Improving the Operational Tropical Cyclone Models at NOAA/NCEP and Navy/FNMOC: Year 2

A proposal submitted to the NOAA Joint Hurricane Testbed Program

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Cost: URI – $125,000; GFDL – $40,000 Duration: September 1, 2014 – August 31, 2015

1. Tasks scheduled for Years 1 and 2

Below are the tasks scheduled for Year 1 (09/01/2013 – 08/31/2014) in our original proposal:

1. *Transition the 1/18° benchmark GFDL/N, perhaps with physics changes, to operations.*
2. *Transition open MP software in 1/18° GFDL/N, for improved efficiency, to operations.*
3. *Begin testing the radiation package with an increased number of vertical levels.*
4. *Continue to test the upgraded Ferrier microphysics in preparation for operations.*
5. *Transition the meso-SAS convective scheme to operations, pending positive results.*
6. *Transition GFDL/MPIPOM-TC to operations in the Atlantic, pending positive results.*
7. *Set up the worldwide MPIPOM-TC domains in GFDN and conduct initial testing.*
8. *Select the optimal set of air-sea interface physics packages and transition the hurricane-wave-ocean coupled system to operations in the Atlantic, pending positive results.*

Below are the tasks scheduled for Year 2 (09/01/2014 – 08/31/2015) in our original proposal:

1. *Transition new open MP software-based changes to operations.*
2. *Transition new radiation package to operations, pending positive results.*
3. *Transition upgraded Ferrier microphysics to operations, pending positive results.*
4. *Evaluation of different initialization products worldwide in GFDN/MPIPOM-TC.*
5. *Transition hurricane-wave-ocean coupled system to operations in the East Pacific, pending positive results.*
6. *Transition GFDL/MPIPOM-TC to operations in the East Pacific, pending positive results.*
7. *Configure and test GFDN hurricane-wave-ocean system worldwide.*

2. Tasks accomplished as of April 17, 2014

a) *Transition the 1/18° GFDL in the Atlantic and Eastern Pacific basins, with both physics and numerics upgrades (listed below), to operations.*
b) *Transition GFDL/MPIPOM-TC to operations in the Atlantic.*
c) *Transition GFDL/MPIPOM-TC to operations in the East Pacific.*
d) *Set up the worldwide MPIPOM-TC domains for GFDN.*

Here is a list of the physics and numerics upgrades implemented into the 2014 GFDL system:

- Improved specification of surface exchange coefficients (C_H, C_D).
- Improved specification of surface roughness and wetness over land (climatology replaced by GFS-based values).
- Modified PBL with variable critical Richardson number (Ri_C).
- Improved targeting of initial storm maximum wind and storm structure in initialization.
- Advection of individual microphysics species (*the rime factor advection impact was neutral and not included*).
- Removed vortex specification for storms of 40 knots and less.
- Upgraded ocean model from POM-TC to MPIPOM-TC with ~9-km grid spacing, a unified trans-Atlantic region for the Atlantic basin, and 3D physics for the Eastern Pacific.
- Introduced direct interpolation from GFS hybrid to GFDL sigma coordinates, which reduced preprocessing from 14 to 4 min.
- Improved computational efficiency: A 126-hr forecast is run in ~65 min, using 45 CPUs (36 CPUs for the atmosphere; 9 CPUs for the ocean).

All of the listed upgrades have been recommended for the operational implementation in 2014. Here is an endorsement from NHC senior forecaster Richard Pasch: "The National Hurricane Center (NHC) endorses the implementation of the upgraded GFDL Hurricane Model for 2014. This implementation, which includes an increase in horizontal resolution of the inner mesh of the model to 1/18 degree, improved specification of the surface drag and heat exchange coefficients, a modified PBL, a unified Atlantic domain for the ocean model, and improved initialization. Retrospective runs of this model for a large number of cases from 4 past hurricane seasons show significantly improved TC intensity forecast skill for both the Atlantic and eastern North Pacific basins, with mostly a neutral impact on track forecast errors. Given the expected improvement in intensity prediction, the NHC looks forward to having this guidance for our operations this coming hurricane season."

3. Work plan for Year 2

We propose some changes to the originally proposed tasks. Significant model speedup was accomplished (~15%) through additional compiler options that enabled higher levels of optimization. This change, in addition to further reduction of timing in the model preprocessing, made the transition to Open MP unnecessary. Also, further testing indicated the advantages of Open MP were very minimal, so this task was withdrawn from further operational consideration. With testing and implementation of additional physics in 2014, as outlined above, we postponed Task 3 originally scheduled for Year 1 to Year 2.

Moving forward, the following GFDL and GFDN upgrades are planned for Year 2:

The primary upgrades to the atmospheric component will include:
a) Increasing the number of vertical levels, particularly in the PBL and lower/middle troposphere,
b) Upgrading the microphysics, radiation, and PBL schemes to account for the increased vertical resolution, and
c) Including spinup of the microphysics during the initialization of the atmospheric model.

The primary upgrades to the ocean model component will include:
a) Implementing alternative ocean analyses for the initialization, pending positive results, and
b) Three-way atmosphere-wave-ocean coupling with advanced physics of the air-sea interface.

All of these upgrades will be introduced and tested in the Atlantic and Eastern Pacific basins for the GFDL system and in all worldwide ocean basins for the GFDN system.

4. Needs for expected travel and staff requirements

Remain the same as in the original proposal.