FY2021

ANNUAL ACCOMPLISHMENTS

A WEATHER-READY NATION INFORMED BY WORLD-CLASS WEATHER RESEARCH

WEATHER PROGRAM OFFICE
National Oceanic and Atmospheric Administration

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LETTER FROM THE DIRECTOR

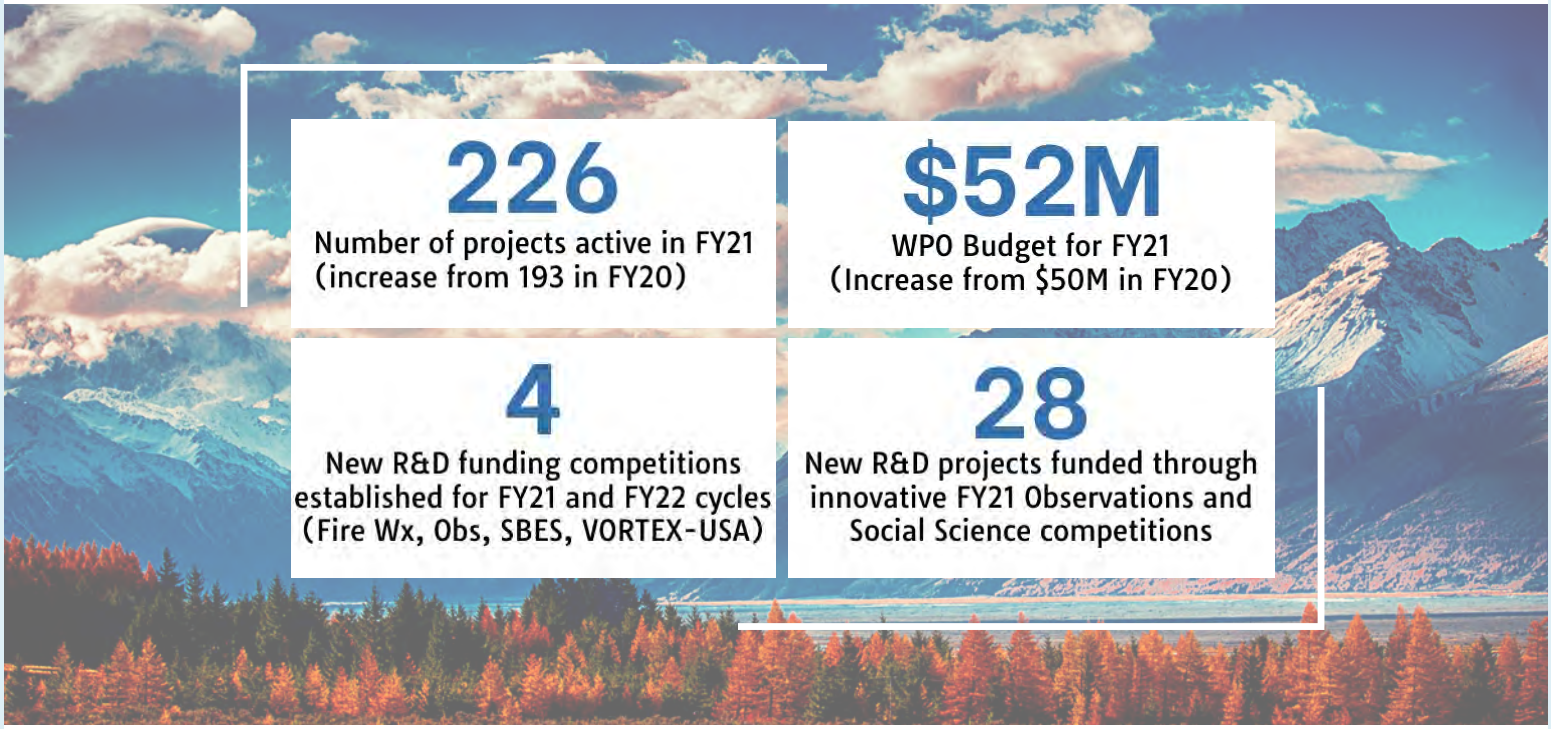
Dorothy Koch, PhD
NOAA Weather Program Office
January 2022

2021 was another year of extremes across the U.S. From the record cold in Texas this past winter, to the record heat in the northwest over the summer, to the inland devastation caused by Hurricane Ida, and finishing with the deadly December tornadoes, the work of the Weather Program Office (WPO) to support innovative solutions to improve forecast skill and delivery is more imperative than ever. In addition to, and in spite of the many challenges of the pandemic, changes in leadership and administration, NOAA's WPO successfully persevered within the virtual working environment to deliver:

> *We remained steadfast in our mission to find, fund, and foster world-class research to save lives, reduce property damage, and enhance the national economy.*

Our team worked tirelessly to collaborate closely with the National Weather Service (NWS) to develop and transition weather research, improving knowledge about tropical cyclones, severe storms, extreme weather, fire weather, air pollution and social science. As you will read in the following pages, we have strengthened our program portfolio and facilitated research in weather, earth-system modeling, and social science. With the help of WPO's Weather Enterprise partners, we've addressed research questions that help us understand and predict our weather and are instrumental in transitioning its outcomes into operational products and applications. We are partnering with climate researchers to anticipate the changes in weather under warming conditions and foster resilient solutions for climate and weather hazards. Alongside our stakeholder communities, we have improved our understanding of how the public receives and reacts to information, and will continue to develop new tools to facilitate effective weather decisions.

As we continue to pursue our goals, we celebrate growth in the following areas:



WPO's highly-qualified staff continued to foster justice, equity, diversity, inclusion, and accessibility (JEDIA) within and outside our office. We are in the process of creating a JEDIA action plan for WPO, and we have opened avenues in all scientific disciplines of our Notice of Funding Opportunity (NOFO), striving to provide members of underrepresented communities equal access to the opportunities we offer.

Our team is our strength. Our staff has remained highly productive and successful through multiple leadership transitions. Before my arrival in 2021, the office had 5 acting directors in the previous 2 years. Recently filling the role of deputy director, John Ten Hoeve will bring added stability and resolute leadership to WPO. With leadership stability in place, we look forward to ongoing support to academic, public and private research communities, coordination with the Oceanic and Atmospheric Research (OAR) Laboratories, and collaborations with other NOAA programs as we all strive together to save lives, reduce property damage, and enhance the national economy.

WPO Staff FY2021

Dorothy Koch, PhD
WPO Director

John Ten Hoeve
WPO Deputy Director

Alison Agather, PhD
FACETs Program Coordinator

Henrique Alves, PhD
Research Physical Scientist supporting EPIC

Christine Bassett
Subseasonal to Seasonal Program Coordinator (Contractor)

Tamara Battle
Weather Act Policy Coordinator (Contractor)

Chantel Bivins, MPA
Communications Specialist (Contractor)

Jessie Carman, PhD
Subseasonal-to-Seasonal Program Manager

Jordan Dale
Testbeds and Air Quality Program Manager

Leah Dubots, MPP
EPIC Management and Program Analyst

Gina Eosco, PhD
FACETS & Social Science Program Manager

Felicia Guarriello
Testbeds Coordinator

Maoyi Huang, PhD
EPIC Program Manager

Kenny James
JTTI Coordinator

Chandra Kondragunta, PhD
JTTI Program Manager

Krishna Kumar, PhD
EPIC Program Coordinator (Contractor)

Valbona Kunkel, PhD
NOAA Atmospheric Scientist R2O Coordinator (Contractor)

Sandra "Sandy" LaCorte
Weather Observations Coordinator (Contractor)

Matthew Mahalik
Research to Operations Transition Analyst (Contractor)

Levi Matthews
Budget Analyst

Mark Olsen, PhD
S2S Deputy Program Manager

Aaron Pratt, PhD
JTTI Program Coordinator (Contractor)

Melissa Pratt-Zossoungbo
Administrative Officer

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S2S Program - LANTERN

Christopher "Chris" Spells, PhD
Hurricane Supplemental

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Budget and Financial Analyst (Contractor)

Mark Vincent, PhD
Weather Observations Research Program Manager

Jennifer Vogt
EPIC Coordinator (Contractor)

Castle Williams, PhD
Social Science Program Coordinator (Contractor)

Claudia S. Womble
Contracting Officer Representative (COR) III

Ben Woods
Hurricane Supplemental Coordinator (Contractor)

Steve Elliott, PhD
AAAS Science and Technology Policy Fellow

Sam Ephraim
William M. Lapenta Intern

Alice Grossman, PhD
AAAS Science and Technology Policy Fellow

Michael Michaud
William M. Lapenta Intern

Alexus Moore
NOAA Pathways Intern

Renee Richardson
Sea Grant John A. Knauss Marine Policy Fellow

A special thanks to our former employees and detailees for their contributions:
Maureen Brooks, PhD; Bonnie Brown, PhD; DaNa Carlis, PhD; Tavia Cummings; Michele (Micki) Olson; Russell Schneider, PhD; Kathryn Shontz, PhD; Jonathan Smith, PhD

VISION, MISSION, AND GOALS

NOAA
Science, Service and Stewardship
To understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources.

NOAA RESEARCH - Oceanic and Atmospheric Research (OAR)
Deliver NOAA's future
Conduct research to understand and predict the Earth system; develop technology to improve NOAA science, service, and stewardship; and transition the results so they are useful to society.

WPO
A Weather-Ready Nation informed by world-class weather research
Mission Statement: Find, fund, and foster collaborative weather and air quality research to discover, develop, and transition products, tools, and services for timely and accurate weather and air quality forecasts.

This annual report summarizes the accomplishments made by WPO and its partners during Fiscal Year 2021 (FY21) in pursuit of the office's four strategic goals:

Goal 1. Improve effective communication of weather information to strengthen decision-making and forecasting through the integration of social, behavioral, and economic science (SBES) into weather research and development.

Goal 2. Advance forecast models and tools to facilitate the production of the best weather forecasts and warnings to build a Weather-Ready Nation. WPO advanced the development and implementation of NOAA's Unified Forecast System (UFS); Subseasonal-to-Seasonal forecasts and tools; and severe weather prediction capabilities.

Goal 3. Effectively and efficiently manage the advancement and transition of weather research into operations and societal applications; ensuring operations and management processes were well-documented, maintained, and refined; and responding in a timely and effective manner to NOAA's Congressional mandates.

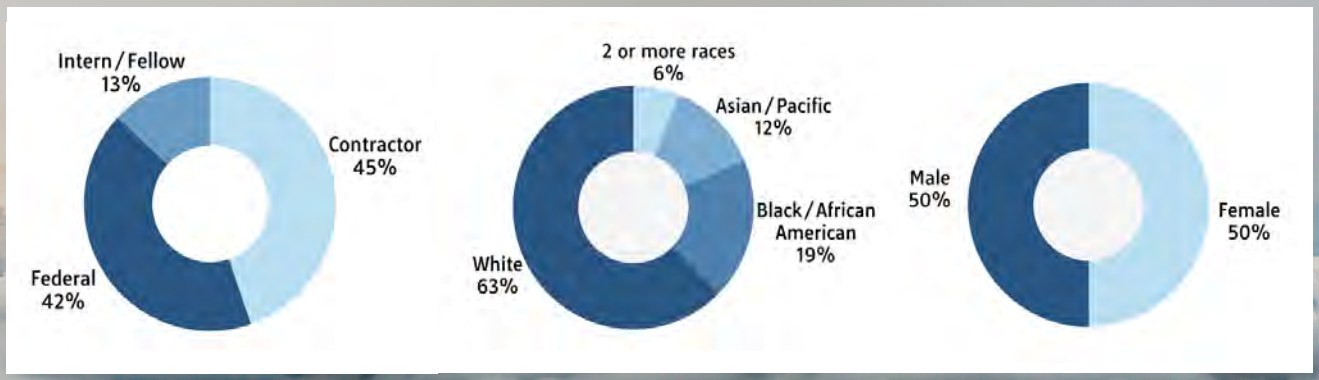
Goal 4. Develop, support, and promote equal access to the opportunities WPO offers by recruiting and maintaining a diverse and highly qualified workforce and integrating diversity and inclusion as a core consideration throughout WPO's funding mechanisms

WPO is in the process of developing a new strategic plan, which will be released in FY22.

Our Team

As a reflection of the community-at-large, those we fund, and the partnerships that we have built, WPO has made a long-term commitment to JEDIA. WPO is committed to providing opportunities to early career individuals as well as students and to that end has hosted 2 William M. LaPenta Student interns, 3 Pathways Program Interns, 1 Sea Grant John A. Knauss Marine Policy Fellow, and 2 American Association for the Advancement of Science (AAAS) Fellows over the last several years, realizing great benefits to the office. By placing people together who have different characteristics, backgrounds, skills and experiences, our office has continued to support the mission and vision of the organization while fostering internal growth through an increase of staff from 30 to 37 this past year.

WPO Employees



WPO diversity profiles for FY21, including breakdowns for position type, race/ethnicity, and gender. (Note: Figures center and right represent Federal employees only. Credit: Office of Oceanic and Atmospheric Research's Equal Employment Opportunity (EEO) Program Office (2021)

The culture of WPO is one that champions JEDIA while also embracing its core principles of integrity, trust, reliability, accountability, transparency, and viability. In celebrating diversity, our office fosters a learning process that strengthens communication and trust across its members. WPO has inspired other NOAA research laboratories and programs to start conversations supporting OAR's commitment to integrating JEDIA with its strong organizational culture.

WPO Staff Awards

- Gina Eosco, PhD received the Daniel L. Albritton Outstanding Science Communicator Award that recognizes outstanding achievement in communicating the meaning and value of NOAA-related science and research to non-scientific audiences.
- Knauss Fellow Renee Richardson received 1st place for her student oral presentation at the 22nd Conference on Air-Sea Interaction hosted at the 101st American Meteorological Society (AMS) Annual Meeting (January 10–15, 2021).
- Ben Woods was elected president of the AMS central VA chapter.
- Claudia S. Womble graduated from NOAA's premier and prestigious leadership succession planning program, Leadership Competencies Development Program (LCDP), Cohort XI, "Transformers". Claudia also received the NOAA Administrator's Award for Leadership with the National Marine Fisheries Service for her work as the Northeast Fisheries Science Center Diversity and Inclusion Officer.

WPO Participation at Events

WPO staff hosted, moderated, or facilitated multiple panels, workshops, and conference sessions, including the AMS Annual Meeting and the AMS Summer Community Meeting, throughout FY21:

- DaNa Carlis (GSL/NOAA), and Leah Dubots (WPO) co-moderated a panel on EPIC at the AMS Summer Community Meeting on September 21, 2021.

WPO Publication Highlights

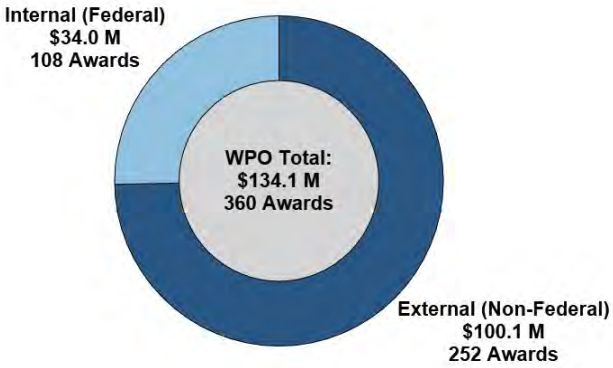
During FY21, the Observations and Supplemental Programs published several public-facing interactive reports using the ArcGIS StoryMaps platform. Each report provides high-level program and project overviews while also emphasizing the importance of the funded research. Also in FY21, the EPIC Program, which supported the UFS Communications and Outreach working group, published four editions of the Bulletin of the UFS Community. This bulletin is a quarterly publication that contributes to increasing engagement and outreach activities within the weather modeling community.

Observations Program: https://wpo.noaa.gov/Programs/Observations

Supplemental Program: https://wpo.noaa.gov/Programs/DRAS

WPO At-A-Glance

In FY21, WPO's budget was approximately $52M, nearly 50% of which was awarded competitively through the grants process. Over the last year, WPO increased the number of active research and development (R&D) projects from 193 in Fiscal Year (FY) 2020 to 226 projects in FY2021, which include over 350 individual financial awards, totaling over $130 million over their combined active periods. In addition, WPO manages 38 projects supported by $75 million disaster-related supplemental funding and funds several collaborative projects through Service Level Agreements (SLAs) with the NWS.



WPO Active awards in FY21.

48 Number of peer-reviewed publications from WPO-funded projects

48 Number of projects that progressed by at least one Readiness Level

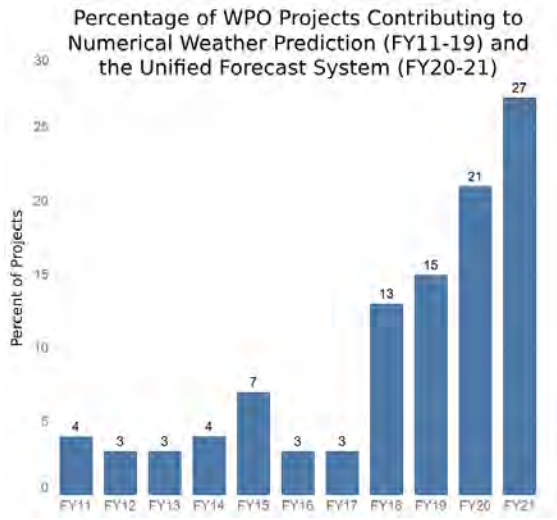
64 Number of Transition Plans approved by NOAA Research

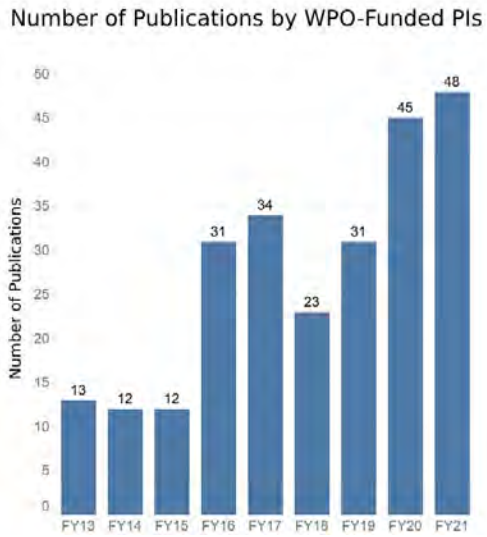
49 Percentage of WPO projects that are collaborations between two or more institutions

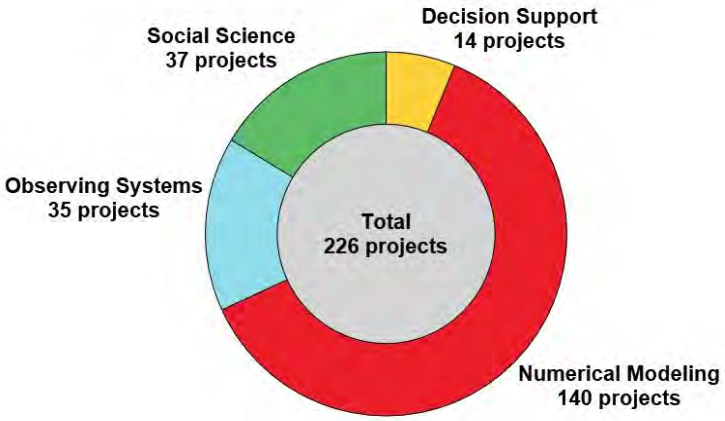
24 Number of projects delivered to NWS for transition into operations

WPO formulated its research funding priorities for FY21 in close coordination with partners from across the weather enterprise including NOAA, other Federal agencies and entities, state, tribal, and local governments, academia, other not-for-profits, and the private sector. Funding applicants were encouraged to consider partnering or otherwise engaging with minority-serving institutions and to provide opportunities for students and underserved populations while planning their proposals.

Our website provides a complete list of WPO-funded projects along with more information about WPO's research funding agreements and award types.

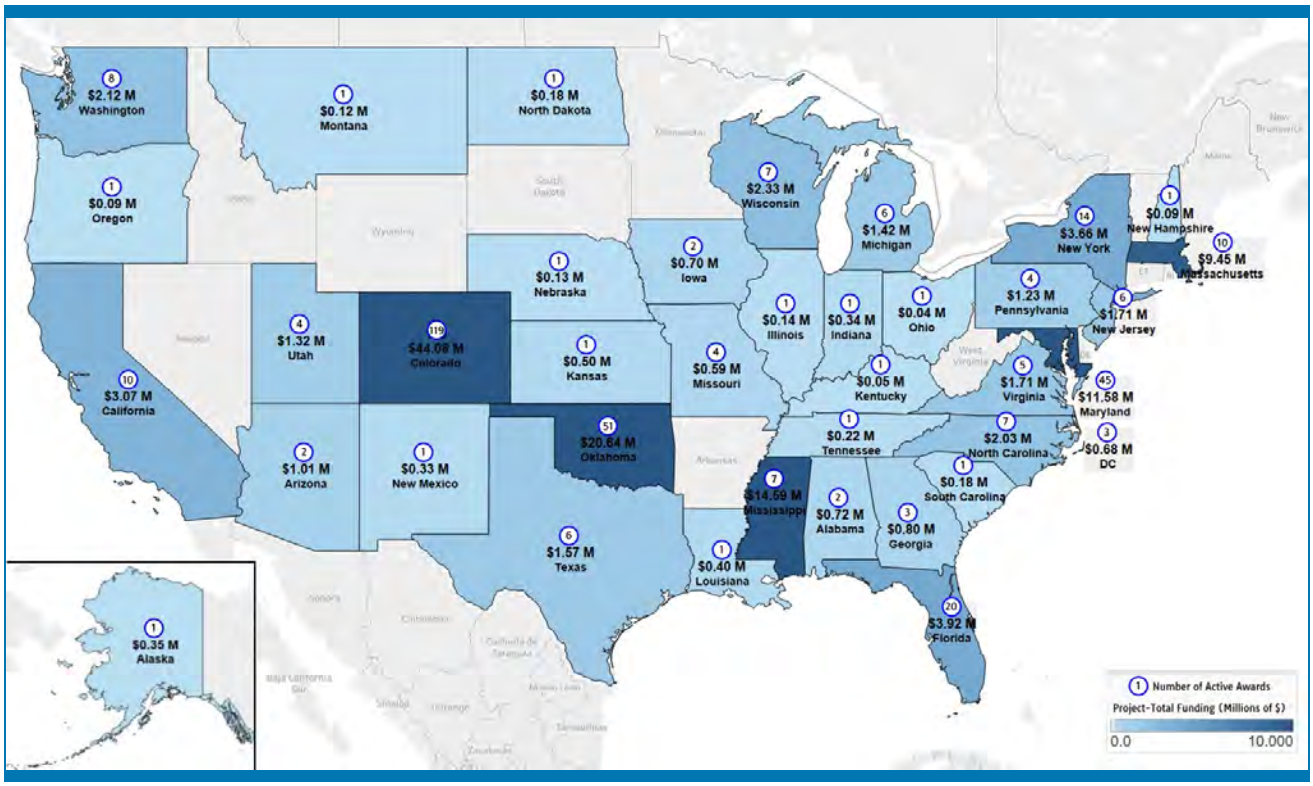




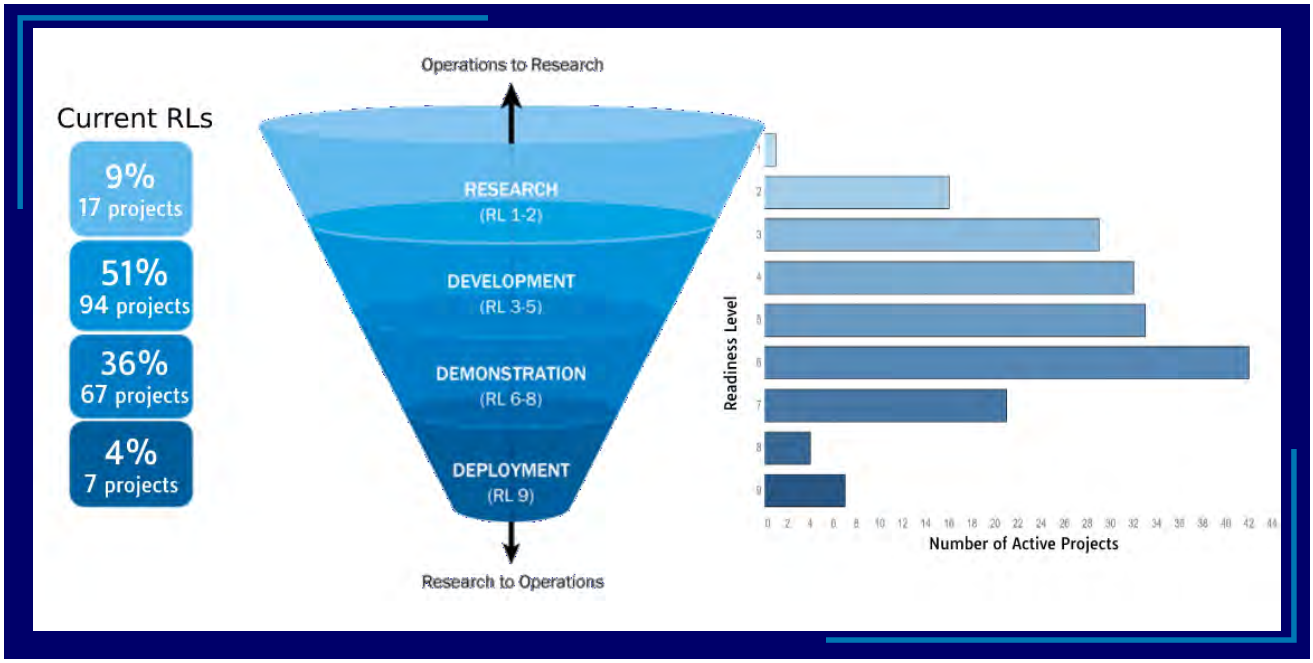


WPO Active projects in FY21
by primary R&D deliverable type.

WPO Active projects in FY21
by primary scientific research focus area addressed.



WPO Active projects and funding in FY21 by state.



WPO active transitionable projects in FY21 by Readiness Level.

In addition to funding research projects, WPO is tasked with administering and/or managing a number of crucial tasks in NOAA, including:

- Providing infrastructure funding for NOAA's Testbeds and Proving Grounds
- Developing Congressional reports summarizing OAR's progress under the Weather Act
- Collecting reports on all non-federal Weather Modification activities in the U.S.
- Co-managing with NWS the UFS Community Research to Operations (R2O) project
- Collecting scientific publications for inclusion in the NOAA Institutional Repository
- Jointly administering awards with the National Severe Storms Laboratory (NSSL) for the Verification of the Origin of Rotation Experiment-Southeast (VORTEX-SE), now VORTEX-USA, program
- Leading the planning for the NOAA Emerging Technologies Workshop
- In addition, WPO leads the coordination, execution, and reporting of Weather-Related Disaster Supplemental Appropriations Including:
    - Bipartisan Budget Act of 2018 Disaster Related Appropriation Supplemental (DRAS), and
    - Improving Forecasting of Hurricanes, Flood, and Wildfires (IFHFW) portfolio of the Additional Supplemental Appropriations for Disaster Relief Act of 2019.

Images courtesy of the NOAA Unsplash page.

FY21 R&D Priorities

WPO formulated its research funding priorities for FY21 in close coordination with partners from across the weather enterprise including NOAA, other Federal agencies and entities, state, tribal, and local governments, academia, other not-for-profits, and the private sector. Funding applicants were encouraged to consider partnering or otherwise engaging with minority-serving institutions and provide opportunities for students and underserved populations while planning their proposals.

- **The Unified Forecast System (UFS)** is a community-based, coupled, comprehensive Earth modeling system that includes computer code, governance rules, and a community of researchers, developers and users from NOAA, educational institutions, other federal agencies, and the private sector. WPO supports several projects related to the UFS, providing an opportunity to leverage collaboration across the office and between researchers associated with several of our programs, including JTTI, S2S, Disaster Supplementals and the Earth Prediction Innovation Center (EPIC).

- **Artificial intelligence (AI) and machine learning (ML)** techniques show great potential in advancing capabilities to analyze and assimilate the expansive amount of data collected by observing networks and produced by modeling systems. AI analytics, intelligent allocation of high performance computing (HPC) resources, and cloud computing platforms are being leveraged to identify, understand, and forecast extreme weather events of all types. R&D funded through WPO aims to support the advancement of AI applications to better extract information from data, enabling better analyses and predictions.

- **Communication** of weather information in a clear and simple way that best serves the public is a crucial component of NOAA's mission. Social, behavioral, and economic sciences (SBES) can inform every aspect of weather forecasting, including providing well-informed and effective warnings. Part of this initiative is Forecasting a Continuum of Environmental Threats (FACETs), a natural hazard forecasting program that seeks societal benefit through the forecasting and communication of probabilistic hazardous weather, water, and climate information.

- **Innovative observing systems** of various phenomena remain a priority in NOAA. Current and recent focus areas supported by WPO include next-generation radar technologies (including the Airborne Phased Array Radar, APAR), snowpack and soil moisture observations and data assimilation to improve the National Water Model (NWM), and the development and application of next-generation mesoscale observing platforms (such as uncrewed aerial systems and mesonet technologies).

Transitions

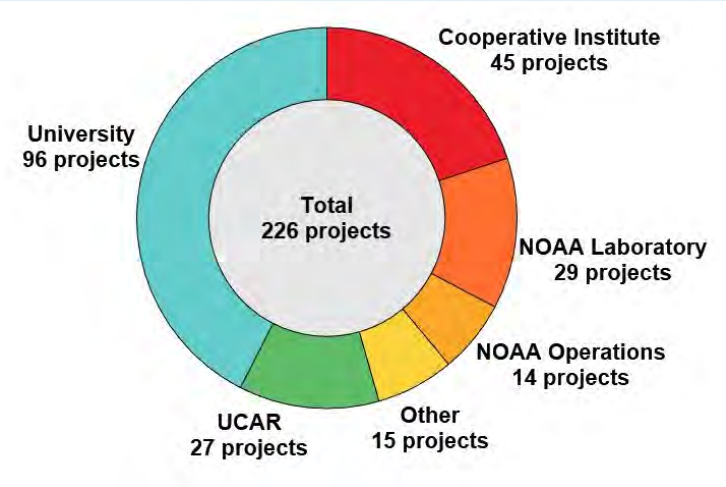
Transitioning research to operations, commercialization, or other applications requires coordination between researchers, developers, and operators. WPO works across NOAA Line Offices (LO) and sectors in the scientific community to determine Readiness Levels (RLs) that assess the relative "readiness" of projects intending to transition, as well as testbed and transition planning documents that outline paths toward implementation. Stakeholder engagement and evaluation of the transition process continually improve existing approaches for the application of R&D in ways that ultimately benefit society through improved forecasts and warnings.

In FY21, WPO programs funded and/or managed projects that transitioned to NOAA operations, contributing to significant improvements in:

- High-Resolution Rapid Refresh (HRRR) model upgrade to Version 4, including hail forecasting, convective-scale ensemble development and verification, and heavy rainfall prediction capabilities
- Global Forecast System (GFS) Localized Aviation Model Output Statistics (MOS) Product (LAMP)
- Multi-Radar Multi-Sensor (MRMS) severe weather and hydrologic observation and prediction systems
- National Ocean Service (NOS) Global Extratropical Surge and Tide Operational Forecast System (G-ESTOFS)
- National Water Model (NWM) upgrade to Version 2.1
- Statistical Hurricane Intensity Prediction Scheme (SHIPS), Logistic Growth Equation Model (LGEM), and Wind Speed Probability (WSP) tropical cyclone models.

WPO is proud to support a variety of partners to advance science toward meeting NOAA's mission:

NOAA Laboratories	Non-NOAA Federal Agencies	Universities
Cooperative Institutes	UCAR/NCAR	Cooperative Institutes



WPO-funded active projects in FY21 by lead researcher affiliation.

Atlantic Oceanographic and Meteorological Laboratory (AOML)
Miami, FL

Air Resources Laboratory (ARL)
College Park, MD, and Oak Ridge, TN

Earth System Research Laboratories (ESRL)
Boulder, CO

Geophysical Fluid Dynamics Laboratory (GFDL)
Princeton, NJ

Great Lakes Environmental Research Laboratory (GLERL)
Ann Arbor, MI

National Severe Storms Laboratory (NSSL)
Norman, OK

Pacific Marine Environmental Laboratory (PMEL)
Seattle, WA

NOAA Laboratories with Principal Investigators (PIs) funded by WPO in FY21. ESRL consists of the Chemical Sciences Laboratory (CSL), Global Monitoring Laboratory (GML), Global Systems Laboratory (GSL), and Physical Sciences Laboratory (PSL). This year, projects at seven NOAA Labs were funded through 69 financial awards.

Cooperative Institute for Climate, Ocean, and Ecosystem Studeis (CICOES)
University of Washington (Seattle, WA)

Cooperative Institute for Great Lakes Research (CIGLR)
University of Michigan (Ann Arbor, MI)

Cooperative Institute for Marine and Atmospheric Studies (CIMAS)
University of Miami (Miami, FL)

Cooperative Institute for Modeling the Earth System (CIMES)
Princeton University (Princeton, NJ)

Cooperative Institute for Mesoscale Meteorological Studies
University of Oklahoma (Norman, OK)

Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin (Madison, WI)

Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado (Boulder, CO)

Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University (Fort Collins, CO)

Cooperative Institutes with PIs funded by WPO in FY21. This year, projects at eight CIs were funded through 42 financial awards. Beginning in FY22, CIMMS is operating as the Cooperative Institute for Severe and High-Impact Weather Research and Operations (CIWRO).

University recipients of WPO FY21 funding.
This year, projects at 59 universities were funded through 165 financial awards.

Overview of WPO Programs

WPO Programs work closely with our partners to fund, foster, and transition weather research through the continuous funding of our active projects and our call for new proposals in our yearly NOFO. Further details about each of WPO's nine programs are provided in the next few pages.

Air Quality Research and Forecasting (AQRF)

Active Projects in FY21: 4
Number of Awards Active in FY21: 6
New Projects Funded in FY21: 0

The Air Quality Program aims to improve air quality forecast operations by focusing on strategic coordination and investments in air quality research and development. Six projects that were initiated in 2016, reached completion in FY20. Four additional projects that began in 2019 are still ongoing through 2021. The AQRF program also developed new funding opportunities for FY22 focused on Fire Weather and Atmospheric Composition research.

Climate Testbed (CTB)

Active Projects in FY21: 11
Number of Awards Active in FY21: 24
New Projects Funded in FY21: 0

The Climate Testbed was created to accelerate the transfer of research and development into improved NOAA operational subseasonal to seasonal climate forecasts, products, and applications. In 2018, funding for CTB was transferred to WPO under the S2S Program. With its management located within NWS/Climate Prediction Center (CPC), the CTB routinely serves as a conduit between the operational, academic and research communities.

Disaster Supplementals (DRAS)

Active Projects in FY21: 32
Number of Awards Active in FY21: 40
New Projects Funded in FY21: 0

Mandated by the Bipartisan Budget Act of 2018, the Disaster Supplementals Program includes research for weather, flood, and hurricane forecasting, wildfire prediction and data assimilation. In FY18, DRAS had $50M allocated to Improving Forecasting and Assimilation (IFAA) and $25M to the FY19 Improving Forecasts of Hurricanes, Floods, and Wildfires (IFHFW) portfolios. Five of the 27 FY18 projects were completed during FY21. WPO jointly manages these Supplementals with other offices in NOAA's NWS, National Ocean Service (NOS), National Environmental, Satellite, and Data Information Service (NESDIS), and Office of Marine and Aviation Operations (OMAO). Many of these projects will leverage the UFS framework for research to operations transitions.

Earth Prediction Innovation Center (EPIC)

Active Projects in FY21: 23
Number of Awards Active in FY21: 31
New Projects Funded in FY21: 12

EPIC will enable the most accurate and reliable operational numerical forecast model in the world by partnering with the modeling community for the benefit of the nation. In FY19 and FY20, the EPIC Program funded approximately 20 innovative projects and supported its vision through community engagement activities to facilitate the use of cloud and

high-performance computing resources. In FY21, the EPIC contract was awarded to Raytheon Intelligence & Space, which will improve community access to the UFS further advancing the community modeling paradigm. The program also continues to fund UFS Community Modeling Support projects, the UFS-R2O project, Joint Center for Satellite Data Assimilation (JCSDA), and the OAR Cloud Pilot Projects, and manages several projects in coordination with the NWS Environmental Modeling Center (EMC) as part of the UFS SLA.

Forecasting a Continuum of Environmental Threats (FACETs)

Active Projects in FY21: 2 (7 through the JTTI Program)
Number of Awards Active in FY21: 2 (11 through the JTTI Program)
New Projects Funded in FY21: 1

The FACETs Program focuses on modernizing the creation, communication, and effective dissemination of a continuous flow of risk-based, calibrated probabilistic hazard information to empower effective response. As a cross-cutting program, FACETs bridges meteorology, technology, and social sciences (among many others) to advance its framework. As a result, the FACETs Program works across OAR labs and programs and with NWS to nurture research collaborations and assist in the collaborative R2O transition process. In FY21, seven projects (consisting of eleven financial awards) funded and managed by the JTTI Program were part of the larger, cross-cutting FACETs initiative.

Joint Technology Transfer Initiative (JTTI)

Active Projects in FY21: 82
Number of Awards Active in FY21: 137
New Projects Funded in FY21: 20

The Joint Technology Transfer Initiative Program was created by the U.S. Congress in 2016 to accelerate the transition of matured research from the weather enterprise to the NWS. The primary mission of the JTTI Program is to ensure continuous, cost-effective development and transition of the latest scientific and technological advancements into NWS operations. Over the life of the program, JTTI has funded 107 projects, 14 of which have already transitioned to NWS operations. In addition, JTTI has provided funding for several projects managed by other WPO Programs (including EPIC, FACETs, and Observations), UFS and extended-range UFS SLA projects.

Observations

Active Projects in FY21: 45
Number of Awards Active in FY21: 73
New Projects Funded in FY21: 18

The WPO Observations Program delivers innovative weather observing technologies that have high potential for advancing a mission-effective, integrated, adaptable, and affordable observation systems portfolio. The program continues to manage a number of projects funded as part of previous Next-Generation Mesoscale Observing Systems, Infrasonic Detection of Tornadoes, Snowpack and Soil Moisture, and Airborne Phased Array Radar (APAR) funding competitions. In FY21, 18 projects were funded to advance in-situ, surface-based and planetary boundary layer (PBL) observing systems, including balloon-borne, radar, and airborne and/or uncrewed systems (UxS) technologies. The Observations Program portfolio is supported by a Weather Act mandate and the National Academy of Sciences report Observing Weather and Climate from the Ground Up (2009), underscoring the importance of improved observations of the lower atmosphere to better understand and predict specific high impact weather events.

Vanda Grubišić, PhD, is the director of the NCAR Earth Observing Laboratory and an NCAR senior scientist. A graduate of Yale University, Dr. Grubišić has contributed significant advancements in meteorological observing technologies that support NOAA's mission and the Weather Research and Forecasting Innovation Act of 2017. Specifically, Vanda has been the Principal Investigator for three WPO awards for developing the innovative Airborne Phased Array Radar (APAR). The notable progress from this research and development has positioned APAR to be a strong candidate for NOAA's Hurricane Surveillance as a replacement for Tail Doppler Radar.

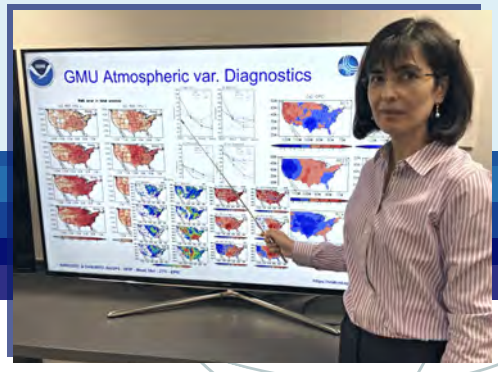
Subseasonal to Seasonal (S2S)

Active Projects in FY21: 21
Number of Awards Active in FY21: 29
New Projects Funded in FY21: 1

The Subseasonal to Seasonal Program supports research on the time scales of two weeks to two years as required by the Weather Act, with external funding calls soliciting innovative as

well as developmental research. The program emphasizes increasing the understanding of predictability, advancing community driven NOAA modeling initiatives and operational systems, and supporting the use and utility of multimodel ensembles for public, private, and academic users. In FY21, the program supported 11 ongoing, competitively-funded external projects totaling $2.6M. These projects include community-based approaches to improving Earth system models, including NOAA's UFS, improving existing ensembles to improve prediction skill and assessments of uncertainty, and ongoing multimodel ensemble efforts on the S2S and climate time scales. The S2S program also assisted in the management of an additional 10 projects as part of the Climate SLA in coordination with NWS, and 8 projects funded through the Weather Portfolio as part of the Precipitation Grand Challenge and Fire Weather initiatives.

Cristiana Stan, PhD, is the Associate Chair of the Atmospheric, Oceanic and Earth Sciences Department at George Mason University. A graduate of Colorado State University, Dr. Stan's research interests center on climate modeling with a focus on the large-scale dynamics and predictability of tropical and midlatitude variability. Specific topics include the role of cloud representation in modeling the monsoon circulations, Madden-Julian Oscillation (MJO), and the El Niño-Southern Oscillation (ENSO) under current conditions and future climate change scenarios and the dynamics of the tropical-extratropical teleconnections on intraseasonal time scale, and S2S variability of the extratropics. She is the co-chair of the MJO and Teleconnections sub-project of the WMO/WWRP/WCRP/S2S Prediction Project, and co-lead of the Medium Range and S2S application team of the NOAA UFS-R2O project, co-sponsored by NWS-Office of Science and Technology Integration (OSTI) and OAR-WPO.



Social Science Program (SSP)

Active Projects in FY21: 25
Number of Awards Active in FY21: 35
New Projects Funded in FY21: 10

The WPO Social Science Program is dedicated to finding, funding, and fostering collaborative social science weather research and its potential applications. Social science is the study of people—what they think, how they feel, and how they respond—in a particular context. With recent societal impacts from hurricanes, floods, snowstorms, and wildfires, there has never been a greater need to understand the intersection of people and meteorology. Social science research findings often have implications for the 24/7 weather warning environment,

including enhancing NWS products, tools, and services. It also has applications and benefits that guide the people, processes, policies, and organizations surrounding the R2O process. As such, SSP activities focus on nurturing relationships across NOAA and with the academic community to translate social science knowledge across the weather enterprise. Through the WPO FY21 NOFO, SSP hosted its first formal social, behavioral, and economic sciences (SBES) funding call. SSP funded 10 new projects in FY21. The new projects have a goal of advancing knowledge on the publics' reception, interpretation, and response to weather warnings and forecast information, as well as addressing risk communication, decision support, and tool creation needs.

Weather Testbeds

Active Projects in FY21: 15
Number of Awards Active in FY21: 18
New Projects Funded in FY21: 0

The Weather Testbeds Program funds projects to test and demonstrate cutting-edge forecast technology in the NOAA weather testbeds to accelerate the technology transition to NWS forecast operations and improve NOAA's services to the public. WPO manages and executes funding to support projects and infrastructure costs associated with the Joint Hurricane Testbed (JHT), Hazardous Weather Testbed (HWT), and the Hydrometeorology Testbed (HMT). Thirty-two projects have been funded in the Testbeds Program through two funding competitions in FY2017 and FY2019.

Highlighted Projects

WPO works closely with NOAA's research laboratories and the weather enterprise to develop and transition scientific innovations that improve knowledge and advance weather, water, and climate forecasting and mitigation.

AIR QUALITY

Accelerating Anthropogenic Emission Updates for NAQFC FV3-CMAQ through Community Collaboration

Project Lead: *Bok H Baek, PhD, George Mason University*

Researchers are developing the National Air Quality Forecast Capability (NAQFC) Community Emission Testbed (NCET) for users from state to local agencies who are interested in

preventing adverse health effects of poor air quality. NCET is a community-based testbed built upon a common platform for air quality research that contributes cost-effectively to future emissions updates in NAQFC. It will allow users to port and test anthropogenic and wildfire emissions updates easily in NOAA operational environments.

The NCET development includes a new dynamic emission coupler in the NAQFC to generate weather-aware emissions from local meteorology-sensitive onroad mobile, agricultural livewaste, and residential heating sources with forecast meteorology to improve air quality forecasts for harmful pollutants such as ozone (O3) and fine particulate matter (PM2.5).

Bok Baek, PhD, is a research associate professor at George Mason University and is developing the National Air Quality Forecast Capability (NAQFC) Community Emission Testbed (NCET) which includes air quality and emissions modeling system developments and modeling applications to improve the accuracy of air quality simulation. NCET also supports environmental policy focusing on local and regional air pollution and adverse human health impacts. In addition, Dr. Baek's research focuses on atmospheric chemistry and modeling, emissions inventory and modeling, and climate change.

EPIC

UFS Community Modeling Cross-Cutting Infrastructure Support

Project Lead(s): Arun Chawla, PhD (EMC), Rusty Benson, PhD (GFDL), Jeff Whitaker, PhD (ESRL), Tony Craig, PhD (STC)

Development of the Unified Forecast System (UFS) requires a shared community modeling infrastructure framework, whereby the entire modeling suite, including UFS components and applications, follows a collaborative development paradigm. The latter is built upon open-development repositories, with proper documentation and code managers for all of the components, as well as continuous integration (CI) teams for testing applications as individual UFS components are upgraded. This initiative is a wide collaboration between NOAA, other federal agencies and the academic community. The proposed collaborative development environment consists of component code managers and CI Teams working together with

science teams across many different disciplines, domains, time zones, and entities, contributing to the UFS and delivering the continuous deployment paradigm. The Community Modeling Cross-Cutting Infrastructure Support project laid the foundation for creating a development and maintenance modeling infrastructure that supports the creation of a UFS community all-inclusive of members from public, private, and academic organizations. The project provides continuing support for code management and continuous deployment for numerous NOAA-built components used in the UFS at institutional levels where they are being developed.

Arun Chawla, PhD, is the Chief of the Engineering and Implementation Branch at NOAA's Environmental Modeling Center (EMC). His branch supports the development of cross-cutting infrastructure framework in support of the Unified Forecast System (UFS), partially-funded by WPO's EPIC Program. Dr. Chawla has been an important collaborator with the EPIC program by providing information for completing a comprehensive assessment of the UFS developments in the last few years, as well as guidelines for transitioning current UFS development tasks to EPIC.

JTTI

Advancing ADCIRC U.S. Atlantic and Gulf Coast Grids and Capabilities to Facilitate Coupling to the National Water Model in the Extratropical Surge and Tide Operational Forecast System (ESTOFS) Operational Forecasting

Project Lead(s): Joannes Westerink, PhD, University of Notre Dame

The primary objective of this project is to improve predictions of water levels caused by extratropical tide and storm surge within the the Global Extratropical Storm and Tide Operational Forecast System (Global ESTOFS), by developing improved meshes and directly incorporating baroclinic and hydrologic physics. Characteristics of the improved Global ESTOFS model include increasing the mesh resolution along the East Coast and Gulf of Mexico for greater water hazard specificity within coastal areas, two-way coupling of the ADvanced CIRCulation (ADCIRC) finite element model and WAVEWATCH III model to

improve water levels, currents, and nearshore waves, as well as coupling to the National Water Model to account for upland hydrology and stream flows into the coastal zone. This model provides NWS forecasters with the forecast guidance of water level conditions caused by storm surges and tides for the entire globe.

Joannes Jacobus Westerink, PhD, is the Joseph and Nona Ahearn Professor of Computational Science and Engineering at the University of Notre Dame. Dr. Westerink has pioneered the development and application of global to channel scale highly heterogeneous unstructured mesh ocean models with resolution varying by up to four orders of magnitude. Dr. Westerink focuses on multi-physics, multi-scale hydrodynamic codes for the coastal ocean and has successfully transitioned these to practitioners for a wide range of applications within academia, government and private sector worldwide.

SOCIAL SCIENCE

Participatory Risk Communication Planning: Learning from Precariously Housed Communities

Project Lead(s): Jamie Vickery, PhD, University of Washington

In 2021, WPO, the National Severe Storms Laboratory (NSSL), and NWS partnered with the NSF-supported Natural Hazards Center (NHC) to implement the Weather Ready Quick Response Research Program. One of the funded projects included learning from individuals who live in precariously housed communities, such as those living without housing. The risk communication literature increasingly has identified the need for inclusivity and sensitivity to the unique needs and capacities of populations labeled as, “access and functional needs,” or “socially vulnerable.” However, there remains a gap in our understanding as to if and how these individuals and communities are integrated into risk communication planning, let alone broader emergency operations planning. The project team is engaging members of the Boulder and Denver communities with lived experiences with homelessness, homeless-serving organizations and emergency management professionals to identify gaps and opportunities in extreme weather risk communication for precariously housed individuals.

Translating the Weather & Society Survey into Spanish

Project Lead(s): Joseph Ripberger, PhD (Lead PI) and Joseph Trujillo-Falcon (student)
University of Oklahoma

Since 2017, the University of Oklahoma's Center for Risk and Crisis Management's (CRCM) annual public Weather Survey has collected data to provide generalizable, longitudinal, and experimental data on the extent to which members of the U.S. public receive, understand, and respond to severe weather forecasts and warnings. Recent results from a comparison of current and past versions of the Weather Survey indicate significant inequalities between English and Spanish speaking communities in their responses to forecasts and tornado warnings. CRCM and the collaborators translated the most recent version of the severe Weather Survey to Spanish and implemented it to Spanish speaking U.S. residents. In addition to providing invaluable information about risk perception and communication in vulnerable communities, it will establish a path for developing and implementing Spanish language versions of the tropical cyclone and winter weather surveys that are in development.

Joe Ripberger, PhD, is an Associate Professor of Public Policy and the Deputy Director for Research at the National Institute for Risk and Resilience at the University of Oklahoma. His research focuses on risk and public policy with an emphasis on weather, climate, and energy policy. Dr. Ripberger is currently working on multiple projects that assess risk communication and information reception, comprehension, and response in the weather/climate domain.

SUBSEASONAL-TO-SEASONAL

Project Title: Development of Fire Weather Related 8-14 Day Forecast Products for the Climate Prediction Center

Project Lead(s): Thomas M. Hamill, PhD, Rochelle Worsnop, PhD, Michael Scheuerer, PhD, Mingyue Chen, PhD (Research to Operations Lead), David DeWitt, PhD, NOAA

NOAA's Physical Sciences Laboratory (PSL) has developed a framework that can generate

skillful probabilistic forecasts of fire indicators 8–14 days ahead and has been selected to be transitioned into operations at the Climate Prediction Center (CPC). The framework consists of numerous pre- and post-processing algorithms as well as simulations from the Global ECMWF Fire Forecast (GEFF) system to produce skillful and reliable probabilistic forecasts of different fire indicators output from the U.S. Forest Service's National Fire Danger Rating System (NFDRS). The algorithms were designed to post-process GEFSv12 meteorological forecasts in operations before inputting them into the GEFF system to produce fire-indicator forecasts. This framework and the resulting forecasts will be used in near real-time by the CPC to produce probabilistic forecast maps of above- and below-normal fire conditions 8–14 days ahead.

Using Simple, Explainable Neural Networks to Predict the Madden-Julian Oscillation

Project Lead(s): Zane Martin, PhD, Elizabeth Barnes, PhD,
Eric Maloney, PhD, Colorado State University

The Madden-Julian oscillation (MJO)—a large-scale, coherent complex of tropical wind and rain—is important for global weather and climate predictions weeks to months into the future. Many different models have been used to study and predict the MJO, but few have used machine learning and artificial intelligence methods. In this work, researchers developed a machine learning model using "artificial neural networks" for real-time MJO forecasting. The neural networks use maps of tropical variables to predict an MJO index several weeks into the future. The study develops and analyzes two types of neural network frameworks: a deterministic forecast model and a probabilistic one. Both frameworks skillfully predict the MJO out to ~2–3 weeks in winter and ~2 weeks in summer. The paper further demonstrates how neural networks explainability methods can help identify sources of MJO prediction skill. This project highlights that simple neural networks could be used to predict a number of climate phenomena, emphasizing that these models are simple to implement, and are computationally affordable.

The study is under review in the Journal of Advances in Modeling Earth Systems located here.

TESTBEDS

Further improvements and Extensions to the Tropical Cyclone Logistical Guidance for Genesis (TCLOGG)

Project Lead(s): Robert Hart, PhD, Florida State University
and Daniel Halperin, PhD, Embry-Riddle Aeronautical University

The Tropical Cyclone Logistical Guidance for Genesis (TCLOGG) is a statistical-dynamical

tropical cyclone (TC) genesis guidance tool based on forecast output from global numerical models. TCLOGG assigns probabilities for the formation of TCs as guidance to forecasters at the National Hurricane Center (NHC) and Central Pacific Hurricane Center (CPHC). TCLOGG has been used extensively by NHC hurricane specialists as guidance for the Tropical Weather Outlook (TWO) since 2014 and continues to be used at a high volume both by NHC forecasters and the general public.

This project has expanded TCLOGG to incorporate new datasets, to produce longer forecast lead time (from 5 to 7 days), and to identify a most-likely time of genesis. Other specific improvements include enhancing its ability to detect and forecast high latitude TC formation, and updating the forecast equations to use the most recent years of training data.

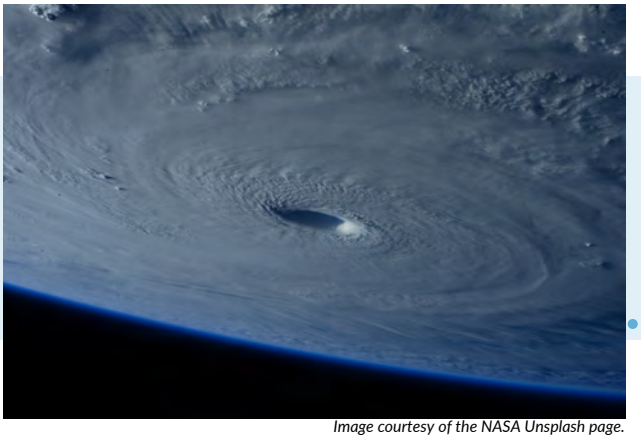


Image courtesy of the NASA Unsplash page.

OBSERVATIONS

Autonomous Measurements of Air-Sea Interaction from Saildrones for Improved Hurricane Intensity

Project Lead(s): Dongxiao Zhang, PhD, University of Washington

Improving the accuracy and ultimate value of NOAA's operational hurricane forecasts requires more complete real-time knowledge of atmospheric and oceanic conditions and more realistic representation of key physical processes in hurricane forecast models. This project addresses these needs through the deployment of Uncrewed Surface Vehicle (USV) saildrones during the peak of the Atlantic hurricane season. Powered by renewable energy (wind and solar), USV saildrones are larger (7 m long, more than 220 lb payload capacity), faster (3–5 kt on average) and have longer endurance (8–12 months science mission) than most other marine Uncrewed Systems (UxS). A new development is the specially designed, reinforced saildrones that can sustain hurricane force wind and high seas. In this project, the uncrewed autonomous marine system will continuously measure the near-surface atmosphere and upper ocean with goals to transmit observations in real-time to the Global Telecommunication System and assimilate into NOAA's operational hurricane forecast models.

Developing new soil moisture technologies and applications for improving assessments and forecasts of water issues in the Southeast such as flash droughts, floods, and ecosystem health

Project Lead(s): Lee Ellenburg, PhD, University of Alabama - Huntsville
John Christy, PhD, University of Alabama - Huntsville
William Lusher, PhD, University of Florida
George Vellidis, PhD, University of Georgia

Soil moisture is a key variable for assessing the onset and magnitude of both drought and flooding extremes, but accurately measuring it over a large spatial extent and systematically reporting it has proven to be challenging. To address this issue, NOAA's Weather Program Office funded a new project, with support from the CPO-led National Integrated Drought Information System (NIDIS), to enhance the soil moisture monitoring network in Alabama, Georgia, and Florida. The project will also improve the application of soil moisture data to decision making in the region.

Reflection, History, and the Future

WPO, previously known as the Office of Weather and Air Quality (OWAQ), was established within NOAA's Office of Oceanic and Atmospheric Research (OAR) in 2009. Under its first director, John Gaynor, WPO began its successful history of facilitating and funding weather research that continues today. WPO began with a budget of $5.5M which has grown tenfold under the leadership of John Cortinas, PhD (2010–19), and now Dorothy Koch, PhD (2021–present), to over $50M. WPO's growth over this time period allowed the office to establish programs such as:

- The Joint Technology Transfer Initiative (JTTI) that funds intramural and extramural research intended to be developed into operational use by the National Weather Service and others
- The Subseasonal to Seasonal (S2S) program to improve the intersection of climate and weather models to better forecast two weeks to two years

- The Social Science Program that coordinates and applies social, behavioral, and economic science research, and
- The Earth Prediction and Innovation Center (EPIC) Program to accelerate community-developed scientific and technological enhancements into the operational applications for numerical weather prediction.

Now with FY22 well underway, WPO continues to make significant progress towards finding, funding, and fostering collaborative weather and air quality research. While the challenges and stressors from the pandemic, climate change, and racial injustice continue to affect us all, resilience and organizational strength has helped WPO weather these storms.

In FY22, WPO is offering up to $19.5M per year for seven competitions:

1. Fire Weather & Atmospheric Composition (FWAC)
2. Climate Testbed (CTB)
3. Weather Testbeds
4. Joint Technology Transfer Initiative (JTTI)
   - a. External - non-NOAA Researchers
   - b. Internal - NOAA Researchers
5. Subseasonal-to-Seasonal (S2S)
6. Verification of the Origins of Rotation in Tornadoes Experiment in the United States (VORTEX-USA)

WPO FY22 competitions seek to improve our understanding of weather, water, and climate phenomena, to develop new observing and forecasting systems, and improve communication of forecast information to NOAA partners and the public.

By the end of FY22, the new 2022–2026 WPO Strategic Plan will influence our future funding opportunities and research activities. The plan will reflect the recently developed Priorities For Weather Research Report, by NOAA's Science Advisory Board, written to address a request from Congress for the provision of federal investments in weather research and forecasting over the next decade.

WPO is also developing a Justice, Equity, Diversity, Inclusion, and Accessibility (JEDIA) Action Plan under the OAR DEIA Strategic Plan to improve diversity and inclusion within WPO and to make our funding opportunities and research activities more equitable. WPO is focused on improving our capacity to evaluate the outcomes of the research we fund, and is preparing for its first ever Program Review in January 2023.

We look forward to everything FY22 has to bring, and we will continue to strive to provide world class weather research to build a Weather-Ready Nation.

APPENDICES

Project List

In support of our vision and mission, the projects listed in the Project Directory are selected and funded by WPO through our funding opportunities. These projects promote a diverse and inclusive research environment, foster collaboration that transitions world-class research into operations and help to ensure timely and accurate weather and air quality forecasts that benefit society by saving lives, reducing property damage, and enhancing the national economy.

List of Abbreviations and Acronyms

Abbreviation/Acronym	Definition	Context for Use
AAAS	American Association for the Advancement of Science	
ADCIRC	ADvanced CIRCulation	
AI	Artificial Intelligence	
AMS	American Meteorological Society	Partner - Not-for-profit
AOML	Atlantic Oceanographic and Meteorological Laboratory	NOAA Lab
APAR	Airborne Phased Array Radar	Equipment
AQRF	Air Quality Research and Forecasting	Sub-program
ARL	Air Resources Laboratory	NOAA Lab
CICOES	Cooperative Institute for Climate, Ocean, and Ecosystem Studies	
CIGLR	Cooperative Institute for Great Lakes Research	
CIMAS	Cooperative Institute for Marine and Atmospheric Studies	

CIMES	Cooperative Institute for Modeling the Earth System	
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies	
CIMSS	Cooperative Institute for Meteorological Satellite Studies	
CIRA	Cooperative Institute for Research in the Atmosphere	
CIRES	Cooperative Institute for Research in Environmental Studies	
CIWRO	Cooperative Institute for Severe and High-Impact Weather Research Operations	
CMAQ	Community Multiscale Air Quality	
CPC	Climate Prediction Center	
CPHC	Central Pacific Hurricane Center	
CPO	Climate Program Office (within OAR)	
CRCM	Center for Risk and Crisis Management	
CTB	Climate Testbed	

DEIA	Diversity, Equity, Inclusion and Accessibility	
DRAS	Disaster-Related Appropriation Supplemental	
ECMWF	European Centre for Medium-Range Weather Forecasts	
EEO	Equal Employment Opportunity	
EPIC	Earth Prediction Innovation Center	
EMC	Environmental Modeling Center	
ESRL	Earth System Research Laboratory	NOAA Lab
ESRL/CSL	Chemical Sciences Laboratory	NOAA Lab
ESRL/GML	Global Monitoring Laboratory	NOAA Lab
ESRL/PSL	Physical Sciences Laboratory	NOAA Lab
ESTOFS	Extratropical Surge and Tide Operational Forecast System	
FACETs	Forecasting a Continuum of Environmental Threats	
FV3	Finite-Volume Cubed-Sphere Dynamical Core	
FWAC	Fire Weather & Atmospheric Composition	

FY	Fiscal Year	
G-ESTOFS	Global Extratropical Surge and Tide Operational Forecast System	
GEFF	Global ECMWF Fire Forecast	
GEFS	Global Ensemble Forecast System	
GFDL	Geophysical Fluid Dynamics Laboratory	
GFS	Global Forecast System	Numerical Weather Prediction Model
GLERL	Great Lakes Environmental Research Laboratory	
HMT	Hydrometeorology Testbed	
HPC	High Performance Computing	
HWT	Hazardous Weather Testbed	
IFHFW	Improving Forecasting of Hurricanes, Flood, and Wildfires	
JCSDA	Joint Center for Satellite Data Assimilation	
JEDIA	Justice, Equity, Diversity, Inclusion, and Accessibility	

JHT	Joint Hurricane Testbed	
JTTI	Joint Technology Transfer Initiative	
LO	Line Office	
MJO	Madden-Julian Oscillation	
ML	Machine Learning	
MRMS	Multi-Radar Multi-Sensor	
NAQFC	National Air Quality Forecast Capability	
NAS	National Academy of Sciences	
NCAR	National Center for Atmospheric Research	
NCET	NAQFC Community Emission Testbed	
NESDIS	National Environmental Satellite, Data, and Information Service	
NHC	National Hurricane Center	
NOAA	National Oceanic and Atmospheric Administration	

NOFO	Notice of Funding Opportunity	
NOS	National Ocean Service	
NSF	National Science Foundation	
NSSL	National Severe Storms Laboratory	NOAA Lab
NWM	National Water Model	
NWS	National Weather Service	Parent Agency
OAR	Oceanic and Atmospheric Research	
OMAO	Office of Marine and Aviation Observations	
OSTI	Office of Science and Technology Integration	
OWAQ	Office of Weather and Air Quality	Former Office Name
PI	Principal Investigator	
PBL	Planetary Boundary Layer	
PMEL	Pacific Marine Environmental Laboratory	NOAA Lab
R&D	Research and Development	

R2O	Research to Operations	
RL	Readiness Level	
S2S	Subseasonal-to-Seasonal	
SBES	Social and Behavioral Science	
SLA	Service-Level Agreements	
SSP	Social Science Program	WPO Sub-program
TC	Tropical Cyclone	
TCLOGG	Tropical Cyclone Logistical Guidance for Genesis	
UCAR	University Corporation for Atmospheric Research	
UFS	Unified Forecast System	
USV	Uncrewed Surface Vehicle	
UxS	Uncrewed Systems	
VORTEX-SE (now VORTEX-USA)	Verification of the Origins of Rotation in Tornadoes Experiment Southeast	
The Weather Act	The Weather Research and Forecasting Innovation Act of 2017	

WCRP	World Climate Research Programme	
WMO	World Meteorological Organization	
WPO	Weather Program Office	New Office Name as of 04/03/2020
WWRP	World Weather Research Programme	