

# HFIP Diagnostics Team Status Report

*Presented 9 Nov 2009, Miami Workshop*

- NESDIS and CIRA
  - M. DeMaria (Team Lead), John Knaff, Brian McNoldy, Louie Grasso
- NCEP/EMC
  - Vijay Tallapragada
- NCEP/NHC
  - Richard Pasch, Ann Schrader, new diagnostician
- OAR/HRD
  - Rob Rogers, Sundararaman Gopalakrishnan (Gopal)
- OAR/ESRL
  - Ligia Bernardet, Michael Fiorino
- NRL
  - James Doyle, Yi Jin, Richard Hodur, Hao Jin
- Tropical Cyclone Modeling Testbed
  - Barb Brown, Louisa Nance

# Status of 2009 Deliverables

1. Initial estimate of HFIP forecast error reduction goals on NHC hurricane warning size and duration (NESDIS, NCEP)
  - Presented at IHC, March 2009 and HFIP Diagnostics Workshop, May 2009
2. Completion of the first diagnostics workshop (All)
  - Held at NHC, May 2009
  - [http://rammb.cira.colostate.edu/research/tropical\\_cyclones/workshop\\_2009](http://rammb.cira.colostate.edu/research/tropical_cyclones/workshop_2009)
3. Completion of initial study of storm environmental variables and model intensity change (HRD, NCEP, NESDIS, NRL)
  - All groups developing diagnostic programs for HWRF, GFDL, GFS, FIM, HWRFx, COAMPS-TC

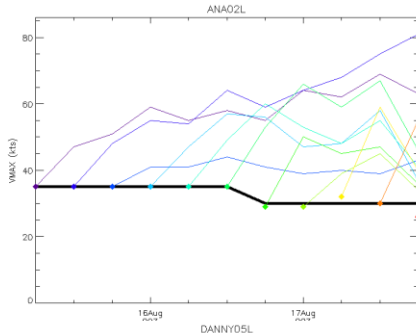
# NESDIS and CIRA Activities

- Administrative
  - Co-organizer of 1<sup>st</sup> Diagnostics Workshop
  - Lead conference calls to obtain ATCF track/intensity files for 2009 demo
    - Initial discussion of file sharing
- Applications of large-scale diagnostics for HWRF model
  - Real-time procedure set up for 2009 GFDL and HWRF
  - Results for 2008 HWRF presented at May 2009 HFIP workshop
  - EMC H-PLOT diagnostic package obtained for CIRA
  - Initial coordination with EMC, NRL and ESRL on generation of synthetic GOES data from model output
- Impact of HFIP forecast goals on hurricane warnings
  - Results presented at IHC and HFIP Workshop, journal paper in preparation
- Evaluation of HyCOM ocean model with satellite OHC retrievals
  - Preliminary discussion with EMC to obtain fields
- Development of ensemble forecast applications
  - NHC operational wind probability model being adapted to use HFIP ensembles
- Examination of cloud top structure in relation to TC formation
  - U. of Arizona (Liz Richie subcontract)

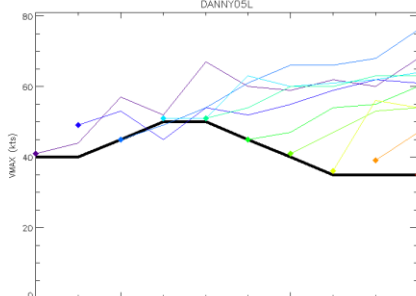
# CIRA Project Highlight

## Comparison of HWRF/GFDL Diagnostics for 2009 High Shear Cases

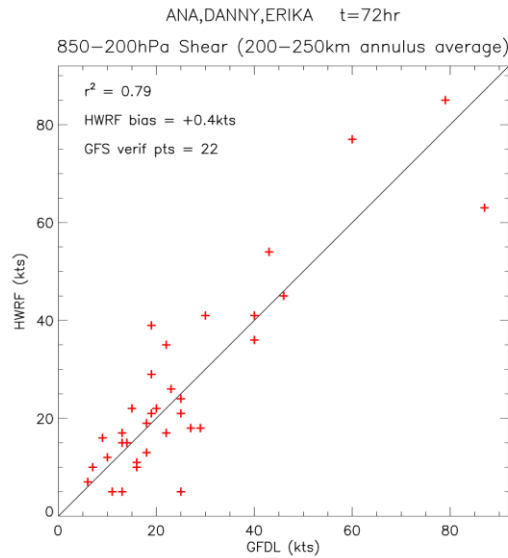
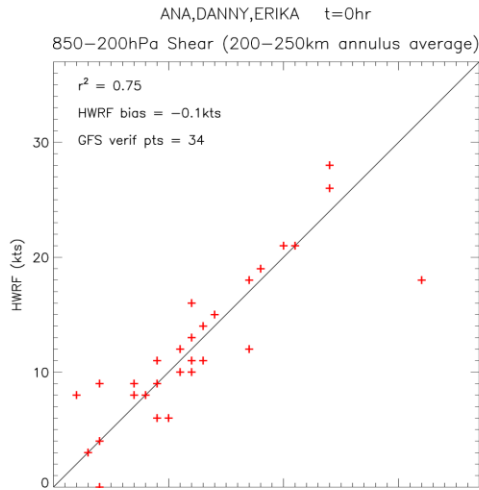
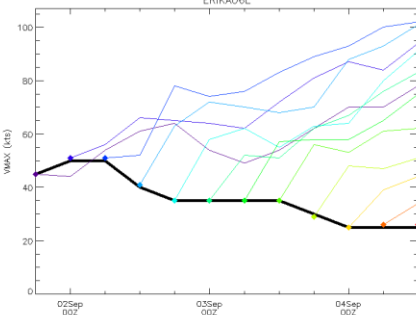
Ana



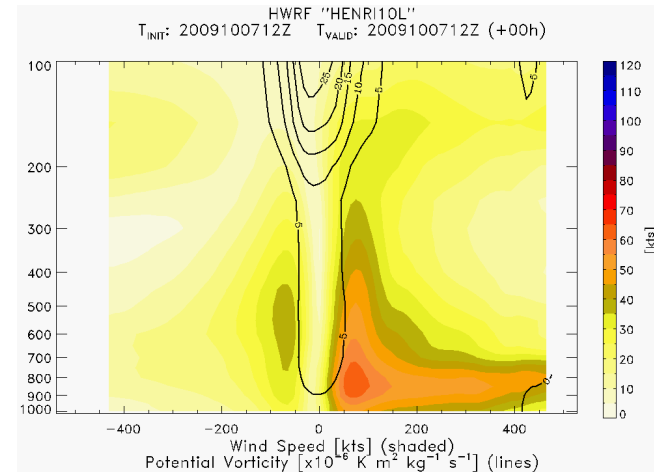
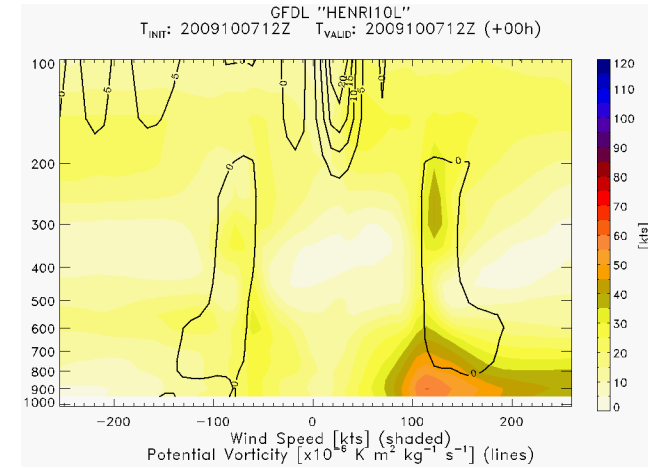
Danny



Erika



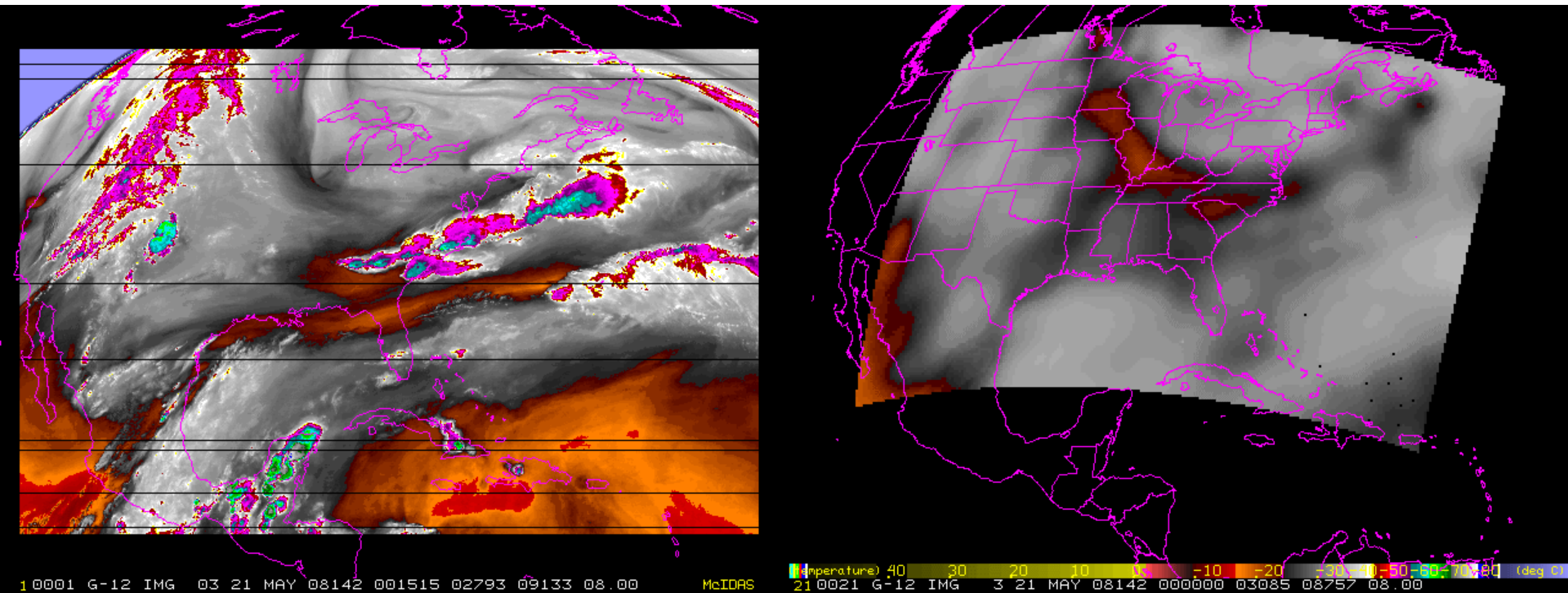
NESDIS/CIRA



# CIRA/NESDIS 3 Year Plan

- Continued real-time diagnostics of HWRF/GFDL
  - Comparison with statistical model relationships
  - Expand to other models using tier 2 fields
  - Coordinate with TCMT and EMC on sensitivity studies, HWRF improvements
  - Forward radiative transfer for satellite comparison
- NHC coordination on real time forecast applications
- Development of ensemble products through adaptation of NHC wind probability program
- Intensity predictability study with statistical model
  - What is contribute of track and environmental prediction improvements to intensity forecasts?

# Real and CoAMPS Synthetic GOES Imagery (WV Channel)



# HFIP Diagnostics Team Status Report - EMC

## Year 1 Milestones and Deliverables:

- Apply storm environment diagnostics to HWRF model forecasts
- Perform steering flow evolution and other basic diagnostics inter-comparison between GFDL, HWRF, and GFS for a selected set of cases
- Begin diagnostic work for tropical cyclone genesis, with emphasis on determining why the GFS appeared to have greater skill in the eastern Atlantic compared to the Caribbean during the 2008 season
- Development and sharing of diagnostic tools

# Work done so far (EMC)

- A comprehensive diagnostics work-plan developed
- Status report at the HFIP diagnostics workshop , Miami, May 2009
- Diagnostics and visualization software (HPLOT) developed
- Preliminary diagnostic study of HWRF, GFDL and GFS:
  - Evolution of large-scale flow (steering currents and shear patterns)
  - Inter-comparison of large-scale flow in HWRF-GFDL-GFS forecasts and comparison with GFS analysis
  - Impact of boundary conditions, vortex initialization for HWRF
  - Surface physics issues in HWRF (impact of Cd/Ch)
  - Wind-Pressure relationship Storm size and structure
  - Vortex evolution and interactions with the storm environment
    - Collaboration with Physics team
  - Topographic effects (east Pacific)
  - Atlantic (2008) Bertha, Fay, Gustav, Ike
  - East Pacific (2008) Kiko
  - Multiple cases from 2009
- Installed HPLOT software at CSU, Fort Collins to facilitate similar diagnostics and evaluation by Mark DeMaria's group.



# EMC Work in progress

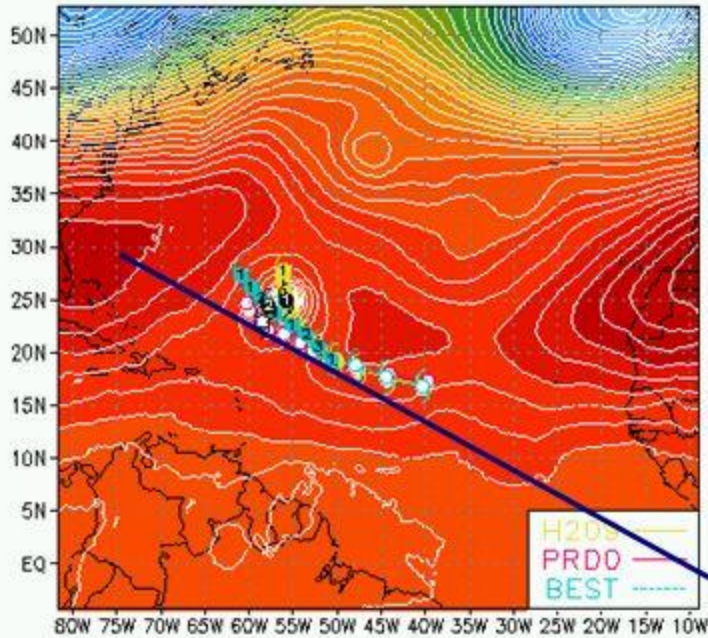
- Add storm-filtering technique to HPLOT software
  - Separate vortex and environmental flow for inter-model comparisons
- Add statistical measures (RMS errors, anomaly correlation, threat scores etc.) to HPLOT software
  - Coordinate with verification team
- Add compositing features to HPLOT for systematic error analysis
- Investigate high intensity bias in 2009 HWRF forecasts
- Collect several forms of observations for model evaluation
  - Satellite imagery, cloud track winds, aircraft observations etc.
  - Coordinate with TCMT/DTC in FY10
- Sensitivity tests of surface exchange parameterizations
  - Coordination with physics team
- Include ocean model output for diagnostics of air-sea interaction (exchange of heat and momentum fluxes, SST) and analysis of ocean cooling and mixed layer depth.

**Evolution of 500 hPa geopotential height  
HWRf compared to GFS**

lt: 2008070600 vt: 2008070918 (90h)

**RMS  $V_{850}$ : 9.5 m/s**

**ACC  $H_{500}$ : 0.72**

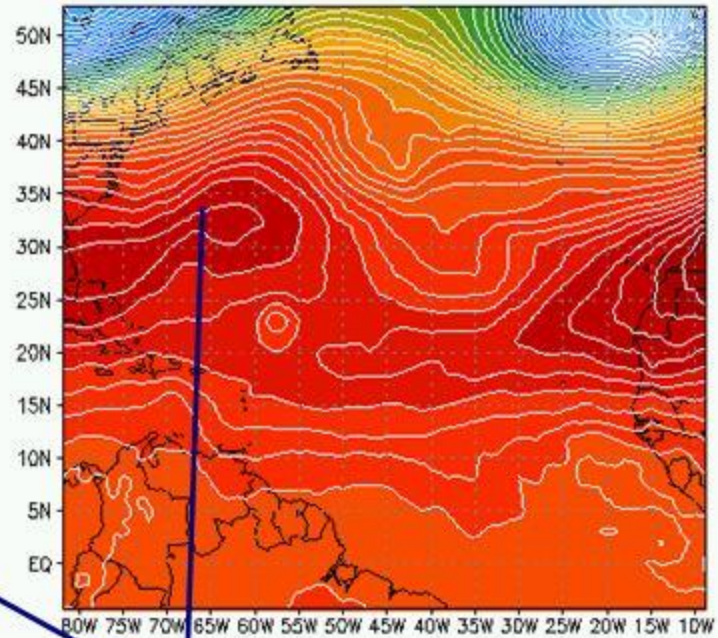


**HWRf**

500 mb geopotential height (shaded, m)

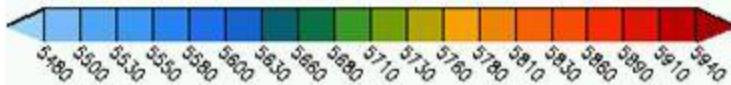
**RMS  $V_{850}$ : 7.3 m/s**

**ACC  $H_{500}$ : 0.85**



**GFS**

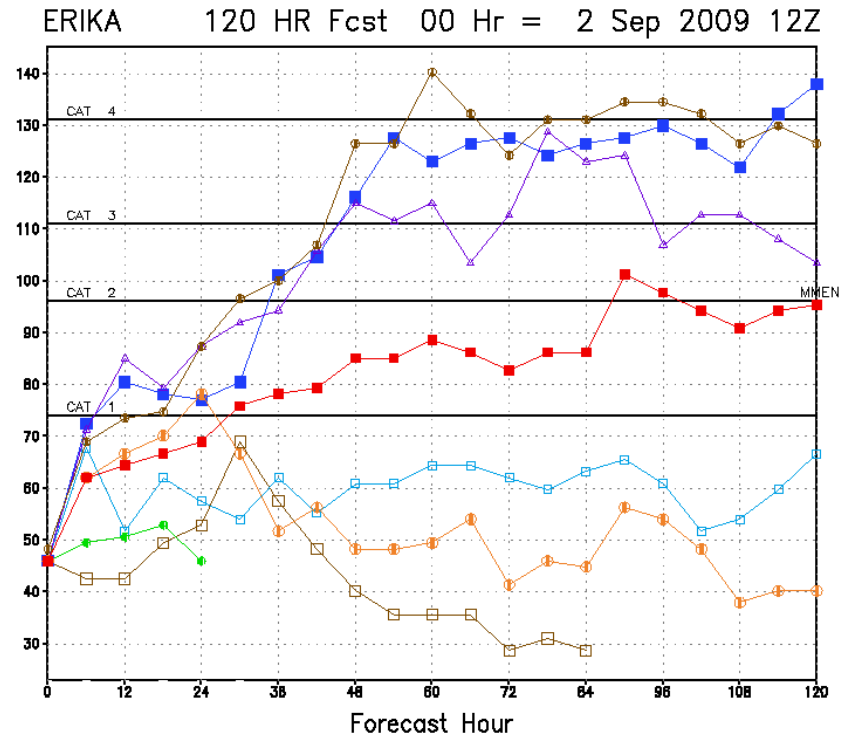
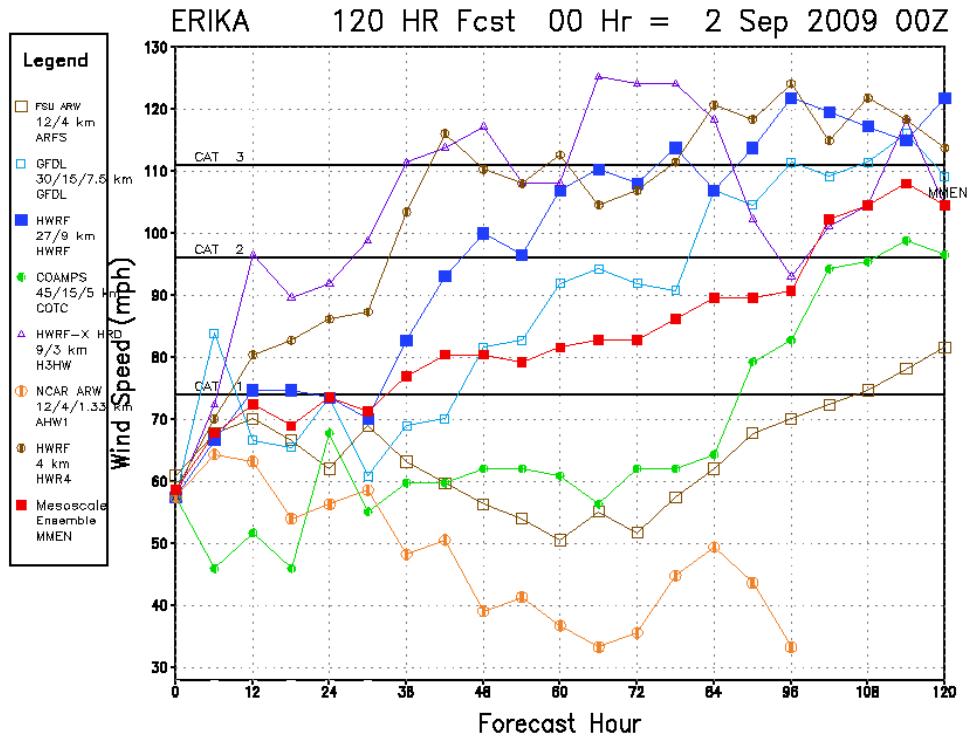
**Weakening of sub-tropical high**



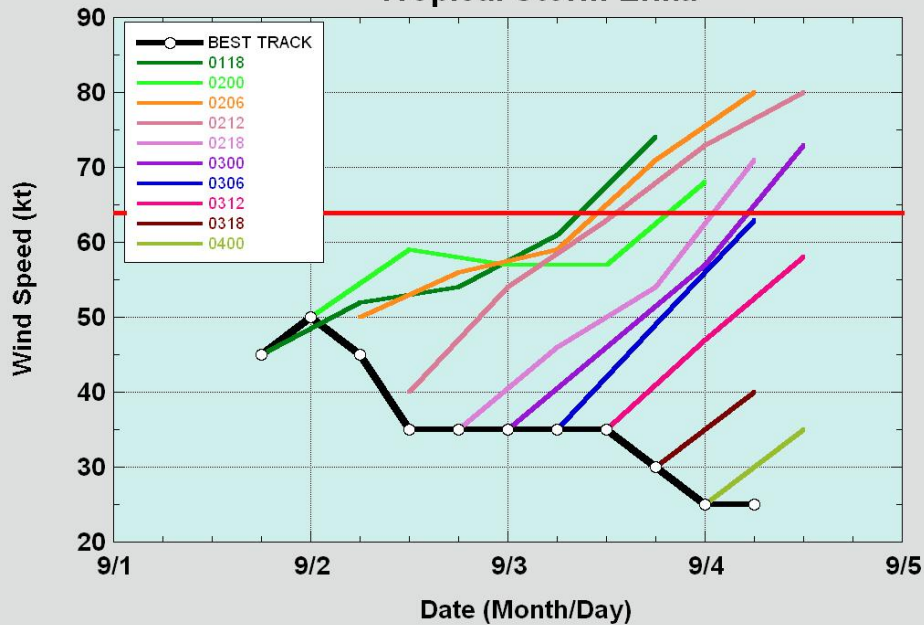
# NCEP/NHC accomplishments

- Offer made for Model Diagnostician position; projected February 2010 start date at NHC
- Real-time or near-real-time evaluation of 2009 operational (Stream 1) model TC forecasts
- Evaluation of some HFIP mesoscale model ensemble output made available in near-real-time during 2009
- Limited evaluation of FIM output
- Evaluation of proposed changes to NWS operational TC forecast models (HWRF, GFS, and impacts on GFDL)

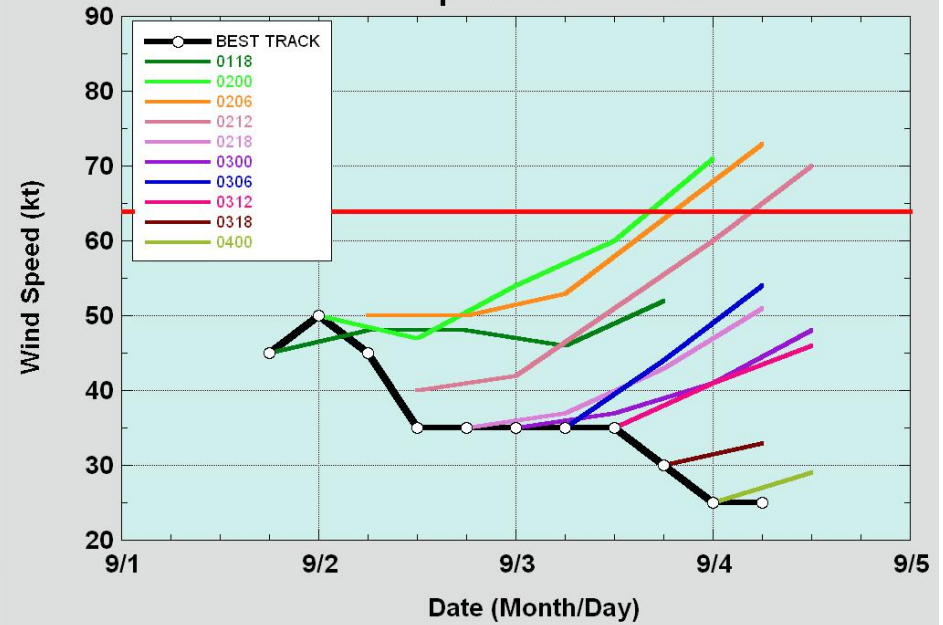
# Sample of HFIP mesoscale ensemble output



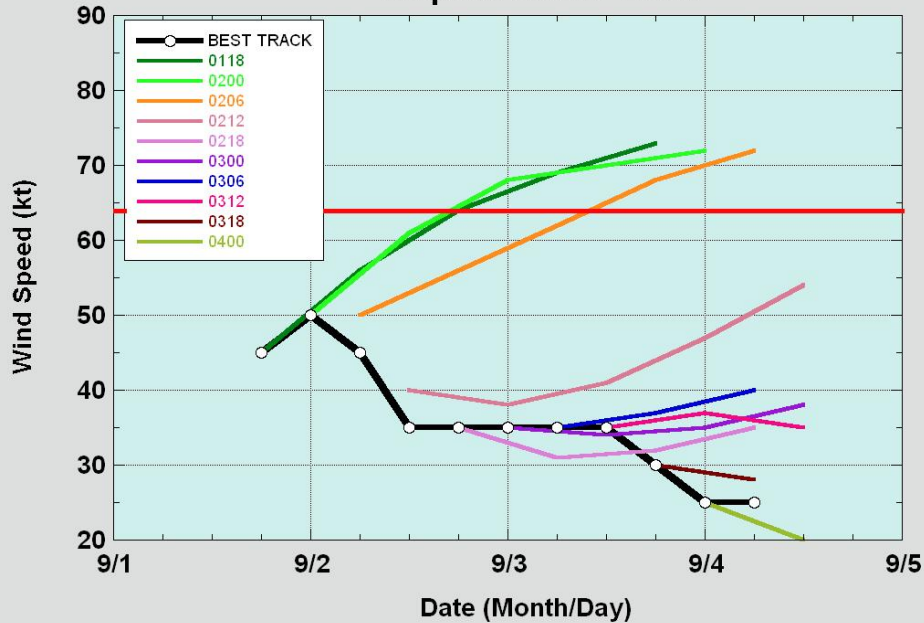
### HWFI Forecasts Tropical Storm Erika



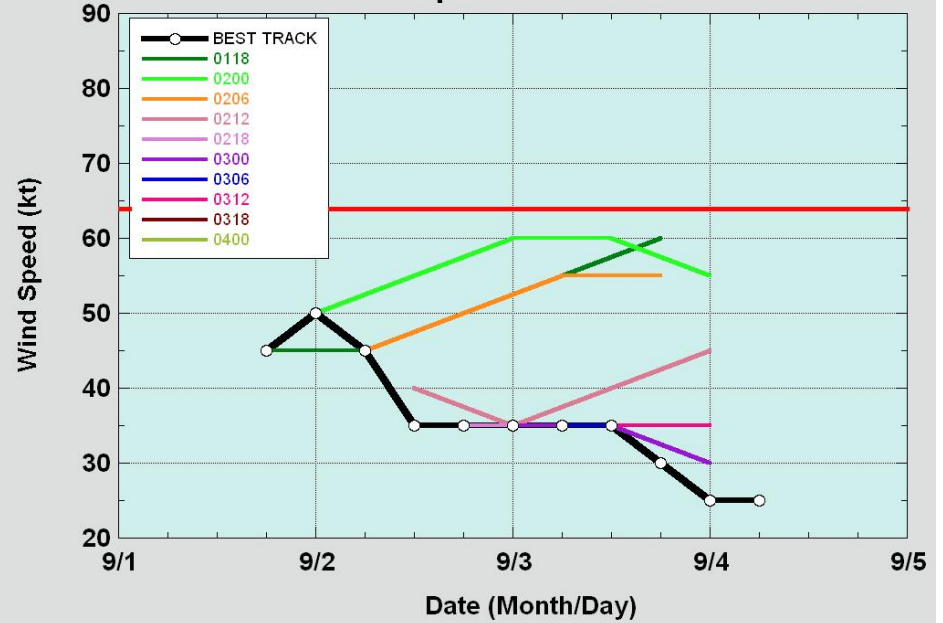
### GHMI Forecasts Tropical Storm Erika



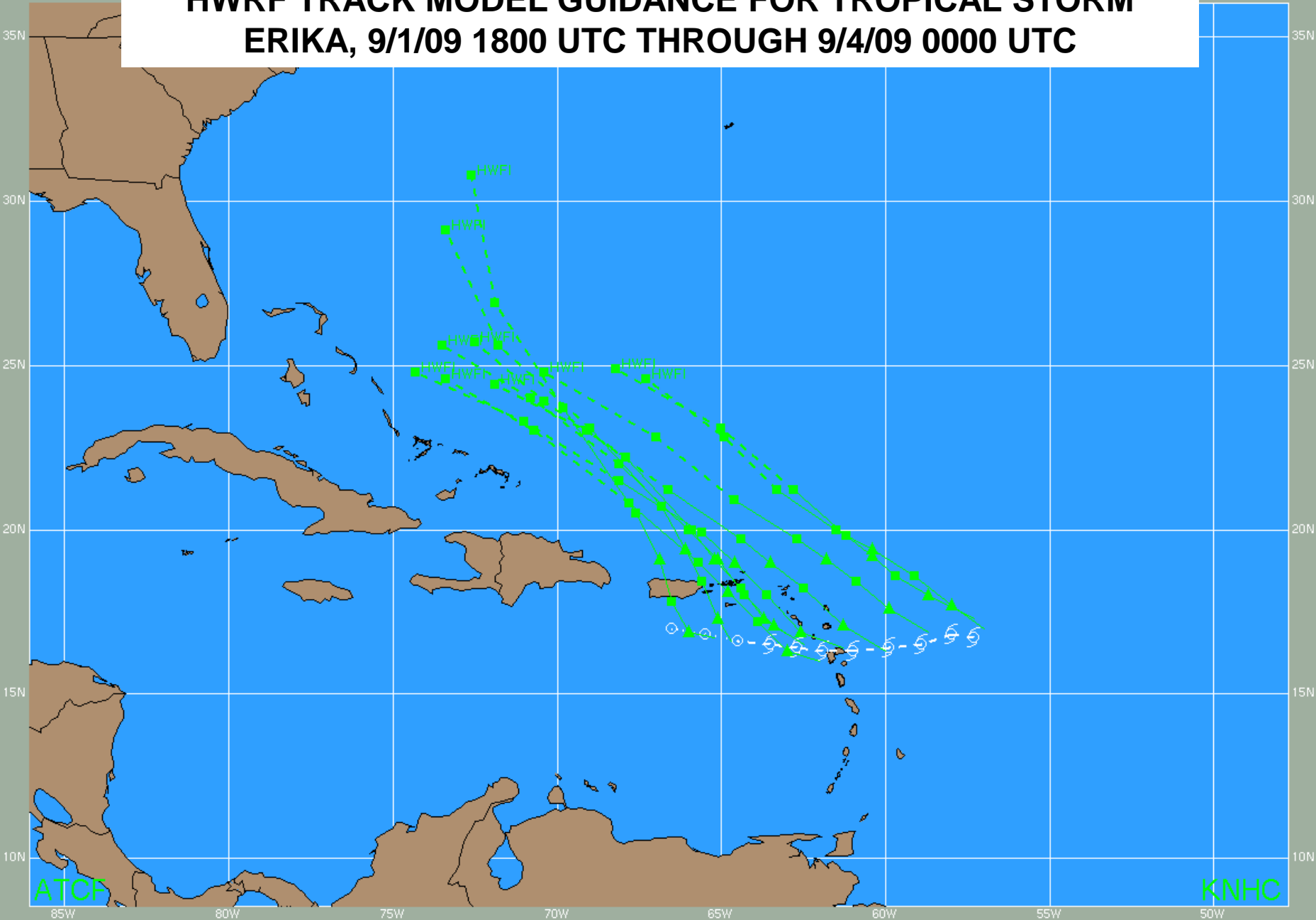
### LGEM Forecasts Tropical Storm Erika



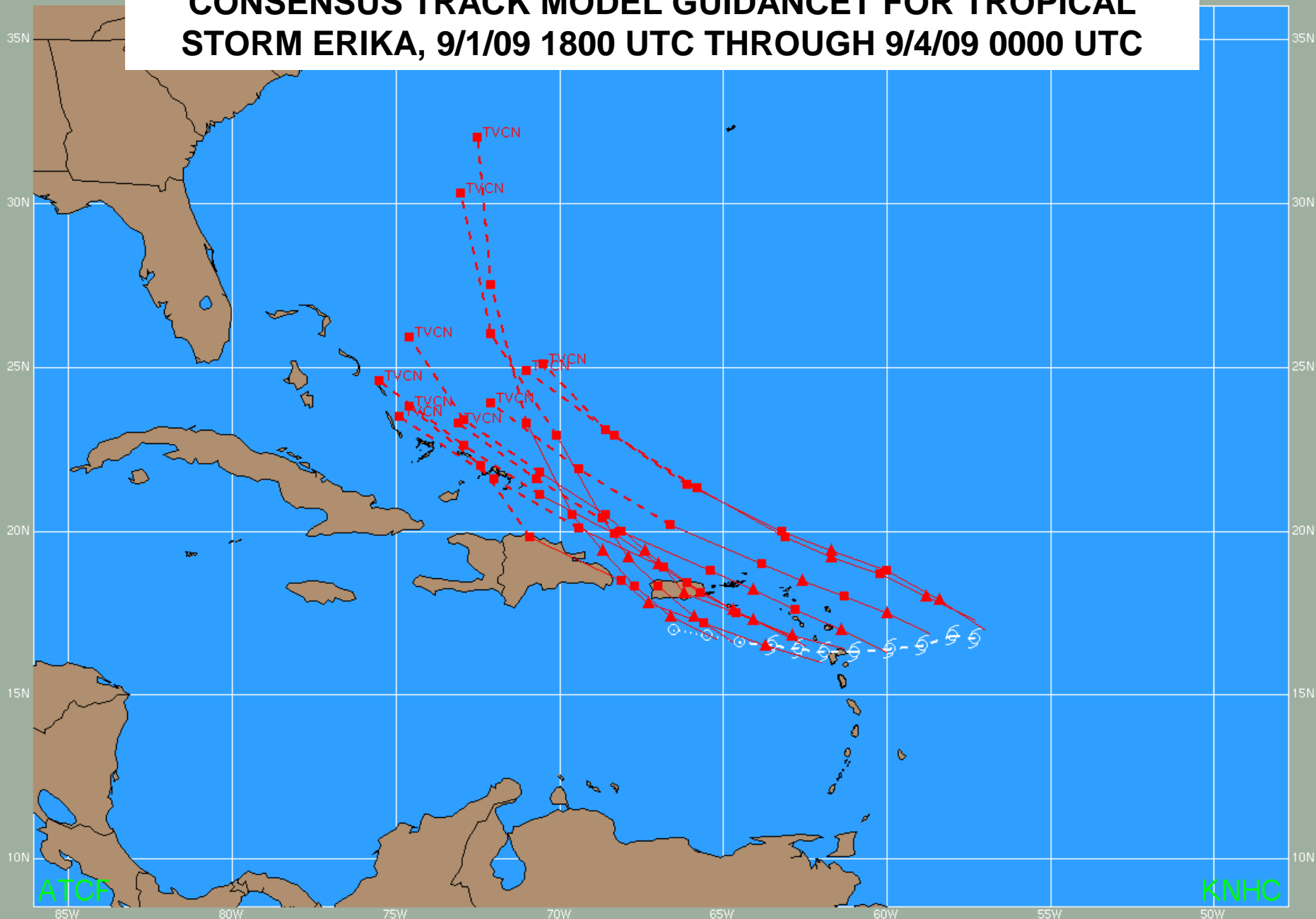
### NHC Official Forecasts Tropical Storm Erika



# HWRF TRACK MODEL GUIDANCE FOR TROPICAL STORM ERIKA, 9/1/09 1800 UTC THROUGH 9/4/09 0000 UTC



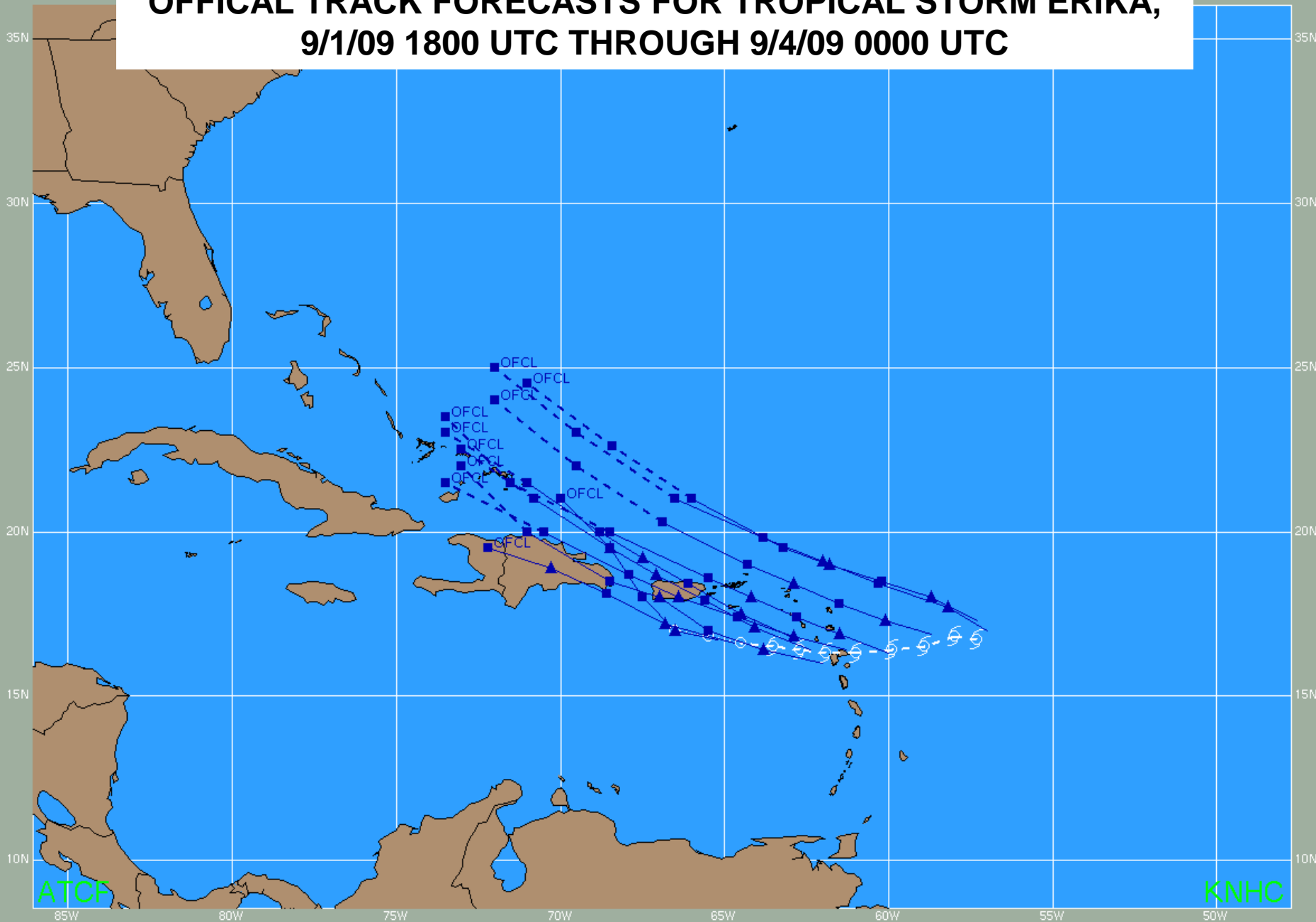
# CONSENSUS TRACK MODEL GUIDANCE FOR TROPICAL STORM ERIKA, 9/1/09 1800 UTC THROUGH 9/4/09 0000 UTC



ATCF

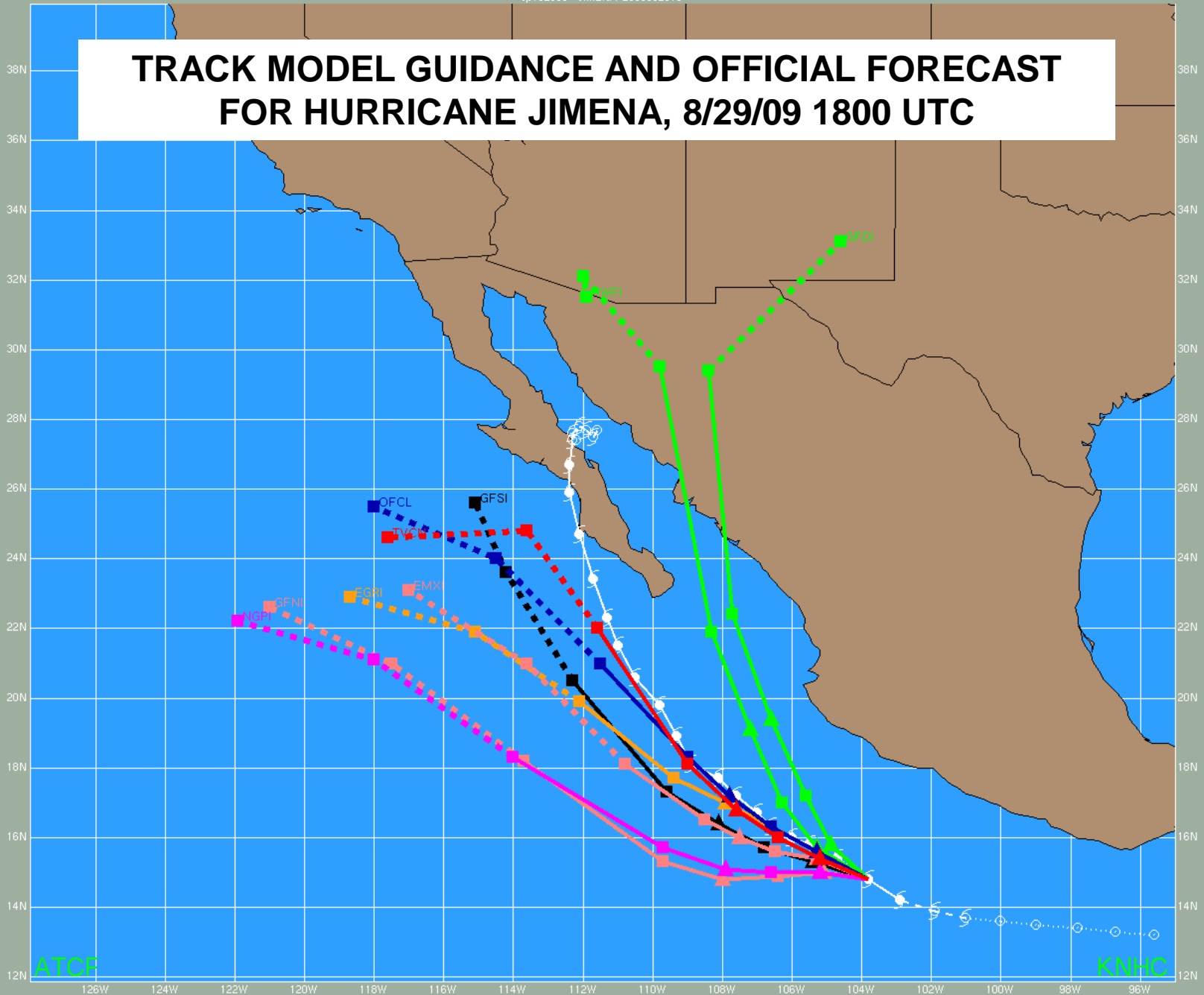
KNHC

# OFFICAL TRACK FORECASTS FOR TROPICAL STORM ERIKA, 9/1/09 1800 UTC THROUGH 9/4/09 0000 UTC





# TRACK MODEL GUIDANCE AND OFFICIAL FORECAST FOR HURRICANE JIMENA, 8/29/09 1800 UTC



# Summary of NHC plans for next 3 years

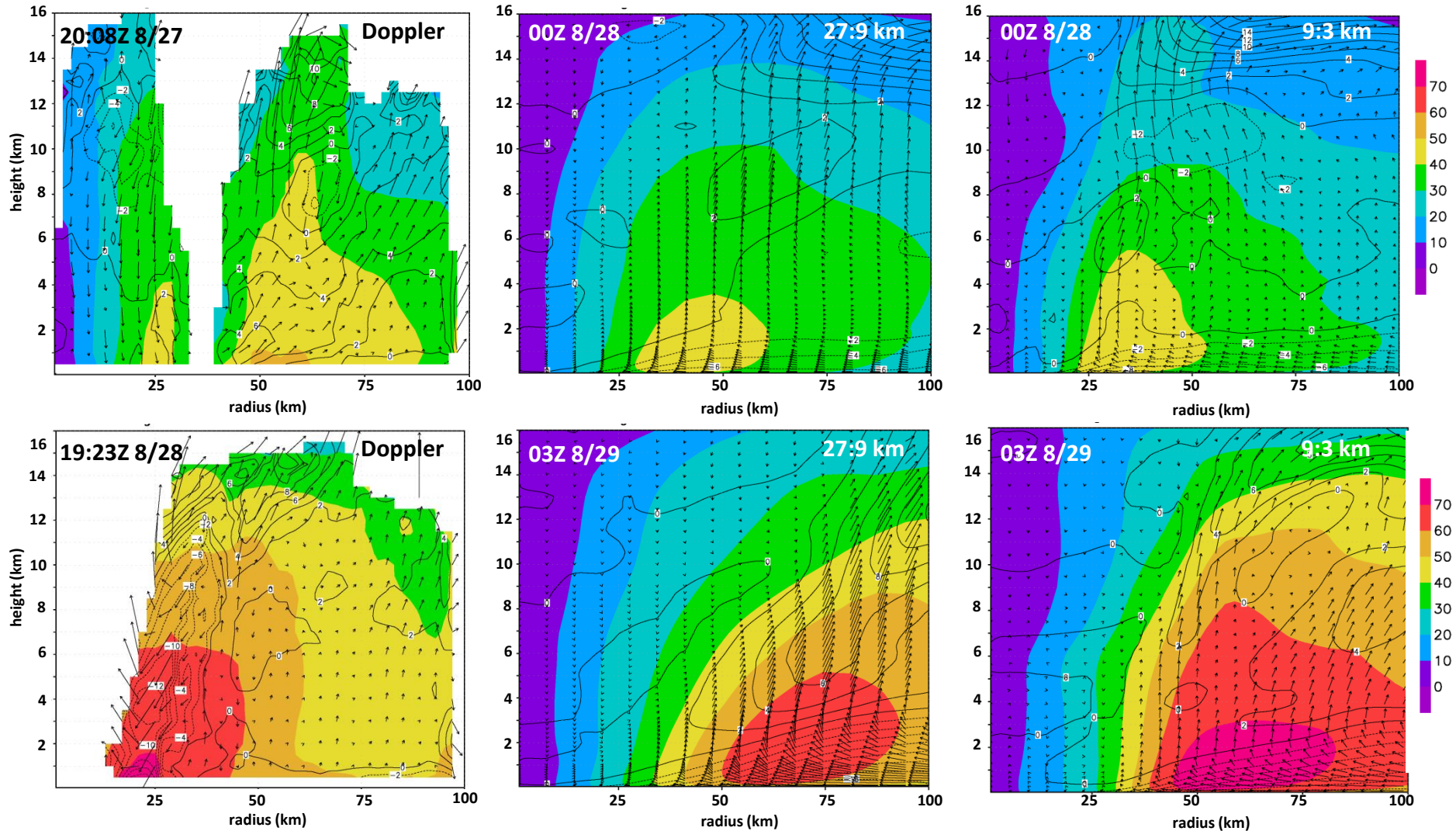
- Work with new HFIP Model Diagnostician, HFIP programmer, and HFIP Diagnostics Team to perform more in-depth diagnostics of model TC predictions for selected cases
- If possible, use results of the diagnoses to make recommendations to modeling centers (esp. EMC) on ways to improve model guidance

# HRD Diagnostics accomplishments

- Environmental-, vortex-, and convective-scale diagnostics code created for HWRFx
- Cylindrical, height, and pressure-level interpolations created for HWRFx
- Plotting capability of airborne Doppler radar swaths created
- Cylindrical interpolations created for airborne Doppler swaths
- Vortex- and convective-scale diagnostics created for Doppler swaths

# HWRFx evaluation: HRH cases (Katrina): Vortex Structure

Hurricane Katrina simulation starting at 00Z 27 August 2008



Axisymmetric tangential (shaded,  $\text{m s}^{-1}$ ) and radial wind (contour,  $\text{m s}^{-1}$ ) for Doppler and HWRf-x

# HRD Diagnostics plans -- observations

## Radar

- merger of radar swaths
- simplex center-finding algorithm implementation
- azimuthal FFT (wavenumbers 0-2)
- swath composites
- hodograph calculation
- reflectivity-based partitioning algorithms (e.g., convective-stratiform)
- area-specific statistical calculations (e.g., eyewall only, upwind/downwind portion of rainbands)
- time-radius Hovmollers
- profiles, statistics of Doppler profiles
- capability for overlaying flight tracks, data on radar, satellite images
- diagnostics from LF imagery

## Dropsondes

- synoptic plots at standard-increment (e.g., 500 m) height and mandatory pressure levels
- generation of gridded analyses at multiple levels from dropsondes
- overlay of dropsondes onto radar swath plots
- compositing of dropsonde profiles

## Flight-level, SFMR, and AXBT

- radial profiles of parameters, center ID
- x-y plots of flight-level parameters
- 1-d or 2-d FFT
- 3-d analyses of ocean T

## Microphysics

- statistics of DSDs and mass from DMT probes
- latent heating fields

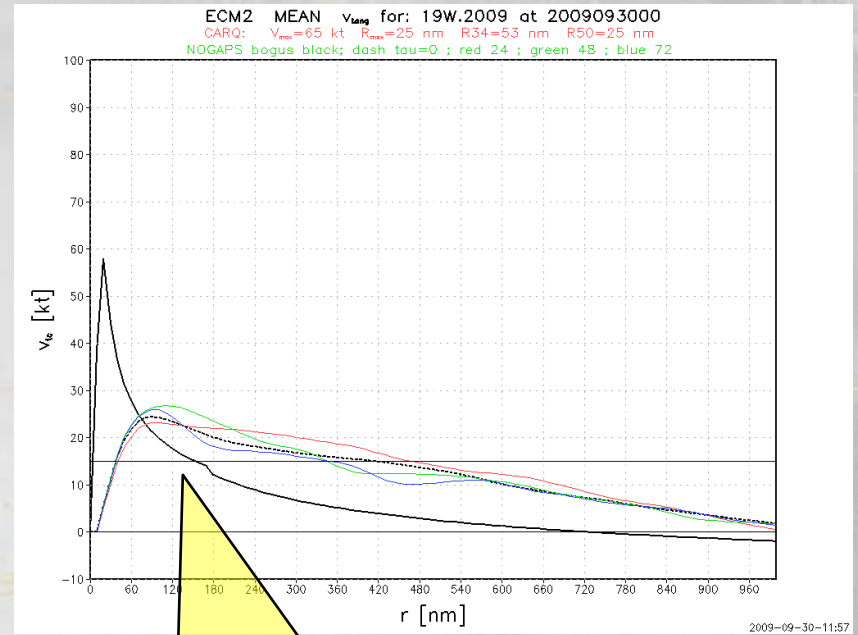
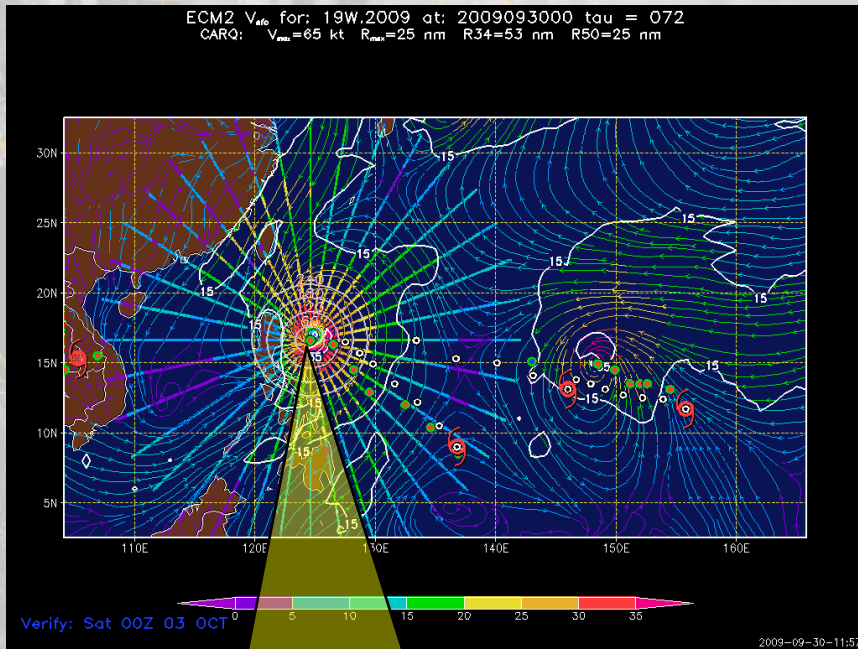
## Buoy obs

- radial profiles
- time series

# HRD Diagnostics plans -- model

- calculation of model-derived reflectivity
- azimuthal FFT
- center-finding algorithms (simplex?)
- model multi-case composite capability
- partitioning algorithms

# ESRL HFIP TC diagnostics – tctrack, tcstruct

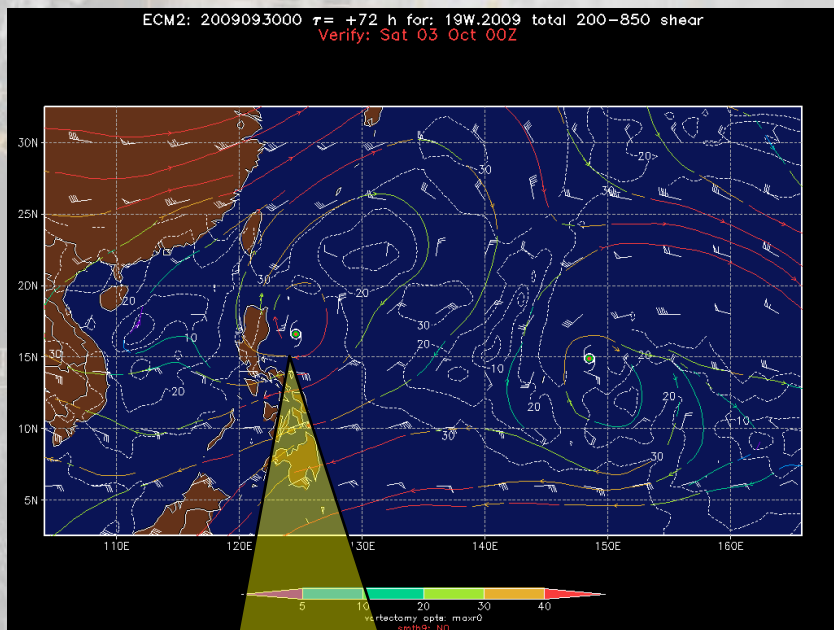


**19W – 2009093000**  
 ECMWF 72-h sfc wind forecast  
 black-white dot = JTWC forecast  
 green-blue dot = model sfc wind center  
 green-red dot = model 850 vort center

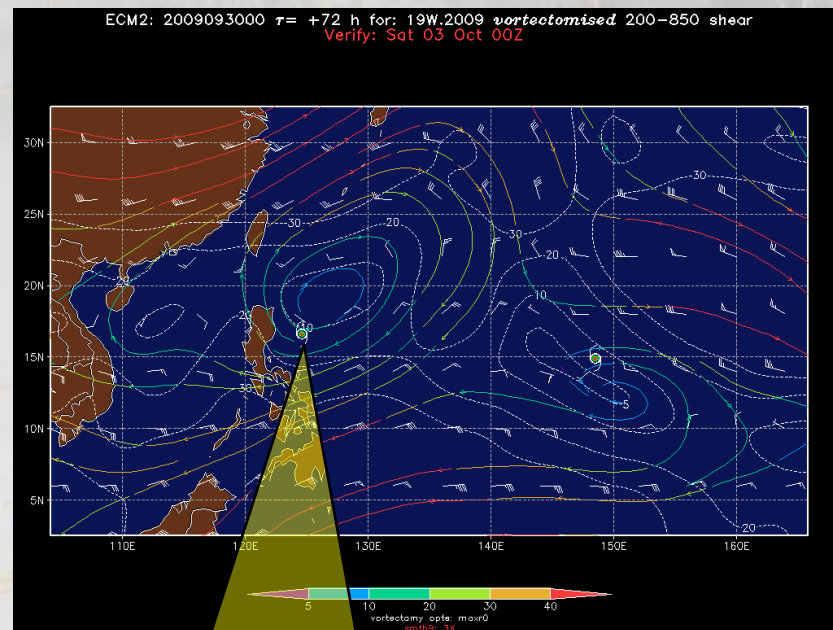
radial sfc wind speed profile at  
 tau=0,24,48,72 (blue)  
 wind profile used in the NOGAPS TC  
 wind retrievals in black + vortex  
 properties from the CARQ (TC vitals)

next step – mfhilo and tcprop functions to locate and find detailed properties of vortex, e.g.,  
 ROCI (radius of outermost closed isobar) & POCL (pressure)

# ESRL HFIP TC diagnostics – *tcfilt* (vortectomy)



**19W – 2009093000**  
ECMWF 72-h forecast – 850-200 shear  
full or with vortex



**19W – 2009093000**  
ECMWF 72-h forecast – 850-200 shear  
without vortices (19W & 18W) – or  
vortectomised  
shear for 19W ~ 10 kt, 18W ~ 7 kt

next step – use vortectomized fields in LGEM for five global models: GFS + FIM + ECMWF + NOGAPS + UKMO → consensus LGEM



# ESRL Plans for next 1-3 y

- ***TC tracking and structure diagnosis***
  - develop TCPROP function to find ROCI/POCI...
  - HRD DIAPOST rehosting
  - fimicanes – partition of convective v large-scale precip ~ TCs
- ***run sLGEM – two-parameter LGEM (w/ CSU)***
  - multiple models; w/ & w/o vortectomy
- ***retrieve satellite radiances from model (w/ CSU 2) – dvorak images from model?***
- ***comparison with CSU sfc wind analyses***



# NRL Status Report

## NRL Diagnostics Team Summary

*James D. Doyle, Yi Jin, Hao Jin, Richard Hodur*  
*[james.doyle@nrlmry.navy.mil](mailto:james.doyle@nrlmry.navy.mil)*

### Major Accomplishments

- **Development of basic diagnostics software package**
- **Diagnosis of COAMPS-TC results for 2008 season**
- **Initial study of storm environmental variables and model intensity change**
- **Development of real-time web page to display basic diagnostics for COAMPS-TC**

<http://www.nrlmry.navy.mil/coamps-web/web/tc>

- **Diagnosis of HFIP Demo project results**
  - *Identify systematic problems with the analysis, physics*
- **Archival of 2009 result on DoD HPC for further diagnosis**
- **Formulate next steps for FY10**

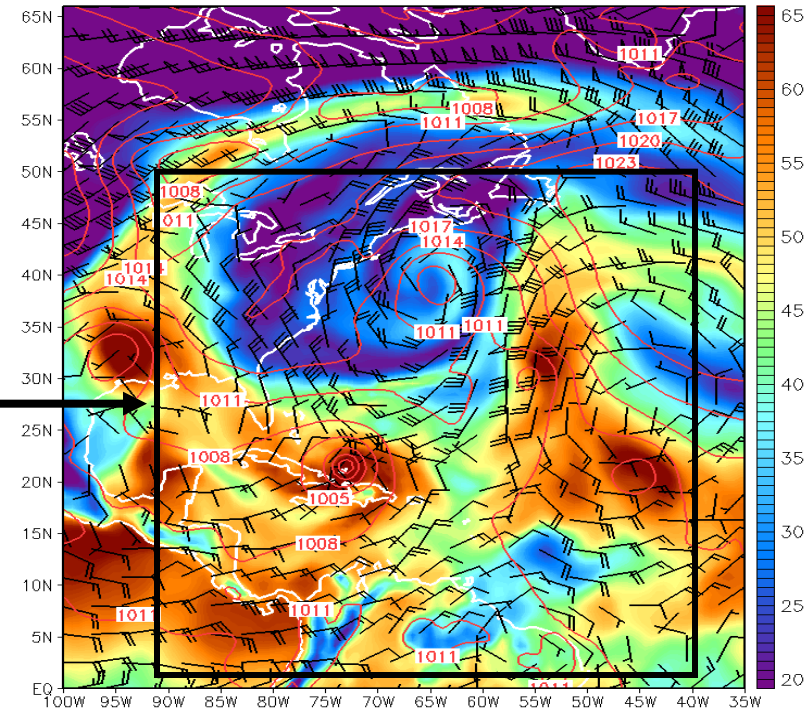
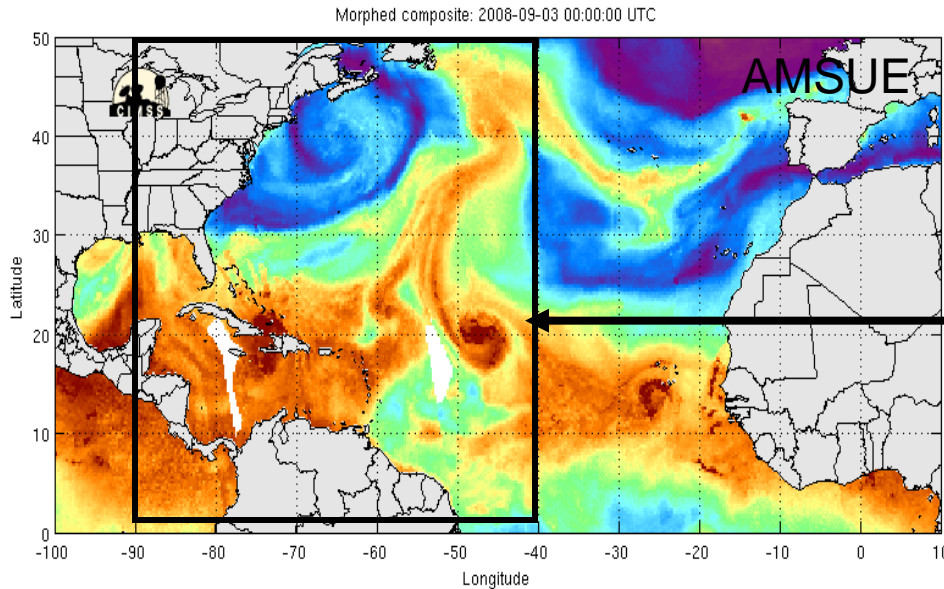


# NRL Status Report for HFIP

## Diagnostics Software Development

### Total Precipitable Water Hurricane Hanna

COAMPS 36 h fcst valid at  
0000UTC 3 September  
(TPW shaded, SLP red, 200 hPa winds)



**Diagnostics development to compare COAMPS-TC results  
with satellite derived products.**



# NRL Status Report

## NRL 3 Year Diagnostics Plans

- **Track forecast diagnostics**
  - Steering flow analysis, locations and strengths of troughs and ridges, large-scale momentum budgets, zonal and meridional shear
- **Intensity and structure verification**
  - Vertical wind shear, eye formation parameters, vertical instability parameters, SST, oceanic heat content, ocean response
- **Diagnostics for convective scale**
  - Analysis of vertical motion, hydrometeor concentrations, storm top structure (for comparison with satellite data), heating rates and profiles, eye-wall structure rapid intensity changes and related parameters
- **Diagnostics for ensemble and sensitivity analysis**
  - Ensemble and adjoint-based analysis
- **Provide real-time basic diagnostics via web page**
- **Shared development of TC diagnostics software**

# HFIP Diagnostics Activities

## DTC and TCMT

### Collect and make available Tier 1 and Tier 2 data

- **Accomplishments**

- Identify and define Tier 1 and Tier 2 datasets to be archived by TCMT
- Collect Tier 1 (ATCF) data, process and post merged files
  - Available on the TCMT/HFIP website (<http://www.ral.ucar.edu/projects/hfip2009/tracker.php>)
  - In process of cleaning up submitted data
- Distribute Output Module and instructions for generating Tier 2 data

- **Plans**

- Collect Tier 2 data, auto-check for basic file specifications and make available to HFIP community
- Develop plans for collection of Tier 1 and Tier 2 data during 2010 Demo and any relevant retrospective testing; collect data and make available
  - Plans need to be coordinated with global and regional modeling, verification and post-processing teams
- Develop and implement visualization tools for model fields and model/analyzed tracks. Make tools and graphics available to community.

# HFIP Diagnostics Activities

## DTC and TCMT

Provide a data service to facilitate access (by HFIP community) to the diverse tropical cyclone-related observations and model output available from distributed sources

- Accomplishments
  - Website for making Tier 1 data available
  - Initial investigation of hardware requirements and available software for setting up a data catalogue
- Plans
  - Survey available data and data sources, as well as data characteristics (e.g., formats, temporal and spatial attributes).
  - Develop a plan to provide direct access to some data sets and pointers to sources for other data; select tools for visualization and analysis. Acquire hardware needed to provide the service.
  - Implement initial data service, which will include datasets that are considered to have the highest priority by HFIP participants, as well as those that can be gathered relatively easily.

# HFIP Diagnostics Activities

## DTC and TCMT

Develop a plan to investigate deficiencies in HWRF model (and possibly other Stream 1 models) with the goal of improving operational forecasts.

- EMC & DTC Accomplishments
  - Established a plan for adding operational HWRF to general WRF repository and using this repository for future development and support of the HWRF system
  - Transitioned significant portions of HWRF capabilities to WRF repository in preparation for HWRF being available as a configuration with the next major WRF release
  - Planning for WRF for Hurricanes Workshop and Tutorial (22-26 February 2010).
- Plans
  - Conduct controlled case studies varying initialization, physics and/or resolution and other model attributes to analyze their impact on forecasts.
  - Conduct diagnostic studies in concert with other groups (e.g., CIRA).
  - Use new verification datasets, such as satellite, to conduct verification using traditional and non-traditional methods (such as spatial evaluation methods); investigate methods for interpretation of ensemble forecast information.

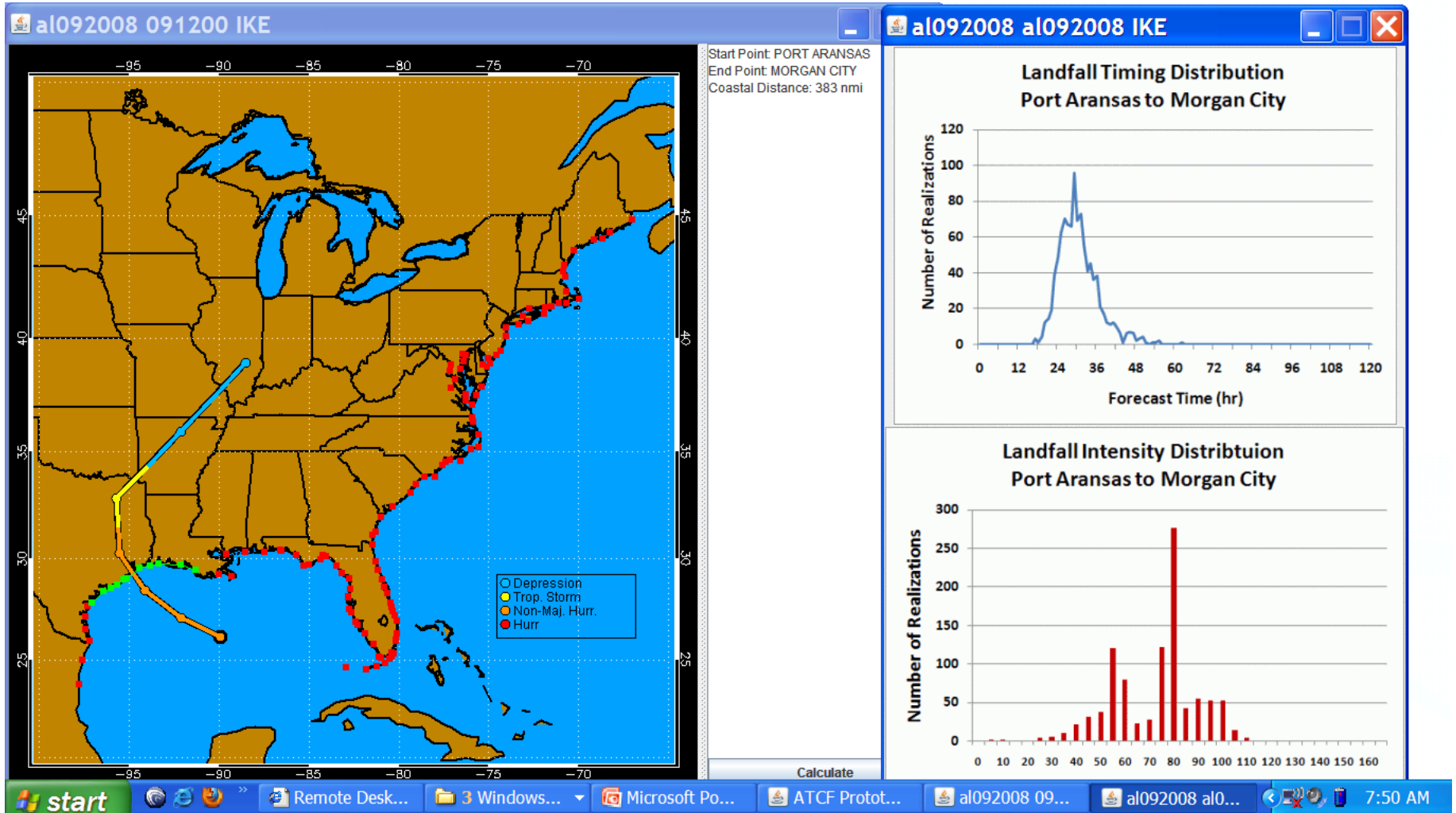
# Lessons Learned in FY09

## *All Groups*

- All groups off to a good start with model specific diagnostic tools
- Some exchange of data and code between diagnostic team members
  - HRD and EMC conference calls should be coordinated
- DTC/TCMT provides needed focus for model, data exchange
  - Tier 2 data available would help with coordination of individual group members
  - Expanded role in FY10
- Progress slow so far on ensemble, ocean, genesis diagnostics
- Method for communicating info between teams needs to be established
- Diagnostics with real-time forecast applications should be transferred to NHC



# Applications of 1000 Statistically-Based Ensembles From NHC Monte Carlo Wind Probability Program



# Back-up Slides

# Diagnostic Team 2009 Milestones and Deliverables from 15 Dec 2008 Plan

- **Milestones**

- 1. Establishment of periodic team conference calls (NESDIS)
- 2. Obtain initial guidance from NHC on model limitations (global and regional) based upon their operational experience (NCEP, NESDIS)
- 3. Apply storm environment diagnostics to HWRF, COAMPS-TC and HRS models and compare relationships with intensity changes to those identified in statistical intensity models (NCEP, HRD, NESDIS, NRL)
- 4. Perform steering flow evolution and other basic diagnostics inter-comparison between GFDL, HWRF, GFS and ECMWF models for a selected set of cases (NCEP)
- 5. Begin study of impact of forecast error reductions on hurricane warnings using NHC probability model (NESDIS, NCEP)
- 6. Identify diagnostic verification tools that will aid in diagnostic studies (DTC)
- 7. Determine best mechanism for dataset storage and sharing (All)
- 8. Begin diagnostic work for tropical cyclone genesis, with emphasis on determining why the GFS appeared to have greater skill in the eastern Atlantic compared to the Caribbean during the 2008 season (NCEP)
- 9. Arrange workshop with verification team and representatives from other teams (All)
- 10. Provide feedback from items 2 and 3 to model developers (All)

- **Deliverables**

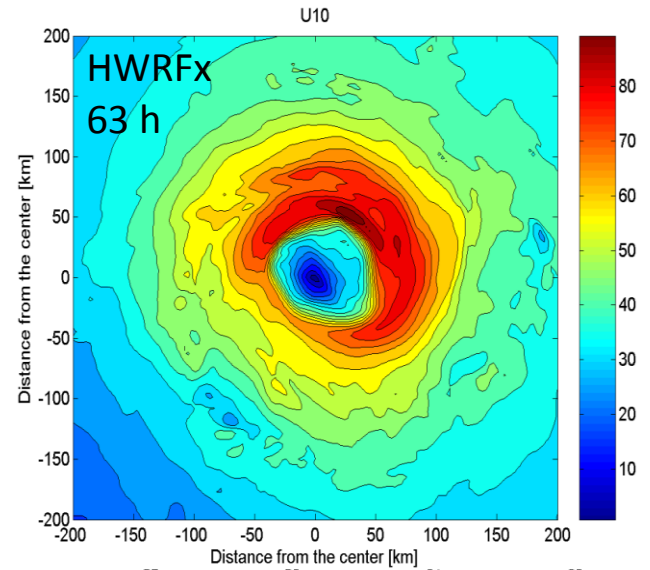
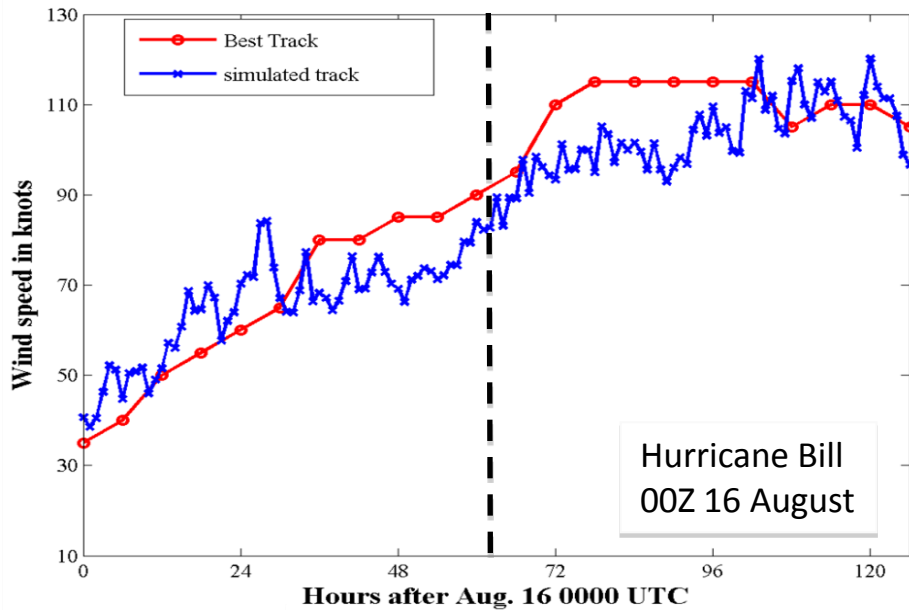
- 1. Initial estimate of HFIP forecast error reduction goals on NHC hurricane warning size and duration (NESDIS, NCEP)
- 2. Completion of the first diagnostics workshop (All)
- 3. Completion of initial study of storm environmental variables and model intensity change (HRD, NCEP, NESDIS, NRL)

# Next Steps

- Update diagnostic team plans for 2010
- Improve collaboration among the groups
- Develop mechanism for reporting results back to other science teams
- Participate in November HFIP Workshop in Miami

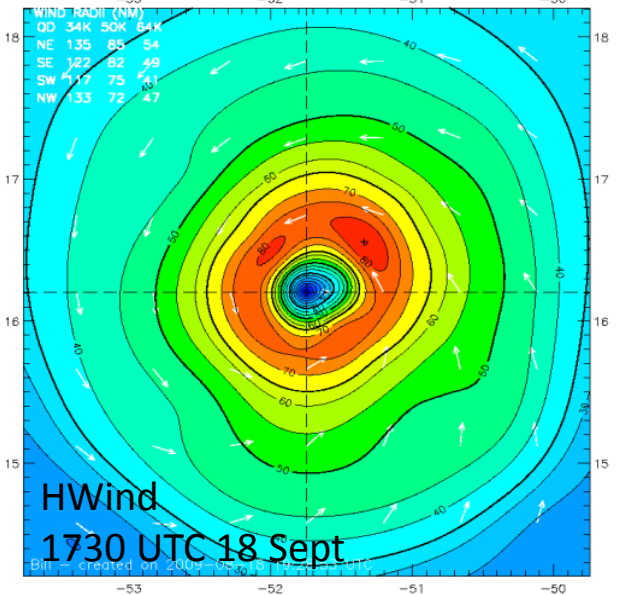
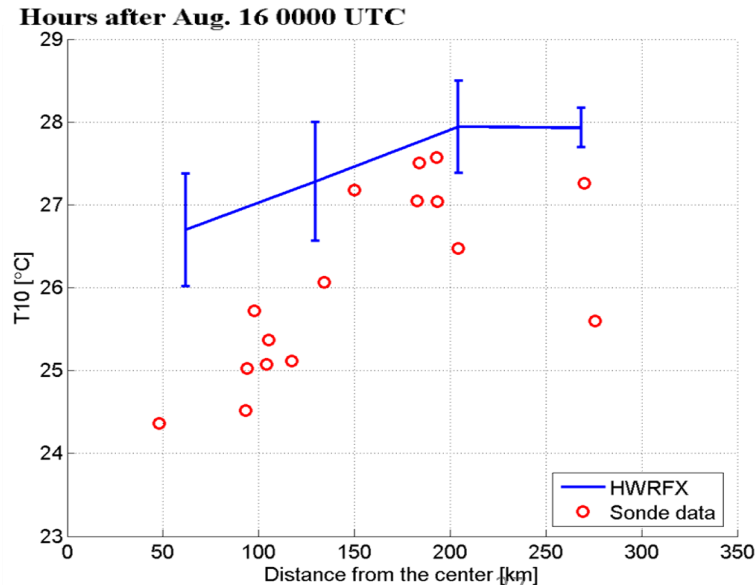
# HWRFx evaluation:

## Bill: Boundary layer and air-sea



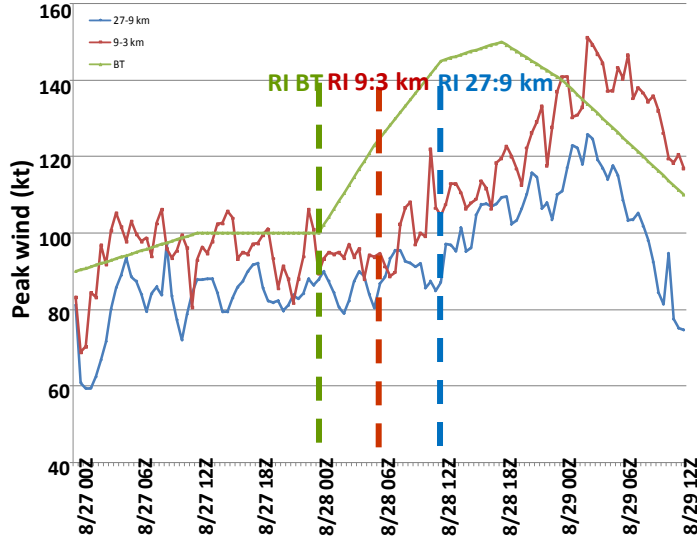
### Hurricane Bill (2009):

- HWRFx wind & thermodynamic structure compared to observations (dropsondes & HWind)
- $U_{10}$  OK,  $T_{10}$  high

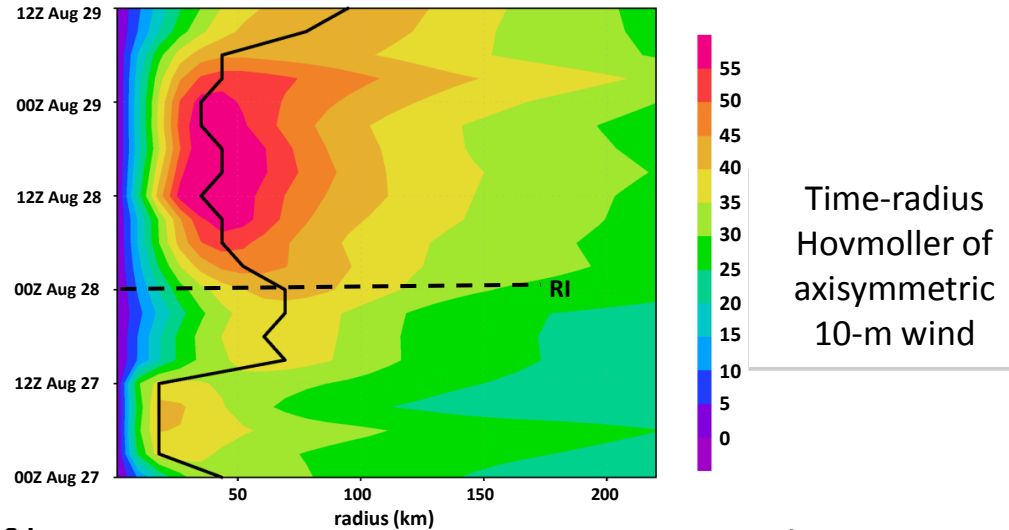


# HWRFx evaluation: HRH cases (Katrina): Vortex Structure

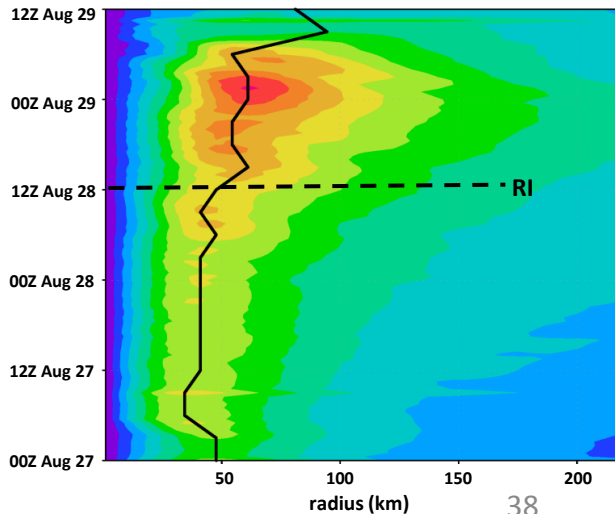
Hurricane Katrina 00Z 27 August 2008



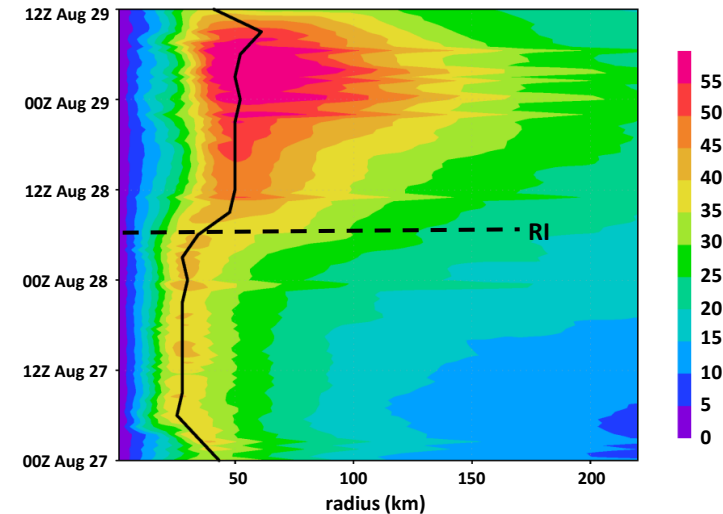
H\*Wind



HWRFx 27:9 km



HWRFx 9:3 km



- Model RI at different times than observed
- Timing is resolution dependent