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

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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_nocpsstugwd 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
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, 7-day forecasts.
Current Status

The HAFSv0.1E Configuration

❖ Basic configuration, based on HAFSv0.1A
  ➢ One control member plus 17 perturbed ensemble members
  ➢ Coarser resolutions: \sim6km 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 v0.1B 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

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 style)
  - 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!