NOAA Office of Oceanic and Atmospheric Research
Chemical Sciences Laboratory
Science Review

February 23-25, 2021

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 internal OAR/NOAA use for planning, programming, and budgeting, and external interests. It helps the Laboratory in its strategic planning of future research directions. These reviews are also intended to ensure that OAR laboratory research is linked to 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.

Each reviewer will independently prepare his or her written evaluations of one or more research areas. The Chair, a Federal employee, will create a report summarizing the individual evaluations. The Chair will not analyze individual comments nor seek a consensus of the reviewers.

Scope of the Review: This review will cover the research of the Chemical Sciences Laboratory (CSL) from 2015 to the present. The research themes and related topics for the review are: 1) Climate, 2) Air Quality, and 3) the Stratosphere.

Description of CSL Research Themes:
For this review CSL research will be evaluated under the topics of climate, air quality and the stratosphere. The foundational aspects of all CSL research are high quality observations and numerical models. Models and observations are essential to advance understanding of the chemical, physical, dynamical, and radiative processes in the atmosphere. Observations are obtained in the laboratory under controlled conditions, in the atmosphere during field studies, or from remote sensing instruments. A variety of numerical models of the atmosphere with a range of complexity are used, often in collaboration and cooperation with other scientific groups. Observations are used to evaluate models with the goal of identifying improvements to the representations of atmospheric processes and deriving guidance for continued observations and laboratory measurements. This iterative process is fundamental to advancing our scientific understanding of climate, air quality, and the stratosphere. Developing and deploying customized instrumentation and new experimental techniques are principal aspects of CSL's approach to obtaining new observations, particularly instruments that are sensitive and selective for "difficult-to-measure," atmospheric gases and particles.

1. Climate Research

Objective: Improved understanding of the processes that affect atmospheric composition and the impacts of those changes on Earth's climate system

CSL climate research has two focal points: (1) understanding aerosol interactions in the climate system; and (2) characterizing the emissions, transport, transformations, and distribution of key climate species. CSL climate research results in an increased understanding and quantification of the radiative, chemical, and dynamical processes that influence climate with a goal of reducing major uncertainties in climate models and, hence, improving our understanding of our current climate and confidence in future climate projections.

Aerosols and their interactions in the climate system are the greatest uncertainties in our ability to model the current and future climate system. The role of aerosols in the climate system is multifaceted, requiring sophisticated instrumentation to measure various parameters such as size distribution, mass, aerosol optical depth, composition, scattering, and absorption. Observations and modeling of aerosols are critical in order to quantify the transport (regionally/globally) and distribution of aerosols that absorb solar radiation and warm Earth's atmosphere (e.g., black carbon) and scatter solar radiation and cool Earth's surface (e.g., sulfate aerosols), including delineation of new chemical pathways for marine sulfate aerosol formation. Observations and modeling also contribute to understanding the climate impacts of aerosols that are not yet well understood (e.g., secondary organic aerosols). Aerosols also play an important role in the climate system due to aerosol-cloud interactions. The influence of aerosols on regional cloud formation, extent, optical properties (Earth's radiation budget - ERB), and precipitation is a continuously evolving field of research. Remote and in-situ observations from the surface, aircraft, ships, and satellites in conjunction with models and machine learning are used to improve the understanding of cloud systems and microphysical processes in order to reduce the uncertainty in determining how aerosol-cloud interactions impact the climate system.

CSL climate research also addresses other key climate species including tropospheric ozone, methane, substitutes for ozone-depleting substances (including hydrofluorocarbons, HFCs), and others. These species contribute directly to climate forcing, influence many climate feedback processes, link climate change and air quality, and are areas of current focus for policy formulation. The distribution and transport of tropospheric ozone influences regional and global climate and ozone is an important trace species for testing climate models. Quantification of the emissions and distribution of chemically active greenhouse gases such as methane is critical in understanding regional and global climate change. Laboratory and modeling studies of solvent and refrigerant replacement chemicals are used to estimate their climate impacts. Observations and modeling of water vapor in the upper troposphere and lower stratosphere (UT/LS) increase our understanding of water vapor's abundance and distribution, which is a critical factor in determining the amount of radiation lost to space and thus determining the energy budget of Earth's surface (also addressed under stratospheric research).

CSL climate research is advancing scientific knowledge, contributing to national and international assessments, and is disseminated to stakeholders. CSL was a lead participant in the 4th US National Climate Assessment, the scientific state-of-understanding assessment report for decision-makers.

2. Air Quality Research

Objective: Improved scientific understanding of processes that influence air quality on local, regional, and global scales to support informed air-quality decision-making at national, state, and local levels

CSL air quality research has three focal points: (1) characterizing emissions and emission trends; (2) understanding chemical, physical, and radiative processes that influence atmospheric composition (i.e., air quality); and (3) understanding atmospheric transport processes from local boundary layers to long-range (e.g., global; stratospheric) flows. Air quality research encompasses directly emitted pollutants, such as carbon monoxide (CO), as well as ozone (O_3) and particulate matter (PM2.5), which are formed by complex chemical reactions in the atmosphere that are influenced by atmospheric composition, physical parameters (e.g., temperature; humidity, sunlight), and mixing and transport. Moreover, poor air quality typically had been considered a summertime phenomenon, but CSL research has shown that colder weather and nighttime chemistry also contribute to air quality degradation.

Emissions from the transportation sector have primarily been responsible for contributing to poor air quality. However, those emissions have been substantially reduced by regulation, and now other sources, such as volatile chemical products (VCPs) are becoming relatively more important. These newly recognized sources influence the chemistry of ozone and PM2.5 formation and require new research strategies (e.g., advanced analytical instrumentation) to understand. A warming climate has also contributed to air quality issues with more frequent large wildfires, especially in the western U.S., that emit massive quantities of species (e.g., aerosols, CO, nitrogen oxides) that degrade air quality locally, but also transform chemically during transport and degrade air quality in regions far downwind.

To more fully understand the chemical and physical processes responsible for changes in air quality, simultaneous deployment of a large suite of measurements is critical, including those for gas phase species, aerosol species, and physical parameters. While CSL has extensive measurement capabilities, to reach the scientific objectives of field missions, such as the Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) study, CSL actively engages in collaborations with other organizations. To fulfill mission objectives CSL also utilizes different types of sampling platforms, including aircraft, ships, mobile vans, and unmanned aircraft systems (UASs).

Understanding atmospheric transport and mixing processes is essential for improving air quality predictive capabilities, but measurements of these processes are difficult. CSL research into developing and deploying remote sensing instruments has proven critical in advancing this understanding. On regional and larger scales, O_3 lidar has demonstrated that long-range transport in both horizontal and vertical dimensions can be a significant factor in local air quality exceedances of O_3. Doppler lidars have been developed and deployed at CSL that measure wind fields in complex terrain. These observations, for example, inform the placement of wind turbines for renewable energy production. Smaller Doppler instruments have been developed for aircraft and are used to determine complex flows in urban areas and coastal regions.

CSL research improves the predictive capability that is essential for air quality management and forecast applications, including a demonstrated capability in working with stakeholders to identify their needs up front, and then communicating research results to air quality decision-makers in a timely, user-friendly manner. For example, national policy, such as the push to increase domestic energy production via oil and natural gas development, has led to significant impacts on regional and local air quality. CSL research is addressing this and other emerging air quality issues through laboratory studies, instrument development activities, intensive field studies coupled with model analysis, and providing the resulting scientific information to users.

3. Stratosphere Research

Objective: Improved understanding of stratospheric composition and chemistry and the impacts of stratospheric changes on the troposphere (e.g., climate, weather, etc.)

CSL stratospheric research has four focal points: (1) studying the relationship between climate change and changes in the stratosphere; (2) examining the chemistry, composition and transport features of the upper troposphere and lower stratosphere; (3) developing and using instrumentation to measure key species such as ozone, black carbon, aerosol composition, water vapor, and sulfur dioxide in the stratosphere; and (4) developing and using atmospheric models to understand the dynamical coupling of the stratosphere and troposphere.

There is strong evidence that climate change and changes in the stratosphere are related. Examples of this include the connection between the recovery of the stratospheric ozone layer and climate change, connections between increases in stratospheric water vapor and surface temperature changes, and changes in stratospheric circulation that influence, and are influenced by, climate change. It is also clear that stratospheric changes affect surface weather. For example, sudden stratospheric warming events in Arctic winter can induce extreme cold-air outbreaks over large regions at the Earth's surface. Finally, the stratosphere has become a focal point for climate intervention strategies.

After decades of study, there is still much to learn about the chemical composition of the stratosphere and the chemical and physical processes that occur in this upper region of the atmosphere. In large part, these gaps of understanding are due to the difficulty of obtaining high quality observations. CSL has had long-standing collaborations with NASA to instrument high-flying aircraft to study stratospheric aerosol, ozone, and water vapor. The interest in understanding the chemistry and budget of sulfur in the stratosphere is increasing. Historically, research opportunities for this work came about from major volcanic eruptions. Currently there is much discussion of intentional release of sulfur species to the stratosphere to enhance sulfate aerosol abundance and mitigate global warming. Policy decisions of whether or not to implement these interventions would benefit from a full scientific understanding of the stratospheric sulfur cycle in order to determine the optimal approach and what unintended consequences may arise.

With state-of-the-art instrumentation and inventive collaborative approaches for in-situ sampling, CSL is advancing the scientific understanding of the stratosphere. These cutting-edge observational activities are intimately linked to advanced numerical modeling approaches used by CSL scientists. CSL modeling research uses in-situ and satellite data, as well as reanalyses of existing data, to further understand the causes and consequences of changes in stratospheric composition and dynamics that affect climate, weather, and climate intervention proposals.

CSL makes ongoing contributions to (1) advancing scientific knowledge regarding the processes involved in ozone-layer depletion by chlorofluorocarbons and other compounds, (2) assessments of the state of knowledge regarding stratospheric ozone, and (3) communication of that information to policymakers in formats that are useful to their decision-making process. For example, CSL continues its long tradition of co-leading state-of-understanding scientific assessment reports of stratospheric ozone depletion for decision-makers, a role it has played since the inception of the United Nations Montreal Protocol, the 1987 international agreement that protects the ozone layer. U.S. policy makers, the U.S. chemical industry, EPA, and other national and international agencies rely on these scientific assessments as a basis for development of scientifically sound, well-informed policies.

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.

In addition to the overall ratings for each research area, if possible, also assign one of these ratings for the subcategories of Quality, Relevance, and Performance within the research area reviewed. Please note that ratings for each research area are relative to the Satisfactory definitions shown below.

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 Quality."
   - **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.
   - **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 scientists 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 Research mission and priorities 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.
   - **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 NOAA strategic documents 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's Research mission and priorities 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.

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 a diverse 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

<u>Proposed Schedule and Time Commitment for Reviewers:</u>

The review will be conducted virtually on February 23-25, 2021. Prior to the review, two teleconferences are planned, the first with the OAR Deputy Assistant Administrator for Science, who will be the liaison with the review team and for the completion of the report. The goal of the first teleconference, in December 2020, 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, planned for February 2021, we will discuss the draft review agenda and the reporting form for reviewers to use for their evaluations. During both calls, we ask that you as a reviewer identify any additional information needs. All relevant information requested by the review team will be provided to the review team as soon as the information is available and will also be posted 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 the OAR Strategic Management Team (oar.hq.smt@noaa.gov). 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 panel provide the draft summary report to the OAR Deputy Assistant Administrator for Science with a copy to the OAR Strategic Management Team (oar.hq.smt@noaa.gov). After receiving the draft report, the Strategic Management Team will ensure that the report meets the requirements before sending it to the CSL review team. CSL will complete a factual (technical) review and provide any proposed changes in "Track Changes" format with a corresponding explanation for each proposed change. CSL will submit these revisions to the Strategic Management Team for transmission to the review panel chair. Within 30 days of receiving the corrections, we ask that the reviewers make any needed edits and submit the final summary report to the OAR Assistant Administrator, OAR Deputy Assistant Administrator for Science, and CSL Director, with a copy to the OAR Strategic Management Team.

Review Team Resources:

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