.nc

msftmyz_Omon_MPI-ESM LR_historical_r1i1p1_185001-200512.nc

prc_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

ps_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

psl_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

tas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

tos_Omon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

uas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

vas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

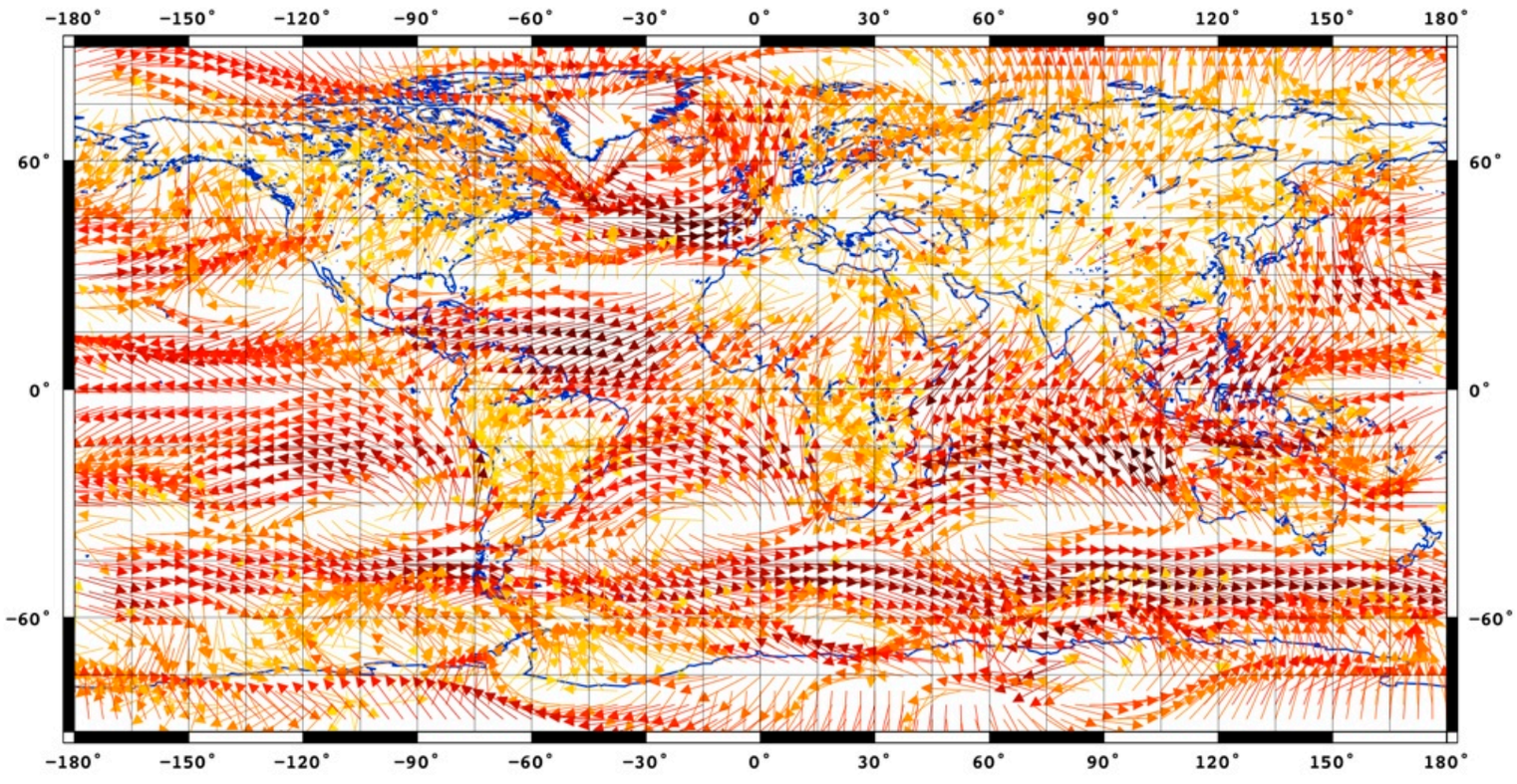
zostoga_Omon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc

NetCDF = Network Common Data Form

DKRZ

Dataprocessing

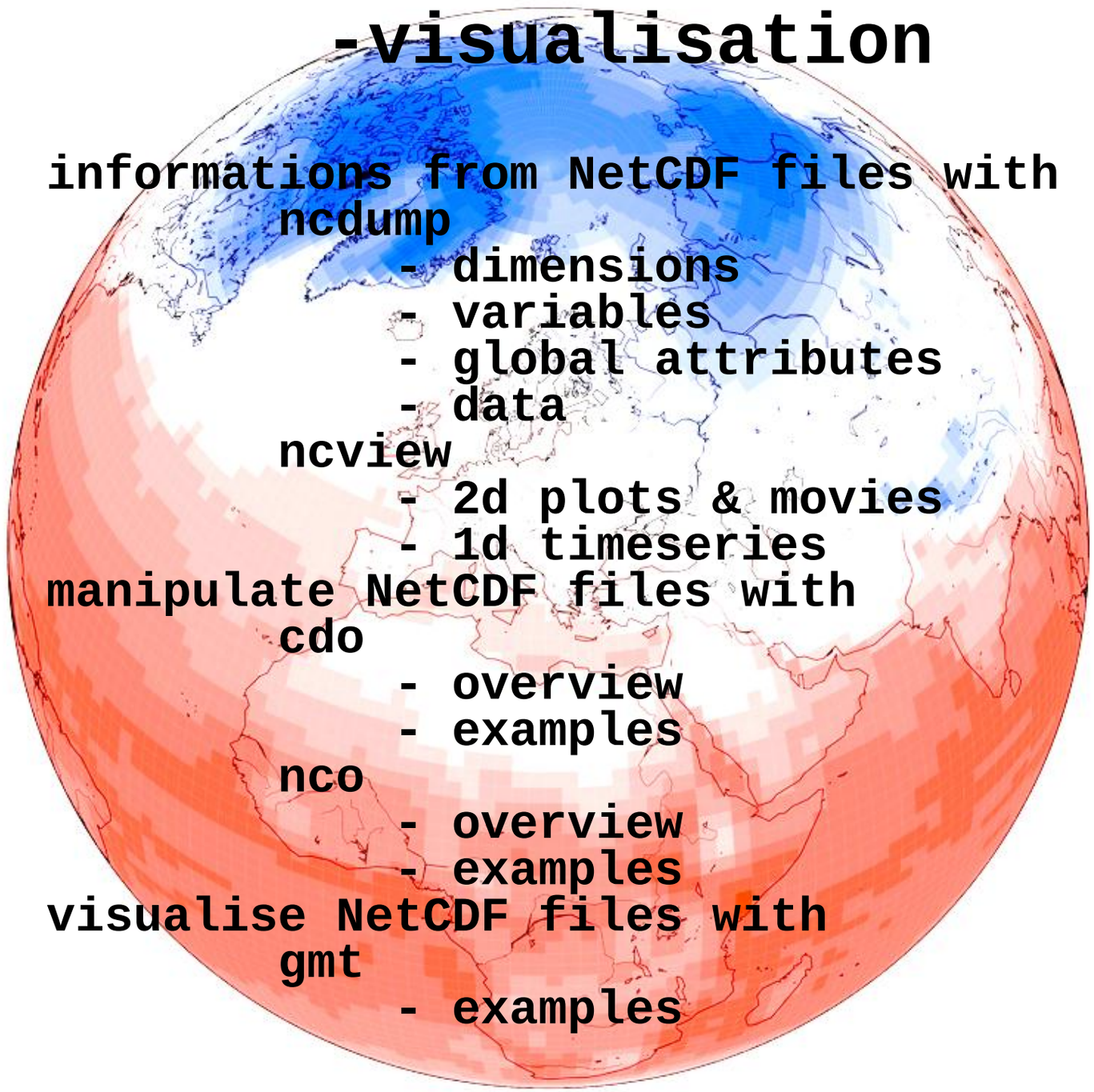
manipulation & visualisation of NetCDF files



Jörg Wegner, 24.02. 2012

DKRZ

Data -formats
-manipulation
-visualisation



informations from NetCDF files with
- ncdump
  - dimensions
  - variables
  - global attributes
  - data
- ncview
  - 2d plots & movies
  - 1d timeseries

manipulate NetCDF files with
- cdo
  - overview
  - examples
- nco
  - overview
  - examples

visualise NetCDF files with
- gmt
  - examples

DKRZ

NetCDF header information

```
netcdf zzz {
dimensions:
        time = UNLIMITED ; // (1872 currently)
        lat = 96 ;
        lon = 192 ;
        bnds = 2 ;
variables:
double lon(lon) ;
                lon:units = "degrees_east" ;
double lat(lat) ;
                lat:units = "degrees_north" ;
double time_bnds(time, bnds) ;
double height ;
double time(time) ;
                time:units = "day since 1850-1-1" ;
float tas(time, lat, lon) ;
                tas:long_name = “Near Surface Air Temperature" ;
                tas:units = “K" ;
// global attributes:
     :institute_id = "MPI-M" ;
     :experiment_id = "historical" ;
data:
time = 1, 2, 3, 4, 5, 6, 7, 8, 9,10;
lon = 0, 1.5, 3, .... 354.5;
lat = -89.5, 88, .... 89.5;
tas = ......;
}
```

This is NetCDF 3 Standard with one unlimited dimension (time in this case) that allows an extension along this axis.
In NetCDF 4 this is called NetCDF classic.

ncdump and ncgen are automatically installed with the netcdf-library.
`ncdump -h zzz.nc`
gives you the header information.

DKRZ

Dimension Variables

```
                                        double time(time) ;
                                               time:bounds = "time_bnds" ;
                                               time:units = "days since 1850-1-1 00:00:00" ;
                                               time:calendar = "proleptic_gregorian" ;
     15.5    45    74.5                        time:axis = "T" ;
   1      31     59      90                     time:long_name = "time" ;
                                               time:standard_name = "time" ;
                                        double time_bnds(time, bnds) ;
                                        double lat(lat) ;
                                               lat:bounds = "lat_bnds" ;
                                               lat:units = "degrees_north" ;
-88.57  -86.72   -84.86                         lat:axis = "Y" ;
-90 -87.65  -85.79  -83.93                     lat:long_name = "latitude" ;
                                               lat:standard_name = "latitude" ;
                                        double lat_bnds(lat, bnds) ;
                                        double lon(lon) ;
                                               lon:bounds = "lon_bnds" ;
                                               lon:units = "degrees_east" ;
                                               lon:axis = "X" ;
                                               lon:long_name = "longitude" ;
                                               lon:standard_name = "longitude" ;
                                        double lon_bnds(lon, bnds) ;
                                        double height ;
                                               height:units = "m" ;
          2                                    height:axis = "Z" ;
                                               height:positive = "up" ;
                                               height:long_name = "height" ;
                                               height:standard_name = "height" ;
```

DKRZ

Variable attributes

```
float tas(time, lat, lon) ;
      tas:standard_name = "air_temperature" ;
      tas:long_name = "Near-Surface Air Temperature" ;
      tas:units = "K" ;
      tas:cell_methods = "time: mean" ;
      tas:cell_measures = "area: areacella" ;
      tas:coordinates = "height" ;
      tas:missing_value = 1.e+20f ;
      tas:_FillValue = 1.e+20f ;
      tas:associated_files = "baseURL: http://cmip-pcmdi.llnl.gov/CMIP5/dataLocation
   gridspecFile: gridspec_atmos_fx_MPI-ESM-LR_historical_r0i0p0.nc areacella:
   areacella_fx_MPI-ESM-LR_historical_r0i0p0.nc" ;
```

```
sophie% cdo info -seltimestep,1 tas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc
cdo info: Started child process "seltimestep,1 tas_Amon_MPI-ESM-
LR_historical_r1i1p1_185001-200512.nc (pipe1.1)".Warning (scanVarAttributes) : NetCDF:
Variable not found - areacella
-1 : Date  Time   Param   Level    Size    Miss :     Minimum     Mean     Maximum
 1 : 1850-01-16 12:00:00 -1 0     18432     0 :      229.22     275.15      306.91
cdo(2) seltimestep: Processed 18432 values from 1 variable over 2 timesteps.( 0.00s )
cdo info: Processed 18432 values from 1 variable over 1 timestep. ( 0.00s )
```

DKRZ

global attributes

```
// global attributes:
      :institution = "Max Planck Institute for Meteorology" ;
      :institute_id = "MPI-M" ;
      :experiment_id = "historical" ;
      :source = "shows the revision numbers of the models;" ;
      :model_id = "MPI-ESM-LR" ;
      :forcing = "GHG Oz SD Sl Vl LU" ;
      :parent_experiment_id = "piControl" ;
      :parent_experiment_rip = "r1i1p1" ;
      :branch_time = 10957. ;
      :contact = "cmip5-mpi-esm@dkrz.de" ;
      :history = "how this data file was created" ;
:references = "where to find informations about the models" ;
:initialization_method = 1 ;
:physics_version = 1 ;
:tracking_id = "c6446bbf-65ed-41cc-a67d-71e3559a2824" ;
:product = "output" ;
:experiment = "historical" ;
:frequency = "mon" ;
:creation_date = "2011-05-27T17:19:00Z" ;
:Conventions = "CF-1.4" ;     :project_id = "CMIP5" ;
:table_id = "Table Amon (27 April 2011) a5a1c518f52ae340313ba0aada03f862" ;
:title = "MPI-ESM-LR model output prepared for CMIP5 historical" ;
:parent_experiment = "pre-industrial control" ;
:modeling_realm = "atmos" ;
:realization = 1 ;
:cmor_version = "2.5.9" ;
```

DKRZ

forcing

example: :forcing = "GHG Oz SD Sl Vl LU"

Nat	Natural forcing
Ant	Anthropogenic forcing
GHG	well mixed Green House Gases
SD	anthropogenic sulfate aerosol, accounting only for direct effects
SI	anthropogenic sulfate aerosol, accounting only for indirect effects
SA	SA (= SD + SI)
TO	tropospheric ozone
SO	stratospheric ozone
Oz	Oz (= TO + SO)
LU	land use change
Sl	solar irradiance
Vl	volcanic areosol
SS	sea salt
Ds	dust
BC	black carbon
MD	mineral dust
OC	organic carbon
AA	a mixture of anthropogenic aerosols, not explicitly defined

http://cmip-pcmdi.llnl.gov/cmip5/docs/cmip5_data_reference_syntax.pdf

tracking_id

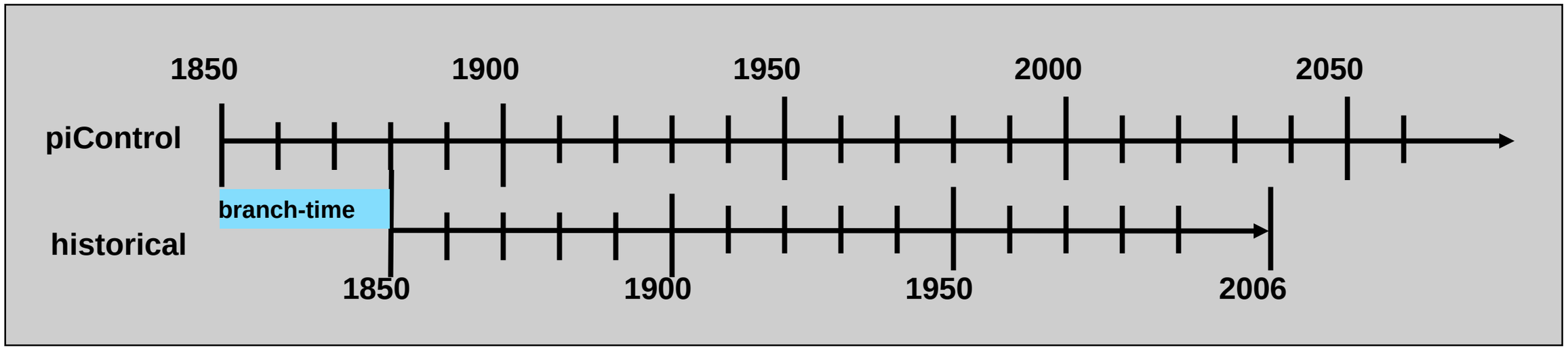
example: :tracking_id = c6446bbf-65ed-41cc-a67d-71e3559a2824" ;

unique number created by a library routine uuid which is called by cmor2

DKRZ

parent_id

```
:parent_experiment_id = "piControl";
:parent_experiment_rip = "r1i1p1" ;
:parent_experiment = "pre-industrial control" ;
```



branch_time

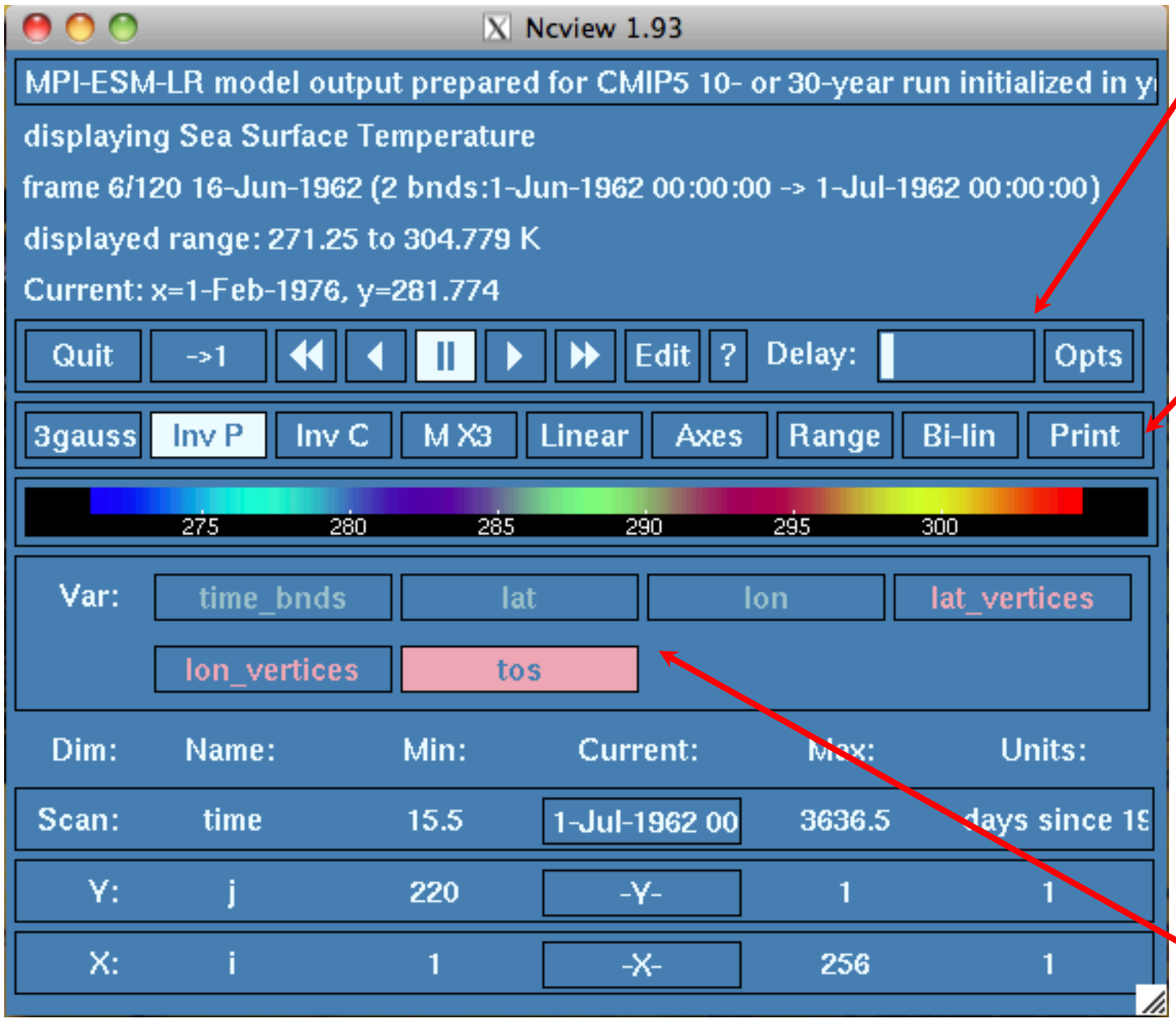
```
:branch_time = 10957. ;
```

= 10957 days since 01.01.1850 = 30 years with 7 leap days

```
time:units    = "days since 1850-1-1 00:00:00" ;
time:calendar = "proleptic_gregorian" ;
#set branchtime = 56978
# 1850-2006 (18500101 - 20051231)
#set branchtime = 10957 # 1850-1880 (18500101 - 18791231)
#set branchtime = 25932 # 1850-1921
#set branchtime = 47481 # 1850-1980
#set branchtime =  5844 # 1850-1866
#set branchtime = 18627 # 1850-1901
#set branchtime = 42368 # 1850-1966
```

DKRZ

ncview I



first row:

1:quit ncview
2:back to the first screen
3 a-e:move through the data
4:edit data
5:infos about the variable
6:delay between two screens
7:contour map overlay!

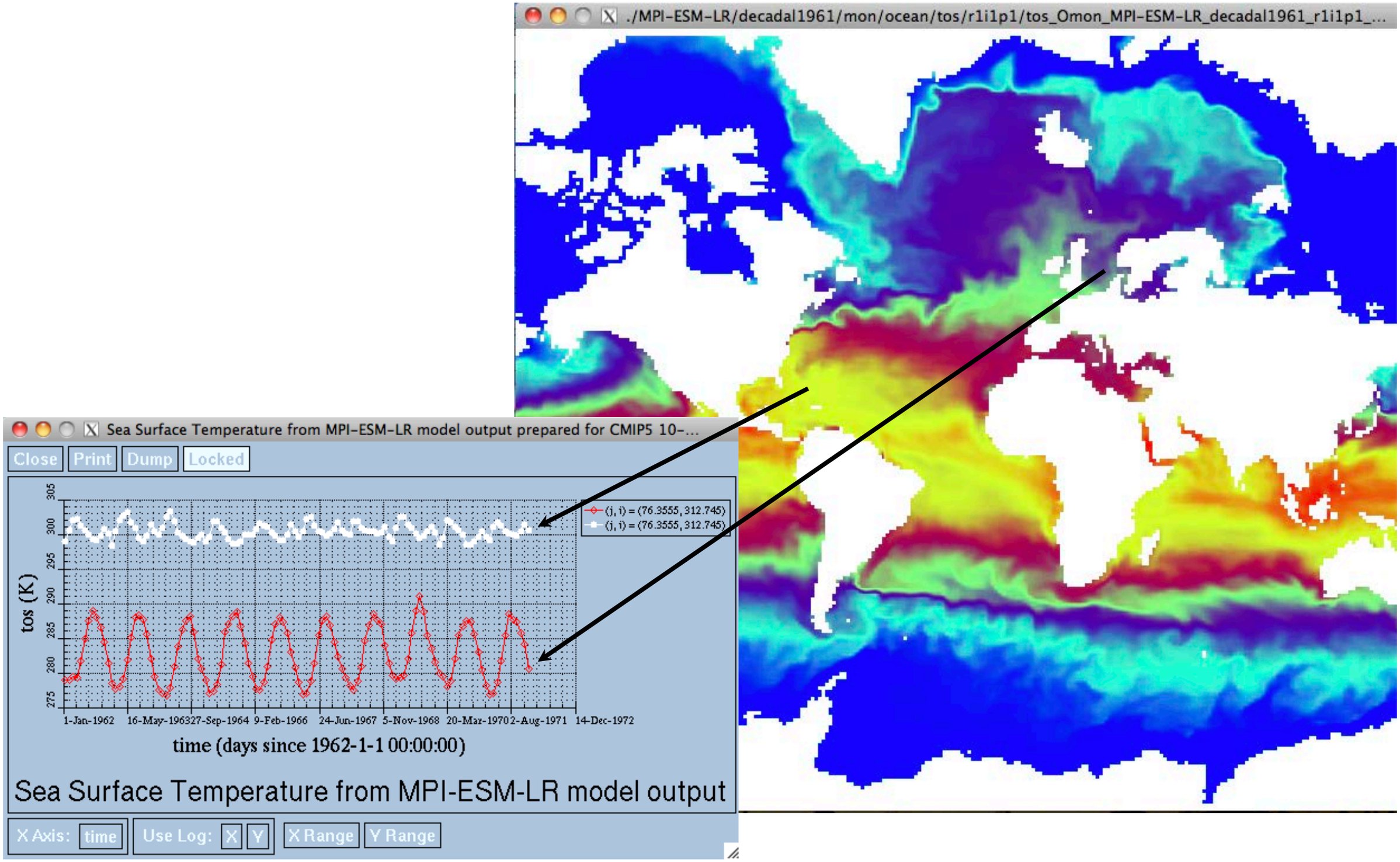
second row:

08:color tables
09:invert plot (turn upside down)
10:invert colors
11:magnify plot(increase:left,
decrease right mouse button click)
12:kind of color filter (hi empha-sizes
high, low low values, linear = off)
13:change axes
14:set data range (klick with the
right mouse button gives the
best range of colors for the plot)
15:bilinear interpolation or
replicate pixels
16:print plot to postscriptfile

third row:

choose variable

ncview II

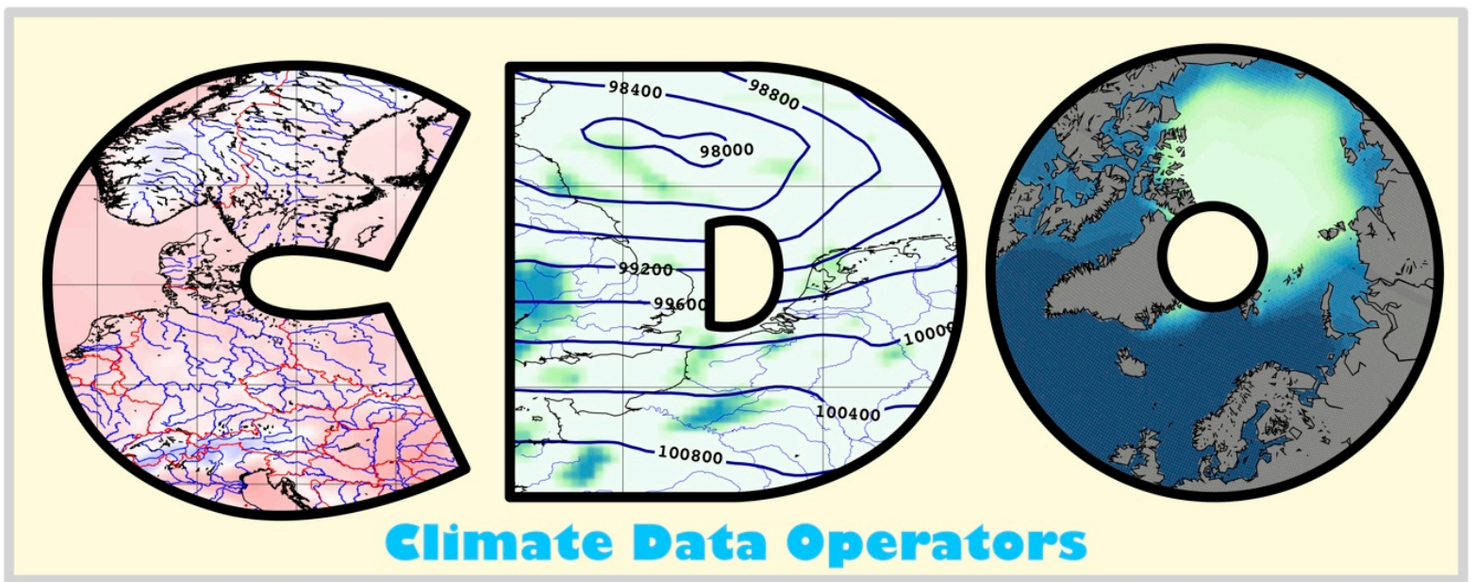

./MPI-ESM-LR/decadal1961/mon/ocean/tos/r1i1p1/tos_Omon_MPI-ESM-LR_decadal1961_r1i1p1_...
Sea Surface Temperature from MPI-ESM-LR model output prepared for CMIP5 10-...
Close
Print
Dump
Locked
(j, i) = (76.3555, 312.745)
(j, i) = (76.3555, 312.745)
tos (K)
305
300
295
290
285
280
275
1-Jan-1962
16-May-1963
27-Sep-1964
9-Feb-1966
24-Jun-1967
5-Nov-1968
20-Mar-1970
2-Aug-1971
14-Dec-1972
time (days since 1962-1-1 00:00:00)
Sea Surface Temperature from MPI-ESM-LR model output
X Axis:
time
Use Log:
X
Y
X Range
Y Range

NetCDF tools

nco: great toolbox for file and header manipulations and statistics
ncview: simple view on netcdf files
ncdump, ncgen: nc to ascii and vice versa
options: -h (header only) -v [var] (header & var data)
cdat, cdms: powerful tool based on python. Dataprocessing and visualisation. Not easy to learn and tricky installation
cdo: mpi choice for data processing
gradsnc: visualisation tool
gmt: visualisation tool
ncl: the NCAR Command Language: a free interpreted language designed for scientific data processing & visualization.

netCDF: http://www.unidata.ucar.edu/software/netcdf/
nco: http://nco.sourceforge.net/
ncview: http://meteora.ucsd.edu/~pierce/ncview_home_page.html
ncdump, ncgen: http://www.unidata.ucar.edu/software/netcdf/
cdat, cdms: http://www-pcmdi.llnl.gov/software/
cdo: https://code.zmaw.de/projects/cdo
gradsnc: http://grads.iges.org/grads/grads.html
ncl:http://www.ncl.ucar.edu/overview.shtml

DKRZ



Usage:

```
cdo [options]              \
    operator[,op[,op]] \
    [-operator]            \
  ifile [ifile ...] [ofile]
```

For:

GRIB-, NetCDF-, ieg-, Service-, Extra-formatted files

DKRZ

There are more than 400 operators available:

- **informations**
  info, infov, sinfo, map, griddes, vardes, ...
  showcode, showvar, showyear, showmonth, showlevel, ...
- **file operations & modifications**
  copy, merge, split, settime, setgatt, invert ...
- **selections**
  selvar, selcode, sellevel, selyear, ...
  sellonlatbox, selindexbox, seltimestep, ...
- **input/ ouput**
  input, output, outputf, gradsdes, outputbounds ...
- **statistic**
  yearmean, yearavg, yearmax, yearsum, yearvar, yearstd
  hour..., day..., mon..., seas...
- **arithmetic, regression & interpolation**
  add, addc, sqr, sqrt, trend, detrend, remapcon, intvert, ...
- **conditional selection**
  ifthen, ifnotthen, ifthenelse, ifthenc, ifnotthenc
- **comparision**
  eq, eqc, ne, nec, le, lec, ge, gec, lt, ltc, gt, gtc
- **others**
  eca-indices, transformation, ...

DKRZ

Piping & conditional selection & arithmetic

How to compute windspeed from u and v component of the wind.
Formula: √(u^2 + v^2)

```
cdo sqrt -add -sqr U1000.nc -sqr V1000.nc SPEED1000.nc
```
Squares the values in V1000.nc, then in U1000.nc, then adds the two files and computes the square root. Result: Windspeed
first operator is executed the last

The wind direction? Formula: 180 / π * atan2(-u,-v) with 180/π = 57.3

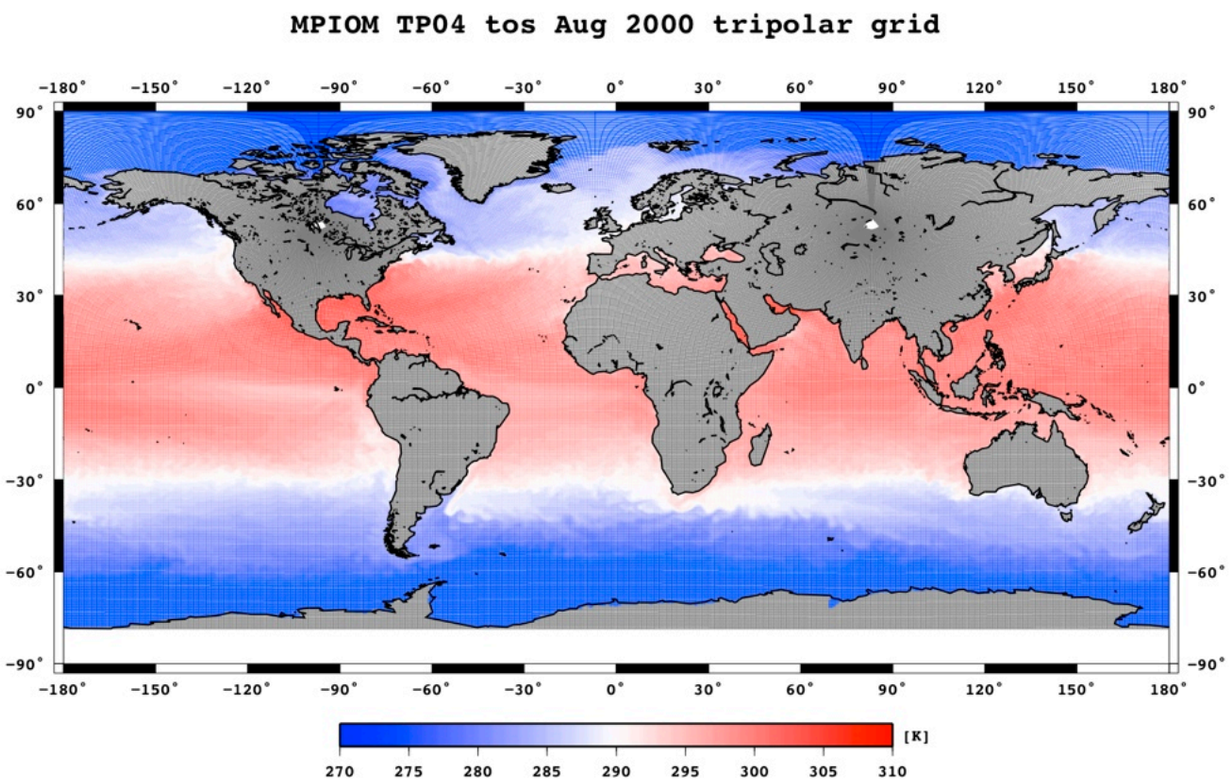
```
cdo mulc,57.3 -atan2 -mulc,-1 U1000.nc -mulc,-1 V1000.nc UV.nc
```
The angle will be between -180 and 180 degree
```
cdo ltc,0 UV.zw2.nc mask
```
Creates a maskfile with 1 for all values smaller than zero and 0 else.
```
cdo ifthen mask -addc,360 uv.zw2.nc unter0.nc
```
For values < 0 use values from ifile, add 360 and set missing_value else.
```
cdo ifnotthen mask uv.zw2.nc ueber0.nc
```
For values > 0 use values from ifile and missing_value else.
```
cdo ifthenelse unter0.nc ueber0.nc uvricht.nc
```
merge both files

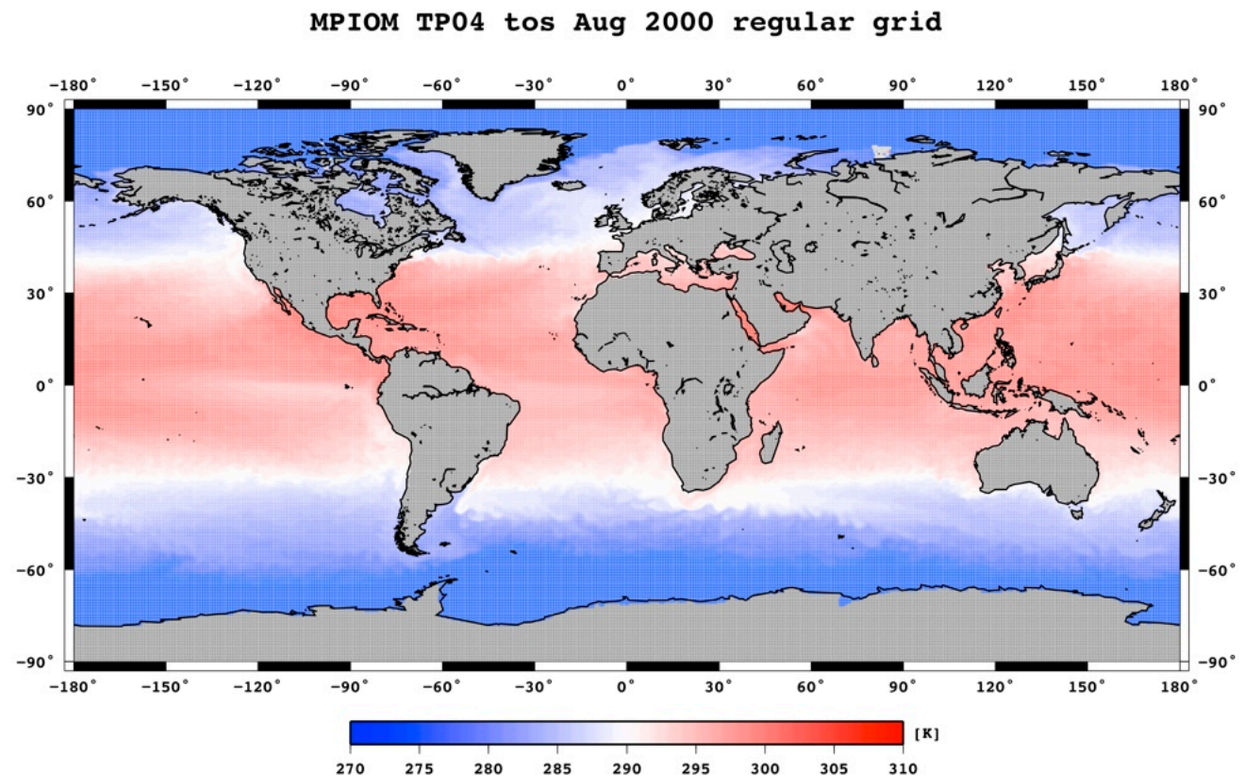
DKRZ

interpolate (conservative remapping)

a tripolar to a regular 800*400 grid

```
cdo -t mpiom1 -f nc setgrid,TP04s.nc \
    -selindexbox,2,801,1,404 \
    tos_Omon_MPI-ESM-MR_historical_r1i1p1_200001-200512.nc \
    tos_Omon_MPI-ESM-MR_hist_r1_200001-200512_woh.nc
cdo remapcon,r800x400 \
    tos_Omon_MPI-ESM-MR_hist_r1_200001-200512_woh.nc
    tos_Omon_MPI-ESM-MR_hist_r1_200001-200512_reg.nc
```





DKRZ

NCO

NetCDF Operators

The operators are:

- **ncatted - attribute editor**
- **ncdiff - differencer**
- **ncea - ensemble averager**
- **ncecat - ensemble concatenator**
- **ncflint - file interpolator**
- **ncks - kitchen sink (extract, cut, paste, print data)**
- **ncra - running averager**
- **ncrcat - record concatenator**
- **ncrename - renamer**
- **ncwa - weighted averager**

DKRZ

ncrename

```
ncrename [-a ...] [-D dbg_lvl] [-d ...] [-h] [--hdr_pad nbr] [-l path]
         [-O] [-o out.nc] [-p path] [-R] [-r] [-v ...] in.nc [[out.nc]]

-a  Attribute's old and new names
-d  Dimension's old and new names
--hdr_pad  Pad output header with nbr bytes
-v  old_var,new_var Variable's old and new names
in.nc         Input file name(s)
[out.nc]              Output file name (or use -o switch)
```

```
Examples:
Rename Dimension longitude to lon
sophie 43%ncrename -d longitude,lon zzsresa2.nc

Rename Dimension and Variable longitude, latitude to lon, lat
sophie 44%ncrename -d longitude,lon -v longitude,lon zzsresa1b.nc
sophie 45%ncrename -d latitude,lat -v latitude,lat zzsresa1b.nc

Rename attribute _FillValue in variable T_2M to missing_value
sophie 46% ncrename -a T_2M:_FillValue,missing_value in.nc
```

DKRZ

ncatted

```
ncatted [-a ...] [-D dbg_lvl] [-h] [--hdr_pad nbr] [-l path] [-O] [-o out.nc]
        [-p path] [-R] [-r] in.nc [[out.nc]]

-a, --attribute att_nm,var_nm,mode,att_typ,att_val Attribute specification:
                    mode = a,c,d,m,o and att_typ = f,d,l,s,c,b
--hdr_pad  Pad output header with nbr bytes
in.nc         Input file name(s)
[out.nc]              Output file name (or use -o switch)

-h  don't change history!
```

```
for mode:    a = append, c = create, d = delete, m = modify, o = overwrite
for att_typ: f = float,  d = double, l = long,   s = short,  c = character,
             b = byte,   i = integer
```

Examples:

add an attribute to the global attributes:

```
ncatted -O -h -a forcing,global,c,c,"GHG Oz SD Sl Vl" zzz.nc
```

append something to an attribute:

```
ncatted -O -h -a forcing,global,a,c," LU" zzz.nc
```

add an attribute to the variable attributes:

```
ncatted -O -h -a grid_type,tas,c,c,"gaussian" zzz.nc
```

DKRZ

ncks

```
ncks [-3] [-4] [-A] [-a] [-B] [-b fl_bnr] [-C] [-c] [-D dbg_lvl] [-d ...]
     [-F] [-H] [-h] [--hdr_pad nbr] [-L lvl] [-l path] [-m] [-M] [-O]
     [-o out.nc] [-P] [-p path] [-Q] [-q] [-R] [-r] [-s format] [-u]
     [-v ...] [-X ...] [-x] in.nc [[out.nc]]
```

```
-A  Append to existing output file, if any
-a  Disable alphabetization of extracted variables
-c  Coordinate variables will all be processed
-C  Associated coordinate variables should not be processed
-d  dim,[min][,[max]][,[stride]] Dimension's limits and stride in hyperslab
-O  overwrite outputfile if exist
-v  var1[,var2[...]] Variable(s) to process (regular expressions supported)
-x  Extract all variables EXCEPT those specified with -v
```

Examples:
File msftmyz_Omon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc
contains lat level values for 3 basins and 156 time steps. Select
each basin and all values from 1900 to 1999:
copy the file (just a shorter name ;-)

```
ncks -O msftmyz_Omon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc base3orig.nc
```

to see the timesteps:

```
ncks -v time base3orig.nc
```

select basin and time:

```
ncks -O -d basin,0 -d time,600,1799 base3orig.nc base1_1900-1999.nc
ncks -O -d basin,1 -d time,600,1799 base3orig.nc base2_1900-1999.nc
ncks -O -d basin,2 -d time,600,1799 base3orig.nc base3_1900-1999.nc
```

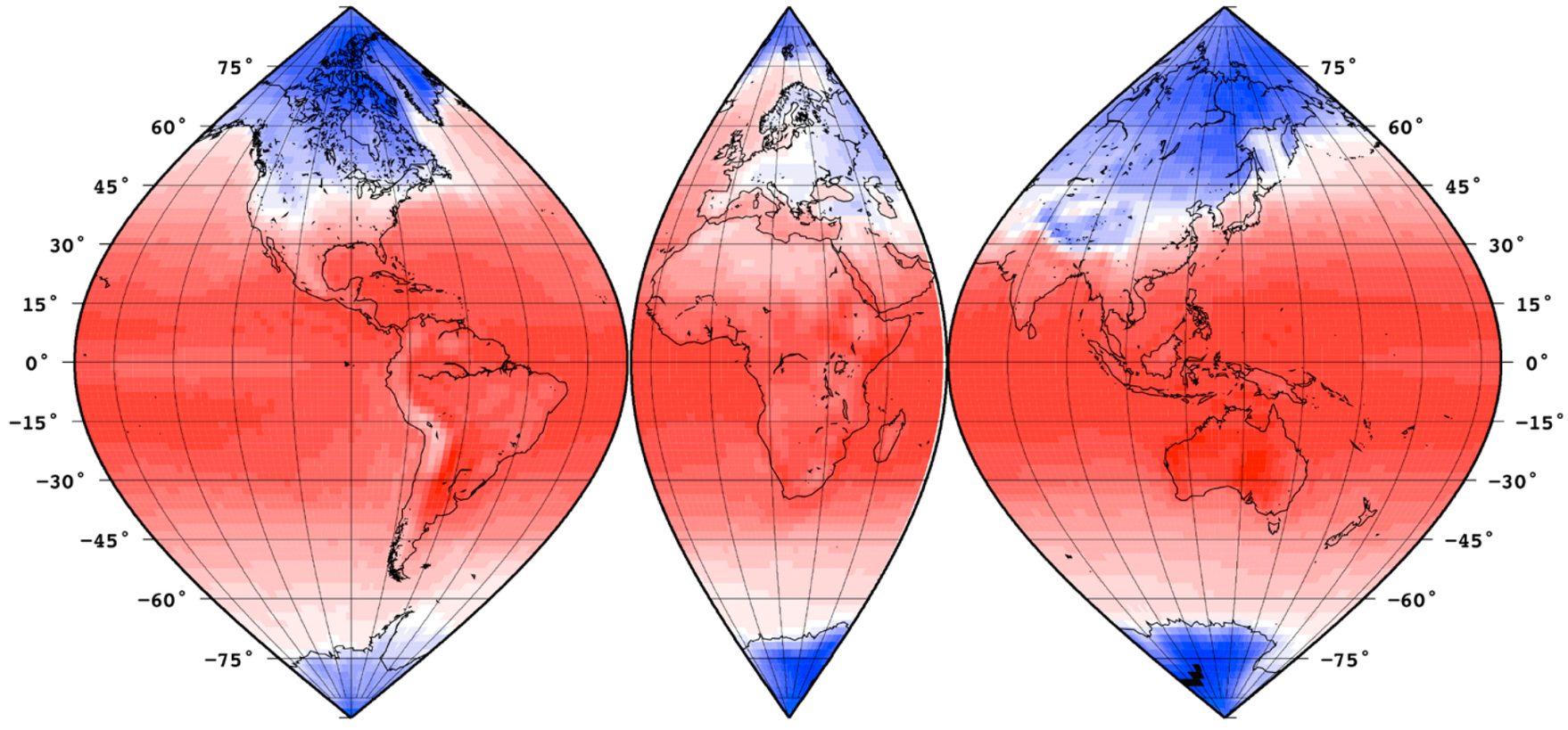
DKRZ

GMT

generic mapping tools

Current officially released version is gmt 4.5.7
http://gmt.soest.hawaii.edu/

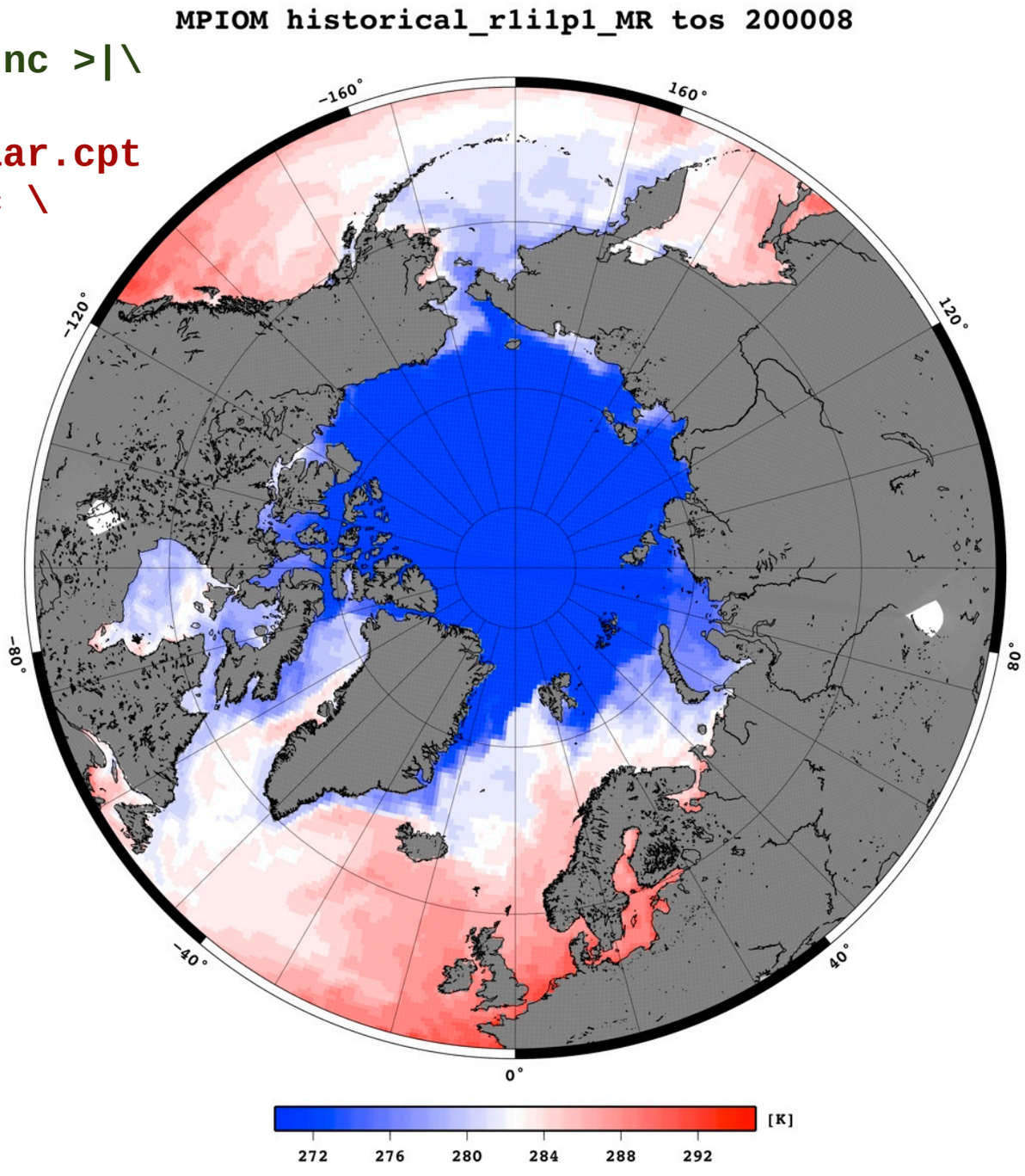
blizzard (version 4.4) : /client/bin
sun solaris (version 4.5.7) : /client/bin
Mac/Windows: also available



> DKRZ

MPIOM north pole

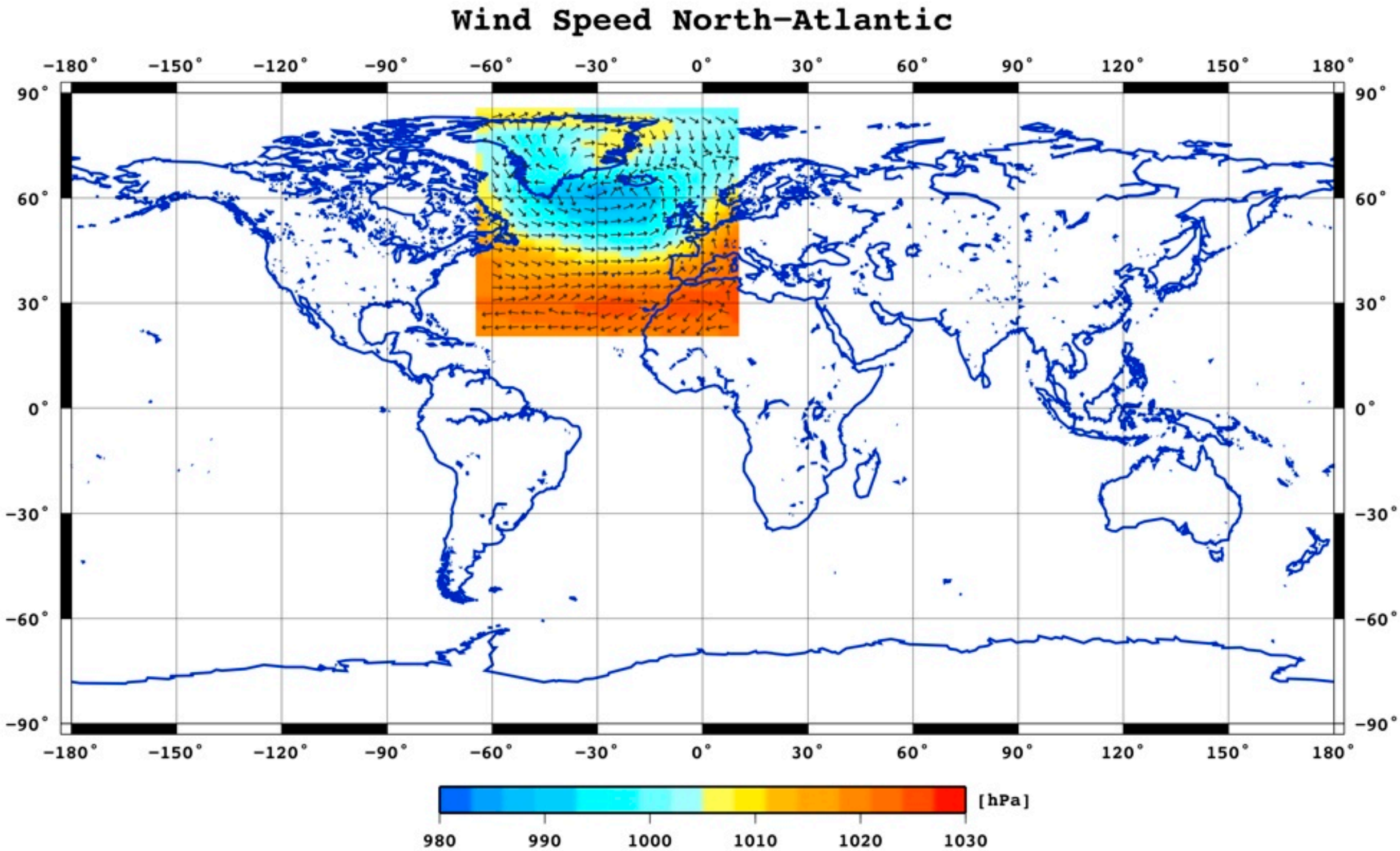
```
#!/bin/ksh
IFILE=tos_Omon_MPI-ESM-MR_historical_r1i1p1_200001-200512.nc
OFILE=tos_polar.ps
TITLE="MPIOM historical_r1i1p1_MR tos 200008”
cdo -t mpiom1 -f nc setgrid,TP04s.nc -selindexbox,2,801,1,404 \
      tos_Omon_MPI-ESM-MR_historical_r1i1p1_200001-200512.nc\
      tos_historical_r1i1p1-MR_200008.nc
cdo outputbounds tos_historical_r1i1p1-MR_200008.nc >|\
                 tos_historical.asc
# COLOURS:makecpt -Cpolar -T270.0/295/1 > tos_polar.cpt
# SETTINGS:psbasemap -R-180/180/46/90 -JG0/90/20c \
          -X0.8c -Y4.0c -B40/40:."$TITLE": \
          -P -K >| $OFILE
# PICTURE:
psxy -R -J -m tos_historical.asc \
     -L -Ctos_polar.cpt -O -K >> $OFILE
# COLOUR BAR:
psscale -Ctos_polar.cpt -D10.0c/-1.2c/10c/0.5ch\
        -B4/:"[K]": -O -K >> $OFILE
# MORE SETTINGS (GRID):
psbasemap -R -J -Bg15/g15 -O -K >> $OFILE
# Coast lines, Rivers, Borders
pscoast -R -J -Dl -W0.5p  -O >> $OFILE
# CHANGING postscript to PDF
ps2pdf $OFILE
#
```



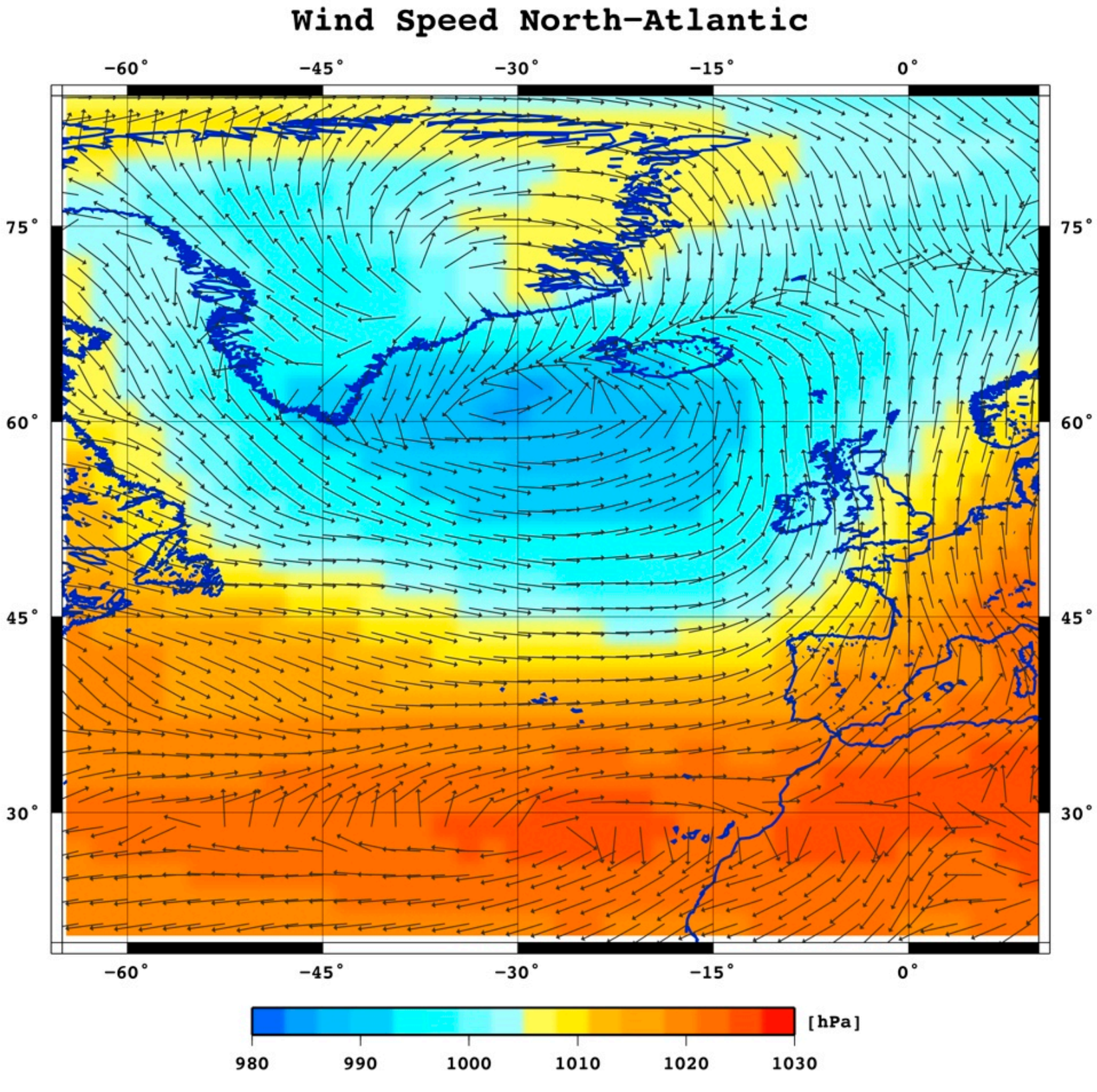
Wind Speed North Atlantic – the script

```
#!/bin/tcsh
set IFILE1 = uas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc
set IFILE2 = vas_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc
set IFILE3 = psl_Amon_MPI-ESM-LR_historical_r1i1p1_185001-200512.nc
#set VAR1 = `cdo showvar $IFILE1`set VAR2 = `cdo showvar $IFILE2`
#cdo sellonlatbox,-65,10,20,85 $IFILE1 nordu.nc
cdo sellonlatbox,-65,10,20,85 $IFILE2 nordv.nc
cdo sellonlatbox,-65,10,20,85 -divc,100 $IFILE3 ${IFILE3:r}_hpa.nc
#set VAR3 = `cdo showvar $IFILE3`
set OFILE = northatlantic2.ps
#makecpt -Cno_green -T980/1030/1 > pressure.cpt
psbasemap -Rg -JQ0/24c -X2.0c -Y-1.5c -B30/30:."Wind Speed North-Atlantic": \
          -K > $OFILE
grdimage "${IFILE3:r}_hpa.nc?${VAR3}" -R -J -Cpressure.cpt -O -K >> $OFILE
pscoast -R -J -Dc -W1.5p,0/0/200 -O -K >> $OFILE
grdvector "nordu.nc?${VAR1}" "nordv.nc?${VAR2}” -R -J -I4 \
    -Q0.005c/0.06c/0.05c -G50/50/50 -W0.1p,50/50/50 -Sl0.2c -O -K >> $OFILE
psbasemap -R -J -Bg30/g30  -O -K >> $OFILE
psscale -Cpressure.cpt -D12.0c/-1.2c/10c/0.5ch -B10/:"[hPa]": -O  >> $OFILE
#
ps2pdf $OFILE
#
```

```
psbasemap -Rg -JQ0/24c -X2.0c -Y-1.5c -B30/30:."Wind Speed North-Atlantic": \
          -K > $OFILE
```



```
psbasemap -R -65/10/20/85 -JQ0/24c -X2.0c -Y-1.5c -B30/30:."Wind Speed North-Atlantic": \
-K > $OFILE
```



DKRZ

Thanks for listening

Questions?