HAFS AT NOAA AOML: GRID DEVELOPMENT, PHYSICS INVESTIGATION, AND TC ANALYSIS

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OVERVIEW

- NOAA AOML is working on multiple aspects of development of the Hurricane Analysis and Forecast System (HAFS)

- Collaborative effort with EMC, GFDL, ESRL, with feedback from operational centers

- The "F" in the HAFS system will be based off of nested FV3

- This presentation will focus on work to date, including:
  1. FV3 global-nest configuration, nested grid development (multiple nests, progressing toward moving nest)
  2. Physics changes based on observations
  3. TC research (Michael case study based on ensembles)

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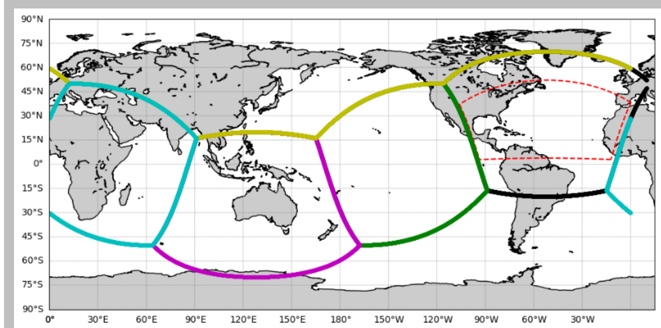
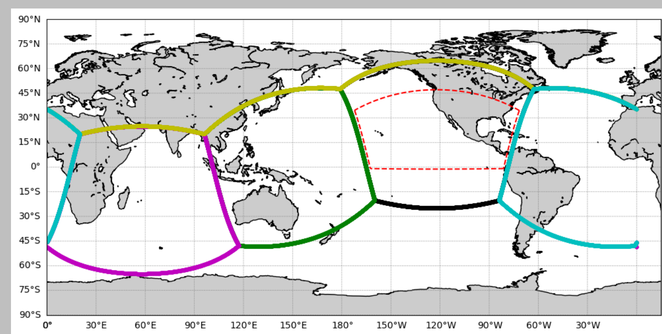
GLOBAL/NEST LAYOUT

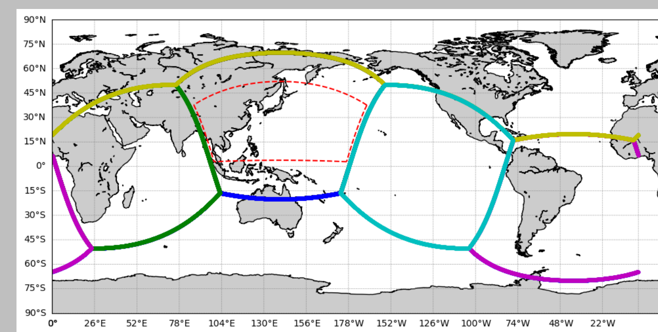
2017-2018 Atlantic Grid



East Pacific Focused

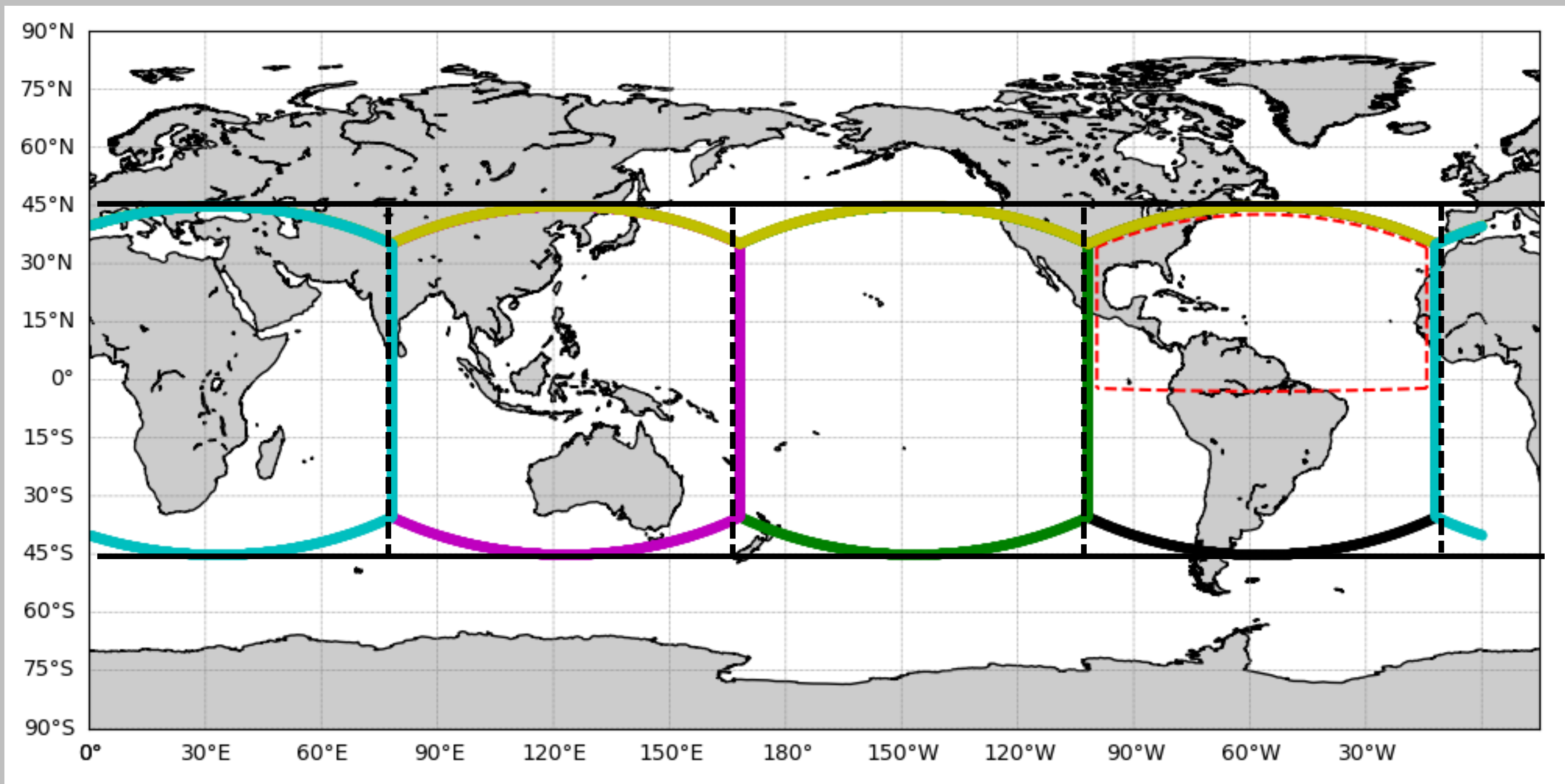


West Pacific Focused



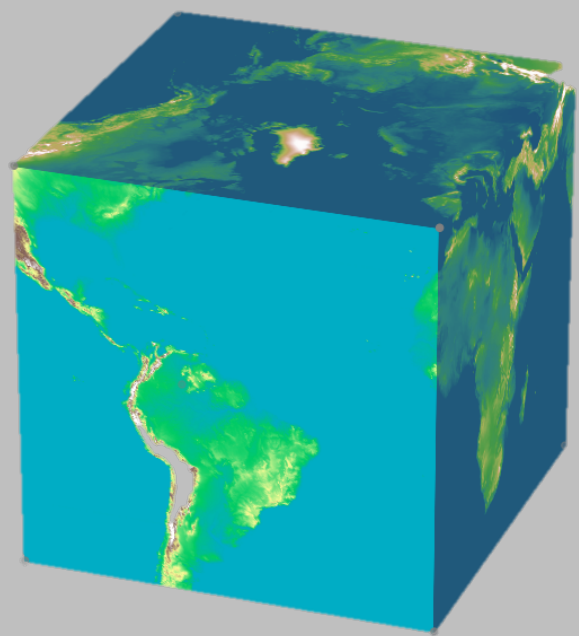
- 2017-2018 real-time Atlantic runs at GFDL were based on a layout with a tile centered at -57W, 25N
- Similar configurations for the EPAC/WPAC can be derived by moving the tiles around
- None of these configurations are optimal for a multiple-nest/moving-nest global configuration (corner points in the Caribbean and/or Bay of Bengal)

TROPICAL CHANNEL CONFIGURATION



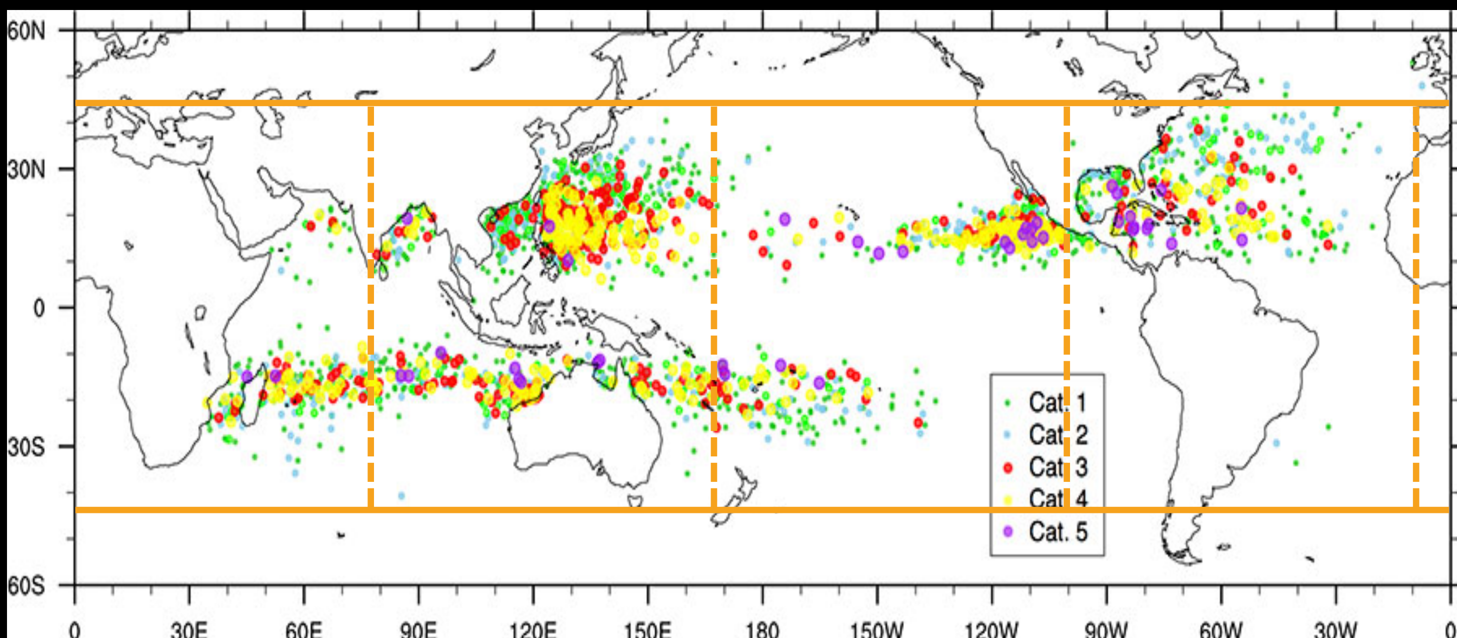
- ➢ Layout of the 6 tiles for global TC prediction

GLOBAL CUBED-SPHERE CONFIGURATION



- ➢Global cubed-sphere for “Tropical Channel” layout
- ➢Atlantic tile covers entire MDR, Caribbean, Gulf

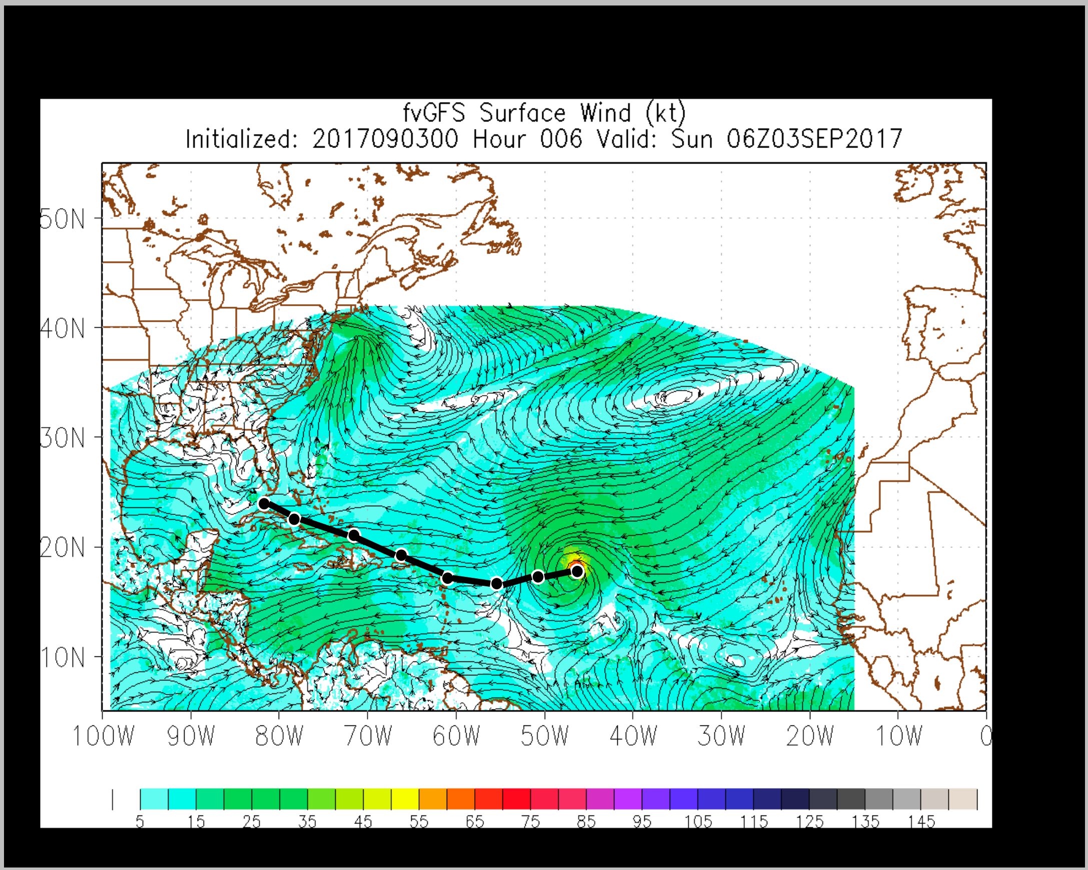
LOCATIONS OF TC LIFETIME MAXIMUM INTENSITY



The locations of lifetime maximum intensities (LMI) of tropical cyclones for the period 1985–2014. LMI is color-coded according to category on the Saffir-Simpson Hurricane Wind Scale.

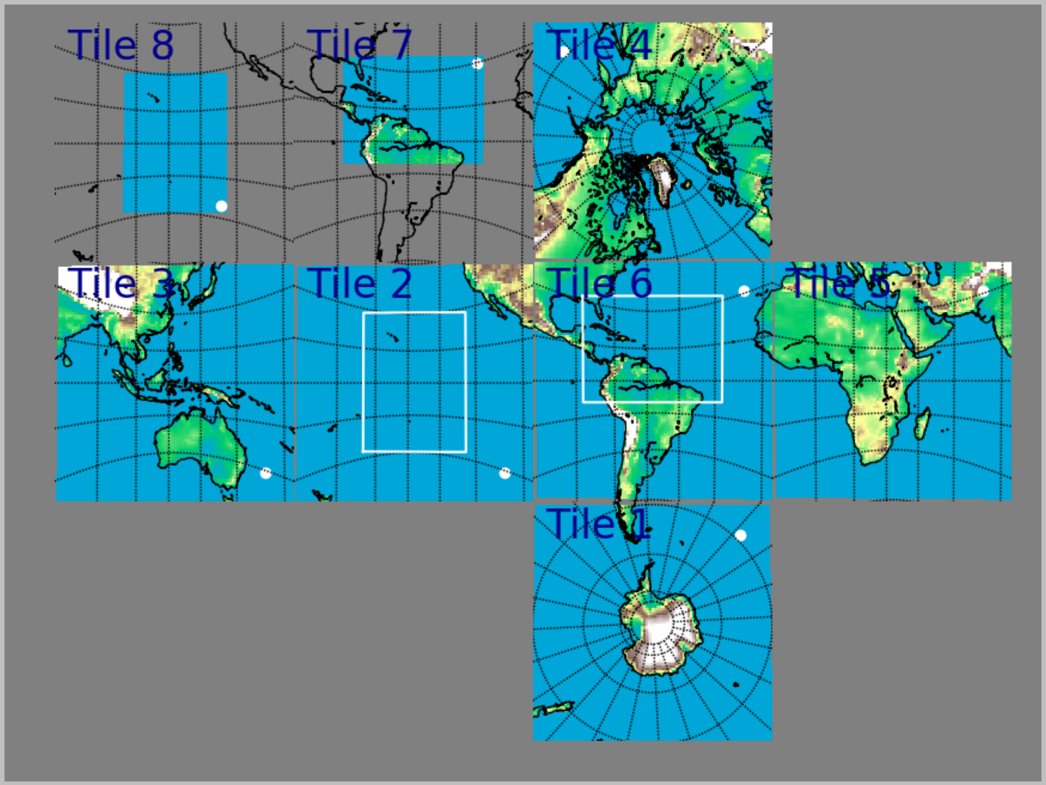
Ramsay, Hamish. 2017 "The Global Climatology of Tropical Cyclones." Oxford Research Encyclopedia of Natural Hazard Science. 15 Aug. 2018.

IRMA EXAMPLE (7-DAY FORECAST)



- Track is generally consistent with obs (slightly NE by Day 7)
- Storm is very intense (down to 890 hPa in the model)
- Ocean coupling needed
- Evaluation and re-calibration of global physics parameterizations in tropics needed

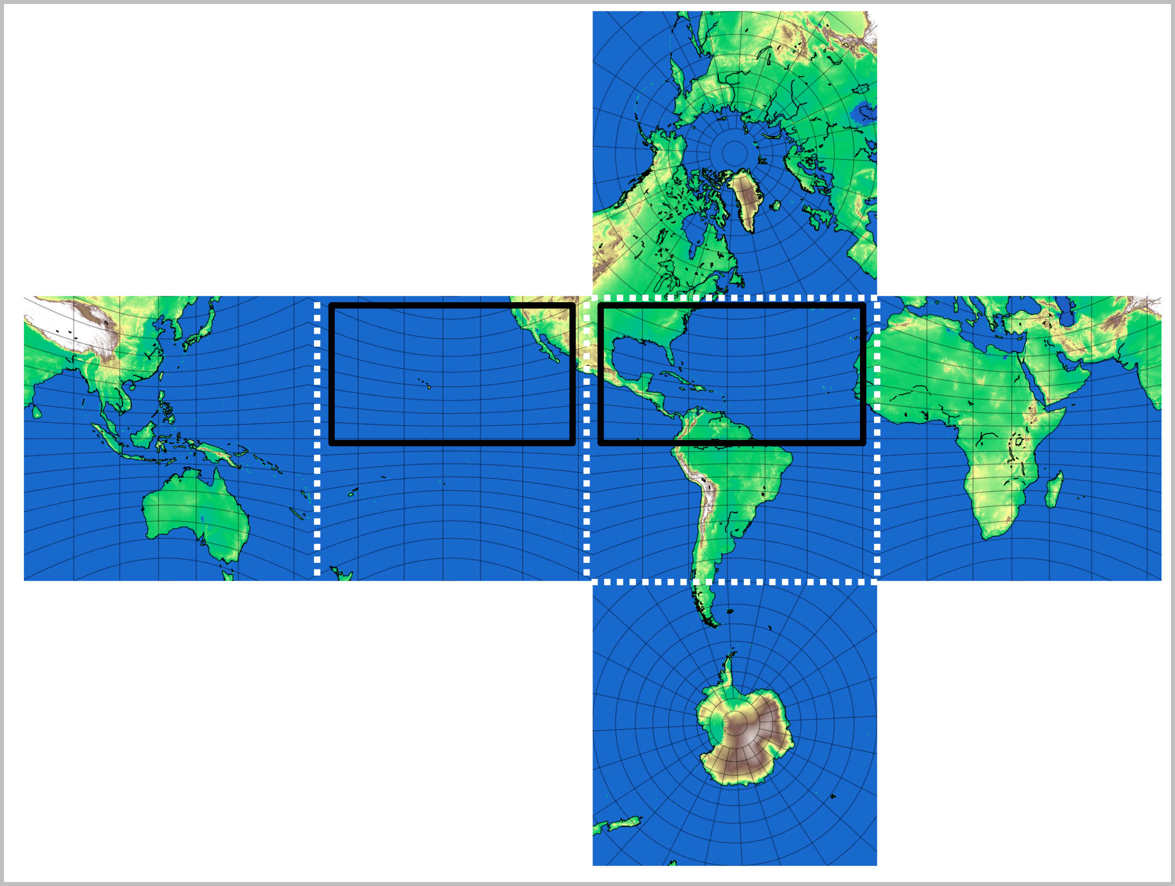
MULTIPLE NESTS



- One of the first steps towards a global moving-nest configuration is the ability to do multiple static nests in one global run
- This capability is in progress (grid and IC generation is done, model runs still in testing)

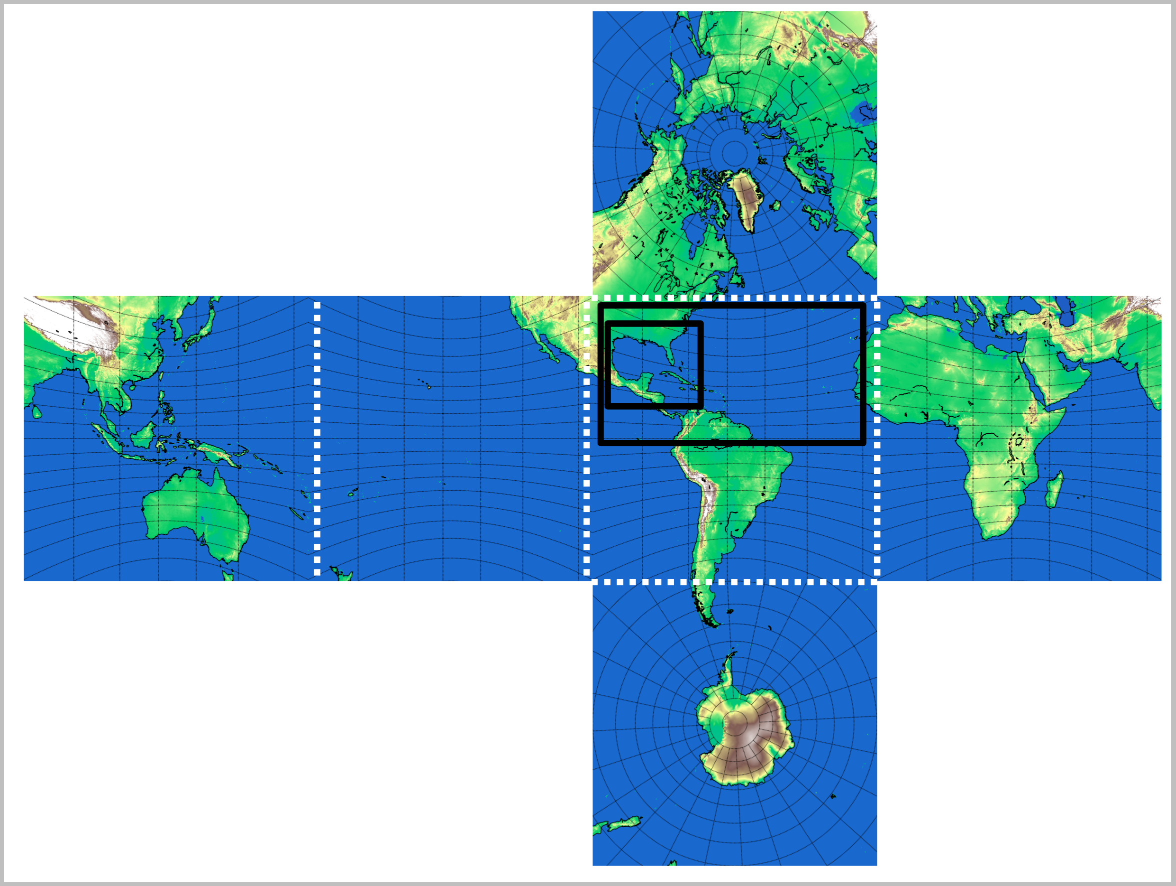
FUTURE DIRECTIONS: NEST DEVELOPMENT

- Incremental approach to nest development:
  - **Two static nests (almost done)**



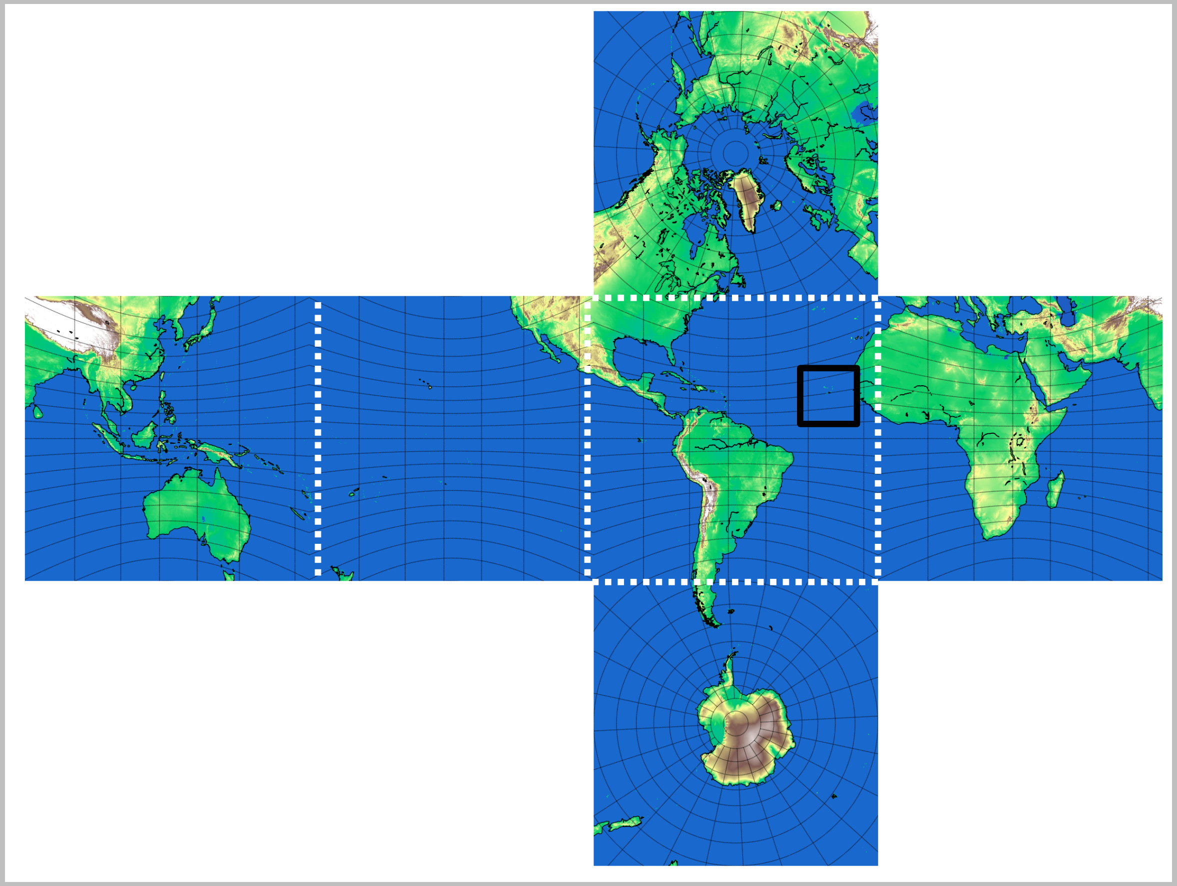
FUTURE DIRECTIONS: NEST DEVELOPMENT

- Incremental approach to nest development:
  - Two static nests (almost done)
  - **Telescoping static nests**



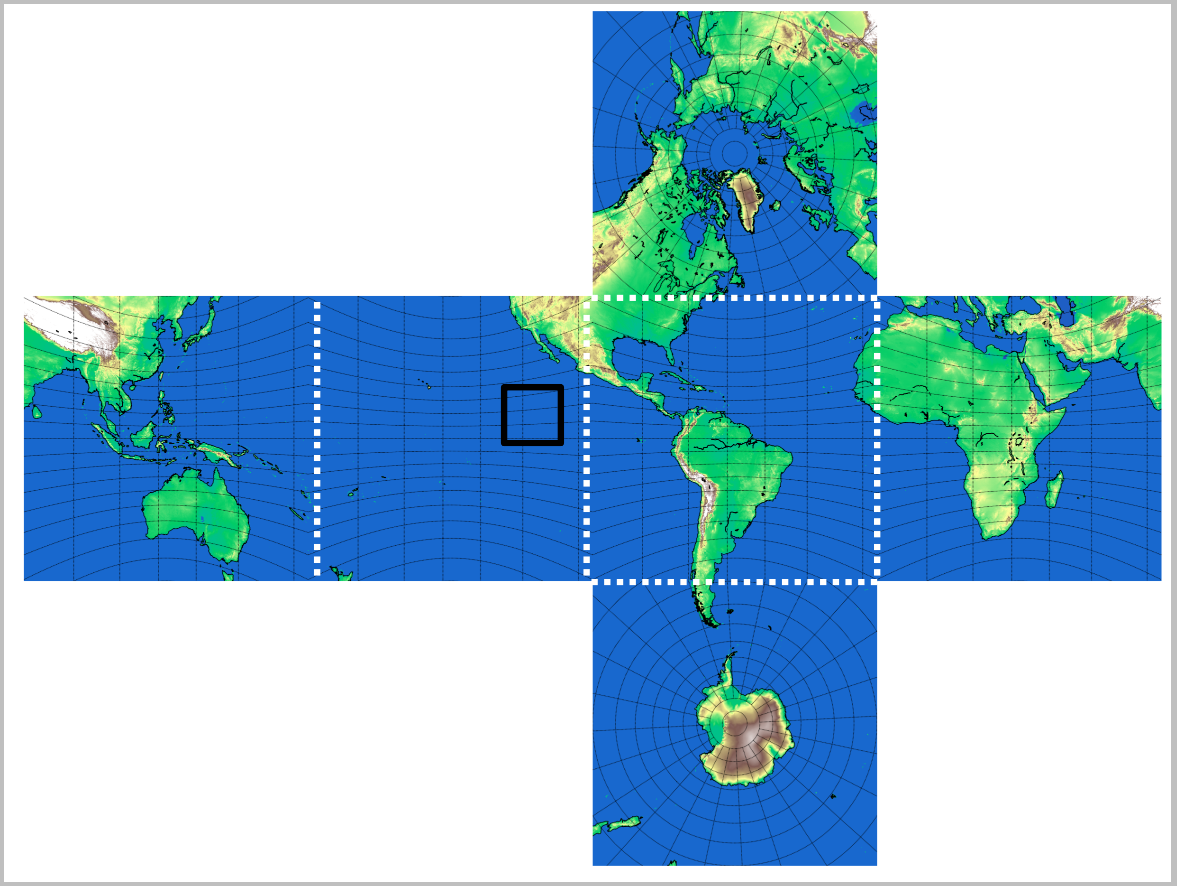
FUTURE DIRECTIONS: NEST DEVELOPMENT

- Incremental approach to nest development:
  - Two static nests (almost done)
  - Telescoping static nests
  - **Nest moving within one tile**



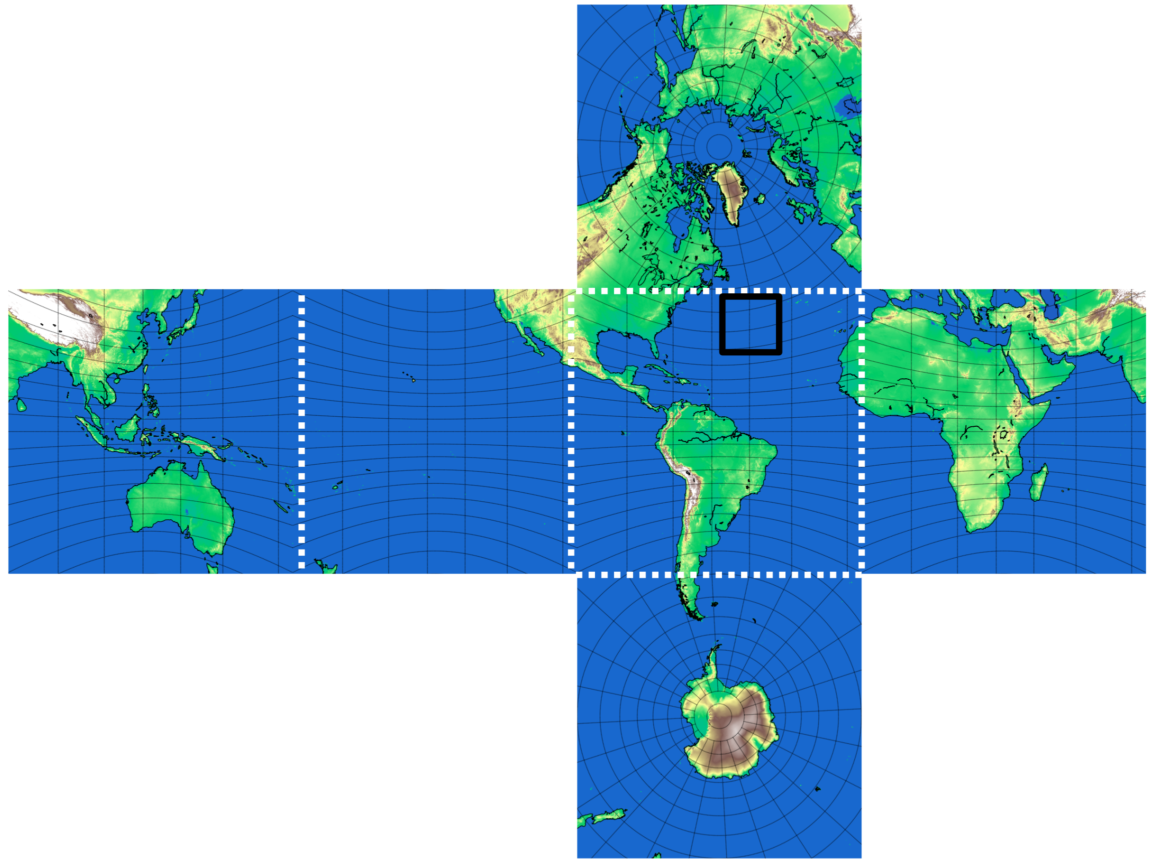
FUTURE DIRECTIONS: NEST DEVELOPMENT

- Incremental approach to nest development:
  - Two static nests (almost done)
  - Telescoping static nests
  - Nest moving within one tile
  - **Nest moving across an edge (likely needed for recurving cases and long tracks)**

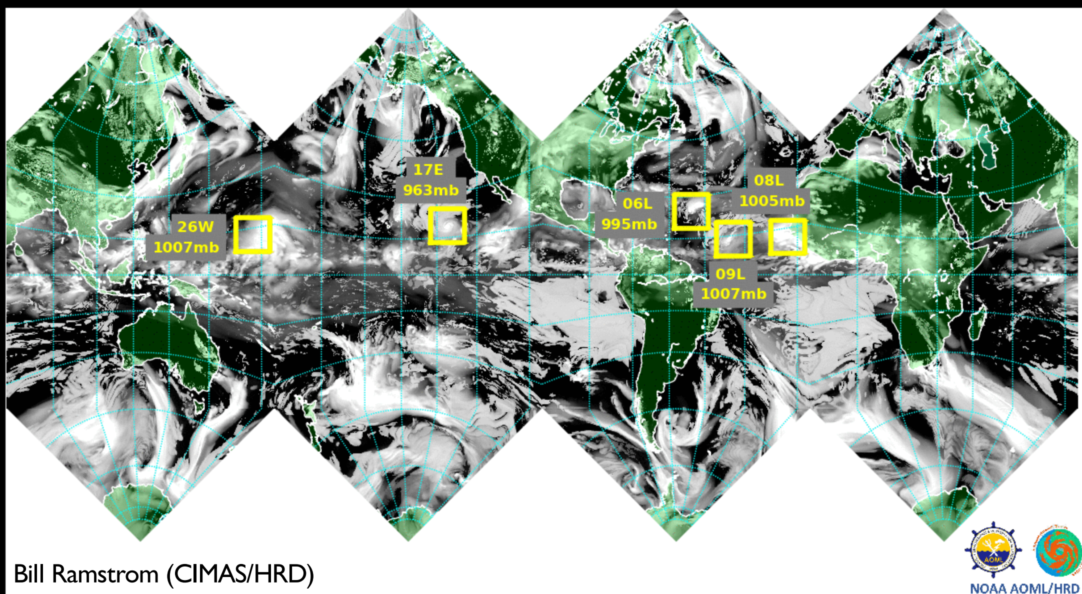


FUTURE DIRECTIONS: NEST DEVELOPMENT

- Incremental approach to nest development:
  - Two static nests (almost done)
  - Telescoping static nests
  - Nest moving within one tile
  - Nest moving across an edge (likely needed for recurving cases and long tracks)
  - **Nest crossing a corner (hopefully less frequent but needs to be dealt with)**



DEMONSTRATION OF FUTURE (MULTIPLE MOVING NESTS IN A GLOBAL FORECAST)



- Global 13-km run with a static 3-km Atlantic nest
- Yellow boxes show how moving nests could follow 5 TCs globally

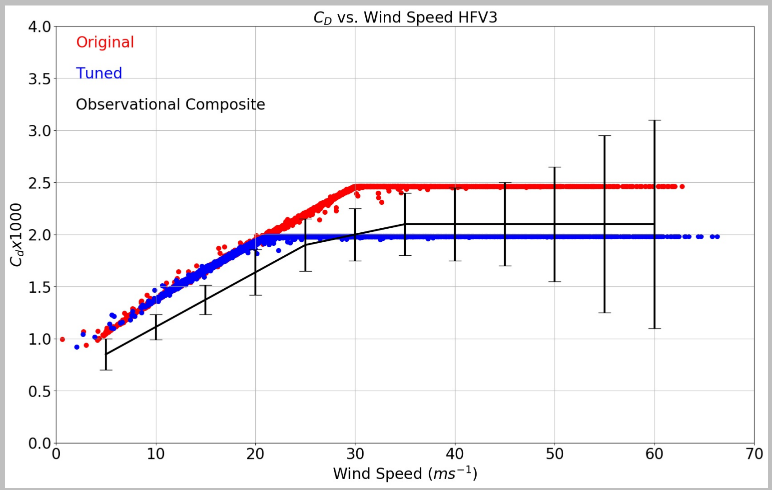
1. FV3 global-nest configuration, nested grid development

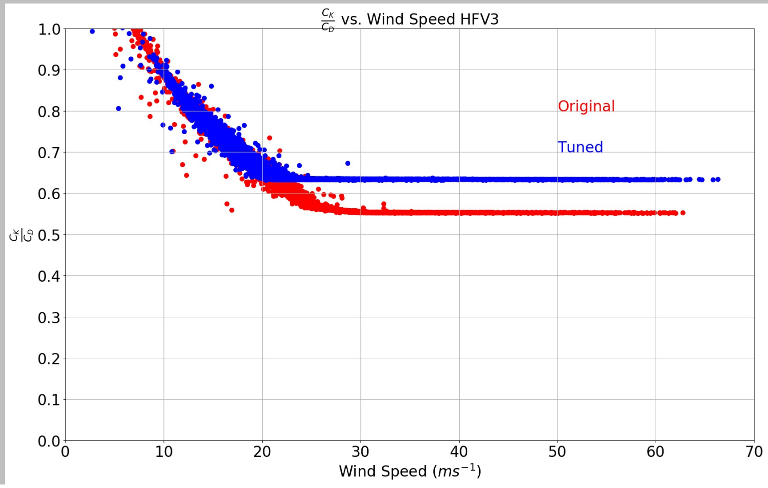
2. Physics changes based on observations

3. TC research (Michael case study based on ensembles)

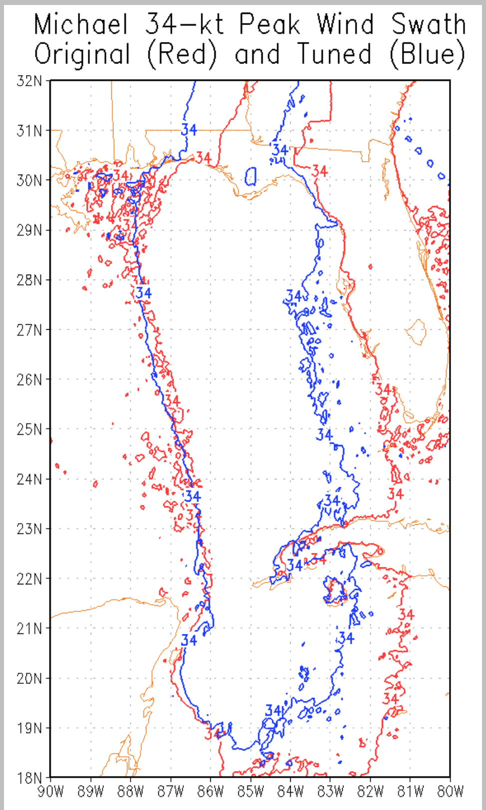
PHYSICS MODIFICATIONS

- Modifications to surface and PBL physics based on comparison with observations (Jun Zhang)
- C_D lowered (capped at a slightly lower wind speed) based on a fit with observations from multiple field experiments
- C_k/C_d ratio closer to observed value of 0.63 reported by Zhang et al. (2008)
- Tests of Irma/Michael showed similar pressure but higher wind speed

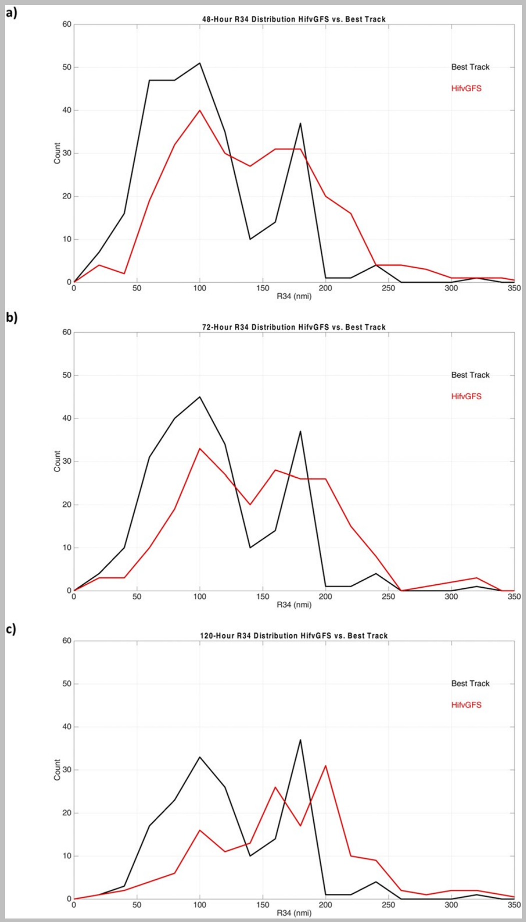




PHYSICS MODIFICATIONS



- C_D changes combined with tuning to the α parameter in the GFS EDMF PBL scheme to reduce vertical diffusivity
- Similar to what was done in HWRF
- Results in narrower wind swath (also slight track shift)
- This wind swath narrowing is positive based on a consistent large bias noted in 2017



FUTURE DIRECTIONS: PHYSICS MODIFICATIONS

- At HRD, we want to take advantage of high-quality obs to help test/adjust model physics
- Further changes to the PBL (testing YSU or other schemes through CCPP) is one priority
- Testing of GFDL microphysics and other microphysics schemes in a TC context another goal
- Take advantage of HRD observations to evaluate physics changes in a structural context

1. FV3 global-nest configuration, nested grid development

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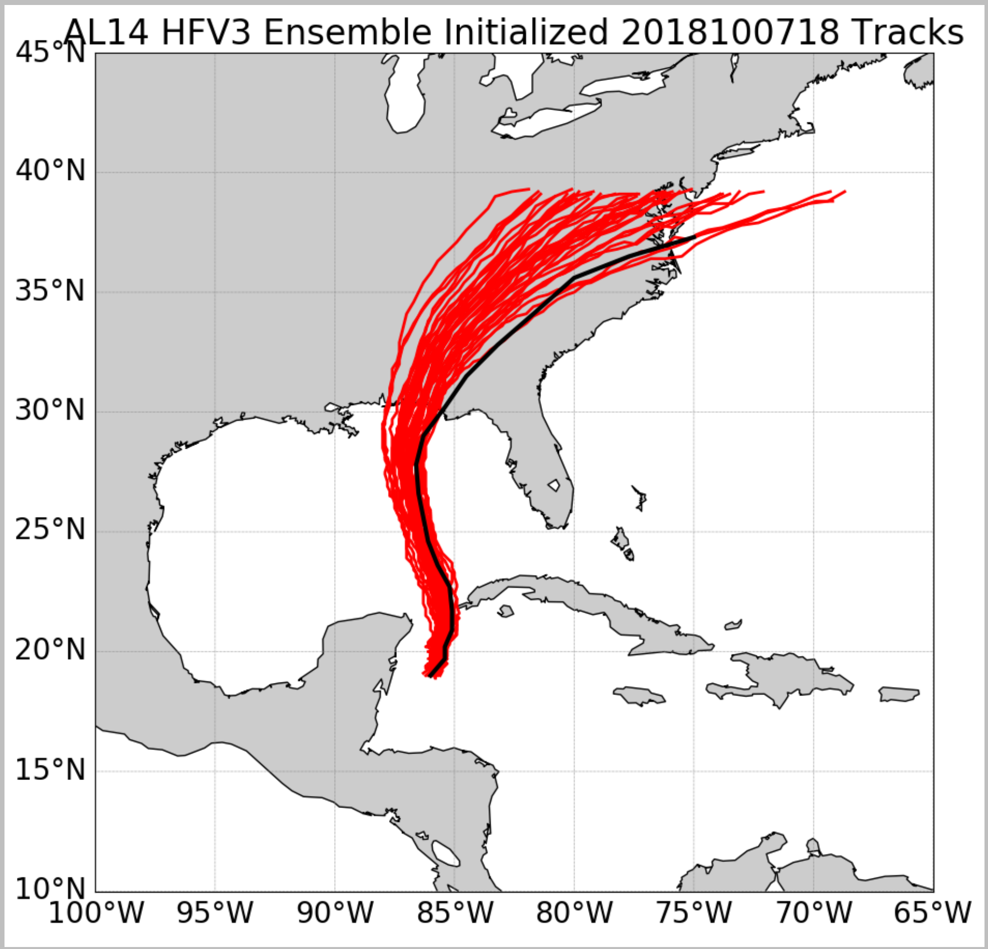
HURRICANE MICHAEL STUDY

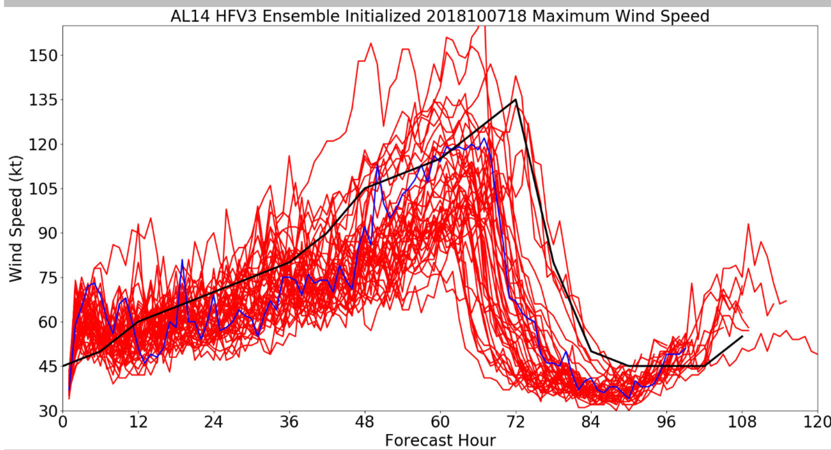
- The global-nested configuration was applied to study the evolution of Hurricane Michael (2018)
- Michael rapidly intensified despite strong shear in excess of 20 kt
- 40 members from GDAS (plus deterministic GFS) were selected to create a 41-member ensemble
- Initialized at 1800 UTC October 7, 2018 (12 hours after genesis)
- Goal is to use this new modelling system to study RI of a sheared TC

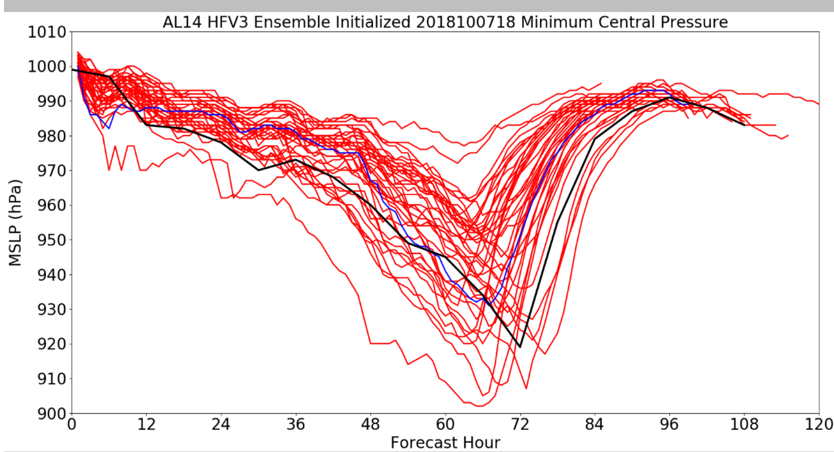
MICHAEL TRACK FORECASTS



- Tracks all correctly show path through Yucatan channel
- Slight left-of-track bias near landfall in some members

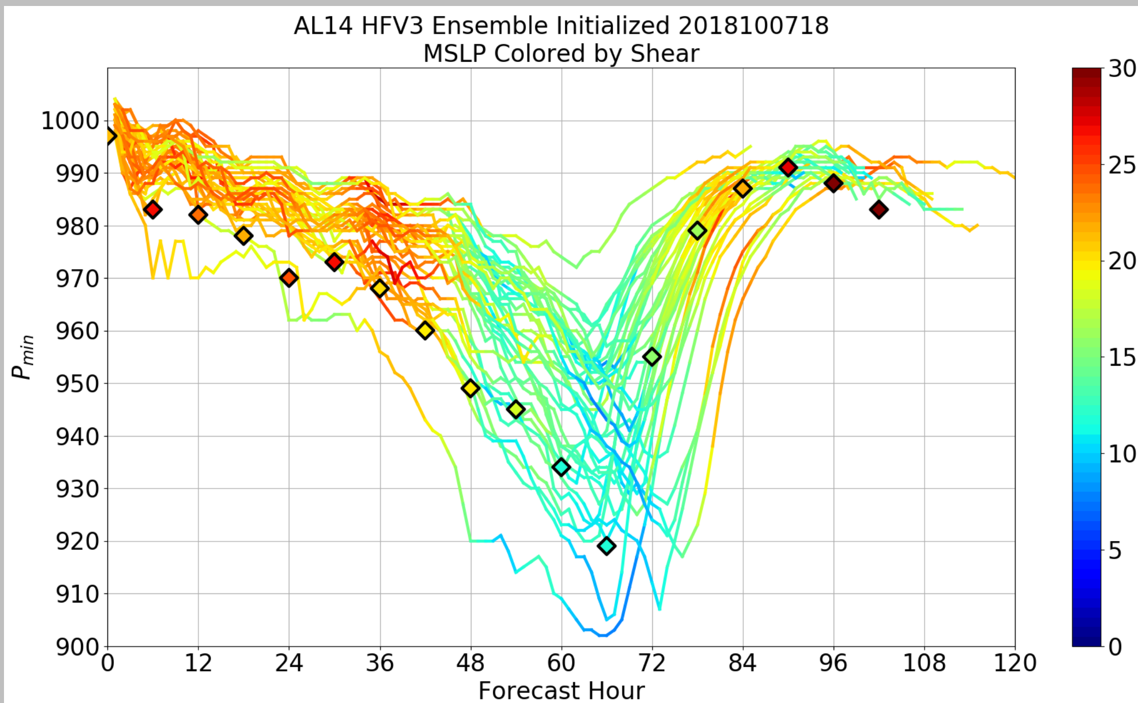
MICHAEL INTENSITY FORECASTS





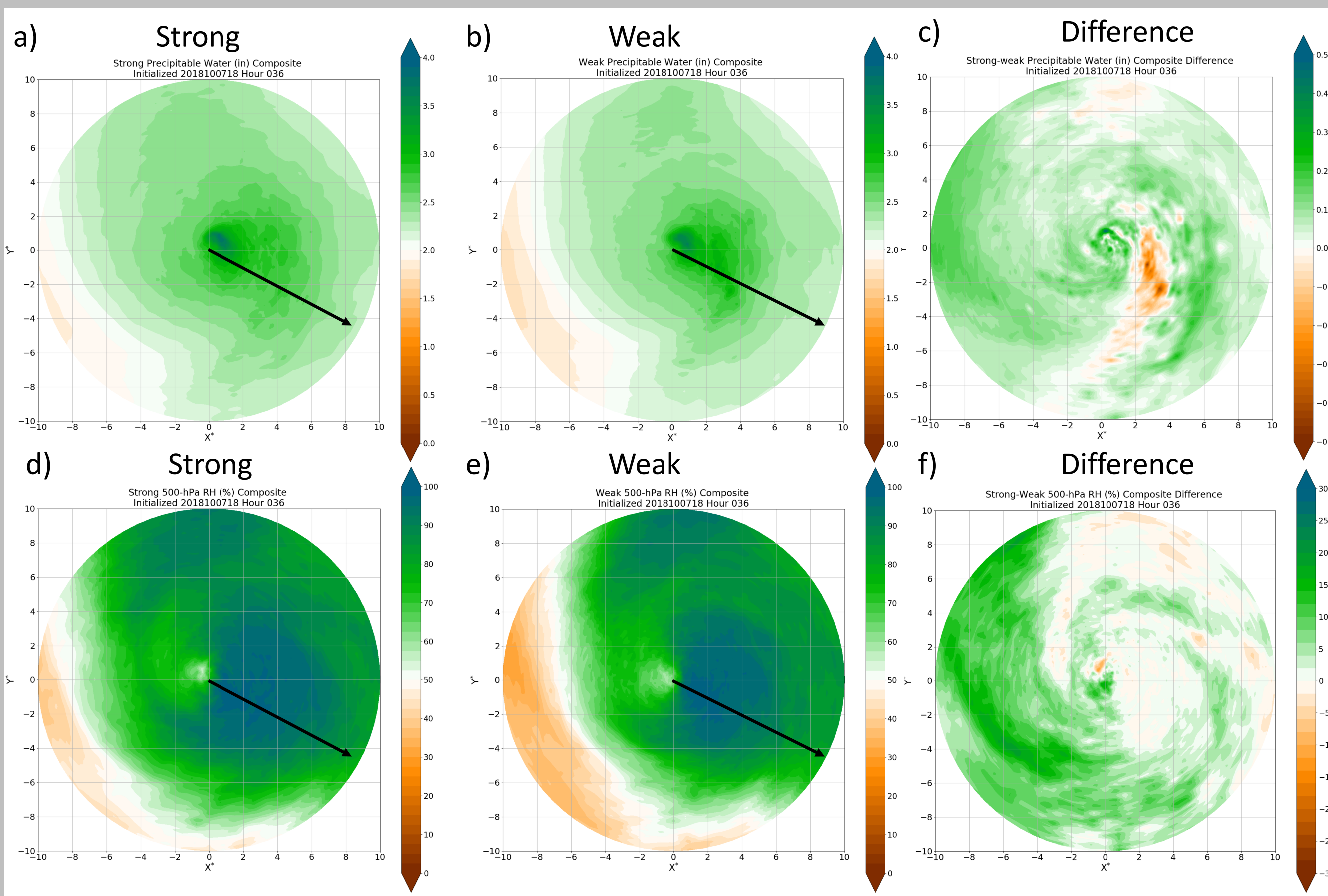
- Large intensity spread (900-980 hPa peak)
- Many members intensified close to observed, some stayed weak
- Good set to study differences in structure, shear

SHEAR EVOLUTION



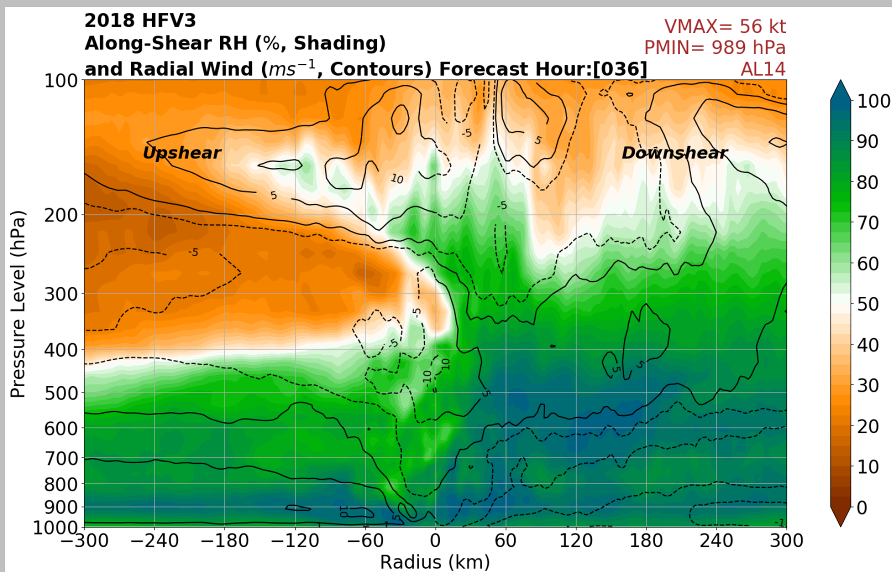
- MSLP shaded by shear (kt)
- Observed (from SHIPS) shown in diamonds
- Shear very high (>20 kt early)
- Shear decreased to ~10 kt near landfall
- Significant intensification in most members late as shear decreased
- Some also deepened quickly despite large-scale shear early

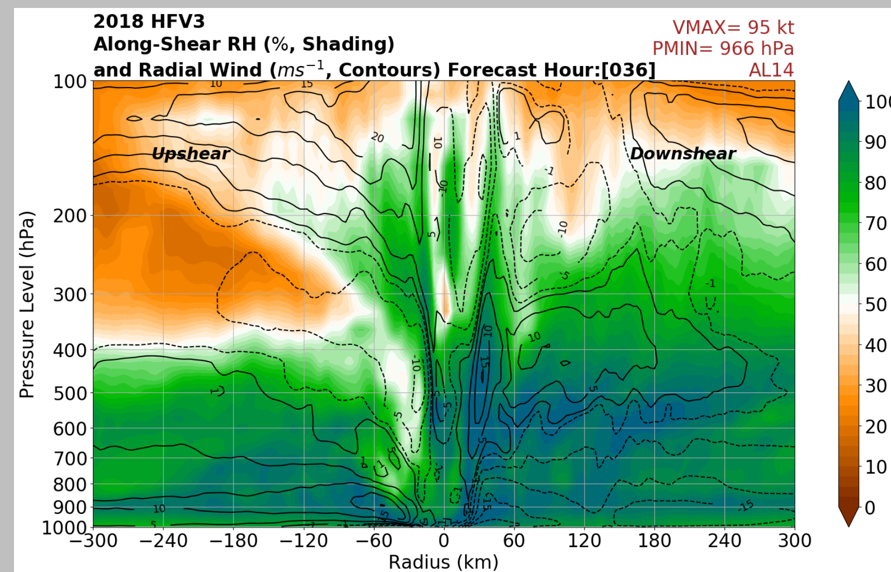
COMPOSITES OF STRONG/WEAK MEMBERS



- Composited based on intensity change from 036-060h forecast
- Mid-level RH and Precipitable water examined
- Large differences ins moisture (especially upshear)
- Importance of moisture discussed for other sheared TCs (Nguyen et al. 2017, Rios-Berrios et al. 2018)

STRONG MEMBER VS. WEAK MEMBER

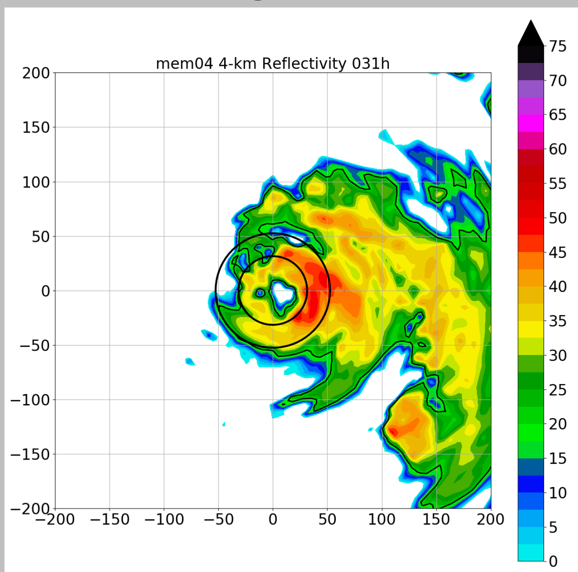




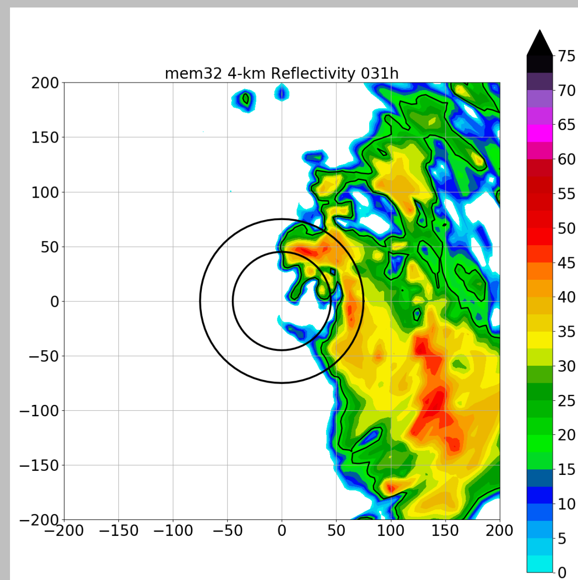
- Shear was very similar between the two members
- The moisture differences were key
- Specifically, the dry air penetrated the core in the weak member, but did not in the strong member

COMPARISON WITH OBSERVED RADAR DATA

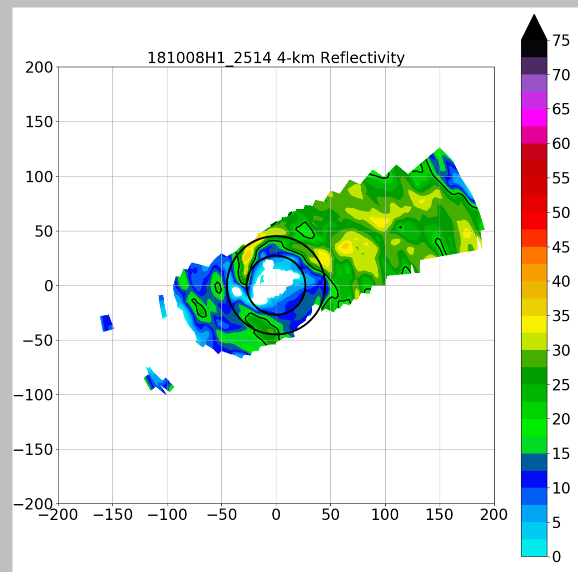
Strong Member



Weak Member



Radar Observations



- In both members, outer-core (r = 100-200 km) convection is confined to the eastern (downshear) region
- However, in the strong member, a core of more symmetric precip wraps around upshear
- This structure was also seen in P-3 observations from the same time

FUTURE DIRECTIONS: TC ANALYSIS

- Take advantage of the quality of the developing HAFS system to analyze complex TC research problems
- Study TCs that prove challenging to HAFS (and/or other models) during the 2019 real-time demo
- Integrate and compare with observations
- Refine an ensemble system for high-resolution prediction (based of the "A" in HAFS?)

SUMMARY

- HAFS work at AOML incorporates several aspects of model development and analysis
- Nesting capability being enhanced, progressing towards global multiple moving nests
- Physics evaluations and refinement based on observations will become critical as new physics options are introduced
- HAFS will be used for research into problems like TCs in shear, rapid intensification, and others
- We look forward to collaborating with our partners to continue this promising work

THANKS! QUESTIONS?