Geophysical Fluid Dynamics Laboratory
Response and Implementation Plan Final Report

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Introduction

The Geophysical Fluid Dynamics Laboratory (GFDL) is extremely grateful to the Review Team for the time and effort they put into reviewing GFDL's science. We are very pleased with the findings of the Review Team, particularly their recognition of GFDL's "remarkable accomplishments of its recent past", "the excellent quality of the lab's research on the underlying dynamics of climate variability and climate change" and that "decades of hard work have brought GFDL to a position of world leadership in climate modeling and in the fundamental science of climate dynamics and physical climatology". We also greatly appreciate the insightful recommendations provided by the Review Team regarding ways GFDL can improve itself and its contributions to climate science within NOAA, the Nation, and the World, especially in the areas of strategic planning for GFDL's research and modeling, improving its external partnerships, and recruitment and retention of GFDL staff. We hope that the detailed responses to each recommendation below, and the accomplishments to date in implementing these recommendations, demonstrate GFDL's ongoing commitment to implementing the Review Team's suggestions.

1. **GFDL's core strengths, in climate model development and in basic research on climate processes and climate change, should be preserved at all costs. These core strengths are unique within NOAA and vital to NOAA's mission. Any reconsideration of GFDL's activities and role within NOAA should acknowledge the importance of these core strengths. New activities should only be mandated for the lab to the extent that they can be undertaken without compromising the lab's strengths in its core areas.**

   Thank you to the Panel for the highly complementary assessment. This is an apt recognition of the payoffs of NOAA's investments in long-lead-time science and an acknowledgment of the value of GFDL's scientific accomplishments over the years.

A general note of importance is that GFDL's scientific research is guided by NOAA Mission-relevant objectives toward being a world-class climate modeling institution. The research needed involves long-lead-times and appropriate utilization of resources that are sustained over time. The recent call for "strengthening science in NOAA" emphasizes the need to maintain the vision of comprehensive research in climate and Earth Systems modeling and applications leading to NOAA-relevant advancements in knowledge, data, information, and products.

To this end, and to preserve and improve the strengths of GFDL, recognized by the Panel, we have worked, and continue to work, actively and directly with OAR, the NOAA Climate Mission Goal (CG), and NOAA Senior Management on the NOAA Next Generation Strategic Plan (NGSP), CG documents such as its Vision document and Implementation Plan, and on our own Strategic Plan. These products bear a strong imprint of GFDL participation and reflect GFDL's expertise. GFDL continues to provide major inputs into OAR in strengthening NOAA science, CG strategic planning, and NOAA by leading key activities in these organizations, particularly in NOAA's new Strategic Execution and Evaluation (SEE) Implementation Plan development process. It is particularly important during anticipated constrained budgets to identify GFDL's unique contributions to climate research and demonstrate the value of preserving them while showing how GFDL's science can move NOAA's mission forward. GFDL's recently completed Strategic Science Plan, distributed to OAR Senior Management in July 2011, serves as a roadmap for this purpose.

2. **The panel strongly recommends that GFDL be moved from its present location to the main Princeton campus. GFDL would benefit tremendously from greater access to Princeton's intellectual talent pool and fundraising resources. In addition, the move would facilitate interaction between lab scientists and Princeton students, to the benefit of both.**

We thank the Panel for this bold recommendation. Comments to this effect have been made in other forums, and this recommendation has also emerged from earlier review panels that have reviewed Princeton University. Another point to note is that GFDL's lease expires at the end of 2016, and if GFDL is to continue at its present location, the lease has to be renewed with Princeton University in the very near future. In the wake of the recommendation here, a Committee with members drawn from each section of the Laboratory and Isaac Held as the Chair was formed by the Director to explore the various options for the future of GFDL's location, including moving to Princeton University as well as the *status quo*. Additionally, the need for expansion of the Laboratory was also examined in view of office space becoming tighter with each passing year as the climate sciences expand rapidly.

This Committee delivered its findings to the Laboratory in February 2011. It concluded that there are substantial benefits to be realized from a move of GFDL to the main Princeton campus. These benefits would likely grow in time through a feedback in which the new energy and expanded scope of the combined NOAA/Princeton efforts in climate

science would then attract the best scientists and students in the field to join this effort. While most of the potential drawbacks to a move could be characterized as implementation issues, a poorly implemented move could greatly reduce or even eliminate the potential benefits to GFDL/NOAA. With careful consideration of these key issues, NOAA can better ensure that a move, if it takes place, achieves the desired goals of a substantial long-term benefit to climate research and climate services within NOAA and to the Nation.

Under the pressures of budgetary constraints anticipated in the coming years, other ways of improving the collaboration with Princeton have been implemented, as discussed in the response to Item 6.

3. **To further its efforts in Earth System Modeling, GFDL should recruit and hire a scientific leader in biogeochemistry. Among other things, a strong in-house leader for ESM activities would help to build the partnership with collaborators at Princeton University.**

Building off GFDL's successful coupled atmospheric-ocean general circulation model (AOGCM) efforts we have invested a substantial amount of resources towards developing an earth system modeling (ESM) capability over the past several years. As of the date of the External Review, we had produced a successful prototype ESM (ESM2.1). We showed results from this model at the review. At that time, we had also developed and were finalizing two new ESMs (ESM2M and ESM2G). Since the review, these two new models are being integrated to produce results for inclusion in the next IPCC report (AR5). These models include new state-of-the-art land and ocean biogeochemical components, which are being used to address and reduce uncertainty associated with carbon flows through the earth climate system. The ESM2M experiments are complete, and the ESM2G experiments are ongoing on Gaea, NOAA's new high-performance computer at the Department of Energy's Oak Ridge National Laboratory.

We thank the panel for noting that GFDL is the appropriate entity to spearhead NOAA's ESM effort at climate time scales. We agree with the assertion in the review that this effort is currently understaffed and under-resourced at GFDL. In fact, we had submitted a funding request to NOAA asking for more resources in the way of additional staff before the External Review (the process was started in early 2008). This request was included in the President's FY 2011 budget but was not included in the final FY11 appropriation.

While this will necessarily limit the expansion of ESM activities at GFDL in the short term, other steps have been taken to improve GFDL's leadership role in Earth System Modeling. Among these are the development and approval by NOAA of a Senior Technical position at GFDL to lead the Climate and Ecosystems group, which is responsible for ESM activities and Earth System Science, and the finalization of the GFDL Science Strategic Plan, which was delivered to OAR leadership in July 2011 and includes a plan for expansion of the group working on ESMs at GFDL as funding becomes available (see Recommendation #7 below). That Plan provides a vision for continued innovative applications and model improvements in GFDL Earth System

Modeling, including: migration to the next generation physical climate model, refinement of components, incorporation of additional biogeochemical cycles, exploration of higher resolution, exploration of the initialization problem for seasonal-to-decadal scale ecological forecasts, and exploration of longer time scale climate variability and change including past climates. The representation of ocean ecology will be expanded beyond its current biogeochemical emphasis to provide a more complete and mechanistic representation of ecological dynamics across trophic levels. This will improve the resolution of biogeochemical dynamics and increase the utility of simulations for assessing climate change impacts on marine resources. Additional nutrient cycles will be added to the land ecology model to resolve the impact of nutrient-limitation on land carbon dynamics. For example, a model for terrestrial nitrogen has been developed for incorporation into GFDL's next generation ESMs. Enhancing the ecosystem and biogeochemical dynamics within the ESMs will also allow novel investigation of human impacts on both the biosphere and on climate (e.g., ocean acidification, coastal eutrophication, hypoxia and anoxia, air pollution, biodiversity loss).

GFDL will use two strategies to meet the need for strong leadership in earth system modeling and the laboratory's future success: (1) develop talent in-house to fill this role, and (2) continue to seek scientists with proven leadership in this area from outside the laboratory. Because we were in the early stages of our Earth System modeling effort at the time of the Review, which largely focused on model development rather than applications, we believe that the Review may not have made fully evident the potential of some existing junior staff to grow into leadership roles. Additionally, GFDL will remain an active member of the team leading the NGSP Enterprise Objective of "An integrated environmental modeling system", which supports NOAA's modeling activities at all time and space scales.

4. **GFDL should become more engaged with the decadal climate prediction problem. While there may be valid scientific reasons for a cautious approach, GFDL should not ignore the demands placed on NOAA to provide forecast guidance on timescales of years to decades. One first step in this direction could be an organized research effort focused on the attribution problem.**

A vigorous research program is now underway at GFDL to better understand decadal variability and predictability in the climate system. This effort will take advantage of newly allocated funding within NOAA. This includes ongoing efforts to improve GFDL's newly developed coupled assimilation system, research to explore the inherent predictability of the climate system and to improve our understanding of the mechanisms and impacts of decadal variability, and the development of a prototype decadal prediction system. Integral to this is also the development of a high resolution coupled climate model to assess the robustness of simulated decadal variability in more energetic climate models; this effort is already underway using computing resources awarded to GFDL through the Department of Energy's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program and on Gaea, NOAA's new high-performance computer. GFDL's approach to addressing the attribution problem is addressed in the GFDL's Strategic Science Plan. This approach includes advanced

representations in GFDL models of clouds, chemistry, and aerosol physics in order to quantify their respective role in natural variability and climate change, exploring how extremes in the climate system (hurricanes, droughts, floods) may change in the future in response to radiative forcing changes and natural variability, and to use high-spatial-resolution atmosphere and coupled models to better characterize and understand the dynamics of climate variability, feedbacks and change, including interactions across time scales (seasonal-to-decadal-to-centennial) and the potential for abrupt change

An additional key component is the use of models to assess the adequacy of various observing systems both for characterizing decadal variability and for initializing models. Additional staff is being recruited to augment this activity, building on an existing strong base. The first of these, a visiting scientist, has been hired. Two additional, potentially long-term, hires have been made to augment GFDL's decadal climate prediction effort. A paper on GFDL's new high-resolution physical coupled model has been submitted to the Journal of Climate. The simulation of many regional scale climatic features has improved substantially with the use of this model, including very significant improvements in the Tropics. For example, the error associated with the Intertropical Convergence Zone (the so-called double-ITCZ) in the eastern Pacific has been cut in half; the simulation of rainfall over the Amazon and Indian monsoonal regions has improved significantly.

It is anticipated that higher resolution models will permit a more realistic simulation and projection of crucial features such as sea surface temperature patterns that are vital for projecting changes in climate extremes e.g., hurricanes and droughts, and to better understand the causes of Arctic climate change. This will enhance our confidence in projected changes in high-impact regional weather and climate phenomena, and thus will be extremely valuable for climate change assessments. Indeed this high-resolution coupled model as well as GFDL's highly praised CM2.1 model, which was used in the IPCC AR4 assessment report, have been used to complete a set of experimental decadal hindcast and prediction results for submission to the Coupled Model Intercomparison Project 5 (CMIP5) database and for subsequent use in developing the IPCC AR5 assessment report.

5. **The lab should work proactively with NOAA administrators to define its role within the NCS. If routine, operational prediction on multi-year and longer timescales is mandated as part of the NCS, decisions must be made regarding the involvement of GFDL. These are not easy decisions, and GFDL must take an active role in the decision process.**

GFDL played an active role in the preliminary development of the proposed National Climate Service (NCS). GFDL was a principal participant in the development of the NCS Vision Document and Implementation Plan. GFDL's imprint is clear in the way the Vision Document (now part of the Climate Mission Goal (CG) documentation) articulates the role of understanding and modeling (GFDL's forte) as core capabilities in reaching the NGSP Strategic Goals, especially toward the CG's objective of "Improved scientific understanding of the changing climate system and its impacts". GFDL will

continue to make significant contributions not only to the development of this CG objective but also toward the other three CG objectives by participating in assessments of current and future states of the climate system, informing mitigation and adaptation efforts with the best possible climate science, and developing a climate-literate public. A rich set of current year deliverables from GFDL, which includes research and modeling needed to understand decadal predictability, is crucial for advancing NOAA's CG. GFDL, through its research and modeling activities, is also making major contributions to NOAA's Environmental Modeling Objective and Holistic Understanding Objective Implementation Plans, which are being coordinated by OAR.

Progress in meeting the CG's goals and the societal challenges identified in its Vision Document depend on GFDL's unique strengths in research and modeling. A variety of GFDL contributions to CG planning in collaboration with other elements of the CG have been articulated in the original NCS documents noted above. These naturally evolve from GFDL's long-term goals of improved understanding of the climate system and the development of increasingly credible models and include:

1. High resolution model simulations leading to increased understanding and more reliable projections of changes in regional climate, drought, and extreme events such as hurricanes, and global-to-regional changes in atmospheric composition including soot, sulfate and dust aerosols. We expect GFDL expertise to contribute to climate research activities that seek to further refine or downscale these high-resolution simulations to the space and time scales of most relevance for impacts, and to quantify uncertainties, in part by analyzing our results in the context of the ensemble of the world's climate models.

2. Research on climate change and variations on decadal time scales, leading to assessments of the predictability of the climate system and to experimental decadal predictions.

3. Attribution studies of observed climate trends and inter-annual to inter-decadal variations. Understanding and communicating the causes of observed variations and changes to external forces and natural factors, and the consequences of physical and biogeochemical feedbacks on the climate system, will be a growing area of research at GFDL, and will also be an important area of collaboration with other elements of CG.

4. Earth System Modeling that is evolving rapidly at GFDL, facilitating research on the carbon cycle and other biogeochemical cycles and their impact on future climate change, as well as the effect of climate change on the land surface and ocean productivity. Potential collaborations with other CG and NOAA units include the impact of climate change on ecosystems, including fisheries.

5. Research on the interface between air chemistry and climate that provides improved understanding of the interactions between climate change and air quality, including global-scale transport of localized pollutant emissions, aerosol-cloud interactions and the stratospheric ozone layer.

6. The continued development and support of publicly available state-of-the-science Ocean Models, with a focus on ocean processes that control the temporal evolution of climate change and sea level, including the interaction between oceans and ice shelves and ice sheets.

7. The GFDL Data Portal, an existing GFDL service that enables public access to GFDL climate models, model output, and derived products, will serve as a vital link between GFDL and CG for model-derived products. We anticipate that providing well-defined products as web services will be a growing area of collaboration between GFDL and other organizations in the CG.

8. National and International Assessments will continue to be a key element of GFDL's service, both through scientific participation, authorships and model simulations; these include IPCC, Ozone Assessments, NARCCAP and WMO expert assessments and the National Climate Assessments.

As an example of our new initiatives, we elaborate on the support that GFDL will provide for regional climate projections. GFDL will leverage its growing involvement and expertise in high-resolution global atmospheric models to create an ensemble of regional climate projections for the 21st century, downscaled and bias corrected, with a special focus on North America. The ensemble would provide both a best estimate and estimates of uncertainty in climate projections on the scales relevant for impact assessments.

The initial system will be built upon the following structure. Global atmospheric models will be run at 25-50km resolution in time-slice mode, using as boundary conditions the ocean temperatures and sea ice distributions projected for the mid-to-late 21st century by an ensemble of coupled models in the archives of the Coupled Model Inter-comparison Project (CMIP), including the CMIP5 models as they become available (GFDL contributions to the CMIP5 archive are a significant component of GFDL's FY11 program deliverables). These results will then be refined using various approaches to statistical downscaling and bias correction. The output from this refinement step will provide our best estimates of the projected changes in meteorological and hydrological conditions, including extreme weather events and droughts, as well as various combinations of meteorological variables, or indices, commonly thought of as relevant for impacts.

Consistent with the Review Panel recommendations, we believe strongly that a dedicated and vibrant research environment at GFDL is central to its ability to attract the world-class talent. This, along with collaborative efforts involving other research partners, forms the scientific basis of credible and authoritative climate products and services. Only by continuing to attract, as well as retain, a talented pool of scientists will GFDL be able to achieve the fundamental breakthroughs, both now and in the future, that are vital to the long-term success of NOAA's CG. GFDL's input into the development of CG science objectives is clear in the documents that exist today, and our contributions will continue to be integrated into those of the other components of the CG through active participation in the CG planning process, which should ensure long-term vitality and sustainability of the climate research and modeling environment at GFDL. GFDL has been and will remain a principal in establishing the strategic framework for the CG and in planning to meet the climate objectives within the NGSP, in part by emphasizing the requirement that climate services be based on credible science.

6. **The lab should expand its efforts to build partnerships within NOAA (e.g. other OAR labs, the CPO RISAs, and service branches like the Fisheries Service), other federal agencies, and academia. In particular, GFDL should seek to strengthen its partnership with Princeton University.**

The GFDL leadership agrees with this recommendation. In some ways, this recommendation is an extension of GFDL's long-standing policy of encouraging collaboration with leading research groups in areas of mutual interest, and in particular with our partners at Princeton University. GFDL recognizes that the range of scientific issues that are important to GFDL's research is increasing dramatically, and that there is a widening range of important societal questions that GFDL's expertise can help to address. This broadening scope calls for enhanced and expanded partnerships between GFDL and other parts of NOAA, other federal agencies and academia. In recent months, it is noted that GFDL has engaged in seeking out potential common fronts involving scientific outcomes with USGS, Forestry, Agriculture and Water sectors. These interactions will be nurtured appropriately in the context of developing NOAA climate services within its Climate Goal.

Several line organizations within NOAA are already using models originally developed at GFDL. The GFDL hurricane model and various applications using the Modular Ocean Model (MOM) for coupled seasonal forecasts are the most obvious examples. Other examples include seasonal model runs provided to the International Research Institute (IRI), and the seasonal-to-decadal runs for the Multi-Model Ensemble experiments at National Center for Environmental Prediction (NCEP). As the models become proficient enough to be useful guides for addressing new questions of interest to NOAA, for example the impacts of climate change on marine ecosystems, GFDL's leadership commits to encouraging new collaborations with partners from other parts of NOAA e.g., its Ecosystems Goal. Indeed, since its review, GFDL expanded this collaboration by hiring a visiting scientist with expertise in modeling marine primary productivity over multiple decades.

Many GFDL scientists serve on the faculty of the Atmospheric and Oceanic Sciences Program (AOSP) at Princeton University, and make substantial contributions to its educational and research missions. GFDL scientists also serve as associated faculty in Princeton's Environmental Institute and the Program in Applied and Computational Mathematics. GFDL has also maintained broad collaborations with various academic departments at Princeton. GFDL and Princeton's Center for Theoretical Science organized a recent week-long symposium on some theoretical aspects of climate science, and another symposium is being planned. GFDL and the Princeton University's Civil & Environmental Engineering and Mechanical & Aerospace Engineering Departments have a newly funded, jointly supervised student project working on stably stratified turbulent boundary layers, which is an area of great interest to geophysical modelers. In addition, several Princeton faculty members from departments outside of Geosciences are being added as Adjunct faculty members of AOSP. These are all concrete examples of an extensive effort to broaden and deepen GFDL's connections with Princeton University. It is expected that these expansion efforts will continue as resources allow.

GFDL is an active participant in several Climate Process Teams, and is a partner in three new teams that have recently been funded by NSF and NOAA. We see this as a particularly effective mode of collaboration with our partners in academia, especially as we draw upon their expertise to improve the comprehensive coupled climate models that GFDL develops for NOAA and the nation. GFDL's leadership is committed to encouraging this type of collaboration, both through formal programs like the Climate Process Teams, and through other collaborations with GFDL scientists that emerge organically.

7. **The lab should engage in more strategic planning activities. The lab should make a conscious, collective effort to define its research agenda, rather than relying entirely on an organic, bottom-up evolution of the agenda or an agenda set externally by the IPCC or other entity. Recommendations include a 5-year strategic R&D plan, updated every other year, periodic strategic planning retreats, and "town hall" meetings.**

   The Laboratory agrees with the Review Committee's recommendation and proposes the following steps:

   a) Develop a GFDL Strategic Plan: A panel composed of members from the GFDL Research Council (RC) with strong representation from newer scientists at GFDL was formed by the Director and instructed to draft a 5-10 year Strategic Plan for GFDL Research and Development Activities out to 2020; this phase was completed and the GFDL Strategic Science Plan delivered to OAR Senior Management in July 2011. Input into the Strategic Plan includes NOAA's Next Generation Strategic Plan (NGSP), the NOAA Climate Goal (CG) Implementation Plan, NOAA Planning activities, recommendations from GFDL's quadrennial reviews, and the NOAA 5-Year Research Plan. By summer 2012, GFDL's Implementation Plan, will be completed, whereby the methods of achieving its strategic goals will be articulated. In particular, one focus of the implementation planning will be on human and computing resources needed to reach GFDL's strategic objectives, while another will be the grand challenges in climate and Earth System sciences (for example, discussed at the NOAA Science Workshop and during Science Day at the NOAA SES Retreat). There will be an annual evaluation of GFDL's research accomplishments and their alignment with the strategic plan, and a biennial review of GFDL's strategies and a Strategic Plan update to be held offsite. All-Hands meetings will be used to obtain inputs and strengthen key points of the Plan.

   b) Participate in the development of related and complementary Strategic Plans: GFDL is a key organization within NOAA's Climate Mission Goal (CG). GFDL's strategic goals will necessarily align with those of the CG and with the NOAA NGSP, as well as the NOAA 5-Year Research Plan. GFDL scientists are, and will remain, key contributors to the development of these complementary plans. Additionally, with plans within NOAA for strengthening science and especially transformational research, GFDL aims to contribute and collaborate in a significant manner to

NOAA's fundamental advancements in the physics, biogeochemistry, dynamics and ecology of the Earth System. At the recent Science Workshop to discuss NOAA's Grand Challenges, four GFDL scientists participated in framing the major science challenges over the next two decades.

c) Assess the degree to which GFDL should drive, or be driven by, external activities such as the IPCC and the development of a Climate Service: Although there was some disagreement among the panel members about the extent of the IPCC's influence, GFDL recognizes that the IPCC time scale is somewhat artificial when considering scientific advancements and their expression in climate models. As part of the development of its Strategic Plan, GFDL must have an open discussion about its strategy for participating in the IPCC, other international assessments, and the National Climate Assessment, the benefits to NOAA and improvement of scientific knowledge per se, and the balance to be struck in terms of time and other resources between the routine delivery of model simulation outputs for assessment purposes and the creative but appropriate science that is in part curiosity-driven and in part driven by relevance for science-driven products coming out of NOAA's CG activities.

In addition, on October 17, 2011 GFDL hosted a Symposium on "GFDL's Climate Research and Modeling: Recent Scientific Results", which focused on important scientific findings from the latest climate modeling and applications research completed since the 2009 Review. GFDL scientists are also participating in the development of US plans for climate modeling through groups empanelled by the United States Global Change Research Program (USGCRP) and the National Academy of Sciences. The role of "operational" climate prediction and projection, such as those provided by NCEP, the National Climate Assessment, and IPCC, are part of these discussions, as are the roles and responsibilities of US climate modeling centers in meeting the Nation's needs in a time of constrained budgets. As part of these activities, GFDL will be developing a white paper on its unique contributions to US climate science through its research and modeling.

8. **The lab should address its shortcomings in minority recruitment and gender balance.**

GFDL accepts this comment and will intensify its efforts in this regard in the coming years. Over the past two years, there have been significant additions with respect to under-represented groups at all levels: (1) Administrative Staff, (2) Visiting Scientists, and (3) Scientific Staff. As a consequence, the balance for new hires is much better than for the total GFDL employee pool. GFDL scientists will expand their participation in activities designed to attract under-represented groups, including the Earth Science Women's Network, the Mentoring Physical Oceanography Women to Increase Retention (MPOWIR) program, summer student and internship programs, job and career fairs, American Meteorological Society and American Geophysical Union meetings, and engagement of primary and secondary educators in the vicinity of GFDL. NOAA's

Equal Employment Opportunity and workforce management teams will be asked to help GFDL develop additional strategies to address its shortcomings in minority recruitment and gender balance.

It should be noted that the turnover of GFDL employees is relatively slow because the average residence time of GFDL employees is relatively long. Therefore improving the balance in the demographics of the employee pool will be an ongoing effort.

Perhaps one of the most significant steps that GFDL (and NOAA) can take to enhance the participation of under-represented groups in NOAA's mission is to build a diverse pool of graduate students and postdocs, which are the lifeblood of our research enterprise. To this end, GFDL will engage its Cooperative Institute partners, which are the source of graduate students advised by GFDL scientists, in developing long-term approaches to achieve a better representation of minorities and women in their graduate student pool. Part of this effort must include consideration of ways to attract and retain vibrant scientists to advise these students in exciting research projects, which is discussed throughout this document. GFDL is making substantial progress in this area: two female postdoctoral scientists are being hosted at the lab under the MPOWIR program, and three of the seven most recently accepted graduate students are female. Key to NOAA's success in the 21st century is attracting a diverse group of exceptional young scientists into the NOAA workforce.

Requests will be made to NOAA via OAR, paying due attention to the objectives outlined in the NOAA Climate Mission Goal planning and implementation documents, for augmentation of fiscal resources over the next four years to support new and enticing research. New funding represents perhaps the best opportunity for rapidly addressing GFDL's shortcomings in minority recruitment and gender balance. However, these considerations may have to be considerably tempered in light of the recent pessimistic budget outlooks.

GFDL's Deputy Director serves on the NOAA Advisory Committee for the Interdisciplinary Scientific Environmental Technology (ISET) Cooperative Science Center (CSC), and he presented a talk as an invited speaker to ISETCSC students on February 11, 2011. GFDL will continue to explore the ISETCSC program as a source of qualified students and visiting scientists. GFDL also participated in a NOAA Workforce Diversity Implementation Strategy Team whose objective was to revise NOAA's Framework Plan for Workforce Diversity in an effort to increase the number of employees in underrepresented groups and so better align NOAA employee demographics with those in the Common Labor Force. A number of recommendations were briefed to NOAA's Assistant Secretary for Conservation and Management, Dr. Larry Robinson, on August 12, 2011, including doing the best possible job in collecting demographic information to identify barriers to diversity within NOAA and to track NOAA's success in overcoming those barriers. Although the formally chartered task is complete, the sub-team (including GFDL's representative) charged with identifying barriers to diversity in NOAA is continuing its efforts in order to increase the rigor of its findings.

9. **Lab managers should strive for greater transparency and participation in the decision-making process, so that junior scientific staff are more informed and involved in management decisions affecting the lab.**

   GFDL agrees with this recommendation. As a start, GFDL has begun posting on its internal website the minutes of the meetings of its two Councils: the Research Council, which deals primarily with scientific direction, and the Management Council, which deals primarily with day-to-day functioning of the lab.

   Due to their ability to bring new ideas into GFDL and for identifying possible areas of collaboration, junior scientific staff have created a seminar series with a curriculum which represents the increasingly expanding scientific scope of the Nation, NOAA, and the Laboratory.

   During the development of GFDL's Strategic Science Plan, GFDL considered further how junior staff can directly contribute to GFDL's decision-making processes in ways that are consistent with GFDL's organizational and supervisory structure (see response 7a). Specifically, GFDL has started inviting newer scientists to GFDL Research Council meetings to address selected subjects as a way to enhance interactions with senior staff. A nucleus of junior scientists has begun interacting with the GFDL Front Office in addressing that group's overall well being.

10. **The lab should strive to create and strengthen opportunities for the advancement of junior scientists. Procedures should be established to help junior scientists grow into more senior roles, including procedures to facilitate the involvement of newer scientists in advising students.**

    The Laboratory's Research Council (RC) has taken on this recommendation. Discussions have been held with the Lab's newer Staff to determine how their interests and advancement can be best promoted, and GFDL has committed to:

    - Allowing talented newer scientists who are showing considerable promise to have a priority in the recruitment of visiting scientists in growth and important climate science areas (meetings to select visiting scientists are held biannually);
    - Ongoing consideration of how to allow newer staff to take the lead on important topical areas where the investigations might lead to novel findings and visibility for the concerned investigators;
    - Plans to revisit the Group structures, with the possibility of revising the structure or adding distinct sub-structures so as to assure a greater degree of participation and corresponding recognition on the part of the junior staff. This will be taken up in the context of GFDL's implementation plan discussed in response 7a;
    - Giving new scientists higher priority when assigning scientists to represent GFDL to distinguished visitors and collaborators and at prominent scientific meetings;
    - Encouraging scientists, especially interested junior staff, through explicit activities in their performance plans to work in communications areas e.g.,

consultants on museum exhibits, forums on climate science and its impacts (this was taken up during the performance review cycle in the fall of 2010).

Although these commitments are ongoing, some actions have been completed:

- Discussion with Princeton University's AOS Program has now resulted in the flexibility of a formal recognition by the University of GFDL's junior scientists, who are not part of the GFDL Adjunct Faculty, for their contributions to mentorship of Ph. D. students' theses and possibly lectures. These will be under the title of "Visiting Research Scholar" and is consistent with the University's practice in its other Departments.
- After a long time and several recommendations by GFDL, the Princeton AOS Program has added 2 new Faculty members in new areas (lower stratosphere and land surface). Their expertise will add to fostering excitement in the newer areas of climate research amongst the Laboratory's junior scientists.
- Discussions have begun with the Department of Civil and Environmental Engineering (CEE) at Princeton University on how increased synergy can be achieved towards joint research ventures in areas of mutual interest such as turbulence and boundary layer, computational fluid dynamics, aerosols and air pollution, and clouds. While GFDL brings in its strength in modeling, CEE brings in their laboratory and measurement/observational skills. As a start, three of the newer scientists from GFDL are engaged in teaching or co-mentoring graduate students and postdocs, and have been recognized by CEE, adding to their career accomplishments.

11. **The lab should establish a nominations committee for achievement awards, to ensure that lab scientists are publicly recognized for their scientific achievements and community service work.**

GFDL agrees with this recommendation. In response, GFDL has developed a small committee comprised of five research scientists and lab support staff to assume responsibility for identifying potential awards and honors for GFDL staff (both within and outside of NOAA), recommending strategies for nominating GFDL scientists taking into consideration all areas and disciplines, and managing the nomination process.

For the current year, GFDL is nominating several scientists for diverse honors for AMS, AGU, Presidential Early Career Award for Scientists and Engineers (PECASE), and OAR, NOAA, and DOC medals. One outcome of this activity is the selection of Arlene Fiore as the 2011 AGU James B. Macelwane Medalist. Arlene is only the second NOAA person to be selected for this award, and in fact is also the second NOAA woman (Susan Solomon being the first). Additionally, a team led by Tom Knutson was awarded a Department of Commerce Gold Medal for its groundbreaking research leading to a more confident assessment of the influence of human-induced climate change on hurricanes. A recently retired GFDL scientist has been recognized for his lifetime achievement, virtually all of it accomplished at GFDL, by the RAICES prize from the Argentine government. The RAICES award was set up by Argentina's Ministry of Science,

Technology and Innovation to honor scientists for their own work and major contribution in science, as well as for promoting Argentine scientists and research and education practices internationally. Another scientist has been honored by Australia's CSIRO Distinguished Visitor honor. The outcome of several other nominations will be known over the next six months or so.

GFDL is also promoting the exceptional accomplishments of its younger scientists. For two years in a row, Hollings Scholars hosted by GFDL scientists were awarded 1st Place Prize for Most Outstanding Oral Presentation at the annual gathering of Scholars at NOAA. At last year's AMS Annual Meeting, a GFDL-sponsored graduate student won the Outstanding Student Poster Presentation Award, and one of our recent PhD students was selected as Congressional Science Fellow. GFDL's promotion of its younger scientists remains an ongoing activity.

12. **For the next quadrennial review, the lab should write a synthetic assessment of its activities to accompany its PowerPoint presentations. Furthermore, panelists should be encouraged to work together to produce a consensus document. Finally, time should be allotted during the review for informal meetings with scientists, particularly junior scientists, and for an open session to discuss the problems and challenges facing the lab.**

GFDL agrees with the first and third recommendations. In response, GFDL will:

- provide a written synthesis of its research activities during the review period, including an assessment of gaps in its research portfolio to be addressed through the development of its strategic and operating plans;
- consider ways to allot time for additional informal meetings with all cadres of scientists, including extending the review period.

For the second recommendation, the possibility of empowering a review committee to develop a consensus report was duly considered during the development of the laboratory review process. However, due to the requirements of the Federal Advisory Committee Act, it was not feasible to pursue that mechanism for this type of review.