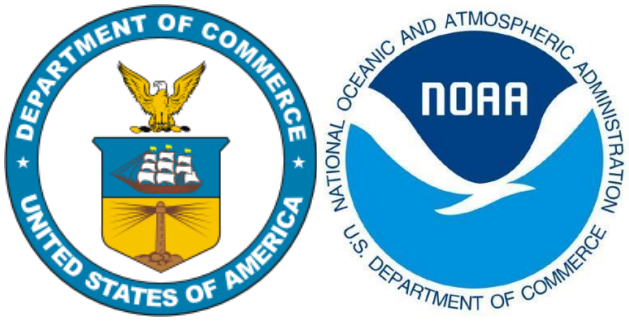

REPORT TO CONGRESS

UNITED STATES WEATHER RESEARCH PROGRAM ANNUAL PROJECT REPORT

Developed pursuant to: Title I, Section 109 of the Weather Research and Forecasting Innovation Act of 2017, codified at 15 U.S.C. § 8520

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TITLE I, SECTION 109 OF THE WEATHER RESEARCH AND FORECASTING INNOVATION ACT OF 2017, at 15 U.S.C. § 8520(a)(5), INCLUDED THE FOLLOWING LANGUAGE:

(5) Submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives, not less frequently than once each year, a report, including —

(A) a list of ongoing research projects;

(B) project goals and a point of contact for each project;

(C) the five projects related to weather observations, short-term weather, or subseasonal forecasts within Office of Oceanic and Atmospheric Research that are closest to operationalization;

(D) for each project referred to in subparagraph (C) —

(i) the potential benefit;

(ii) any barrier to operationalization; and

(iii) the plan for operationalization, including which line office will financially support the project and how much the line office intends to spend;

THIS REPORT RESPONDS TO THE CONGRESSIONAL REQUIREMENT.

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I. Introduction

This report is in response to Section 109 of the Weather Research and Forecasting Innovation Act of 2017 (15 U.S.C. § 8501 note, hereafter referred to as the "Weather Act"), signed into law on April 18, 2017. Section 109 of the Weather Act amends Section 108 of the National Oceanic and Atmospheric Administration (NOAA) Authorization Act of 1992 (15 U.S.C. § 313 note), which authorizes the United States Weather Research Program (USWRP). Section 109 of the Weather Act includes the following language (which references USWRP research projects):

> *(5) submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives, not less frequently than once each year, a report, including —*
>
> *(A) a list of ongoing research projects;*
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> *(B) project goals and a point of contact for each project;*
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>
> *(ii) any barrier to operationalization; and*
>
> *(iii) the plan for operationalization, including which line office will financially support the project and how much the line office intends to spend;*

II. USWRP Overview

USWRP began in the 1990s, with a principal motivation to accelerate the rate of forecast improvements by taking advantage of science results and technology advancements, which satisfy an increased need for improved weather information in weather sensitive economic sectors. The program has continued to emphasize the transition of research in five critical areas to produce advances in observational, computing, and modeling capabilities to support substantial improvement in weather forecasting and prediction of high-impact weather events: heavy precipitation and associated flooding; tropical storms; air quality; severe weather; and the social science necessary to improve the communication of weather information to decision-makers.

USWRP funds projects that test and demonstrate new cutting-edge science and technology, which the National Weather Service (NWS) can use operationally to improve NOAA's weather and hydrologic forecasting services for the public. The goal of these projects is to apply new innovative forecasting techniques, models, and products in a quasi-operational environment where NWS forecasters are able to learn and use the products during simulated

forecasting and warning exercises. Most of the USWRP-supported transition activities[1] have been associated with three NOAA testbeds: the Hydrometeorology Testbed,[2] located at the NWS Weather Prediction Center in College Park, Maryland; the Joint Hurricane Testbed,[3] located at the NWS National Hurricane Center (NHC) in Miami, Florida; and the Hazardous Weather Testbed,[4] located at the National Weather Center in Norman, Oklahoma.

USWRP also funds projects at universities, NOAA Cooperative Institutes, and private companies that seek to improve NWS weather and air quality forecasting services. NWS provides forecasting guidance to Federal and state governments that are responsible for public air quality alerts. These products include ozone, smoke, and particulate matter products updated on a daily basis that impact human health.

III. Current USWRP Activities

Current USWRP-supported research that transitions to NWS will provide forecasters with improved tools and guidance that will help produce more accurate forecasts and warnings. As of January 1, 2018, there are 54 active projects currently funded by USWRP that are managed by the Office of Oceanic and Atmospheric Research (OAR), with continued significant involvement by NWS (Appendix A). As such, the point of contact for these projects is the Assistant Administrator of OAR.

Currently funded testbed projects are analyzing new weather and hydrologic models and statistical analysis and forecast techniques, such as convection-allowing models (i.e., models that can replicate complex processes within thunderstorms) and ensemble forecast techniques that can provide more probabilistic forecasts (which considers the likelihood, or probability, that an event will occur), in addition to standard deterministic (e.g., binary, yes/no) forecasts. It is expected that these projects will demonstrate new applications that NWS forecasters can use once implemented operationally. This will help to improve the quality and timeliness of forecasts for high-impact weather such as tornadoes, severe thunderstorms, flooding, and hurricanes.

USWRP also is supporting projects on topics including: improvements for ozone and particulate matter model forecasts; improved chemical model initialization data and techniques; improved wildfire smoke forecast models; improved wildfire model initialization; and testing of new ensemble-based air quality forecast models. These projects will advance forecasting science and technology and improve NOAA's forecast services for air quality across the Nation.

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[1] "USWRP-supported transition activities" include projects that were previously funded by USWRP and are in transition to operations, as well as testbed projects currently funded by USWRP.
[2] https://hmt.noaa.gov
[3] https://www.nhc.noaa.gov/jht/
[4] https://hwt.nssl.noaa.gov

IV. USWRP Projects Closest to Operationalization

OAR employs a rigorous process for identifying and monitoring USWRP projects that will be transitioned into operations. This process includes establishing a partnership between the principal investigator and the NWS office that will ultimately transition the research into operations when the project begins. This collaboration is maintained throughout the project to ensure continuous feedback from NWS and an understanding of the requirements and resources necessary for transition. In February 2018, OAR and NWS reviewed the USWRP portfolio and identified the five projects that are closest to operationalization. OAR will support any remaining research associated with these activities, but NWS will support the transition of these projects into operations. The projects listed below will provide forecasters with improved forecast guidance for tropical storms, severe storms, water prediction, air quality, and high-impact weather.

A. Project 1: A Probabilistic Tropical Cyclone Genesis Forecast Tool Utilizing an Ensemble of Global Models[5]	
Potential Benefit:	Will provide the probability of tropical cyclone genesis in the Atlantic and Pacific Ocean basins based on forecasts from five global numerical models, which will improve hurricane forecasts to help prevent loss of life and property.
Where to be implemented:	NWS NHC – Miami, Florida
Barriers to Operationalization:	None
Plan to Operationalize:	NHC will continue to convert the tool computer code and will work with the NWS Office of Dissemination to development a final implementation plan.
Line Office Financial Support:	OAR
Cost to Transition:	$230,000

B. Project 2: Information Extraction and Verification of Convection-Allowing Models for Severe Hail Forecasting	
Potential Benefit:	Using CAM applications to identify features associated with severe hail observations, which will provide guidance to improve hail forecasting and public warnings for hail events.
Where to be implemented:	NWS Storm Prediction Center (SPC) – Norman, Oklahoma
Barriers to Operationalization:	None
Plan to Operationalize:	SPC staff will work with the NWS National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) to incorporate computer code into operational convective-allowing models as part of regular updates to output processing.
Line Office Financial Support:	N/A
Cost to Transition:	$0[6]

[5] This project is no longer funded by USWRP, but is continuing the transition to operationalization through collaboration between OAR and NWS.

[6] Minimal cost, since similar operational upgrades were recently completed.

C. Project 3: Demonstration of Advanced Ensemble Prediction Services for NWS Hydrometeorological Forecast Operations[7]	
Potential Benefit:	An enhancement to the National Water Model, using ensemble precipitation data to improve forecasts of severe storm events.
Where to be implemented:	NWS Office of Water Prediction (OWP) – Tuscaloosa, Alabama
Barriers to Operationalization:	None
Plan to Operationalize:	OWP will transition the National Water Model Medium Range Ensemble into operations by the end of Quarter 3 of Fiscal Year (FY) 2019
Line Office Financial Support:	NWS
Cost to Transition:	$150,000

D. Project 4: Post-Processing of the Community Multiscale Air Quality Modeling System Air Quality Predictions: Research to Operations	
Potential Benefit:	Improvements to an existing NWS operational model forecast bias-correction algorithm for fine particulate matter and application of the algorithm to numerical model forecasts of ozone, to improve accuracy of NWS air quality forecasts and public health alerts, with additional improvements in smoke, visibility, and cloud/precipitation forecasts.
Where to be implemented:	NWS NCEP EMC – College Park, Maryland
Barriers to Operationalization:	None
Plan to Operationalize:	EMC will incorporate bias correction into the post-processing of output from the NWS operational air quality forecasting system as part of the Quarter 4 FY 2018 routine upgrade.
Line Office Financial Support:	NWS, OAR
Cost to Transition:	$65,000 (NWS), $215,000 (OAR)

E. Project 5: Refinement and Evaluation of Automated High-Resolution Ensemble-Based Hazard Detection Guidance Tools for Transition to NWS Operations	
Potential Benefit:	Create and provide improved ensemble-based hazard prediction tools for heavy rain and snowfall to aid NWS forecasters in their decision making and communication of forecast uncertainty to partners and the public.
Where to be implemented:	NWS NCEP Central Operations – College Park, Maryland
Barriers to Operationalization:	None
Plan to Operationalize:	EMC to implement calibrated probabilistic forecast product generation from the current, operational, high-resolution NCEP ensemble.
Line Office Financial Support:	OAR
Cost to Transition:	$30,000

[7] This project is not currently funded by USWRP, but is continuing the transition to operationalization through collaboration between OAR and NWS.

V. Summary

USWRP provides important support for research focused on improving tools and guidance for forecasting high-impact events. USWRP projects include a strong partnership between researchers and forecasters that focuses on transitioning research results into NWS operations. In FY 2018, USWRP supported 54 projects that included ongoing involvement of NWS in research, transition, and management activities. Five USWRP projects that are closest to becoming operational will provide NWS forecasters with improved guidance for forecasting tropical storms, hail-producing storms, flooding potential, ozone and particulate matter, and the probability of high-impact hazardous weather.

List of Acronyms

EMC	Environmental Modeling Center
NCEP	National Centers for Environmental Prediction
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OAR	Oceanic and Atmospheric Research
OWP	Office of Water Prediction
SPC	Storm Prediction Center
USWRP	United States Weather Research Program

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Appendix A: List of Active USWRP Projects (as of January 2018)

Project Title	Lead Organization	Project Goal
Demonstration of a Rapid Update Convection-Permitting Ensemble Forecast System to Improve Flash Flood and Winter Weather Prediction	National Center for Atmospheric Research	The objective is to design and test an improved National Center for Atmospheric Research convection-permitting ensemble forecast model system using new techniques that will produce high-resolution probabilistic forecasts of precipitation for real-time evaluation during the Hydrometeorology Testbed experiments.
Convection-Allowing Ensemble Prediction for Heavy Precipitation in Support of the Hydrometeorology Testbed: New Quantitative Precipitation Forecast Products, Data Assimilation Techniques and Prediction Model	University of Oklahoma	The objective is to design and test an improved University of Oklahoma convection-permitting ensemble forecast model system using new radar data assimilation techniques that will produce high-resolution probabilistic forecasts of precipitation for real-time evaluation during the Hydrometeorology Testbed experiments.
Enabling Effective Use of Deterministic-to-Probabilistic Precipitation Forecasts for Heavy and Extreme Events	National Center for Atmospheric Research	The objective is to develop and test tools to measure the accuracy and forecaster utilization of precipitation output products from deterministic and probabilistic convection-allowing forecast models to improve forecaster utilization of these new products
Improving Lake-Effect Snow and Ice Forecasting for the Great Lakes Region	NOAA OAR Great Lakes Environmental Research Laboratory	The objective is to develop and test an improved coupled lake hydrodynamic-ice forecast model and output products, through real-time evaluation by NWS forecasters, to improve lake-ice and lake-effect snowfall/ice forecasts in the Great Lakes region.
Assessment of Hydrologic Forecasts Generated Using Multi-Model and Multi-Precipitation Product Forcing	University of Iowa	The objective is to assess uncertainty and sensitivity of ensemble hydrologic models and probabilistic hydrologic forecasts using variously configured distributed hydrologic forecast models, including the National Water Model, and precipitation forcings in the study area of Iowa.
Comparison of Model versus Observationally-Driven Water Vapor Profiles for Forecasting Heavy Precipitation Events	Colorado State University – Cooperative Institute for Research in the Atmosphere	The objective is to assess the value of satellite-based layered moisture products relative to NWS forecast model representations of layered

		moisture as a model diagnostic tool for understanding and improving NWS precipitation forecasts
Probabilistic Warn-on-Forecast System for Heavy Rainfall and Flash Flooding	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	The objective is to develop and evaluate a new short-term probabilistic hydrologic forecast model, based on the deterministic Flooded Locations And Simulated Hydrographs model, to improve flash flood forecasting using NWS forecaster feedback during the Hydrometeorology Testbed experiments.
Quantifying Observational Requirements for WRF-Hydro Forcing in the West Using Russian River Hydrometeorological Testbed Experience and Data to Inform National Water Center Tools	University of California, San Diego – Scripps Institution of Oceanography – Cooperative Institute for Marine Ecosystems and Climate	The objective is to implement the NWS operational hydrologic model in California in a test-mode to evaluate and test the value of high resolution observations of soil moisture and other input observation datasets to improving hydrologic model forecasts.
Demonstration of a Rapid Update Convection-Permitting Ensemble Forecast System to Improve Hazardous Weather Prediction	National Center for Atmospheric Research	The objective is to design and test an improved convection-permitting ensemble forecast model system using new techniques that will produce high resolution probabilistic forecasts of severe thunderstorms and tornadoes for evaluation during the Hazardous Weather Testbed experiments.
Integration of Multi-Radar Multi-Sensor Azimuthal Shear into a contiguous United States Conditional Probability of Tornado Intensity Product in the Hazardous Weather Testbed	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	The objective is to improve an existing high-resolution probability of tornado product over the United States using radar wind shear data to improve the information NWS forecasters use for tornado warnings.
Improving NWS Convection Allowing Hazardous Weather Ensemble Forecasts through Optimizing Multi-Scale Initial Condition Perturbations	University of Oklahoma	The objective is to design and evaluate improved initial condition specification methods for convective-scale ensemble forecast models and produce real-time model forecasts for evaluation during the Hazardous Weather Testbed experiments.
Evaluating stochastic physics approaches within select Convection Allowing Model members included in the Community Leveraged Unified Ensemble during the Hazardous Weather Testbed Spring Experiment	National Center for Atmospheric Research	The objective is to evaluate stochastic physics perturbation methods to create multiple ensemble members for convection-allowing forecast models and to evaluate their performance during the Hazardous Weather Testbed experiments.

Developing an objective evaluation scorecard for storm scale prediction	National Center for Atmospheric Research	The objective is to engage the forecasting and research communities to identify and test innovative new metrics to measure the performance of convection-allowing forecast models.
Development and Optimization of Radar-Assimilating Ensemble-Based Data Assimilation for Storm-Scale Ensemble Prediction in Support of Hazardous Weather Testbed Spring Experiments	University of Oklahoma	The objective is to develop advanced radar data assimilation techniques for convection-allowing ensemble forecast models, including NOAA's new Finite-Volume Cube-Sphere Dynamical Core Model, and to generate output forecast products for evaluation during the Hazardous Weather Testbed experiments.
Improving the design and utility to severe weather forecasters of convection permitting ensembles through application of a probabilistic object-based, post-processing, and verification technique	University of Oklahoma	The objective is to develop, test, and deliver new convection-allowing ensemble forecast model verification techniques and tools based on object-based methods using operational NWS forecaster feedback during the Hazardous Weather Testbed experiments.
Improvements and extensions to an existing probabilistic genesis forecast tool using an ensemble of global models	Florida State University	The objective is to improve an existing real-time dynamic/statistical forecast tool based on global weather models that provides NWS forecasters with probabilistic guidance on the genesis of new tropical cyclones in the Atlantic and eastern Pacific Oceans.
Improvements to Operational Statistical Tropical Cyclone Intensity Forecast Models using Wind Structure and Eye Predictors	Colorado State University – Cooperative Institute for Research in the Atmosphere	The objective is to improve on existing real-time operational tropical cyclone intensity forecast models based on statistical-dynamic techniques and to evaluate them in coordination with NWS hurricane forecasters through the Joint Hurricane Testbed.
Evolutionary Programming for Probabilistic Tropical Cyclone Intensity Forecasts	University of Wisconsin – Milwaukee	The objective is to improve on operational tropical cyclone intensity forecasts using a new modeling technique that creates multiple ensemble forecast members that will produce deterministic and probabilistic intensity forecast products for forecaster evaluation.
Ensemble-based Pre-genesis Watches and Warnings for Atlantic and North Pacific	University of Colorado – Colorado Springs	The objective is to develop new location, track, and intensity guidance products for NWS forecasters using United States and European ensemble weather forecast models to aid in

		forecasting genesis of tropical cyclones in the Atlantic and Pacific Oceans.
Transition of Machine-Learning Based Rapid Intensification Forecasts to Operations	Mississippi State University – Northern Gulf Institute	The objective is to develop and test artificial intelligence approaches to forecasting rapid intensification of tropical cyclones in coordination with forecasters at the Joint Hurricane Testbed.
Estimation of Tropical Cyclone Intensity Using Satellite Passive Microwave Observations	Florida International University	The objective is to improve and test an algorithm to estimate current tropical cyclone intensity using microwave satellite observations.
Airborne Phased Array Radar Development and Risk Mitigation Project	National Center for Atmospheric Research	The objective is to do preliminary engineering design and requirements studies and testing to reduce risks of developing the first aircraft-based C-band dual-Doppler polarimetric-phased array radar to make high-resolution measurement of storm systems.
Evaluation and Improvements of Tornado Detection using Infrasound Remote Sensing: Comparative Analysis of Infrasound, Radar, Profiler, and Meteorological Data Sets, and Potential Impacts on NOAA/NWS Operations	General Atomics, Inc.	The objective is to collect and compare infrasound data and other meteorological radar data in northern Alabama to evaluate the ability of infrasound measurements to identify tornadoes detected by established Doppler radar methods.
Infrasound Detection of Tornadoes	University of Mississippi	The objective is to collect infrasound data in northern Alabama to evaluate the ability of infrasound measurements to identify and track tornadoes.
Augmentation of the Verifications of the Origins of Rotation in Tornadoes Experiment-Southeast (VORTEX-SE) Intensive Observations Period Measurements with Infrasound Observations to Detect and Track Tornadoes	University of Mississippi	The objective is to collect infrasound data in northern Alabama to evaluate the ability of infrasound measurements to identify and track tornadoes.
Direct Detection of Tornadoes Using Infrasound Remote Sensing: Assessment of Capabilities Through Comparison with Dual Polarization Radar and Other Direct Detection Measurements	University of Alabama Huntsville	The objective is to collect and compare infrasound data and other meteorological radar data in northern Alabama to evaluate the ability of infrasound measurements to identify tornadoes detected by established Doppler radar methods.
Post-Processing of the Community Multiscale Air Quality Modeling System Air	University of Colorado – Cooperative Institute for	The objective is to improve and evaluate an existing operational NWS model forecast bias-correction

Quality Predictions: Research to Operations	Research in Environmental Sciences	algorithm for fine particulate matter and to apply this advanced algorithm to numerical model forecasts of ozone to improve accuracy of deterministic and probabilistic air quality forecasts.
A Novel Ensemble Design for Particulate Matter ($PM_{2.5}$) Probabilistic Predictions and Quantification of their Uncertainty	National Center for Atmospheric Research	The objective is to explore and quantify the potential value of ensemble-based numerical forecast predictions of fine particulate matter for possible future operational implementation.
Developing a unified online air quality forecasting system based on Community Multiscale Air Quality Model and Next Generation Global Prediction System	NOAA OAR Earth System Research Laboratory	The objective is to develop and test a new "online" coupled operational air quality forecasting system by integrating the NWS operational global weather model framework with the Environmental Protection Agency's air chemistry transport model to improve air quality forecasting.
Towards the Improvement of Chemical Lateral Boundary Conditions for the National Air Quality Forecast Capability	Universities Space Research Association – National Aeronautics and Space Administration Goddard Space Flight Center	The objective is to develop improved numerical modeling methods for specifying lateral boundary conditions for NWS air quality forecasting models.
Top-down Estimation of Wildfire Smoke Emission Based on the Hybrid Single Particle Lagrangian Integrated Trajectory Model and NOAA National Environmental Satellite, Data, and Information Service Geostationary Operational Environmental Satellite Aerosol/Smoke Products to Improve Smoke Forecasts in the United States	University of Maryland – Cooperative Institute for Climate Science	The objective is to improve on current NWS smoke forecasts from deficient BlueSky estimates by advanced modeling of wildfire smoke emission source strengths, locations, and timing using NOAA satellite observations.
Improving Spatial Resolution of Wildland Fire Location and Fuel Biomass Data Inputs to NOAA's National Air Quality Forecast Capability	Sonoma Technology, Inc.	The objective is to improve on current NWS smoke forecasts by using high resolution NOAA satellite observations of wildfire locations and make better estimates of fuel sources and types that affect wildfire smoke emissions.
Multi-Radar/Multi-Sensor Hydrometeorological Testbed-Hydro Experiment	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	The objective is to investigate the impact of merged radar and rain gauge rainfall estimates on the quality of streamflow products from a distributed hydrologic forecast model to improve flash flood forecasting.
Validation and Improvement of Microphysical Parameterizations	University of Colorado – Cooperative Institute for	The objective is to evaluate and test multiple cloud and precipitation

for Better Orographic Precipitation Forecasts	Research in Environmental Sciences	microphysical parameterization schemes of numerical weather forecast models to improve forecasting of precipitation in the mountainous Western United States through comparison with observations.
Improving Initial Conditions and their Perturbations through Ensemble-Based Data Assimilation for Optimized Storm-Scale Ensemble Prediction in Support of Hazardous Weather Testbed Severe Weather Forecasting	University of Oklahoma	The objective is to develop and test through the Hazardous Weather Testbed new data assimilation techniques for high-resolution convection-allowing forecast models that make use of all operational data sets and full-volume radar data.
Integration and Evaluation of ProbSevere within the Probabilistic Hazard Information tool in the Hazardous Weather Testbed	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	The objective is to integrate a new ProbSevere model into the Probabilistic Hazard Information tool to improve local warnings for tornadoes, hail, and severe weather and to test it within the Hazardous Weather Testbed with NWS forecaster feedback.
Convection-permitting Ensemble Forecast System for Prediction of Extreme Weather	National Center for Atmospheric Research	The objective is to develop and test convection-permitting ensemble forecasts and models of extreme short-term weather events and provide the output forecast products to the Hazardous Weather Testbed for evaluation by NWS forecasters.
Information Extraction and Verification of Convection-Allowing Models for Severe Hail Forecasting	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	The objective is to study convection-allowing models to find features that are correlated with severe hail observations, to verify these relationships, and to provide this probabilistic-based guidance to forecasters to improve hail forecasting.
Developing and Evaluating a Gridpoint Statistical Interpolation-based ensemble Kalman filter-Variational Hybrid Data Assimilation for NCEP North American Regional Reanalysis to Improve Convection-Allowing Hazardous Weather Forecast	University of Oklahoma	The objective is to further develop the direct assimilation of radar observations into forecast models. This work will further extend the capability of the existing NWS data assimilation system and conduct extensive testing and evaluating of the system in the NWS's modeling framework.
Probabilistic Prediction of Tropical Cyclone Rapid Intensification Using Satellite Passive Microwave	University of Wisconsin – Cooperative Institute for Meteorological Satellite Studies	The objective is to improve the accuracy of probabilistic tropical cyclone rapid intensification forecasting using multiple forecast models with microwave satellite imagery and testing

		it during two hurricane seasons in the Atlantic and Pacific Oceans.
Improvements to Operational Statistical Tropical Cyclone Intensity Forecast Models	Colorado State University – Cooperative Institute for Research in the Atmosphere	The objective is to improve two of the standard tropical cyclone forecast models and the Rapid Intensification Index tool to improve the operational products used by hurricane forecasters in the Atlantic and Pacific Oceans.
Improved eyewall replacement cycle forecasting using a microwave-based algorithm	University of Wisconsin – Cooperative Institute for Meteorological Satellite Studies	The objective is to develop an improved forecast model to detect and provide forecaster guidance on hurricane eyewall replacement using microwave satellite imagery.
Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index for NHC/Joint Typhoon Warning Center Forecast Basins	Florida International University	The objective is to develop an improved probability-based microwave rapid intensification index that can be used by forecasters as guidance in forecasting rapid intensification of tropical cyclones.
Guidance on observational undersampling over the tropical cyclone lifecycle	University of Miami	The objective is to study underestimates of hurricane intensity measured by various in-situ and remote sensing instruments to provide guidance to forecasters on interpreting this data when developing forecasts of tropical cyclone intensity.
Improvement of the Tropical Cyclone Genesis Index	University of Miami – Cooperative Institute for Marine and Atmospheric Studies	The objective is to make improvements to a probabilistic statistical forecasting tool to aid forecasters in predicting tropical cyclone genesis and intensification and to extend its use to the Pacific Ocean.
Transition of the Coastal and Estuarine Storm Tide Model to an Operational Model for Forecasting Storm Surges	Florida International University	The objective is to develop and test a new hurricane storm surge forecast model to better predict storm surge flooding in coastal areas compared to the existing NWS model.
Probability of What? Understanding and Conveying Uncertainty through Probabilistic Hazard Services	NOAA OAR National Severe Storms Laboratory	This project will build an end-to-end capability for the NWS to deliver high frequency, probabilistic weather information to decision makers.
Refinement and Evaluation of Automated High-Resolution Ensemble-Based Hazard Detection Guidance Tools for Transition to NWS Operations	NOAA OAR Earth Systems Research Laboratory	This work will lead to the creation of NWS forecaster tools that will facilitate the rapid integration of available computer model guidance to enable probabilistic forecast services.

Collaborative Research: Online Hazard Communication in the Terse Regime	University of Kentucky	This project is developing an algorithm that allows for an examination of NWS office use of terse, Twitter messages across the weather communication continuum to identify message strategies that enhance engagement during threat and non-threat periods.
Improving Public Response to Weather Warnings	University of Washington	This project explores public and emergency manager perceptions of changing weather forecasts and warnings. Specifically, this study measures the effect of a consistent versus inconsistent forecast on public trust; explores what role probabilities play in this process; and how forecaster framing of uncertainty vs confidence during decision-support changes forecast understanding.
Next Generation, Resilient Warning Systems for Tornadoes and Flash Floods	University of Massachusetts Amherst	This project is developing a methodological approach and strategy for capturing understanding of human behavior and response to severe weather and warnings.
Development of a Digital Collaboration Environment for the Alliance for Integrative Approaches to Extreme Environmental Events, Phase I: Scoping and Functional Requirements Development	University of Oklahoma – Cooperative Institute for Mesoscale Meteorological Studies	This project will create an online portal for digital collaboration that brings together diverse academic disciplines, organizations, and sectors across the weather enterprise.
An Examination of the State of Knowledge on Risk Perceptions and Understanding Response to Uncertainty Information	Howard University	This project will conduct a systematic literature review on public understanding and response to uncertainty providing NOAA with a baseline understanding and identification of research gaps.
OAR Hurricane Moving Nest	NOAA OAR Atlantic Oceanic and Meteorological Laboratory	This project seeks to improve the hurricane intensity and structure forecasting capabilities of NOAA model cores.