# Innovation for Community Modeling Competition - Information Sheet

## FY2023 Notice of Funding Opportunity
## NOAA Weather Program Office Research Programs

## Introduction

The Weather Program Office (WPO) Innovations for Community Modeling Competition funds an energized and committed community that includes researchers from the full weather enterprise - academia, government, and industry - partnering with NOAA to improve scientific understanding and forecasting through innovation. We seek high-risk/high-reward projects accelerating scientific research and modeling contributions through continuous and sustained community engagement. Proposals must address the ultimate goal of improving forecast skill, in close alignment with NOAA's vision and mission towards advancing the Unified Forecast System (UFS) to become the world's most accurate and reliable operational modeling system in the world.

The UFS is a community based, coupled, comprehensive Earth modeling system that can be configured to provide predictive information for weather, ocean, air quality, and coastal systems spanning time scales from a few hours to two years. Further innovation will improve high-resolution, coupled forecasts and extend forecast information for severe weather, including tropical storms, heavy precipitation, extreme temperatures, to Earth system processes that drive predictability of weather systems at subseasonal-to-seasonal timescales.

To qualify as innovative, proposals submitted to this competition must focus on substantially new approaches and not on incremental changes. Model developments should focus on UFS systems that are expected to be implemented into operations in 5 years or later, i.e. "next plus one" generations of the UFS. By adding a focus on innovative research to the objectives and priorities from other competitions in this notice of funding opportunity, WPO seeks to strengthen an open partnership between NOAA and the external community, enabling the co-development of high-quality modeling systems reflecting cutting-edge science. Approaches that benefit portability across HPC resources that are easier to transition across the research-to-operations funnel are encouraged. Successful proposals must articulate how their research is addressing priorities set out in NOAA's Science Advisory Board's Priorities for Weather Research[1], forecast system deficiencies derived from the 2020-21 NOAA Office of Science and Technology Integration

[1] https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf

(OSTI) Forecasters Workshops priority report[2], and community priorities identified in the UFS Strategic Plan[3].

Research themes which will receive particular emphasis in this competition shall fall within priorities associated with three program areas, addressing topics identified in the priorities section of this NOFO. Proposals must address at least one priority within one of the following program areas.

- Program Area I: Numerical Weather Prediction Capabilities, with funding from the Joint Technology Transfer Initiative (JTTI) and Earth Prediction Innovation Center (EPIC) Programs.
- Program Area II: Western States Hydrology, with funding from the Subseasonal to Seasonal (S2S) Program.
- Program Area III: Fire Weather Subseasonal-to-Seasonal Forecasting, with funding from the Atmospheric Composition (AC) Program.

Project awards will include an optimal balance of  smaller high-risk, low-cost proof-of-concept ideas as well as larger collaborative proposals. Although focusing on high-risk/high-reward projects at the lower readiness levels (RLs 2-4), this competition will also accept innovative proposals with potential for operational transition at higher readiness levels. Formal transition plans are not required for projects at lower RLs unless the project expects to progress to RL 5 or greater by the end of the period of performance. If the project has potential to progress beyond an RL of 4 at any point, per NAO 216-105B, the PI is required to submit a research-to-operations transition plan with the first progress report.

All applicants are encouraged to align the development of proposals with the EPIC Program capabilities (see section below). Proposals shall indicate which specific capabilities would be leveraged. If there are specific proposed activities that would require software engineering support from EPIC to integrate new modules/libraries/datasets/regression tests into the UFS code base and continuous integration/continuous deployment pipelines, projects would receive software engineering support from EPIC and shall provide:

1. A schedule for key milestones that would involve collaboration with EPIC and
2. Estimated level of efforts for software engineers to integrate advancements into the UFS model.

[2]https://www.weather.gov/media/sti/Final%20Consolidated%20Forecasters%20requests%20April%202021.pdf
[3]https://vlab.noaa.gov/documents/12370130/12437941/20210406_UFS_Strategic_Plan_2021-2025_v1.0.pdf

Opportunities for collaborating with EPIC are summarized in the program description section below, and provided in more details in the EPIC Community Portal[4]. Prospective projects must commit to software development approaches in accord with UFS and EPIC best practices described in the following documents.

- UFS Weather Model Code Development: https://github.com/ufs-community/ufs-weather-model/wiki/Making-code-changes-in-the-UFS-weather-model-and-its-subcomponents
- UFS Short-Range Weather (SRW) App Contributor's Guide: https://ufs-srweather-app.readthedocs.io/en/develop/ContributorsGuide.html

Selected projects may be expected to participate in an annual workshop for the duration of the project, and share results with other researchers via webinars.

For general information about this opportunity contact Jose-Henrique Alves, manager for the Innovations for Community Modeling Competition, using the email Henrique.Alves@NOAA.gov.

## Program Area I: Numerical Weather Prediction Capabilities

Proposals addressing priorities defined under this program area will receive funding from the Joint Technology Transfer Initiative (JTTI) and Earth Prediction Innovation Center (EPIC) Programs. This section provides general information about JTTI and EPIC, and specific guidance for developing proposals submitted to associated program area priorities.

Projects under the Numerical Weather Prediction Capabilities program area support the development and advancements of the UFS to become a fully-coupled Earth prediction system, addressing all scales from the mesoscale short range to the seasonal-to-subseasonal predictions across the linked weather-water-climate domain. Envisaging high-risk/high-reward opportunities that may accelerate the development of such capabilities in the UFS, projects funded within this program area will develop next-plus-1-generation capabilities in component models or systems, such as atmospheric physics or dynamics, coupled data assimilation, ocean, ice and/or land systems, for example.

Proposals may include an optional whitepaper-style section on improving computational performance and/or working with alternative next-generation hardware systems, as it relates to the UFS scientific component of the project. The computational whitepaper section should include an estimation of required resources, including computing or software engineering.

[4] https://epic.noaa.gov/

Proposals selected for the science component will be subsequently considered for the computational performance component in a follow-on process. Examples include: improve computational performance of the UFS code and coupling infrastructure, flexible workflow, parallel performance, and multiplatform capabilities.

Innovative approaches such as code refactoring for HPC efficiency and next-gen computer performance, updating code language, and developing and using cloud-computing infrastructure for UFS applications, and proposals addressing needs towards converging community modeling systems in the long term are also strongly encouraged. At the end of the period of performance, successful and promising innovation projects with higher potential for transition to NOAA operations will be further evaluated by a panel of experts and selected for further funding by the JTTI and/or EPIC program dependent upon available federal budget appropriations.

Further information is provided next about the JTTI and EPIC Programs relevant to proposals submitted to NOFO priorities under the Numerical Weather Prediction Capabilities program area.

**Joint Technology Transfer Initiative (JTTI) Program**

National Oceanic and Atmospheric Administration (NOAA) collaborates with the American Weather Enterprise on cooperative research activities and provides financial support to transition weather technologies from the American Weather Enterprise to NOAA's National Weather Service (NWS) operations through several funding programs. The Joint Technology Transfer Initiative (JTTI), created by the Congress in 2016, is one such program to accelerate the transition of matured weather research to NWS operations. The mission of the JTTI is to ensure continuous, cost effective development and transition of the latest scientific and technological advances into NWS operations. Within NOAA's Office of Oceanic and Atmospheric Research (OAR), WPO manages and implements the JTTI program in close collaboration with the NWS.

JTTI focuses on the following areas in support of UFS: Advancing and transitioning coupled data assimilation techniques, stochastic physics, post-processing of ensembles, and verification and validation through development, testing and evaluation for regional and global models on hourly to sub-seasonal times scales. In addition, JTTI also focuses on improving water prediction capabilities, extreme and high impact weather forecasting, and communicating forecast uncertainty using social and behavioral science. JTTI meets WPO's objectives through funding matured transition projects that can transition to operations within 3-5 years.

For further information about JTTI, contact Dr. Chandra Kondragunta, Program Manager, using the email Chandra.Kondragunta@NOAA.gov.

**Earth Prediction Innovation Center (EPIC) Program**

The Weather Research and Forecasting Innovation Act of 2017 (WRFIA; Public Law 115-25) instructs NOAA to prioritize improving weather data, modeling, computing, forecasting, and warnings for the protection of life and property and for the enhancement of the national economy. The National Integrated Drought Information System Reauthorization Act of 2018 (NIDISRA; Public Law 115-423) instructs NOAA to establish the Earth Prediction Innovation Center (EPIC) to accelerate community-developed scientific and technological improvements into the operational applications for Numerical Weather Prediction (NWP).

EPIC is a virtual center that leverages resources to better coordinate the weather research and modeling community to continually inform and accelerate advances in our nation's operational weather forecast model systems. EPIC will advance weather modeling skill, reclaiming and maintaining international leadership in the area of Numerical Weather Prediction, and improving Research to Operations (R2O) by:

- Leveraging the weather enterprise to remove barriers to improving NWP;
- Enabling scientists and engineers to effectively collaborate in areas important for improving operational global NWP skills;
- Strengthening NOAA's ability to undertake research projects in pursuit of substantial advancements in weather forecast skill;
- Utilizing and leveraging existing resources across NOAA's enterprise; and
- Creating a community global weather research modeling system that is accessible by the public, meets end-user requirements, and utilizes innovative strategies and methods, including cloud-based computing, when appropriate and cost-effective.

EPIC supports the software infrastructure of the UFS, as well as community engagement, user support and scientific innovation. EPIC will establish and provide access to Continuous Integration/Continuous Delivery (CI/CD) pipelines that enable and accelerate the infusion and testing of innovations in the UFS and its applications. The EPIC team is in the process of making the UFS weather model cloud-ready, including providing necessary high-performance computing (HPC) configurations and relevant data needed for model execution, evaluation, and validation in cloud platforms. An EPIC service desk will be established to provide user support and ensure access and usability by all community members, regardless of the level of expertise in forms of training, tutorials, hackathons, code sprints, and workshops.

Proposals in this competition relevant to the development of the UFS are strongly encouraged to collaborate with EPIC considering the following capabilities:

- Multi-platform-ready and portable UFS source codes and dependent libraries supporting cloud and on-premise HPC platforms.
- Open-source codes and scripts released publicly via UFS open-development Github repositories.
- Provision of dependent data in open platforms to support research and development of the UFS on cloud and on-premise platforms,
- Collaborative platforms for community interactions on the design and development of workflow for UFS applications that are portable across cloud and on-premise platforms.
- Containerized versions of the UFS with support to improve developer productivity, performance, efficiency, and application portability.
- Integration of the UFS to cloud services for the purpose of continuous integration, data services, model integration, reforecasts/reanalysis, and portability.

Further information about the EPIC Program may be found through the following links,

- EPIC Community Portal: https://epic.noaa.gov/
- EPIC Program page: https://wpo.noaa.gov/Programs/EPIC
- Technical FAQs: https://epic.noaa.gov/technical-faqs
- General program FAQs: https://wpo.noaa.gov/Programs/EPIC/FAQs

For further information about the EPIC Program, contact Dr. Maoyi Huang, Program Manager, using the email Maoyi.Huang@NOAA.gov.

## Program Area II: Western States Hydrology

Proposals addressing priorities defined under this program area will receive funding from the Subseasonal to Seasonal (S2S) Program. This section provides general information about the S2S Program, and specific guidance to developing proposals submitted to associated program area priorities.

The Weather Research and Forecasting Innovation Act of 2017 calls for NOAA to improve its Subseasonal to Seasonal (S2S) capabilities, and defines subseasonal to seasonal as the range between two weeks and two years. NOAA's OAR is aligning its subseasonal to seasonal research with other observational and weather research within the Weather Program Office to efficiently support the Weather Act goals. NOAA OAR is also seeking to address the emerging need for improved precipitation and hydrology prediction, particularly for the Western states, to meet decision needs over S2S timescales. Through this effort, NOAA will address a spectrum of issues on the S2S time frame crucial for improving western-US hydrologic forecasts.

NOAA is moving toward a unified modeling approach to support prediction of extreme weather and its associated drivers at extended time ranges. A key aim is to harness predictability sources across scales present in the Earth system crucial to the S2S prediction problem, from the synoptic range out to two years, and incorporate the ability to characterize these interactions into the UFS S2S prototypes. Such predictability sources include cyclical modes of variability (i.e. MJO, ENSO, NAO, QBO, etc.) as well as their interactions and impacts on extremes and high-impact weather, particularly hydrologic extremes impacting the Western states.

The WPO S2S program will support the progression of NOAA's ability to address these challenges. In particular, the program will emphasize innovative projects to increase capabilities related to basin-scale hydrologic prediction, such as precipitation, its excess, shortfalls, duration, type, and precision of spatial and temporal placement, as well as streamflow, land modeling, land-atmosphere interactions on the subseasonal to seasonal scale. A myriad of factors known and unknown contribute to accurate prediction of hydrology, including precipitation or drought beyond two weeks. Additional factors such as vegetation or fuel development exacerbating fire weather precursors and their impacts on hydrology are of interest. Projects to improve hydrological prediction in the western US states should address improvements in the two areas of immediate need detailed below: numerical model processes and component interaction via the community-based UFS, and coupled data assimilation.

While projects investigating any of these factors will be considered, WPO will consider most relevant in the Western States Hydrology program area those projects that utilize and improve models and components participating in NOAA's UFS. Proposals must address one of the following two S2S priorities.

1. To improve model capabilities, it is crucial to identify and address sources of model bias across NOAA's modeling suite. This involves understanding the sources of biases such as issues in models' physical process representation, model component interaction, numerical approach, or interactions between these issues, via a systematic process-oriented evaluation of the biases.

   The WPO S2S Program is interested in community-based approaches to improve Earth system models via development and evaluation of individual sub-elements within model components. For example, surface drag parameterization in a surface-layer turbulence scheme or ocean mixed layer thermohaline processes, single column modeling, limited area modeling, planetary boundary layer (PBL) modeling to parameterize land-atmosphere interaction, improved streamflow within land modeling, and more. PBL studies and their developed schemes within the land surface hydrology model can enhance prediction skill of precipitation patterns associated with land development practices in the western United States such as irrigation for agricultural products.

Development and evaluation may focus on processes occurring within one component of the Earth system models or on characterizing the component-to-component interactions, i.e., land-atmosphere, ocean-atmosphere, ocean-ice flux exchanges. For example, improvements to PBL representation and interaction with land surface properties can improve both the precipitation and hydrology processes; improvements to flux exchanges and component interactions driving precipitation and hydrologic extremes, or other predictive phenomena, will be beneficial. Evaluations should include the interactions of such sub-elements or processes, with all those model parts progressively connected/coupled in a hierarchy that culminates in a global Earth system model (that could include atmosphere/aerosols/chemistry, ocean/sea-ice/waves, and land-hydrology/land-ice earth system components).

This program area focus emphasizes a range of phenomena related to precipitation/drought and land interactions, processes influencing these, and implications of modeled precipitation or its lack for forecast utility. The portfolio will only consider models and components designed to improve or supplement the community-based NOAA Unified Forecast System development.

2. Improved data assimilation (DA) connecting Earth system components such as the cryosphere, ocean, waves, land surface, and atmospheric composition and the incorporation of new observation types is critical to better monitoring Earth system variability across all time scales. Coupled DA, where observations in one component of the Earth system are allowed to directly impact the state estimation in other components, is crucial to advance subseasonal-to-seasonal prediction through improved model initialization. The optimum approach(es) to coupled DA in the context of Earth system modeling and prediction is an open research question, and thus represents a major research need for NOAA. Projects supporting improved DA will:
    - Develop a new methodology, or significantly advance an existing methodology, for coupled DA with demonstrable relevance to the Earth system prediction and/or monitoring needs on the subseasonal to seasonal scale of one or more NOAA Line Offices;
    - Emphasize the implications and application of these technologies on prediction of precipitation, particularly winter snowfall to better evaluate the hydrological processes in the western United States (Western Region Hydrology) on the subseasonal to seasonal scale while utilizing existing NOAA, WMO, NOAA National Water Center (NWC), and other agency datasets.

For further information about S2S, contact Jessie Carman, Program Manager, using the email Jessie.Carman@NOAA.gov.

## Program Area III: Fire Weather Subseasonal-to-Seasonal Forecasting

Proposals submitted to the priorities defined under this program area will receive funding from the Atmospheric Composition (AC) Program. This section provides general information about the AC Program, and specific guidance to developing proposals submitted to associated program area priorities.

The Organic Act of 1890 provides NOAA broad authority to provide weather and climate information for the nation. Other Federal actions, such as the 1988 Stafford Disaster Relief and Emergency Assistance Act and the 2017 Weather Act, directs NOAA to support state and local emergency assistance efforts through improved observations, forecasts, and impact-based decision support services (IDSS), including those associated with wildland fires. These activities span a range of timescales in the fire lifecycle, from subseasonal-to-seasonal (S2S) prediction of conditions that are correlated with a high likelihood of dangerous wildfire (e.g., drought conditions), to early ignition detection, short-term and medium-term forecasting associated with the near-fire environment and the downstream air quality, and post-fire hazards.

The increase in the frequency of drought and hot-dry-windy conditions over the last several decades, combined with the continued expansion into the wildfire-urban interface region, has led to a marked increase in the number of acres burned by hazardous wildfires. The number of wildfires and the acres burned are projected to further increase as the climate warms, with profound changes to certain ecosystems. Wildfires threaten forest and grasslands, housing and communities, aquatic and soil ecosystems, and air quality both near to and far from the fires, and ultimately costs the Nation billions of dollars a year when accounting for the local costs of damage to buildings and communities and the downstream impacts on human health associated with smoke and the resulting poor air quality.

There are a large number of gaps that need to be addressed to provide better predictions and tools to help forest and emergency managers, operational forecasters, and local, state, and national agencies better prepare and address hazardous wildfires. Some of the gaps are due to lack of observations or the current inability to utilize these observations as well as possible in high resolution modeling systems. Acquiring and maturing the use of technologies to incorporate profiles of temperature, humidity, wind, and fire emissions into NOAA modeling systems will provide new insights into interactions among fire, weather, chemistry, and air quality.

Other gaps are associated with uncertainties or lack of capability of predictive modeling systems. Improvements in UFS synoptic and S2S models, which are used to predict drought and other conditions correlated with hazardous fires and thereby allow communities to prepare for potentially dangerous conditions, are drastically needed. A coupled fire-atmosphere high

resolution modeling system is needed to predict how a currently burning fire might spread in the hours-to-days ahead time frame. Ensemble prediction systems are needed to provide probabilistic guidance for various stakeholders on how fires might spread and impact downstream air quality.

Lastly, there are gaps in the tools needed to present these advanced observations and forecast model predictions in easy-to-understand, interactive ways to the user community. These tools should enable better communication of the risks and evolving conditions, to ultimately help to save lives and property, improve downstream health impacts from the emitted smoke, and save potentially millions of dollars.

NOAA is moving toward a unified modeling approach to support prediction of extreme weather and its associated drivers at extended time ranges. Fire weather development projects must focus on developing the UFS. It is strongly recommended that proposals articulate how they would collaborate with the Earth Prediction Innovation Center (EPIC), leveraging and incorporating scientific advances to adopt EPIC's continuous improvement continuous deployment framework, providing code documentation, incorporating code testing, or utilizing cloud computing. Further details on EPIC are provided in an information sheet included in this NOFO package.

For further information about AC, contact Jordan Dale, Program Manager, using the email Jordan.Dale@NOAA.gov.