Report of the Review of the

NOAA Earth System Research Laboratory

GLOBAL MONITORING DIVISION

21-24 May 2018

Review Panel

Dr. Anne M. Thompson, NASA-Goddard, Chair

Dr. David Crisp, JPL, Caltech
Prof. Kenneth J. Davis, Penn State Univ.
Prof. Eric Saltzman, Univ. Calif. - Irvine
Dr. Paul Stackhouse, NASA-Langley
Prof. Ray F. Weiss, Univ. Calif. – San Diego/Scripps Inst. Oceanography
Prof. Steven C. Wofsy, Harvard Univ.

Executive Summary. The Review of NOAA ESRL's Global Monitoring Division (GMD) by a 7-member Panel in May 2018 finds the highest level of quality measurements, with time-series increasing in demand and importance. GMD's datasets, which are as vital to the Nation's "climate readiness" as NOAA's satellites and radar are to "weather readiness," are delivered and interpreted by some of the finest scientists in the world. There is no substitute for GMD's observatories, data or expert staff in the US or elsewhere. Recent losses in GMD data collection brought about by budget challenges and reduction of staff and observatories pose a risk to the Nation that must be reversed as soon as possible. Specific recommendations include immediate hiring of 10-12 Federal staff and funding increases in GMD's three scientific sectors and supporting infrastructure. Furthermore, NOAA OAR needs to recognize the unique role of GMD in its research portfolio and commit to an appropriate growth trajectory. NOAA must also raise the visibility of GMD's remarkable track record of observations, science and technology. GMD management in turn should consider consolidation of some groups as it carries out succession planning. The Director needs to work with senior staff to plan the future more strategically and to reward and promote staff, including for external recognition. In all three scientific areas (Greenhouse Gases/Carbon Cycle, Ozone-Depleting Substances/O_3 & Water Vapor, Radiation/Clouds and Aerosols) GMD should leverage its expertise, networks, innovative and established capabilities to expand and sustain growth with stakeholder partners, other Agencies and evolving national programs. The recommended actions should pay back to NOAA as well as GMD. Renewed and better supported leadership will foster even better science and inspire the best talent to make careers with GMD as it continues to monitor the health of the earth's atmosphere.

27Sept 2018

1. OVERVIEW

1.1 Background & Summary

Every five years an Expert Peer Panel convenes to review the NOAA (National Oceanic and Atmospheric Administration) Global Monitoring Division (GMD). The 2018 Review was conducted from 21-24 May 2018 with Days 2 and 3 (22-23 May) coincident with the 46th GMAC, the Global Monitoring Annual Conference. The purpose of the Review is to report to OAR and GMD on (1) the alignment of GMD research with NOAA's Strategic Plan; (2) how GMD's work relates to NOAA's research priorities and mission; (3) the quality and relevance of GMD's work; (4) the effectiveness (performance) of GMD's work within the framework on NOAA's mission and budgets.

Operationally GMD research is carried out in five groups supported by Calibration/ Standards infrastructure and the Atmospheric Baseline Observatories (ABO):

- Green House Gases (GHGs) and Carbon Cycle
- Global Radiation
- Halocarbons and Other Trace Species (HATS)
- Ozone and Water Vapor
- Aerosols

The Review Panel, consisting of seven people, was briefed by OAR on two telecons ahead of the Review. The Panel was given written materials prior to the Review, including guidelines for the Review, NOAA's Strategic Plan and GMD's Research Plan, and all the presentation materials. Presentations by members of the five groups and visits to GMD laboratories were included in the Review, along with two lunches arranged with GMD staff. Because of the coupling of the Review with the GMD Global Monitoring Annual Conference (GMAC) the opportunities to interact with GMD staff and stakeholders, dozens of whom attended GMAC, and to ask questions about scientific findings and operations were greatly expanded beyond a typical review. However, there was less time for the Review Panel to prepare findings in an organized manner and to complete recommendations. The latter has delayed this Report.

GMD's activities are grouped into three Scientific Themes:

- Tracking Greenhouse Gases and Understanding Carbon Cycle Feedbacks "GHG/C"
- Monitoring and Understanding Changes in Surface Radiation, Clouds and Aerosol Distributions "Rad-CA"
- Guiding Recovery of Stratospheric Ozone "ODS/O_3"

The Reviewers were asked to evaluate the quality, relevance and performance of the scientific theme(s) closest to their expertise along with the Atmospheric Baseline Observatories (ABOs) and Calibration/Standards program. Each Panel member has provided OAR with pre-formatted Evaluation Reports that inform much of this Report. The Evaluations are summarized in the Table below (a blank means did not rate; H = Highest Performance; E = Exceeds Expectations). There was strong consensus in the Panel scores as well as in the Evaluation Reports that contained detailed write-ups of findings and recommendations.

Summary of Individual Ratings

Reviewer	Rating Categories	GHG/C	Rad-CA	ODS/O_3	ABO	Cal&Stds
Crisp	Overall	H	E	H	H	H
	Quality	H	E	H	H	H
	Relevance	H	H	H	H	H
	Performance	E	E	---	H	H
Davis	Overall	H/E	---	---	---	H
	Quality					
	Relevance					
	Performance					
Saltzman	Overall	H	E	E	H	H
	Quality	H	E	H	H	H
	Relevance	H	E	H	H	H
	Performance	H	E	H	H	H
Stackhouse	Overall		E		E	H
	Quality		H		H	H
	Relevance		H		H	H
	Performance		E		E	H
Thompson	Overall	E	E	H	H	H
	Quality	H	H	H	H	H
	Relevance	H	E	H	H	H
	Performance	E	S	E	H	H
Weiss	Overall			H	E	H
	Quality			H	E	H

	Relevance Performance			H H	H E	H H
Wofsy	Overall Quality Relevance Performance	H H H E		H H H E		

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:* Laboratory meets expectations and the criteria for a Satisfactory rating.

1.2 Summary of Laboratory-wide Findings and Recommendation

The criteria of the Panel evaluation were given by NOAA as: Quality, Relevance and Performance. The findings are summarized below.

1.2.1 Quality

The quality of NOAA GMD work in every area of activity is outstanding. GMD is not only an ESRL and NOAA star but it is one of the most distinguished and best-known scientific organizations in the Nation. In the three Scientific Theme areas – GHG/CC, ODS/O_3 and Rad-CA -- GMD is a leader, producing data that the global scientific community depends on. Of all the output produced by NOAA atmospheric modeling and measuring researchers, GMD's time-series datasets are *the irreplaceable* ones and the most in-demand. They are also the most enduring. Decade after decade, reports on the State of the Climate and national and international assessments rely on GMD. GMD leads with technology and interpretation as well as with the observations, available to all. Well-aligned with NOAA's Strategic Plan, GMD's delivery is top-notch.

1.2.2 Relevance

The relevance of GMD could not be higher. Not only does its scientific output, focused on the most important aspects of climate-related monitoring, support this finding but so do GMD's sustained interactions with national programs and international partners. There is no other laboratory or organization in NOAA or the Nation charged with the monitoring activities that GMD conducts. The observatories, standards and technology as well as its highly trained scientists and the products they release, cannot be duplicated or replaced. The three main reasons for this are: (1) the unique nature of GMD's in-situ observations, which complement and verify regional or space-based measurements; (2) the global distribution of its 60-year old observatories, with the standards maintained in GMD labs; (3) the high-quality scientists who are expert in assembling the data and interpreting it for NOAA's stakeholders. Metrics like publication per PhD scientist, the highest in NOAA, also attest to the eminence of GMD. National "environmental security" depends on GMD as does

global environmental health. No other Nation or research entity has GMD's infrastructure nor the specialized scientific staff who distribute and interpret the data.

1.2.3 Performance

GMD's remarkable performance owes to a well-defined set of priorities that match national needs as well as NOAA's Strategic Plan. GHG/CC, ODS/O_3 and Rad-CA foci with their five departmental units, have fostered technological growth along with the highest quality output in terms of datasets, interpretive publications and assessments. NOAA, the Nation and global stakeholders have benefited. This effort needs to be rewarded and expanded, not down-sized due to budget constraints or a mistaken impression that other methods or organizations can replace GMD's work, i.e., that it is obsolete. Case in point: GMD's recent finding that, after 20 years of steady decline, ozone-depleting CFC-11 is being produced in Asia. This alarming discovery implies that stratospheric ozone recovery is slowing down, a threat that no one anticipated. Only GMD and partners with their time-series and standards could have detected the CFC-11 change.

The performance of GMD is remarkably strong and becoming even stronger in many areas despite on-going challenges in resources. A post-2013 Review bump-up in budget allowed some critical observatory repairs to be made and GMD was able to maintain most of its staff and observing systems over the past 5 years. However, year-by-year inflation associated with normal salary increases, and with facility and equipment upkeep, has left GMD at virtually where it was in 2012, minus two ABOs. The total GMD staff continues to decline, from 123 ten years ago to 115 five years ago to 107 in 2018. Frequency of data-taking in some places has eroded; several stations have been shut down. *Thus, it has not been possible to implement the recommendations of the 2013 Report to expand rather than contract its science and to commit to succession planning.* Whereas expanded efforts and visibility for GMD's work were strongly recommended, their support within OAR has effectively declined. In summary, a statement that GMD finds itself in crisis in 2018 despite growing scientific prominence, impact and national need is not an exaggeration. This situation must be remedied by NOAA as soon as possible.

Summary: Grow, do not shrink, GMD. This requires funding increases in every area, not necessarily huge, but *solid and sustained*. Federal hires, 10-12 of them divided evenly between senior Management/group leaders and more junior scientists, need to occur as soon as possible.

Topical findings and recommendations for GMD as a whole appear in **Sections 2** and **3**. **Section 3** highlights specific findings and recommendations for the three Science Themes.

2. General Findings and Recommendations

2.1 Topic #1: GMD's Portfolio & Position in NOAA's Mission

Finding. The three themes of NOAA GMD, (1) greenhouse gases and carbon dioxide (GHG/CC); (2) ozone recovery (ODS/O_3); (3) radiation, clouds and aerosols (Rad-CA) are the most appropriate priorities for its mission. Its approach of in-house dedicated science leader experts taking data, developing new techniques, and reporting the measurements is the optimal way to assure the integrity and consistency of the information delivered to the US Government and its assessment activities. If the charge of NWS is to make us "weather-ready," GMD's work is to make the US "climate-ready" by collecting the best data for modelers and policymakers tasked with preparing for the century ahead. In other words, GMD is as important to the Nation as the National Weather Service.

Recommendation. The science conducted by GMD needs to expand to keep up with demands for climate-related data in all these areas and to enable partnerships that transfer knowledge for even greater benefit to the Nation and beyond. A fundamental change in OAR's priorities must take place if GMD is not to be destroyed one species, one unit or one facility at a time.

Related Facts. Advances in the three themes have been strengthened in the past 5 years (**Section 3**). Investments in each area have paid off. However, budget challenges and the shrinking workforce have prevented GMD from reaching its greatest potential. NOAA must recognize that OAR's most essential activities are carried out by the Labs that monitor environmental health and climate forcing variables, including atmospheric composition and radiative properties. GMD must be considered *the core* atmospheric observing lab within NOAA and ESRL for two reasons. Its unique, long-term datasets put other atmospheric data in context and are used to quantify feedbacks that constrain climate models. NOAA must give GMD's mission and activities higher ranking.

2.2 Topic #2: GMD Support and Resources

Finding. NOAA GMD is closely aligned with NOAA's Strategic Plan and with the needs of its stakeholders in the US and abroad, and it continues to excel in its core mission of monitoring atmospheric composition. This is an asset of strategic importance because changes in GHG/CC, stratospheric ozone, and radiation are essential to the health of the Nation and the planet. However, NOAA resources are not commensurate with the pre-eminence of GMD's mission, quality and impact.

Recommendations. Budget and hiring plans must support their work and both need to expand to allow GMD to better fulfill its mission. Funding from NOAA must be increased in every area. The ABOs must be maintained; there is no redundancy. The decline in numbers of Federal personnel need to be reversed. Succession planning to attract experienced leaders and to put promising junior scientists on a career track must occur as soon as possible.

Related Facts. There is no substitute for securing more NOAA funding for GMD because cutbacks in observations and personnel continue. Leading staff, who are charged with analyzing data and distributing it to stakeholders, cannot do their best when energy is

diverted into budget exercises, backfilling staff and writing proposals. Furthermore, the additional funds allotted after the 2013 Report have been undermined by rising expenses.

There appear to be no under-studies for the current Director and Science Deputy positions, all of whom have retirement five years closer than at the 2013 Report. The O_3/WV group has been without a Federal lead for more than 5 years. More junior levels need to be filled to keep up with analysis, publication and technology development. Having non-Federal employees, some of whom write independent proposals, detracts from core efforts and undermines each group's effectiveness as a whole. GMD notes that there are up to 10 unfilled Federal positions with qualified CIRES employees on site who could be potential high quality applicants.

2.3 Topic #3: GMD Visibility

Finding. The overall lack of visibility for GMD within NOAA is harmful and hard to understand. ESRL and GMD are scarcely mentioned in NOAA's Strategic Plan. Their data, scientific output and scientists are the first thing most US and international atmospheric researchers think of when they hear the word "NOAA." The lack of visibility undermines GMD's outstanding accomplishments and is detrimental to the morale of its exceptional staff. The succession recommendation of the 2013 GMD Report was not carried out.

Recommendation. NOAA and GMD both need to make GMD's work and its scientists more visible. Actions could include: (1) more publications postings, press releases and updated personnel websites; (2) NOAA awards and promoting recognition by professional societies.

Related Facts. The recommended actions cost little and they bring more visibility to NOAA as well as to GMD and ESRL. It should not be difficult to carry out the recommended actions. For example, AGU and AMS, have awards for a range of activities and for junior and mid-career scientists. GMD scientists do newsworthy projects around the world. Metrics of eminence are in the Report (Tab 8) provided to the Review Panel. Citations per PhD for GMD are higher than other OAR and ESRL Labs but GMD staff appear to lag in recognition. An awards committee could promote both Federal and CIRES scientists.

2.4 Topic #4 GMD Leadership & Management

Finding. Under pressure to do more work with fewer resources, GMD senior management has responded with positive steps, e.g., replacing Air Quality with Radiation as a core focus with the hiring of fresh leadership. The Director distributed funds to keep all core groups operating, a strategy that has allowed GMD to stay strong and even add some data products for stakeholders. However, other measurements were eliminated and key hires have been delayed. The overall perception among GMD staff is a lack of transparency on important decisions.

Recommendation. Senior management should follow best practices in working with group leaders as a team. The current five groups should be merged into three units that match the themes. This would make two units (Rad-CA, ODS/O_3) roughly comparable in

core support. Consolidation should save management costs and allow personnel more time to strengthen analysis output and visibility for those two groups.

Related Facts. Although the Director is the final decider, hiring and budget matters need to be discussed and alternatives considered strategically. Shared governance better aligns and inspires leaders and staff alike. A team approach also means envisioning new technology to keep GMD state-of-the art. Shared vision will energize and attract the scientists needed to sustain GMD's excellence and leadership. GMD needs to recruit the best people for positions that will transition in the next few years. GMD staff expressed frustration on lack of direction to the Panel. Consistent mentoring of junior and mid-level staff seemed to be lacking. Career paths for long-term CIRES personnel were most unclear.

2.5 Topic #5: GMD Leveraging & Partnerships

Finding. GMD's activities in the Nation's interest include leveraging work by stakeholders from many sectors and international partners as well. NOAA's mandate to play a leading role in national and international assessments rests on commitments from GMD scientists. GMD's observatories and datasets are integral parts of the WMO/GAW, Network for the Detection of Atmospheric Composition Change (NDACC), Integrated Carbon Observation System (ICOS), Global Climate Observing System (GCOS) and similar networks. Climate, ozone and similar assessments could not be sustained without GMD measurements. In addition, GMD is often called upon for calibrations, instrument intercomparisons and advice on data systems.

Recommendation. NOAA budgets and personnel must continue to support a range of activities that follow from national and international commitments to data collection, calibration, scientific reviews and the assessment process.

Related Facts. NOAA scientists are leaders in the National Climate Assessment, IPCC Assessments, WMO/UNEP Ozone Assessments and in related activities like SPARC-sponsored ozone profiles and water vapor assessments. The quality and impact of those reports depends on GMD's expertise. In turn the assessments raise the visibility of GMD data and people. For example, the US is obligated to monitor constituents to support the Montreal Protocol to Protect the Ozone Layer. The Protocol is a living agreement, with NOAA scientists having key roles at annual Meetings of the Parties. Any future agreements related to climate will depend on GMD's measurements of GHGs and CO_2 time-series and products. The strength of the US position in these discussions relies on the integrity of GMD's time-series and scientific experts.

2.6 Topic #6. Integration of Efforts Within and Beyond GMD

Finding. GMD's work is outstanding, fundamental and trail-blazing in a number of areas. Their data constitute the definitive record for tracking change in the atmospheric variables they measure. However, GMD could be even more effective with stronger integration of efforts within and across groups, across NOAA and beyond. Lack of visibility for GMD and stove-piping of various groups within NOAA have limited this growth area. Collaborative efforts are a necessary strategy for bringing in more external funding,

strengthening GMD science and for better serving the US Earth-system sciences community. Innovation is needed!

Recommendation. Collaborative opportunities for all of GMD's groups should be better exploited within GMD, across NOAA and with outside organizations.

Related Facts. Other NOAA entities are obvious customers for GMD data, e.g., ozone profiles for Air Quality modeling (ARL), products from the Rad-CA and GHG/CC for weather forecasts (NWS) and climate modeling (GFDL). Surface radiation and carbon fluxes, as measured by GMD, can reduce uncertainties in hydrological-land use and climate models. They are also missing pieces in evolving measurement programs like NEON (National Ecological Observatory Network), Ameriflux and Critical Zone Observatories. With groups within GMD combined to achieve critical mass and better sharing of resources (Topic 4), it should be easier to pursue collaborations and new funding opportunities.

3. Findings and Recommendations for the Three Scientific Themes

Important capabilities are detailed here along with guidance to enhance performance.

3.1 Theme: Tracking Greenhouse Gases and Understanding the Carbon Cycle

Findings. The GHG/CC theme constitutes the largest in terms of people and funding at GMD. It draws from the Carbon Cycle group as well as from many of the trace gas measurements in the HATS group. The legendary CO_2 record of GMD began in 1958 with measurements by Dave Keeling, SIO, at NOAA's Mauna Loa Observatory, Hawaii. Just as important, the GHG/CC staff has led in measurements of methane and N_2O and established the climate threat of these non-CO_2 GHG. Quite simply, the measurements of this group constitute the foundation of the Nation's (and the world's) understanding of the changing GHG composition of the atmosphere. Without their data we could not analyze past climate nor predict the future with any certainty.

The impact of the GHG/CC theme continues to grow because of the outstanding analysis systems that its scientists have developed (along with the data) with the global science community. Specific strengths of GHG/CC include:

- An optimized global CO_2 observing system, that augments the historical record from the ABOs with tall tower measurements, AirCore, airborne monitoring and participation in airborne experiments (mostly NASA-sponsored);
- The buildup and sharing of unique analytical tools for understanding these trace gas sources and transport: CarbonTracker, CarbonTracker-CH_4, CarbonTracker-Lagrange;
- A critical mass of top-notch scientists whose measurement capabilities, datasets and interpretive capabilities are matchless;
- *The* US system for validating new space-based CO_2 measurements.

However, the current mixture of junior, mid-career and senior scientists appears to be poorly organized and without a clear strategy for the future. GHG/CC scientists are exceptionally dedicated to "mission," staff expressed frustration about a lack of overall direction. They feel that are not having the impact they merit .

Recommendations.

- With GMD senior leadership, GHG/CC needs to develop a strategy that defines goals for the next 5 and 10 years along with appropriate implementation. Better integration of measurements and models within the Theme and with NOAA's climate model Labs and beyond, should be part of such a plan.
- Refresh GHG/CC leadership at all levels. There should be clear career paths and timetables for promotion of Federal staff and hiring promising CIRES scientists to Federal appointments. The group should be writing fewer external proposals.

3.2 Theme: Monitoring & Understanding Changes in Surface Radiation, Clouds and Aerosol Distributions

Findings. Two groups, G-RAD (operating the Surface Radiation Network (SURFRAD), Solar Radiation Urban Network (SOLRAD), NOAA Brewer Spectrometer Network (NEUBrew) and Aerosols (that runs NFAN (NOAA Federated Aerosol Network), constitute the Rad-CA activity. This theme is a welcome new emphasis since the 2013 Review, having replaced the Air Quality element that was more peripheral to GMD's mission. The radiative properties of clouds and aerosols and their feedbacks with surface radiation remain the largest uncertainty in understanding and predicting climate forcing. UV changes are linked to ozone changes so this theme is closely connected to monitoring ODS/O_3. Thus, the Rad-CA theme is central to NOAA and GMD's mission to build a strong climate data record.

G-RAD and aerosol scientists collect measurements of solar and thermal radiation that tell us how surface radiative forcing is responding to climate variations. The G-RAD group's datasets are world-class, highly relevant and applicable to many related projects that need the rigorously calibrated parameters that they measure. An essential function of G-RAD data is ground-truth for a host of satellites: NASA CERES, NOAA's GOES and the joint NASA-NOAA JPSS series. Specific capabilities of the Rad-CA include:

- The SURFRAD, non-US BSRN, SOLRAD, NFAN, NEUBrew, UV networks and radiation instruments at the ABO.
- Collecting radiation data that are invaluable for applications, e.g. monitoring agricultural yields, tracking changes in solar brightness.
- First-class instrumentation operated with meticulous protocols and with data traceable to the world standards (Davos, NIST).
- Deploying a suite of portable instruments on campaigns for targeted satellite validation and process studies.

- Supplying data to correct temperature biases in NWS forecast models for more accurate weather prediction.
- Providing solar resource maps for the renewable power industry.

The Rad-CA theme is a bright spot in GMD with exceptional potential for high-impact and wider visibility. Scientists in the Rad-CA theme have a strong record of accomplishments. With fresh leadership they are well positioned to integrate their measurement capabilities into major NOAA programs and beyond. However, as with other GMD groups, thin resources preclude expansion and even basic operations are threatened.

Recommendations for the Rad-CA theme:

- Commit resources to fill out instrumentation at existing networks, e.g. add SURFRAD type instruments to existing UV, aerosol and latent/sensible heat flux sites and vice versa, to provide denser sampling of US climate zones.
- Expand measurements at existing sites, e.g., install ceilometers and cloud optical depth spectrometers.
- More closely integrate the aerosol group science with G-Rad. Better yet, combine the two groups to achieve closer to critical mass.
- Expand products useful for the renewables market.

3.3 Theme: Guiding the Recovery of Stratospheric Ozone

Findings.

GMD's ODS/O_3 research is conducted by two of the longest-running and best-known groups within all of NOAA: the group measuring Ozone-Depleting Substances [ODS] and similar GHG and the group monitoring ozone itself and water vapor (O_3/WV). Measurements are made at long-term monitoring sites and during airborne and ground-based campaigns.

The high-quality measurements of these groups have been foundations of ozone and related assessments for over 30 years. Because ODS are also GHGs, their monitoring is essential for national and international climate assessments. The ODS/O_3 research is as relevant today as it ever was for two reasons. One is tracking the stratospheric ozone recovery, where GMD's gold-standard data and expertise in ODS recently led to the discovery of rogue Asian sources of CFC-11. Secondly, ozone recovery is occurring concurrent with increased GHG-driven climate forcing. Changes in key regions (e.g. the tropics) and near the tropopause, where interactions among ozone, temperature and dynamics are complex, are hard to predict and monitoring is essential.

The strengths of GMD's ODS/O_3 research rest on top-flight analytical capabilities, many of them unique. Leadership areas:

- Maintaining the Halocarbons and Trace Species (HATS) network and global standards for ODS that also support the synergistic Advanced Global Atmospheric Gas Experiment (AGAGE) network;
- Development of new analytical methods enabling addition of new ozone depleting substances (ODSs) to their "legacy" species;

- Public distribution and access to the ODS, ozone, and water vapor data.
- Maintaining the world reference Dobson instrument, traveling standard and regional intercomparisons of the Dobson network. Dobson are still the gold standard for total ozone satellite calibration;
- Setting quality assurance standards for ozonesondes.
- Developing and distributing more robust hardware and software for ozonesonde data, the demand for which is growing with the need to monitor ozone profiles.
- Maintaining the Ozone-Depleting Gas Index and conducting outreach activities to keep public and policymakers informed about ozone threats.

The strength of ODS/O_3 data collection and calibration also derive from a dedicated team of experts who interpret their observations. Highly cited publications testify to the impact of GMD research.

The preeminence of GMD's ODS/O_3 research is at risk. Staying at the forefront of ODS measurements requires keeping current with equipment and the specialists who operate them. Demand for data is growing but support has decreased so that both staff and data-taking have been reduced. GMD has stopped launching sondes at 3 stations and scaled back frequency at partner sites in the tropics where more, not less, data are required. The harmful effects of other cutbacks are more subtle. For example, fewer staff means less documentation of methods and fewer publications that give GMD credit.

One of the greatest needs in the ODS/O_3 area is for re-invigorated leadership. Of the two groups making up this theme, there does not seem to be a cohort of more junior scientists being trained for leadership. There has been no Federal Head of the O_3/WV for 5-plus years. Succession planning for the HATS group is unclear.

<u>Recommendations.</u>

- Implement a succession plan for group leadership and consider combining the HATS and O_3/WV groups.
- Restore sonde measurements as much as possible, keeping in mind the need for weekly statistics for assessments.
- Provide sufficient resources to keep ODS data-collection techniques current.

Summary of Recommendations

1. **Overall Recommendation:** Grow, do not shrink, GMD. This requires funding increases in every area, not necessarily huge, but *solid and sustained*. Federal hires, 10-12 of them divided evenly between senior Management/group leaders and more junior scientists, need to occur as soon as possible.
2. The science conducted by GMD must expand to keep up with demands for climate-related data in all these areas and to enable partnerships that transfer knowledge for even greater benefit to the Nation and beyond. A fundamental change in OAR's priorities must take place if GMD is not to be destroyed one species, one unit or one facility at a time.

3. Budget and hiring plans must support their work and both need to expand to allow GMD to better fulfill its mission. Funding from NOAA must be increased in every area. The ABOs must be maintained; there is no redundancy. The decline in numbers of Federal personnel, in particular senior staff, must be reversed. Succession planning to attract experienced leaders and to put promising junior scientists on a career track must occur as soon as possible.
4. NOAA and GMD both need to make GMD's work and its scientists more visible. Actions could include: (1) more publications postings, press releases and updated personnel websites; (2) NOAA awards and promoting recognition by professional societies.
5. Senior management should follow best practices in working with group leaders as a team. The current five groups should be merged into three units that match the themes. This would make two units (Rad-CA, ODS/O_3) roughly comparable in core support. Consolidation should save management costs and allow personnel more time to strengthen analysis output and visibility for those two groups.
6. NOAA budgets and personnel must continue to support a range of activities that follow from national and international commitments to data collection, calibration, scientific reviews and the assessment process.
7. Collaborative opportunities for all of GMD's groups should be better exploited within GMD, across NOAA and with outside organizations.
8. With GMD senior leadership, GHG/CC needs to develop a strategic plan that defines goals for the next 5 and 10 years along with appropriate implementation. Better integration of measurements and models within the Theme and with NOAA's climate model Labs and beyond, should be included in such a plan.
9. Refresh GHG/CC leadership at all levels. There need to be clear career paths and timetables for promotion of Federal staff and hiring promising CIRES scientists to Federal appointments. The group should be writing fewer external proposals.
10. Recommendations for the Rad-CA theme are:
    - Commit resources to fill out instrumentation at existing networks, e.g. add SURFRAD type instruments to existing UV, aerosol and latent/sensible heat flux sites and vice versa, to provide denser sampling of US climate zones.
    - Expand measurements at existing sites, e.g., install ceilometers and cloud optical depth spectrometers.
    - More closely integrate the aerosol group science with G-Rad. If possible, combine the two groups to achieve closer to critical mass.
    - Expand products useful for the renewables market.
11. Recommendations for the ODS/O_3 theme are:
    - Restore sonde measurements as much as possible, keeping in mind the need for weekly statistics for assessments.
    - Provide sufficient resources to keep ODS data-collection techniques current.
    - Implement a succession plan for group leadership and consider combining the HATS and O_3/WV groups.