CDO User's Guide

Climate Data Operators
Version 1.4.5
June 2010

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1. Introduction

The Climate Data Operators (**CDO**) software are a collection of many operators for standard processing of climate and forecast model output. 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 data formats SERVICE, EXTRA and IEG are also supported.

There are some limitations for GRIB and netCDF datasets. A GRIB dataset has to be consistent, similar to netCDF. That means all time steps needs to have the same variables, and within a time step each variable may occur only once. 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 user interface and some operators are similar to the PINGO [PINGO] package. There are also some operators with the same name as in PINGO but with a different meaning. Appendix A gives an overview of those operators.

The main **CDO** features are:

- More than 400 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

1.1. Building from sources

This section describes how to build **CDO** from the sources on a UNIX system. **CDO** uses the GNU configure and build system for compilation. The only requirement is a working ANSI C99 compiler.

First go to the `download` page (`http://www.mpimet.mpg.de/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 (`http://www.unidata.ucar.edu/packages/netcdf`) version 3 or higher.
  This is needed to process netCDF [netCDF] files with **CDO**.
- HDF5 szip library (`http://www.hdfgroup.org/doc_resource/SZIP`) version 2.1 or higher.
  This is needed to process szip compressed GRIB [GRIB] files with **CDO**.
- HDF5 library (`http://www.hdfgroup.org/HDF5`) version 1.6 or higher.
  This is needed to import CM-SAF [CM-SAF] HDF5 files with the **CDO** operator **import_cmsaf**.
- PROJ.4 library (`http://trac.osgeo.org/proj`) version 4.6 or higher.
  This is needed to convert Sinusoidal and Lambert Azimuthal Equal Area coordinates to geographic coordinates, for e.g. remapping.

1.1.1. 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
```

   Or with netCDF [netCDF] support:

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

   The netCDF-4 configuration depends on the netCDF-4 and HDF5 installation! You have to define the location of the HDF5 installation if netCDF-4 was build with HDF5 support:

```
./configure --with-netcdf=<netCDF-4 root directory> \
            --with-hdf5=<HDF5 root directory>
```

   You have to specify also the location of the SZLIB if HDF5 was build with SZLIB support.

   To enable szip [szip] support add:

```
--with-szlib=<SZLIB 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.

1.1.2. 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.

1.2. Usage

This section descibes 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 — Generate an absolute time axis.

-b <nbits> — Set the number of bits for the output precision. The valid precisions depend on the file format:

<format>	*<nbits>*
`grb`	`1 - 32`
`nc, nc2, nc4`	`I8/I16/I32/F32/F64`
`srv, ext, ieg`	`F32/F64`

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

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

File format	*<format>*
GRIB version 1	`grb`
netCDF	`nc`
netCDF version 2 (64-bit)	`nc2`
netCDF-4 classic (HDF5)	`nc4`
SERVICE	`srv`
EXTRA	`ext`
IEG	`ieg`

-g <grid> — Define the default grid description by name or from file (see chapter 1.3 on page 9). Available grid names are: `t`<RES>`grid`, `r`<NX>`x`<NY>, `gme`<NI>

-h — Help information for the operators.

-M — Switch to indicate that the I/O streams have missing values.

-m <missval> — Set the default missing value (default: `-9e+33`).

-Q — Sort netCDF variable names.

-R — Convert GRIB data from reduced to regular grid.

-r — Generate a relative time axis.

-s — Silent mode.

-t <partab> — Set the default parameter table name or file (see chapter 1.6 on page 14). Predefined tables are: `echam4 echam5 mpiom1`

-V — Print the version number.

-v — Print extra details for some operators.

-z szip — Compress GRIB records with szip.

zip — Deflate compression of netCDF4 variables.

1.2.2. Operators

There are more than 400 operators available. A detailed description of all operators can be found in the **Reference Manual** section.

1.2.3. Combining operators

All operators with a fixed number of input streams and one output stream can pipe the result directly to an other operator. The operator must begin with "–", in order to combine it with others. This can improve the performance by:

- reducing unnecessary disk I/O
- parallel processing

Use

```
cdo sub -dayavg ifile2 -timavg ifile1 ofile
```

instead of

```
cdo timavg ifile1 tmp1
cdo dayavg ifile2 tmp2
cdo sub tmp2 tmp1 ofile
rm tmp1 tmp2
```

Combining of operators is implemented over POSIX Threads (pthread). Therefore this **CDO** feature is not available on operating systems without POSIX Threads support.

1.2.4. Operator parameter

Some operators need one or more parameter.

- STRING
  Unquoted characters without blanks and tabs. The following command select the variables with the names `pressure` and `tsurf`:

  ```
  cdo selvar,pressure,tsurf ifile ofile
  ```

- 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 ifile ofile
  ```

- INTEGER
  A list of integers can be specified by *first/last[/inc]*. To select the days 5, 6, 7, 8 and 9 use:

  ```
  cdo selday,5/9 ifile ofile
  ```

  This is the same as:

  ```
  cdo selday,5,6,7,8,9 ifile ofile
  ```

1.3. 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 (operator: interpolate, remapXXX and genXXX)
- Generating variables (operator: const, random)

As now described, there are several possibilities to define a horizontal grid. Predefined grids are available for global regular, gaussian or icosahedral-hexagonal GME grids.

1.3.1. Predefined grids

The following pre-defined grid names are available: `r<NX>x<NY>`, `lon=<LON>_lat<LAT>`, `t<RES>grid` and `gme<NI>`

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 selected at will. 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 one grid point of a lon/lat grid.

Global gaussian grid: `t<RES>grid`

`t<RES>grid` defines a global gaussian grid. Each valid triangular resolution can be used for `<RES>`. 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` is the number of intervals on a main triangle side.

1.3.2. 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 this program. 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.

1.3.3. SCRIP grids

SCRIP is a Spherical Coordinate Remapping and Interpolation Package. It uses a common grid description in netCDF. You can use it to describe curvilinear grids or unstructured grid cells. For more information about this format see [SCRIP]. That grid description format is only available if the program 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_xsize = 120 ;
        grid_ysize = 101 ;
        grid_corners = 4 ;
        grid_rank = 2 ;
variables:
        int grid_dims(grid_rank) ;
        float grid_center_lat(grid_ysize, grid_xsize) ;
                grid_center_lat:units = "degrees" ;
                grid_center_lat:bounds = "grid_corner_lat" ;
        float grid_center_lon(grid_ysize, grid_xsize) ;
                grid_center_lon:units = "degrees" ;
                grid_center_lon:bounds = "grid_corner_lon" ;
```

```
            int grid_imask(grid_ysize, grid_xsize) ;
                    grid_imask:units = "unitless" ;
                    grid_imask:coordinates = "grid_center_lon grid_center_lat" ;
            float grid_corner_lat(grid_ysize, grid_xsize, grid_corners) ;
                    grid_corner_lat:units = "degrees" ;
            float grid_corner_lon(grid_ysize, grid_xsize, grid_corners) ;
                    grid_corner_lon:units = "degrees" ;

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

1.3.4. PINGO grids

PINGO uses a very simple grid description in ASCII format to describe regular longitude/latitude or global gaussian grids. All PINGO grid description files are supported by **CDO**. For more information about this format see [PINGO].

PINGO grid description example of a T21 gaussian grid:

```
Grid Description File
(Comments start at non digit characters and end at end of line)
First part: The dimensions.
64 32 = Number of longitudes and latitudes
Second part: The listed longitudes.
2 means equidistant longitudes
0.000000 5.625000 = Most western and second most western longitude
Third part: The listed latitudes.
32 means all 32 latitudes are given in the following list:
 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
```

1.3.5. 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, cell)
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
yvals	FLOAT ARRAY	y values of the grid
xnpole	FLOAT	x value of the north pole (rotated grid)
ynpole	FLOAT	y value of the north pole (rotated grid)
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
yfirst, yinc	FLOAT, FLOAT	macros to define yvals with a constant increment

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	curvilinear	cell
gridsize	xsize*ysize	xsize*ysize	xsize*ysize	**ncell**
xsize	**nlon**	**nlon**	**nlon**	gridsize
ysize	**nlat**	**nlat**	**nlat**	gridsize
xvals	xsize	xsize	gridsize	gridsize
yvals	ysize	ysize	gridsize	gridsize
xnpole	0			
ynpole	90			
nvertex	2	2	4	**nv**
xbounds	2*xsize	2*xsize	4*gridsize	nv*gridsize
ybounds	2*ysize	2*ysize	4*gridsize	nv*gridsize

The keywords nvertex, xbounds and ybounds are optional if area weights are not needed.

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
```

For a lon/lat grid with a rotated pole, the north pole must be defined. As far as you define the keywords xnpole/ynpole all coordinate values are for the rotated system.

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

```
gridtype = lonlat
xsize    = 81
ysize    = 91
xfirst   =   -19.5
xinc     =     0.5
yfirst   =   -25.0
yinc     =     0.5
xnpole   = -170
ynpole   =    32.5
```

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

1.4. 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.

1.5. 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. Some time range statistic operators create an absolute time axis (e.g. timsel$<STAT>$, run$<STAT>$, seas$<STAT>$, ...).

1.5.1. 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`".

1.5.2. 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, 360 days, 365 days and 366 days calendars. The relative time axis is preferably used by weather forecast 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`".

1.5.3. 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'.

1.6. 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]
```

1.7. Missing values

Most operators can handle missing values. The default missing value for GRIB, SERVICE, EXTRA and IEG files is $-9e+33$. 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.

addition	**b**		**miss**
a	$a+b$		$miss$
miss	$miss$		$miss$
subtraction	**b**		**miss**
a	$a-b$		$miss$
miss	$miss$		$miss$
multiplication	**b**	**0**	**miss**
a	$a*b$	0	$miss$
0	0	0	0
miss	$miss$	0	$miss$
division	**b**	**0**	**miss**
a	a/b	$miss$	$miss$
0	0	$miss$	$miss$
miss	$miss$	$miss$	$miss$
maximum	**b**		**miss**
a	$max(a,b)$		a
miss	b		$miss$
minimum	**b**		**miss**
a	$min(a,b)$		a
miss	b		$miss$
sum	**b**		**miss**
a	$a+b$		a
miss	b		$miss$

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.

1.7.1. 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.

2. 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 `ifile` or `ifile1`, `ifile2`, etc., and an unlimited number of input files are named `ifiles`. All output files are named `ofile` or `ofile1`, `ofile2`, etc. Further the following notion is introduced:

$i(t)$	Timestep t of `ifile`
$i(t, x)$	Element number x of the field at timestep t of `ifile`
$o(t)$	Timestep t of `ofile`
$o(t, x)$	Element number x of the field at timestep t of `ofile`

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	Dataset information listed by code number
infov	Dataset information listed by variable name
map	Dataset information and simple map
sinfo	Short dataset information listed by code number
sinfov	Short dataset information listed by variable name
diff	Compare two datasets listed by code number
diffv	Compare two datasets listed by variable name
npar	Number of parameters
nlevel	Number of levels
nyear	Number of years
nmon	Number of months
ndate	Number of dates
ntime	Number of time steps
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
pardes	Parameter description
griddes	Grid description
zaxisdes	Z-axis description
vct	Vertical coordinate table

2.1.1. INFO - Information and simple statistics

Synopsis

<*operator*> `ifiles`

Description

This module writes information about the structure and contents of all input datasets to standard output. The information displayed depends on the chosen operator.

Operators

info Dataset information listed by code number
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
- Code number and Level
- Size of the grid and number of Missing values
- Minimum, Mean and Maximum
  The mean value is computed without the use of area weights!

infov Dataset information listed by variable name
The same as operator info but using the name instead of the code number to identify the variables.

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.

Example

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

```
cdo infov ifile
```

This is an example result of a dataset with one 2D variable over 12 time steps:

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

2.1.2. SINFO - Short information

Synopsis

<*operator*> `ifiles`

Description

This module writes information about the structure of all input datasets to standard output. The information displayed depends on the chosen operator.

Operators

sinfo Short dataset information listed by code number
Prints short information of a dataset. The information is divided into 4 sections. Section 1 prints one line per variable with the following information:

- institute and source
- parameter table and code number
- horizontal grid size and number
- number of vertical levels and z-axis number

Section 2 and 3 gives a short overview of all horizontal and vertical grids. And the last section contains short information of the time axis.

sinfov Short dataset information listed by variable name
The same as operator sinfo but using the name instead of the code number and parameter table to identify the variables.

Example

To print short information of a dataset use:

```
cdo sinfov ifile
```

This is the result of an ECHAM5 dataset with 3 variables over 12 time steps:

```
   -1 : Institut Source  Varname  Time  Typ  Grid Size Num  Levels Num
    1 : MPIMET   ECHAM5  GEOSP    con   F32       2048   1       1   1
    2 : MPIMET   ECHAM5  T        var   F32       2048   1       4   2
    3 : MPIMET   ECHAM5  TSURF    var   F32       2048   1       1   1
  Horizontal grids :
    1 : gaussian      > size      : dim = 2048  nlon = 64  nlat = 32
                        longitude : first = 0  last = 354.375  inc = 5.625
                        latitude  : first = 85.7605871  last = -85.7605871
  Vertical grids :
    1 : surface                 : 0
    2 : pressure             Pa : 92500 85000 50000 20000
  Time axis :  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
```

2.1.3. DIFF - Compare two datasets field by field

Synopsis

<operator> `ifile1 ifile2`

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 same header information and dimensions.

Operators

diff Compare two datasets listed by code number
Provides statistics on differences between two datasets. For each pair of fields the operator prints one line with the following information:

- Date and Time
- Code number and Level
- Size of the grid and number of Missing 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

$$Absdiff(t,x) = |i_1(t,x) - i_2(t,x)|$$

$$Reldiff(t,x) = \frac{|i_1(t,x) - i_2(t,x)|}{\max(|i_1(t,x)|, |i_2(t,x)|)}$$

diffv Compare two datasets listed by variable name
The same as operator diff. Using the name instead of the code number to identify the variable.

Example

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

```
cdo diffv ifile1 ifile2
```

This is an example result of two datasets with one 2D variable over 12 time steps:

```
               Date     Time    Varname  Level  Size   Miss  : S Z  Max_Absdiff  Max_Reldiff
   1 : 1987-01-31 12:00:00  SST          0  2048   1361  : F F   0.00010681   4.1660e-07
   2 : 1987-02-28 12:00:00  SST          0  2048   1361  : F F   6.1035e-05   2.3742e-07
   3 : 1987-03-31 12:00:00  SST          0  2048   1361  : F F   7.6294e-05   3.3784e-07
   4 : 1987-04-30 12:00:00  SST          0  2048   1361  : F F   7.6294e-05   3.5117e-07
   5 : 1987-05-31 12:00:00  SST          0  2048   1361  : F F   0.00010681   4.0307e-07
   6 : 1987-06-30 12:00:00  SST          0  2048   1361  : F F   0.00010681   4.2670e-07
   7 : 1987-07-31 12:00:00  SST          0  2048   1361  : F F   9.1553e-05   3.5634e-07
   8 : 1987-08-31 12:00:00  SST          0  2048   1361  : F F   7.6294e-05   2.8849e-07
   9 : 1987-09-30 12:00:00  SST          0  2048   1361  : F F   7.6294e-05   3.6168e-07
  10 : 1987-10-31 12:00:00  SST          0  2048   1361  : F F   9.1553e-05   3.5001e-07
  11 : 1987-11-30 12:00:00  SST          0  2048   1361  : F F   6.1035e-05   2.3839e-07
  12 : 1987-12-31 12:00:00  SST          0  2048   1361  : F F   9.3553e-05   3.7624e-07
```

2.1.4. NINFO - Print the number of parameters, levels or times

Synopsis

<operator> `ifile`

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 time steps
Prints the number of time steps.

Example

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

```
cdo npar ifile
```

To print the number of months in a dataset use:

```
cdo nmon ifile
```

2.1.5. SHOWINFO - Show variables, levels or times

Synopsis

<*operator*> `ifile`

Description

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

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 time steps (format YYYY-MM-DD).
showtime	Show time information Prints time information of all time steps (format hh:mm:ss).
showtimestamp	Show timestamp Prints timestamp of all time steps (format YYYY-MM-DDThh:mm:ss).

Example

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

```
cdo showcode ifile
```

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

```
129 130 139
```

To print all months in a dataset use:

```
cdo showmon ifile
```

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

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

2.1.6. FILEDES - Dataset description

Synopsis

<*operator*> `ifile`

Description

This module prints the description of the parameters, the grids, the z-axis or the vertical coordinate table.

Operators

pardes Parameter description
Prints a 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.

Example

Assume all variables of the dataset are on a T21 gausssian grid. To print the grid description of this dataset use:

```
cdo griddes ifile
```

Result:

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

2.2. File operations

This section contains modules to perform operations on files.

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

copy	Copy datasets
cat	Concatenate datasets
replace	Replace variables
merge	Merge datasets with different fields
mergetime	Merge datasets sorted by date and time
splitcode	Split code numbers
splitname	Split variable names
splitlevel	Split levels
splitgrid	Split grids
splitzaxis	Split z-axes
splittabnum	Split parameter table numbers
splithour	Split hours
splitday	Split days
splitmon	Split months
splitseas	Split seasons
splityear	Split years
splitsel	Split time selection

2.2.1. COPY - Copy datasets

Synopsis

<operator> `ifiles ofile`

Description

This module contains operators to copy or concatenate datasets. Each input dataset is required to have the same variables with complete time steps.

Operators

copy Copy datasets
Copies all input datasets to `ofile`.

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

Example

To change the format of a dataset to netCDF use:

```
cdo -f nc copy ifile ofile.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 ifile ofile.nc
```

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

```
cdo copy ifile1 ifile2 ifile3 ofile
```

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

```
cdo cat ifile1 ifile2 ifile3 ofile
```

2.2.2. REPLACE - Replace variables

Synopsis

replace `ifile1 ifile2 ofile`

Description

Replaces all common variables of `ifile2` and `ifile1` with those of `ifile1` and write the result to `ofile`. Both input datasets need to have the same number of time steps.

Example

Assume the first input dataset `ifile1` has three variables with the names geosp, t and tslm1 and the second input dataset `ifile2` has only the variable tslm1. To replace the variable tslm1 in `ifile1` with tslm1 from `ifile2` use:

```
cdo replace ifile1 ifile2 ofile
```

2.2.3. MERGE - Merge datasets

Synopsis

<*operator*> `ifiles ofile`

Description

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

Operators

merge Merge datasets with different fields
Merges time series of different fields from several input datasets. The number of fields per time step written to `ofile` is the sum of the field numbers per time step in all input datasets. The time series on all input datasets are required to have different fields and the same number of time steps.

mergetime Merge datasets sorted by date and time
Merges all time steps of all input files sorted by date and time. After this operation every input time step is in `ofile` and all time steps are sorted by date and time. Each input file is required to have the same variables and different time steps.

Example

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

```
cdo merge ifile1 ifile2 ifile3 ofile
```

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 ifile1 ifile2 ifile3 ifile4 ofile
```

2.2.4. SPLIT - Split a dataset

Synopsis

<operator> `ifile oprefix`

Description

This module splits a dataset to several files with names formed from the field header information and the string `oprefix`.

Operators

splitcode Split code numbers
Splits a dataset into pieces, one for each different code number. Appends three digits with the code number to `oprefix` to form the output file names.

splitname Split variable names
Splits a dataset into pieces, one for each variable name. Appends a string with the variable name to `oprefix` to form the output file names.

splitlevel Split levels
Splits a dataset into pieces, one for each different level. Appends six digits with the level to `oprefix` to form the output file names.

splitgrid Split grids
Splits a dataset into pieces, one for each different grid. Appends two digits with the grid number to `oprefix` to form the output file names.

splitzaxis Split z-axes
Splits a dataset into pieces, one for each different z-axis. Appends two digits with the z-axis number to `oprefix` to form the output file names.

splittabnum Split parameter table numbers
Splits a dataset into pieces, one for each GRIB1 parameter table number. Appends three digits with the table number to `oprefix` to form the output file names.

Example

Assume an input GRIB 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 ifile code
```

Result of '`dir code*`':

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

2.2.5. SPLITTIME - Split time steps of a dataset

Synopsis

<*operator*> `ifile oprefix`

Description

This module splits time steps of a dataset to several files with names formed from the field header information and the string `oprefix`.

Operators

splithour	Split hours Splits a file into pieces, one for each different hour. Appends two digits with the hour to `oprefix` to form the output file names.
splitday	Split days Splits a file into pieces, one for each different day. Appends two digits with the day to `oprefix` to form the output file names.
splitmon	Split months Splits a file into pieces, one for each different month. Appends two digits with the month to `oprefix` to form the output file names.
splitseas	Split seasons Splits a file into pieces, one for each different season. Appends three characters with the season to `oprefix` to form the output file names.
splityear	Split years Splits a file into pieces, one for each different year. Appends four digits with the year to `oprefix` to form the output file names.

Example

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

```
cdo splitmon ifile 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
```

2.2.6. SPLITSEL - Split selected time steps

Synopsis

splitsel,*nsets[,noffset[,nskip]]* `ifile oprefix`

Description

This operator splits a dataset into pieces, one for each adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range. Appends three digits with the sequence number to `oprefix` to form the output file names.

Parameter

nsets	INTEGER	Number of input time steps for each output file
noffset	INTEGER	Number of input time steps skipped before the first time step range (optional)
nskip	INTEGER	Number of input time steps skipped between time step ranges (optional)

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:

selcode	Select variables by code number
delcode	Delete variables by code number
selname	Select variables by name
delname	Delete variables by name
selstdname	Select variables by standard name
sellevel	Select levels
sellevidx	Select levels by index
selgrid	Select grids
selzaxis	Select z-axes
selltype	Select GRIB level types
seltabnum	Select parameter table numbers
seltimestep	Select time steps
seltime	Select times
selhour	Select hours
selday	Select days
selmon	Select months
selyear	Select years
selseas	Select seasons
seldate	Select dates
selsmon	Select single month
sellonlatbox	Select a longitude/latitude box
selindexbox	Select an index box

2.3.1. SELVAR - Select fields

Synopsis

selcode,*codes* `ifile ofile`

delcode,*codes* `ifile ofile`

selname,*varnames* `ifile ofile`

delname,*varnames* `ifile ofile`

selstdname,*stdnames* `ifile ofile`

sellevel,*levels* `ifile ofile`

sellevidx,*levidx* `ifile ofile`

selgrid,*grids* `ifile ofile`

selzaxis,*zaxes* `ifile ofile`

selltype,*ltypes* `ifile ofile`

seltabnum,*tabnums* `ifile ofile`

Description

This module selects some fields from `ifile` and writes them to `ofile`. The fields selected depend on the chosen operator and the parameters.

Operators

selcode Select variables by code number
Selects all fields with code numbers in a user given list.

delcode Delete variables by code number
Deletes all fields with code numbers in a user given list.

selname Select variables by name
Selects all fields with variable names in a user given list.

delname Delete variables by name
Deletes all fields with variable names in a user given list.

selstdname Select variables by standard name
Selects all fields with standard names in a user given list.

sellevel Select levels
Selects all fields with levels in a user given list.

sellevidx Select levels by index
Selects all fields with index of levels in a user given list.

selgrid Select grids
Selects all fields with grids in a user given list.

selzaxis Select z-axes
Selects all fields with z-axes in a user given list.

selltype Select GRIB level types
Selects all fields with GRIB level type in a user given list.

seltabnum Select parameter table numbers
Selects all fields with parameter table numbers in a user given list.

Parameter

codes	INTEGER	Comma separated list of code numbers
varnames	STRING	Comma separated list of variable names
stdnames	STRING	Comma separated list of standard names
levels	FLOAT	Comma separated list of levels
levidx	INTEGER	Comma separated list of index of levels
ltypes	INTEGER	Comma separated list of GRIB level types
grids	STRING	Comma separated list of grid names or numbers
zaxes	STRING	Comma separated list of z-axis names or numbers
tabnums	INTEGER	Comma separated list 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 ifile ofile
```

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

```
cdo delcode,130 ifile ofile
```

2.3.2. SELTIME - Select time steps

Synopsis

seltimestep,*timesteps* `ifile ofile`

seltime,*times* `ifile ofile`

selhour,*hours* `ifile ofile`

selday,*days* `ifile ofile`

selmon,*months* `ifile ofile`

selyear,*years* `ifile ofile`

selseas,*seasons* `ifile ofile`

seldate,*date1[,date2]* `ifile ofile`

selsmon,*month[,nts1[,nts2]]* `ifile ofile`

Description

This module selects user specified time steps from `ifile` and writes them to `ofile`. The time steps selected depends on the chosen operator and the parameters.

Operators

seltimestep	Select time steps Selects all time steps with a time step in a user given list.
seltime	Select times Selects all time steps with a time in a user given list.
selhour	Select hours Selects all time steps with a hour in a user given list.
selday	Select days Selects all time steps with a day in a user given list.
selmon	Select months Selects all time steps with a month in a user given list.
selyear	Select years Selects all time steps with a year in a user given list.
selseas	Select seasons Selects all time steps with a month of a season in a user given list.
seldate	Select dates Selects all time steps with a date in a user given range.
selsmon	Select single month Selects a month and optional an unlimited number of time steps before and after this month.

Parameter

timesteps	INTEGER	Comma separated list of time steps
times	STRING	Comma separated list of times (format hh:mm:ss)
hours	INTEGER	Comma separated list of hours
days	INTEGER	Comma separated list of days
months	INTEGER	Comma separated list of months
years	INTEGER	Comma separated list of years
seasons	STRING	Comma separated list of seasons (DJF, MAM, JJA, SON)
date1	STRING	Start date (format YYYY-MM-DDThh:mm:ss)
date2	STRING	End date (format YYYY-MM-DDThh:mm:ss)
nts1	INTEGER	Number of time steps before the selected month [default: 0]
nts2	INTEGER	Number of time steps after the selected month [default: nts1]

2.3.3. SELBOX - Select a box of a field

Synopsis

sellonlatbox,*lon1*,*lon2*,*lat1*,*lat2* `ifile ofile`

selindexbox,*idx1*,*idx2*,*idy1*,*idy2* `ifile ofile`

Description

Selects a box of the rectangular understood field. All input fields need to have the same horizontal grid.

Operators

sellonlatbox Select a longitude/latitude box
Selects a longitude/latitude box. The user has to give the longitudes and latitudes of the edges of the box.

selindexbox Select an index box
Selects an index box. The user has to give the indexes of the edges of the box. The index of the left edge may be greater then that of the right edge.

Parameter

lon1	FLOAT	Western longitude
lon2	FLOAT	Eastern longitude
lat1	FLOAT	Southern or northern latitude
lat2	FLOAT	Northern or southern latitude
idx1	INTEGER	Index of first longitude
idx2	INTEGER	Index of last longitude
idy1	INTEGER	Index of first latitude
idy2	INTEGER	Index of last latitude

Example

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

```
cdo sellonlatbox,120,-90,20,-20 ifile ofile
```

If the input dataset has fields on a T21 Gaussian grid, the same box can be selected with selindexbox by:

```
cdo selindexbox,23,48,13,20 ifile ofile
```

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:

ifthen	If then
ifnotthen	If not then
ifthenelse	If then else
ifthenc	If then constant
ifnotthenc	If not then constant

2.4.1. COND - Conditional select one field

Synopsis

<*operator*> `ifile1 ifile2 ofile`

Description

This module selects field elements from `ifile2` with respect to `ifile1` and writes them to `ofile`. The fields in `ifile1` 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 `ifile1` has either to be the same as in `ifile2` or the same as in one time step of `ifile2` or only one. The fields in `ofile` inherit the meta data from `ifile2`.

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 `ifile2` if the corresponding field element of `ifile1` is greater than 0 use:

```
cdo ifthen ifile1 ifile2 ofile
```

2.4.2. COND2 - Conditional select two fields

Synopsis

ifthenelse `ifile1 ifile2 ifile3 ofile`

Description

This operator selects field elements from `ifile2` or `ifile3` with respect to `ifile1` and writes them to `ofile`. The fields in `ifile1` 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 `ifile1` has either to be the same as in `ifile2` or the same as in one time step of `ifile2` or only one. `ifile2` and `ifile3` need to have the same number of fields. The fields in `ofile` inherit the meta data from `ifile2`.

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

Example

To select all field elements of `ifile2` if the corresponding field element of `ifile1` is greater than 0 and from `ifile3` otherwise use:

```
cdo ifthenelse ifile1 ifile2 ifile3 ofile
```

2.4.3. CONDC - Conditional select a constant

Synopsis

<*operator*>,*c* `ifile ofile`

Description

This module creates fields with a constant value or missing value. The fields in `ifile` 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

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

Parameter

c FLOAT Constant

Example

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

```
cdo ifthenc,7 ifile ofile
```

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:

eq	Equal
ne	Not equal
le	Less equal
lt	Less than
ge	Greater equal
gt	Greater than
eqc	Equal constant
nec	Not equal constant
lec	Less equal constant
ltc	Less than constant
gec	Greater equal constant
gtc	Greater than constant

2.5.1. COMP - Comparison of two fields

Synopsis

<operator> `ifile1 ifile2 ofile`

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 `ifile1` should be the same as in `ifile2`. One of the input files can contain only one time step or one field. The fields in `ofile` inherit the meta data from `ifile1` or `ifile2`. The type of comparison depends on the chosen operator.

Operators

eq Equal

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

ne Not equal

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

le Less equal

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

lt Less than

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

ge Greater equal

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

gt Greater than

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

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 ifile1 ifile2 ofile
```

2.5.2. COMPC - Comparison of a field with a constant

Synopsis

<*operator*>,*c* `ifile ofile`

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

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

nec Not equal constant

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

lec Less equal constant

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

ltc Less than constant

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

gec Greater equal constant

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

gtc Greater than constant

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

Parameter

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 ifile ofile
```

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:

setpartab	Set parameter table
setcode	Set code number
setname	Set variable name
setlevel	Set level
setltype	Set GRIB level type
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
setreftime	Set reference time
setcalendar	Set calendar
shifttime	Shift time steps
chcode	Change code number
chname	Change variable name
chlevel	Change level
chlevelc	Change level of one code
chlevelv	Change level of one variable
setgrid	Set grid
setgridtype	Set grid type
setzaxis	Set z-axis
setgatt	Set global attribute
setgatts	Set global attributes
invertlat	Invert latitudes
invertlev	Invert levels
maskregion	Mask regions
masklonlatbox	Mask a longitude/latitude box
maskindexbox	Mask an index box
setclonlatbox	Set a longitude/latitude box to constant
setcindexbox	Set an index box to constant
enlarge	Enlarge fields
setmissval	Set a new missing value
setctomiss	Set constant to missing value
setmisstoc	Set missing value to constant
setrtomiss	Set range to missing value
setvrange	Set valid range

2.6.1. SET - Set field info

Synopsis

setpartab,*table* `ifile ofile`

setcode,*code* `ifile ofile`

setname,*name* `ifile ofile`

setlevel,*level* `ifile ofile`

setltype,*ltype* `ifile ofile`

Description

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

Operators

setpartab	Set parameter table Sets the parameter table for all variables.
setcode	Set code number Sets the code number for all variables to the same given value.
setname	Set variable name Sets the name of the first variable.
setlevel	Set level Sets the first level of all variables.
setltype	Set GRIB level type Sets the GRIB level type of all variables.

Parameter

table	STRING	Parameter table file or name
code	INTEGER	Code number
name	STRING	Variable name
level	FLOAT	New level
ltype	INTEGER	GRIB level type

Example

To assign the parameter table echam5 to the input dataset use:

```
cdo setpartab,echam5 ifile ofile
```

2.6.2. SETTIME - Set time

Synopsis

setdate,*date* `ifile ofile`

settime,*time* `ifile ofile`

setday,*day* `ifile ofile`

setmon,*month* `ifile ofile`

setyear,*year* `ifile ofile`

settunits,*units* `ifile ofile`

settaxis,*date*,*time[,inc]* `ifile ofile`

setreftime,*date*,*time[,units]* `ifile ofile`

setcalendar,*calendar* `ifile ofile`

shifttime,*sval* `ifile ofile`

Description

This module sets the time axis or part of the time axis. Which part of the time axis is overwritten depends on the chosen operator.

Operators

setdate	Set date Sets the date in every time step to the same given value.
settime	Set time of the day Sets the time in every time step to the same given value.
setday	Set day Sets the day in every time step to the same given value.
setmon	Set month Sets the month in every time step to the same given value.
setyear	Set year Sets the year in every time step to the same given value.
settunits	Set time units Sets the base units of a relative time axis.
settaxis	Set time axis Sets the time axis.
setreftime	Set reference time Sets the reference time of a relative time axis.
setcalendar	Set calendar Sets the calendar of a relative time axis.
shifttime	Shift time steps Shifts all time steps by the parameter sval.

Parameter

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: 0hour]
calendar	STRING	Calendar (standard, proleptic, 360days, 365days, 366days)
sval	STRING	Shift value (e.g. -3hour)

Example

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

```
cdo settaxis,1987-01-16,12:00,1mon ifile ofile
```

Result of '`cdo showdate ofile`' for a dataset with 12 time steps:

```
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 ifile ofile
```

Result of '`cdo showdate ofile`':

```
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
```

2.6.3. CHANGE - Change field header

Synopsis

chcode,*oldcode*,*newcode[,...]* `ifile ofile`

chname,*oldname*,*newname*,*...* `ifile ofile`

chlevel,*oldlev*,*newlev*,*...* `ifile ofile`

chlevelc,*code*,*oldlev*,*newlev* `ifile ofile`

chlevelv,*name*,*oldlev*,*newlev* `ifile ofile`

Description

This module reads fields from `ifile`, changes some header values and writes the results to `ofile`. 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.
chname	Change variable name Changes some user given variable names to new user given names.
chlevel	Change level Changes some user given levels to new user given values.
chlevelc	Change level of one code Changes one level of a user given code number.
chlevelv	Change level of one variable Changes one level of a user given variable name.

Parameter

code	INTEGER	Code number
oldcode,newcode,...	INTEGER	Pairs of old and new code numbers
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 ifile ofile
```

2.6.4. SETGRID - Set grid type

Synopsis

setgrid,*grid* `ifile ofile`

setgridtype,*gridtype* `ifile ofile`

Description

This module sets the grid description of all fields with the same grid size as the new grid.

Operators

setgrid	Set grid Sets the grid description of all fields.
setgridtype	Set grid type Sets the grid type of all grids to a user given value.

Parameter

grid	STRING	Target grid description file or name
gridtype	STRING	Target grid type (curvilinear or cell)

Example

Assuming a dataset has fields with 2048 gridpoints without or with wrong grid description. To set the grid description of all input fields to a T21 Gaussian grid (2048 gridpoints) use:

```
cdo setgrid,t21grid ifile ofile
```

2.6.5. SETZAXIS - Set z-axis type

Synopsis

setzaxis,*zaxis* `ifile ofile`

Description

This operator sets the z-axis description of all variables with the same number of level as the new z-axis.

Parameter

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

2.6.6. SETGATT - Set global attribute

Synopsis

setgatt,*attname,attstring* `ifile ofile`

setgatts,*attfile* `ifile ofile`

Description

This module sets global text attributes of a dataset. Depending on the chosen operator the attributes are read from a file or can be specified by a parameter.

Operators

setgatt	Set global attribute Sets one user defined global text attribute.
setgatts	Set global attributes Sets user defined global text attributes. The name and text of the global attributes are read from a file.

Parameter

attname,attstring	STRING	Name and text of the global attribute (without spaces!)
attfile	STRING	File name which contains global text attributes

Note

Besides netCDF none of the supported data formats supports global attributes.

Example

To set the global text attribute "myatt" to "myattcontents" in a netCDF file use:

```
   cdo setgatt,myatt,myattcontents ifile ofile
```

Result of '`ncdump -h ofile`':

```
netcdf ofile {
dimensions: ...

variables: ...

// global attributes:
                :myatt = "myattcontens" ;
}
```

2.6.7. INVERT - Invert latitudes

Synopsis

invertlat `ifile ofile`

Description

This operator inverts the latitudes of all fields with a regular lon/lat grid.

Example

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

```
cdo invertlat ifile ofile
```

2.6.8. INVERTLEV - Invert levels

Synopsis

invertlev `ifile ofile`

Description

This operator inverts the levels of all non hybrid 3D variables.

2.6.9. MASKREGION - Mask regions

Synopsis

maskregion,*regions* `ifile ofile`

Description

Masks different regions of fields with a regular lon/lat grid. The elements inside a region are untouched, the elements outside are set to missing value. All input fields must have the same horizontal grid. The user has to give ASCII formatted files with different regions. A region is defined by 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 &.

Parameter

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 ifile ofile
```

For this example the polygon description file `myregion` should contain the following four coordinates:

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

2.6.10. MASKBOX - Mask a box

Synopsis

masklonlatbox,*lon1*,*lon2*,*lat1*,*lat2* `ifile ofile`

maskindexbox,*idx1*,*idx2*,*idy1*,*idy2* `ifile ofile`

Description

Masks a box of the rectangular understood field. 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 a longitude/latitude box. The user has to give the longitudes and latitudes of the edges of the box.
maskindexbox	Mask an index box Masks an index box. The user has to give the indexes of the edges of the box. The index of the left edge can be greater then the one of the right edge.

Parameter

lon1	FLOAT	Western longitude
lon2	FLOAT	Eastern longitude
lat1	FLOAT	Southern or northern latitude
lat2	FLOAT	Northern or southern latitude
idx1	INTEGER	Index of first longitude
idx2	INTEGER	Index of last longitude
idy1	INTEGER	Index of first latitude
idy2	INTEGER	Index of last latitude

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 ifile ofile
```

If the input dataset has fields on a T21 Gaussian grid, the same box can be masked with maskindexbox by:

```
cdo maskindexbox,23,48,13,20 ifile ofile
```

2.6.11. SETBOX - Set a box to constant

Synopsis

setclonlatbox,*c*,*lon1*,*lon2*,*lat1*,*lat2* `ifile ofile`

setcindexbox,*c*,*idx1*,*idx2*,*idy1*,*idy2* `ifile ofile`

Description

Sets a box of the rectangular 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 indexes of the edges of the box. The index of the left edge can be greater than the one of the right edge.

Parameter

c	FLOAT	Constant
lon1	FLOAT	Western longitude
lon2	FLOAT	Eastern longitude
lat1	FLOAT	Southern or northern latitude
lat2	FLOAT	Northern or southern latitude
idx1	INTEGER	Index of first longitude
idx2	INTEGER	Index of last longitude
idy1	INTEGER	Index of first latitude
idy2	INTEGER	Index of last latitude

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 ifile ofile
```

If the input dataset has fields on a T21 Gaussian grid, the same box can be set with setcindexbox by:

```
cdo setcindexbox,-1.23,23,48,13,20 ifile ofile
```

2.6.12. ENLARGE - Enlarge fields

Synopsis

enlarge,*grid* `ifile ofile`

Description

Enlarge all fields of `ifile` to a user given 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.

Parameter

grid	STRING	Target grid description file or name

Example

Assumed you want to add two datasets. The first dataset is on a T21 grid (2048 field elements) and the second dataset is only 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,t21grid ifile2 tmpfile
cdo add ifile1 tmpfile ofile
```

Or shorter using operator piping:

```
cdo add ifile1 -enlarge,t21grid ifile2 ofile
```

2.6.13. SETMISS - Set missing value

Synopsis

setmissval,*newmiss* `ifile ofile`

setctomiss,*c* `ifile ofile`

setmisstoc,*c* `ifile ofile`

setrtomiss,*rmin*,*rmax* `ifile ofile`

setvrange,*rmin*,*rmax* `ifile ofile`

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

$$o(t,x) = \begin{cases} \text{newmiss} & \text{if } i(t,x) = \mathit{miss} \\ i(t,x) & \text{if } i(t,x) \neq \mathit{miss} \end{cases}$$

setctomiss Set constant to missing value

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

setmisstoc Set missing value to constant

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

setrtomiss Set range to missing value

$$o(t,x) = \begin{cases} \text{miss} & \text{if } i(t,x) \geq \mathit{rmin} \wedge i(t,x) \leq \mathit{rmax} \\ i(t,x) & \text{if } i(t,x) < \mathit{rmin} \vee i(t,x) > \mathit{rmax} \end{cases}$$

setvrange Set valid range

$$o(t,x) = \begin{cases} \text{miss} & \text{if } i(t,x) < \mathit{rmin} \vee i(t,x) > \mathit{rmax} \\ i(t,x) & \text{if } i(t,x) \geq \mathit{rmin} \wedge i(t,x) \leq \mathit{rmax} \end{cases}$$

Parameter

newmiss	FLOAT	New missing value
c	FLOAT	Constant
rmin	FLOAT	Lower bound
rmax	FLOAT	Upper bound

Example

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 ifile ofile
```

Result of '`cdo info ifile`':

```
-1 :       Date   Time Code Level  Size  Miss :  Minimum    Mean  Maximum
 1 : 1987-12-31 12:00  139     0  2048     0 :   246.27  276.75   303.71
```

Result of '`cdo info ofile`':

```
-1 :       Date   Time Code Level  Size  Miss :  Minimum    Mean  Maximum
 1 : 1987-12-31 12:00  139     0  2048   871 :   273.16  287.08   303.71
```

2.7. Arithmetic

This section contains modules to arithmetically process datasets.

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

expr	Evaluate expressions
exprf	Evaluate expressions from script file
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
reci	Reciprocal value
addc	Add a constant
subc	Subtract a constant
mulc	Multiply with a constant
divc	Divide by a constant
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
monadd	Add monthly time series
monsub	Subtract monthly time series
monmul	Multiply monthly time series
mondiv	Divide monthly time series
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
muldpm	Multiply with days per month
divdpm	Divide by days per month
muldpy	Multiply with days per year
divdpy	Divide by days per year

2.7.1. EXPR - Evaluate expressions

Synopsis

expr,*instr* `ifile ofile`

exprf,*filename* `ifile ofile`

Description

This module arithmetically processes every time step of the input dataset. Each individual assignment statement have to end with a semi-colon. The basic arithmetic operations addition +, subtraction −, multiplication ∗, division / and exponentiation ˆ can be used. The following intrinsic functions are available:

sqrt(x)	Square Root of x
exp(x)	Exponential of x
log(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

Operators

expr Evaluate expressions
The processing instructions are read from the parameter.

exprf Evaluate expressions from script file
Contrary to expr the processing instructions are read from a file.

Parameter

instr	STRING	Processing instructions (without spaces!)
filename	STRING	File with processing instructions

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;' ifile ofile
```

The same example, but the instructions are read from a file:

```
cdo exprf,myexpr ifile ofile
```

The file `myexpr` contains:

```
var1 = aprl + aprc;
var2 = ts - 273.15;
```

2.7.2. MATH - Mathematical functions

Synopsis

<operator> `ifile ofile`

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
$o(t,x) = \arccos(i(t,x))$

reci Reciprocal value
$o(t,x) = 1/i(t,x)$

Example

To calculate the square root for all field elements use:

```
cdo sqrt ifile ofile
```

2.7.3. ARITHC - Arithmetic with a constant

Synopsis

<operator>,c `ifile ofile`

Description

This module performs simple arithmetic with all field elements of a dataset and a constant. The fields in `ofile` inherit the meta data from `ifile`.

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
$o(t, x) = i(t, x)/c$

Parameter

c	FLOAT	Constant

Example

To sum all input fields with the constant -273.15 use:

```
cdo addc,-273.15 ifile ofile
```

2.7.4. ARITH - Arithmetic on two datasets

Synopsis

<*operator*> `ifile1 ifile2 ofile`

Description

This module performs simple arithmetic of two datasets. The number of fields in `ifile1` should be the same as in `ifile2`. One of the input files can contain only one time step or one field. The fields in `ofile` inherit the meta data from `ifile1` or `ifile2`.

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
$o(t, x) = \min(i_1(t, x), i_2(t, x))$

max Maximum of two fields
$o(t, x) = \max(i_1(t, x), i_2(t, x))$

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).

$o(t, x) = \mathrm{atan2}(i_1(t, x), i_2(t, x))$

Example

To sum all fields of the first input file with the corresponding fields of the second input file use:

```
cdo add ifile1 ifile2 ofile
```

2.7.5. MONARITH - Monthly arithmetic

Synopsis

<*operator*> `ifile1 ifile2 ofile`

Description

This module performs simple arithmetic of a time series and one time step with the same month and year. For each field in `ifile1` the corresponding field of the time step in `ifile2` with the same month and year is used. The header information in `ifile1` have to be the same as in `ifile2`. Usually `ifile2` is generated by a call 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 ifile -monavg ifile ofile
```

2.7.6. YMONARITH - Multi-year monthly arithmetic

Synopsis

<*operator*> `ifile1 ifile2 ofile`

Description

This module performs simple arithmetic of a time series and one time step with the same month of year. For each field in `ifile1` the corresponding field of the time step in `ifile2` with the same month of year is used. The header information in `ifile1` have to be the same as in `ifile2`. Usually `ifile2` is generated by a call 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 and a multi-year monthly time series.
ymondiv	Divide multi-year monthly time series Divides a time series and a multi-year monthly time series.

Example

To subtract a multi-year monthly time average from a time series use:

```
cdo ymonsub ifile -ymonavg ifile ofile
```

2.7.7. ARITHDAYS - Arithmetic with days

Synopsis

<*operator*> `ifile ofile`

Description

This module multiplies or divides each time step 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
$o(t,x) = i(t,x)/days\_per\_year$

Example

Assume an input dataset is a monthly mean time series. To compute the yearly mean from the correct weighted monthly mean use:

```
cdo muldpm ifile tmpfile1
cdo yearsum tmpfile1 tmpfile2
cdo divdpy tmpfile2 ofile
```

Or all in one command line:

```
cdo divdpy -yearsum -muldpm ifile ofile
```

2.8. Statistical values

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.
In this section the abbreviations as in the following table are used:

sum	$\sum_{i=1}^{n} x_i$
mean resp. **avg**	$n^{-1} \sum_{i=1}^{n} x_i$
mean resp. **avg** weighted by $\{w_i, i = 1, ..., n\}$	$\left(\sum_{j=1}^{n} w_j\right)^{-1} \sum_{i=1}^{n} w_i\, x_i$
Variance **var**	$n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2$
var weighted by $\{w_i, i = 1, ..., n\}$	$\left(\sum_{j=1}^{n} w_j\right)^{-1} \sum_{i=1}^{n} w_i \left(x_i - \left(\sum_{j=1}^{n} w_j\right)^{-1} \sum_{j=1}^{n} w_j\, x_j\right)^2$
Standard deviation **std**	$\sqrt{n^{-1} \sum_{i=1}^{n} (x_i - \overline{x})^2}$
std weighted by $\{w_i, i = 1, ..., n\}$	$\sqrt{\left(\sum_{j=1}^{n} w_j\right)^{-1} \sum_{i=1}^{n} w_i \left(x_i - \left(\sum_{j=1}^{n} w_j\right)^{-1} \sum_{j=1}^{n} w_j\, x_j\right)^2}$

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

consecsum	Consecutive Sum
consects	Consecutive Timesteps

ensmin	Ensemble minimum
ensmax	Ensemble maximum
enssum	Ensemble sum
ensmean	Ensemble mean
ensavg	Ensemble average
ensvar	Ensemble variance
ensstd	Ensemble standard deviation
enspctl	Ensemble percentiles

fldmin	Field minimum
fldmax	Field maximum
fldsum	Field sum
fldmean	Field mean
fldavg	Field average
fldvar	Field variance
fldstd	Field standard deviation
fldpctl	Field percentiles
zonmin	Zonal minimum
zonmax	Zonal maximum
zonsum	Zonal sum
zonmean	Zonal mean
zonavg	Zonal average
zonvar	Zonal variance
zonstd	Zonal standard deviation
zonpctl	Zonal percentiles
mermin	Meridional minimum
mermax	Meridional maximum
mersum	Meridional sum
mermean	Meridional mean
meravg	Meridional average
mervar	Meridional variance
merstd	Meridional standard deviation
merpctl	Meridional percentiles
gridboxmin	Gridbox minimum
gridboxmax	Gridbox maximum
gridboxsum	Gridbox sum
gridboxmean	Gridbox mean
gridboxavg	Gridbox average
gridboxvar	Gridbox variance
gridboxstd	Gridbox standard deviation
vertmin	Vertical minimum
vertmax	Vertical maximum
vertsum	Vertical sum
vertmean	Vertical mean
vertavg	Vertical average
vertvar	Vertical variance
vertstd	Vertical standard deviation
timselmin	Time range minimum
timselmax	Time range maximum
timselsum	Time range sum
timselmean	Time range mean
timselavg	Time range average
timselvar	Time range variance
timselstd	Time range standard deviation
timselpctl	Time range percentiles

runmin	Running minimum
runmax	Running maximum
runsum	Running sum
runmean	Running mean
runavg	Running average
runvar	Running variance
runstd	Running standard deviation
runpctl	Running percentiles
timmin	Time minimum
timmax	Time maximum
timsum	Time sum
timmean	Time mean
timavg	Time average
timvar	Time variance
timstd	Time standard deviation
timpctl	Time percentiles
hourmin	Hourly minimum
hourmax	Hourly maximum
hoursum	Hourly sum
hourmean	Hourly mean
houravg	Hourly average
hourvar	Hourly variance
hourstd	Hourly standard deviation
hourpctl	Hourly percentiles
daymin	Daily minimum
daymax	Daily maximum
daysum	Daily sum
daymean	Daily mean
dayavg	Daily average
dayvar	Daily variance
daystd	Daily standard deviation
daypctl	Daily percentiles
monmin	Monthly minimum
monmax	Monthly maximum
monsum	Monthly sum
monmean	Monthly mean
monavg	Monthly average
monvar	Monthly variance
monstd	Monthly standard deviation
monpctl	Monthly percentiles
yearmin	Yearly minimum
yearmax	Yearly maximum
yearsum	Yearly sum
yearmean	Yearly mean
yearavg	Yearly average
yearvar	Yearly variance
yearstd	Yearly standard deviation

yearpctl	Yearly percentiles
seasmin	Seasonal minimum
seasmax	Seasonal maximum
seassum	Seasonal sum
seasmean	Seasonal mean
seasavg	Seasonal average
seasvar	Seasonal variance
seasstd	Seasonal standard deviation
seaspctl	Seasonal percentiles
yhourmin	Multi-year hourly minimum
yhourmax	Multi-year hourly maximum
yhoursum	Multi-year hourly sum
yhourmean	Multi-year hourly mean
yhouravg	Multi-year hourly average
yhourvar	Multi-year hourly variance
yhourstd	Multi-year hourly standard deviation
ydaymin	Multi-year daily minimum
ydaymax	Multi-year daily maximum
ydaysum	Multi-year daily sum
ydaymean	Multi-year daily mean
ydayavg	Multi-year daily average
ydayvar	Multi-year daily variance
ydaystd	Multi-year daily standard deviation
ydaypctl	Multi-year daily percentiles
ymonmin	Multi-year monthly minimum
ymonmax	Multi-year monthly maximum
ymonsum	Multi-year monthly sum
ymonmean	Multi-year monthly mean
ymonavg	Multi-year monthly average
ymonvar	Multi-year monthly variance
ymonstd	Multi-year monthly standard deviation
ymonpctl	Multi-year monthly percentiles
yseasmin	Multi-year seasonal minimum
yseasmax	Multi-year seasonal maximum
yseassum	Multi-year seasonal sum
yseasmean	Multi-year seasonal mean
yseasavg	Multi-year seasonal average
yseasvar	Multi-year seasonal variance
yseasstd	Multi-year seasonal standard deviation
yseaspctl	Multi-year seasonal percentiles
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
ydrunvar	Multi-year daily running variance
ydrunstd	Multi-year daily running standard deviation

ydrunpctl	Multi-year daily running percentiles

2.8.1. CONSECSTAT - Consecute timestep periods

Synopsis

<operator> `ifile ofile`

Description

This module computes periods over all time steps in `ifile` where a certain property is valid. The propery can be choosen 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 lenght 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 misvall.

Example

For a given time series of daily temperatures, the periods of summer days can be calculated with inplace maskting the input field:

```
cdo consects -gtc,20.0 ifile1 ofile
```

2.8.2. ENSSTAT - Statistical values over an ensemble

Synopsis

ensmin `ifiles ofile`

ensmax `ifiles ofile`

enssum `ifiles ofile`

ensmean `ifiles ofile`

ensavg `ifiles ofile`

ensvar `ifiles ofile`

ensstd `ifiles ofile`

enspctl,p `ifiles ofile`

Description

This module computes statistical values over an ensemble of input files. Depending on the chosen operator the minimum, maximum, sum, average, variance, standard deviation, or a certain percentile over all input files is written to `ofile`. The date information of a time step in `ofile` 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
$o(t,x) = \mathbf{max}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

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
$o(t,x) = \mathbf{avg}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensvar Ensemble variance
$o(t,x) = \mathbf{var}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

ensstd Ensemble standard deviation
$o(t,x) = \mathbf{std}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

enspctl Ensemble percentiles
$o(t,x) = \mathbf{pth\ percentile}\{i_1(t,x), i_2(t,x), \cdots, i_n(t,x)\}$

Parameter

p INTEGER Percentile number in 1, ..., 99

Example

To compute the ensemble mean over 6 input files use:

```
cdo ensmean ifile1 ifile2 ifile3 ifile4 ifile5 ifile6 ofile
```

Or shorter with filename substitution:

```
cdo ensmean ifile[1-6] ofile
```

To compute the 50th percentile (median) over 6 input files use:

```
cdo enspctl,50 ifile1 ifile2 ifile3 ifile4 ifile5 ifile6 ofile
```

2.8.3. FLDSTAT - Statistical values over a field

Synopsis

fldmin `ifile ofile`

fldmax `ifile ofile`

fldsum `ifile ofile`

fldmean `ifile ofile`

fldavg `ifile ofile`

fldvar `ifile ofile`

fldstd `ifile ofile`

fldpctl,*p* `ifile ofile`

Description

This module computes statistical values of the input fields. According to the chosen operator the field minimum, maximum, sum, average, variance, standard deviation or a certain percentile is written to `ofile`.

Operators

fldmin Field minimum
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{min}\{i(t,x'), x_1 < x' \leq x_n\}$

fldmax Field maximum
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{max}\{i(t,x'), x_1 < x' \leq x_n\}$

fldsum Field sum
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{sum}\{i(t,x'), x_1 < x' \leq x_n\}$

fldmean Field mean
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{mean}\{i(t,x'), x_1 < x' \leq x_n\}$
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:
$o(t,1) = \mathbf{avg}\{i(t,x'), x_1 < x' \leq x_n\}$
weighted by area weights obtained by the input field.

fldvar Field variance
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{var}\{i(t,x'), x_1 < x' \leq x_n\}$
weighted by area weights obtained by the input field.

fldstd Field standard deviation
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{std}\{i(t,x'), x_1 < x' \leq x_n\}$
weighted by area weights obtained by the input field.

fldpctl Field percentiles
For every gridpoint $x_1, ..., x_n$ of the same field it is:
$o(t,1) = \mathbf{pth\ percentile}\{i(t,x'), x_1 < x' \leq x_n\}$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Example

To compute the field mean of all input fields use:

```
cdo fldmean ifile ofile
```

To compute the 90th percentile of all input fields use:

```
cdo fldpctl,90 ifile ofile
```

2.8.4. ZONSTAT - Zonal statistical values

Synopsis

zonmin `ifile ofile`

zonmax `ifile ofile`

zonsum `ifile ofile`

zonmean `ifile ofile`

zonavg `ifile ofile`

zonvar `ifile ofile`

zonstd `ifile ofile`

zonpctl,*p* `ifile ofile`

Description

This module computes zonal statistical values of the input fields. According to the chosen operator the zonal minimum, maximum, sum, average, variance, standard deviation or a certain percentile is written to `ofile`. All input fields need to have the same regular lonlat grid.

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.
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.
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.
zonstd	Zonal standard deviation For every latitude the standard deviation over all longitudes is computed.
zonpctl	Zonal percentiles For every latitude the pth percentile over all longitudes is computed.

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Example

To compute the zonal mean of all input fields use:

```
cdo zonmean ifile ofile
```

To compute the 50th meridional percentile (median) of all input fields use:

```
cdo zonpctl,50 ifile ofile
```

2.8.5. MERSTAT - Meridional statistical values

Synopsis

mermin `ifile ofile`

mermax `ifile ofile`

mersum `ifile ofile`

mermean `ifile ofile`

meravg `ifile ofile`

mervar `ifile ofile`

merstd `ifile ofile`

merpctl,*p* `ifile ofile`

Description

This module computes meridional statistical values of the input fields. According to the chosen operator the meridional minimum, maximum, sum, average, variance, standard deviation or a certain percentile is written to `ofile`. All input fields need to have 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.
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.
merstd	Meridional standard deviation For every longitude the standard deviation over all latitudes is computed.
merpctl	Meridional percentiles For every longitude the pth percentile over all latitudes is computed.

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Example

To compute the meridional mean of all input fields use:

```
cdo mermean ifile ofile
```

To compute the 50th meridional percentile (median) of all input fields use:

```
cdo merpctl,50 ifile ofile
```

2.8.6. GRIDBOXSTAT - Statistical values over grid boxes

Synopsis

<operator>,nx,,ny `ifile ofile`

Description

This module computes statistical values over surrounding grid boxes. According to the chosen operator the minimum, maximum, sum, average, variance, or standard deviation of the neighboring grid boxes is written to `ofile`. All gridbox operators only works on quadrilateral curvilinear grids.

Operators

gridboxmin	Gridbox minimum
gridboxmax	Gridbox maximum
gridboxsum	Gridbox sum
gridboxmean	Gridbox mean
gridboxavg	Gridbox average
gridboxvar	Gridbox variance
gridboxstd	Gridbox standard deviation

Parameter

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 ifile ofile
```

2.8.7. VERTSTAT - Vertical statistical values

Synopsis

<operator> `ifile ofile`

Description

This module computes statistical values over all levels of the input variables. According to chosen operator the vertical minimum, maximum, sum, average, variance or standard deviation is written to `ofile`.

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.
vertsum	Vertical sum For every gridpoint the sum over all levels is computed.
vertmean	Vertical mean For every gridpoint the mean over all levels is computed.
vertavg	Vertical average For every gridpoint the average over all levels is computed.
vertvar	Vertical variance For every gridpoint the variance over all levels is computed.
vertstd	Vertical standard deviation For every gridpoint the standard deviation over all levels is computed.

Example

To compute the vertical sum of all input variables use:

```
cdo vertsum ifile ofile
```

2.8.8. TIMSELSTAT - Time range statistical values

Synopsis

<operator>,nsets[,noffset[,nskip]] `ifile ofile`

Description

This module computes statistical values for a selected number of time steps. According to the chosen operator the minimum, maximum, sum, average, variance or standard deviation of the selected time steps is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

timselmin Time range minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{min}\{i(t', x), t_1 < t' \leq t_n\}$

timselmax Time range maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{max}\{i(t', x), t_1 < t' \leq t_n\}$

timselsum Time range sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{sum}\{i(t', x), t_1 < t' \leq t_n\}$

timselmean Time range mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{mean}\{i(t', x), t_1 < t' \leq t_n\}$

timselavg Time range average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{avg}\{i(t', x), t_1 < t' \leq t_n\}$

timselvar Time range variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{var}\{i(t', x), t_1 < t' \leq t_n\}$

timselstd Time range standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:
$o(t, x) = \mathbf{std}\{i(t', x), t_1 < t' \leq t_n\}$

Parameter

nsets	INTEGER	Number of input time steps for each output time step
noffset	INTEGER	Number of input time steps skipped before the first time step range (optional)
nskip	INTEGER	Number of input time steps skipped between time step 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 ifile ofile
```

2.8.9. TIMSELPCTL - Time range percentile values

Synopsis

timselpctl,*p*,*nsets[,noffset[,nskip]]* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentile values over a selected number of time steps in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding timselmin and timselmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same selected time range it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \leq t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99
nsets	INTEGER	Number of input time steps for each output time step
noffset	INTEGER	Number of input time steps skipped before the first time step range (optional)
nskip	INTEGER	Number of input time steps skipped between time step ranges (optional)

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

2.8.10. RUNSTAT - Running statistical values

Synopsis

<operator>,nts `ifile ofile`

Description

This module computes running statistical values over a selected number of time steps. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of a selected number of consecutive time steps read from `ifile` is written to `ofile`. The date information in `ofile` is the date of the middle contributing time step in `ifile`.

Operators

runmin Running minimum
$o(t + (nts - 1)/2, x) = \mathbf{min}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runmax Running maximum
$o(t + (nts - 1)/2, x) = \mathbf{max}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runsum Running sum
$o(t + (nts - 1)/2, x) = \mathbf{sum}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runmean Running mean
$o(t + (nts - 1)/2, x) = \mathbf{mean}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runavg Running average
$o(t + (nts - 1)/2, x) = \mathbf{avg}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runvar Running variance
$o(t + (nts - 1)/2, x) = \mathbf{std}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

runstd Running standard deviation
$o(t + (nts - 1)/2, x) = \mathbf{std}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$

Parameter

nts INTEGER Number of time steps

Environment

`RUNSTAT_DATE` Sets the date information in ofile to the ”first”, ”last” or ”middle” contributing time step in ifile.

Example

To compute the running mean over 9 time steps use:

```
cdo runmean,9 ifile ofile
```

2.8.11. RUNPCTL - Running percentile values

Synopsis

runpctl,*p*,*nts* `ifile1 ofile`

Description

This module computes running percentiles over a selected number of time steps in `ifile1`. The date information in `ofile` is the date of the medium contributing time step in `ifile1`.

$$o(t + (nts - 1)/2, x) = \textbf{pth percentile}\{i(t, x), i(t + 1, x), ..., i(t + nts - 1, x)\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99
nts	INTEGER	Number of time steps

Example

To compute the running 50th percentile (median) over 9 time steps use:

```
cdo runpctl,50,9 ifile -runmin,9 ifile -runmax,9 ifile ofile
```

2.8.12. TIMSTAT - Statistical values over all time steps

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values over all time steps in `ifile`. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of all time steps read from `ifile` is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

timmin Time minimum
$o(1, x) = \textbf{min}\{i(t', x), t_1 < t' \leq t_n\}$

timmax Time maximum
$o(1, x) = \textbf{max}\{i(t', x), t_1 < t' \leq t_n\}$

timsum Time sum
$o(1, x) = \textbf{sum}\{i(t', x), t_1 < t' \leq t_n\}$

timmean Time mean
$o(1, x) = \textbf{mean}\{i(t', x), t_1 < t' \leq t_n\}$

timavg Time average
$o(1, x) = \textbf{avg}\{i(t', x), t_1 < t' \leq t_n\}$

timvar Time variance
$o(1, x) = \textbf{var}\{i(t', x), t_1 < t' \leq t_n\}$

timstd Time standard deviation
$o(1, x) = \textbf{std}\{i(t', x), t_1 < t' \leq t_n\}$

Example

To compute the mean over all input time steps use:

```
cdo timmean ifile ofile
```

2.8.13. TIMPCTL - Percentile values over all time steps

Synopsis

timpctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding timmin and timmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

$o(1, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \leq t_n\}$

Parameter

p INTEGER Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS` Sets the number of histogram bins. The default number is 101.

Example

To compute the 90th percentile over all input time steps use:

```
cdo timmin ifile minfile
cdo timmax ifile maxfile
cdo timpctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo timpctl,90 ifile -timmin ifile -timmax ifile ofile
```

2.8.14. HOURSTAT - Hourly statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values over time steps of the same hour. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of time steps of the same hour is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

hourmin Hourly minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{min}\{i(t', x), t_1 < t' \le t_n\}$

hourmax Hourly maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{max}\{i(t', x), t_1 < t' \le t_n\}$

hoursum Hourly sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{sum}\{i(t', x), t_1 < t' \le t_n\}$

hourmean Hourly mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{mean}\{i(t', x), t_1 < t' \le t_n\}$

houravg Hourly average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{avg}\{i(t', x), t_1 < t' \le t_n\}$

hourvar Hourly variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{var}\{i(t', x), t_1 < t' \le t_n\}$

hourstd Hourly standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:
$o(t, x) = \mathbf{std}\{i(t', x), t_1 < t' \le t_n\}$

Example

To compute the hourly mean of a time series use:

```
cdo hourmean ifile ofile
```

2.8.15. HOURPCTL - Hourly percentile values

Synopsis

hourpctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps of the same hour in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding hourmin and hourmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same hour it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \leq t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the hourly 90th percentile of a time series use:

```
cdo hourmin ifile minfile
cdo hourmax ifile maxfile
cdo hourpctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo hourpctl,90 ifile -hourmin ifile -hourmax ifile ofile
```

2.8.16. DAYSTAT - Daily statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values over time steps of the same day. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of time steps of the same day is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

daymin Daily minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{min}\{i(t',x), t_1 < t' \le t_n\}$

daymax Daily maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{max}\{i(t',x), t_1 < t' \le t_n\}$

daysum Daily sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{sum}\{i(t',x), t_1 < t' \le t_n\}$

daymean Daily mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{mean}\{i(t',x), t_1 < t' \le t_n\}$

dayavg Daily average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{avg}\{i(t',x), t_1 < t' \le t_n\}$

dayvar Daily variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{var}\{i(t',x), t_1 < t' \le t_n\}$

daystd Daily standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:
$o(t,x) = \mathbf{std}\{i(t',x), t_1 < t' \le t_n\}$

Example

To compute the daily mean of a time series use:

```
cdo daymean ifile ofile
```

2.8.17. DAYPCTL - Daily percentile values

Synopsis

daypctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps of the same day in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, respectively. The default number of histogram bins is 101. The default can be overridden by defining the environment variable `CDO_PCTL_NBINS`. The files `ifile2` and `ifile3` should be the result of corresponding daymin and daymax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same day it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \le t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the daily 90th percentile of a time series use:

```
cdo daymin ifile minfile
cdo daymax ifile maxfile
cdo daypctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo daypctl,90 ifile -daymin ifile -daymax ifile ofile
```

2.8.18. MONSTAT - Monthly statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values over time steps of the same month. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of time steps of the same month is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

monmin Monthly minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{min}\{i(t', x), t_1 < t' \leq t_n\}$

monmax Monthly maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{max}\{i(t', x), t_1 < t' \leq t_n\}$

monsum Monthly sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{sum}\{i(t', x), t_1 < t' \leq t_n\}$

monmean Monthly mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{mean}\{i(t', x), t_1 < t' \leq t_n\}$

monavg Monthly average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{avg}\{i(t', x), t_1 < t' \leq t_n\}$

monvar Monthly variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{var}\{i(t', x), t_1 < t' \leq t_n\}$

monstd Monthly standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:
$o(t, x) = \mathbf{std}\{i(t', x), t_1 < t' \leq t_n\}$

Example

To compute the monthly mean of a time series use:

```
cdo monmean ifile ofile
```

2.8.19. MONPCTL - Monthly percentile values

Synopsis

monpctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps of the same month in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding monmin and monmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same month it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \leq t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the monthly 90th percentile of a time series use:

```
cdo monmin ifile minfile
cdo monmax ifile maxfile
cdo monpctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo monpctl,90 ifile -monmin ifile -monmax ifile ofile
```

2.8.20. YEARSTAT - Yearly statistical values

Synopsis

<operator> `ifile ofile`

Description

This module computes statistical values over time steps of the same year. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of time steps of the same year is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Operators

yearmin Yearly minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{min}\{i(t', x), t_1 < t' \le t_n\}$

yearmax Yearly maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{max}\{i(t', x), t_1 < t' \le t_n\}$

yearsum Yearly sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{sum}\{i(t', x), t_1 < t' \le t_n\}$

yearmean Yearly mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{mean}\{i(t', x), t_1 < t' \le t_n\}$

yearavg Yearly average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{avg}\{i(t', x), t_1 < t' \le t_n\}$

yearvar Yearly variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{var}\{i(t', x), t_1 < t' \le t_n\}$

yearstd Yearly standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:
$o(t, x) = \mathbf{std}\{i(t', x), t_1 < t' \le t_n\}$

Note

The operators yearmean and yearavg compute only arithmetical means!

Example

To compute the yearly mean of a time series use:

```
cdo yearmean ifile ofile
```

To compute the yearly mean from the correct weighted monthly mean use:

```
cdo divdpy -yearsum -muldpm ifile ofile
```

2.8.21. YEARPCTL - Yearly percentile values

Synopsis

yearpctl,p `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps of the same year in `ifile1`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding yearmin and yearmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same year it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \le t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the yearly 90th percentile of a time series use:

```
cdo yearmin ifile minfile
cdo yearmax ifile maxfile
cdo yearpctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo yearpctl,90 ifile -yearmin ifile -yearmax ifile ofile
```

2.8.22. SEASSTAT - Seasonal statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values over time steps of the same season. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of time steps of the same season is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`. Be careful about the first and the last output time step, they may be incorrect values if the seasons have incomplete time steps.

Operators

seasmin Seasonal minimum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{min}\{i(t', x), t_1 < t' \leq t_n\}$

seasmax Seasonal maximum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{max}\{i(t', x), t_1 < t' \leq t_n\}$

seassum Seasonal sum
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{sum}\{i(t', x), t_1 < t' \leq t_n\}$

seasmean Seasonal mean
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{mean}\{i(t', x), t_1 < t' \leq t_n\}$

seasavg Seasonal average
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{avg}\{i(t', x), t_1 < t' \leq t_n\}$

seasvar Seasonal variance
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{var}\{i(t', x), t_1 < t' \leq t_n\}$

seasstd Seasonal standard deviation
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:
$o(t, x) = \mathbf{std}\{i(t', x), t_1 < t' \leq t_n\}$

Example

To compute the seasonal mean of a time series use:

```
cdo seasmean ifile ofile
```

2.8.23. SEASPCTL - Seasonal percentile values

Synopsis

seaspctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator computes percentiles over all time steps in `ifile1` of the same season. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding seasmin and seasmax operations, respectively. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`. Be careful about the first and the last output time step, they may be incorrect values if the seasons have incomplete time steps.
For every adjacent sequence $t_1, ..., t_n$ of time steps of the same season it is:

$$o(t, x) = \textbf{pth percentile}\{i(t', x), t_1 < t' \leq t_n\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the seasonal 90th percentile of a time series use:

```
cdo seasmin ifile minfile
cdo seasmax ifile maxfile
cdo seaspctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo seaspctl,90 ifile -seasmin ifile -seasmax ifile ofile
```

2.8.24. YHOURSTAT - Multi-year hourly statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values of each hour and day of year. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of each hour and day of year in `ifile` is written to `ofile`. The date information in an output field is the date of the last contributing input field.

Operators

yhourmin Multi-year hourly minimum

$$o(0001, x) = \mathbf{min}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{min}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhourmax Multi-year hourly maximum

$$o(0001, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhoursum Multi-year hourly sum

$$o(0001, x) = \mathbf{sum}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{sum}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhourmean Multi-year hourly mean

$$o(0001, x) = \mathbf{mean}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{mean}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhouravg Multi-year hourly average

$$o(0001, x) = \mathbf{avg}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{avg}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhourvar Multi-year hourly variance

$$o(0001, x) = \mathbf{var}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{var}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

yhourstd Multi-year hourly standard deviation

$$o(0001, x) = \mathbf{std}\{i(t, x), \mathrm{day}(i(t)) = 0001\}$$
$$\vdots$$
$$o(8784, x) = \mathbf{std}\{i(t, x), \mathrm{day}(i(t)) = 8784\}$$

Example

To compute the hourly mean for all days over all input years use:

```
cdo yhourmean ifile ofile
```

2.8.25. YDAYSTAT - Multi-year daily statistical values

Synopsis

<*operator*> `ifile ofile`

Description

This module computes statistical values of each day of year. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of each day of year in `ifile` is written to `ofile`. 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

$$o(001, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \mathbf{max}\{i(t, x), \mathrm{day}(i(t)) = 366\}$$

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

$$o(001, x) = \mathbf{var}\{i(t, x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \mathbf{var}\{i(t, x), \mathrm{day}(i(t)) = 366\}$$

ydaystd Multi-year daily standard deviation

$$o(001, x) = \mathbf{std}\{i(t, x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \mathbf{std}\{i(t, x), \mathrm{day}(i(t)) = 366\}$$

Example

To compute the daily mean over all input years use:

```
cdo ydaymean ifile ofile
```

2.8.26. YDAYPCTL - Multi-year daily percentile values

Synopsis

ydaypctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator writes a certain percentile of each day of year in `ifile1` to `ofile`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` 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.

$$o(001, x) = \textbf{pth percentile}\{i(t, x), \mathrm{day}(i(t)) = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{pth percentile}\{i(t, x), \mathrm{day}(i(t)) = 366\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the daily 90th percentile over all input years use:

```
cdo ydaymin ifile minfile
cdo ydaymax ifile maxfile
cdo ydaypctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo ydaypctl,90 ifile -ydaymin ifile -ydaymax ifile ofile
```

2.8.27. YMONSTAT - Multi-year monthly statistical values

Synopsis

<operator> `ifile ofile`

Description

This module computes statistical values of each month of year. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of each month of year in `ifile` is written to `ofile`. The date information in an output field is the date of the last contributing input field.

Operators

ymonmin Multi-year monthly minimum

$$o(01, x) = \mathbf{min}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{min}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonmax Multi-year monthly maximum

$$o(01, x) = \mathbf{max}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{max}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonsum Multi-year monthly sum

$$o(01, x) = \mathbf{sum}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{sum}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonmean Multi-year monthly mean

$$o(01, x) = \mathbf{mean}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{mean}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonavg Multi-year monthly average

$$o(01, x) = \mathbf{avg}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{avg}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonvar Multi-year monthly variance

$$o(01, x) = \mathbf{var}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{var}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

ymonstd Multi-year monthly standard deviation

$$o(01, x) = \mathbf{std}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \mathbf{std}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

Example

To compute the monthly mean over all input years use:

```
cdo ymonmean ifile ofile
```

2.8.28. YMONPCTL - Multi-year monthly percentile values

Synopsis

ymonpctl,*p* `ifile1 ifile2 ifile3 ofile`

Description

This operator writes a certain percentile of each month of year in `ifile1` to `ofile`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` 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.

$$o(01, x) = \textbf{pth percentile}\{i(t, x), \mathrm{month}(i(t)) = 01\}$$
$$\vdots$$
$$o(12, x) = \textbf{pth percentile}\{i(t, x), \mathrm{month}(i(t)) = 12\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the monthly 90th percentile over all input years use:

```
cdo ymonmin ifile minfile
cdo ymonmax ifile maxfile
cdo ymonpctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo ymonpctl,90 ifile -ymonmin ifile -ymonmax ifile ofile
```

2.8.29. YSEASSTAT - Multi-year seasonal statistical values

Synopsis

<operator> `ifile ofile`

Description

This module computes statistical values of each season. Depending on the chosen operator the minimum, maximum, sum, average, variance or standard deviation of each season in `ifile` is written to `ofile`. The date information in an output field is the date of the last contributing input field.

Operators

yseasmin Multi-year seasonal minimum

$o(1,x) = \textbf{min}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{min}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{min}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{min}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseasmax Multi-year seasonal maximum

$o(1,x) = \textbf{max}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{max}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{max}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{max}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseassum Multi-year seasonal sum

$o(1,x) = \textbf{sum}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{sum}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{sum}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{sum}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseasmean Multi-year seasonal mean

$o(1,x) = \textbf{mean}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{mean}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{mean}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{mean}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseasavg Multi-year seasonal average

$o(1,x) = \textbf{avg}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{avg}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{avg}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{avg}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseasvar Multi-year seasonal variance

$o(1,x) = \textbf{var}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{var}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{var}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{var}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

yseasstd Multi-year seasonal standard deviation

$o(1,x) = \textbf{std}\{i(t,x), \text{month}(i(t)) = 12,\ 01,\ 02\}$

$o(2,x) = \textbf{std}\{i(t,x), \text{month}(i(t)) = 03,\ 04,\ 05\}$

$o(3,x) = \textbf{std}\{i(t,x), \text{month}(i(t)) = 06,\ 07,\ 08\}$

$o(4,x) = \textbf{std}\{i(t,x), \text{month}(i(t)) = 09,\ 10,\ 11\}$

Example

To compute the seasonal mean over all input years use:

```
cdo yseasmean ifile ofile
```

2.8.30. YSEASPCTL - Multi-year seasonal percentile values

Synopsis

yseaspctl,p `ifile1 ifile2 ifile3 ofile`

Description

This operator writes a certain percentile of each season in `ifile1` to `ofile`. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` 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.

$$o(1,x) = \textbf{pth percentile}\{i(t,x), \mathrm{month}(i(t)) = 12,\ 01,\ 02\}$$
$$o(2,x) = \textbf{pth percentile}\{i(t,x), \mathrm{month}(i(t)) = 03,\ 04,\ 05\}$$
$$o(3,x) = \textbf{pth percentile}\{i(t,x), \mathrm{month}(i(t)) = 06,\ 07,\ 08\}$$
$$o(4,x) = \textbf{pth percentile}\{i(t,x), \mathrm{month}(i(t)) = 09,\ 10,\ 11\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 101.

Example

To compute the seasonal 90th percentile over all input years use:

```
cdo yseasmin ifile minfile
cdo yseasmax ifile maxfile
cdo yseaspctl,90 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo yseaspctl,90 ifile -yseasmin ifile -yseasmax ifile ofile
```

2.8.31. YDRUNSTAT - Multi-year daily running statistical values

Synopsis

<operator>,nts `ifile ofile`

Description

This module writes running statistical values for each day of year in `ifile` to `ofile`. Depending on the chosen operator, the minimum, maximum, sum, average, variance or standard deviation of all time steps in running windows of wich the medium time step corresponds to a certain day of year is computed. The date information in an output field is the date of the medium time step in 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 time steps after the first time step of the input time series and ends (nts-1)/2 time steps 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

$$o(001,x) = \mathbf{var}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{var}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

ydrunstd Multi-year daily running standard deviation

$$o(001,x) = \mathbf{std}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366,x) = \mathbf{std}\{i(t,x), i(t+1,x), ..., i(t+nts-1,x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

Parameter

nts INTEGER Number of time steps

Example

Assume the input data provide a continuous time series of daily measurements. To compute the running multi-year daily mean over all input time steps for a running window of five days use:

```
cdo ydrunmean,5 ifile ofile
```

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 ifile ofile
```

2.8.32. YDRUNPCTL - Multi-year daily running percentile values

Synopsis

ydrunpctl,*p*,*nts* `ifile1 ifile2 ifile3 ofile`

Description

This operator writes running percentile values for each day of year in `ifile1` to `ofile`. A certain percentile is computed for all time steps in running windows of which the medium time step corresponds to a certain day of year. The algorithm uses histograms with minimum and maximum bounds given in `ifile2` and `ifile3`, 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 `ifile2` and `ifile3` should be the result of corresponding ydrunmin and ydrunmax operations, respectively. The date information in an output field is the date of the medium time step in 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 time steps after the first time step of the input time series and ends (nts-1)/2 time steps 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.

$$o(001, x) = \textbf{pth percentile}\{i(t, x), i(t+1, x), ..., i(t+nts-1, x); \mathrm{day}[(i(t+(nts-1)/2)] = 001\}$$
$$\vdots$$
$$o(366, x) = \textbf{pth percentile}\{i(t, x), i(t+1, x), ..., i(t+nts-1, x); \mathrm{day}[(i(t+(nts-1)/2)] = 366\}$$

Parameter

p	INTEGER	Percentile number in 1, ..., 99
nts	INTEGER	Number of time steps

Environment

`CDO_PCTL_NBINS`	Sets the number of histogram bins. The default number is 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 time steps for a running window of five days use:

```
cdo ydrunmin,5 ifile minfile
cdo ydrunmax,5 ifile maxfile
cdo ydrunpctl,90,5 ifile minfile maxfile ofile
```

Or shorter using operator piping:

```
cdo ydrunpctl,90,5 ifile -ydrunmin ifile -ydrunmax ifile ofile
```

2.9. Correlation

This sections contains modules for correlation in space and time.

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

fldcor	Correlation in grid space
timcor	Correlation over time

2.9.1. FLDCOR - Correlation of grid space

Synopsis

fldcor `ifile1 ifile2 ofile`

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 stream. For every timestep t only those field elements x belong to the sample, which have $i_1(t,x) \neq missval$ and $i_2(t,x) \neq missval$.

2.9.2. TIMCOR - Correlation over time

Synopsis

timcor `ifile1 ifile2 ofile`

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. 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 $i_2(t,x) \neq missval$.

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	Regression
detrend	Detrend
trend	Trend
subtrend	Subtract trend

2.10.1. REGRES - Regression

Synopsis

regres ifile ofile

Description

The values of the input file `ifile` 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 time steps t belong to the sample $S(x)$, which have $i(t,x) \neq \text{miss}$. It is

$$o(1,x) = \frac{\sum\limits_{t \in S(x)} \left(i(t,x) - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} i(t',x) \right) \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)}{\sum\limits_{t \in S(x)} \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)^2}$$

2.10.2. DETREND - Detrend time series

Synopsis

detrend ifile ofile

Description

Every time series in `ifile` is linearly detrended. For every field element x only those time steps t belong to the sample $S(x)$, which have $i(t,x) \neq \text{miss}$. 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

$$b(x) = \frac{\sum\limits_{t \in S(x)} \left(i(t,x) - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} i(t',x) \right) \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)}{\sum\limits_{t \in S(x)} \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)^2}$$

it is

$$o(t,x) = i(t,x) - (a(x) + b(x)t)$$

Note

This operator has to keep the fields of all time steps concurrently in the memory. If not enough memory is available use the operators trend and subtrend.

Example

To detrend the data in `ifile` and to store the detrended data in `ofile` use:

```
cdo detrend ifile ofile
```

2.10.3. TREND - Trend of time series

Synopsis

trend `ifile ofile1 ofile2`

Description

The values of the input file `ifile` 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 time steps t belong to the sample $S(x)$, which have $i(t, x) \neq \text{miss}$. 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

$$o_2(1, x) = \frac{\sum\limits_{t \in S(x)} \left(i(t, x) - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} i(t', x) \right) \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)}{\sum\limits_{t \in S(x)} \left(t - \frac{1}{\#S(x)} \sum\limits_{t' \in S(x)} t' \right)^2}$$

Thus the estimation for a is stored in `ofile1` and that for b is stored in `ofile2`. To subtract the trend from the data see operator subtrend.

2.10.4. SUBTREND - Subtract a trend

Synopsis

subtrend `ifile1 ifile2 ifile3 ofile`

Description

This operator is for subtracting a trend computed by the operator trend. It is

$$o(t, x) = i_1(t, x) - (i_2(1, x) + i_3(1, x) \cdot t)$$

where t is the time steps.

Example

The typical call for detrending the data in `ifile` and storing the detrended data in `ofile` is:

```
cdo trend ifile afile bfile
cdo subtrend ifile afile bfile ofile
```

The result is identical to a call of the operator detrend:

```
cdo detrend ifile ofile
```

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:
Rudolph W. Peisendorfer: Principal Component Analysis, Elsevier (1988).
Details about calculation in the time- and spatial spaces are found in:
Hans von Storch, Walter Zwiers: Statistical Analysis in Climate Research, Cambridge University Press (1999).

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.

$$\langle z_j \rangle = n^{-1} \sum_{i=1}^{n} z_j(i) = 0 \; \forall \; 1 \leq j \leq p$$

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	Calculate EOFs in spatial or time space
eoftime	Calculate EOFs in time space
eofspatial	Calculate EOFs in spatial space
eofcoeff	Calculate principal coefficients of EOFs

2.11.1. EOFS - Empirical Orthogonal Functions

Synopsis

<*operator*>,*neof* `ifile ofile1 ofile2`

Description

This module calculates empirical orthogonal functions of the data in `ifile` 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 time steps is larger than the number of grid-points. Data in `ifile` are assumed to be anomalies. If they are not, the behavior of this module is **not** well defined. After execution `ofile1` will contain the eigen-values and `ofile2` the eigenvectors e_j. Note, thate the resulting EOF in `ifile2` is e_j and thus **not weighted** for consistency.
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 `ifile`.

Operators

eof	Calculate EOFs in spatial or time space
eoftime	Calculate EOFs in time space
eofspatial	Calculate EOFs in spatial space

Parameter

neof	INTEGER	Number of eigen functions

Example

To calculate the first 40 EOFs of a data-set containing anomalies use:

```
cdo eof,40 ifile ofile1 ofile2
```

If the dataset does not containt anomalies, process them first, and use:

```
cdo sub ifile1 -timmean ifile1 anom_file
cdo eof,40 anom_file ofile1 ofile2
```

2.11.2. EOFCOEFF - Principal coefficients of EOFs

Synopsis

eofcoeff `ifile1 ifile2 obase`

Description

This module calculates the time series of the principal coefficients for given EOF (empirical orthogonal functions) and data. Time steps in `ifile1` are assumed to be the EOFs, Time steps in `ifile2` are assumed to be the time series. Weights are taken into account, which is why EOF output is **not** weighted. Note, that this operator calculates a weighted dot product of the fields in `ifile1` and `ifile2`. Given a set of EOFs e_j and a time series of data $z(t)$ with p entries for each time step from which e_j have been calculated, this operator calculates the time series of the projections of data onto each EOF

$$o_j(t) = \sum_{x=1}^{p} W(x,x)z(t,x)e_j(x)$$

where W is the diagonal matrix containing area weights as above. 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.

$$\sum_{t=1}^{n} o_j(t)o_k(t) = \begin{cases} 0 \; if \; j \neq k \\ \lambda_j \; if \; j = k \end{cases} \quad with \; \sum_{t=1}^{n} o_j(t) = 0 \forall j \in \{1, \ldots, p\}.$$

There will be a separate file containing a time series of principal coefficients with time information from `ifile2` for each EOF in `ifile1`. Files will be numbered as <`obase`>_<`neof`>.<`suffix`> where $neof + 1$ is the number of the EOF (time step) in `ifile1` and suffix is a file-suffix derived from the current file format.

Example

To calculate principal coefficients of the first 40 EOFs of `anom_file`, and write them to files beginning with obase, use:

```
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 `obase_000000.nc` (and so forth for higher EOFs, nth EOF will be in `obase_<n-1>`).
If the dataset `ifile` does not containt anomalies, process them first, and use:

```
cdo sub ifile -timmean ifile anom_file
cdo eof,40 anom_file eval_file eof_file
cdo eofcoeff eof_file anom_file obase
```

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	Bilinear interpolation
remapbic	Bicubic interpolation
remapdis	Distance-weighted average remapping
remapnn	Nearest neighbor remapping
remapcon	First order conservative remapping
remapcon2	Second order conservative remapping
remaplaf	Largest area fraction remapping
genbil	Generate bilinear interpolation weights
genbic	Generate bicubic interpolation weights
gendis	Generate distance-weighted average remap weights
gennn	Generate nearest neighbor remap weights
gencon	Generate 1st order conservative remap weights
gencon2	Generate 2nd order conservative remap weights
genlaf	Generate largest area fraction remap weights
remap	SCRIP grid remapping
remapeta	Remap vertical hybrid level
ml2pl	Model to pressure level interpolation
ml2hl	Model to height level interpolation
intlevel	Linear level interpolation
inttime	Interpolation between time steps
intntime	Interpolation between time steps
intyear	Interpolation between two years

2.12.1. REMAPGRID - SCRIP grid interpolation

Synopsis

<*operator*>*,grid* `ifile ofile`

Description

This module contains operators to remap all input fields to a new horizontal grid. Each operator uses a different remapping method. The interpolation is based on an adapted SCRIP library version. For a detailed description of the remapping methods see [SCRIP].

Operators

remapbil	Bilinear interpolation Performs a bilinear interpolation on all input fields. This interpolation method only works on quadrilateral curvilinear grids.
remapbic	Bicubic interpolation Performs a bicubic interpolation on all input fields. This interpolation method only works on quadrilateral curvilinear grids.
remapdis	Distance-weighted average remapping Performs a distance-weighted average remapping of the four nearest neighbor values on all input fields.
remapnn	Nearest neighbor remapping Performs a nearest neighbor remapping on all input fields.
remapcon	First order conservative remapping Performs a first order conservative remapping on all input fields.
remapcon2	Second order conservative remapping Performs a second order conservative remapping on all input fields.
remaplaf	Largest area fraction remapping Performs a largest area fraction remapping on all input fields.

Parameter

grid	STRING	Target grid description file or name

Environment

`NORMALIZE_OPT`	This variable is used to choose the normalization of the conservative remapping. By default NORMALIZE_OPT is set to 'fracarea' and will include the destination area fraction in the output weights; other options are 'none' and 'destarea' (for more information see [SCRIP]).
`REMAP_EXTRAPOLATE`	This variable is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for remapdis, remapnn and for circular grids.

Note

For this module the author has converted the original Fortran 90 SCRIP software to ANSI C99. If there are any problems send a bug report to CDO and not to SCRIP!

Example

Say `ifile` contains fields on a quadrilateral curvilinear grid. To remap all fields bilinear to a T42 Gaussian grid type:

```
cdo remapbil,t42grid ifile ofile
```

2.12.2. GENWEIGHTS - Generate SCRIP grid interpolation weights

Synopsis

<operator>,grid `ifile ofile`

Description

Interpolation between different horizontal grids can be a very time-consuming process. Especially if the data are on an unstructured or a large grid. In this case the SCRIP 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 method should be used only if all input fields are on the same grid and a possibly mask (missing values) does not change. This module contains operators to generate SCRIP interpolation weights of the first input field. Each operator is using a different interpolation method.

Operators

genbil	Generate bilinear interpolation weights Generates bilinear interpolation weights and writes the result to a file. This interpolation method only works on quadrilateral curvilinear grids.
genbic	Generate bicubic interpolation weights Generates bicubic interpolation weights and writes the result to a file. This interpolation method only works on quadrilateral curvilinear grids.
gendis	Generate distance-weighted average remap weights Generates distance-weighted average remapping weights of the four nearest neighbor values and writes the result to a file.
gennn	Generate nearest neighbor remap weights Generates nearest neighbor remapping weights and writes the result to a file.
gencon	Generate 1st order conservative remap weights Generates first order conservative remapping weights and writes the result to a file.
gencon2	Generate 2nd order conservative remap weights Generates second order conservative remapping weights and writes the result to a file.
genlaf	Generate largest area fraction remap weights Generates largest area fraction remapping weights and writes the result to a file.

Parameter

grid	STRING	Target grid description file or name

Environment

`NORMALIZE_OPT`	This variable is used to choose the normalization of the conservative interpolation. By default NORMALIZE_OPT is set to 'fracarea' and will include the destination area fraction in the output weights; other options are 'none' and 'destarea' (for more information see [SCRIP]).
`REMAP_EXTRAPOLATE`	This variable is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for remapdis, remapnn and for circular grids.

Note

For this module the author has converted the original Fortran 90 SCRIP software to ANSI C99. If there are any problems send a bug report to CDO and not to SCRIP!

Example

Say `ifile` contains fields on a quadrilateral curvilinear grid. To remap all fields bilinear to a T42 Gaussian grid use:

```
cdo genbil,t42grid ifile remapweights.nc
cdo remap,t42grid,remapweights.nc ifile ofile
```

2.12.3. REMAP - SCRIP grid remapping

Synopsis

remap,*grid*,*weights* `ifile ofile`

Description

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. The netCDF file with the weights should follow the SCRIP convention. Normally these weights come from a previous call to module GENWEIGHTS or were created by the original SCRIP package.

Parameter

grid	STRING	Target grid description file or name
weights	STRING	Interpolation weights (SCRIP netCDF file)

Environment

`NORMALIZE_OPT`	This variable is used to choose the normalization of the conservative interpolation. By default NORMALIZE_OPT is set to 'fracarea' and will include the destination area fraction in the output weights; other options are 'none' and 'destarea' (for more information see [SCRIP]).
`REMAP_EXTRAPOLATE`	This variable is used to switch the extrapolation feature 'on' or 'off'. By default the extrapolation is enabled for remapdis, remapnn and for circular grids.

Note

For this module the author has converted the original Fortran 90 SCRIP software to ANSI C99. If there are any problems send a bug report to CDO and not to SCRIP!

Example

Say `ifile` contains fields on a quadrilateral curvilinear grid. To remap all fields bilinear to a T42 Gaussian grid use:

```
cdo genbil,t42grid ifile remapweights.nc
cdo remap,t42grid,remapweights.nc ifile ofile
```

2.12.4. REMAPETA - Remap vertical hybrid level

Synopsis

remapeta,*vct[,oro]* `ifile ofile`

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) profile interpolation
- interpolation in free atmosphere
- merging of both profiles
- 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 troposhere. Therefore the total mass above a given reference level is conserved. As reference level the geopotential height of the 500 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 profiles 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]. All input fields have to be on the same horizontal grid.

Parameter

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)

Note

The code numbers or the variable names of the required parameter have to follow the [ECHAM] convention. Presently, the vertical coordinate definition of a netCDF file has also to follow the ECHAM convention. This means:

- the dimension of the full level coordinate and the corresponding variable is called mlev,
- the dimension of the half level coordinate and the corresponding variable is called ilev (ilev must have one element more than mlev)
- the hybrid vertical coefficient a is given in units of Pa and called hyai (hyam for level midpoints)
- the hybrid vertical coefficient b is given in units of 1 and called hybi (hybm for level midpoints)
- the mlev variable has a borders attribute containing the character string 'ilev'

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 "1.4 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 ifile ofile
```

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
...
 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
```

2.12.5. INTVERT - Vertical interpolation

Synopsis

ml2pl,*plevels* `ifile ofile`

ml2hl,*hlevels* `ifile ofile`

Description

Interpolate 3D variables on hybrid model levels to pressure or height levels. The input file should contain the log. surface pressure or the surface pressure. To interpolate the temperature, the orography (surface geopotential) is also needed. The pressure, temperature, and orography are identified by their code numbers. Supported parameter tables are: WMO standard table number 2 and ECMWF local table number 128. Use the alias **ml2plx/ml2hlx** or the environment variable `EXTRAPOLATE` to extrapolate missing values. All input fields have to be on the same horizontal grid.

Operators

ml2pl Model to pressure level interpolation
Interpolates 3D variables on hybrid model levels to pressure levels.

ml2hl Model to height level interpolation
Interpolates 3D variables on hybrid model levels to height levels. The procedure is the same as for the operator mh2pl except for the pressure levels being calculated from the heights by: $plevel = 101325 * exp(hlevel / -7000)$

Parameter

plevels	FLOAT	Pressure levels in pascal
hlevels	FLOAT	Height levels in meter (max level: 65535 m)

Environment

`EXTRAPOLATE`	If set to 1 extrapolate missing values.

Note

The netCDF CF convention for vertical hybrid coordinates is not supported, yet!

Example

To interpolate hybrid model level data to pressure levels of 925, 850, 500 and 200 hPa use:

```
cdo ml2pl,92500,85000,50000,20000 ifile ofile
```

2.12.6. INTLEVEL - Linear level interpolation

Synopsis

intlevel,*levels* `ifile ofile`

Description

This operator performs a linear vertical interpolation of non hybrid 3D variables.

Parameter

levels	FLOAT	Target levels

Example

To interpolate 3D variables on height levels to a new set of height levels use:

```
cdo intlevel,10,50,100,500,1000 ifile ofile
```

2.12.7. INTTIME - Time interpolation

Synopsis

inttime,*date*,*time[,inc]* `ifile ofile`

intntime,*n* `ifile ofile`

Description

This module performs linear interpolation between time steps.

Operators

inttime	Interpolation between time steps This operator creates a new dataset by linear interpolation between time steps. The user has to define the start date/time with an optional increment.
intntime	Interpolation between time steps This operator performs linear interpolation between time steps. The user has to define the number of time steps from one time step to the next.

Parameter

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 time steps from one time step to the next

Example

Assumed a 6 hourly dataset starts at 1987-01-01 12:00. To interpolate this time series to a one hourly dataset use:

```
cdo inttime,1987-01-01,12:00,1hour ifile ofile
```

2.12.8. INTYEAR - Year interpolation

Synopsis

intyear,*years* `ifile1 ifile2 oprefix`

Description

This operator performs linear interpolation between two years time step by time step. Appends four digits with the year to `oprefix` to form the output file names.

Parameter

years	INTEGER	Comma separated list of years

Example

Assume there are two monthly mean datasets over a year. The first dataset has 12 time steps 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 ifile1 ifile2 year
```

Example result of '`dir year*`' for netCDF datasets:

```
year1986.nc year1987.nc year1988.nc year1989.nc
```

2.13. Transformation

This section contains modules to perform spectral transformations.

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

sp2gp	Spectral to gridpoint
sp2gpl	Spectral to gridpoint (linear)
gp2sp	Gridpoint to spectral
gp2spl	Gridpoint to spectral (linear)
sp2sp	Spectral to spectral
dv2uv	Divergence and vorticity to U and V wind
dv2uvl	Divergence and vorticity to U and V wind (linear)
uv2dv	U and V wind to divergence and vorticity
uv2dvl	U and V wind to divergence and vorticity (linear)

2.13.1. SPECTRAL - Spectral transformation

Synopsis

sp2gp `ifile ofile`

sp2gpl `ifile ofile`

gp2sp `ifile ofile`

gp2spl `ifile ofile`

sp2sp,*trunc* `ifile ofile`

Description

This module transforms fields on Gaussian grids to spectral coefficients and vice versa.

Operators

sp2gp Spectral to gridpoint
Convert all fields with spectral coefficients to a regular Gaussian grid. The number of latitudes of the resulting Gaussian grid is calculated from the triangular truncation by: nlat $= NINT((\text{trunc} * \boxed{3} + 1.)/2.)$

sp2gpl Spectral to gridpoint (linear)
Convert all fields with spectral coefficients to a regular Gaussian grid. The number of latitudes of the resulting Gaussian grid is calculated from the triangular truncation by: nlat $= NINT((\text{trunc} * \boxed{2} + 1.)/2.)$

Use this operator to convert ERA40 data e.g. from TL159 to N80.

gp2sp Gridpoint to spectral
Convert all Gaussian gridpoint fields to spectral coefficients. The triangular truncation of the resulting spherical harmonics is calculated from the number of latitudes by: trunc $= (\text{nlat} * 2 - 1)/\boxed{3}$

gp2spl Gridpoint to spectral (linear)
Convert all Gaussian gridpoint fields to spectral coefficients. The triangular truncation of the resulting spherical harmonics is calculated from the number of latitudes by: trunc $= (\text{nlat} * 2 - 1)/\boxed{2}$

Use this operator to convert ERA40 data e.g. from N80 to TL159 instead of T106.

sp2sp Spectral to spectral
Change the triangular truncation of all spectral fields. The operator performs downward conversion by cutting the resolution. Upward conversions are achieved by filling in zeros.

Parameter

trunc	INTEGER	New spectral resolution
wnums	INTEGER	Comma separated list of wave numbers

Example

To transform spectral coefficients from T106 to N80 Gaussian grid use:

```
cdo sp2gp ifile ofile
```

To transform spectral coefficients from TL159 to N80 Gaussian grid use:

```
cdo sp2gpl ifile ofile
```

2.13.2. WIND - Wind transformation

Synopsis

<*operator*> `ifile ofile`

Description

This module converts relative divergence and vorticity to U and V wind and vice versa.

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. The number of latitudes of the resulting Gaussian grid is calculated from the triangular truncation by:
nlat $= NINT((\text{trunc} * \boxed{3} + 1.)/2.)$

dv2uvl Divergence and vorticity to U and V wind (linear)
Calculate U and V wind on a Gaussian grid from spherical harmonic coefficients of relative divergence and vorticity. The divergence and vorticity need tohave the names sd and svo or code numbers 155 and 138. The number of latitudes of the resulting Gaussian grid is calculated from the triangular truncation by:
nlat $= NINT((\text{trunc} * \boxed{2} + 1.)/2.)$

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 have the names u and v or the code numbers 131 and 132. The triangular truncation of the resulting spherical harmonics is calculated from the number of latitudes by:
trunc $= (\text{nlat} * 2 - 1)/\boxed{3}$

uv2dvl U and V wind to divergence and vorticity (linear)
Calculate spherical harmonic coefficients of relative divergence and vorticity from U and V wind. The U and V wind need to have the names u and v or the code numbers 131 and 132. The triangular truncation of the resulting spherical harmonics is calculated from the number of latitudes by:
trunc $= (\text{nlat} * 2 - 1)/\boxed{2}$

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 use:

```
cdo dv2uv ifile ofile
```

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:

import_binary	Import binary data sets
import_cmsaf	Import CM-SAF HDF5 files
import_amsr	Import AMSR binary files
input	ASCII input
inputsrv	SERVICE ASCII input
inputext	EXTRA ASCII input
output	ASCII output
outputf	Formatted output
outputint	Integer output
outputsrv	SERVICE ASCII output
outputext	EXTRA ASCII output

2.14.1. IMPORTBINARY - Import binary data sets

Synopsis

import_binary `ifile ofile`

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

Example

To convert a binary data file to netCDF use:

```
cdo -f nc import_binary ifile.ctl ofile.nc
```

Here is an example of a GrADS data descriptor file:

```
DSET   ^ifile.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 ifile.bin contains one parameter on a global 1 degree lon/lat grid written with FORTRAN record length headers (sequential).

2.14.2. IMPORTCMSAF - Import CM-SAF HDF5 files

Synopsis

import_cmsaf `ifile ofile`

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.4 library (version 4.6 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 output.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
```

2.14.3. IMPORTAMSR - Import AMSR binary files

Synopsis

import_amsr `ifile ofile`

Description

This operator imports gridded binary AMSR (Advanced Microwave Scanning Radiometer) data. The binary data files are available from the AMSR ftp site (ftp://ftp.ssmi.com/amsre). Each file consists of twelve (daily) or five (averaged) 0.25 x 0.25 degree grid (1440,720) byte maps. For daily files, six daytime maps in the following order, Time (UTC), Sea Surface Temperature (SST), 10 meter Surface Wind Speed (WSPD), Atmospheric Water Vapor (VAPOR), Cloud Liquid Water (CLOUD), and Rain Rate (RAIN), are followed by six nighttime maps in the same order. Time-Averaged files contain just the geophysical layers in the same order [SST, WSPD, VAPOR, CLOUD, RAIN]. More information to the data is available on the AMSR homepage http://www.remss.com/amsr.

Example

To convert monthly binary AMSR files to netCDF use:

```
cdo -f nc amsre_yyyymmv5 amsre_yyyymmv5.nc
```

2.14.4. INPUT - Formatted input

Synopsis

input,*grid* `ofile`

inputsrv `ofile`

inputext `ofile`

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 `ofile`. The numbers read are exactly that ones which are written out by output.

inputsrv SERVICE ASCII input
Reads fields with ASCII numbers from standard input and stores them in `ofile`. 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 outputsrv.

inputext EXTRA ASCII input
Read fields with ASCII numbers from standard input and stores them in `ofile`. Each field should have header of 4 integers (EXTRA likely). The numbers read are exactly that ones which are written out by outputext.

Parameter

grid	STRING	Grid description file or name

Example

Assume an ASCII dataset contains a field on a global regular grid with 32 longitudes and 16 latitudes (512 elements). To create a GRIB dataset from the ASCII dataset use:

```
cdo -f grb input,r32x16 ofile.grb < my_ascii_data
```

2.14.5. OUTPUT - Formatted output

Synopsis

output `ifiles`

outputf,*format*,*nelem* `ifiles`

outputint `ifiles`

outputsrv `ifiles`

outputext `ifiles`

Description

This module prints all values of all input datasets to standard output. All input fields need to have the same horizontal grid. 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*.

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).

Parameter

format	STRING	C-style format for one element (e.g. %13.6g)
nelem	INTEGER	Number of elements for each row

Example

To print all field elements of a dataset formatted with "%8.4g" and 8 values per line use:

```
cdo outputf,%8.4g,8 ifile
```

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
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
```

2.15. 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:

gridarea	Grid cell area
gridweights	Grid cell weights
gradsdes1	GrADS data descriptor file (version 1 GRIB map)
gradsdes2	GrADS data descriptor file (version 2 GRIB map)
smooth9	9 point smoothing
setvals	Set list of old values to new values
setrtoc	Set range to constant
setrtoc2	Set range to constant others to constant2
timsort	Sort over the time
const	Create a constant field
random	Create a field with random numbers
rotuvb	Backward rotation
mastrfu	Mass stream function
histcount	Histogram count
histsum	Histogram sum
histmean	Histogram mean
histfreq	Histogram frequency
sethalo	Set the left and right bounds of a field
wct	Windchill temperature
fdns	Frost days where no snow index per time period
strwin	Strong wind days index per time period
strbre	Strong breeze days index per time period
strgal	Strong gale days index per time period
hurr	Hurricane days index per time period

2.15.1. GRIDCELL - Grid cell quantities

Synopsis

<operator> `ifile ofile`

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 description. 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 earth radius to square meters.

gridweights Grid cell weights
Writes the grid cell area weights to the output stream.

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.

2.15.2. GRADSDES - GrADS data descriptor file

Synopsis

<operator> `ifile`

Description

Creates a GrADS data descriptor file. Supported file formats are GRIB, SERVICE, EXTRA and IEG. For GRIB 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 `ifile` in order to create filenames for the descriptor (`ifile.ctl`) and the map (`ifile.gmp`) file. "gradsdes" is an alias for gradsdes2.

Operators

gradsdes1 GrADS data descriptor file (version 1 GRIB map)
Creates a GrADS data descriptor file. Generated a machine specific version 1 GrADS map file for GRIB datasets.

gradsdes2 GrADS data descriptor file (version 2 GRIB map)
Creates a GrADS data descriptor file. Generated a machine independent version 2 GrADS map file for GRIB datasets. This map file can be used only with GrADS version 1.8 or newer.

Example

To create a GrADS data descriptor file from a GRIB dataset use:

```
cdo gradsdes2 ifile.grb
```

This will create a descriptor file with the name `ifile.ctl` and the map file `ifile.gmp`.
Assumed the input GRIB dataset has 3 variables over 12 time steps on a T21 grid. The contents of the resulting GrADS data description file is approximately:

```
DSET  ^ifile.grb
DTYPE  GRIB
INDEX  ^ifile.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  ifile.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
```

2.15.3. SMOOTH9 - 9 point smoothing

Synopsis

smooth9 `ifile ofile`

Description

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.

2.15.4. REPLACEVALUES - Replace variable values

Synopsis

setvals,*oldval,newval[,...]* `ifile ofile`

setrtoc,*rmin,rmax,c* `ifile ofile`

setrtoc2,*rmin,rmax,c,c2* `ifile ofile`

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

$$o(t,x) = \begin{cases} \text{c} & \text{if } i(t,x) \geq \mathit{rmin} \wedge i(t,x) \leq \mathit{rmax} \\ i(t,x) & \text{if } i(t,x) < \mathit{rmin} \vee i(t,x) > \mathit{rmax} \end{cases}$$

setrtoc2 Set range to constant others to constant2

$$o(t,x) = \begin{cases} \text{c} & \text{if } i(t,x) \geq \mathit{rmin} \wedge i(t,x) \leq \mathit{rmax} \\ \text{c2} & \text{if } i(t,x) < \mathit{rmin} \vee i(t,x) > \mathit{rmax} \end{cases}$$

Parameter

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

2.15.5. TIMSORT - Timsort

Synopsis

timsort `ifile ofile`

Description

Sorts the elements in ascending order over all time steps for every field position. After sorting it is:

$o(t_1, x) <= o(t_2, x) \qquad \forall (t_1 < t_2), x$

Example

To sort all field elements of a dataset over all time steps use:

```
cdo timsort ifile ofile
```

2.15.6. VARGEN - Generate a field

Synopsis

const,*const,grid* `ofile`

random,*grid[,seed]* `ofile`

Description

Generates a dataset with one field. The size of the field is specified by the user given grid description. According to the chosen operator all field elements are constant or filled with random numbers.

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 distrubuted random numbers in the interval [0,1].

Parameter

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

2.15.7. ROTUV - Rotation

Synopsis

rotuvb,*u*,*v*,*...* `ifile ofile`

Description

This is a special operator for datsets 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.

Parameter

u,*v*,*...* STRING Pairs of zonal and meridional velocity components (use variable names or code numbers)

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 ifile ofile
```

2.15.8. MASTRFU - Mass stream function

Synopsis

mastrfu `ifile ofile`

Description

This is a special operator for the post processing of the atmospheric general circulation model ECHAM. It computes the mass stream function (code number 272). The input dataset have to be a zonal mean of v-velocity (code number 132) on pressure levels.

Example

To compute the mass stream function from a zonal mean v-velocity dataset use:

```
cdo mastrfu ifile ofile
```

2.15.9. HISTOGRAM - Histogram

Synopsis

<operator>,bounds `ifile ofile`

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 ouput 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 Frequency of elements in the bin range.

Parameter

bounds	FLOAT	Comma separated list of the bin bounds (-inf and inf valid)

2.15.10. SETHALO - Set the left and right bounds of a field

Synopsis

sethalo,*lhalo,rhalo* `ifile ofile`

Description

This operator sets the left and right bounds of the rectangularly understood fields. Positive numbers of the parameter *lhalo* enlarges the left bound by the given number of columns from the right bound. The parameter *rhalo* does the similar for the right bound. Negative numbers of the parameter *lhalo*/*rhalo* can be used to remove the given number of columns of the left and right bounds.

Parameter

lhalo	INTEGER	Left halo
rhalo	INTEGER	Right halo

2.15.11. WCT - Windchill temperature

Synopsis

wct `ifile1 ifile2 ofile`

Description

Let `ifile1` and `ifile2` be time series of temperature and wind speed records, then a corresponding time series of resulting windchill temperatures is written to `ofile`. 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 `ofile`. Note that temperature and wind speed records have to be given in units of °C and m/s, respectively.

2.15.12. FDNS - Frost days where no snow index per time period

Synopsis

fdns `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily minimum temperatures TN and `ifile2` be a corresponding series of daily surface snow amounts. Then counted is the number of days where TN < 0 °C and the surface snow amount is less than 1 cm. The temperature TN have to be given in units of Kelvin. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

2.15.13. STRWIN - Strong wind days index per time period

Synopsis

strwin*[,v]* `ifile ofile`

Description

Let `ifile` be a time series of daily maximum horizontal wind speeds VX, then counted is the number of days where VX > v. 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 time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

v	FLOAT	Horizontal wind speed threshold (m/s, default v = 10.5 m/s)

2.15.14. STRBRE - Strong breeze days index per time period

Synopsis

strbre `ifile ofile`

Description

Let `ifile` be a time series of daily maximum horizontal wind speeds VX, then counted is the number of days where VX is greater than or equal to 10.5 m/s. 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 time step in `ofile` is the date of the last contributing time step in `ifile`.

2.15.15. STRGAL - Strong gale days index per time period

Synopsis

strgal `ifile ofile`

Description

Let `ifile` be a time series of daily maximum horizontal wind speeds VX, then counted is the number of days where VX is greater than or equal to 20.5 m/s. 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 time step in `ofile` is the date of the last contributing time step in `ifile`.

2.15.16. HURR - Hurricane days index per time period

Synopsis

hurr `ifile ofile`

Description

Let `ifile` be a time series of daily maximum horizontal wind speeds VX, then counted is the number of days where VX is greater than or equal to 32.5 m/s. 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 time step in `ofile` is the date of the last contributing time step in `ifile`.

2.16. Climate indices

This section contains modules to compute the climate indices of daily temperature and precipitation extremes.

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

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
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	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_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

2.16.1. ECACDD - Consecutive dry days index per time period

Synopsis

eca_cdd `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then counted is the largest number of consecutive days where RR is less than 1 mm. A further output variable is the number of dry periods of more than 5 days. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the largest number of consecutive dry days of a time series of daily precipitation amounts use:

```
cdo eca_cdd rrfile ofile
```

2.16.2. ECACFD - Consecutive frost days index per time period

Synopsis

eca_cfd `ifile ofile`

Description

Let `ifile` be a time series of daily minimum temperatures TN, then counted is the largest number of consecutive days where TN < 0 ℃. Note that TN have to be given in units of Kelvin. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the largest number of consecutive frost days of a time series of daily minimum temperatures use:

```
cdo eca_cfd tnfile ofile
```

2.16.3. ECACSU - Consecutive summer days index per time period

Synopsis

eca_csu[*,T*] `ifile ofile`

Description

Let `ifile` be a time series of daily maximum temperatures TX, then counted is the largest number of consecutive days where TX > T. The number T is an optional parameter with default T = 25 ℃. Note that TN have to be given in units of Kelvin, whereas T have to be given in degrees Celsius. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

T	FLOAT	Temperature threshold (Celsius, default: T = 25 Celsius)

Example

To get the largest number of consecutive summer days of a time series of daily minimum temperatures use:

```
cdo eca_csu txfile ofile
```

2.16.4. ECACWD - Consecutive wet days index per time period

Synopsis

eca_cwd `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then counted is the largest number of consecutive days where RR is at least 1 mm. A further output variable is the number of wet periods of more than 5 days. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the largest number of consecutive wet days of a time series of daily precipitation amounts use:

```
cdo eca_cwd rrfile ofile
```

2.16.5. ECACWDI - Cold wave duration index wrt mean of reference period

Synopsis

eca_cwdi*[,nday[,T]]* `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily minimum temperatures TN, and let `ifile2` be the mean TNnorm of daily minimum temperatures for any period used as reference. Then counted is the number of days where, in intervals of at least nday consecutive days, TN < TNnorm - T. The numbers nday and T are optional parameters with default nday = 6 and T = 5 ℃. A further output variable is the number of cold waves longer than or equal to nday days. Note that both TN and TNnorm have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Parameter

nday	INTEGER	Number of consecutive days (default: nday = 6)
T	FLOAT	Temperature offset (Celsius, default: T = 5 Celsius)

Example

To compute the cold wave duration index of a time series of daily minimum temperatures use:

```
cdo eca_cwdi tnfile tnnormfile ofile
```

2.16.6. ECACWFI - Cold-spell days index wrt 10th percentile of reference period

Synopsis

eca_cwfi*[,nday]* `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily mean temperatures TG, and `ifile2` be the 10th percentile TGn10 of daily mean temperatures for any period used as reference. Then counted is the number of days where, in intervals of at least nday consecutive days, TG < TGn10. The number nday is an optional parameter with default nday = 6. A further output variable is the number of cold-spell periods longer than or equal to nday days. Note that both TG and TGn10 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Parameter

nday	INTEGER	Number of consecutive days (default: nday = 6)

Example

To compute the number of cold-spell days of a time series of daily mean temperatures use:

```
cdo eca_cwfi tgfile tgn10file ofile
```

2.16.7. ECAETR - Intra-period extreme temperature range

Synopsis

eca_etr ifile1 ifile2 ofile

Description

Let `ifile1` and `ifile2` be time series of maximum and minimum temperatures TX and TN, respectively. Then the extreme temperature range is the difference of the maximum of TX and the minimum of TN. Note that TX and TN have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time steps in `ifile1` and `ifile2`.

Example

To get the intra-period extreme temperature range for two time series of maximum and minimum temperatures use:

```
cdo eca_etr txfile tnfile ofile
```

2.16.8. ECAFD - Frost days index per time period

Synopsis

eca_fd ifile ofile

Description

Let `ifile` be a time series of daily minimum temperatures TN, then counted is the number of days where $TN < 0\ ^\circ C$. Note that TN have to be given in units of Kelvin. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the number of frost days of a time series of daily minimum temperatures use:

```
cdo eca_fd tnfile ofile
```

2.16.9. ECAGSL - Thermal Growing season length index

Synopsis

eca_gsl*[,nday[,T[,fland]]]* `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily mean temperatures TG, and `ifile2` be a land-water mask. Within a period of 12 months, the thermal growing season length is officially defined as the number of days between:

- frist occurrence of at least nday consecutive days with TG > T within the first 6 months
- first occurrence of at least nday consecutive days with TG < T within the last 6 months

On northern hemispere, this period corresponds with the regular year, whereas on southern hemispere, it starts at july 1^{st}. Please note, that this definition may lead to weird results concerning values TG = T: In the first half of the period, these days do not contribute to the gsl, but they do within the second half.
The numbers nday and T are optional parameter with default nday = 6 and T = 5 ℃. The number fland is an optional parameter with default value fland = 0.5 and denotes the fraction of a grid point that have to be covered by land in order to be included in the calculation. A further output variable is the start day of year of the growing season. Note that TG have to be given in units of Kelvin, whereas T have to be given in degrees Celsius.
The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

nday	INTEGER	Number of consecutive days (default: nday = 6)
T	FLOAT	Temperature threshold (degree Celsius, default: T = 5 Celsius)
fland	FLOAT	Land fraction threshold (default: fland = 0.5)

Example

To get the growing season length of a time series of daily mean temperatures use:

```
cdo eca_gsl tgfile maskfile ofile
```

2.16.10. ECAHD - Heating degree days per time period

Synopsis

eca_hd*[,T1[,T2]]* `ifile ofile`

Description

Let `ifile` be a time series of daily mean temperatures TG, then the heating degree days are defined as the sum of T1 - TG, where only values TG < T2 are considered. If T1 and T2 are omitted, a temperature of 17 ℃ is used for both parameters. If only T1 is given, T2 is set to T1. Note that TG have to be given in units of kelvin, whereas T1 and T2 have to be given in degrees Celsius. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

T1	FLOAT	Temperature limit (Celsius, default: T1 = 17 Celsius)
T2	FLOAT	Temperature limit (Celsius, default: T2 = T1)

Example

To compute the heating degree days of a time series of daily mean temperatures use:

```
cdo eca_hd tgfile ofile
```

2.16.11. ECAHWDI - Heat wave duration index wrt mean of reference period

Synopsis

eca_hwdi*[,nday[,T]]* `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily maximum temperatures TX, and let `ifile2` be the mean TXnorm of daily maximum temperatures for any period used as reference. Then counted is the number of days where, in intervals of at least nday consecutive days, TX > TXnorm + T. The numbers nday and T are optional parameters with default nday = 6 and T = 5 ℃. A further output variable is the number of heat waves longer than or equal to nday days. Note that both TX and TXnorm have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Parameter

nday	INTEGER	Number of consecutive days (default: nday = 6)
T	FLOAT	Temperature offset (Celsius, default: T = 5 Celsius)

Example

To compute the heat wave duration index of a time series of daily maximum temperatures use:

```
cdo eca_hwdi txfile txnormfile ofile
```

2.16.12. ECAHWFI - Warm spell days index wrt 90th percentile of reference period

Synopsis

eca_hwfi[,*nday*] `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily mean temperatures TG, and `ifile2` be the 90th percentile TGn90 of daily mean temperatures for any period used as reference. Then counted is the number of days where, in intervals of at least nday consecutive days, TG > TGn90. The number nday is an optional parameter with default nday = 6. A further output variable is the number of warm-spell periods longer than or equal to nday days. Note that both TG and TGn90 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Parameter

nday	INTEGER	Number of consecutive days (default: nday = 6)

Example

To compute the number of warm-spell days of a time series of daily mean temperatures use:

```
cdo eca_hwfi tgfile tgn90file ofile
```

2.16.13. ECAID - Ice days index per time period

Synopsis

eca_id `ifile ofile`

Description

Let `ifile` be a time series of daily maximum temperatures TX, then counted is the number of days where TX < 0 ℃. Note that TX have to be given in units of Kelvin. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the number of ice days of a time series of daily maximum temperatures use:

```
cdo eca_id txfile ofile
```

2.16.14. ECAR10MM - Heavy precipitation days index per time period

Synopsis

eca_r10mm `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then counted is the number of days where RR is at least 10 mm. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the number of days with precipitation greater than 10 mm for a time series of daily precipitation amounts use:

```
cdo eca_r10mm rrfile ofile
```

2.16.15. ECAR20MM - Very heavy precipitation days index per time period

Synopsis

eca_r20mm `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then counted is the number of days where RR is at least 20 mm. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the number of days with precipitation greater than 20 mm for a time series of daily precipitation amounts use:

```
cdo eca_r20mm rrfile ofile
```

2.16.16. ECAR75P - Moderate wet days wrt 75th percentile of reference period

Synopsis

eca_r75p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 75th percentile RRn75 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the percentage of wet days with RR > RRn75. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of wet days where the daily precipitation amount is greater than the 75th percentile of the daily precipitation amount at wet days for a given reference period use:

```
cdo eca_r75p rrfile rrn75file ofile
```

2.16.17. ECAR75PTOT - Precipitation percent due to R75p days

Synopsis

eca_r75ptot `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 75th percentile RRn75 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the ratio of the precipitation sum at wet days with RR > RRn75 to the total precipitation sum. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

2.16.18. ECAR90P - Wet days wrt 90th percentile of reference period

Synopsis

eca_r90p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 90th percentile RRn90 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the percentage of wet days with RR > RRn90. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of wet days where the daily precipitation amount is greater than the 90th percentile of the daily precipitation amount at wet days for a given reference period use:

```
cdo eca_r90p rrfile rrn90file ofile
```

2.16.19. ECAR90PTOT - Precipitation percent due to R90p days

Synopsis

eca_r90ptot `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 90th percentile RRn90 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the ratio of the precipitation sum at wet days with RR > RRn90 to the total precipitation sum. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

2.16.20. ECAR95P - Very wet days wrt 95th percentile of reference period

Synopsis

eca_r95p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 95th percentile RRn95 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the percentage of wet days with RR > RRn95. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of wet days where the daily precipitation amount is greater than the 95th percentile of the daily precipitation amount at wet days for a given reference period use:

```
cdo eca_r95p rrfile rrn95file ofile
```

2.16.21. ECAR95PTOT - Precipitation percent due to R95p days

Synopsis

eca_r95ptot `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 95th percentile RRn95 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the ratio of the precipitation sum at wet days with RR > RRn95 to the total precipitation sum. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

2.16.22. ECAR99P - Extremely wet days wrt 99th percentile of reference period

Synopsis

eca_r99p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 99th percentile RRn99 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the percentage of wet days with RR > RRn99. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of wet days where the daily precipitation amount is greater than the 99th percentile of the daily precipitation amount at wet days for a given reference period use:

```
cdo eca_r99p rrfile rrn99file ofile
```

2.16.23. ECAR99PTOT - Precipitation percent due to R99p days

Synopsis

eca_r99ptot `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily precipitation amounts RR, and `ifile2` be the 99th percentile RRn99 of daily precipitation amounts at wet days for any period used as reference. Then calculated is the ratio of the precipitation sum at wet days with RR > RRn99 to the total precipitation sum. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

2.16.24. ECARR1 - Wet days index per time period

Synopsis

eca_rr1 `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then counted is the number of days where RR is at least 1 mm. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the number of wet days of a time series of daily precipitation amounts use:

```
cdo eca_rr1 rrfile ofile
```

2.16.25. ECARX1DAY - Highest one day precipitation amount per time period

Synopsis

eca_rx1day*[,mode]* `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then the maximum of RR is written to `ofile`. If the optional parameter mode is set to 'm', then maximum daily precipitation amounts are determined for each month. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

mode STRING Operation mode (optional). If mode = 'm' then maximum daily precipitation amounts are determined for each month

Example

To get the maximum of a time series of daily precipitation amounts use:

```
cdo eca_rx1day rrfile ofile
```

If you are interested in the maximum daily precipitation for each month, use:

```
cdo eca_rx1day,m rrfile ofile
```

Apart from metadata information, both operations yield the same as:

```
cdo timmax rrfile ofile
cdo monmax rrfile ofile
```

2.16.26. ECARX5DAY - Highest five-day precipitation amount per time period

Synopsis

eca_rx5day*[,x]* `ifile ofile`

Description

Let `ifile` be a time series of 5-day precipitation totals RR, then the maximum of RR is written to `ofile`. A further output variable is the number of 5 day period with precipitation totals greater than x mm, where x is an optional parameter with default x = 50 mm. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

x	FLOAT	Precipitation threshold (mm, default: x = 50 mm)

Example

To get the maximum of a time series of 5-day precipitation totals use:

```
cdo eca_rx5day rrfile ofile
```

Apart from metadata information, the above operation yields the same as:

```
cdo timmax rrfile ofile
```

2.16.27. ECASDII - Simple daily intensity index per time period

Synopsis

eca_sdii `ifile ofile`

Description

Let `ifile` be a time series of daily precipitation amounts RR, then the mean precipitation amount at wet days (RR > 1 mm) is written to `ofile`. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Example

To get the daily intensity index of a time series of daily precipitation amounts use:

```
cdo eca_sdii rrfile ofile
```

2.16.28. ECASU - Summer days index per time period

Synopsis

eca_su*[,T]* `ifile ofile`

Description

Let `ifile` be a time series of daily maximum temperatures TX, then counted is the number of days where TX > T. The number T is an optional parameter with default T = 25 ℃. Note that TX have to be given in units of Kelvin, whereas T have to be given in degrees Celsius. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

T	FLOAT	Temperature threshold (degree Celsius, default: T = 25 Celsius)

Example

To get the number of summer days of a time series of daily maximum temperatures use:

```
cdo eca_su txfile ofile
```

2.16.29. ECATG10P - Cold days percent wrt 10th percentile of reference period

Synopsis

eca_tg10p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily mean temperatures TG, and `ifile2` be the 10th percentile TGn10 of daily mean temperatures for any period used as reference. Then calculated is the percentage of time where TG $<$ TGn10. Note that both TG and TGn10 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily mean temperature is less than the 10th percentile of the daily mean temperature for a given reference period use:

```
cdo eca_tg10p tgfile tgn10file ofile
```

2.16.30. ECATG90P - Warm days percent wrt 90th percentile of reference period

Synopsis

eca_tg90p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily mean temperatures TG, and `ifile2` be the 90th percentile TGn90 of daily mean temperatures for any period used as reference. Then calculated is the percentage of time where TG $>$ TGn90. Note that both TG and TGn90 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily mean temperature is greater than the 90th percentile of the daily mean temperature for a given reference period use:

```
cdo eca_tg90p tgfile tgn90file ofile
```

2.16.31. ECATN10P - Cold nights percent wrt 10th percentile of reference period

Synopsis

eca_tn10p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily minimum temperatures TN, and `ifile2` be the 10th percentile TNn10 of daily minimum temperatures for any period used as reference. Then calculated is the percentage of time where TN < TNn10. Note that both TN and TNn10 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily minimum temperature is less than the 10th percentile of the daily minimum temperature for a given reference period use:

```
cdo eca_tn10p tnfile tnn10file ofile
```

2.16.32. ECATN90P - Warm nights percent wrt 90th percentile of reference period

Synopsis

eca_tn90p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily minimum temperatures TN, and `ifile2` be the 90th percentile TNn90 of daily minimum temperatures for any period used as reference. Then calculated is the percentage of time where TN > TNn90. Note that both TN and TNn90 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily minimum temperature is greater than the 90th percentile of the daily minimum temperature for a given reference period use:

```
cdo eca_tn90p tnfile tnn90file ofile
```

2.16.33. ECATR - Tropical nights index per time period

Synopsis

eca_tr[,T] `ifile ofile`

Description

Let `ifile` be a time series of daily minimum temperatures TN, then counted is the number of days where TN > T. The number T is an optional parameter with default T = 20 ℃. Note that TN have to be given in units of Kelvin, whereas T have to be given in degrees Celsius. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile`.

Parameter

T	FLOAT	Temperature threshold (Celsius, default: T = 20 Celsius)

Example

To get the number of tropical nights of a time series of daily minimum temperatures use:

```
cdo eca_tr tnfile ofile
```

2.16.34. ECATX10P - Very cold days percent wrt 10th percentile of reference period

Synopsis

eca_tx10p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily maximum temperatures TX, and `ifile2` be the 10th percentile TNx10 of daily maximum temperatures for any period used as reference. Then calculated is the percentage of time where TX < TXn10. Note that both TX and TXn10 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily maximum temperature is less than the 10th percentile of the daily maximum temperature for a given reference period use:

```
cdo eca_tx10p txfile txn10file ofile
```

2.16.35. ECATX90P - Very warm days percent wrt 90th percentile of reference period

Synopsis

eca_tx90p `ifile1 ifile2 ofile`

Description

Let `ifile1` be a time series of daily maximum temperatures TX, and `ifile2` be the 90th percentile TXn90 of daily maximum temperatures for any period used as reference. Then calculated is the percentage of time where TX > TXn90. Note that both TX and TXn90 have to be given in the same units. The date information of a time step in `ofile` is the date of the last contributing time step in `ifile1`.

Example

To compute the percentage of time where the daily maximum temperature is greater than the 90th percentile of the daily maximum temperature for a given reference period use:

```
cdo eca_tx90p txfile txn90file ofile
```

Bibliography

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Satellite Application Facility on Climate Monitoring, from the German Weather Service (Deutscher Wetterdienst, DWD)

[ECHAM]
The atmospheric general circulation model ECHAM5, from the Max Planck Institute for Meteorologie

[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 Meteorologie

[MPIOM]
Ocean and sea ice model, from the Max Planck Institute for Meteorologie

[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 Meteorologie

[REMO]
Regional Model, from the Max Planck Institute for Meteorologie

[PROJ.4]
Cartographic Projections Library, originally written by Gerald Evenden then of the USGS.

[SCRIP]
SCRIP Software Package, from the Los Alamos National Laboratory

[szip]
Szip compression software, developed at University of New Mexico.

A. Hints for PINGO user

Some **CDO** operators have the same name as in PINGO but the meaning is different. The following table gives an overview of those operators.

Operator name	**CDO**	PINGO
min	Minimum of two fields	Time minimum
max	Maximum of two fields	Time maximum
daymean	Daily mean	Multi-year daily mean
daymin	Daily minimum	Multi-year daily minimum
daymax	Daily maximum	Multi-year daily maximum
monmean	Monthly mean	Multi-year monthly mean
monmin	Monthly minimum	Multi-year monthly minimum
monmax	Monthly maximum	Multi-year monthly maximum
seasmean	Seasonally mean	Multi-year seasonally mean

There are also some **CDO** operators with the same functionality as in PINGO but the name is different. The following table gives an overview of those operators.

	CDO	PINGO
Maximum of two fields	max	max2
Minimum of two fields	min	min2
Field mean, min, max	fldmean, fldmin, fldmax	meanr minr, maxr
Time mean, min, max	timmean, timmin, timmax	mean, min, max
Daily mean, min, max	daymean, daymin, daymax	daymeans, daymins, daymaxs
Monthly mean, min, max	monmean, monmin, monmax	monmeans, monmins, monmaxs
Yearly mean, min, max	yearmean, yearmin, yearmax	yearmeans, yearmins, yearmaxs
Running mean	runmean	runmeans
Seasonally mean	seasmean	seasmeans
Multi-year daily mean	ydaymean	daymean
Multi-year monthly mean	ymonmean	monmean
Multi-year seasonally mean	yseasmean	seasmean

B. Grid description examples

B.1. Example of a curvilinear grid description

Here is an example for the **CDO** description of a curvilinear grid. xvals/yvals describes the position 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
```

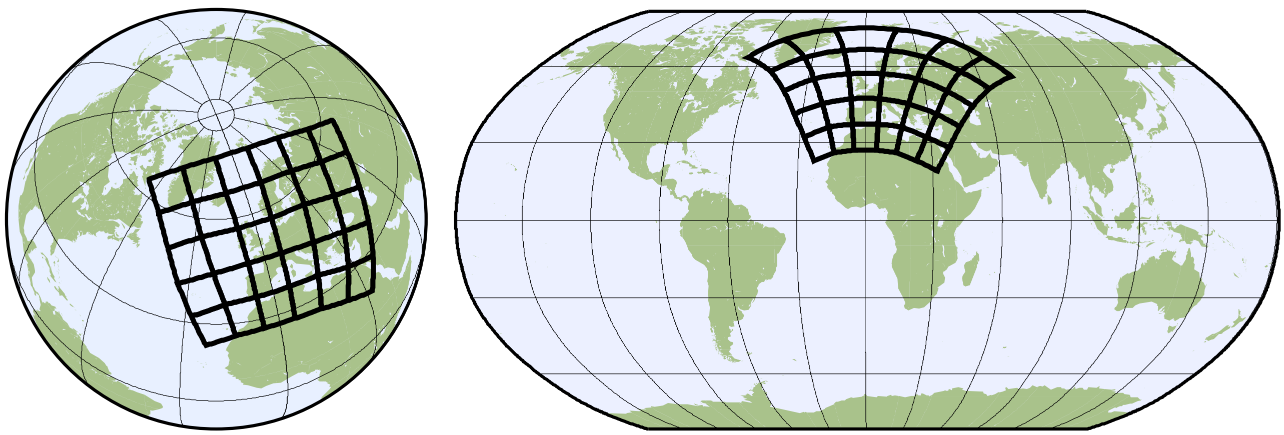

Figure B.1.: Orthographic and Robinson projection of the curvilinear grid

B.2. Example description for unstructured grid cells

Here is an example of the **CDO** description for unstructured grid cells. xvals/yvals describes the position of 30 independent hexagonal grid cells. The first 6 values of xbounds/ybounds are the corners of the first grid cell.

```
gridtype  = cell
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
```

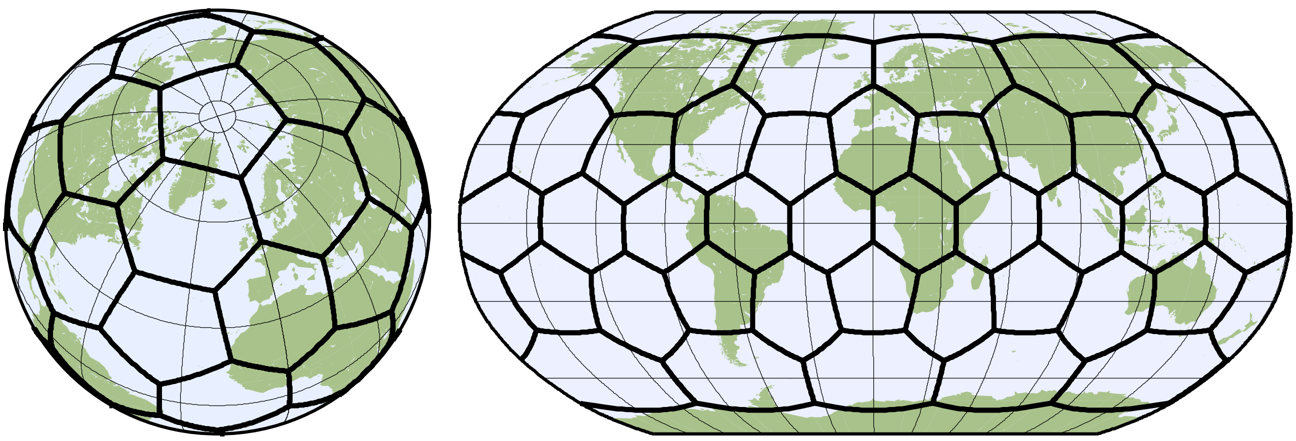

Figure B.2.: Orthographic and Robinson projection of the unstructured grid cells

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