Current and Proposed HAFS Configurations for Initial Operational Capability (IOC)

Avichal Mehra[1] , Zhan Zhang[1], Xuejin Zhang[2] and Vijay Tallparagada[1]

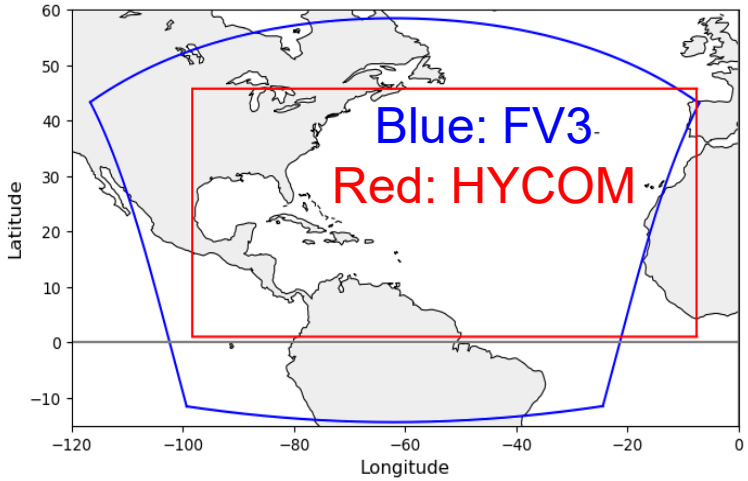
[1]NOAA/NWS/EMC, MD, USA
[2] NOAA/OAR/AOML/HRD

HFIP Annual Review Meeting, November 19, 2020

Current Status

HAFS v0.1A Configuration

- The FV3 component (based on 2019 HAFS.v0.0A)
  - FV3 model domain (~85x72 deg)
  - 91 vertical levels from
  - Use the HAFS_V0_gfdlmp_nocpnsstugwd physics suite
    - GFDL microphysics; RRTMG radiation; No CP; Noah LSM; GFS surface layer with HWRF exchange coefficients; GFS EDMF PBL with HWRF modification; Both convective and orographic GWD are turned off; Turning off the NSST component
  - GFS NEMSIO file for IC; 3-hrly GFS grib2 files for LBC
  - 177 nodes, 5-day forecasts
- Data Assimilation
  - GSI-based TC relocation
  - 3DEnVAR
- The HYCOM ocean model component
  - Cover NATL basin (1-45.78N, 261.8-352.5E) at a 1/12-degree resolution with 41 vertical layers
  - Ocean IC from RTOFS nowcast and/or forecasts
  - Use persistent oceanic LBC
  - Atmospheric forcing from 0.25-degree GFS grib2 files to cover non-overlapped area



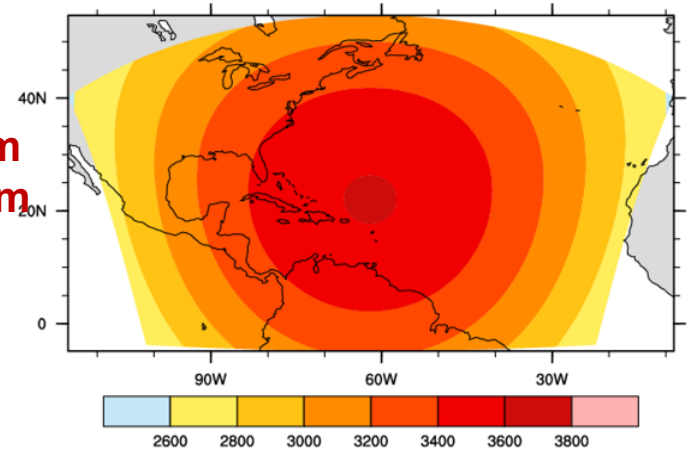
Current Status

HAFS v0.1J with ESG (Extended Schmidt Gnomonic) grid
- a more uniform grid for HAFS

- The default GFDL grid has non-uniform resolution over a large Atlantic domain: coarser resolution in the center; higher resolution over edges
- A more homogenous grid allows larger timestep; not necessarily limited by the minimum resolution in GFDL grid
- Easy design for large domains (e.g. basin-scale HAFS)
- 88 nodes, 7day forecasts

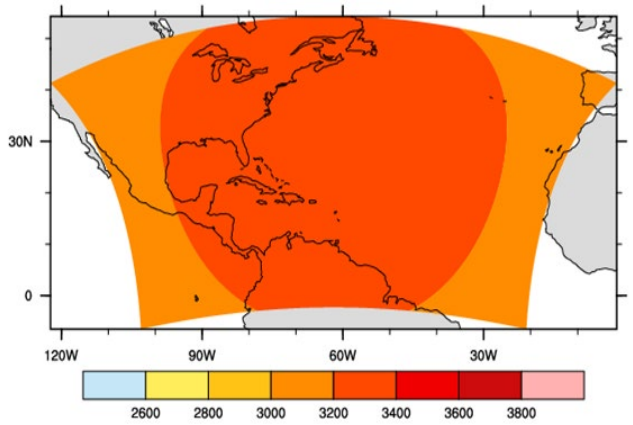
GFDL grid (default)

Min: 2.56 km
Max: 3.61 km



A more homogenous grid

ESG grid



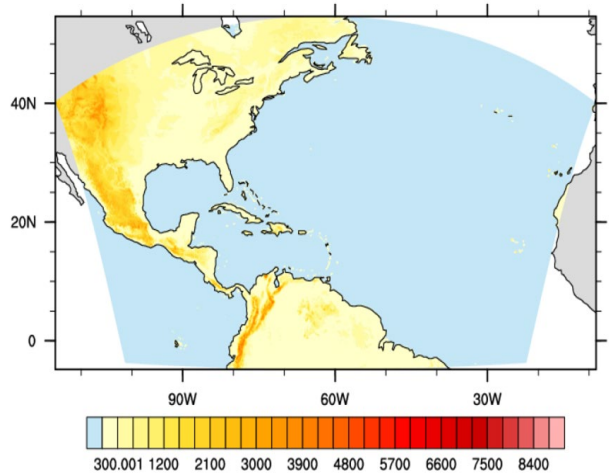
Min: 3.18 km
Max: 3.22 km

A basin-scale HAFS ESG domain (North Atlantic + East Pacific)

Current Status

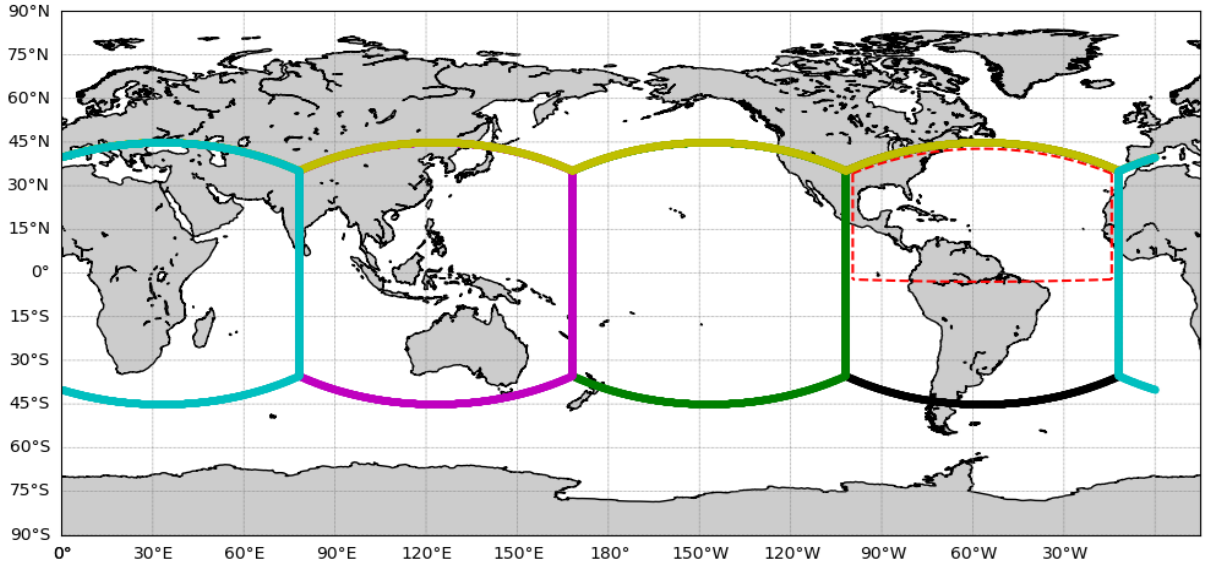
The HAFSv0.1E Configuration

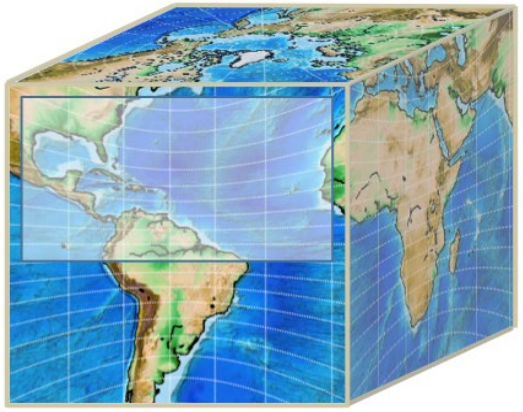
- ❖Basic configuration, based on HAFSv0.1A
  - ➢ One control member plus 17 perturbed ensemble members
  - ➢ Coarser resolutions: ~6km vs. 3km; L64 vs. L91
  - ➢ Cumulus parameterization on
  - ➢ Twice a day (00Z and 12Z), Atlantic basin only
- ❖IC/BC Perturbation:
  - ➢ IC/BC: GEFS grib2 (0.5x0.5)
- ❖Model Physics:
  - ➢ Stochastic kinetic energy backscatter (SKEB)
    - ■ Counteract excessive energy dissipation from numerical diffusion and interpolation, mountain and gravity wave drag, and deep convection
    - ■ Stream function is randomly perturbed to represent upscale kinetic energy transfer
  - ➢ Stochastically perturbed physics tendencies (SPPT)
    - ■ Represents uncertainties in physical parameterizations
    - ■ Multiplicative noise modifies total parameterized tendency
  - ➢ Stochastically perturbed PBL humidity (SHUM)
    - ■ Represents variability in the sub-grid humidity field
    - ■ Similar to SPPT, but directly modifies low-level humidity field instead of tendency



Current Status

The HAFSv0.1B Configuration





- One static nest over the Atlantic.
- Use “tropical channel” global layout of FV3.
- Forecasts length of 174 hours (7.25 days) in order to provide 7-day interpolated forecast .
- Include results for the global domain, to allow for direct comparison with operational GFS; assess impact of the nest on the global domain through 2-way feedback.
- Physics and dynamics options similar to HAFS v0.B in 2019, upgrades to PBL physics.

Goal: In addition to facilitating comparisons with operational and experimental model guidance, assess impact of high-resolution nests in HAFS on the global circulation, as well as feedback of the nests on each other.

Hurricane Analysis and Forecast System (HAFS): A collaborative Project in UFS Framework

07 NCAR/DTC

06 OFCM/AOC

05 ESRL/NESII

04 ESRL/GSD

NCEP/EMC 01

AOML/HRD 02

GFDL 03

Transition to UFS Applications

Assumptions for Proposed Configurations

- Maintain current CONOPS: max 5 storms in NHC AOR for HWRF & HMON; max 7 storms for HWRF in all global basins (NHC, CPHC and JTWC) i.e. total max 12 storms.

- Functionality before 2021 Hurricane season (06/01/21) for all targets:
  - Formal Vortex Initialization (VI/VM and/or GSI-based)
  - Coupling with ocean (2-way with HYCOM; 1-way with Waves)
  - GSI-based Data Assimilation capability
  - Workflow

- **All decisions on HAFS IOC based on EMC and NHC science evaluations**

HPC Resources for the Forecast job*

Operational:

- HWRF: 5x2149+2x2038=14821 cores
- HMON: 5x1032=5160 cores

- Total: 19981 cores = 833 nodes (on WCOSS Cray)*

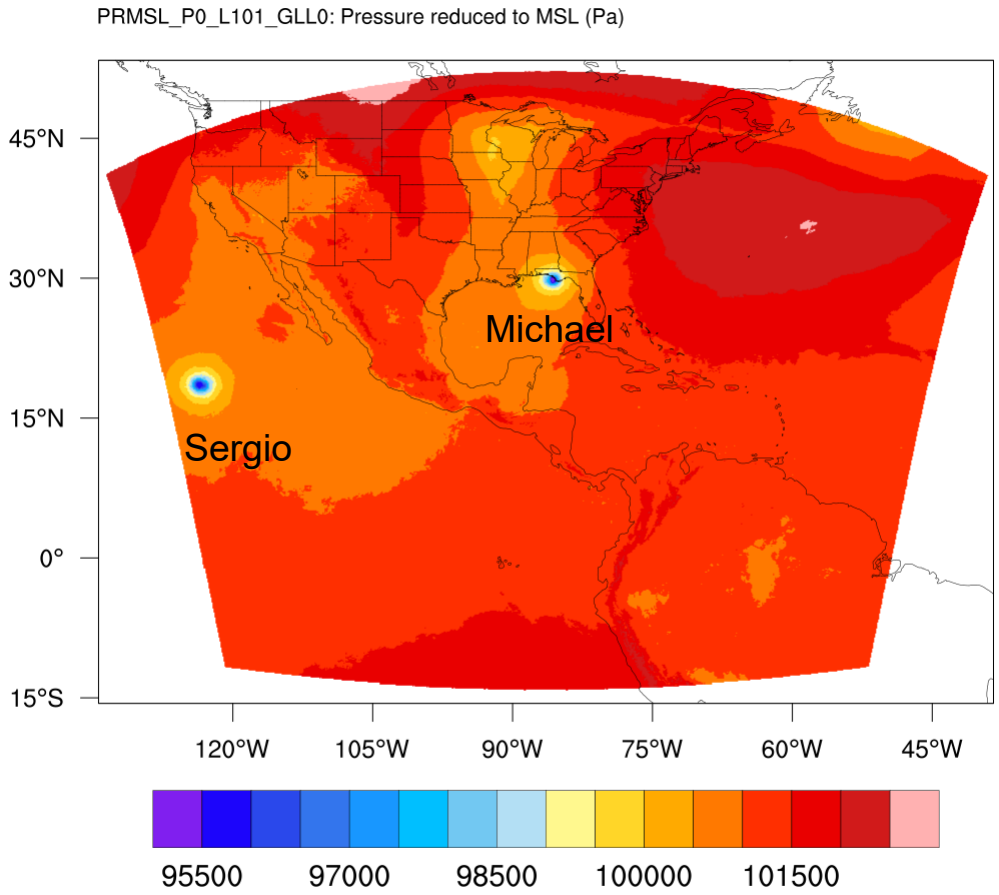
Experimental:

- HAFS-A: 4248 cores 5-days, 3km/L91; wall clock time ~ 5 hrs
- HAFS-J: 2122 core 7-days, 3km/L64; wall clock time ~ 5 hrs

* Operational forecast jobs needs to be completed in ~96min

Target Option 1* (with single moving nests)

- Storm-centric with smaller outer domain at 4.5 km, embedded moving nests at 1.5 km; ~127L; (maximum **12/5**; two variants for NHC regions)
- Vortex Initialization
- Coupling with ocean (2-way with HYCOM;1-way with Waves), Use CMEPS
- Data Assimilation: dual-resolution; hybrid 3DEnVar; self cycled (similar to operational HWRF)

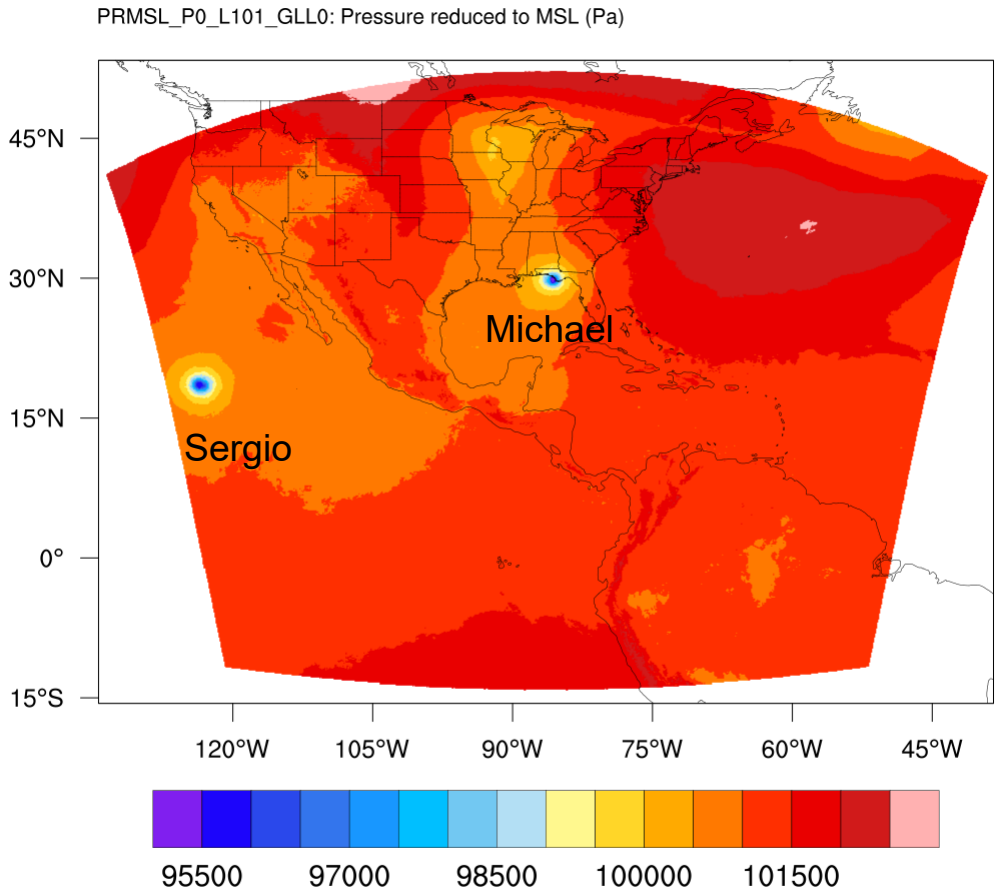


* **Primary for FY22; 12 domains replace both HWRF & HMON; 5 domains replace HMON**

Target Option 1* (with single moving nests)

Risks/Issues:

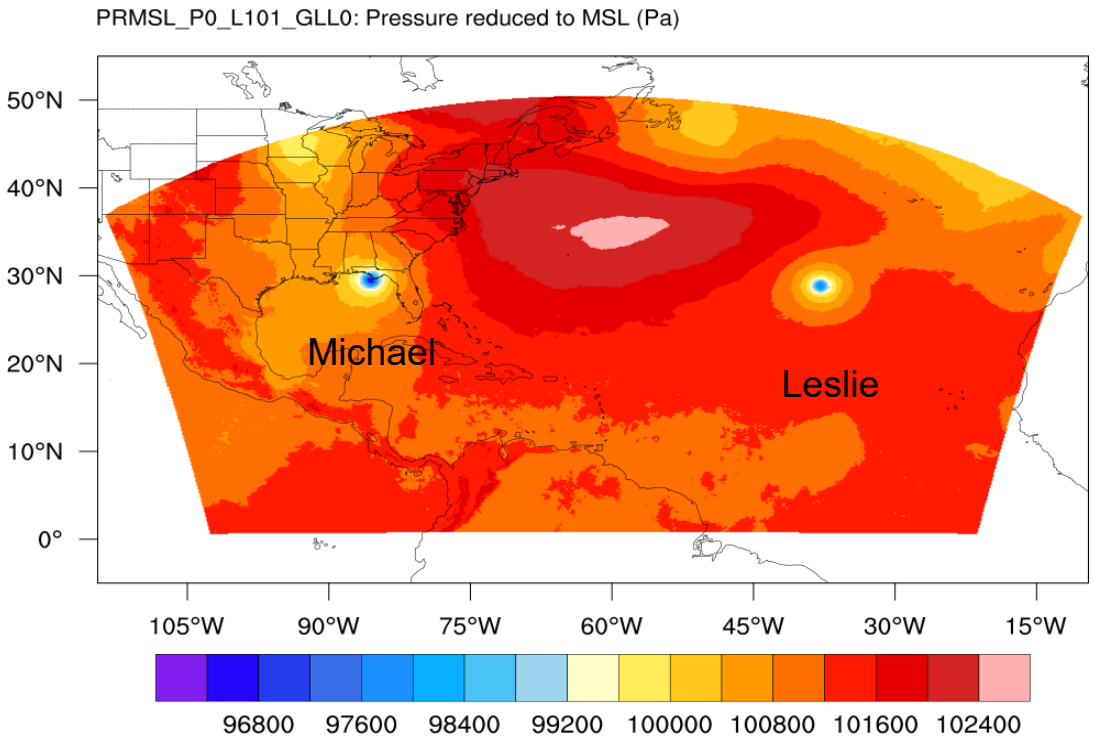
- Moving nests (ready by FY 21 season)
- Vortex Initialization
- Dual resolution self-cycled DA
- Inner-core DA
- Computer resources



* **Primary for FY22; 12 domains replace both HWRF & HMON; 5 domains replace HMON**

Target Option 2* (static nests; with LAM domains)

- Two separate domains at 3 km – NATL and EPAC (bigger than HAFS v0.1A), ~127L
- Vortex Initialization
- Coupling with ocean (2-way with HYCOM; 1-way with Waves), Use CMEPS
- Data Assimilation: Hybrid 3DEnVar; self-cycled

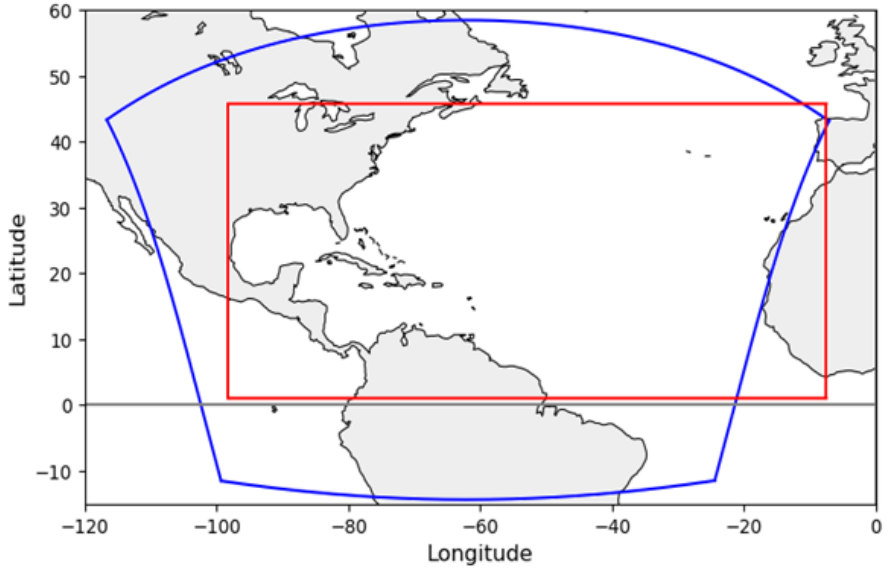


* **Back-up for FY22**; **Replaces HWRF or HMON**

Target Option 2A* (static nests; with LAM domains)

❖ NATL/EPAC/CPAC (5 storms)

- ➢ Two copies of Basin-centric HAFS-A or HAFS-J
- ➢ ~3km, L127, no moving nests
- ➢ GSI-based relocation (or HWRF style)
- ➢ Dual resolution, Self-cycled parent domain, inner-core DA with relocation
- ➢ Ocean/Wave coupling



❖ Other basins (2 storms)

- ➢ Storm-centric domains
- ➢ GSI-based relocation (or HWRF stsyle)
- ➢ 3DEnVar DA
- ➢ Ocean/Wave coupling

❖ Risks/Issues

- ➢ Self-cycled DA
- ➢ Computer resources

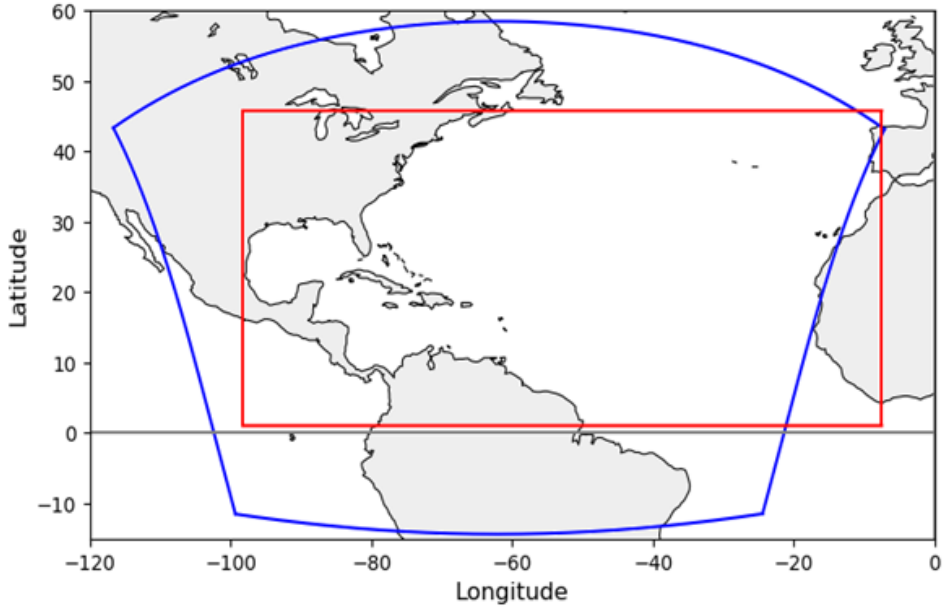
* **Back-up for FY22; Replaces HWRF**

Target Option 2B* (static nests; with LAM domains)

- **NATL/EPAC/CPAC (5 storms)**
  - Two copies of Basin-centric HAFS-A or HAFS-J
  - 3km, L127, no moving nests
  - Dual resolution, Self-cycled parent domain, in-core DA with relocation
  - Ocean/Wave coupling

- **Other basins (2 storms)**
  - Current operational HWRF

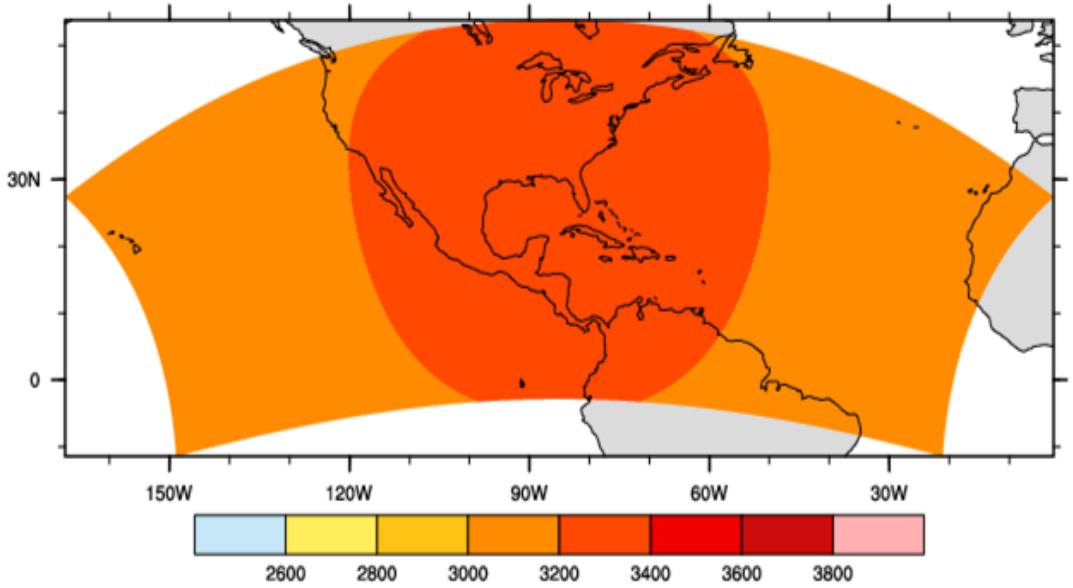
- **Risks/Issues**
  - Self-cycled DA
  - Computer resources



* **Back-up for FY22; Replaces HMON**

Target Option 3A* (with moving nests)

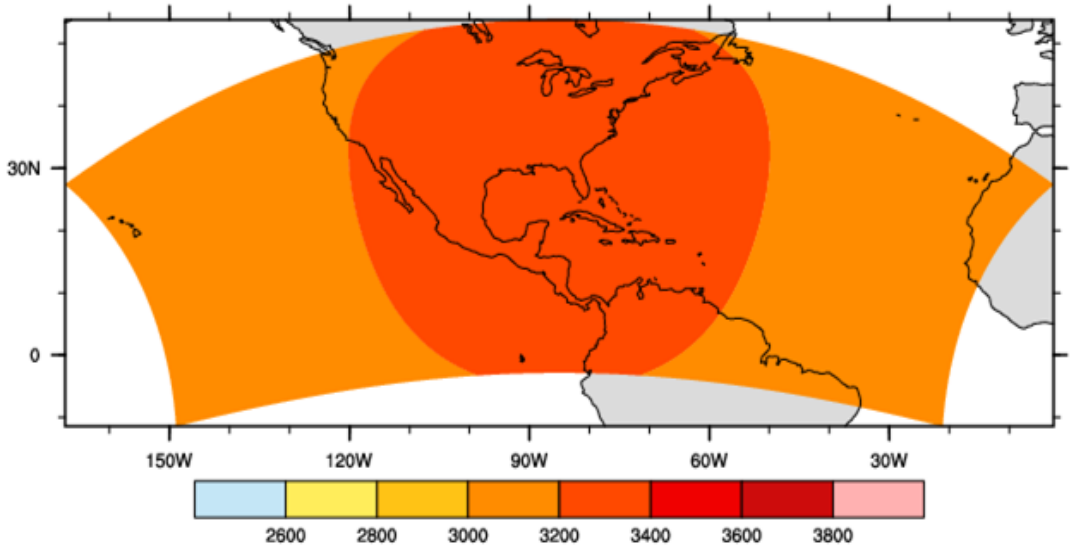
- **Basin scale (NATL, EPAC & CPAC) at 4.5 km, ~127L**
  - Moving nests at 1.5 km (maximum 5)
  - Vortex Initialization (VR/VM)
  - Coupling with ocean (2-way with HYCOM; 1-way with Waves), Use CMEPS
  - Data Assimilation: 3DEnVAR, dual-resolution self-cycled; inner core?
  - 30- or 40-member ensemble for self-cycled DA
- **Other basins (2 storms)**
  - Storm-centric domains
  - 3DEnVar DA
  - Ocean/Wave coupling
- **Risks/Issues**
  - Multiple moving nests
  - Current HAFS-J has issue with large domain size
  - Self-cycled DA, inner-core DA
  - Computer resources
  - CPAC?



* **Primary for FY23; Replaces both HWRF & HMON**

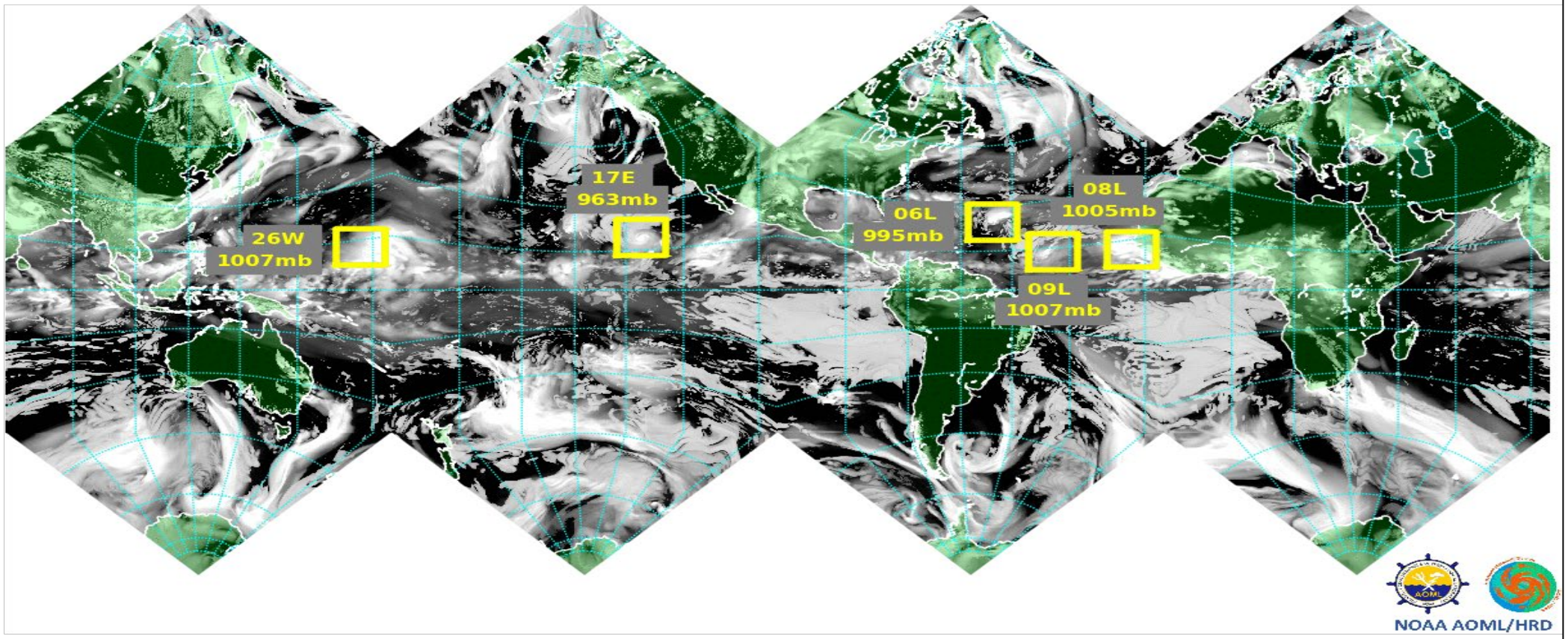
Target Option 3B* (with moving nests)

- **Basin scale (NATL, EPAC & CPAC) at 6 km, ~127L**
  - 6km parent, 2km moving nests, L127 (maximum 5)
  - Vortex Initialization (VR/VM)
  - Coupling with ocean (2-way with HYCOM; 1-way with Waves), Use CMEPS
  - Data Assimilation: 3DEnVAR, dual-resolution self-cycled; inner core?
  - Two-member ensemble
- **Other basins (2 storms)**
  - Storm-centric domain
  - 3DEnVar DA
  - Ocean/Wave coupling
- **Risks/Issues**
  - Multiple moving nests
  - Current HAFS-J has issue with large domain size
  - Self-cycled DA, inner-core DA
  - Computer resources
  - CPAC?



* **Back-up for FY23; Replaces both HWRF & HMON**

Long-term Target for HAFS/GFS



06L: Florence; 08L: Helene; 09L: Isaac; 17E: Olivia; 26W: Mangkhut

Thank You !