

**Physical Sciences Laboratory  
Science Review  
November 16-20, 2020**

**Physical Sciences Laboratory  
Response to Panel Review Recommendations**

May 17, 2021

Submitted by:  
Robert S. Webb, Director

## Introduction

### Purpose of the Review

Laboratory science reviews are conducted every five years to evaluate the quality, relevance, and performance of research conducted in the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Research (OAR) laboratories. This review is for both internal OAR/NOAA use for planning, programming, and budgeting, and external interests. It helps the Laboratory in its strategic planning of its future science. These reviews are also intended to ensure that OAR laboratory research is linked to the NOAA Research mission and priorities, and other relevant strategic plans, is of high quality as judged by preeminence criteria, and is carried out with a high level of performance.

The NOAA Physical Sciences Laboratory (PSL) 5-Year Laboratory Review took place November 16-20, 2020. Each reviewer independently prepared evaluations of at least one research area. The Chair, Dr. David Raff, as a US Bureau of Reclamation (USBR) Federal employee, created a report summarizing the individual evaluations but did not analyze individual comments or seek a consensus of the reviewers. This review covered PSL research over the last five years. The research areas and related topics for the review are: 1) Physical Science for Water Resource Management; 2) Physical Science for Marine Resource Management; and 3) Physical Science for Predicting Extremes.

More information on the review can be found on the PSL review website:

<https://psl.noaa.gov/reviews/2020/>

In this report, each actionable recommendation provided by the Science Review Panel is italicized and followed by the PSL response. Given the overlap between a number of the panel's recommendations, some of these recommendations were grouped and provided a combined response.

A table summarizing the actions along with timelines for completion is included below. Detailed Responses are provided in the section following the table.

## Recommendations and Actions

PSL Science Review Action Sheet				
Recommendation	Action	Champion	Target start & Completion Dates	Status /Notes
<p><i>1) NOAA should take better advantage of the portfolio of PSL research and leadership in this thematic area [predicting extremes] to improve on existing prediction approaches from daily through decadal timescales</i></p>	<p>Enhance collaboration with National Weather Service partners through joint seminars, research meetings, working groups, co-development of products, and participation in testbeds.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Associate Director Richard J. Lataitis</p>	<p>Start: April 1, 2021</p> <p>Completion: Ongoing</p>	
<p><i>2) PSL research on extremes would benefit from more timely access to the latest code base for NOAA's operational models</i></p>	<p>The NOAA Unified Forecast System is a critical framework to facilitate access and use of model code. NOAA level actions include establishment of a NOAA Modeling Board to prioritize and implement outcomes that improve research, development, and operational capabilities and the selection of Raytheon Intelligence and Space to design and develop the <a href="#">Earth Prediction Innovation Center (EPIC)</a> as a NOAA extramural center that will create the most user-friendly and user-accessible comprehensive Earth modeling system.</p>	<p>OAR DAA for Science Gary Matlock</p>	<p>Start: April 26, 2021</p> <p>Completion: Ongoing</p>	
<p><i>3) Address how the research findings and products using targeted instruments for the California Department of Water Resources (CaDWR) can be extended to other areas in the United States</i></p>	<p>PSL will pursue collaborative partnerships with NWS NCEP/Weather Prediction Center, and OWP/ National Water Center to target hydrometeorological forecasting challenges across the coterminous USA that can be better understood using PSL expertise and resources.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Hydrometeorology Modeling and Applications Research Team Lead Robert Cifelli</p> <p>PSL Hydrometeorology Observations and Processes Research Team Lead Allen B. White</p>	<p>Start: October 1, 2021</p> <p>Completion: Ongoing</p>	

<p>4) <i>Improve remote sensing for soil moisture to complement in situ measurements and improve remote sensing of satellite-based snowpack and snowmelt to yield information suitable for assimilation into the National Water Model and weather forecast models</i></p>	<p>UAV technologies and field observations will be deployed as part of the the PSL-led Study of Precipitation, the Lower Atmosphere and Surface for Hydrometeorology (SPLASH) to bridge the gap between in situ (point scale, multi-depth) and satellite (coarse resolution, global scale, top 5 cm depth) soil moisture measurements. The feasibility of UAV-mounted active multi-wavelength soil moisture remote sensing technology will be explored to measure soil moisture over the full profile and under snow. Data assimilation strategies will be explored for ingesting remotely sensed snow and soil moisture observations, into NOAA's Unified Forecast System and National Water Model.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Hydrometeorology Modeling and Applications Research Team Lead Robert Cifelli</p> <p>PSL Dynamics and Multiscale Interaction Research Team Alexander G. Voronovich</p>	<p>Start: October 1, 2021</p> <p>Completion: December 31, 2023</p>	
<p>5) <i>Use PSL's experience with flash flooding in the Western United States to extend flood forecasting to urban areas</i></p>	<p>PSL will focus research on improving forecasts of high impact flood events, how land use changes impact flood events, potential role of urbanization on flood response time, and model experiments to assess the role the urbanized land surface plays in flash flood likelihood and forecast skill.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Hydrometeorology Modeling and Applications Research Team Lead Robert Cifelli</p> <p>PSL Hydrometeorology Observations and Processes Research Team Lead Allen B. White</p>	<p>Start: July 15, 2021</p> <p>Completion: Ongoing</p>	
<p>6) <i>Continue work in these areas to support NOAA's marine resources management, particularly with NOAA Fisheries work for exploited species</i></p>	<p>PSL will hire additional scientists to conduct research to advance the understanding and prediction of environmental conditions impacting marine resources and actively participate in the 'OAR-NMFS Climate and Fisheries Initiative Implementation Approach'.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Atmosphere-Ocean Processes Research Team Lead Michael A. Alexander</p>	<p>Start: September 1, 2021</p> <p>Completion: Ongoing</p>	
<p>7) <i>Encourage split-funding scientists to directly bridge PSL and NOAA Fisheries</i></p>	<p>Budgets allowing, PSL will pursue split-funding of scientists to directly bridge laboratory activities with Fisheries Science Centers, Center for Operational Oceanographic Products and Services, National Water Center, Climate Prediction Center and Weather Prediction Center</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Deputy Director Brian K. Gorton</p>	<p>Start: October 1, 2021</p> <p>Completion: December 31, 2024</p>	
<p>8) <i>Identify and encourage interactions among PSL scientists and NOAA modeling centers to assess and improve model realism</i></p>	<p>Expand internal investments in cross-laboratory integrating research activities to bring PSL observation, understanding and modeling expertise together to collaborate with NOAA modeling centers in the assessment and improvement of model realism. Participate in testbeds partnerships with NOAA modeling centers.</p>	<p>PSL Director Robert S. Webb</p> <p>Eight PSL Research Team Leads</p>	<p>Start: June 1, 2021</p> <p>Completion: Ongoing</p>	

<p>9) <i>Use feedback from field work to assess and address any model shortcomings</i></p>	<p>Include regular weather/water/climate briefings during field campaigns to evaluate NOAA's operational and experimental model performance. Grow the PSL "observer program" to provide numerical modelers and data analysts with opportunities to participate in field experiments. Facilitate model evaluation and model-data comparisons with Merged Observation Data Files (MODF) and process-oriented diagnostic packages.</p>	<p>PSL Director Robert S. Webb</p> <p>Eight PSL Research Team Leads</p>	<p>Start: July 1, 2021</p> <p>Completion: Ongoing</p>	
<p>10) <i>Provide a more structured or defined interaction between PSL modeling and the predictions systems that their science could improve</i></p>	<p>Use the Unified Forecast System Research to Operations Project (<a href="#">UFS-R2O</a>) as a mechanism to better integrate PSL model and data assimilation science with operational NOAA predictive systems research and development efforts.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Forecast and Modeling Development Research Team Lead Jeffrey Whitaker</p>	<p>Start: August 1, 2021</p> <p>Completion: Ongoing</p>	
<p>11) <i>Innovative stochastic parameterization schemes are commendable and are showing promising improvements to predictive models. In addition, continued or additional focus on understanding of the physics will help NOAA predict phenomena more accurately</i></p>	<p>Pursue two-prong approach of both incorporating advances in the physics of resolvable processes into predictive models and developing stochastic parameterizations of inherently chaotic and sub-grid scale processes.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Forecast and Modeling Development Research Team Lead Jeffrey Whitaker</p>	<p>Start: March 1, 2021</p> <p>Completion: Ongoing</p>	
<p>12) <i>Examine how PSL can identify, prioritize, strengthen, and promote more formal and strategic partnerships rather than ad hoc collaborations</i></p>	<p>Formalize partnerships through institutional and interagency level agreements, outreach while serving as chair, principle investigator, advisory board member, and lead scientist in NOAA-wide initiative, programs, testbeds and projects, quarterly meetings with leadership level peers across NWS, NOS NMFS, other federal agencies and state agencies</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Senior Scientist Roger S. Pulwarty</p>	<p>Start: August 1, 2021</p> <p>Completion: Ongoing</p>	
<p>13) <i>Focus more on NOAA's operational needs while using PSL's unique position to address user-inspired research</i></p>	<p>Engage NOAA service line offices in science planning and discussions of operational forecast and prediction challenges, and external core users or deep core partners to ensure PSL's use-inspired research is targeted to enhance NOAA's future mission capabilities.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Senior Scientist Roger S. Pulwarty</p>	<p>Start: May 1, 2021</p> <p>Completion: Ongoing</p>	
<p>14) <i>Use PSL's unique strength to develop of R2O products for NOAA's line offices</i></p>	<p>Collaborate in cross-agency initiatives, testbeds and projects, target field campaigns to contribute to R2O advances for NOAA's line offices, play an active role in the design and implementation of NOAA science priorities such as the Precipitation Prediction Grand Challenge, OAR-NMFS Climate and Fisheries</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Senior Scientist Roger S. Pulwarty</p>	<p>Start: June 1, 2021</p> <p>Completion: Ongoing</p>	

	Initiative, NOS-led Coastal Resilience, Hydrometeorological Testbed, the <a href="#">Earth Prediction Innovation Center (EPIC)</a> , Unified Forecast System Research to Operations Project ( <a href="#">UFS-R2O</a> ).			
<i>15) Develop ways to transfer satellite data applications and develop products from the research</i>	Strengthen existing relationships with NOAA operational service line offices to enhance and expand operational utilization of experimental satellite data applications, pursue the application of satellite remotely sensed observations to represent ocean, land and atmospheric processes and conditions, explore the use of machine learning and artificial intelligence numerical techniques to preprocess and cull satellite data for assimilation .	PSL Director Robert S. Webb  PSL Hydrometeorology Observations and Processes Research Team Scientist Gary A. Wick  PSL Forecast and Modeling Development Research Team Lead Jeffrey Whitaker	Start: June 1, 2021  Completion: Ongoing	
<i>16) Develop metrics to assess R2X success</i>	Work with OAR Headquarters to build upon the NOAA metrics for tracking success in transitions and categories of transition outputs as defined in the <a href="#">NOAA Administrative Order (NAO) 216-105B: Policy on Research and Development Transitions</a> and described in the accompanying <a href="#">Handbook</a> . Explore development of an innovative metric of R2X success based on the readiness level 10 (RL-10) proposed by Straub (2015). Investigate the use of logic models to assess and document R2X efforts.	PSL Director Robert S. Webb  NOAA Testbed and Proving Ground Coordinating Committee Chair Andrea J. Ray	Start: July 1, 2021  Completion: December 31, 2023	
<i>17) Coordinate staff training in appropriate and ethical behavior and develop means to respond to negative interactions between PSL and CI staff</i>  <i>22) Develop a unified approach between PSL and CIRES including education, training, and human resources actions that:</i> <i>- Support a civil workplace</i> <i>- Encourage bystanders to step in and change the cultural norms</i>	Host an informational briefing on ‘ <i>Bullying in the Workplace</i> ’. Hold biweekly laboratory-wide townhalls to enhance two-way communication and discussions of acceptable behavior. Conduct quarterly ‘ <i>Pulse Surveys</i> ’ to assess trends in staff sentiments. The PSL Workplace Advisory Committee will prepare a report. These activities will be used to inform the development of a multi-organizational, staff-wide agreed upon ‘ <i>PSL Rules of Engagement</i> ’ which clearly defines expectations in terms of behavior and conduct for all people affiliated with PSL.	PSL Director Robert S. Webb  PSL Deputy Director Brian K. Gorton	Start: January 1, 2021  Completion: Ongoing	

<p>18) <i>Work with CIs to maintain alignment of PSL's core research activities and the themes and staffing for the CIs to carry forward in their 5-year cycle of umbrella proposals to NOAA</i></p>	<p>Expand PSL Science Board to increase the number of CI staff participating in discussions with the PSL Director and Senior Scientist. Work across NOAA to develop research priorities for federal funding opportunities for future cooperative agreements to ensure PSL core research activities and staffing requirements are addressed in upcoming cooperative institute 5-year umbrella proposals.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Associate Director Richard J. Lataitis</p>	<p>Start: February 1, 2021</p> <p>Completion: July 31, 2022</p>	
<p>19) <i>Create a central access for clear documentation and the latest code base for operational models</i></p>	<p>The selection of Raytheon Intelligence and Space to design and develop the <a href="#">Earth Prediction Innovation Center (EPIC)</a> as a NOAA extramural center to create the most user-friendly and user-accessible comprehensive Earth modeling system will address these issues.</p>	<p>Earth Prediction Innovation Center (EPIC) Program Manager</p>	<p>Start: April 26, 2021</p> <p>Completion: Ongoing</p>	
<p>20) <i>Create an environment where it is "safe to fail" by re-examining transition plan requirements, priorities, and success metrics</i></p>	<p>Will pursue development of R2X Collaboration Plans that focus on anticipated pathways for scientific findings to be transformed into actionable science in support of NOAA's mission.</p>	<p>PSL Director Robert S. Webb</p> <p>NOAA Testbed and Proving Ground Coordinating Committee Chair Andrea J. Ray</p>	<p>Start: September 1, 2021</p> <p>Completion: December 31, 2023</p>	
<p>21) <i>Devise metrics for performance evaluations beyond peer-reviewed journal articles that address partnership and R2O activities</i></p>	<p>Standardize performance metrics used in annual evaluations to recognize partnership, R2O activities, significance of the employee's scientific authority, stature and accomplishments. Work with cooperative institute and contractor leadership to promote the adoption of these metrics.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Associate Director Richard J. Lataitis</p> <p>OAR DAA for Science Gary Matlock</p>	<p>Start: September 1, 2021</p> <p>Completion: November 30, 2023</p>	
<p>23) <i>Establish a human resources process to resolve issues in a transparent manner</i></p>	<p>Partner with CI and contractor leadership to clearly articulate the access to appropriate human resources processes within NOAA, CIs and contractors for their respective staff.</p>	<p>PSL Director Robert S. Webb</p> <p>PSL Deputy Director Brian K. Gorton</p>	<p>Start: August 1, 2021</p> <p>Completion: December 31, 2021</p>	

## Detailed Responses

**R1:** *NOAA should take better advantage of the portfolio of PSL research and leadership in this thematic area to improve on existing prediction approaches from daily through decadal timescales*

**R1 Response:** Agree. PSL will not succeed in bridging the R2O gap if we wait for others to capitalize on our research findings. For NOAA to take advantage of PSL research advances to improve on existing prediction approaches requires PSL to proactively reach out to collaborate with our National Weather Service partners (Climate Prediction Center, Weather Prediction Center, Environmental Modeling Center, Meteorological Development Lab, and Office of Water Prediction/National Water Center) through joint seminars, research meetings, working groups, co-development of products, and participation in testbeds.

**R1 Action Plan:** PSL will engage in proactive reach out to collaborate through:

- Participation in the Unified Forecast System seminar series.
- Regular communication of research results in seminars at the Climate Prediction Center.
- Regular communication of research results in meetings of the UFS parameterization working, data assimilation working and postprocessing working group.
- Regular communication of research results in meetings with Meteorological Development Lab.
- Regular communication of research results in meetings with Office of Water Prediction and National Water Center
- Regular communication of research results in meetings with the Weather Prediction Center
- Collaborative development of experimental realtime long-range tropical seasonal forecast web page,
- Participation in CPC's weekly Week 3-4 Outlook Forecast Discussion.
- Joint-leadership of the NOAA Hydrometeorological Testbed.

**R2:** *PSL research on extremes would benefit from more timely access to the latest code base for NOAA's operational models*

**R2 Response:** Agree. Providing timely access to the latest code base for NOAA's operational and research-quality models needs to be addressed at the agency and line office levels with the NOAA Unified Forecast System as a critical framework to facilitate access and use of model code. NOAA recently created a NOAA Modeling Board and awarded a contract to implement the [Earth Prediction Innovation Center](#) (EPIC).

**R2 Action Plan:** The establishment of a NOAA Modeling Board to prioritize and implement outcomes that improve research, development, and operational capabilities will help resolve this issue. The selection of Raytheon Intelligence and Space to design and develop the [Earth Prediction Innovation Center](#) (EPIC) as a NOAA extramural center that will create the most user-friendly and user-accessible comprehensive Earth modeling system to address this issue.

**R3:** *Address how the research findings and products using targeted instruments for the California Department of Water Resources (CaDWR) can be extended to other areas in the United States*

**R3 Response:** Agree. PSL will need to build upon existing and pursue new collaborative partnerships with NWS NCEP/Weather Prediction Center, and OWP/ National Water Center to



target hydrometeorological forecasting challenges across the coterminous USA that can be better understood and predicted using PSL expertise and resources.

**R3 Action Plan:** PSL will pursue collaborative research partnerships that include applying knowledge gained studying precipitation phase transitions in California to winter storm rain-snow transitions along the Mid-Atlantic, studies of Atmospheric Rivers impacting other areas of the US such as the Gulf of Mexico, studies of orographic precipitation processes for inland topography, and the Wind Forecast Improvement Project 3 (WFIP3) focused on Southern New England offshore clean energy. These collaborative research interest will help PSL identify opportunities for targeted placement of gap-filling X-band radars, profilers and other equipment to support observation-based process studies of critical weather and climate phenomena.

**R4:** *Improve remote sensing for soil moisture to complement in situ measurements and improve remote sensing of satellite-based snowpack and snowmelt to yield information suitable for assimilation into the National Water Model and weather forecast models*

**R4 Response:** Agree. The diversity of expertise in PSL positions the laboratory to improve both the remote sensing of soil moisture and snow, as well as the understanding and use of such observations, particularly in data assimilation.

**R4 Action Plan:** PSL will apply subject matter expertise in research to improve the remote sensing of soil moisture and snow, the understanding and use of such observations, and in data assimilation through activities such as:

- Within the PSL-lead Study of Precipitation, the Lower Atmosphere and Surface for Hydrometeorology (SPLASH), deploy UAV technologies and field experiments as a way to bridge the gap between in situ (point scale, multi-depth: and satellite (coarse resolution, global scale, top 5 cm depth) soil moisture measurements.
- Explore feasibility of UAV-mounted active multi-wavelength soil moisture remote sensing technology to measure soil moisture over the full profile and under snow.
- Advance data assimilation strategies for ingesting remotely sensed observations, including snow and soil moisture, into NOAA's Unified Forecast System and National Water Model

**R5:** *Use PSL's experience with flash flooding in the Western United States to extend flood forecasting to urban areas*

**R5 Response:** Agree. PSL will build upon existing and pursue new flash-flood-relevant hydrological and meteorological research focused on improved forecasts of high impact flood events and how land use changes impact flood events.

**R5 Action Plan:** PSL will pursue research to examine the potential role of urbanization on flood response time through processes such as channeling and decreasing land surface permeability. PSL will conduct modeling experiments to assess the role the urbanized land surface plays in alleviating/exacerbating flash flood likelihood and possible forecast skill as a function of lead time. In addition, PSL will pursue research on generating and evaluating experimental hydrometeorological ensembles. As new NOAA meteorological forecast models, especially convection-permitting, ensemble forecast models, are moved from research to operations, PSL will design and execute experiments to test the impact meteorological improvements have on hydrologic forecasts. PSL will work to disentangle meteorological and hydrological model errors in NOAA hydrological forecasts. Improving forecasts of hydrologic conditions and impacts requires the ability to distinguish, describe, understand, and quantify errors stemming from both (1) the atmospheric inputs that serve as forcing for hydrologic model prediction, and (2)

hydrologic model structure, parameters, and states. PSL will design and execute targeted case studies focused on understanding the source of these errors in operationally relevant hydrological models. PSL will conduct studies to better understand how land use changes have impacted hydrological impacts for high-impact flood events. Urbanization impacts flood response time by decreasing the permeability of the land surface. PSL will design and execute modeling experiments to understand the role the urbanized land surface plays in alleviating/exacerbating flash flood likelihood and possible forecast skill as a function of lead time.

**R6:** *Continue work in these areas to support NOAA's marine resources management, particularly with NOAA Fisheries work for exploited species*

**R6 Response:** Agree. PSL appreciates the reviewers' comments and is taking steps to expand research in support of marine resource management and fisheries through the hiring of additional staff and participation in the OAR-NMFS climate and fisheries initiative. A joint appointment between PSL and NOAA's Southwest Fisheries Science Center has helped, and is expected to continue to help, to advance many of these activities by facilitating collaboration across NOAA line offices.

**R6 Action Plan:** PSL will add critical mass in the physical sciences for marine resource management with the hiring of an early career scientist to conduct climate and oceanographic research to advance the understanding and prediction of environmental conditions impacting marine resources. PSL is partnering with OAR and NMFS colleagues on the design of the 'OAR-NMFS Climate and Fisheries Initiative Implementation Approach' to deliver and support the regional hindcasts, nowcasts, forecasts, and projections needed across the temporal and spatial scales required to effectively fulfill NOAA's stewardship missions in a changing climate. PSL will use augmentations of resources to pursue research to understand how climate impacts marine and coastal species and ecosystems, and to inform strategies to reduce risks and increase resilience. PSL will perform studies using observations, global and regional model simulations, and ocean reanalyses to better understand the local and remote drivers of variables that are critical for marine resources, such as sea surface and bottom temperature, sea level, sea ice conditions, and off-shore winds in US coastal regions. PSL will observe surface fluxes of physical and biogeochemical variables to advance process understanding and support development and verification of model parameterizations at the air-sea interface, particularly in areas characterized by complexity such as near coasts and over sea ice. PSL will contribute to the development and application of the regional version of the MOM6 ocean model and the CAFS sea ice forecast model, and use these tools to explore the impacts of variability and change at weather and climate scales. PSL will enhance the ability for scientists, managers and the general public to access, analyze, and visualize marine resource relevant data and model output. PSL will use expertise and experience predicting ENSO with empirical models, such as linear inverse models and model analogs, to forecast conditions along US coasts. These methods, along with diagnosis of ocean reanalyses and model simulations, will be used to better understand and predict extreme conditions such as marine heat waves and coastal inundation.

**R7:** *Encourage split-funding scientists to directly bridge PSL and NOAA Fisheries*

**R7 Response:** Agree. Within the existing budgetary constraints of PSL and partner institutions, split-funding of scientists has the potential to directly bridge laboratory activities with NOAA Fisheries Science Centers and NOS Center for Operational Oceanographic Products and

Services, as well as NWS OWP National Water Center, NCEP Climate Prediction Center and Weather Prediction Center.

**R7 Action Plan:** PSL will actively pursue new base resources in cross-agency budget initiatives to support the split-funding of scientists to directly bridge laboratory activities with NOAA partner research and development centers.

**R8:** *Identify and encourage interactions among PSL scientists and NOAA modeling centers to assess and improve model realism*

**R8 Response:** Agree. Greater interactions among PSL scientists and collaborative research partnerships with NOAA modeling centers will enhance agency-wide efforts to assess and improve the realistic representation of processes and outcomes in NOAA weather, water and climate models. PSL diagnostics and process-understanding research into model realism in producing reliable and skillful forecasts and predictions will help modeling centers ensure the models are getting the right answers for the right reasons.

**R8 Action Plan:** PSL will expand internal investments in cross-laboratory integrating research activities focused on bringing the observation, understanding and modeling expertise together to collaborate with NOAA modeling centers in the assessment and improvement of model realism. The expansion of activities in partnership with the NOAA modeling community will better leverage PSL observation-based, process-understanding, diagnostic capabilities, and model evaluation to improve model realism and advance prediction of weather, water and climate extremes.

**R9:** *Use feedback from field work to assess and address any model shortcomings*

**R9 Response:** Agree. PSL will expand efforts to apply observations and advances in process understanding from field campaigns to better assess and then pursue research to address forecast and prediction challenges in NOAA's operational and experimental weather, water and climate modeling systems. The rapid-response, laboratory-wide application of field experiment data to evaluate and improve NOAA's operational weather forecast models is a golden opportunity for PSL to accelerate the transition of research to operations process by immediately demonstrating the utility and value of these field observations.

**R9 Action Plan:** To accelerate the real time and near-real time application of field experiment data to evaluate and improve NOAA's operational weather forecast models, PSL led field experiments will include regular weather/water/climate briefings during the campaigns to evaluate NOAA's operational and experimental model performance, assess systematic errors in model forecasts, identified opportunities to better understand the sources of model errors, and ways forward to reduce biases in NOAA forecast. PSL will grow the highly successful "observer program" that provides numerical modelers and data analysts with opportunities to experience, and better appreciate, how data is collected during field experiments, as well as insights on how observations can be used to identify and interpret model prediction challenges. To maximize the use information collected during field campaigns to assess experimental and operation modeling systems, PSL will implement a consolidated and streamlined process to generate products to facilitate model evaluation and model-data comparisons: 1) Merged Observation Data Files (MODF) to meet F.A.I.R data standards and accommodate validation, parameterization testing, assimilation and model testing, and 2) process-oriented diagnostic packages to distill physical process oriented information from raw measurements to better understand and interpret performance of weather, water and climate models.

**R10:** *Provide a more structured or defined interaction between PSL modeling and the predictions systems that their science could improve*

**R10 Response:** Agree. PSL is actively engaged in the Unified Forecast System Research to Operations Project ([UFS-R2O](#)) which aims to provide an integrated and collectively managed framework for advancing NOAA operational models, based on a unified modeling and collaborative framework.

**R10 Action Plan:** PSL will pursue a strategy to integrate its model and data assimilation development efforts within the UFS-R2O project, thereby guaranteeing that those efforts are coordinated with our partners and have a direct path into NOAA operations.

**R11:** *Innovative stochastic parameterization schemes are commendable and are showing promising improvements to predictive models. In addition, continued or additional focus on understanding of the physics will help NOAA predict phenomena more accurately*

**R11 Response:** Agree. Maintaining a research focus on understanding and improving the representation of microphysical processes in predictive models is a high priority for PSL to help NOAA predict phenomena more accurately. However, given the inherently unresolvable and/or chaotic nature of some physical processes, PSL is equally committed to developing a next generation of physically-based, stochastic parameterization schemes that can be directly informed by theory and observations.

**R11 Action Plan:** PSL will pursue a two-prong approach that will allow both for incorporating advances in physics into predictive models and improved physical understanding of sub-grid scale, unresolved and inherently stochastic processes to be leveraged to improve the stochastic parameterizations schemes that represent their effects in NOAA models.

**R12:** *Examine how PSL can identify, prioritize, strengthen, and promote more formal and strategic partnerships rather than ad hoc collaborations*

**R12 Response:** Agree. PSL currently engages in a spectrum of collaborations and partnerships, ranging from informal scientist-to-scientist interactions, to institutional partnerships and formal interagency MOU/MOAs. PSL has developed many long-standing, strategic partnerships spanning the major science themes of Predicting Extremes, Water Resources Management, and Marine Resources Management.

**R12 Action Plan:** To foster and develop new formal strategic partnerships PSL will pursue the following roles, responsibilities and actions:

- Chair of the NOAA Testbed and Proving Grounds Coordinating Committee
- Serve as co-PI of the NOAA Unified Forecast System Research to Operations Project
- Serve on the NWS National Blend of Models Science Advisory Board
- Participate in the implementation of the NOAA Integrated Ecosystem Assessment (IEA) Program
- Engage quarterly at the leadership level with NOAA peers in the Climate Prediction Center, Weather Prediction Center, Environmental Modeling Center, Office of Water Prediction, National Water Center, Ocean Service Coastal Inundation and Resilience, and Fisheries Service Science Programs
- Engage quarterly at the leadership level with peers from US Bureau of Reclamation, US Army Corps of Engineers, DOD Strategic Environmental Research and Development Program, California Department of Water Resources, and the Association of State Dam Safety Officials.

**R13:** *Focus more on NOAA's operational needs while using PSL's unique position to address user-inspired research*

**R13 Response:** Agree. PSL focus on NOAA operational needs is and will remain a priority. Our selection of external stakeholders to work with is always related to those who have an interest in a current, or need for potential future, NOAA operational products. Some of these are described within NWS as core users or deep core partners, and who are the intended end-consumer of operational NOAA informational products and services

**R13 Action Plan:** PSL will engage NOAA service line offices on an ongoing basis in science planning efforts and in the development of use-inspired research through discussions of operational forecast and prediction challenges such as on the need to improve predictions of extreme precipitation, flooding, winter precipitation, precipitation type/snow level, coastal inundation, boundary current upwelling and marine heatwaves. PSL will focus engagement of external stakeholders who line offices identify as core users or deep core partners with an interest or need for potential future NOAA operational products to ensure PSL's use-inspired research is targeted to enhance NOAA's future mission capabilities.

**R14:** *Use PSL's unique strength to develop of R2O products for NOAA's line offices*

**R14 Response:** Agree. PSL field campaigns are targeted to contribute to R2O advances for NOAA's line offices, and this focus will remain a priority. PSL field campaigns provide a better observation-based process understanding that contributes to developing or refining operational models. In addition, PSL field campaigns have been highlighted by NWS leadership as prime examples of O2R, or operations informing research.

**R14 Action Plan:** PSL field campaigns will share real-time observations with NWS Climate Prediction Center, Weather Prediction Center, Environmental Modeling Center, Office of Water Prediction, National Water Center as well as field offices such as River Forecast Centers and Weather Forecast Offices. PSL will foster collaborative partnerships with NWS offices as an essential component of the design and planning of targeted field campaigns. As collaborative partners, PSL will be positioned to motivate NWS offices to develop and provide specialized products to support the campaigns. In turn, PSL field campaigns strive to develop webpages for dissemination of real or near-real time data to the NWS offices and other users. PSL uses this co-development and sharing of observations and forecasts to build relationships with operational providers which involve them in the research process, while providing PSL a better understanding of operational needs. PSL will apply strengths in development of R2O products for NOAA line offices through proactive participation in opportunities to collaborate in cross-agency initiatives, testbeds and projects such as the Precipitation Prediction Grand Challenge, OAR-NMFS Climate and Fisheries Initiative, NOS-led Coastal Resilience, Hydrometeorological Testbed, internal NOAA contributions the [Earth Prediction Innovation Center](#) (EPIC), Unified Forecast System Research to Operations Project ([UFS-R2O](#))

**R15:** *Develop ways to transfer satellite data applications and develop products from the research*

**R15 Response:** Agree. PSL will strengthen existing relationships with NOAA operational service line offices to enhance and expand operational utilization of experimental satellite data applications. PSL will build upon demonstrated successes in 1) the transitioning of research involving observations and simulation of diurnal warming in satellite sea surface temperature

(SST) data into an operational blended SST product at NESDIS through collaboration with STAR, 2) the use of satellite-derived water vapor data to characterize atmospheric rivers (ARs) and 3) experimental web-based AR resources being utilized by the NWS Weather Prediction Center and local Weather Forecast Offices.

**R15 Action Plan:** PSL will partner with NWS to pursue the application of experimental satellite SST observations to produce improved diurnally-resolved SST products and model output fields. PSL will apply expertise in field observations to advance the development of blended satellite products and their calibration and validation. PSL will use the wealth of observational data from field programs to characterize the accuracy and representativeness of multiple satellite-derived quantities of SST, sea surface salinity, water vapor, surfaces fluxes, soil moisture properties, snow cover characteristics, drought intensity, atmospheric water vapor, near-surface air temperature and humidity, and boundary layer and lower tropospheric winds. PSL will explore the use of machine learning and artificial intelligence numerical techniques to inform the preprocessing and culling of satellite data for assimilation.

#### **R16: Develop metrics to assess R2X success**

**R16 Response:** Agree. NOAA has metrics for tracking success in transitions, including the number of transitions by lab and changes in readiness levels which represent stages in transitions, not just the final handoff, e.g., proof of concept; tested as a demonstration, as a pilot, or tested in an operational setting, and documented uptake of knowledge transfers. NOAA also tracks categories of transition outputs: system, process, service, tool, product, or assessment. These metrics are and will continue to be tracked by PSL as milestones as part of the NOAA Annual Operating Plan process.

**R16 Action Plan:** PSL will work with OAR Headquarters to build upon the NOAA metrics for tracking success in transitions and categories of transition outputs as defined in the [NOAA Administrative Order \(NAO\) 216-105B: Policy on Research and Development Transitions](#) and described in the accompanying [Handbook](#). In parallel, PSL will also explore development of an innovative metric of R2X success based on the technical readiness level 10 (TRL-10) by Straub (2015): "*This TRL includes upgrades and refinements to improve the functionality of the operating system, repair latent defects and reduce troubleshooting and repair requirements*" with "*Ongoing support operations are established and upgrades and refinements may be made to improve the functionality of the software, repair latent defects and reduce troubleshooting and repair requirements.*". PSL will also investigate logic models to assess and document R2X efforts as an alternative way to measure transition success. Employing a logic model approach would link the intents and activities of a project or set of projects to the intended outcomes, and to assess if and how those intents created the desired benefits.

**R17:** *Coordinate staff training in appropriate and ethical behavior and develop means to respond to negative interactions between PSL and CI staff*

**R22:** *Develop a unified approach between PSL and CIRES including education, training, and human resources actions that:*

*- Support a civil workplace*

*- Encourage bystanders to step in and change the cultural norms*

**R17/22 Response:** Agree. PSL recognizes the need to improve workplace culture and diversity, address unacceptable behavior, support a civil workplace, promote bystander intervention, deal with unprofessional interactions and ensure a safe and secure workplace free from bullying and



aggression. PSL fully embraces the principles laid out in NOAA's Diversity and Inclusion Strategic Plan (FY 2020-2024) to strengthen diversity and inclusion through the three stated goals and eight high-priority objectives, and will operate to recruit a diverse, highly capable workforce, build an inclusive work environment, and ensure continued progress and commitment.

**R17/22 Action Plan:** PSL will host an informational briefing on *'Bullying in the Workplace'* to ensure there is a unified understanding and expectation among all staff. PSL will hold biweekly laboratory-wide townhalls to enhance two-way communication and discussions of acceptable behavior. PSL will conduct quarterly *'Pulse Surveys'* to evaluate laboratory morale, to assess trends in staff sentiments, and to understand the effectiveness of efforts to improve communication. PSL Workplace Advisory Committee will prepare a report containing recommendations to PSL leadership for addressing unacceptable behavior in the workplace in response to the town hall follow up on the OAR-Sponsored Organizational Health and Culture Assessment (OHCA) PSL lab-specific report. The information from these activities will be used to inform the development of a multi-organizational, staff-wide agreed upon *'PSL Rules of Engagement'* which clearly defines expectations in terms of behavior and conduct for all people affiliated with PSL (federal, cooperative institute, contractor) in professional settings working inside and outside the laboratory, including attending conferences and participating in field work.

**R18:** *Work with CIs to maintain alignment of PSL's core research activities and the themes and staffing for the CIs to carry forward in their 5-year cycle of umbrella proposals to NOAA*

**R18 Response:** Agree. PSL recognizes the important contributions of CIs for the success of the laboratory as invaluable resources providing a rich and diverse pool of subject matter experts conducting research to advance NOAA mission capabilities. The alignment of PSL's core research areas with CI research themes and staffing is critical to PSL to meet strategic goals, objectives and annual milestones.

**R18 Action Plan:** PSL will expand the number of members of the PSL Science Board to increase the number of CI staff participating in discussions with the PSL Director and Senior Scientist on long-term strategic directions, challenges, and opportunities for weather, water and climate research in the laboratory. In accordance with the policy and procedures described in NOAA Administrative Order 216-107 and the *Cooperative Institute Interim Handbook*, PSL is working with OAR and other line offices in the development of research themes to inform prospectus and federal funding opportunities for future cooperative agreements to ensure PSL core research activities and staffing requirements are addressed in upcoming cooperative institute 5-year umbrella proposals

**R19:** *Create a central access for clear documentation and the latest code base for operational models*

**R19 Response:** Agree. PSL and OAR recognizes NOAA's need for improved coordination among operational and research groups within NOAA that are developing, refining and using numerical models.

**R19 Action Plan:** Access to and documentation of the latest code base for NOAA operational models is part of the portfolio of duties that are expected to be addressed with the selection of Raytheon Intelligence and Space to design and develop the [Earth Prediction Innovation Center](#) (EPIC) as a NOAA extramural center to create the most user-friendly and user-accessible comprehensive Earth modeling system.

**R20:** *Create an environment where it is “safe to fail” by re-examining transition plan requirements, priorities, and success metrics*

**R20 Response:** Agree. PSL recognizes that delivering NOAA’s future requires fostering culture and environment which promotes exploratory research and scientists are encouraged to innovate in pursuit of transformative breakthroughs without worries on whether it is safe to fail or the need to have a transition plan in place before any hypothesis has been tested.

**R20 Action Plan:** PSL will fully embrace the OAR Strategy 2020-2026 goal

- Drive Innovative Science and subgoals
- Reinforce a culture of innovation and adaptability.
- Invest in high-risk, high-reward science
- Accelerate the delivery of mission-ready, next-generation science

In adopting an approach rewarding innovation, investing in high risk science and fostering a safe to fail environment in pursuit of high-reward research to advance NOAA mission capabilities, PSL will reconsider the role and character of transition plans in the context of innovative science. As an alternative to transition plans that can impede the fostering of innovative science, PSL will pursue the development of R2X Collaboration Plans (presented at the March 2021 NWS-OAR Leadership Collaboration Summit) that focus on anticipated pathways for scientific findings to be transformed into actionable science in support of the NOAA mission agency goals to transition research into applications, operations and services. As an outcome of the March 2021 NWS-OAR summit, a joint NWS-OAR R2O Working Group/Task Team was created to investigate whether the existing R2O process is sufficiently adaptable and flexible to support early collaboration and R2D plans, or if additional processes might be necessary. and provide recommendations for any necessary process modifications. The findings of this working group/task team will inform PSL’s efforts.

**R21:** *Devise metrics for performance evaluations beyond peer-reviewed journal articles that address partnership and R2O activities*

**R21 Response:** Agree. PSL’s role as a NOAA laboratory in a mission agency means that performance should be evaluated by more than just peer-review journal publications and include metrics that value scientific contributions through partnerships and R2O transitions which advance NOAA mission capabilities. PSL will draw upon criteria in the *OAR Research and Development Level Evaluation Package Guidelines* criteria that assess the significance of the employee’s scientific authority, stature and accomplishments towards NOAA’s mission.

**R21 Action Plan:** In consultation with OAR Headquarters, PSL will standardize performance metrics used in annual evaluations to recognize the important contributions of partnership development and maintenance and R2O activities. PSL will incorporate metrics for performance evaluation drawing from the *OAR Research and Development Level Evaluation Package Guidelines* criteria: a) peer-reviewed scientific papers; b) scientific assessments; c) management or other scientific advice (e.g., Congressional testimony, decision support tools, technical assistance, guides & manuals); d) new or improved instruments, numerical models, data storage systems, communications networks, or tools; e) transitions of research to applications; and f) non-peer reviewed publications (e.g., books, technical reports, maps, proceedings, newsletters, advisory reports, curriculum guides, videos, CD-Roms, computer programs and other miscellaneous types of documents) that represent a new or more comprehensive understanding of



a subject produced. PSL will work with cooperative institutes and contractors to promote the adoption of these standardized performance metrics in annual evaluations of affiliated staff.

**R23:** *Establish a human resources process to resolve issues in a transparent manner*

**R23 Response:** Agree. PSL, CI and contractor management will engage in discussions to coordinate staff training in appropriate and ethical behavior and develop means to respond to negative interactions between PSL, contractor and CI staff. PSL will benefit from a clearly articulated and agreed upon approach across the different and separate PSL, CI and contractor management structures for dealing with human resources, behavior and workplace culture in a uniform, consistent, and transparent process that is consistently communicated to and understood by all staff affiliated with PSL.

**R23 Action Plan:** PSL will partner with CI and contractor leadership to ensure there is clearly articulated access to the appropriate human resources processes within the NOAA for federal employees, with the universities for CI employees and within contractors for contracting staff.