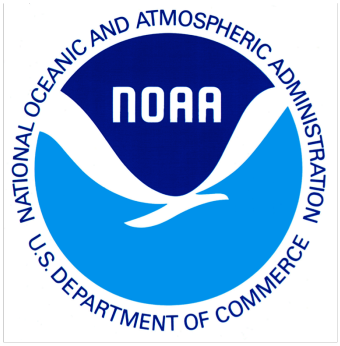

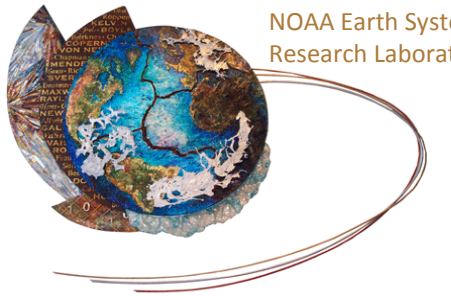

GEFS reforecasts:
a data set suitable for initializing retrospective WRF forecasts

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NCAR, Mesoscale and Microscale Meteorology Division
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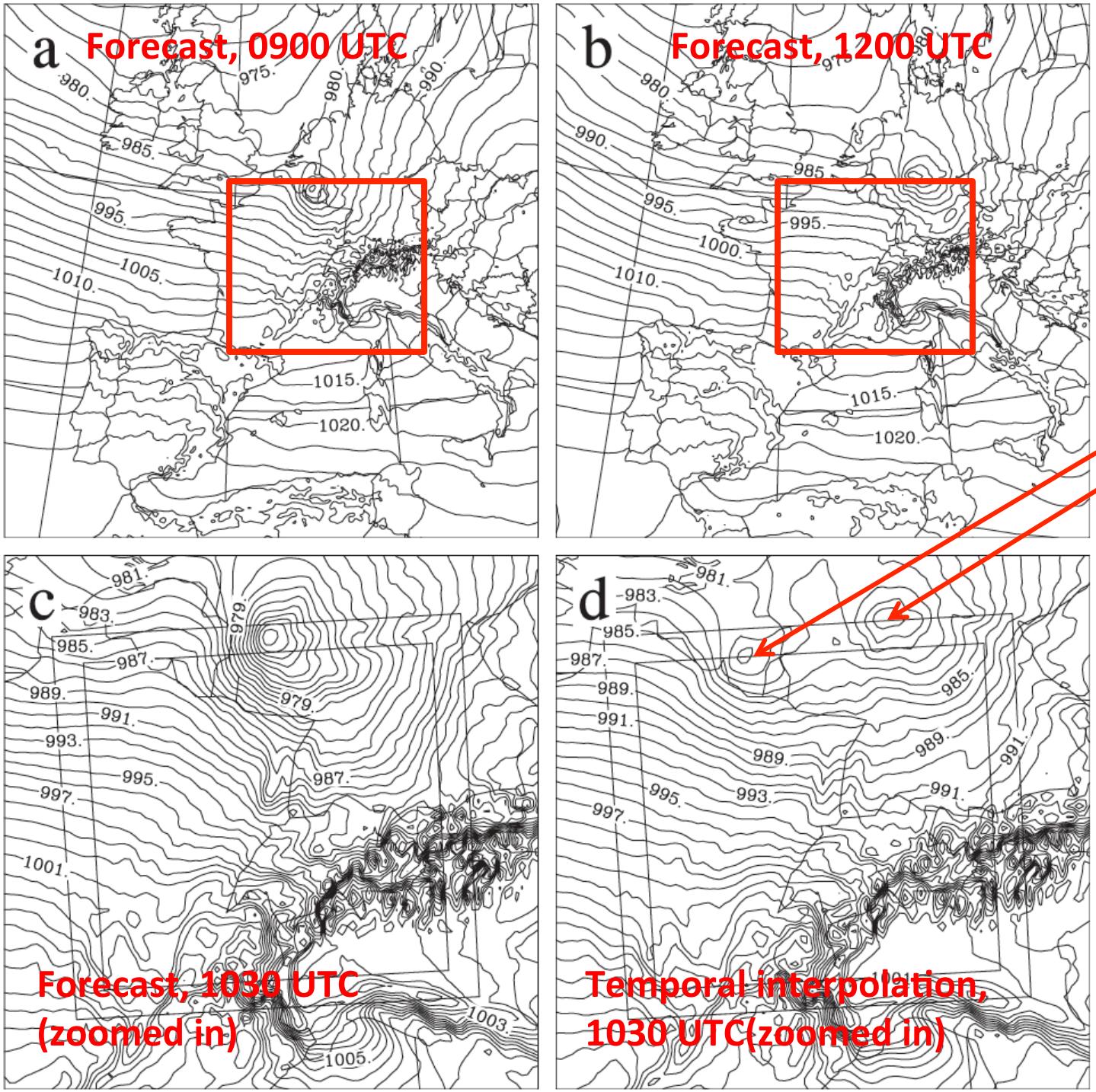
also: Jeff Whitaker, Gary Bates, Don Murray, Francisco Alvarez, Mike Fiorino, Tom Galarneau

Challenge: realistic LBC's for WRF

- Use of reanalysis data rather than global forecast data for LBC's can result in:
  - Inappropriately small errors in forecast LBC's, hence results that are unrealistic of real-time applications.
  - Large time interpolation at lateral boundary due to 6-hourly updates common with reanalyses.
- Possible remedies
  - Nested domains, with very large outer domain.
  - Use a global model forecast data for LBCs…but from where?



Example: interpolation errors in Aladin simulation of 1999 Lothar storm

temporal interpolation creates two lows from one.

Ref: Tudor & Termonia, MWR, July 2010

Reforecasts (hindcasts)

Numerical simulations of the past weather using the same forecast model and assimilation system that is used operationally.

2nd-generation GEFS reforecast: details

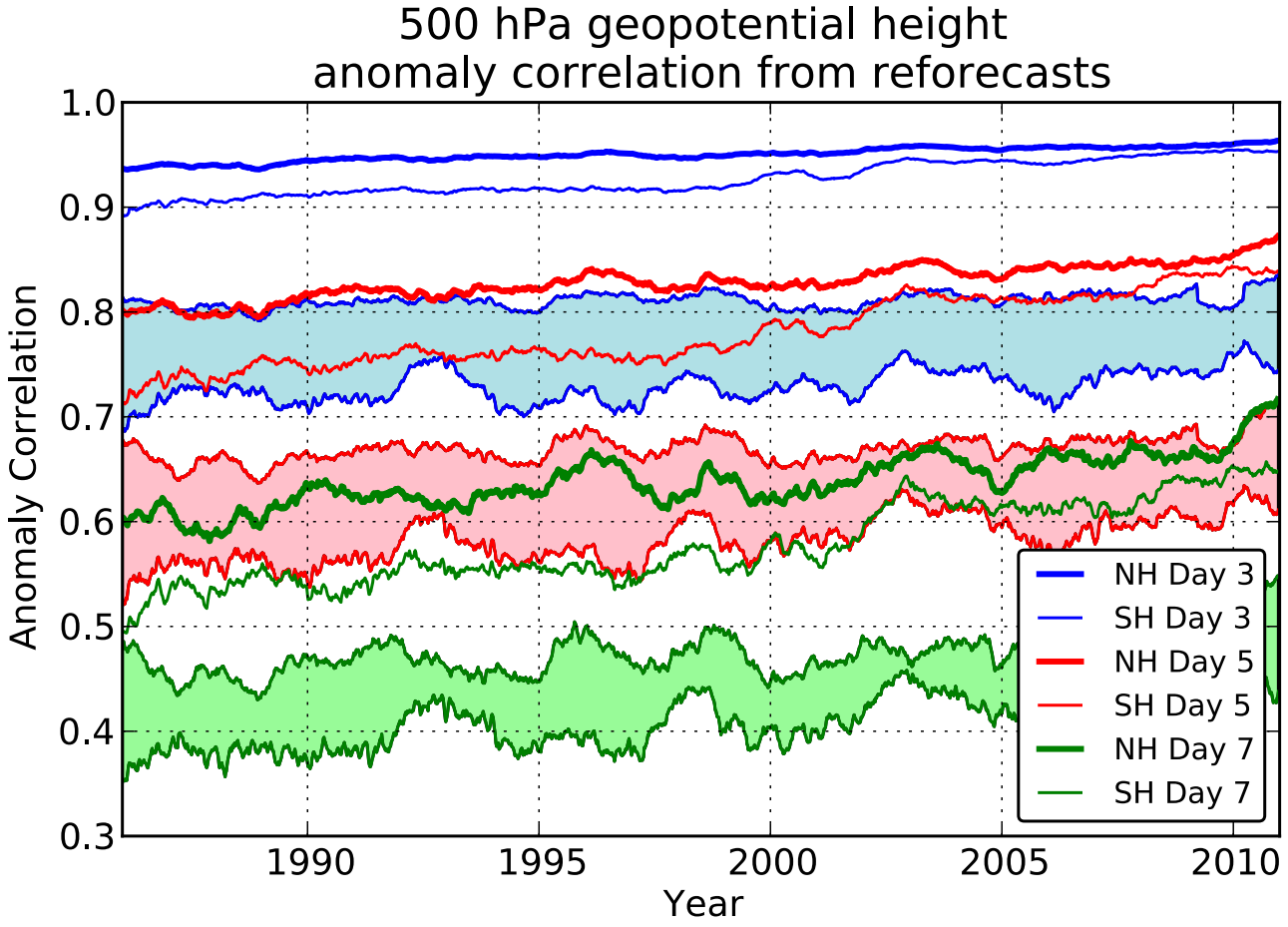
- Past forecasts using NCEP GEFS operational configuration as of February 2012. This version still operational, though data assimilation method was improved in May 2012.
- Reforecasts produced every day, for 1984120100 to current.
- Each 00Z, 11-member forecast, 1 control + 10 perturbed.
- CFSR (NCEP's Climate Forecast System Reanalysis) initial conditions (3D-Var) + ETR perturbations (cycled with 10 perturbed members). After ~ 22 May 2012, initial conditions from hybrid EnKF/3D-Var.
- Spatial resolution: T254L42 to day 8, T190L42 from days 7.5 to day 16.
- Temporal resolution: 3-hourly to +72 h, 6 hourly thereafter.
- Fast data archive at ESRL of 99 variables, 28 of which stored at original ~1/2-degree resolution during week 1. All stored at 1 degree. Also: mean and spread to be stored.
- Full model archive at DOE/Lawrence Berkeley Lab, where data set was created under DOE grant.

Status of the reforecast v2 archive.

- 00Z reforecast data and (since mid-2012) 00Z GEFS real-time forecasts are publicly available from our archive.
- Download web sites are open to you now:
  - NOAA/ESRL site: fast access, limited data (99 fields). Also there, README & info on how to ftp.
    - http://www.esrl.noaa.gov/psd/forecasts/reforecast2/
  - US Department of Energy: slow access, but full model states.
    - http://portal.nersc.gov/project/refcst/v2/

Skill of the raw reforecasts

500 hPa Z anomaly correlation
(from deterministic control)

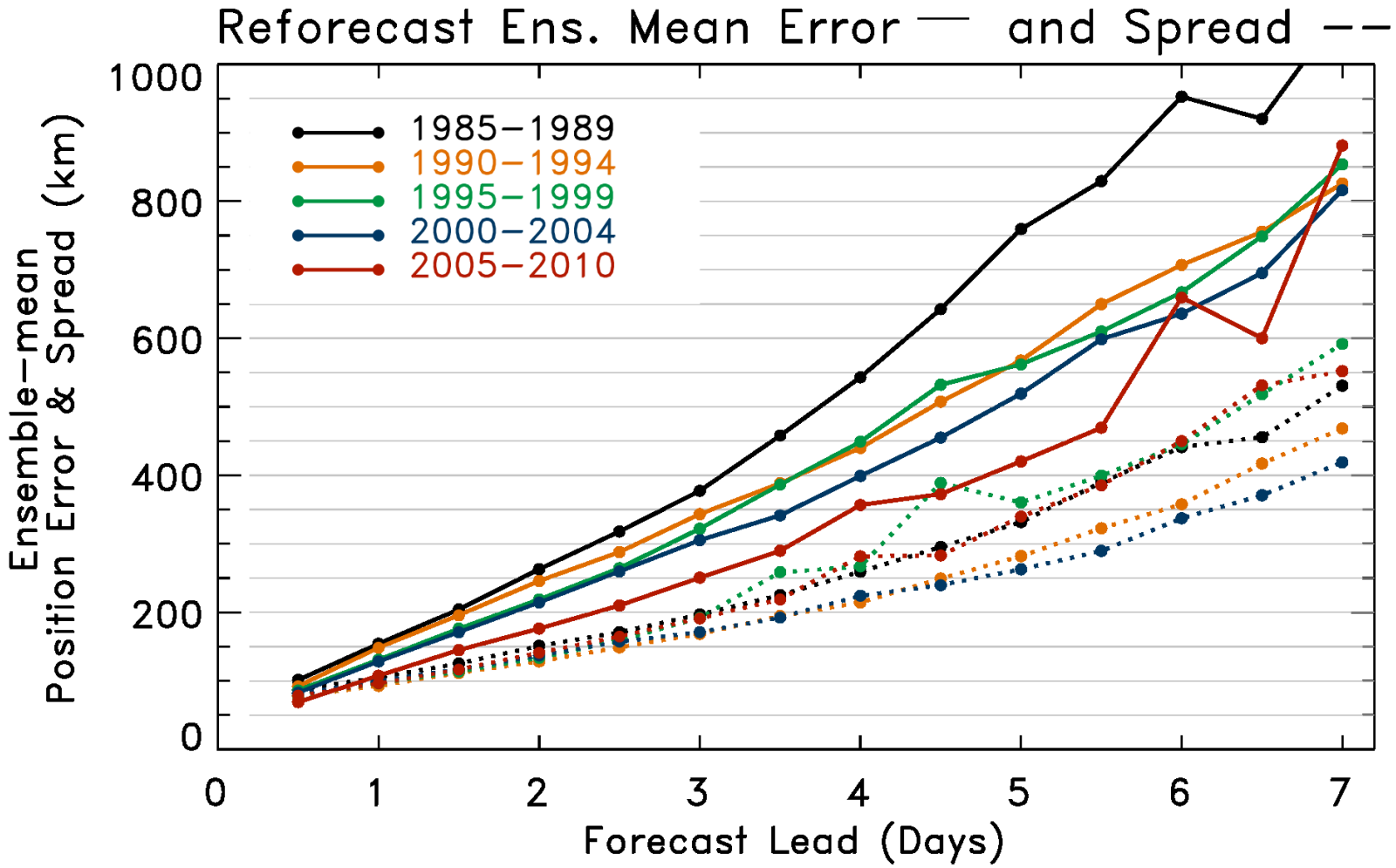


Lines w/o filled colors for second–generation reforecast (2012, T254)

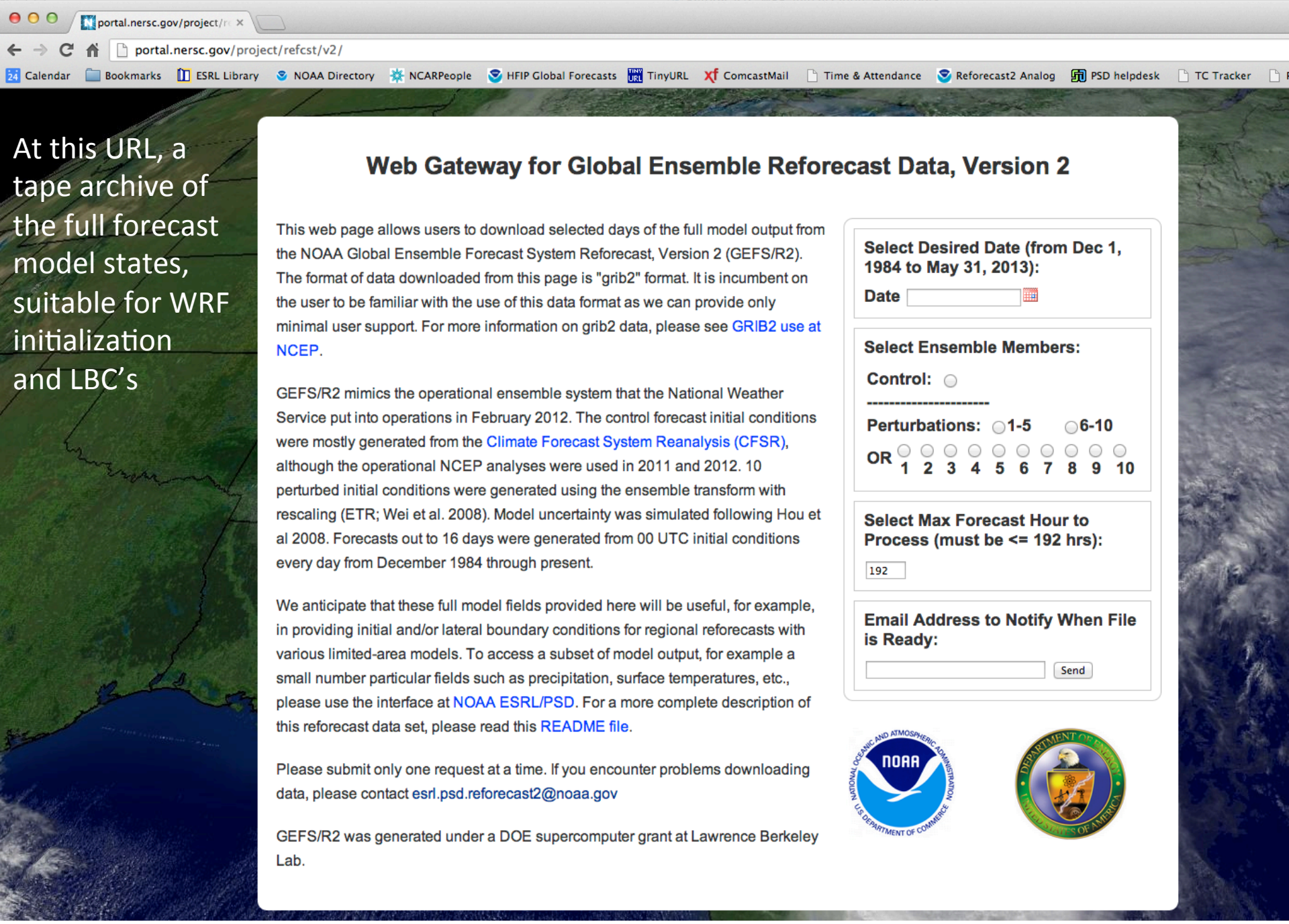
Lines with filled colors for first-generation reforecast (1998, T62).

Perhaps a 1.5-2.5 day improvement relative to 1st-generation reforecasts.

Tropical cyclone track errors



Less statistical consistency of errors over the period of the reforecasts, as opposed to 500 hPa anomaly correlation, which emphasizes mid-latitude variability.


portal.nersc.gov/project/
portal.nersc.gov/project/refcst/v2/
Calendar
Bookmarks
ESRL Library
NOAA Directory
NCARPeople
HFIP Global Forecasts
TinyURL
ComcastMail
Time & Attendance
Reforecast2 Analog
PSD helpdesk
TC Tracker
At this URL, a tape archive of the full forecast model states, suitable for WRF initialization and LBC's
Web Gateway for Global Ensemble Reforecast Data, Version 2
This web page allows users to download selected days of the full model output from the NOAA Global Ensemble Forecast System Reforecast, Version 2 (GEFS/R2). The format of data downloaded from this page is "grib2" format. It is incumbent on the user to be familiar with the use of this data format as we can provide only minimal user support. For more information on grib2 data, please see GRIB2 use at NCEP.
GEFS/R2 mimics the operational ensemble system that the National Weather Service put into operations in February 2012. The control forecast initial conditions were mostly generated from the Climate Forecast System Reanalysis (CFSR), although the operational NCEP analyses were used in 2011 and 2012. 10 perturbed initial conditions were generated using the ensemble transform with rescaling (ETR; Wei et al. 2008). Model uncertainty was simulated following Hou et al 2008. Forecasts out to 16 days were generated from 00 UTC initial conditions every day from December 1984 through present.
We anticipate that these full model fields provided here will be useful, for example, in providing initial and/or lateral boundary conditions for regional reforecasts with various limited-area models. To access a subset of model output, for example a small number particular fields such as precipitation, surface temperatures, etc., please use the interface at NOAA ESRL/PSD. For a more complete description of this reforecast data set, please read this README file.
Please submit only one request at a time. If you encounter problems downloading data, please contact esrl.psd.reforecast2@noaa.gov
GEFS/R2 was generated under a DOE supercomputer grant at Lawrence Berkeley Lab.
Select Desired Date (from Dec 1, 1984 to May 31, 2013):
Date
Select Ensemble Members:
Control:
Perturbations: 1-5 6-10
OR 1 2 3 4 5 6 7 8 9 10
Select Max Forecast Hour to Process (must be <= 192 hrs):
192
Email Address to Notify When File is Ready:
Send
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

Some notes running WRF using data from this archive

(from http://www.esrl.noaa.gov/psd/forecasts/reforecast2/README.GEFS_Reforecast2.pdf)

- The proper Vtable file must be created prior to preprocessing the GEFS reforecast data. To do this, copy Vtable.GFS to your working directory for preprocessing the GRIB2 GEFS reforecast data. Rename the Vtable.GFS file as Vtable.reforecast, and modify the file as follows. First, add a line for specific humidity on pressure levels and at 2 m. The specifications for specific humidity should be as follows:

  metgrid Description: Specific Humidity
  metgrid units: kg kg-1
  metgrid Name: SPECHUMD
  GRIB2 Discp=0, Catgy=1, Param=0, Level=100
  GRIB1 Param=52, Level Type=100, From Level1=*
  metgrid Description: Specific Humidity at 2 m
  metgrid units: kg kg-1
  metgrid Name: SPECHUMD
  GRIB2 Discp=0, Catgy=1, Param=0, Level=103
  GRIB1 Param=52, Level Type=105, From Level1=2

- Second, remove the GRIB2 parameter number for relative humidity on pressure levels and at 2m. Note that ungrib.exe and metgrid.exe will calculate relative humidity for you if you have specific humidity. Finally, change the GRIB2 parameter number for PMSL from 1 to 0. No other known modifications to the Vtable are needed. Now that the Vtable.reforecast file is properly created, follow the instructions for running WRF-ARW on the WRF Users' Page [http://www.mmm.ucar.edu/wrf/users/].

- The files downloaded from DOE will have the fields for the different forecast lead times merged into one grib file. It will be your responsibility to break up that into separate grib files for each lead time.

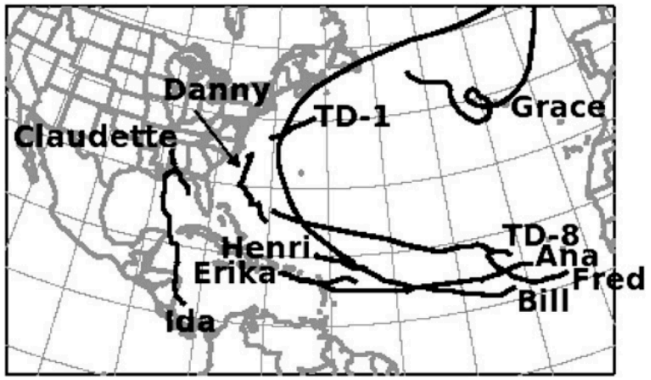
Demo: WRF ARW Regional Reforecast of Hurricane Rita (2005)

- An example of generating a WRF high-resolution regional reforecast ensemble using GEFS initial and LBCs
- Will show in this case that regional reforecast WRF ensemble provided value-added guidance to global ensemble forecast.

Details of reforecast with WRF ARW v3.4 using GEFS for initial, boundary conditions

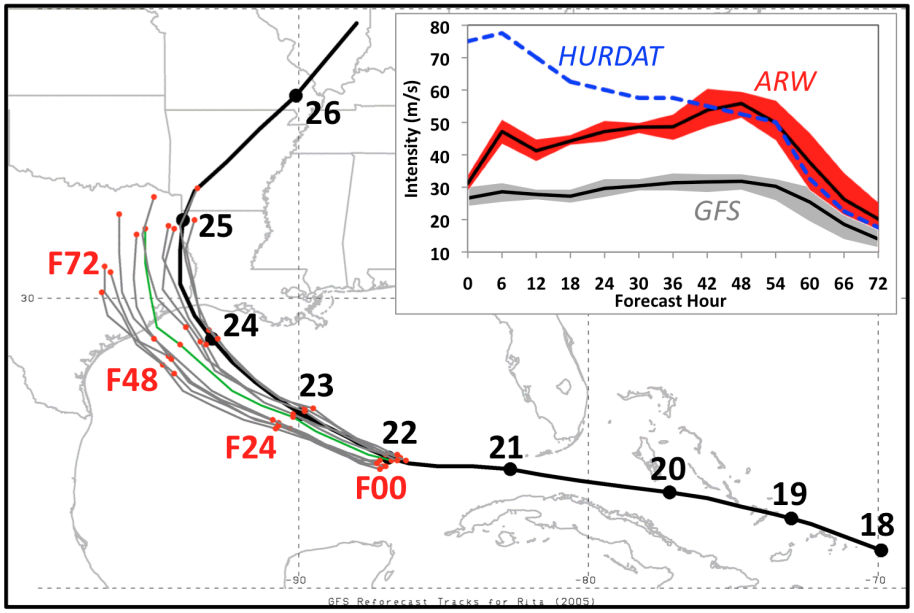
- Nested simulation 36-, 12- and 4-km with 36 vertical levels
  - 12- and 4-km moving nests
- Time steps: 180, 60, and 20 s
- Initial and boundary conditions from GFS reforecast ensemble members
- Tiedtke cumulus scheme on 36 and 12 km; explicit on 4 km
- YSU PBL scheme
- HYCOM ocean analysis
- WSM6 microphysics
- Noah land surface
- 2D Smagorinsky turbulence scheme
- Goddard shortwave radiation
- RRTM longwave radiation
- Second order diffusion
- Positive definite scalar advection
- Donelan wind-dependent drag formulation
- Garratt wind-dependent enthalpy surface fluxes

outer WRF domain

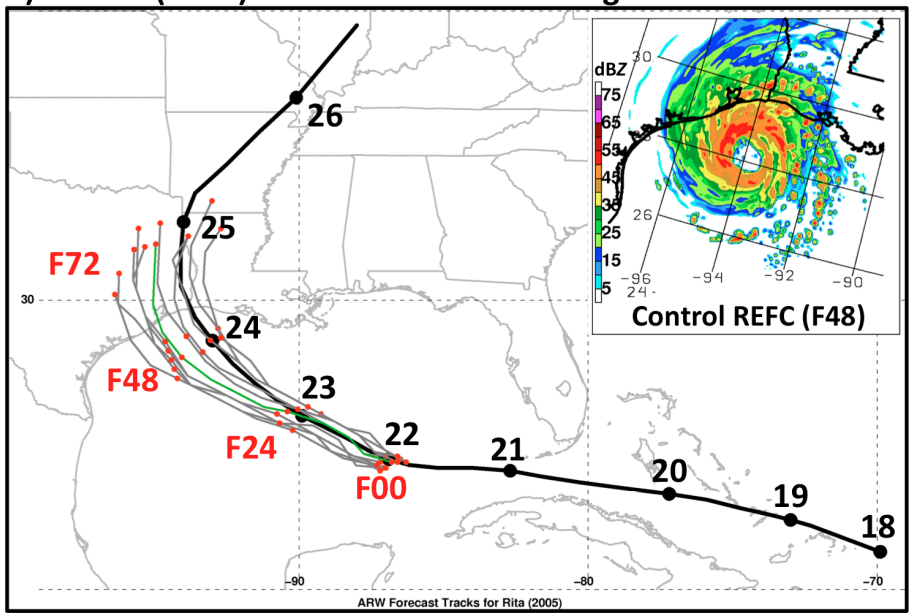


WRF-ARW reforecast ensemble results

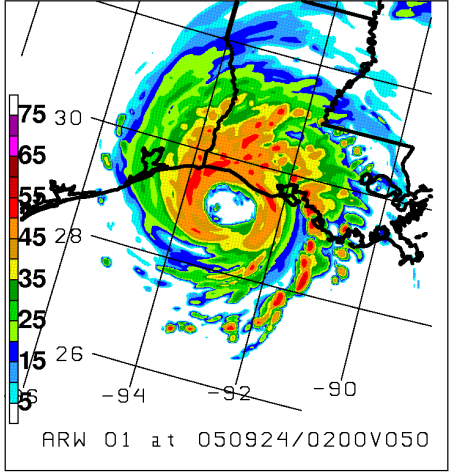
a) TC Rita (2005) 72-h GFS Ensemble Reforecast

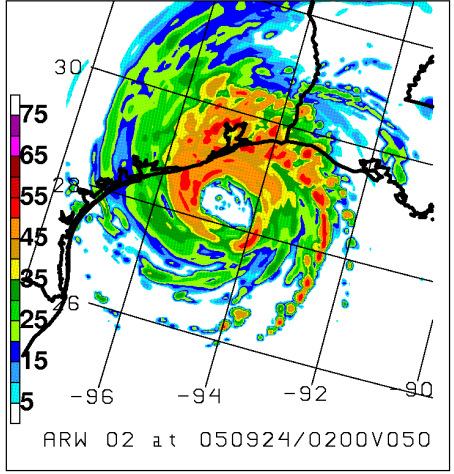


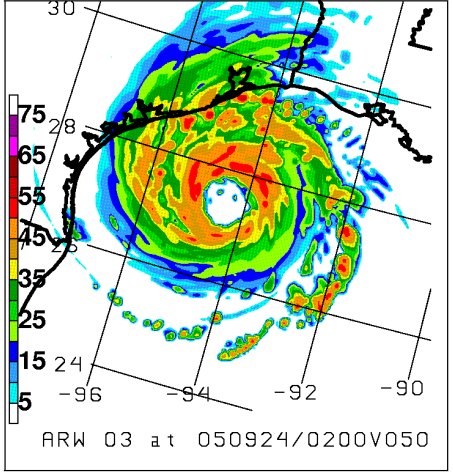
b) TC Rita (2005) 72-h ARW Ensemble Regional Reforecast

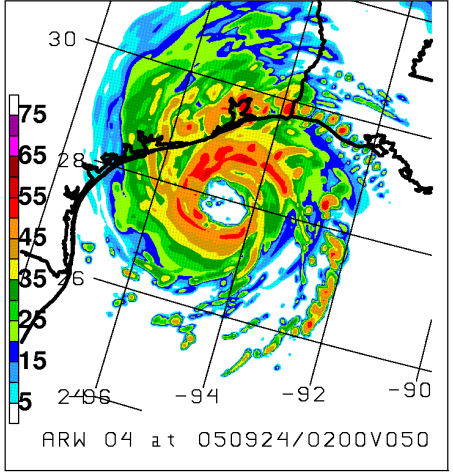


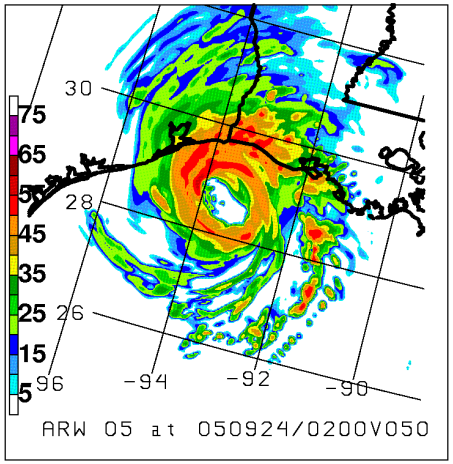
- Global reforecast ensemble is consistent with NHC forecast; indicating potential impact on Houston
- Significant left-of-track error and intensity was underestimated
- Rita vortex intensified in ARW regional reforecast despite terrible initial vortex
- Similar left-of-track error in ARW; suggests large-scale control on TC motion

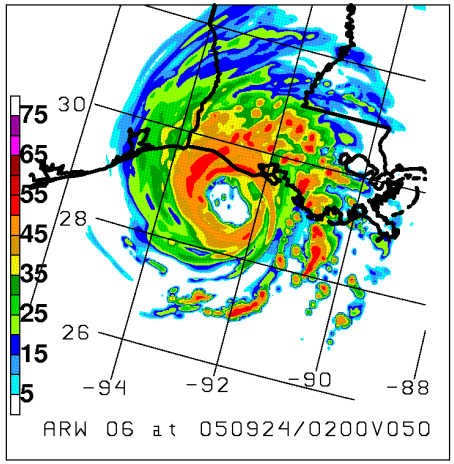


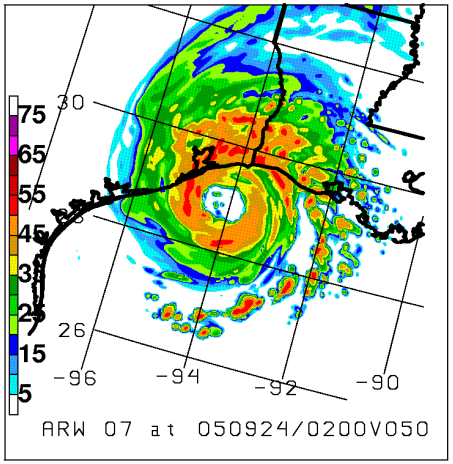


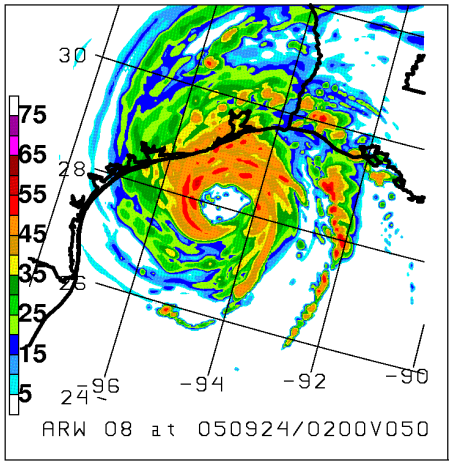


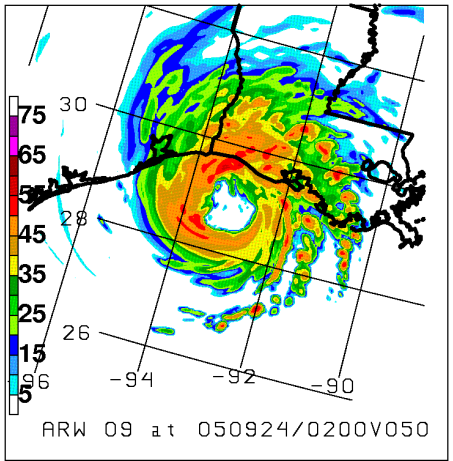


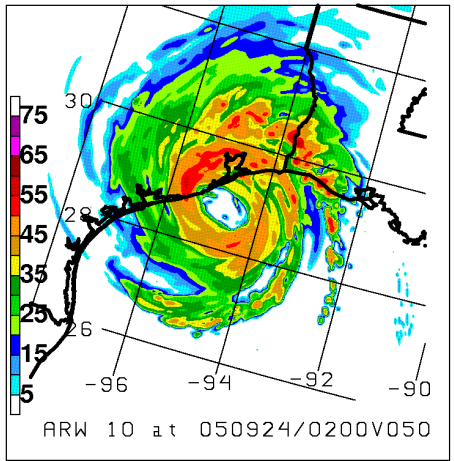


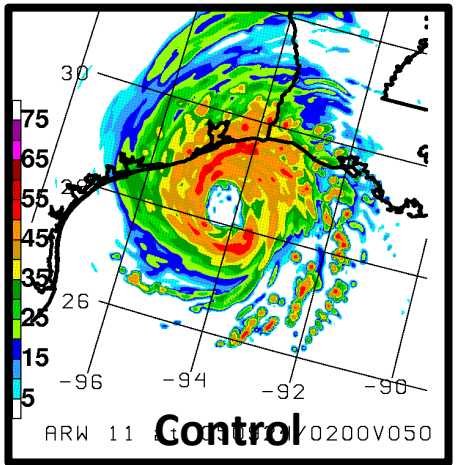




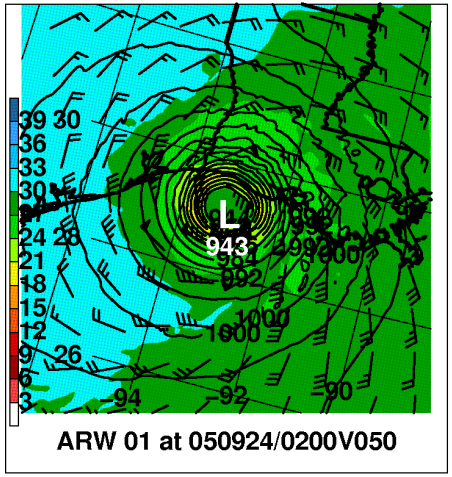


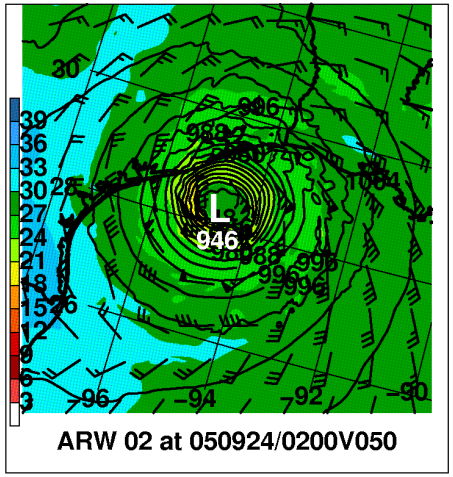


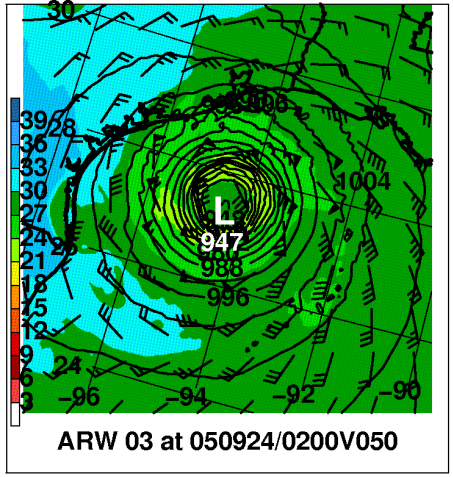


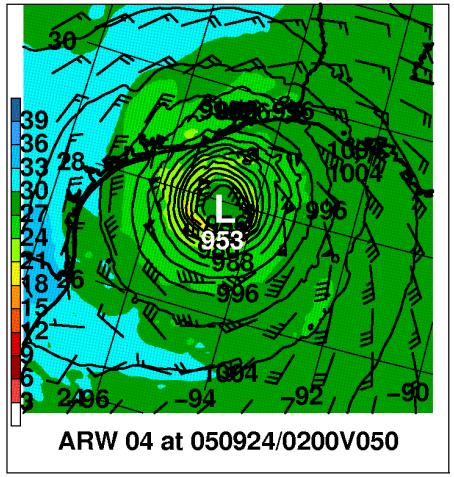


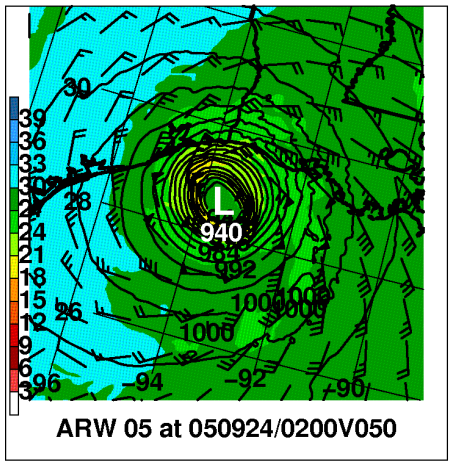
Maximum reflectivity (dBZ)
50-h ARW Forecast
Verifying 02Z/24 Sep '05

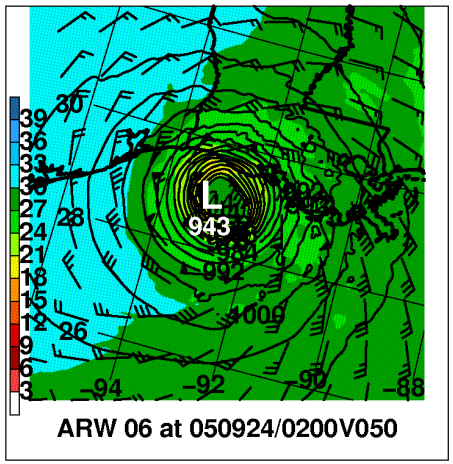


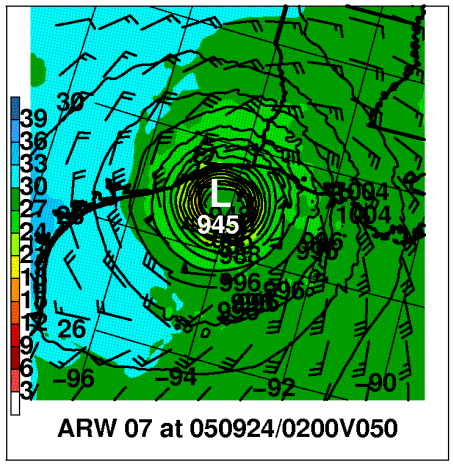


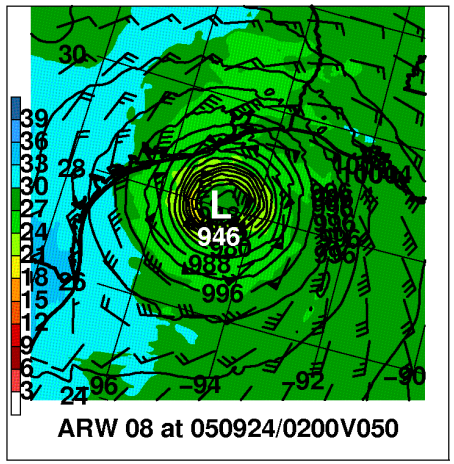


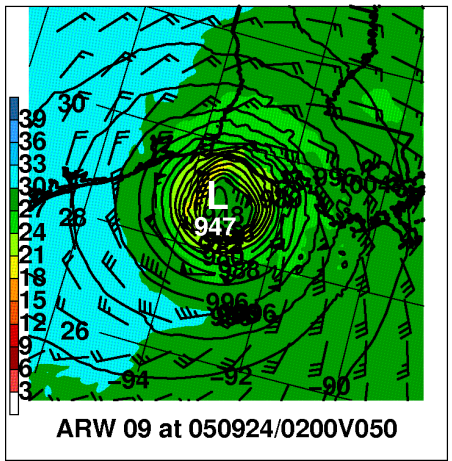


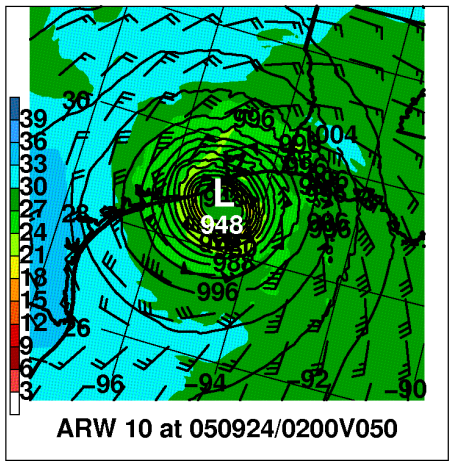


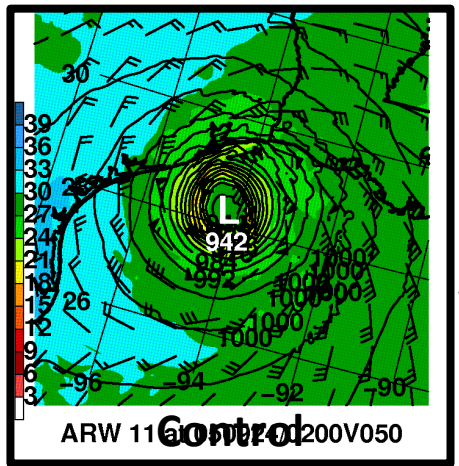




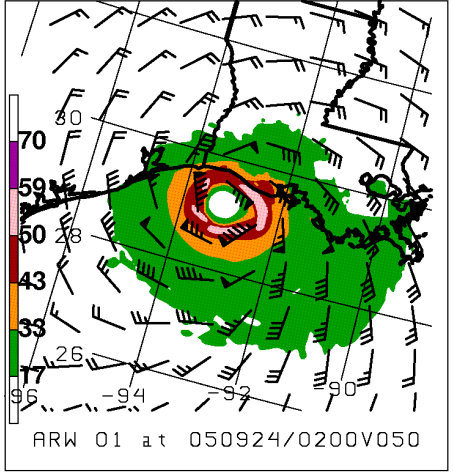


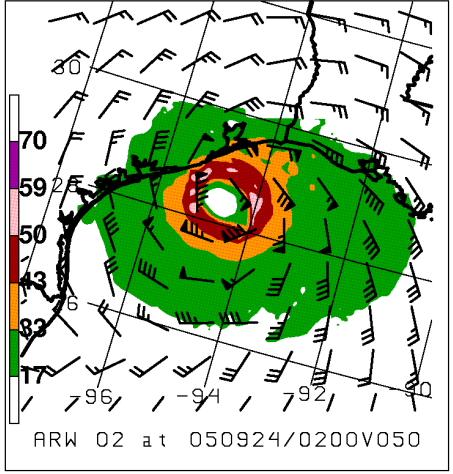


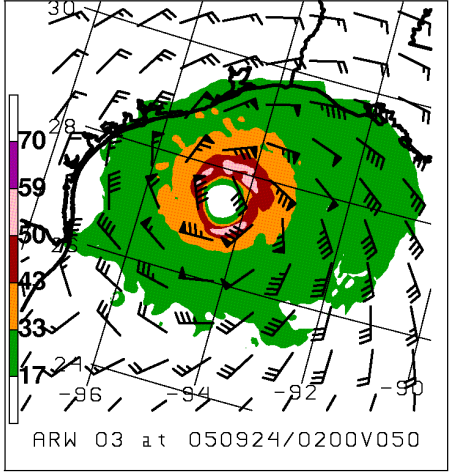


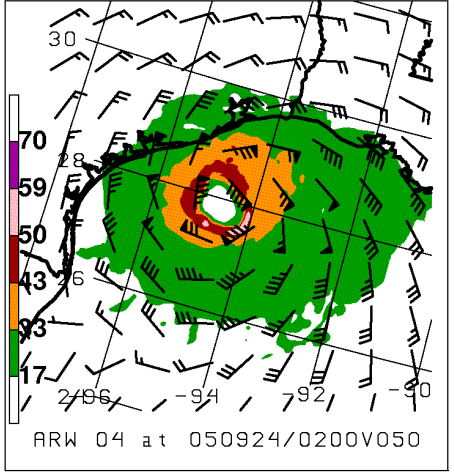


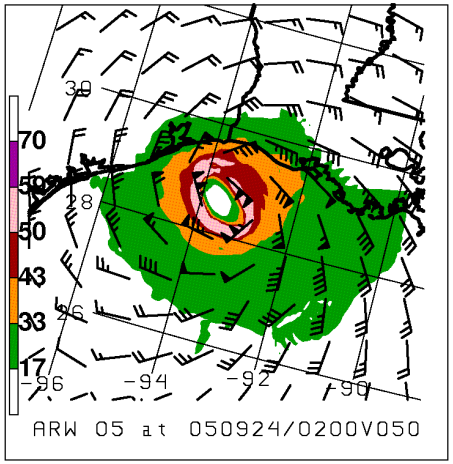
SLP (contours every 4 hPa)
2-m Temperature (shaded in °C)
10-m wind (barbs in knots)
50-h ARW Forecast
Verifying 02Z/24 Sep '05

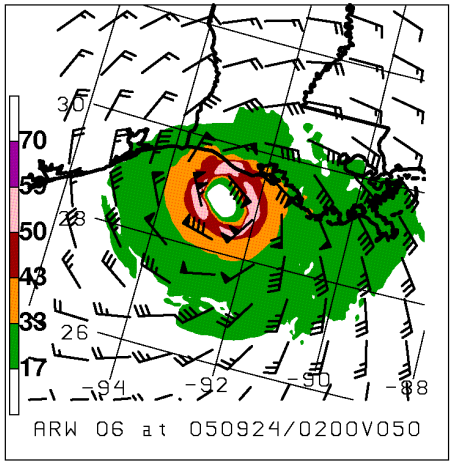


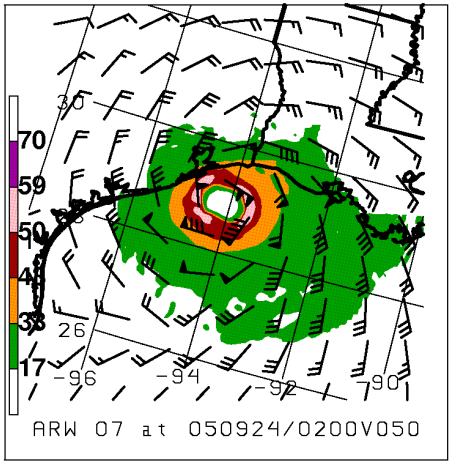


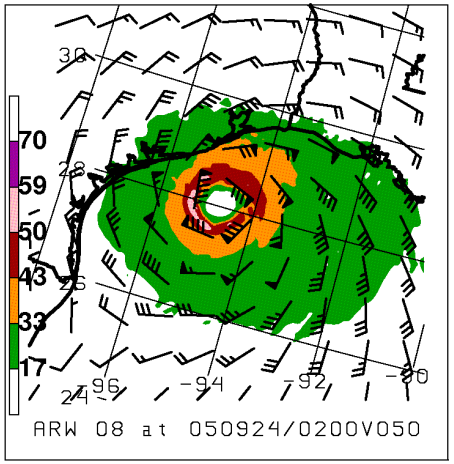


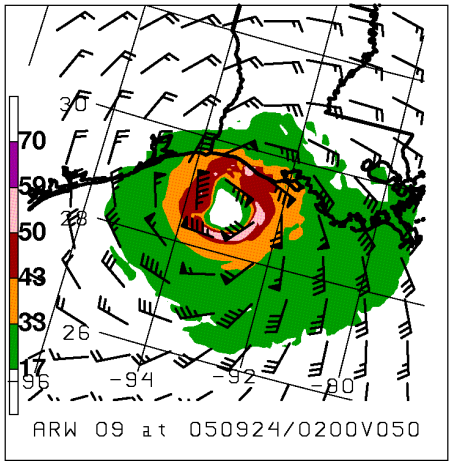


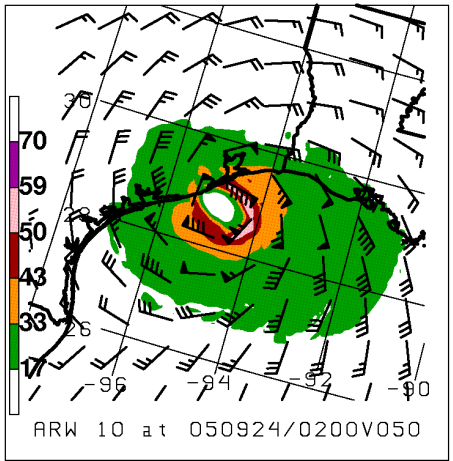


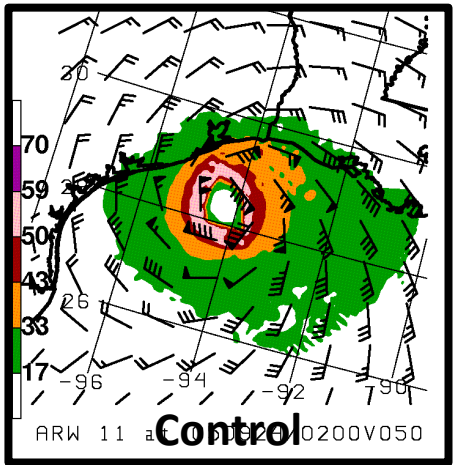








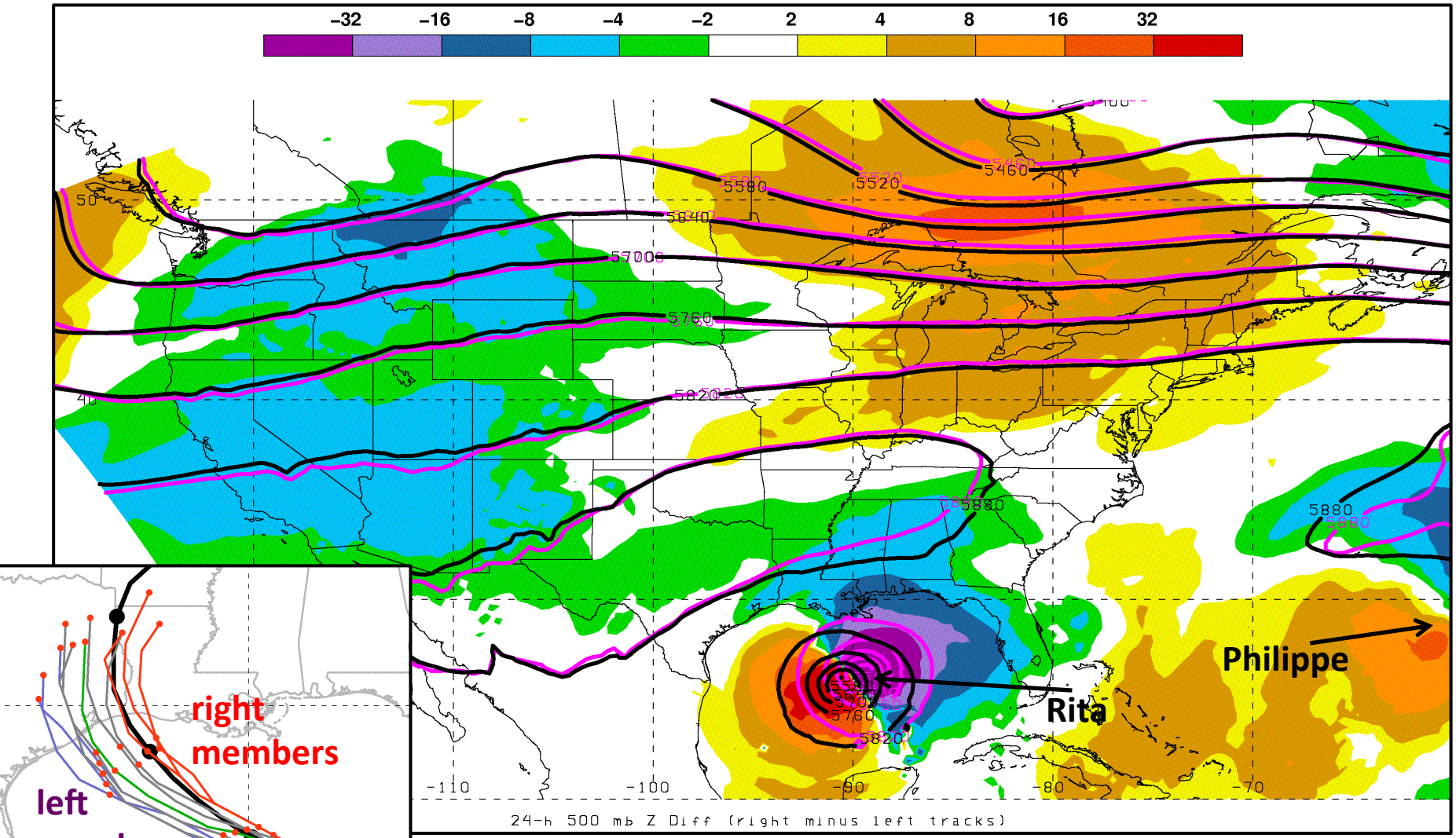




10-m wind speed (m/s)
10-m wind (barbs in knots)
50-h ARW Forecast
Verifying 02Z/24 Sep ‘05

Ensemble Analysis: 500 hPa Z

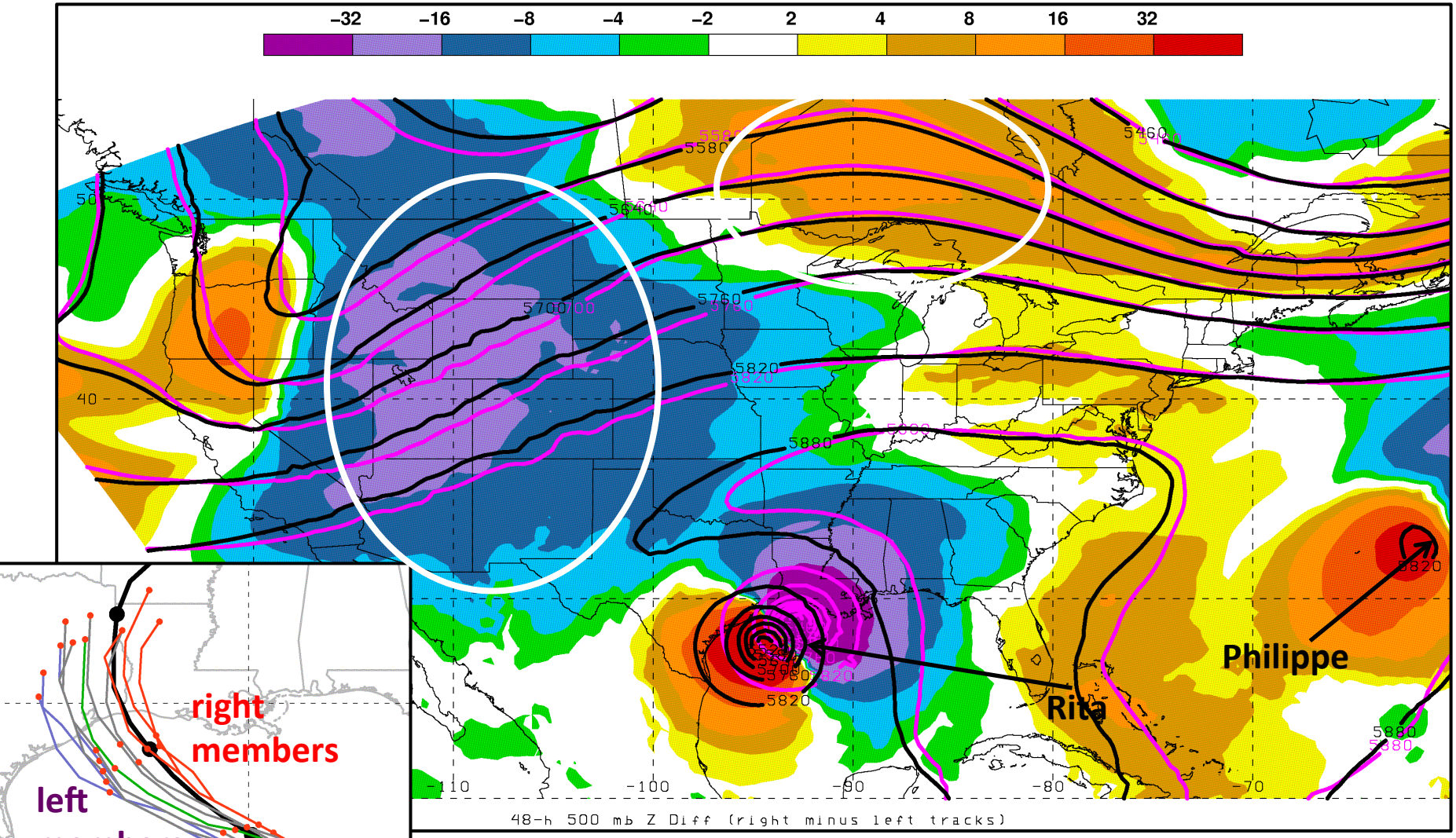
24-h ARW Forecast (36-km domain) verifying 0000 UTC 23 Sep 2005



500 hPa Z difference (right minus left; shaded in m), right mean (magenta every 60 m), and left mean (black every 60 m)

Ensemble Analysis: 500 hPa Z

48-h ARW Forecast (36-km domain) verifying 0000 UTC 24 Sep 2005



500 hPa Z difference (right minus left; shaded in m), right mean (magenta every 60 m), and left mean (black every 60 m)

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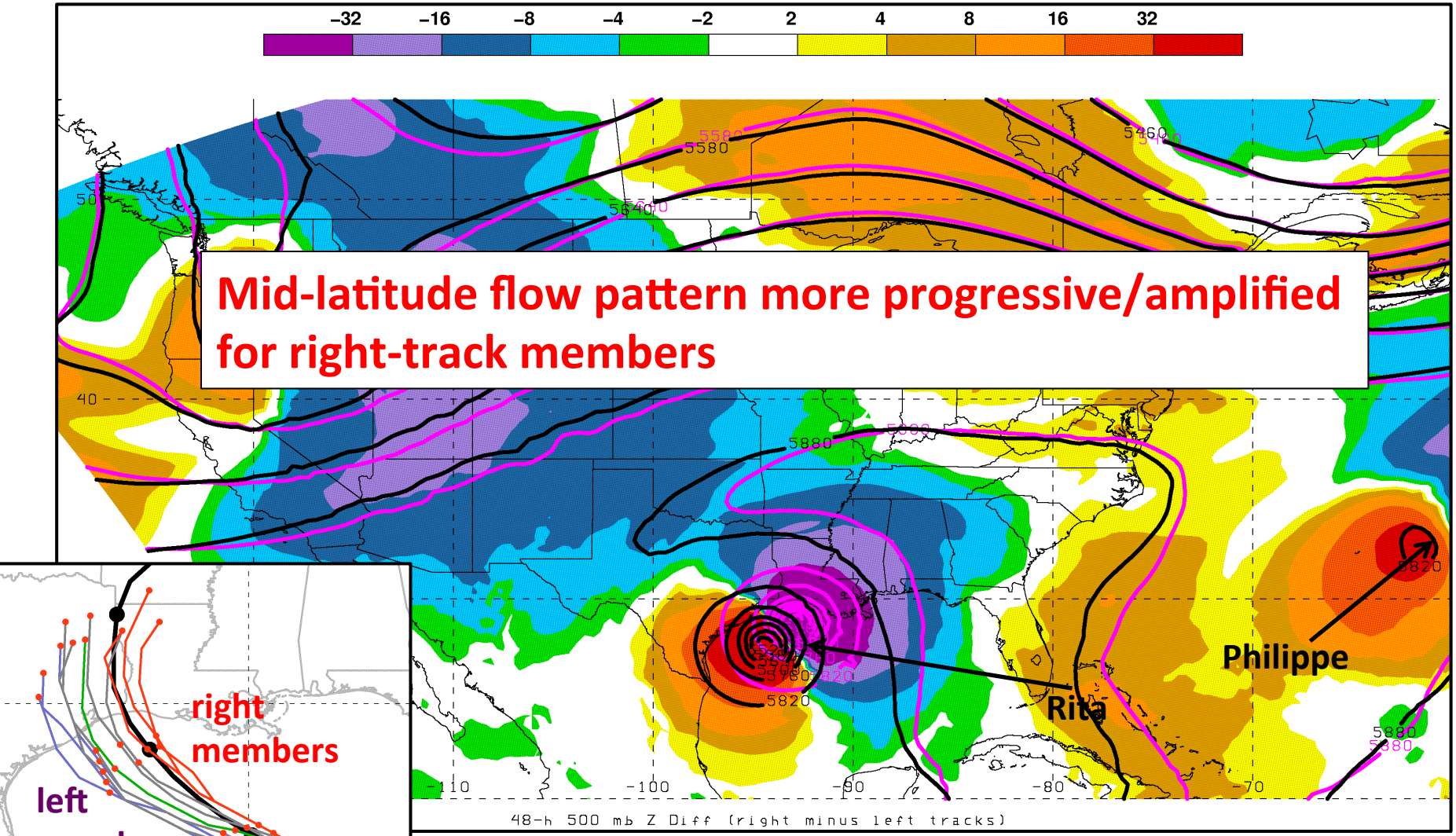


500 hPa Z difference (right minus left; shaded in m), right mean (magenta every 60 m), and left mean (black every 60 m)

Conclusions

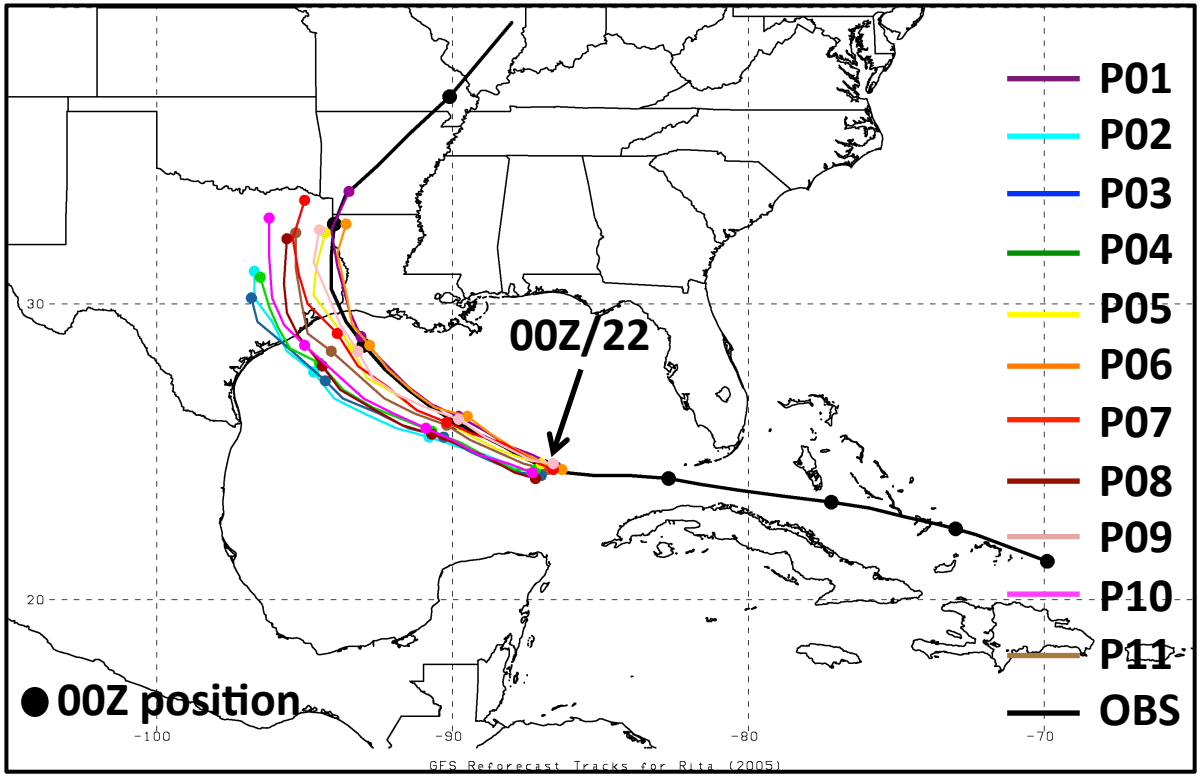
- This new GEFS global reforecast data set may facilitate running retrospective WRF forecasts in a more appropriate manner, with LBC's from a *forecast model*, thus more realistic of a real-time configuration.
- Demonstrated successfully for hurricane Rita.
- GEFS information readily available, easy to use.
- An article on the data set and its applications is in press at BAMS,

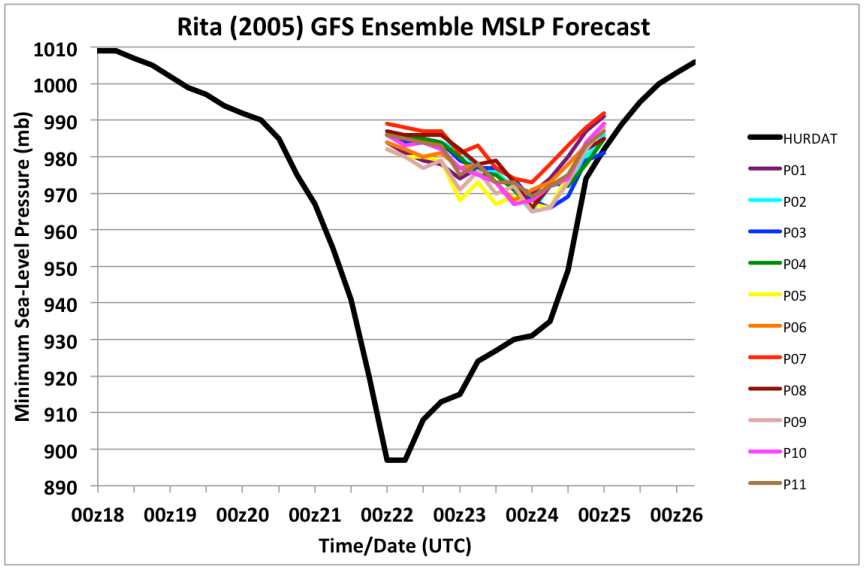
http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00014.1

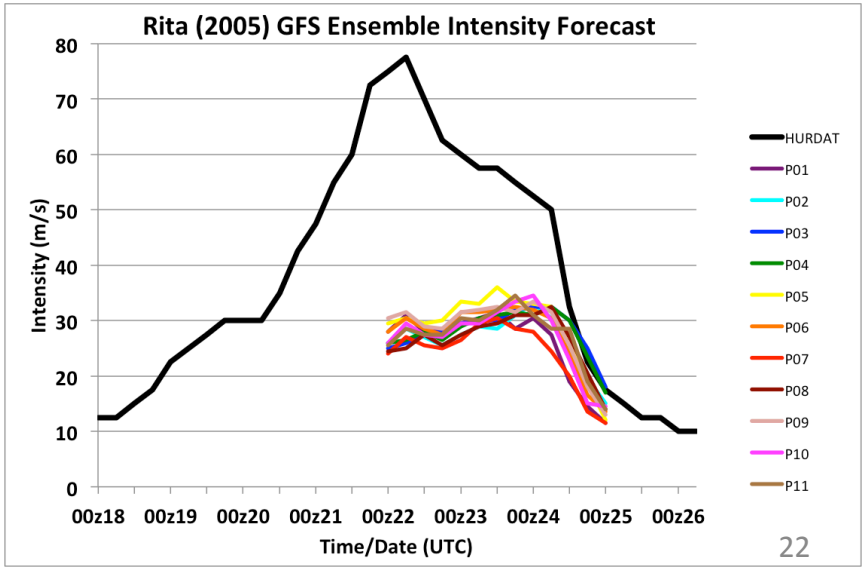
TC Rita (2005)

GFS reforecast ensemble

72-h forecast initialized at 00Z 22 Sept



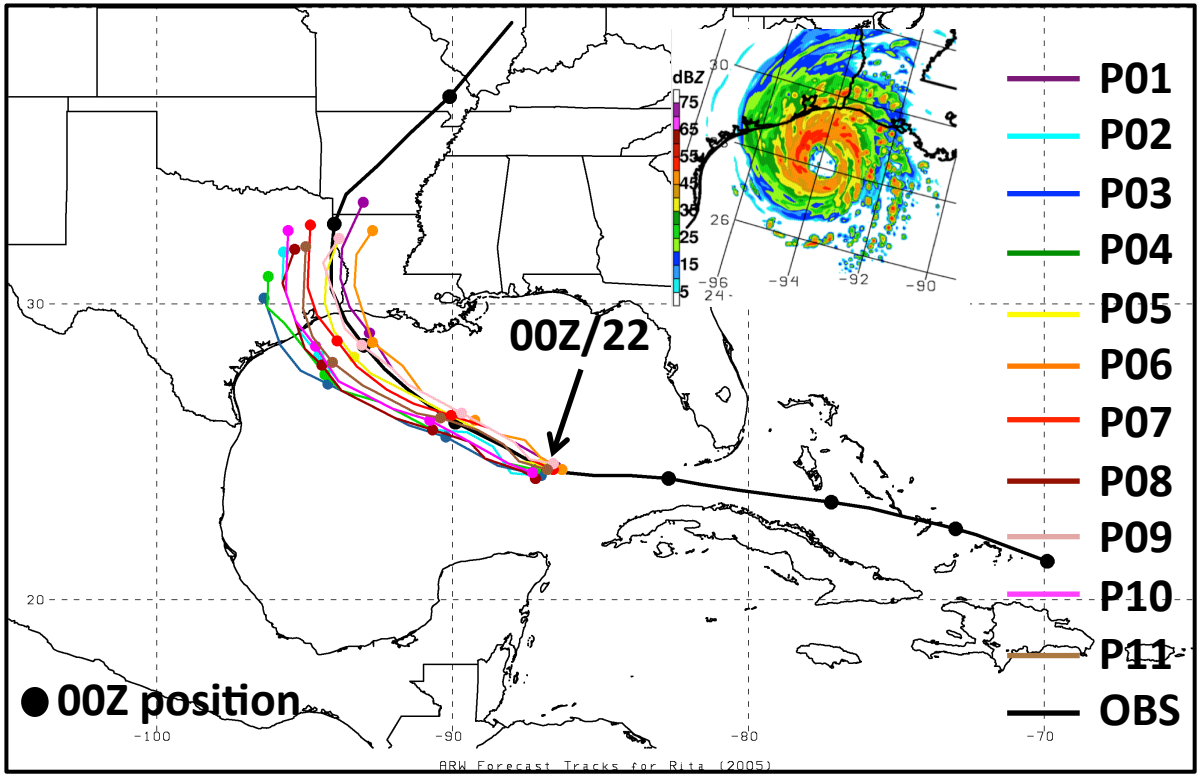


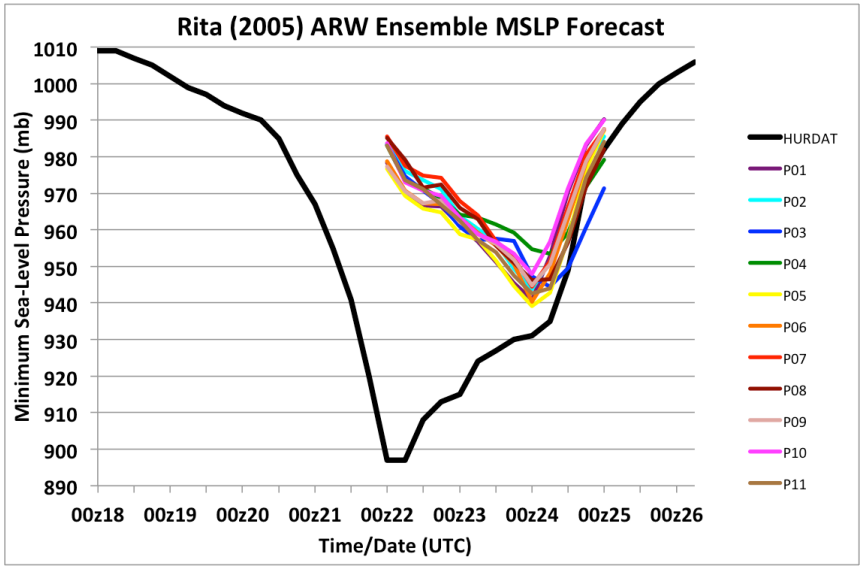


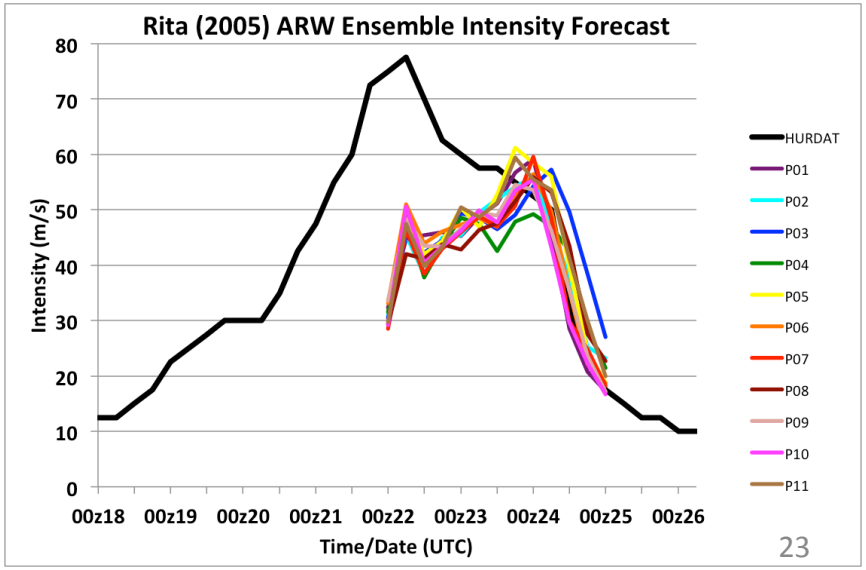
TC Rita (2005)

ARW ensemble with GFS reforecast ensemble as boundary and initial conditions

72-h forecast initialized at 00Z 22 Sept







Data that is readily available on spinning disk from ESRL

Table 1: Reforecast variables available for selected mandatory and other vertical levels. Φ indicates geopotential height, and an X indicates that this variable is available from the reforecast data set at 1-degree resolution; a Y indicates that the variable is available at the native ~0.5 degree resolution. AGL indicates "above ground level."

Vertical Level	U	V	T	Φ	q	Wind Power
10 hPa	X	X	X	X		
50 hPa	X	X	X	X		
100 hPa	X	X	X	X		
200 hPa	X	X	X	X		
250 hPa	X	X	X	X		
300 hPa	X	X	X	X	X	
500 hPa	X	X	X	X	X	
700 hPa	X	X	X	X	X	
850 hPa	X	X	X	X	X	
925 hPa	X	X	X	X	X	
1000 hPa	X	X	X	X	X	
$\sigma \cong 0.996$	X	X		X		
$\sigma \cong 0.987$	X	X		X		
$\sigma \cong 0.977$	X	X		X		
$\sigma \cong 0.965$	X	X		X		
80m AGL	X,Y	X,Y				X,Y

This is rather coarse vertical resolution for initialization of a regional model, though.

Data that is readily available on spinning disk from ESRL (continued)

Variable (units)
Mean sea-level pressure (Pa) [Y]
Skin temperature (K) [Y]
Soil temperature, 0.0 to 0.1 m depth (K) [Y]
Volumetric soil moisture content 0.0 to 0.1 m depth (fraction between wilting and saturation) [Y]
Water equivalent of accumulated snow depth (kg m^{-2}, i.e., mm) [Y]
2-meter temperature (K) [Y]
2-meter specific humidity (kg kg^{-1} dry air) [Y]
Maximum temperature (K) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
Minimum temperature (K) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
10-m u wind component (ms^{-1}) [Y]
10-m v wind component (ms^{-1}) [Y]
Total precipitation (kg m^{-2}, i.e., mm) in last 6-h period (00, 06, 12, 18 UTC) or in last 3-h period (03, 09, 15, 21 UTC) [Y]
Water runoff (kg m^{-2}, i.e., mm) [Y]
Average surface latent heat net flux (W m^{-2}) [Y]
Average sensible heat net flux (W m^{-2}) [Y]
Average ground heat net flux (W m^{-2}) [Y]
Convective available potential energy (J kg^{-1}) [Y]

Convective inhibition (J kg^{-1}) [Y]
Precipitable water (kg m^{-2}, i.e., mm) [Y]
Total-column integrated condensate (kg m^{-2}, i.e., mm) [Y]
Total cloud cover (%)
Downward short-wave radiation flux at the surface (W m^{-2}) [Y]
Downward long-wave radiation flux at the surface (W m^{-2}) [Y]
Upward short-wave radiation flux at the surface (W m^{-2}) [Y]
Upward long-wave radiation flux at the surface (W m^{-2}) [Y]
Upward long-wave radiation flux at the top of the atmosphere (W m^{-2}) [Y]
Potential vorticity on the 320K isentropic surface (×10-6 K m^2 kg^{-1} s^{-1})
U component on 2 PVU (1 PVU = 1×10-6 K m^2 kg^{-1} s^{-1}) isentropic surface (ms^{-1})
V component on 2 PVU isentropic surface (ms^{-1})
Temperature on 2 PVU isentropic surface (K)
Pressure on 2 PVU isentropic surface (Pa)
80-m u wind component (ms^{-1}) [Y]
80-m v wind component (ms^{-1}) [Y]
Vertical velocity at 850 hPa (Pa s^{-1})
Water runoff (kg m^{-2}, i.e., mm)
Wind mixing energy at 80 m (J) [Y]

[Y] indicates that this variable is available at the native ~0.5-degree resolution as well as the 1-degree resolution.

http://esrl.noaa.gov/psd/forecasts/reforecast2/download.html

Select Desired Variables and Associated Levels:

Single Level (1°x1°) | Pressure Levels (1°x1°) | Hybrid Levels (1°x1°) | Single Level (Gaussian ~.5°)

- Total Accumulated Precipitation
- U-Component of Wind at 10 meters
- U-Component of Wind at 80 meters
- Convective Available Potential Energy
- Surface Downward Long-Wave Radiation Flux
- Surface Upward Long-Wave Radiation Flux
- Ground Heat Flux
- Surface Sensible Heat Net Flux
- Surface Pressure
- Volumetric Soil Moisture Content
- Total Cloud Cover
- Skin Temperature
- Minimum Temperature
- Upward Long-Wave Radiation Flux
- Water Equivalent of Accumulated Snow Depth
- Vertical Velocity at 850 hPa Surface
- Pressure on 2 PVU Surface
- V-Component of Wind on 2 PVU Surface
- Temperature at 2 meters
- V-Component of Wind at 10 meters
- V-Component of Wind at 80 meters
- Convective Inhibition
- Surface Downward Short-Wave Radiation Flux
- Surface Upward Short-Wave Radiation Flux
- Surface Latent Heat Net Flux
- Mean Sea Level Pressure
- Precipitable Water
- Specific Humidity at 2 meters
- Total Column-Integrated Condensate
- Maximum Temperature
- Soil Temperature (0-10 cm below surface)
- Water Runoff
- Wind Mixing Energy
- Temperature on 2 PVU Surface
- U-Component of Wind on 2 PVU Surface
- Potential Vorticity on 320 K Isentrope

Select Desired Dates (Available from Dec 1 1984 to Dec 31 2010):

From: **To:**

- Download all the forecasts within the chosen time period. Help
- Download forecasts within the month-days range for the chosen years. Help

Select Desired Forecast Hour(s):

High Resolution: (Select All or Clear)

0	3	6	9	12	15	18	21	24	27
30	33	36	39	42	45	48	51	54	57
60	63	66	69	72	78	84	90	96	102
108	114	120	126	132	138	144	150	156	162
168	174	180	186	192					

Low Resolution: (Select All or Clear)

186	192	198	204	210	216	222	228	234	240
246	252	258	264	270	276	282	288	294	300
306	312	318	324	330	336	342	348	354	360
366	372	378	384						

Produces netCDF files.

Also: direct ftp access to allow you to download the raw grib files.