Hurricane Model Transitions to Operations at NCEP/EMC

2008 IHC Conference, Charleston, SC

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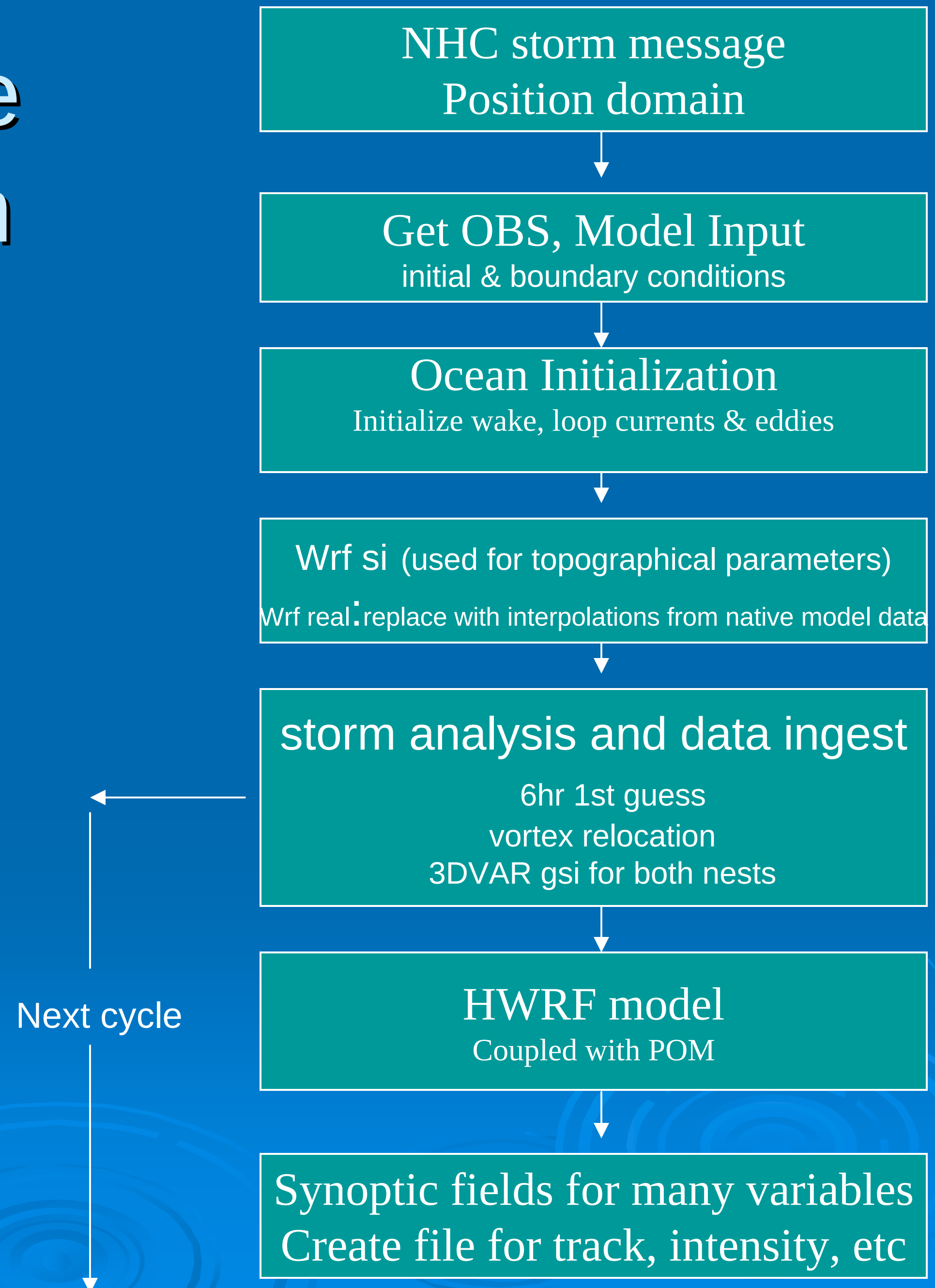
** JHT sponsored*

Project Goals and Emphasis

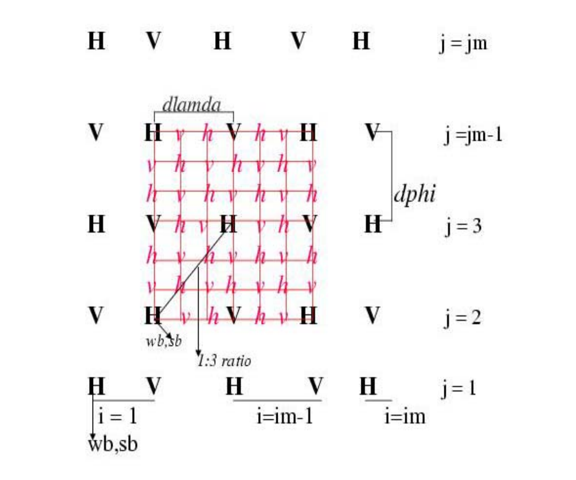
- Participate in the operational implementation of HWRF
- Establish baseline of skill for WRF development …use of GFDL physics
- Upgrade HWRF system
- Continued collaboration with URI, Florida State, GFDL, and others

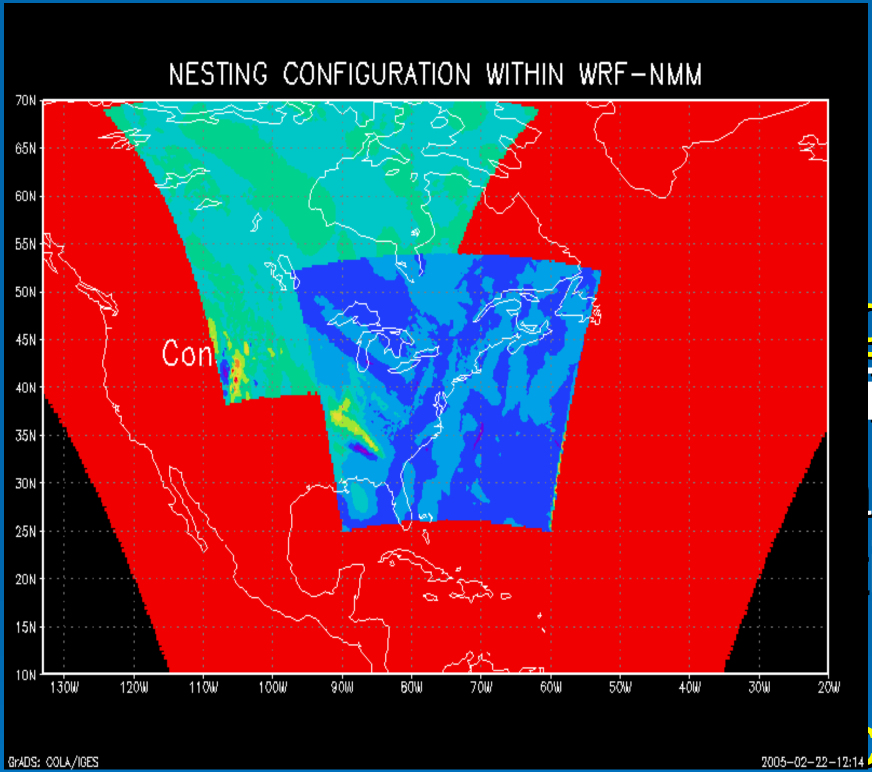
HWRF Hurricane Forecast System



The NMM-WRF Modeling System

http://www.dtcenter.org/wr





Nest

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id (sigma_p-P) coordinate.

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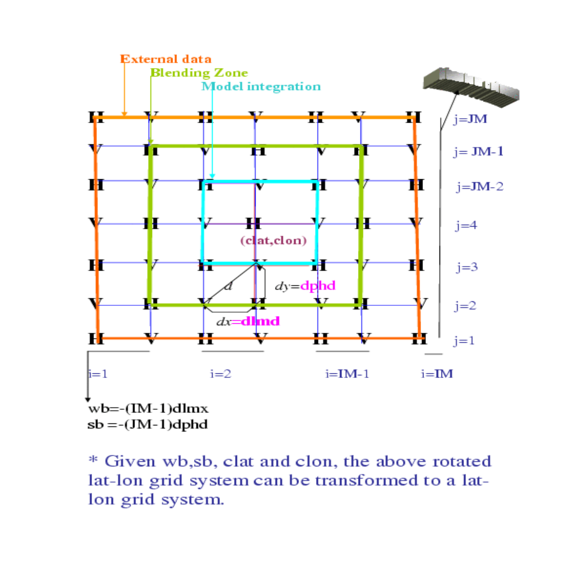


cheme

surface, boundary layer physic

radiation and Ferrier Microphy

- Ocean coupled modeling syst

HWRF – GFDL

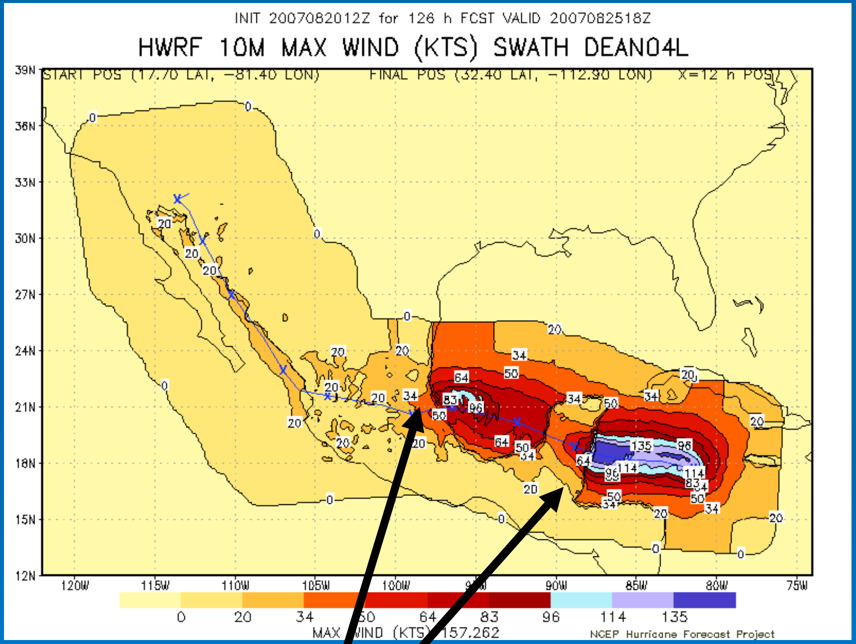
Grid configuration	2-nests (coincident)	3-nests(not coincident)
Nesting	Force-feedback	Interaction thru intra-nest fluxes
Ocean coupling	POM (atlantic only)	POM
Convective parameterization	SAS mom.mix.	SAS mom.mix.
Explicit condensation	Ferrier	Ferrier
Boundary layer	GFS non-local	GFS non-local
Surface layer	GFDL ..(Moon et. al.)	GFDL ..(Moon et. al.)
Land surface model	GFDL slab	GFDL slab
Dissipative heating	Based on D-L Zhang	Based on M-Y tke 2.5
Radiation	GFDL (cloud differences)	GFDL

Implementation of TPC post processing guidance

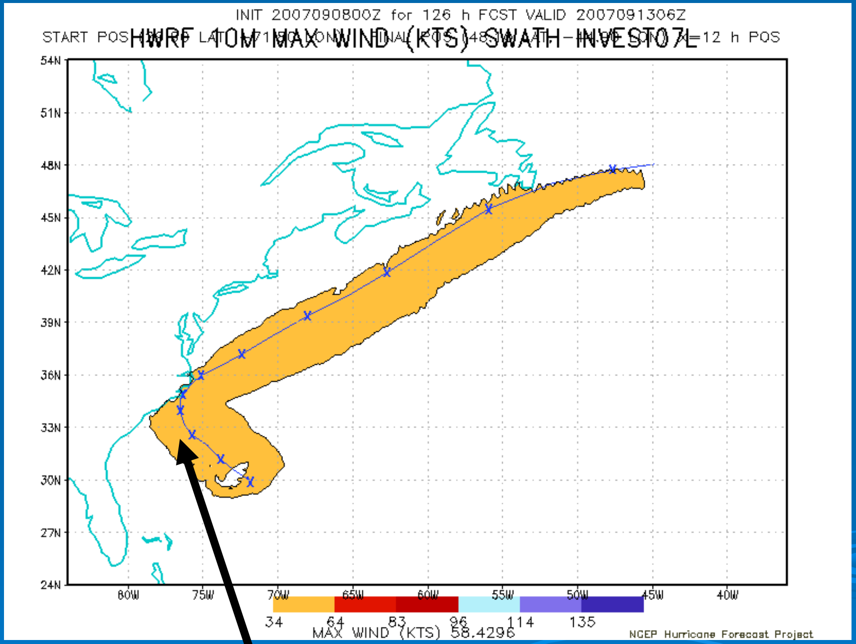
- Standard text files
- Low level wind swath
- Rainfall swath
- Additional hourly data

HWRF wind swaths

DEAN



GABRIELLE

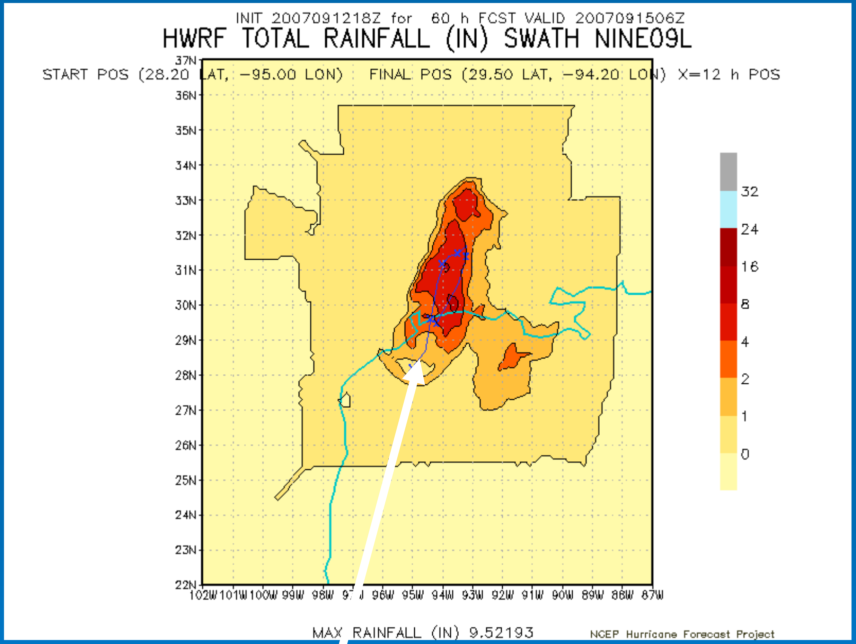


2 landfalls

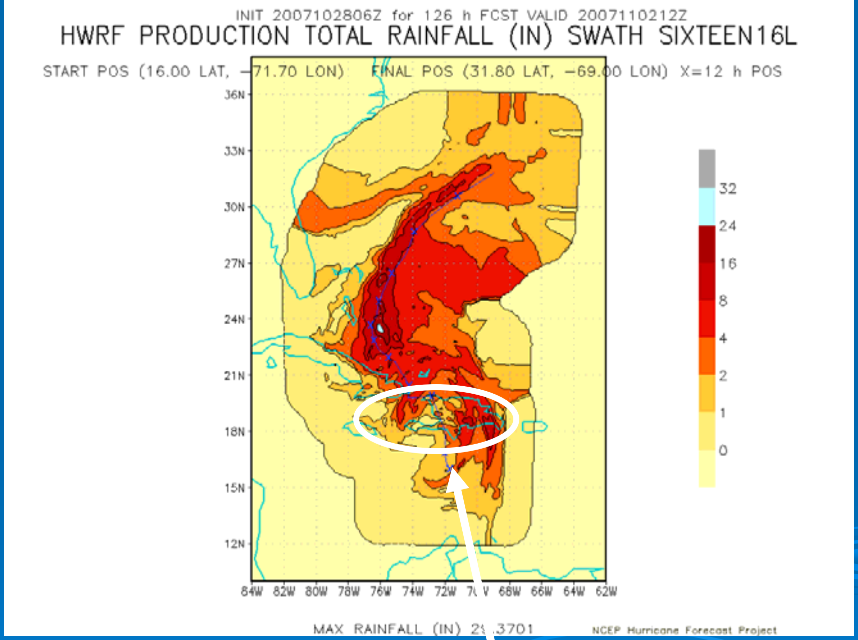
glancing blow

HWRF rainfall swaths

Humberto



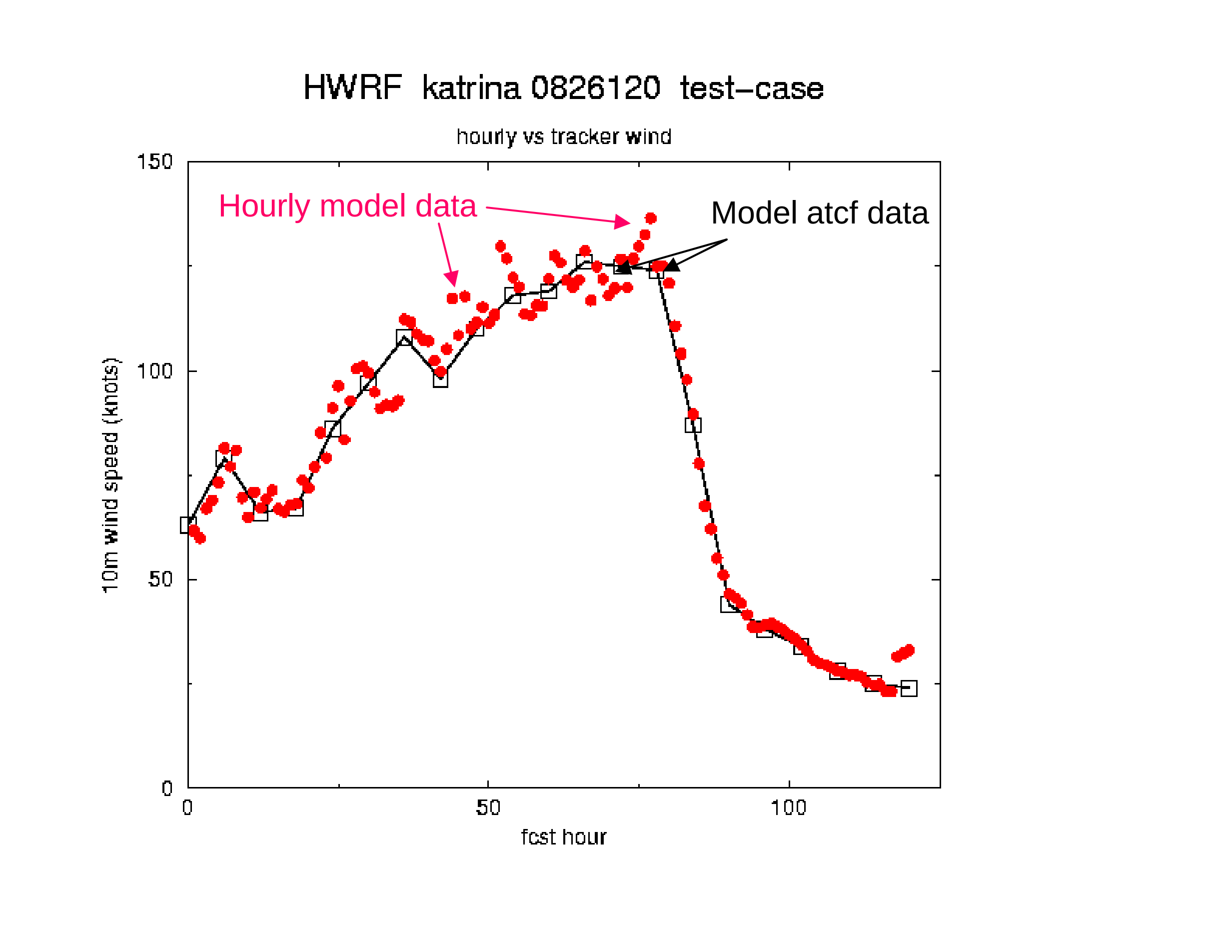
Noel



Heavy rain at landfall

Floods in Dominican Republic & Cuba

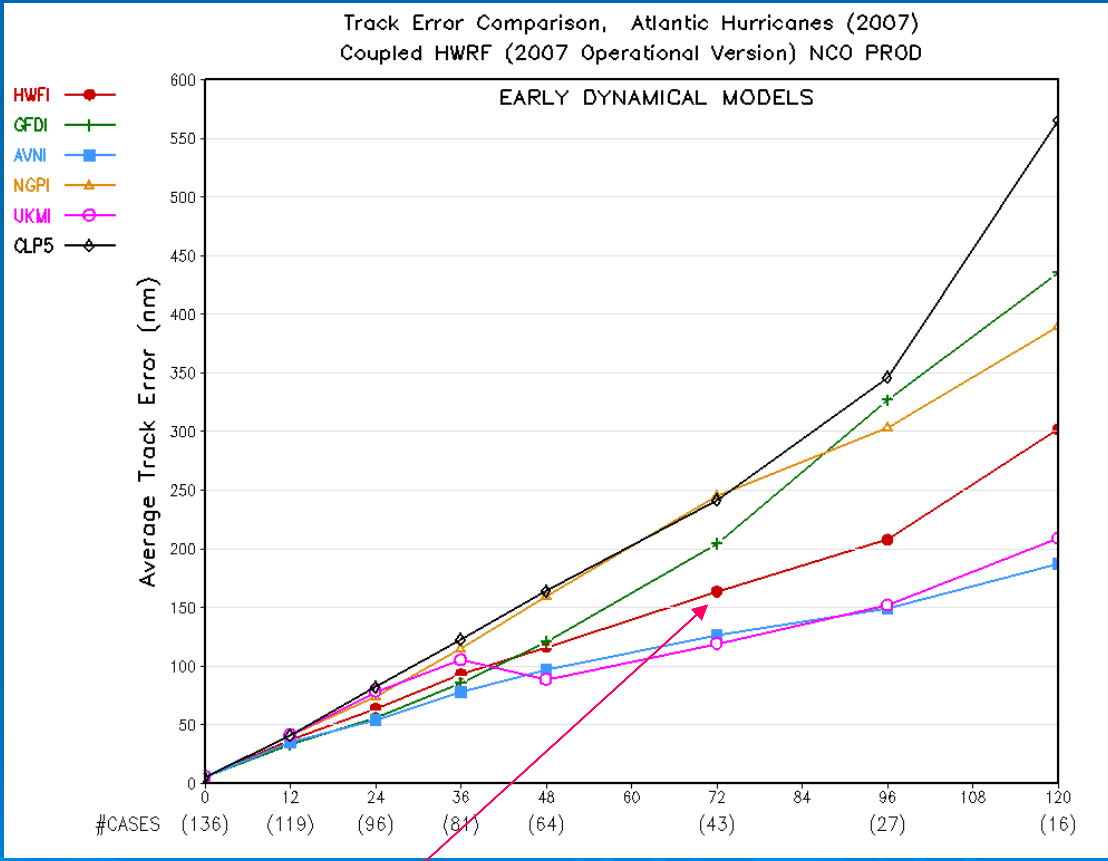
Hourly track & intensity



Model variability may be important ?

HWRF Track Skill

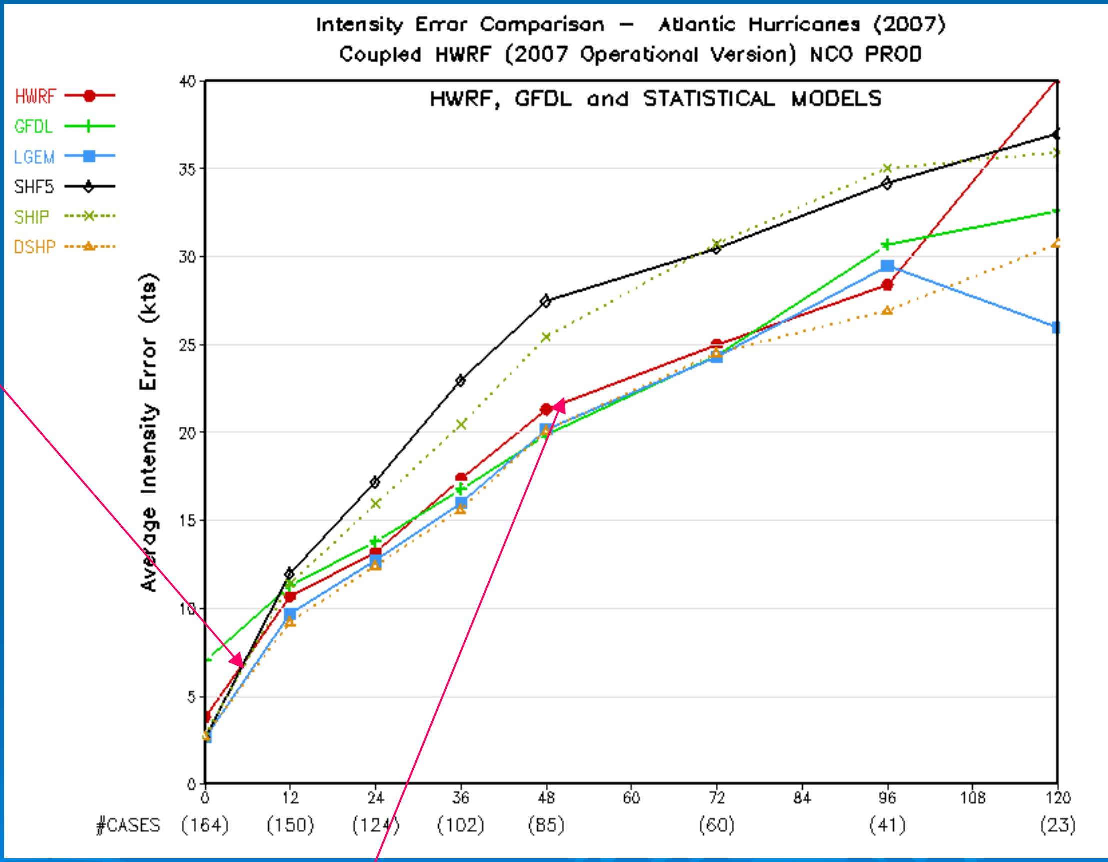
- Competitive with other guidance
- Better than GFDL & NGAPS
- GFS & UKMET quite good
- Few long lasting storms in 2007
- EPAC HWRF not as good



HWRF

HWRF Intensity Skill

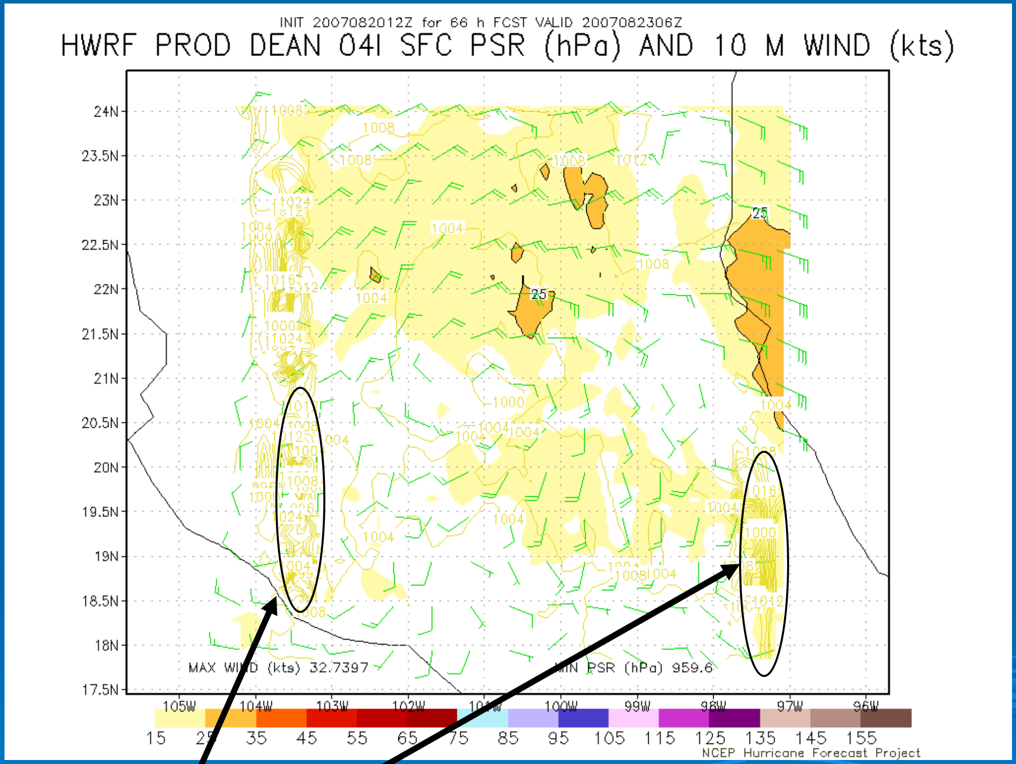
- Competitive with other guidance
- Some improvement over GFDL at early times
- Not a good year for dynamic models after accounting for landfall
- EPAC intensity degraded-no ocean coupling



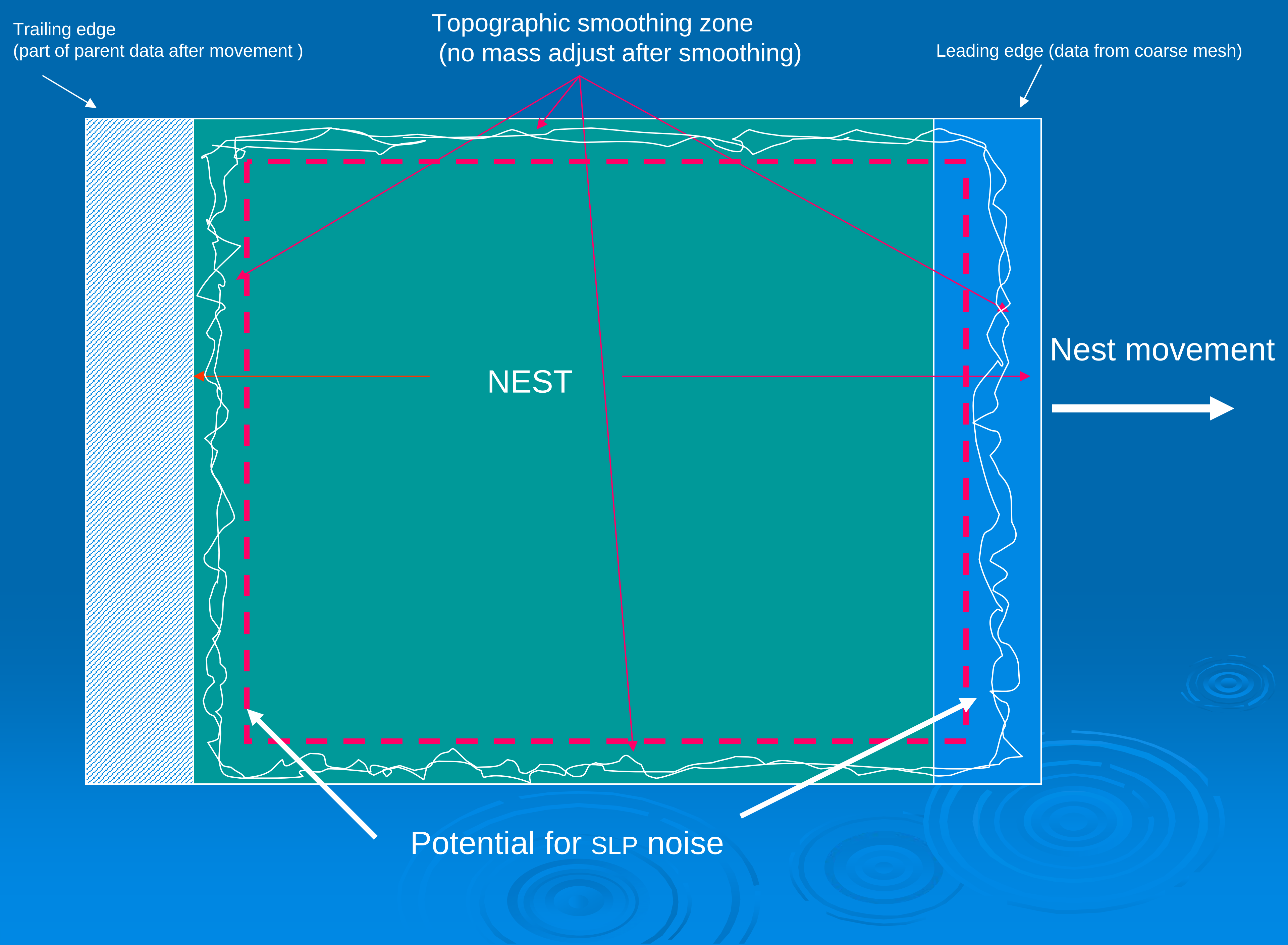
HWRF

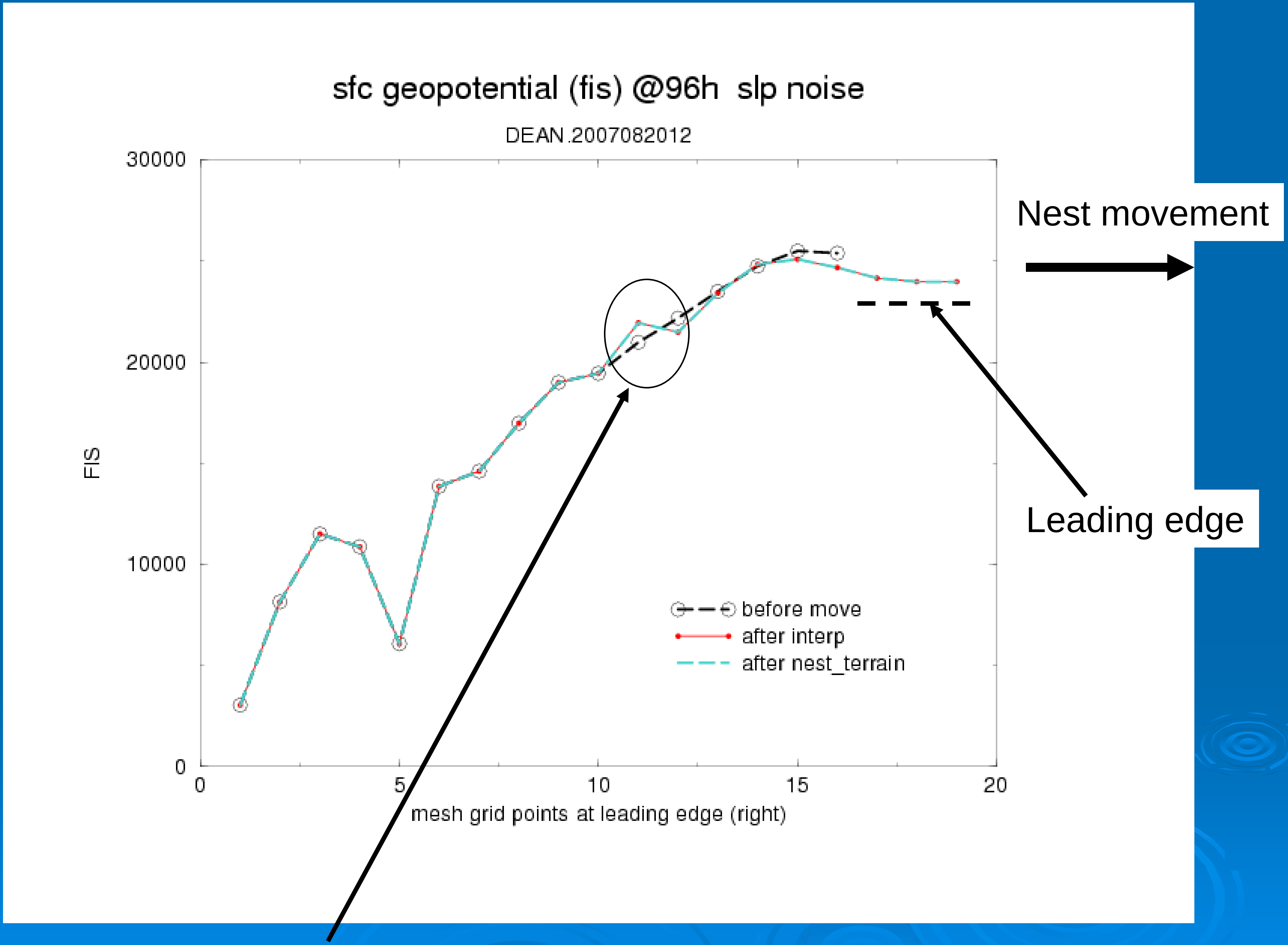
Sporadic SLP noise

- Sea level pressure diagnostic
- Model or post processing ??
- Traced to grid movement



Noise

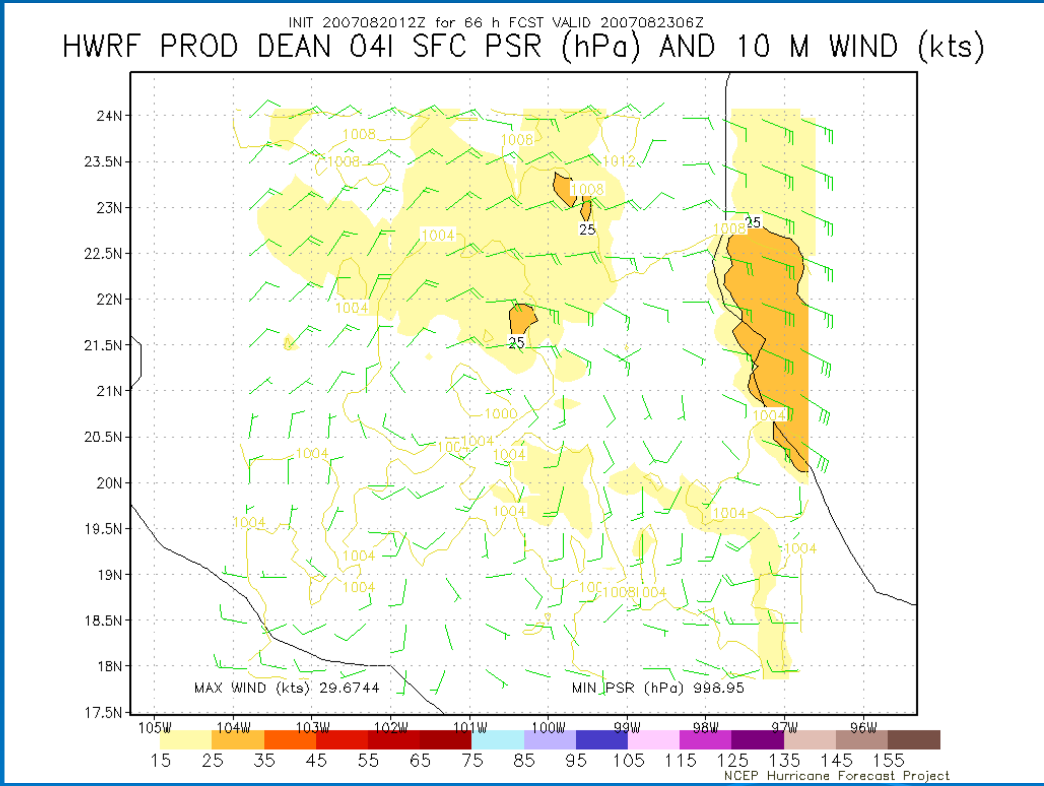

Trailing edge
(part of parent data after movement)
Topographic smoothing zone
(no mass adjust after smoothing)
Leading edge (data from coarse mesh)
NEST
Nest movement
Potential for SLP noise



Change in topography causes noise in sea level pressure

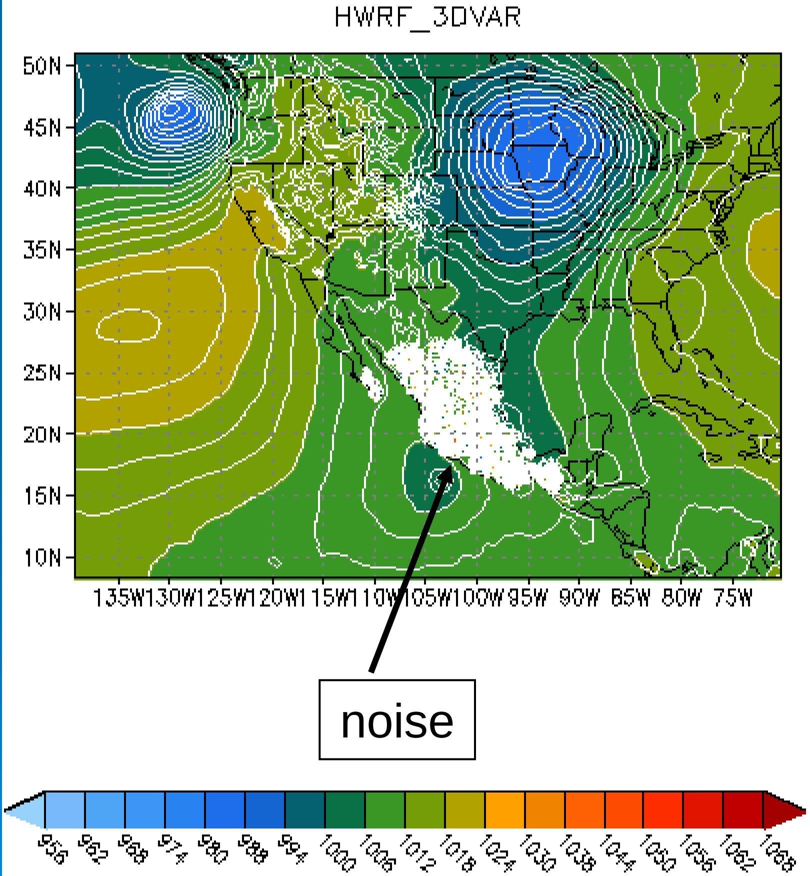
Eliminate SLP Noise

- Modify topographic smoothing zone
- Adjust mass fields
- No more Noise !



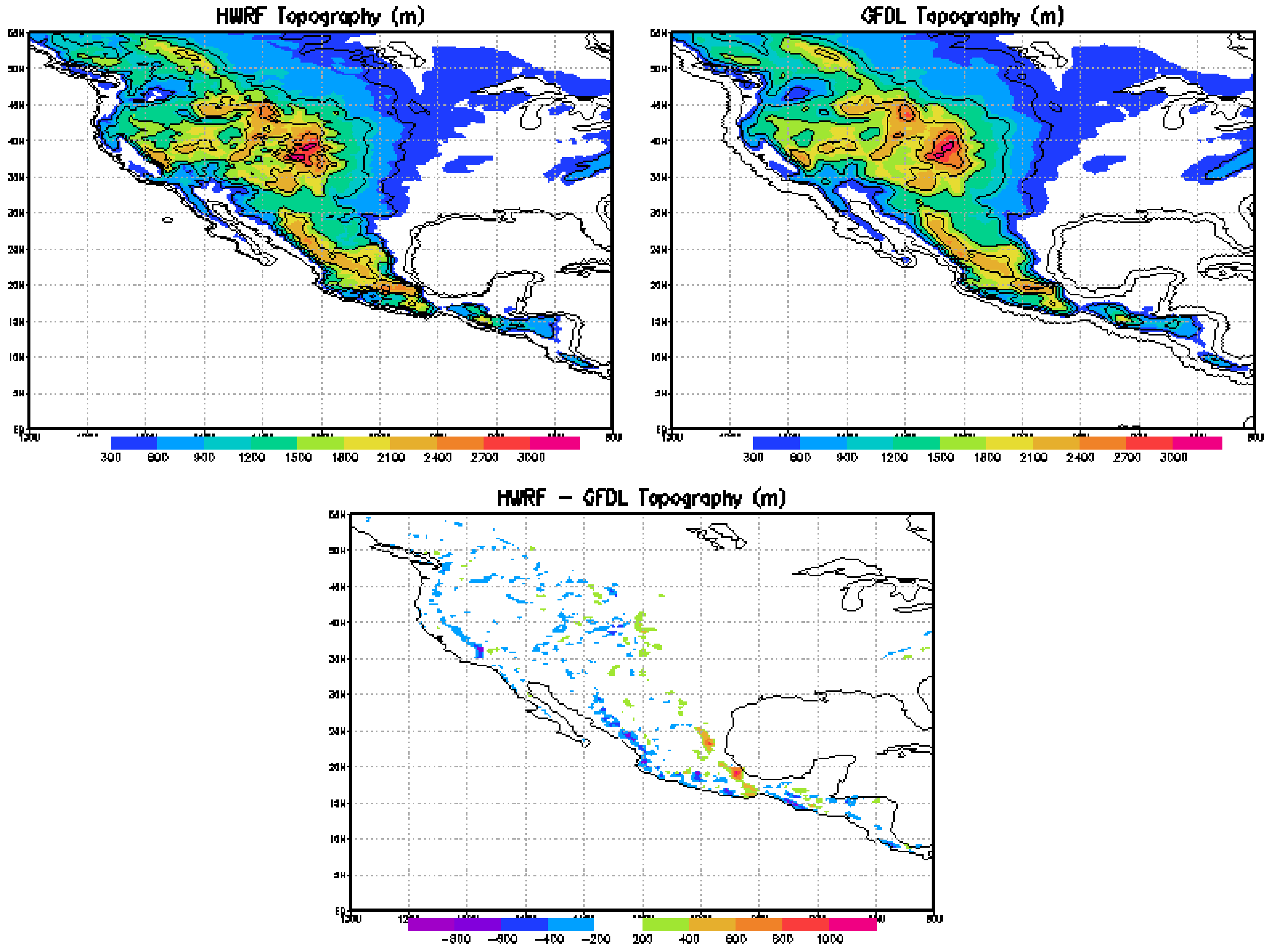
SLP Noise in initial HWRF fields

Traced to 3dvar & mass adjustment



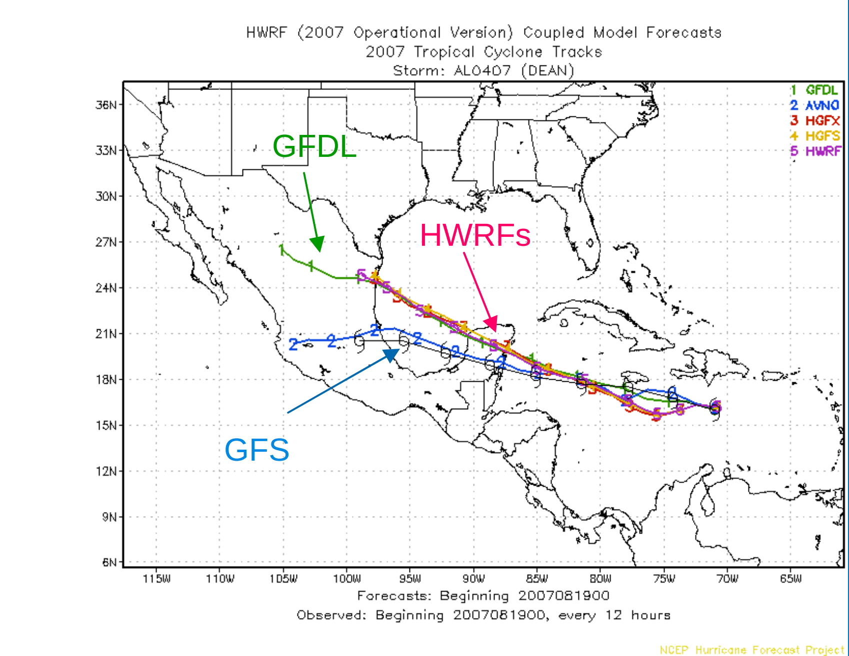
Other problem issues

- Topographical differences between models
- Surface flux formulations & land surface modeling
- Wind-pressure relationship

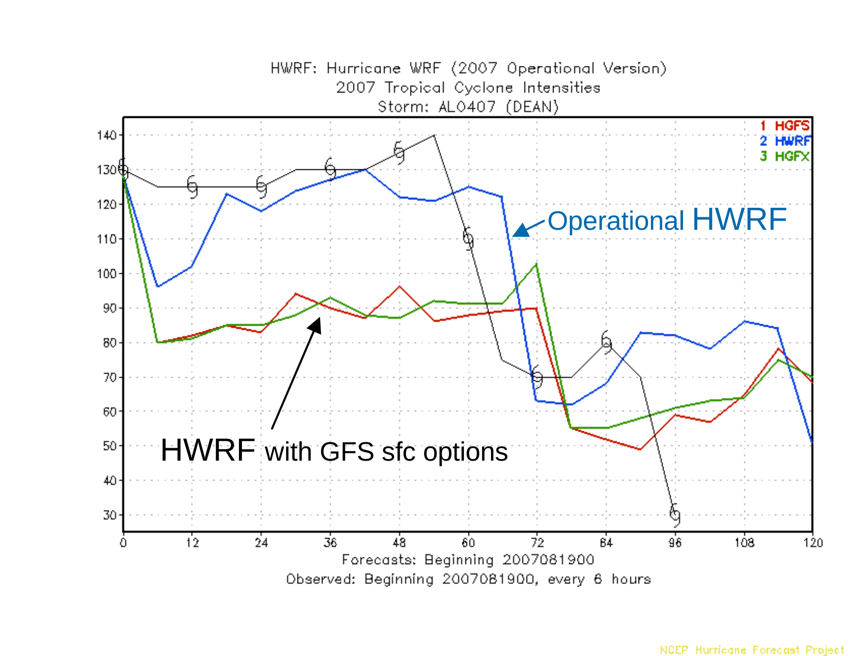

HWRF Topography (m)
300 600 900 1200 1500 1800 2100 2400 2700 3000
GFDL Topography (m)
300 600 900 1200 1500 1800 2100 2400 2700 3000
HWRF – GFDL Topography (m)
-800 -600 -400 -200 200 400 600 800 1000

HWRF with GFS physics surface flux & Noah LSM

Dean track



Dean Intensity



Physics are important !!

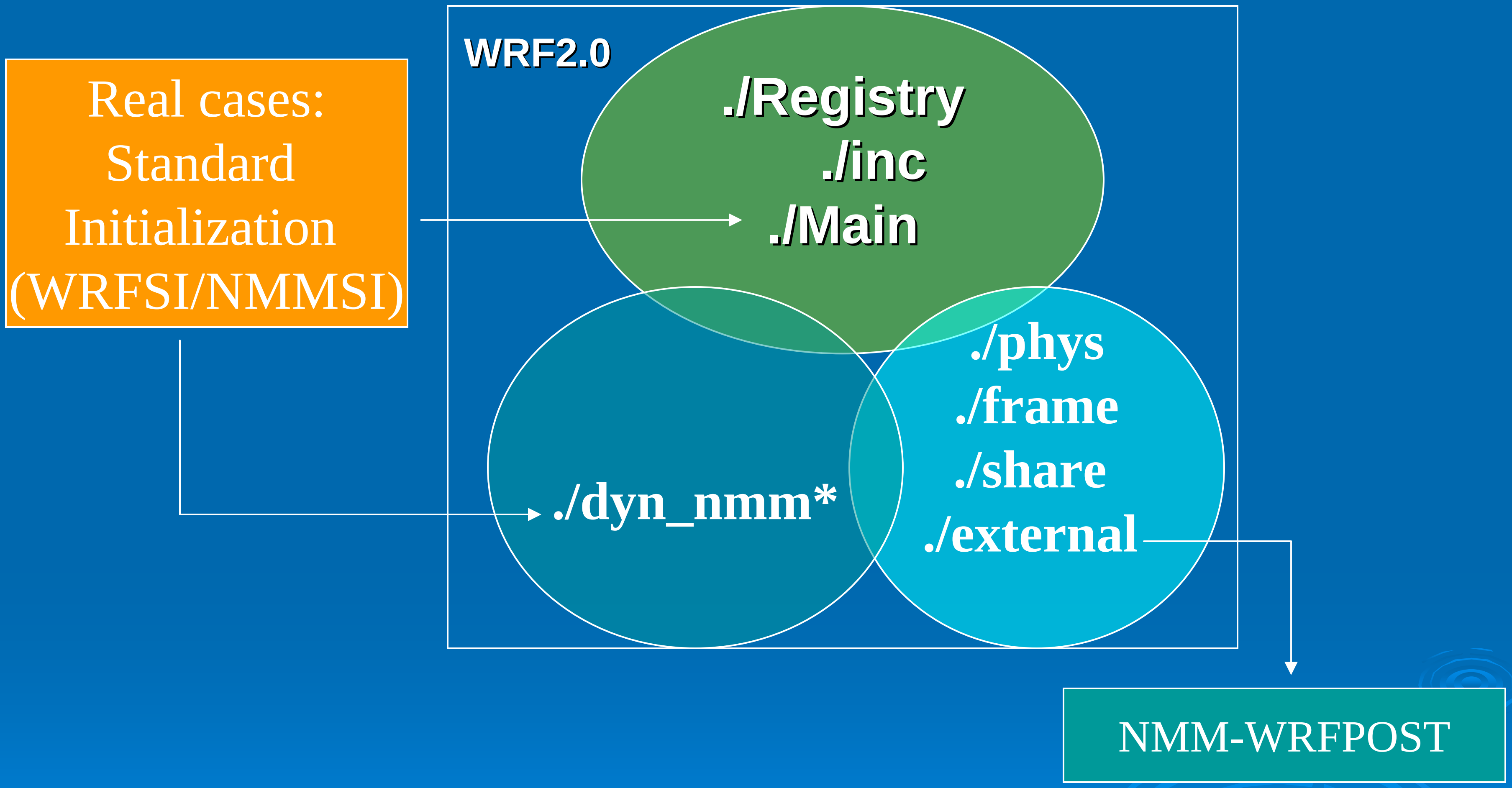
HWRF Accomplishments

- Successfully installed operational system for the 2007 tropical season which runs in robust, timely fashion
- HWRF competitive with best operational guidance.

HWRF Plans

- Upgrade physics and test ensembles
- Implement new ocean model
- Implement wave model

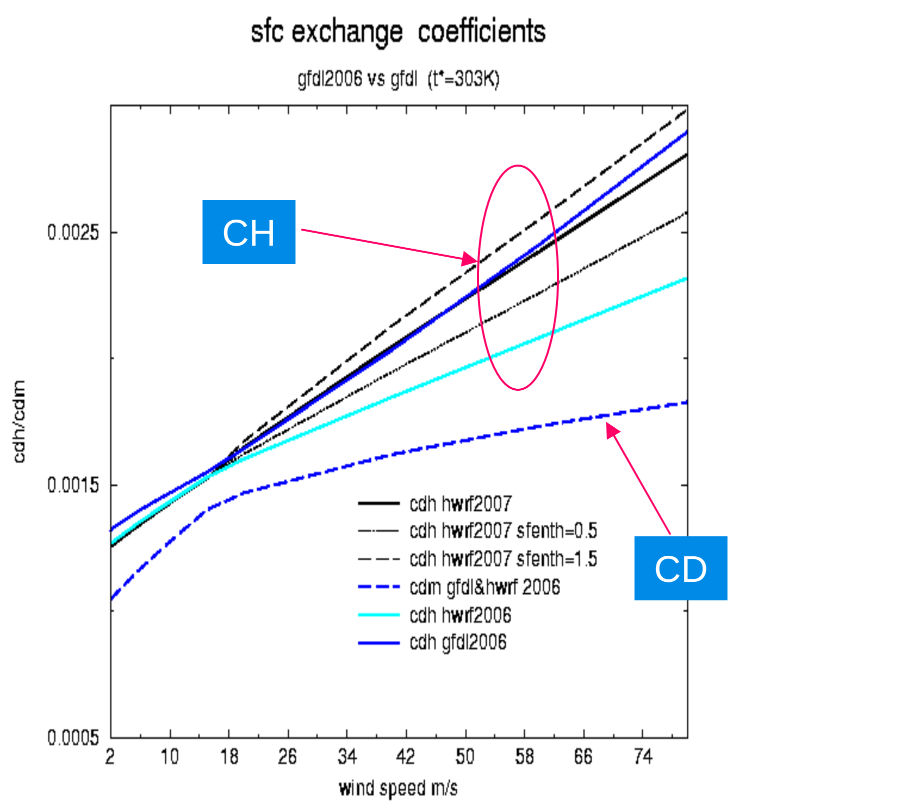
NMM- HWRF: The Hurricane Model



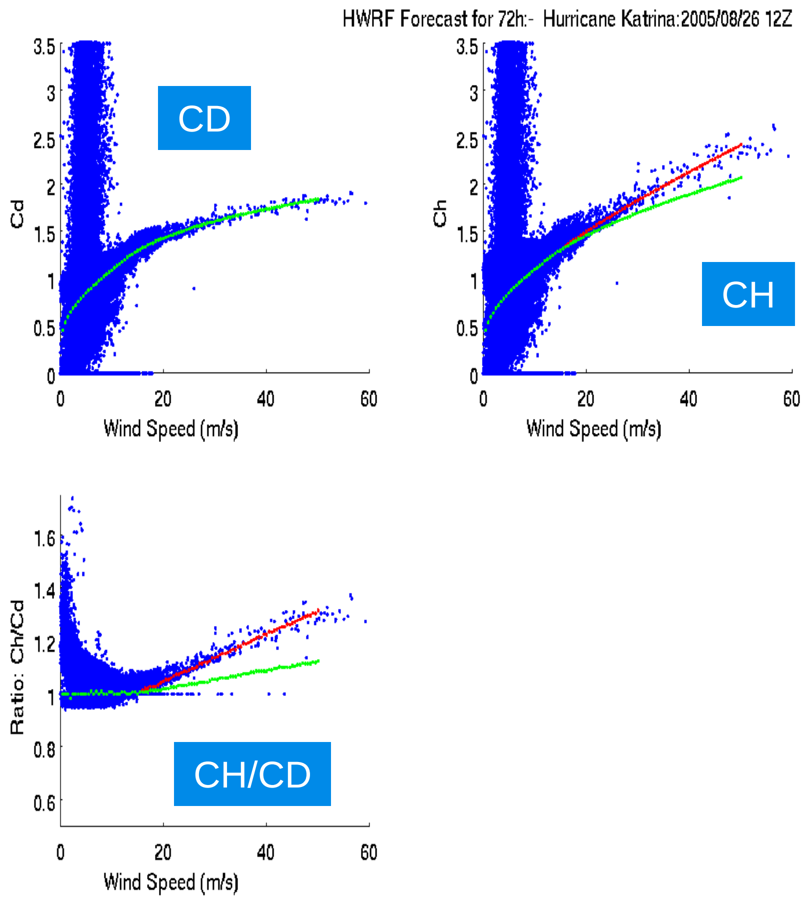
*This WRF core has been linked to a complete hurricane forecast system with nesting integrated

Sensitivity of physics packages
Surface exchanges…..collaboration with URI

analytical



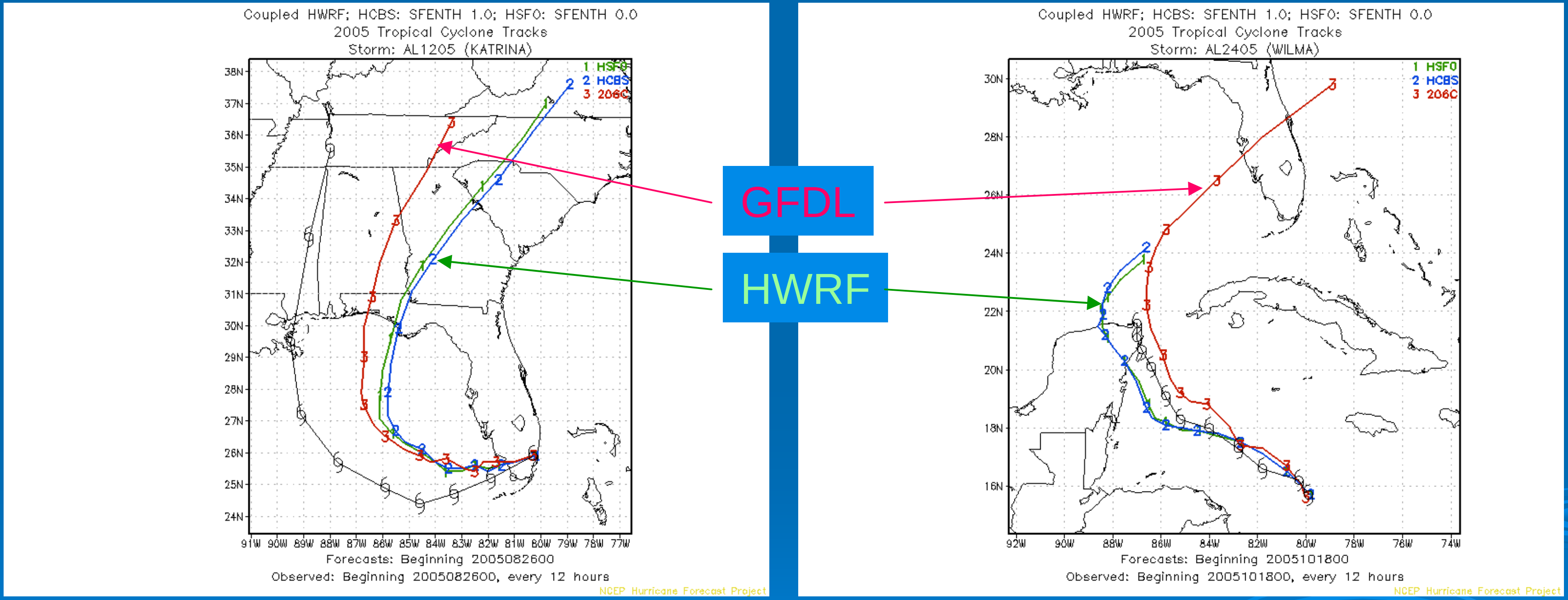
HWRF model



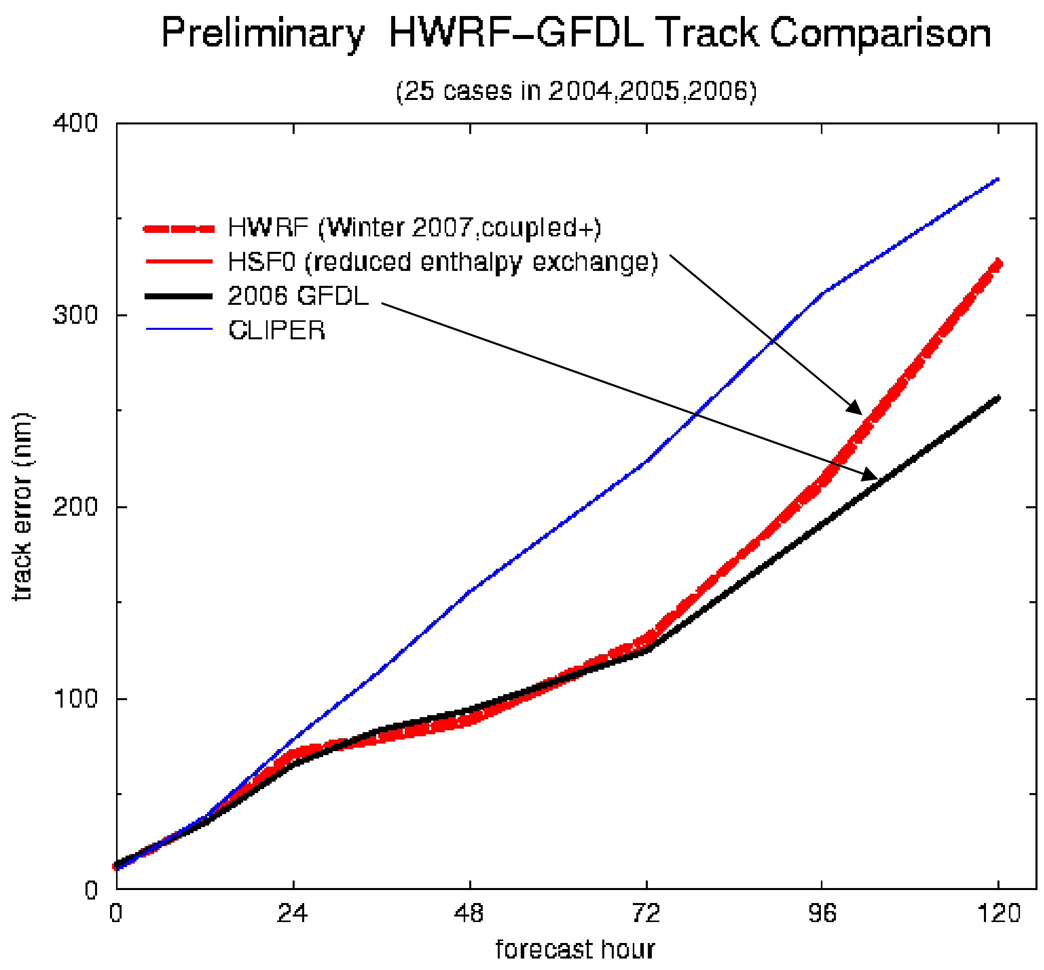
Sensitivity of track to enthalpy exchange

Katrina

Wilma



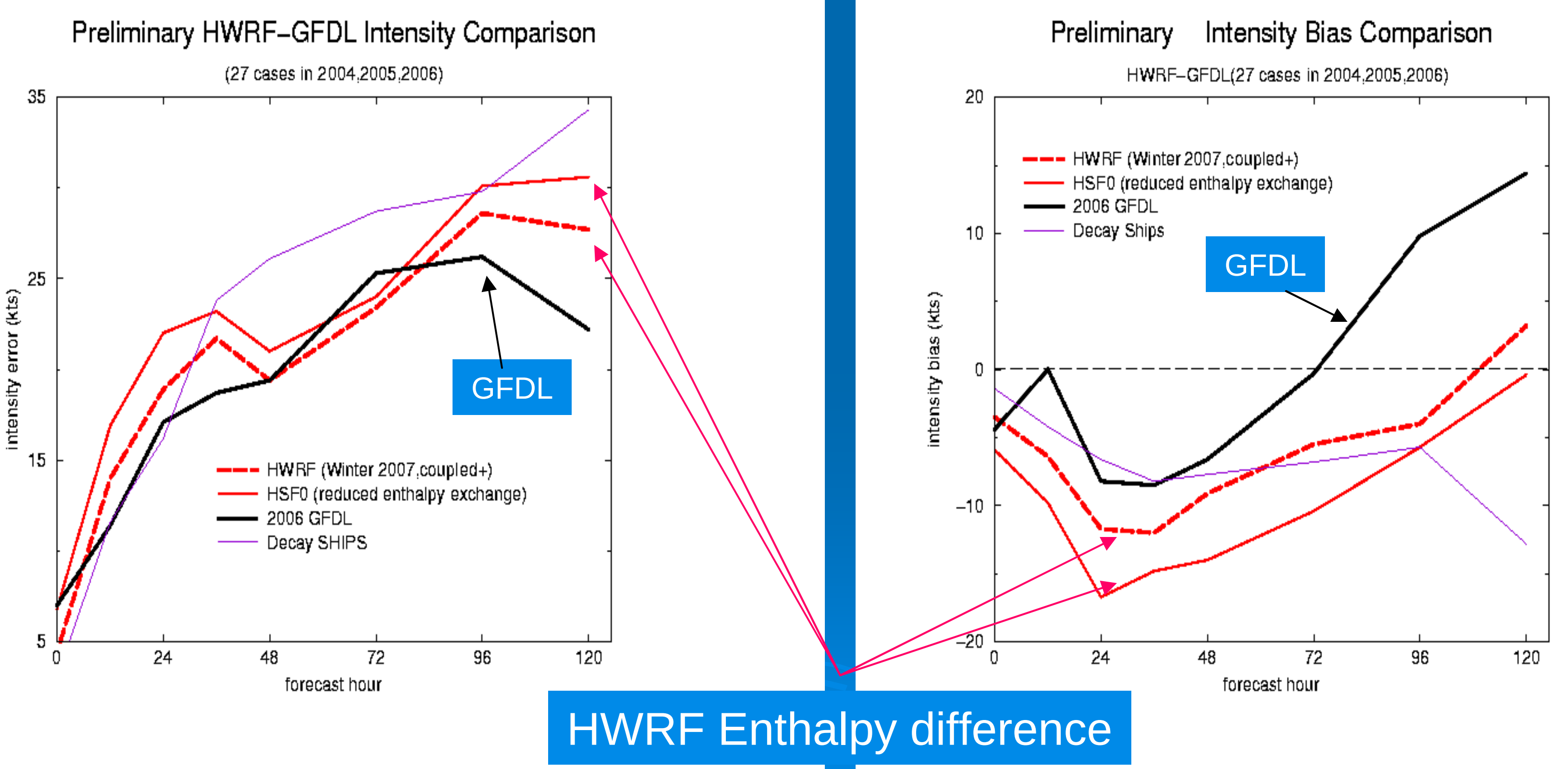
Sensitivity of track to enthalpy exchange (little difference)



Sensitivity of intensity to enthalpy exchange

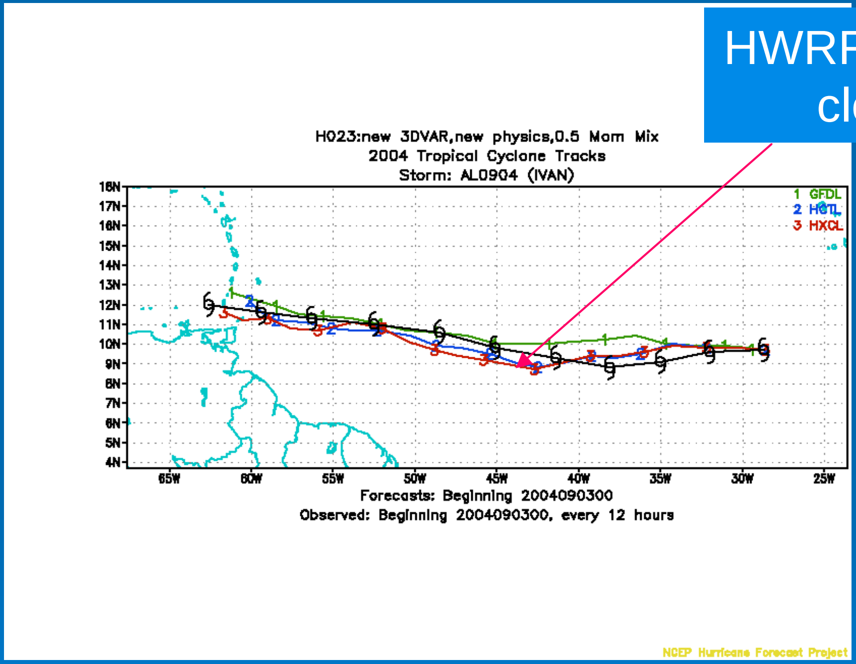
magnitude

bias



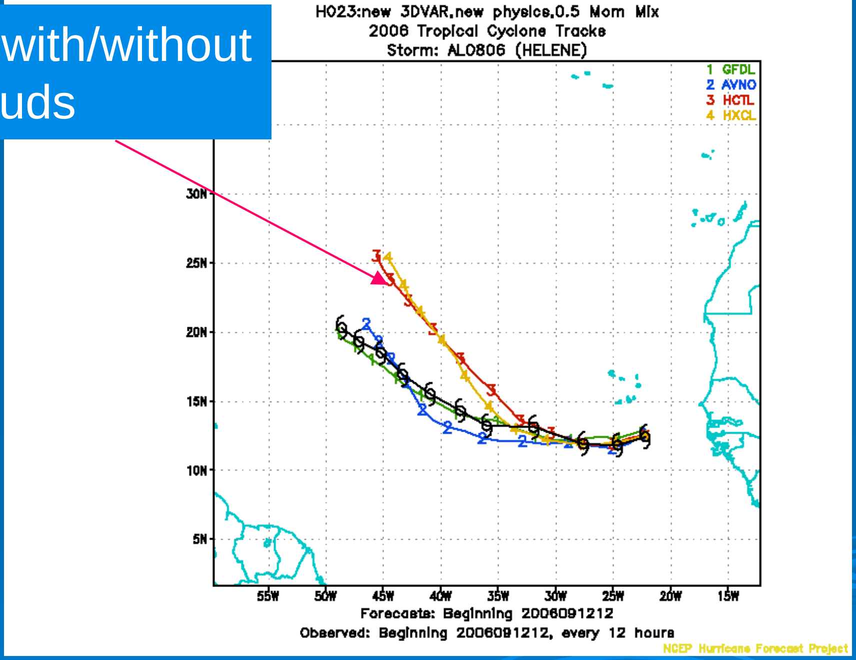
HWRF sensitivity to radiation & clouds (not much difference)

Ivan



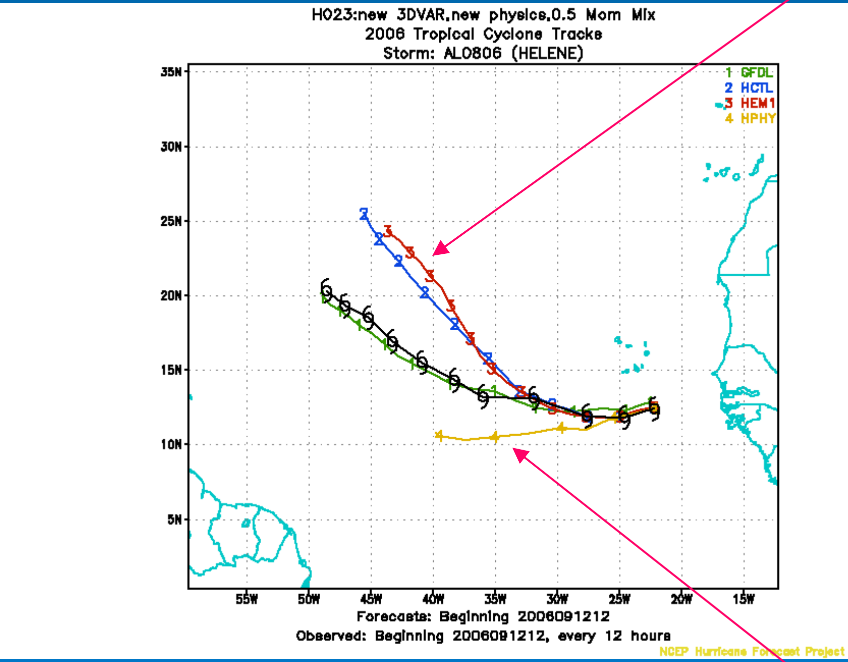
HWRF with/without clouds

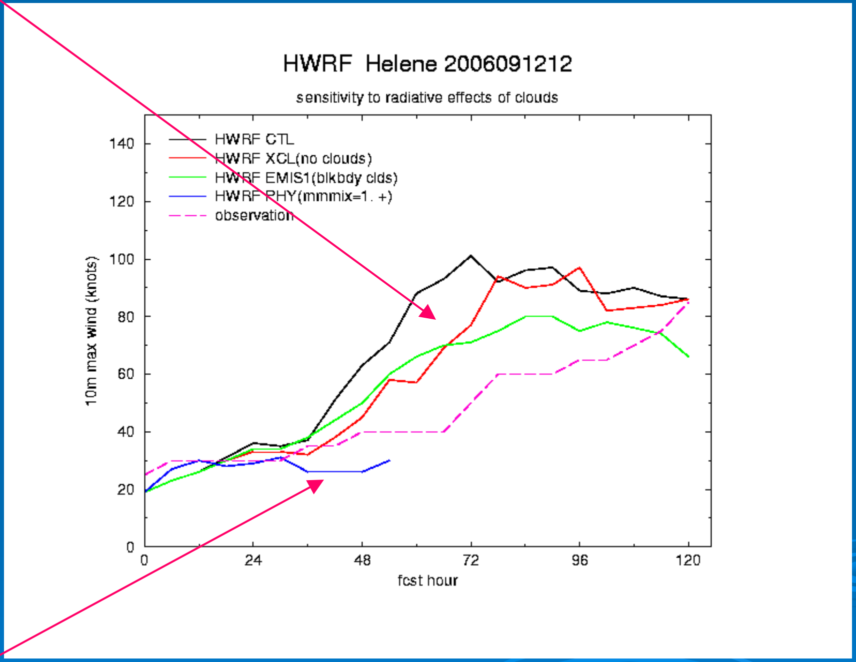
Helene



Sensitivity of clouds vs momentum mixing

HWRF with cloud differences (Helene)





HWRF with strong momentum mixing

HWRF accomplishments

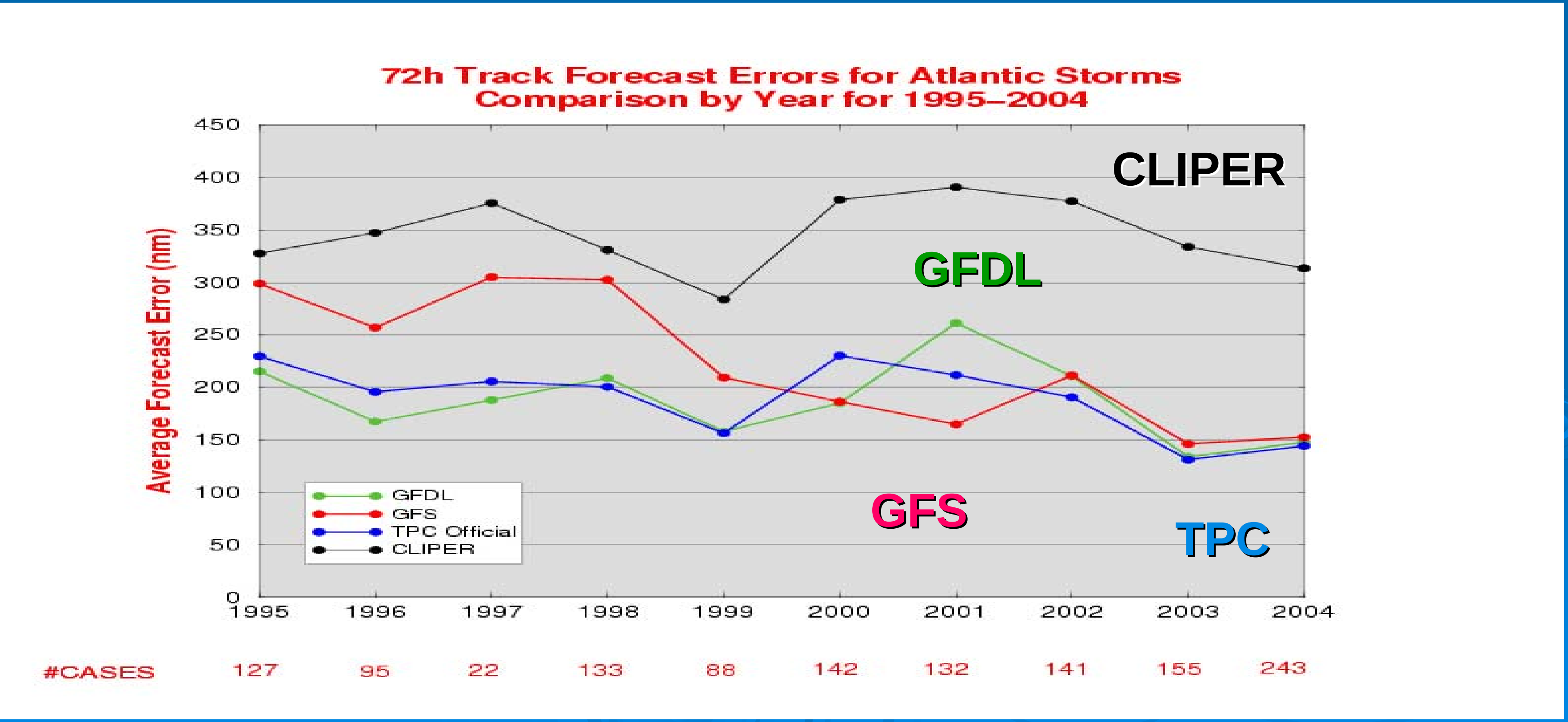
- Ran real-time parallel moveable nested 5-day runs for 2006 season (2-way interaction with GFS physics/GFDL&GFS initial conditions) in robust fashion
- Made changes to system to improve accuracy

A. Fixed inconsistency of cumulus momentum mixing
B. Transitioned from GFDL & GFS initial condition to vortex relocation with data assimilation
C. Installed momentum and enthalpy exchange consistent with 2006 GFDL
D. Installed preliminary version of ocean coupling together with URI
E. HWRF system to run in binary and start-up from higher accuracy native GFS data

Summary & Plans

- Upgrade, evaluate and tune physics
  ….surface layer, lsm, microphysics,
  ….radiation & clouds, lateral b.c.
- Continue parallel HWRF runs….
  forecast/analysis cycle
- Compare with GFDL and other models
- Implement operational HWRF

✓ Dramatic improvement in tropical cyclone track forecasts have occurred through advancements in high quality observations, high speed computers and improvements in dynamical models. Similar advancement now need to be made for tropical cyclone intensity, structure and rainfall prediction. Can these advancements be made with advanced non-hydrostatic models while achieving track and intensity skill comparable to GFDL??



TRANSITIONING TO HURRICANE WRF

02-03 03-04 05 06 07

Mesoscale Data Assimilation for Hurricane Core

GFDL Begin Physics Upgrades Continue upgrades GFDL frozen
HWRF T&E

HWRF Operational

(9km/42?L)

HWRF Begin R&D Prelim. Test HWRF physics HWRF T&E

Advancing HURRICANE WRF System

08 09 10 11 12

Mesoscale Data Assimilation for Hurricane Core

Implement advance (reflectivity) → **A4DDA**

Atm. Model physics and resolution upgrades (continuous)

Air sea fluxes: wave drag, enthalpy (sea spray)

Microphysics

Incr. resolution

(4km/>64L?)

Waves: moving nest Multi-scale imp. Highest-Res coast

Ocean: 4km. - continuous upgrades in ODAS, model res.

The GFDL Modeli

- Regional Scale, Moving Nest, Atm
- equations fo … e-
  grid and nor
  system.
- that uses
  alistic storm
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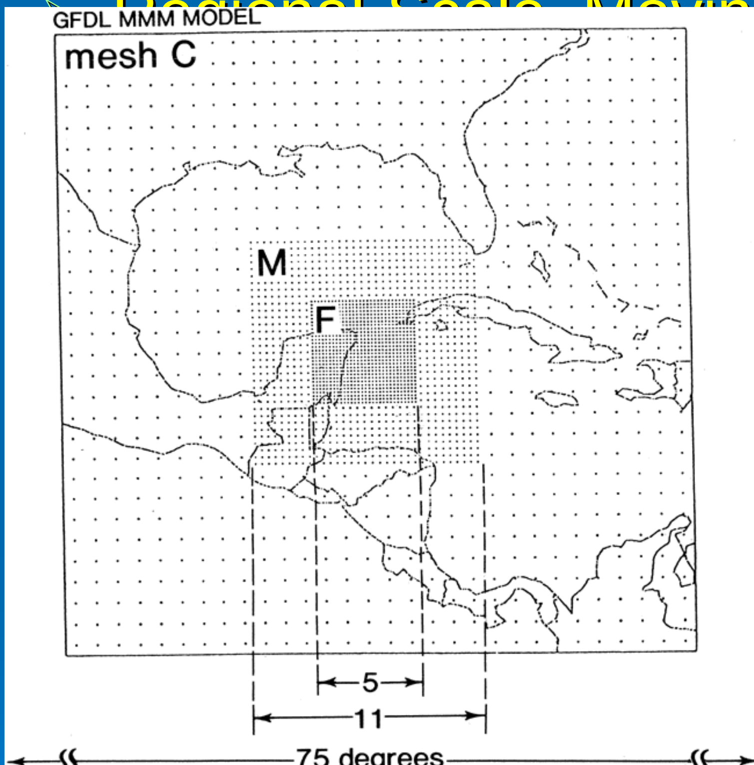
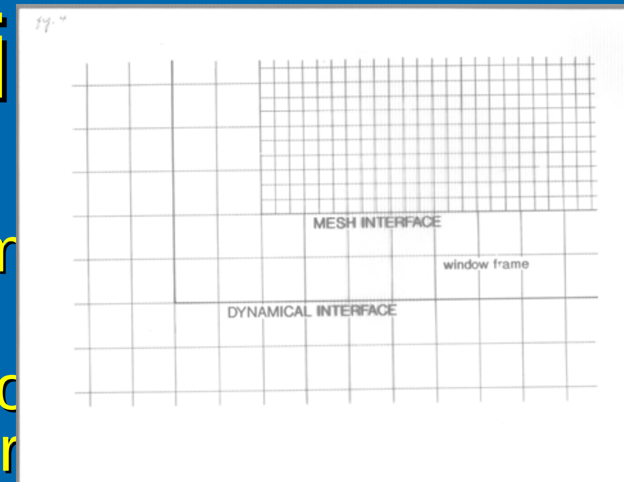




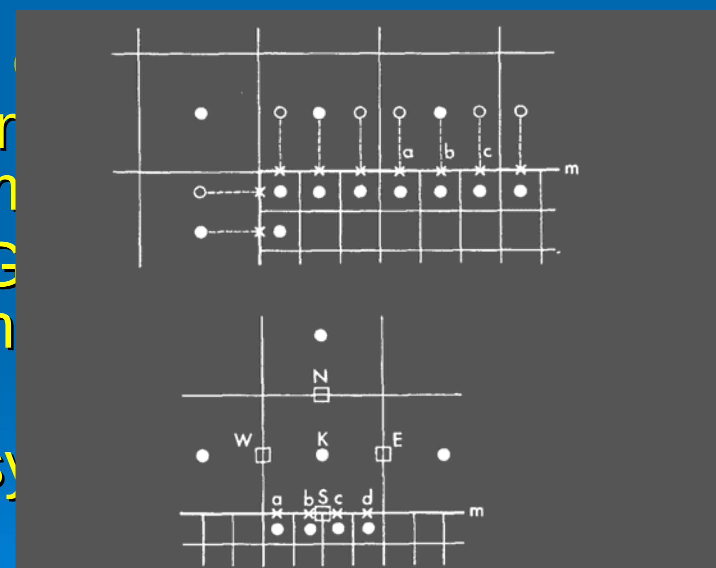
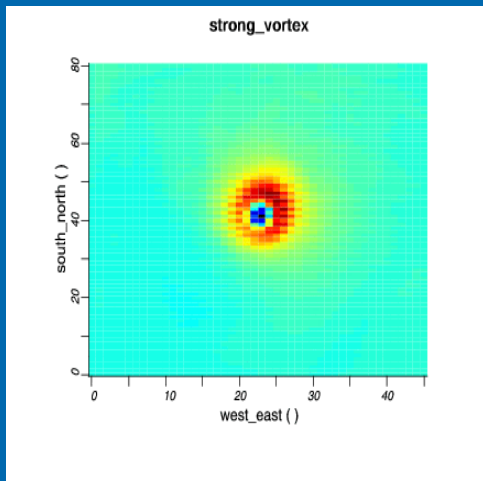
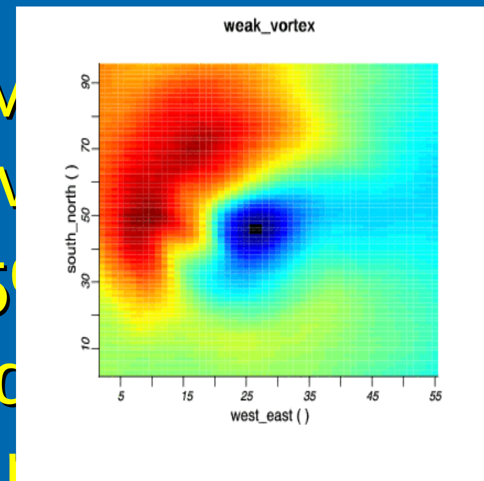


FIG. 5. Interpolation near a mesh interface m. Black dots indicate grid points. Values at the coarse grids are first interpolated to the auxiliary points (open circles). Subsequent interpolation between the auxiliary points and the fine grids yields the values at the interface points (cross marks). In the lower part, open squares indicate the north (N), east (E), south (S) and west (W) points for a key grid (K).

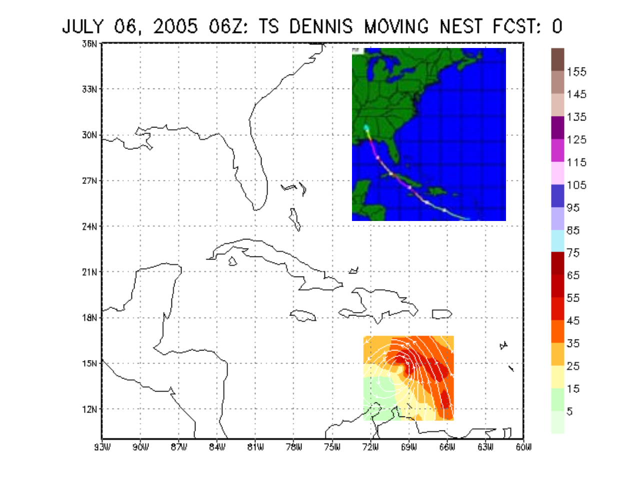
NMM-WRF GRID MOTION

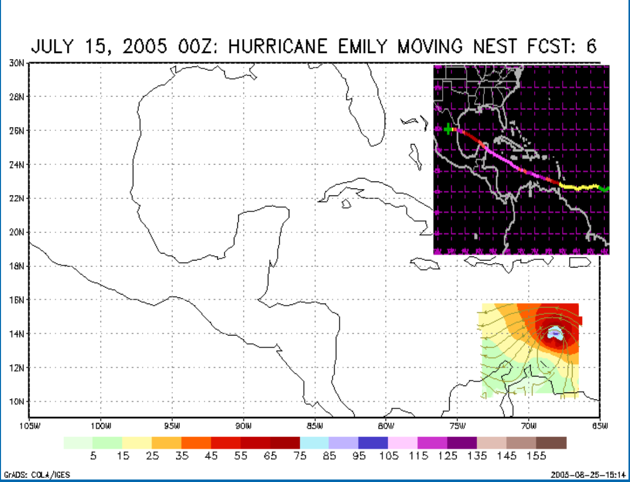


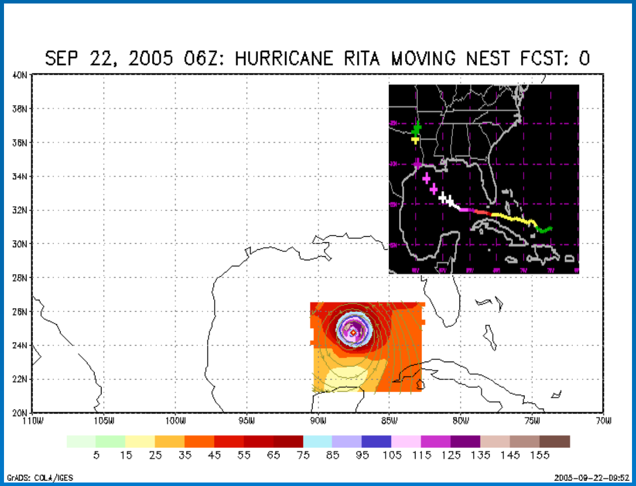


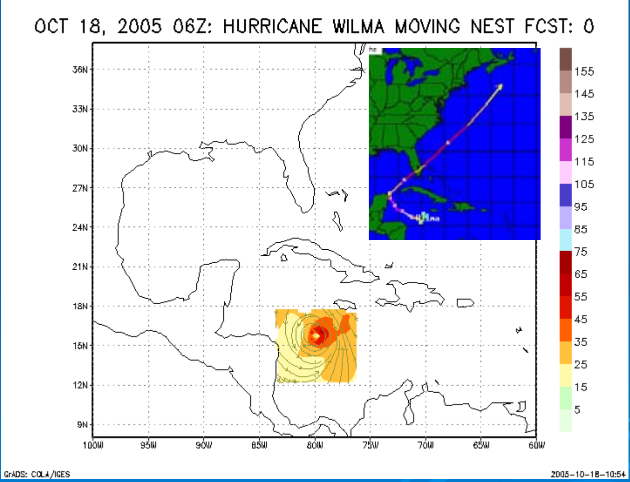
- rocedure is M t and is way interactiv
- n is ~75^0x75^0 nter at esolution and est is about 9 km r
- The nest is "set to sail" on the parent domain using a simple criterion based on variations in dynamic pressure. The so called “stagnation point” was chosen to be the center of the storm (Gopalakrishnan et al 2002, MWR.)

Test Cases with NMM grid motion









****** For configuration provided earlier, it takes about 55 minutes of run time (excludes wrfsi and real). . for 5 days of forecast using 72 processors in our IBM cluster.**