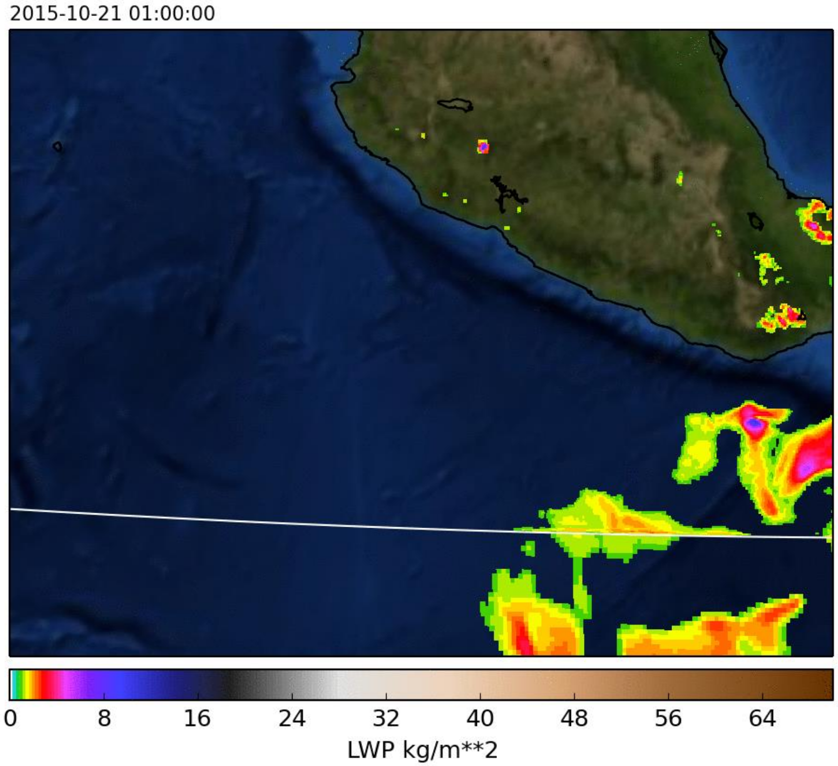
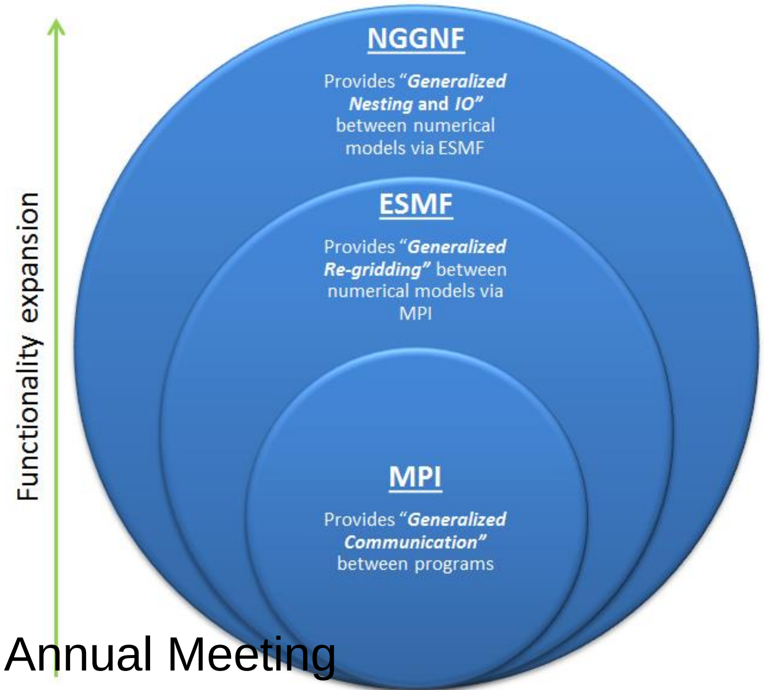
Nesting and Convective Systems

Update on Team Plans and Activities

Vijay Tallapragada

NOAA/NWS/NCEP/EMC





NGGPS Annual Meeting
August 4, 2016

NGGPS Nesting/Convective Systems Team Membership

- 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

NGGPS Nesting/Convective Systems Global-Meso Unification Strategies

- 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

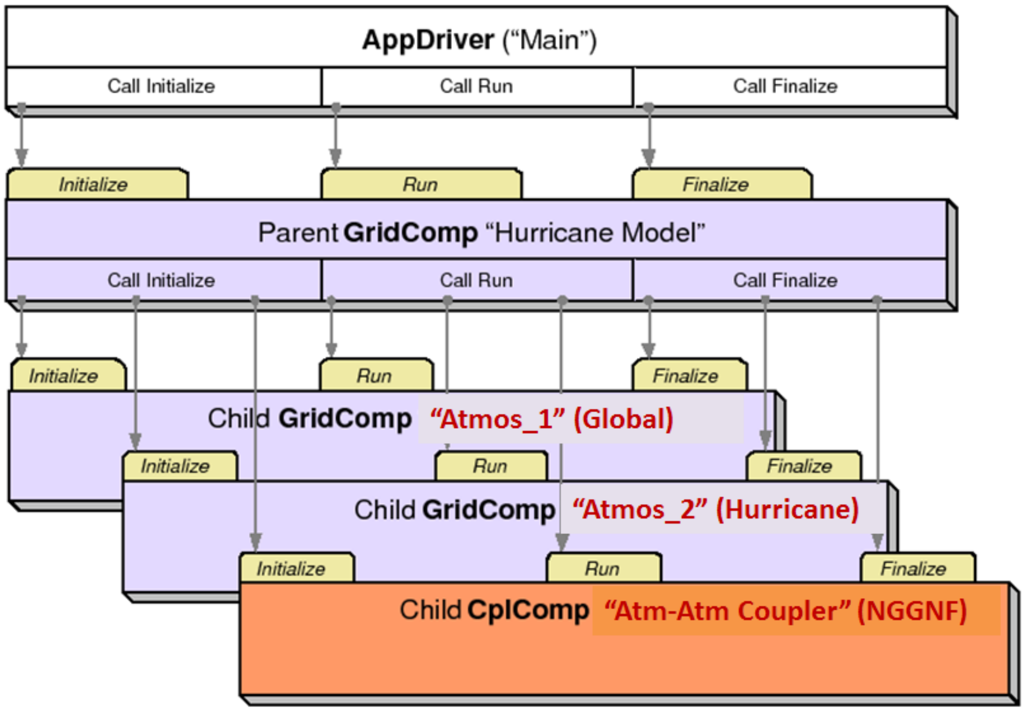
– Implement variable resolution configurations and grid-nesting (static and moveable) techniques for FV3 dynamic core in NEMS

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

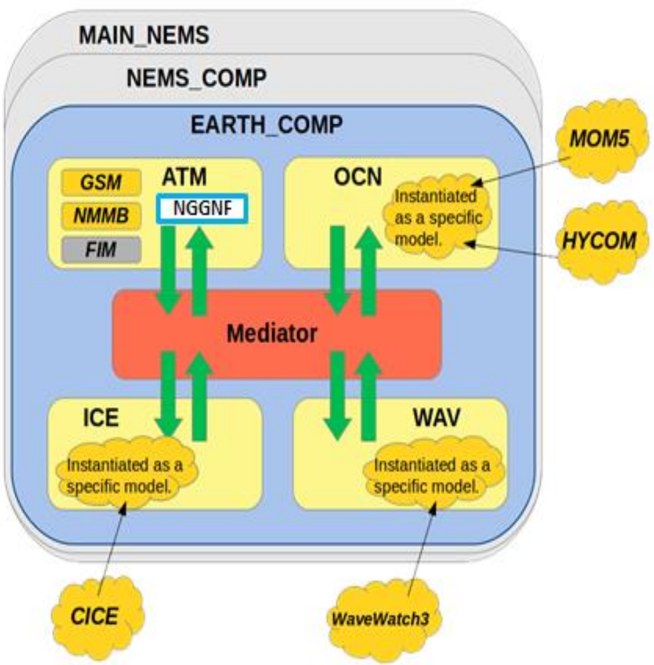
Generalized Nesting By Coupling

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



Use of NEMS Coupler Functionality for ATM-ATM 3D coupling

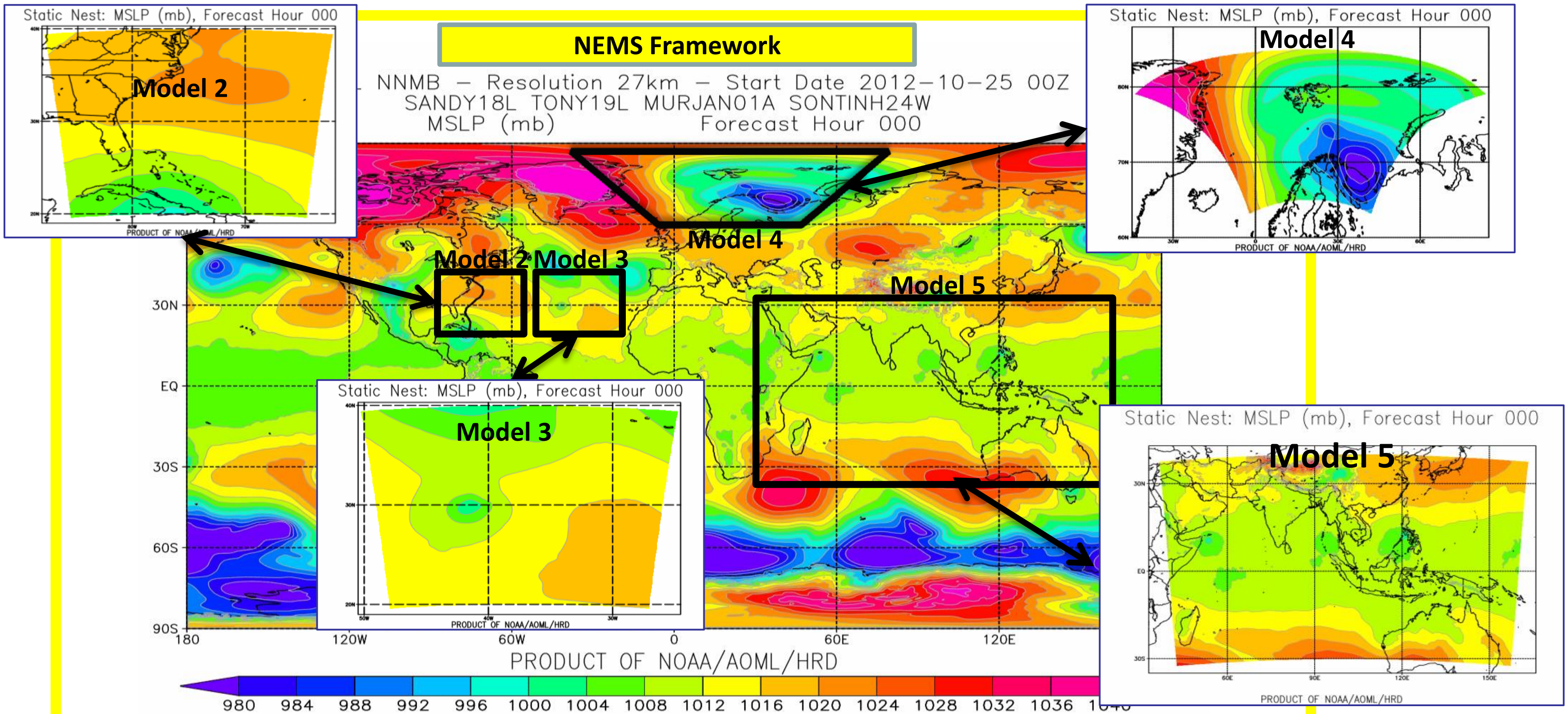
The Coupled NEMS Project



Architecture of the NEMS NUOPC "mediator" with the NGGNF dynamic layer

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).



*Example of Core, Grid, and Projection Independent, dynamical (up/)downscaling using and **advancing** ESMF re-gridding*

SVN Repository path: https://svnemc.ncep.noaa.gov/projects/hnmmb/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

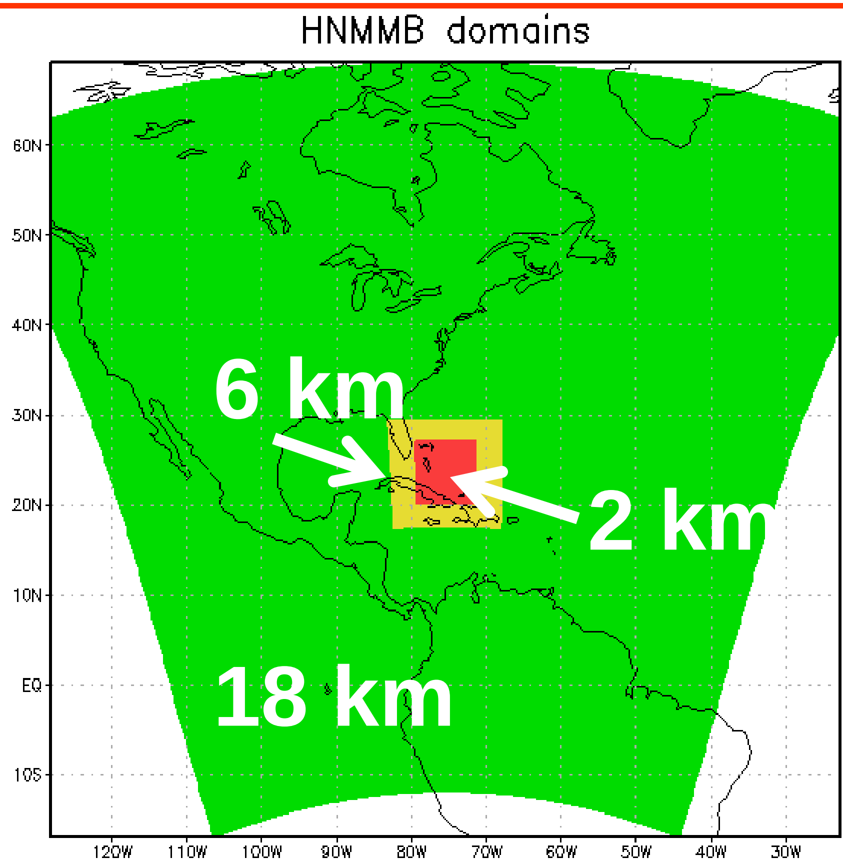
Hurricane Developments in NMMB/NEMS

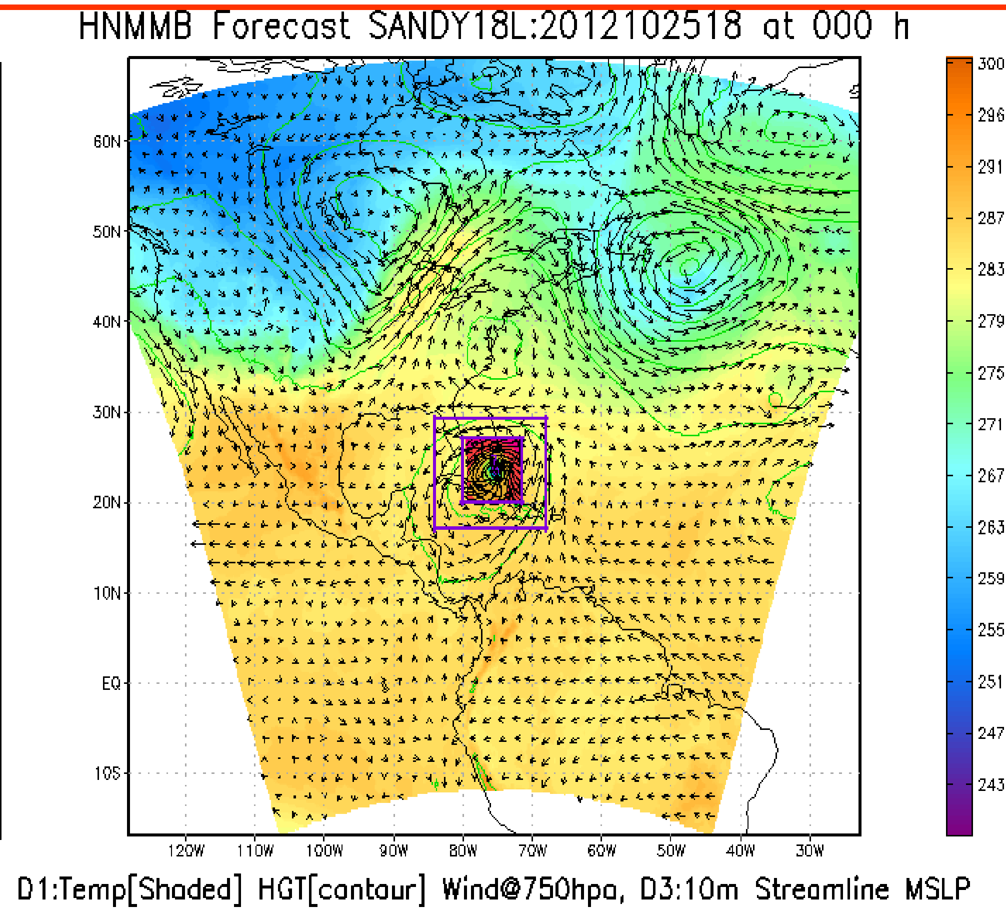
(EMC-HRD Collaborations supported by HFIP, HIWPP and R2O/NGGPS)

- 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)



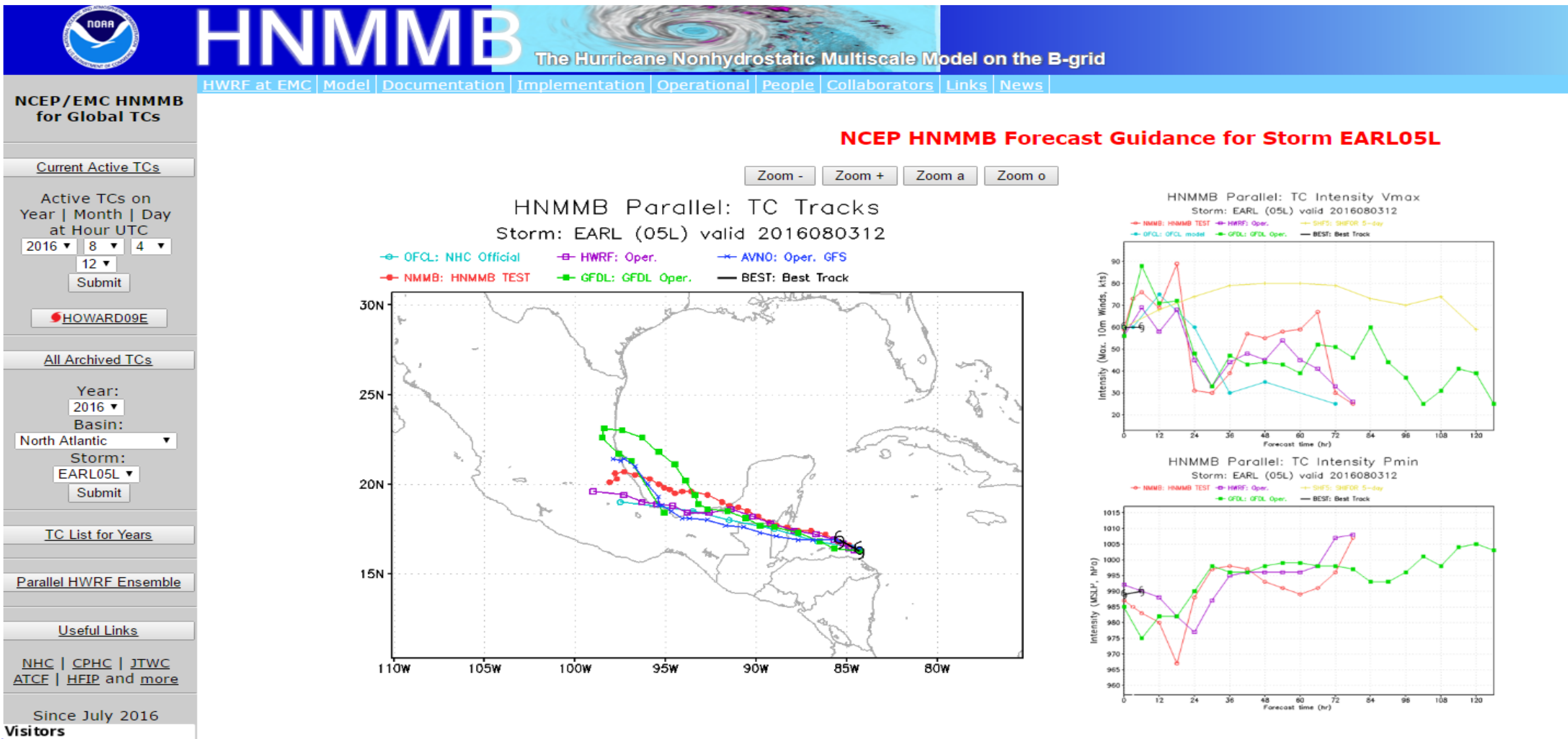


Operations-ready configuration of hurricane nests in NMMB/NEMS

Evaluation of the HNMMB in Real-Time for 2016 hurricane season

http://www.emc.ncep.noaa.gov/gc_wmb/vxt/HNMMB/

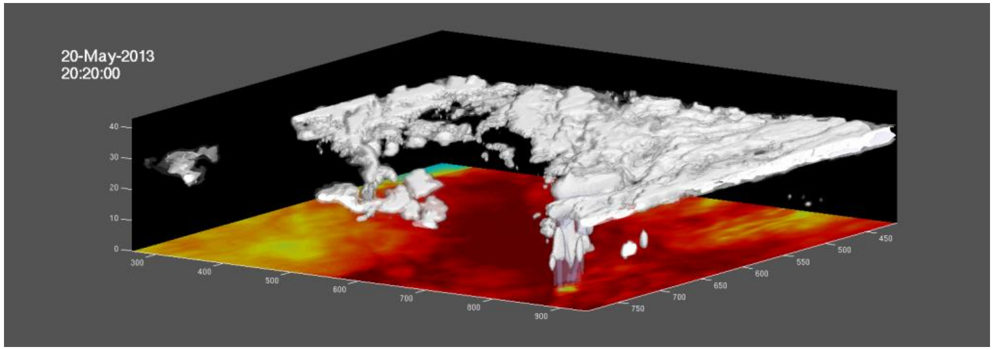
- EMC hurricane team is performing real-time forecasts of HNMMB/NEMS at 18:06:02km for 2016 hurricane season
  - Developed an end-to-end automation system for real-time forecasts



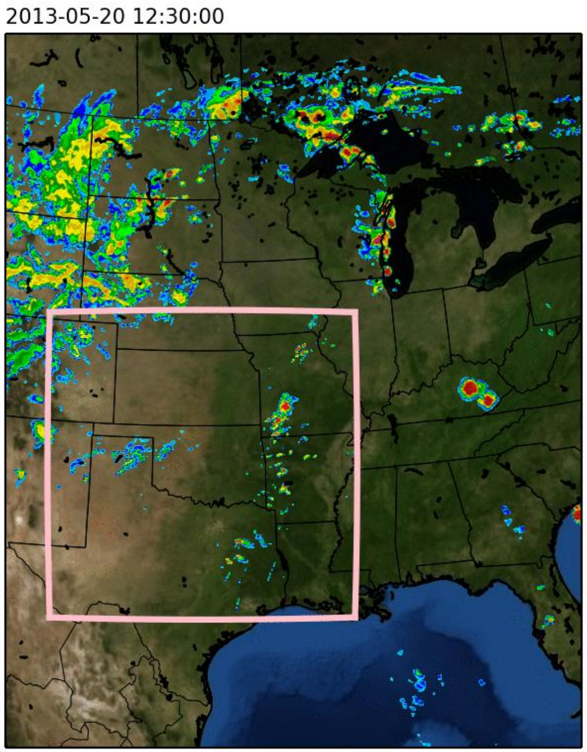
Slide courtesy: Weiguo Wang & Avichal Mehra, NCEP/EMC

Two-Way Nesting Capabilities in GFDL FV3

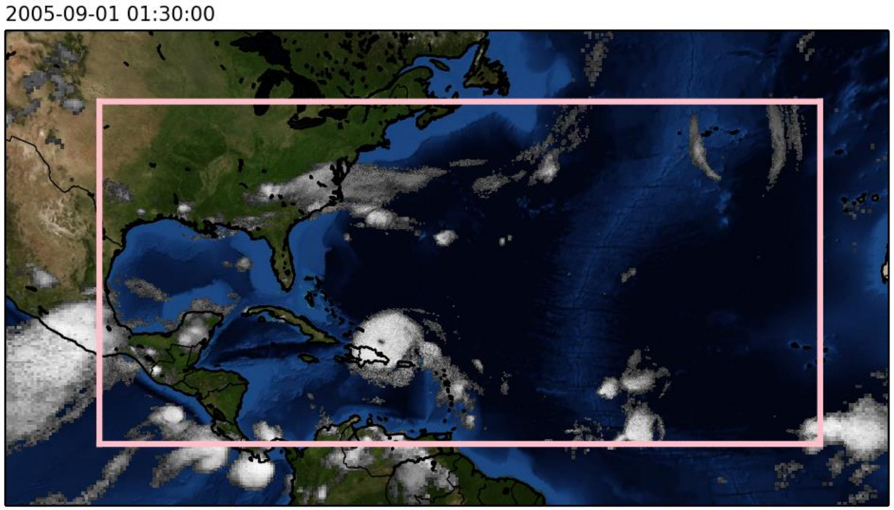
(Recent developments using HiRAM and FV3)



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



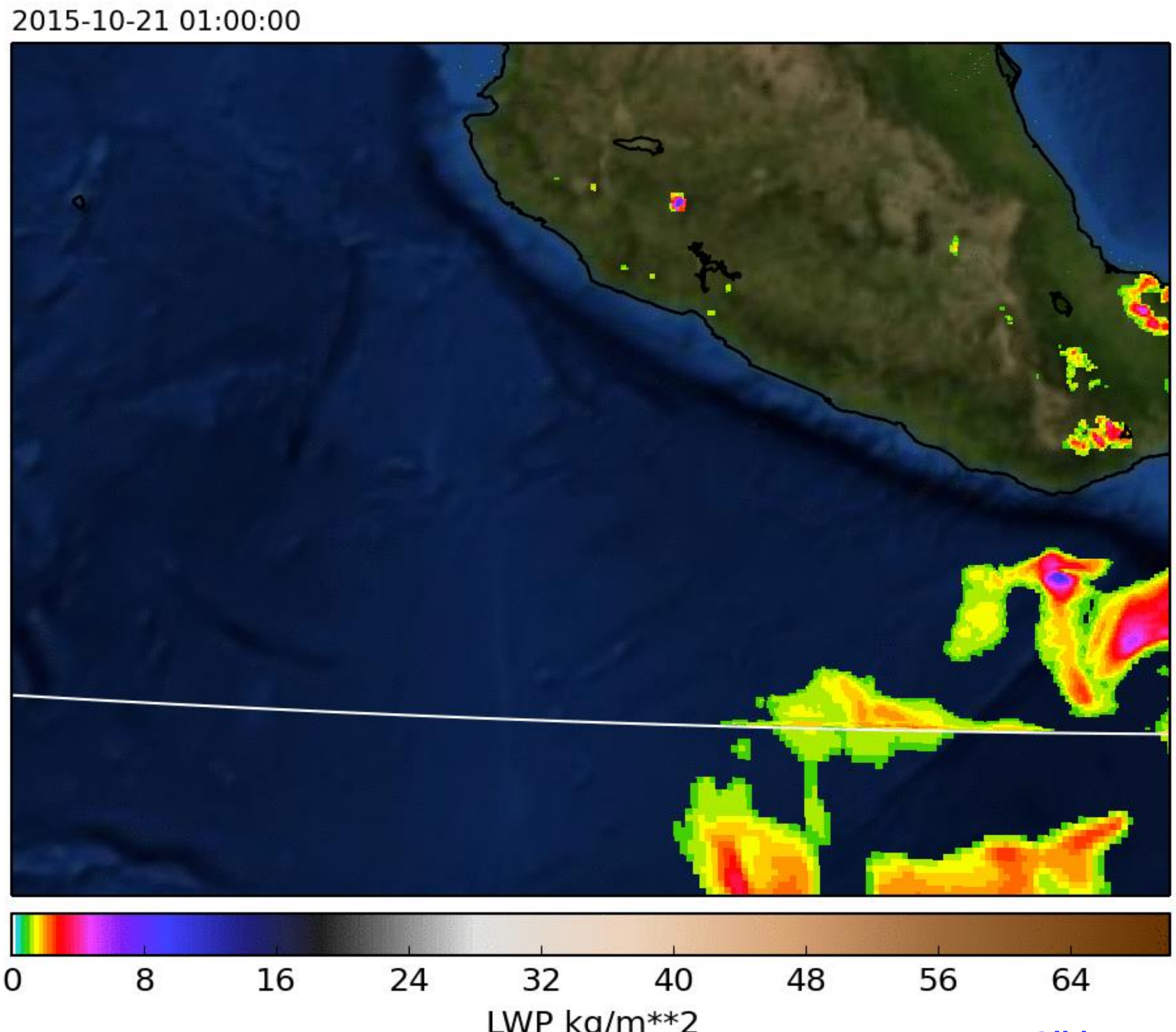
three-day HiRAM forecasts of severe convection during the Moore, OK tornado outbreak of May 2013, in a simulation nesting down to 1.3 km over the southern plains (using HIWPP 3km global runs)



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

Slide courtesy: Lucas Harris, GFDL

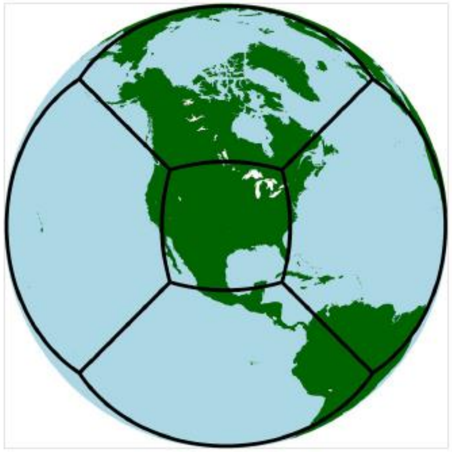
Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)



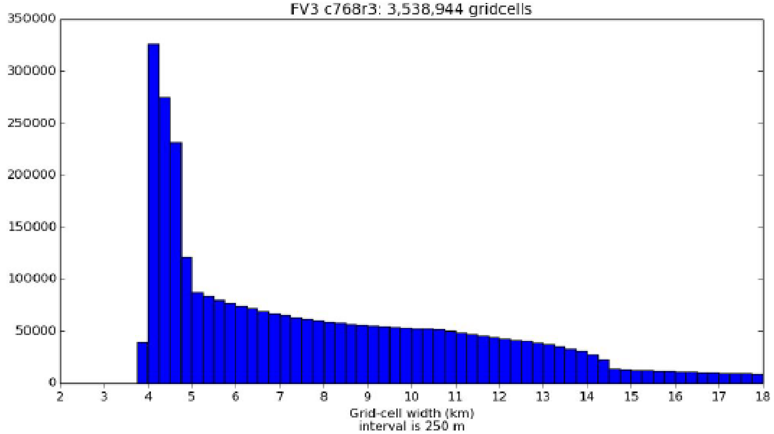
FV3 dynamical core with GFS physics (explicit convection) - nest down to 3 km for Hurricane Patricia. This configuration achieves one simulated day in about 11 minutes with about 6100 cores on Gaea-C3.

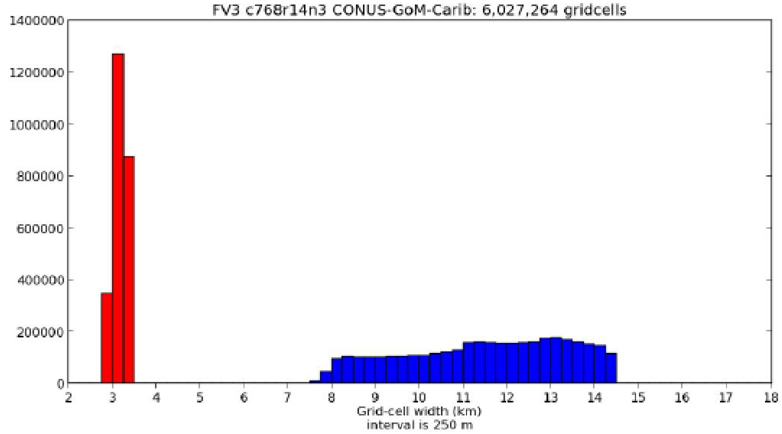
Slide courtesy: Lucas Harris, GFDL

GFDL FV3: Stretched Grid vs. Nested Grid



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



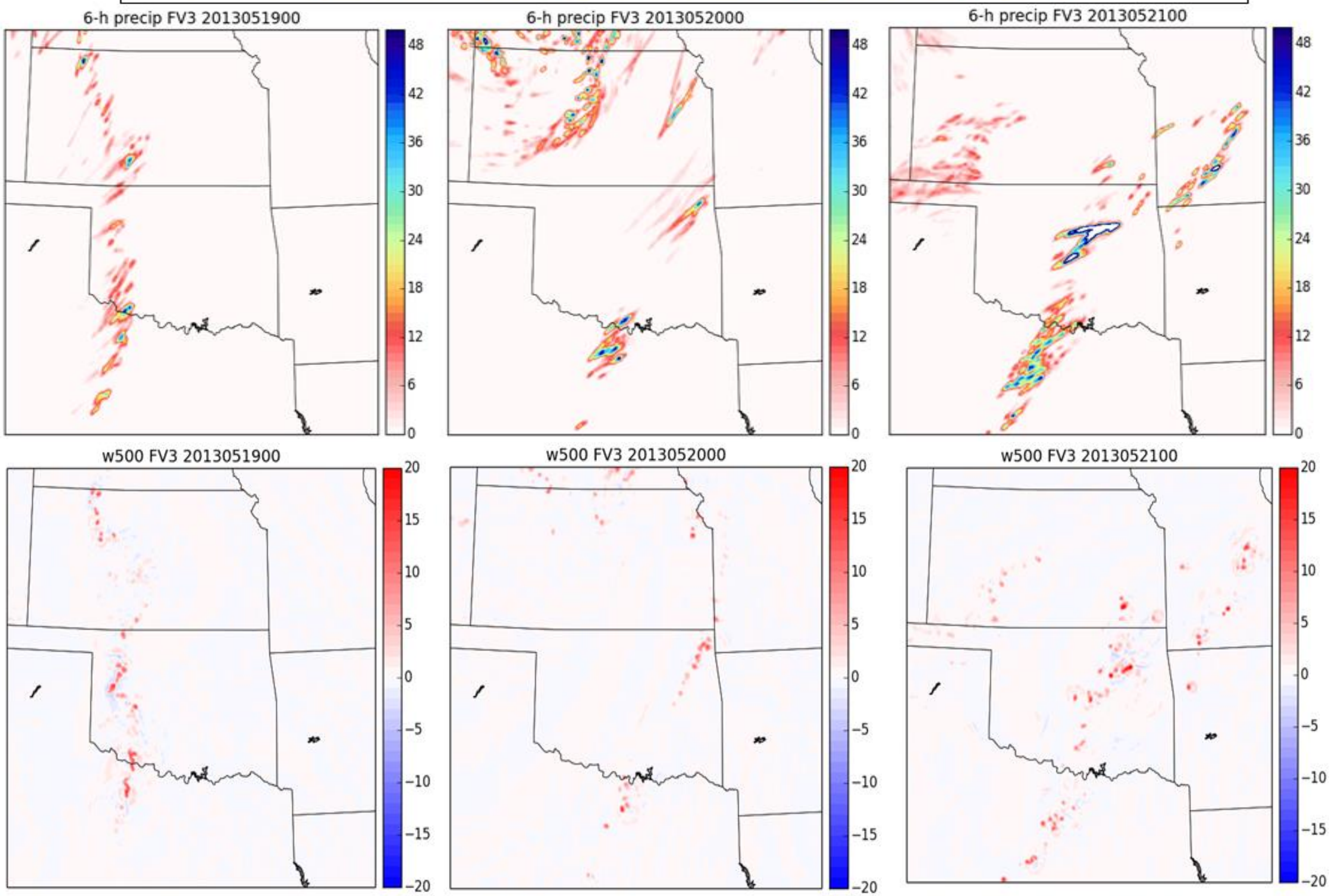


Distribution of grid-cell width of (left) C768r3 stretched-grid and (right) C768r14n3 nested-grid. Red bars indicate nested grid.

Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)

15-3km results for Moore Tornado case

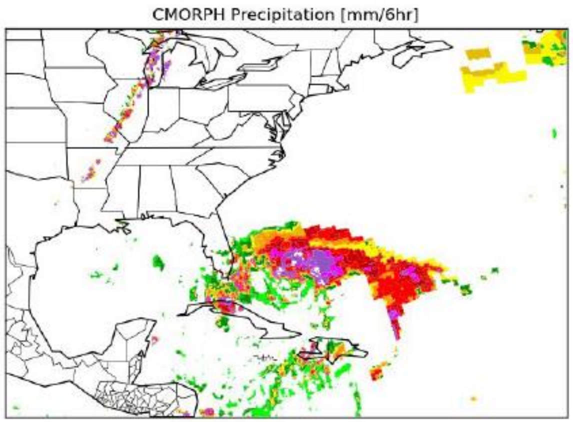
6-h acc precip and W500 for 00UTC May 19,20,21 (days 1-3)



Slide courtesy: Jeff Whitaker

Recent Examples of Nested Simulations with GFDL FV3 (DTG Phase 2)

Hurricane Sandy Case



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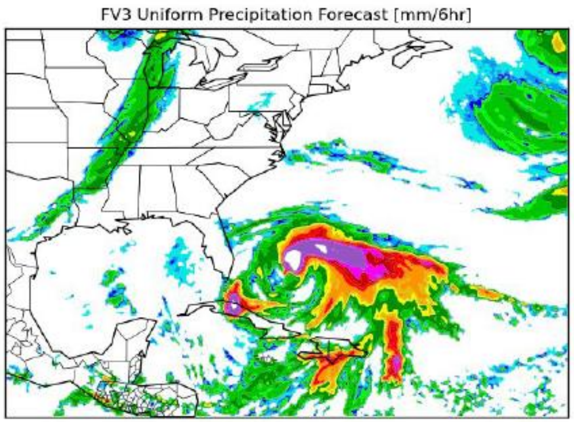
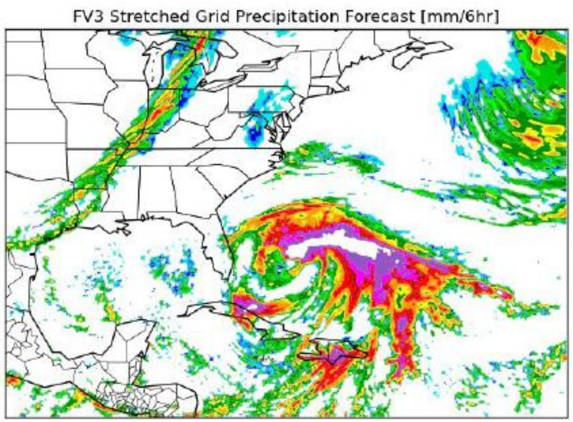
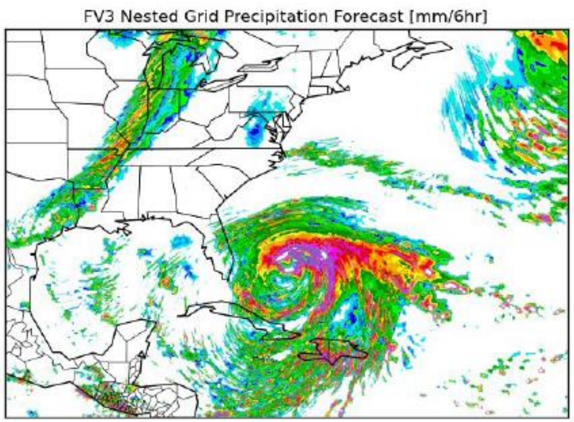


Uniform Grid



Stretched Grid



Nested Grid

60-hr forecast of 6-hr total precip from various configurations of FV3 with GFS physics

Slide courtesy: GFDL

NGGPS Nesting Team: Updates from PSU

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

- 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

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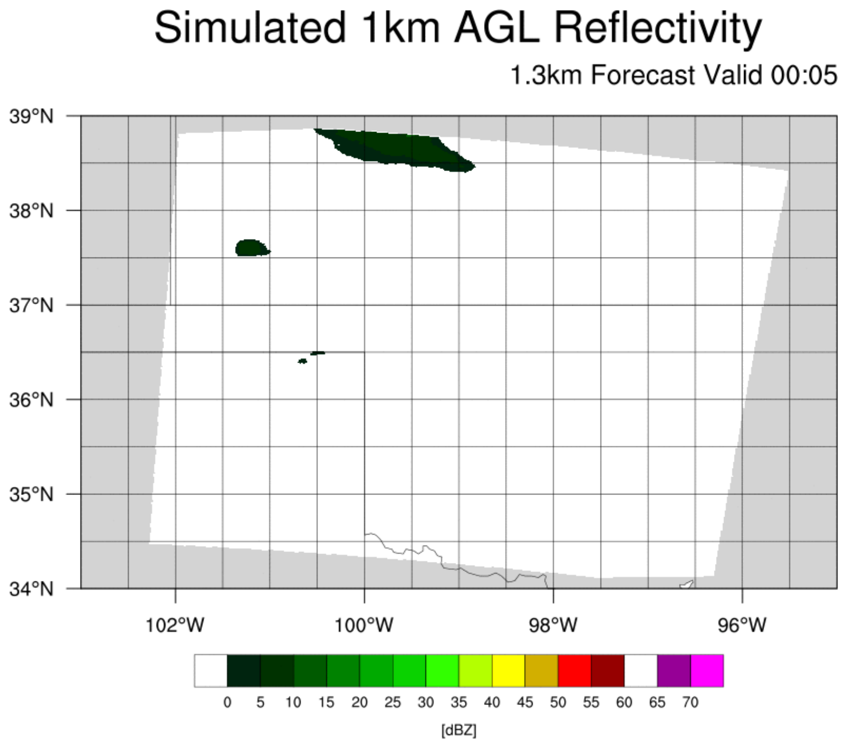
Advancing Storm-Scale Forecasts over Nested Domains for High Impact Weather



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?