WRF Data, Utilities & Post-processing

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July 2018

Input Data

Input Data: Mandatory Fields

- **3D Data**
  - Temperature
  - U and V components of wind
  - Geopotential height
  - Relative Humidity (or Specific Humidity)
- **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

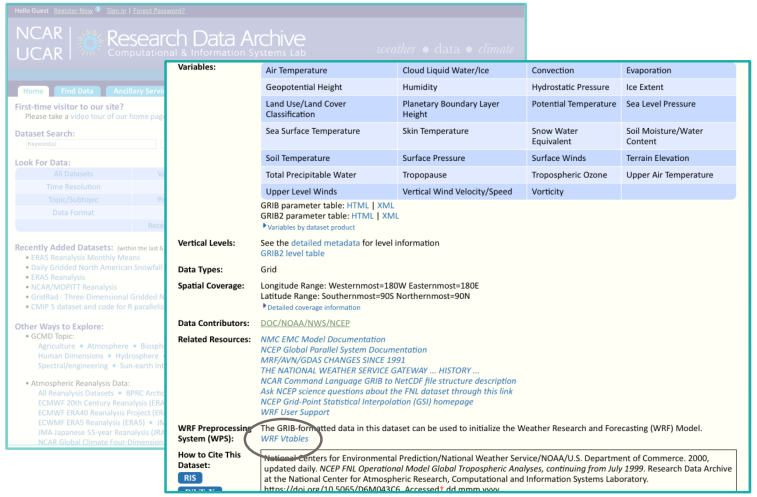
External Data Sources: Climate

Name	Resolution	Coverage	Temporal Availability	Website
NCEP Climate Forecast System Reanalysis (CFSR)	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

External Data Sources: RDA

http://rda.ucar.edu

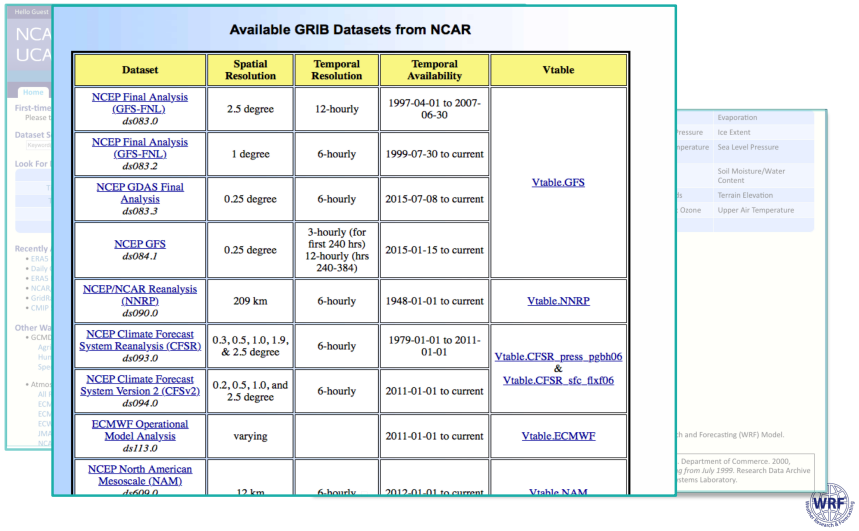
External Data Sources: RDA



https://rda.ucar.edu/datasets/ds083.2/

External Data Sources: RDA

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

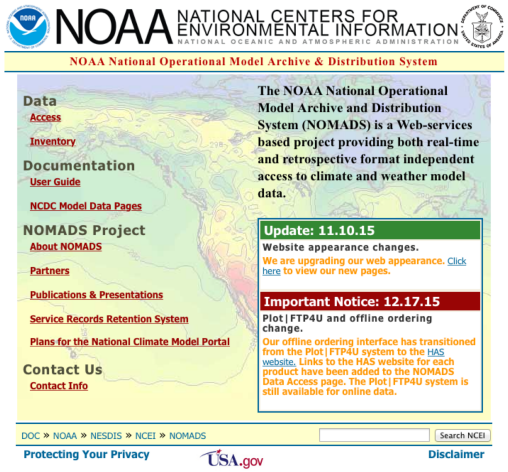


Available GRIB Datasets from NCAR

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_pgbh06 & Vtable.CFSR_sfc_flxf06
NCEP Climate Forecast System Version 2 (CFSv2) *ds094.0*	0.2, 0.5, 1.0, and 2.5 degree	6-hourly	2011-01-01 to current	
ECMWF Operational Model Analysis *ds113.0*	varying		2011-01-01 to current	Vtable.ECMWF
NCEP North American Mesoscale (NAM) *ds609.0*	12 km	6-hourly	2012-01-01 to current	Vtable.NAM

External Data Sources: NOMADS

http://nomads.ncdc.noaa.gov



- 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/

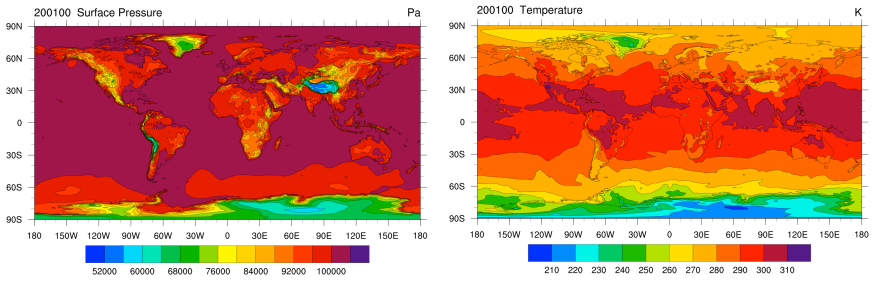
- **rd_intermediate**

```
=========================================
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 ungribbed intermediate files

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



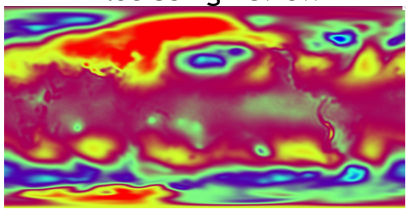
Found in WPS/util/

Plot Intermediate Files in netCDF Format

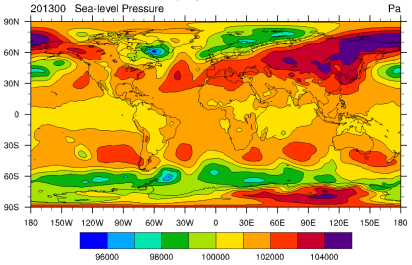
- Use the utility **int2nc.exe**
  - Converts intermediate files created by ungrib.exe to netcdf format
  - `./int2nc.exe FILE:yyyy-mm-dd_hh`
- To plot: **plotfmt_nc.ncl**

```
ncl plotfmt_nc.ncl 'inputFILE="FNL:2007-09-15_00.nc"'
```

Plot Using ncview



Plot Using plotfmt_nc.ncl



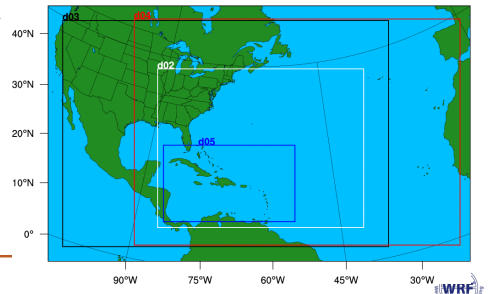
***Both are found in WPS/util/**

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)
```

- plotgrids.ncl
  - *WPS/util/plotgrids.ncl*
  - Reads namelist information to generate plot
  - X11, png, pdf

Test Domain

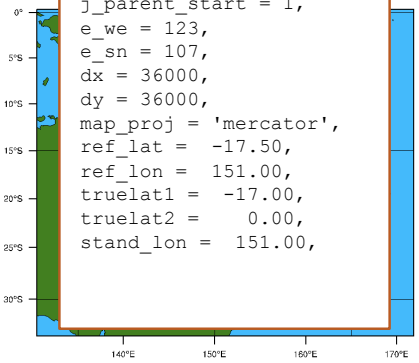


Model Domain Design

```
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 are command-line programs that take netCDF (HDF and/or DAP) files as input, then operate (e.g., derive new data, compute stats, print, manipulate metadata) and output to the screen or files in various formats (text, binary, netCDF, etc.)

- 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, or concatenates files

```
ncrcat -d file1.nc file2.nc combined.nc
ncrcat -d Time,0,231 -v RAINNC wrfout* RAINNC.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

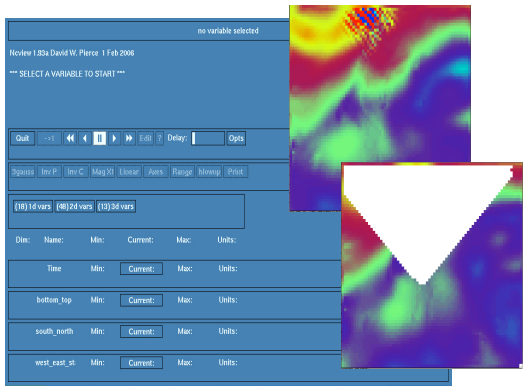
```
ncks -d Time,1,1 wrfout -o wrfout1.nc
```

NCO 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

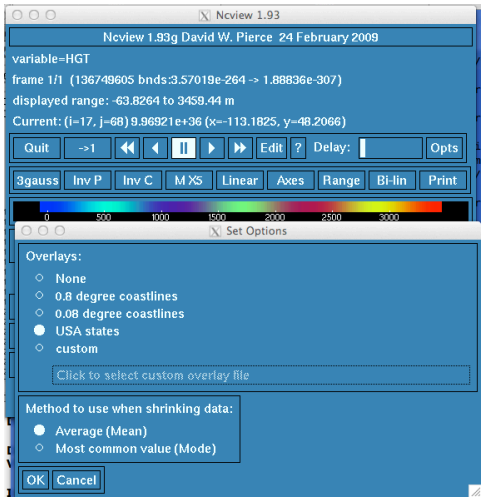
http://meteora.ucsd.edu/~pierce/ncview_home_page.html

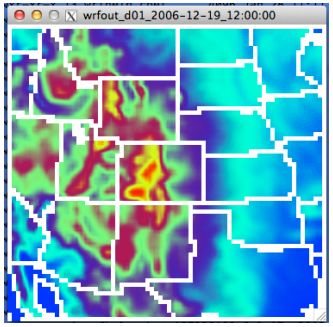


- A graphical interface that allow quick viewing of netCDF files
  - All variables found in file
  - Detect where things go wrong
- Other options
  - Time series
  - Vertical Cross Section
- WRF/WPS files
  - Any netCDF format file

    geo_em.d0*, met_em.d0*, wrfinput_d0*, wrfout.d0*, wrfrst.d0*

ncview

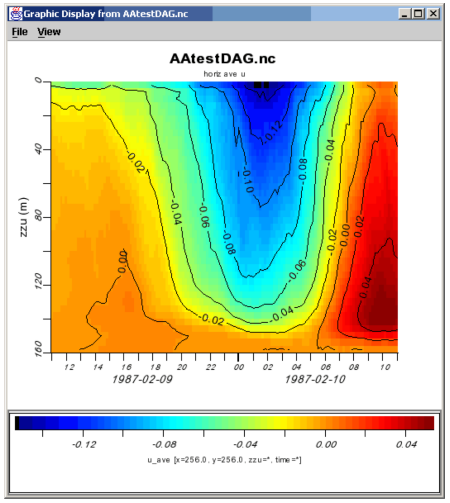




- Beginning V3.7
- Works with wrfinput* and wrfout* files
- Must have 1 time period per file

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

```
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 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 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
  - 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:

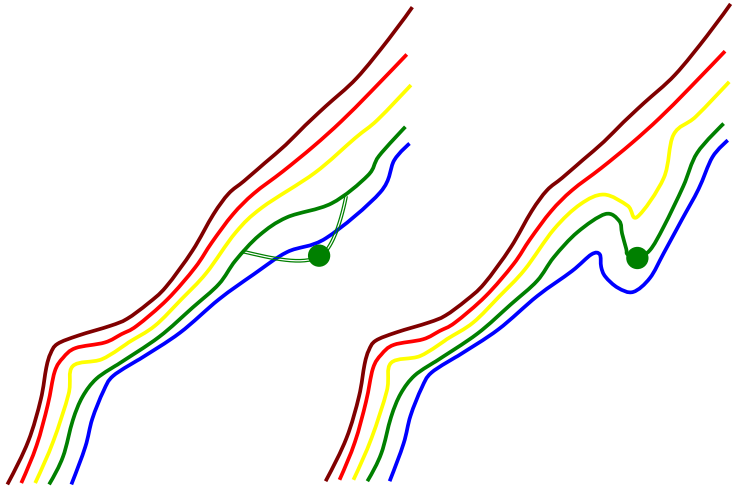
Total geopotential	**PH + PHB**
Total geopotential height in m	(PH + PHB) / 9.81
Total potential temp in K	T + 300
Total pressure in mb	(P + PB) * 0.01
Wind components, grid relative	U, V
Surface pressure in Pa	Psfc
Surface winds, grid relative	U10, V10 (valid at mass points)
Surface temp and mixing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

- Link the 'metoa_em*' files to WRF running directory

```
ln -sf ../../../OBSGRID/metoa_em.d01.* .
```

- Add the following to the &time_control section of the namelist

```
auxinput1_inname = "metoa_em.d<domain>.<date>"
```

- Run real.exe
- Run wrf.exe

OBSGRID - Grid Nudging: Surface

- If you are interested in doing surface analysis nudging
- OBSGRID creates a file called wrfsfdda_d0*
- How to use this:
  - In &fdda, set **`grid_fdda = 1`** and **`grid_sfdda = 1`**
  - Run real.exe and get a file called **`wrffdda_d01`**, and use with **`wrfsfdda_d01`**, **`wrfinput_d01`**, and **`wrfbdy_d01`**
  - Run wrf.exe
- For more information, refer to Jimy Dudhia's ARW Nudging talk

OBSGRID – Observation Nudging

- Allows for input observation data & quality control
- Used if you have a large number of extra observations, and a single case study (not recommended for climate studies)
- Can get obs data from CISL (little R format)
- To Use:
  - OBSGRID creates files called **`OBSDOMAIN_XXX`**
    - can concatenate files into 1: **`OBSDOMAIN_101`**
  - In &fdda, add **`obs_nudge_opt = 1`**
  - In &time_control, add **`auxinput11_interval_s = 180`**, **`auxinput11_end_h = 24`**
  - Will need **`OBSDOMAIN_101`**, **`wrfinput_d01 and wrfbdy_d01`** files
  - Run real.exe and wrf.exe as usual
- For more information, see
  - http://www2.mmm.ucar.edu/wrf/users/wrfv3.1/How_to_run_obs_fdda.html
  - Jimy Dudhia's ARW Nudging talk

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

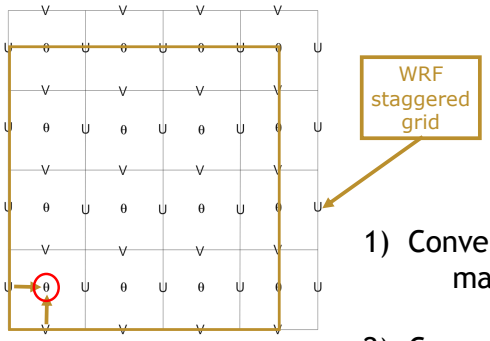
	NCL	RIP4	GrADS	UPP	VAPOR	IDV
netCDF		ripdp	ARWpost	converter	converter	converter
GRIB						
ASCII						
shapefiles						
geogrid & metgrid output						
intermediate file format	*V6.2.0 V6.3.0*					
wrfinput data						
Idealized data						
wrfoutput						
big data						

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?



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)

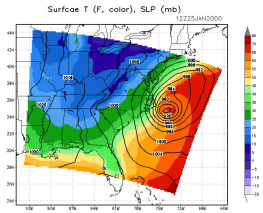
ARWpost

ARWpost: General Information

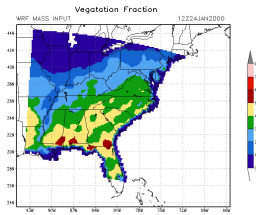
- Converter
  - Reads in wrf-arw model data, creates GrADS output files
  - Requires GrADS to display
- GrADS software is only needed to display data, not needed to compile the code
  - http://www.iges.org/grads/grads.html
- Generate a number of graphical plots
  - Horizonal
  - Cross-section
  - skewT
  - Meteogram
  - Panel
- Download Code
  - http://www2.mmm.ucar.edu/wrf/users/download/get_sources.html
- Online Tutorial
  - http://www2.mmm.ucar.edu/wrf/users/graphics/ARWpost/ARWpost.htm

ARWpost: Example Plots

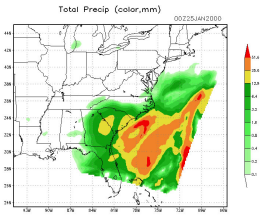
Surface Temp



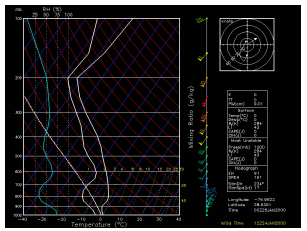
Vegetation Fraction



Total Precipitation

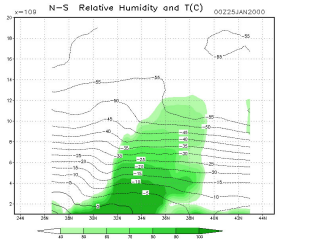


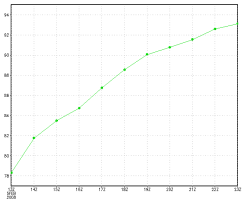
Skew-T Diagram



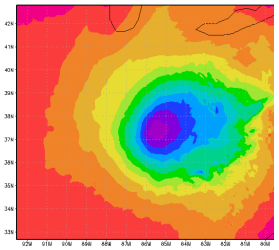
ARWpost: Example Functions

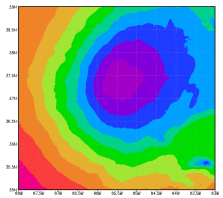
Cross-Sections





Zooming





ARWpost: Diagnostics

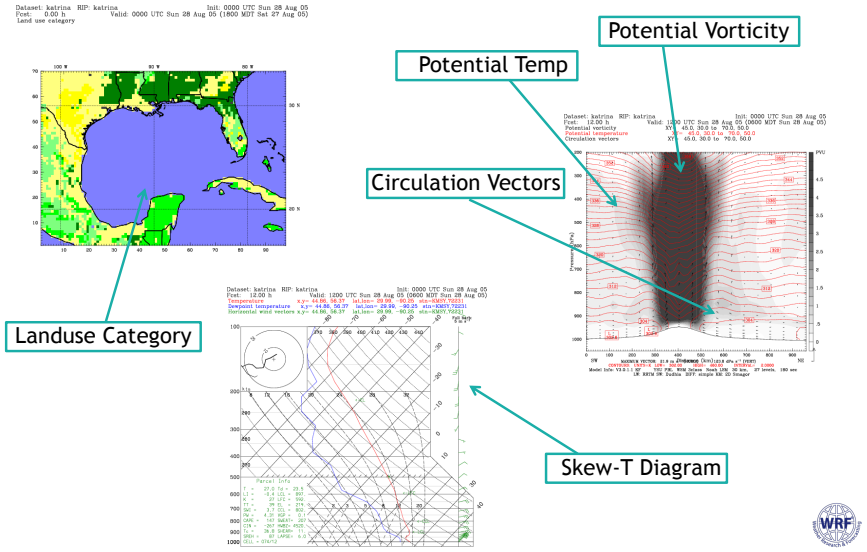
- cape - 3d cape
- cin - 3d cin
- mcape - maximum cape
- mcin - minimum cin
- clfr - low/middle/high cloud fraction
- dbz - 3d reflectivity
- max_dbz - maximum reflectivity
- geopt - geopotential
- height - model height in km
- lcl - lifting condensation level
- lfc - level of free convection
- pressure - 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

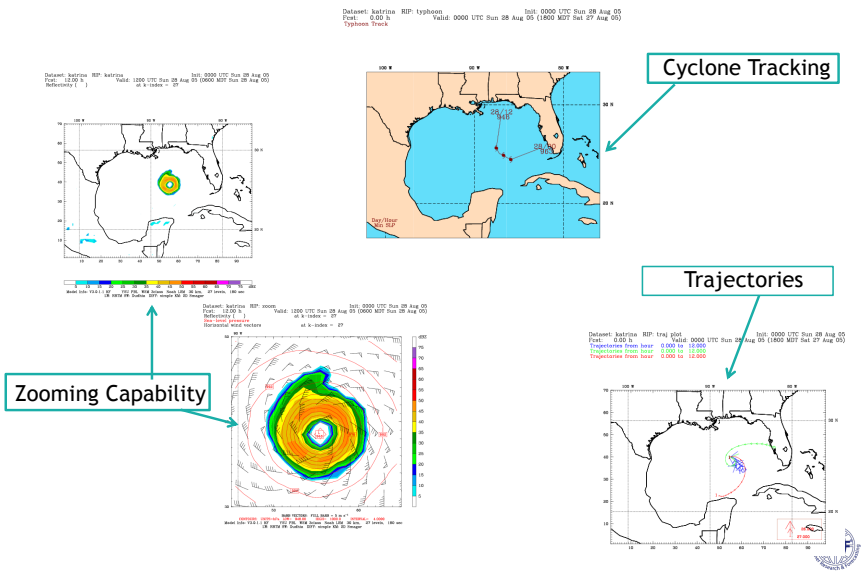
Script Name	Description
cbar.gs	Plots a color bar on shaded plots
rgbset.gs	Allows you to add/change colors from color # 20 - 99
skew.gs	Program to plot a skewT
plot_all.gs	Automatically finds all .ctl files in the directory and lists them so the user can pick when to use, will plot all fields chosen
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)

RIP4

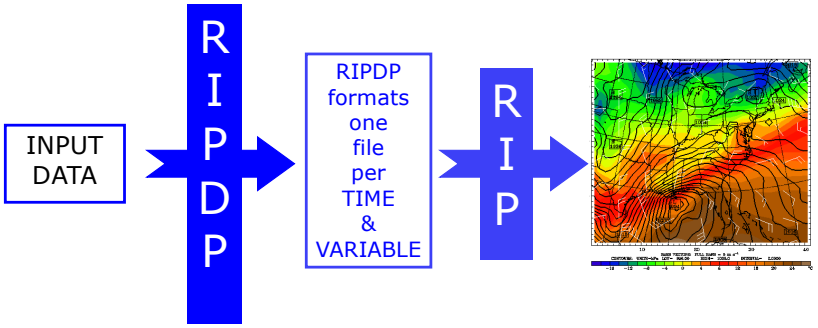
RIP4: Example Plots



RIP4: Example Plots



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

RIP4: Common Error Message

```
 GKS ERROR NUMBER   2 ISSUED FROM SUBROUTINE
GCLKS :--GKS NOT IN PROPER STATE: GKS SHALL BE IN
STATE GKOPFORTRAN STOP
```

- Usually NOT a graphics error.
- More often this is an error with the times you are asking RIP to process
  - Check the ptimes in your .in file
  - Check the xtimes files created by RIPDP

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/users/graphics/RIP4/RIP4.htm

Questions?