Advanced Hurricane Modeling in NOAA: The HWRF

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WHERE AMERICA’S CLIMATE AND WEATHER SERVICES BEGIN
• Final GFDL upgrades
• Transition to the HWRF
• T&E
MESOSCALE DATA ASSIMILATION FOR HURRICANE CORE

TRANSITIONING TO HURRICANE WRF

02-03  03-04  05  06  07

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

ATLANTIC TRACK SKILL

NUMBER OF CASES: (133, 133 133, 131, 122, 105, 86)
Operational '05 GFDL (green) vs. w/microphysics w/o ocean (red) vs. w/microphysics and ocean (blue)
Transitioning to the HWRF system.....
Hurricane-Wave-Ocean-Surge-Inundation Coupled Models

NCEP/Environmental Modeling Center
Atmosphere- Ocean-Wave-Land

HWRF SYSTEM

NMM hurricane atmosphere
NOAH LSM

Atmosphere/oceanic Boundary Layer
winds
air temp.
waves
SST
currents

HYCOM
3D ocean circulation model
wave fluxes
elevations
currents
3D salinities
temperatures

WAVEWATCH III
Spectral wave model

NOS
land and coastal waters
surge inundation

High resolution Coastal, Bay & Estuarine hydrodynamic model
runoff
radiative fluxes
other fluxes

Fluxes

3D salinities
temperatures
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
Hurricane Katrina
AUG 26, 2005 18Z: HURRICANE KATRINA MOVING NEST FCST: 0

HWRF
Hurricane Katrina
2005 Tropical Cyclone Tracks
Storm: AL1205 (KATRINA)

Forecasts: Beginning 2005082712
Observed: Beginning 2005082712, every 12 hours

NOPEP Hurricane Forecast Project
OCT 18, 2005 06Z: HURRICANE WILMA MOVING NEST FCST: 0

HWRF
Hurricane Wilma
2005 Tropical Cyclone Tracks
Storm: AL2405 (WILMA)

Forecasts: Beginning 2005101906
Observed: Beginning 2005101906, every 12 hours
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…
Mesoscale Data Assimilation for Hurricane Core

Implement advance (reflectivity) 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