Introduction to the ClimValDiagTool

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Preparations

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Touch the parts (mostly namelist type files) you are likely to change when using the tool

8. Create a new variable and a new diagnostic

DLR Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

FONA
Decadal
Climate Prediction
BMBF

MiKlip

1. General Info: ClimValDiagTool

- Designed for comparing and plotting climate parameters from model, reanalysis and observational data, given in NetCDF format.

- A wealth of analysis routines is inherited from previous and current multi-model intercomparison/verification projects. The ClimValDiagTool is an extension of the CCMVal Diagnostic Tool (http://www.pa.op.dlr.de/CCMVal/CCMVal_DiagnosticTool.html).

- Please cite and refer to:
  Gettelman, A. et al., A community diagnostic tool for chemistry climate model validation, Geosci. Model Dev., 5, 1061-1073,doi:10.5194/gmd-5-1061-2012, 2012.

- Current license for use: CCMValDiagTool_license.txt (in the root folder of the tool).
  The option to output references and acknowledgements for the parts used is in preparation.

- Goal for MiKlip: compile namelists with standard diagnostics for the MPI-ESM decadal simulations → model skill assessment at the push of a button

1. General Info: This Tutorial

Goals:

- Enable you to use the ClimValDiagTool on the MiKlip server
- Encourage you to contribute your own diagnostics to the ClimValDiagTool

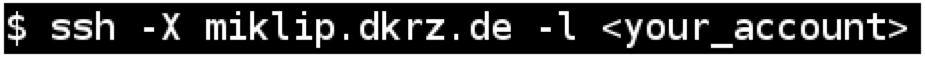
Practical matters:

- The handout is supposed to be self-explanatory. We might go through 1 – 5 together, then you are encouraged to work through the tutorial individually.
- Tasks in sections 6, 7, 8 are almost independent of each other: Choose what you would like to do (but note that your plots might look different if not sticking to the proposed order)
- Selected lines in the code have been disabled for tasks 5, 6, 7. You need to enable them, which forces you to touch some control points without much editing. The yellow boxes show how it should look like in order to work.
- Task 8 is more advanced, with plenty of freedom on how to do it. One solution will be provided, and might serve as a template for your own diagnostics.

2. Access miklip.dkrz.de

- connect to WLAN

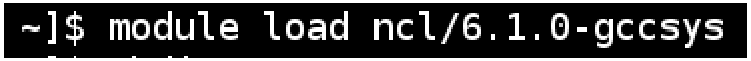
- login at miklip.dkrz.de



```
$ ssh -X miklip.dkrz.de -l <your_account>
```

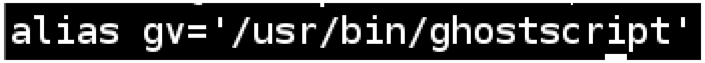
- make sure you can get graphics windows from the remote machine
  (e.g. from MS Windows: enable X11 forwarding in putty, use Exceed, MobaXterm …)

- set up environment (e.g. in .bashrc)



```
~]$ module load ncl/6.1.0-gccsys
```

… we do need NCL

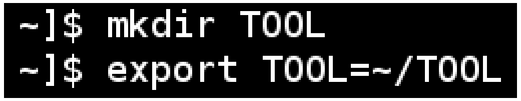


```
alias gv='/usr/bin/ghostscript'
```

… this is just for your convenience

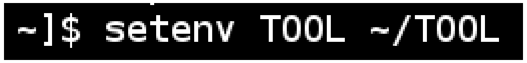
3. Get the code

- Create a directory (e.g. “TOOL”), where you have 300 MB of free disk space (e.g. in your $HOME). You may choose any other name & location.



```
~]$ mkdir TOOL
~]$ export TOOL=~/TOOL
```

(bash)

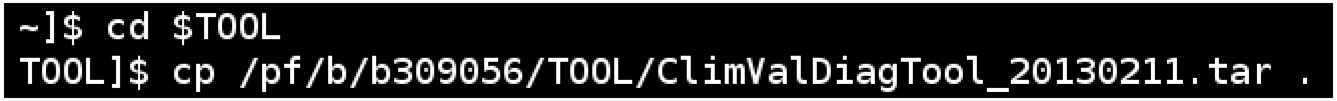


```
~]$ setenv TOOL ~/TOOL
```

(csh)

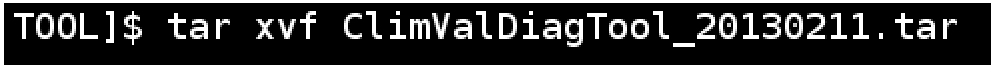
- **$TOOL will refer to this directory from now on**

- Copy the code into $TOOL



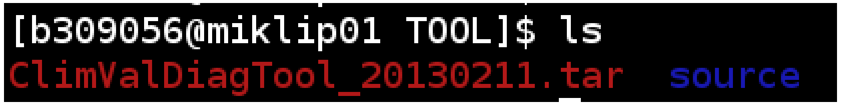
```
~]$ cd $TOOL
TOOL]$ cp /pf/b/b309056/TOOL/ClimValDiagTool_20130211.tar .
```

- Unpack



```
TOOL]$ tar xvf ClimValDiagTool_20130211.tar
```

- Check



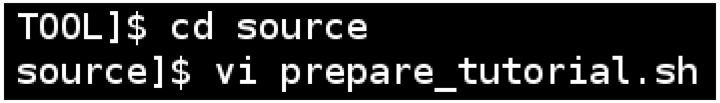
```
[b309056@miklip01 TOOL]$ ls
ClimValDiagTool_20130211.tar  source
```

4. Prepare data

We need model data and observations/reanalysis to compare them to.

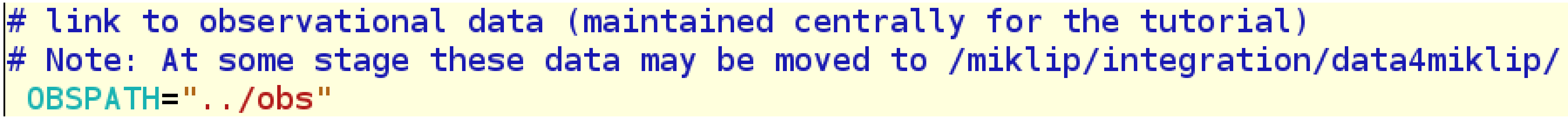
This version of the ClimValDiagTool (still) expects a certain input file name structure, which may be realized by soft links to the original data. A shell script does this for you.

- Check out the script, then execute it

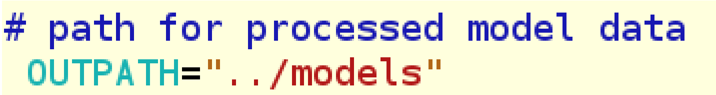


```
TOOL]$ cd source
source]$ vi prepare_tutorial.sh
```

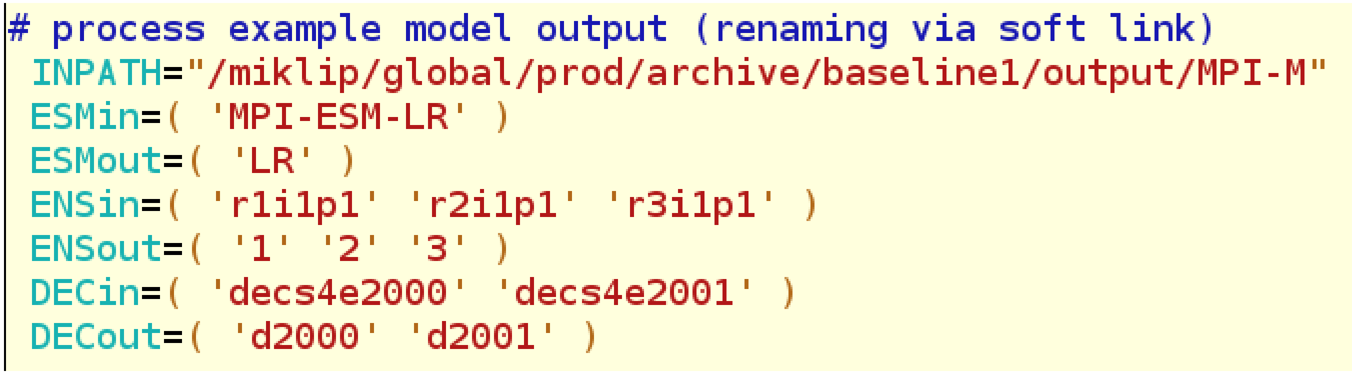
You may use any other editor.



```
# link to observational data (maintained centrally for the tutorial)
# Note: At some stage these data may be moved to /miklip/integration/data4miklip/
 OBSPATH="../obs"
```

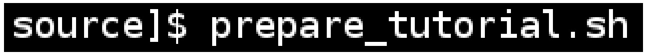


```
# path for processed model data
 OUTPATH="../models"
```



```
# process example model output (renaming via soft link)
 INPATH="/miklip/global/prod/archive/baseline1/output/MPI-M"
 ESMin=( 'MPI-ESM-LR' )
 ESMout=( 'LR' )
 ENSin=( 'r1i1p1' 'r2i1p1' 'r3i1p1' )
 ENSout=( '1' '2' '3' )
 DECin=( 'decs4e2000' 'decs4e2001' )
 DECout=( 'd2000' 'd2001' )
```

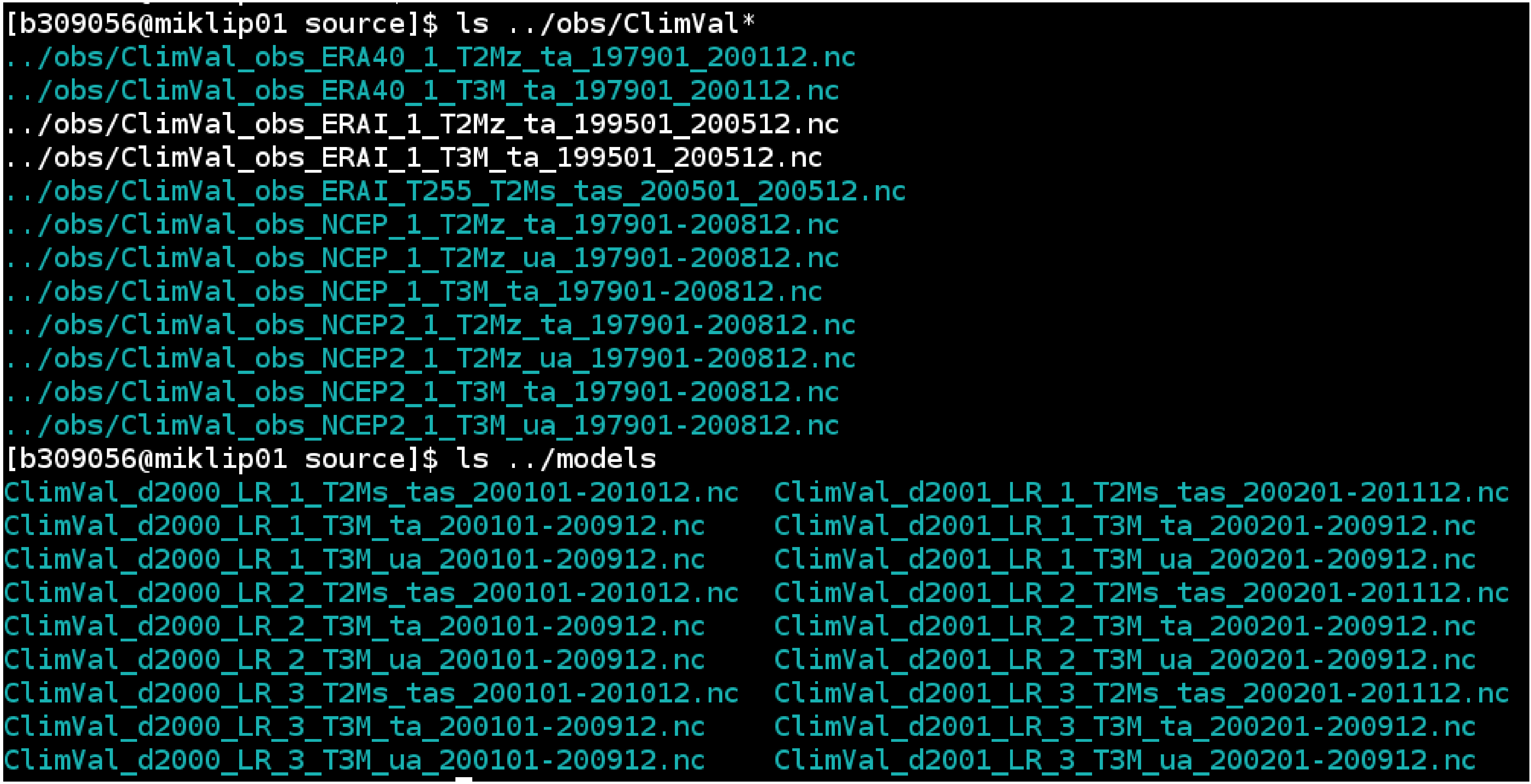
...



```
source]$ prepare_tutorial.sh
```

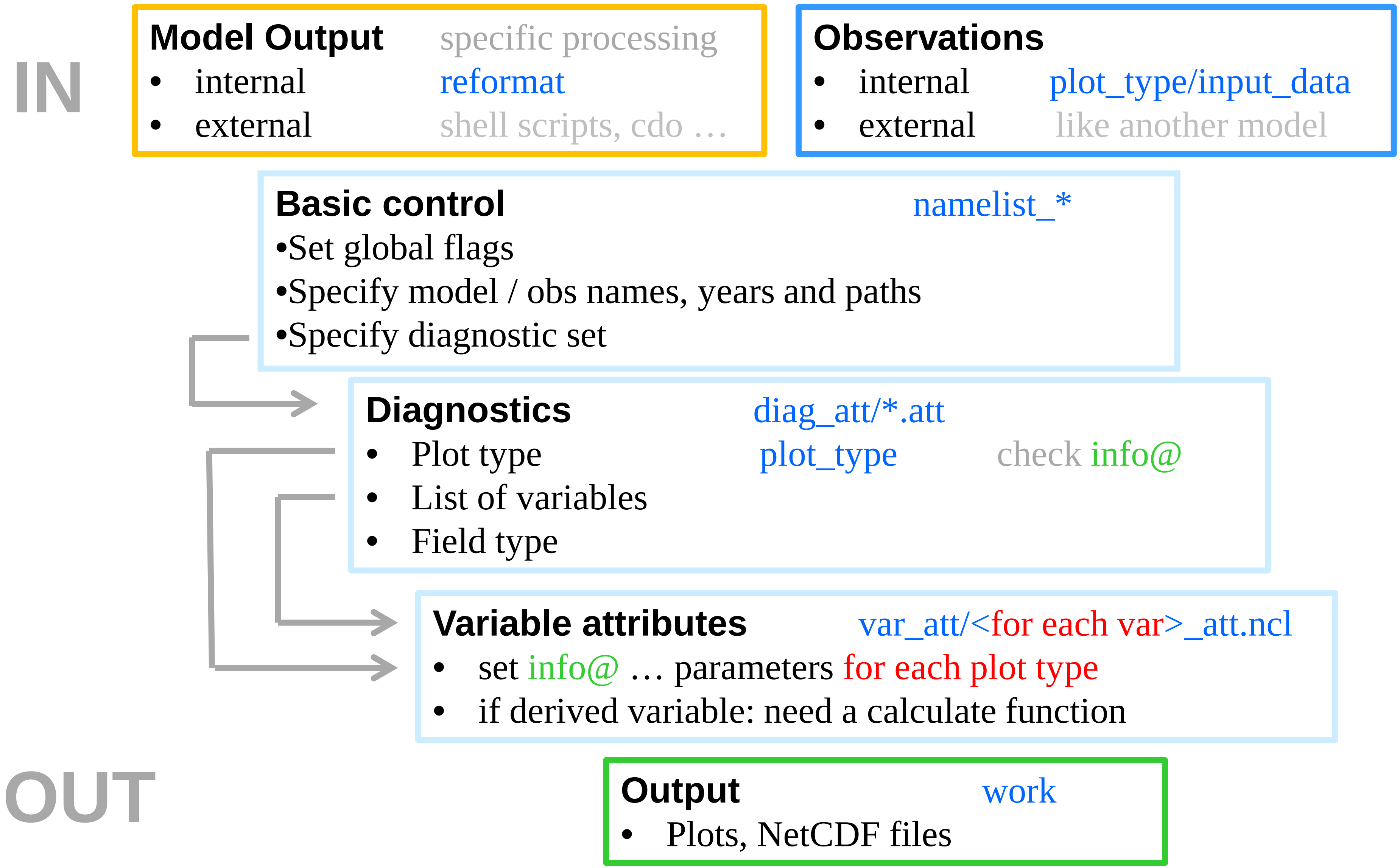
4. Prepare data

- Check the results



```
[b309056@miklip01 source]$ ls ../obs/ClimVal*
../obs/ClimVal_obs_ERA40_1_T2Mz_ta_197901_200112.nc
../obs/ClimVal_obs_ERA40_1_T3M_ta_197901_200112.nc
../obs/ClimVal_obs_ERAI_1_T2Mz_ta_199501_200512.nc
../obs/ClimVal_obs_ERAI_1_T3M_ta_199501_200512.nc
../obs/ClimVal_obs_ERAI_T255_T2Ms_tas_200501_200512.nc
../obs/ClimVal_obs_NCEP_1_T2Mz_ta_197901-200812.nc
../obs/ClimVal_obs_NCEP_1_T2Mz_ua_197901-200812.nc
../obs/ClimVal_obs_NCEP_1_T3M_ta_197901-200812.nc
../obs/ClimVal_obs_NCEP2_1_T2Mz_ta_197901-200812.nc
../obs/ClimVal_obs_NCEP2_1_T2Mz_ua_197901-200812.nc
../obs/ClimVal_obs_NCEP2_1_T3M_ta_197901-200812.nc
../obs/ClimVal_obs_NCEP2_1_T3M_ua_197901-200812.nc
[b309056@miklip01 source]$ ls ../models
ClimVal_d2000_LR_1_T2Ms_tas_200101-201012.nc  ClimVal_d2001_LR_1_T2Ms_tas_200201-201112.nc
ClimVal_d2000_LR_1_T3M_ta_200101-200912.nc    ClimVal_d2001_LR_1_T3M_ta_200201-200912.nc
ClimVal_d2000_LR_1_T3M_ua_200101-200912.nc    ClimVal_d2001_LR_1_T3M_ua_200201-200912.nc
ClimVal_d2000_LR_2_T2Ms_tas_200101-201012.nc  ClimVal_d2001_LR_2_T2Ms_tas_200201-201112.nc
ClimVal_d2000_LR_2_T3M_ta_200101-200912.nc    ClimVal_d2001_LR_2_T3M_ta_200201-200912.nc
ClimVal_d2000_LR_2_T3M_ua_200101-200912.nc    ClimVal_d2001_LR_2_T3M_ua_200201-200912.nc
ClimVal_d2000_LR_3_T2Ms_tas_200101-201012.nc  ClimVal_d2001_LR_3_T2Ms_tas_200201-201112.nc
ClimVal_d2000_LR_3_T3M_ta_200101-200912.nc    ClimVal_d2001_LR_3_T3M_ta_200201-200912.nc
ClimVal_d2000_LR_3_T3M_ua_200101-200912.nc    ClimVal_d2001_LR_3_T3M_ua_200201-200912.nc
```

5. Walk through an example: Primer



IN

Model Output specific processing
- internal reformat
- external shell scripts, cdo …

Observations
- internal plot_type/input_data
- external like another model

Basic control namelist_*

•Set global flags

•Specify model / obs names, years and paths

•Specify diagnostic set

Diagnostics diag_att/*.att
- Plot type plot_type check info@
- List of variables
- Field type

Variable attributes var_att/<for each var>_att.ncl
- set info@ … parameters for each plot type
- if derived variable: need a calculate function

OUT

Output work
- Plots, NetCDF files

Paths on this slide are relative to $TOOL/source/

5. Walk through an example: Primer

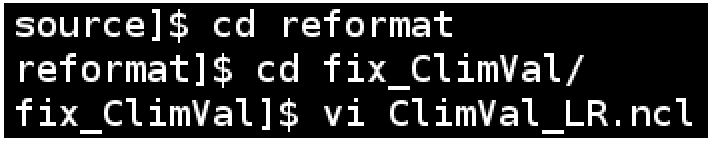
IN

Model Output
- internal
- external

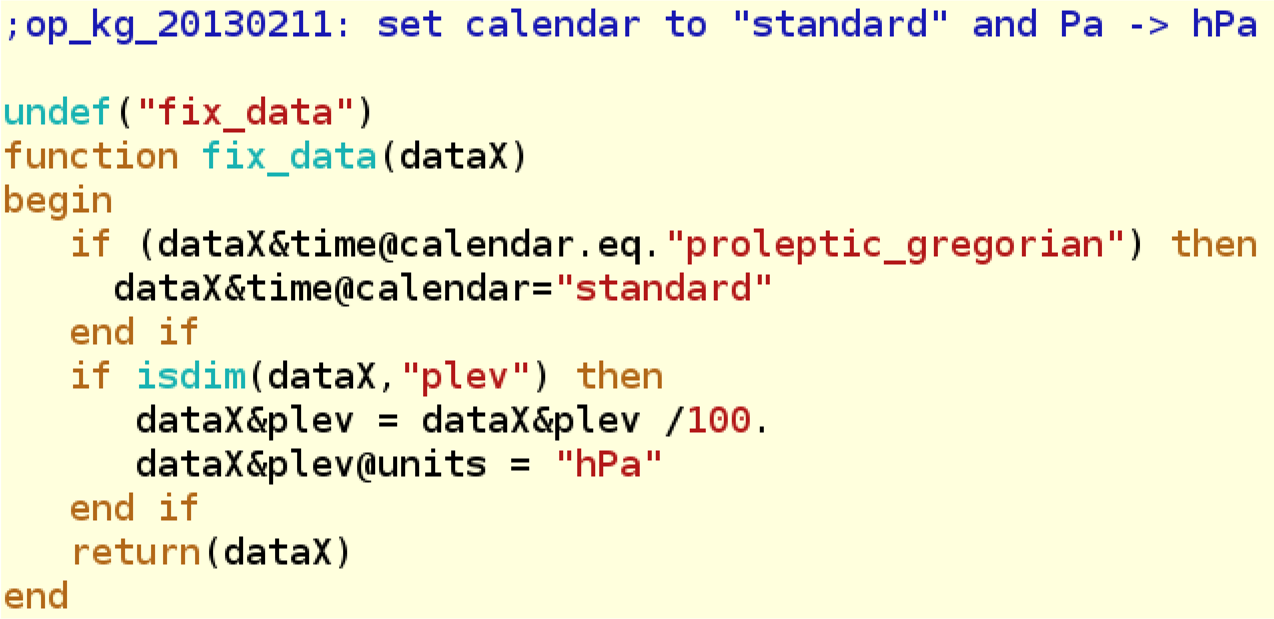
specific processing
reformat
shell scripts, cdo …

This slide shall just make you aware of this intermediate step. No action needed.

- Check the reformat branch:



```
source]$ cd reformat
reformat]$ cd fix_ClimVal/
fix_ClimVal]$ vi ClimVal_LR.ncl
```



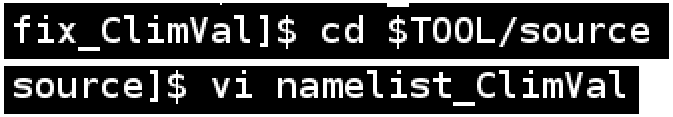
```
;op_kg_20130211: set calendar to "standard" and Pa -> hPa

undef("fix_data")
function fix_data(dataX)
begin
   if (dataX&time@calendar.eq."proleptic_gregorian") then
     dataX&time@calendar="standard"
   end if
   if isdim(dataX,"plev") then
      dataX&plev = dataX&plev /100.
      dataX&plev@units = "hPa"
   end if
   return(dataX)
end
```

Here you have the chance to make model specific adjustments to the input data …

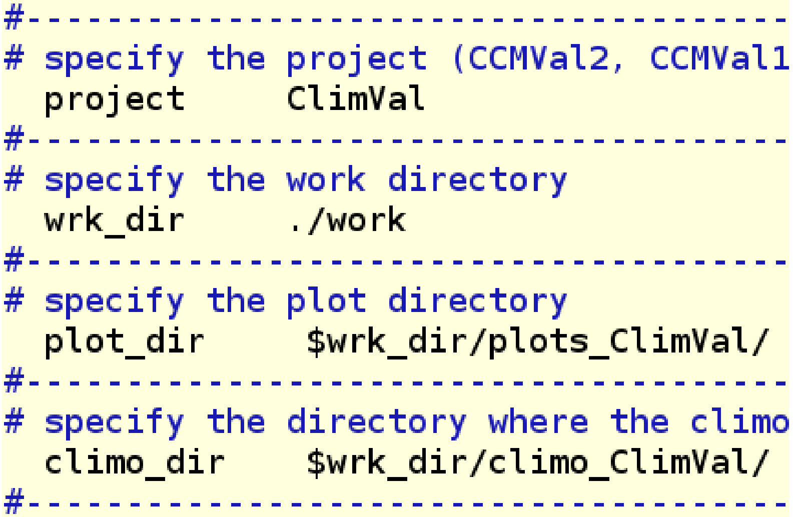
or just apply some q&d fixes that should go into the code later.

5. Walk through an example

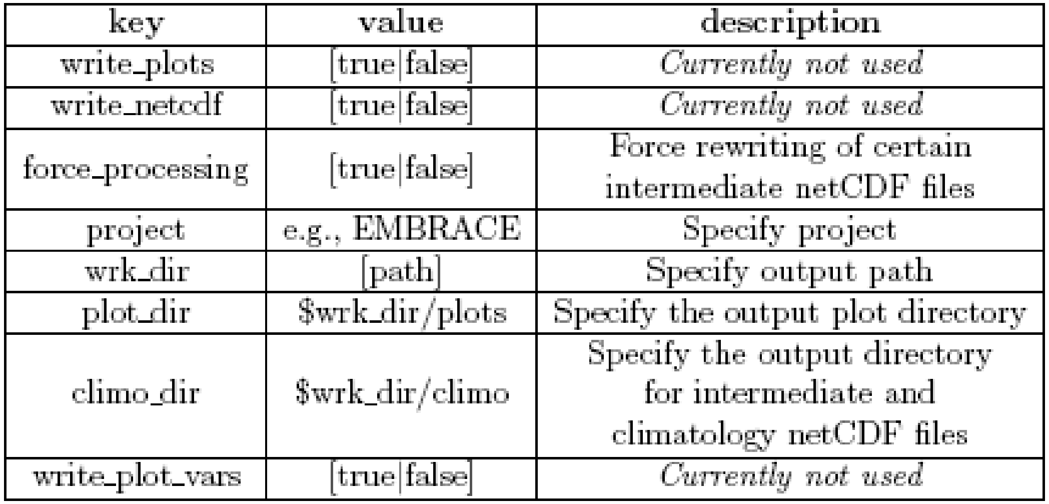
Adjust the main namelist:



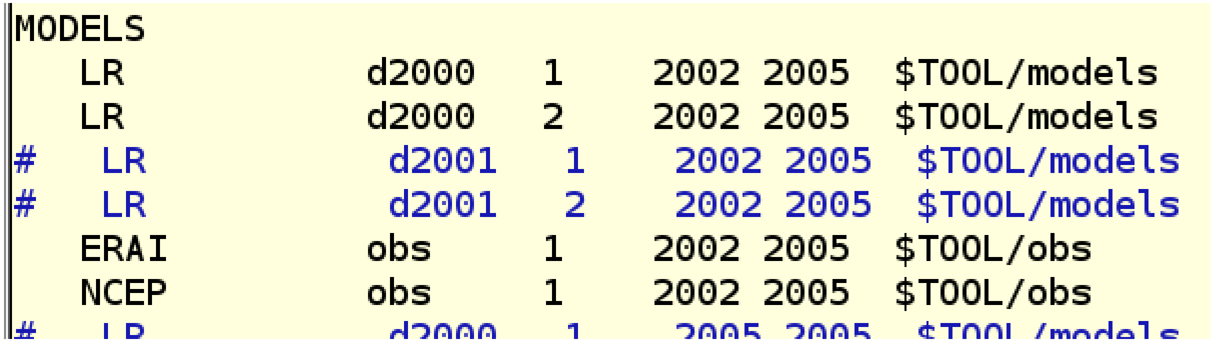
```
fix_ClimVal]$ cd $TOOL/source
source]$ vi namelist_ClimVal
```



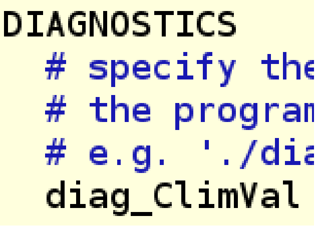
```
#-----------------------------------------
# specify the project (CCMVal2, CCMVal1
  project     ClimVal
#-----------------------------------------
# specify the work directory
  wrk_dir     ./work
#-----------------------------------------
# specify the plot directory
  plot_dir     $wrk_dir/plots_ClimVal/
#-----------------------------------------
# specify the directory where the climo
  climo_dir    $wrk_dir/climo_ClimVal/
#-----------------------------------------
```



key	value	description
write_plots	[true|false]	*Currently not used*
write_netcdf	[true|false]	*Currently not used*
force_processing	[true|false]	Force rewriting of certain intermediate netCDF files
project	e.g., EMBRACE	Specify project
wrk_dir	[path]	Specify output path
plot_dir	$wrk_dir/plots	Specify the output plot directory
climo_dir	$wrk_dir/climo	Specify the output directory for intermediate and climatology netCDF files
write_plot_vars	[true|false]	*Currently not used*



```
MODELS
   LR            d2000   1    2002 2005  $TOOL/models
   LR            d2000   2    2002 2005  $TOOL/models
#   LR            d2001   1    2002 2005  $TOOL/models
#   LR            d2001   2    2002 2005  $TOOL/models
   ERAI          obs     1    2002 2005  $TOOL/obs
   NCEP          obs     1    2002 2005  $TOOL/obs
#   LR            d2000   1    2005 2005  $TOOL/models
```

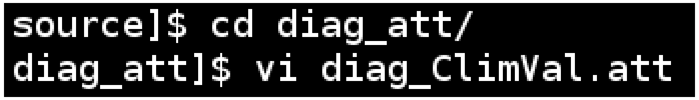


```
DIAGNOSTICS
  # specify the
  # the program
  # e.g. './dia
  diag_ClimVal
```

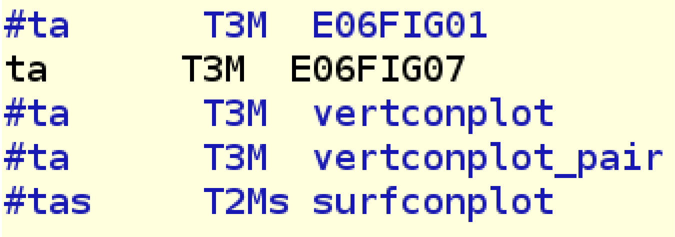
… just remove the appropriate #
to make your namelist_ClimVal look like here

5. Walk through an example

Adjust the diagnostic namelist:



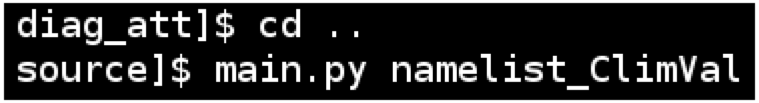
```
source]$ cd diag_att/
diag_att]$ vi diag_ClimVal.att
```



```
#ta       T3M  E06FIG01
ta       T3M  E06FIG07
#ta       T3M  vertconplot
#ta       T3M  vertconplot_pair
#tas      T2Ms surfconplot
```

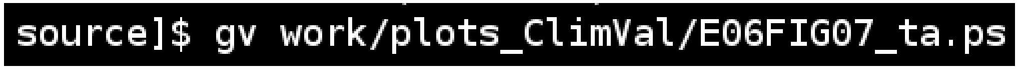
variable *type* *diagnostic*

- Execute the main python script

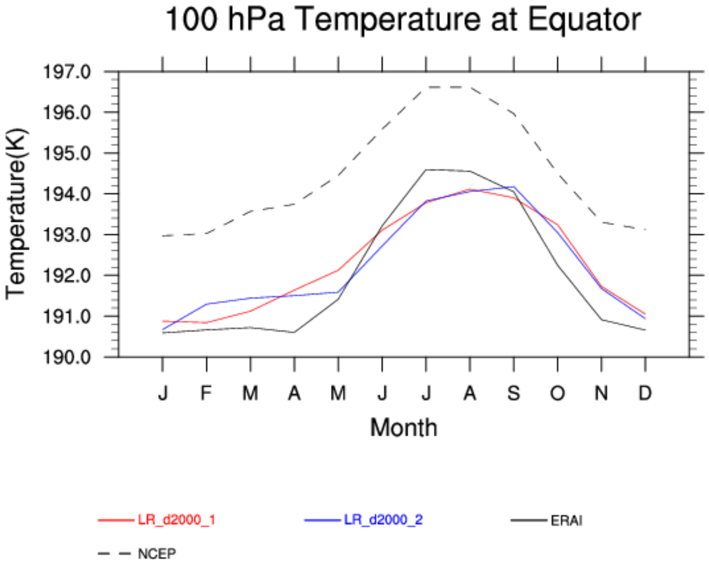


```
diag_att]$ cd ..
source]$ main.py namelist_ClimVal
```

- Check the plot



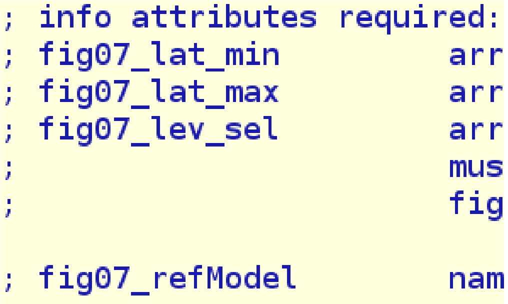
```
source]$ gv work/plots_ClimVal/E06FIG07_ta.ps
```



6. Modify the example
6.1. Specify a reference model

- Check which parameters are evaluated by the diagnostic routine

```
source]$ cd plot_type/
plot_type]$ vi E06FIG07.ncl
```

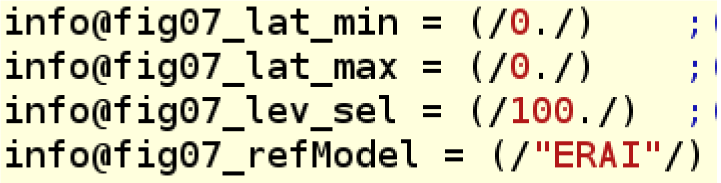


```
; info attributes required:
; fig07_lat_min          arr
; fig07_lat_max          arr
; fig07_lev_sel          arr
;                        mus
;                        fig

; fig07_refModel         nam
```

- Those parameters are expected from the variable namelist, which is specified by "ta" in $TOOL/source/diag_att/diag_ClimVal.att.

- Find corresponding section in $TOOL/source/var_att/ta_att.ncl & enable info@fig07_refModel

```
plot_type]$ cd ..
source]$ cd var_att
var_att]$ vi ta_att.ncl
```

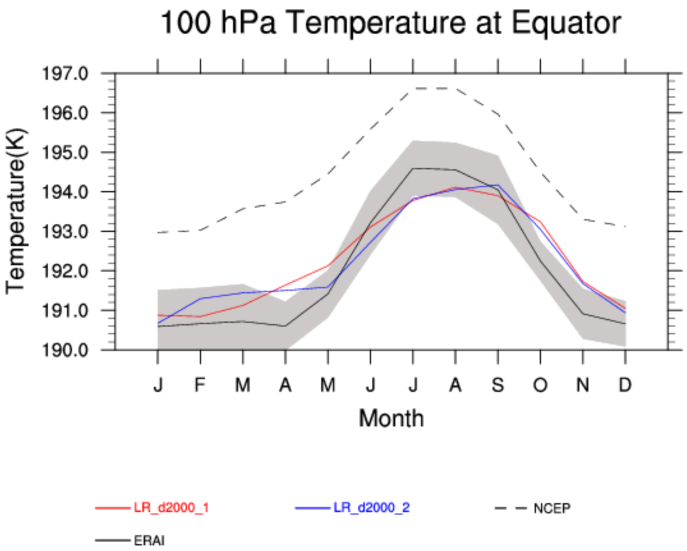


```
info@fig07_lat_min = (/0./)     ;
info@fig07_lat_max = (/0./)     ;
info@fig07_lev_sel = (/100./)   ;
info@fig07_refModel = (/"ERAI"/)
```

- Redo the plot and see what has changed

```
source]$ main.py namelist_ClimVal
```

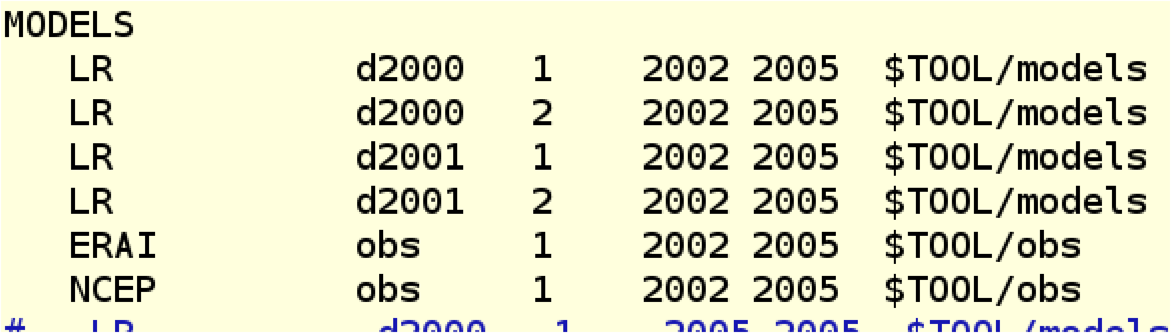
```
source]$ gv work/plots_ClimVal/E06FIG07_ta.ps
```



6. Modify the example
6.2. Add another simulation

- Modify the main namelist

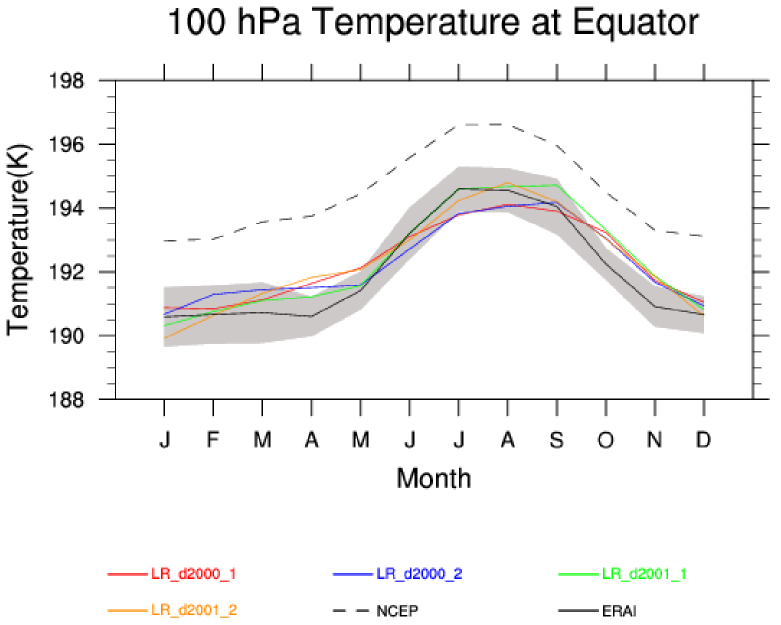
```
source]$ vi namelist_ClimVal
```



```
MODELS
   LR             d2000   1    2002 2005  $TOOL/models
   LR             d2000   2    2002 2005  $TOOL/models
   LR             d2001   1    2002 2005  $TOOL/models
   LR             d2001   2    2002 2005  $TOOL/models
   ERAI           obs     1    2002 2005  $TOOL/obs
   NCEP           obs     1    2002 2005  $TOOL/obs
#    LR             d2000   1    2005 2005  $TOOL/models
```

- Redo the plot and see what has changed

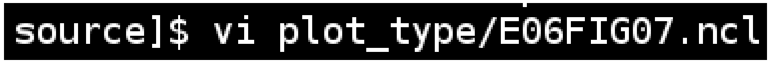
```
source]$ main.py namelist_ClimVal
source]$ gv work/plots_ClimVal/E06FIG07_ta.ps
```



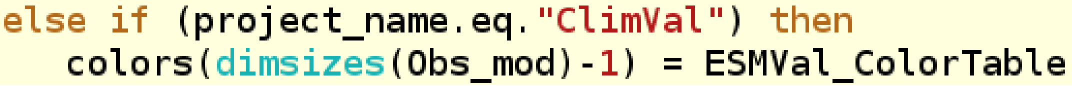
6. Modify the example
6.3. Explicitely specify colors

- CCMVal assigned a specific color to each model.
  ClimVal default: Unspecifically assigns a different color to each Model-Case-Ensemble combination. Suppose you want identical colors for each group of decadals …

- Check which color table is called in E06FIG07.ncl

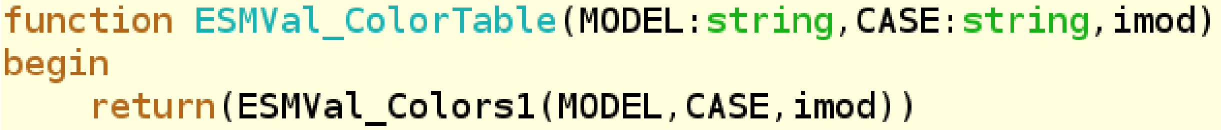


```
source]$ vi plot_type/E06FIG07.ncl
```



```
else if (project_name.eq."ClimVal") then
   colors(dimsizes(Obs_mod)-1) = ESMVal_ColorTable
```

- Colors are defined in ~/TOOL/source/plot_type/CCMVal_FUNCTION/misc_function.ncl

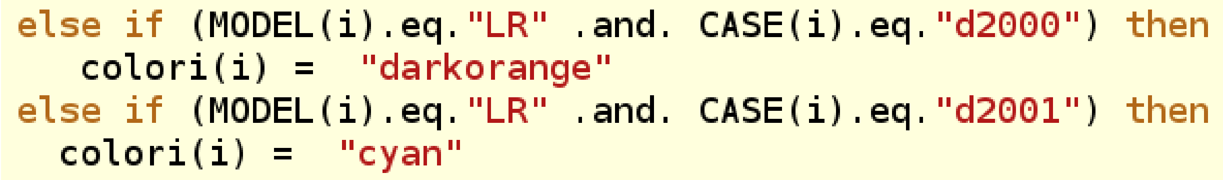


```
function ESMVal_ColorTable(MODEL:string,CASE:string,imod)
begin
    return(ESMVal_Colors1(MODEL,CASE,imod))
```

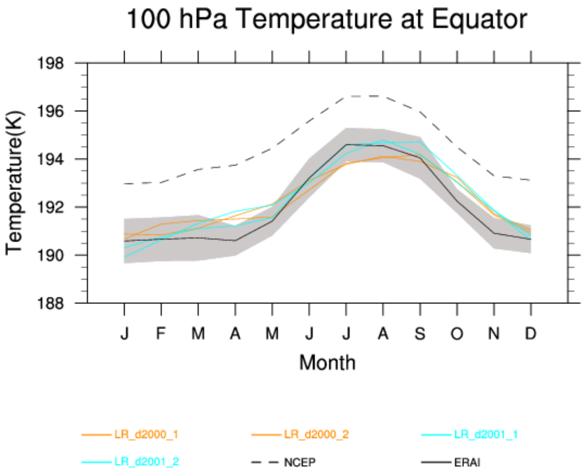
ESMVal_ColorTable

calls ESMVal_Colors1

- Enable lines with “LR“ (& “end if”) in ESMVal_Colors1



```
else if (MODEL(i).eq."LR" .and. CASE(i).eq."d2000") then
   colori(i) =  "darkorange"
else if (MODEL(i).eq."LR" .and. CASE(i).eq."d2001") then
  colori(i) =  "cyan"
```

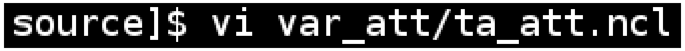


- Redo the plot and see what has changed

6. Modify the example
6.4. Panelling

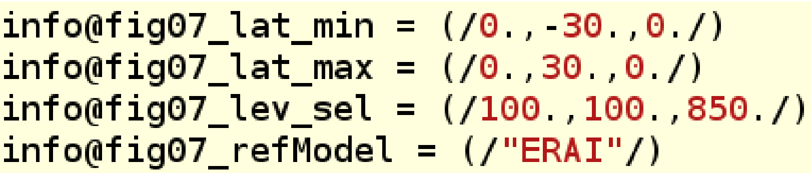
- E06FIG07.ncl allows multiple plots on a page.

- The number of plots is determined by the number of latitude-level combinations given in the variable attributes namelist.



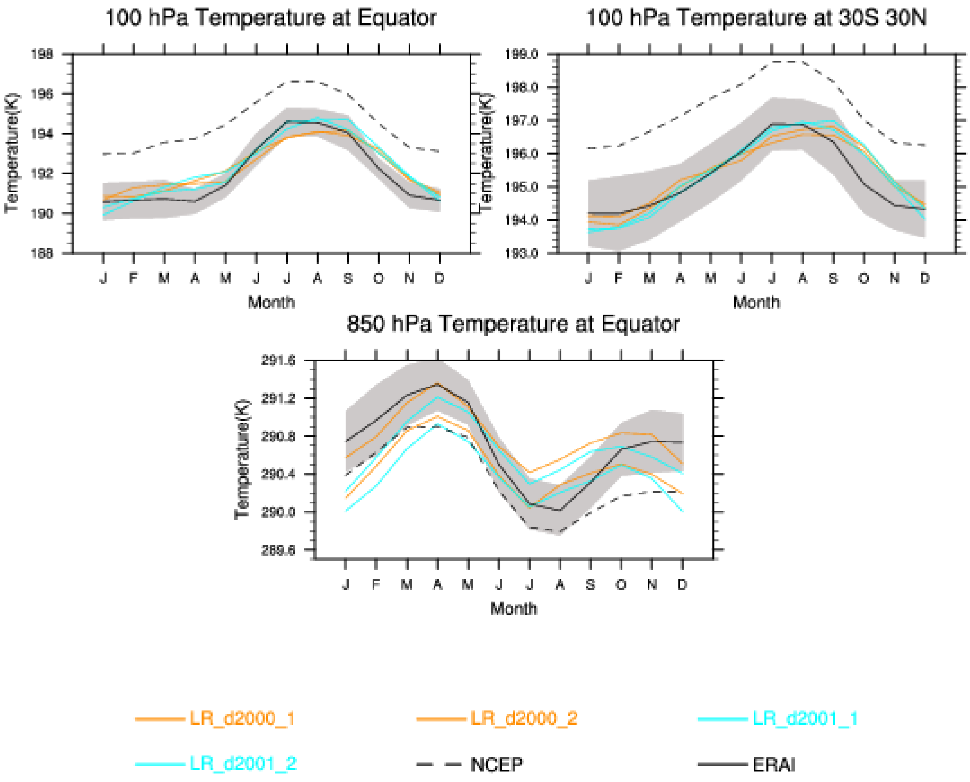
```
source]$ vi var_att/ta_att.ncl
```

- Extend the appropriate vectors:



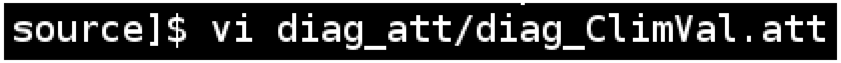
```
info@fig07_lat_min = (/0.,-30.,0./)
info@fig07_lat_max = (/0.,30.,0./)
info@fig07_lev_sel = (/100.,100.,850./)
info@fig07_refModel = (/"ERAI"/)
```

- Redo the plot and see what has changed

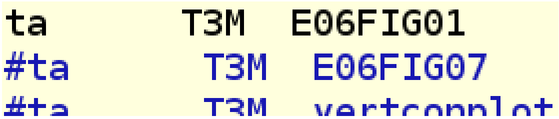


7. Other diagnostics
7.1. Add a plot type with internal observations

- Modify the diagnostic namelist

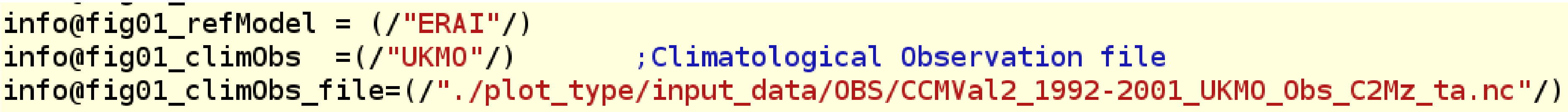


```
source]$ vi diag_att/diag_ClimVal.att
```



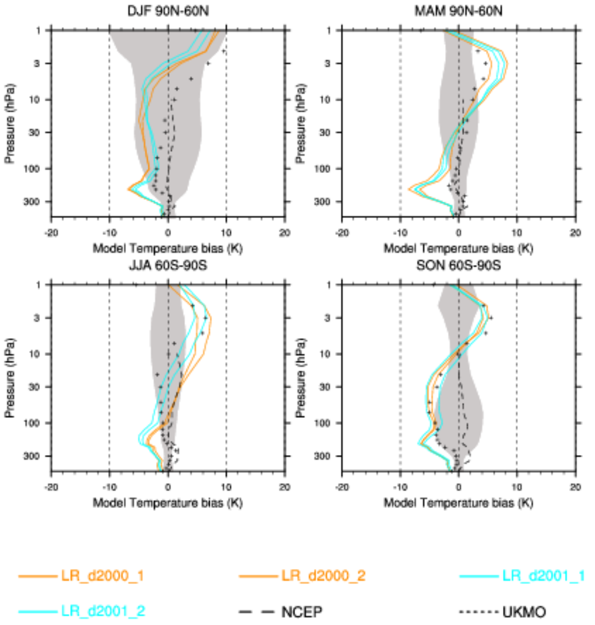
```
ta        T3M   E06FIG01
#ta        T3M   E06FIG07
#ta        T3M   vertconplot
```

- Check required info attributes in ~/TOOL/source/plot_type/E06FIG01.ncl and adjust ~/TOOL/source/var_att/ta_att.ncl

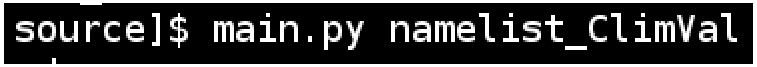


```
info@fig01_refModel = (/"ERAI"/)
info@fig01_climObs  =(/"UKMO"/)        ;Climatological Observation file
info@fig01_climObs_file=(/"./plot_type/input_data/OBS/CCMVal2_1992-2001_UKMO_Obs_C2Mz_ta.nc"/)
```

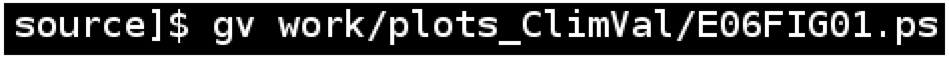
Note "info@fig01_climObs_file"
-> UKMO from internal observations
-> ERAI treated like a model



- Create and check the additional plot



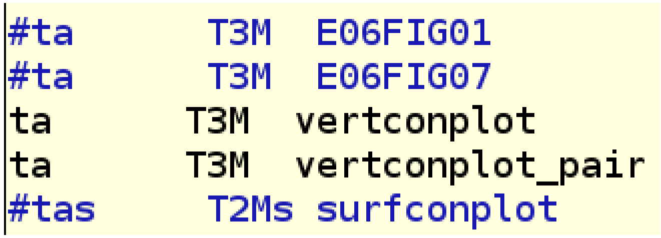
```
source]$ main.py namelist_ClimVal
```



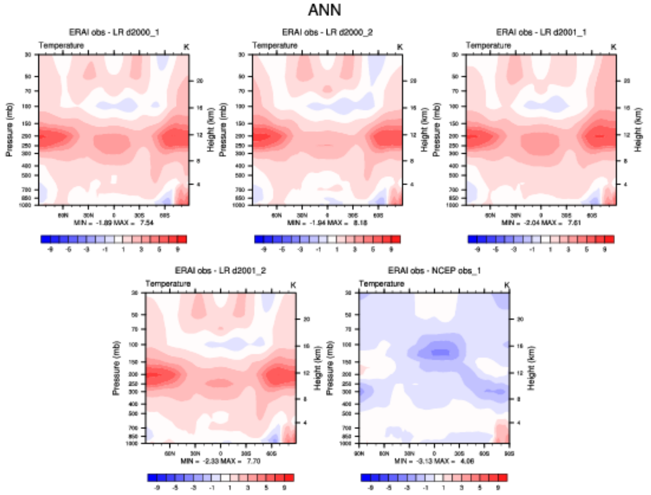
```
source]$ gv work/plots_ClimVal/E06FIG01.ps
```

7. Other diagnostics
7.2. Just try more …

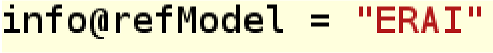
- Adjust the following lines in $TOOL/source/diag_att/diag_ClimVal.att



```
#ta       T3M  E06FIG01
#ta       T3M  E06FIG07
ta       T3M  vertconplot
ta       T3M  vertconplot_pair
#tas      T2Ms surfconplot
```

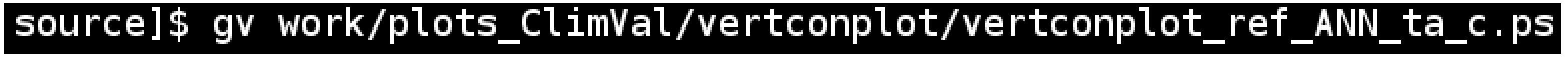


$TOOL/source/var_att/ta_att.ncl contains

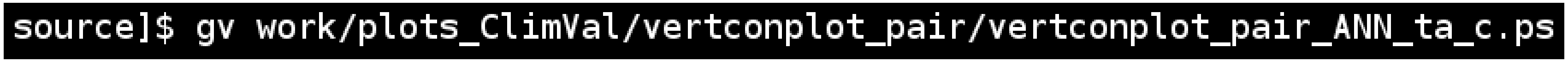


```
info@refModel = "ERAI"
```

- Difference to that reference is plotted by vertconplot

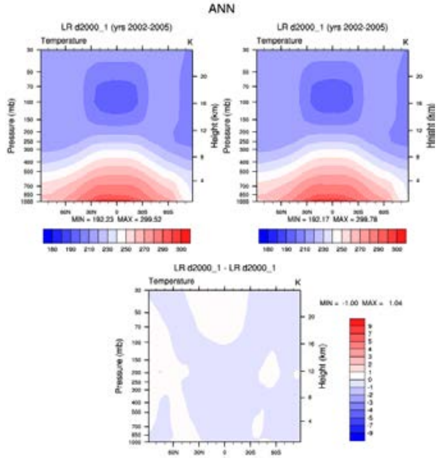


```
source]$ gv work/plots_ClimVal/vertconplot/vertconplot_ref_ANN_ta_c.ps
```



```
source]$ gv work/plots_ClimVal/vertconplot_pair/vertconplot_pair_ANN_ta_c.ps
```

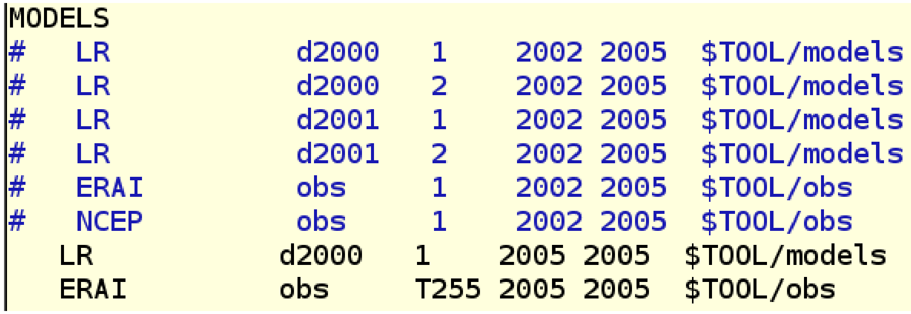
- vertconplot_pair compares first two "models" of $TOOL/source/namelist_ClimVal



7. Other diagnostics

7.3. Try a different data type (the new ERAI data on the MiKlip server)

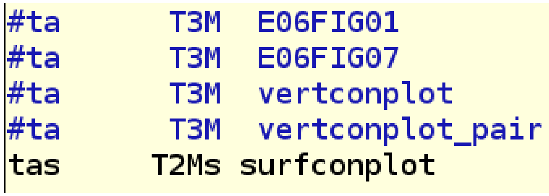
```
source]$ vi namelist_ClimVal
```



```
MODELS
#   LR          d2000   1    2002 2005  $TOOL/models
#   LR          d2000   2    2002 2005  $TOOL/models
#   LR          d2001   1    2002 2005  $TOOL/models
#   LR          d2001   2    2002 2005  $TOOL/models
#   ERAI        obs     1    2002 2005  $TOOL/obs
#   NCEP        obs     1    2002 2005  $TOOL/obs
   LR          d2000   1    2005 2005  $TOOL/models
   ERAI        obs     T255 2005 2005  $TOOL/obs
```

Note: same year

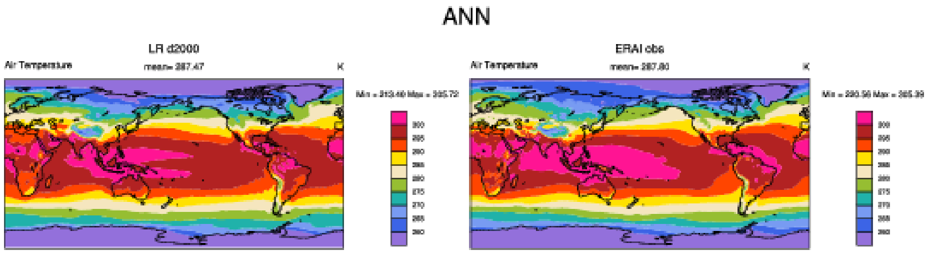
```
source]$ vi diag_att/diag_ClimVal.att
```



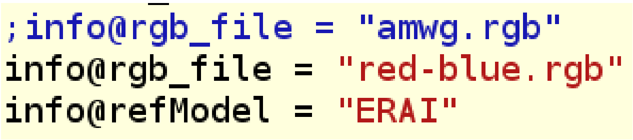
```
#ta      T3M   E06FIG01
#ta      T3M   E06FIG07
#ta      T3M   vertconplot
#ta      T3M   vertconplot_pair
tas     T2Ms surfconplot
```

```
source]$ main.py namelist_ClimVal
```

```
source]$ gv work/plots_ClimVal/surfconplot/surfconplot_ANN_tas_c.ps
```



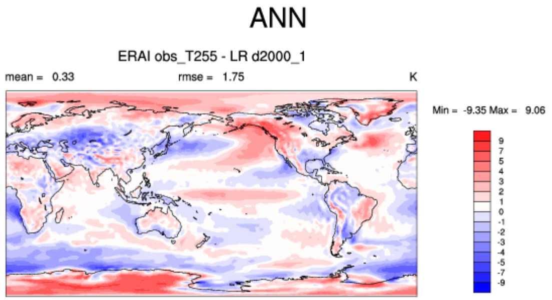
```
source]$ vi var_att/tas_att.ncl
```



```
;info@rgb_file = "amwg.rgb"
info@rgb_file = "red-blue.rgb"
info@refModel = "ERAI"
```

```
source]$ main.py namelist_ClimVal
```

```
source]$ gv work/plots_ClimVal/surfconplot/surfconplot_ref_ANN_tas_c.ps
```



8. Create a new variable and a new diagnostic

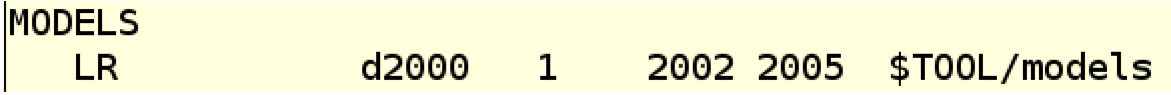
8.1. Create a derived variable “MyVar” that contains ta @ 200 hPa

```
source]$ cd var_att
var_att]$ vi MyVar_att.ncl
```

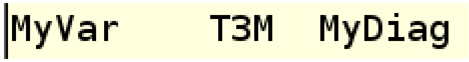
The string “200 hPa” shall be passed on via an info attribute.

- Take another variable as template and consider $TOOL/source/ncl_code/extract_data.ncl
- Note: The ‘Comment’ header of MyVar_att.ncl is actually evaluated!

8.2. Adjust main and diagnostic namelists to contain only these entries:

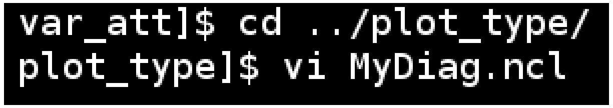


```
MODELS
   LR            d2000   1    2002 2005  $TOOL/models
```

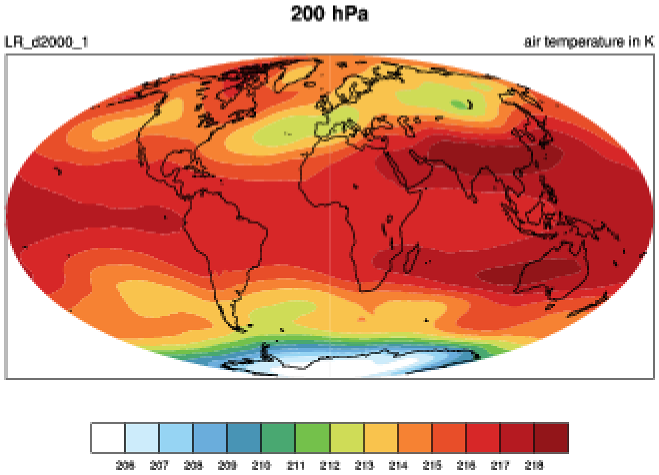


```
MyVar    T3M  MyDiag
```

8.3. Create a diagnostic that calculates the time mean & plots a Mollweide projection of MyVar



```
var_att]$ cd ../plot_type/
plot_type]$ vi MyDiag.ncl
```

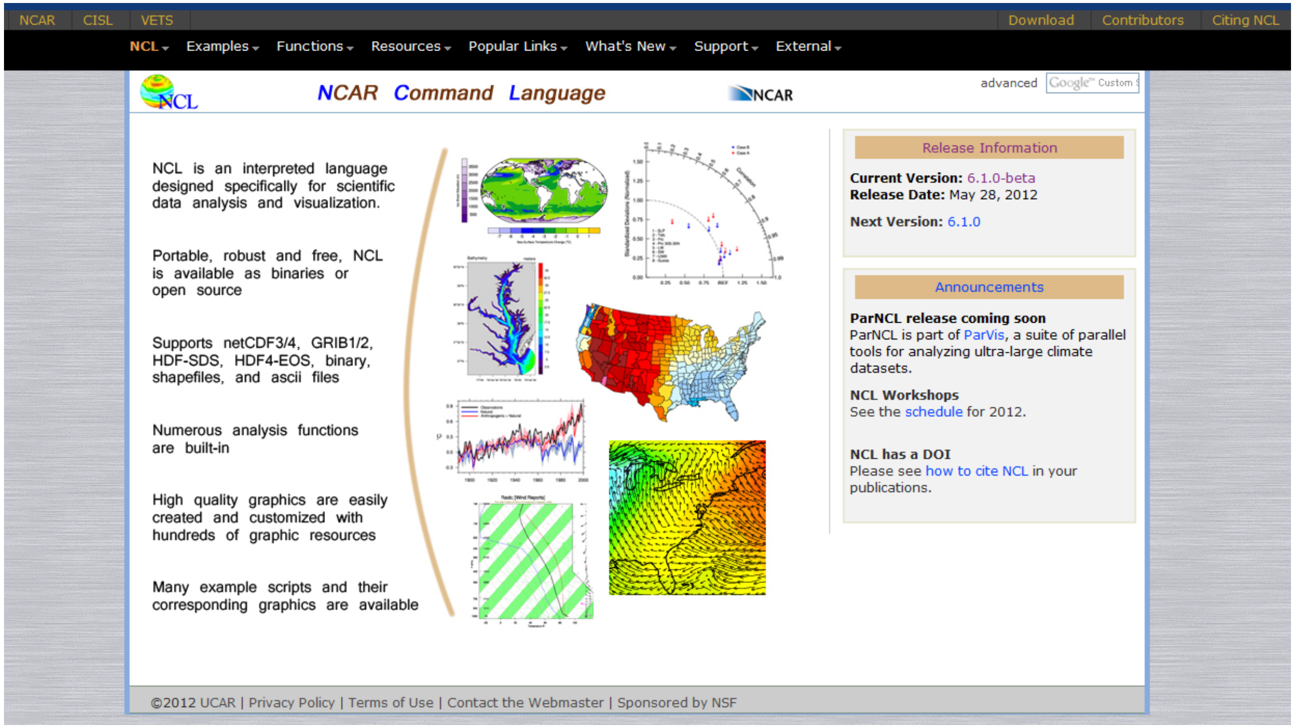


Hints (consult www.ncl.ucar.edu):

- list_vars() lists all currently defined variables
- Average time with dim_avg_n_Wrap
- Open ps file: gsn_open_wks
- Colors: gsn_define_colormap
- Plot ressources: mpProjection, cnFillOn, tiMainString, gsnSpreadColors, gsnLeftString, gsnRightString
- Plot with gsn_csm_contour_map

8. Create a new variable and a new diagnostic, Further information: NCL

- Please take existing code from the ESMValTool as template and consult the NCL website (http://www.ncl.ucar.edu/)



NCL is an interpreted language designed specifically for scientific data analysis and visualization.

Portable, robust and free, NCL is available as binaries or open source

Supports netCDF3/4, GRIB1/2, HDF-SDS, HDF4-EOS, binary, shapefiles, and ascii files

Numerous analysis functions are built-in

High quality graphics are easily created and customized with hundreds of graphic resources

Many example scripts and their corresponding graphics are available

Release Information

Current Version: 6.1.0-beta
Release Date: May 28, 2012

Next Version: 6.1.0

Announcements

ParNCL release coming soon
ParNCL is part of ParVis, a suite of parallel tools for analyzing ultra-large climate datasets.

NCL Workshops
See the schedule for 2012.

NCL has a DOI
Please see how to cite NCL in your publications.

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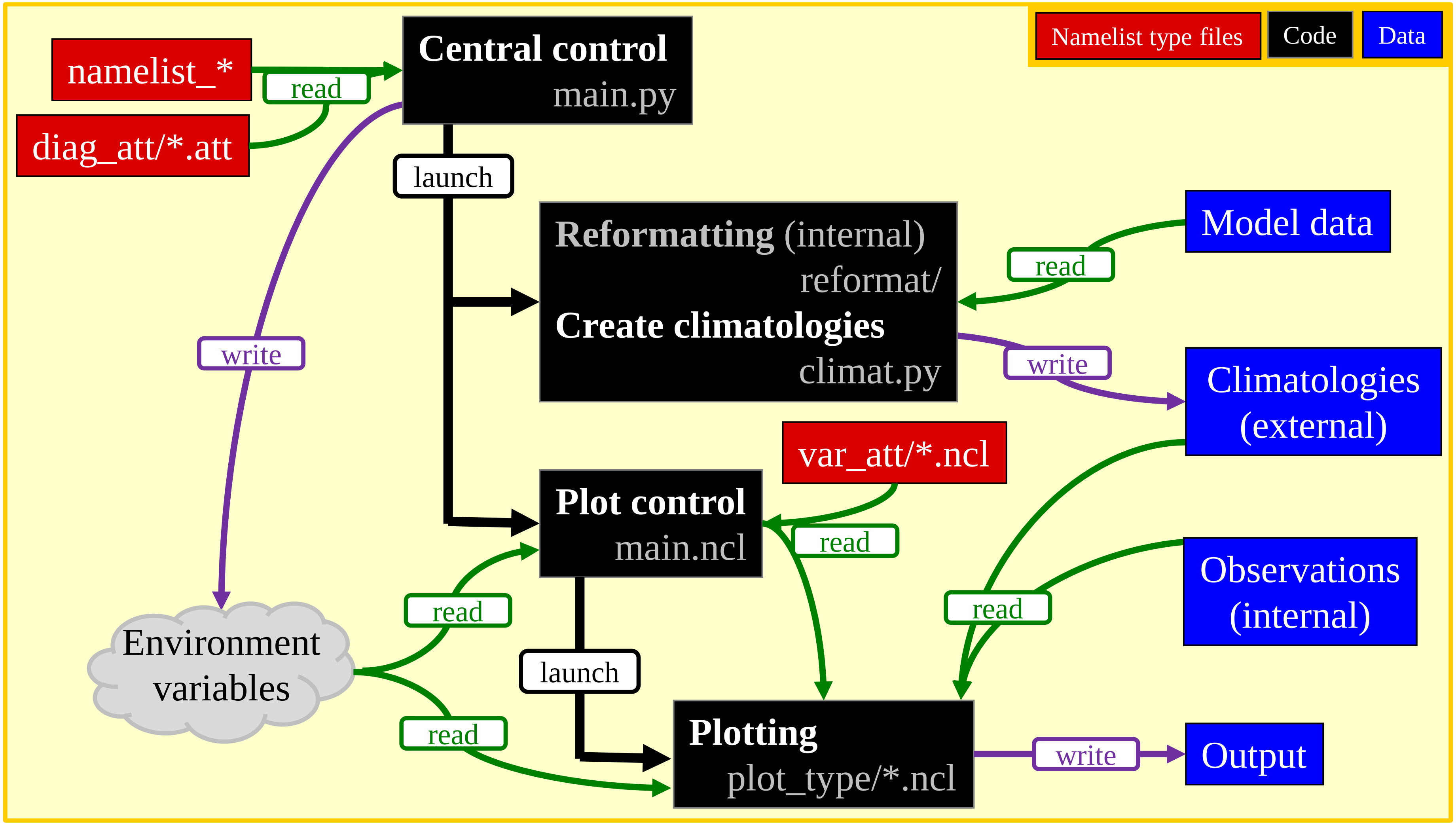
Good to know about NCL …

- Parameters are global by default and available in all routines, even if not explicitely passed
- Parameters need to be deleted explicitely before changing dimensions or type
- Parameter exchange with Python is via environment variables
- Index count starts from 0

8. Create a new variable and a new diagnostic, Further information: Code components

- See $TOOL/source/doc/tutorial.pdf
  $TOOL/source/doc/README_20120719.txt

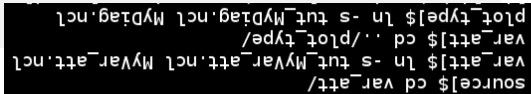


Paths on this slide are relative to ~/TOOL/source/

8. Create a new variable and a new diagnostic, Further information: Control flow

- See $TOOL/source/doc/control_flow.txt

```
main.py nml
  |
  |--read_namelist.py  reads 'nml' with GENERAL settings: paths, what to do, etc
  |          MODEL settings: five variables per line: model name, case name, ensemble no, years, path
  |          DIAGNOSTICS settings: list of diagnostics to perform (what to plot). These are defined  in the diag_att/  folder.
  |
  |--loop over all diagnostics defined above
  |   |
  |   |--read_diag_att(type) from diag_att/
  |   |  Read the diagnostics, each defined as a combination of  a variable a field, & a plot.
  |   |
  |   |--loop over variables
  |   |  |
  |   |  |--loop over models
  |   |  |  |
  |   |  |  |--create case folder if necceary
  |   |  |  |--ccsm.py (e.g.): if necessary, rewrite data to time series
  |   |  |  |--cf_convert.py
  |   |  |  |  write time series into specified time chunks, standardize variable names (lat/lon/time/plev)
  |   |  |  |--climat.py: compute climatology, annual, seasonal, monthly, from the chosen field
  |   |  |       (see reformat/attribute.ncl for a full list of supported fields)
  |   |  |
  |   |  |--main.ncl
  |   |  |  |--load variable attributes  (var_att/variable_att.ncl)
  |   |  |  |
  |   |  |  |--loop over models
  |   |  |  |  |
  |   |  |  |  |--if it is a derived variable, calculate dependent variables (unless it is precomputed)
  |   |  |  |  |--loop over plot_types and plot
```



```
source]$ cd var_att/
var_att]$ ln -s tut_MyVar_att.ncl MyVar_att.ncl
var_att]$ cd ../plot_type/
plot_type]$ ln -s tut_MyDiag.ncl MyDiag.ncl
```