Nesting and Convective Systems
*Update on Team Plans and Activities*

Vijay Tallapragada
NOAA/NWS/NCEP/EMC

NGGPS Annual Meeting
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• Chair: Vijay Tallapragada, EMC
• Members:
  – **EMC**: Tom Black, Samuel Trahan, Dusan Jovic, Matt Pyle, John Michalakes, Bin Liu
  – **AOML**: S.G. Gopalakrishnan, Thiago Quirino, Steven Diaz
  – **GFDL**: S.J. Lin, Lucas Harris, Morris Bender, Tim Marchok
  – **ESRL**: Stan Benjamin, Jin Lee, Ligia Bernardet
  – **NCAR**: Bill Skamarock, Chris Davis
  – **Navy**: Jim Doyle
  – **PSU**: David Stensrud, Paul Markowski, Yvette Richardson
  – **U. Michigan**: Christiane Jablonowski, C.M. Zarzycki
NGGPS Nesting/Convective Systems
Team Objectives

• Incorporate more sophisticated nesting or mesh refinement capabilities in the NEMS framework
• Development of generalized nesting or mesh refinement techniques
• Implement multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, sea ice, land, etc.) models using NEMS infrastructure
• Implement scale-aware physics appropriate for the high-resolution nests
• Post-processing, product development and verification of high-resolution model output
• Strategic development approach
  – Generalized nesting technique using “coupling approach”
    – proof of concept (HRD/EMC/NESII)
  – Scalability and efficiency with two-way interactive nests are critical for operational considerations (interactions with overarching system/software architecture and engineering teams)
  – Appropriate physics and initialization techniques (interactions with atmospheric physics and data assimilation teams)
  – Advanced diagnostic and verification tools for evaluating non-hydrostatic model forecasts at cloud resolving scales
Near term Developments

- Take advantage of already developed (and ongoing developmental) work in the HWRF and NMMB/NEMS systems

- Accelerate design and development of efficient two-way interactive nests using generalized nesting framework using ESMF/NUOPC coupler functionality in NEMS

- Implement variable resolution configurations and grid-nesting (static and moveable) techniques for FV3 dynamic core in NEMS
General Requirements for Operational Nesting or Grid Enhancement

- Static/moving
- 1-way/2-way interactive (nests)
- Multiple nests run simultaneously
- Bit reproducible and restartable (static/moving/1-way/2-way)

- **Very fast and efficient!**
- Dynamics, physics and initialization appropriate and applicable for high-resolution nests within the global model
AOML in partnership with EMC and other OAR labs is building the Next Generation Generalized Nesting Framework (NGGNF) within NEMS to advance global-2-local scale modeling for hurricanes.

The Coupled NEMS Project

Use of NEMS Coupler Functionality for ATM-ATM 3D coupling
Example: Generalized Nesting By Coupling

Project Statement: “The current nesting techniques in HWRF and NMMB are based on the projection center of the parent grid, limiting their applications to a confined region in the tropics, and limiting their ability to scale well at higher resolutions and pole-ward locations. A generalized nesting, core independent nesting technique that can work independent of the parent model’s grid structure as well as map projections will advance the state-of-the-art in nesting techniques (one-way as well as two-way).

SVN Repository path: https://svnemc.ncep.noaa.gov/projects/hnmmmb/branches/AOML-HRD/NGGNF
Generalized Nesting: Immediate Challenges

• Appropriate strategy for developing the “nesting by coupling” technique
  – NGGNF and NUOPC Mediator (Coupled NEMS Project) are currently developed independently
  – HRD and NESII are currently evaluating each other’s approach through extensive code reviews
  – Development plans to be revised based on implementation of FV3 dynamic core in NEMS
EMC developing HNMMB/NEMS as a potential second hurricane model for operations

- All major developments completed (physics, nesting, vortex initialization, post-processing & products)
- Ocean coupling and Hurricane Data Assimilation work to be completed by end of August
- Real-time experimental demo started on August 1, 2016
- Initial configuration of HNMMB to imitate operational HWRF (with choice of different physics and initialization options)
- HNMMB has more computationally efficient nesting techniques compared to HWRF
- Evaluate efficiency and potential for transition of multi-storm (basin-scale) configuration
- Test ground for future hurricane nests in FV3 dynamic core based NEMS/GFS
- Explore coupling to multiple components (ocean, wave, surge, hydrology and inundation)
Hurricane Developments in NMMB/NEMS
(EMC-HRD Collaborations supported by HFIP, HIWPP and R2O/NGGPS)

Operations-ready configuration of hurricane nests in NMMMB/NEMS
EMC hurricane team is performing real-time forecasts of HNMMB/NEMS at 18:06:02km for 2016 hurricane season

- Developed an end-to-end automation system for real-time forecasts

Slide courtesy: Weiguo Wang & Avichal Mehra, NCEP/EMC
Two-Way Nesting Capabilities in GFDL FV3
(Recent developments using HiRAM and FV3)

Examples of high-resolution nested grid simulations using HiRAM and FV3

Three-day HiRAM forecasts of severe convection during the Moore, OK tornado outbreak of May 2013, in a simulation nesting down to 1.3 km over the southern plains (using HIWPP 3km global runs)

Year-long nonhydrostatic HiRAM simulation using 2005 SSTs, using an 8-km nest over the tropical Atlantic

Slide courtesy: Lucas Harris, GFDL
Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)

FV3 dynamical core with GFS physics (explicit convection) - nest down to 3 km for Hurricane Patricia. This configuration achieves one simulated day in about 11 minutes with about 6100 cores on Gaea-C3.
GFDL FV3: Stretched Grid vs. Nested Grid

Tile boundary of (left) C768r3 stretched-grid and (right) C768r14n3 nested-grid.

Distribution of grid-cell width of (left) C768r3 stretched-grid and (right) C768r14n3 nested-grid. Red bars indicate nested grid.
Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)

15-3km results for Moore Tornado case
Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)
Hurricane Sandy Case

CMORPH

FV3 Uniform Precipitation Forecast [mm/6hr]

FV3 Stretched Grid Precipitation Forecast [mm/6hr]

FV3 Nested Grid Precipitation Forecast [mm/6hr]

Stretched Grid

Nested Grid

60-hr forecast of 6-hr total precip from various configurations of FV3 with GFS physics
• Assess the ability of the North American Model (NAM) 4 km Conus Nest and 1.33 km Fire Wx Nest to provide realistic and accurate forecasts of severe convective weather (capability and accuracy)

• Develop useful diagnostics for forecasters and model developers

• Focus evaluation on supercells and convection initiation (CI) as key phenomena

• In-depth study of two cases

• Examine model output every 5 minutes and compare forecast storms and CI with observations (Doppler radar, Mesonet, surface, soundings, satellite, etc). Examine the physical processes of supercells and CI in the model
NGGPS Nesting Team: Updates from PSU
Advancing Storm-Scale Forecasts over Nested Domains for High Impact Weather

Simulated 1km AGL Reflectivity
1.3km Forecast Valid 00:05

Value of 5-minute model output!
NGGPS Nesting Team: Updates from PSU
Advancing Storm-Scale Forecasts over Nested Domains for High Impact Weather

Major Accomplishment in FY16:

Identified added value of FireWx nest compared to CONUS nest for convective storms

Identified areas where improvement is needed: pulsing of weak reflectivity, cold pool depth, low-level clouds, numerical waves, supersaturation in convective region. Several already corrected.

Showed value of 5-minute model output when exploring model behaviors

Priority Focus for FY17

Continue in-depth evaluation of model CI and supercells to identify key diagnostics

Key Issue

Physical process parameterization schemes need improvement – community issue
NGGPS Nesting Team Long-Term Objectives

- Continue to increase resolution of nests that can operate at cloud-resolving scales
- Couple nesting capability with more components as added to NEMS
- Demonstrate global models operating at cloud resolving scales with high-resolution nests for more accurate forecasts of significant weather events
- Develop advanced post-processing techniques, products, verification and diagnostic tools.
- Close interactions with other NGGPS atmospheric dynamics, physics, data assimilation, overarching system, software architecture and engineering teams.
Questions?