WPO Research Focus Areas

WPO works closely with NOAA’s research laboratories and the weather enterprise—a community that includes NOAA, other Federal agencies, academia, research institutions, and the private sector—to develop and transition weather research to improve knowledge about tropical cyclones, severe storms, extreme precipitation, air pollution, and social science. In addition, our office also seeks to integrate weather, water, and climate forecasting and mitigation.

In FY20, WPO fostered and transitioned research that was informed by social science, and focused on tropical cyclones, air quality & wildfires, severe weather, and climate/S2S forecasts, as well as the full use of artificial intelligence in prediction. These broad areas are illustrative but do not represent the breadth of research that WPO supports.

Each of these research focus areas cuts across multiple WPO Programs. Such an integrated approach is best explained by a description presented of selected projects illustrating how WPO supports “A Weather-Ready Nation informed by world-class weather research.”

Tropical Cyclones

Tropical cyclones are heat-driven cyclonic storm systems that form over tropical or subtropical waters. Known variously as hurricanes (Atlantic and Eastern Pacific Oceans), typhoons (Northwestern Pacific), and tropical cyclones (South Pacific and Indian Ocean), their impacts can be devastating: winds and storm surge can cause deaths and devastating property losses, ranging from damaged roads and bridges to destroyed homes and businesses.

The 2020 North Atlantic hurricane season was the most active on record, with 30 named storms, including 13 hurricanes, six major hurricanes, and a record 11 tropical cyclones that made landfall in the contiguous United States. NOAA tropical cyclone research aims to improve the ability of forecasters to predict their occurrence and effectively communicate associated hazards to the public. NOAA’s JHT continues to be an important partner in testing, evaluating, and accelerating development of tropical cyclone forecasting tools, technologies, and techniques.

In FY20, approximately 10% of active WPO-funded projects contributed to tropical cyclone research. Including the following highlights:

WPO’s hurricane and tropical cyclone FY20 research priorities plan to:

1. Improve operational analysis of the surface wind field in tropical cyclones.
2. Identify new applications of ensemble modeling systems for track, intensity, and structure forecasting.
3. Improve tropical cyclone genesis and intensity guidance.
4. Advance coastal inundation modeling and/or applications, visualization, and/or dissemination technology.
5. Develop probabilistic wave height forecasts.
6. Integrate relevant social and behavioral science methodologies to improve forecasters’ use of convection allowing/resolving data, techniques, and guidance, as well as end-users’ ability to receive, assess, understand, and respond to forecasts and warnings.

Figure 12. Hurricane Earth Satellite Tracking. Credit: iStockPhoto

DID YOU KNOW?

The 2020 Spring Forecasting Experiment was entirely virtual.

The Hazardous Weather Testbed (HWT), which is supported by WPO, hosted its first-ever 100% virtual Spring Forecast Experiment in April-May 2020. Despite it being completely virtual, over 80 forecasters and researchers participated in the meeting.

Way to go!
Improving Predictive Modeling for Hurricanes

Physics and improved vertical resolution for improving hurricane prediction and tropical convection in the GFS

Dr. Lucas Harris, Mr. Linjiong Zhou, Mr. Kun Gao, and Mr. Morris Bender, Princeton University/NOAA Geophysical Fluid Dynamics Laboratory (GFDL)

Improvements in hurricane intensity forecasts can save lives. Global Forecast System (GFS) predictions of hurricane intensity have become more accurate over the last several years, as model resolution increases and parameterizations are improved. GFDL has continually made improvements to SHiELD (System for High-resolution Prediction on Earth-to-Local Domains) by improving the FV3 Dynamical Core, GFDL microphysics, PBL (Planetary Boundary Layer) scheme, and surface interactions. In 2020, both 13-km global SHiELD and 3-km nested T-SHiELD performed comparably in intensity skill with operational models. Notably, T-SHiELD had a very low bias, maintaining intensity well over the lifetime of the forecast without over-intensification. 13-km SHiELD also showed intensity skill on par with specialized hurricane models -- a first for any global model.

As improvements in SHiELD and other UFS configurations continue, and GFSv17 becomes operational as part of the Unified Forecasting System (UFS), the National Hurricane Center (NHC) will benefit from these improvements in hurricane intensity forecasts.

Figure 13. With a combination of IC perturbations, BC perturbations, SPP, and SPPT, we achieved our goal of producing large spread in convective-storm forecasts with a single-model, single-physics ensemble. Final Report 2020, Figure 10 on page 10. Credit: Alexander, et al.

Increasing the Prediction Accuracy of Hurricanes

Enhancing the Prediction of Landfalling Hurricanes Through Improved Data Assimilation with the Gridpoint Statistical I (GSI)-based Ensemble-Variational Hybrid System and Joint Effort for Data assimilation Integration (JEDI)

Dr. Zhaoxia Pu
University of Utah

Gridpoint Statistical Interpolation-based ensemble-variational hybrid system and the Joint Center for Satellite Data Assimilation’s (JCSDA) JEDI for predictions of time, location, inland evolution, intensity and structure changes of landfalling hurricanes. Advances are possible: (1) by enhancing the assimilation of satellite-measured ocean surface wind and surface Mesonet observations on land and of ground-based NEXRAD observations; and (2) from incorporating new observations from the hurricane inner-core region.

This research meets several JTTI priorities, primarily by strengthening predictions for intensity and track of landfalling hurricanes for current operational hurricane forecast models, such as the GFS-FV3.

Hurricane Boundary Layer Wind Observations

New, Three-Dimensional, Hurricane Boundary Layer Winds from the Imaging Wind and Rain Airborne Profiler (IWRAP) Radar

Dr. Zorana Jelenak
University Corporation for Atmospheric Research (UCAR)

Dr. Stephen Guimond
University of Maryland - Baltimore County (UMBC)

Dr. Paul Chang
NOAA NESDIS

This project will provide next-generation observations of the three-dimensional (3D) hurricane boundary layer (HBL) and ocean surface vector winds (OSVW) from the NOAA WP-3D aircraft, utilizing the IWRAP. IWRAP is a powerful instrument that can fully capture large, turbulent gusts of wind throughout the extent of the HBL, which is not possible from in-situ measurements such as dropsondes. The IWRAP observations will be provided in real-time to the NHC and will be of significant value to forecasters providing warnings for damaging winds and storm surge. In addition, the observations can be used to improve numerical weather prediction models through data assimilation and optimizing turbulence parameterizations.
Advancing New Radar Technologies
Airborne Phased Array Radar (APAR)

Dr. Vanda Grubišić
NCAR Earth Observing Laboratory (EOL)

Figure 14. C-130 with Airborne Phased Array Radar (APAR) Panels.

Airborne weather radars are the most effective instruments available for observing storms over complex terrain, oceans, polar regions, and forested areas. Once developed, APAR will fill the critical need for a fast-scanning weather radar with deep storm penetrating capability and will be available to the research community for 20-25 years through the well-established request process for National Science Foundation’s (NSF’s) Lower Atmosphere Observing Facilities (LAOF).

An airborne weather radar such as APAR will also directly support NOAA’s long-term mission and goal of developing America’s capabilities as a “weather-ready” nation and directly addresses NOAA’s strategic objective of providing improved understanding and timely alerting of severe and adverse weather events. It will also help advance the goal of an operational APAR on the aircraft used by the NHC for flights into hurricanes for greater storm analysis, such as the NSF/NCAR C-130 aircraft by 2028 and the next-generation NOAA hurricane hunter aircraft by 2030.

Assessing the Public's Consumption of Changing Tropical Cyclone Forecasts Over Time

Wait, that Forecast Changed? Assessing How Public’s Consume and Process Changing Tropical Cyclone (TC) Forecasts Over Time

Dr. Rebecca Morss, Dr. Julie Demuth, Mr. Robert Presley, Ms. Andrea Schumacher, Mr. Josh Alland
NCAR
Ms. Gabrielle Wong-Parodi, Ms. Natalie Herbert
Stanford University
Ms. Leysia Palen, Mr. Ken Anderson, Ms. Melissa Bica
University of Colorado-Boulder

To learn more about how the public consumes and processes tropical cyclone information in the modern information environment, this project deployed a longitudinal survey before, during, and after Hurricanes Marco and Laura (2020) to investigate how at-risk people process, understand, and use the complex collection of evolving forecast and warning information available during a tropical cyclone threat. This includes examining whether and when members of the public anchor on forecast information and how they shift their risk perception as updated tropical cyclone forecast information emerges.

DID YOU KNOW?

The Weather Observations Research Program is actually 3 programs in 1.

The WPO Weather Observations Research Program (WORP) not only supports projects for severe storm observations, but also infrasonic detection of severe weather, as well as soil moisture and snowpack measurements. This means the Obs Program effectively and affordably observes weather and climate from the ground up.

That's a lot to cover!
Air Quality and Wildfires

In many areas of the country, the public is exposed to unhealthy levels of air pollutants and sensitive ecosystems are damaged by air pollution. Among other hazards, wildfires, high surface ozone, and other pollutants contribute to poor air quality.

In 2020, a record-setting wildfire season affected the Western U.S. California experienced five of its six largest wildfires on record, resulting in widespread smoke and haze. In the East, heat waves, high humidity, and urban pollution combined to produce hazardous air quality conditions. NOAA works with the Environmental Protection Agency, state and local air quality agencies, academia, and the private sector to address these problems, providing an air quality forecast capability for the nation called the National Air Quality Forecasting Capability.

WPO’s air quality and wildfires FY20 research priorities plan to:

1. Develop and evaluate high-resolution (1-4 km) air quality forecast capabilities that are consistent with NOAA weather forecast models at these resolutions.
2. Improve spatial and temporal estimates of anthropogenic and natural pollutant emissions.
3. Explore and quantify the potential value of ensemble model approaches and post processing to operational air quality forecasting.
4. Improve model representation in the FV3 model of physical/chemical processes for long-range transport.
5. Develop high-density observation capabilities that quantify how extreme temperatures, combined with dew point and wind speed, impact air quality and outdoor activities.

In FY20, approximately 10% of active WPO-funded projects contributed to air quality and wildfire research, including the following highlights:

Improving the Forecasts of Smoke from Wildfires

Top-Down Estimation of Wildfire Smoke Emission Based on HYSPLIT Model and NOAA NESDIS GOES Aerosol/Smoke Products to Improve Smoke Forecasts in the U.S.

Dr. Tianfeng Chai
University of Maryland (UMD)

Researchers intend to provide a better smoke forecast by developing a Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) inversion system to better estimate wildfire smoke sources.

Researchers plan to evaluate and improve the inverse system while working on real-time operation capability. Proposed actions include:

- Transitioning the inverse system code to the NOAA operational environment, if appropriate;
- Modifying the code interface to read near-real-time GOES Aerosol/Smoke Products; and
- Evaluating the smoke forecasts using the optimally estimated emissions.

Assessing and Communicating Uncertainty in Modeled Transport, Dispersion, and Deposition of Hazardous Materials Using HYSPLIT Ensemble Dispersion Modeling for Forecasting Applications

Drs. Barbara Stunder & Alice Crawford
NOAA Air Resources Laboratory (ARL)

Researchers intend to improve on deterministic approaches with products that assess and communicate uncertainty in the modeling of hazardous material transport, dispersion, and deposition.

The results may serve emergency response applications as diverse as simulating atmospheric plumes from chemical releases and volcanic ash.

Severe Weather

The term “severe weather” is used to describe local, intense, often-damaging storms such as thunderstorms, severe wind and hail storms, and tornadoes. Annually, the U.S. is struck by 100,000 thunderstorms, 10,000 severe thunderstorms, and 1,000 tornadoes.

NOAA’s severe weather research aims to improve forecaster ability to predict and communicate warnings to the general public. NOAA’s Hazardous Weather Testbed continues to be an important partner in testing, evaluating, and accelerating development of severe weather tools, technologies, and forecasting and communication techniques.

WPO’s severe weather FY20 research priorities plan to:

1. Identify and validate concepts and techniques to improve NOAA’s convection-allowing/resolving ensemble forecast system performance.
2. Identify and validate innovative post-processing and verification techniques for NOAA’s deterministic models and ensembles across spatial and temporal scales to create skillful and reliable probabilistic thunderstorm and severe hazard threat guidance.
3. Improve numerical weather prediction modeling through data assimilation, post-processing, and verification capabilities.
4. Advance technologies that characterize boundary layer vertical profiles of water vapor, temperature, pressure, and winds.
5. Integrate relevant social and behavioral science methodologies to improve forecasters’ use of convection allowing/resolving data, techniques, and guidance, as well as end-users’ ability to receive, assess, understand, and respond to forecasts and warnings.

In FY20, approximately 20% of active WPO-funded projects contributed to severe weather research, including the following highlights:

Advancing Convection-Allowing Models with Objective Mode Identification Using Convective Mode Information for Hazard Prediction With Convection-Allowing Models

Mr. Ryan Sobash
NCAR

Researchers intend to employ and then assess a convective mode identification system in the post-processing workflow of the NOAA HWT Community Leveraged Unified Ensemble (CLUE). Existing algorithms will be used to build the system, which will be objectively and subjectively tested in the HWT. The model-agnostic system will be refined for use with various new and current guidance products, and for potential validation of convection-mode forecasts.

Resulting research products will be accessible to the public and to NOAA stakeholders (e.g., scientists, forecasters) in organizations such as NOAA’s Storm Prediction Center (SPC), NSSL, and the HWT.
Improving Research-to-Operations Transitions for FACETs
FACETs: Advancing Physical and Social Science Concepts Toward Operational Implementation of Probabilistic Hazard Information

Mr. Alan Gerard
NOAA NSSL

This project continues the R2O transition process for key aspects of the FACETs effort for convective hazards, and will elevate the RLs of physical and social science concepts that serve as foundations for FACETs. Collaboration with the NWS will also support and improve current services and programs related to convective hazards through targeted transitions to operations.

FACETs is a proposed next-generation watch and warning framework that is designed to communicate clear and simple hazardous weather information to the public. FACETs supports NOAA’s Weather-Ready Nation initiative to build community resilience in the face of increasing vulnerability to extreme weather events.

Understanding How the Public Responds to Forecasts and Warnings
Communicating Forecast Uncertainty and Probabilistic Information: Experimenting with Social Observation Data in the Hazardous Weather Testbed

Drs. Carol Silva and Joseph Ripberger
University of Oklahoma (OU)

Researchers seek to improve communication of forecast uncertainty and probabilistic information by building upon the Severe Weather and Society Survey, a new data collection capacity that provides generalizable, longitudinal, and experimental data on how members of the U.S. public receive, understand, and respond to uncertainty and probabilistic information in severe weather forecasts and warnings. Although still in development, current data are available. To ensure a smooth transition from research to operations, researchers will engage with the National Weather Service’s Warning Decision Training Division before, during, and after the Hazardous Weather Testbed experiment.

Improving Hazardous Weather Prediction
Convection-Allowing Model Ensembles Optimal Configuration for Short and Longer Time Scales and Multigrid Background Error Covariance Model

Dr. Curtis Alexander
NOAA Earth System Research Laboratory, GSL
Dr. Jacob Carley
NOAA Environmental Modeling Center (EMC)
Dr. Nusrat Yussouf
University of Oklahoma - Cooperative Institute for Mesoscale Meteorological Studies (OU CIMMS)/NSSL

Researchers explored the optimal ensemble design for probabilistic forecasts of hazardous weather threats that represents forecast errors in the 0-6 hour time frame, as well as the 0-36 hour time frame. Researchers also worked to improve the quality and structure of the analysis increment in the data assimilation system through the development of a multi-grid beta filter to model the background error covariance, the development also addresses computational bottlenecks present in the existing operational infrastructure.

Development of these capabilities supports the Unified Forecast System and forms a foundation for success in the National Centers for Environmental Prediction’s future high-resolution modeling and forecast capabilities in the Rapid Refresh Forecast System, Warn-on-Forecast System, and 3D Real Time and UnRestricted Mesoscale Analysis system.

DID YOU KNOW?
The FACETs framework was originally developed to revolutionize severe storm monitoring? It now aims to expand in the near future to include hurricanes, flooding and ice storms. This will definitely keep us on our toes!
Artificial Intelligence

NOAA recognizes the potential of artificial intelligence (AI) and machine learning (ML) techniques to advance capabilities in analyzing the expansive amount of data collected by observing networks and produced by modeling systems. AI analytics and cloud computing platforms are being leveraged to identify, understand, and forecast extreme weather events of all types, including severe weather, flooding, tropical cyclones, subseasonal to seasonal, and others. R&D funded through WPO aims to support the advancement of AI applications to better extract information from data, thereby enabling better analyses and predictions.

WPO’s AI/ML FY20 research priorities plan to:

1. In collaboration with the UFS community, further develop, test and enhance data assimilation techniques, develop and evaluate physics, improve model component coupling techniques and capabilities, and utilize AI/ML for improving forecasts.
2. Accelerate the use of AI in product generation in operations, particularly for better use of existing ensembles, and creation of auto-tuning and auto-calibration capabilities for machine learning techniques to reduce operations and maintenance costs.
3. Improve climate- and S2S-scale model post-processing via innovative statistical techniques and applications of existing statistical techniques, AI/ML methods.

AI is a new but rapidly growing component of WPO’s research portfolio and is a part of less than 10% of active WPO projects in FY2020. Examples of WPO AI-focused projects follow.

Using Deep Learning to Analyze Fronts
Deep Learning for Operational Identification and Prediction of Synoptic-Scale Fronts

Dr. Amy McGovern
University of Oklahoma (OU)
Dr. John Allen
Central Michigan University

Researchers will develop an automated ML approach for frontal analysis that may be integrated into regular analysis procedures by human forecasters. ML will provide a first-guess map for warm, cold, occluded, and stationary fronts, as well as drylines, over the region covered by the Unified Surface Analysis. An effective, automated first-guess map will allow human forecasters to significantly reduce the time needed to produce a final analysis. This project will make use of deep learning, which has recently emerged as a high-performing ML algorithm in a variety of fields.

Calibrated Forecast Guidance for Severe Weather
Generating calibrated forecast guidance for severe weather beyond Day 1

Drs. Russ Schumacher and Aaron Hill
Colorado State University

Severe weather predictions pose significant challenges for forecasters, especially past the short range (less than 2 days) when fewer forecast tools are available. In this project, a severe weather ML model will be extended to post-process global model output and produce CONUS-wide forecasts of severe weather to aid SPC forecasters at days 2-8 (36-204 hours). The project will leverage the new Unified Forecast System FV3-based Global Ensemble Forecast System (GEFSv12), which became operational in September 2020, as input to the ML model and generate probabilistic severe weather forecasts. Researchers will objectively and subjectively evaluate the probabilistic forecasts at the Hazardous Weather Testbed Spring Forecast Experiment and with SPC forecasters.

Did you know?

JTTI is celebrating a significant anniversary?

The Joint Technology Transfer Initiative (JTTI) program was created in 2016, to accelerate the transition of matured research from America’s Weather Enterprise to NWS.

Happy 5th Anniversary, JTTI!
Climate/S2S

Long-range weather and climate predictability on the scale of S2S and beyond remains a challenging area of research. Through the S2S competitive call and the Climate Testbed, WPO supports a wide range of research toward developing a baseline of S2S predictability, community-based approaches to improving Earth system models, and improving existing ensembles to improve prediction skill and assessments of uncertainty. Together, these begin to fulfill the S2S (defined as a forecast period of two weeks to two years) requirements of the Weather Act while emphasizing the models and components in NOAA’s UFS, the North American Multi-Model Ensemble, and ongoing multi-model ensemble efforts on the S2S timescale (e.g. the continuation of the Subseasonal Experiment and support to the S2S datasets at the International Research Institute for Climate and Society’s Data Library).

WPO’s climate/S2S FY20 research priorities plan to:

1. Improve climate-scale model post-processing via innovative statistical techniques and applications of existing statistical techniques, AI/ML methods.
2. Accelerate the S2S portion of the UFS through new methods or improvements to existing scale- and aerosol aware parameterizations.
3. Enhance data assimilation systems that support climate monitoring and prediction, specifically related to ocean, sea ice, and land data assimilation using the JEDI.

In FY20, approximately 15% of WPO-funded projects contributed to climate and S2S research, including the following highlights:

**Evaluating Seasonal and Subseasonal Forecasts**

*Applications of Model Evaluation Tools (METplus) to Subseasonal Climate Outlooks, Multi-Model Ensembles, Process Studies, and Extremes*

*Ms. Tara Jensen*
NCAR

*Ms. Melissa Ou*
NOAA NWS/CPC

Utilizing the METplus to enhance the capability of evaluating seasonal and subseasonal official outlooks and model guidance, this project aims to improve these forecasts by better understanding their skill. Results will determine how well models replicate climatological characteristics and the ability of models and post-processed tools to forecast hazards and extremes using various types of thresholds.

Figure 20. Derechos are known for having a swath of wind damage extend for more than 240 miles and include wind gusts of at least 58 mph, or greater, along most of its length.
Credit: Jim Reed/Corbis via Getty Images

Figure 21. Examples of temperature and precipitation guidance.
(a) Top Left: Example of the Climate Prediction Center (CPC)’s experimental weeks 3-4 temperature forecast. (b) Top Right: Example of CPC’s weeks 3-4 precipitation forecast. (c) Bottom Left: Example of CPC’s week-2 official, probabilistic hazards forecast for temperature, based on guidance from the GEFS Reforecast Tool (Bottom Right).
Credit: Tara Jensen (2020)
Improving Subseasonal to Seasonal Prediction in the UFS

Accelerating Progress in Subseasonal to Seasonal Prediction Capabilities by Improving Subgrid-Scale Parameterizations in the UFS

Dr. Benjamin W. Green
Cooperative Institute for Research in Environmental Sciences (CIRES) / University of Colorado-Boulder/NOAA GSL
Dr. Vijay Tallapragada
NOAA NWS

In this project, researchers test the impact of incorporating three new parameterizations of atmospheric subgrid-scale physical processes into the existing physics suite used for NOAA’s UFS. The intent is to advance S2S prediction capabilities, including forecasts of precipitation and temperature, over the U.S. and globally. The gains in S2S forecast skill will result from testing and evaluating the new parameterization schemes and comparing their performance against current operational parameterizations of scale-aware convection, planetary boundary layer, and cloud microphysics maintained by NOAA’s EMC.

Improving 2-4 Week Precipitation
Identifying physical processes responsible for tropical UFS errors and their relation to UFS week 2-4 precipitation predictability in the western US

Drs. Juliana Dias and Elizabeth Thompson
NOAA PSL
Dr. Shan Sun
NOAA GSL

Part of NOAA’s Precipitation Grand Challenge initiative, this project aims to quantify improvements in western U.S. precipitation forecasts at 2-4 week lead times. Improvements are expected from reducing tropical sources of uncertainty related to subseasonal limits of predictability, lack of observational constraints, systematic model errors, and model parameterizations. This will help advance work toward the improvement of predictions of the amounts and locations of rain and snow, as well as other precipitation-related forecasts.

Figure 23. Illustration of U.S. areas where UFS week 3-4 precipitation error is reduced (blue) when nudging is applied to the tropical atmosphere. Shading shows percent differences in mean absolute error (MAE) of precipitation if the entire tropical atmosphere is nudged to reanalysis. Reforecast period is November-March (1999-2018). Credit: Juliana Dias, 2020

Water

Precipitation, ocean modeling, flooding, snowpack and soil moisture all contribute to WPO’s precipitation and hydrologic research focus area. Flooding is the result of an overflow or inundation from a river or other body of water that causes or threatens damage. Annually, the U.S. is struck by over 5,000 floods or flash floods. Coastal storms, heavy rain, and melting snow are all potential causes. When flooding is on coastal lands, it is termed “coastal inundation.” Although it could be caused by wave action, it is usually the result of riverine flooding, spring tides, severe storms, or underwater seismic activity resulting in a tsunami.

WPO precipitation and hydrology research is focused on improving observations and forecasts of heavy precipitation, snowpack, soil moisture, and flooding threats, in addition to improving ocean and rivershed modeling capabilities. NOAA’s HMT continues to be an important partner in testing, evaluating, and accelerating development of hydrologic forecasting tools, technologies, and techniques.

Figure 22. Bivariate skill score for the RMM index, indicating skill of forecasting the Madden-Julian Oscillation (MJO). Each curve represents the aggregate skill of a particular experiment: the control is in black, GF convection in red, MYNN boundary layer in blue, and Thompson microphysics in purple. The green dashed line denotes a score of 0.6; scores above this are considered to be skillful. Thus, the Thompson experiment is skillful beyond 14 days, whereas the other 3 experiments are skillful beyond 13 days.

Credit: Benjamin W. Green (2021)

Did you know?
The U.S. Congress has provided supplemental funds to NOAA to support recovery from high-impact weather events?

In 2013, the 114th U.S. Congress provided funding to NOAA to improve and streamline disaster assistance, and study the impacts of Super Storm Sandy.
WPO’s water FY20 research priorities plan to:

1. Identify and validate new or improved methods, models, or decision-support tools to improve flash-flood monitoring and forecasting.
2. Identify and validate new or improved methods, data assimilation, models, or decision-support tools to improve utilization of precipitation forecasts and production of streamflow forecasts.
3. Identify and validate new or improved methods, models, or decision-support tools to improve probabilistic winter precipitation forecasts for snowfall amounts and/or ice accumulation.
4. Improve water prediction capabilities to include efforts to enhance hydrologic prediction through improved data assimilation and model extension for hydrological data sets.
5. Focus on advancements leading to improved surface-based or airborne-based observing capabilities of snow depth (snow water equivalent) and soil moisture.
6. Improve observations, data assimilation, and physics parameterization of snow depth and soil moisture.

In FY20, approximately 20% of active WPO-funded projects contributed to water hazard research, including the following highlights:

**Detecting Snow with Remote Sensing**
*Experimental Framework for Testing the National Water Model: Operationalizing the Use of Snow Remote Sensing in Alaska*

*Dr. Katrina Bennett*  
Los Alamos National Laboratory  
*Dr. Vladimir Alexeev*  
University of Alaska - Fairbanks  
*Mrs. Aubrey Dugger*  
Research Applications Lab

This project will develop a near-real-time data stream of simple, first-order assimilation of remotely sensed snow cover extent and snow water equivalent data in Alaska. The components of this work will be operationalized for use in NOAA’s Community Hydrologic Prediction System (CHPS) framework. Researchers also will develop a first-ever experimental NWM for Alaska river basins to test, validate, and benchmark NWM model skill to better capture the processes critical to hydrologic prediction in Alaska.

**Evaluating Heavy Rainfall and Flash Flooding Forecasts**
*Probabilistic Warn-on-Forecast System for Heavy Rainfall and Flash Flooding*

*Mr. Steven Martinaitis*  
University of Oklahoma - Cooperative Institute for Mesoscale Meteorological Studies (OU CIMMS)/NSSL  
*Dr. Jonathan Gourley*  
NOAA NSSL

This project uses the HMT Multi-Radar Multi-Sensor (MRMS) Hydro Experiment with the goal of evaluating new probabilistic products and methodologies for forecasting heavy rainfall and flash flooding within the Flooded Locations and Simulated Hydrographs (FLASH) system while incorporating short-term forecasts from NOAA NSSL’s Warn-on-Forecast system model.

Researchers presented the latest research developments and techniques to forecasters for optimizing probabilistic products coupled with short-term ensemble modeling for eventual use in the NWS’ flash flood warning operations. Findings from the experiment have shown the potential for increasing warning lead times and reducing false alarm area.

Figure 24. A participating forecaster issues a flash flood warning based on probabilistic FLASH data coupled with Warn-on-Forecast precipitation forecasts during a simulation of the 27 May 2018 Ellicott City, MD event.  
*Credit: James Murnan/NOAA*
Leveraging High Resolution Terrain Data to Address National Water Model Limitations
Estimating Inundation Extent and Depth from National Water Model Outputs and High Resolution Topographic Data

Dr. Paola Passalacqua
University of Texas - Austin

This work addresses shortcomings in the NWM for predicting flood inundation extent and depth by using the workflow GeoFlood, which draws on NWM output and high resolution terrain (HRT) data for increased accuracy of the river network and terrain elevation. NWM output uses 10m resolution terrain data, which are overlaid on 3m or finer HRT data, thus misplacing NHDPlus medium range centerlines with regards to visible channel location in the HRT.

GeoFlood corrects the issue by applying geodesic minimization principles and topographic attributes computed using HRT data, and then employing the Height Above Nearest Drainage (HAND) method. GeoFlood will eventually enable seamless transition from 10m resolution to 1m products with expansion of HRT data coverage (Passalacqua 2019).

Social Science

NOAA must communicate clear and simple weather information that serves the public, which is why social science must inform every aspect of weather forecasting, including providing well-informed and effective warnings. WPO and its partners coordinate social science research needs, determine approaches to translating social science research to applications, and learn from the operational community to understand the next research challenges.

Social Science priorities were informed by WPO’s goals, especially to improve effective communication of weather information to strengthen decision-making and forecasting ability.

WPO’s social science FY20 research priorities plan to:

1. Develop and test methodologies that systematically collect data on end users, including forecaster needs in the operational decision environment, measuring the effectiveness of Impact-Based Decision Support Services (IDSS), and measuring how the public receives, interprets, perceives, and responds to weather information.
2. Improve visual and verbal communication of forecast risk and uncertainty, including probabilistic forecast information.

In FY20, approximately 15% of active projects funded by WPO contributed to social science research priorities, including the following highlights:

Helping the Public Understand Uncertainty
Making Sense of Uncertainty: Improving the Use of Hydrologic Probabilistic Information in Decision-Making

Ms. Rachel Carr
Nurture Nature Center

This research builds on a series of studies conducted by the research team since 2012, each of which is centered on how professional and residential users understand flood and hydrologic forecasts, including those representing uncertainty and probabilistic information.

Accomplishments include the development of a series of user-tested prototype products, developed in cooperation with operational offices and advanced toward operational use, as well as a final report with findings, general recommendations for probabilistic communication, and an explanatory video about the project’s findings.
Understanding the Value of Improving Hurricane Forecasts
A Web-Based Survey to Estimate the Economic Value of Improved Hurricane Forecasts

Dr. David Letson, Dr. Renato Molina, Brian McNoldy
NOAA AOML
Dr. Pallab Mozumder,
Florida International University

The Hurricane Forecast Improvement Program prioritizes hurricane research that improves hurricane track, intensity, and storm surge forecasts. By focusing on areas recently hit by Hurricanes Florence and Michael, this project merged atmospheric modeling to estimate the value of improvements in storm track, wind speed, and precipitation forecast precision. Preliminary results based on this sample suggest that the public values these dimensions of forecast improvement a minimum of $327 million per year across regions that are vulnerable to hurricanes.

Using Social and Behavioral Data to Improve Forecast Communication
Communicating Forecast Uncertainty and Probabilistic Information: Expanding and Embedding Social and Behavioral Data in National Weather Service Operations

Dr. Joseph Ripberger
University of Oklahoma (OU)

This project will improve forecast communication and decision support during extreme weather and high impact weather events by building upon the Severe Weather and Society Survey and the Severe Weather and Society Dashboard. Results will provide generalizable, longitudinal, and experimental data on how members of the Continental U.S. public receive, understand, and respond to uncertainty and probabilistic information in severe weather forecasts and warnings. This information can then be used in future operations to more effectively communicate forecasts to the general public.

The Way Forward

WPO aims to further our collaborative efforts within NOAA and with our stakeholders, partners, the public and the weather enterprise by supporting WPO’s 10 Programs. In concurrence with congressional mandates and our goals, WPO Programs will continue to manage the creation and implementation of research tools and applications through the transition of research into operations or knowledge.

Over the next couple of months, WPO will reassess its mission, goals, structure, and connections in preparation for the 5-year update to our Strategic Plan. This plan guides WPO in prioritizing weather research that saves lives, reduces property damages, and enhances the national economy. In addition, WPO will continue to promote a diverse, equitable, and inclusive research and work environment that supports and fosters collaborations through our annual NOFO.

As we move ahead, ongoing innovation, the funding of weather-related projects, and building upon or expanding our relationships will remain top priorities for WPO as we prepare for our future.

To help navigate the best path ahead, WPO will support the continued emergent NOAA research focus areas:

- Improving methods for incorporating data into forecast models and for model coupling to improve weather forecasting operations from hourly to seasonal time scales.
- Testing/developing the coupled (sub-hourly to subseasonal timescale) UFS; accelerate the S2S application of the UFS.
- Improving forecasts of extreme weather and high-impact weather events.
- Understanding and reducing societal vulnerability to tornadoes and other high-impact events.
- Researching operational NWS and partners’ forecast and warning decision-making process and public response.
- Improving risk communication, risk perception, and information use in protective decision-making.
- Improving model post-processing via innovative statistical techniques and the use of AI/ML methods.