# HURRICANE MODELING at EMC

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WHERE AMERICA'S CLIMATE AND WEATHER SERVICES BEGIN

# Overview

**Model Performance in 2004 hurricane season**

**Proposed GFDL upgrades for 2005 hurricane season**

**HWRF**

- **Implementation Strategy**
- **Development Status**
- **Time Line for transition of GFDL to HWRF**

# GFDL UPGRADES IN 2004

Evaporation of Rain in Large-Scale Condensation

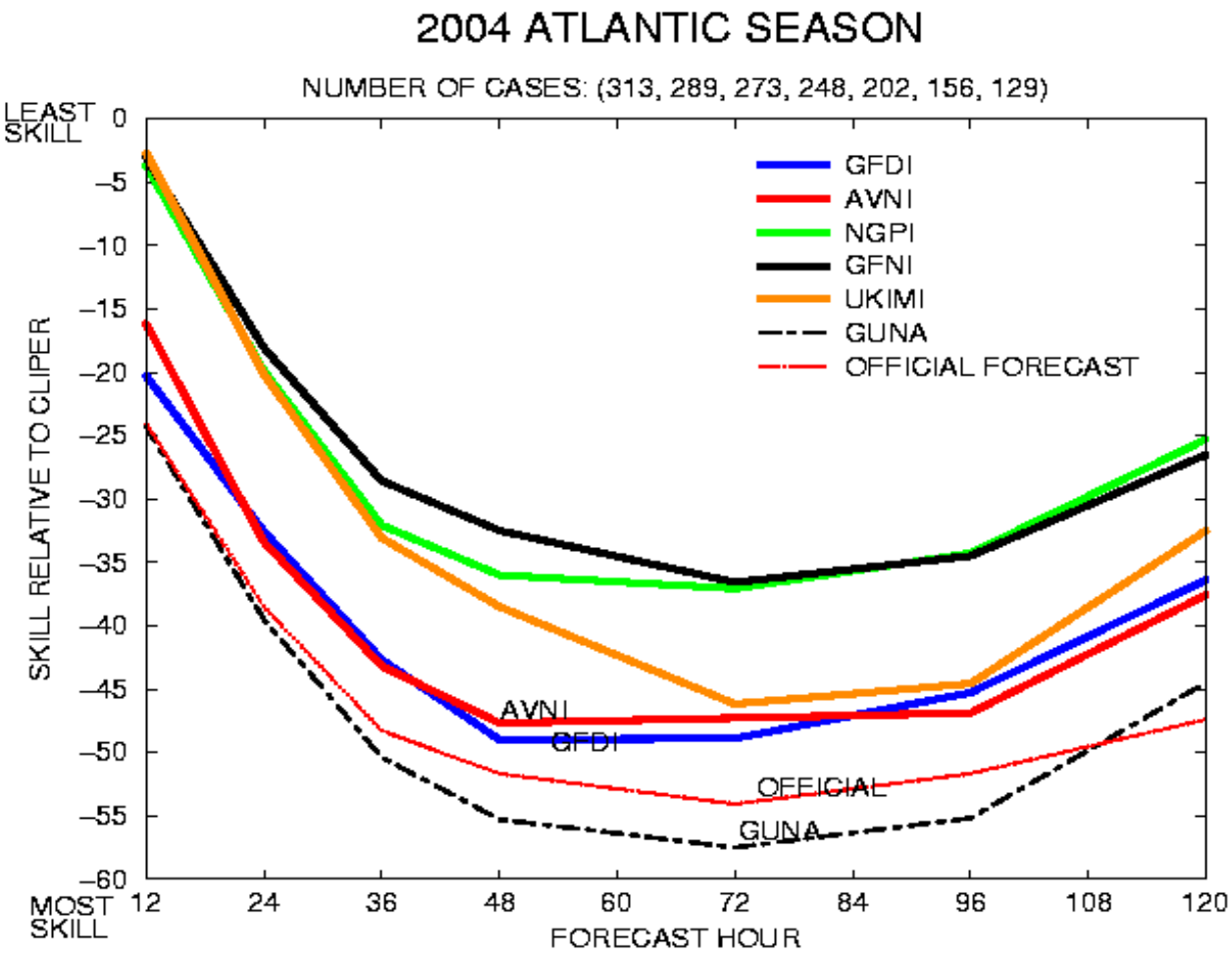
(** Implemented July 28th, 2003 **)

Reduction of Momentum Mixing in Storm Region

Reduction of Threshold for Large-Scale Condensation from 100% to 98%.

Ocean Coupling Extended to the EPAC

# Track Verifications for 2004 Season



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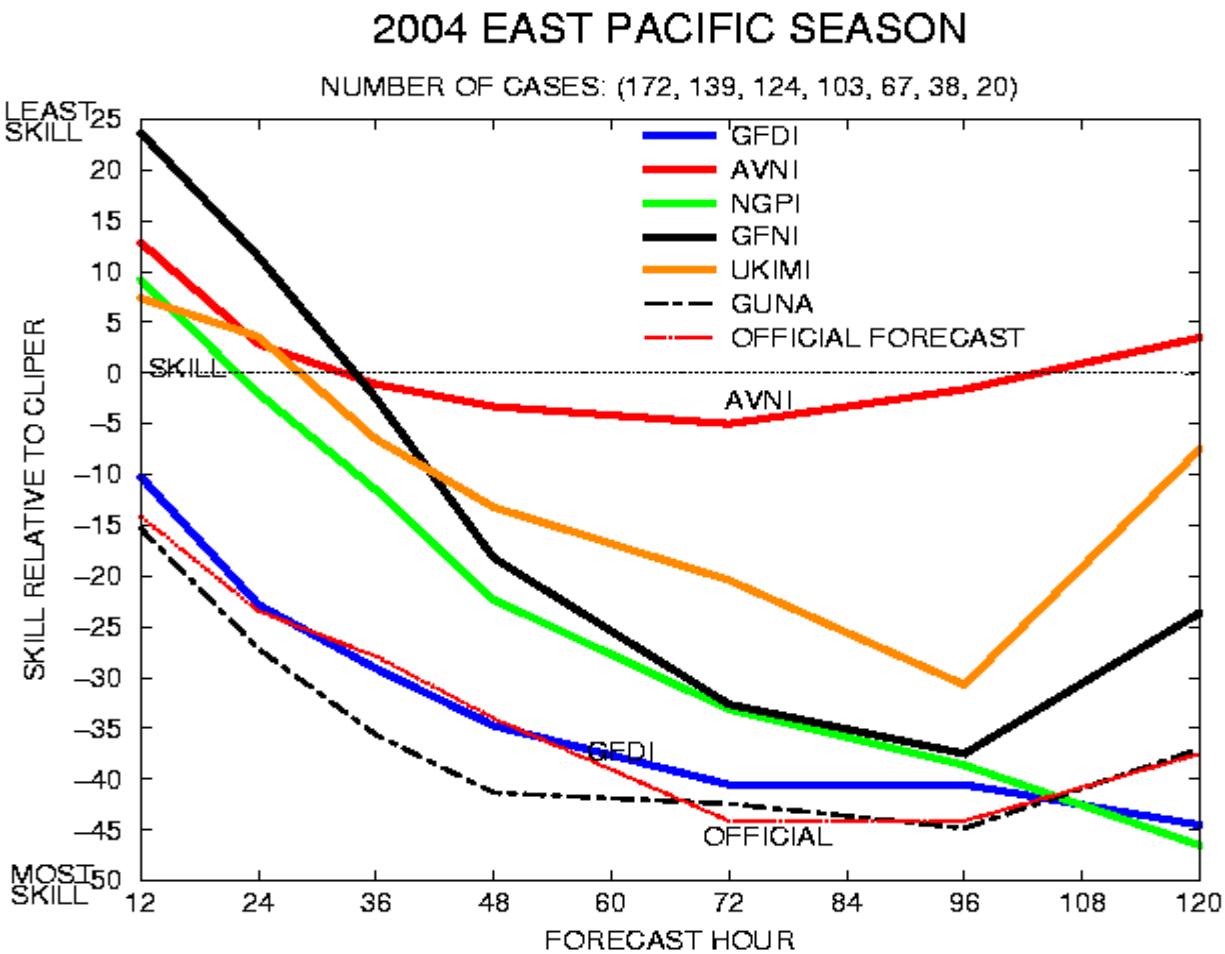
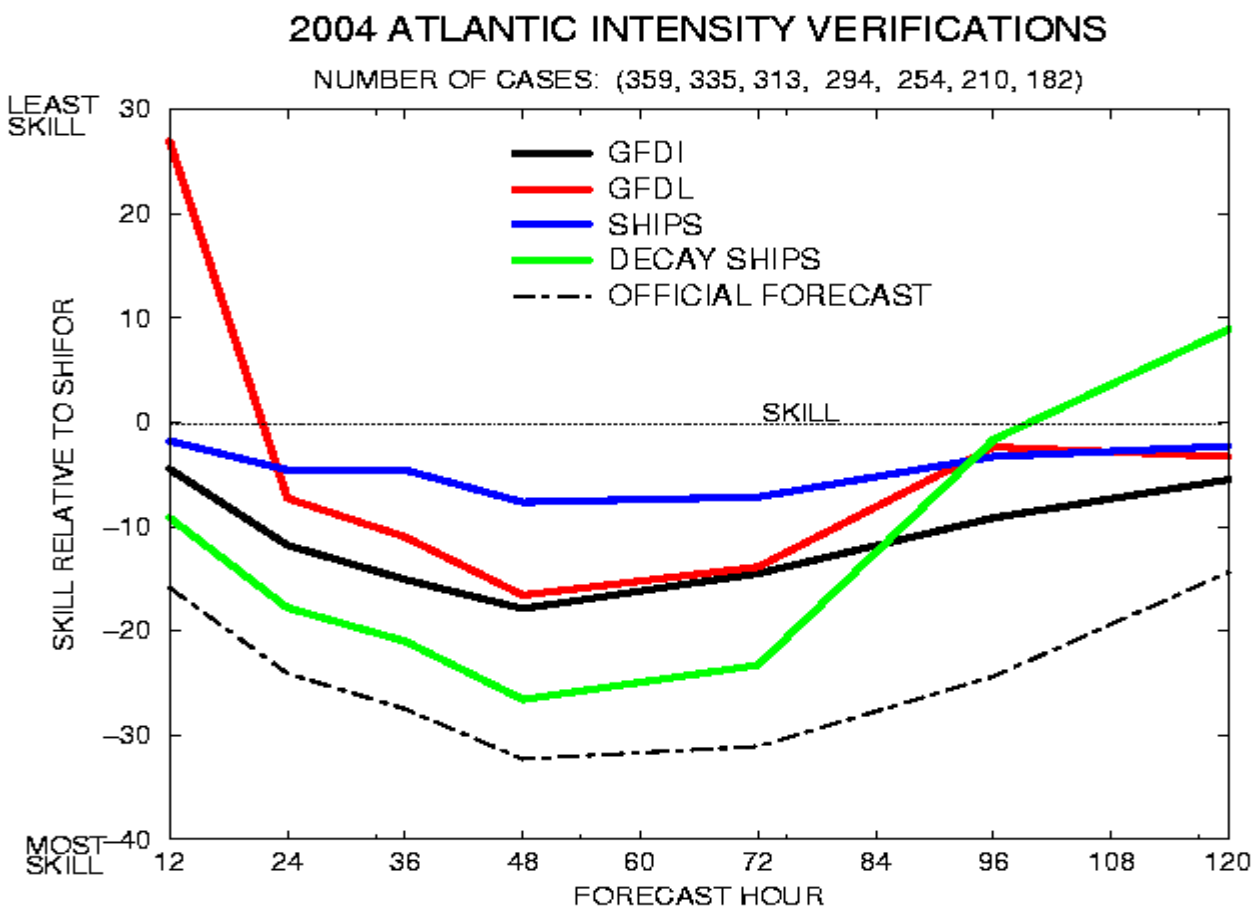
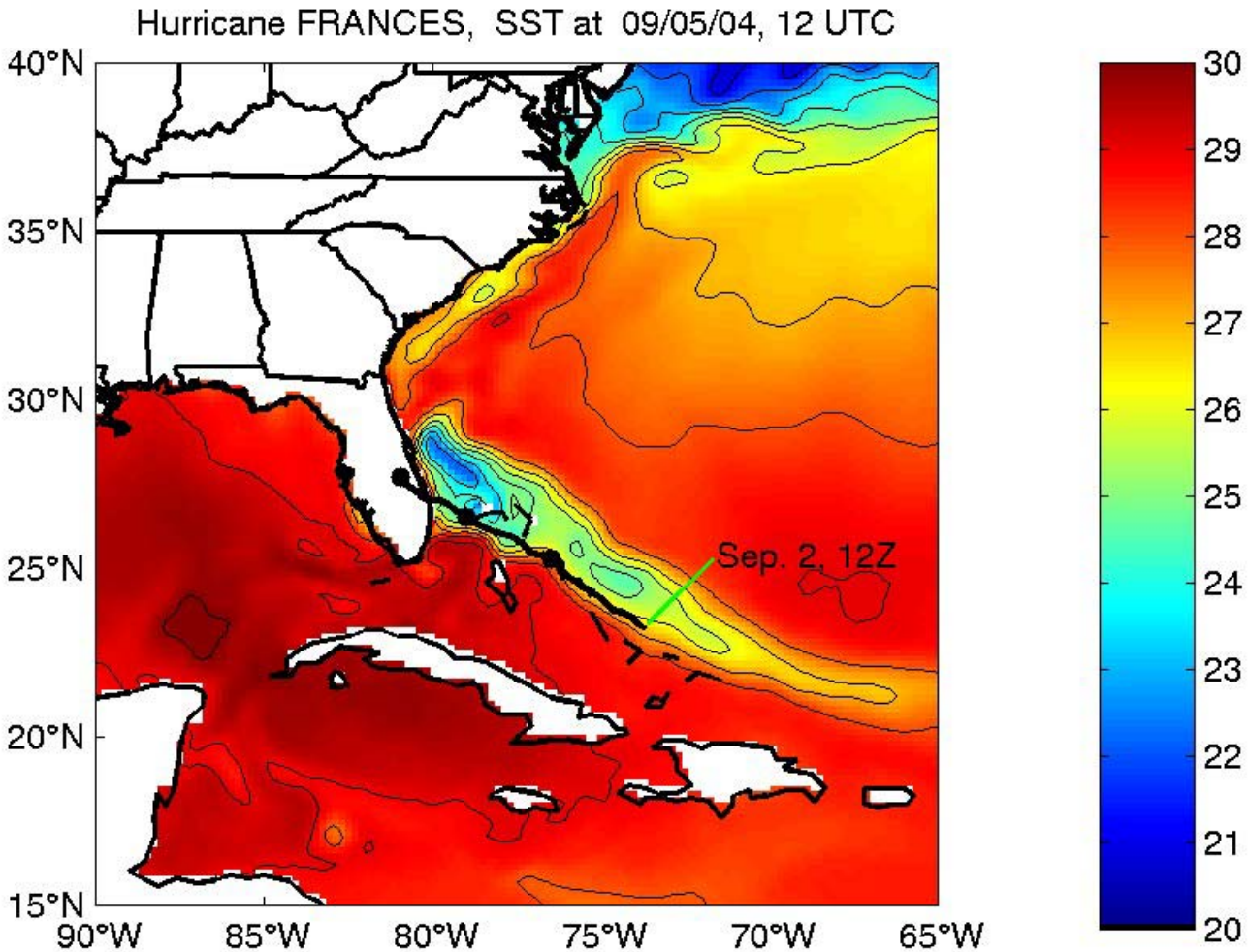


# Intensity Verifications for 2004 Season

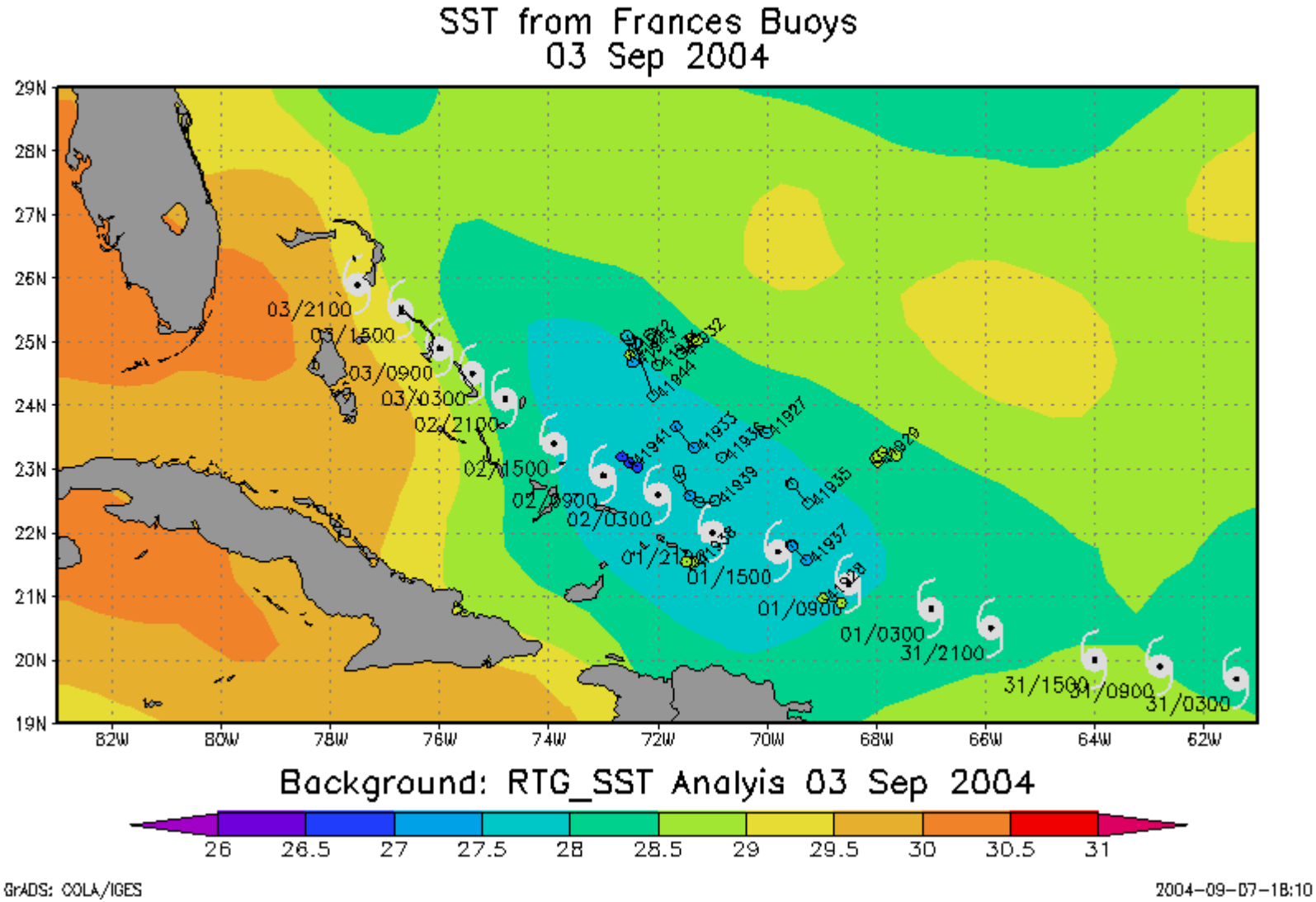


# GFDL Coupled Model
# Hurricane Frances

## Sea Surface Temperature



# C-BLAST BUOYS DURING FRANCES

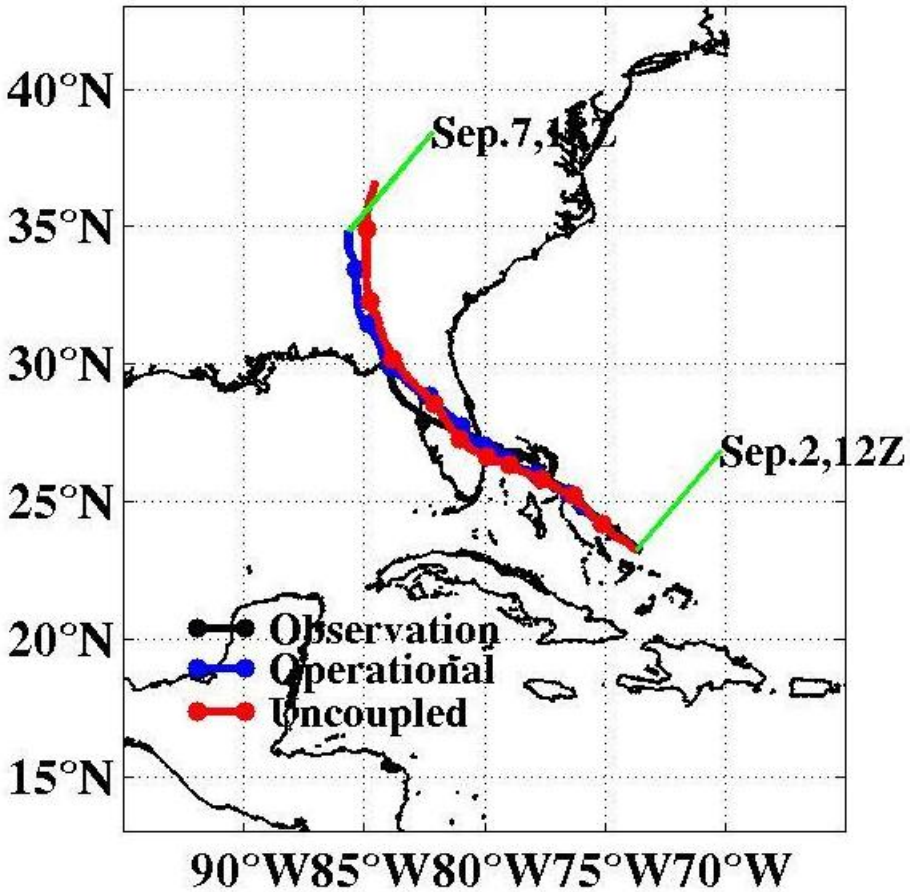


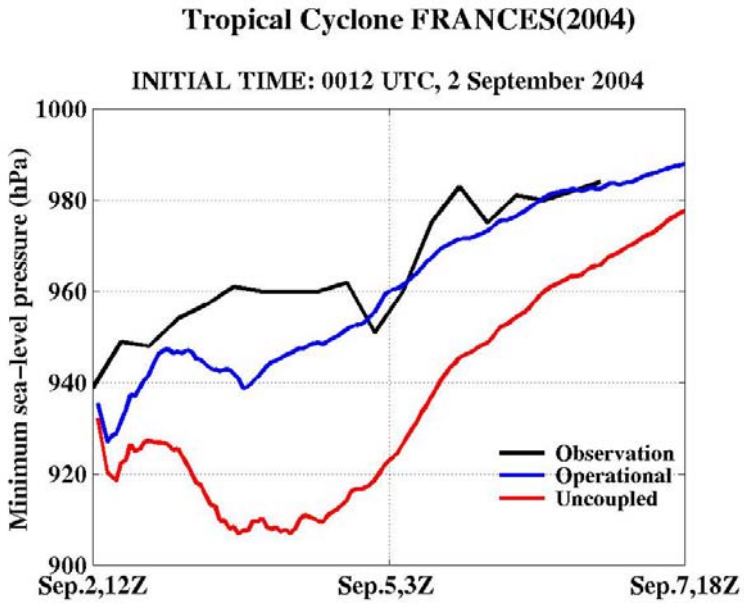
# Hurricane Frances – impact of coupling

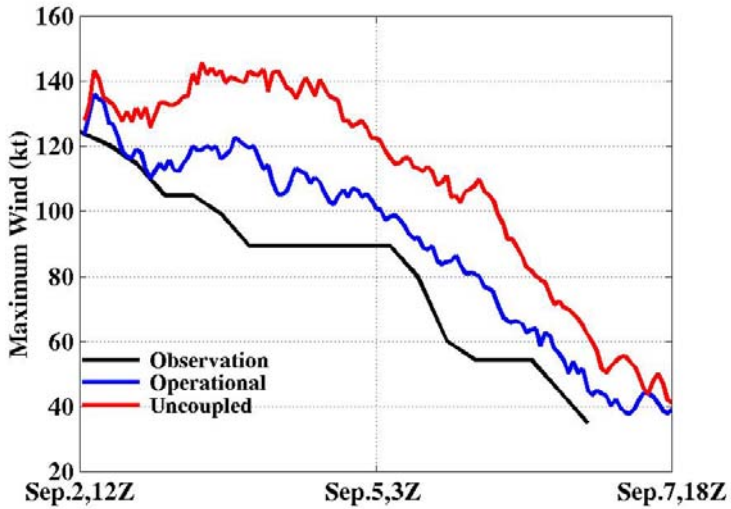
**Black – observations**

**Blue- GFDL operational coupled model**

**Red- GFDL uncoupled model**



# Potential GFDL Upgrades for 2005 Implementation

Implementation of New Vortex Initialization with Physics Consistent with 3Dimensional Model

Elimination of Mass Initialization.

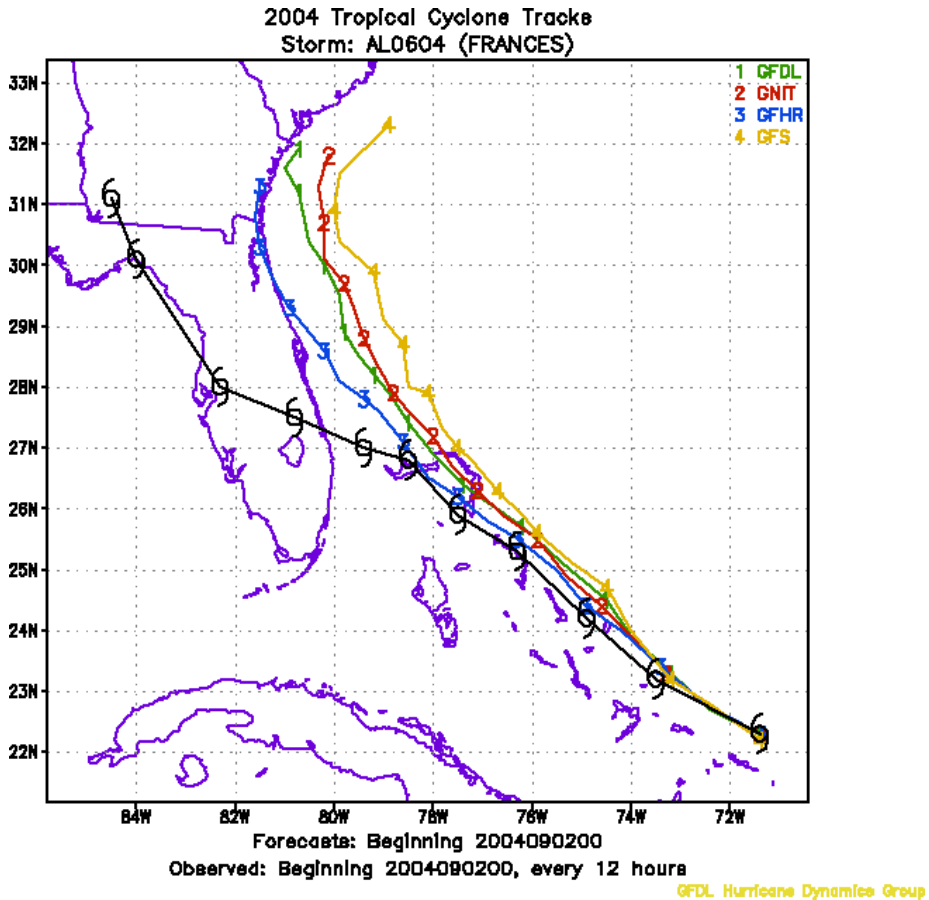
Modification of Humidity in Initialized Vortex

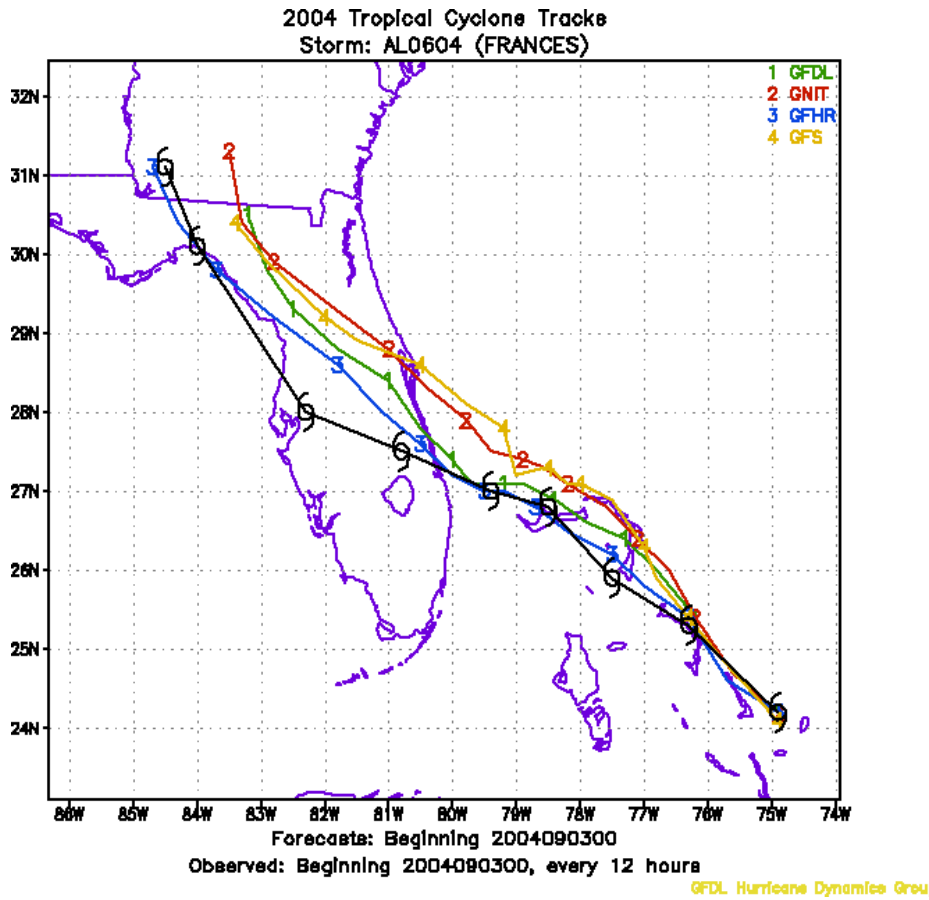
Increase resolution to 1/12 degree (inner nest)

# Hurricane Frances

**1 GFDL (Operational), 2 GNIT (New Initialization)**

**3 (GFHR) (New Initialization and High Resolution), 4 (GFS model)**

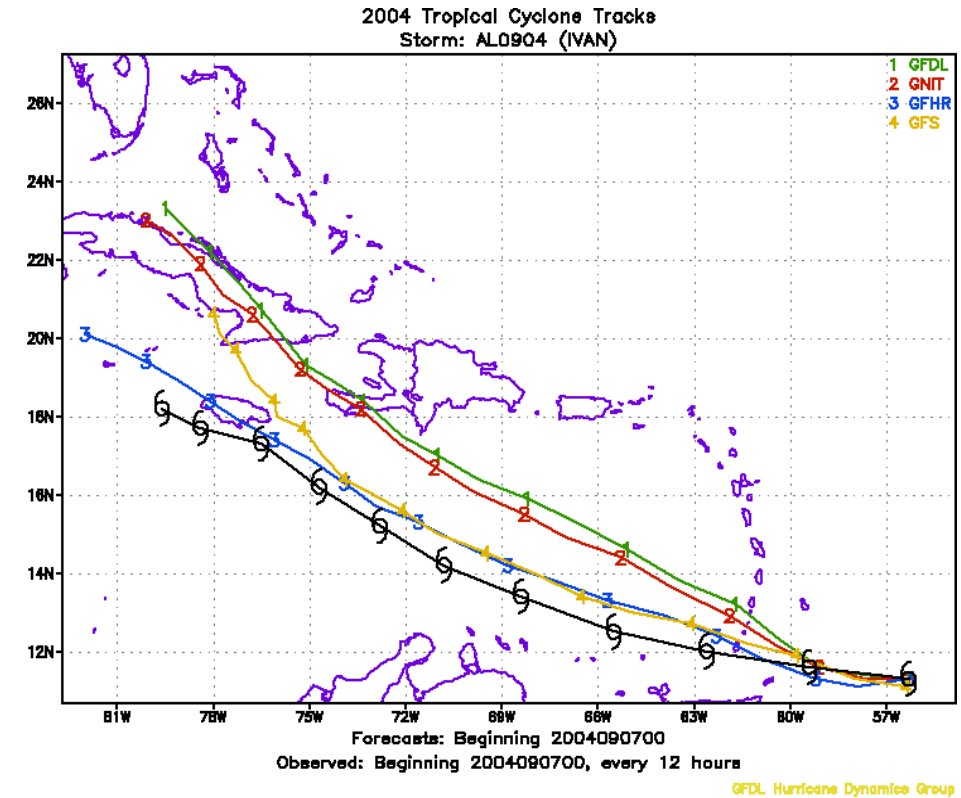


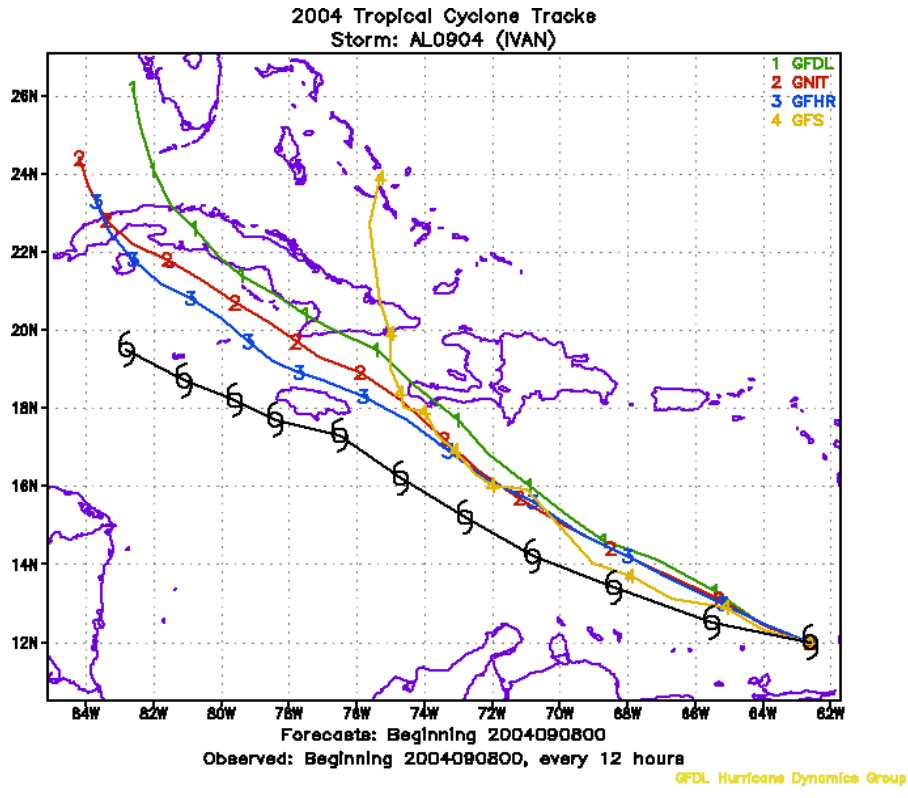



# Hurricane Ivan

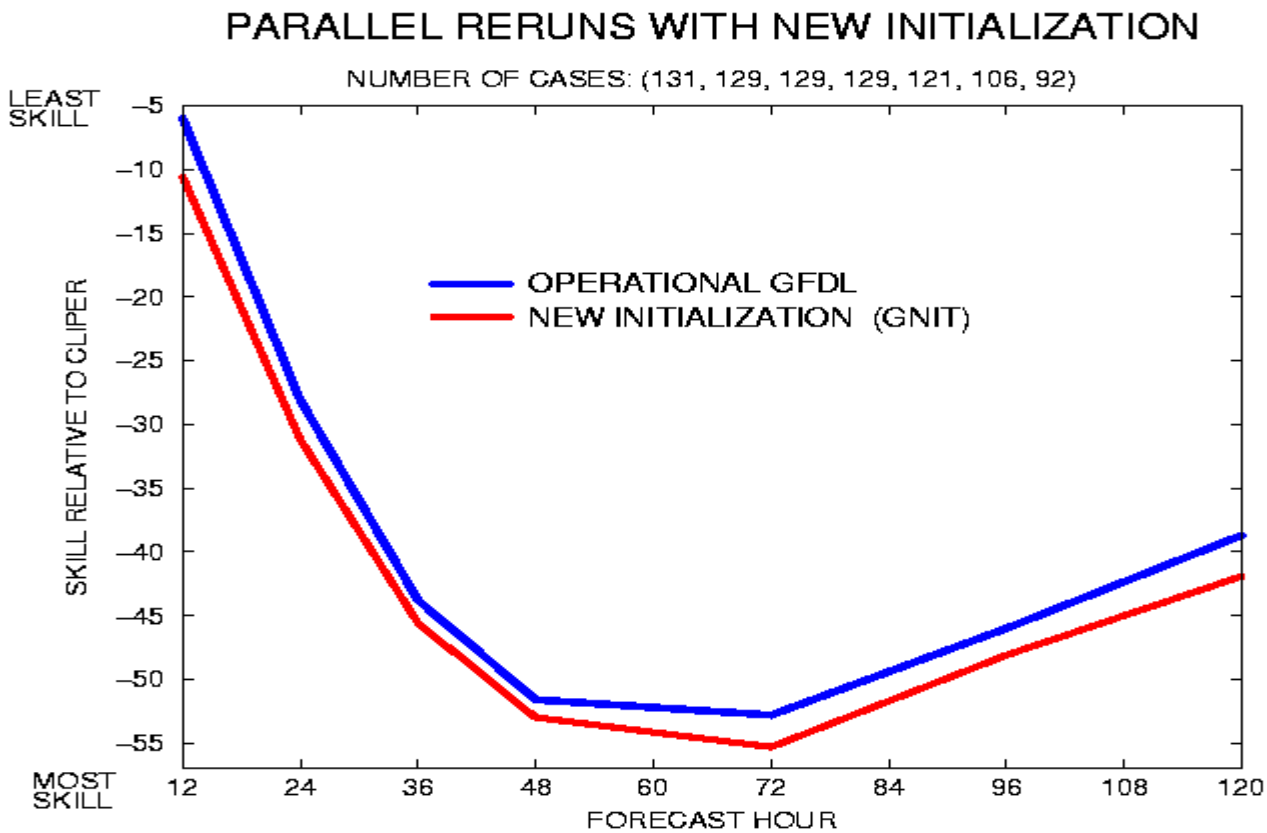
**1 GFDL (Operational), 2 GNIT (New Initialization)**

**3 (GFHR) (New Initialization and High Resolution), 4 (GFS model)**

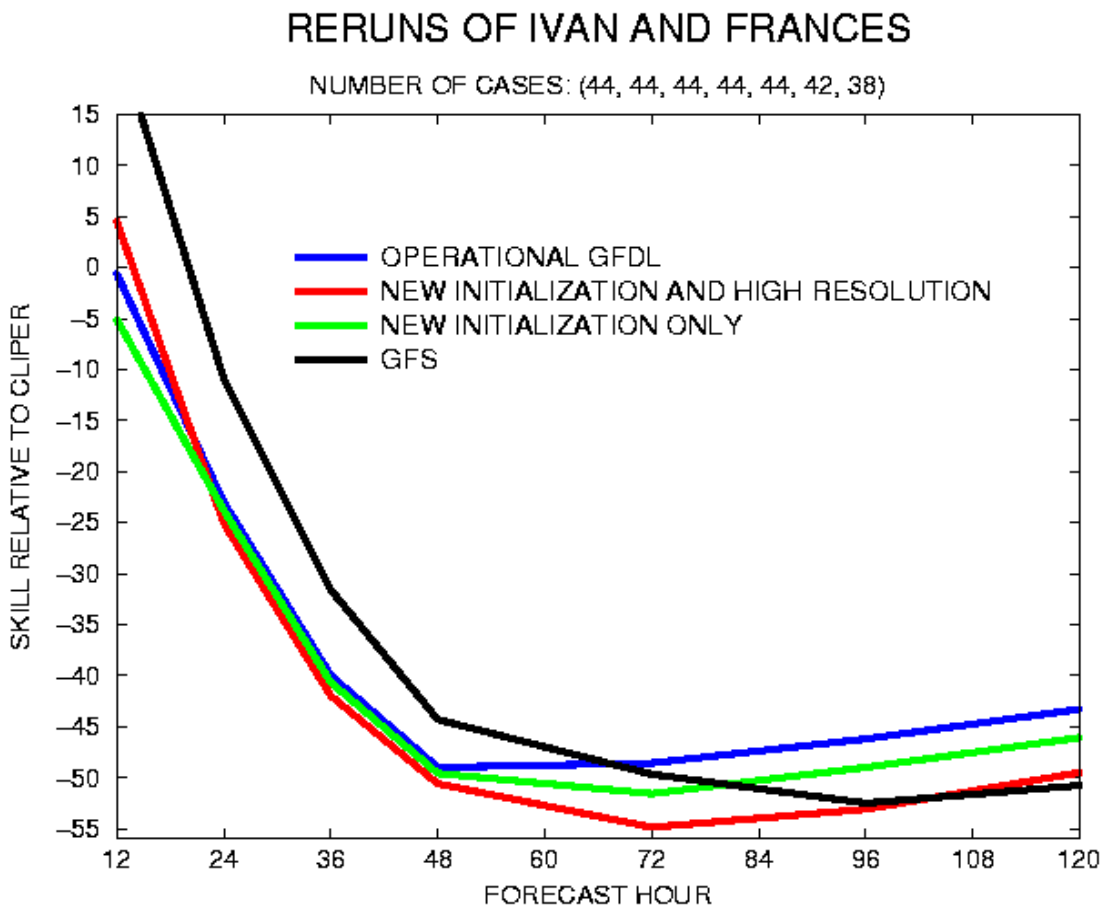


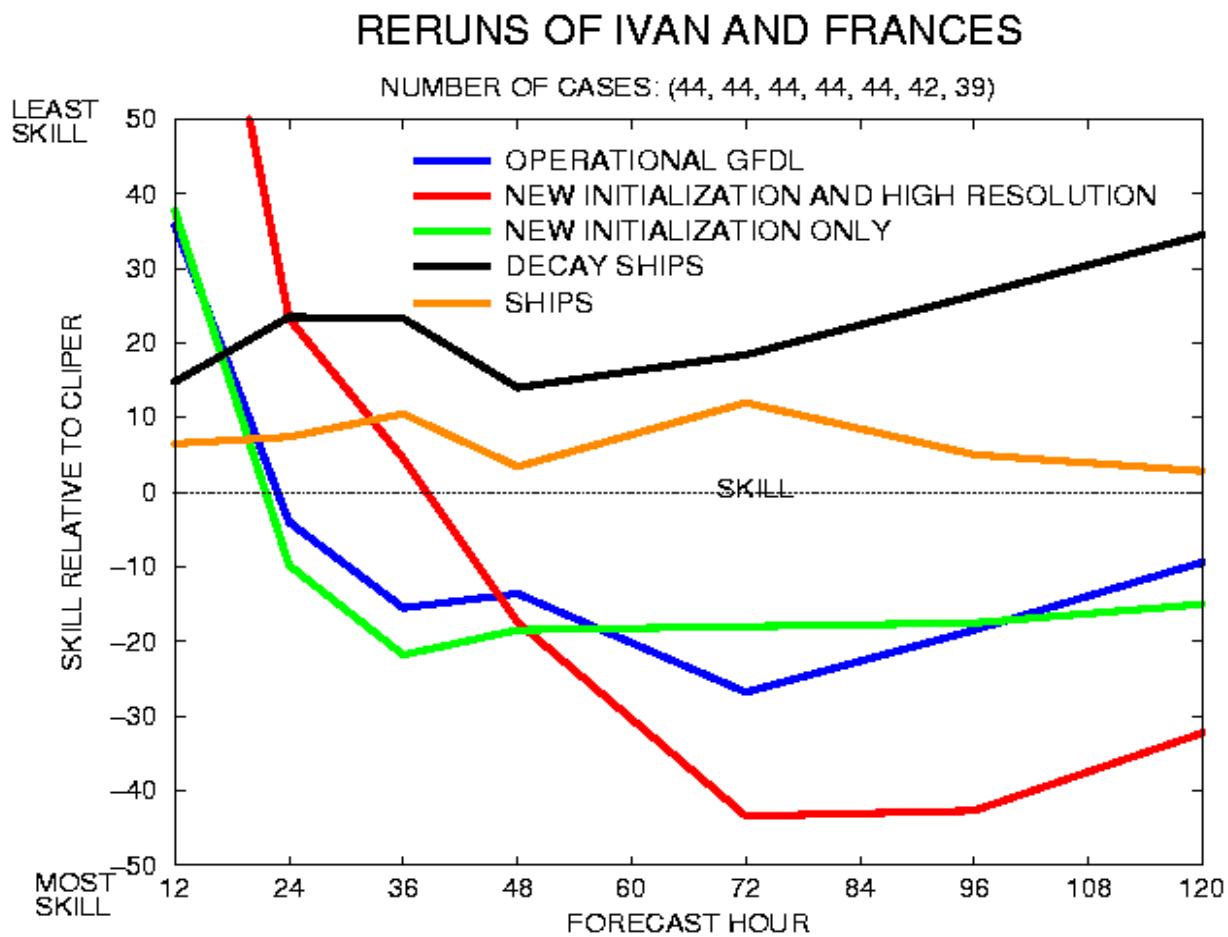
# TRACK VERIFICATIONS WITH NEW INITIALIZATION ONLY



# TRACK VERIFICATIONS WITH ALL 2005 CHANGES



# INTENSITY VERIFICATIONS WITH ALL 2005 CHANGES



# Continuation of GFDL Model Upgrades

**Development of high-resolution GFDL model with Ferrier Bulk Microphysics**

**Development of GFDL Coupled System with NOAH Land Model**

**Improved Vortex initialization**

**Improved air-sea physics**

# 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**

**MM5** → **Transition to HWRF** → **HWRF Operational**

**HWRF** Begin R&D — Prelim. Test HWRF physics → **HWRF T&E**

# THE HURRICANE WRF (HWRF)

# PREDICTION SYSTEM

Community based next generation hurricane prediction system

Will replace the GFDL in 2007

Coupled air-sea-land prediction system

Advanced data assimilation for hurricane vortex

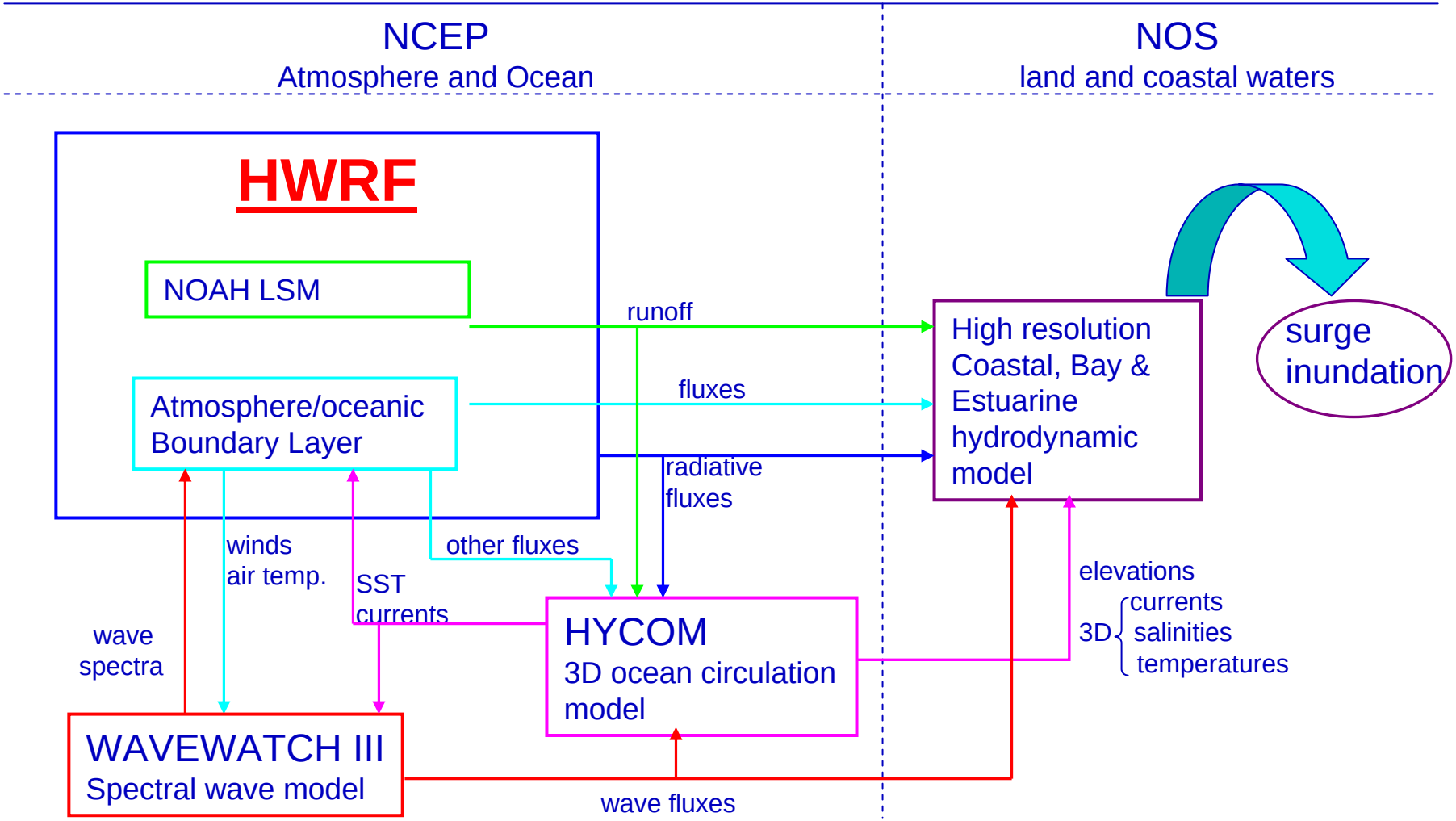
Advanced physics for high resolution

Land surface coupled to hydrology/inundation

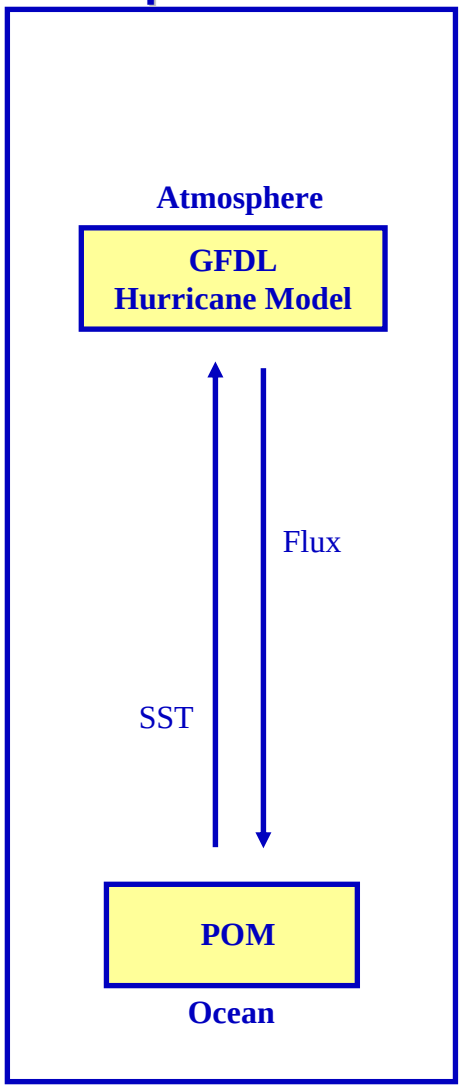
Nested wave prediction

Coupling to dynamic storm surge

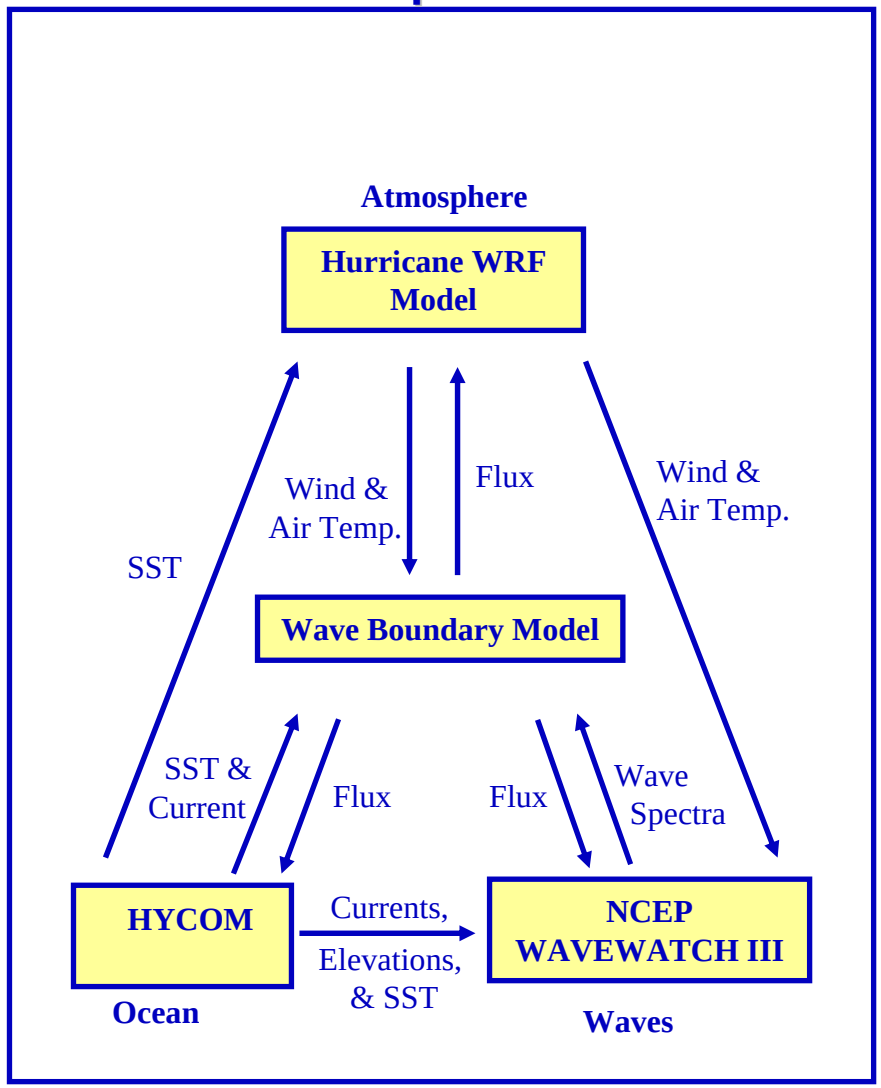
# Hurricane-Wave-Ocean-Surge-Inundation Coupled Models



## Operational GFDL/URI Coupled Model




## Future Hurricane-Wave-Ocean Coupled Model



# Pre-Implementation Strategy for HWRF

- ✓ **INCREASE RESOLUTION**
- ✓ **UPGRADE GFDL PHYSICS WITH GFS PHYSICS**

  **IMPLEMENT MICROPHYSICS, SFC. PHYSICS**
- ✓ **PUT PHYSICS IN WRF FRAMEWORK**
- ➢ **MIGRATE ALL PHYSICS TO NMM, E.G. HWRF**

  **CARRY OUT T&E ON UPGRADED GFDL SYSTEM (GFDL FROZEN '05-06)**

  **PERFORM EXTENSIVE COMPARISONS BETWEEN GFDL AND HWRF FOR MULTIPLE SEASONS AND STORMS**

# DEVELOPMENT OF THE HWRF SYSTEM

- ✓Movable, nested grid (configuration, domain)
- ✓Initialization (development of DA for hurricane vortex) (LONG TERM EFFORT)
- ✓Coupling to HYCOM
- ✓Coupling to WAVEWATCH III (+ multi-
- ✓Coupling to LSM
- ✓Development/Upgrade of hurricane verification system (PPT, STRUCTURE)
- Development of forecast guidance products
- Coupling to storm surge-wave coupled model (planning stage)
- HWRF ensembles????

# HWRF nesting

**Development of a basic nesting paradigm for the E-grid NMM core**

**Development of code related to interpolation schemes within the WRF frame-work**

**Development of initial and boundary conditions for one way interaction**

**Simple testing of the one way interaction within the WRF framework (gravity wave test)**

**Inclusion of terrain effects within one way nest**

# Nesting - continuation

**Further testing of one way nesting**

**Development of the two way interactive system within NMM-WRF framework**

**Testing of idealized and real hurricane cases**

**Development of movable nest**

# 2004 preliminary HWRF forecasts

Ran at least one storm per day (00utc)

120 uniform resolution cases

~20km resolution with 42 GFDL levels

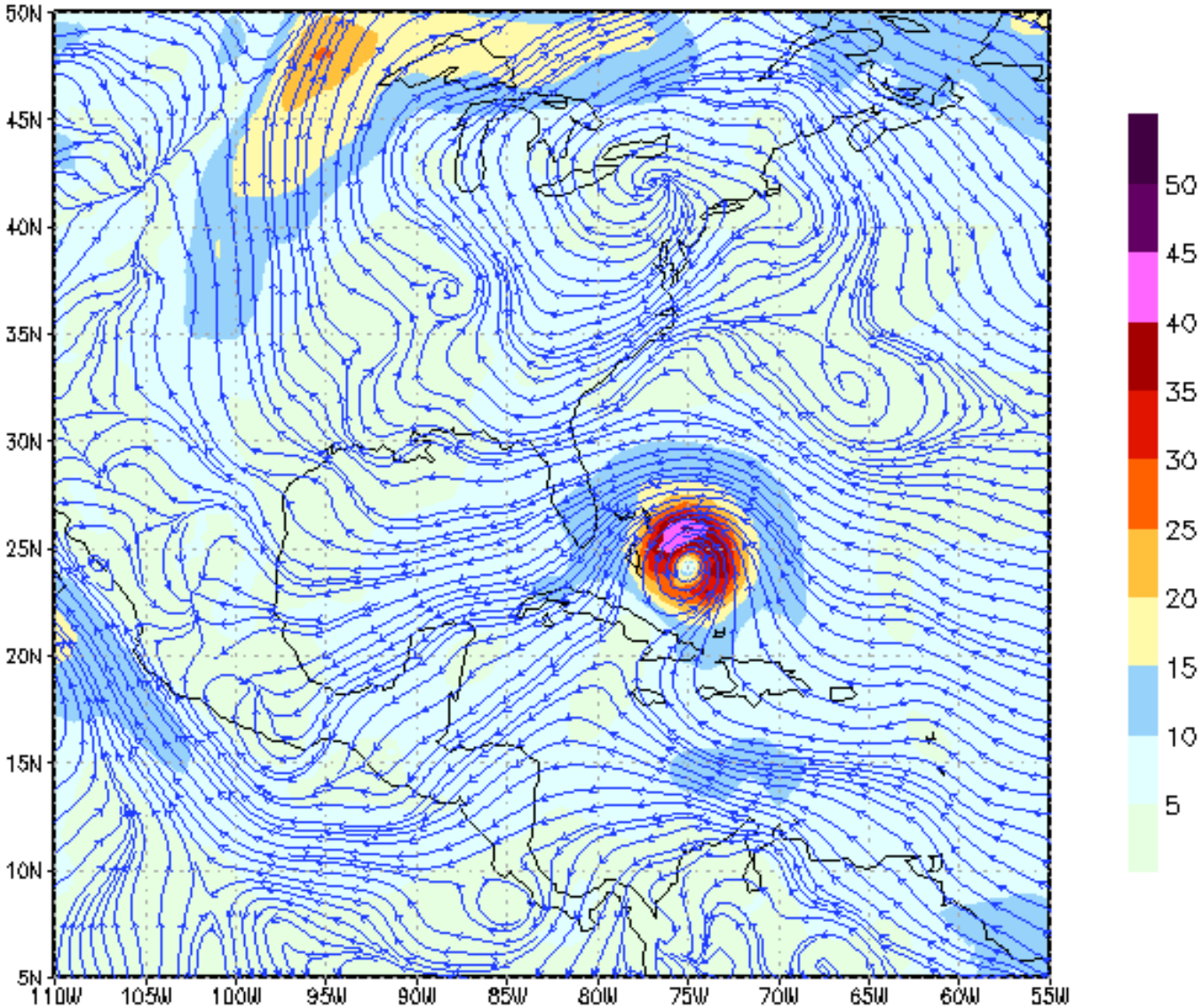
System found to be quite robust with few if any non-user failures

Started with eta-physics, GFS initial condition

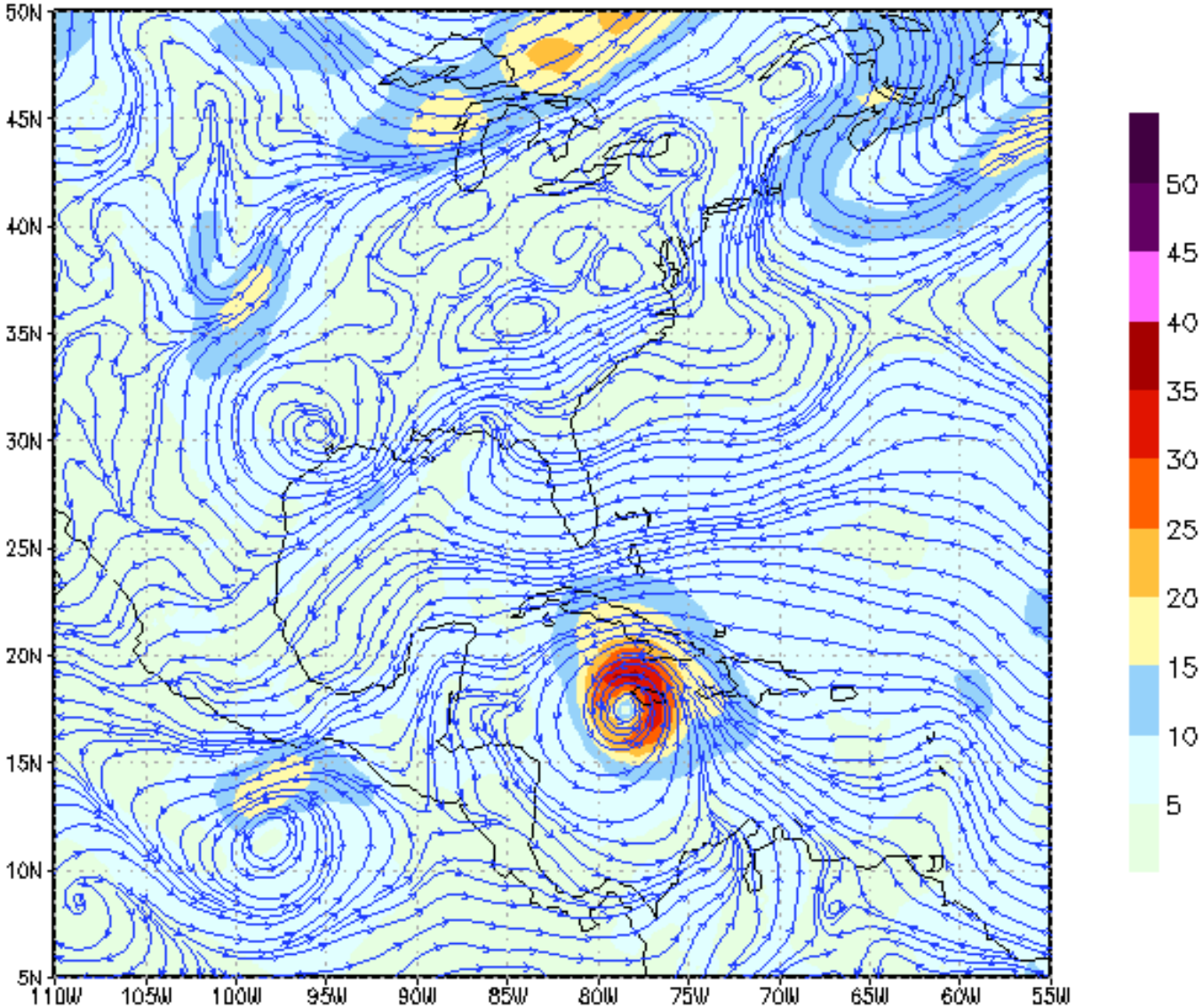
Developed HWRF prototype system

Can now run from GFDL IC

# HWRF: HURRICANE FRANCES 03 SEP 2004, 00Z FORECAST



# HWRF: HURRICANE IVAN 03 SEP 2004, 00Z FORECAST



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**HWRF TUTORIAL – 26-27 OCTOBER 2004**

**HOSTED BY EMC**

**TARGETING PRELIM GROUP FOR USE OF HWRF**

**25 ATTENDEES**

- **NASA/GSFC**
- **NRL**
- **UNIVERISTY OF MARYLAND**
- **FLORIDA STATE**
- **COLORADO STATE**
- **UNIVERSITY OF MIAMI**
- **UNIVERISTY OF RHODE ISLAND**
- **NOAA/NESDIS**

# OTHER HURRICANE ACTIVITIES….

**ENSEMBLE RELOCATION**

**GENESIS DOCUMENTATION**

# SUMMARY

**WE'RE MAKING GOOD PROGRESS**

**LOTS OF WORK TO BE DONE**

**LOTS OF TESTING TO DO**

**LOTS OF STORMS FROM PAST HURRICANE SEASON TO DO THE T&E……**

**BUT ALL HWRF DEVELOPMENT IS RESOURCE DEPENDENT…….**