Advanced Hurricane Modeling in NOAA: The HWRF

Naomi Surgi

HWRF Program Leader

NCEP/Environmental Modeling Center

WHERE AMERICA'S CLIMATE AND WEATHER SERVICES BEGIN

- **Final GFDL upgrades**
- **Transition to the HWRF**
- **T&E**

TRANSITIONING TO HURRICANE WRF

02-03 03-04 05 06 07

Mesoscale Data Assimilation for Hurricane Core

GFDL

Begin Physics upgrades

Continue upgrades

Final GFDL upgrades

HWRF

Begin R&D

Prelim. Testing grid, hurricane physics

T&E

IOC

Pre-Implementation Strategy for HWRF

FOR THE HWRF IOI: HWRF MUST PERFORM AT LEAST AS WELL AS THE GFDL MODEL

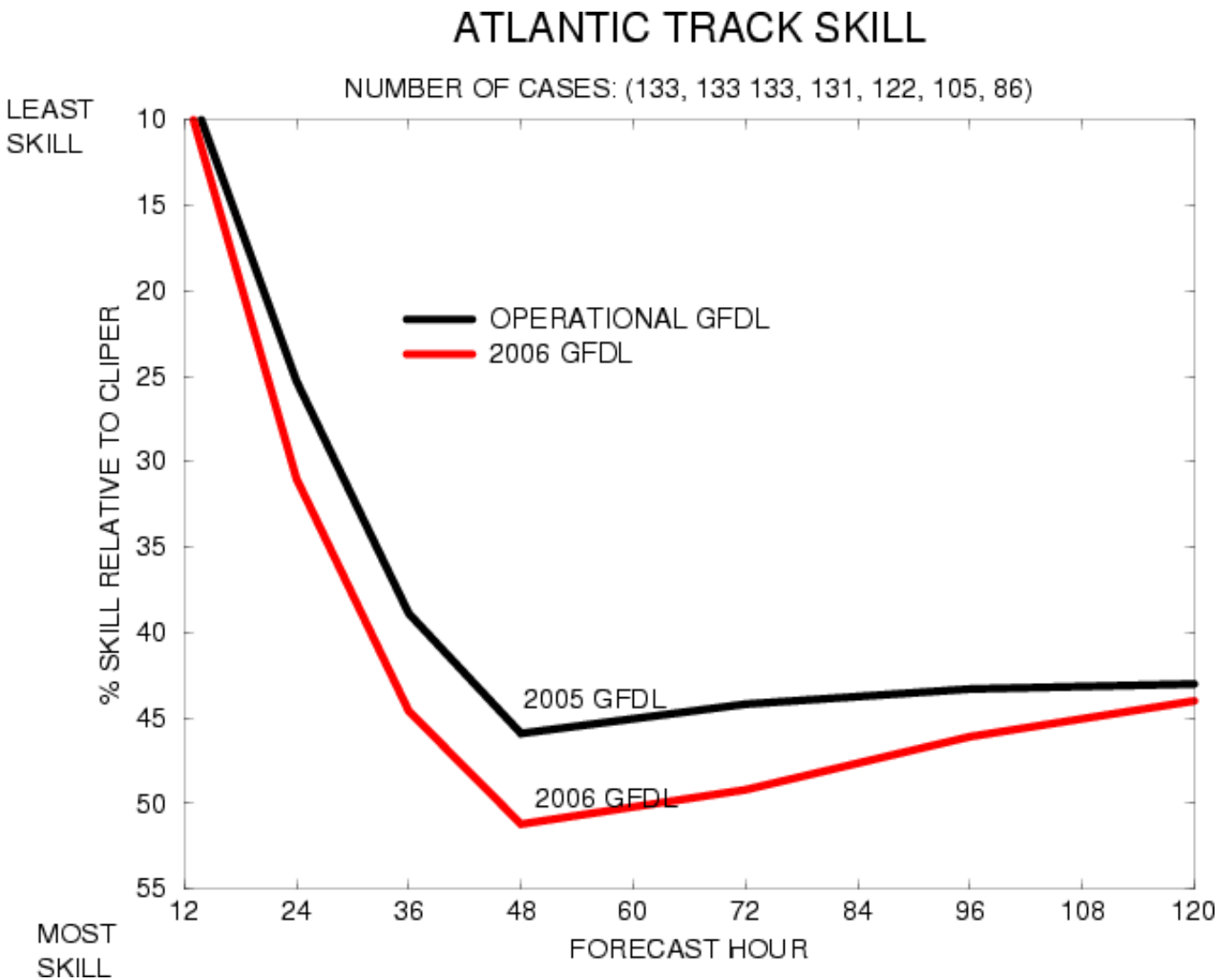
- UPGRADE GFDL SYSTEM
  resolution, atm. physics, air-sea physics, ocean, waves
- TRANSITION GFDL UPGRADES TO HWRF
- PERFORM EXTENSIVE COMPARISONS BETWEEN GFDL AND HWRF FOR MULTIPLE SEASONS AND STORMS

Joint EMC/TPC T&E document now available

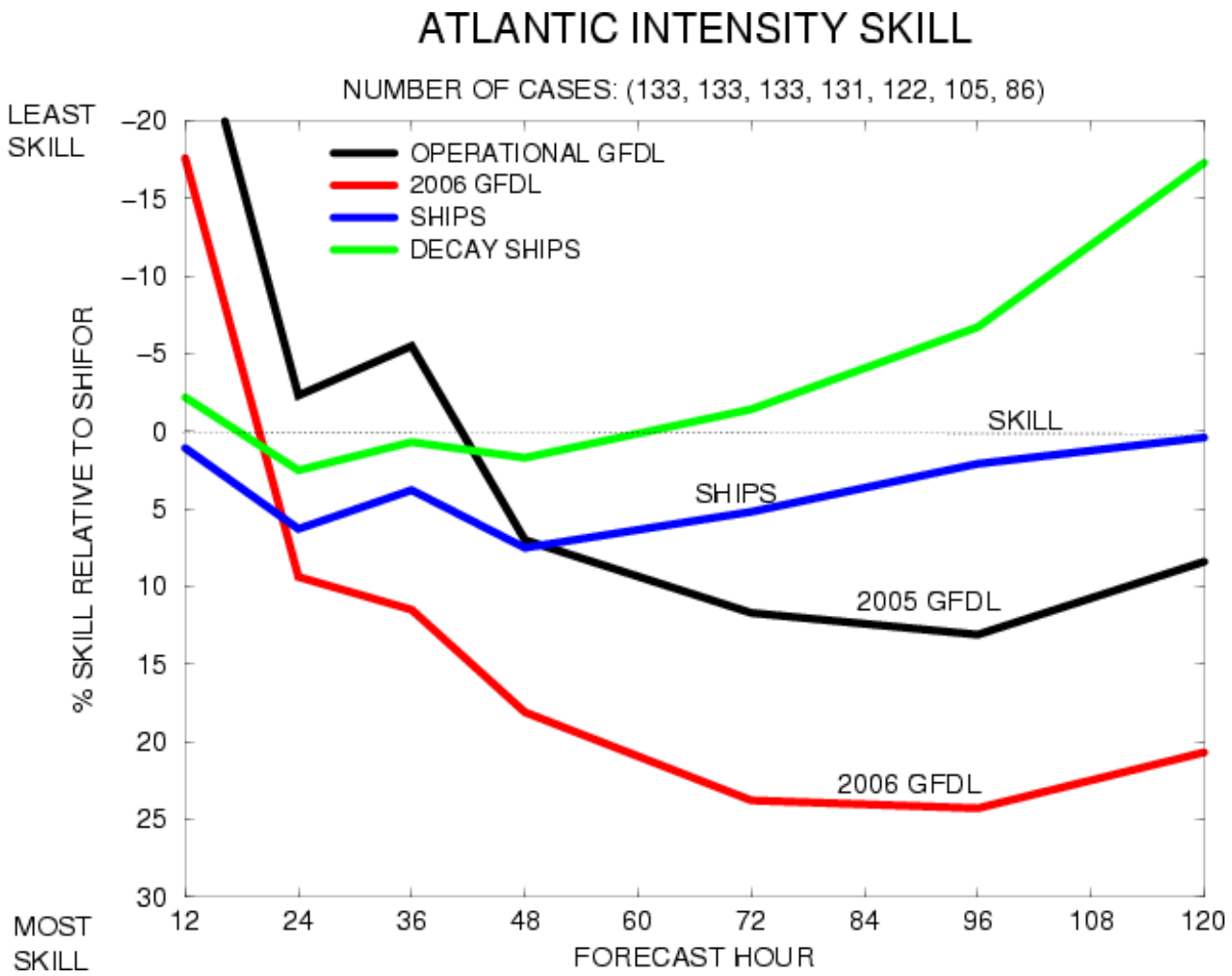
Proposed GFDL upgrades for ‘06

- MICROPHYSICS
- IMPROVED AIR-SEA PHYSICS
- BETTER POSITIONING OF THE LOOP CURRENT
- IMPROVED OCEAN INITIALIZATION
- COUPLING TO WAVES (IN PROGRESS)

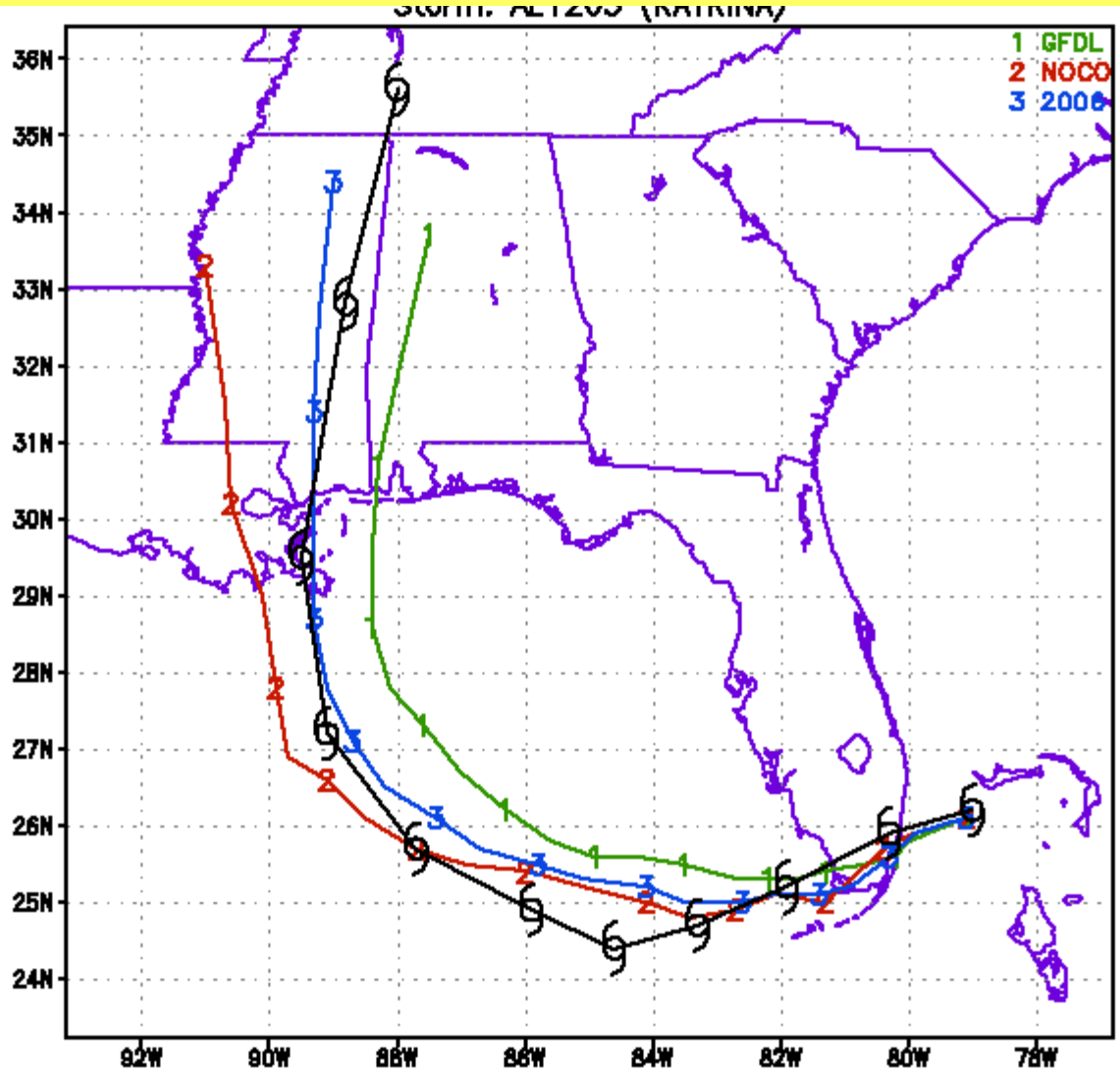
2006 UPGRADE SHOULD PROVIDE REDUCED ERRORS IN TRACK PREDICTION



2006 GFDL UPGRADES



Operational '05 GFDL (green) vs. w/microphysics w/o ocean (red) vs. w/microphysics and ocean (blue)



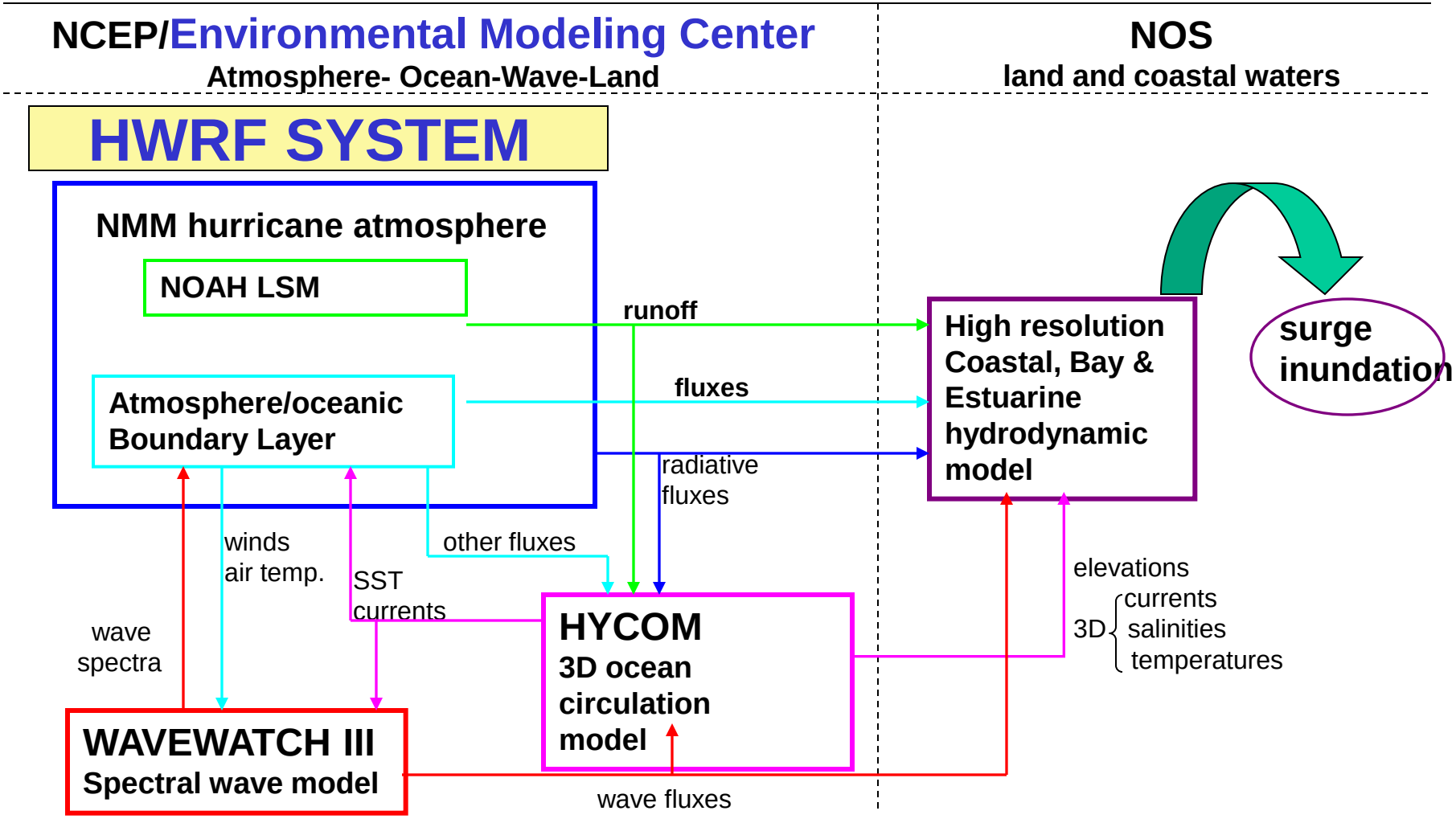
Forecasts: Beginning 2005082512

Observed: Beginning 2005082512, every 12 hours

GFDL Hurricane Dynamics Group

Transitioning to the HWRF system…..

Hurricane-Wave-Ocean-Surge-Inundation Coupled Models



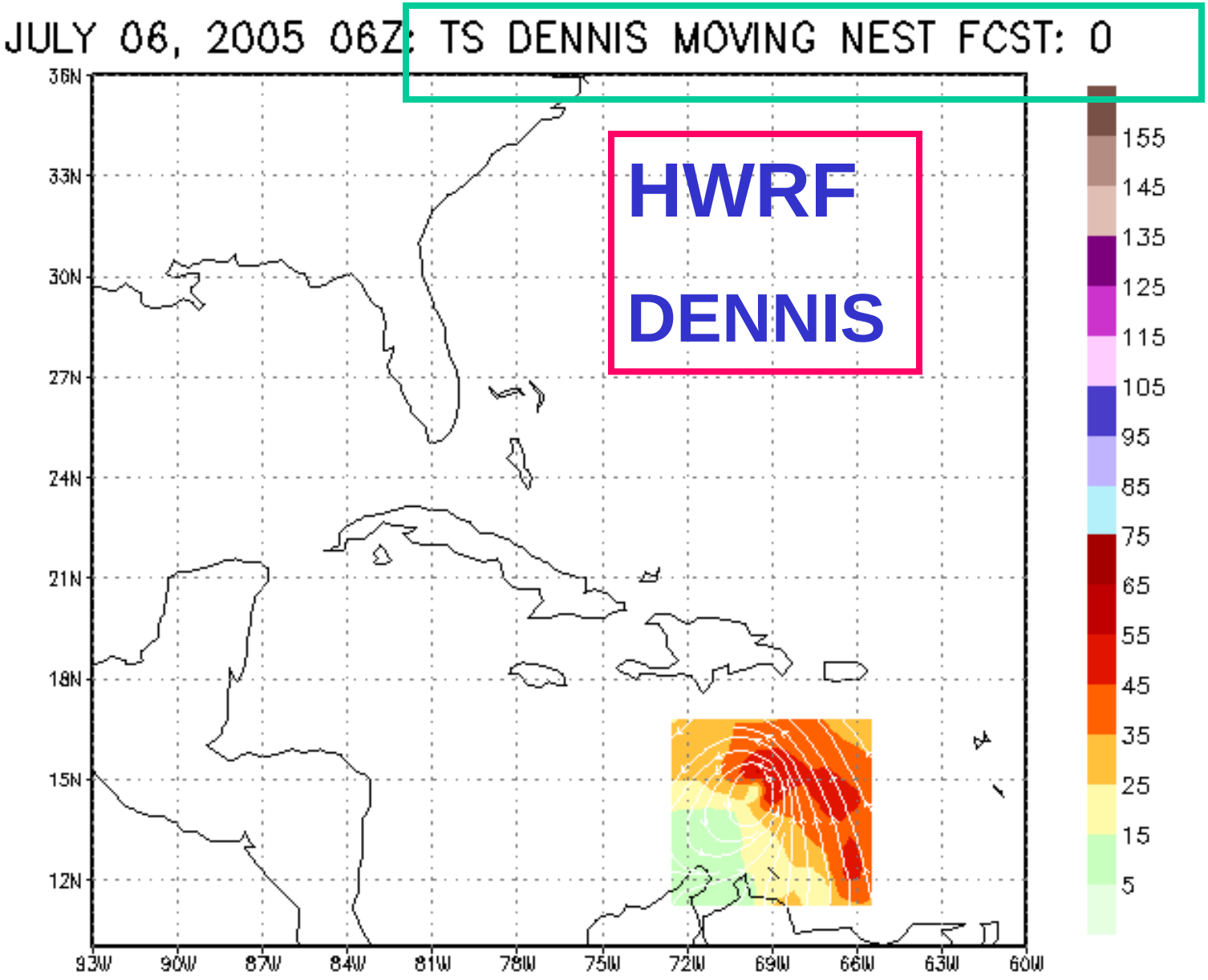
DEVELOPMENT OF THE HWRF SYSTEM

- ✓ Development of movable, 2- way nested grid
- ✓ Development of Physics
- ✓ Development of 3-D var and vortex initialization **
- ✓ Development of HYCOM for HWRF configuration
- Coupling to WAVEWATCH III (+ multi-scale model)
- Coupling to LSM
- Development/Upgrade of hurricane verification system (Intensity/structure, ppt)
- (Coupling of HWRF with storm surge (EMC, NOS – Frank Aikman) (2010?)
- Development of HWRF ensembles (near future)

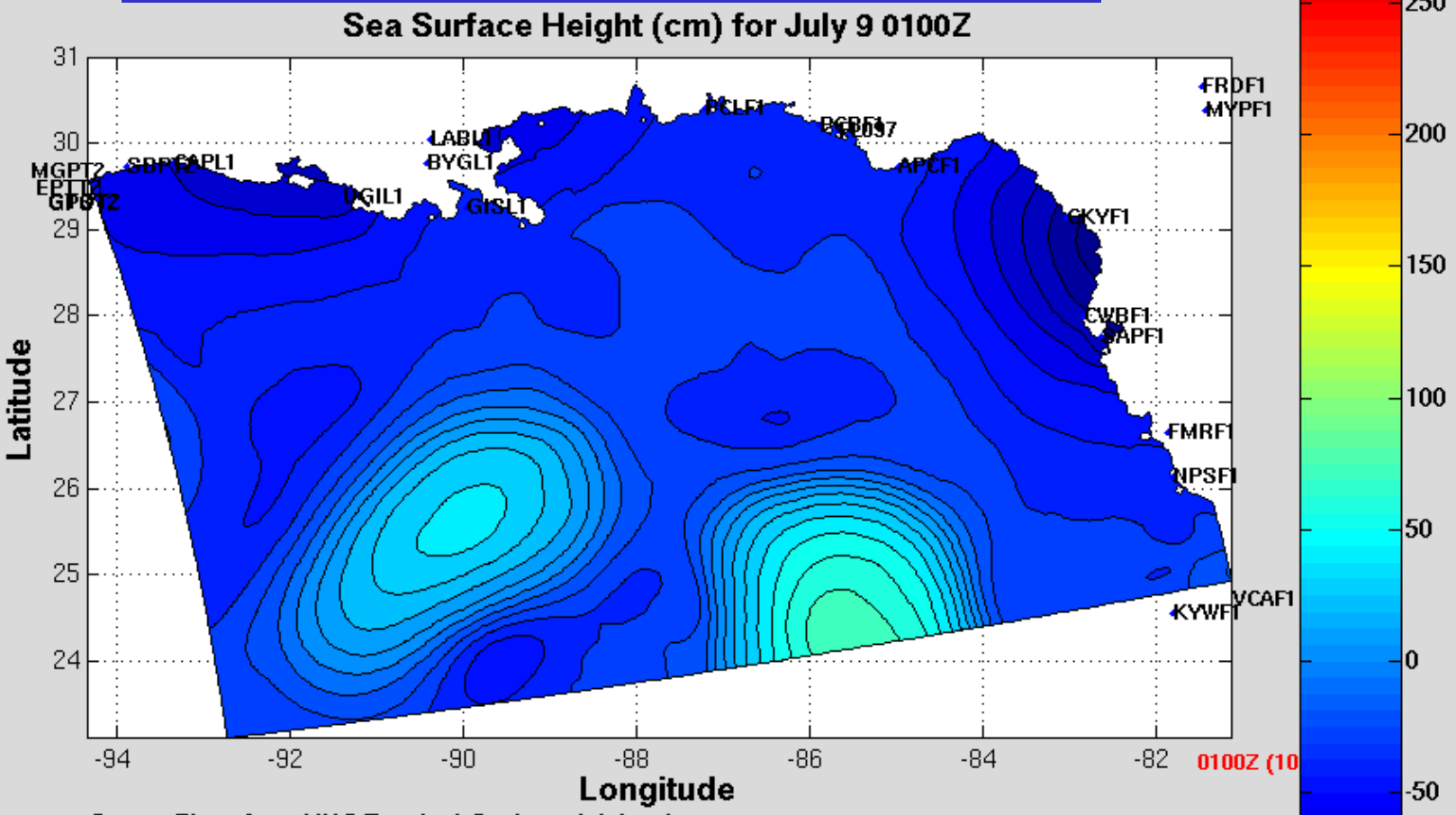
’05 Preliminary HWRF results

HWRF – ran 4X daily throughout ’05 hurricane season for all storms – system very stable and reliable

HYCOM testing/validation

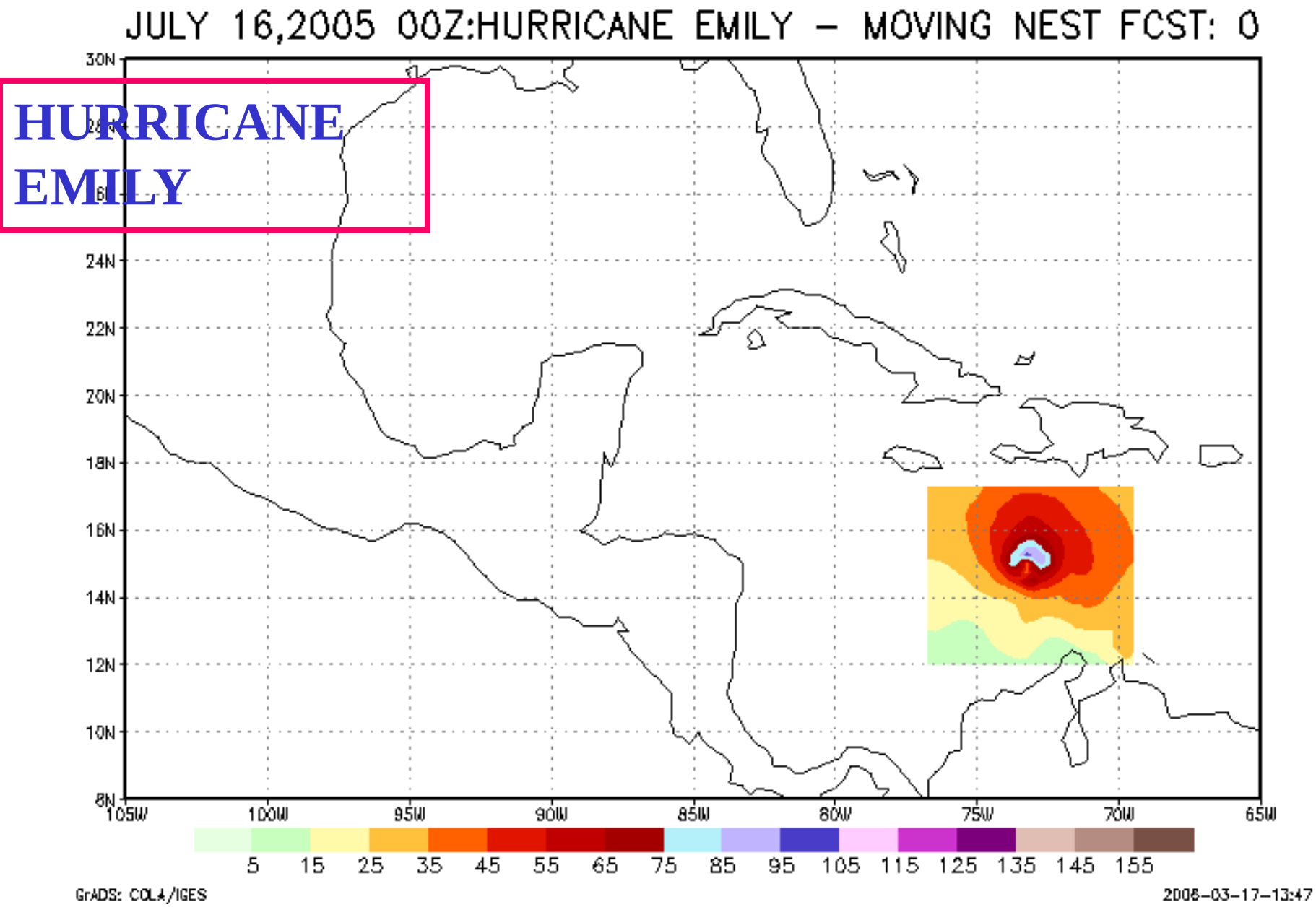

JULY 06, 2005 06Z: TS DENNIS MOVING NEST FCST: 0
HWRF
DENNIS
36N
33N
30N
27N
24N
21N
18N
15N
12N
93W
90W
87W
84W
81W
78W
75W
72W
69W
66W
63W
60W
155
145
135
125
115
105
95
85
75
65
55
45
35
25
15
5

HYCOM TESTING

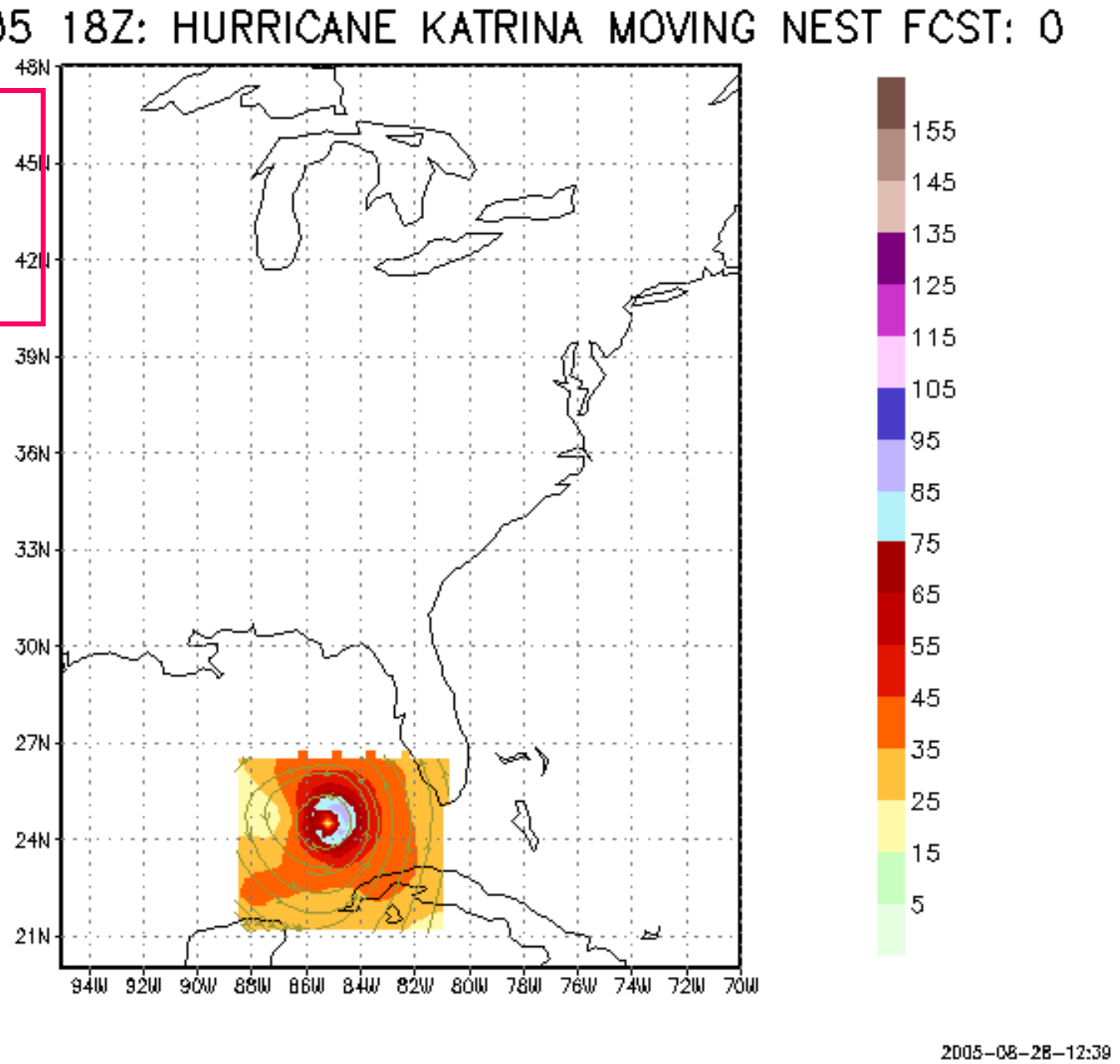


Center Fixes from NHC Tropical Cyclone Advisories

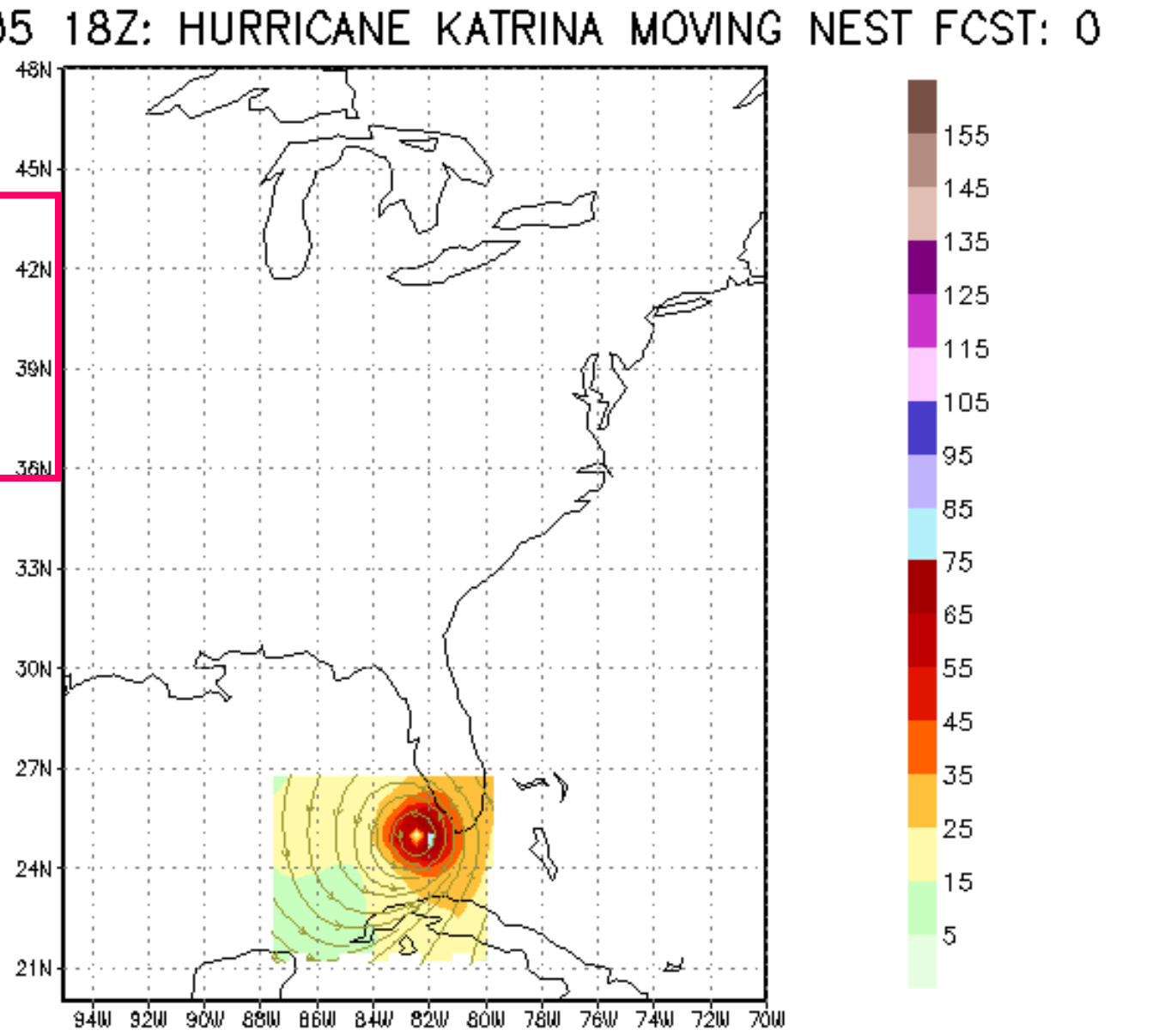
SSH Contour Intervals 10 cm

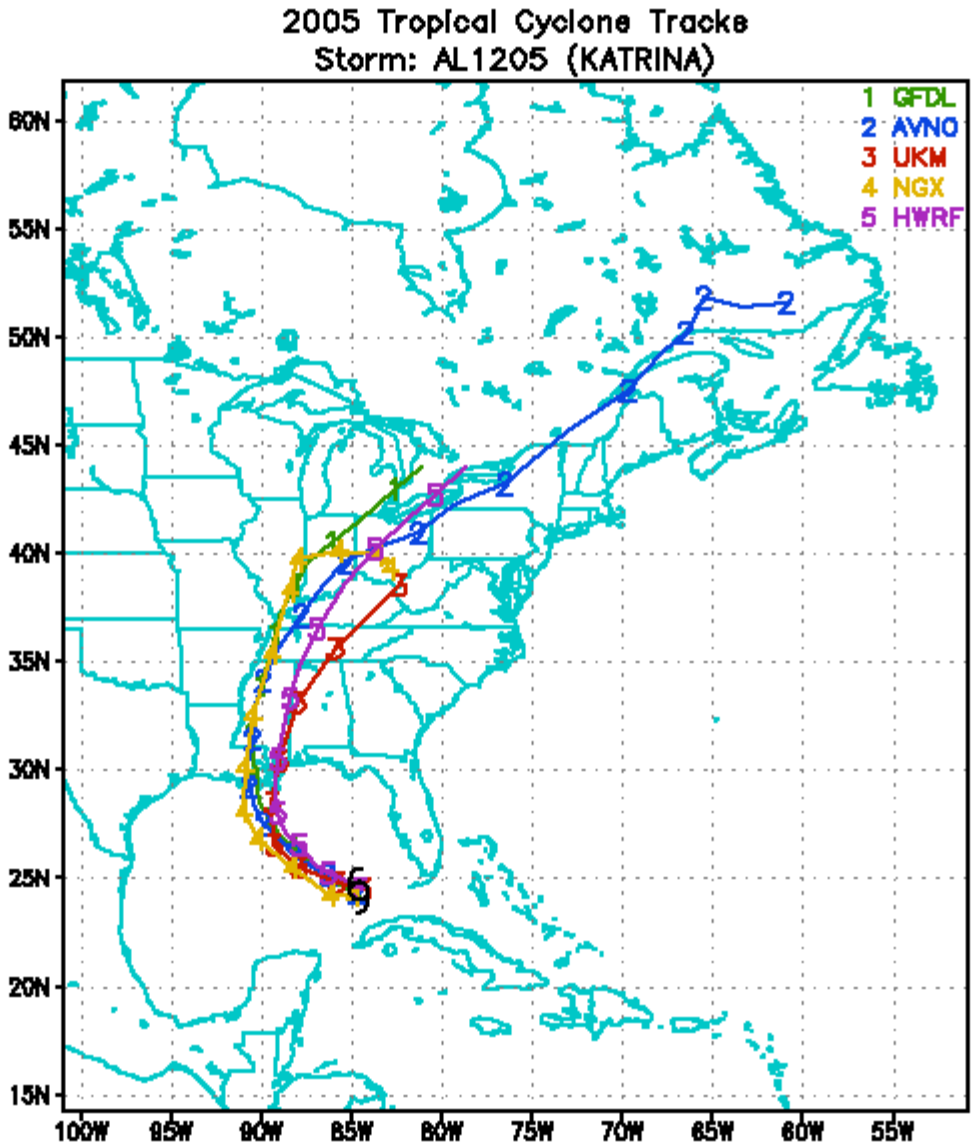

JULY 16,2005 00Z:HURRICANE EMILY – MOVING NEST FCST: 0
HURRICANE EMILY
30N
28N
26N
24N
22N
20N
18N
16N
14N
12N
10N
8N
105W
100W
95W
90W
85W
80W
75W
70W
65W
5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155
GrADS: COLA/IGES
2006-03-17-13:47

Hurricane Katrina

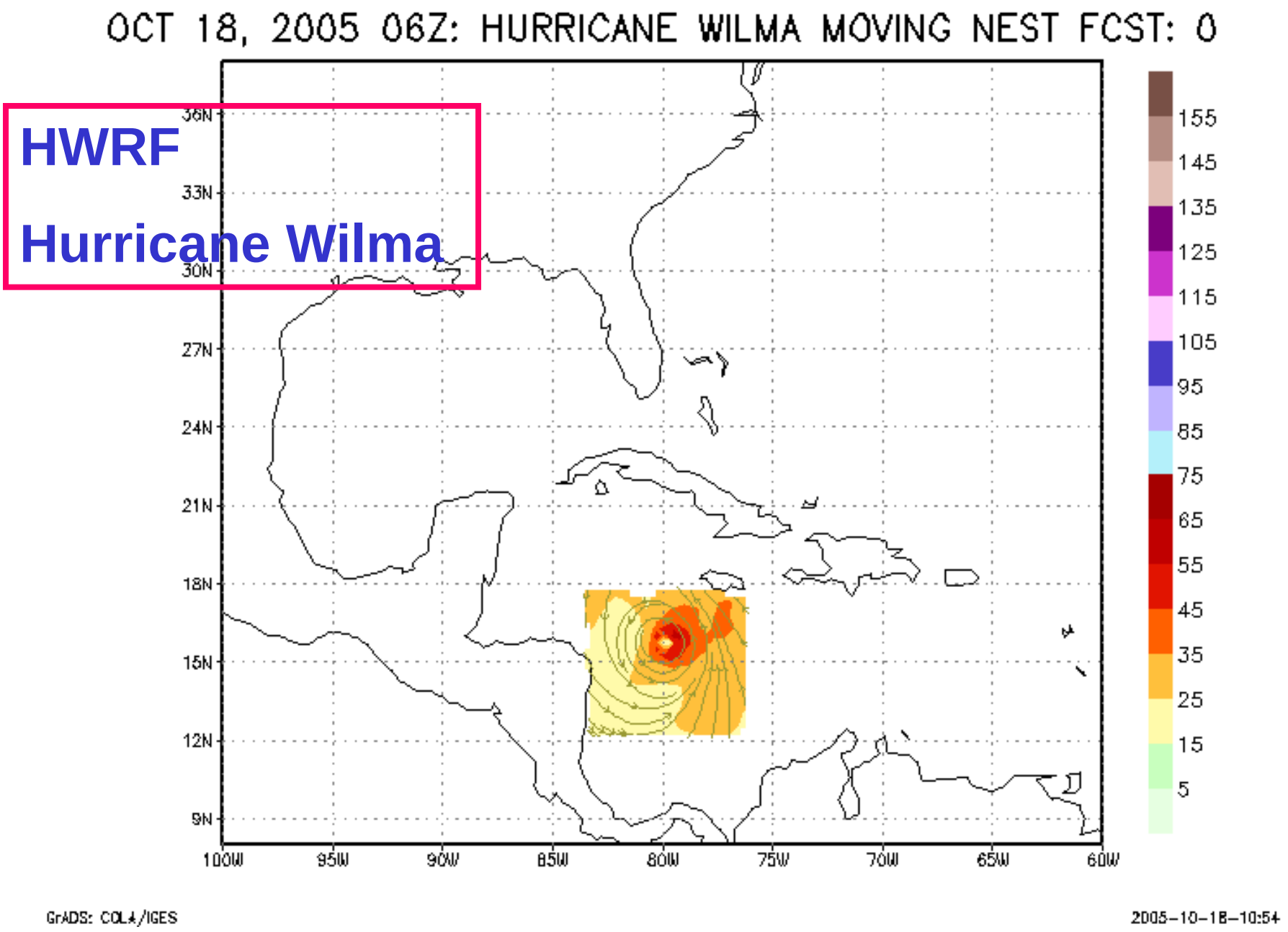


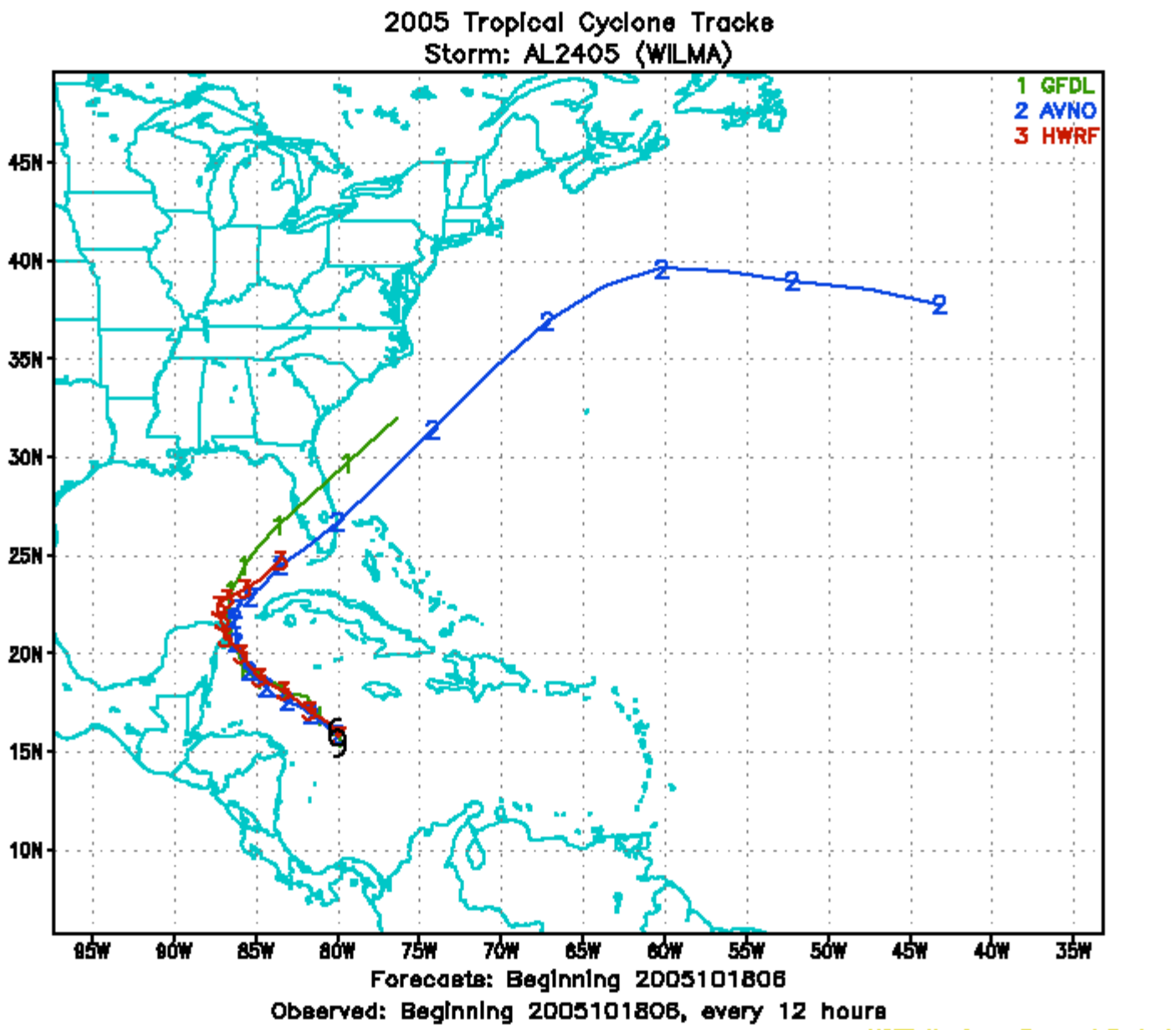
HWRF Hurricane Katrina

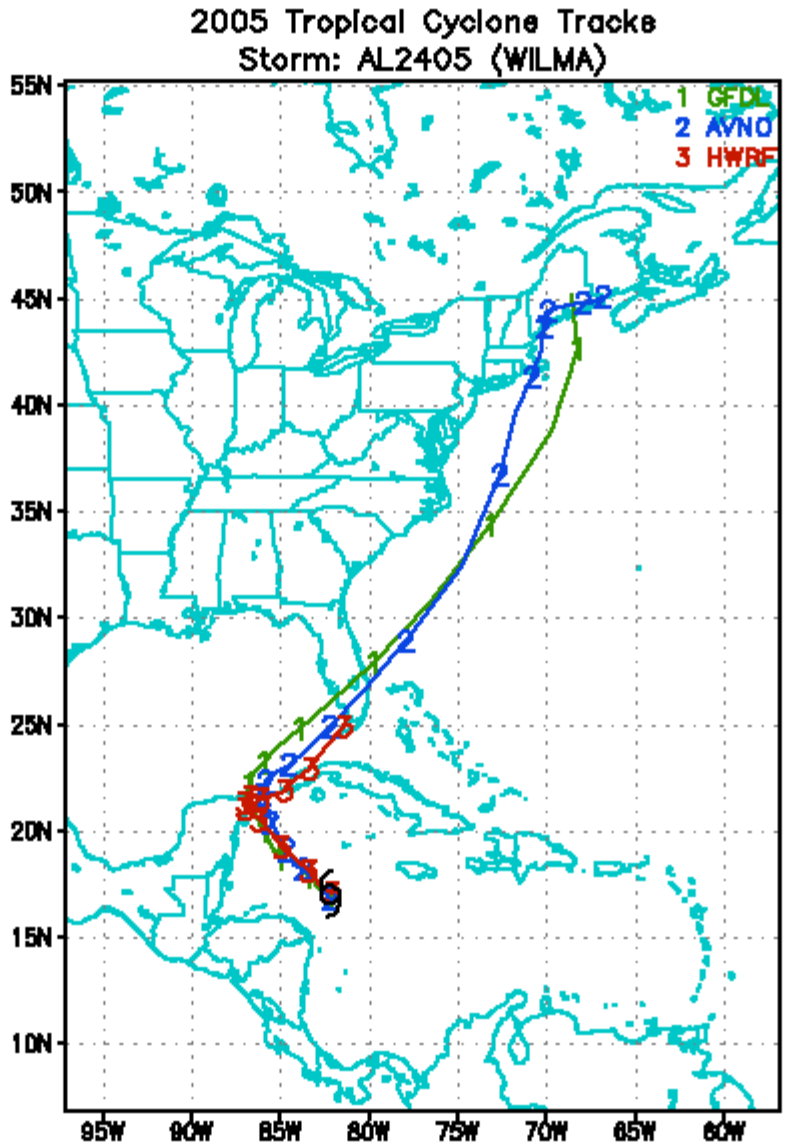




NCEP Hurricane Forecast Project


OCT 18, 2005 06Z: HURRICANE WILMA MOVING NEST FCST: 0
HWRF
Hurricane Wilma
36N
33N
30N
27N
24N
21N
18N
15N
12N
9N
100W
95W
90W
85W
80W
75W
70W
65W
60W
155
145
135
125
115
105
95
85
75
65
55
45
35
25
15
5
GrADS: COLA/IGES
2005-10-18-10:54


2005 Tropical Cyclone Tracks
Storm: AL2405 (WILMA)
1 GFDL
2 AVNO
3 HWRF
45N
40N
35N
30N
25N
20N
15N
10N
95W
90W
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
Forecasts: Beginning 2005101806
Observed: Beginning 2005101806, every 12 hours
NCEP Hurricane Forecast Project



NCEP Hurricane Forecast Project

For the ’06 hurricane season

- **Pre-op implementation testing of the HWRF**

  - Final transition of GFDL upgrades

  - Run HWRF - various configurations

  - 3-D var data assimilation of doppler winds for hurricane initialization (will require tasking of P-3’s)

Begin HWRF T&E for ’06 and previous two seasons for extensions comparisons with GFDL

NOAA Aircraft in Hurricanes

Need to develop op flight strategies for GIV and P-3's

Two mission profiles: Environment & core

Observations: Dropsonde, AXBT's, Radar

P-3 op core mission in '07; GIV op core mission '09

New NOAA paradigm: proposed NWS requirement for operational status of P-3; new mission for hurricane core winds (GIV IOC for core in '09)

P-3 will be tasked this season to provide core obs for the HWRF 3-D var. Also, AXBT deployments

HWRF and the community

- **Current release HWRF w/movable, nested grid (2-way)**
- **Updated physics**
- **Future version: coupled HWRF system to become available in autumn of ‘06**

Most important of all……

EMC and TPC thank and congratulate the GFDL group for their outstanding and pioneering contributions over this past decade towards advancing hurricanes forecasts by bringing the best of R&D hurricane modeling into operations

Bob Tuleya

Morris Bender

Tim Marchok

THANK YOU

FOR YOUR

ATTENTION…

Advancing HURRICANE WRF System

08 **09** 10 11 12

Mesoscale Data Assimilation for Hurricane Core

Implement advance (reflectivity) → **A4DDA**

rad vel DA

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.

Data Assimilation for Hurricane Vortex

1. Create 3D data sets for outer nest and inner nest, as well as the boundary conditions for the outer nest from GFS 6h forecast fields
2. Interpolate HWRF 6h forecast data onto the new HWRF grids in the overlap area to create the guess fields.
3. Separate hurricane vortex from the guess fields.
4. Correct the hurricane intensity before inserting the storm at the observed location (for both inner nest and outer nest)
5. Run GDAS for both inner nest and outer nest
6. Merge two data sets near the inner nest boundary

THE HURRICANE WRF (HWRF) PREDICTION SYSTEM

- Will replace the GFDL in 2007
- Coupled air-sea-land prediction system
- Advanced data assimilation for hurricane vortex
- Advanced physics for high resolution
- Coupling with wave model
- Land surface coupled to hydrology/inundation
- Coupling with dynamic storm surge

Development of Collaborations

- **HWRF WORKSHOP – JUNE 2002 (EMC)**

  (45 attendees – estab. hurricane community)

- **1st HWRF TUTORIAL – Oct. 2004 (EMC)**

  (26 attendees – precocious hurr. modeling types)

- **AIR-SEA WORKSHOP – MAY 2005 (EMC)**

  (35 attendees – introduction of ocean community)

- **WRF/NMM Tutorial – Sept 2005 (JMT/Boulder)**

  the beginning of "formal" training

Evaluation of HYCOM

HYCOM configured for Atlantic (same as POM)

1/6 degree; same forcing

Initialization of Gulf Stream and loop current

Ongoing verification

Experiments with Dennis, Katrina storm surge