

WRF Data, Utilities & Post-processing

Kelly Werner
January 2020



This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

Input Data

Input Data: Mandatory Fields

- **3D Data (for data on constant pressure levels)**

- Temperature

- U and V components of wind

- Geopotential height

- Relative Humidity (or Specific Humidity)

- **3D Data (for data on native model levels)**

- Temperature

- U and V components of wind

- Geopotential height

- Relative Humidity (or Specific Humidity)

- Pressure

- **2D Data**

- Surface pressure

- Mean sea-level pressure

- Skin temperature/SST

- 2 meter temperature and relative humidity

- 10 meter U and V components of wind

- Soil data (temperature and moisture) and soil height

- * Recommended Fields**

- LANDSEA mask field for input data

- Water equivalent snow depth

- SEAICE

- Additional SST data

External Data Sources: Global

Name	Resolution	Coverage	Temporal Availability	Website
NCEP/NCAR Reanalysis (R1/NNRP)	209 km 6-hourly	Global	Jan 1948 - present	http://rda.ucar.edu/datasets/ds090.0
NCEP/DOE Reanalysis (R2)	209 km 6-hourly	Global	Jan 1979 - present	http://rda.ucar.edu/datasets/ds091.0
ERA Interim Data	1.125° - 0.703° 6-hourly	Global	Jan 1979 - present	http://rda.ucar.edu/datasets/ds627.0
ECMWF's Operational Model Analysis	Varying		Jan 2011 - present	http://rda.ucar.edu/datasets/ds113.0
NCEP GDAS/FNL Reanalysis	0.25° 6-hourly	Global	July 2015 - present	http://rda.ucar.edu/datasets/ds083.3
GFS Real-time	1°	Global		ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gfs
NCEP GFS/FNL Reanalysis	1° 6-hourly	Global	Aug 1999 - present	http://rda.ucar.edu/datasets/ds083.2
GFS Gridded Model Data	0.5° 24-hourly	Global	Dec 2002 - present	http://rda.ucar.edu/datasets/ds335.0
NCEP GFS 0.25°	0.25° 3-hourly & 12-hourly	Global	Jan 2015 - present	http://rda.ucar.edu/datasets/ds084.1

External Data Sources: North America

Name	Resolution	Coverage	Temporal Availability	Website
NAM Real-time	32/12 km 6-hourly	North America		ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/nam
NAM Analysis	12 km 6-hourly	North America	Jan 2012 - present	http://rda.ucar.edu/datasets/ds609.0
GCIP NCEP Eta	40 km 3-hourly & 6-hourly	North America	April 1995 - present	http://rda.ucar.edu/datasets/ds609.2
NCEP NARR	32 km 3-hourly	North America	Nov 1979 - present	http://rda.ucar.edu/datasets/ds608.0

External Data Sources: Climate

Name	Resolution	Coverage	Temporal Availability	Website
NCEP Climate Forecast System Reanalysis (CFRSR)	0.3° to 2.5° 6-hourly	Global	Jan 1979 - Dec 2010	http://rda.ucar.edu/datasets/ds093.0
NCEP Climate Forecast System Reanalysis II (CFSv2)	0.2° to 2.5° 6-hourly	Global	Jan 2011 - present	http://rda.ucar.edu/datasets/ds094.0
NCAR CESM CMIP5 data (netCDF format)	6-hourly	Global	Jan 1950 - 2100	http://rda.ucar.edu/datasets/ds316.0
NCAR CESM CMIP5 data (IM - Bias Corrected)	6-hourly	Global	Jan 1951 - 2100	http://rda.ucar.edu/datasets/ds316.1
SST DATA				
NCEP SST Analysis	1° - 1/12°	Global		http://polar.ncep.noaa.gov/sst
NOMAD3 SST	1° - 0.25°	Global	Jan 1854 - present (depending which product)	http://nomads.ncdc.noaa.gov/data.php
NCEP & NCDC Reconstructed SST	1° - 2°	Global	Jan 1854 - Dec 2015	http://rda.ucar.edu/datasets/ds277.0

Download RDA Dataset Example

- From the WRF Users' page: <http://www2.mmm.ucar.edu/wrf/users/>

WRF USERS PAGE

Home Model System User Support **Download** Doc / Pub Links Physics

WRF MODEL USER'S GUIDE

Welcome to the Research and Forecasting Model (WRF, for short). WRF is a mesoscale numerical weather prediction modeling system designed for both meteorological research and numerical weather prediction. It offers a host of options for atmospheric research and can run on a variety of platforms. WRF excels in a broad range of scales ranging from tens of meters to thousands of kilometers, including the following:

- Meteorological studies

Download WRF

WRF General Information

Public Domain Notice

WRF User Support

WRF Version 4 User's Guide

How to Cite WRF

Download

- Downloads Overview
- WRF
- WPS Geographic Static Fields
- Post-processing and Utilities
- WRF Testing Framework
- Input Data for WRF**
- NCEP ftp

WRF FORECAST

Step 1: Click Download, then scroll down and click 'Input Data from NCAR'

Step 2: Click the dataset you wish to use (for this example, we will use 'FNL from GFS')

Dataset	Spatial Resolution	Temporal Resolution	Temporal Availability	Vtable
NCEP Final Analysis (GFS-FNL) ds083.0	2.5 degree	12-hourly	1997-04-01 to 2007-06-30	Vtable.GFS
NCEP Final Analysis (GFS-FNL) ds083.2	1 degree	6-hourly	1999-07-30 to current	
NCEP GDAS Final Analysis ds083.3	0.25 degree	6-hourly	2015-07-08 to current	
NCEP GFS ds084.1	0.25 degree	3-hourly (for first 240 hrs) 12-hourly (hrs 240-384)	2015-01-15 to current	
NCEP/NCAR Reanalysis (NNRP) ds090.0	209 km	6-hourly	1948-01-01 to current	Vtable.NNRP
NCEP Climate Forecast System Reanalysis (CFSR) ds093.0	0.3, 0.5, 1.0, 1.9, & 2.5 degree	6-hourly	1979-01-01 to 2011-01-01	Vtable.CFSR_press_pg06

***Note:** The NOMADS site has several types of useful data: <http://nomads.ncdc.noaa.gov>

Download RDA Dataset Example

Step 3: Register, or sign-in (if you already have an account)

Hello Guest [Register Now](#) [Sign In](#) | [Forgot Password?](#)

NCAR | **Research Data Archive**
Computational & Information Systems Lab

NCAR is sponsored by National Science Foundation

[Go to Dataset:](#) nnn.n

[Home](#) [Find Data](#) [Ancillary Services](#) [About/Contact](#) [Data Citation](#) [Web Services](#) [Metrics](#) [For Staff](#)

NCEP GDAS/FNL 0.25 Degree Global Tropospheric Analyses and Forecast Grids
ds083.3 | DOI: 10.5065/D65Q4T4Z

For assistance, contact [Riley Conroy](#) (303 497-2467).

[Description](#) [Data Access](#) [Documentation](#) [Software](#) [Metrics](#)

Help with this page: [RDA dataset description page video tour](#)

Step 4: Click 'Data Access'

Step 5: Click 'Web File Listing' for the span of years you need

NCEP GDAS/FNL 0.25 Degree Global Tropospheric Analyses and Forecast Grids
ds083.3 | DOI: 10.5065/D65Q4T4Z ☆


For assistance, contact [Riley Conroy](#) (303 497-2467).

[Description](#) [Data Access](#) [Documentation](#) [Software](#) [Metrics](#)

Mouse over the table headings for detailed descriptions

Data File Downloads			Customizable Data Requests	Other Access Methods	NCAR-Only Access	
Web Server Holdings	Globus Transfer Service (GridFTP)	Data Format Conversion	Subsetting	THREDDS Data Server	Central File System (GLADE) Holdings	Tape Archive (HPSS) Holdings
Web File Listing	Request Globus Transfer	Get Converted Files	Get a Subset	TDS Access	GLADE File Listing	HPSS File Listing

Download RDA Dataset Example

**NCEP GDAS/FNL 0.25 Degree Global Tropospheric Analyses and Forecast Grids**
ds083.3 | DOI: 10.5065/D65Q4T4Z ☆
For assistance, contact [Riley Conroy](#) (303 497-2467).

[Description](#) [Data Access](#) [Documentation](#) [Software](#) [Metrics](#)

View listings of our Internet-accessible* data file holdings and download the files. You can download files one-by-one by clicking their links, or you can take advantage of the tools that we provide that will allow you to easily download many files. Your options are:

[Faceted Browse](#)
Interactively browse the Internet-accessible collection of data files and make selections to create a list of only the files you need. **Please note** that this is not a subsetting service. You will still receive whole

[Complete File List](#)
View a hierarchical listing of the full collection of data files

Step 6: Click 'Complete File List'

Step 7:
Choose the year

[Description](#) [Data Access](#) [Documentation](#)

[\[Web server holdings \]](#)

Group/Subgroup Summary

Group ID	Data Description
▼ Hide Detail Information	
NCEP-GDAS_FNL0P25	NCEP GDAS 0.25 Degree 0.25 Degree
2015	NCEP GDAS 0.25 Degree Final Analy
2016	NCEP GDAS 0.25 Degree Final Analy
2017	NCEP GDAS 0.25 Degree Final Analy
2018	NCEP GDAS 0.25 Degree Final Analy
2019	NCEP GDAS 0.25 Degree Final Analy
TOTAL	1/5 Group/Subgroups

[Description](#) [Data Access](#) [Doc](#)

[\[Web server holdings \]](#)

◀ 2019 — NCEP GDAS 0.25 Degree Fi

Subgroup Summary

Group ID	Data Description
2019-01	NCEP GDAS 0.25 Degree Final Analy
2019-02	NCEP GDAS 0.25 Degree Final Analy
2019-03	NCEP GDAS 0.25 Degree Final Analy
2019-04	NCEP GDAS 0.25 Degree Final Analy
2019-05	NCEP GDAS 0.25 Degree Final Analy
2019-06	NCEP GDAS 0.25 Degree Final Analy

Step 8: Choose the month



Download RDA Dataset Example

[Csh Download Script](#) [Python Download Script](#) [Jupyter notebook download Script](#) [?](#)

[Globus download](#) [What is Globus?](#)

- Total **496 Files (101.0G)** are listed below
- Click a file name to download a single file
- Select multiple files to download as a single tar file (limit 2 GB per download)
- Currently **3 Files (609.21M)** selected [Clear Selection](#)

[Scroll to **END** of the filelist]

<input type="checkbox"/> ?	INDEX	File Name↓↑	Size↓↑	Data Format	Date Archived↓↑
<input type="checkbox"/>	1	gdas1.fn10p25.2019050100.f00.grib2 i	176.0M	GRIB2	05/01/2019
<input type="checkbox"/>	2	gdas1.fn10p25.2019050100.f03.grib2 i	201.1M	GRIB2	05/01/2019
<input checked="" type="checkbox"/>	3	gdas1.fn10p25.2019050100.f06.grib2 i	208.1M	GRIB2	05/01/2019
<input checked="" type="checkbox"/>	4	gdas1.fn10p25.2019050100.f09.grib2 i	211.5M	GRIB2	05/01/2019
<input checked="" type="checkbox"/>	5	gdas1.fn10p25.2019050106.f00.grib2 i	189.5M	GRIB2	05/02/2019
<input type="checkbox"/>	6	gdas1.fn10p25.2019050106.f03.grib2 i	206.2M	GRIB2	05/02/2019
<input type="checkbox"/>	7	gdas1.fn10p25.2019050106.f06.grib2 i	211.0M	GRIB2	05/02/2019
<input type="checkbox"/>	8	gdas1.fn10p25.2019050106.f09.grib2 i	210.5M	GRIB2	05/02/2019

Step 8: Choose a box for each time span that you need

Step 9: Once you have chosen all your times, choose a method to download the files

External Data Sources: NOMADS

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

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA National Operational Model Archive & Distribution System

Data
[Access](#)
[Inventory](#)

Documentation
[User Guide](#)
[NCDC Model Data Pages](#)

NOMADS Project
[About NOMADS](#)
[Partners](#)
[Publications & Presentations](#)
[Service Records Retention System](#)
[Plans for the National Climate Model Portal](#)

Contact Us
[Contact Info](#)

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.

Update: 11.10.15
Website appearance changes.
We are upgrading our web appearance. [Click here](#) to view our new pages.

Important Notice: 12.17.15
Plot|FTP4U and offline ordering change.
Our offline ordering interface has transitioned from the Plot|FTP4U system to the [HAS website](#). Links to the HAS website for each product have been added to the NOMADS Data Access page. The Plot|FTP4U system is still available for online data.

DOC > NOAA > NESDIS > NCEI > NOMADS

[Protecting Your Privacy](#) [USA.gov](#) [Disclaimer](#)

NAM
GFS
RUC
CFS
NARR
R1/R2
SST



Utilities

- Grib and Intermediate Data
- Designing a model domain
- netCDF tools
- Other Utilities
- ImageMagick
- Special WRF Output Variables
- OBSGRID
- MET

GRIB Data Handling

■ Documents

- <https://rda.ucar.edu/index.html#gribdoc> (GRIB1 data)
- <https://rda.ucar.edu/index.html#grib2doc> (GRIB2 data)

■ Decoders

- *wgrib, wgrib2, unpackgrib2.c, grib2to1.c*
<http://rda.ucar.edu/#!/GRIB>
<http://www.cpc.ncep.noaa.gov/products/wesley/wgrib.html>
<http://www.cpc.ncep.noaa.gov/products/wesley/wgrib2>
- *g1print.exe and g2print.exe*
 - Show data available in GRIB1 and GRIB2 files
 - Available from util/ directory in WPS

GRIB Data Handling (cont'd)

- **grib2ctl.pl**

- Create .ctl and .idx files, so that you can plot GRIB files with GrADS
- <http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html>

- **ncl_convert2nc**

- Converts from grib format to netcdf format
- http://www.ncl.ucar.edu/Document/Tools/ncl_convert2nc.shtml

Writing Intermediate File Format

http://www2.ucar.edu/wrf/users/docs/user_guide_V4/v4.0/users_guide_chap3.html#_Writing_Meteorological_Data

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_wrtie_int(IM_name, FIELD, UNITS, DESC, VAR(:, :), opt)

Fortran script to convert netCDF to Intermediate format:

http://www2.mmm.ucar.edu/wrf/users/special_code.html



Reading Intermediate Format Files

NCL Code

▪ wrf_wps_read_int

! opens file

```
istatus = wrf_wps_open_int(filename)
```

! reads header

```
wrf_wps_rdhead_int(istatus,head_real,field,hdate,\
```

```
units,map_source,desc)
```

! reads slab

```
Slab = wrf_wps_rddata_int(istatus,nx,ny)
```

! Loop until reaching the end of the file

Found in WPS/util/

▪ rd_intermediate.exe

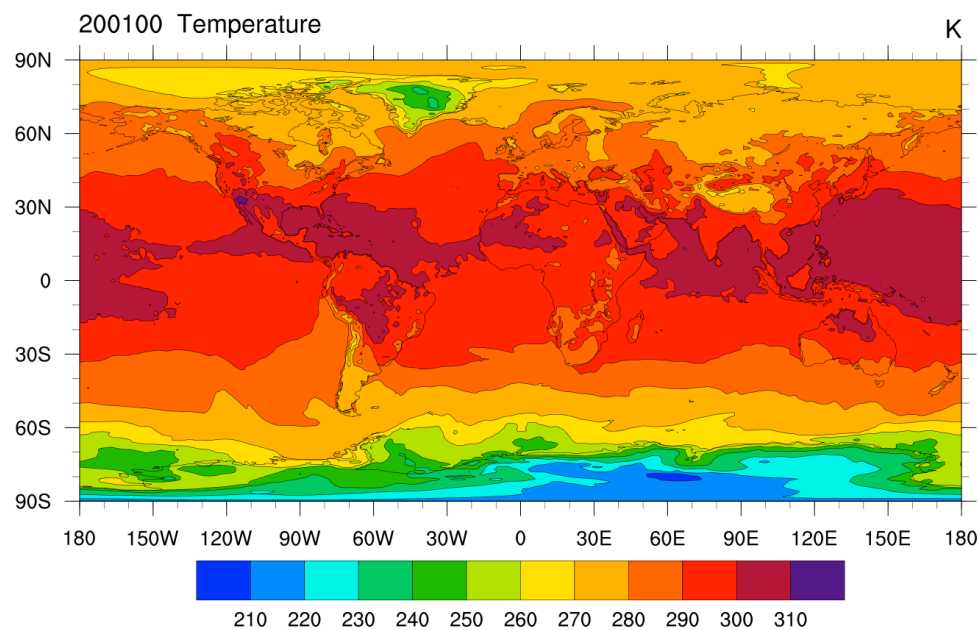
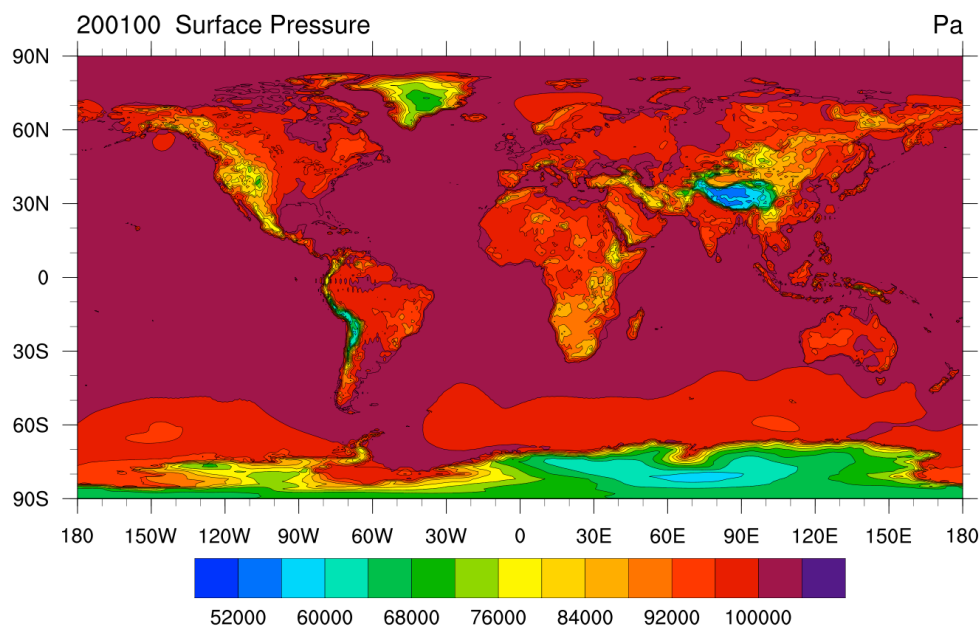
```
=====
FIELD = TT
UNITS = K DESCRIPTION = TEMPERATURE
DATE = 2000-01-24_12:00:00 FCST = 0.000000
SOURCE = unknown model from NCEP GRID 212
LEVEL = 200100.000000
I,J DIMS = 185, 129
IPROJ = 1
    REF_X, REF_Y = 1.000000, 1.000000
    REF_LAT, REF_LON = 12.190000, -133.459000
    DX, DY = 40.635250,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

Plot intermediate files

Utility: plotfmt

- The plotfmt program plots the fields in the ungribbed intermediate files

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



Found in WPS/util/

Plot Intermediate Files in netCDF Format

Use the utility **int2nc.exe**

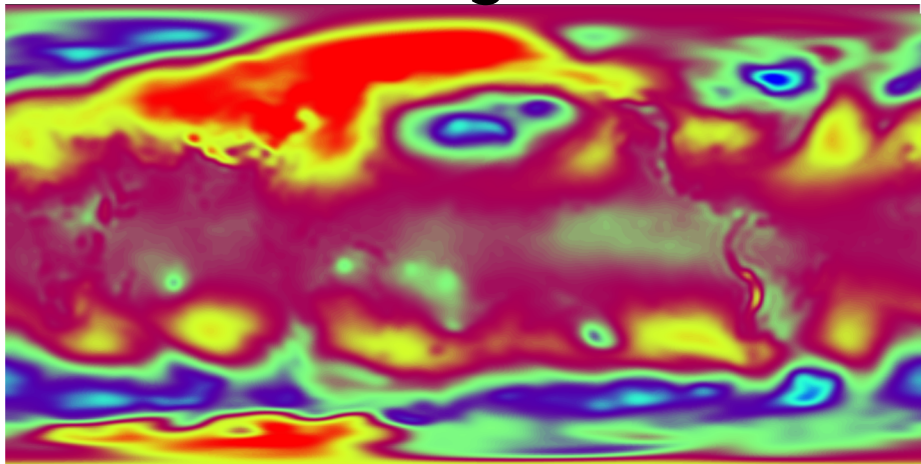
- Converts intermediate files created by **ungrib.exe** to netCDF format

```
> ./int2nc.exe FILE:yyyy-mm-dd_hh
```

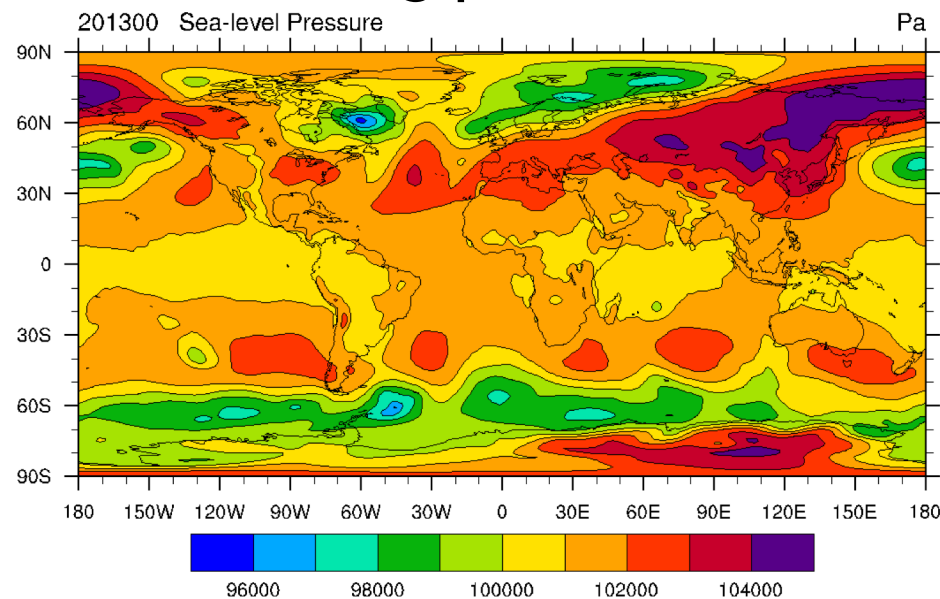
To plot: **plotfmt_nc.ncl**

```
> ncl plotfmt_nc.ncl 'inputFILE="FNL:YYYY-MM-DD_HH.nc"'
```

Plot Using **ncview**



Plot Using **plotfmt_nc.ncl**



***Both are found in WPS/util/**

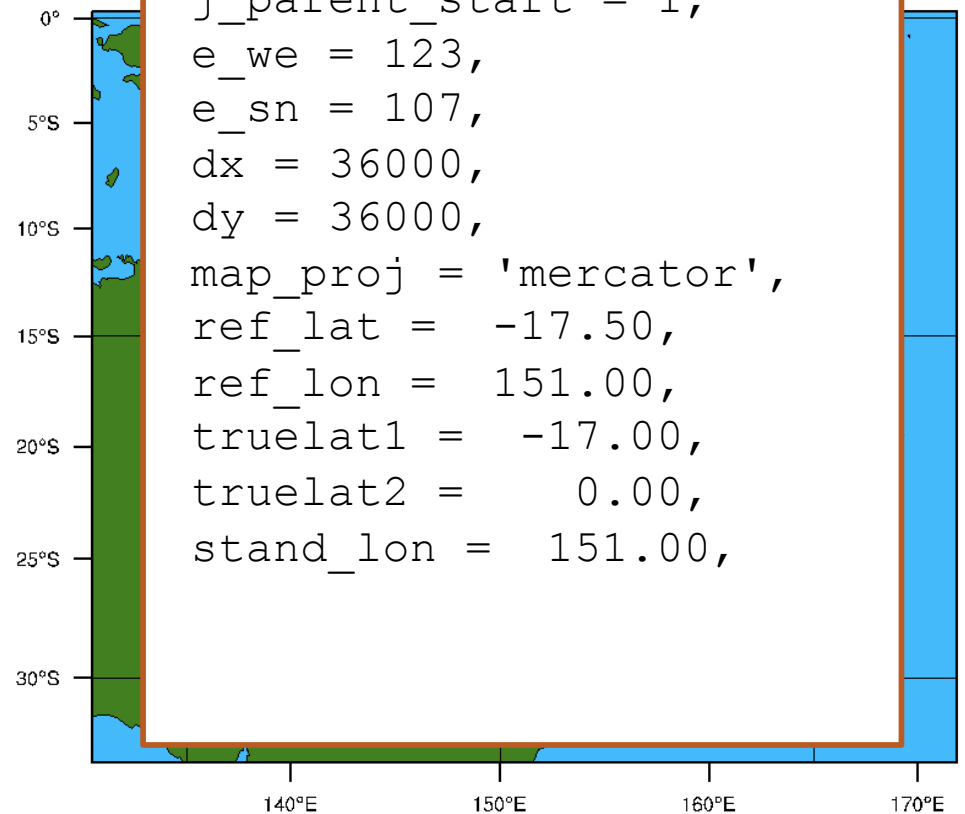
Model Domain Design

```
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 /)
```

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,
```



http://www2.mmm.ucar.edu/wrf/users/special_code.html

netCDF Tools

NCO Tools

<http://nco.sourceforge.net>

netCDF Operators:

- command-line programs
- take netCDF input -> perform operation -> output in various formats (text, binary, netCDF, etc.)

Examples:

- **ncdiff**
 - Shows the differences between 2 files
> `ncdiff input1.nc input2.nc diff.nc`
- **ncrcat** (nc cat)
 - Writes specified variables & times to a new file
> `ncrcat -d Time,0,231 -v RAINNC wrfout* RAINNC.nc`
 - Concatenates files
> `ncrcat file1.nc file2.nc combined.nc`
- **ncra** (nc average)
 - Averages variables in files and writes to a new file
> `ncra -v T2 file1.nc file2.nc -o T2.nc`
> `ncra -v T2 wrfout* -o T2.nc`

NCO Tools (continued)

<http://nco.sourceforge.net>

- **ncrename**

- Renames variables, dimensions, attributes

```
ncrename -v LANDUSE, LAND -a missing_value, _FillValue  
file.nc
```

- **ncks** (nc kitchen sink)

- Combination of several NCO tools to allow cutting/pasting subsets of data into a new file

- Extracting a specific variable

```
ncks -v RAINNC wrfout_d01_2015-06-01_00:00:00 RAINNC.nc
```

- Splitting files

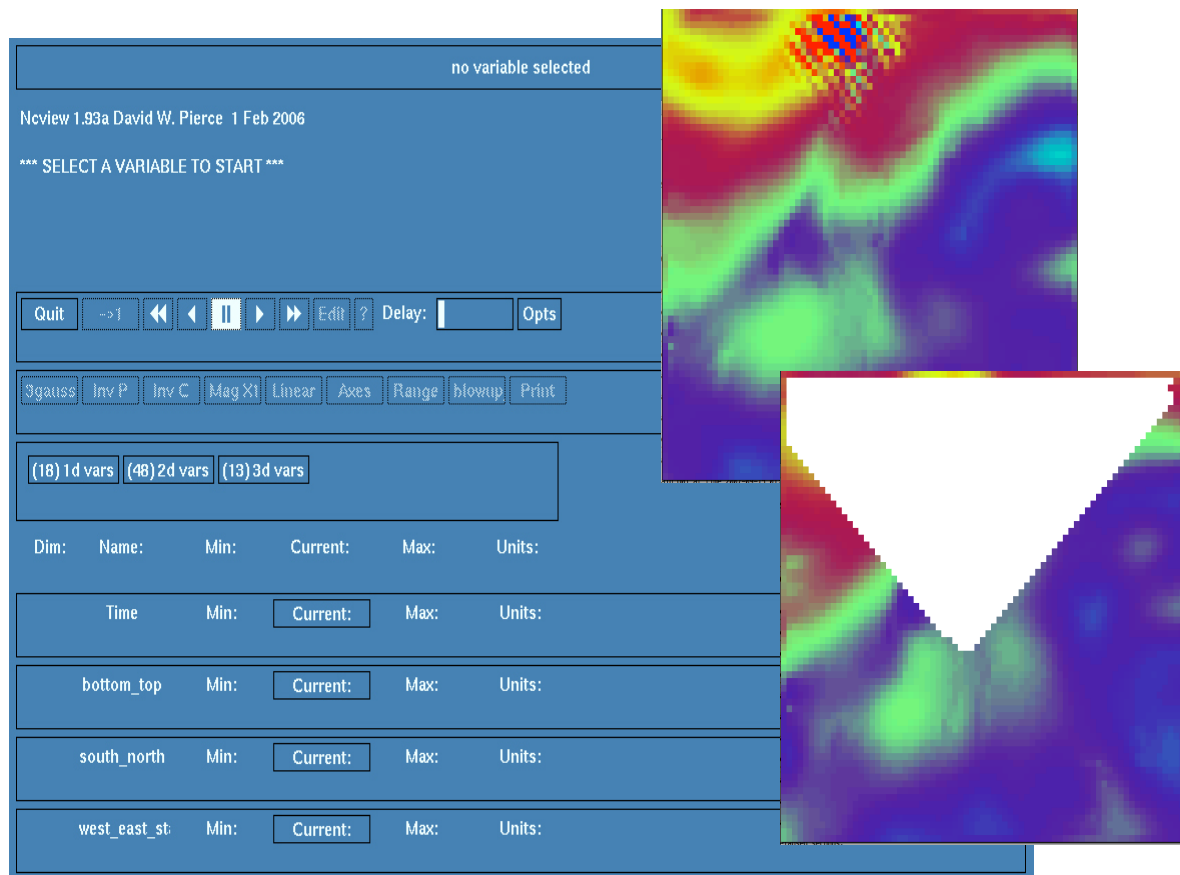
```
ncks -d Time, 1, 1 wrfout_d01_2015-06-01_00:00:00 -o  
wrfout1.nc
```

NC0 Tools: Other Available Operators

- **ncap2:** arithmetic processor
- **ncatted:** ATtribute editor
- **ncbo:** binary operator (includes ncadd, ncsubtract, ncmultiply, ncdivide)
- **ncea:** ensemble averager
- **ncecat:** ensemble conCATenator
- **ncflint:** FiLe INTerpolator
- **ncpdq:** permute dimensions quickly, pack data quietly
- **ncwa:** weighted averager

ncview

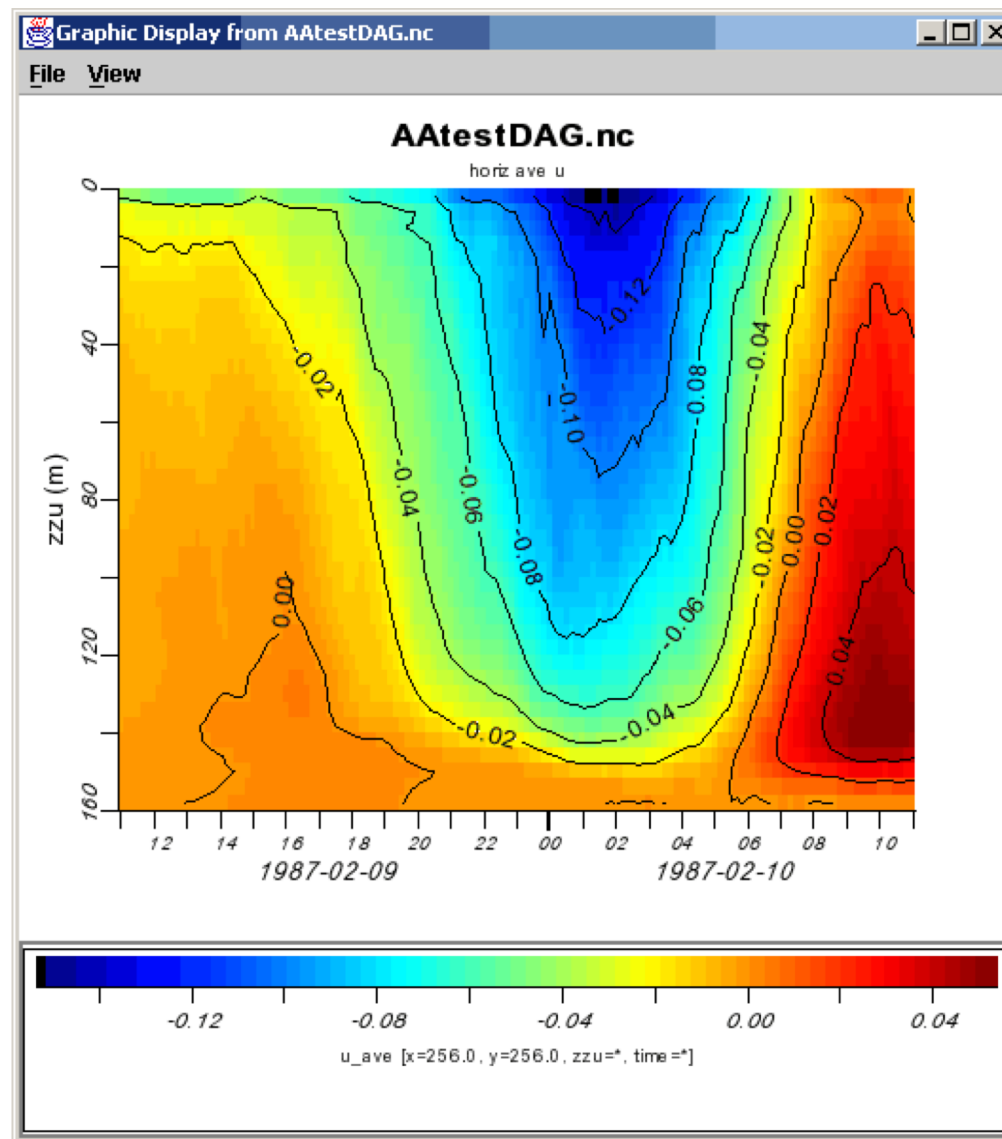
http://meteora.ucsd.edu/~pierce/ncview_home_page.html



- Graphical interface that allows quick viewing of netCDF files
 - All variables found in file
 - Detect where things go wrong
- Other options
 - Time series
 - Vertical Cross Section
- Any netCDF format file:
 - geo_em.d0*
 - met_em.d0*
 - wrfinput_d0*
 - wrfout.d0*
 - wrfst.d0*

ncBrowse

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



ncdump

- Reads a netCDF dataset and prints information from that dataset
- **ncdump -h *file***
 - Prints header (inclusive list of variables in the file)
- **ncdump -v *VAR file***
 - Prints specific data for the variable 'VAR'
- **ncdump -v *Times file***
 - Prints the times that are included in the file

ncdump -v Times *file*

```
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"
```

Other Utilities

- Additional WRF utilities
 - `read_wrf_nc`: reads WRF netCDF file, outputs various data
 - `iowrf`: extracts a box from WRF netCDF files, thin or destagger data
 - `wrf_interp`: interpolates WRF output files to pressure, height-agl, height-msl, potential temp, and equivalent potential temp, and can perform underground extrapolation
 - `p_interp`: converts wrfout data (from sigma levels) to pressure levels
 - `v_interp`: adds vertical levels in WRF input and boundary files
 - `diffwrf`: performs several functions, including making comparisons of two WRF files (available in WRF/external/io_netcdf/)
 - For more details on the above utilities, see:
<http://www2.mmm.ucar.edu/wrf/users/utilities/util.htm>
- To download utilities:
http://www2.mmm.ucar.edu/wrf/users/download/get_sources.html

ImageMagick

<http://www.imagemagick.org>

- Converts graphical files from one format to another
 - convert file.pdf file.png*
 - convert file.png file.bmp*
- Many options available
 - Rotate frames, trim white space, etc.
 - 2 ways to use
 - 1) *display plot.png*
 - 2) *Convert -trim +repage -background white -flatten plot.pdf plot.png*
- Can make movies
 - Can create individual frames for each image
- Maintains high resolution - great for publishing!
- Cannot deal with .ncgm files

Special WRF Output Variables

- The WRF model outputs the state variables defined in the Registry file, and these state variables are used in the model's prognostic equations. Some of these variables are perturbation fields and therefore, the following definitions for reconstructing meteorological variables are necessary:

Total geopotential	$PH + PHB$
Total geopotential height in m	$(PH + PHB) / 9.81$
Total potential temp in K	$T + 300$
Total pressure in mb	$(P + PB) * 0.01$
Wind components, grid relative	U, V
Surface pressure in Pa	Psfc
Surface winds, grid relative	U10, V10 (valid at mass points)
Surface temp and mixing ratio	T2, Q2

See [WRF/Registry/Registry.EM_COMMON](#) for description of variables

OBSGRID

OBSGRID

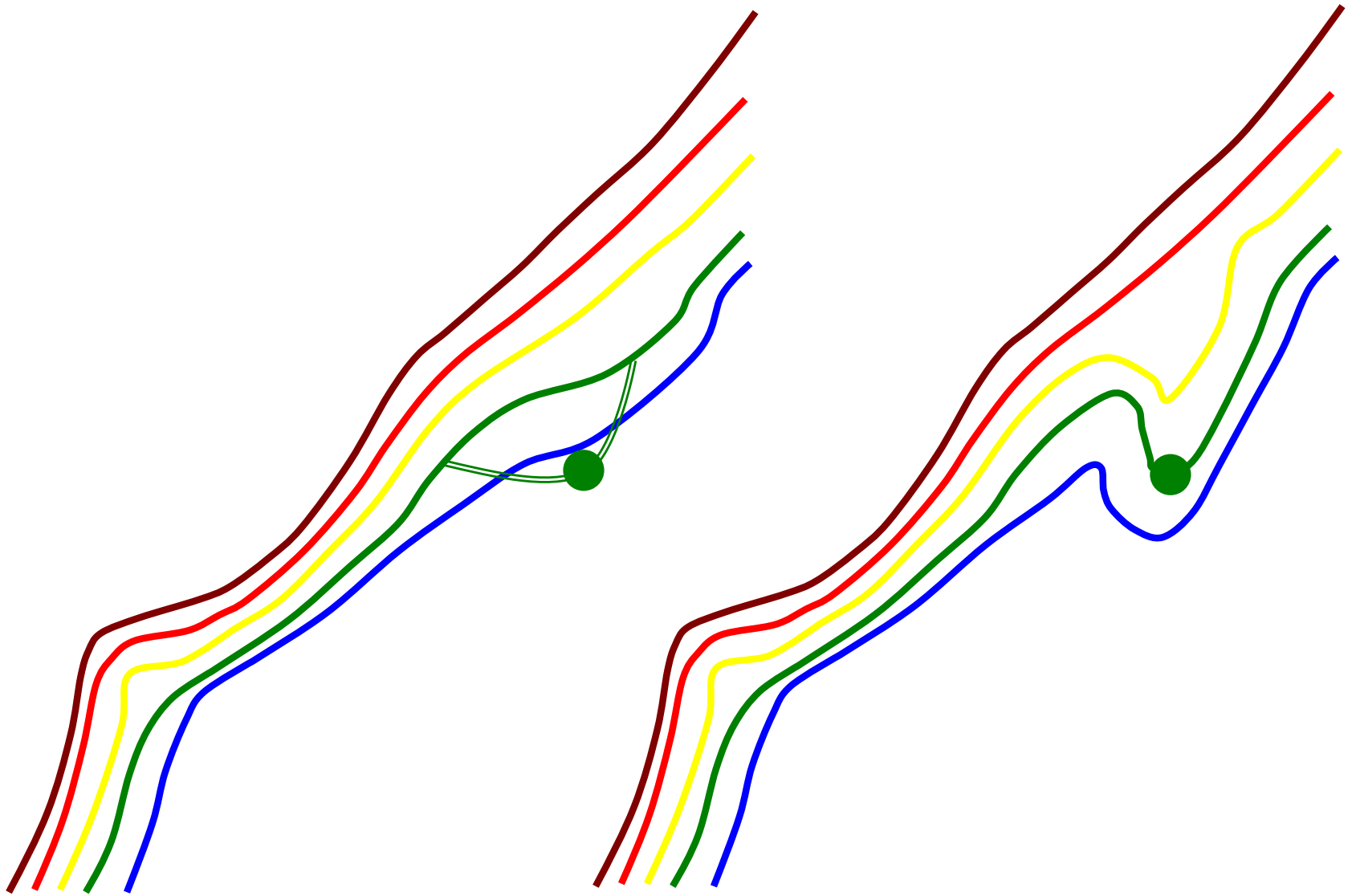
To improve a first-guess gridded analysis by incorporating additional observational information

- Traditionally first-guess analysis came from low-resolution global analysis and forecast grids
- These days, higher-resolution, regional scale analyses are more readily available

When is this method useful?

- When using very coarse resolution first-guess input data
- If you conducted a field campaign and have acquired very high-resolution station data (for example)

OBSGRID: Basic Concept



OBSGRID: How to Run

- Get the source code

<http://www2.mmm.ucar.edu/wrf/users/downloads.html>

- Compile (serially)
- Prepare observation files
- Edit the namelist.oa
- Link in met_em* files from WPS
- Run the program
 - ./obsgrid.exe
- Check your output

See the WRF Users' Guide for detailed information:

http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V4/v4.0/users_guide_chap7.htm

OBSGRID: Output

- **metoa_em***

- Final analysis files at sfc and pressure levels
- Can be used to replace met_em* files during real.exe for analysis nudging

- **wrfsfdda_d0***

- Contains sfc analyses for T, TH, U, V, RH, QV, PSFC, PMSL, and a count of obs within 250 km of each grid point
- Use as input for surface analysis nudging (in &fdda section of namelist, set grid_fdda = 1 and **grid_sfdda = 1**)

- **OBS_DOMAIN*01** (e.g., OBS_DOMAIN101, OBS_DOMAIN103)

- Contain list of all observations available to OBSGRID program
- User has option to set values > a specified value to “missing”
- Used during WRF for observational nudging
- Must all be concatenated into a single file (OBS_DOMAIN101)
 - Use ‘run_cat_obs_files.csh’ to do this

OBSGRID: Output (continued)

- **qc_obs_raw.d01.YYYY-MM-DD_HH:mm:ss.tttt(.nc)**
 - Similar to OBS_DOMAINXXX, but raw data, and output is in either ASCII or netCDF format
 - ASCII file can be used as input to plotting utility “plot_sounding.exe”
 - NetCDF file can be used to plot both station & sounding data
- **qc_obs_used.d01.YYYY-MM-DD_HH:mm:ss.tttt(.nc)**
 - Same as above (can be used in the same way), but identical data to OBS_DOMAIN*01 files
- **qc_obs_used_earth_relative.d01.YYYY-MM-DD_HH:mm:ss.tttt(.nc)**
 - Identical to above, but winds are in an earth-relative framework, rather than model-relative
 - The non-netCDF version can be used as input to MET verification software
- **plotobs_out.d01.YYYY-MM-DD_HH:mm:ss.tttt**
 - Lists data by variable and by level
 - Each observation used for objective analysis is grouped with all associated observations for plotting or other diagnostic purposes

OBSGRID: Plot Utilities

- **sounding.ncl (found in util/)**
 - Generates & plots soundings from qc_obs_raw* and qc_obs_used*
- **station.ncl (found in util/)**
 - creates station plots for each analysis level

MET Verification Software

- Model Evaluation Tools (MET)
- Provides all the basics (e.g., RMSE, bias, skill scores)
- Provides
 - Advanced spatial methods (wavelets, objects)
 - Confidence intervals
- Download it
<http://www.dtcenter.org/met/users/downloads/>
- Support
met_help@ucar.edu
- Documentation
<http://www.dtcenter.org/met/users/docs/overview.php>

Post-processing

- Supported Packages
- ARWpost
- RIP4

Supported Post-processing Packages

http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3/contents.html

Package	Users' Guide Page #	Information
NCL	9-2	Graphical package supported by NCAR/CISL (http://forum.mmm.ucar.edu/ and ncl-talk@ucar.edu)
ARWpost	9-29	Converter (GrADS); ARWpost supported by wrfhelp: http://forum.mmm.ucar.edu/
RIP4	9-20	Converter and interface to graphical package, NCAR graphics, supported by wrfhelp: http://forum.mmm.ucar.edu/)
UPP	9-36	Converter (GrADS & GEMPAK) (upp-help@ucar.edu)
VAPOR	9-38	Converter and graphical package Supported by VAPOR (vapor@ucar.edu)
IDV	None - see unidata.ucar.edu	GRIB (from UPP) GEMPAK (from wrf2gem) Vis5d CF compliant data (from wrf_to_cf) Supported by unidata (support@unidata.ucar.edu)
GEMPAK	None - see: unidata.ucar.edu/software/ gempak	Data from wrf2gem or UPP Supported by unidata (support@unidata.ucar.edu)

Choosing the Right Tool

- Can it read your data?
- Will you need to pre-process the data first?
- Is it purely a visualization tool, or does it include post-processing?
- Can it handle big datasets?
- Which diagnostic/statistical functions does it have?
- How easy is it to add diagnostics?
- 3D or 2D visualization?
- Can it handle staggered grids?
- How is data below the ground handled?
- Vertical grids?
- How are model time stamps handled?
- Easy to use?
- Cost of package?
- How well supported is it?

Data Handling

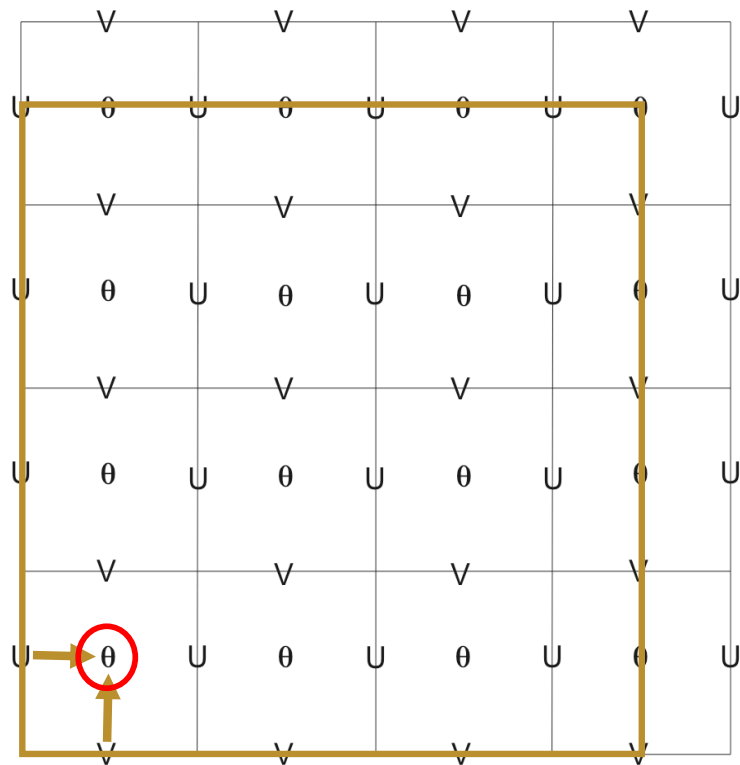
	NCL	RIP4	GrADS	UPP	VAPOR	IDV
netCDF		ripdp	ARWpost	converter	converter	converter
GRIB						
ASCII						
shapefiles						
geogrid & metgrid output						
intermediate file format	V6.2.0 V6.3.0					
wrfinput data						
Idealized data						
wrfoutput						
big data						

Post-processing

	NCL	RIP4	GrADS	UPP	VAPOR	IDV
Post-processing						
Data output						
3D						
diagnostics	some	a lot	some	some	limited	limited
Add diagnostics	Very easy	easy	easy	Relatively easy	Not as easy	Not as easy
Vertical output Coordinate	Model pressure height	Model pressure height	Model pressure height	pressure	model	model
Extrapolate Below ground						

Model Staggering

Why is a converter necessary if a package can display netCDF files?



WRF
staggered
grid

- 1) Converter co-locates data to mass points
- 2) Converter translates variables
- e.g., “T” is not really temp.
Must add 300 for actual temp (K)

ARWpost

ARWpost: General Information

Converter that generates graphical plots

- Reads in wrf-arw model data, creates GrADS output files
- Requires GrADS to display

GrADS software is only needed to display data, not needed to compile the code

- <http://www.iges.org/grads/grads.html>

Download Code

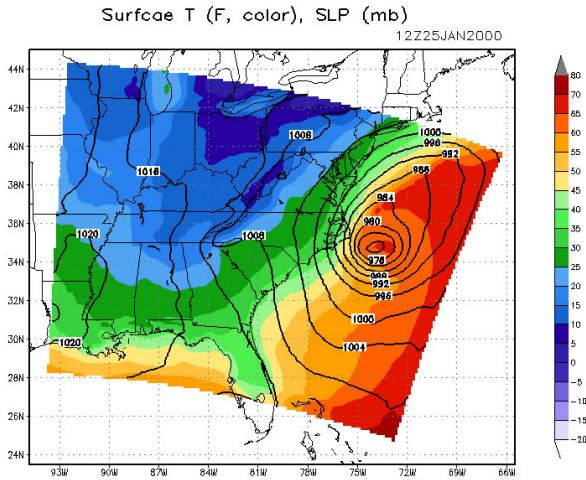
- http://www2.mmm.ucar.edu/wrf/users/download/get_sources.html

Online Tutorial

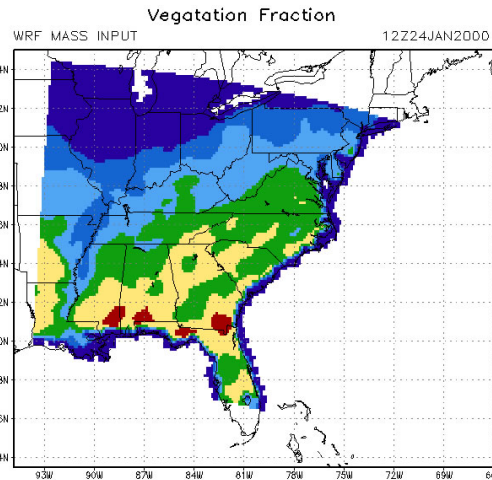
- <http://www2.mmm.ucar.edu/wrf/OnLineTutorial/Graphics/ARWpost/index.php>

ARWpost: Example Plots

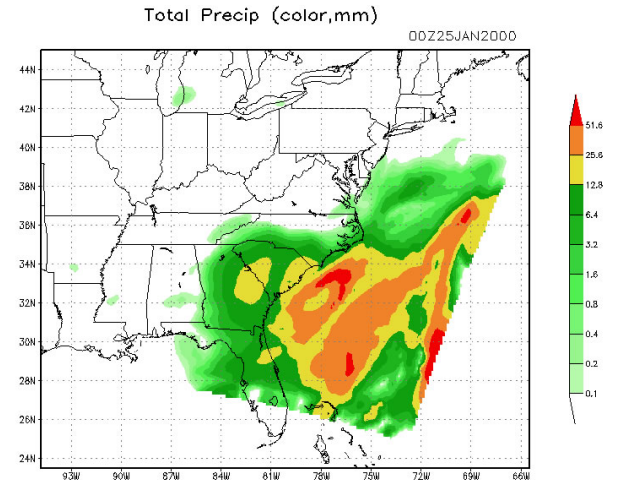
Surface Temp



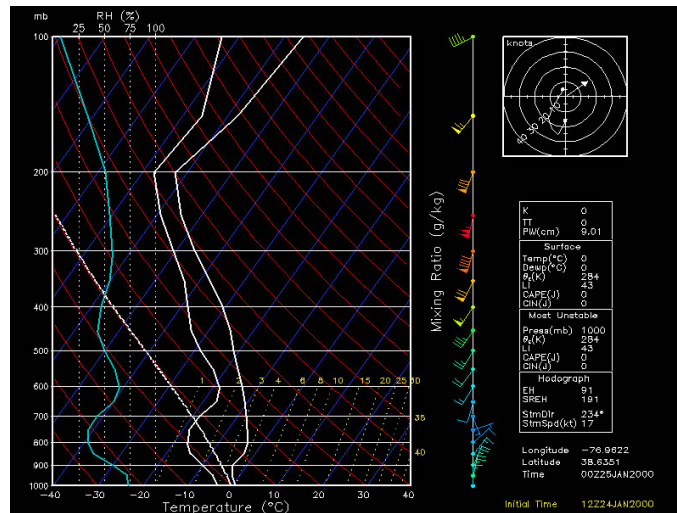
Vegetation Fraction



Total Precipitation

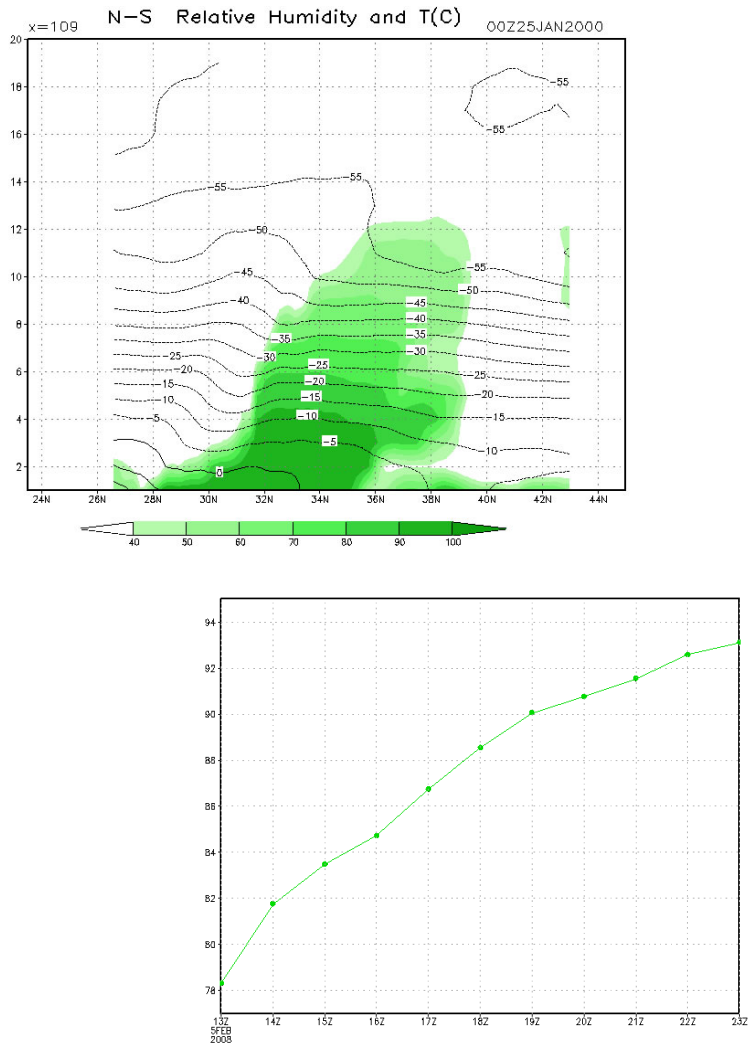


Skew-T Diagram

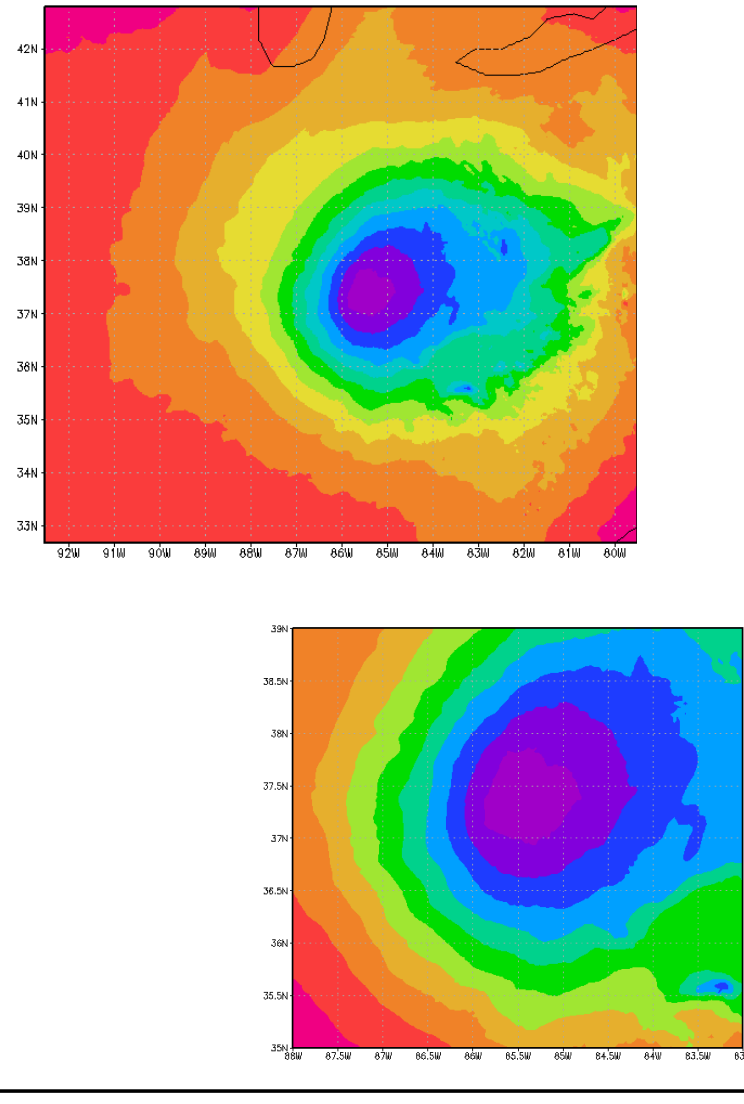


ARWpost: Example Functions

Cross-Sections



Zooming



ARWpost: Diagnostics

- cape - 3d cape
- cin - 3d cin
- mcape - maximum cape
- mcin - minimum cin
- clfr - low/middle/high cloud fraction
- dbz - 3d reflectivity
- max_dbz - maximum reflectivity
- geopt - geopotential
- height - model height in km
- lcl - lifting condensation level
- lfc - level of free convection
- pressure - full model pressure in hPa
- rh - relative humidity
- rh2 - 2 m relative humidity
- theta - potential temperature
- tc - temperature in degrees C
- tk - temperature in degrees K
- td - dew point temperature in degrees C
- td2 - 2m dew point temperature in degrees C
- slp - sea level pressure
- umet & vmet - winds rotated to Earth coordinates
- u10m & v10m - 10 m winds rotated to Earth coordinates
- wdir - wind direction
- wspd - wind speed coordinates
- wd10 - 10 m wind direction
- ws10 - 10 m wind speed

ARWpost: Scripts

Script Name	Description
cbar.gs	Plots a color bar on shaded plots
rgbset.gs	Allows you to add/change colors from color # 20 - 99
skew.gs	Program to plot a skewT
plot_all.gs	Automatically finds all .ctl files in the directory and lists them so the user can pick when to use, will plot all fields chosen
rain.gs (real data only)	Plots total rainfall (must have data that contain fields RAINC and RAINNC)
cross_z.gs (real data only)	Plots a NS and EW cross section of RH and T (C)

RIP

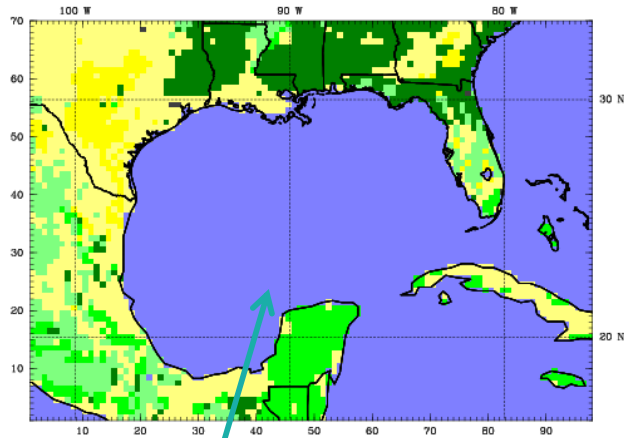
(Read, Interpolate, Plot)

RIP4: General Information

- Requires NCAR Graphics Libraries
 - <http://www.ncl.ucar.edu>
- Source Code
 - http://www2.mmm.ucar.edu/wrf/users/download/get_source.html
- Documentation
 - Included in program's tar file (in Doc/ directory)
 - <http://www2.mmm.ucar.edu/wrf/users/docs/ripug.htm>
- Online Tutorial
 - <http://www2.mmm.ucar.edu/wrf/OnLineTutorial/Graphics/RIP4/index.php>

RIP4: Example Plots

Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
Fcst: 0.00 h Valid: 0000 UTC Sun 28 Aug 05 (1800 MDT Sat 27 Aug 05)
Land use category



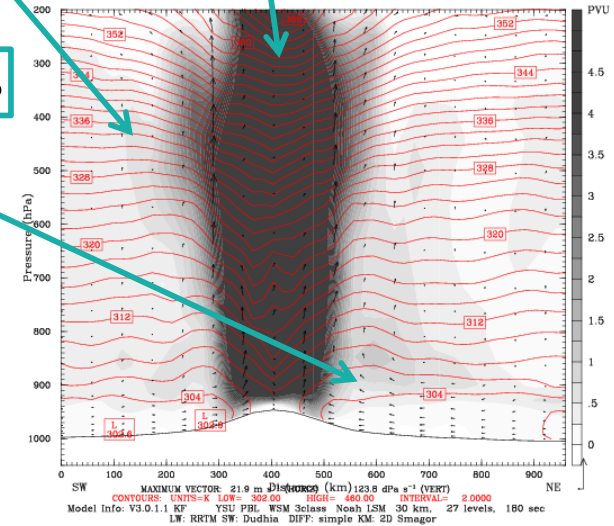
Landuse Category

Potential Temp

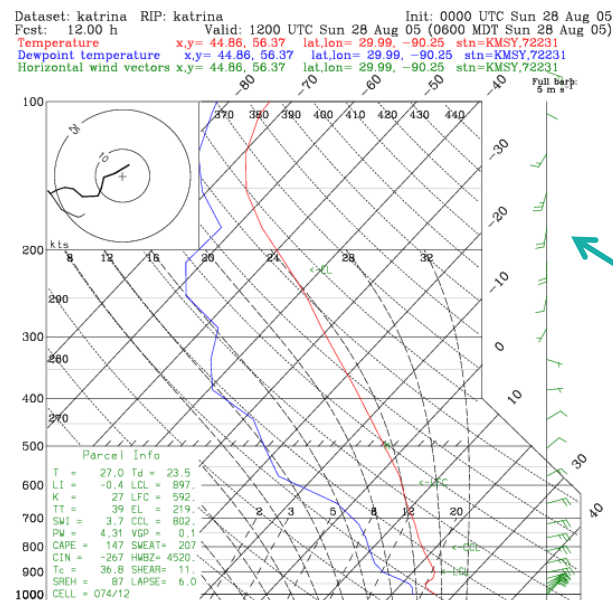
Potential Vorticity

Circulation Vectors

Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
Fcst: 12.00 h Valid: 1200 UTC Sun 28 Aug 05 (0600 MDT Sun 28 Aug 05)
Potential vorticity XY: 45.0, 30.0 to 70.0, 50.0
Potential temperature XY: 45.0, 30.0 to 70.0, 50.0
Circulation vectors XY: 45.0, 30.0 to 70.0, 50.0



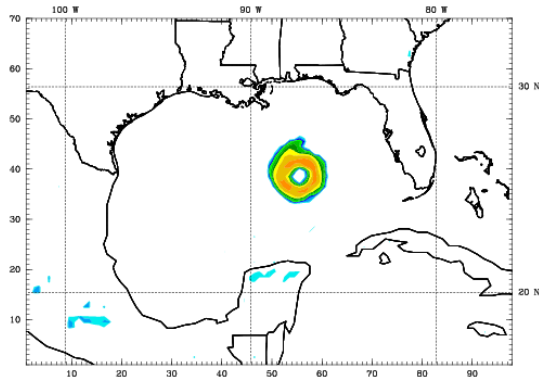
Skew-T Diagram



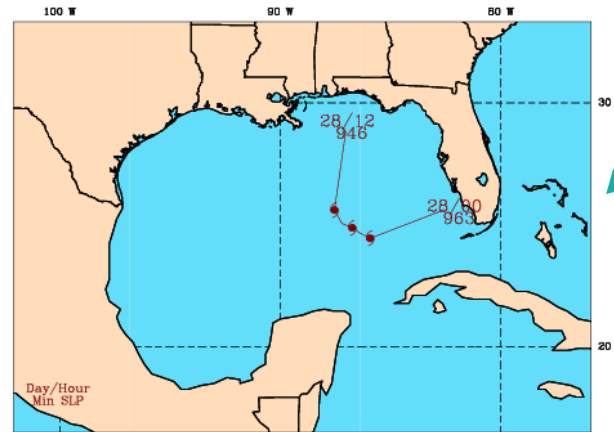
RIP4: Example Plots

Dataset: katrina RIP: typhoon Init: 0000 UTC Sun 28 Aug 05
 Fcst: 0.00 h Valid: 0000 UTC Sun 28 Aug 05 (1800 MDT Sat 27 Aug 05)
 Typhoon Track

Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
 Fcst: 12.00 h Valid: 1200 UTC Sun 28 Aug 05 (0600 MDT Sun 28 Aug 05)
 Reflectivity () at k-index = 27



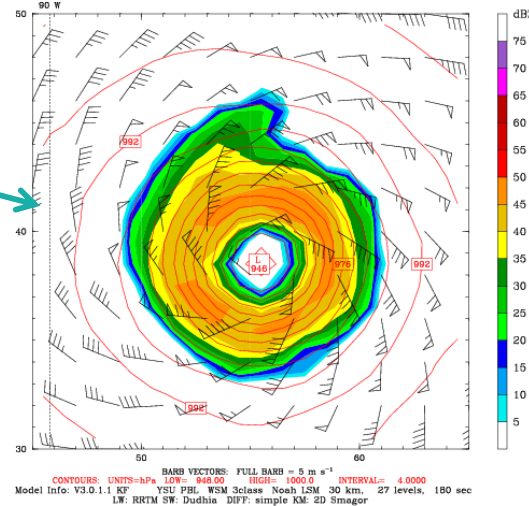
Model Info: V3.0.1.1 KF YSU PBL WSM 3class Noah LSM 30 km, 27 levels, 180 sec
 LW: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor



Cyclone Tracking

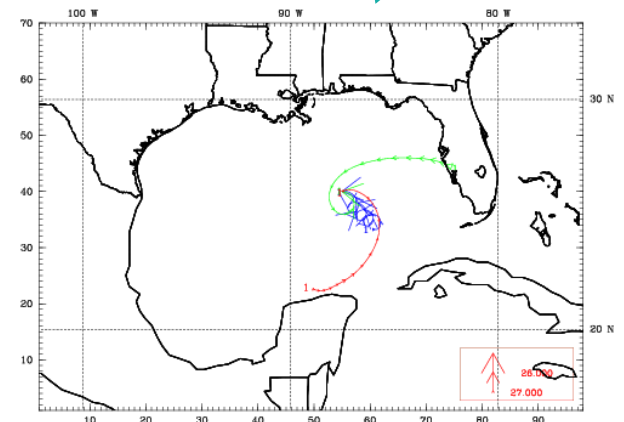
Trajectories

Dataset: katrina RIP: zoom Init: 0000 UTC Sun 28 Aug 05
 Fcst: 12.00 h Valid: 1200 UTC Sun 28 Aug 05 (0600 MDT Sun 28 Aug 05)
 Reflectivity () at k-index = 27
 Sea-level pressure
 Horizontal wind vectors

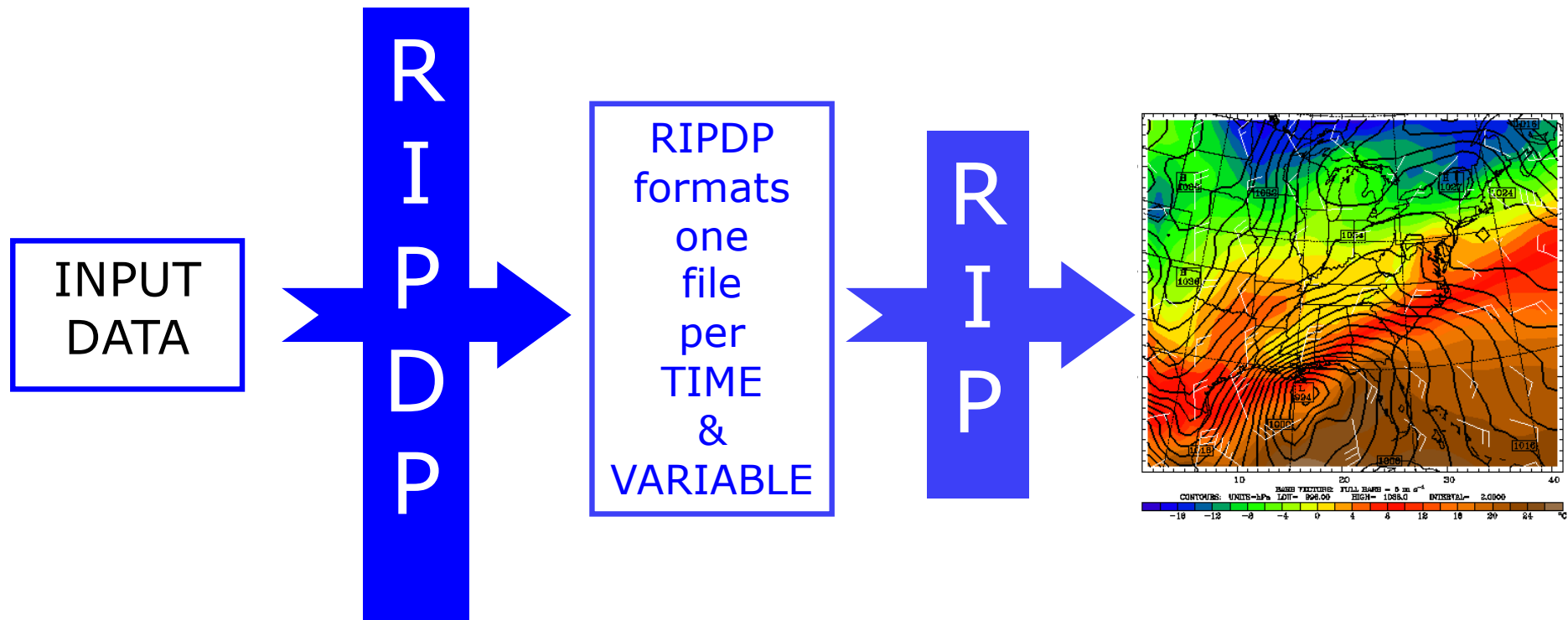


Zooming Capability

Dataset: katrina RIP: traj plot Init: 0000 UTC Sun 28 Aug 05
 Fcst: 0.00 h Valid: 0000 UTC Sun 28 Aug 05 (1800 MDT Sat 27 Aug 05)
 Trajectories from hour 0.000 to 12.000
 Trajectories from hour 0.000 to 12.000
 Trajectories from hour 0.000 to 12.000



RIP4: Program Flow



RIP4: Namelist (*&userin*)

- Use namelist to control
 - processing times, intervals, title information, text quality on a plot
 - whether to do time series, trajectory, or to write output for Vis5D
 - *Full explanation for namelist variables is available in the user document*
- **ptimes, ptimeunits** - times to process
- **tacc** - tolerance for processing data
- **iusedaylightrule** - 1 applied, 0 not applied
- **idotser** - generate time series output
- **icgmsplit** - split metacode into several files
- **itrajcalc** - 0, 1 ONLY when doing trajectory calculations
- **rip_root** - override RIP_ROOT
- **ncarg_root** - output type: X11, cgm, pdf, ps

Questions?