Hurricane Model Transitions to Operations at NCEP/EMC

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Project Goals and Emphasis

- EMC aided the upgrade of the GFDL model through implementing improved physics packages... microphysics already in WRF
- Establish baseline of skill for WRF development ...use of GFDL physics
- Transition of Hurricane model from GFDL to WRF
- Continued collaboration with URI and GFDL
HWRF Hurricane Forecast System

- NHC storm message
- Position domain

- Get OBS, Model Input
- initial & boundary conditions

- Ocean Initialization
- Initialize wake, loop currents & eddies

- Wrf si (used for topographical parameters)
- Wrf real: replace with interpolations from native model data

- Storm analysis and data ingest
- 6hr 1st guess
- vortex relocation
- 3DVAR gsi for both nests

- WRF coupled model
- 1. NMM HWRF 2. POM 3. COUPLER

- Synoptic fields for many variables
- Create file for track, intensity, etc

Next cycle
Real cases: Standard Initialization (WRFSI/NMMSI)

*This WRF core has been linked to a complete hurricane forecast system with nesting integrated*
The NMM-WRF Modeling System
http://www.dtcenter.org/wrf

NMM-WRF Modeling System

Regional-Scale, Moving Nest, Atmospheric Modeling System.

Non-Hydrostatic system of equations formulated on a rotated latitude, Arakawa E-grid and a vertical, pressure hybrid (sigma_p-P) coordinate.

Advanced HWRF, 3D Variational analysis that includes vortex reallocation and adjustment to actual storm intensity.

Uses SAS convection scheme, GFS/GFDL surface, boundary layer physics, GFDL/GFS radiation and Ferrier Microphysical Scheme.

Ocean coupled modeling system.
Salient Features: Telescopic E-Grid

- All interpolations are done on a rotated lat-lon, E-grid with the reference lat-lon located at the centre of the parent domain.

- Consequently the nested domain can be freely moved anywhere within the grid points of the parent domain, yet the nested domain lat-lon lines will coincide with the lat-lon lines of the parent domain at integral parent-to-nest ratio.

- This coincidence of grid points between the parent and nested domain eliminates the need for more complex, generalized remapping calculations in the WRF Advanced Software Framework and is expected to aid better distributed memory performance, and portability of the modeling system.
## HWRF – GFDL

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

analytical

HWRF model

sfc exchange coefficients
gfs2006 vs gfsi (T=303K)

CH

CD

CD

CH

CD

CH/CD

HWRF Forecast for 72h- Hurricane Katrina 2005/09/26 12Z
Sensitivity of track to enthalpy exchange

Katrina

Wilma

Coupled HWRF; HCBS: SFENH 1.0; HSFO: SFENH 0.0
2005 Tropical Cyclone Tracks
Storm: AL2005 (Katrina)

Coupled HWRF; HCBS: SFENH 1.0; HSFO: SFENH 0.0
2005 Tropical Cyclone Tracks
Storm: AL2405 (Wilma)

Observed: Beginning 2005082500, every 12 hours
Forecasts: Beginning 2005082500

GFDL

HWRF
Sensitivity of track to enthalpy exchange (little difference)

Preliminary HWRF-GFDL Track Comparison


- HWRF (Winter 2007, coupled+)
- HSF0 (reduced enthalpy exchange)
- 2006 GFDL
- CLIPER

track error (nm)

forecast hour
Sensitivity of intensity to enthalpy exchange

magnitude

bias

Preliminary HWRF–GFDL Intensity Comparison

Preliminary Intensity Bias Comparison

HWRF Enthalpy difference
HWRF sensitivity to radiation & clouds (not much difference)
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, Ism, 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  Begin R&D  Prelim. Test  HWRF Operational
HWRF physics
HWRF T&E

(9km/42?L)
Advancing HURRICANE WRF System

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

Waves: moving nest Multi-scale imp. Highest-Res coast
Ocean: 4km. - continuous upgrades in ODAS, model res.
The GFDL Modeling System

- Regional Scale, Moving Nest, Atmospheric Modeling System

- Hydrostatic system of equations formulated on a latitude-longitude grid and normalized pressure (sigma) coordinate system.

- Advanced initialization that uses GFS analysis, yet an improved and more realistic storm vortex that blends in well with the large scale environment.

- Uses SAS convection scheme, GFS boundary layer physics, updated surface exchange, GFDL radiation and Ferrier microphysics.

- POM Ocean coupled modeling system.
The nesting procedure is Mass consistent and is currently two-way interactive.

Parent domain is \(~75^0\times75^0\) at the center at about 27 km resolution and the moving nest is about 6x6 at about 9 km resolution.

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.