Hurricane Forecast Improvement Project (HFIP): Transition to Hurricane Analysis and Forecast System (HAFS)

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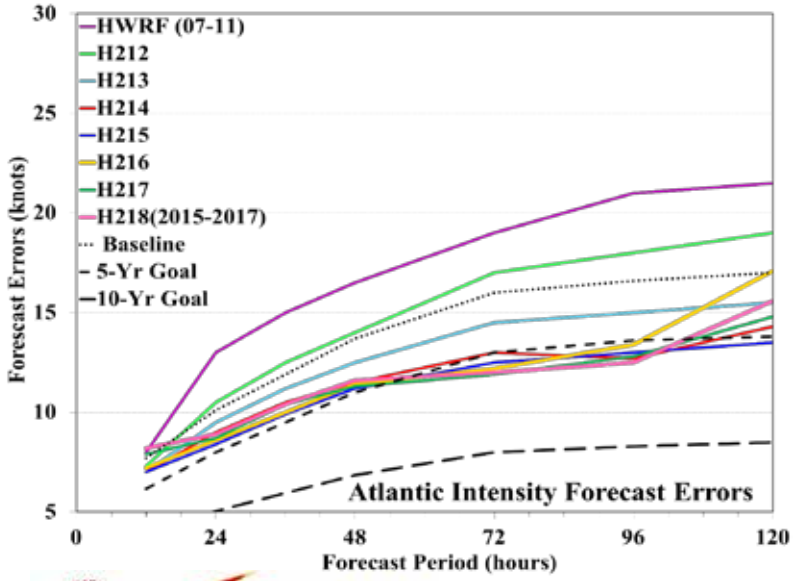
Hurricane Forecast Improvement Project (HFIP) Highlights for 2018

- Operational HWRF continues to provide best dynamical intensity guidance model in ATL basin
- New products and tools at NHC ready for Operations
- HMON performed very well for track forecasts in EPAC
- Basin-scale HWRF demonstrated improved track forecast skill over operational HWRF
- FV3GFS demonstrated better intensity guidance than any global model
- Ran experimental HWRF and HMON driven by FV3GFS initial conditions and boundary conditions
- Continued demonstration of HWRF/HMON ensembles

HWRF: Hurricane Weather Research and Forecast System

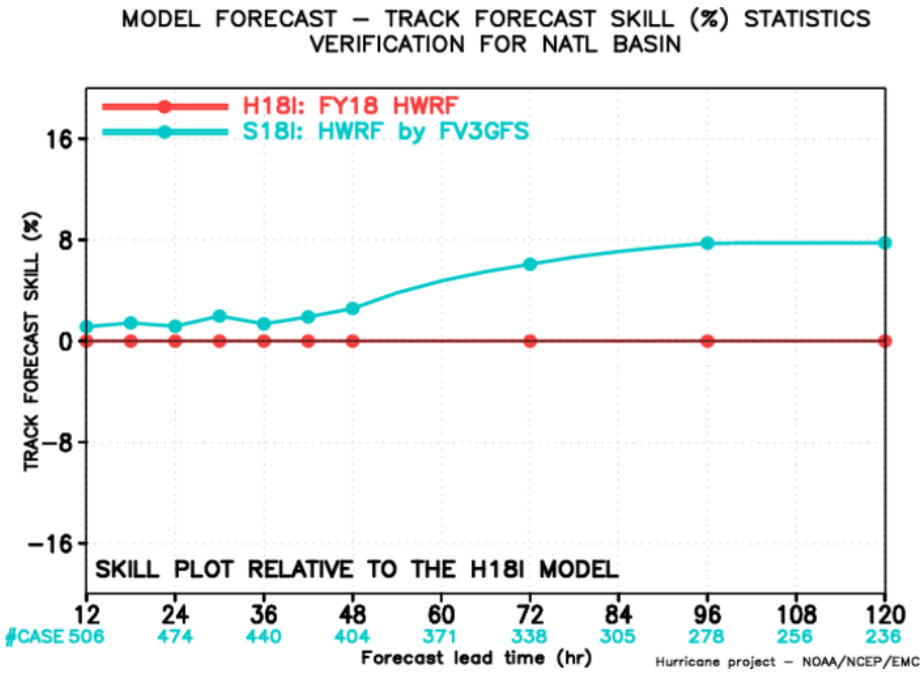
- HWRF continuously improved in the past 9 years through support from HFIP
- Successful community modeling approach for accelerated transition of research to operations
- New in 2018 for operational HWRF:
  - Increase horizontal resolution to 13.5/4.5/1.5 kms (proposed)
  - Updates to RRTMG radiation scheme
  - New datasets for assimilation in the hurricane inner core and environment
    - SFMR, dropsonde drifts
    - G-IV TDR
    - GOES-16 AMV's and NOAA-20
- Unified HWRF/HMON coupler

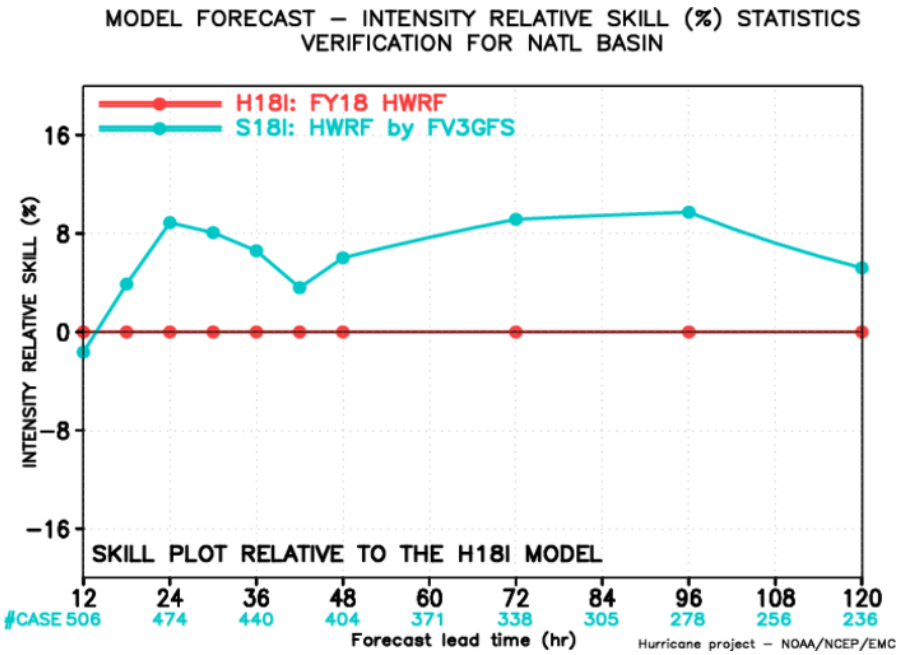
Results from annual retrospectives



Expanded international partnerships & collaborations

FY18 HWRF Testing with FV3GFS
(priority storms, Early Models)

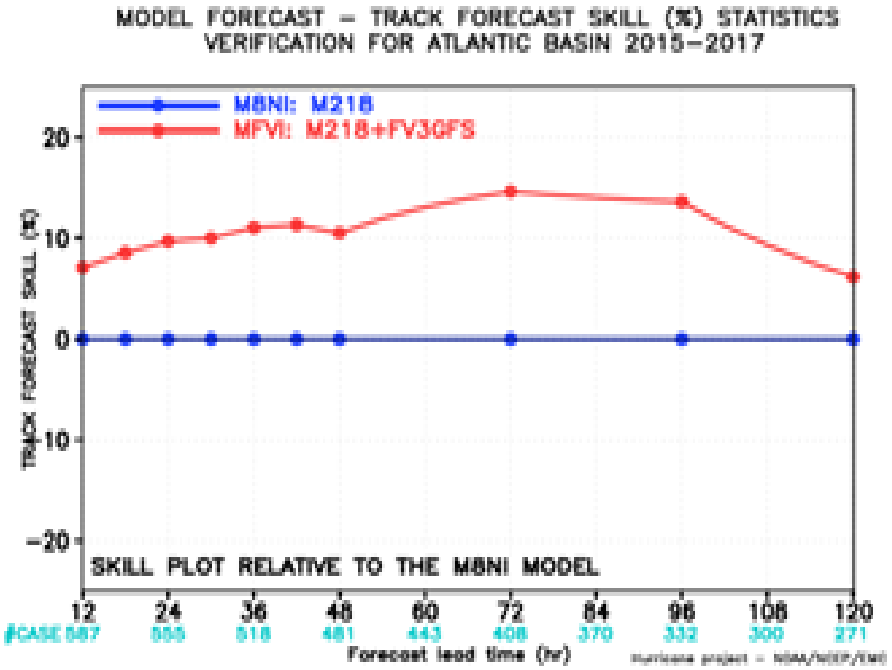


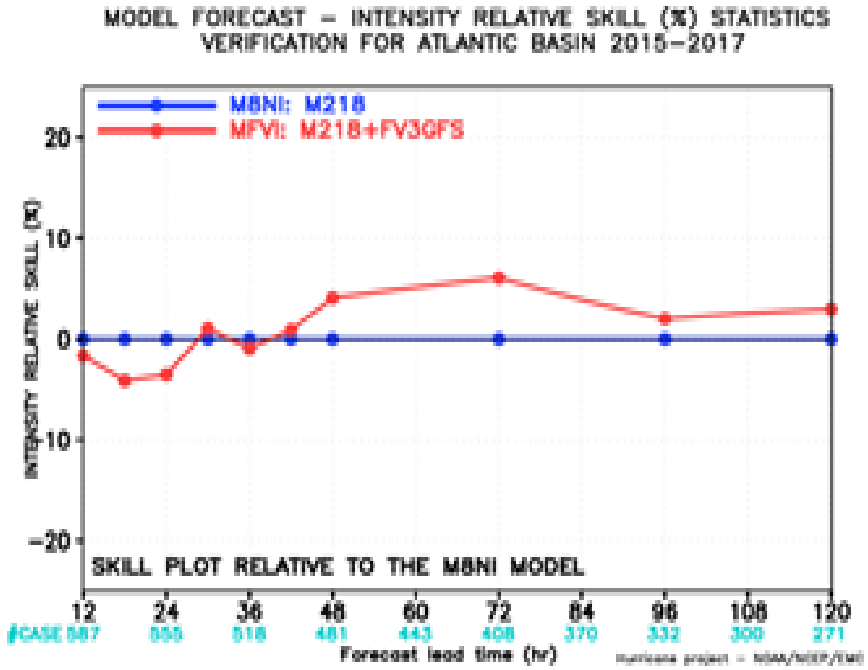


There is good improvement in track skill especially for longer lead times reaching 8% at Days 4 and 5. Intensity skill improvements are evident at all lead times with more than 8% improvements at Day 1 and again at Day 4.

H18I: Interpolated results for FY18 HWRF using 2017 GFS (operational GFS v14) results (2015-2017)
S18I: Interpolated results for FY18 HWRF using FV3GFS (proposed GFS v15) retrospective results (2015-2017)

FY18 HMON Testing with FV3GFS
(priority storms, Early Models)





There is good improvement in track skill especially for longer lead times reaching >10% at Days 3 and 4. Intensity skill improvements are evident at lead times >48 h with 5-6% improvements at Day 2 and 3.

M18I: Interpolated results for FY18 HMON using 2017 GFS (operational GFS v14) results (2015-2017)
MFVI: Interpolated results for FY18 HMON using FV3GFS (proposed GFS v15) retrospective results (2015-2017)

Weather Act Sec.104: HFIP

An updated plan, detailing the specific research, development, and technology transfer activities necessary to sustain HFIP and achieve the 3 focus areas in **Section 104 of the Weather Research and Forecasting Innovation Act**:

1. improving the prediction of rapid intensification and track of hurricanes
2. improving the forecast and communication of storm surges from hurricanes
3. incorporating risk communication research to create more effective watch and warning products

The plan details long-term HFIP goals, priorities, and approaches.

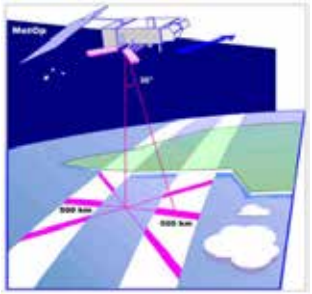
Revised HFIP Goals aligned with the Weather Act

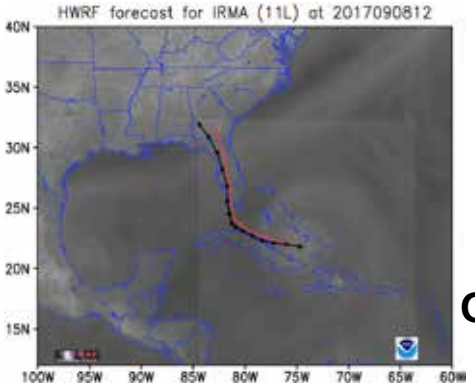
- Reduce numerical forecast guidance errors, including during rapid intensification, by 50% from 2017
- Produce 7-day forecast guidance that is similar to 2017 5-day forecast guidance
- Improve guidance on pre-formation disturbances, including genesis timing, and track and intensity forecasts, by 20% from 2017
- Improve hazard guidance and risk communication, based on social and behavioral science, to modernize the TC product suite (products, information, and services) for actionable lead-times for storm surge and all other threats

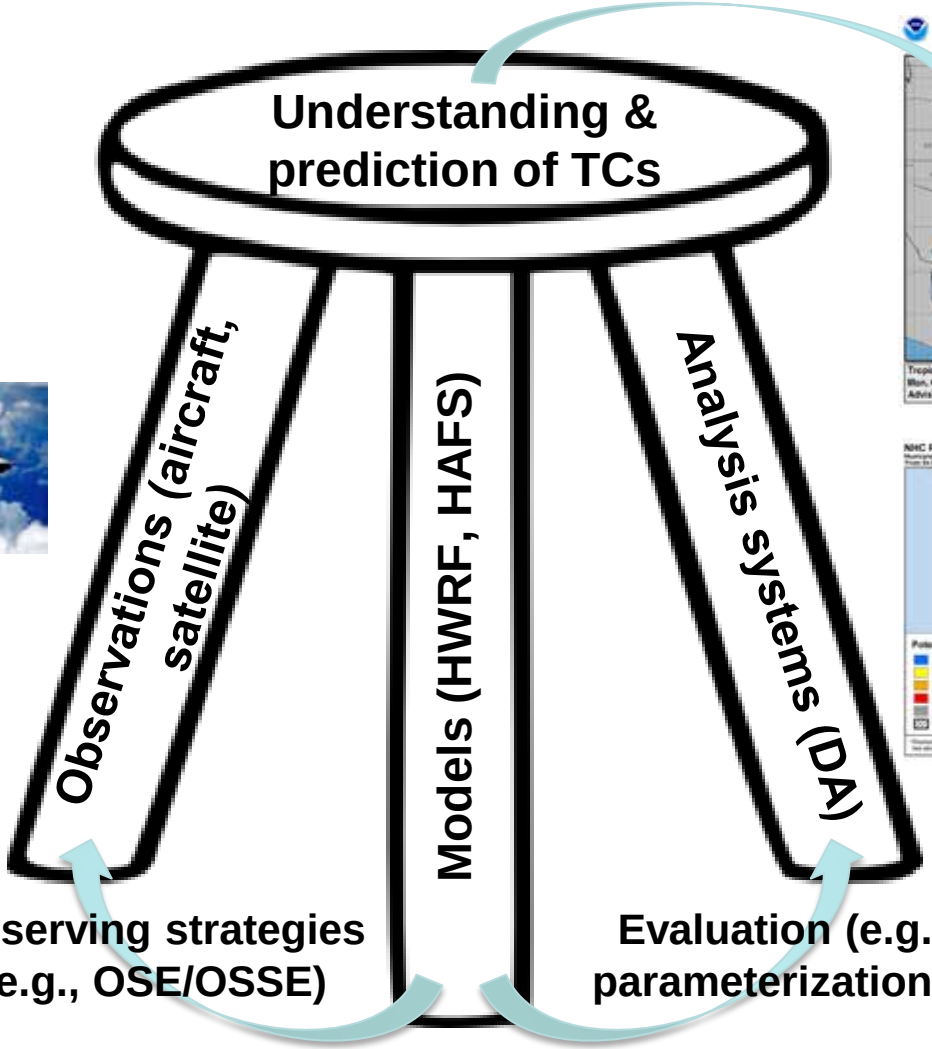
Hurricane Research Priorities

1. **Develop Hurricane Analysis and Forecast System (HAFS)**
   - Advance deterministic & ensemble prediction capabilities
   - Advance DA techniques to maximize the usefulness of observations & identification of sources of model biases/errors
   - Advance physical processes representation (e.g., air-sea, BL, microphysical/aerosol/radiation)
2. **Develop probabilistic hazard guidance**
   - Characterize observed uncertainty for all TC hazards
   - Advance ensemble guidance post-processing to characterize & extract model-based uncertainty
   - Incorporate guidance uncertainty into hazard models & products
3. **Enhance communication of risk/uncertainty based on social & behavioral science research**
   - Evaluate and modernize products for effective communication of risk

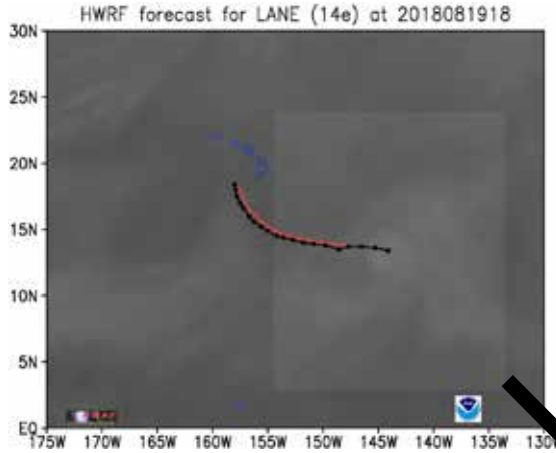
Development of HAFS





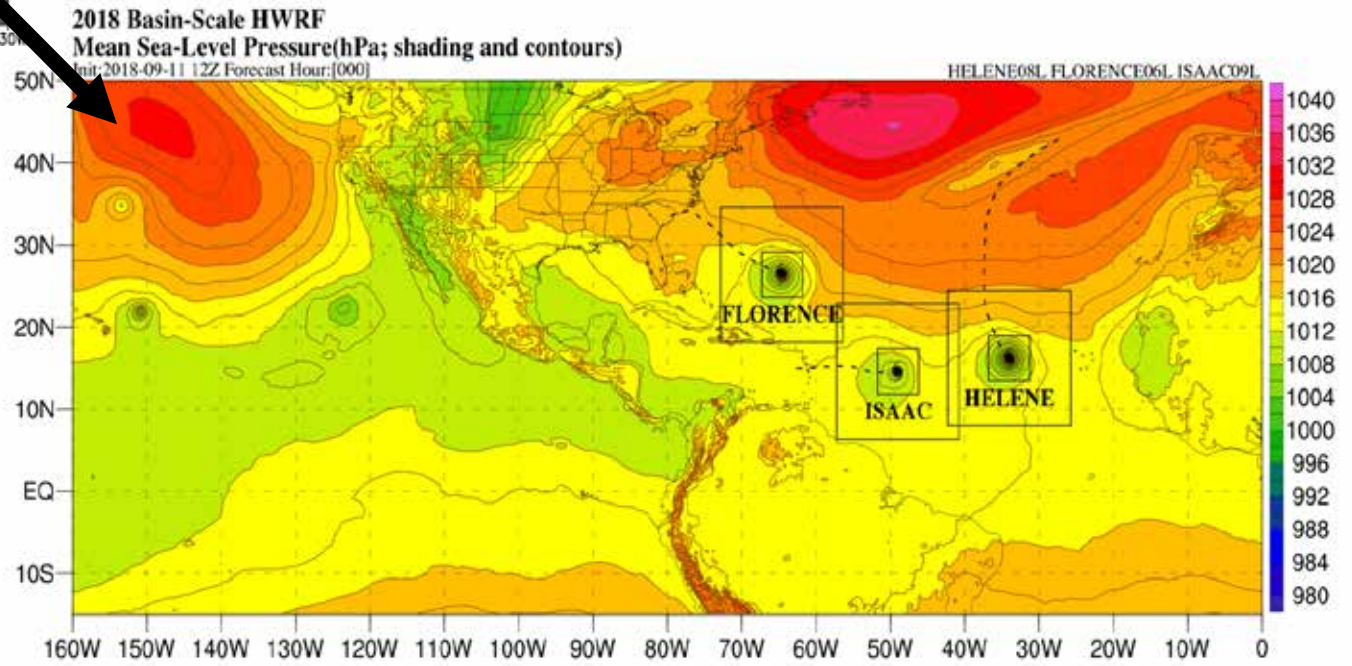


Development of HAFS:
Global to regional Model R&D



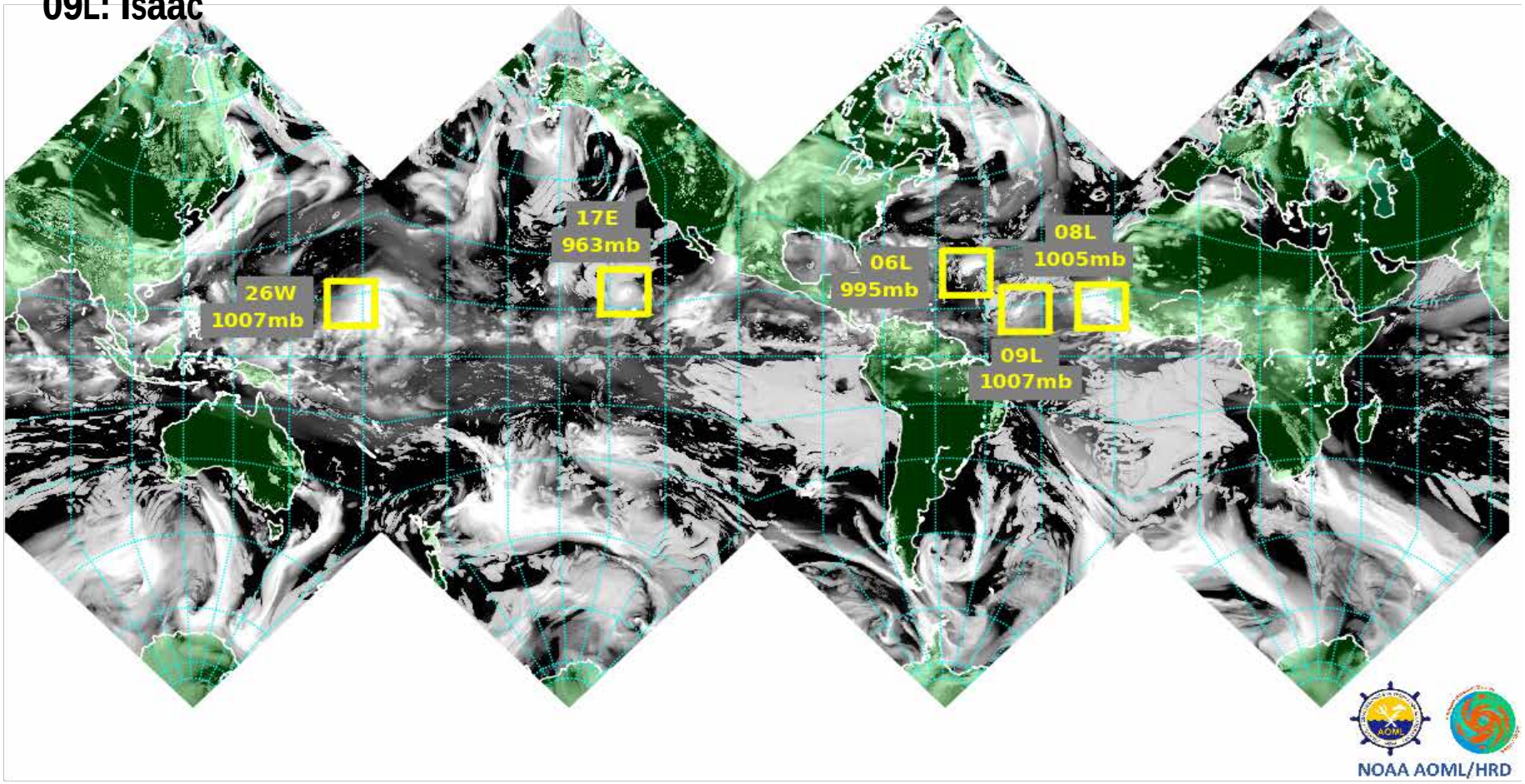
- HFIP worked tirelessly to advance hurricane forecasting through HWRF since 2009
- HWRF has propelled hurricane model intensity guidance in the nation forward

- Basin-scale HWRF improves storm-storm and land-storm interactions and provides a basis for moving nest in HAFS



What do multiple moving nests look like in global model?

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



Lessons learned & research challenges

Lessons Learned:

- Model improvements **must** be in synch with DA improvements
- DA helps identify model biases related to physics, e.g.:
- Vortex spin-down in high initial intensity cases affects DA reducing observation impact
- Better analyses mean better model & DA systems

Research Challenges:

- Incorporation of moving nests & inner-core DA into FVGFS
- Make better use of satellite observations
- Address microphysics & radiative transfer physics biases
- DA system to address high temporal & spatial resolution

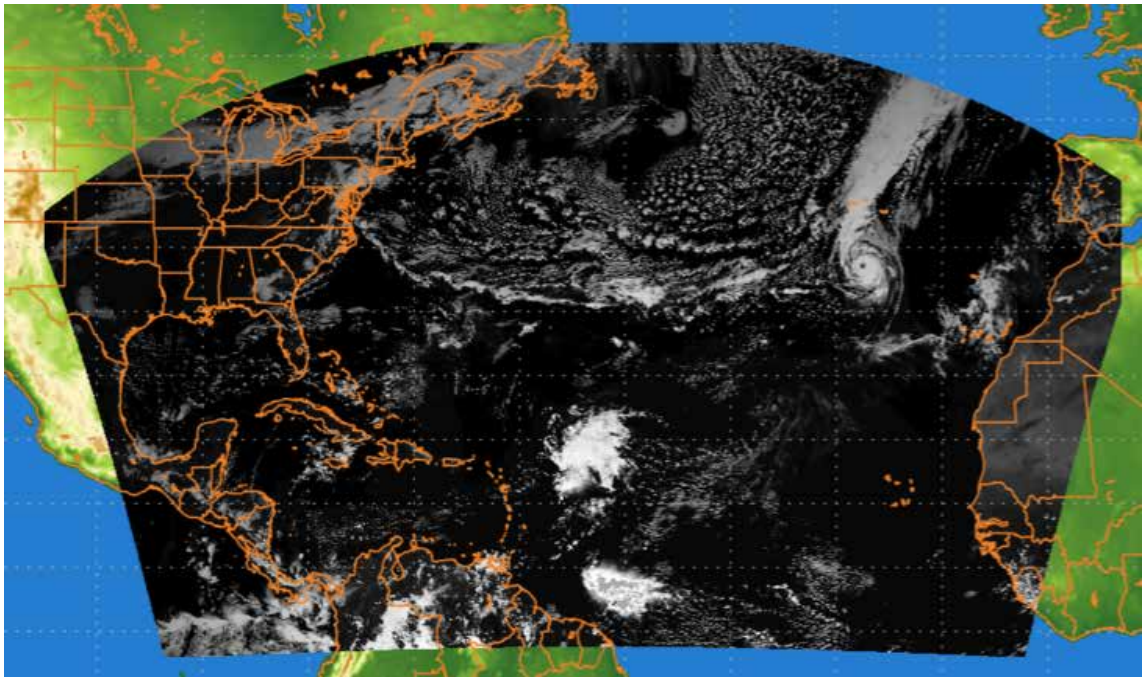
HAFS Development Plans

1. Observations and DA:
    - IC/BC from FVGFS or FVGFS + HWRF analysis
    - NHC recommend cases for retrospective
    - Run semi real-time in 2019
2. Nesting strategy:
    - CAM configuration like small basin-scale 3 km res
    - Nest in global FVGFS like hfvGFS with 3 km res
3. Physics options:
    - Use same suite of physics available through CCPP
    - One-way ocean coupling IC/BC from FVGFS
4. Testing and evaluation plan:
    - Standard metrics developed for HFIP
    - Enhanced metrics
    - Develop common workflow

2019: HAFS V0.0A

Model Configuration of the Nested 3-km FVGFS Real-Time Forecast System:

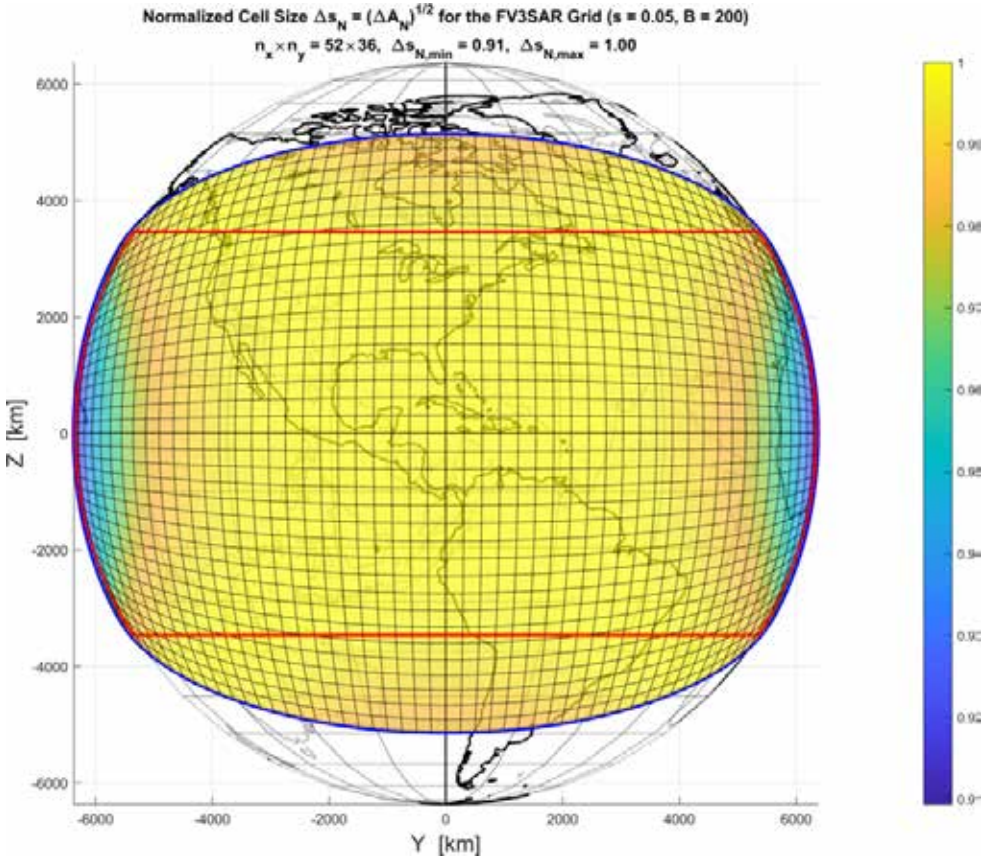
- FV3 dynamical core with GFS physics (FVGFS)
- 13-km global, 3-km nest (2-way interaction) covering the entire Atlantic
- GFDL 6-class microphysics
- Scale-aware SAS convective scheme
- 63 vertical levels



2019: HAFS V0.0B

Model Configuration of the Stand Alone Regional (SAR) 3-km Nest FVGFS Real-Time Forecast System:

- FV3 dynamical core with GFS physics (FVGFS)
- 3-km stand alone nest (same as CAM) covering ATL & EPAC
- GFDL 6-class microphysics
- Scale-aware SAS convective scheme
- 63 vertical levels

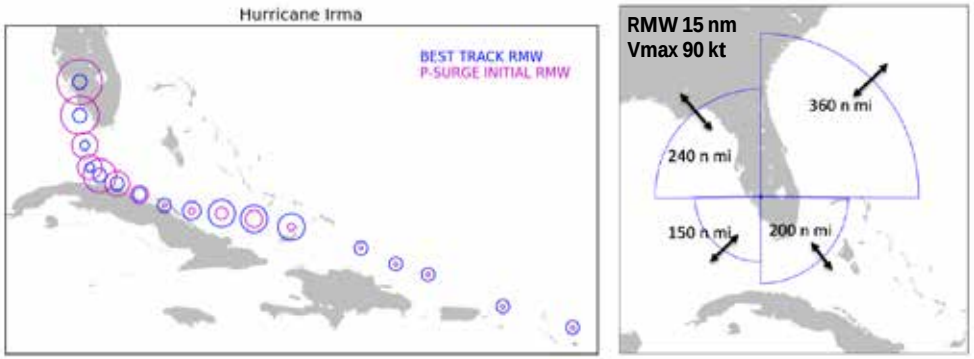


HAFS: Guidance & Products

Improve probabilistic guidance

- Calibrate guidance with HAFS
- Incorporate dynamically-based uncertainty into hazard models and products
- R&D for hazard-specific products from HAFS

Planned improvements to P-Surge to Improve the Potential Storm Surge Flooding Map



Potential Storm Surge Flooding Map

Enhance communication of risk and uncertainty

- Evaluate TC products for the effective communication of risk
- Modernize TC products as informed by social and behavioral science

Lessons learned & research challenges

Lessons Learned:

- Currently the uncertainty in TC hazard guidance is expressed based on past performance not on current forecast uncertainty.

Research Challenges:

- Utilize FACETs framework to transform TC hazard guidance blending social & behavioral science with physical science R&D
- Improve probabilistic hazard guidance utilizing model uncertainty of track, intensity, & structure for each storm.
- Improve communication of risk & uncertainty for emergency managers and the public through social & behavioral science research to provide more effective TC products.

Summary

- 2017 Weather Research & Forecasting Innovation Act calls for HFIP renewal to: improve prediction of RI & track; improve forecasts & communication of storm surge and other hazards; & incorporation of risk communication research to create more effective products
- Current forecast products, metrics, & verification fall short of those needed to support 2017 Weather Research & Forecasting Innovation Act goals
- Research must expand to address all impacts from hurricanes (e.g., wind, surge, inland flooding, severe weather) & incorporate risk communication research to create more effective TC products

Questions and Discussion