Precipitation Exceeds the 95th Percentile of Wet Day Precipitation
etccdi_r99p	Annual Total Precipitation when Daily Precipitation Exceeds the 99th Percentile of Wet Day Precipitation
etccdi_rx1day	Maximum 1-day Precipitation
etccdi_rx5day	Highest five-day precipitation amount per time period
etccdi_su	Summer days index per time period
etccdi_tn10p	Percentage of Days when Daily Minimum Temperature is Below the 10th Percentile
etccdi_tn90p	Percentage of Days when Daily Minimum Temperature is Above the 90th Percentile
etccdi_tr	Tropical nights index per time period
etccdi_tx10p	Percentage of Days when Daily Maximum Temperature is Below the 10th Percentile
etccdi_tx90p	Percentage of Days when Daily Maximum Temperature is Above the 90th Percentile
etccdi_wsdi	Warm Spell Duration Index
exp	Exponential
expr	Evaluate expressions
exprf	Evaluate expressions script
fdns	Frost days where no snow index per time period
fldavg	Field average
fldcor	Correlation in grid space
fldcount	Field count
fldcovar	Covariance in grid space
fldint	Field integral
fldkurt	Field kurtosis
fldmax	Field maximum
fldmean	Field mean
fldmedian	Field median
fldmin	Field minimum
fldpctl	Field percentile
fldrange	Field range
fldskew	Field skewness
fldstd	Field standard deviation
fldstd1	Field standard deviation (n-1)
fldsum	Field sum
fldvar	Field variance
fldvar1	Field variance (n-1)
fourier	Fourier transformation
ge	Greater equal
gec	Greater equal constant
genbic	Generate bicubic interpolation weights
genbil	Generate bilinear interpolation weights
gencon	Generate 1st order conservative remap weights
gendis	Generate distance weighted average remap weights
gendis	Generate distance weighted average remap weights
genknn	Generate k-nearest neighbor remap weights
genlaf	Generate largest area fraction remap weights
genlevelbounds	Generate level bounds
gennn	Generate nearest neighbor remap weights
gennn	Generate nearest neighbor remap weights
gh2hl	Geometric height interpolation

continues on next page

Table 1 – continued from previous page

gheight	Geopotential height on full-levels
gheight_half	Geopotential height on half-levels
gmtcells	GMT multiple segment format
gmtxyz	GMT xyz format
gp2sp	Gridpoint to spectral
gradsdes	GrADS data descriptor file
graph	Line graph plot
grfill	Shaded gridfill plot
gridarea	Grid cell area
gridboxavg	Gridbox average
gridboxkurt	Gridbox kurtosis
gridboxmax	Gridbox maximum
gridboxmean	Gridbox mean
gridboxmedian	Gridbox median
gridboxmin	Gridbox minimum
gridboxrange	Gridbox range
gridboxskew	Gridbox skewness
gridboxstd	Gridbox standard deviation
gridboxstd1	Gridbox standard deviation (n-1)
gridboxsum	Gridbox sum
gridboxvar	Gridbox variance
gridboxvar1	Gridbox variance (n-1)
gridcellindex	Get grid cell index
griddes	Grid description
gridweights	Grid cell weights
gt	Greater than
gtc	Greater than constant
highpass	Highpass filtering
histcount	Histogram count
histfreq	Histogram frequency
histmean	Histogram mean
histsum	Histogram sum
houravg	Hourly average
hourmax	Hourly maximum
hourmean	Hourly mean
hourmin	Hourly minimum
hourpctl	Hourly percentile
hourrange	Hourly range
hourstd	Hourly standard deviation
hourstd1	Hourly standard deviation (n-1)
hoursum	Hourly sum
hourvar	Hourly variance
hourvar1	Hourly variance (n-1)
hpdegrade	Degrade healpix
hpupgrade	Upgrade healpix
hurr	Hurricane days index per time period
ifnotthen	If not then
ifnotthenc	If not then constant
ifthen	If then
ifthenc	If then constant
ifthenelse	Conditional selection
import_binary	Import binary data sets
import_cmsaf	Import CM-SAF HDF5 files
info	Dataset information listed by identifier
infon	Dataset information listed by name
input	ASCII input

continues on next page

Table 1 – continued from previous page

inputext	EXTRA ASCII input
inputsrv	SERVICE ASCII input
int	Integer value
intlevel	Linear level interpolation
intlevel3d	Linear level interpolation from/to 3D vertical coordinates
intntime	Interpolation between timesteps
inttime	Interpolation between timesteps
intyear	Interpolation between two years
invertlat	Invert latitudes
invertlev	Invert levels
isosurface	Extract isosurface
le	Less equal
lec	Less equal constant
ln	Natural logarithm
log10	Base 10 logarithm
lowpass	Lowpass filtering
lt	Less than
ltc	Less than constant
map	Dataset information and simple map
maskindexbox	Mask an index box
masklonlatbox	Mask a longitude/latitude box
maskregion	Mask regions
mastrfu	Mass stream function
max	Maximum of two fields
maxc	Maximum of a field and a constant
meravg	Meridional average
merge	Merge datasets with different fields
mergegrid	Merge grid
mergetime	Merge datasets sorted by date and time
merkurt	Meridional kurtosis
mermax	Meridional maximum
mermean	Meridional mean
mermedian	Meridional median
mermin	Meridional minimum
merpctl	Meridional percentile
merrange	Meridional range
merskew	Meridional skewness
merstd	Meridional standard deviation
merstd1	Meridional standard deviation (n-1)
mersum	Meridional sum
mervar	Meridional variance
mervar1	Meridional variance (n-1)
min	Minimum of two fields
minc	Minimum of a field and a constant
ml2pl	Model to pressure level interpolation
monadd	Add monthly time series
monavg	Monthly average
mondiv	Divide monthly time series
monmax	Monthly maximum
monmean	Monthly mean
monmin	Monthly minimum
monmul	Multiply monthly time series
monpctl	Monthly percentile
monrange	Monthly range
monstd	Monthly standard deviation
monstd1	Monthly standard deviation (n-1)

continues on next page

Table 1 – continued from previous page

monsub	Subtract monthly time series
monsum	Monthly sum
monvar	Monthly variance
monvar1	Monthly variance (n-1)
mrotuvb	Backward rotation of MPIOM data
mul	Multiply two fields
mulc	Multiply with a constant
mulcoslat	Multiply with the cosine of the latitude
muldpm	Multiply with days per month
muldpy	Multiply with days per year
ndate	Number of dates
ne	Not equal
nec	Not equal constant
ngridpoints	Number of gridpoints
ngrids	Number of horizontal grids
nint	Nearest integer value
nlevel	Number of levels
nmon	Number of months
not	Logical NOT
npar	Number of parameters
ntime	Number of timesteps
nyear	Number of years
output	ASCII output
outputext	EXTRA ASCII output
outputf	Formatted output
outputint	Integer output
outputsrv	SERVICE ASCII output
outputtab	Table output
pack	Pack data
partab	Parameter table
pow	Power
pressure	Pressure on full-levels
pressure_half	Pressure on half-levels
projuvLatLon	Cylindrical Equidistant projection
random	Create a field with random numbers
reci	Reciprocal value
reducegrid	Reduce fields to user-defined mask
regres	Regression
remap	Grid remapping
remapavg	Remap average
remapbic	Bicubic interpolation
remapbil	Bilinear interpolation
remapcon	First order conservative remapping
remapdis	Distance weighted average remapping
remapdis	Distance weighted average remapping
remapeta	Remap vertical hybrid levels
remapknn	k-nearest neighbor remapping
remapkurt	Remap kurtosis
remaplaf	Largest area fraction remapping
remapmax	Remap maximum
remapmean	Remap mean
remapmedian	Remap median
remapmin	Remap minimum
remapnn	Nearest neighbor remapping
remapnn	Nearest neighbor remapping
remaprange	Remap range

continues on next page

Table 1 – continued from previous page

remapskew	Remap skewness
remapstd	Remap standard deviation
remapstd1	Remap standard deviation (n-1)
remapsum	Remap sum
remapvar	Remap variance
remapvar1	Remap variance (n-1)
replace	Replace variables
rhopot	Calculates potential density
rotuvNorth	Rotate u/v wind to North pole
rotuvb	Backward wind rotation
runavg	Running average
runmax	Running maximum
runmean	Running mean
runmin	Running minimum
runpctl	Running percentile
runrange	Running range
runstd	Running standard deviation
runstd1	Running standard deviation (n-1)
runsum	Running sum
runvar	Running variance
runvar1	Running variance (n-1)
samplegrid	Resample grid cells
sealevelpressure	Sea level pressure
seasavg	Seasonal average
seasmax	Seasonal maximum
seasmean	Seasonal mean
seasmin	Seasonal minimum
seaspctl	Seasonal percentile
seasrange	Seasonal range
seasstd	Seasonal standard deviation
seasstd1	Seasonal standard deviation (n-1)
seassum	Seasonal sum
seasvar	Seasonal variance
seasvar1	Seasonal variance (n-1)
selcircle	Select cells inside a circle
selcode	Select parameters by code number
seldate	Select dates
selday	Select days
select	Select fields
selgrid	Select grids
selgridcell	Select grid cells
selhour	Select hours
selindexbox	Select an index box
sellevel	Select levels
sellevidx	Select levels by index
sellonlatbox	Select a longitude/latitude box
selltype	Select GRIB level types
selmonth	Select months
selmulti	Select multiple fields
selname	Select parameters by name
selparam	Select parameters by identifier
selregion	Select cells inside regions
selseason	Select seasons
selsmon	Select single month
selstdname	Select parameters by standard name
seltabnum	Select parameter table numbers

continues on next page

Table 1 – continued from previous page

seltime	Select times
seltimeidx	Select timestep by index
seltimestep	Select timesteps
selyear	Select years
selyearidx	Select year by index
selzaxis	Select z-axes
selzaxisname	Select z-axes by name
seq	Create a time series
setattribute	Set attributes
setcalendar	Set calendar
setchunkspec	Specify chunking
setcindexbox	Set an index box to constant
setclonlatbox	Set a longitude/latitude box to constant
setcode	Set code number
setcodetab	Set parameter code table
setctomiss	Set constant to missing value
setdate	Set date
setday	Set day
setfilter	Specify filter
setgrid	Set grid
setgridarea	Set grid cell area
setgridcell	Set the value of a grid cell
setgridmask	Set grid mask
setgridtype	Set grid type
sethalo	Set the bounds of a field
setlevel	Set level
setltype	Set GRIB level type
setmaxsteps	Set max timesteps
setmiss	Set missing values
setmisstoc	Set missing value to constant
setmisstodis	Set missing value to distance-weighted average
setmisstonn	Set missing value to nearest neighbor
setmissval	Set a new missing value
setmon	Set month
setname	Set variable name
setparam	Set parameter identifier
setpartabn	Set parameter table
setpartabp	Set parameter table
setprojparams	Set proj params
setreftime	Set reference time
setrtoc	Set range to constant
setrtoc2	Set range to constant others to constant2
setrtomiss	Set range to missing value
setstdname	Set standard name
settaxis	Set time axis
settbounds	Set time bounds
settime	Set time of the day
settunits	Set time units
setunit	Set variable unit
setvals	Set list of old values to new values
setvrange	Set valid range
setyear	Set year
setzaxis	Set z-axis
shaded	Shaded contour plot
shifttime	Shift timesteps
shiftx	Shift x

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Table 1 – continued from previous page

shifty	Shift y
showattribute	Show attributes
showchunkspec	Show chunk specification
showcode	Show code numbers
showdate	Show date information
showfilter	Show filter specification
showformat	Show file format
showlevel	Show levels
showltype	Show GRIB level types
showmon	Show months
showname	Show variable names
showstdname	Show standard names
showtime	Show time information
showtimestamp	Show timestamp
showyear	Show years
sin	Sine
sinfo	Short information listed by identifier
sinfon	Short information listed by name
smooth	Smooth grid points
smooth9	9 point smoothing
sp2gp	Spectral to gridpoint
sp2sp	Spectral to spectral
splitcode	Split code numbers
splitdate	Splits a file into dates
splitday	Split days
splitensemble	Split ensembles
splitgrid	Split grids
splithour	Split hours
splitlevel	Split levels
splitmon	Split months
splitname	Split variable names
splitparam	Split parameter identifiers
splitseas	Split seasons
splitsel	Split selected timesteps
splittabnum	Split parameter table numbers
splityear	Split years
splityearmon	Split in years and months
splitzaxis	Split z-axes
sqr	Square
sqrt	Square root
stdatm	Create values for pressure and temperature for hydrostatic atmosphere
strbre	Strong breeze days index per time period
strgal	Strong gale days index per time period
strwin	Strong wind days index per time period
sub	Subtract two fields
subc	Subtract a constant
subtrend	Subtract trend
symmetrize	Mirrors data at the equator
tan	Tangent
tee	Duplicate a data stream and write it to file
timavg	Time average
timcor	Correlation over time
timcovar	Covariance over time
timcumsum	Cumulative sum over all timesteps
timfillmiss	Temporal filling of missing values
timmax	Time maximum

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Table 1 – continued from previous page

timmaxidx	Index of time maximum
timmean	Time mean
timmin	Time minimum
timminidx	Index of time minimum
timpctl	Temporal percentile
timrange	Time range
timselavg	Time selection average
timselmax	Time selection maximum
timselmean	Time selection mean
timselmin	Time selection minimum
timselpctl	Time range percentile
timselrange	Time selection range
timselstd	Time selection standard deviation
timselstd1	Time selection standard deviation (n-1)
timselsum	Time selection sum
timselvar	Time selection variance
timselvar1	Time selection variance (n-1)
timsort	Temporal sorting
timstd	Time standard deviation
timstd1	Time standard deviation (n-1)
timsum	Time sum
timvar	Time variance
timvar1	Time variance (n-1)
topo	Create a field with topography
topvalue	Extract top level
trend	Trend of time series
unpack	Unpack data
uv2dv	U and V wind to divergence and vorticity
uv2dv_cfd	U and V wind to divergence
uv2vr_cfd	U and V wind to relative vorticity
uvDestag	Destaggering of u/v wind components
varsavg	Variables average
varskurt	Variables kurtosis
varsmax	Variables maximum
varsmean	Variables mean
varsmedian	Variables median
varsmin	Variables minimum
varspctl	Variables percentile
varsrange	Variables range
varsskew	Variables skewness
varsstd	Variables standard deviation
varsstd1	Variables standard deviation (n-1)
varssum	Variables sum
varsvar	Variables variance
varsvar1	Variables variance (n-1)
vct	Vertical coordinate table
vector	Lon/Lat vector plot
verifygrid	Verify grid coordinates
vertavg	Vertical average
vertfillmiss	Vertical filling of missing values
vertmax	Vertical maximum
vertmean	Vertical mean
vertmin	Vertical minimum
vertrange	Vertical range
vertstd	Vertical standard deviation
vertstd1	Vertical standard deviation (n-1)

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Table 1 – continued from previous page

vertsum	Vertical sum
vertvar	Vertical variance
vertvar1	Vertical variance (n-1)
wct	Windchill temperature
xsinfo	Extra short information listed by name
xsinfop	Extra short information listed by identifier
ydayadd	Add multi-year daily time series
ydayavg	Multi-year daily average
ydaydiv	Divide multi-year daily time series
ydaymax	Multi-year daily maximum
ydaymean	Multi-year daily mean
ydaymin	Multi-year daily minimum
ydaymul	Multiply multi-year daily time series
ydaypctl	Multi-year daily percentile
ydayrange	Multi-year daily range
ydaystd	Multi-year daily standard deviation
ydaystd1	Multi-year daily standard deviation (n-1)
ydaysub	Subtract multi-year daily time series
ydaysum	Multi-year daily sum
ydayvar	Multi-year daily variance
ydayvar1	Multi-year daily variance (n-1)
ydrunavg	Multi-year daily running average
ydrunmax	Multi-year daily running maximum
ydrunmean	Multi-year daily running mean
ydrunmin	Multi-year daily running minimum
ydrunpctl	Multi-year daily running percentile
ydrunstd	Multi-year daily running standard deviation
ydrunstd1	Multi-year daily running standard deviation (n-1)
ydrunsum	Multi-year daily running sum
ydrunvar	Multi-year daily running variance
ydrunvar1	Multi-year daily running variance (n-1)
yearadd	Add yearly time series
yearavg	Yearly average
yeardiv	Divide yearly time series
yearmax	Yearly maximum
yearmaxidx	Index of yearly maximum
yearmean	Yearly mean
yearmin	Yearly minimum
yearminidx	Index of yearly minimum
yearmonmean	Yearly mean from monthly data
yearmul	Multiply yearly time series
yearpctl	Yearly percentile
yearrange	Yearly range
yearstd	Yearly standard deviation
yearstd1	Yearly standard deviation (n-1)
yearsub	Subtract yearly time series
yearsum	Yearly sum
yearvar	Yearly variance
yearvar1	Yearly variance (n-1)
yhouradd	Add multi-year hourly time series
yhouravg	Multi-year hourly average
yhourdiv	Divide multi-year hourly time series
yhourmax	Multi-year hourly maximum
yhourmean	Multi-year hourly mean
yhourmin	Multi-year hourly minimum
yhourmul	Multiply multi-year hourly time series

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Table 1 – continued from previous page

yhourrange	Multi-year hourly range
yhourstd	Multi-year hourly standard deviation
yhourstd1	Multi-year hourly standard deviation (n-1)
yhoursub	Subtract multi-year hourly time series
yhoursum	Multi-year hourly sum
yhourvar	Multi-year hourly variance
yhourvar1	Multi-year hourly variance (n-1)
ymonadd	Add multi-year monthly time series
ymonavg	Multi-year monthly average
ymondiv	Divide multi-year monthly time series
ymoneq	Compare time series with Equal
ymonge	Compares if time series with GreaterEqual
ymongt	Compares if time series with GreaterThan
ymonle	Compare time series with LessEqual
ymonlt	Compares if time series with LessThan
ymonmax	Multi-year monthly maximum
ymonmean	Multi-year monthly mean
ymonmin	Multi-year monthly minimum
ymonmul	Multiply multi-year monthly time series
ymonne	Compare time series with NotEqual
ymonpctl	Multi-year monthly percentile
ymonrange	Multi-year monthly range
ymonstd	Multi-year monthly standard deviation
ymonstd1	Multi-year monthly standard deviation (n-1)
ymonsub	Subtract multi-year monthly time series
ymonsum	Multi-year monthly sum
ymonvar	Multi-year monthly variance
ymonvar1	Multi-year monthly variance (n-1)
yseasadd	Add multi-year seasonal time series
yseasavg	Multi-year seasonal average
yseasdiv	Divide multi-year seasonal time series
yseaseq	Compare time series with Equal
yseasge	Compares if time series with GreaterEqual
yseasgt	Compares if time series with GreaterThan
yseasle	Compare time series with LessEqual
yseaslt	Compares if time series with LessThan
yseasmax	Multi-year seasonal maximum
yseasmean	Multi-year seasonal mean
yseasmin	Multi-year seasonal minimum
yseasmul	Multiply multi-year seasonal time series
yseasne	Compare time series with NotEqual
yseaspctl	Multi-year seasonal percentile
yseasrange	Multi-year seasonal range
yseasstd	Multi-year seasonal standard deviation
yseasstd1	Multi-year seasonal standard deviation (n-1)
yseassub	Subtract multi-year seasonal time series
yseassum	Multi-year seasonal sum
yseasvar	Multi-year seasonal variance
yseasvar1	Multi-year seasonal variance (n-1)
zaxisdes	Z-axis description
zonavg	Zonal average
zonkurt	Zonal kurtosis
zonmax	Zonal maximum
zonmean	Zonal mean
zonmedian	Zonal median
zonmin	Zonal minimum

continues on next page

Table 1 – continued from previous page

zonpctl	Zonal percentile
zonrange	Zonal range
zonskew	Zonal skewness
zonstd	Zonal standard deviation
zonstd1	Zonal standard deviation (n-1)
zonsum	Zonal sum
zonvar	Zonal variance
zonvar1	Zonal variance (n-1)

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[CDI] Climate Data Interface, from the Max Planck Institute for Meteorology

[CM-SAF] Satellite Application Facility on Climate Monitoring, from the German Weather Service (Deutscher Wetterdienst, DWD)

[CMOR] Climate Model Output Rewriter, from the Program For Climate Model Diagnosis and Intercomparison (PCMDI)

[ecCodes] API for GRIB decoding/encoding, from the European Centre for Medium-Range Weather Forecasts (ECMWF)

[ECHAM] The atmospheric general circulation model ECHAM5, from the Max Planck Institute for Meteorology

[GMT] The Generic Mapping Tool, from the School of Ocean and Earth Science and Technology (SOEST)

[GrADS] Grid Analysis and Display System, from the Center for Ocean-Land-Atmosphere Studies (COLA)

[GRIB] GRIB version 1, from the World Meteorological Organisation (WMO)

[HDF5] HDF version 5, from the HDF Group

[INTERA] INTERA Software Package, from the Max Planck Institute for Meteorology

[Magics] Magics Software Package, from the European Centre for Medium-Range Weather Forecasts (ECMWF)

[MPIOM] Ocean and sea ice model, from the Max Planck Institute for Meteorology

[NetCDF] NetCDF Software Package, from the UNIDATA Program Center of the University Corporation for Atmospheric Research

[PINGO] The PINGO package, from the Model & Data group at the Max Planck Institute for Meteorology

[REMO] Regional Model, from the Max Planck Institute for Meteorology

[Preisendorfer] Rudolph W. Preisendorfer: Principal Component Analysis in Meteorology and Oceanography, Elsevier (1988)

[PROJ] Cartographic Projections Library, originally written by Gerald Evenden then of the USGS.

[SCRIP] SCRIP Software Package, from the Los Alamos National Laboratory

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