Global Monitoring Division

Recommendations from the

2002 and 2008 GMD Reviews

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Goddard Institute for Space Studies
2880 Broadway
New York, NY 10025

Code 940

June 21, 2002

Dr. Alfred M. Beeton
Chair, NOAA Science Advisory Board
14th and Constitution Avenue, NW
Washington, DC 20230

Dear Dr. Beeton,

We enclose our review of the scientific program of the NOAA Climate Monitoring and Diagnostics Laboratory. Overall, we view the Laboratory as an exemplary and invaluable national resource. The ability of CMDL to excel in the face of a decline in real resources during the past decade is an indication of the dedication of some exceptional people. However, this success cannot be sustained without substantial strengthening of resource support. We hope that increased recognition of the need to understand long-term change of the atmosphere, and recognition of CMDL responsibilities for atmospheric monitoring, will make it possible to find ways to address these resource needs.

Cordially,

Original signed by

James E. Hansen, Chair

John Cunningham, NPOESS
James Edmonds, University of Maryland
Robert Harriss, NCAR
Arthur Maxwell, University of Texas
Steve Pacala, Princeton University
Len Pietrafesa, North Carolina State University
Richard Rosen, AER, Inc.

cc: David L. Evans (NOAA), David J. Hofmann (NOAA)
Michael Uhart (NOAA), Lucia Tsaoussi (NOAA)

Scientific Review of the National Oceanic and Atmospheric Administration Climate Monitoring and Diagnostics Laboratory

May 22-24, 2002

1. Importance of the Work and Relevance to Society

The Climate Monitoring and Diagnostics Laboratory (CMDL), based in Boulder, Colorado, is one of 12 Research Laboratories/Centers of the National Oceanic and Atmospheric Administration's Oceanic and Atmospheric Research (NOAA-OAR) Line Office. CMDL conducts long-term monitoring of the sources, sinks, and trends of global distributions of atmospheric constituents associated with three important national and international issues: climate change, ozone depletion, and baseline air quality.

CMDL is an important national resource producing unique and valuable contributions to national and human welfare. CMDL data on climate change, ozone depletion, and air quality are used by scientists within CMDL, across the United States, and around the world as a foundation upon which to build and test scientific understanding of atmospheric variability and change. CMDL has created a continuous record of atmospheric observations that describe aspects of the state of the atmosphere over time and space. CMDL products make possible human understanding of climate change, ozone, and baseline air quality in a manner that facilitates the development of policy informed by the best available data. CMDL monitoring and research are guided by the NOAA mission to predict and assess climate change on time scales from seasonal to centennial. CMDL's commitment to continuously measure atmospheric constituents and radiation while maintaining the highest standards is vital to the success of the NOAA mission, and it is an invaluable asset to the Nation and to the world.

2. Productivity and Quality of the Work

CMDL continues to literally set the standard for monitoring atmospheric constituents and radiation, establishing a benchmark against which the international community judges its own performance. The quality and value of CMDL's data and research are reflected in the more than 13,000 citations of CMDL publications in the scientific literature in the past 10 years. The wealth of data and quality of its research have made CMDL attractive to some of the world's top scientists. These scientists have pushed the frontier of knowledge in the areas of climate change, ozone, and baseline air quality, and have thereby helped to articulate the data requirements to advance scientific understanding still further. The interaction with user communities has been essential to the health and vitality of the Laboratory. The Laboratory has been highly successful in leveraging its resources with those of other organizations in cooperative enterprises and, in the process, promulgating its high standards in the wider national and international research communities.

In recent years limited resources have forced changes at CMDL. The number of students at CMDL dropped from 10 to 5 between 1998 and 2002. Recruitments of new scientific staff

declined from 11 to 3 during the same period. Total employees declined from 92 to 81. This has resulted in an aging staff, particularly in leadership positions, with fewer resources available for use in activities outside data collection, quality control, and archiving.

The carbon cycle group, for example, is one of the strongest centers for scientific leadership and data development in the world. Despite its excellence and international prominence, the carbon cycle group has suffered in recent years because of declines in inflation-adjusted funding. In 2001 two ship transects were dropped – the data lost forever. CIRES employees in the group could be hired only for three months at a time due to delays in the funding process, creating uncertainty in planning and inefficiencies in operations. Despite its economies and improvements in efficiency, the group remains hard pressed.

The scientific productivity of the entire CMDL program shows signs of potential decline due to the strain in simply maintaining the high quality products for which CMDL has become world renowned. A decreasing staff leaves the institution with low morale and vulnerable to the loss of key personnel. In some parts of the organization staff size has fallen below critical mass, undermining the institution's ability to provide leadership to the scientific community. While some parts of the organization are intellectually vital and maintain morale, resource limitations present a clear and present danger to the health and vitality of one of NOAA's and America's precious national resources.

3. Responsibilities and Opportunities

Increased recognition of the need to understand the natural state and variability of the atmosphere and the possible influence of humans on the atmosphere leads to new challenges and responsibilities for CMDL. At the same time, these challenges represent an opportunity to invigorate the scientific program and revitalize the workforce internally and via increased external interactions. We discuss four research areas that are central to the CMDL mission.

3.1 Carbon Cycle

The CMDL Carbon Cycle group led by Pieter Tans is the single most important effort of its kind in the world. The group organizes the only systematic and global collection of data on atmospheric CO_2 and related gases, and performs approximately 80% of the measurements. Its GLOBALVIEW data set is the foundation of virtually every scientific paper that relies on global measurements of atmospheric CO_2, and is used extensively in all important global assessments. The group's policy of timely and open data availability and its impressive web-based data distribution system provide a model that should be copied by other labs within NOAA and by other federal agencies. The data are universally trusted because of the scientific reputations of the scientists involved and because the group has organized an innovative system of measurement inter-comparisons with other labs. Together, the open-handed policy on data distribution and rigorous standards have led to collaborations with dozens of scientists of other institutions and many critical findings. Moreover, the group has itself made or led several of the most important discoveries about the carbon cycle, including the discovery of the Northern

Hemisphere carbon sink. Finally, the group has consistently pioneered new techniques including inverse modeling methods and the use of very tall towers and aircraft to study the signature of CO_2 sources and sinks in a fluctuating planetary boundary layer.

The impending expansion of research outlined in the U.S. Carbon Cycle Science Plan had its origins in Pieter Tan's effort in 1995 to establish an expanded network of aircraft sampling of CO_2 in the US (the "Carbon America" plan). Since then, the CMDL Carbon Cycle group has been at the forefront of the effort to organize the community of US carbon cycle scientists and agencies around a cooperative plan. Their behavior is a model for the successful application of NOAA's Research Initiatives process. The inclusion of the first new funds in 2002 may enable a much-needed doubling of the CMDL Carbon Cycle group over the next five years.

The U.S. Carbon Cycle Science Plan includes a wide array of field inventories, intensive process studies, modeling, data assimilation methods development, and atmospheric sampling from towers and aircraft. The CMDL Carbon Cycle group is the only group with the expertise to construct and operate the backbone of the system. If implemented fully, the CMDL plan will require 20 additional positions, mostly hired through the joint institutes. These personnel will be necessary simply to make the measurements and process the data. The planned expansion of the group into 4000 ft^2 of newly renovated space is obviously essential. The committee has every confidence that the group will be able to process and distribute the data, because of its past performance and awareness of the size of the new problem. However, the totality of the measurements outlined in the U.S. Carbon Cycle Research Plan will require new and complex methods of data assimilation. Although the CMDL will continue to develop important new methods of analysis, the size of the new effort makes it inevitable that most of the methods will be developed by other institutions. It is thus critical for the CMDL to partner with these efforts.

In the flurry of activity over the U.S. effort, the CMDL must not lose sight of its global mission. The global sampling network is currently too sparse to allow useful estimation of fluxes from several entire continents and ocean basins. A backbone global monitoring network is required. The Carbon Cycle Group plans a modest but vital expansion of its global network to fill holes in the current network including 2 new shipboard ocean transects (L.A. to New Zealand and N.Y. to Capetown) and new surface stations in Kenya, Indonesia, Brazil, Nauru, Bolivia, Spain and Sao Tome (off equatorial West Africa). NOAA should support this effort if at all possible, because the CO_2 problem is global and because the large holes in the existing network greatly increase uncertainty in inverse modeling estimates of all regions.

3.2 Methane

Methane is a powerful greenhouse gas, a source of stratospheric water vapor, and a participant in tropospheric photochemical processes that modulate atmospheric concentrations of crucial constituents like ozone and the hydroxyl radical. Thus, methane cuts across the interests of most of the science programs in the CMDL. CMDL research programs will be essential to documenting any changes in atmospheric composition that may result from future methane emission reduction programs by the U.S. or other nations. CMDL researchers are also well positioned to be actively involved in studying possible connections between anthropogenic

methane emissions and observed increases in stratospheric water vapor. An enhanced program of methane research will require smaller, robust, less expensive sensors for methane detection at remote field sites. The CMDL trace gas scientists could lead a research and development program on next-generation methane measurement instrumentation.

In the United States, recent annual estimates of greenhouse gas emissions by the Environmental Protection Agency and Department of Energy suggest that methane emissions may already be stable or slightly declining. However, there is currently no systematic research program that integrates the CMDL global methane observations with models and other observations to understand how changes in methane emission sources relate to changes in atmospheric concentrations. CMDL should better integrate its various internal methane measurement efforts that cut across the carbon cycle and trace gas programs to address specific scientific questions related to the role of methane in global atmospheric composition and climate dynamics. CMDL should also try to use cooperative programs to address methane issues that cannot be covered by in-house researchers (e.g., modeling).

The CMDL has an active program of atmospheric methane concentration measurements at baseline monitoring sites around the world. These measurements help provide the world's best assessment of atmospheric trends and variability of global atmospheric methane. It is vital to U.S. national interests that the CMDL global atmospheric methane research and assessment program be continued. It is also important that the CMDL expand its methane research program to include selected assessments of urban and regional methane source emissions and trends in the United States. The North American Carbon Program offers an excellent opportunity for the design and evaluation of sampling strategies for assessing methane emission sources associated with large urban regions. A strategy for using atmospheric measurements to document changes in urban-to-regional scale methane measurements will require close collaboration between the CMDL carbon cycle and halocarbon/trace gas groups. This research would require additional staff and funding, as well as contributions from external collaborators. However, a substantial investment of NOAA core funds dedicated to methane research could result in national and international leadership in the crucial challenge of reducing uncertainties in understanding the role of methane in climate dynamics and change.

3.3 Ozone and Trace Gases

CMDL has been a world leader in monitoring both the state of stratospheric ozone and the chemical agents responsible for changes in that state. Although we have gained sufficient understanding of stratospheric ozone chemistry to support affirmative steps to protect the ozone layer, our understanding remains incomplete, requiring continued research and vigilance. The monitoring programs at CMDL are central to international efforts to prevent future degradation of the ozone layer, including any that might result from "surprises" not currently accounted for in our models of the ozone layer. To this end, CMDL scientists have positioned themselves at the frontier of trace gas measurement techniques, but shortages in several areas threaten this position, including technical personnel to maintain instruments, programming personnel to aid data management and visualization, and funds to purchase instrumentation. A critical problem

also exists in a lack of depth in the scientific staff; for example, expertise on the worldwide Dobson total ozone measurement currently resides primarily in one person.

Tropospheric ozone, a prime ingredient in urban smog and one of the most important air pollutants, is damaging to human health and agricultural productivity. In addition, this human-made low-level ozone causes a climate forcing (warming) that is at least 25%, and perhaps 50%, as large as that of CO_2. Our understanding of tropospheric ozone changes is very poor. CMDL ozone monitoring is important for improving our understanding of tropospheric ozone change and assessing the effect of actions aimed at reducing the amount of this pollutant. Ozonesondes provide valuable information about the vertical distribution of ozone, but additional sounding stations are needed. In a similar vein, soundings of water vapor in the lower stratosphere/upper troposphere are too sparse to characterize global trends. CMDL measurements of moisture in these regions are accurate and extremely valuable, and CMDL should be given the resources to extend them.

We note the outstanding success of CMDL programs led by Jim Elkins in measuring and making promptly available data on the long-term change of a variety of trace gases, which are important both for their role in stratospheric ozone depletion and their role as greenhouse gases. This group has not only responded to science community requirements but has also been at the forefront of defining and initiating needed measurements. Such capability is an important national resource that should be nurtured.

3.4 Aerosols and Radiation

Aerosols are recognized as causing a global climate forcing that is comparable in magnitude to the forcing caused by carbon dioxide, but the aerosol forcing is more complex, spatially inhomogeneous, and poorly measured. Aerosol properties must be measured precisely to allow determination of their role in global climate change. Changes of aerosols are anticipated in years and decades ahead as the United States and other countries attempt to reduce sulfur emissions, which cause acid rain and soot (black carbon) emissions, which have adverse health effects and contribute to global warming. Aerosols must be monitored to assess the effectiveness of policies aimed at reducing aerosols and to permit analysis of observed climate change.

Required aerosol measurements include monitoring from satellites and surface stations plus focused field studies. Contributions are needed from several United States agencies, but the monitoring requirements are identified as the responsibility of NOAA and ground station monitoring is specifically the responsibility of CMDL. CMDL has been monitoring aerosol properties from several sites for periods from years to decades, including complementary radiation measurements. However, resource constraints have limited the ability to maintain and upgrade these capabilities. Aerosol measurements have been suspended at one ground station (Sable Island), and it may seem tempting to sacrifice measurements at locations, such as Samoa and the South Pole, with limited aerosol amounts. We suggest that aerosol information in clean regions is important, and that enhancement of the information content of the aerosol measurements is needed. Radiation measurements are also in need of upgrading; for example,

spectral radiation monitoring with a stable interferometer would greatly increase the information content.

Enhancement of the aerosol and radiation activities is needed for CMDL to play its mandated role in climate monitoring. There has been a notable loss of personnel in recent years and an inability to upgrade or even maintain measurement capabilities. The aerosol, radiation, and climate problem necessarily involves participants from the broad scientific community. It may be helpful to seek the advice of this community in developing a strategic approach for CMDL's long-term monitoring of aerosols and radiation.

4. Nature of Workforce

CMDL must prepare for eventual turnover in its scientific and technical staff by engaging highly qualified young personnel. To ensure an orderly transition with staff who are familiar with the mission and responsibilities of present CMDL staff, the laboratory must seek out and hire new employees who will transition and carry forward the lab's research and monitoring activities. A strategy for hiring early career scientists and engineers should be developed immediately as part of the overall CMDL strategic planning process. It is likely that a mix of federal and CIRES hires will be required. New staff should include undergraduate and graduate students.

CMDL is conveniently located near several university campuses, a consortium of national universities, and a distributed center for atmospheric research. This gives CMDL direct access to the university research community and graduate students of that enterprise. By engaging this community of students, CMDL will benefit from a highly intellectually and physically leveraged workforce, while the students will gain experience in CMDL/NOAA related research, ensuring a pool of next generation scientists for the laboratory and agency.

Postdoctoral fellows, and early career scientists and engineers with several years experience beyond the Ph.D. degree also should be engaged. Post Doctoral staff will produce peer-reviewed publications at an ambitious rate and mentor graduate students assigned to work on CMDL projects as well. Support for the Post Docs must be provided by the parent agency NOAA via its Research line office. The support for the Post Docs must be provided separately from the existing CMDL operational lines and must be protected from budget cutbacks.

There are significant morale issues among some staff. This is not unexpected due to the prolonged period of increased responsibilities and declining funding. It is important for CMDL to pay close attention to staff mentoring and career development opportunities for both federal and contract employees. CMDL should work closely with the Director of CIRES on a program that reduces the perception of some employees that CIRES contract personnel are receiving "second class" treatment.

5. Data Management

The Carbon Group data staff have done an excellent job in designing their data presentation. They have made large volumes of data easily accessible to numerous and diverse users, and their method of presentation and tools provided greatly increase the utility. The timeliness is extraordinary; data less than one month old, nearly real-time for science class data, is provided.

The Carbon Group is faced with a significant challenge. They anticipate a large increase in the amount of data if their research initiative is funded. They also recognize that the worldwide interest in their data will attract many users to their website. These users are expected to span a range from interested citizens to amateur scientists to professional researchers. The number of expected web "hits" is a challenge, as is the need to present the data in a "user friendly" manner. Of equal importance is the age-old challenge of data -- raw data may not be correct, but the time required to ensure the quality of the data can make the formal posting of that data delayed by months to years, decreasing the opportunity to couple data with on-going observations of other phenomena.

The Group has made very admirable plans to meet all these objectives. For example, they have simplified the data search procedure, including a point and click map that will bring up a list of available data sets. Users can see the data in its rawest form, or they can request specialized displays. Multiple measurements can be presented on the same graph or multiple graphs can be presented on the same page. The unvalidated data are also displayed, but with a colored background so that they are clearly highlighted as unvalidated.

However, the Review Team makes two suggestions relative to data management at CMDL. First, should the expected funding become available and this data archive/retrieval system be brought on line and it proves to be a successful way of presenting data, there would be significant benefit to the other CMDL research groups to either copy the format (with obvious modification to fit their data) or to have their data sets included in this tool. This would provide the common look and feel that helps web users navigate and would ease the task of the outside researcher trying to locate different data sets for comparison. An example of this would be a researcher wanting to consider relationships among trace carbon gasses, halocarbons, aerosols, and surface ozone to evaluate related climate forcing functions. These data sets are produced by multiple CMDL research groups. We recommend that provisions for sufficient address and storage space be included in the design for future growth to include other appropriate data sets.

Second, NOAA has been tasked with maintaining data archives. NESDIS via NCDC has been assigned the responsibility of developing an archive to hold satellite data and all the *in situ* records from large data sources such as NEXRAD. There may be benefit in integrating the CMDL data into this larger set, so that researchers could easily find the "weather" data relating to anomalies in the CMDL data. Even if the sets are not integrated, consideration should be given to providing linkages to direct web users to the other archive web page. It is recommended that the CMDL data archive designers discuss the architecture and plans of the NESDIS CLASS (Comprehensive Large Array Storage System) development with that design team to gain lessons learned and help ensure that the data sets are compatible with each other.

6. Recommendations

CMDL, through its present monitoring system, has done an outstanding job in providing for a better understanding of (1) the forcing functions of climate change, (2) the causes of depletion of the ozone layer, and (3) the factors affecting baseline air quality. Many of these monitoring systems have evolved from situations of opportunity and through the development of measurements for specific problems. As stated above, these have been of great value to scientists and others concerned with long-term climate change, ozone depletion, and air quality. In fact, the data have become essential to developing national policy on environmental issues in a global community. The need for these data will only increase dramatically in the future.

In spite of improvements in funding, which included an adjustment to base of $500K in FY2002 and funding of a new Baseline Observatory Initiative ($2M in FY2001, $2.5M in FY2002), CMDL's ability to maintain continuity of measurements remains seriously hampered by the earlier long-term budgetary decline. Personnel have left and positions have not been filled. Instrumental development, acquisition, and operational activities have been curtailed or eliminated. Consequently, CMDL is handicapped in its ability to evaluate and implement that atmospheric monitoring deemed to be essential. Because many of the existing monitored parameters are interdependent, a new monitoring observation network may need to be designed that will integrate the observations on appropriate spatial and temporal scales. New instruments will be needed for such a network, and automation should be employed wherever possible to reduce manpower requirements - particularly in remote areas. CMDL is aware of these issues but requires the resources to deal with them.

CMDL has interacted proactively with the scientific community in designing its observational network, but it could do more in that regard – especially with scientists developing models for climate change, ozone depletion, etc. This increased interaction would be useful in identifying what other scientists require and, in addition, it would also acquaint others more fully with CMDL's existing monitoring programs. This could result in a stronger alliance and increased collaborations with and increased support from the scientific community.

Following are the overall recommendations of the review team to NOAA Research:

Recommendations

Recommendation 1: Maintain the Core National Asset

CMDL's baseline measurement record represents a national treasure and is among the best organized, systematic, global collection of climate forcing data in the world. This data collection effort must be continued to ensure the long-term record and to provide data to recognize trends and to inform policy decisions. The collection system is at risk due to lack of personnel and aging equipment, all driven by lack of sufficient resources.

The Committee recommends that NOAA provide funding to replace outdated/obsolete/high maintenance equipment and ensure that the CMDL baseline monitoring is maintained at a level at least equal to that required by inflation.

Recommendation 2: Human Resources—An Urgent CMDL Need

A balanced, active recruitment of undergraduate and graduate students, post-doctoral fellows, and early career scientists and engineers will be crucial to the continued leadership and excellence of the CMDL program.

The committee recommends that the CMDL program develop an aggressive effort to enhance its human resources.

Recommendation 3: Begin Planning the Next Scientific Initiative

The committee recommends that CMDL develop new cross-cutting research initiatives to follow on the success of the carbon cycle initiative.

A prime candidate would be to focus on methane. Methane is an important greenhouse gas, a precursor for tropospheric ozone, and a possible source of increased stratospheric water vapor. The Laboratory is already making many of the necessary measurements and is thus ideally positioned to lead the scientific community. The effort would also help to further unify the separate elements within CMDL.

Recommendation 4: Resources

It goes almost without saying that CMDL cannot execute its mission in the absence of adequate resources. A corollary to the need for appropriate resources is the need for timely resources. NOAA should develop mechanisms to streamline the process by which peer review of proposals from CMDL proceed.

The Committee recommends that adequate resources be provided to maintain and renew the core capability to continuously monitor over the long-term key atmospheric constituents relevant to climate change, ozone, and baseline air quality.

The Committee recommends that additional resources be provided to establish new initiatives as recommended above, and to train the next generation of scientific leadership in these fields.

Earth System Research Laboratory 2008 Atmospheric Chemistry Review

ESRL Director: Dr. Alexander MacDonald
Global Monitoring Division Director: Dr. James Butler
Chemical Sciences Division Director: Dr. A.R. Ravishankara

Earth System Research Laboratory
David Skaggs Research Center
325 Broadway Street
Boulder, CO 80305

Review Themes:

- Chemical Transformation and Long Range Transport
- Regional Air Quality
- Stratospheric Ozone
- Aerosols and Climate
- Carbon Dioxide, Methane, and Climate
- Non-Carbon Dioxide Climate Gases

Review Panel:

Reviewer	Position	Affiliation
Dr. Jarvis Moyers[1]	Acting Director of the Geosciences Directorate	National Science Foundation
Dr. Jack Kaye[1]	Director of the Research and Analysis Program of the Earth-Sun System Division in NASA's Science Mission Directorate	National Aeronautics and Space Administration
Dr. Leonard Barrie	Director of the Atmospheric Research and Environment Programme Department at WHO	World Meteorological Organization
Dr. Ronald Prinn	Director of the Center for Global Change Science and Co-Director of the Joint Program on the Science and Policy of Global Change	Massachusetts Institute of Technology
Dr. Mack McFarland	Environmental Fellow at DuPont Fluoroproducts and recognized with the 2007 Pedersen Award, a C&P Flagship Award, Environmental Respect Awards, and Environmental Excellence Awards	Dupont Company
Dr. Daniel Jacob	Vasco McCoy Family Professor of Atmospheric Chemistry and Environmental Engineering and the lead scientist for the GEOS-CHEM chemical transport model	Harvard University
Dr. Steven Wofsy	Abbott Lawrence Rotch Professor of Atmospheric and Environmental Sciences in the Department of Earth and Planetary Sciences	Harvard University
Dr. Owen Brian Toon	Founding chair of the Department of Atmospheric and Oceanic Sciences	University of Colorado

ESRL Panel Comment or Recommendation	**Laboratory Response**
For the non-CO2 climate gases science area, concern was expressed about limited current staffing and the need to avoid any reductions that might be contemplated.	Support for long-term monitoring of the non-CO_2 greenhouse and ozone-depleting gases has been recently augmented with two new hires and a recent reassignment of duties for another. ESRL continues active participation in potential recruitment through the Practical Hands-on Application to Science Education (PHASE) program and other educational and training opportunities, as well as through national and international partnerships.
The collaboration with NASA has been very effective, but the group should look to build additional connections.	Joint work with NASA is now emerging that makes use of unmanned aircraft systems (UASs). The GloPac (Global Hawk Pacific) mission, for example, is slated for late spring/early summer of 2009.
The reason for use of European Centre for Medium-Range Weather Forecasts (ECMWF) winds in Carbon Tracker (as opposed to winds from a NOAA-produced product) was not well explained.	Since the ESRL Atmospheric Chemistry Review, we subsequently subjected CarbonTracker, and the observation system supporting it, to an independent review that included panel members and formal observers from several agencies and universities. ESRL plans to incorporate NOAA/NCEP Global Forecasting System fields, and develop CarbonTracker to run a multi-model ensemble, but can only move slowly in that direction without some additional resources or support from other parts of NOAA. ESRL has begun some effort to do that already by enlisting some of the capabilities of other ESRL Divisions (i.e., PSD and GSD).
The connection to other activities, including those within NOAA and outside was not as well described as one might have expected.	Since the review, ESRL has begun taking the lead in developing carbon cycle science as a comprehensive activity within NOAA. ESRL scientists are now working with those from PMEL, AOML, GFDL, NESDIS, and NWS to develop a NOAA-wide carbon cycle research plan

Some details of the measurement approach (e.g., rationale for measurement locations, any use of Observing System Simulation Experiments (OSSEs) to optimize measurement distribution) were not well spelled out.	ESRL has recently performed several OSSEs to quantify the influence of certain existing sites as well as potential sites. ESRL is working toward making the recommended improvements from the CarbonTracker review which, in part, is why ESRL is taking the lead in developing a NOAA-wide carbon cycle research plan. As such improvements are made, we look to see OSSE's yield better information for locating additional observation sites.
The Non-CO2 Climate Gasses Group's ability to work on multiple platforms (aircraft, unmanned aerial vehicles, balloon) is a strength, although care should be taken not to overly rely on Altair and to be able to articulate strategy for use of platforms (NOAA and other).	In June-July 2009, ESRL instrumentation will operate on the NASA Global Hawk UAS during the GloPac mission, including a new ozone instrument developed at ESRL specifically for UAS deployments.
There may be a need for improved coordination of atmospheric chemistry transport modeling activities with other NOAA units e.g. NWS, GFDL.	The coordinated work of ESRL and GFDL on the Task Force of HTAP provides a key linkage for continuing work. In addition and funding permitting, GFDL will be a partner with ESRL and other NOAA and external colleagues in the planned 2010 field mission to study intercontinental transport, climate, and air quality in California. NWS involvement is planned in the modeling and forecasting aspects of the research.