

Earth System Research Laboratory
Physical Sciences Division Review
May 12-14, 2015

Charge to Reviewers

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 Strategic Plan, is relevant to NOAA Research mission and priorities, is of high quality as judged by preeminence criteria, and is carried out with a high level of performance. Each reviewer will independently prepare his or her written evaluations of at least one research area. The Chair, a Federal employee, will create a report summarizing the individual evaluations. The Chair will not analyze individual comments or seek a consensus of the reviewers.

Scope of the Review: This review will cover the research of the Earth System Research Laboratory's (ESRL) Physical Sciences Division (PSD) over the last five years. The research areas and related topics for the review are:

1. Observing the Physical System

Observations are critical for monitoring, analyzing, interpreting and predicting atmospheric, oceanic, cryospheric, and land surface processes. PSD has expertise in the design, testing, development, deployment, and maintenance of *in situ* and remote sensing observing systems that advance an observation-based process understanding of the current environmental conditions, how these conditions may be changing, and why. PSD sustains a long-term monitoring program of research-quality observations of key environmental data that provide critical information on boundary and surface layer fluxes between and among the atmosphere, ocean, sea-ice, and land. PSD makes strategic use of observations to advance scientific understanding of physical processes controlling high-impact extreme weather and climate events that include flux measurements in tropical cyclones and vertical profiles of atmospheric systems for nowcasting the intensity and duration of extreme precipitation. Advances in PSD's observation-based scientific understanding are used to guide development of physically based parameterizations of physical processes that can improve the skill and reliability of global and regional forecast models.

PSD observations of key parameters range from the microscale to the synoptic scale, and include air-sea/ice/land fluxes, cloud and sea-spray microphysical properties, surface and cloud radiation, tropospheric winds, orographic precipitation, soil moisture, and aerosols. Through its engineering expertise, PSD has the flexibility to obtain these kinds of measurements from land-based sites, research aircraft, and research vessels at sea. Examples include a long history of using ships to investigate air-sea transfer processes in the tropical ocean to better understand and parameterize these interactions in climate models, the establishment of long-term Arctic atmospheric observatories to better monitor and understand changing conditions in the Arctic, the development and deployment of a novel radar system for measuring the ocean's sea spray

layer from aircraft (a critical and poorly observed variable needed for the accurate prediction of hurricane track and intensity), and the operation of a wind profiler and surface meteorological network currently deployed across California and the Pacific Northwest to support the monitoring and improved prediction of heavy precipitation events, and to help address associated flooding and water resource management challenges.

2. Understanding the Physical System

An integrated understanding of Earth system processes spanning weather and climate timescales is essential to improve the quality of environmental intelligence NOAA delivers to the nation. PSD research describes, interprets, and assesses the predictability of weather and climate variations and trends on time scales ranging from hours to a century. PSD applies innovative weather and climate diagnostic methods to advance capabilities to detect, understand, explain, and predict weather and climate extreme events, and trends in these extremes. Understanding how weather and climate conditions are currently being impacted and may be affected in a changing climate not only provides early warning and informs preparedness, but also identifies prospects for improved future forecasts and predictions. PSD's efforts to improve current knowledge of the complete water cycle advance our ability to fully understand the linkages between weather, climate, and water. The collective understanding from PSD research provides the foundation to create effective and credible scientific knowledge that is needed to inform policy, planning, and decision making in the management of current and future risks.

For example, reanalyses tools, both developed and assessed by PSD scientists, contribute to the ability to investigate and understand the physical system, and are a mechanism for PSD science to extend to the broader scientific community. Carefully crafted attribution studies carried out by PSD scientists are critical for establishing the principal causes or physical explanation for observed climate conditions and phenomena. Analyses of hydrometeorological measurements made by PSD scientists have increased the capability to measure and predict precipitation, increasing the understanding of the evolution of droughts, floods, and stream flows from the short-term (e.g., extreme precipitation events over hours and days) to the long-term (e.g., estimating streamflow for the Colorado River in the coming years).

3. Modeling the Physical System

Observations and physical process understanding are transformed into predictive capabilities through numerical modeling. PSD develops and applies data assimilation systems that couple atmospheric, oceanic, and land data in global and regional earth system modeling to advance analysis, forecast, and prediction capabilities. PSD develops new parameterizations and forecasting approaches that are applied in global and regional forecast and prediction modeling systems to advance forecast and prediction capabilities. PSD advances the scientific basis to provide early warning and inform preparedness across weather and climate time scales through improved global and regional forecast and prediction modeling systems. Collectively, PSD's assimilation, development, analysis, and modeling research are critical to meet NOAA's mission responsibilities to understand and predict changes in climate, weather, oceans, and coasts, and to share that knowledge and information with others.

PSD continues its long-term relationship with the NOAA National Centers for Environmental Prediction to improve forecasts. PSD developed, maintains and continues to improve the Ensemble Kalman filter data assimilation system now used operationally for global weather prediction. PSD also developed a set of stochastic parameterizations designed to represent model

uncertainty in the operational NCEP global prediction model. In the realm of improved parameterizations, PSD developed an air-sea coupling module for NCEP's operational hurricane prediction model that includes an advanced sea-spray parameterization scheme to account for the complexity in air-sea interaction under high winds. It also developed a research platform to evaluate the cloud parameterization schemes in NCEP's global and regional prediction models using observations of cloud microphysics properties. Through the NOAA Wind Forecast Improvement Project, PSD is also working with the Department of Energy to improve the skill of NOAA's short-term weather forecast models at predicting foundational weather parameters (for example, wind speed, turbulence intensity, and icing conditions) that impact wind energy generation.

4. Research to Applications, Operations and Services

The transition of research findings, products and methods into applications, operations and services is fundamental to ensure the best available science is being applied to support NOAA mission responsibilities. To address growing service demands and needs for increased accuracy of weather and climate information, PSD works closely with the NOAA service line offices and external partners to accelerate the timely transfer of research advances into operational settings and the delivery of information for use in policy, planning, and decision making.

For example, PSD works closely with the NOAA National Weather Service (NWS) to incorporate weather and climate research to operations, including: implementation of testbeds, data assimilation techniques, regional prediction capabilities, air-sea heat flux parameterizations, post-processing forecast tools and techniques, seasonal and subseasonal climate, drought, and hazard outlooks, monitoring analyses, and El Nino Southern Oscillation (ENSO) diagnostic discussions. PSD partners with the NOAA National Marine Fisheries Service (NMFS) to develop actionable information in the form of science-based climate and weather knowledge that has been transformed to be readily understandable and immediately available to support decision making. PSD also collaborates with groups such as: the US Bureau of Reclamation (USBR), the U.S. Agency for International Development (USAID), the U.S. Army Corps of Engineers (USACE), the U.S. Department of Defense (DOD), the U.S. Department of Energy (DOE), the State of California Department of Water Resources (CA-DWR) and Sonoma County Water Agency (SCWA), and the National Integrated Drought Information System (NIDIS) to provide the best available weather and climate science to inform policy and management decisions. In addition, PSD conducts research on how stakeholders use weather and climate information to assess what is needed for the information to be useable and actionable, thus linking management planning processes and operational issues with potential uses of weather and climate forecasts and information.

Evaluation Guidelines:

For each research area reviewed, each reviewer will provide one of the following overall ratings:

- Highest Performance--Laboratory greatly exceeds the Satisfactory level and is outstanding in almost all areas.
- Exceeds Expectations--Laboratory goes well beyond the Satisfactory level and is outstanding in many areas.
- Satisfactory--In general, Laboratory meets expectations and the criteria for a Satisfactory rating.

- Needs Improvement--In general, Laboratory does not reach expectations and does not meet the criteria for a Satisfactory rating. The reviewer will identify specific problem areas that need to be addressed.

Reviewers are to consider the quality, relevance, and performance of the laboratory.

1. Quality: Evaluate the quality of the Laboratory's research and development. Assess whether appropriate approaches are in place to ensure that high quality work will be performed in the future. Assess progress toward meeting OAR's goal to conduct preeminent research as listed in the "Indicators of Preeminence."

➤ **Quality Rating Criteria:**

- *Satisfactory* rating -- Laboratory scientists and leadership are often recognized for excellence through collaborations, research accomplishments, and national and international leadership positions. While good work is done, Laboratory scientists are not usually recognized for leadership in their fields.
- *Needs Improvement* rating -- In general, Laboratory does not reach expectations and does not meet the criteria for a *Satisfactory* rating. The reviewer will identify specific problem areas that need to be addressed.

➤ **Evaluation Questions to consider:**

- Does the Laboratory conduct preeminent research? Are the scientific products and/or technological advancements meritorious and significant contributions to the scientific community?
- How does the quality of the Laboratory's research and development rank among Research and Development (R&D) programs in other U.S. federal agencies? Other science agencies/institutions?
- Are appropriate approaches in place to ensure that high quality work will be done in the future?
- Do Laboratory researchers demonstrate scientific leadership and excellence in their respective fields (e.g., through collaborations, research accomplishments, externally funded grants, awards, membership and fellowship in societies)?

➤ **Indicators of Quality:** Indicators can include, but not be limited to the following (note: not all may be relevant to each Laboratory)

- A Laboratory's total number of refereed publications per unit time and/or per scientific Full Time Equivalent scientific staff (FTE).
- A list of technologies (e.g. observing systems, information technology, numerical modeling algorithms) transferred to operations/application and an assessment of their significance/impact on operations.
- The number of citations for a lab's scientific staff by individual or some aggregate.
- A list of awards won by groups and individuals for research, development, and/or application.
- Elected positions on boards or executive level offices in prestigious organizations (e.g., the National Academy of Sciences, National Academy of Engineering, or fellowship in the American Meteorological Society, American Geophysical Union or the American Association for the Advancement of Science etc.).
- Service of individuals in technical and scientific societies such as journal editorships, service on U.S. interagency groups, service of individuals on boards and committees of international research-coordination organizations.

- A measure (often in the form of an index) that represents the value of either individual scientist or the Laboratory's integrated contribution of refereed publications to the advancement of knowledge (e.g., Hirsch Index).
 - Evidence of collaboration with other national and international research groups, both inside and outside of NOAA including Cooperative Institutes and universities, as well as reimbursable support from non-NOAA sponsors.
 - Significance and impact of involvement with patents, invention disclosures, Cooperative Research and Development Agreements and other activities with industry.
 - Other forms of recognition from NOAA information customers such as decision-makers in government, private industry, the media, education communities, and the public.
 - Contributions of data to national and international research, databases, and programs, and involvement in international quality-control activities to ensure accuracy, precision, inter-comparability, and accessibility of global data sets.
2. **Relevance:** Evaluate the degree to which the research and development is relevant to NOAA's mission and of value to the Nation.
- **Relevance Rating Criteria:**
 - *Satisfactory* rating -- The R&D enterprise of the Laboratory shows linkages to NOAA's mission, Strategic Plan, and Research Plan, and is of value to the Nation. There are some efforts to work with customer needs but these are not consistent throughout the research area.
 - *Needs Improvement* rating -- In general, Laboratory does not reach expectations and does not meet the criteria for a *Satisfactory* rating. The reviewer will identify specific problem areas that need to be addressed.
 - **Evaluation Questions to consider:**
 - Does the research address existing (or future) societally relevant needs (national and international)?
 - How well does it address issues identified in the NOAA strategic plan and research plans or other policy or guiding documents?
 - Are customers engaged to ensure relevance of the research? How does the Laboratory foster an environmentally literate society and the future environmental workforce? What is the quality of outreach and education programming and products?
 - Are there R&D topics relevant to national needs that the Laboratory should be pursuing but is not? Are there R&D topics in NOAA and OAR plans that the Laboratory should be pursuing but is not?
 - **Indicators of Relevance:** Indicators can include, but not be limited to the following (note: not all may be relevant to each Laboratory)
 - Results of written customer survey and interviews
 - A list of research products, information and services, models and model simulations, and an assessment of their impact by end users, including participation or leadership in national and international state-of-science assessments.
3. **Performance:** Evaluate the overall effectiveness with which the Laboratory plans and conducts its research and development, given the resources provided, to meet NOAA Strategic Plan objectives and the needs of the Nation. The evaluation will be conducted

within the context of three sub-categories: **a) Research Leadership and Planning, b) Efficiency and Effectiveness, c) Transition of Research to Applications (when applicable and/or appropriate).**

➤ **Performance Rating Criteria:**

- *Satisfactory* rating --
 - The Laboratory generally has documented scientific objectives and strategies through strategic and implementation plans (e.g., Annual Operating Plan) and a process for evaluating and prioritizing activities.
 - The Laboratory management generally functions as a team and works to improve the operation of the Laboratory.
 - The Laboratory usually demonstrates effectiveness in completing its established objectives, milestones, and products.
 - The Laboratory often works to increase efficiency (e.g., through leveraging partnerships).
 - The Laboratory is generally effective and efficient in delivering most of its products/outputs to applications, operations or users.
- *Needs Improvement* rating -- In general, Laboratory does not reach expectations and does not meet the criteria for a *Satisfactory* rating. The reviewer will identify specific problem areas that need to be addressed.

A. Research Leadership and Planning: Assess whether the Laboratory has clearly defined objectives, scope, and methodologies for its key projects.

➤ **Evaluation Questions to consider:**

- Does the Laboratory have clearly defined and documented scientific objectives, rationale and methodologies for key projects?
- Does the Laboratory have an evaluation process for projects: selecting/continuing those projects with consistently high marks for merit, application, and priority fit; ending projects; or transitioning projects?
- Does the laboratory have the leadership and flexibility (i.e., time and resources) to respond to unanticipated events or opportunities that require new research and development activities?
- Does the Laboratory provide effective scientific leadership to and interaction with NOAA and the external community on issues within its purview?
- Does Laboratory management function as a team and strive to improve operations? Are there institutional, managerial, resource, or other barriers to the team working effectively?
- Has the Laboratory effectively responded to and/or implemented recommendations from previous science reviews?

➤ **Indicators of Leadership and Planning:** Indicators can include, but not be limited to, the following (Note: Not all may be relevant to each Laboratory).

- a. Laboratory Strategic Plan
- b. Program/Project Implementation Plans.
- c. Active involvement in NOAA planning and budgeting process.
- d. Final report of implementation of recommendations from previous Laboratory review.

B. Efficiency and Effectiveness: Assess the efficiency and effectiveness of the Laboratory's research and development, given the Laboratory's goals, resources, and

constraints and how effective the Laboratory is in obtaining needed resources through NOAA and other sources.

➤ **Evaluation Questions to consider:**

- Does the Laboratory execute its research in an efficient and effective manner given the Laboratory goals, resources, and constraints?
- Is the Laboratory organized and managed to optimize the conduct and planning of research, including the support of creativity? How well integrated is the work with NOAA's and OAR's planning and execution activities? Are there adequate inputs to NOAA's and OAR's planning and budgeting processes?
- Is the proportion of the external funding appropriate relative to its NOAA base funding?
- Is the Laboratory leveraging relationships with internal and external collaborators and stakeholders to maximize research outputs?
- Are human resources adequate to meet current and future needs? Is the Laboratory organized and managed to ensure diversity in its workforce? Does the Laboratory provide professional development opportunities for staff?
- Are appropriate resources and support services available? Are investments being made in the right places?
- Is infrastructure sufficient to support high quality research and development?
- Are projects on track and meeting appropriate milestones and targets? What processes does management employ to monitor the execution of projects?

➤ **Indicators of Efficiency and Effectiveness:** Indicators can include, but not be limited to, the following (Note: Not all may be relevant to each Laboratory).

- a. List of active collaborations
- b. Funding breakout by source
- c. Lab demographics

C. Transition of Research to Applications: How well has the Laboratory delivered products and communicated the results of their research? Evaluate the Laboratory's effectiveness in transitioning and/or disseminating its research and development into applications (operations and/or information services).

➤ **Evaluation Questions to consider:**

- How well is the transition of research to applications and/or dissemination of knowledge planned and executed?
- Are end users of the research and development involved in the planning and delivery of applications and/or information services? Are they satisfied?
- Are the research results communicated to stakeholders and the public?

➤ **Indicators of Transition:** Indicators can include, but not be limited to, the following (Note: Not all may be relevant to each Laboratory).

- a. A list of technologies (e.g. observing systems, information technology, numerical modeling algorithms) transferred to operations/application and an assessment of their significance/impact on operations/applications.

- b. Significance and impact of involvement with patents, Cooperative Research and Development Agreements (CRADAs) and other activities with industry, other sectors, etc.
- c. Discussions or documentation from Laboratory stakeholders

Proposed Schedule and Time Commitment for Reviewers:

The on-site review will be conducted May 12-14, 2015 in Boulder Colorado. Two teleconferences are planned with the Deputy Assistant Administrator for OAR, who will be the liaison with the review team and for the completion of the report. The goal of the first teleconference, in April 2015, will be to discuss the charge to you, the reviewer, as well as the scope of the review, focus areas for the review questions to be addressed, and initial information provided to reviewers that addresses the questions. In the second phone call, to be scheduled for early May 2015, the Deputy Assistant Administrator will discuss the draft review agenda and the reporting form for reviewers to use for their evaluations. During this call, we ask that you as a reviewer identify any additional information needs. All relevant information requested by the review team will be provided on the review website at least two weeks before the review and prior to the second pre-review teleconference with the review team.

Each reviewer is asked to independently prepare their written evaluations on each research theme, including an overall rating for the theme and provide these to the Chair with a copy to Michael Uhart in OAR headquarters. The Chair, a Federal employee, will create a report summarizing the individual evaluations. The Chair will not analyze individual comments or seek a consensus of the reviewers. We request that within 45 days of the review, the review team provide the draft summary report to the Deputy Assistant Administrator, OAR. Once the report is received, OAR staff will review the report to identify any factual errors and will send corrections to the review team. The final individual evaluations and the summary report are to be submitted to the Assistant Administrator, OAR.

Review Team Resources:

OAR will provide resources necessary for the review team to complete its work.

1. Review Team Support: Information to address each of the Laboratory's research themes to be reviewed will be prepared and posted on a public review website. Preliminary information will be compiled and posted before the first teleconference meeting and the second major update, which includes final review presentations and materials, will be provided prior to the second teleconference. A copy of all the information on the website will also be provided to reviewers at the review.
2. Travel arrangements for the onsite review will be made and paid for by OAR.