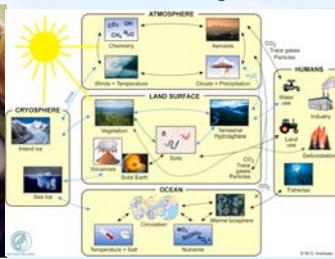


cdo: climate data operators

```

!sum0
!0000 IVSEP
!0000 INWAVE
DO ZIB j=1,ipromo
  IF(.not.(flag(j))) THEN
    it = NINT(eps(j,kk)*1000...dp)
    IF (it>jptlucul...OR...it>jptlucul2) lookpoverflow = .TRUE.
    it = MAX(MIN(it,jptlucul2),jptlucul)
    zes=tlucul(it)/ps(jl)
    zes=MING(zes,zes)
    LD=zes*0.4_dp
    zcor=1...dp/(1...dp-vtempcl*zes)
    zesot=zes*zcor
    it1=it+1
    it1 = MAX(MIN(it1,jptlucul2),jptlucul)
    zes1=tlucul(it1)/ps(jl)
    zes1=MING(zes1,zes1)
    zes1=zast1(1...dp-vtempcl*zes1)
    zesot=(zes1-zesot)*1000...dp
  
```

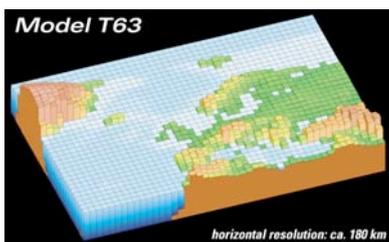


January 31 2008, MPI for Meteorology

The cdo: An essential tool for Earth System Modeling

By Uwe Schulzweida, Luis Kronbluh, and Reinhard G. Budich, MPI for Meteorology, Bundesstr. 53, D-20146 Hamburg, Germany; E-mail: reinhard.budich@zmvw.de

For many years the Max Planck Institute for Meteorology has developed the cdo to handle and analyse the vast data sets produced by climate models. Read on about the status of this tool essential now for many researchers around the world.



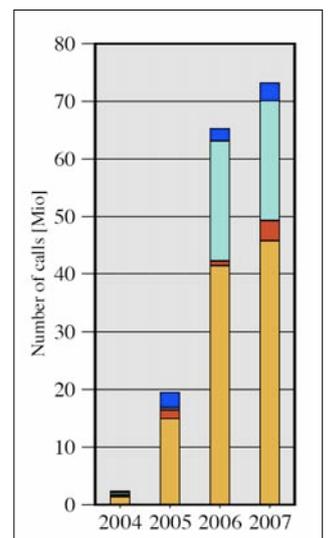
CDO are a software package providing functions to process and analyse data produced by a variety of climate and NWP models. Currently about 100 functions (see the reference card, link given below) are available e.g. for file operations, simple statistics, arithmetics, interpolation, or the calculation of climate indices. Most of the functions can be combined into a single CDO call, which is the first step in efficiently using the latest computer hardware.

File formats supported are GRIB1 (GRIB2 see below) and netCDF (following the CF-convention), which are used most often, but also several institution's internal binary formats (List to be extended upon request). A large set of grids is supported as well as spectral data, (reduced) Gaussian grids, regular (rotated) lat-lon grids, conformal mapped quadrilateral grids, and finally unstructured grids. Models supported are e.g. COSMOS, ECHAM, IFS, MPIOM, NEMO, GME, REMO, CLM/LM, or HIRLAM.

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Main development targets have been high performance, flexibility, and reliability. For portability and performance reasons the code is implemented in pure ANSI-C. It has a medium grade of complexity by now with about 100000 lines of code; installation is handled via GNU autoconf.

The code is used by around 150 groups world-wide. To name a few important users: installations are available at ECMWF, DWD, SMHI, and ETH Zürich, but also CALTEC, GFDL, UCAR or JAMSTEC. At DKRZ/ZMAW the CDO are used by around 200 users calling the CDO around 200000 times per day (See right).



The increasing number of installations and users generates a very high demand for support and requires the development and sustainment of professional services.

To improve the **support situation** the following actions are planned:

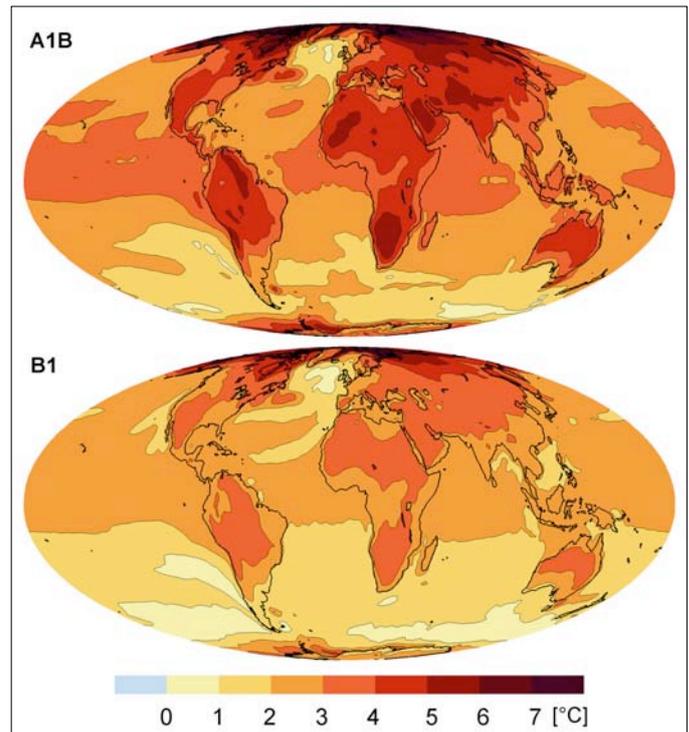
- ▶ Develop the currently rather technical into a much more user-friendly documentation
- ▶ Develop a tutorial
- ▶ Establish and maintain
 - ◉ FAQs
 - ◉ Best practices
 - ◉ Tips and Tricks
 - ◉ Usage examples
- ▶ Develop application related examples
- ▶ Extend the usability by explaining the usage together with e.g. statistical packages like R
- ▶ Install and run WEB based tools
 - ◉ Help-desk
 - ◉ Bug-tracking system
 - ◉ User wiki and forum
 - ◉ Project management system
- ▶ Development of an e-learning system based on the bullets above

▶ Offer an installation service for different platforms

An important issue for future developments is the reduction of the data size. First steps have been taken on this by adding lossless compression (NASA szip) to the packed GRIB data. This reduces the file sizes by a factor of two to three, while maintaining the I/O performance of CDO.

For the further development of CDO, the most important other aspects are:

- ▶ Additional functionality upon user requests
- ▶ Improve performance
 - ◉ Algorithms
 - ◉ Numerics



Temperature Patterns from a scenario run as they are produced by the cdo

- ◉ Additional parallelisation efforts, based on explicit multi-threading.

- ▶ Introduce additional data formats like GRIB2 and netCDF4
- ▶ Introduce automatic, systematic unit testing for functionality verification
- ▶ Lossless high-performance compression for netCDF

(A remark to the last bullet: The whole package is currently a GPL based project. The only exception is NASA's szip algorithm based on several patented algorithms. Fortunately NASA is providing this without royalty fees to the research and education community.)

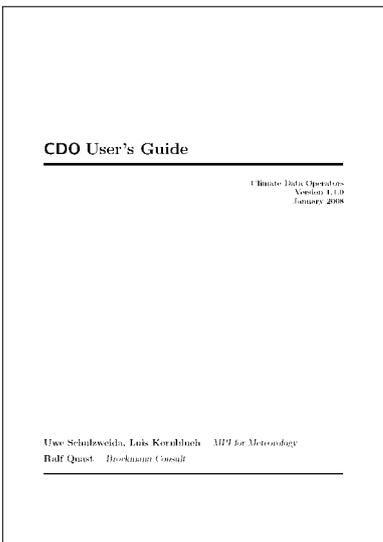
Long-term plans: The cdo are an essential part of the workflows developed in the German [c3-grid](#). Direct in- and digest of data in data bases like [CERA](#) and [MARS](#) are currently investigated.

The cdo homepage:

<http://www.mpimet.mpg.de/cdo>

Reference Card showing the cdo functions:

http://www.mpimet.mpg.de/fileadmin/software/cdo/cdo_refcard.pdf



The cdo manual as it is available on the web site today (see below.)