HAFS Development Status Report from EMC

- HAFSv0.2 baseline configuration
- HAFS Data Assimilation advancement
- Static telescopic and moving nest development
- Ongoing work and near future plan

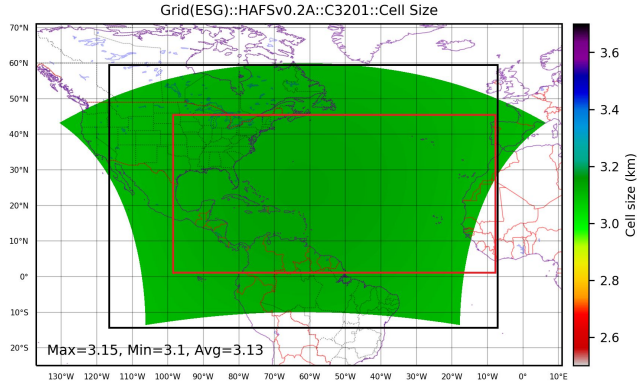
HAFS Development Team at EMC (04/28/2021)

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

The HAFSv0.2A Phase 1 Baseline Configuration

(H2AB: Based on the 2020 HAFS.v0.1A/S experiments)

- The FV3ATM component
  - Use the feature/hafsv0.2_baseline branch with its subcomponents synced with their latest authoritative branches (as of 01/20/2021)
  - 3-km regional ESG grid with the L91 (10 hPa top) vertical levels
  - GFSv16 netcdf files for IC; 3-hrly GFSv16 grib2 files for LBC
  - dt_atmos=90s; k_split=4; n_split=5; radiation time step: 1800s
  - Lateral boundary condition blending (nrows_blend=10)
  - Use the HAFS_V0_gfdlmp_nonsst physics suite
    - GFDL microphysic; RRTMG radiation; Scale-aware SAS convection; Noah LSM; GFS surface layer with HWRF exchange coefficients; GFS EDMF PBL with HWRF modification; Turn on orographic GWD but keep convective GWD off; Turning off the NSST component
- The HYCOM component
  - CMEPS based ocean coupling with the bilinear regridding method
  - 1/12-degree NATL domain (1-45.78N, 261.8-352.5E) with L41
  - Ocean IC from RTOFSv2 and persistent oceanic LBC
  - Atmospheric forcing from GFSv16 grib2 files for non-overlap area



FV3ATM model domain

FV3ATM output domain

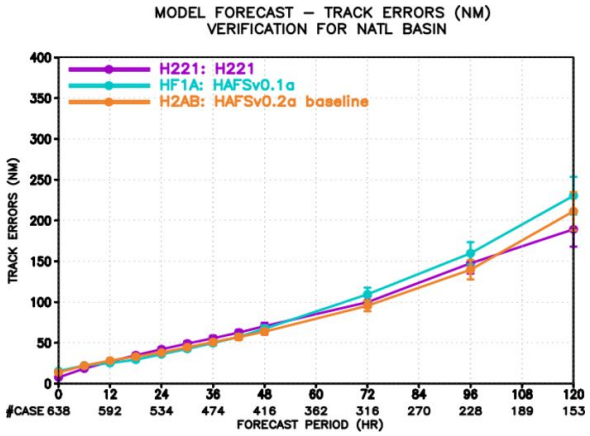
HYCOM ocean domain

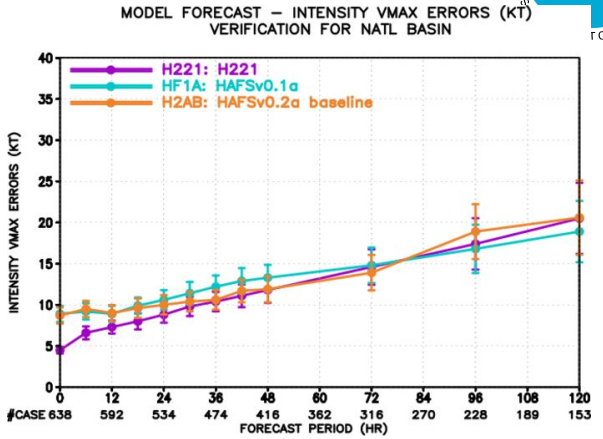
HAFSv0.2A Baseline Performance

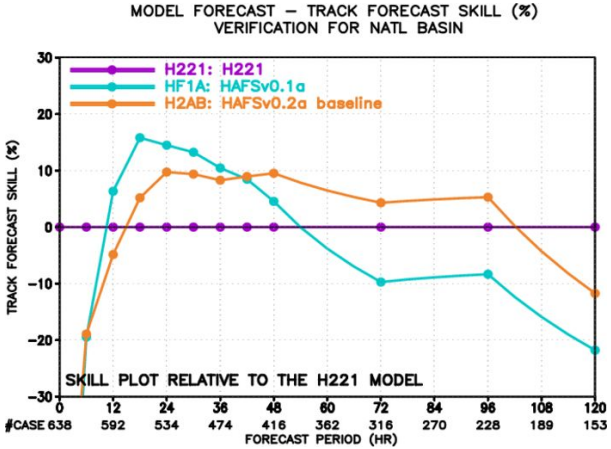
- H221: Operational HWRF
- HF1A: HAFSv0.1A, HFIP 2020 real time expt., GFSV15/RTOFS
- H2AB: HAFSv0.2A baseline with GFSV16/RTOFSv16, regional ESG grid

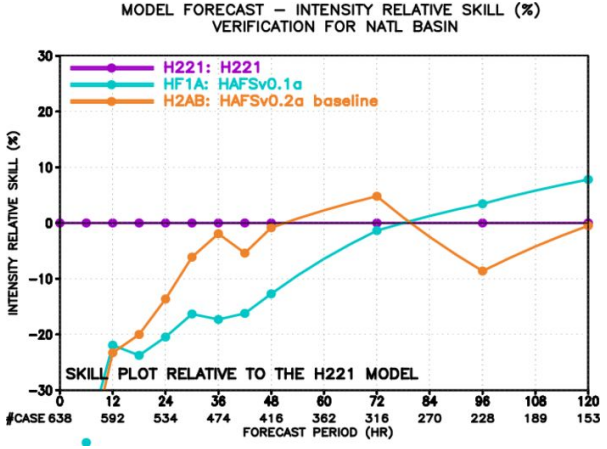
Storms:

- 2020 03-28L
- 2019 05-12L



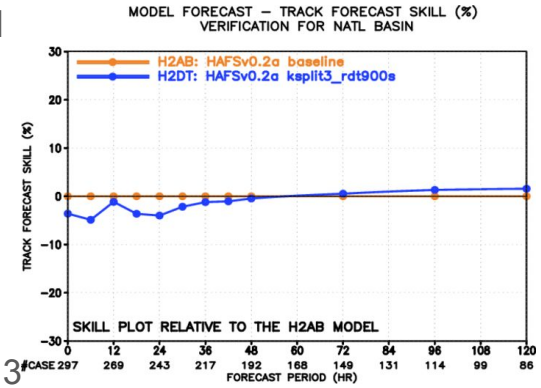


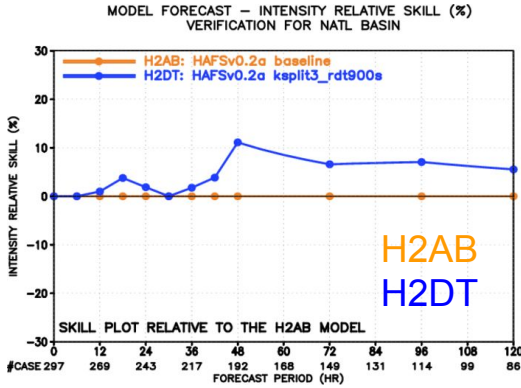


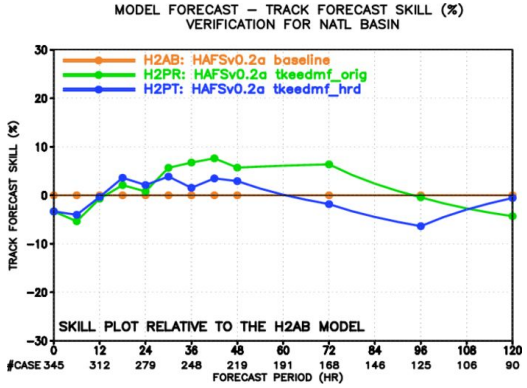


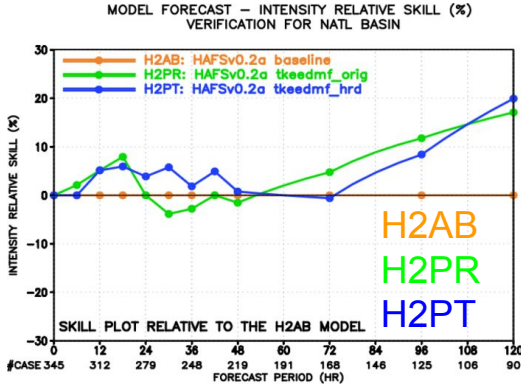
Phase-2 Experiments based on HAFSv0.2A Baseline

- **Vertical resolution/distribution and model top**
  - L96 with 2hPa model top (H96L)
  - L108, with 2hPa model top (H108)
- **Combined radiation and vertical remapping time steps (H2DT)**
  - Smaller radiation time step (900s vs 1800s)
  - Larger vertical remapping time step (k_split of 3 vs 4)
- **Model physics**
  - TKE-based EDMF GFS PBL scheme, used in 2020 HAFS-B configuration (H2PT)
  - Original GFSv16 TKE-based EDMF GFS PBL scheme (H2PR)
  - Hybrid EDMF GFS PBL scheme modification from Ping Zhu, FIU (H2PF)
  - Use the e-epison PBL scheme (H2PE)









Track Skill

Intensity Skill

The HAFSv0.2A Phase 2 Combined Configuration

(H2PC: Based on HAFSv0.2A baseline configuration)

- The FV3ATM component
  - Use the HAFS feature/hafs_ensda_202104 branch
  - 3-km ESG C3099 grid with L91 (10 hPa top) vertical levels
  - GFSv16 netcdf files for IC; 3-hrly GFSv16 grib2 files for LBC
  - dt_atmos=90s; k_split=3; n_split=5; radiation time step: 900s
  - LBC blending with nrows_blend=10
  - Turn off the two thickness parameters in the GFDL tracker
  - Use the HAFS_V0_gfdlmp_nonsst physics suite
    - GFDL microphysic; RRTMG radiation; Scale-aware SAS convection; Noah LSM; GFS surface layer with HWRF exchange coefficients; GFSv16 scale-aware TKE-EDMF PBL scheme; Turn on orographic GWD but keep convective GWD off; Turning off the NSST component
- The HYCOM component
  - CMEPS based ocean coupling with the bilinear regridding method
  - 1/12-degree NATL domain (1-45.78N, 261.8-352.5E) with L41
  - Ocean IC from RTOFSv2 and persistent oceanic LBC
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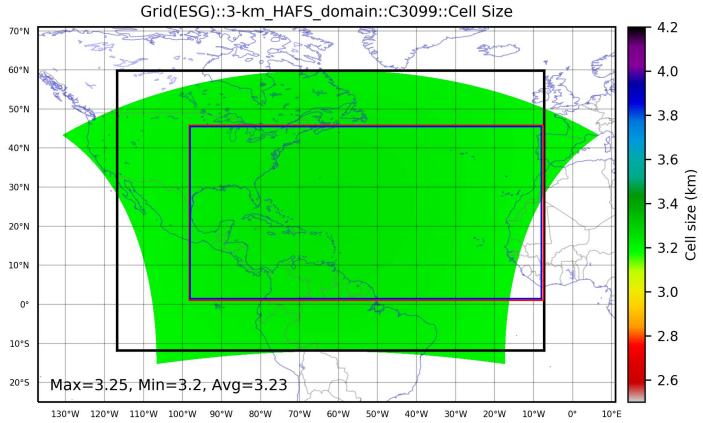


FV3ATM model domain

FV3ATM output domain

HYCOM ocean domain

WW3 wave domain

Updates on HAFS DA Development

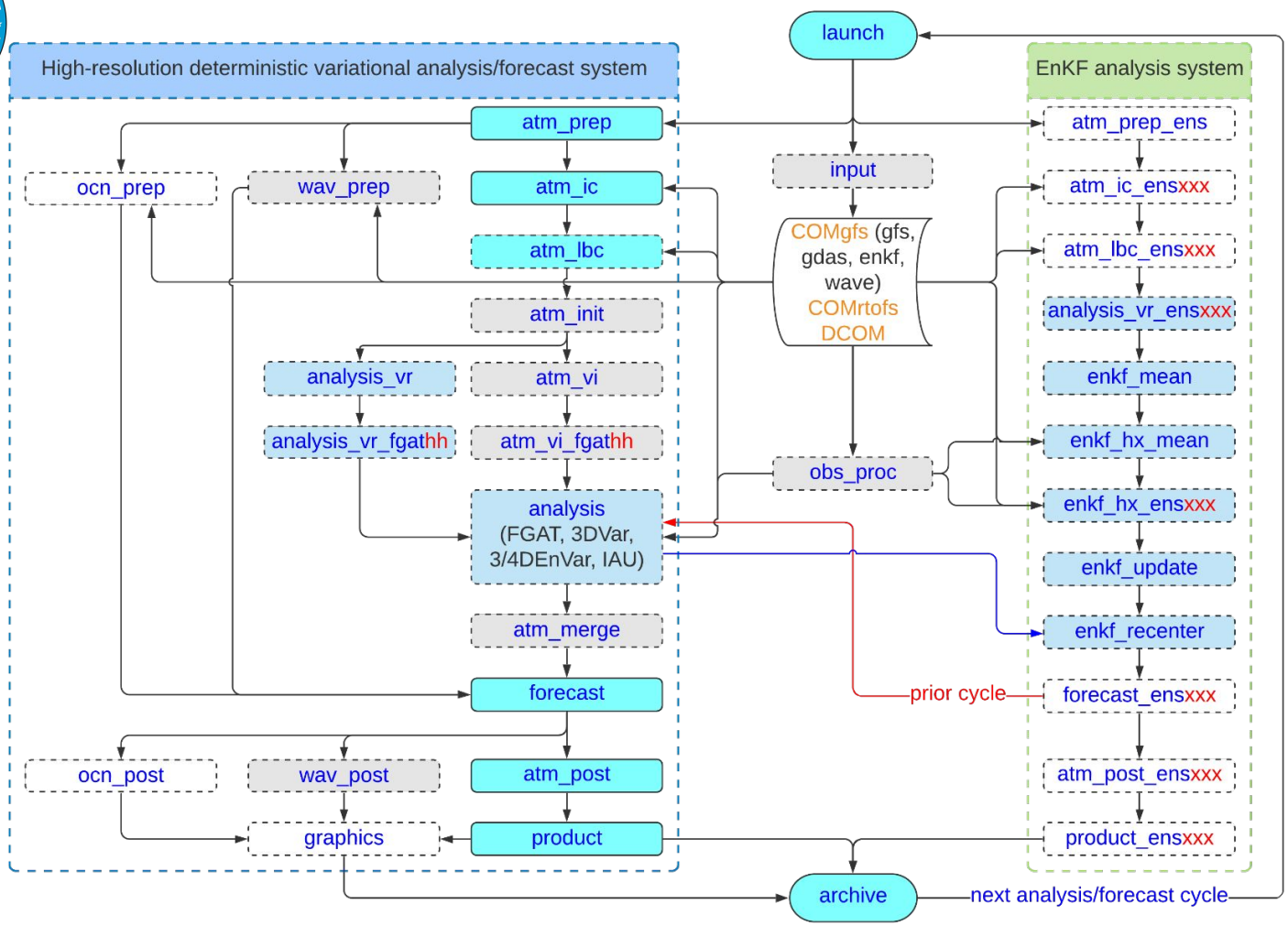
Collaborative effort among the HAFS DA Development Team

- EMC hurricane project team in close collaboration with the FV3CAM group
- OU collaborators
- UMD collaborators
- HRD and UM CIMAS collaborators
- DTC collaborators
- University at Albany collaborators

Current available HAFS DA capabilities:

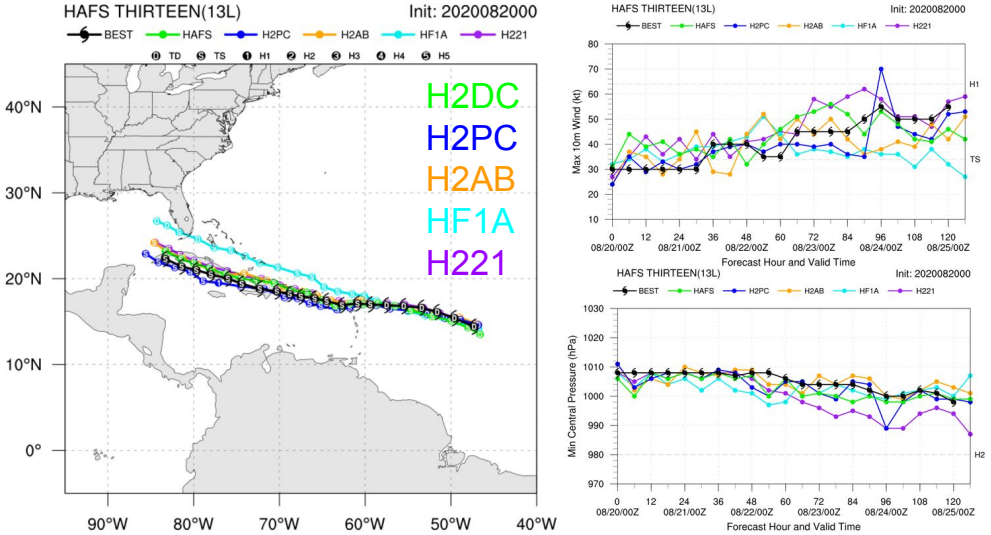
- Cold-start, warm-start capabilities
- GSI-based Vortex Relocation (originally developed by Henry Winterbottom)
- 3DVar and 3DEnVar with GDAS ensembles
- FGAT capability (OU)
- 3DEnVar with dual-resolution self-cycled EnKF ensembles (EMC/OU)
- Assimilating all observations ingested in HWRF/GDAS/GFS
- Standardized/generalized HAFS ESNDA workflow jobs/tasks

Latest HAFS ENSDA Workflow



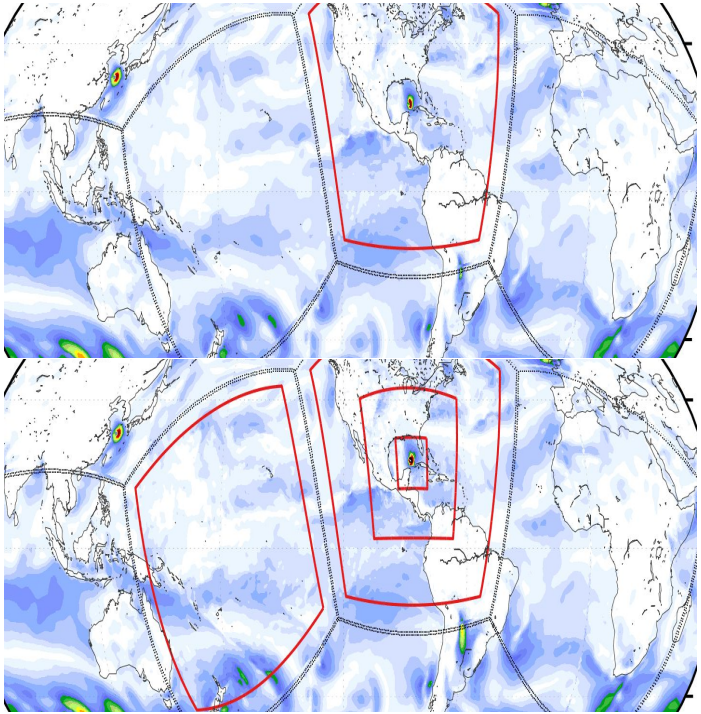
Kicked off Two HAFS DA Experiments based on H2PC

- H2DB: (Li)
  - Based on HAFSv0.2A phase-2 combined configuration (H2PC)
  - 3 hourly FGAT
  - 3DEnVar with GDAS ensembles
  - Assimilating full observations ingested in HWRF/GFS/GDAS
- H2DC:
  - Based on H2DB
  - 40 dual-resolution (6-km C1550 vs 3-km C3099), self-cycled HAFS ensembles
  - 3DEnVar using full covariance from the self-cycled HAFS ensembles
- Storms and time periods to run (running, pending)
  - 2020081918 --- 2020082718 (Laura13L, Marco14L)
  - 2020090612 --- 2020092300 (17-24L)
  - 2019082406 --- 2019091006 (Dorian05L-08L)



Updates on HAFS Global-Nesting Development
In close collaboration with HRD and GFDL collaborators

- Synced support/HAFS branch with the authoritative ufs-weather-model develop branch as of 04/16/2021
- Synced HAFS feature/multi_nests branch with the latest HAFS develop branch, supporting the pre-processing steps for multiple static and telescopic global nests (with HRD collaborators)
- Conducted technical testings for various global multiple static and telescopic nesting capabilities, e.g.,
  - C96 global (6 tiles) with 1 nest (tile# 7 in tile# 6)
    - global 6 tiles: ~100 km; tiles# 7 (inside tile# 6): ~33 km
  - C96 global (6 tiles) with 4 multiple static and telescopic nests
    - global 6 tiles: ~100 km; tiles# 7 (EPAC nest inside tile# 2) and 8 (NATL nest inside tile# 6): ~ 33 km; tile# 9 (inside tile# 8): ~11 km; tile# 10 (inside tile# 9): ~ 3.6 km
- Working on syncing HAFS moving nest branches with the latest HAFS develop branch and working on the moving over land capability for the nests together with HRD collaborators



48-hr surface wind speed forecasts initialized at 2020082512Z focused on Hurricane Laura13L. Animations created by Yonghui Weng.

Ongoing and near future developments

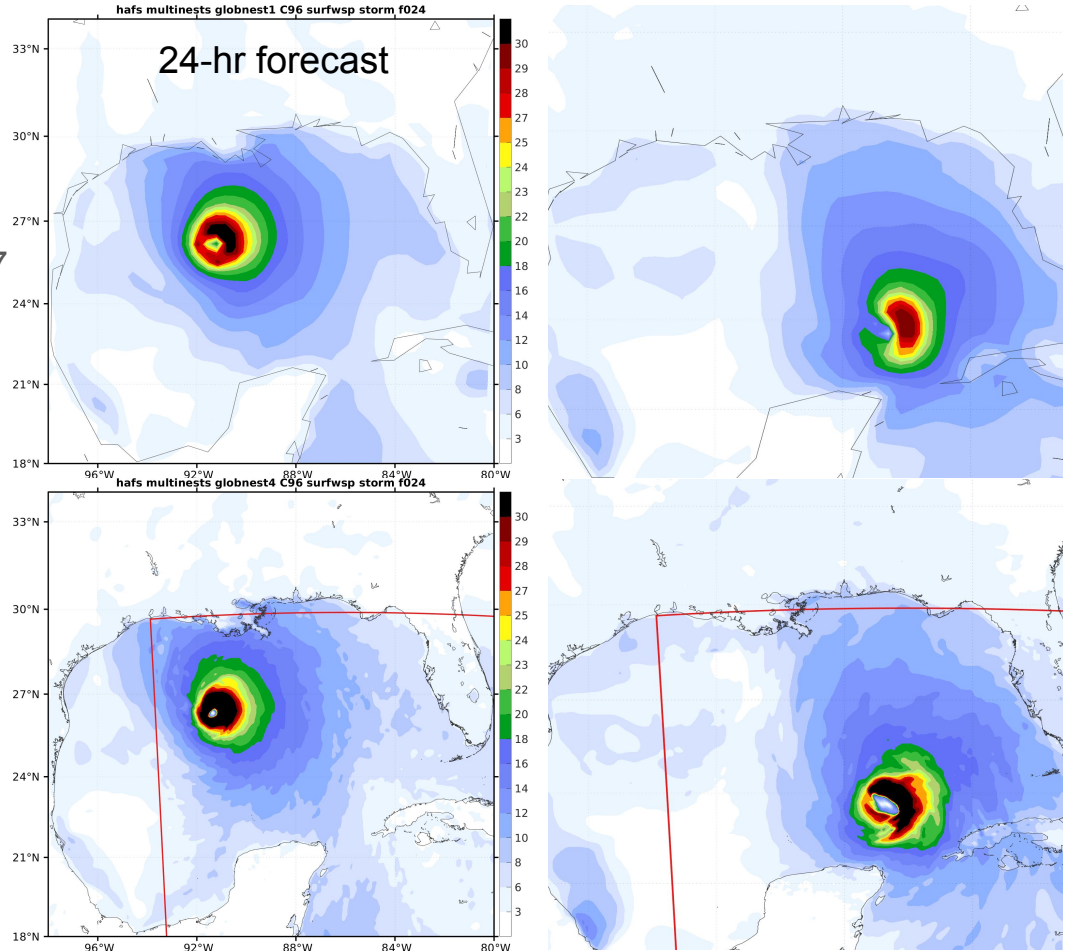
- **HAFSv0.2 Baseline (2021 real time demo)**
  - Test GFSv17 TKE-based EDMF GFS PBL scheme
  - Test with the new version of UGWP
  - Improve HAFS HYCOM coupling
  - Develop HAFS WW3 one-way coupling
- **Data Assimilation and TC Initialization**
  - Assimilate mesonet/metar, enhanced AMVs from GOES-R
  - Analyze/verify results from various DA options, e.g. HAFS ens. Vs GDAS ens.
  - Explore TC relocation, initialization capability
  - Hurricane specific obsproc, domain merging, and increment processing techniques
  - Configurable and more frequent (3-hrly or hourly) DA/analysis cycling
  - HAFS DA system with high-resolution storm-following moving nests
- **Telescopic and Moving Nests in Global Framework**
  - Enable shifting surface variables with the moving nest
  - Add/merge to moving nest to HAFS workflow
  - Add write component capability for both parent and nest domains

Thanks!

High-resolution vs low-resolution nests

global 6 tiles (~100 km) with a 33 km nest (tile# 7 inside tile# 6)

C96 global (6 tiles) with 4 multiple static and telescopic nests (highest resolution of ~3.6 km)



48-hr surface wind speed forecasts initialized at 2020082512Z focused on Hurricane Laura13L. Figures and animations created by Yonghui Weng.