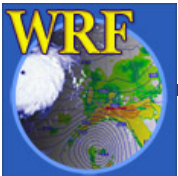


Post-processing Tools

Cindy Bruyère



Graphical Packages

- **NCL**

UG: 9-2

- Graphical package

- **ARWpost**

UG: 9-28

- Converter (GrADS)

- **RIP4**

UG: 9-19

- Converter and interface to graphical package NCAR Graphics

- **UPP**

UG: 9-35

- Converter (GrADS & GEMPAK)

- **VAPOR**

UG: 9-58

- Converter and graphical package
- *Support: VAPOR*

- **IDV**

unidata.ucar.edu

- GRIB (from UPP)
- GEMPAK (from wrf2gem)
- Vis5d
- CF complaint data (from wrf_to_cf)
- *Support: unidata*

- **GEMPAK**

- Data from wrf2gem or UPP
- *Support: unidata*

MatLab / IDL / R / ferret

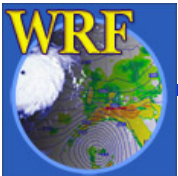
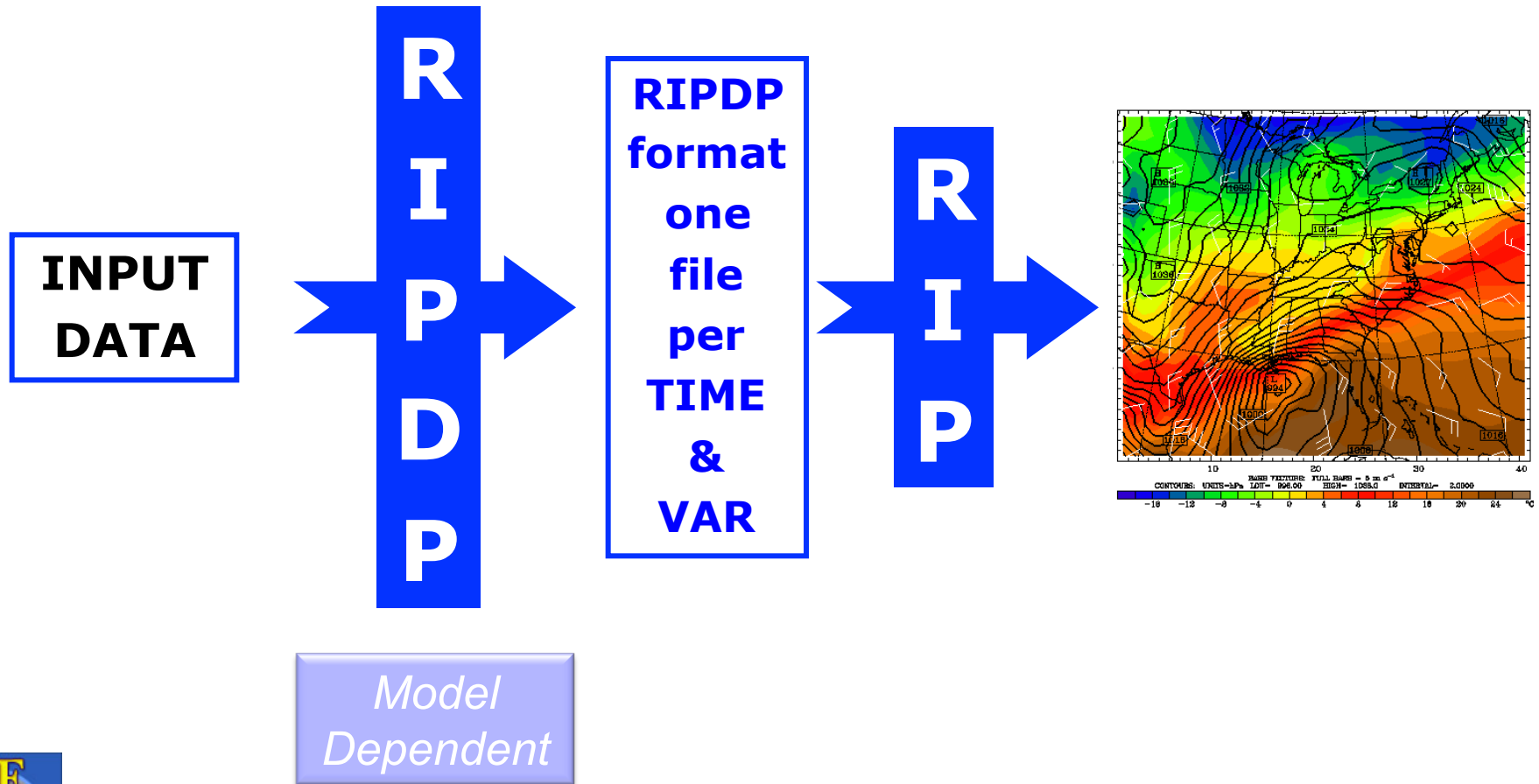


Graphical Packages

	NCL	RIP4	ARWpost (GrADS)	UPP	VAPOR	IDV
Directly ingest WRF data	Y	N <i>converter</i>	N / (Y) <i>converter</i>	N <i>converter</i>	N / (Y) <i>converter</i>	N / (Y)
Intermediate files	N	lots	large file	Y	large file	Y
WPS DATA	Y	Y	Y	N	N	Y
wrfinput data	Y	Y	Y	N	N	Y
Idealized data files	Y	Y	Y	N	N	Y
Input format	<i>netCDF</i>	<i>netCDF</i>	<i>netCDF</i>	<i>netCDF / binary</i>	<i>netCDF</i>	<i>netCDF</i>
Vertical Output Coordinate	eta pressure height	eta pressure height	eta pressure height	pressure	eta	if pre- processed
Software required (All binaries are free)	<i>NCL</i>	<i>NCARG</i>	<i>GrADS</i>	<i>GrADS / GEMPAK</i>	<i>VAPOR</i>	<i>JAVE</i>
Diagnostics	<i>some</i>	<i>> 100</i>	<i>some</i>	<i>some</i>	<i>limited</i>	<i>limited</i>

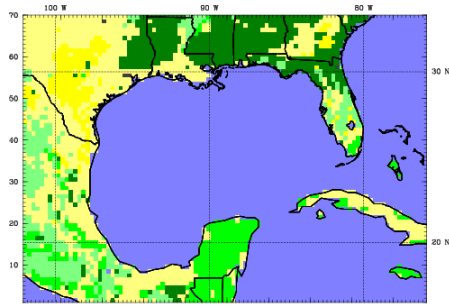


RIP4

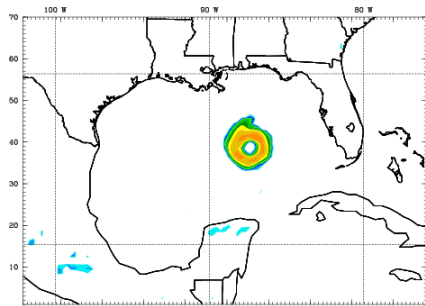


RIP4 - Examples

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

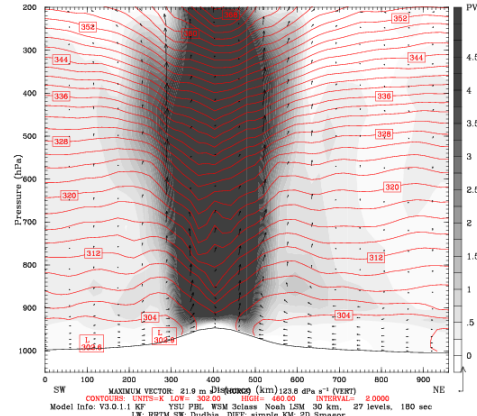


Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
Fest: 12.00 h Valid: 1200 UTC Sun 28 Aug 05 (0600 MDT Sun 28 Aug 05)
Reflectivity () at k-index = 27



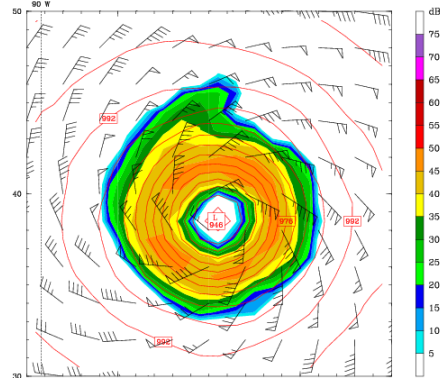
Model Info: V3.0.1.1 KT YSU PBL WSM Schem Noah LSM 30 km 27 levels 180 sec
LW RSTM SW Dufhia DIFF simple KM 2D Smagor

Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
Fest: 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



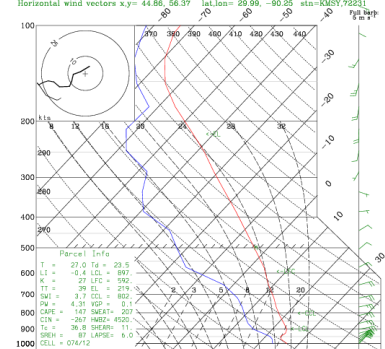
Model Info: V3.0.1.1 KT YSU PBL WSM Schem Noah LSM 30 km 27 levels 180 sec
LW RSTM SW Dufhia DIFF simple KM 2D Smagor

Dataset: katrina RIP: zoom Init: 0000 UTC Sun 28 Aug 05
Fest: 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

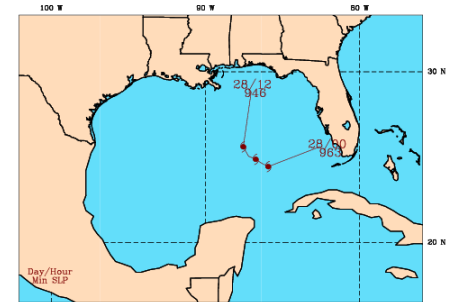


Model Info: V3.0.1.1 KT YSU PBL WSM Schem Noah LSM 30 km 27 levels 180 sec
LW RSTM SW Dufhia DIFF simple KM 2D Smagor

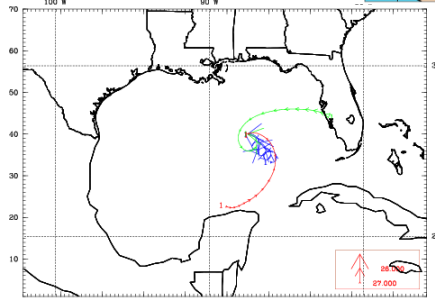
Dataset: katrina RIP: katrina Init: 0000 UTC Sun 28 Aug 05
Fest: 12.00 h Valid: 1200 UTC Sun 28 Aug 05 (0600 MDT Sun 28 Aug 05)
Temperature XY= 44.86, 56.27 latlon= 29.99 -80.35 min-KMSV72231
Dewpoint temperature XY= 44.86, 56.27 latlon= 29.99 -80.35 min-KMSV72231
Horizontal wind vectors XY= 44.86, 56.27 latlon= 29.99 -80.35 min-KMSV72231



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

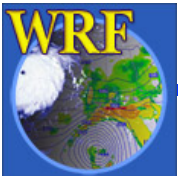


Dataset: katrina RIP: traj plot Init: 0000 UTC Sun 28 Aug 05
Fest: 0.00 h Valid: 0000 UTC Sun 28 Aug 05
Trajectories from hour 0.000 to 12.000
Trajectories from hour 0.000 to 12.000
Trajectories from hour 0.000 to 12.000



RIP4 General Information

- Requires NCL
 - <http://www.ncl.ucar.edu>
- Source Code:
 - http://www.mmm.ucar.edu/wrf/users/download/get_source.html
 - <http://www.dtcenter.org/wrf-nmm/users/downloads/index.php>
- Documentation
 - In program tar file under the Doc/ directory
 - <http://www.mmm.ucar.edu/wrf/users/docs/ripug.htm>
 - http://www.dtcenter.org/wrf-nmm/users/docs/user_guide/RIP/ripug.htm
- OnLine Tutorial:
 - <http://www.mmm.ucar.edu/wrf/users/graphics/RIP4/RIP4.htm>
 - <http://www.dtcenter.org/wrf-nmm/users/OnLineTutorial/NMM/RIP/index.php>



RIP4 on your computer

- set environment variables

```
setenv RIP_ROOT /usr/$USER/RIP4  
setenv NCARG_ROOT /usr/local/ncl
```

- Configure

```
./configure
```

*check configure.rip to ensure netCDF paths are correct
gfortran ; z and png libraries may be required*

```
-L<path_to_png_lib> -lpng  
-L<path_to_z_lib> -lz  
-L<path_to_gfortran_lib> -lgfortran
```

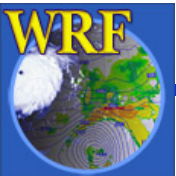
- Compile

```
./compile
```

- RIP4 has 2 parts (RIPDP and RIP)

ripdp_mm5

ripdp_wrfarw
ripdp_wrfnmm



Running ripdp & rip

`ripdp_wrfxxx [-n namelist-file] optional`
`<model_data_name> [basic/all] <input_file(s)>`

`rip [-f] <model_data_name> rip-execution-name`

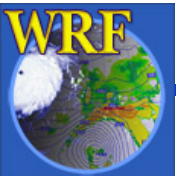
Example:

`ripdp_wrfxxx RIPDP/CaseX all wrfout*`

`rip [-f] RIPDP/CaseX rip_sample.in`

output

*[rip_sample.out]
rip_sample.TYPE*



ripdp namelist

- **ptimes** (*times for ripdp to process*)

- *List of time OR (start, -end, interval)*

- 0, 1, 2, 3, 4, 5, 6 (0, 1, 2, 3, 4, 5, 6)

- 0, -6, 1 (0, 1, 2, 3, 4, 5, 6)

- 0, 2, -4, 1, 6 (0, 2, 3, 4, 6)

- **tacc:** *input files not on exact times*

- 2013-01-31_00

- 2013-01-31_09

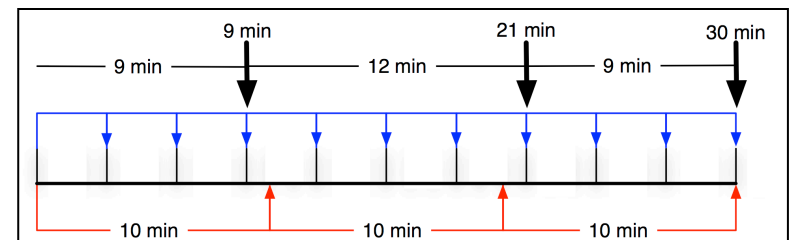
- 2013-01-31_21

- 2013-01-31_30

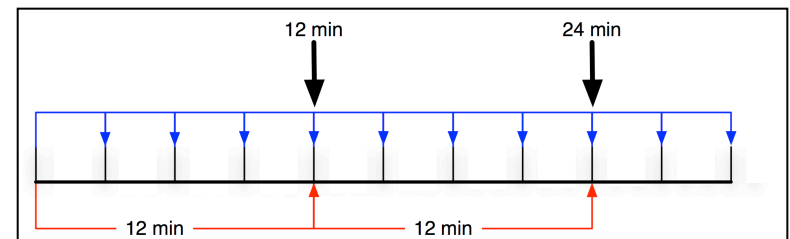
- Delta Times =

- 9 ; 12 ; 9 minutes

history_interval=10 ; time_step=180 (3 min)



history_interval=12 ; time_step=180 (3 min)



RIP4 User Input File

```
&userin  
.....  
&end  
&trajcalc  
.....  
&end
```

Namelist controlling general parameters

Namelist for trajectory calculations
Only used if itrajcalc=1, in userin namelist

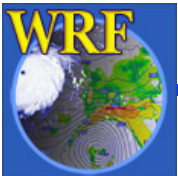
```
=====
```

----- Plot Specification Table -----

```
=====
```

feld=
feld=
=====

feld=
feld=
=====



rip 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

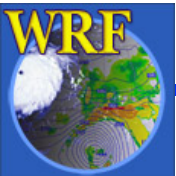
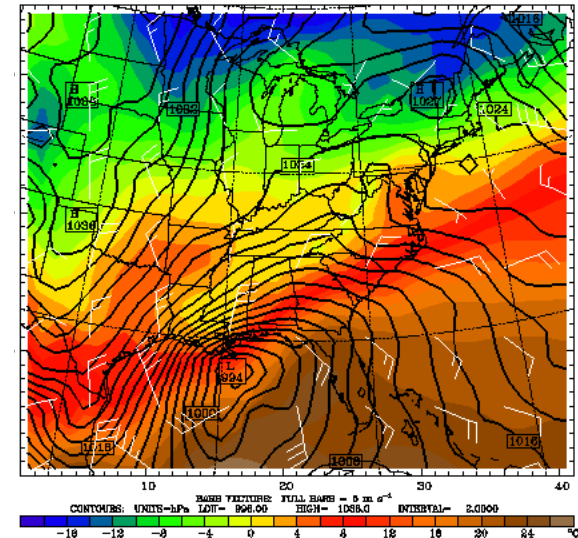


Creating a Plot with RIP4

feld=
diagnostics - *tmc*
native - *PSFC*

```
vcor=s; levs=2fb
vcor=s; levs=1,2,3
vcor=p; levs=800,500
vcor=p; levs=800,-300,100
```

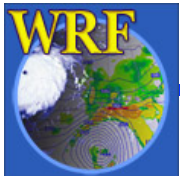
```
feld=tmc; ptyp=hc; vcor=s; levs=1fb; >
  cint=2; cmth=fill; >
  cosq=32,light.violet,-16,blue, >
  0,yellow,16,orange,32,light.gray
feld=slp; ptyp=hc; cint=2; linw=2
feld=uuu,vvv; ptyp=hv; vcmx=1; >
  colr=white;intv=5
feld=map; ptyp=hb
feld=tic; ptyp=hb
```



RIP4 Common Error Message

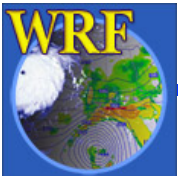
- Most often this is NOT a graphics error.
- More often this is an error with the times you are asking RIP to process
 - Check the ptimes in your .in file
 - Check the xtimes files created by RIPDP

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

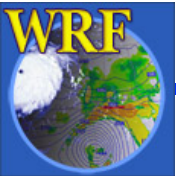
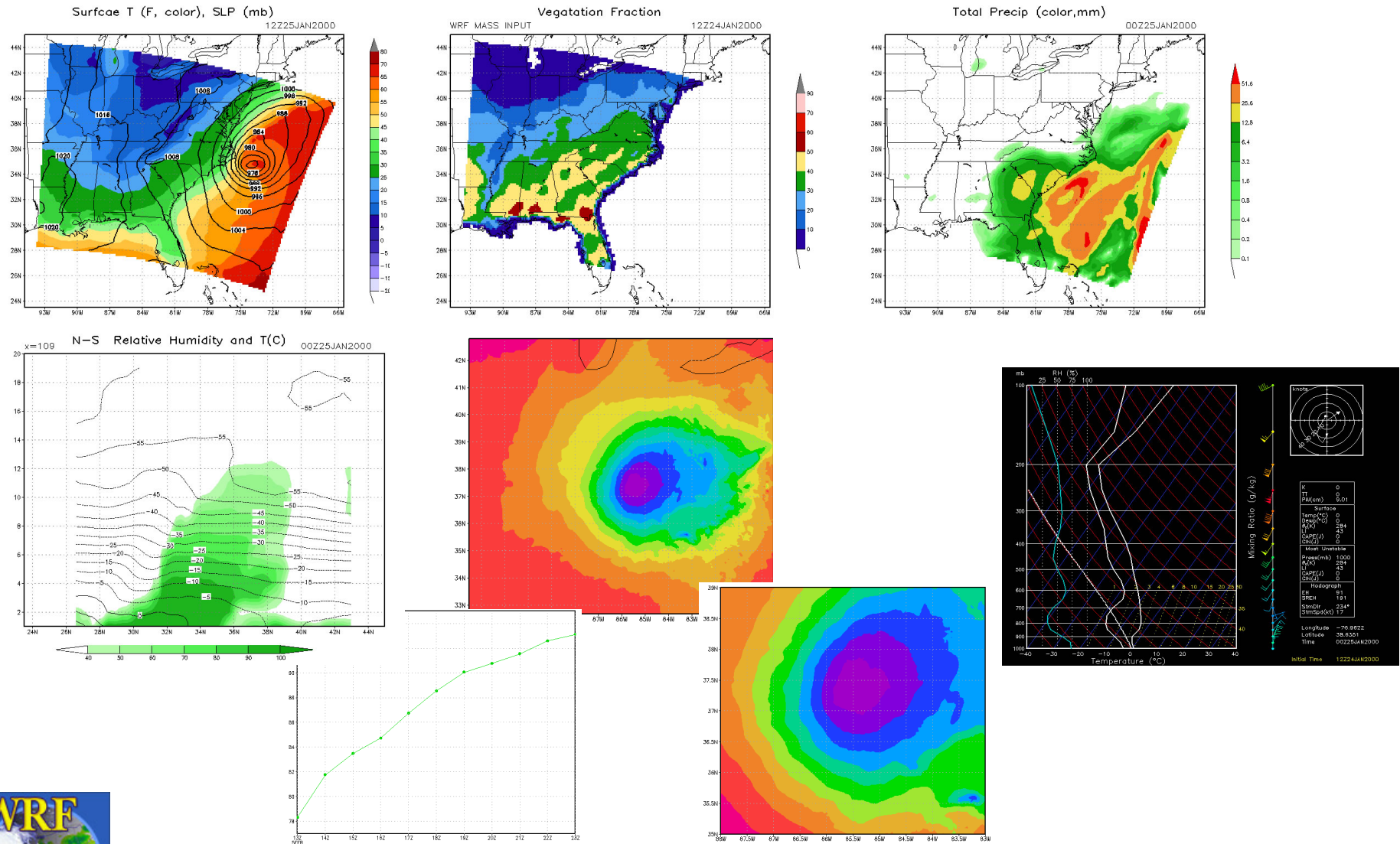


ARWpost

- **Converter**
 - Requires GrADS to display data
- **GrADS software only needed to display data, not needed to compile the code**
- **Generate a number of graphical plots**
 - Horizontal, cross-section, skewT, meteogram, panel
- **Version 2 (old – not recommended)**
 - Could produce vis5d output
 - Needed WRFV3 complied

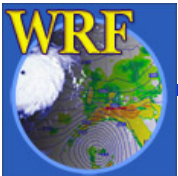


ARWpost - Examples

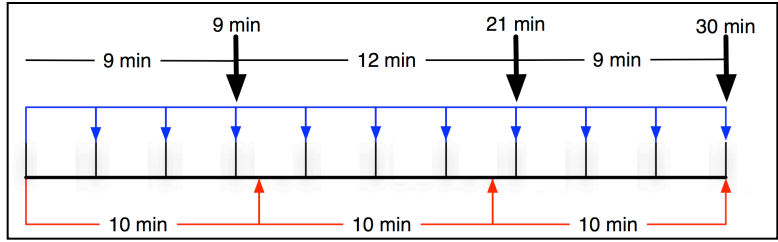


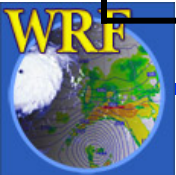
ARWpost - *converter*

- Download Code (<http://www.mmm.ucar.edu/wrf/users>)
- OnLine Tutorial
<http://www.mmm.ucar.edu/wrf/users/graphics/ARWpost/ARWpost.htm>
- Compile (*similar to WPS*)
./configure & ./compile
- For GrADS output
 - GrADS libraries only needed to display data (*freely available*)
 - <http://grads.iges.org/grads/grads.html>



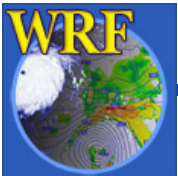
namelist.ARWpost

<i>start_date</i> <i>end_date</i>	Start & end date Format: <i>YYYY-MM-DD_HH:mm:ss</i>
<i>interval_seconds</i>	Seconds between times to process. <i>Code will skip times not required. Data can be in multiple files.</i>
<i>tacc</i>	If model output is not at regular intervals, use closest time within <i>tacc</i> seconds of time requested. <i>(150 sec)</i> 
<i>debug_level</i>	Set high for extra information



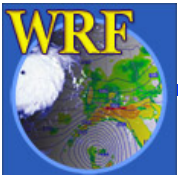
namelist.ARWpost

<i>input_root_name</i>	Path and root name of files to use as input. <i>Do not only provide directory name.</i> Can use wild characters.
<i>output_root_name</i>	Output root name. output_root_name.dat & output_root_name.ctl
<i>mercator_defs</i>	Set to true if mercator plots are distorted

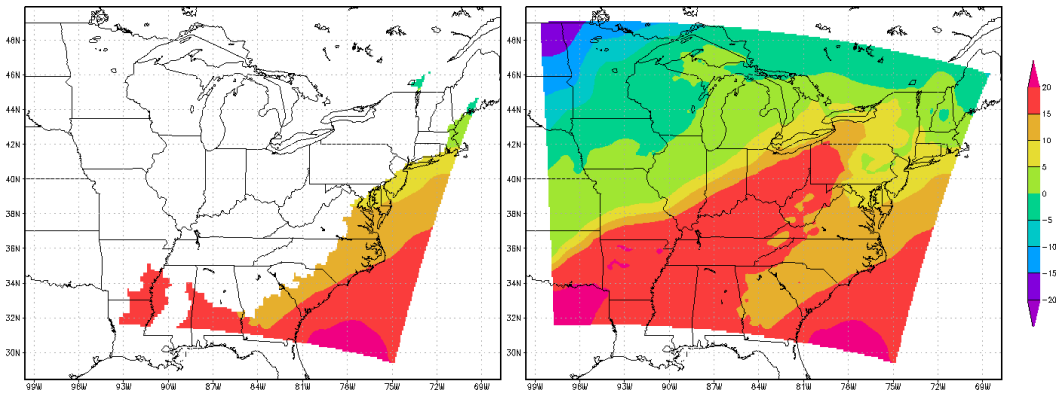


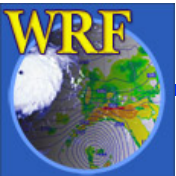
namelist.ARWpost

<i>split_output</i>	Split your GrADS output files into a number of smaller files (<i>a common .ctl file will be used for all .dat files</i>).
<i>frames_per_outfile</i>	If <i>split_output</i> is .True. , how many time periods are required per output (.dat) file.
<i>plot</i>	Which fields to process. (<i>all, list, all_list</i>) Order has no effect, i.e., “all_list” and “list_all” “list” – list variables in “fields”
fields	Fields to plot. Only used if list was used in the “plot” variable. Must use to generate diagnostics.
Available diagnostics: cape, cin, mcape, mcin, clfr, dbz, max_dbz, geopt, height, lcl, lfc, pressure, rh, rh2, theta, tc, tk, td, td2, slp, umet, vmet, u10m, v10m, wdir, wspd, wd10, ws10	



namelist.ARWpost

interp_method	0 = sigma levels, -1 = code defined "nice" height levels, 1 = user defined height or pressure levels
interp_levels	Only used if interp_method=1 Supply levels to interpolate to, in hPa (<i>pressure</i>) or km (<i>height above sea level</i>) Supply levels bottom to top
extrapolate	Extrapolate below ground (<i>default .false.</i>) 



GrADS - .ctl file

```
dset ^test.dat
```

```
options byteswapped
```

```
undef 1.e37
```

```
title OUTPUT FROM WRF V2.2 MODEL
```

```
pdef 259 163 lcc 40.000 -98.000 130.000 82.000  
      60.00000 30.00000 -98.00000 22000.000 22000.000
```

```
xdef 877 linear -141.49254 0.09909910
```

```
ydef 389 linear 18.88639 0.09909910
```

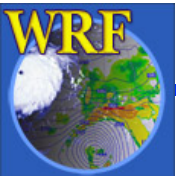
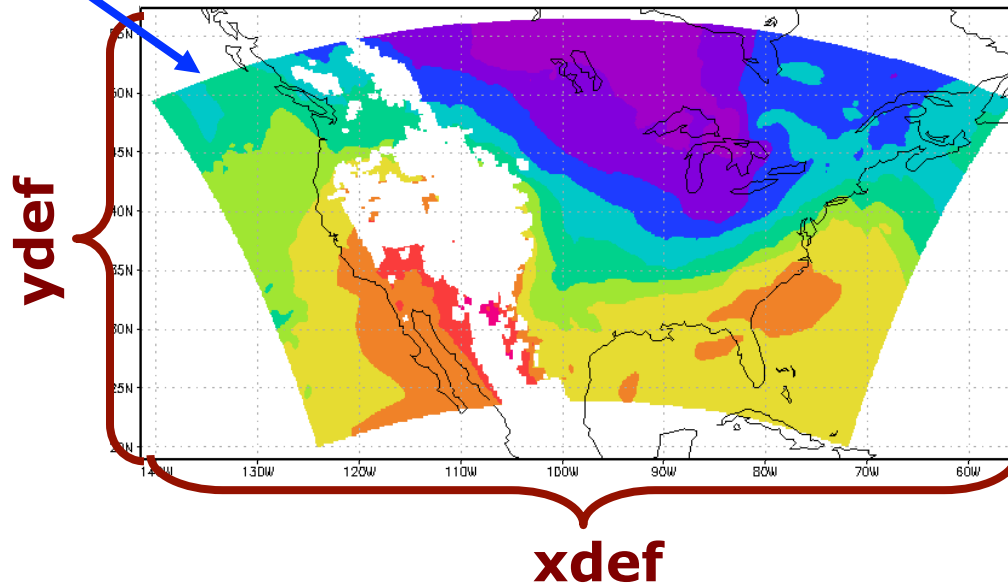
options byteswapped

*Needed on some machines - if you get NaNs when you plot,
remove this line from .ctl file*



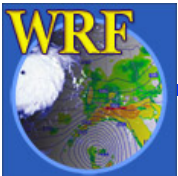
GrADS - .ctl file

```
dset ^test.dat
options byteswapped
title OUTPUT FROM WRF V3.2 MODEL
pdef 259 163 lcc 40.000 -98.000 130.000 82.000
60.000000 30.000000 -98.000000 22000.000 22000.000
xdef 877 linear -141.49254 0.09909910
ydef 389 linear 18.88639 0.09909910
```



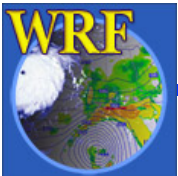
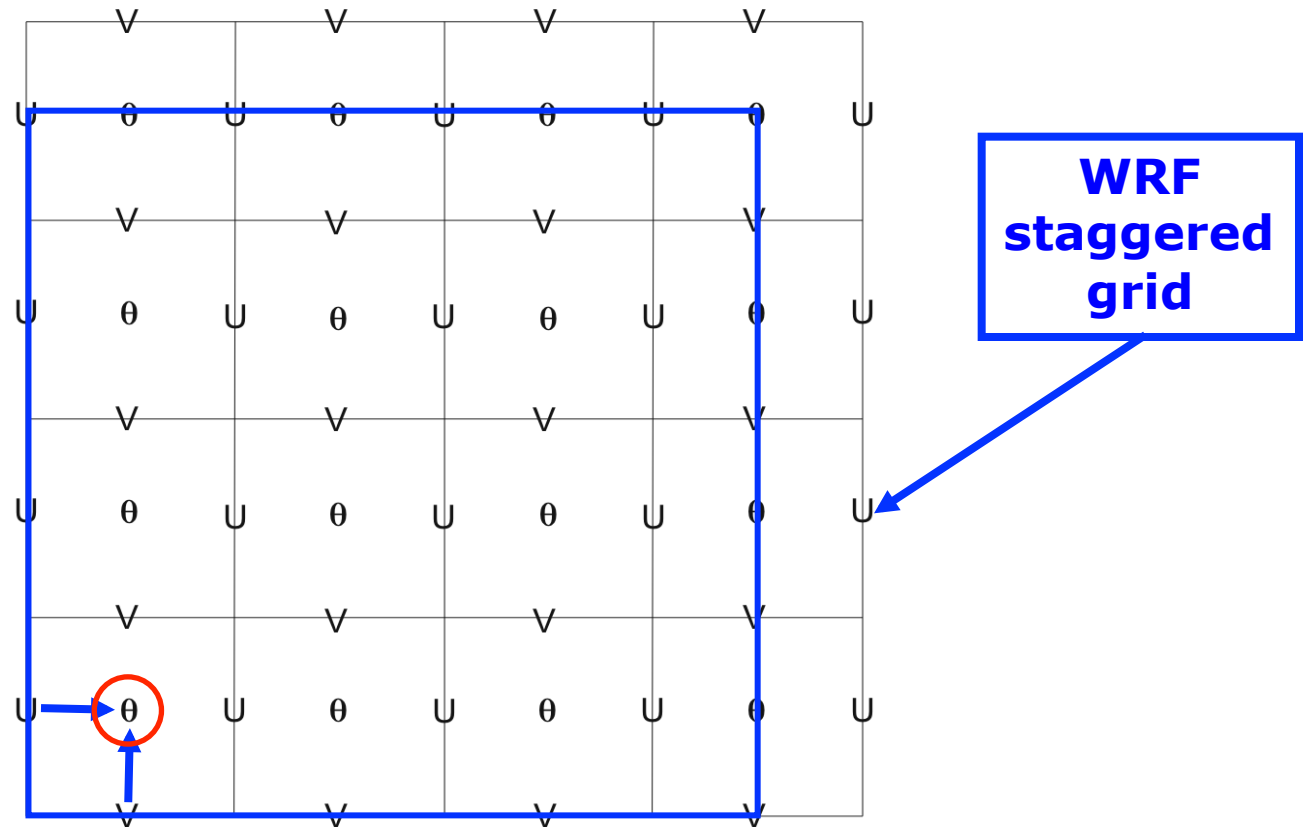
GrADS conversion - question

- Why is a converter needed if GrADS can display netCDF files?
 - Can only display model surface coordinates
 - Cannot interpolate to height or pressure levels
 - All diagnostics must be added via GrADS script files
 - GRIB1 model output can also be read directly by GrADS, but above issues are still valid
 - For GRIB1, there is also a stagger problem



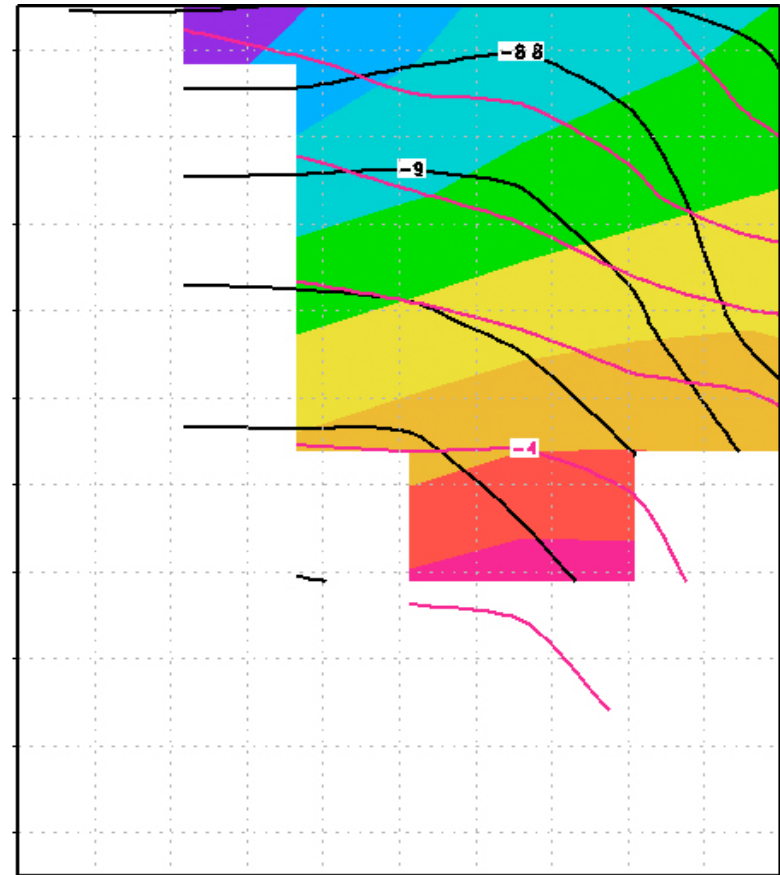
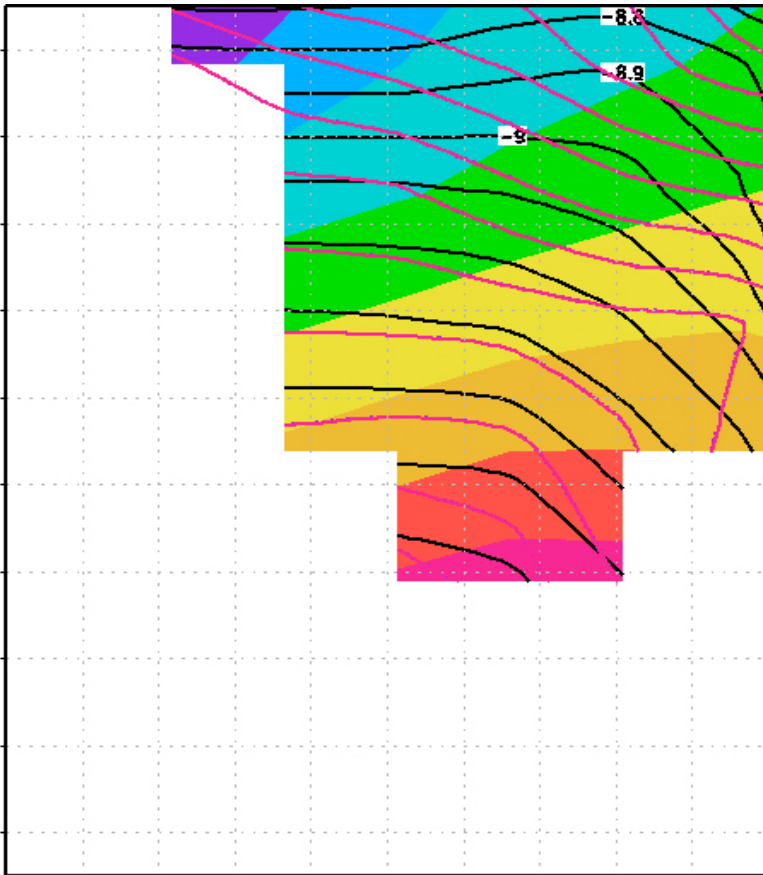
GrADS conversion - question

- Why is a converter needed if GrADS can display netCDF files?



Staggering

shaded=T ; black=U ; red=V

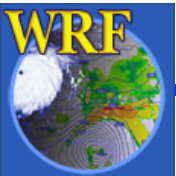
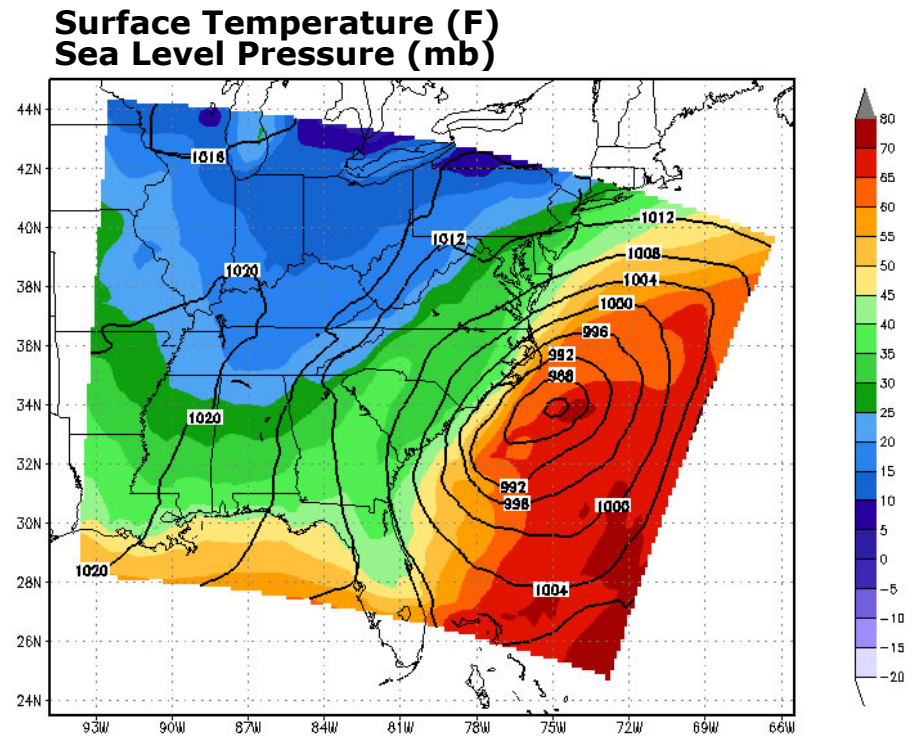


Creating a Plot

```
open em_real.ctl  
set mpdset hires  
set display color white
```

```
define tf=1.8*tc + 32  
set gxout shaded  
set z 1  
d tf  
run cbar.gs
```

```
set gxout contour  
set ccolor 1  
set cint 4  
d slvl
```



How to add diagnostics

- **RIP4**

- Create a subroutine (note RIP4 expects the code to be in “j/l/-k” orientation)
- Add links to the RIP4/src/fields.f routine
- Add new subroutine to RIP4/src/Makefile

- **ARWpost**

- Create a subroutine
- Add links to ARWpost/src/module_diagnostics.f90
- Add new subroutine to ARWpost/src/Makefile



Visualization and Analysis Platform for Oceanic, atmospheric and solar Research

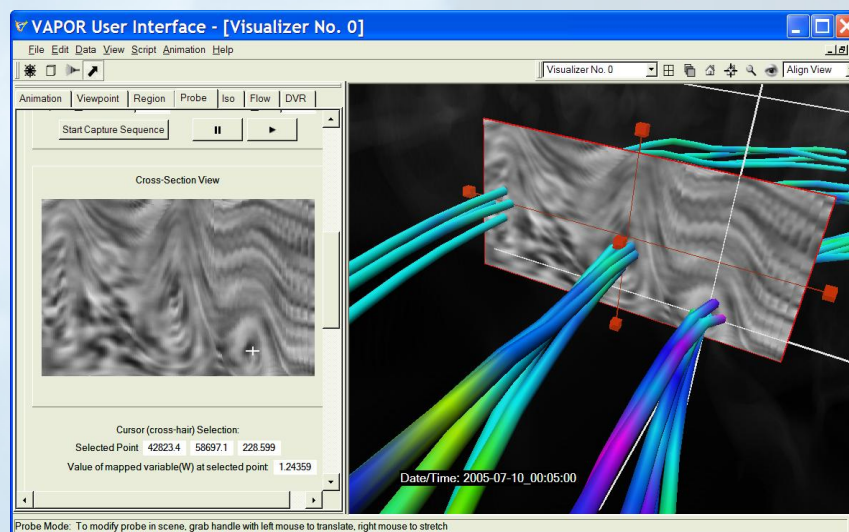
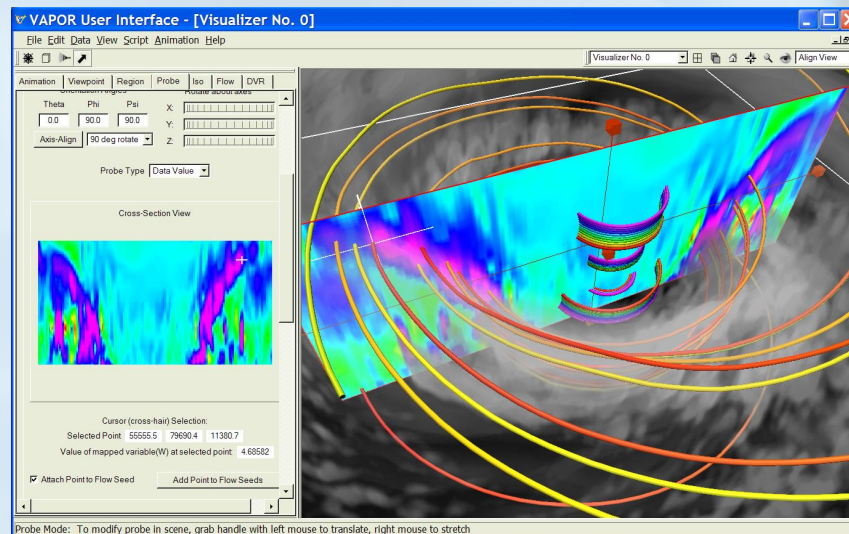
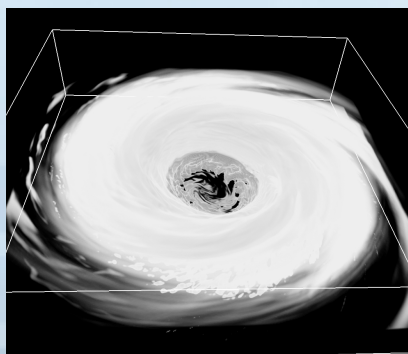
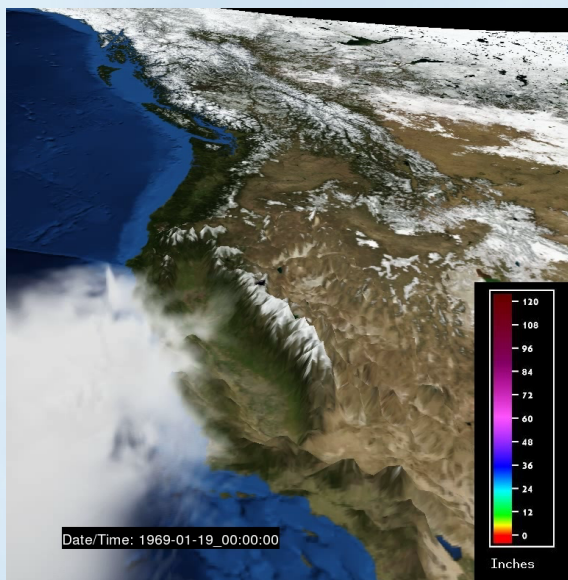
Alan Norton

alan@ucar.edu

vapor@ucar.edu

National Center for Atmospheric Research

VAPOR visualization of WRF-ARW data



VAPOR Installation



- Available for Linux, Windows, or Mac systems
- Should have a reasonably modern graphics card
 - nVidia, ATI or AMD graphics cards are good; others may not perform all visualizations.
- From the VAPOR website <http://www.vapor.ucar.edu>: Download appropriate binary installer from the VAPOR download page, follow the installation instructions.
- You will need Administrative privileges on Mac
- Note that on Linux and Mac you need to source vapor-install.csh in your shell before running any VAPOR commands.
- Run the vaporgui application to visualize your data

VAPOR visualization of WRF-ARW data



A short summary of VAPOR capabilities

1. Read or convert WRF-ARW output files
2. Apply geo-referenced images to the terrain
3. Calculate 2D and 3D derived variables in Python
4. Volume render 3D variables
5. Display isosurfaces of 3D variables
6. Display color-mapped 2D variables on planes or terrain-mapped.
7. Use wind barbs to show flow direction and speed
8. Display streamlines or path lines in scene
9. Insert contour planes, use them to position flow seeds.
10. Image-based flow shows flow motion in 2D slices
11. Create animated 3D sequences

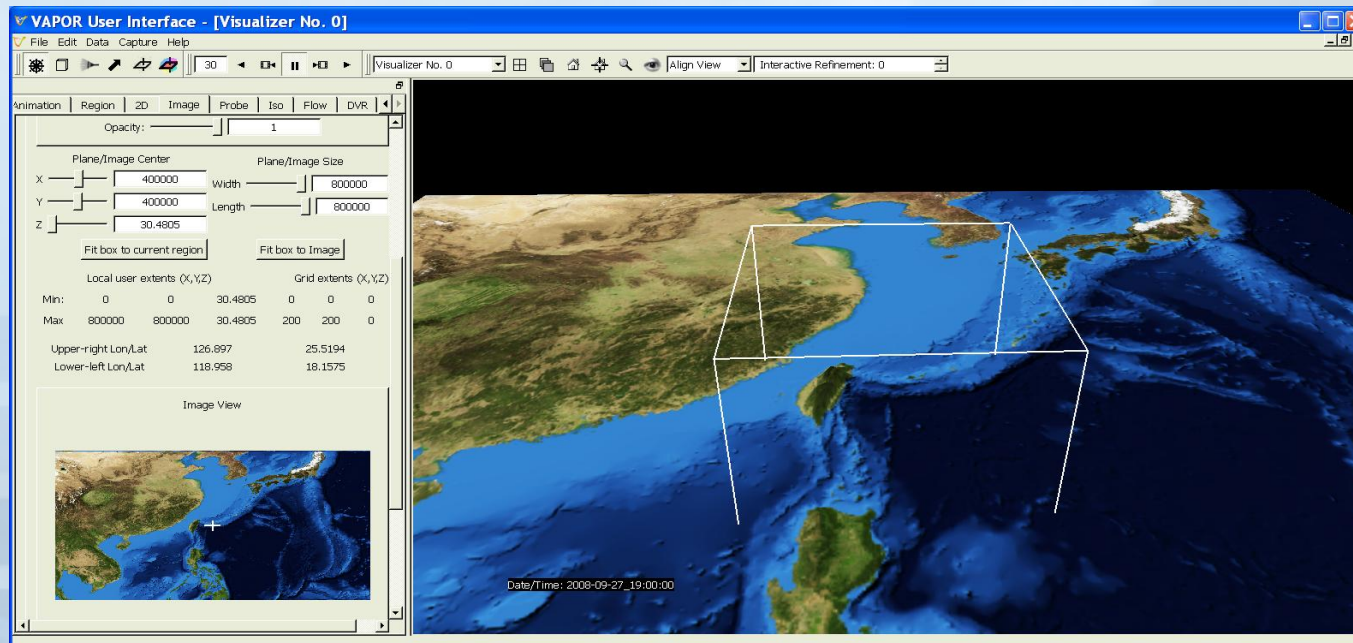
Reading or converting WRF-ARW output files



- To directly read WRF output:
 - Run vaporgui
 - All data must be on the same grid, using the same nesting level.
 - Specify “Import WRF-ARW output files” from the Data menu, and select all the wrfout files to visualize
- For interactive visualization of large WRF-ARW datasets, it’s best to convert WRF data to the VAPOR data format, using wrfvdfcreate and wrf2vdf utilities.
 - `wrfvdfcreate wrfoutfiles... vdf file.vdf`
creates a VAPOR metadata file “vdf file.vdf” that describes a set of wrfout files.
 - `wrf2vdf vdf file.vdf wrfoutfiles...`
converts the specified wrfout files to a vapor data collection
 - From the vaporgui Data menu, load the file “vdf file.vdf” to visualize the converted data

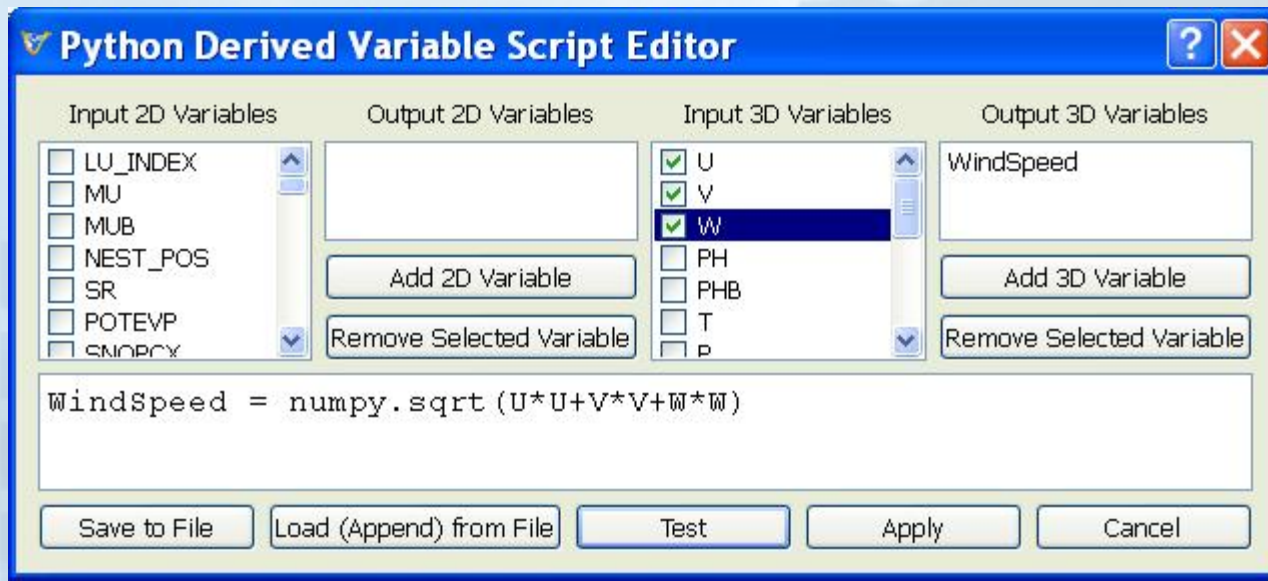
Apply images to use in the VAPOR scene

- Geo-referenced satellite images can be retrieved from the Web, and VAPOR will insert them at the correct world coordinates.
 - VAPOR provides a shell script “getWMSImage.sh” that can be used to retrieve Web Mapping Service images for a specified longitude/latitude rectangle
- Also, several useful images are installed with vapor; e.g. state or national boundary maps, NASA’s Blue Marble image of the earth.
- From the image panel, specify the image file, apply to terrain.



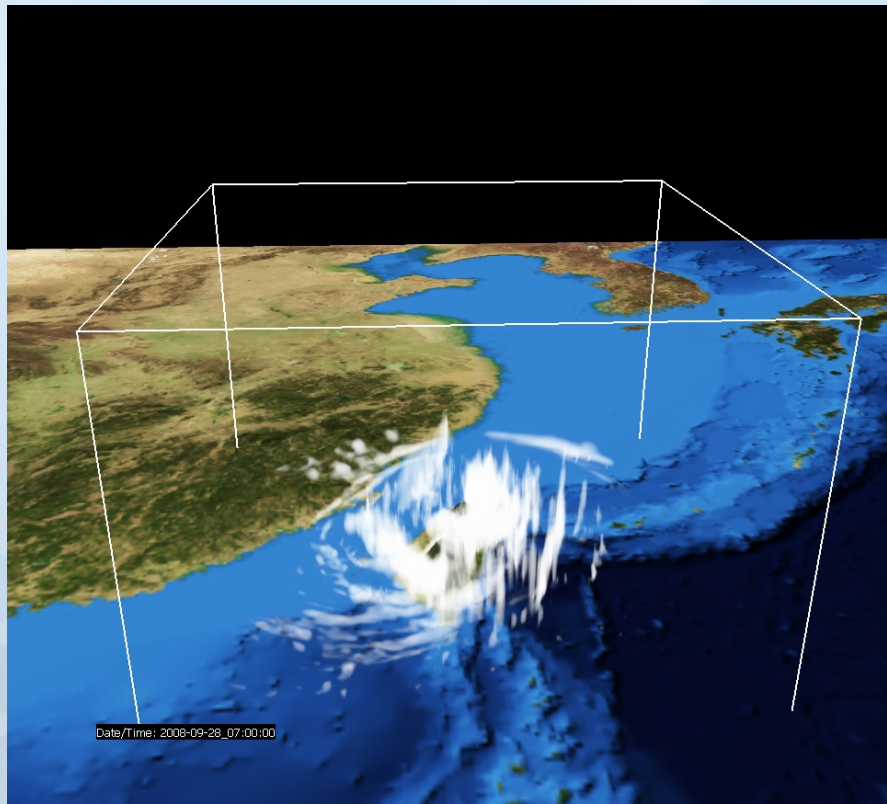
Create derived variables with Python

- From the Edit menu, “Edit Python program defining a new variable”
- Use Python script editor to define variables as arithmetic expressions of other variables.
- Variables are evaluated and cached as needed for visualization
- Python functions are also provided to derive several useful variables from WRF data; e.g. cloud-top temperature, relative humidity, potential vorticity, sea-level pressure, dewpoint temperature, radar reflectivity, equivalent potential temperature, wind shear, temperature in degrees Kelvin.



Volume-render 3D variables to identify important features in the data

- Volume rendering can be used to identify significant 3D features of the WRF data.
- Use a transfer function to control transparency and color:
 - Make the unimportant features transparent, to highlight items of interest
 - Color can be used to distinguish different values of variable



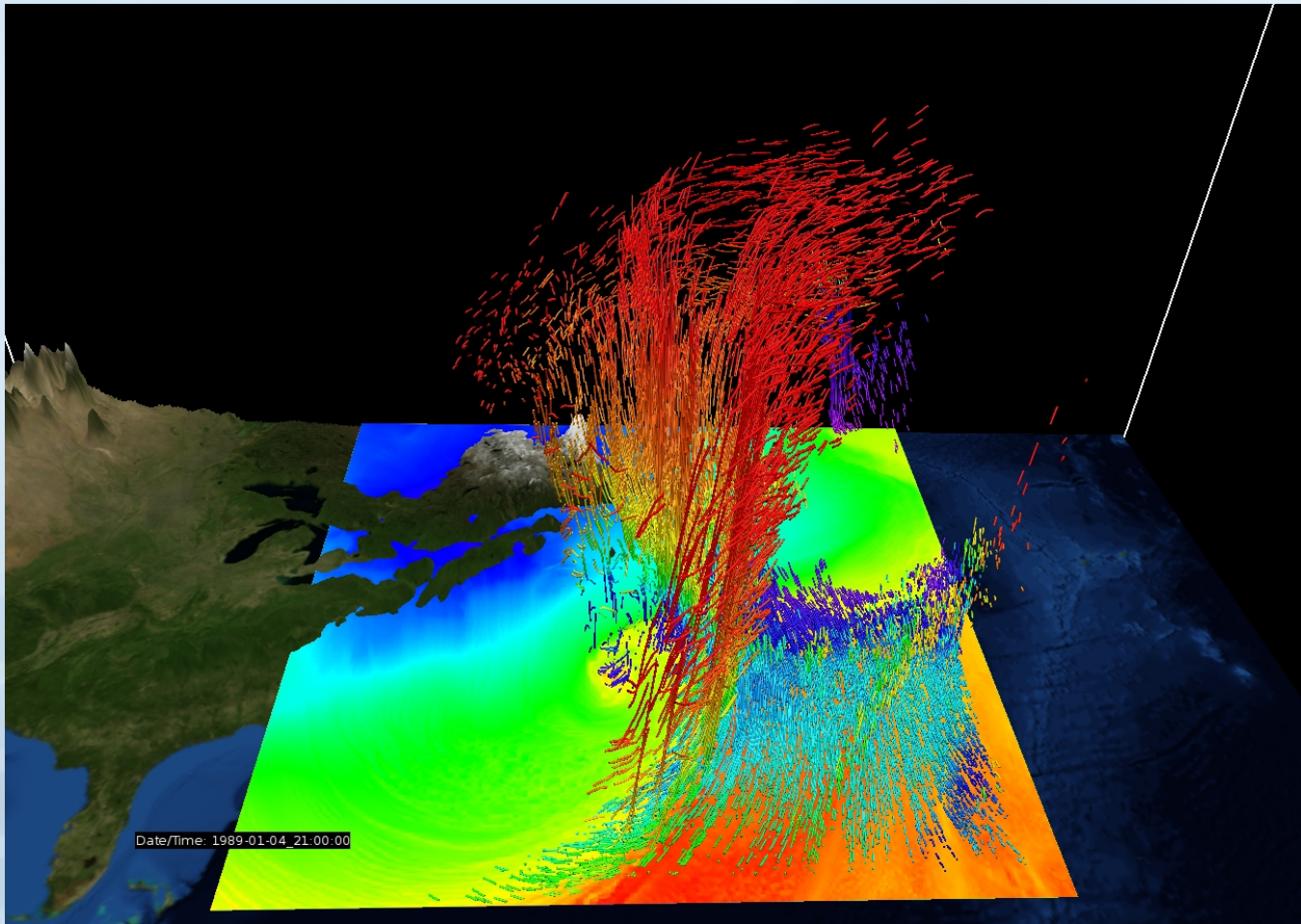
Wind Barbs

- Specify a grid of seed points in the scene where barbs will appear
 - This grid can be aligned to the WRF data grid
- Specify variables that define X, Y, and Z components of velocity field.
- Grid can be displaced by terrain height.



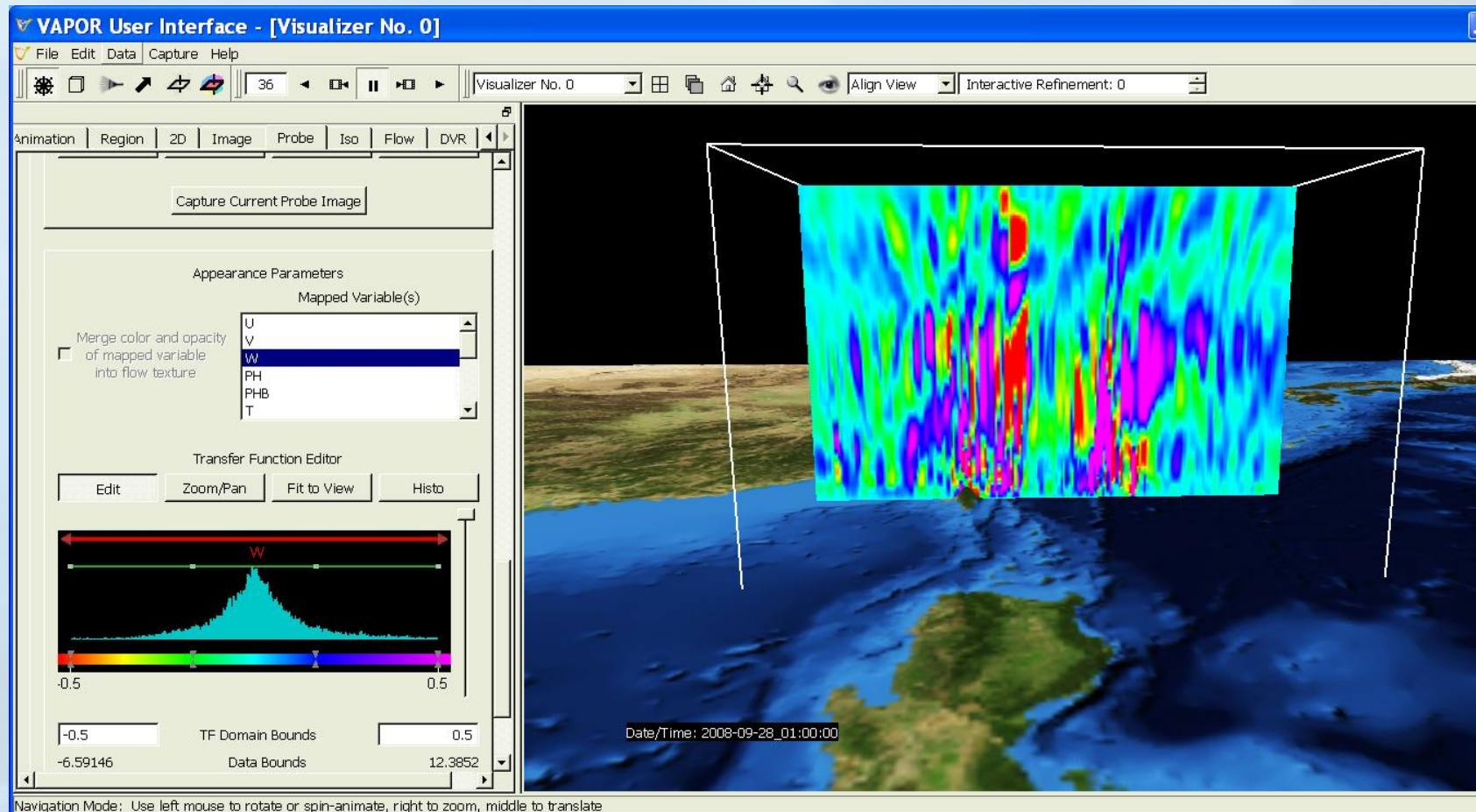
Streamlines and Path lines

- In the Flow panel, specify flow type and velocity components.
- Streamlines indicate the instantaneous direction of the wind flow.
- Path lines track the movement of massless particles over time.



Contour planes and the Probe

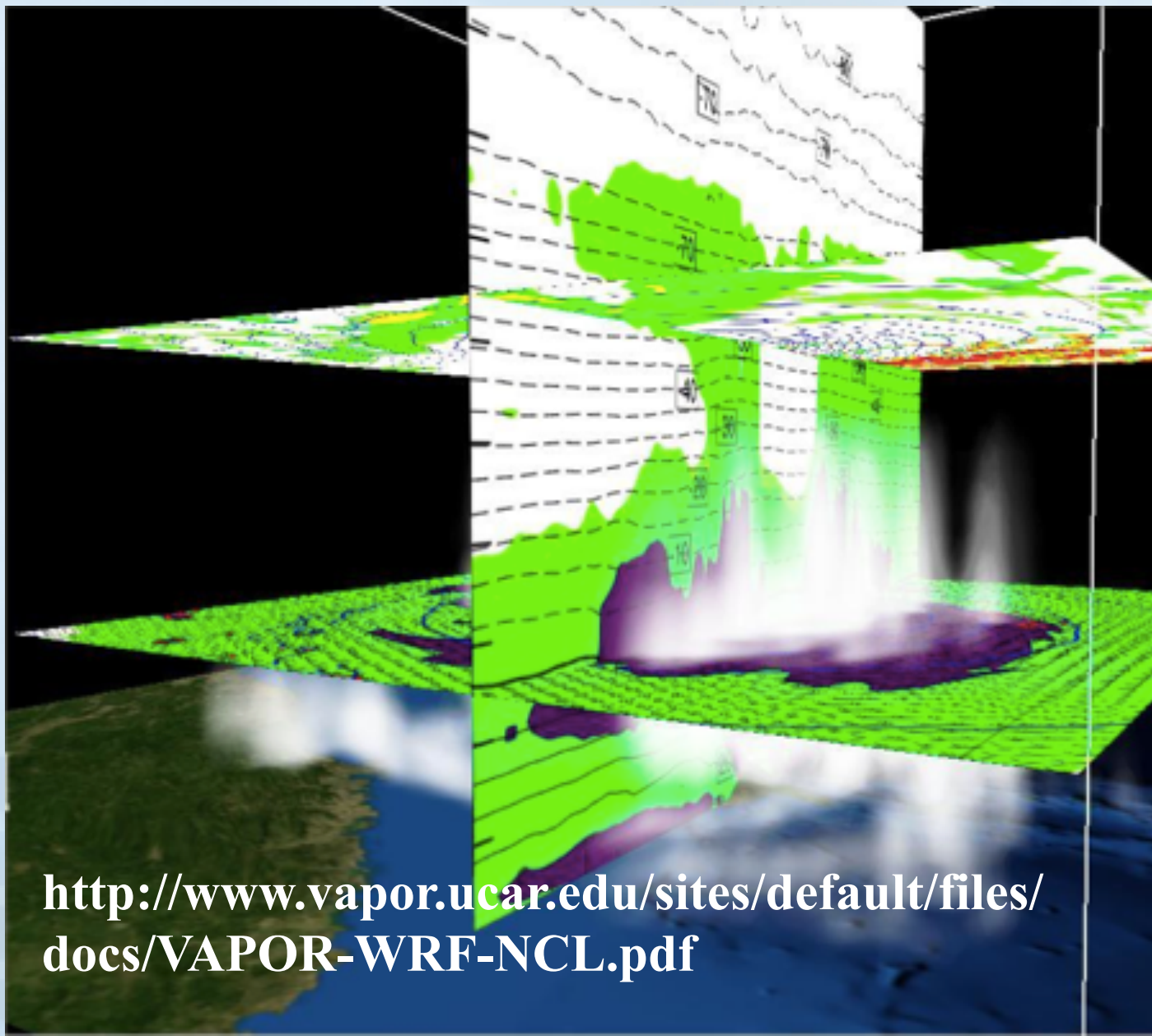
- Use the Probe panel to position rectangle in scene
- Use transfer function to color-map the rectangle
- Probe can also enable interactive specification of flow seeds.



VAPOR / NCL



NCAR



<http://www.vapor.ucar.edu/sites/default/files/docs/VAPOR-WRF-NCL.pdf>

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/wrf/WRFUserARW.ncl"

begin
  a = addfile("./wrfout_d01_2012-09-28_00:00:00.nc","r")
  wks = gsn_open_wks("X11","plt_Surface")

  T2 = wrf_user_getvar(a,"T2",-1)
  times = wrf_user_getvar(a,"times",-1)
  ntimes = dimsizes(times)

  mpres = True
  pltres = True

  do it=0,ntimes-1
    opts = True
    opts@cnFillOn = True
    contour_t2 = wrf_contour(a,wks,T2(it,:,:),opts)
    plot = wrf_map_overlays(a,wks,(/contour_t2/),pltres,mpres)
  end do
```

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/wrf/WRFUserARW.ncl"
load "$VAPOR_HOME/share/examples/NCL/wrf2geotiff.ncl"

begin
  a = addfile("./wrfout_d01_2012-09-28_00:00:00.nc","r")
  wks = gsn_open_wks("ps","plt_Surface")
  wrf2gtiff = wrf2geotiff_open(wks)

  T2 = wrf_user_getvar(a,"T2",-1)
  times = wrf_user_getvar(a,"times",-1)
  ntimes = dimsizes(times)

  mpres = True
  pltres = True
  pltres@gsnFrame = False

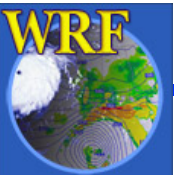
  do it=0,ntimes-1
    opts = True
    opts@cnFillOn = True
    contour_t2 = wrf_contour(a,wks,T2(it,:,:),opts)
    plot = wrf_map_overlays(a,wks,(/contour_t2/),pltres,mpres)
    wrf2geotiff_write(wrf2gtiff,a,times(it), wks, plot, False)
    frame(wks)
  end do
```



IDV

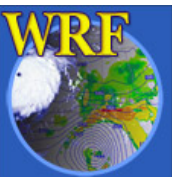
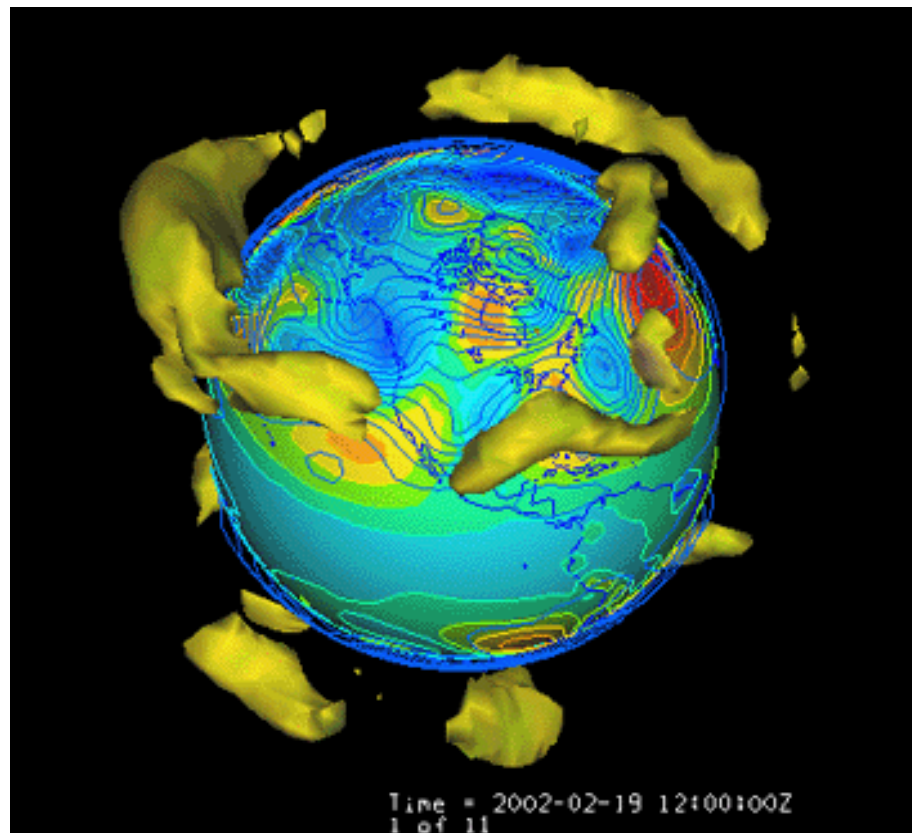
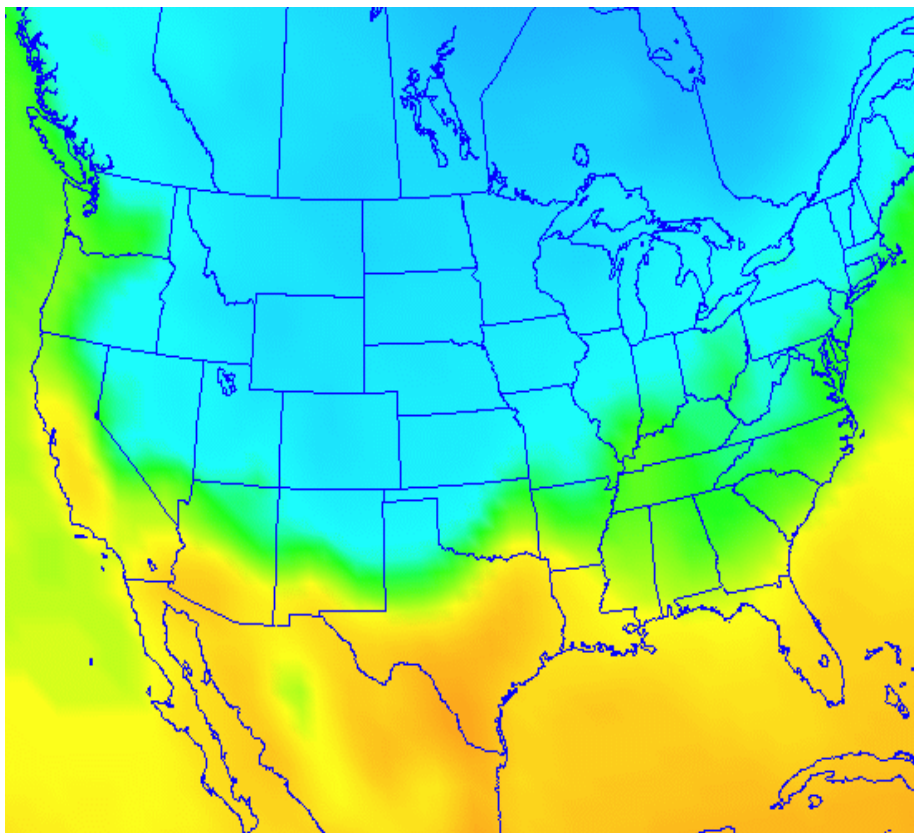
Integrated Data Viewer

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Unidata Program Center/UCAR



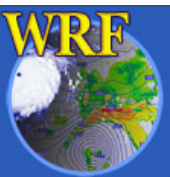
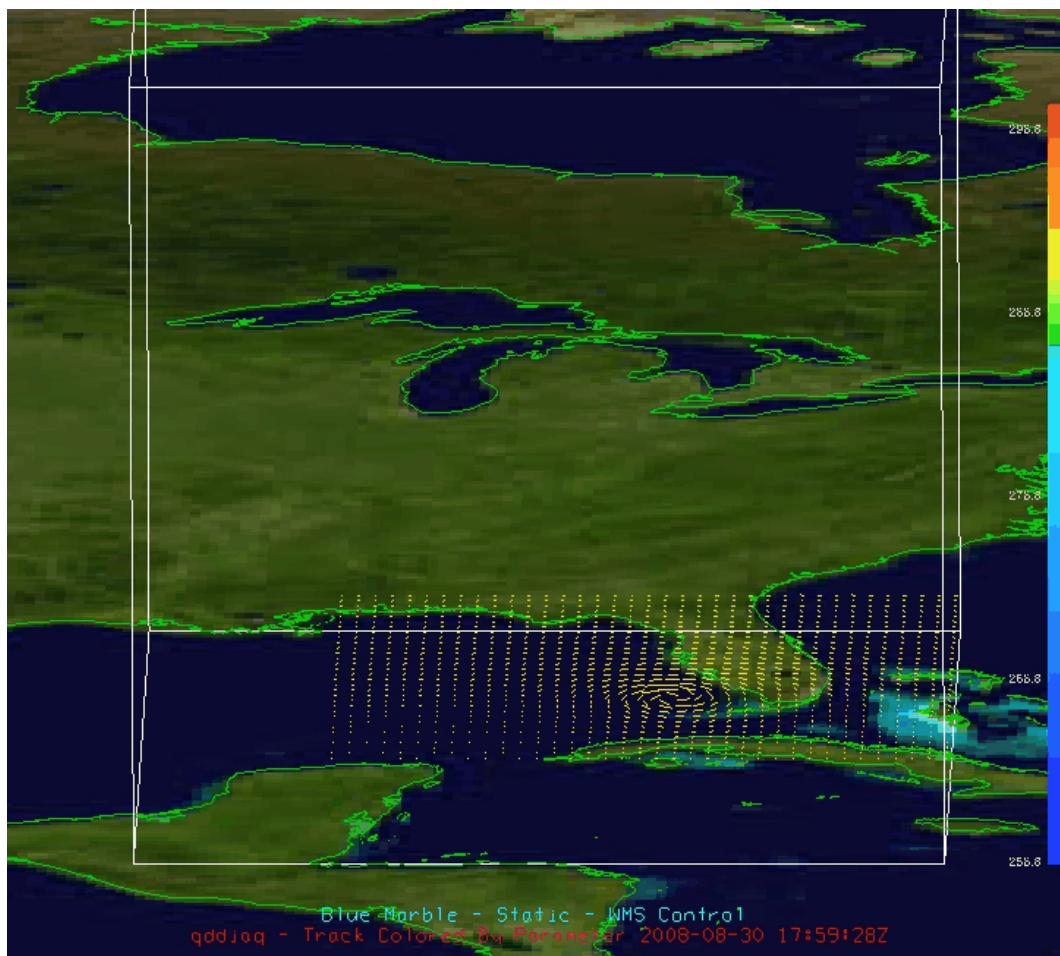


Unidata IDV – What can it do?





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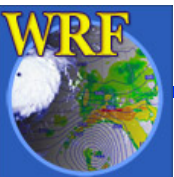
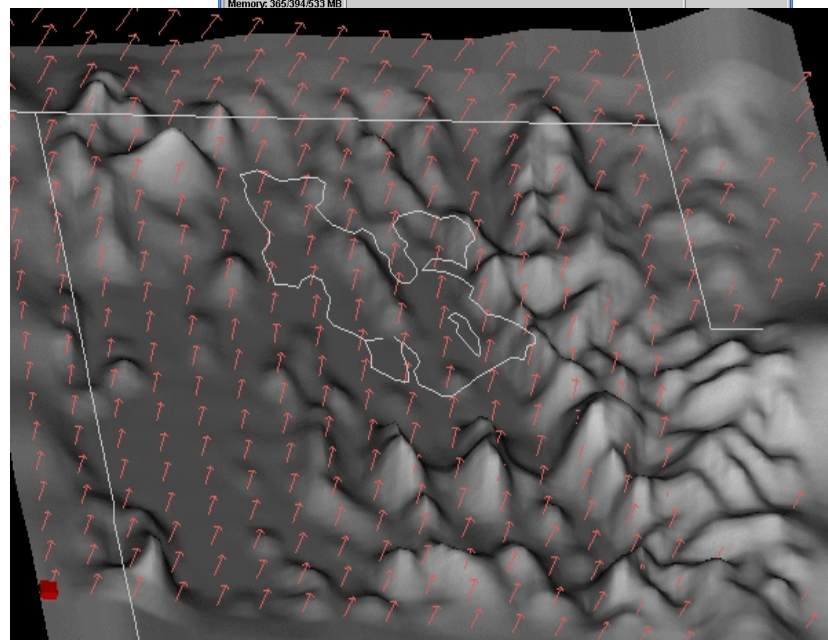
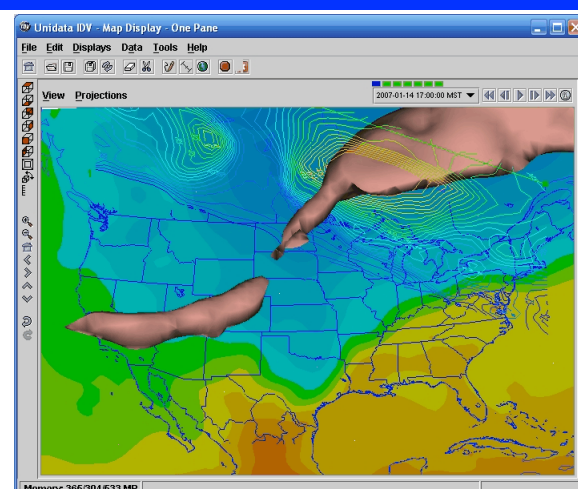




Unidata IDV – What is it?

- Unidata Integrated Data Viewer

- 2D and 3D visualization
 - GUI or scripting (Jython, ISL) interface
- Interactive probes for dataset exploration
 - Parameter readouts, vertical profiles, time/height displays, etc.
- A rich set of analysis capabilities
- Integrate model and observational data
- Access local and remote datasets
- Visualize and analyze post-processed WRF output
 - works best if grid is unstaggered





Supported Data Sources

- **Data Types:**

- Gridded model output
- Satellite imagery
- Radar data
- Point observations
- Balloon soundings
- NOAA Profiler Network winds
- Aircraft Tracks
- Fronts
- GIS data (WMS, shapefile)
- Quick Time movies
- Web Cams

- **Vertical Coordinates**

- Pressure
- Height/Depth
- Other (2D only)

- **Sample of Supported Formats:**

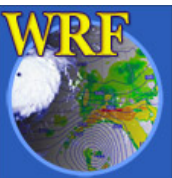
- netCDF
- GRIB
- Vis5D
- KML
- CSV
- GEMPAK grid
- ADDE

- **Access Methods:**

- Local files
- HTTP
- ADDE, TDS and OPeNDAP servers
- WMS

ADDE = Abstract Data Distribution Environment

TDS (THREDDS) = Thematic Realtime Environmental Distributed Data Services





Unidata IDV – Where to get it?

- <https://www.unidata.ucar.edu/software/idv>
 - Point-and-click installers
 - Windows (.exe), Mac (.dmg), and Linux (.sh) installers available for both 32 and 64-bit systems
- **System requirements:**
 - 2+ GB RAM
 - Java 1.6
 - *Latest* video card driver

