

PSD-1: PSD should ensure that sufficient project review processes exist so that research activities are properly poised to advance the science and are well supported within the science.

PSD has implemented a review process that assesses how research activities align relative to the PSD Strategic Plan (2016-2020) and directly supports advancement of the funded subset of the dozen PSD integrating research activities. In addition to the peer and panel review process in the proposal submission process, specific questions being asked to ensure that research activities are well posed and relevant include:

- Explanation of how the proposed research will contribute directly to one or more of the PSD Strategic Plan research priority goal objectives.
- Description of how the proposed research will advance the mission of your PSD research team as articulated on the individual research team webpage.
- Description of how the proposed research will advance, support or contribute to one or more of the PSD research council developed integrating research activity proposals.
- Description of how the resulting scientific findings will be transformed into actionable science in support of the NOAA R2X goal of transitioning research into applications, operations and services.

PSD-2: PSD should provide greater emphasis on coupling between the atmosphere and other components of the climate system; this is evident in hydrology, Arctic, and tropical variability activities. This could be accomplished through selective hires or strategic partnerships with external organizations.

PSD envisions building upon our expertise in observation-based process understanding of the coupling between and among of key components of the climate system (atmosphere, ocean, sea ice, land surface) through an extensive forecast system modeling effort. Model experiments using the NOAA operational Climate Forecasting System (CFS) will provide a capability to diagnose, understand, and assess the realism of couple processes with observation and process understanding serving as the basis to evaluate and validate model results. The use of a coupled model framework is intended to provide an improved scientific understanding of the changing climate system and its impacts and a capability to assess current and future states of the climate system that identify potential impacts and inform science, service, and stewardship decisions. In addition, PSD has develop an internal list of targeted hiring priorities that focus on building a critical mass of research expertise in the coupling of Earth System components between and among the atmosphere and ocean, sea ice, land surface hydrology. In the last year PSD has actively recruited graduate students, post-docs and other early career scientist with expertise and interesting the coupling of atmosphere with other components of the Earth system.

PSD-3: PSD should look for and engage with high-impact opportunities to bring together regional efforts to focus on key problems (e.g., water scarcity in the west), develop comprehensive, shared visions for how to surmount them, and build effective partnerships for sustained progress in the requisite science and R2X.

PSD receives base and pass-through funding to invest in research to advance mechanistic understanding the dynamics and prediction of regional drought/water scarcity and other key problems involving regional weather and climate extremes. In addition, of the dozen PSD integrating research activities developed by the PSD Research Council, six of the activities have

a regional focus on key problems (too much and too little water in California, hydrologic forecast improvement project building on WFIP-2 in the Columbia River Basin, Arctic Clouds, Arctic Transports, Arctic Turbulent Flux Parameterizations, Arctic Sea Ice Forecasting, initial response of the equatorial central Pacific atmosphere to El Niño SSTs). A high priority for PSD leadership will be to find additional funding to support high-impact opportunities that brings expertise together across the division to focus on currently unfunded key regional research challenges.

PSD-4: PSD should formalize succession planning of lab and scientific leadership positions. Succession planning is a serious issue with 23 of 42 PSD NOAA federal employee eligible for retirement in 2016, and 33 of 42 PSD NOAA federal employees eligible by 2020. PSD is providing training and mentoring to mid-career scientists a part of a strategy to groom these junior staff for future laboratory leadership positions. Formation of the PSD Research Council and the PSD Science Board has created two independent forums for a much wider range of division staff to actively participate in, and gain leadership experience as they provide input into the near-term implementation and long-term strategic planning of PSD science goals and objectives. The NOAA implementation of the DOC Phased Retirement Policy will provide PSD with a new tool to address and facilitate succession planning. Phased retirement will allow certain retirement-eligible, full-time employees to work a part-time schedule while also beginning to draw about half of their retirement benefits. Participants in the phased retirement program will be required to devote 20 percent of their time to mentoring and transferring of knowledge and skills to one or more fellow employees /or learning activities providing training, documenting institutional knowledge as well as sharing strategies and processes that supports the development succession capabilities for lab and scientific leadership responsibilities.

PSD-5: Once observing priorities are set, PSD needs to develop a strategy for sustaining and enhancing the chosen priorities and leveraging observing capabilities from other ESRL Divisions, other NOAA laboratories, and other non-NOAA laboratories and institutes nationwide and worldwide.

In response to initial feedback during the review, PSD has produced a draft report titled “The role of observations in PSD”. The draft report examines the role of observations in PSD in terms of current capabilities and future trends. A near-term recommendation for restructuring the current PSD observational enterprise to address identified structural deficits is offered, along with a long-term look into the possible evolution of PSD’s observational capability. Key findings coming out of the report are:

PSD’s observational capability is supported by a suite of instruments, and a talented technical staff made up of engineers, computer scientists, technicians, deployment personnel, and data management specialists. It has historically been managed through its research branches and teams, which has the advantage of keeping observational resources closely coupled with the sciences they support, but suffers from a lack of oversight, coordination and cross-fertilization across the full PSD observational enterprise. In addition, almost all of PSD’s observational activities are supported by external funds, which leads to an unstable funding base. These two structural deficits can be addressed by:

- Identifying a lead(s) for PSD's observational enterprise who would maintain oversight for and coordinate PSD-wide observational activities, and
- Devoting some level of overhead and base funds to lend stability and continuity to a long-term core observational capability.

PSD-6: PSD should maintain a strong engineering team to support the scientific work at the lab, possibly through sharing expertise with other ESRL divisions.

PSD has a long tradition of world-class engineering in support of NOAA research. Steps to maintain this strong tradition include better coordination and sharing of engineering expertise internally within PSD. The draft report (described in the response to recommendation PSD-5) and titled "The role of observations in PSD" identified two following near-term recommendations for restructuring the current PSD observational enterprise to address structural issues:

- *Create an Environmental Technology Group (ETG) within the Director's Office to include a subset of the current technical staff and instrument inventory that has the broadest PSD-wide applicability. ETG would be supported by some level overhead funds in a manner similar to the current Information Technology Group. ETG staff would be listed under the Director's Office, and also within their research teams. They would remain colocated with these teams.*
- *Assign as a collateral duty one federal and one CIRES scientist or engineer from current PSD staff to lead this group. Possible candidates include the leads of the Hydrometeorology Observation and Processes (HOP), Boundary Layer Observations and Processes (BLO), and Polar Observations and Processes (POP) research teams.*

PSD is also exploring opportunities to recruit and nurture early-career engineering staff through the Pathways Program that provides federal internships for students and to careers for recent graduates that include meaningful training and career development opportunities for individuals who are at the beginning of their Federal service. In addition to continued roles for federal staff, PSD will continue to utilize Cooperative Institute staff (CIRES and CIRA) and contractors to provide expertise to support technology advancement and engineering support.

PSD-7: Coordination with other ESRL divisions on instruments should be strengthened.

Coordination with other ESRL division on instruments will continue to be strengthened. PSD closely partners with the Global Monitoring Division in the shared interest to develop and manage the integrated Arctic network of long term observatories to provide long-term, continuous, high- quality observations of key aspects of the atmosphere across the Arctic. PSD has partnered with GMD and CSD by providing research-quality measurement of physical characteristics of boundary layer and lower troposphere needed to understand the complex air flow in targeted field campaigns to evaluate satellite estimate of anomalous methane concentrations in the San Juan Basin, New Mexico, and oil- and natural gas-production wintertime ozone pollution events. PSD anticipates a continued complementary relationship with other ESRL divisions that draws on PSD's strengths in the measurements of physical aspects of the boundary layer and lower troposphere

PSD-8: PSD should continue the role of serving NOAA and the entire research community as a provider of raw and processed data collected by PSD and by the research

community-at-large.

PSD's observational capability is supported by a suite of instruments, and a talented technical staff made up of engineers, computer scientists, technicians, deployment personnel, and data management specialists. Observations are a foundation of PSD's physical science research. Scientists in PSD, in NOAA and in the external research community use the observational data collected by PSD scientists and by the deployment of PSD instruments in the synoptic analysis of regional weather and climate phenomena, process understanding studies, in the evaluation and validation of weather and climate forecast systems, and as initial conditions assimilated in local, regional and global forecast systems. As noted in earlier responses, PSD has produced a draft report titled "The role of observations in PSD" that contains both near-term and long-term recommendations for ensuring the continued resilience and sustainability of the PSD world-class observational enterprise.

PSD-9: PSD should enhance its participation in national and international multi-institutional, and/or multi-national field campaigns and seek opportunities to play more leadership roles in such large-scale field projects.

PSD has embraced the suggested leadership role in large-scale field projects and is actively investing resources for the planning and execution of large-scale national and international multi-institutional, field campaigns to observe and understand the coupled behavior of the atmosphere over land, oceans, ice, and snow. In the winter of 2016 PSD led the NOAA El Niño Rapid Response Field Campaign unprecedented scientific opportunity to accelerate advances in understanding and predictions of an extreme climate event and its impacts. This field campaign examines the response of the atmosphere to the warm ocean water at the heart of this very strong El Niño. The observations being collected help scientists better understand the chain of events that produces, among many other weather impacts, extreme precipitation on the West Coast. PSD looks forward to a similar level of participation in the Year of Polar Prediction (YOPP) 2017-2019 and the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAIC) 2019-2020 field campaigns

PSD-10: Update the instrument website.

The PSD instrument website

[<http://www.esrl.noaa.gov/psd/data/obs/instruments/SurfaceMetDescription.html>] will be continue to be updated as part of the ongoing changes to address and strengthen observing capabilities in the division. The draft report (described in the response to recommendation PSD-5) and titled "The role of observations in PSD" contains a wealth of information that will be drawn upon in the updating process.

PSD-11: PSD should develop a plan to make its research-based observational data more real time access (e.g., NSF-funded projects).

The PSD data access plan adheres to higher level guidance from OSTP and NOAA.

The White House Office of Science and Technology Policy (OSTP) issued a Memorandum on Feb. 22, 2013 entitled Increasing Access to the Results of Federally Funded Research directing each Federal agency that conducts over \$100 million annually in research and development expenditures to develop a plan to support increased public access to the results of that research. In response to the OSTP Memorandum, the NOAA Research Council issued the NOAA Plan for Increasing Public Access

to Research Results (PARR) in February 2015. Among other requirements, the NOAA PARR Plan instructs the NOAA Environmental Data Management Committee (EDMC) to revise its existing NOAA Data Sharing Policy for Grants and Cooperative Agreements; this document (version 3.0) is the revised directive and supersedes the previous version (2.0). "Data sharing" means making data publicly visible and accessible in a timely manner at no cost (or no more than the cost of reproduction), in a format which is machine-readable and based on open standards, along with metadata, necessary to find and properly use the data.

The Data and Publication Sharing Directive for NOAA Grants, Cooperative Agreements, and Contracts specifies requirements for NOAA Programs that issue grants, cooperative agreements, or contracts. In particular, NOAA Programs are required to consider, in advance, how to ensure public accessibility and long-term preservation of externally-funded data, to provide guidance for proposers to use in developing a plan for data access, and to track and enforce conditions imposed on awardees. Appendix B of this Directive provides text to be included in Federal Funding Opportunity (FFO) Announcements and Contract Solicitations, and in Notices of Award and Contracts.

PSD has not had explicit jurisdiction over the data access of projects that are funded independently of NOAA grants, cooperative agreements or contracts such as proposals funded by NSF and other agencies directly to the University of Colorado or Colorado State University. Recognizing this issue, PSD is taking steps to reduce its exposure to this past jurisdiction problem by limiting the number of grant proposals. In the limited number of cases when a university-based proposal is submitted, a letter to the university specifying PSD support for the research project in the form of the general office space, administrative support and technical support will include the following language: *"In addition, because NOAA/ESRL/PSD is in part supporting this research, not only must NOAA policies on access to research results and data be followed,....."*

PSD-12: PSD should be more systematic in how it sets priorities and evaluates how well these priorities are met.

Full implementation of the PSD Research Council and Science Board is intended to provide a rigorous framework to for the systematic setting of priorities and the evaluation of how well priorities are met.

The PSD Research Council has been charged to energize collaboration across PSD and thus to optimize the investment of PSD's science and technology resources and to better utilize PSD research science expertise. The PSD Research Council works to foster the integration of research across the division through enhanced communication and improved understanding of the full spectrum of research in PSD. The PSD Research Council recommends near term priorities for a coordinated research approach in the scientific progress needed to meet PSD's annual research goals, to identify new opportunities for integrative research spanning PSD, and to promote collaboration among the research teams to advance science in support of NOAA mission responsibilities.

PSD Science Board has been charged to take a step back and provides an ongoing long view on overarching and long-term weather and climate science horizons (3 to 5 years and beyond)

in the division. Made up of senior scientists PSD Science Board serves in an advisory capacity to the PSD Director on long-term strategic directions and challenges through activities such as providing guidance on the direction of PSD research goals and objectives relative to NOAA, OAR and ESRL priorities, assessing progress in fostering collaboration and integration of research across PSD, providing oversight of PSD's overall science progress in advancing a coherent research agenda, and periodically evaluating the PSD research strategic plan.

PSD-13: PSD should maintain a core capability in understanding the physical system to support its efforts in climate trend and extreme event assessment and attribution. PSD should be more of a leader or partner in creating an activity in this area that strives for rapid consensus and clear communication of scientific uncertainty.

PSD strives to maintain a scientific core capability in understanding the physical system to support analysis of climate trend and extreme event predictability and attribution assessments. Core to this capability is the Facility for Climate Assessments (FACTS) that provides multi-model, multi-forcing climate experiments that can be used by PSD scientists, PSD partners and the climate science community to understand and predict changes in climate and weather. The FACTS climate model experiments are designed to study the effects of realtime evolving modes of ocean variability (e.g. ENSO, PDO, AMO) on observed weather/climate extremes. This open access core capability is essential for the PSD, its research partners, and the climate science community to develop robust interpretations and consensus understanding of not only the underlying climate dynamics resulting in observed variations, trends and extremes but also the foundational information that is needed to be able to clearly communicate what is known along with numerical estimates of how well it is known.

PSD-14: PSD should continue to maintain a core underpinning science capability in understanding the physical system that can provide the underpinning science clearly needed for a range of applications.

PSD observation-based research provides the core capability required to identify and quantify the roles of various physical processes in the Earth System. PSD expertise in physical processes research extends from global-to-local scales, from the tropics to the poles, and from the ocean to the stratosphere. PSD predictions research creates, develops, and tests methods for improving the skill of models and forecasts. PSD innovative partnerships support a broad range of scientific and practical applications and inspire new directions for our physical sciences research. While dealing with a relatively flat budget and managing increasing costs through the attrition of staff, PSD strives to maintain a scientific core capability to understand the weather-climate connection and advance the prediction of weather and climate extremes, too little and too much water, and the Arctic system coupling. Future cross-NOAA efforts to increase investments in Arctic research are anticipated to provide PSD with the resources to grow its support of the core underpinning science necessary to advance the understanding and the prediction of the Arctic system coupling.

PSD will continue to invest in foundational science that supports the two Overarching Science Goals identified in the PSD 2016-2020 Strategic Plan

- 1. Develop new knowledge and capabilities to explain observed weather and climate extremes, variations, trends, and their impacts to inform risk management and*

adaptation decisions.

2. *Identify new sources of predictive skill and improve predictions of weather, water, and climate through observations, understanding and modeling of physical processes and phenomena of the coupled Earth system,*

and support the three Priority Research Goals identified in the PSD 2016-2020 Strategic Plan

1. *Rigorously characterize and predict weather, water, and climate extremes and their uncertainties to inform decision-making.*
2. *Develop new process understanding, observing, and modeling capabilities to predict conditions associated with too much or too little water for early warning, preparedness, resource management, and adaptation.*
3. *Increase process understanding of the coupled Arctic system and Arctic-lower latitude interactions to improve NOAA weather, climate, and sea ice forecasts.]*

PSD-15: PSD should seek to ensure the core funded staff is maintained and enhanced where possible particularly on the key strategic areas of strength.

This issue is the highest priority for PSD leadership. PSD is working with OAR HQ to increase base funding to ensure there are resources to core fund the critical mass of researchers and supplement resources to enhance the number of staff in the key strategic areas identified in the PSD Strategic Plan (2016-2020): Weather and Climate Extremes, Too little and too much water and the coupled Arctic system.

PSD-16: PSD should ensure that there is a clear appreciation by all Division scientists of the potential benefits of their work.

PSD values the scientists and the potential benefits of the world-class research being done that promotes the division's unique identity and advance scientific capabilities in support of NOAA mission responsibilities. Working with the CIRES and NOAA leads of each of the eight PSD Research Team and through participation on focused tiger teams opened to all interested scientists to define the integrating research activities and develop the workplans, allows all division scientists opportunities to insert a collaborative role for their scientific expertise and research interests into PSD high priority integrating research activities.

PSD-17: PSD should use more effort to move the results of their research into model improvements.

PSD research provides a physical basis for understanding and predicting extremes and other weather and climate phenomena to advance NOAA's mission responsibilities to provide early warning and inform preparedness. The PSD leadership is fully committed to a continuum of research activities that advances NOAA mission responsibilities to provide early warning and inform preparedness by accelerating advances in the observation-based understanding of high-impact weather and climate needed to guide model development advances and enhance forecasting capabilities. PSD recently invested in an integrating research activity is focused on improving forecast model capability through the development of stochastic parameterizations informed by observations . This is an example of the unique end-to-end spectrum of research that PSD leadership is committed to:

1. *Deployment of existing observing technologies, and development of new technologies, to advance observation-based process understanding.*
2. *Analysis of data and information to provide diagnostic explanations and to advance predictive understanding.*
3. *Development and application of models to transform predictive understanding into predictive capabilities to forecast and predict past and future conditions.*
4. *Transformation of PSD science-based knowledge into actionable science that is readily available to support operations, applications and decision making.*

PSD-18: Improve the clarity of public communication of the results of their climate assessments and attribution.

PSD produces weather and climate attribution and predictability assessments that are a scientific process for identifying the major causes of observed climate and weather patterns. This research includes explaining extreme events for which great public interest exists because they produce profound societal impacts, and trends of decade-to-century duration. Key research questions are: What are the causes of extreme events? Is there a change in frequency? To what extent are human influences or natural processes at play? Are these events predictable?

Policy-makers, decision-makers, and the public are increasingly interested in explanations of current climate conditions and how they compare with the past. They also want to know why climate is evolving as observed; that is, to provide attribution of the causes for observed climate variations and change. Of equal importance is ensuring that natural variability, when occurring, is not misunderstood to indicate that climate change is either not happening or that it is happening more intensely than the true human influence. For example, learning whether recent drought in the western U.S. is due mainly to natural variability and a return toward previous conditions might be anticipated, or instead there is a longer-term trend toward increasing dryness in the region due to human-caused climate change. Armed with this information, preparations can be made to respond to and minimize the impacts of similar events in the future.

PSD-19: PSD should sustain high priority activities unique to NOAA mission needs and PSD core capabilities through core support.

PSD has developed criteria to ensure that activities unique to the NOAA mission needs and PSD expertise and core capabilities are high priorities to be sustained through core laboratory support. Within PSD core support is a priority for research 1) that will contribute directly to one or more of the PSD Strategic Plan research priority goal objectives in support of NOAA mission agency responsibilities to provide early warning and inform preparedness, and 2) that a pathway can be articulated describing how the resulting scientific findings will be transformed into actionable science in support of the NOAA R2X goal of transitioning research into applications, operations and services.

PSD-20: PSD should validate dynamical downscaling work through observations.

The evaluation and validation of dynamical downscaling work through observations is critical to

ensure the research community is not simply providing information and empowers the policy and decision-making community to do the wrong thing more precisely. PSD has a long tradition use the observational data in the synoptic analysis of regional weather and climate phenomena, process understanding studies, in the evaluation and validation of weather and climate forecast systems, and as initial conditions assimilated in local, regional and global forecast systems. Recently PSD agreed to partner with NCAR and GFDL in a DOD funded project to evaluate and validate dynamical downscaling provided by NA-CORDEX Simulations. Research will include assessing the degree to which these higher resolution runs add value, and examining the ability of regional climate models to represent the critical, observed small-scale atmospheric processes resulting in extreme weather and climate events.

PSD-21: PSD should be more of a leader or partner in the area of climate trend and extreme event assessment and attribution, striving for rapid consensus and clear communication of scientific uncertainty.

PSD leads in partnership with the NOAA NWS Climate Prediction Center, the NOAA drought taskforce, NASA, university-based scientists, state climatologist and researchers from other federal and state agencies in a Weather and Climate Attribution Activity to provide explanations and assessment of predictability of the observed state of the climate system. Examples include: U. S. annual surface temperature and precipitation; U.S. extreme events and major climate anomalies, including drought, cold outbreaks, heat waves, and floods; intensity of the hurricane season; and apparent abrupt regional changes. The PSD-led coalition has assessed, and will continue to, assess the performance of weather and climate predictions including: explaining the success and failure of U.S. seasonal temperature and precipitation predictions, ocean predictions and drought outlooks. The scientific methods used can involve both analyzing observations and their past climate relationships, and experiments with weather and climate models to evaluate physical processes that could result in the observed changes. Timely and authoritative explanations of current and evolving weather and climate conditions are required to meet surging public interest and needs for climate information, to provide early warning, and to inform preparedness Without clear and present knowledge of the state of the climate system, policy and decision makers cannot make informed decisions concerning how society should invest in critical infrastructure in risk-prone areas. Since 1980 the U.S. has sustained 188 weather and climate disasters with damages/costs of \$1 billion or more. In 2015, there were 10 events with losses exceeding \$1 billion each across the United States, resulting in the deaths of 155 people. These deaths and the significant economic effects are striking examples of the need to inform policy and decision makers of the causes of such events and related implications for the future. PSD has led the assessment of several recent droughts impacting the Nation's commerce and economy: the Texas 2011 event, the U.S. 'Cornbelt' 2012 event, and the 2012- 2014 California drought. These studies are performed in coordination with interagency groups and with the National Integrated Drought Information System (NIDIS) in order to provide timely and expert scientific information to stakeholders and decision makers seeking to mitigate drought impacts. Floods, such as in the Missouri River Basin in 2011 for which attribution and predictability assessments were done in partnership with the U.S. Army Corp of Engineers, or over northeast Colorado in 2013, address additional societal risks from weather and climate extremes. The causes of these and other events are examined in a

predictive context to learn what factors could have led to improved early warning and preparedness.

PSD-22: PSD should consider expanding its emphasis and strength in hydrometeorology and other aspects of the water cycle highlighted in the Water Cycle Report while also carefully consider how to best partner with other labs, EMC, NWC, and other groups.

The PSD Strategic Plan (2016-2020) Research Priority Goal 2 is to develop new process understanding, observing, and modeling capabilities to predict conditions associated with too much or too little water for early warning, preparedness, resource management, and adaptation. PSD has carefully evaluated its areas of strength and opportunities for growth in water and hydrometeorology research and identified a number of science questions, research objectives and indicators of success.

Key science questions related to the PSD water research priority goal are:

1. How can we improve understanding of water in all forms to better anticipate and prepare for floods and droughts?
2. How can we improve forecasts for freshwater resource management?

Research objectives for the PSD water research priority goal are:

1. Improve and expand measurements related to hydrometeorology using innovative ground-based in situ and remote sensing technologies.
2. Employ observations to improve understanding of precipitation processes in complex terrain, assimilate land surface observations, and develop new techniques for statistical post processing to improve QPF of extreme events and their impacts on hydrologic forecasts.
3. Increase process understanding of aerosol-cloud-precipitation interactions to improve precipitation predictions.
4. Improve understanding of the role of tropical-extratropical dynamics and moisture transport on extreme precipitation in the Western U.S.
5. Improve understanding of drought from within an evapotranspiration and evaporative demand-based context to better characterize drought early warning, onset, and severity.
6. Advance understanding of regional hydrometeorological processes and land-surface feedbacks in order to develop experimental applications to support to water resource risk management in a variable and changing climate.
7. Contribute to the development and application of coupled hydrologic and atmospheric modeling systems for understanding and predicting floods and communicating flood risks.
8. Characterize how QPF uncertainty translates into hydrologic uncertainty through improved pre- and post-processing techniques.

Indicators for success for the PSD water research priority goal are:

1. Actionable intelligence is provided to inform water management and/or ecosystem services decision-making on flood risk and water storage over time scales ranging from minutes to seasonal.

2. QPE, QPF, and/or atmospheric and hydrologic model errors are identified and improvement pathways are suggested.
3. QPF skill is extended to longer lead times.
4. Uncertainty in atmospheric forcing and hydrologic response for extreme events is characterized and quantified.
5. Results of research advances are transitioned to operational products for improved flood and drought forecasts.

PSD is selectively partnering with EMC and WPC to work on improving forecasts of extreme precipitation, HMT on improved atmospheric forcings for hydrologic prediction, NWC on validation and verification of National Water Model (NWM) predictions for targeted watersheds, NIDIS on drought prediction and extreme precipitation in ending drought, OAR Water Team, NOAA Integrated Water team, NCAR on WRF-Hydro development and applications, USACE on Forecast Informed Reservoir Operations, and USBR on climate change and flood research.

PSD-23: Consider opportunities and demands for broadening the focus to non-NOAA stakeholders.

Partnerships with non-NOAA stakeholders are critical to the success of PSD. Engagements with these stakeholders are central to successful transitions from research to operations, applications, or for other purposes (R2X). At the same time, partnerships and user interactions help to identify key science questions and needs that inform future PSD research directions (X2R). PSD has extensive partnerships from local to global levels, and from research to services and applications.

For example PSD partnerships with water management agencies have helped to realize the value of PSD research for informing decision-making, while also helping PSD scientists to identify critical research needs. PSD has contributed strongly to national partnerships through contributions to the National Integrated Drought Information System, USGCRP and Interagency Arctic Research Policy Committee (IARPC), and international partnerships through the Intergovernmental Panel on Climate Change (IPCC), the World Meteorological Organization (WMO) World Weather Research Programme (WWRP) and World Climate Research Programme (WCRP), and the Famine Early Warning System (FEWS) network.

Nevertheless, PSD does not have the critical mass of physical science researchers or experts in the communication and application of scientific findings to participate in all opportunities and demands to engage non-NOAA stakeholders. For this reason, PSD works with large federal agencies such as USACE, USBR, USDA USAID and FERC, state agencies such as the California Department of Water Resources and Colorado Water Conservation Board, and regional organizations such as the Western States Water Council and Upper Colorado River Commission. PSD also depends heavily on boundary institutions such as NOAA-funded RISAs, NOAA Fisheries Science Centers, NOAA Regional Climate Centers, NOAA Regional Teams, NOAA Cooperative Institutes, NOAA Sea Grant, DOI Climate Science Centers, and state climatologists to engage non-NOAA stakeholders and introduce and explain PSD advances in prediction and production of actionable science as information that can be used to support operations, applications and

decision making.

OAR-1: Labs should present more of their own self-assessment based on clear evaluation metrics and evaluation processes.

OAR-2: NOAA should make it easier for other agencies to invest in NOAA work.