HFIP Report to Review

A Presentation to the
NOAA Science Advisory Board

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Outline

- Purpose
- Issue
- NOAA's Response - HFIP
- Discussion

Purpose

- Present NOAA's response to Environmental Information Services Working Group (EISWG) recommendations on the HFIP Five-Year Plan submitted to Congress in response to Section 104 of the Weather Research and Forecasting Innovation Act of 2017
- Request the SAB to:
  - Review NOAA's response
  - Provide comments and suggestions
  - Approve the response

Issue

- EISWG reviewed the HFIP plan NOAA prepared in 2018 that outlined specific research, development, and technology-transfer activities necessary to address the three primary focus areas stated in Section 104 of the Weather Research and Forecasting Innovation Act of 2017.
- In 2019 NOAA also prepared a 5-year HFIP Strategic Plan that expands on the plan sent to Congress identifying specific goals, 6 key strategies to achieve those goals, and metrics to measure progress toward them.
- To address expanded HFIP scope requires ~$22M/year. NOAA is using existing base (~$14M/year) and short-term Disaster Supplemental resources from 2018 and 2019 (~$20M over 3 years) on focused research to address the expanded HFIP scope.
- This response outlines how NOAA and HFIP are utilizing those resources and leveraging other NOAA research and development activities to address the EISWG recommendations.

Response to EISWG Recommendation 1

Overall Project Plan: To address The Weather Act Title I, Sec. 104 (c), the expanded scope must be mapped to necessary resources and timelines.

Response: NOAA base support (~$14M/year for FY19-FY22) and short-term (2-3 year) supplemental projects under the Bipartisan Budget Act of 2018 (P.L.115-123) and the Additional Supplemental Appropriations for the Disaster Relief Act of 2019 (P.L.116-20) were used to accelerate four key strategies outlined in the 2019 HFIP Strategic Plan:

1. Development of the Hurricane Analysis and Forecast System (HAFS) to improve forecast guidance on track and intensity, including rapid intensity change;
2. Social Behavioral and Economic Science (SBES) Research to improve communication of risk;
3. Increased Research and Development High Performance Computing (RDHPC); and
4. Provide grants to broaden expertise and expand interaction with external community.

HFIP budget reduction in FY15 slowed rate of progress towards 10-year goals. To address expanded scope HFIP requires ~$22M/year. FY18 & FY19 Disaster Supplemental resources provided one-time support of ~$20M over 3 years (~60% to Federal grants), and ~$25M for RDHPC.

Response to EISWG Recommendation 2

Rapid Intensification (RI) and Track: Expand participation through dedicated science campaigns that cross the atmosphere-ocean interface to improve model physics and data assimilation, and increase the use of probabilistic forecasts to quantify uncertainty. Continue HAFS development and entrain more external researchers.

Response: HAFS development is leveraging the advancing in the Unified Forecast System (UFS) and Joint Effort for Data Assimilation (JEDI) systems through Disaster Supplemental, UFS R2O, Earth Prediction Innovation Center (EPIC), and Federal grants, which also serve as touchpoints with broader community efforts.

HFIP developed collaborations with Office of Naval Research (ONR) on Tropical Cyclone Rapid Intensification (TCRI) initiative (2020-22) and OAR/Global Ocean Monitoring and Observing (GOMO) and NOS/ Integrated Ocean Observing System (IOOS) on use of ocean observations to improve RI guidance (2021-2022).

Response to EISWG Recommendation 3

Forecast and Communication of Storm Surges: Communicating storm-surge risk should be prioritized, account for uncertainty from multiple sources, and address diversities of human perception, behavior, and needs. Evaluation and improvement of operational storm surge models should also be prioritized.

Response: Owing to the budget reduction, storm surge research & development is now largely being supported by the Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act and UFS. Current storm surge modeling activities are now coordinated under UFS through the Marine and Land Working Groups.

Disaster supplemental and COASTAL Act supported extension of storm surge forecast lead times to 3 days with the same skill as 2-day and the OCONUS development of storm surge guidance for Puerto Rico, U.S. Virgin Islands, Hawaii, and Guam.

UFS is setting up a testbed to compare community coupled atmosphere-wave-ocean-hydrology models to assess their relative performance.

Response to EISWG Recommendation 4

Risk Communication Research for Watch/Warning Products: Watch and warning products need to address risk from multiple threats. Developing a strategic plan for SBES research with milestones and metrics should be a high priority to ensure forecasts and forecast products address diverse societal needs and impacts.

Response: HFIP Strategic Plan Appendix A.2.4 outlines the goals and metrics for SBES research to improve hazard guidance and communications of risk for all hazards. Due to budget reduction, HFIP is not able to support social science research at the levels planned or desired. Disaster supplementals provided ~$3M for this research (FY19-22) to support 6 projects. Additionally, the Office of Oceanic and Atmospheric Research (OAR) Weather Program Office (WPO) and National Weather Service (NWS) Science Technology and Integration (OSTI) budget portfolios are providing ~$1.5 M to support an additional 5 SBES projects for research, testing, and evaluation of hurricane Hazard Services

Response to EISWG Recommendation 5

Expanding Partnerships and Collaboration: Increase internal coordination across OAR, NWS and National Ocean Service (NOS), and expand science and technology partnerships to achieve Weather Act goals.

Response: Enhanced collaboration across OAR, NWS, and NOS is occurring through the UFS R2O project, NOAA Climate and Modeling Board, Disaster Supplemental, Storm Surge, GOMO's Extreme Events Ocean Observing Task Team (EEOOTT), and COASTAL Act.

For overall hurricane research to operation enhancement, we integrate more with NOAA testbeds such as the Joint Hurricane Testbed (JHT), Developmental Testbed Center (DTC), Joint Center for Satellite Data Assimilation (JCSDA), and Hazardous Weather Testbed (HWT).

NOAA Coordination & Views

- Coordination with:
  - HFIP Executive Oversight Board (HEOB) co-chaired by OAR and NWS Directors, and includes representation from all NOAA Line Offices
  - UFS Working Groups (e.g. R2O)
  - COASTAL Act
- What has NOAA done to address this issue
  - Develop a detailed HFIP Strategic Plan with specific operational goals and metrics
  - Develop collaborations between HFIP and other NOAA R&D activities (e.g., UFS, COASTAL Act) to leverage resources and to make best use of Disaster Supplemental support.
- Present NOAA's coordinated view on the report.

Desired Outcome

- SAB endorse the strategic plan to address The Weather Act Title I, Sec. 104.

Backup Slides

Response to EISWG Recommendation 1

1. To address The Weather Act Title I, Sec. 104 (c), the expanded scope must be mapped to necessary resources & timelines. (Higher priority recommendations in blue): NOAA Disaster Supplemental (DSUP) projects supported acceleration of two key strategies in HFIP's Strategic Plan; the Hurricane Analysis and Forecast System (HAFS) development and Social Behavioral and Economic Science (SBES) Research to improve communication of risk (~$14M FY19-FY22). Disaster Supplemental resources from FY18 and FY19 total approximately $20M in Hurricane focused research.

- **Historical goals**: Starting in FY 2015, NOAA dedicated fewer resources to HFIP due to competing budget priorities. This reduction slowed the rate of progress towards the 10-year HFIP goals. Reduced funding levels also hindered engagement with the academic community.
- **Scope, Resources and Timelines:** HFIP, Disaster Supplemental resources, the UFS R2O Project, and AOML base funding targets high-priority components of the HFIP strategic plan. Full execution of the plan within a reasonable timeline will require significant new resources.
- **Developing a Convergent Interdisciplinary and Integrated Approach**: HFIP is a joint effort between OAR and NWS, and the team is actively engaged with other NOAA line offices, including NOS and NESDIS, and external community through HFIP, DSUP, UFS R2O, and AOML base funding to address gaps. HFIP also provides Federal grant funding opportunities every two years to help transition high readiness level research from the external community to operations.

Response to EISWG Recommendation 2

2. Rapid Intensification and Track (Higher priority recommendations in blue): Collaborations with Office of Naval Research (ONR) on Tropical Cyclone Rapid Intensification (TCRI) initiative (2020-22) and OAR/Global Ocean Monitoring and Observing (GOMO) and NOS/IOOS on use of ocean observations to improve RI guidance (2021-2022).

- **Addressing the Challenges of Forecasting Intensity Change and Track:** The HFIP 5-Year Strategic Plan clearly articulates the model development priorities with a focus on high-resolution ocean/wave/surge coupled system with advanced DA capabilities, which are geared to addressing forecast improvements to genesis, track, intensity change, structure, precipitation, and landfall impacts.
- **Expanding Probabilistic Forecasts:** HFIP started an experiment combining NOAA's own real-time TC ensemble with Navy's operational COAMPS-TC ensemble to create a national TC multi-model ensemble. The experiment provides additional uncertainty associated with deterministic TC track and intensity forecast guidance, as well as multi-model ensemble mean forecasts.
- **Advancing Ocean Model Data Assimilation:** With support from DSUP projects, a prototype Marine JEDI with 3DVar methodology for ocean DA for MOM6 has been achieved. Further advancements to a hybrid DA approach is a near-future focus. Further support is required for joint AOML-EMC-PSL efforts to explore and develop JEDI based coupled DA for regional HAFS.
- **Improving Coupled Atmosphere-Ocean Process Parameterizations:** Progress is being made in ocean and coupled (atmosphere-ocean) data assimilation via projects supported by HSUP and others like GOMO's EEOOTT.

Response to EISWG Recommendation 2 (Contd.)

- **Expanded Metrics:** Comprehensive key verification and validation metrics for UFS applications, including the Hurricane application, were identified through NOAA sponsored DTC UFS Evaluation Metrics Workshop. Final metrics lists were developed and shared with all UFS applications and working groups.
- **Conducting the Science Campaigns:** In 2021 IFEX is partnering with ONR's TCRI and NASA's Convective Properties Experiment (CPEX), and with GOMO's EEOOTT. As HFIP increases support for research into TC hazards at landfall, IFEX is evolving into Advancing Prediction of Hurricane Experiment (APHEX) with closer ties to partners supporting the COASTAL Act observation program.
- **Continue Building the Model Test Environment - HAFS:** HAFS is being developed as a coupled atmosphere/ ocean/wave system using UFS coupling infrastructure tools and utilities including NUOPC, CMEPS and CDEPS. These tools are also being used to provide freshwater-saltwater coupling in other projects (e.g., COASTAL Act) which will facilitate future advancements within HAFS.
- **Building the Distributed Data Archive:** Flight level data and Doppler data from NOAA P-3s are available at AOML. The model analysis and forecast data are available at NCEP via NOAA Operational Model Archive and Distribution System (NOMADS) server.
- **Forming the Diverse Research Teams:** HAFS is being developed as the next generation TC forecast system as a UFS allowing infrastructure and science working groups from the UFS community to engage in technical and scientific advancements of TC research. It also helps build cross-collaborations with other ongoing projects -- namely JCSDA's JEDI, OAR funded Ocean IMPACTS; IOOS funded COMT, COASTAL Act and NAS Gulf Research Program.

Response to EISWG Recommendation 3 (Contd.)

- **Enhancing Communication of Risk and Uncertainty for Hurricane Storm Surge:** Leveraging other funding sources (WPO SSP, WPO JTTI, and DSUP), the team is looking across all TC hazards (storm surge, rain, inland flooding, tornadoes, winds, etc.), looking at numeracy and how risk perceptions evolve over the course of a hurricane. Research guided recommendations for some improvements and product design enhancements are being suggested.
- **Data Uncertainty and Considerations to Support R2O Enhancement:** NHC is a leader in incorporating both social and physical sciences into their uncertainty product development as well as the adoption of new warning dissemination systems. NHC recently led the adoption of a fully collaborated gridded warning for storm surge which dramatically increased the spatial and temporal resolution from zone-based approaches to 2.5 km gridded approaches. Additional improvements will require significant investments in NWS dissemination, the adoption of polygon-based warning systems (aka Hazard Services) and overall improvements in AWIPS architecture and/or cloud-based approaches. In partnership with OAR, efforts are underway to expand the JHT capabilities to enable the testing and evaluation of the aforementioned service improvements.

Response to EISWG Recommendation 4

4. Risk Communication Research for Watch/Warning Products (Higher priority recommendations in blue): HFIP Strategic Plan Appendix A.2.4 outlines goals and metrics for SBES research to improve hazard guidance and risk communications. DSUP provided ~$3M for this research (FY19-22). Additionally, OAR WPO and NWS STI are supporting SBES research, testing, and evaluation of Hazard Services

- **Elevating Social and Behavioral Sciences in Risk Communication Research:** HSUP and WPO funded projects look across multiple hazards, (including one that assesses COVID-19 as well). They also support tropical projects that include NWS core partners and their needs. We continue to look to advance these R&D efforts, as well as NWS IDSS applications.
- **Setting Metrics and Broadening Approaches to Enhancing Risk Communication:** In September 2019, WPO hosted a weather-focused, Social Science Research to Operations Workshop where they focused on development of meaningful metrics. Currently, there are many initiatives underway within NWS, WPO, and NOAA-at-large (including with NOAA Social Science Committee), to enhance social science organizational infrastructure to support these efforts. We are actively looking for resources to further our TC baseline and longitudinal data collection efforts to support information requirement development, measuring progress, as well as advancing risk communication in the agency.

Response to EISWG Recommendation 5

5. Expanding Partnerships and Collaboration: **Higher priority recommendations in blue):**
Enhanced collaboration across OAR, NWS, and NOS is occurring through the UFS R2O project, NOAA Modeling Board, Disaster Supplemental, Storm Surge, GOMO's EEOOTT, and COASTAL Act.

- **Expanding Partnerships to Meet the Challenge:** Partnerships within OAR, NWS, NOS and NESDIS are strong, particularly through HSUP projects which are coordinated across LOs. Further coordination is provided by AA Level of each LO through NOAA's HEOB and the WWCB. NOAA also is coordinating with the Navy on TC observations, coupled atmosphere-ocean modeling. UFS R2O Project includes NOAA EMC, Labs, CIs, UCAR and Academia. For social sciences, there are past and ongoing WPO partnerships with NSF to leverage NSF's theory building projects and bridge them to applications. There is also a current IAA with NSF to the Natural Hazards Center to support "Weather Ready Research" quick response research tied to the priorities in the Weather Act.

- **Expanding Collaborations with NOAA's National Ocean Service:** There are active, ongoing collaborations between OAR, NWS, NOS, and ONR through the GOMO's EEOOTT (includes academia). EEOOTT convened a number of working groups to address multiple facets of improving hurricane intensity forecasts, including modeling and data assimilation, integrated ocean-atmosphere observations (e.g., gliders, drifters, Saildrones, Argo and ALAMO floats, sUAS, etc.), and resourcing.

Response to EISWG Recommendation 5 (Contd.)

- **Leveraging Collaborations with the U.S. Navy:** NOAA/HFIP should revive an earlier partnership with the US Navy to explore use of multi-model ensembles, including COAMPS-TC, for generation of probabilistic guidance for the forecasters. NOAA and the US Navy can also collaborate on exploring and leveraging coupled/ocean/wave data assimilation methods for coupled TC forecasts using COAMPS-TC and HAFS. Through IFEX, HFIP is collaborating with the US Navy on ONR's TCRI experiment to collect observations that can be used to evaluate COAMPS-TC, HWRF, and HMON's ability to forecast RI. NOAA and the US Navy are collaborating on exploring the use of ocean gliders to improve the coupled TC forecasts using COAMPS-TC and HAFS. This successful collaboration between OAR, NOS, and the US Navy led to largest deployment of uncrewed systems in tropical storm environments in FY20 and FY21.
- **Building a Focused Collaborative Network:** Through IFEX, HFIP provided a means for NOAA to partner with other Agencies (ONR, NASA, and NSF) to increase the capacity to collect observations in TCs to accelerate model development, evaluation, and analysis to initialize the hurricane forecast models. In 2021 IFEX is partnering with ONR's TCRI and NASA's CPEX, and in 2022 with GOMO's EEOOTT. The FY18 and FY19 Disaster Supplemental resources are supporting deployment of gliders, drifters and sail drones and other new observational technologies targeted to improve hurricane forecasting. IOOS and GOMO continue to invest in ocean observing systems that will benefit TC forecasting.