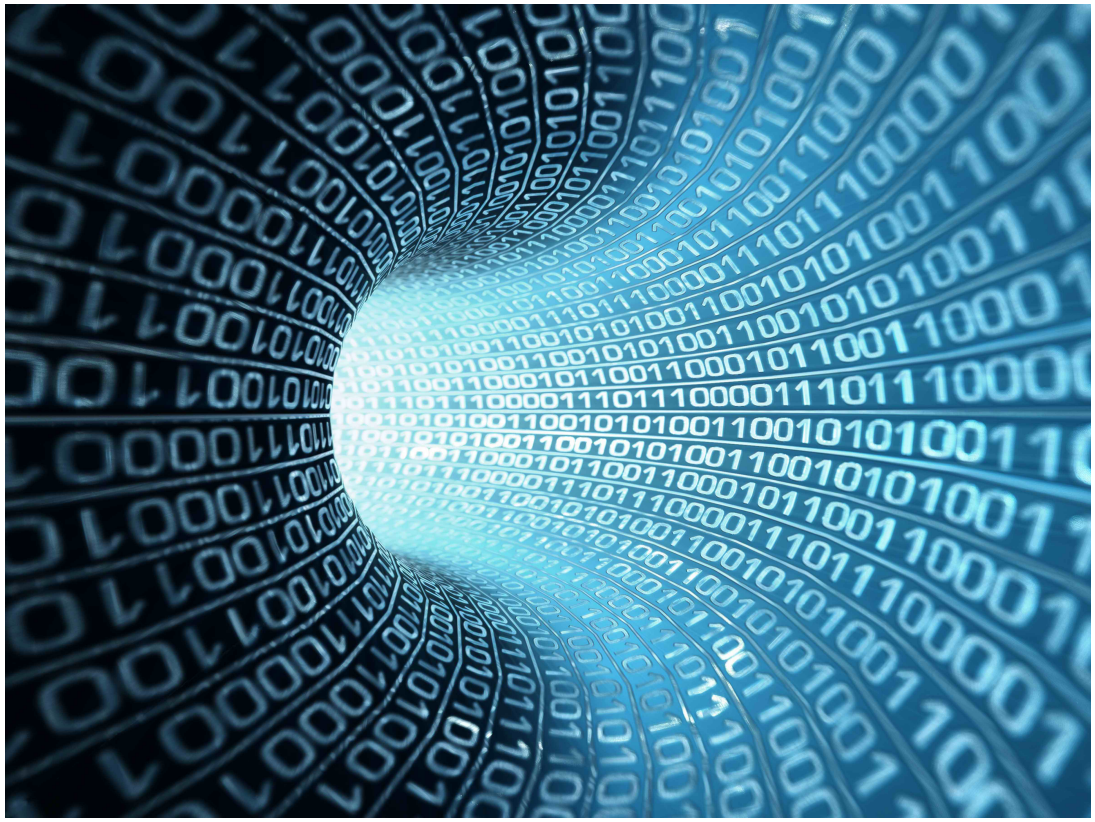
WRF Utilities

Cindy Bruyère



Utilities

UG: Chapter 3 & 10

- Graphics
- Designing a model domain
- Data

Input	Intermediate	Output
grib 1&2	intermediate format	netcdf
netcdf		

- netCDF tools
- MET

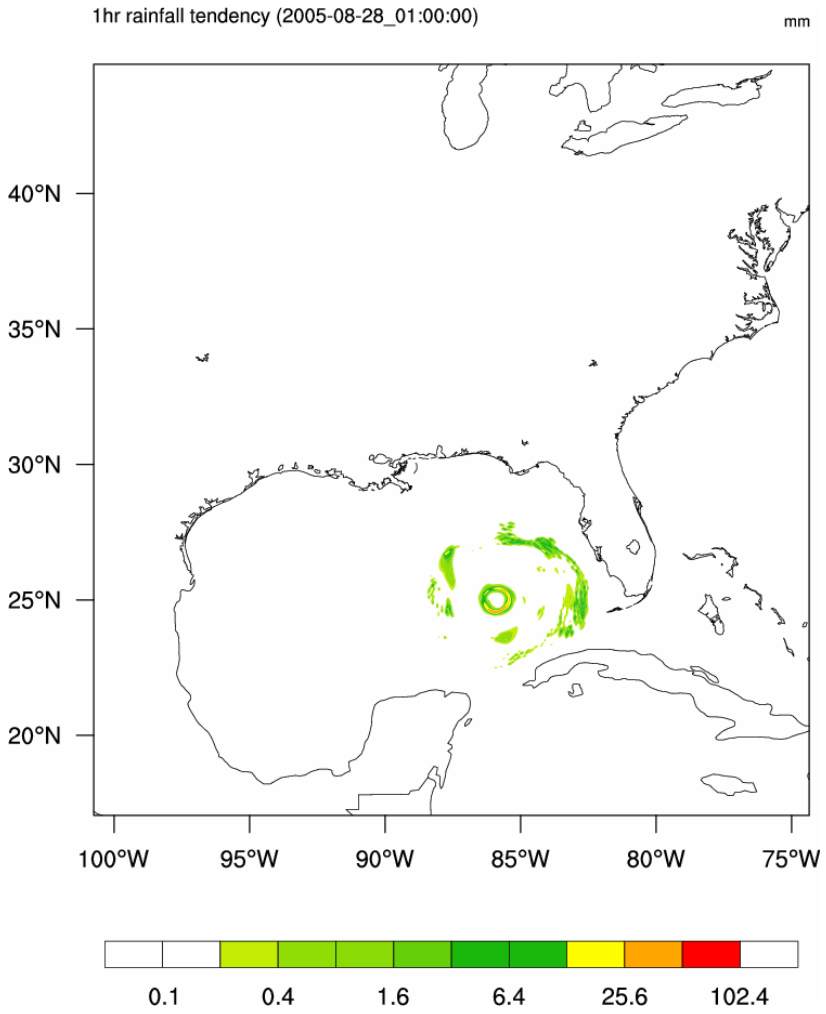
Graphics : ImageMagick

- **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	*file*.pdf	*file*.png
convert	*file*.png	*file*.bmp
convert	*file*.pdf	*file*.gif
convert	*file*.ras	*file*.png

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

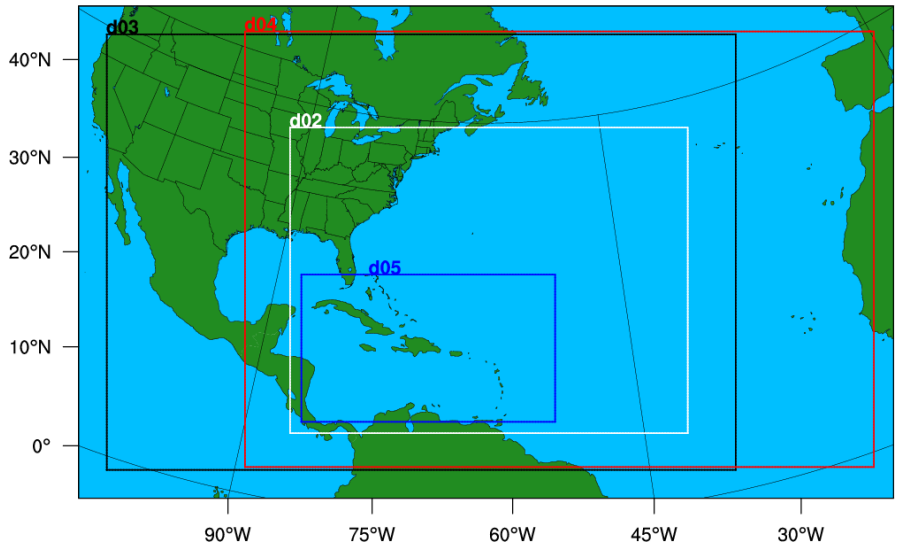


WRF Model Domain Design

```
mpres@mpFillColors  =
 (/"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

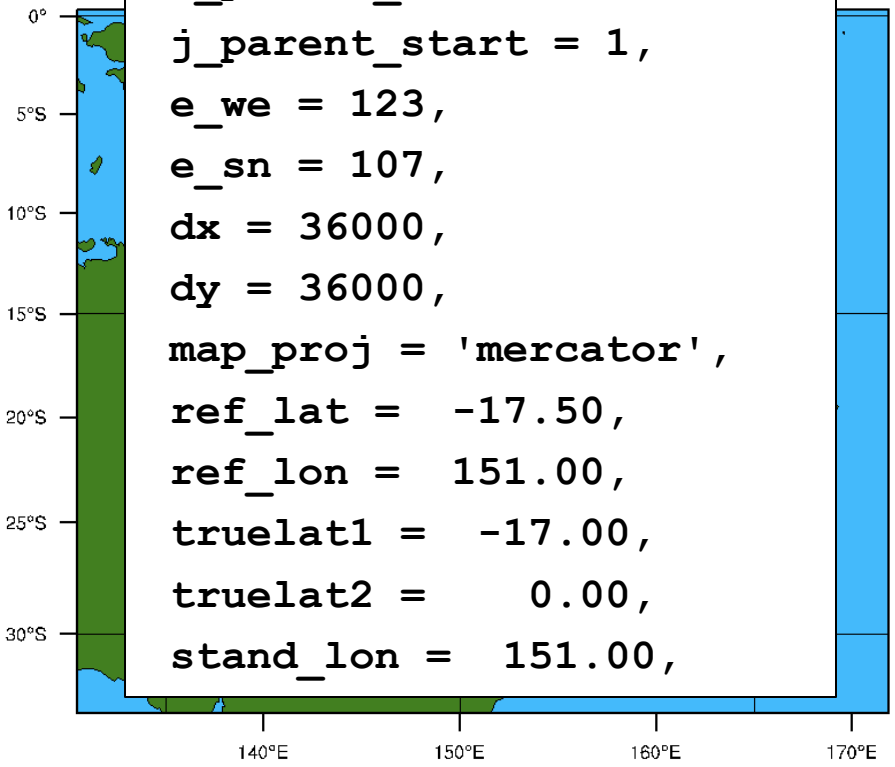


WRF Model Domain Design

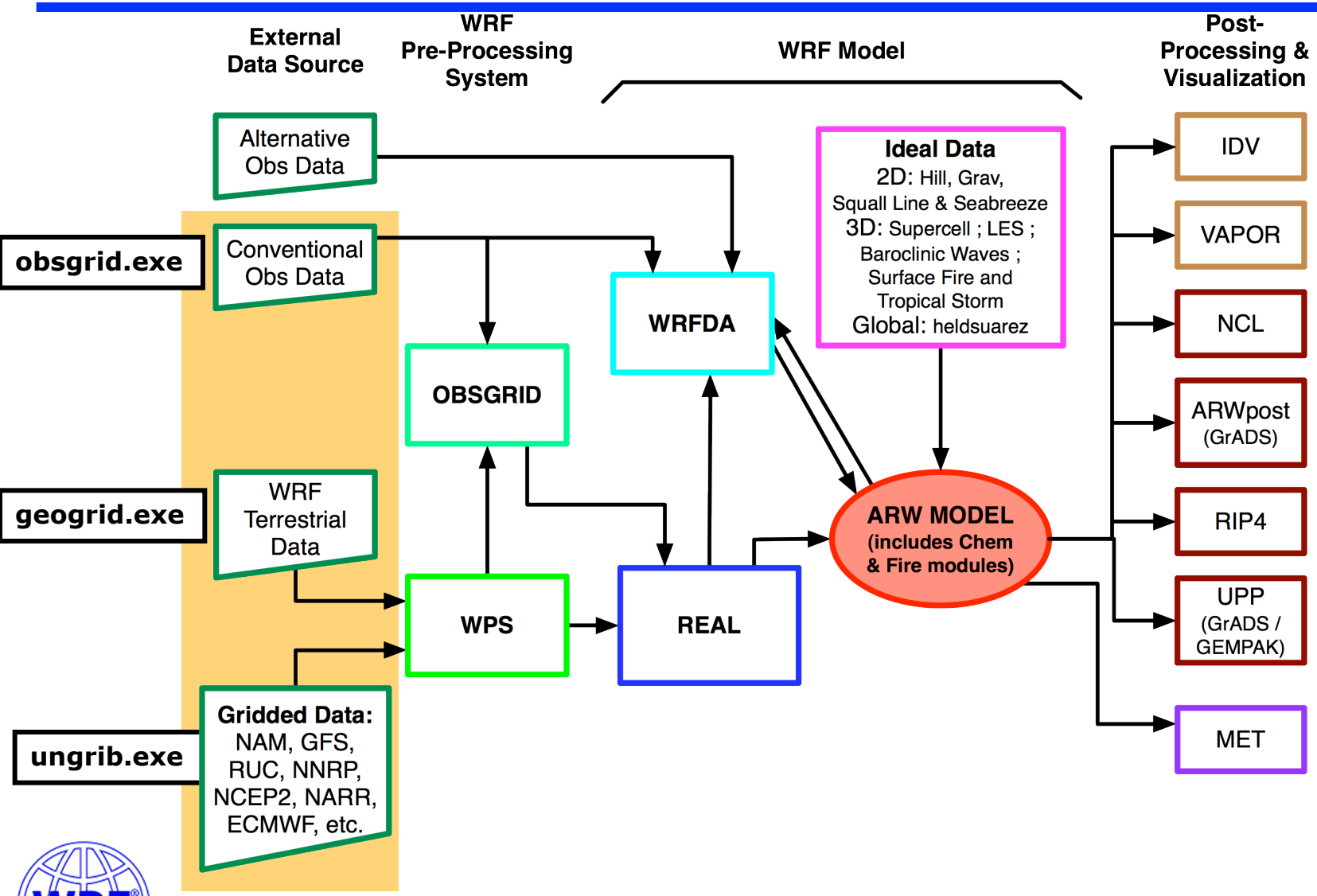
```
DOMS = 1
DX = 36.
MAP = "mercator"
LAT1 = (/ -35.0, -45., -27. /)
LAT2 = (/   0., -20., -23. /)
LON1 = (/ 131., 121., 125./)
LON2 = (/ 171., 159., 131./)
parent_id = (/ 0, 1, 2 /)
parent_grid_ratio = (/ 1, 3, 3 /)
```

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,
```

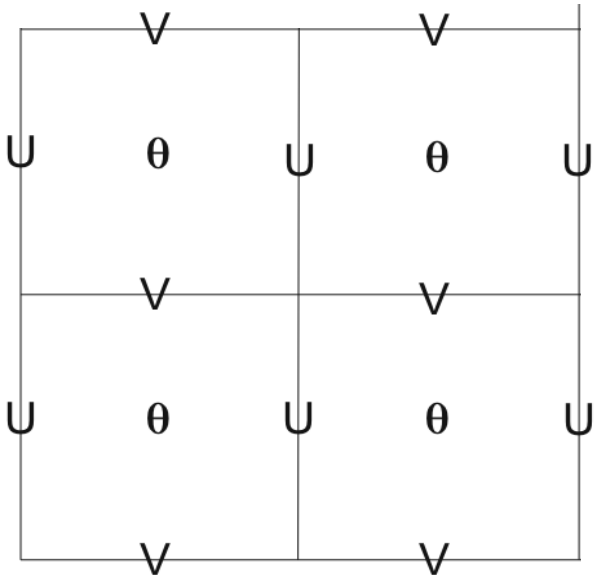


WRF Modeling System Flow Chart



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

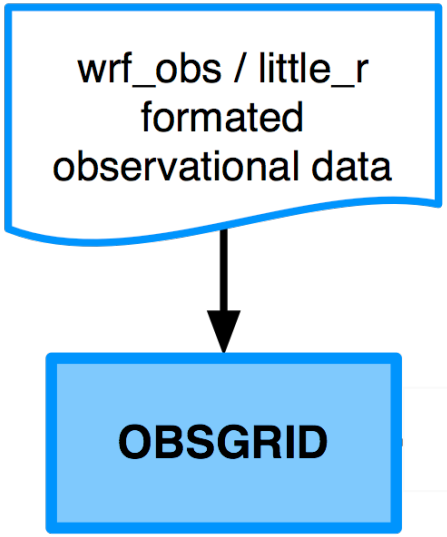
- http://rda.ucar.edu/datasets/ds351.0

  BUFRdecode_ADPuprair_littlr.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_littlr.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: Web Server Holdings	Customizable Data Requests: Subsetting
	Union of Available Products	Web File Listing	
PRODUCTS	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 formated observational data

OBSGRID

BUFRdecode_ADPsfc_littlr.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**

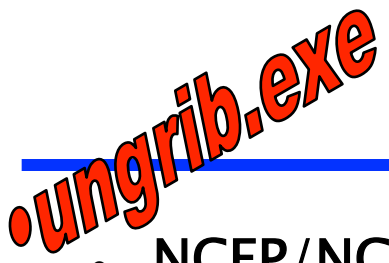
2D Data

- **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)
  (~ 2.5º Global; Jan 1948 to present)
  http://rda.ucar.edu/datasets/ds090.0

- NCEP / DOE Reanalysis II *(~ 2.5º Global; Jan 1979 to present)*
  http://rda.ucar.edu/datasets/ds091.0

- GFS 0.5º Global data *(Dec 2002 to present)*
  http://rda.ucar.edu/datasets/ds335.0

- ERA Interim Data *(~ 0.7º Global; Jan 1979 to present)*
  http://rda.ucar.edu/datasets/ds627.0

- Final Analysis *(~ 1.0º Global; FNL; Aug 1999 to present)*
  http://rda.ucar.edu/datasets/ds083.2

ungrib : External Data Sources

ungrib.exe

- 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)*

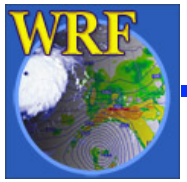
ungrib : External Data Sources

- GFS Real-time 1º Global
  http://www.emc.ncep.noaa.gov

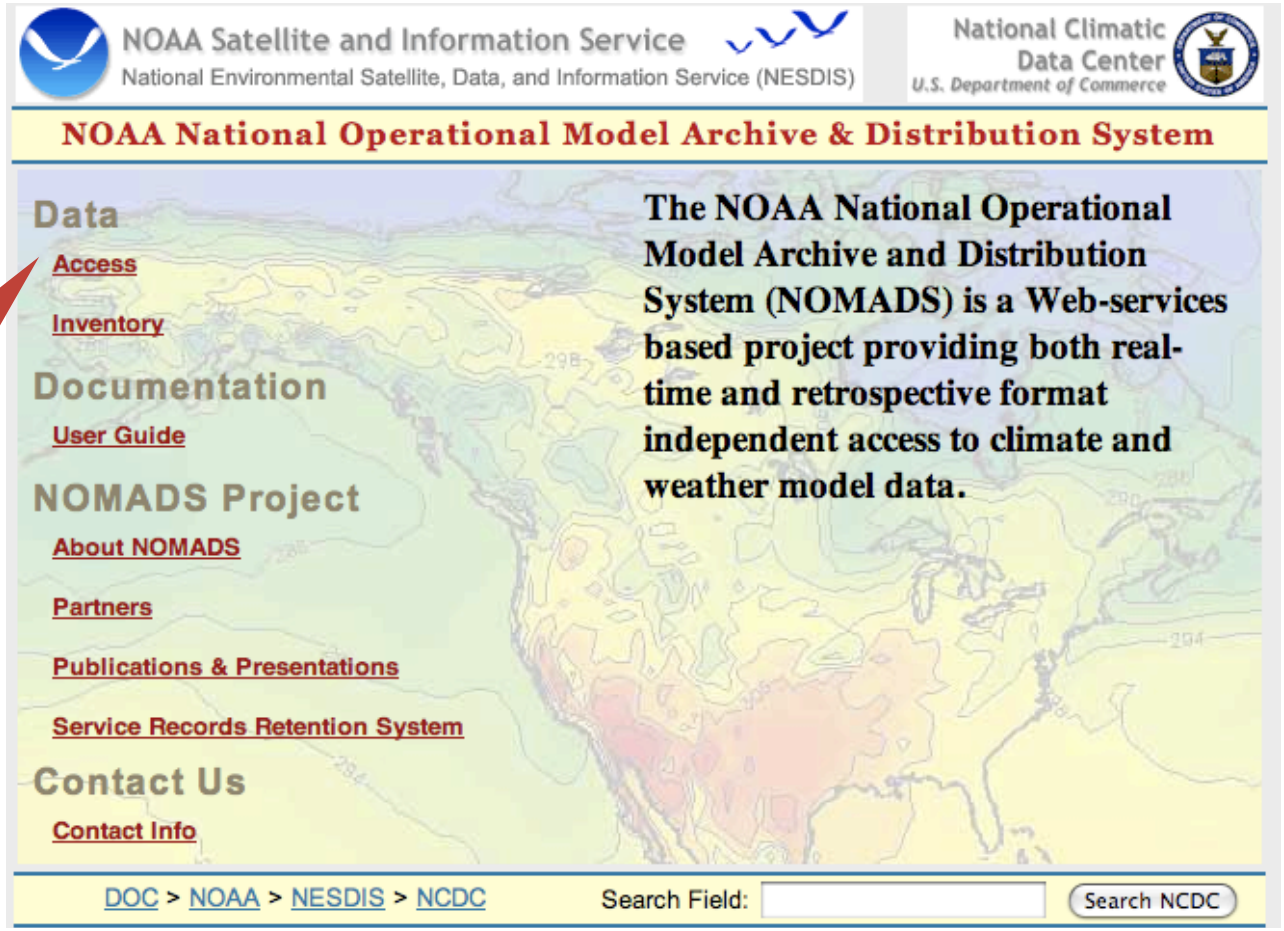
- NAM Real-time 32/12km North America
  http://www.emc.ncep.noaa.gov

- 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



- 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

WPS Intermediate Files

- **wrf_wps_read_int**

```
istatus =  wrf_wps_open_int(filename)
wrf_wps_rdhead_int(istatus,head_real,field,hdate,  \
                           units,map_source,desc)
slab = wrf_wps_rddata_int(istatus,nx,ny)
```

Loop till reaching end of IM file

WPS Intermediate Files

- wrf_wps_write_int

```
FIELD   = "SST"
UNITS   = "K"
DESC    = "Sea Surface Temperature"

opt = True
opt@map_source              = "ERA-I Data"
opt@projection              = 0
opt@startloc                = "SWCORNER"
opt@startlon                = 0.0
opt@startlat                = -90.0
opt@deltalon                = 1.25
opt@deltalat                = 0.942408
opt@is_wind_earth_relative  = False
opt@date                    = "2015-07-26_00:00:00"
opt@level                   = 200100.

wrf_wps_write_int(IM_name,FIELD,UNITS,DESC, VAR(:,:),opt)
```

Utility: rd_intermediate

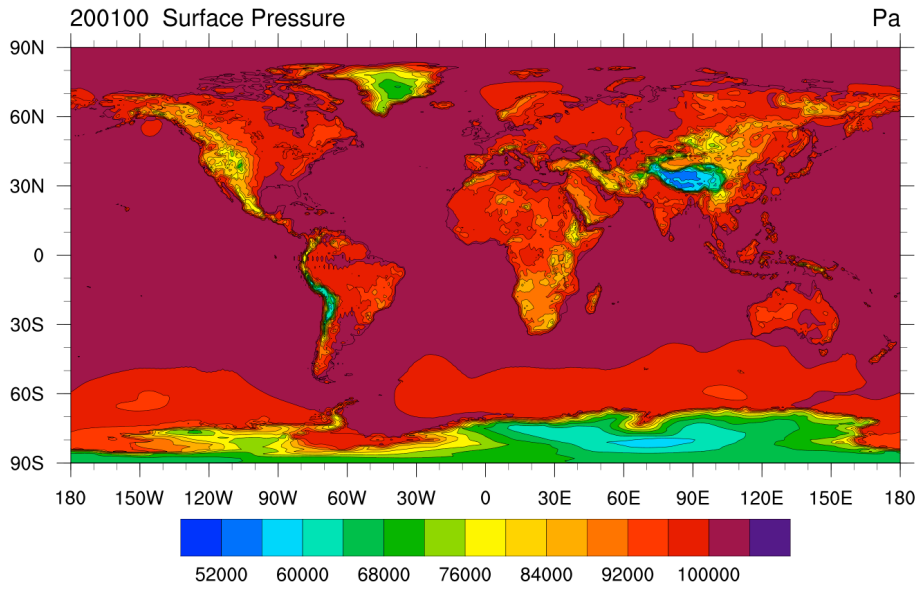
The rd_intermediate lists information about the fields found in an intermediate-format file

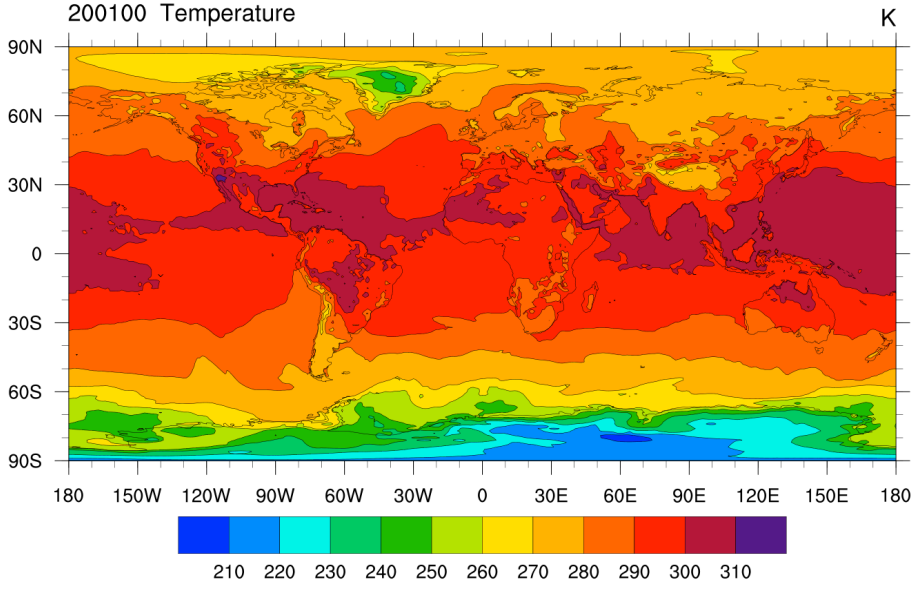
```
================================================
FIELD = TT
UNITS = K DESCRIPTION = Temperature
DATE = 2000-01-24_12:00:00 FCST = 0.000000
SOURCE = unknown model from NCEP GRID 212
LEVEL = 200100.000000
I,J DIMS = 185, 129
IPROJ = 1
  REF_X, REF_Y = 1.000000, 1.000000
  REF_LAT, REF_LON = 12.190000,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

Utility: plotfmt

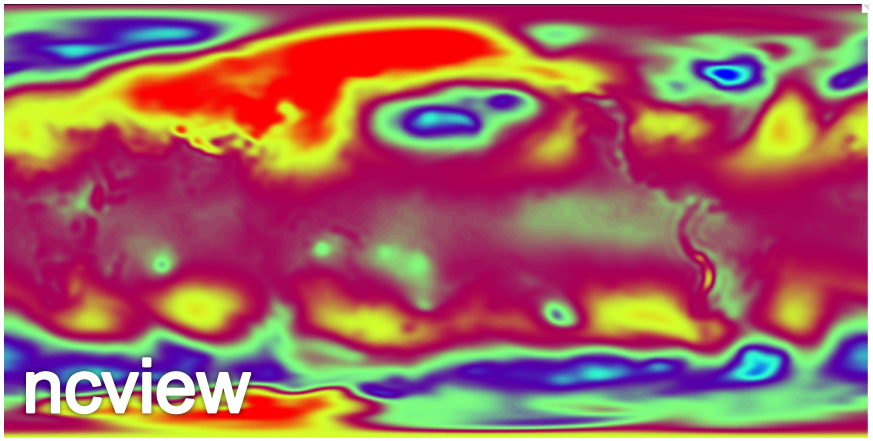
The plotfmt program plots the fields in the ungrib intermediate-formatted files

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



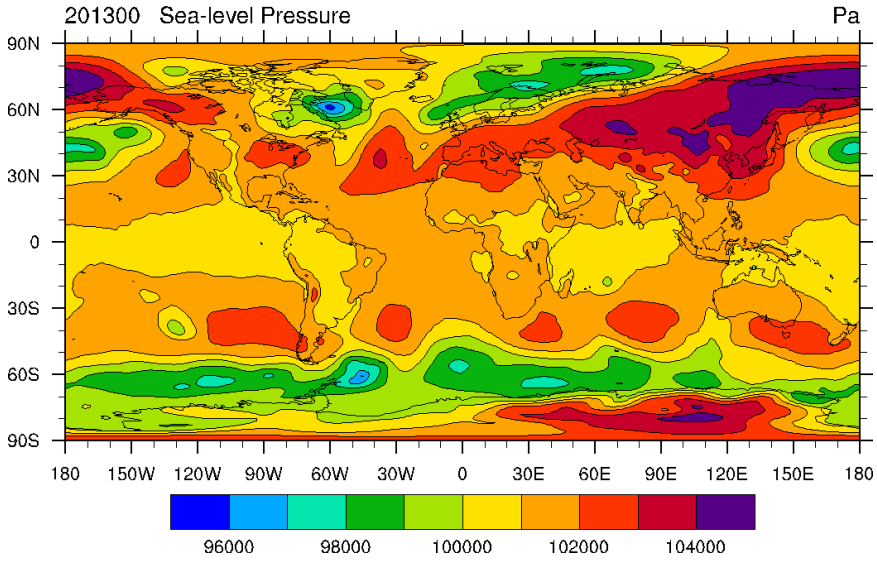


Intermediate Files in netCDF Format



Utility: int2nc.exe

Plot: plotfmt_nc.ncl



netCDF

- netCDF stands for ***net**work **C**ommon **D**ata **F**orm*

- 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

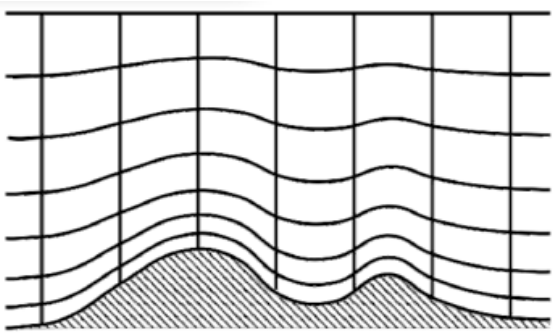
NCO tools

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"
```

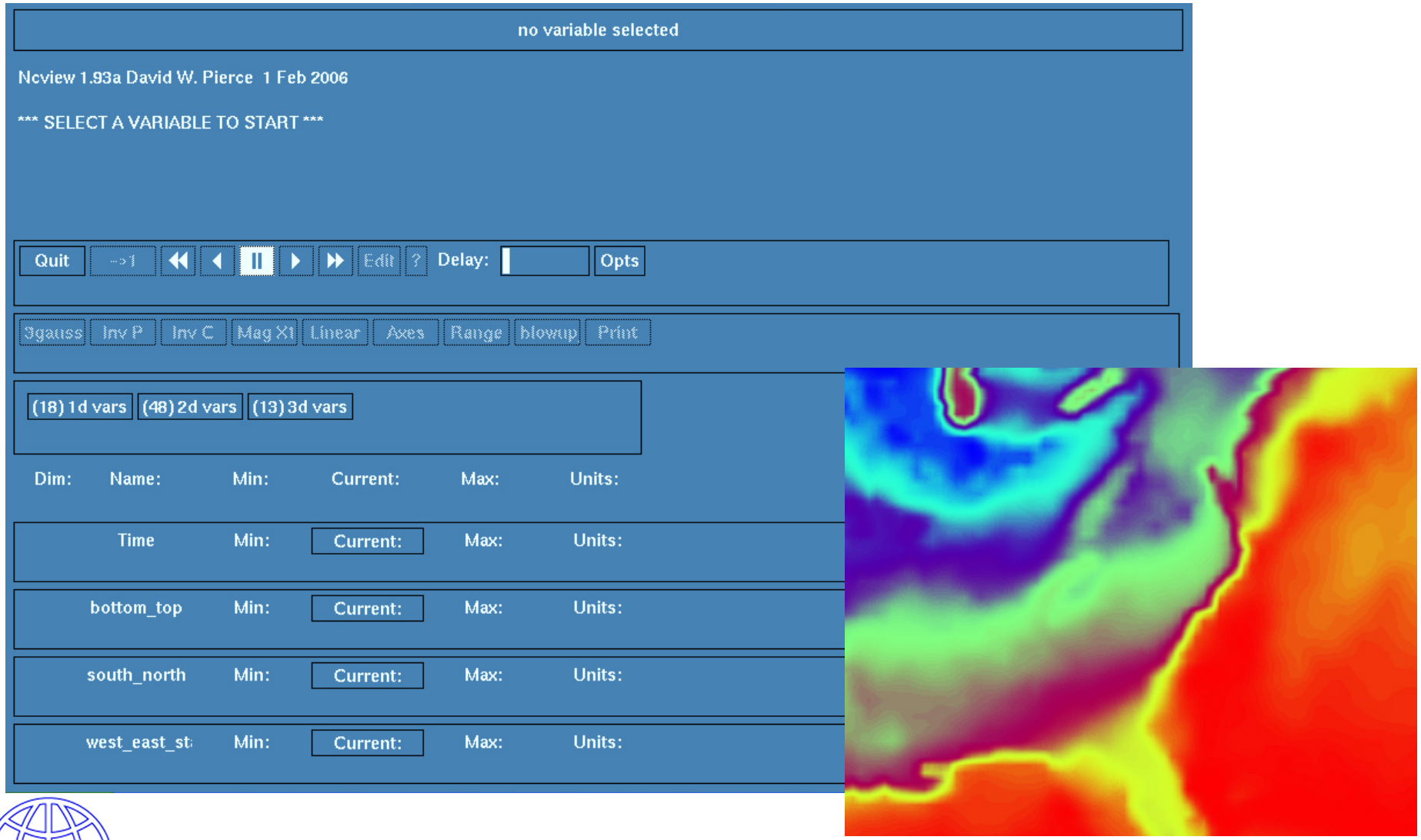
Wrfout output fields *(ncdump -h)*

ALBBCK	ALBEDO	CANWAT	CF1	CF2
CF3	CFN	CFN1	COSALPHA	DN
DNW	DZS	E	EDT_OUT	EMISS
F	FNM	FNP	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	RAINCV	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



ncview

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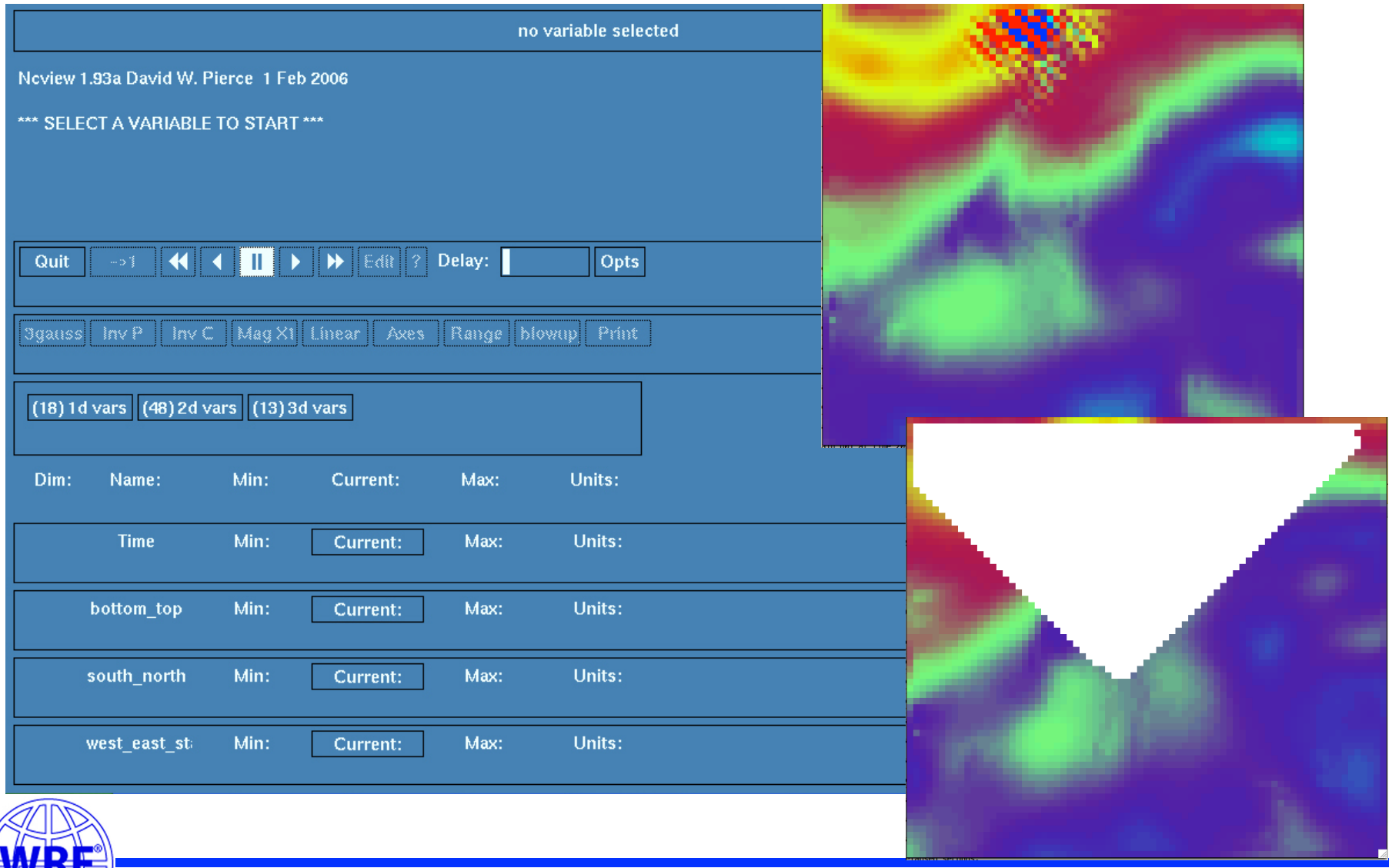
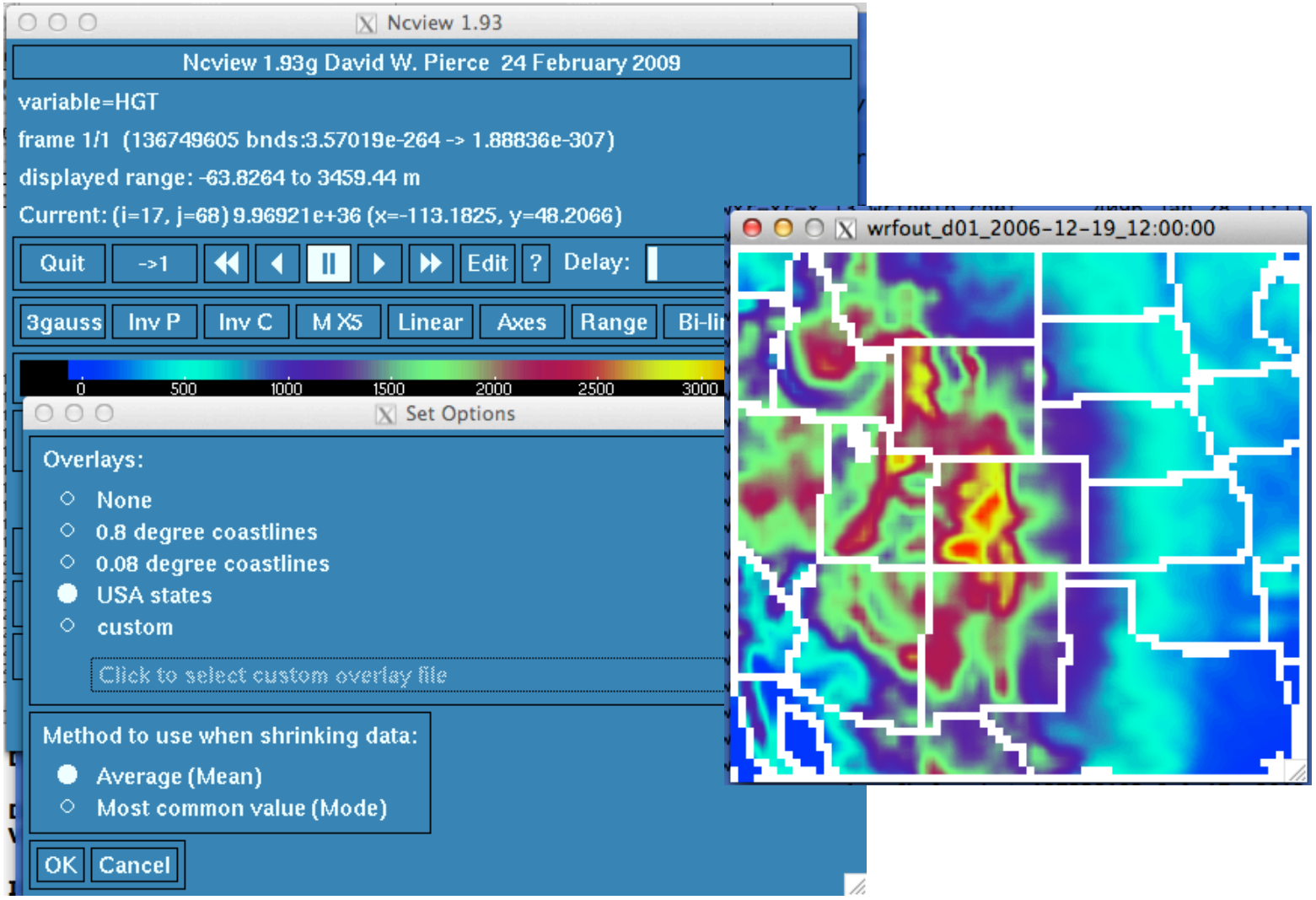


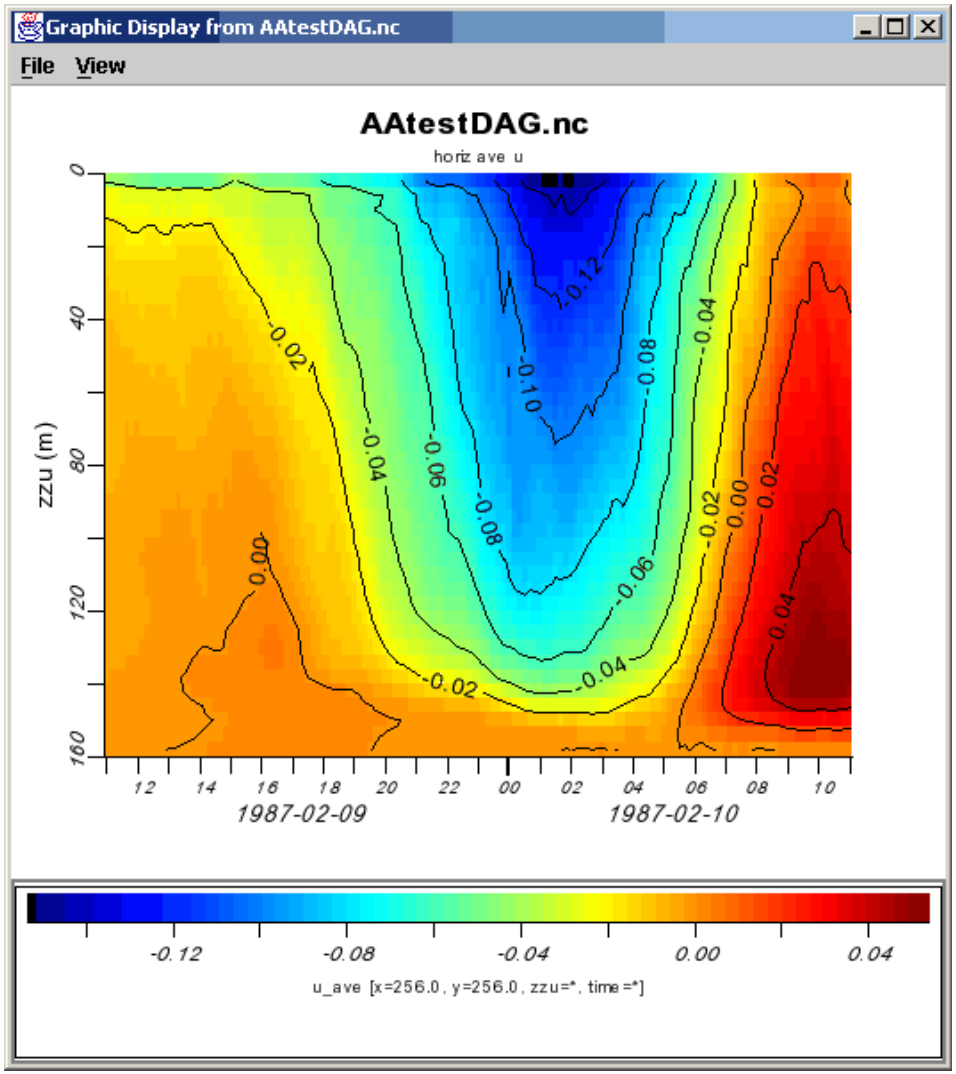
ncview

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



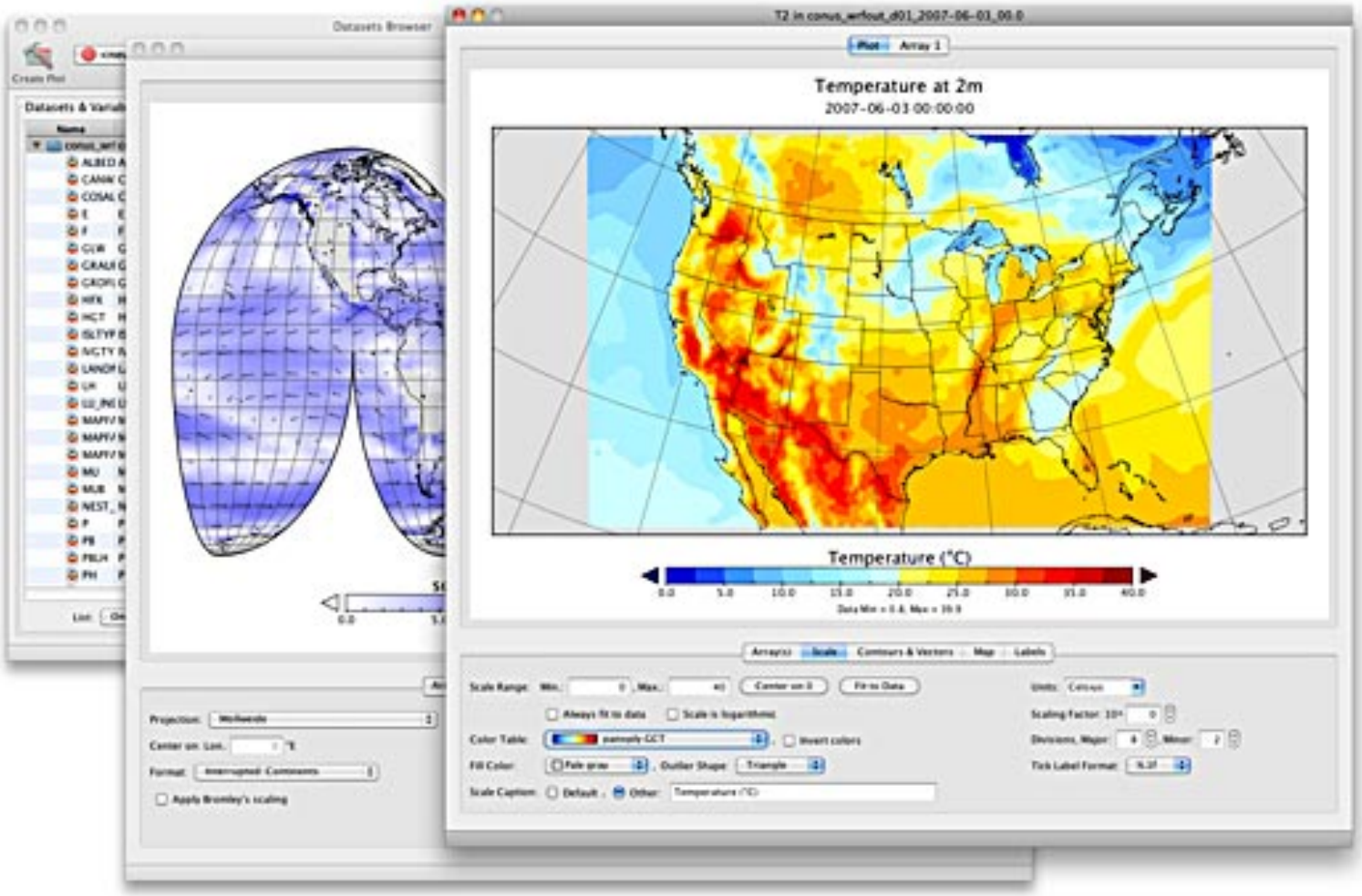
ncBrowse

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