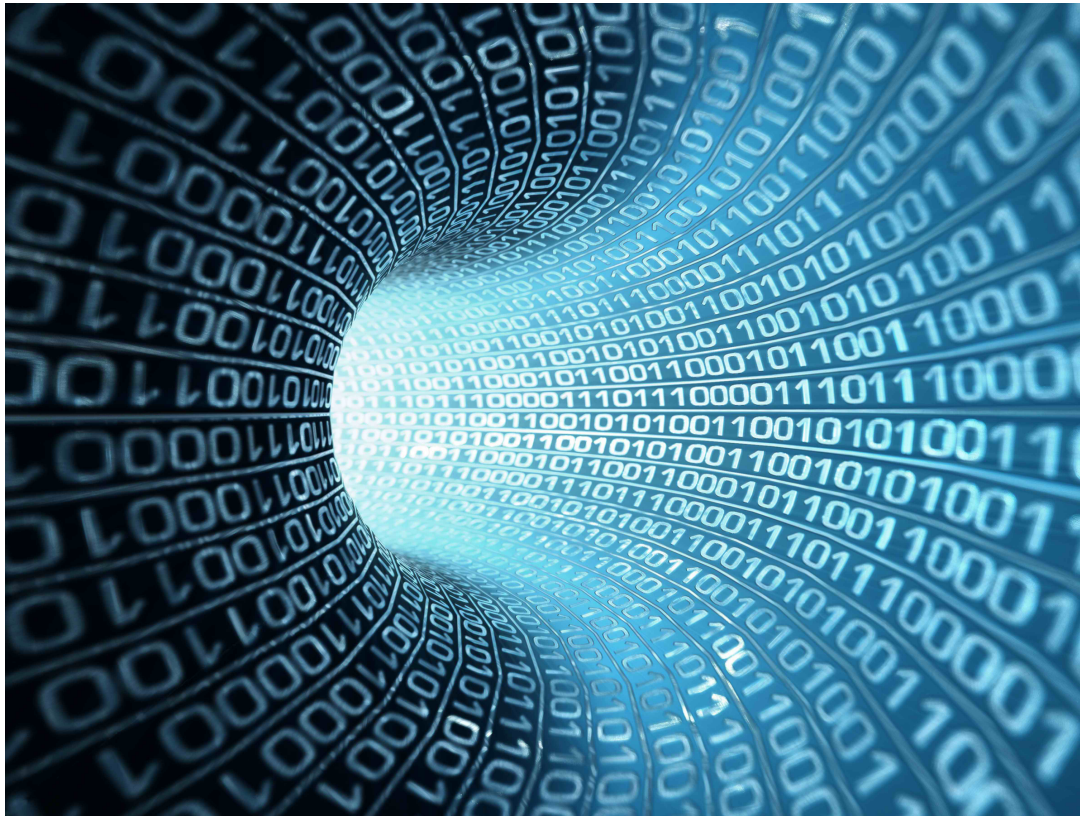


WRF Utilities

Cindy Bruyère



- Graphics
- Designing a model domain
- Data

Input	Intermediate	Output
grib 1&2	intermediate format	netcdf
<i>netcdf</i>		

- netCDF tools
- MET



Graphics : ImageMagick

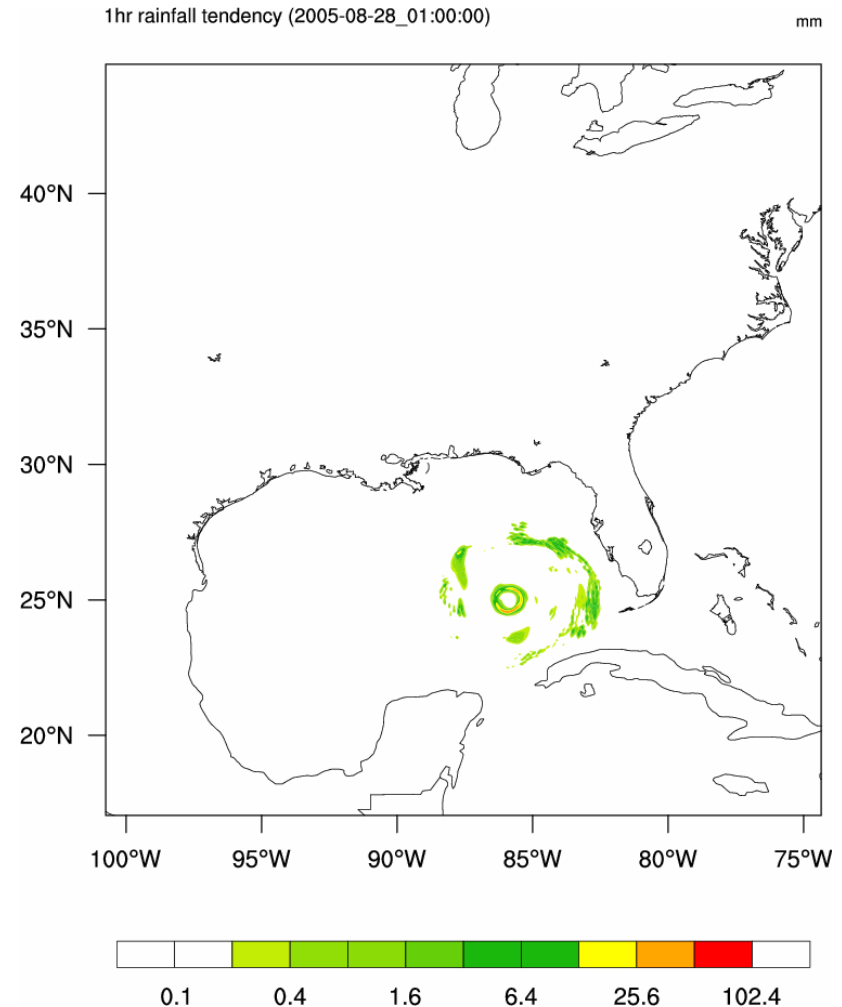
- Convert graphical files from one format to another
 - Many options available (*rotate* frames, *trim* white space, etc.)
 - Can be used for files with single or multiple frames
 - *Cannot deal with .ncgm files*
 - <http://www.imagemagick.org>

convert	<i>file.pdf</i>	<i>file.png</i>
convert	<i>file.png</i>	<i>file.bmp</i>
convert	<i>file.pdf</i>	<i>file.gif</i>
convert	<i>file.ras</i>	<i>file.png</i>



Making Movies

- Run graphical package
- Create individual frames for each image
 - Either directly from graphical package;
 - Or with a tool like ImageMagick
- Use a movie making tool to create movie
 - {GIF Movie Gear ; Windows ; commercial software }
- `convert -delay 20 *png movie.gif`

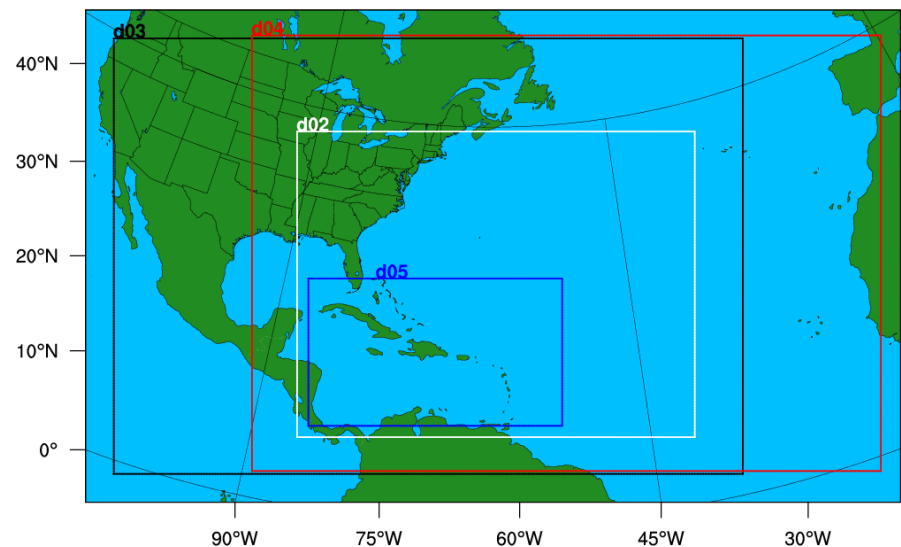


WRF Model Domain Design

```
mpres@mpFillColor      =  
  (/ "background", "DeepSkyBlue",  
    "ForestGreen", "DeepSkyBlue",  
    "transparent" / )  
  
mpres@mpGridSpacingF    = 45  
  
lnres@domLineColors     = (/ "white",  
  "Red" , "Red" , "Blue" / )  
  
mpres@mpOutlineBoundarySets  
  "NoBoundaries"      ; "Geophysical"  
  "National"          ; "USStates"  
  "GeophysicalAndUSStates"  
  "AllBoundaries"  
  
pares = True  
pmres@gsMarkerColor    = "White"  
pmres@gsMarkerIndex    = 16  
pmres@gsMarkerSizeF    = 0.01  
gsn_polymarker(wks,mp,-77.26,38.56,  
               pmres)
```

- NCL
 - WPS/util/plotgrids.ncl
 - *plotgrids_new.ncl* (NCL 6.1.0+)
 - reads namelist information to generate plot
 - create plot x11/png/pdf

Test Domain



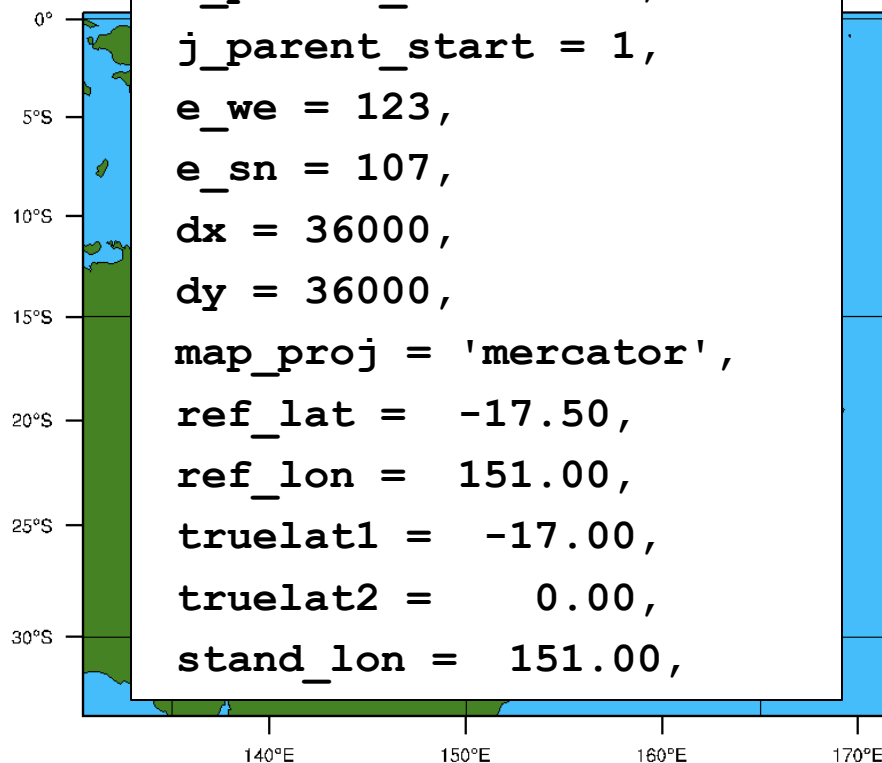
WRF Model Domain Design

```
DOMS = 1
DX = 36.
MAP = "mercator"
LAT1 = (/ -35.0, -45., -27. /)
LAT2 = (/ 0., -20., -23. /)
LON1 = (/ 131., 121., 125./)
LON2 = (/ 171., 159., 131./)
parent_id = (/ 0, 1, 2 /)
parent_grid_ratio = (/ 1, 3, 3 /)
```

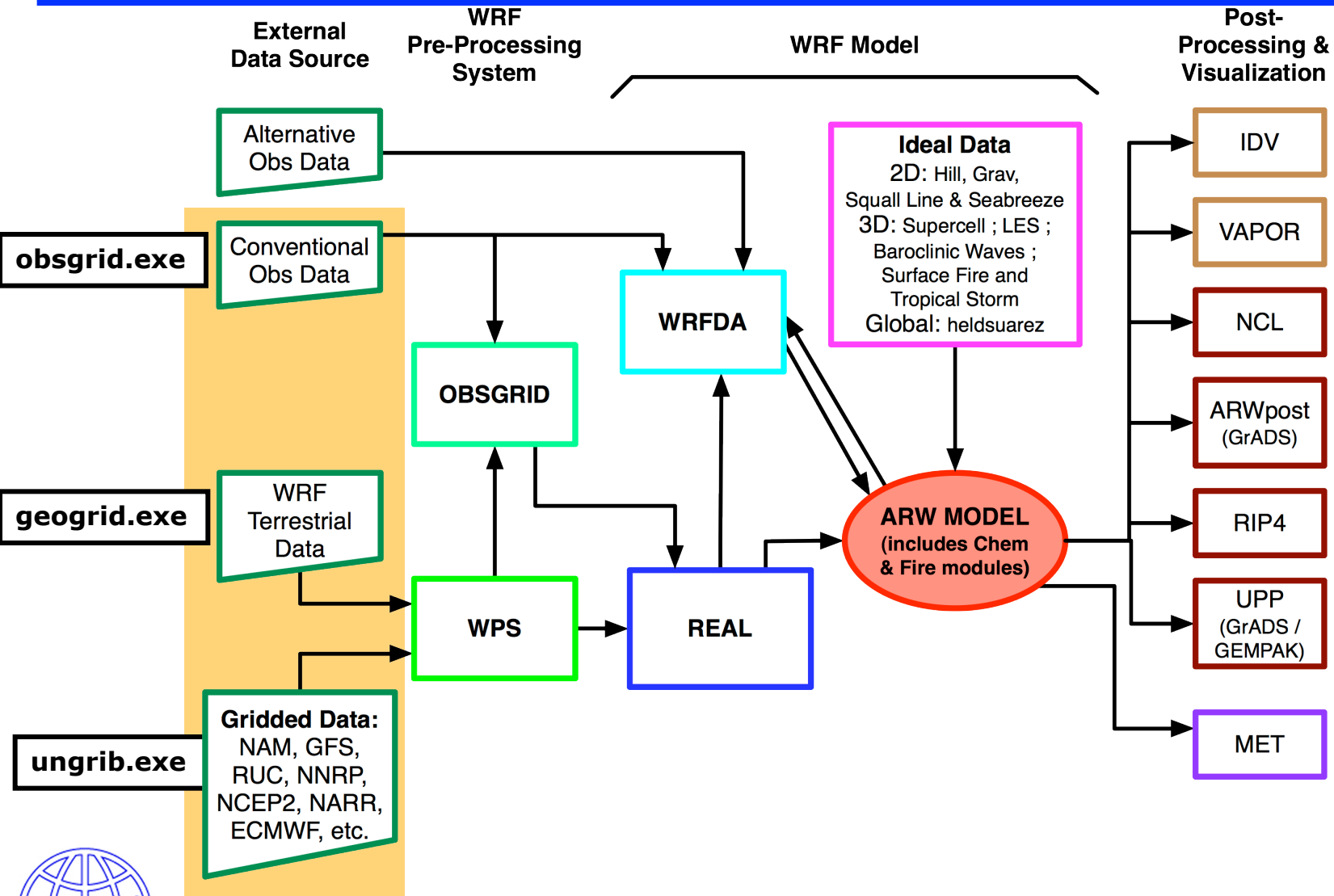
ncl design_grids.ncl

Suggested namelist options

```
parent_id = 0,
parent_grid_ratio = 1,
i_parent_start = 1,
j_parent_start = 1,
e_we = 123,
e_sn = 107,
dx = 36000,
dy = 36000,
map_proj = 'mercator',
ref_lat = -17.50,
ref_lon = 151.00,
truelat1 = -17.00,
truelat2 = 0.00,
stand_lon = 151.00,
```

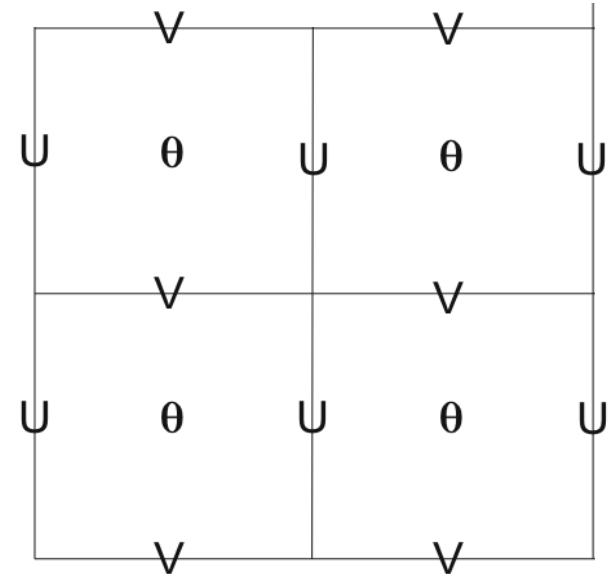


WRF Modeling System Flow Chart



Fields in geo_em files

- All invariant (static) data
 - XLAT & XLONG
 - MAPFAC
 - LANDMASK
 - HGT
 - GREENFRAC
 - LANDUSEF & LU_INDEX
 - ALBEDO12M & SNOALB
 - SOILTEMP; SOILCTOP & SOILCBOT



Data availability: <http://www.mmm.ucar.edu/wrf/users/>



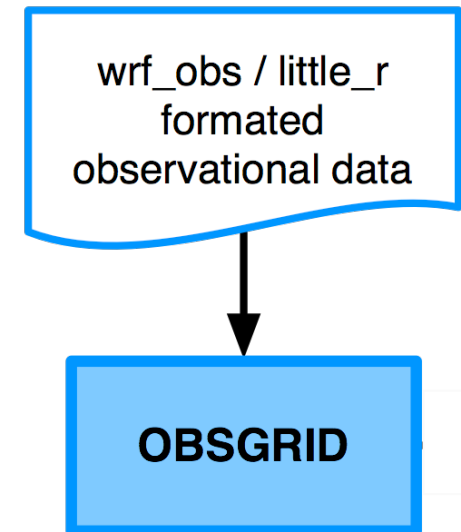
Observational Data

- <http://rda.ucar.edu/datasets/ds353.4>
- <http://rda.ucar.edu/datasets/ds464.0>

} ADP or ON29

- <http://rda.ucar.edu/datasets/ds351.0>
BUFRdecode_ADPUprair_little_r.tar is available at:
http://rda.ucar.edu/datasets/ds351.0/software/glade/p/rda/data/ds351.0/little_r
- <http://rda.ucar.edu/datasets/ds461.0>
BUFRdecode_ADPSfc_little_r.tar is available at:
http://rda.ucar.edu/datasets/ds461.0/software/glade/p/rda/data/ds461.0/little_r

} NCEP dump-bufr



[OBSGRID/util/get_rda_data.f](#)



Observational Data

Description Data Access Documentation Software			
Mouse over the table headings for detailed descriptions			
Data Description		Data File Downloads	Customizable Data Requests
		Web Server Holdings	Subsetting
Union of Available Products		Web File Listing	
PRODUCT	GDAS Upper Air Observations (daily tar files)	Web File Listing	Get a Subset
	GDAS ADPUPA Upper Air Observations (sonde data only)	Web File Listing	
	GDAS Upper Air Observations (synoptic BUFR files)		
	GDAS Upper Air Observations (little_r format) for use with MM5 and WRF data ingest software	Web File Listing	

} ADP or ON29

} NCEP dump-bufr

wrf_obs / little_r
formatted
observational data

OBSGRID

BUFRdecode_ADPsfc_little_r.tar is available at:
http://rda.ucar.edu/datasets/ds461.0/software/glade/p/rda/data/ds461.0/little_r



Fields needed for IM files – 6hourly

3D Data (e.g. data on pressure levels)

Temperature ; U and V components of Wind

Geopotential Height; Relative Humidity

2D Data

Surface Pressure; Mean Sea Level Pressure

Skin Temperature

2 meter Temperature and Relative Humidity

10 meter U and V components of wind

Recommended

LANDSEA

Soil data (temperature and moisture) & soil height

SST (climate runs – requires)

Water equivalent snow depth & SEAICE



ungrib : External Data Sources

- NCEP/NCAR Global Reanalysis (NNRP / R1)
(~ 2.5° Global; Jan 1948 to present)
<http://rda.ucar.edu/datasets/ds090.0>
- NCEP / DOE Reanalysis II (~ 2.5° Global; Jan 1979 to present)
<http://rda.ucar.edu/datasets/ds091.0>
- GFS 0.5° Global data (Dec 2002 to present)
<http://rda.ucar.edu/datasets/ds335.0>
- ERA Interim Data (~ 0.7° Global; Jan 1979 to present)
<http://rda.ucar.edu/datasets/ds627.0>
- Final Analysis (~ 1.0° Global; FNL; Aug 1999 to present)
<http://rda.ucar.edu/datasets/ds083.2>



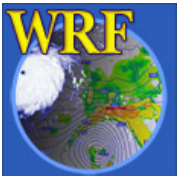
ungrib : External Data Sources

- NCEP Climate Forecast System Reanalysis (CFSR)
(~38km, *Global; Jan 1979 to Dec 2010*)
<http://rda.ucar.edu/datasets/ds093.0>
- NCEP Climate Forecast System Reanalysis (CFSR2)
(0.2°, *Global; Jan 2011 to present*)
<http://rda.ucar.edu/datasets/ds094.0>
- SST data
<http://polar.ncep.noaa.gov/sst> (Weekly to Daily; 1° to 1/12°)
<http://nomad3.ncep.noaa.gov/pub/sst> (Monthly to Weekly)
<http://rda.ucar.edu/datasets/277.0> (1894–present; Weekly)
- NCAR CESM – CMIP5 data
<http://rda.ucar.edu/datasets/ds316.0/> (*netCDF*)
<http://rda.ucar.edu/datasets/ds316.1/> (*IM – Bias corrected*)



ungrib : External Data Sources

- GFS Real-time 1° Global
<http://www.emc.ncep.noaa.gov>
- NAM Real-time 32/12km North America
<http://www.emc.ncep.noaa.gov>
- GCIP NCEP Eta model output 40km North America
<http://rda.ucar.edu/datasets/ds609.2>
- NCEP North American Regional Reanalysis (NARR)
32km North America
<http://rda.ucar.edu/datasets/ds608.2>



• ungrib.exe

<http://nomads.ncdc.noaa.gov>

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center
U.S. Department of Commerce

NOAA National Operational Model Archive & Distribution System

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The NOAA National Operational Model Archive and Distribution System (NOMADS) is a Web-services based project providing both real-time and retrospective format independent access to climate and weather model data.

DOC > NOAA > NESDIS > NCDC

Search Field:

- NAM
- GFS
- RUC
- CFS
- NARR
- R1/R2
- SST



GRIB

- Documents and decoders:
 - GRIB1 and GRIB2
wgrib; wgrib2; unpackgrib2.c; grib2to1.c
<http://rda.ucar.edu/#!/GRIB>
- g1print.exe & g2print.exe
 - Show data available in GRIB1 & GRIB2 files
Available from util/ directory in WPS
- grib2ctl.pl
 - Create .ctl and .idx files, so one can plot GRIB files with GrADS
<http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html>
- ncl_convert2nc
 - http://www.ncl.ucar.edu/Document/Tools/ncl_convert2nc.shtml



WPS Intermediate Files

- Output format of ungrid
- WPS util/ directory
 - plotfmt.ncl (*graphical interface to view intermediate file*)
 - rd_intermediate.exe
- Create your own intermediate files
 - example if you have input data in netCDF format
 - http://www.mmm.ucar.edu/wrf/OnLineTutorial/WPS/IM_files.htm



Utility: rd_intermediate

The rd_intermediate lists information about the fields found in an intermediate-format file

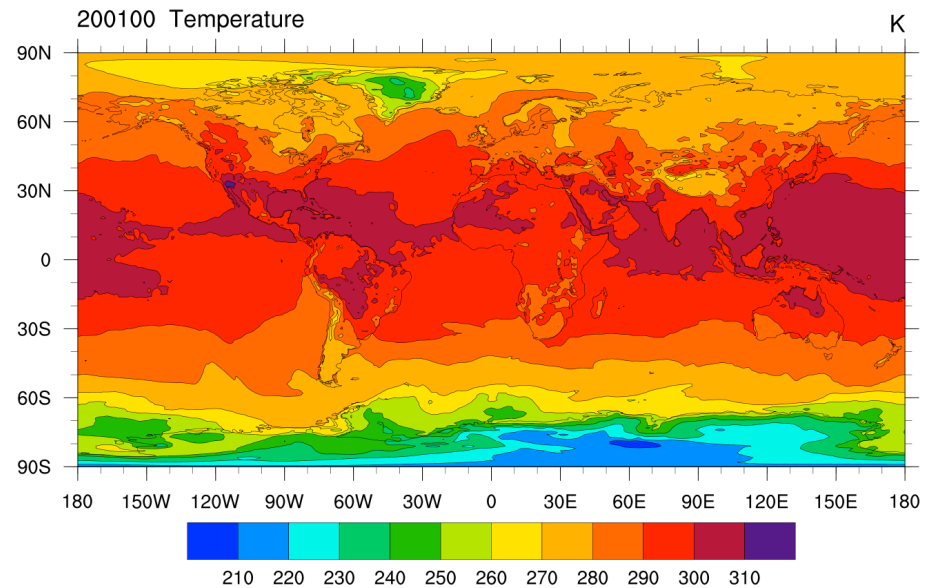
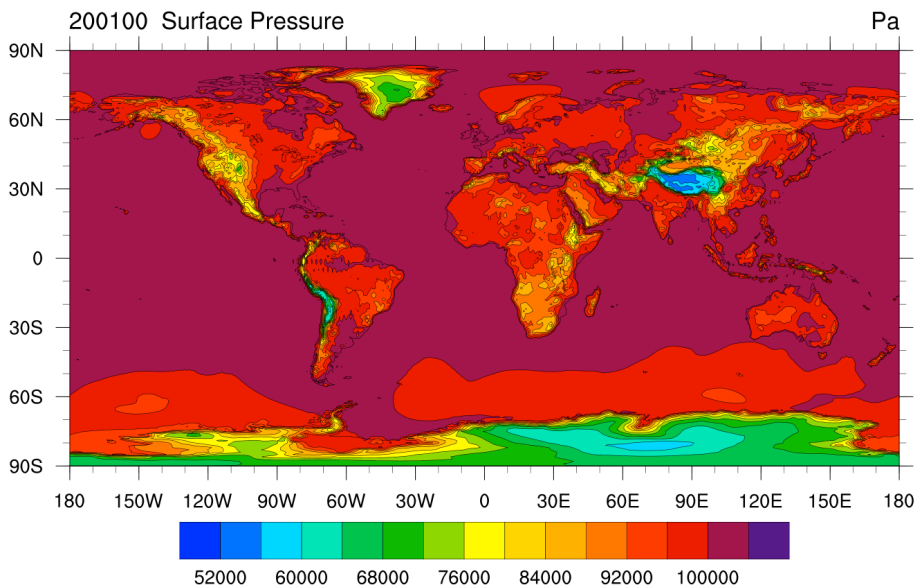
```
=====
FIELD = TT
UNITS = K DESCRIPTION = Temperature
DATE = 2000-01-24_12:00:00 FCST = 0.000000
SOURCE = unknown model from NCEP GRID 212
LEVEL = 200100.000000
I,J DIMS = 185, 129
IPROJ = 1
  REF_X, REF_Y = 1.000000, 1.000000
  REF_LAT, REF_LON = 12.190000, -133.459000
  DX, DY = 40.635250, 40.635250
  TRUELAT1 = 25.000002
DATA(1,1)=295.910950
=====
```



Utility: plotfmt

The plotfmt program plots the fields in the ungrib intermediate-formatted files

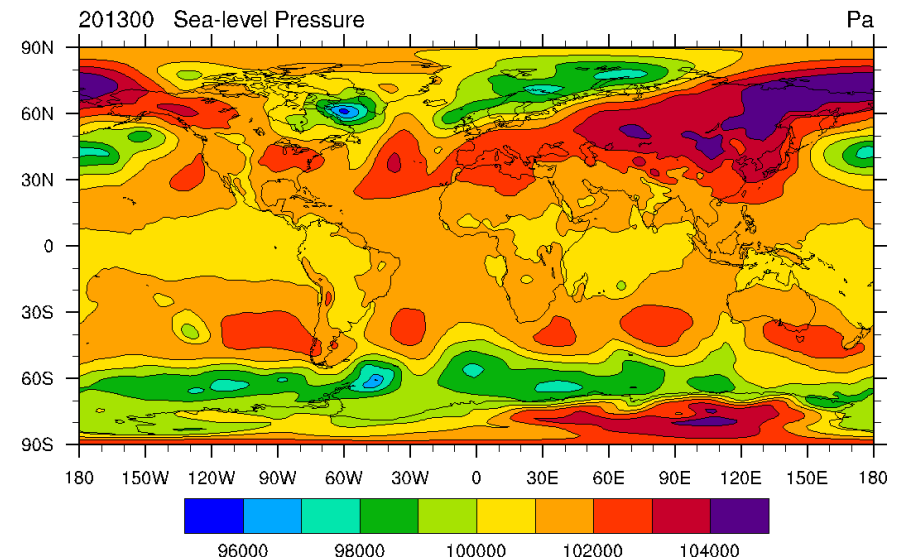
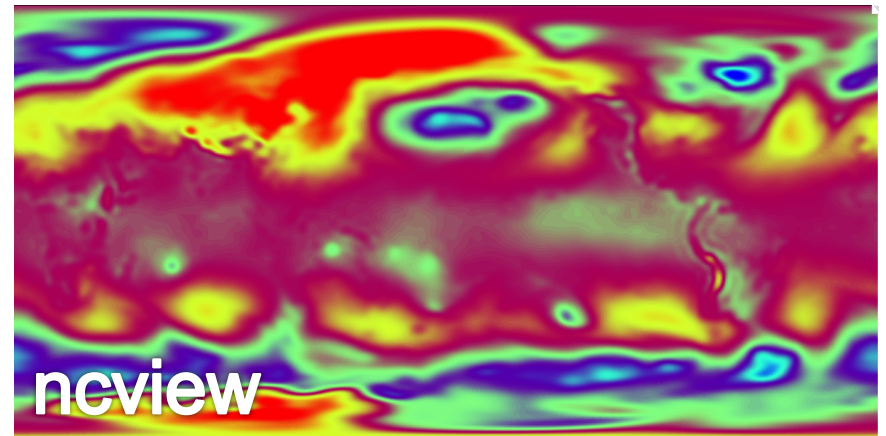
```
ncl plotfmt.ncl 'filename="FNL:2007-09-15_00"'
```



Intermediate Files in netCDF Format

Utility: `int2nc.exe`

Plot: `plotfmt_nc.ncl`



netCDF

- netCDF stands for *network Common Data Form*
- netCDF is one of the current supported data formats chosen for WRF I/O API
 - WRF I/O supports netCDF (*not fully CF compliant – climate and Forecast Metadata Convention*)/ binary/GRIB/HDF
 - Most support graphical packages currently only support netCDF file format
- <http://www.unidata.ucar.edu> (*documentation*)
- <http://www.unidata.ucar.edu/software/netcdf/docs/netcdf-f77.pdf>
<http://www.unidata.ucar.edu/software/netcdf/docs/netcdf-f90.pdf>
(*writing Fortran programs to read/write netCDF files*)



NCO tools

<http://nco.sourceforge.net/>

- **ncdiff**

- Difference two file

```
ncdiff input1.nc input2.nc -o output.nc
```

- **ncrcat (nc cat)**

- Write specified variables / times to a new file

```
ncrcat -v RAINNC wrfout* -o RAINNC.nc
```

```
ncrcat -d Time,0,231 -v RAINNC wrfout* -o RAINNC.nc
```

- **ncra (nc average)**

- Average variables and write to a new file

```
ncra -v OLR wrfout* -o OLR.nc
```

- **ncks (nc kitchen sink)**

- Combination of NCO tools all in one (handy: one tool for multiple operations)

Specifically handy to split files

```
ncks -d Time,1,1 wrfout -o wrfout1.nc
```



NCO tools

<http://nco.sourceforge.net/>

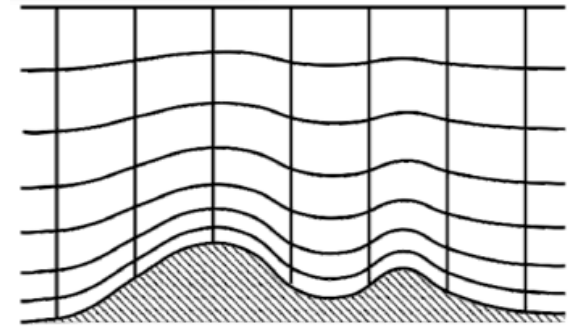
- **ncap2** Arithmetic Processor
- **ncatted** ATtribute Editor
- **ncbo** Binary Operator (includes ncadd, ncsubtract, ncmultiply, ncdivide)
- **ncea** Ensemble Averager
- **ncecat** Ensemble conCATenator
- **ncflint** FiLe INTerpolator
- **ncks** Kitchen Sink
- **ncpdq** Permute Dimensions Quickly, Pack Data Quietly
- **ncra** Record Averager
- **ncrcat** Record conCATenator
- **ncrename** RENAMEer
- **ncwa** Weighted Averager



Converting Data

- WRF model data is written out on terrain following eta levels.

- To convert the data to other vertical coordinates, use either:



- Graphical tools like NCL, ARWpost, RIP4, UPP, etc.
- Or our Vertical Interpolation program
 - *Fortran Code*
 - *Read / Write netCDF*
 - *Interpolate to: pressure; height (AGL/ASL); theta*
 - *Output can be used as input to Model Evaluation Tools Software (MET)*



netCDF : Utilities

- **ncdump**
 - reads a netCDF dataset and prints information from the dataset
 - **ncdump -h file**
print header (inc. list of variables in the file)
 - **ncdump -v VAR file**
print data of the variable VAR
ncdump -v Times file



netCDF : *ncdump -v Times*

```
netcdf wrfout_d01_2000-01-24_12:00:00 {
dimensions:
    Time = UNLIMITED ; // (3 currently)
    DateStrLen = 19 ;
    west_east = 73 ;
    south_north = 60 ;
    west_east_stag = 74 ;
    bottom_top = 27 ;
    south_north_stag = 61 ;
    bottom_top_stag = 28 ;
variables:
    char Times(Time, DateStrLen) ;
    float LU_INDEX(Time, south_north, west_east) ;
        LU_INDEX:FieldType = 104 ;
        LU_INDEX:MemoryOrder = "XY " ;
    LU_INDEX:description = "LAND USE CATEGORY" ;
    LU_INDEX:units = "" ;
    LU_INDEX:stagger = "" ;

.....

global attributes:

    :TITLE = " OUTPUT FROM WRF V3.4.1 MODEL";
    :START_DATE = "2000-01-24_12:00:00" ;
    :WEST-EAST_GRID_DIMENSION = 74 ;
    :SOUTH-NORTH_GRID_DIMENSION = 61 ;
    :BOTTOM-TOP_GRID_DIMENSION = 28 ;
    :DX = 30000.f ;
    :DY = 30000.f ;

.....

data:
    Times =
        "2000-01-24_12:00:00",
        "2000-01-24_18:00:00",
        "2000-01-25_00:00:00"
```



Wrfout output fields (*ncdump -h*)

ALBBCK	ALBEDO	CANWAT	CF1	CF2
CF3	CFN	CFN1	COSALPHA	DN
DNW	DZS	E	EDT_OUT	EMISS
F	FNM	FNPF	GLW	GRAUPELNC
GRDFLX	HFX	HGT	HGT_SHAD	ISLTYP
ISTEP	IVGTYP	LANDMASK	LH	LU_INDEX
MAPFAC_M	MAPFAC_MX	MAPFAC_MY	MAPFAC_U	MAPFAC_UX
MAPFAC_UY	MAPFAC_V	MAPFAC_VX	MAPFAC_VY	MAX_MSTFX
MAX_MSTFY	MF_VX_INV	MU	MUB	NEST_POS
OLR	P_TOP	P	PB	PBLH
PH	PHB	POTEVP	PRATEC	PSFC
Q2	QCLOUD	QFX	QNDROPSOURCE	QRAIN
QVAPOR	RAINC	RAINC_V	RAINNC	RDN
RDNW	RDX	RDY	RESM	RHOSN
SEAICE	SFROFF	SH2O	SINALPHA	SMOIS
SNOPCX	SNOW	SNOWC	SNOWH	SNOWNC
SOILTB	SR	SST	SWDOWN	T
T2	TH2	Times	TMN	TSK
TSLB	U	U10	UDROFF	UST
V	V10	VEGFRA	W	X
XICEM	XLAND	XLAT	XLAT_U	XLAT_V
XLONG	XLONG_U	XLONG_V	ZETATOP	ZNU
ZNW	ZS			
Total Geopotential, staggered (PH+PHB)		Total Pressure in Pa (P+PB)		
Wind components, grid relative, staggered (U & V)		Total Potential Temperature (T+300)		
10m wind components, grid relative, mass points (U10 & V10)		Surface temperature in K (T2)		



ncview

http://meteora.ucsd.edu/~pierce/ncview_home_page.html

no variable selected

Ncview 1.93a David W. Pierce 1 Feb 2006

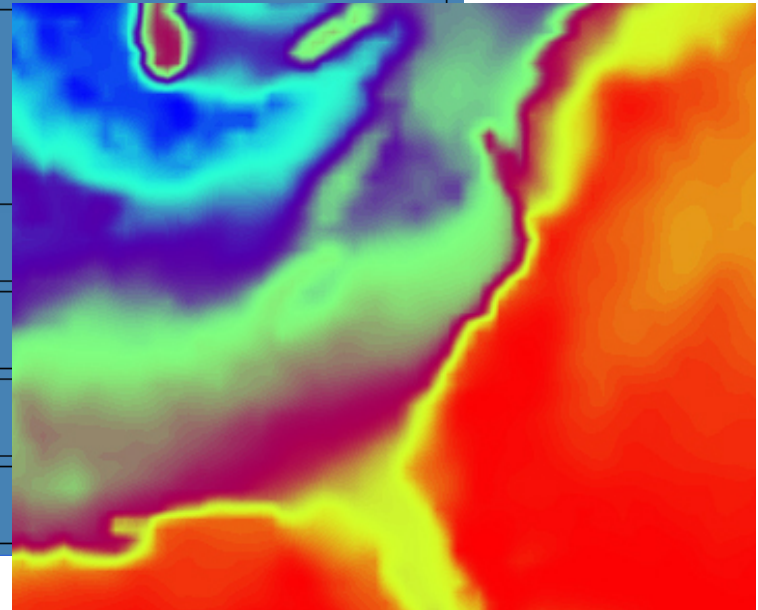
*** SELECT A VARIABLE TO START ***

Quit -->1 << < || > >> Edit ? Delay: Opts

3gauss Inv P Inv C Mag X1 Linear Axes Range blowup Print

(18) 1d vars (48) 2d vars (13) 3d vars

Dim:	Name:	Min:	Current:	Max:	Units:
	Time	Min:	Current:	Max:	Units:
	bottom_top	Min:	Current:	Max:	Units:
	south_north	Min:	Current:	Max:	Units:
	west_east_st	Min:	Current:	Max:	Units:



ncview

http://meteora.ucsd.edu/~pierce/ncview_home_page.html

no variable selected

Ncview 1.93a David W. Pierce 1 Feb 2006

*** SELECT A VARIABLE TO START ***

Quit

-->1

◀◀

◀

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▶

▶▶

Edit

?

Delay:

Opts

3gauss

Inv P

Inv C

Mag X1

Linear

Axes

Range

blowup

Print

(18) 1d vars

(48) 2d vars

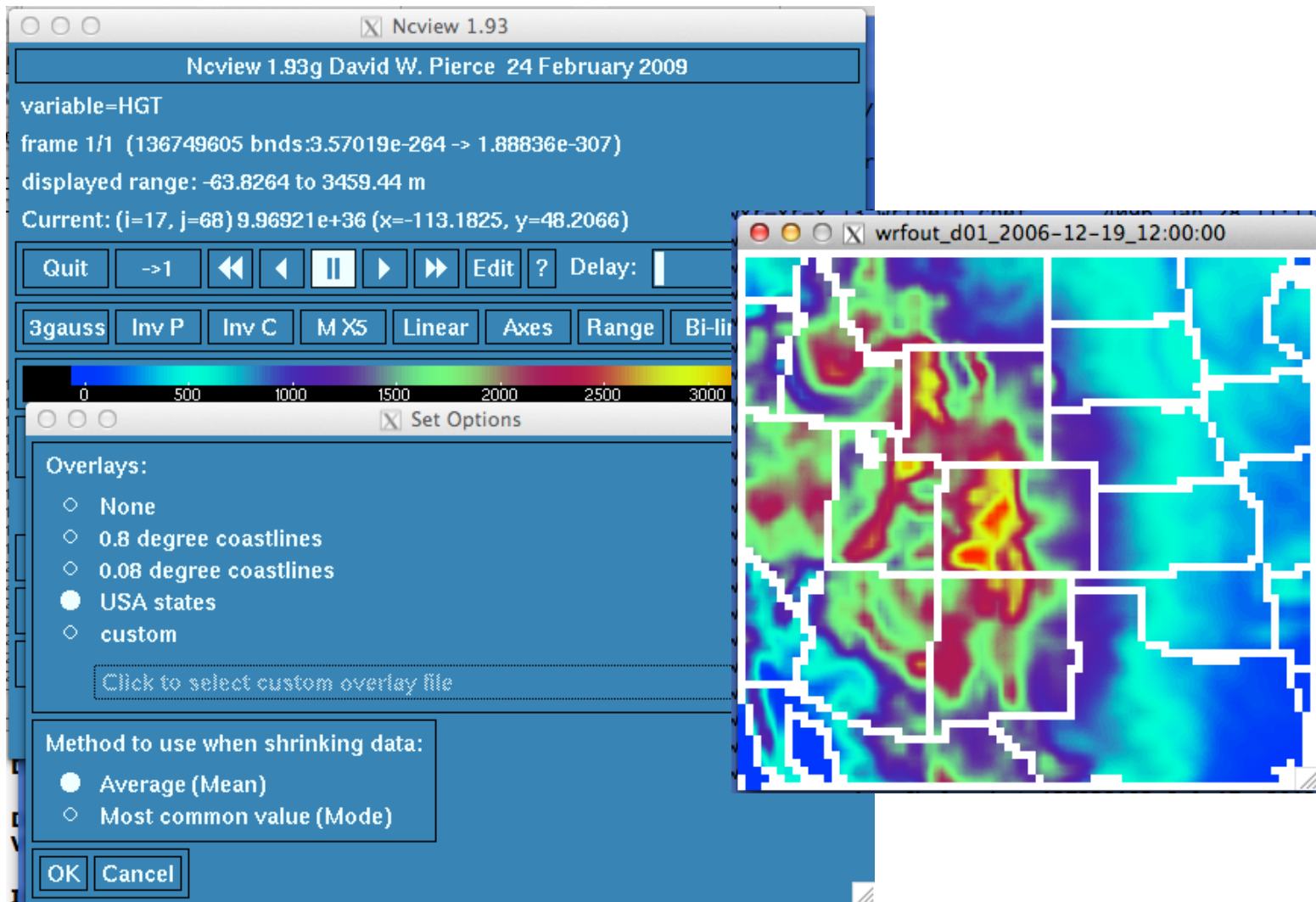
(13) 3d vars

Dim:	Name:	Min:	Current:	Max:	Units:
	Time	Min:		Max:	Units:
	bottom_top	Min:		Max:	Units:
	south_north	Min:		Max:	Units:
	west_east_st:	Min:		Max:	Units:



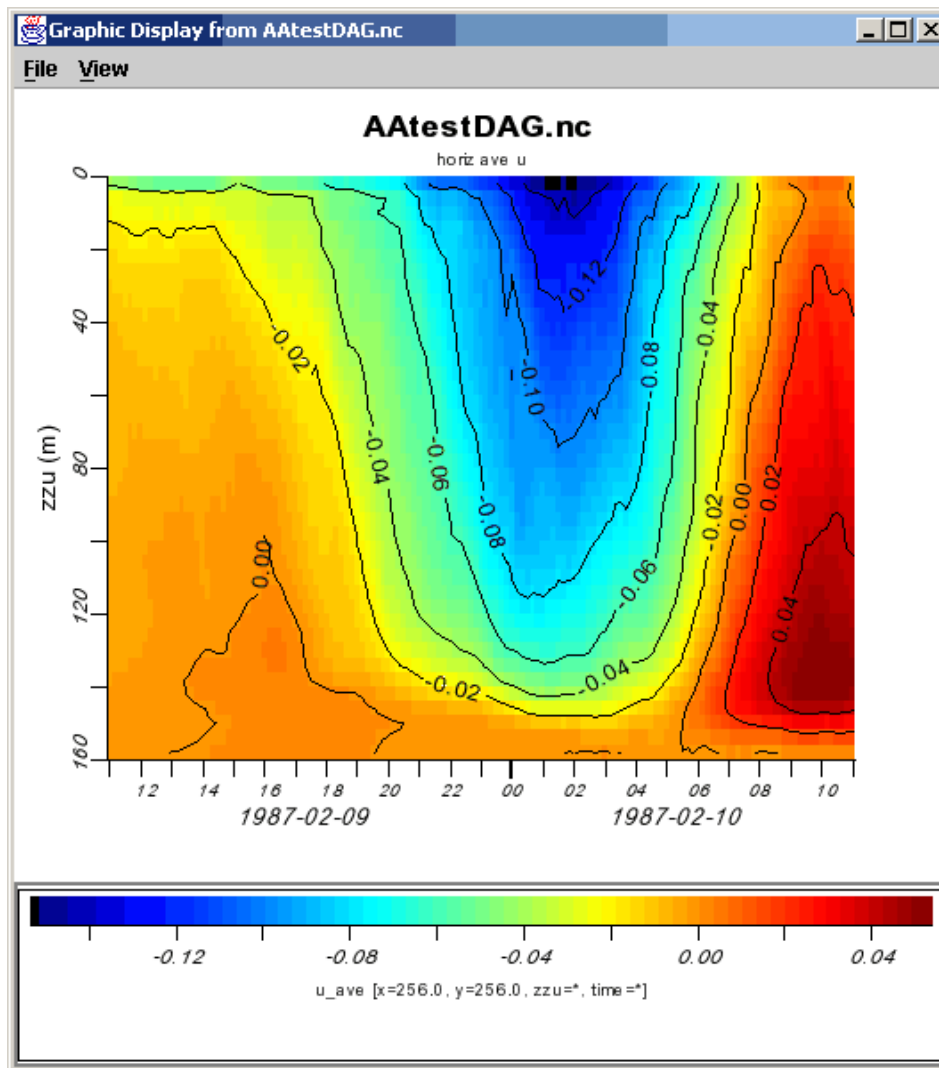
ncview

http://meteora.ucsd.edu/~pierce/ncview_home_page.html



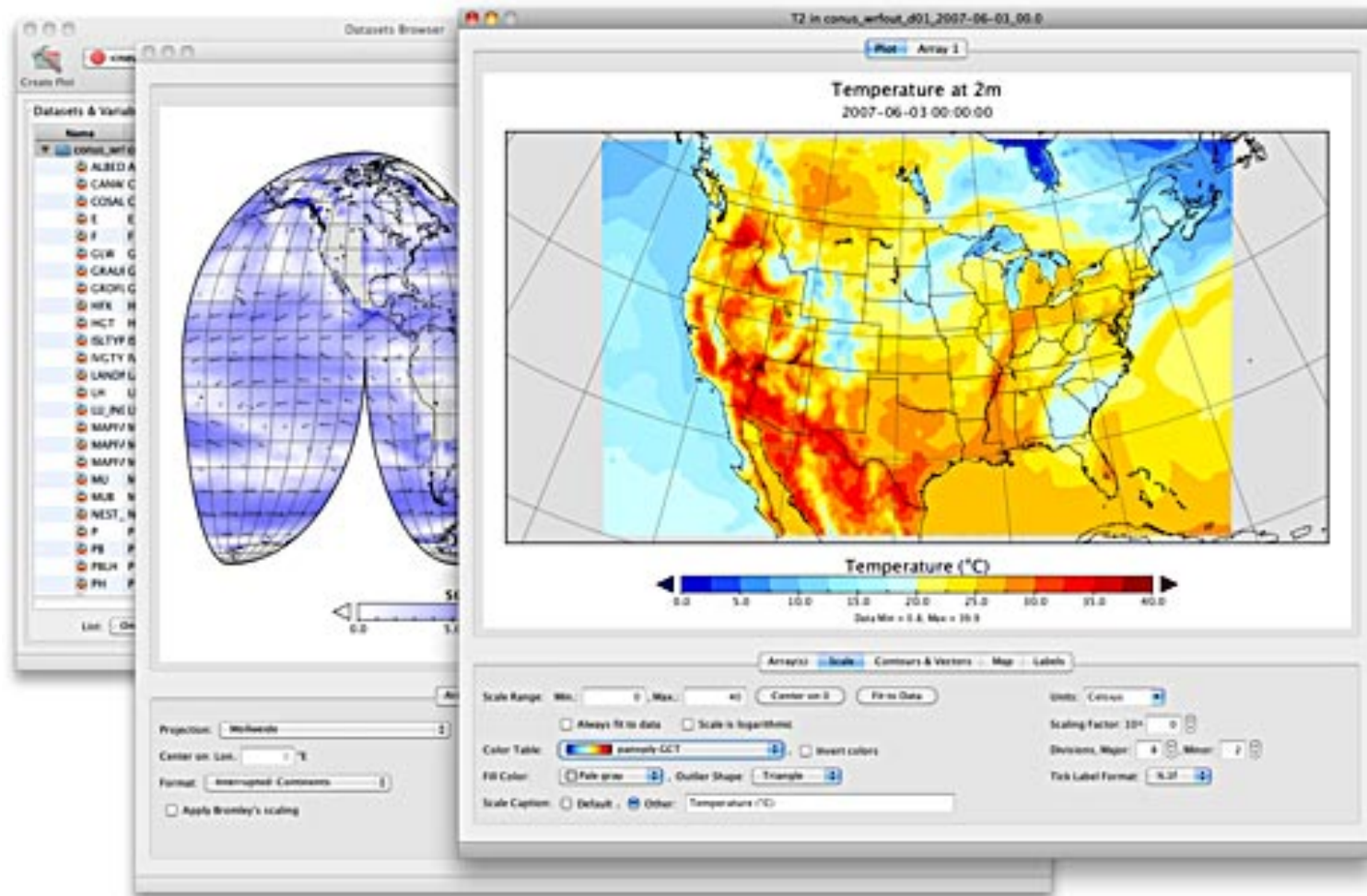
ncBrowse

<http://www.epic.noaa.gov/java/ncBrowse/>



Panoply

<http://www.giss.nasa.gov/tools/panoply/>



MET verification software

- Model Evaluation Tools
- All the basics (e.g. RMSE, bias, skill scores)
- Plus
 - advanced spatial methods (wavelets, objects)
 - confidence intervals
- Get it here: <http://www.dtcenter.org/met/users/downloads/>
- Get help from met_help@ucar.edu or the documentation

