FY22 Program Information Sheet

Program Name

Competition Name: OAR/CPO/CVP - NWS/OSTI/Modeling Division - Joint Competition to Advance Process Understanding and Representation of Precipitation in Models

Program Name: Oceanic and Atmospheric Research/ Climate Program Office/ Climate Variability and Predictability (CVP) Program

Program Name: National Weather Service/ Office of Science and Technology Integration (OSTI)/ Modeling Division

Program Mission

The Climate Variability and Predictability (CVP) Program supports research that enhances our process-level understanding of the physical climate system through observation, modeling, analysis, and field studies. This vital knowledge is needed to improve climate models and predictions so that scientists and society can better anticipate the impacts of future climate variability and change. The CVP Program sits within the Earth System Science and Modeling (ESSM) Division of the NOAA Office of Oceanic and Atmospheric Research (OAR) Climate Program Office (CPO; see http://cpo.noaa.gov/CVP). CVP is a critical component of the integrated research enterprise at CPO and maintains important connections to the other CPO program areas, such as COM (Climate Observations and Monitoring) Program, MAPP (Modeling, Analysis, Predictions and Projections) Program, Atmospheric Chemistry, Carbon Cycle, & Climate (AC4) Program, and Climate and Societal Interactions (CSI) Division.

The Office of Science and Technology Integration (OSTI) Modeling Division is responsible for supporting a variety of NWS modeling and research initiatives to improve weather forecasts. This is accomplished by funding research projects to accelerate and advance the development of new models, and foster collaboration among NOAA research scientists, federal labs, operational forecasters and the academic community. Examples of programs managed by this division include efforts to advance research to improve and extend precipitation forecast skill; and implement a fully-coupled numerical weather prediction system for both medium-range weather and subseasonal-to-seasonal prediction.

To achieve its mission, the CPO/CVP Program and NWS/OSTI/Modeling Division support research and research to operation (R2O) transition carried out at NOAA and other federal laboratories, NOAA Cooperative Institutes, and academic institutions. Both Programs coordinate sponsored projects with major national and international scientific bodies including the World Climate Research Programme (WCRP), the International and U.S. Climate Variability and Predictability (CLIVAR/US CLIVAR) Program, and the U.S. Global Change Research Program (USGCRP).

Focus for FY22 - Short description

OAR/CPO/CVP - NWS/OSTI/Modeling Division - Joint Competition to Advance Process Understanding and Representation of Precipitation in Models

In FY22, CVP and OSTI are interested in understanding, diagnosing and modeling of key processes for improving the simulation of subseasonal to seasonal (S2S) precipitation in weather and climate models. This timescale bridges the weather and climate continuum and is an expanding area of research interests in support of NOAA extended-range to seasonal operational forecast systems. Additionally, improving key processes associated with precipitation can provide benefits for information on timescales of weather through climate change.

> **Focus Area A** - Identifying and understanding key processes that influence model biases and systematic errors in the simulation of precipitation at the subseasonal to seasonal (S2S) timescale (CVP Program)
>
> **Focus Area B** - Research to advance NOAA's Unified Forecast System (UFS) prototype operational system for subseasonal to seasonal (S2S) prediction (NWS/OSTI)

[Note, there are additional coordinated solicitations through the Weather Program Office (WPO) under the Subseasonal to Seasonal (S2S) and Climate Test Bed (CTB) Programs. Please see their Program's Information Sheets in near future for details.]

Funding for FY22

Focus Area A: It is anticipated that there will be $1,500,000 available in FY22 for CVP to fund new awards. It is anticipated that most awards will be at a funding level between $200,000 and $300,000 per year for 3 years, depending on the availability of funding. Funding of 5 to 7 projects is anticipated.

Focus Area B: It is anticipated that there will be $1,000,000 available in FY22 for NWS/OSTI/Modeling Division to fund new awards. It is anticipated that most awards will be at a funding level between $100,000 and $250,000 per year for 2 or 3 years, depending on the availability of funding. Funding of 4 to 6 projects is anticipated.

Focus Area A and B are unique areas of interest for this joint-competition. Applicants should specify which Focus Area that their application addresses. Please do not use a single proposal to apply to both areas. If funding is available, funding from CVP and/or OSTI may be considered for the funding of either applications within Focus Area A or B. Projects will start in FY22 or FY23, depending on the needs of the project and the availability of funding.

Competition Information - Detailed Description

The Climate Variability and Predictability (CVP) Program supports research that enhances our process-level understanding of the climate system through observation, modeling, analysis, and field studies. This vital knowledge is needed to improve climate models and predictions so that scientists and society can better anticipate the impacts of future climate variability and change. The Office of Science and Technology Integration (OSTI) Modeling Division is responsible for supporting a variety of NWS modeling and research initiatives to improve weather forecasts. This is accomplished by funding research projects to accelerate and advance the development of new models, and foster collaboration among NOAA research scientists, federal labs, operational forecasters and the academic community. Examples of programs managed by this division include efforts to advance research to improve and extend precipitation forecast skill; and implement a fully-coupled numerical weather prediction system for both medium-range weather and subseasonal-to-seasonal prediction. To achieve the missions, the CPO/CVP Program and NWS/OSTI/Modeling Division support research and research to operation (R2O) transition carried out at NOAA and other federal laboratories, NOAA Cooperative Institutes, and academic institutions. Both Programs coordinate sponsored projects with major national and international scientific bodies including the World Climate Research Programme (WCRP), the International and U.S. Climate Variability and Predictability (CLIVAR/US CLIVAR) Program, and the U.S. Global Change Research Program (USGCRP).

During the past two years, NOAA has developed the *Precipitation Prediction Grand Challenge (PPGC) Strategic Plan* to help further align NOAA's research efforts on improving precipitation skill. The goal of the initiative is to "provide more accurate, reliable, and timely precipitation forecasts across timescales from weather to subseasonal to seasonal (S2S) to seasonal-to-decadal (S2D) through the development and application of a fully coupled Earth system prediction model." An important aspect of that effort is to gain a better understanding of ocean and atmospheric processes through data analysis, and global or regional modeling experiments, which target key model deficiencies that limit precipitation prediction skill.

In November of 2020, NOAA and DOE jointly held a workshop (NOAA-DOE Precipitation Processes and Predictability Workshop) that identified that to accelerate progress in addressing precipitation biases and improving precipitation simulations and predictions across a broader set of phenomena and timescales, it is important to know practicable predictability limits and opportunities therein. Many model biases are due to inadequate representations of key physical processes (such as convection, aerosol-cloud interactions, coupling of atmosphere-, ocean-, sea ice- and land- boundary layer) in models. These biases and errors involve complex interactions, and feedbacks that deserves systematic examination.

In FY22, CVP and OSTI are interested in understanding, diagnosing and modeling of key processes for improving the simulation of subseasonal to seasonal (S2S) precipitation in weather and climate models. This timescale bridges the weather and climate continuum and is an expanding area of research interests in support of NOAA extended-range to seasonal operational forecast systems. Additionally, improving key processes associated with

precipitation can provide benefits for information on timescales of weather through climate change.

For both focus areas, it is expected that there will be a joint PI meeting, held annually and virtually (not in-person), for funded projects to exchange knowledge about common biases and underlying causes, present recent progress/results, and interact with each other on common topics.

Focus Area A - Identifying and understanding key processes that influence model biases and systematic errors in the simulation of precipitation at the subseasonal to seasonal (S2S) timescale (CVP Program)

Current modeling systems have yet to realize the full extent of predictability limits due to biases and systematic errors[1,2]. As referenced in the *PPGC Strategic Plan*, "the Precipitation Prediction Grand Challenge Working Group documented many of the major systematic errors/model limitations that are believed to limit predictive skill for precipitation across timescales. These errors are understood to be cumulative, so that forecast skill on longer timescales is negatively impacted by errors on shorter timescales." A partial list of those systematic errors/model limitations of interest are:

- Timing, magnitude and location of the diurnal cycle of precipitation
- Predicted precipitation amount
- Incorrect subseasonal and intraseasonal tropical variability, such as Madden-Julian Oscillation (MJO)
- Incorrect spatial distribution of S2S precipitation variability
- Incorrect subseasonal to seasonal sea surface temperature forecasts
- Double ITCZ [intertropical convergence zone]
- El Niño Southern Oscillation (ENSO) false alarms
- Incorrect Quasi-Biennial Oscillation (QBO)
- Incorrect seasonal-to-decadal variability

The CVP Program is interested in a process-based approach to identifying and understanding key processes that influence biases and systematic errors in the simulation of precipitation at the S2S timescales through data analysis, and global or regional modeling experiments. This includes examining how these processes impact/cause model biases and how model biases can be reduced by different approaches. Experimental approaches include but are not limited to: studies of increased model resolution in a coupled model framework, using observations to improve physical parameterizations of unresolved processes, and/or developing new knowledge or theories about processes and multiscale process interactions.

[1] NOAA-DOE Precipitation Processes and Predictability Workshop Report. Published June 2021.
[2] National Academies of Sciences, Engineering, and Medicine. 2016. Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts. Washington, DC: The National Academies Press. https://doi.org/10.17226/21873.

Priority interest areas from the CVP Program are ocean-atmosphere interactions in the air-sea "transition zone"[1] (the upper ocean, air-sea interface, and atmospheric marine boundary layer); the coastal "transition zone" (coastal land and ocean, and the atmospheric boundary layer above land and ocean); and physical processes of clouds (including aerosol-cloud interactions) and boundary layers. Target regions that are known to host sources of precipitation predictability[1] are the Atlantic, tropical Pacific, and the Indo-Pacific Maritime Continent and its surrounding seas and will be given priority.

Projects that are most appropriate for the Focus Area A generally fall in or near the "basic research" or "applied research" levels of technical maturity, i.e., Readiness Levels (RLs) of 1 or 2 RL during the duration of the project. (see details on the NAO 216-105B Policy on Research and Development Transitions https://www.noaa.gov/organization/administration/nao-216-105b-policy-on-research-and-development-transitions)

Collaborations and partnerships with NOAA laboratories, cooperative institutes, and centers are encouraged but not required. Additionally, the use of NOAA models is encouraged but not required. If appropriate, use of observations from recent NOAA-funded field campaigns and modeling projects is encouraged, such as Eastern Pacific Investigation of Climate (EPIC), Pan American Climate Studies (PACS), VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS), Dynamics of the Madden-Julian Oscillation (DYNAMO), Years of Maritime Continent (YMC), Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ), Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign/ Elucidating the Role of Clouds-Circulation Coupling in Climate (ATOMIC/EUREC^{4}A), and/or North American Multi-Model Ensemble (NMME).

Focus Area B: Research to advance NOAA's Unified Forecast System (UFS) prototype operational system for subseasonal to seasonal (S2S) prediction (NWS/OSTI).

Required by the Weather Research and Forecasting Innovation Act of 2017 (section 201), the NWS will establish a new seasonal forecast program to enhance sub-seasonal (two weeks to three months) to seasonal (three months to two years) temperature and precipitation forecasts. The Seasonal Forecast System (SFS v1) will be based on the Unified Forecast System (UFS), which provides a framework to engage the extensive research community and creates an environment for NOAA to more efficiently and effectively translate research advances into operational outcomes (see details at https://ufscommunity.org).

The SFS v1 will be developed by extending key features of NOAA's medium-range global forecast model (GFS) and the sub-seasonal global ensemble forecast system (GEFS) that is currently being developed by NOAA's Unified Forecast System Research to Operations Project (UFS-R2O). The SFS v1 is targeted to replace the current operational Climate Forecast System (CFSv2) in FY25-FY26. The UFS is configured to be a six-way coupled Earth prediction system, including atmosphere, ocean, land, sea-ice, waves and atmospheric composition. A sequence of coupled model prototypes

for GFS v7 and GEFS v13 have been developed and the model output is made available on Amazon Web Services (AWS). The prototype model code, referred to as "ufs-weather-model", is continuously updated on Github, and a public release of the prototype model is planned in summer 2022.

The SFS v1 will require improvement in model components, particularly in land, sea ice and atmospheric physics, as well as representation of component-to-component interactions that are critical for representing the mean climate as well as low frequency variability. Testing of simulation of climate modes associated with North Atlantic Oscillation (NAO), MJO, ENSO, QBO, large-scale weather regimes, teleconnection and stratosphere-troposphere coupling and other key modes of variability is needed.

The NWS/OSTI is interested in a process-based approach[3] to identify key processes in the SFS prototype that influence biases and systematic errors in the simulation of precipitation at the S2S timescales through data analysis, and global or regional modeling experiments. For data analysis, researchers should establish a close collaboration with the UFS R2O team (UFS R2O Project Leads: ufs-r2o-leads@noaa.gov; UFS R2O Project Engineers: ufs-r2o-engineers@noaa.gov; website: https://vlab.noaa.gov/web/ufs-r2o/home), and use various diagnostics and validation tools[3] to assess the strength and weakness of the coupled model prototypes and provide feedback to the model development team. For modeling experiments, researchers should use the prototype model code, "ufs-weather-model" on Github, so that testing and evaluation results would be closely related to the development of SFS v1.

Since precipitation is influenced by both local processes (e.g. land-air interactions, aerosol-cloud interactions) and remote processes (e.g. tropical diabatic heating and stratosphere-troposphere interactions),ata analysis should apply process-oriented metrics and metrics aligned with improved operational outcomes to measure the fidelity of the model in representing those key processes and identifying underlying causes of model biases. Modeling experiments should aim to reduce model biases in representing those key processes and improve the simulation of climate modes. Experimental approaches could include but are not limited to: studies of impacts of new and advanced physical parameterization schemes in or introduced in the Common Community Physics Package (CCPP), influences of model configurations in horizontal and vertical resolution, benefits of representing processes with artificial intelligence (AI)/machine learning (ML) tools, impacts of updated model components (e.g. land, sea ice, atmospheric composition), and statistical postprocessing (traditional or AI/ML). Note that the latter postprocessing can be used both to improve final products, and to identify systematic model errors to be considered for incremental model improvement

[3] For example, the enhanced Model Evaluation Tools (METplus), a community-based verification infrastructure for the UFS (https://dtcenter.org/community-code/metplus), or the Model Diagnostics Task Force (MDTF)-Diagnostics package, which is a portable framework for running process-oriented diagnostics (PODs) on weather and climate model data (https://www.gfdl.noaa.gov/mdtf-diagnostics/).

Projects that are most appropriate for the Focus Area B generally fall in or near the "demonstration" level of technical maturity, i.e., Readiness Levels (RLs) of 5 through 8 RL (see details on the NAO 216-105B Policy on Research and Development Transitions website:https://www.noaa.gov/organization/administration/nao-216-105b-policy-on-research-and-development-transitions) during the duration of the project. Projects selected for funding from this announcement should be ready or nearly ready to test and demonstrate their new capabilities in analysis and modeling that would contribute to progression and maturity of SFS v1.

Eligible applicants are U.S. institutions of higher education; U.S.-based commercial organizations; state, local and Indian tribal governments in the U.S.; other U.S. nonprofit organizations and federally funded educational institutions such as the Naval Postgraduate School.

Focus Area B will be awarded as a Cooperative Agreement as NOAA will be substantially involved in the implementation of the project.

For Focus Area B, federal employees are not eligible to be Lead-PIs, except as noted for Naval Postgraduate School. However, federal employees could be co-PI, co-I, and/or collaborators. To ensure successful research to operation transition, Lead-PIs can budget up to, but not more than 20%, of the proposed budget in support for NOAA laboratory or NCEP modeling center collaborators. For a collaboration that includes funding for federal institutions, the amount to be awarded through Grants Online would only be the portion for the non-government recipient and the maximum project cost is $250,000, which is a combined project cost for all PIs, co-Is, co-PIs, and/or collaborator costs, regardless of their federal or non-federal status.A letter of support acknowledging participation in the proposed project by federal employees or federal contractors must be included within the application.

Due to NOAA's shortage of high performance computing and storage for research, investigators are strongly encouraged to seek computing resources, including cloud computing resources, from other sources and should be aware that NOAA resources will most likely not be available for their project. The project description should clearly state whether the project intends to leverage computing resources from NOAA.

For review purposes of Focus Area B, the following questions will be considered when evaluating the selection criteria that are defined in the FY22 CPO NOFO.

1. Importance/Relevance and Applicability of Application to the Program Goals (Final Weight=25%): This criterion ascertains whether there is intrinsic value in the proposed work and/or relevance to NOAA, federal, regional, state or local activities. This includes the following questions:
    a. What is the likelihood of the proposed science activities to improve operational environmental analyses and/or forecasts?

b. Are proposed research activities easily transitioned to development of UFS and a coupled system?

c. Is there sufficient collaboration with NCEP modeling centers, NOAA research labs, and other NOAA personnel throughout the project to ensure the likely transition of proposed research into operations?

d. What is the level of planning by researchers to test and evaluate proposed modeling advancements to meet operational model skill standards for potential transition into operations successfully and efficiently?

e. Is the proposed work responsive to the topics identified in the funding opportunity?

2. Technical/Scientific Merit (Final Weight=52.5%): This criterion assesses whether the approach is technically sound and/or innovative, if the methods are appropriate, and whether the goals of the Competition will be realized through clear project goals and objectives. This includes:

a. What is the intrinsic scientific or technical value and maturity of the subject and the study proposed as they relate to the specific science priorities?

b. Does the proposal demonstrate adequacy of the metrics proposed for testing and evaluation, and quantify the potential impact of the project on NCEP's operations?

c. Are focused scientific objectives and strategies, including data management considerations and project milestones used?

3. Overall Qualification of Applicants (Final Weight=15%): This criterion ascertains whether the applicant team possesses the necessary education, experience, training, facilities and administrative resources to accomplish the project. This includes:

a. Do PIs have the necessary education, experience, training, facilities, and administrative resources to accomplish the project?

b. Do PIs clearly document past scientific collaborations with operational modeling scientists or operational weather forecasters that contained potential to improve operational forecasts?

c. Have past interactions with NOAA been successful?

d. Are researchers likely to maintain effective and consistent interactions with NCEP and other NOAA modeling scientists or operational weather forecasters throughout the course of the proposed research program?

4. Project Costs (Final Weight=7.5%): This criterion evaluates the budget to determine if it is realistic and commensurate with the project needs and time-frame. This includes:

a. Are the requested costs realistic, reasonable, allowable, allocable, necessary and commensurate with the project benefits, deliverables, and time period?

b. Is there a high ratio of operationally useful results versus proposed costs?

Note: Focus Area A and B are unique areas of interest for this joint-competition. Applicants should specify which Focus Area that their application addresses. Please do not use a single proposal to apply to both areas. If funding is available, funding from CVP and/or OSTI may be considered for the funding of either applications within Focus Area A or B. Projects will start in FY22 or FY23, depending on the needs of the project and the availability of funding.

Data Archiving and Computational Resources

Data Management Guidance: The Responsible NOAA Official for questions regarding this guidance and for verifying accessibility of data produced by funding recipients: Sandy Lucas, sandy.lucas@noaa.gov and Yan Xue, yan.xue@noaa.gov

Data Accessibility: The Programs require that public access to grant/contract-produced data be enabled in one of the following ways (select one):

- ❏ Funding recipients are planning to submit data to NOAA National Centers for Environmental Information (NCEI), which will provide public access and permanent archiving[4]. Point of Contact for NCEI is Nancy Ritchey (Nancy.Ritchey@noaa.gov)
- ❏ Data are to be submitted to an International Council for Science (ICSU) World Data System facility: https://www.icsu-wds.org/community/membership/regular-members)
- ❏ An existing publicly accessible online data server at the funded institution is to be used to host this data (described in proposal).
- ❏ Data are to be submitted to a public data repository appropriate to this scientific domain (describe in the proposal).
- ❏ Proposal may request permission not to make data publicly accessible (proposal to explain rationale for lack of public access, and if funded approval to be obtained from Responsible NOAA Official listed above).
- ❏ Archival of data at an established Cloud Computing facility, if cost effective and reliable

Technical recommendations:
The Programs requires the following data format(s), data access method(s), or other technical guidance:

- ❏ Data must be made available in a common machine-readable non-proprietary format with appropriate metadata and clear labels and descriptors. Use of netCDF is encouraged.
- ❏ Data should be available via public and discoverable data portals, as described above.

[4] NCEI supports the creation of adequate metadata and data ingest into long term repository holdings using tools such as Send2NCEI (www.nodc.noaa.gov/s2n, for small volume, one-time only data collections) and Advanced Tracking and Resource tool for Archive Collections or ATRAC (www.ncdc.noaa.gov/atrac, for recurring and/or large volume data collections).

- ❏ At a minimum, investigators should plan to archive and make available modeling data used in producing any figures in publications from research supported by their grants, as well as data that support conclusions reached in papers or stated publicly. Only those data which are necessary for demonstrating reproducibility of published results need be archived and made public unless otherwise required as part of the solicitation.
- ❏ In situ observational data collected during the field campaign should be made freely available to the public either 2 years after collection and validation or at the time of publication, whichever is sooner.
- ❏ Model data should be made available for at least 3 years after it is initially published or made otherwise publicly available.

Resources:
Proposals are permitted to include the costs of data sharing and/or archiving in their budgets within solicitation specified proposal cost limit. Proposed methods and approaches should use reasonable means to minimize data management costs.

Program Contact information:
For additional program announcement information, investigators should contact the following

CVP Program Manager: Sandy Lucas (Sandy.Lucas@noaa.gov, 301-734-1253)
NWS/OSTI Program Manager: Yan Xue (Yan.Xue@noaa.gov)

Letters of Intent should be submitted directly to both the CVP Program Manager and the NWS/OSTI Program Manager with an indication of the Focus Area you are addressing in your Letter of Intent.