HURRICANE MODELING
at EMC

N. Surgi, R. Tuleya, Qingfu-Liu, S. Gopalkrishnan,
W. Shen, D. Jovic, A. Falkovich
M. Bender, T. Marchok (GFDL)
I. Ginis, Biju Thomas (URI)

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
GFDD UPDATES 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

2004 ATLANTIC SEASON

NUMBER OF CASES: (313, 289, 273, 248, 202, 156, 129)

- GFDI
- AVNI
- NGPI
- GFNI
- UKIMI
- GUNA
- OFFICIAL FORECAST
Track Verifications for 2004 Season

2004 EAST PACIFIC SEASON

NUMBER OF CASES: (172, 139, 124, 103, 67, 38, 20)

FORECAST HOUR

SKILL

SKILL RELATIVE TO COMPILED

LEAST SKILL

GFDI
AVNI
NGPI
GFNI
UKIMI
GUNA
OFFICIAL FORECAST

MOST SKILL

12 24 36 48 60 72 84 96 108 120
Intensity Verifications for 2004 Season

2004 ATLANTIC INTENSITY VERIFICATIONS
NUMBER OF CASES: (359, 335, 313, 294, 254, 210, 182)

- GFDI
- GFDL
- SHIPS
- DECAY SHIPS
- OFFICIAL FORECAST
GFDL Coupled Model
Hurricane Frances
Sea Surface Temperature
C-BLAST BUOYS DURING FRANCES

SST from Frances Buoys
03 Sep 2004

Background: RTG_SST Analysis 03 Sep 2004

2004-09-07 18:10

GrADS: COLA/IGES
Hurricane Frances – impact of coupling

Black – observations
Blue- GFDL operational coupled model
Red- GFDL uncoupled model

Tropical Cyclone FRANCES(2004)
INITIAL TIME: 0012 UTC, 2 September 2004

Minimum sea-level pressure (hPa)
- Observation
- Operational
- Uncoupled

Maximum Wind (kt)
- Observation
- Operational
- Uncoupled
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

PARALLEL RERUNS WITH NEW INITIALIZATION

NUMBER OF CASES: (131, 129, 129, 129, 121, 106, 92)

LEAST SKILL
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55

MOST SKILL
12 24 36 48 60 72 84 96 108 120

FORECAST HOUR

SKILL RELATIVE TO CLIPER

OPERATIONAL GFDL
NEW INITIALIZATION (GNIT)
TRACK VERIFICATIONS WITH ALL 2005 CHANGES

RERUNS OF IVAN AND FRANCES

NUMBER OF CASES: (44, 44, 44, 44, 44, 44, 38)

SKILL RELATIVE TO CLIPER

FORECAST HOUR

-55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15

OPERATIONAL GFDL
NEW INITIALIZATION AND HIGH RESOLUTION
NEW INITIALIZATION ONLY
GFS
INTENSITY VERIFICATIONS WITH ALL 2005 CHANGES

RERUNS OF IVAN AND FRANCES

NUMBER OF CASES: (44, 44, 44, 44, 44, 42, 39)

- Blue: Operational GFDL
- Red: New initialization and high resolution
- Green: New initialization only
- Black: Decay ships
- Orange: Ships
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
TRANSMITIONG 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 Begin R&D

Prelim. Test HWRF physics

HWRF T&E

HWRF Operational
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

NCEP
Atmosphere and Ocean

NOS
land and coastal waters

HWRF
NOAH LSM
Atmosphere/oceanic Boundary Layer

HYCOM
3D ocean circulation model

WAVEWATCH III
Spectral wave model

runoff
radiative fluxes

3D ocean circulation model

High resolution Coastal, Bay & Estuarine hydrodynamic model

surge inundation

elevations
currents
salinities

3D salinities temperatures

winds
air temp.
SST currents
wave spectra
other fluxes
Operational GFDL/URI Coupled Model

- Atmosphere
  - GFDL Hurricane Model
  - Flux
  - SST
  - POM
  - Ocean

Future Hurricane-Wave-Ocean Coupled Model

- Atmosphere
  - Hurricane WRF Model
  - Wind & Air Temp.
  - Flux
  - Wind & Air Temp.

- Wave Boundary Model
  - SST
  - SST & Current
  - Flux
  - NCEP WAVEWATCH III
  - Wave Spectra
  - Flux
  - Currents, Elevations, & SST
  - HYCOM
  - Ocean
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
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  Begin R&D  Prelim. Test  HWRF physics  HWRF T&E

MM5  Transition to HWRF  HWRF Operational
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

UNIVERISTY 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……