



# Hurricane Forecast Improvement Program (HFIP) Overview/Updates

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# Outline



- HFIP Goals and Weather Act
- Key Strategies and Progress
- HAFS as UFS Applications
- HFIP 2020 highlights
- HAFS Development
- Community Outreach
- Future directions





# HFIP Goals aligned with Weather Act

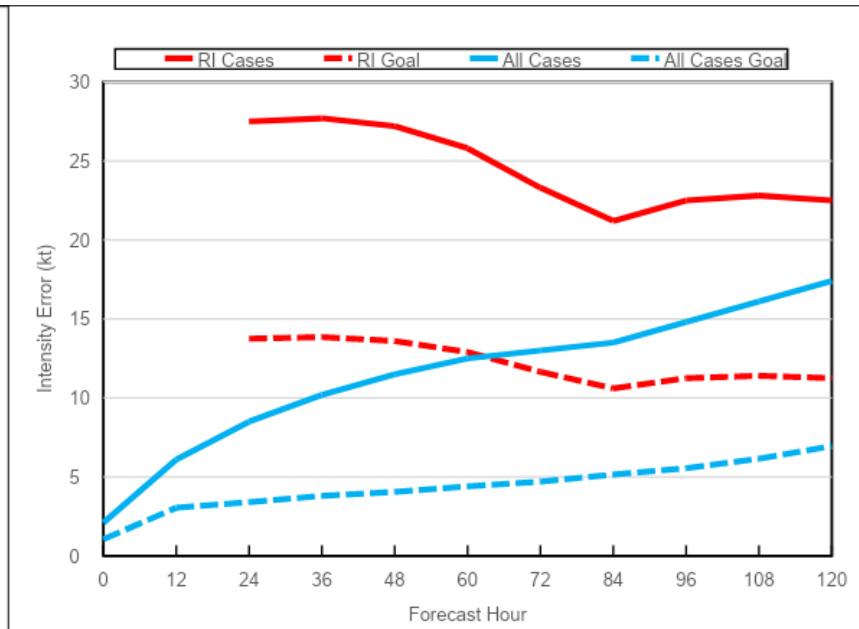
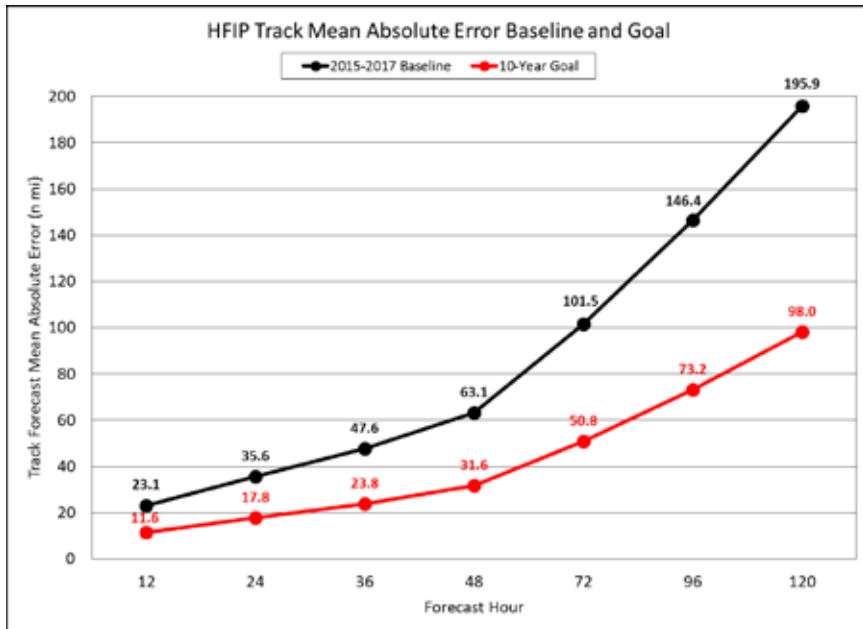


- [HFIP Strategic Plan](#) provides details on long-term HFIP goals (Appendix A), priorities, and strategies – June 2019
1. Reduce numerical forecast guidance errors, [including during rapid intensification](#), by 50% from 2017;
  2. Produce 7-day forecast guidance similar to 2017 5-day forecast guidance;
  3. [Improve guidance on pre-formation disturbances, including genesis timing, track and intensity forecasts, by 20% from 2017](#); and
  4. [Improve hazard guidance and risk communication, based on social and behavioral science](#), to modernize TC product suite for actionable lead times for storm surge [and all other threats](#).





# HFIP Goals aligned with Weather Act





# Key Strategies and Progress

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1. Advance an operational Hurricane Analysis and Forecast System (HAFS): **4 Versions tested this season**
2. Improve probabilistic guidance: **Tropical Roadmap, P-surge, Graphical Product Improvements**
3. Enhance communication of risk and uncertainty: **9 SBES Projects**
4. Support dedicated high performance computing allocation: **>60M h/month for development, testing, & evaluation**
5. R2O Enhancement: **Enhanced JHT capability, AWIPS/ATCF improvements**
6. Broaden expertise and expand interaction with external community: **6th round of proposals (3 supported)**



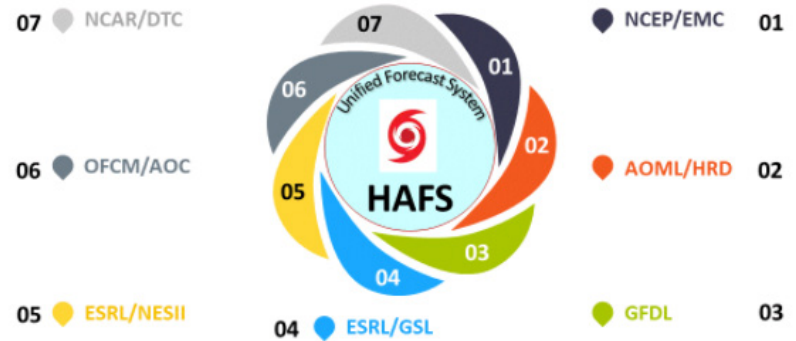


# Key Strategies: Next-generation Hurricane model, HAFS



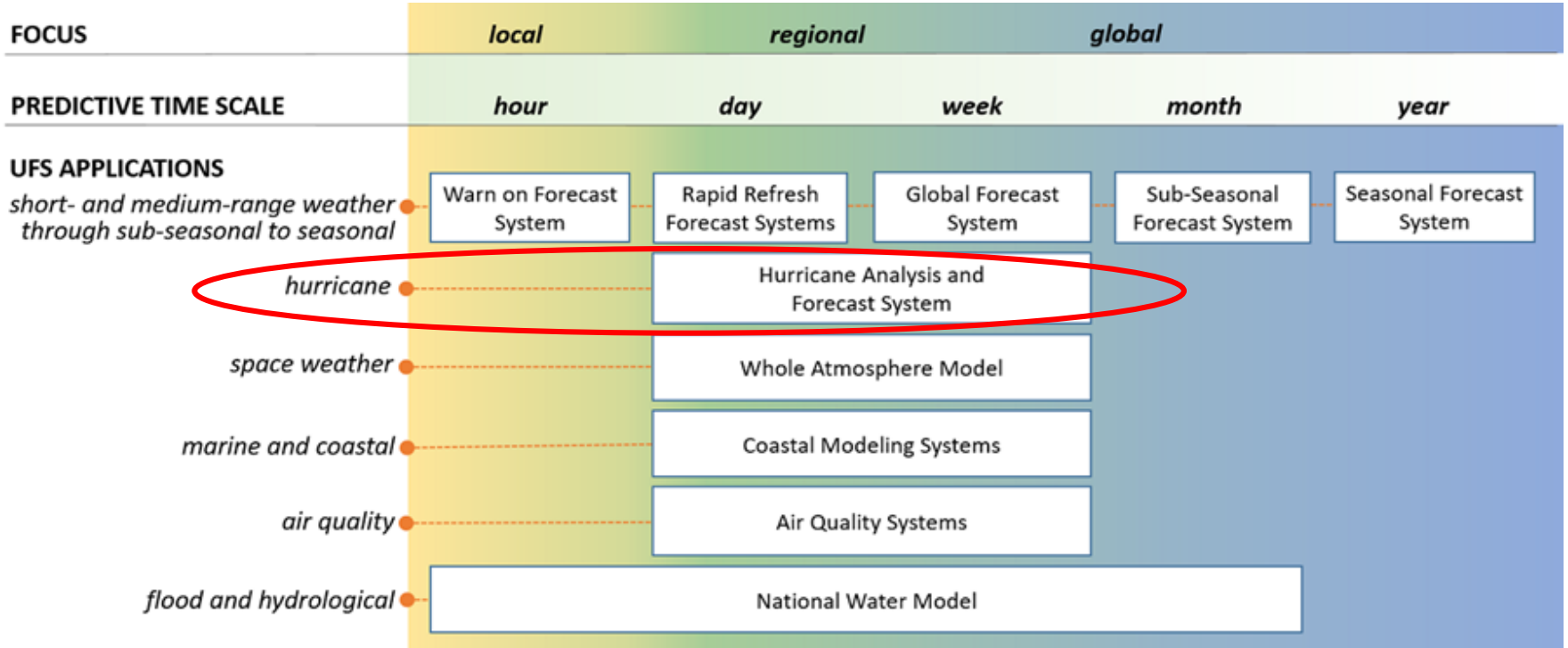
Hurricane Analysis and Forecast System (HAFS) is FV3-based multi-scale model and data assimilation system capable of providing Tropical Cyclone (TC, including Hurricanes and Typhoons) analyses and forecasts of the inner core structure and the large-scale environment.

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





# Unified Forecast System (UFS)



<https://ufscommunity.org>

NOAA Hurricane Forecast Improvement Program

Meeting the Nation's Needs





# Hurricane Forecast Improvement Project (HFIP) Highlights for 2020



- 2020 HFIP Real-time Experiment (HREx) for UFS-HAFS
  - Hurricane Analysis and Forecast System (HAFS) version 0.1A (ocean-coupled), version 0.1B (global-nesting), version 0.1J (ESG grid) and version 0.1E (ensembles) tested in real time for 2020 hurricane season.
- HAFS-Ocean Model (HYCOM) Coupling
  - The regional HAFS is coupled with the HYbrid Coordinate Ocean Model (HYCOM) to take into account the impact of air-sea interaction on hurricane forecasting. The coupled system is being demonstrated in HREx.
- Providing guidance for NHC's experimental 6 and 7 day forecasts
  - NHC's statistical post-processing intensity models (SHIPS and LGEM) were extended to provide forecasts through 7 days.
- HWRF Model upgrades implemented on August 5, 2020



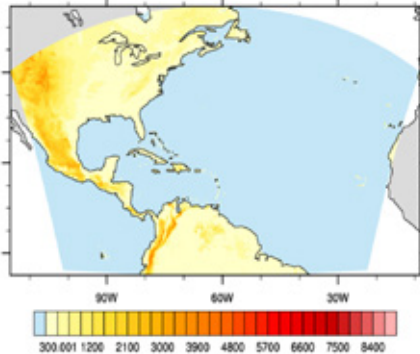




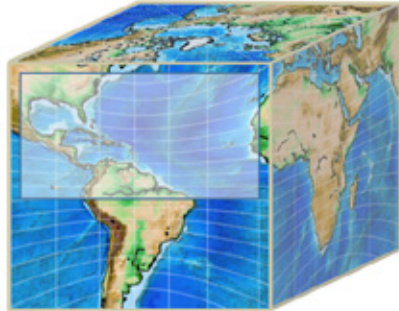
# HAFS Development in 2020

- HAFS-Ocean Model (HYCOM) Coupling
- HFIP Real-time Experiment (HREx) for UFS-HAFS for 2020 hurricane season

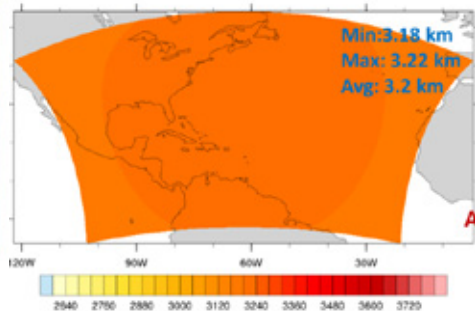
HAFS v0.1A  
(Limited domain)



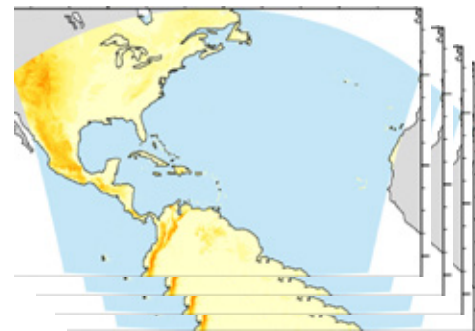
HAFS v0.1B  
(Global with nest)



HAFS v0.1J  
(Uniform grid)



HAFS v0.1E  
(Ensemble)





# HFIP Real-time Experiment (HREx) 2020



Real-time Reservation Project 2020 (Aug-Oct)	Organization	# cases
HAFS v0.1A - limited area model with ocean coupling	EMC	1505
HAFS v0.1B - global with a nest (static nest)	AOML	1221
HAFS v0.1J - LAM 3 km on ESG grid	EMC	1115
HWRF-B: Basin Scale HWRF	AOML	2244
HAFS v0.1E - HAFS ensemble	EMC	7193
FV3GFSv16 with RAP/HRRR Physics	GSL	529
HWRF based CNN method in prediction of RI	NCAR	





# HAFS Performance Evaluation



## • Skill relative to HWRF

### ○ NATL

- HAFS-B best track skill overall
- All HAFS configurations lag HWRF intensity skill.
- HAFS-A catches up Day 3.

### ○ EPAC

- HAFS-A and HAFS-J best track skill.
- All HAFS lag in intensity behind HWRF.

NATL

HWRF

HF1A

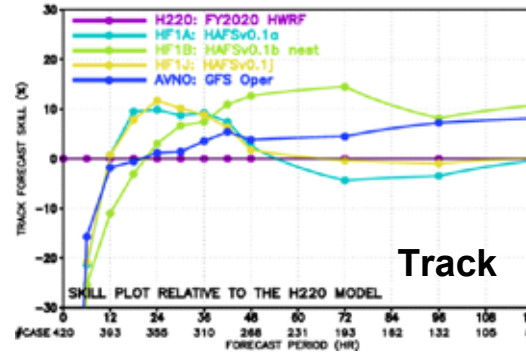
HF1B

HF1J

AVNO

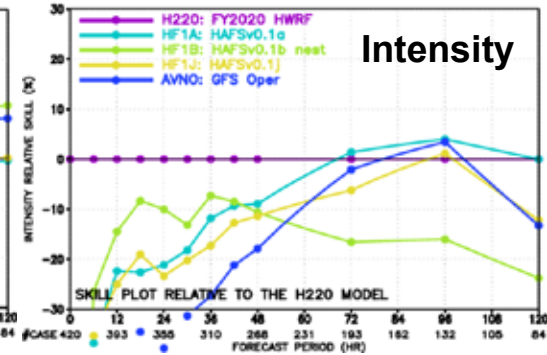
EPAC

MODEL FORECAST – TRACK FORECAST SKILL (%) VERIFICATION FOR NATL BASIN



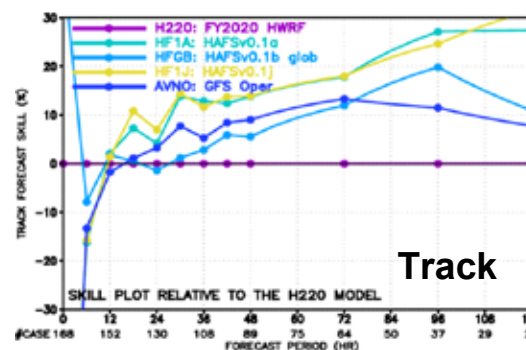
Track

MODEL FORECAST – INTENSITY RELATIVE SKILL (%) VERIFICATION FOR NATL BASIN



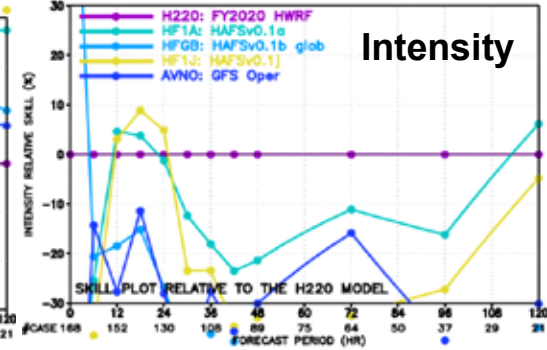
Intensity

MODEL FORECAST – TRACK FORECAST SKILL (%) VERIFICATION FOR EPAC BASIN



Track

MODEL FORECAST – INTENSITY RELATIVE SKILL (%) VERIFICATION FOR EPAC BASIN



Intensity

NOAA Hurricane Forecast Improvement Program

Meeting the Nation's Needs





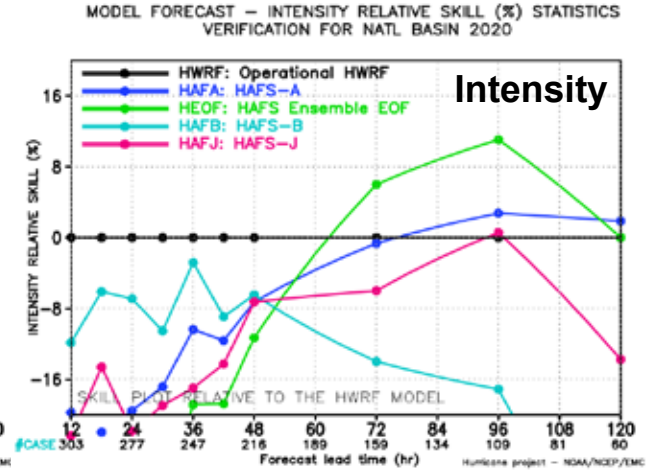
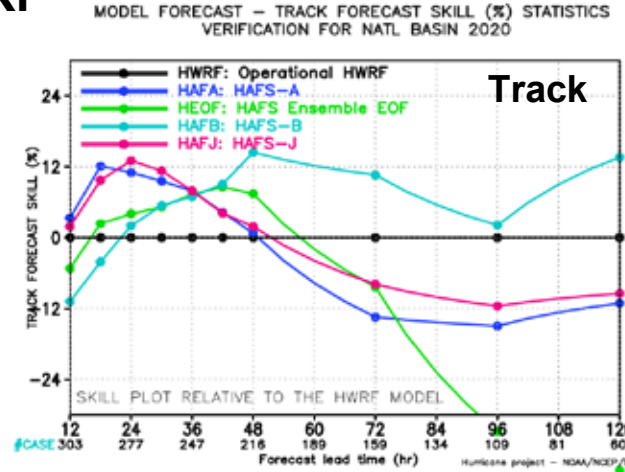
# HAFS Performance Evaluation



- Skill relative to HWRF

- NATL

- HAFS-E has comparable track skill with HAFS-A and HAFS-J till Day-3, but lower thereafter.
- HAFS-E has lowest intensity errors for extended lead times for Days 3-5.

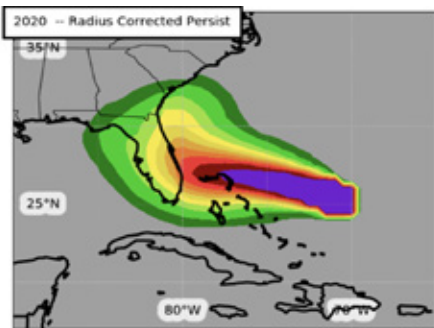


## Improve probabilistic guidance

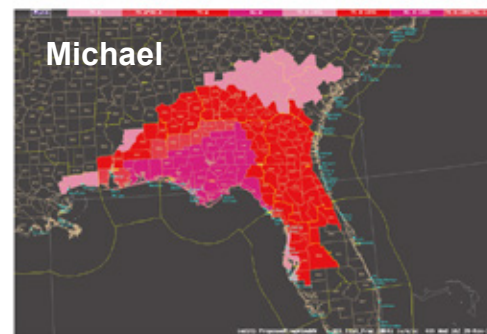
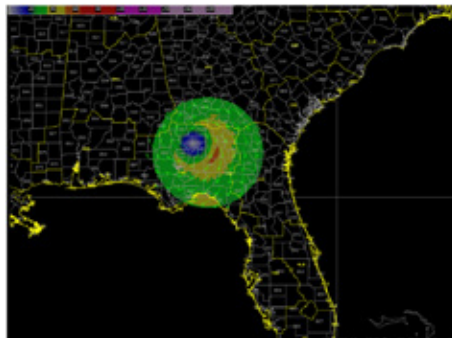
- Incorporate dynamically-based uncertainty into hazard models & products
- R&D for hazard-specific products from [AFS Tropical Roadmap](#)



### Wind Speed Probability



### TC Wind Hazard Recommender





# Outreach and Community Participation



- User support by DTC on HWRF community version
  - Trainings, workshops and online forum
- HFIP monthly Seminar - platform for sharing research outcome and initiating community discussion
- New interface to HFIP website - **coming soon!**
- HFIP Annual Report in NOAA repository: <https://doi.org/10.25923/qzd3-m787>
- Continue to engage with University partners through Notice of Federal Opportunity (NOFO): <https://www.grants.gov/web/grants/view-opportunity.html?oppld=322105>
  - Three PI's are awarded for 2020 grants (Round 6)
- Coordinate with OAR FACETs, JHT, & HWT on projects using social & behavioral science research to evaluate TC products - 9 OAR & Supplemental Projects





# HFIP Annual Review Meeting Outcome



**Date: November 17-19, 2020**

## **Recommendations:**

- **Evaluation of 2020 operational problem cases** - We need to answer **WHY?** Pick 1-2 cases & explore reasons for issue in multiple ways: e.g., E-W track bias, R34 bias
- **Observation Impact Evaluation** - Do OSEs for 2020 retrospective cases with TDR to explore impacts. Also, need OSEs for ocean observations impacts
- **HAFS Development** - Define IOC of HAFS given operational HPC resources
- **Data Display Capability on AWIPS II** - Integrate observations with model guidance & provide depiction of observations assimilated in @ model cycle
- **Resources** - Maintain real-time test capability on RDHPC (Jet, Hera, & Orion)

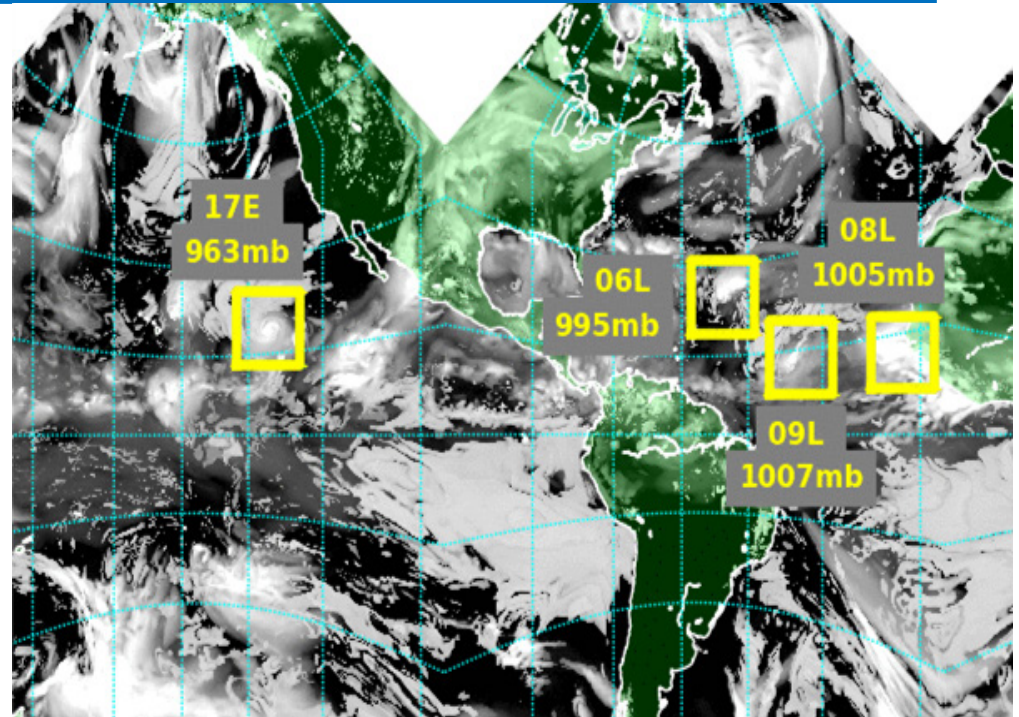




# Future Directions



- Alignment of hurricane models with UFS
- HAFS Implementation plan
  - Initial operational capability demonstration in 2021
  - Operational implementation in 2023
- Future HAFS configuration
  - 3-way coupling with ocean (HYCOM -> MOM6) and wave (WW3)
  - DA: Transition to JEDI
  - Multiple moving nests following multiple storms







# Questions?





# Weather Act Sec.104: HFIP

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Develop 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. improve prediction of rapid intensification and track of hurricanes
2. improve forecast and communication of storm surges from hurricanes
3. incorporate risk communication research to create more effective watch and warning products

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



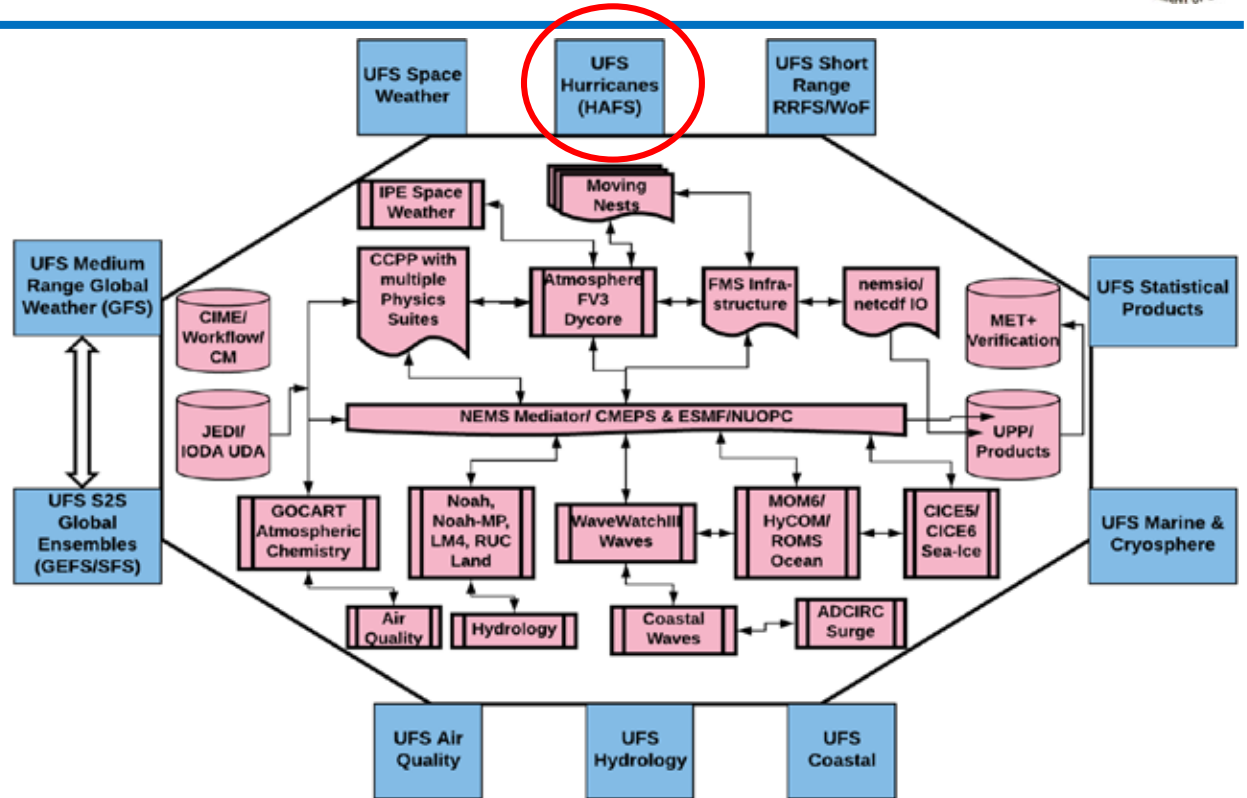


# HAFS within UFS Applications



Conceptual UFS applications in production covering all NPS applications.

Components of UFS are configured to develop distinct applications while maintaining the dependencies between the applications and products



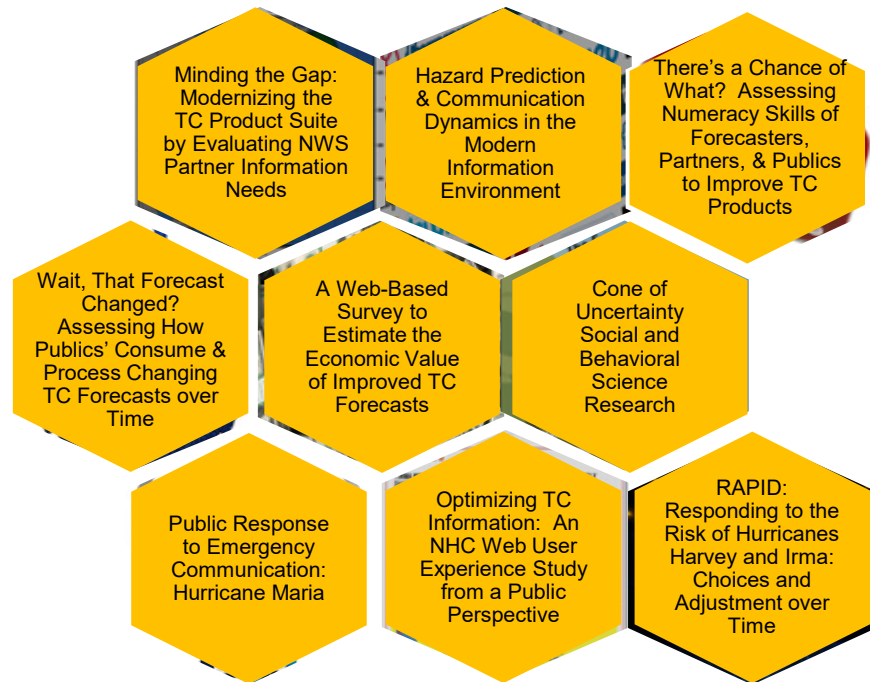


# Outreach to Community

## HFIP Collaborative Awards Round VI (2020-2022)

PI Name	PI Institution	Project Title
Alan Brammer	CSU-CIRA	Extending the Tropical Cyclone Genesis Index to Global Ensemble Forecasts
Enrique Curchitser	Rutgers	Developing Regional Ocean Modeling Capabilities with MOM6 for use in the UFS
Ryan Torn	SUNY Albany	Application of Innovation Statistics to Diagnose Biases in the HAFS System

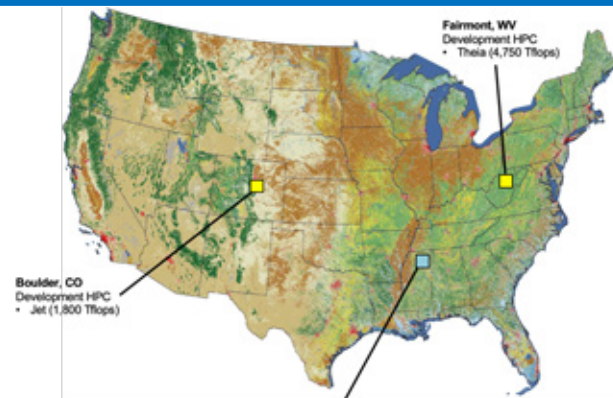
## 9 OAR & Hurricane Supplemental Projects using SBES research to evaluate TC products



# Key Strategies: HPC & R2O

## 4. Increase HPC Capacity

- NOAA R&D and **operational** computing to support HAFS development
- Hurricane Supplemental will provide R&D HPC **~24M core h/month** for HAFS development (**Hera & Orion**)



## 5. Research to Operations (R2O) Enhancements

- Accelerate transition to operations by following NOAA's best practices for promoting readiness levels (RLs)
- Develop a process to prioritize research targeted for operational improvements
- Integrated use & support of Testbeds (JHT, DTC, JCSDA, HWT, HMT, & EPIC)

