Note: Dynamics and Nesting team plans will be combined in the future. Current dynamics activities/dynamic core testing details are listed under the NGGPS Dycore Testing link on the NGGPS website.

Co-Leads: Vijay Tallapragada (NWS/EMC)/Jeff Whitaker (ESRL/PSD)

Nesting

1.1 State of the Science

Grid nesting has been successfully used in various operational regional models at NCEP (e.g., GFDL, NAM, HWRF) for several years now. Grid nesting techniques are also widely used in severe weather prediction (NAM nests, cloud-resolving WRF ARW nests), sub-seasonal hurricane prediction (GFDL FV3), and coastal wave predictions (WAVEWATCH-III).
NCEP operational HWRF modeling system currently uses an advanced two-layered telescopic two-way interactive nests that follow the tropical storm path, providing higher grid resolution near the storm region for more accurate tropical cyclone intensity and structure forecasts. Recent developments allowed demonstration of multiple moving nests within a large basin-scale HWRF system for tracking multiple storms simultaneously. The current nesting techniques in HWRF have also been transitioned to NMMB in NEMS framework. However, the current nesting techniques 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. The next generation global prediction system will be designed to have the capability of running the global model with high-resolution two-way interactive nests.

1.2 Objectives

The primary objective of the NGGPS Nesting Team is to incorporate more sophisticated nesting capabilities in the NEMS framework. Development of a generalized nesting technique that can work independent of the parent model's grid structure as well as map projections will be the major activity that will be undertaken by the Nesting Team. These capabilities will be extended for implementing 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. Post-processing, product development and verification of high-resolution model output will be other high-priority objectives of this team.

1.3 Milestones, Resource Requirements, and Outcomes for Near-Term Objectives

1.3.1: Transition HWRF hurricane nesting techniques (two-way interactive) and nest movement algorithm, and develop generalized free-standing nests within the NEMS framework using NMMB

- **Lead organization:** EMC
- **Activities:** Develop and implement high-resolution storm following nests in the NMMB/NEMS model
- **Milestones and deliverables:**
  - August 2015 – Transition HIWPP funded HWRF nest movement algorithm and nesting techniques to NMMB/NEMS
  - October 2015 – Design of free-standing nests completed
  - May 2016 – Development of free-standing nests completed and codes committed to the NMMB/NEMS subversion repository
- **Anticipated collaborating organizations:** AOML
- **Priority (Low, medium, high):** High
- **Duration:** 12 months
- **Points of contact: Samuel Trahan and Tom Black**
- **Work Plan**:

In order to accomplish these objectives, design of free-standing nests will be undertaken at EMC using NMMB in NEMS framework as the initial choice of regional/global model. The following criteria will be followed for the development of generalized nesting:

- For a two-level nesting, the innermost nested domain needs to be able to move independently but the top-level moving nests have their own projection that remain constant during their lifetime.
- Expand the techniques to add multiple generations of nesting, with only one generation introduces a change in projections. All descendants of such a grid share their parent's projection.
- Nest motion is handled by a data shift followed by interpolation from the parent, regardless of what generation the nest belongs to.

An advantage to this approach is that the number of projections throughout the lifetime of the forecast is kept very small (one global plus one per "significant event" of interest, e.g., tropical cyclone). It also allows nests at any generational depth to move independently without causing additional problems. Only one level of the generations needs a change in the nesting code: the level between the top-level storm generation and its parent. All generations above and below that do not have a change in projections between generations, so the existing nesting codes in HWRF can be efficiently transitioned to NMMB/NEMS, greatly reducing the testing required.

1.3.2: Develop a Hurricane NMMB Subversion repository and transition HIWPP funded upgrades, including ports of the HWRF nest movement algorithm and idealized tropical cyclone framework to the NMMB/NEMS model, to the repository

- **Lead organization:** AOML
- **Activities:** Develop Hurricane NMMB Subversion repository and upgrades
- **Milestones and deliverables:**
  - April 2015 – Work with EMC to develop a hurricane NMMB repository

    - August 2015 – Transition HIWPP funded idealized tropical cyclone framework upgrades to the repository, deliver components to EMC
    - October 2015 – Transition HIWPP funded HWRF nest movement algorithm upgrades to the repository, deliver components to EMC repository
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:** 7 months
- **Points of contact:**

1.3.3: Test and evaluate the basin-scale HWRF multi-storm initialization in NMMB/NEMS framework and assess potential for demonstrating the initialization real-time in FY16 and implementing it in FY17.

- **Lead organization:** AOML
- **Activities:** Test and evaluate multi-storm initialization in NMMB/NEMS framework
- **Milestones and deliverables:**
    - November 2015 – Transition the basin-scale HWRF capabilities into NMMB/NEMS framework; deliver components to EMC repository
    - January 2016 – Test and evaluate multi-nest initialization and model integration with multiple nests, deliver test results
    - February 2016 – Assess the impact of storm-storm interaction on hurricane forecasts, deliver assessment document
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:** 11 months
- **Points of contact:**

1.3.4: Determine the efficiency and scalability of NMMB/NEMS with two-way interactive nests through testing the computational efficiency of the generation technique NMMB uses in the NEMS framework (distributing the MPI ranks to multiple domains, allowing for simultaneous integration) when configured with multiple for two-way interactive nests

- **Lead organization:** AOML
- **Activities:** Improve the efficiency and scalability of NMMB/NEMS with two-way interactive nests
- **Milestones and deliverables:**
    - January 2016 - Test standard configuration of NMMB/NEMS with single and multiple two-way interactive nests, report on the scalability of the model in terms of computational efficiency, deliver test results and scalability report
    - February 2016 - Test alternate configurations (larger nests, higher resolution parent domain with no intermediate domain, e.g., 6km/2km etc.), deliver test results and considerations and recommendations; Conduct detailed profiling of model integration, identify components that cause significant slowdown, and recommend modifications to the model framework that can further improve the model scalability, deliver assessment document.
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:** 11 months

- **Points of contact:**

1.3.5: Develop, test, and evaluate generalized grid-independent interpolation techniques for free-standing nests in the NMMB/NEMS framework. Use the HWRF nest movement algorithm, two-way feedback procedures and nest-parent interpolation techniques

- **Lead organization:** AOML
- **Activities:** Develop generalized grid-independent interpolation techniques for free-standing nests in the NMMB/NEMS framework
- **Milestones and deliverables:**
  - February 2015 – Develop grid-independent free standing nesting component in the NEMS super structure for hurricane applications using the NMMB model; demonstrate prototype and deliver component to EMC repository.
  - March 2016 - Test and evaluate the new nesting capability and compare with capability of the HWRF nesting implemented in NMMB; deliver test and comparison results. Test and evaluate the new nesting techniques for hurricane applications; deliver test results.
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:** 12 months
- **Points of contact:**

1.3.6: Subseasonal hurricane prediction in a prototype variable-resolution global NGGPS model

- **Lead organization:** PI: Lucas Harris, NOAA/GFDL, Co-I: Shaian-Jiann Lin NOAA/GFDL, Han-Huey Chen UCAR/GFDL
- **Activities:** Design and test a variable-resolution NGGPS model configured for skillful Atlantic subseasonal hurricane forecasts, validated by performing 10 years of retrospective 30-day forecasts during each hurricane season
- **Milestones and deliverables:**
  - September 2015 - Validated FV3 global model refined to convection-resolving scales over the Atlantic, of grid spacings of 4 km or smaller, using a 12-km base global grid and a factor-of-three refinement via a nest over the tropical Atlantic, and via stretching over the western Atlantic and eastern U.S.
  - March 2015 - Full set of retrospective subseasonal forecasts to demonstrate the model's capabilities. Tests will include extended-range predictions of individual storms and predictions of cyclone activity in the 10-30 day forecast range. Initially a reduced set of 30-day forecast simulations will be performed for selected events, including both particularly active and inactive months.
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:** One year
  - **Points of contact:** Lucas Harris, lucas.harris@noaa.gov

1.3.7: Advancing Storm-Scale Forecasts over Nested Domains for High-Impact Weather

- **Lead organization:** David J. Stensrud, Pennsylvania State University, CO:I's: Paul M. Markowski, Penn State, Yvette P. Richardson, Penn State

- **Activities:** Analyze the 5-minute model output from several perspectives in order to assess how well the parameterization schemes are capturing relevant processes at convection allowing scales, guide further parameterization development, identify needed model diagnostics, and determine the value added by the 1.33-km version compared to the 4-km NAM nest.
- **Milestones and deliverables:**
  - Year 1
    - Select and rerun cases using the current convection-allowing 4-km NAM CONUS Nest and the 1.33 km Fire Weather Nest. Transfer data to Penn State and stored on local computers and backed up to tape.
    - Develop graphics and diagnostics to look at CI and severe convection and asses physical processes. Download the WSR-88D observations and MADIS data for the cases and compare storm motion, storm reflectivity structures, and surface temperatures associated with cold pools.
      - Study all predicted storms, looking at low-level mesocyclone evolution and storm cycling.
      - Develop diagnostics for examining CI and the physical processes that lead to CI.
      - Conduct comparisons of location, initial cell size, development time and observational clues to CI physical processes between CI in the model and observations.
      - Apply similar approaches and comparisons against both observations and the 1.33-km run.
  - Year 2
      - Continue storm and CI diagnostics.
      - Explore whether or not the model comparisons with observations show consistent patterns that shed light on the appropriateness of the NAM model physics.
      - Explore model microphysical variables, PBL scheme behavior, and their interactions with radiation.
- **Anticipated collaborating organizations:** SPC, EMC
- **Priority (Low, medium, high):** High
- **Duration:** 05/01/2015-04/30/2017
- **Points of contact:** Professor David J. Stensrud, david.stensrud@psu.edu

1.3.8: Further testing of generalized nesting techniques

- **Lead organization:** AOML
- **Activities:** Testing new generalized nesting
- **Milestones and deliverables:**
  - February 2016 - Assess multi-storm initialization with newly developed generalized nesting techniques. Deliver assessment document
  - January 2017 - Conduct stress tests (nests moving over high terrain, nests following weaker depressions and faster moving storms etc.) – deliver test results.
- **Anticipated collaborating organizations:** EMC
- **Priority (Low, medium, high):** High
- **Duration:**

- **Points of contact:**

1.3.9: Couple nests with other components

- **Lead organization:** EMC
- **Activities:** Couple moving nests with other models
- **Milestones and deliverables:**
    - Demonstrate moving nests coupled to ocean models.
    - Capability for multiple moving nests fully (one- and two-way) coupled with various models.
- **Anticipated collaborating organizations:** ESRL, AOML
- **Priority (Low, medium, high):** High
- **Duration:**
- **Points of contact:** Vijay Tallapragada, Gopal

1.4 Milestones, Resource Requirements, and Outcomes for 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
- Develop advanced post-processing techniques, products, verification and diagnostic tools.
- Demonstrate global models operating at cloud resolving scales with high-resolution nests for more accurate forecasts of significant weather events