

CORE QUESTIONS and REPORT TEMPLATE
for
FY 2007 NSF COMMITTEE OF VISITOR (COV) REVIEWS

Guidance to NSF Staff: This document includes the FY 2007 set of Core Questions and the COV Report Template for use by NSF staff when preparing and conducting COVs during FY 2007. Specific guidance for NSF staff describing the COV review process is described in Subchapter 300-Committee of Visitors Reviews (NSF Manual 1, Section VIII) that can be obtained at <www.inside.nsf.gov/od/oia/cov>.

NSF relies on the judgment of external experts to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. Committee of Visitor (COV) reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the results generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals.

Many of the Core Questions are derived from NSF performance goals and apply to the portfolio of activities represented in the program(s) under review. The program(s) under review may include several subactivities as well as NSF-wide activities. The directorate or division may instruct the COV to provide answers addressing a cluster or group of programs – a portfolio of activities integrated as a whole – or to provide answers specific to the subactivities of the program, with the latter requiring more time but providing more detailed information.

The Division or Directorate may choose to add questions relevant to the activities under review. NSF staff should work with the COV members in advance of the meeting to provide them with the report template, organized background materials, and to identify questions/goals that apply to the program(s) under review.

Guidance to the COV: The COV report should provide a balanced assessment of NSF's performance in two primary areas: (A) the integrity and efficiency of the **processes** related to proposal review; and (B) the quality of the **results** of NSF's investments that appear over time. The COV also explores the relationships between award decisions and program/NSF-wide goals in order to determine the likelihood that the portfolio will lead to the desired results in the future. Discussions leading to answers for Part A of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. *COV reports should not contain confidential material or specific information about declined proposals.* Discussions leading to answers for Part B of the Core Questions will involve study of non-confidential material such as results of NSF-funded projects. The reports generated by COVs are used in assessing agency progress in order to meet government-wide performance reporting requirements, and are made available to the public. Since material from COV reports is used in NSF performance reports, the COV report may be subject to an audit.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions. For past COV reports, please see <http://www.nsf.gov/od/oia/activities/cov/covs.jsp>.

**FY 2007 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)**

The table below should be completed by program staff.

Date of COV: September 5-7, 2007
Program/Cluster/Section: Lower Atmosphere Research Section
Division: ATM
Directorate: GEO
Number of actions reviewed: Awards: 82 Declinations: 72
Total number of actions within Program/Cluster/Division during period under review: Awards: 606 Declinations: 721
Manner in which reviewed actions were selected: <p>Program officers chose an appropriate balance of proposals, with a bias towards highly rated declines and low rated awards. Special programs, such as CAREER and RUI were also represented. The COV was given access to additional proposals that they had interest in.</p>

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program's use of merit review procedures. Provide comments in the space below the question. Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCEDURES	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE¹
<p>1. Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments:</p> <p>LARS employs a mix of mail reviews and panels. The majority of the proposals submitted to the LARS core programs received mail reviews. Panels were utilized by the ESH program and for proposals associated with some field campaigns. Panels were used in situations where proposal pressure was high</p>	YES

¹ If "Not Applicable" please explain why in the "Comments" section.

<p>(e.g. solicited ESH calls for proposals and proposals associated with large field campaigns) and used by program officers to help manage the workload, better review multidisciplinary projects, and help define coherent projects. The COV finds that the mix of approaches is appropriate, but is concerned that the rationale for choosing when to use panels for proposals associated with field campaigns isn't well understood by the community.</p> <p><i>Recommendation:</i> Program officers should have the flexibility to choose to utilize panels when needed and/or appropriate, but in the case of proposals associated with large field campaigns they should strive to communicate to the community the reasons for their choice.</p>	
<p>2. Is the review process efficient and effective? Comments:</p> <p>The COV feels the review process is both efficient and effective. The return rate of solicited reviews speaks to the program officers doing an excellent job selecting reviewers. The reviewer response rate for the CLD program was especially high due to the program officers requesting a response from potential reviewers whether s/he will review the proposal.</p> <p>With regard to the NSF goal that 70% of proposals be processed within six months, when this goal was not met, the program officers often documented the reasons and informed the associated PIs. The COV was informed that complications involving field programs and budget timing can often delay the decisions. The COV encourages continuing this practice – case dependent overruns of the six-month processing goal are understandable and acceptable provided PIs are kept informed.</p>	YES
<p>3. Do the individual reviews (either mail or panel) provide sufficient information for the principal investigator(s) to understand the basis for the reviewer's recommendation? Comments:</p> <p>The amount of information contained in mail reviews varies, but the COV found program officers to be diligent in collecting enough mail reviews to provide sufficient information for the PIs to understand the basis for the overall recommendation. The majority of the individual mail reviewers did a superb job of providing information associated with Intellectual Merit, but not always Broader Impacts. While over 90% of reviewers commented on the Broader Impacts, the comments tend to be cursory, perhaps reflecting the perception that the Broader Impact is not an important component of the proposal.</p> <p>Panel reviews, which are understandably broader-based, were generally found to be more complete and provided much more information about broader impacts. Numerous instances of a mail reviewer's comments seemingly not meshing with the reviewer's overall scoring of the proposal were found by the COV. The COV also notes that these apparent mis-matches are recognized by the program officers and are carefully considered in the Form 7 analysis.</p>	YES

<p>4. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments:</p> <p>The panel summaries were found to provide excellent information for the PIs to understand the basis for the panel recommendation. In most cases, they did an excellent job providing information on both the Intellectual Merits and the Broader Impacts of proposed work. Panels were found to do a good job providing a synthesis, balancing reviews, and prioritizing.</p>	<p>YES</p>
<p>5. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments:</p> <p>The COV commends the LARS program officers for their thorough and exemplary analyses of the proposed research and the reviews. The COV finds that the program officers are very careful in reading into the reviews, and is impressed with their ability to make sound judgments in the face of conflicting information. Many examples were found where program officers were faced with proposals with inconsistent reviewer ratings and narrative, or with a wide spread of ratings. In every case program officers carefully described the situation and explained the reason for their recommendation.</p>	<p>YES</p>
<p>6. Is the time to decision appropriate? Comments:</p> <p>As was detailed in question 2 above, the COV finds that the time to decision is appropriate. We note again that many aspects of time to decision are out of the control of the program officers and that communication with the PIs is of paramount importance.</p>	<p>YES</p>
<p>7. Additional comments on the quality and effectiveness of the program's use of merit review procedures:</p> <p>The COV finds that current approach for selection and level of funding for SGER is appropriate.</p> <p>The review mechanism now in place for Scientific Program Overview proposals of large field programs seems appropriate, in that it helps with longer term planning of significant resources across the LARS core programs while identifying a clear proposal process for investigators.</p>	

A.2 Questions concerning the implementation of the NSF Merit Review Criteria (intellectual merit and broader impacts) by reviewers and program officers.

Provide comments in the space below the question. Discuss issues or concerns in the space provided.

IMPLEMENTATION OF NSF MERIT REVIEW CRITERIA	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE²
<p>1. Have the individual reviews (either mail or panel) addressed both merit review criteria? Comments:</p> <p>Over 90% of reviews make some comment on both merit review criteria. The reviewers' treatment however is highly uneven. It seems clear that most of the reviewers emphasize intellectual merits and many provide only very general or obvious comments on educational aspects (e.g. "supports graduate students") or on broader scientific or societal impacts; comments on broader aspects are, by their nature, difficult to support with specifics.</p> <p>As observed by the previous COV, intellectual merit is by far the main criterion for reviewers' recommendations. This is as it should be for most programs (CAREER being a notable exception). This COV finds, however, that reviewers seem to take the second criterion less seriously than intended in the guidelines. Proposals were rarely seriously criticized for being lacking in the treatment of broader aspects. Exceptions can be found in the CAREER and REU proposals, where educational aspects are of greater recognized importance. These were often reviewed in a much more balanced way.</p>	YES
<p>2. Have the panel summaries addressed both merit review criteria? Comments:</p> <p>The COV found that panels addressed the two criteria in a more balanced way, giving more attention to broader aspects. COV members who have served on multiple panels received more direct guidance on the expected balance of the two criteria.</p>	YES
<p>3. Have the <i>review analyses</i> (Form 7s) addressed both merit review criteria? Comments:</p> <p>The COV found that the review analyses were much more balanced in their treatment of the two criteria. The program officers made every effort to evaluate educational and broader scientific and societal impacts, even when</p>	YES

² In "Not Applicable" please explain why in the "Comments" section.

<p>the reviewers had not dealt with it. Program officers clearly considered broader impacts more fully than did the reviewers. The analyses suggested that the second criterion was used as a discriminator between proposals of comparable scientific merit, rather than overriding scientific considerations. The COV finds this usage appropriate.</p> <p>Overall, the COV was very impressed with the content and completeness of the review analyses. These decision-making process documents are extremely helpful and clear. The program officers are to be commended for the obvious effort and time they put into these analyses.</p>	
<p>4. Additional comments with respect to implementation of NSF's merit review criteria:</p> <p>Currently reviewers are told of the two criteria and referred to a web site for further details. The review template, of course, asks for comments on both. The COV doubts that all reviewers will take the trouble to follow-up on the instruction. In particular, it would be difficult for them to get a sense of the balance expected, on how their opinions on broader impacts will be used in reaching a decision, and on how much they should try to document their review of the secondary criterion.</p> <p><i>Recommendation:</i> Program officers should detail these aspects prominently in their instructions and emphasize it in their communications with reviewers.</p>	

A.3 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE ³
<p>1. Did the program make use of an adequate number of reviewers? Comments:</p> <p>In general, the stated target of four reviews per proposal was exceeded, with an average of five reviews per proposal throughout. There was some concern that multidisciplinary proposals and proposals that cut across programs and/or sub-programs are not well served by this target. If a proposal is truly multidisciplinary, a target of four reviews translates, at best, to two reviews per discipline.</p> <p><i>Recommendation:</i> For multidisciplinary proposals and proposals that cut across programs and/or sub-programs, a target greater than four reviews per proposal should be set to ensure an adequate breadth of coverage needed for a full evaluation.</p>	YES
<p>2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments:</p> <p>The program officers do an excellent job in securing reviewers with appropriate expertise and qualifications. The typical proposal uses an appropriate mix of both senior and junior scientists. The COV noted that in many cases, senior reviewers tended to be more positive in their comments than junior reviewers and it is thus essential to maintain the mix and to be cognizant of differences.</p> <p>In cases where the proposals were interdisciplinary, the reviewers were chosen from several areas to provide the needed balance.</p>	YES
<p>3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups?⁴ Comments:</p> <p>Reviewer demographics indicate that an appropriate balance of reviewers was used. Reviewers were drawn from every state, with larger states and states with</p>	YES

³ If “Not Applicable” please explain why in the “Comments” section.

⁴ Please note that less than 35 percent of reviewers report their demographics last fiscal year, so the data may be limited.

<p>a higher number of atmospheric scientists providing larger percentages of reviewers. Reviewers came from a range of institutions including 4-year colleges, business, government, foreign institutions, PhD institutions and research-intensive PhD institutions, with the latter providing the highest percentage of reviewers. The reviewers reflect an appropriate balance of underrepresented groups, although the numbers of minorities are small.</p>	
<p>4. Did the program recognize and resolve conflicts of interest when appropriate? Comments:</p> <p>The program officers are doing an outstanding job identifying any conflicts of interest early in review process. Extreme care was taken to avoid even the smallest conflict to ensure the integrity of the process. In addition, the program officers were very diligent in keeping track of any conflicts that may have arisen during the review process. When unreported conflicts did arise, the conflicting review was disregarded.</p>	<p>YES</p>
<p>5. Additional comments on reviewer selection:</p> <p>The previous COV was concerned that the number of international reviewers was relatively low. During the current review period, this no longer seems to be an issue with almost every proposal having at least one foreign reviewer. In addition, better demographic data is available this year than has been available in the past, allowing a better assessment of reviewer balance.</p>	

A.4 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

<p align="center">RESULTING PORTFOLIO OF AWARDS</p>	<p align="center">APPROPRIATE, NOT APPROPRIATE⁵, OR DATA NOT AVAILABLE</p>
<p>1. Overall quality of the research and/or education projects supported by the program. Comments:</p> <p>The program has a very good balance of research and education throughout. Educational programs are strongly supported and virtually all proposals have strong educational components through the education of graduate students, the support of post-doctoral associates, or the involvement of undergraduates. Examples of outcomes of this effort are provided in Section B of this report. Decisions for distributing available funds are appropriate. Programs such as CAREER, REU, and RUI are of high quality.</p>	<p align="center">APPROPRIATE</p>
<p>2. Are awards appropriate in size and duration for the scope of the projects? Comments:</p> <p>We feel that the program officers are very good judges in determining the scope, size, and duration of the projects. Decisions made to adjust requested funding are well considered, including assessment of risk and need of individual projects. Decisions to reduce funds are often well justified and involve interaction with the PI to assure that the objectives of the proposals can be met. Although there has been no formal target amount for awards, they seem to be well balanced in and among programs in LARS, averaging around \$130-150K per year.</p> <p>Large projects funded for long duration, along with Accomplishment Based Renewals, are clearly anomalies in the record, yet these anomalies appear well justified. The program officers consider several factors in continuing these awards, including productivity, value to education, multidisciplinary involvement, support from other agencies, and reviewer assessments.</p>	<p align="center">APPROPRIATE</p>
<p>3. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Innovative/high-risk projects?⁶ <p>The determination of what is high-risk or innovative was based in good part on the program officers' assessments. Often high risk proposals had mixed</p>	<p align="center">APPROPRIATE</p>

⁵ If “Not Appropriate” please explain why in the “Comments” section.

⁶ For examples and concepts of high risk and innovation, please see Appendix III, p. 66 of the Report of the Advisory Committee for GPRA Performance Assessment, available at <www.nsf.gov/about/performance/acgpa/reports.jsp>.

<p>reviews, particularly regarding the likelihood of success. In these instances the program officer would have to consider the potential benefit of the research in light of the risk identified by reviewers. There were some examples of funding requests for efforts that were both innovative and risky in which the program officer trimmed the budget or reduced the duration of the project to reflect the balance of risk to reward. The COV considers large field programs to carry considerable risk, as their probability of success can depend upon instrument development, weather, platform availability and other difficult-to-control variables. The number of awards for risky or innovative projects appears balanced within the programs and is further evidenced in part by the number of SGER grants given.</p>	
<p>4. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Multidisciplinary projects? <p>Comments:</p> <p>From the information provided, the COV feels that the balance of multidisciplinary projects is healthy. Program officers reach out to other programs within LARS, ATM, and the Directorate as a whole in seeking to provide reviews and resources for these multidisciplinary efforts. In some instances, when these efforts fail to bring in additional resources, the program manager adequately evaluates the potential benefit to the program and chose to fund the entire multidisciplinary effort from the individual program. There is considerable evidence of interdisciplinary efforts that were funded entirely within a single program. During this time it appears that resources coming in to ATM exceeded those going out to programs outside of ATM, but the difference is small.</p>	<p>APPROPRIATE</p>
<p>5. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Funding for centers, groups and awards to individuals? <p>Comments:</p> <p>Most awards are for individual projects, but about 1/5 of the amount awarded is for collaborative research. Funding is provided in support of centers, particularly if outside resources are included. Collaborative funding was a little lower for one of the LARS programs, but that appeared to be offset by the number of interdisciplinary proposals that were funded. The balance between interdisciplinary and collaborative proposals seems to be a function of how scientists in the particular fields choose to organize their efforts.</p>	<p>APPROPRIATE</p>
<p>6. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Awards to new investigators? <p>Comments:</p> <p>The COV was satisfied with the fraction of grants (~20%) awarded to new investigators. This is consistent with NSF as a whole. Our assessment is further supported by the number of CAREER grants awarded within LARS.</p>	<p>APPROPRIATE</p>

<p>7. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Geographical distribution of Principal Investigators? <p>Comments:</p> <p>All states, Washington DC and Puerto Rico were represented; however, assessments of regional biases in the number or amounts of awards (e.g., California and Colorado) were difficult because of the challenges in normalizing the data to the number of atmospheric scientists in the areas relative to the populations of the states.</p>	<p>APPROPRIATE</p>
<p>8. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Institutional types? <p>Comments:</p> <p>All institutional types were represented in the portfolio and the distributions reflected the relative degree of activity among institutional types. Most (~75%) awards in the section went to PhD-granting research institutions. This was remarkably consistent among the four LARS programs.</p>	<p>APPROPRIATE</p>
<p>9. Does the program portfolio have an appropriate balance of:</p> <ul style="list-style-type: none"> • Projects that integrate research and education? <p>Comments:</p> <p>Virtually all research proposals provided resources for training and support of graduate students, undergraduate students, and post-doctoral research associates. PIs, reviewers, and program officers all seem acutely aware of this need. There is a healthy number of CAREER, REU, and RUI grants that are supported within the core and across programs. K-12 and teacher training were routinely integrated in these grants.</p>	<p>APPROPRIATE</p>
<p>10. Does the program portfolio have an appropriate balance:</p> <ul style="list-style-type: none"> • Across disciplines and subdisciplines of the activity and of emerging opportunities? <p>Comments:</p> <p>The large number of awards and the amount awarded for projects co-funded with other NSF programs speaks well of the interdisciplinary nature of research conducted in this section. In that new ideas often derive from working at the interface between different disciplines, this provides considerable opportunity for new and emerging research. Although there has been no listing of what LARS or its core programs sense as emerging research, several of the SEGRs reflect the interdisciplinary nature of new or exploratory efforts.</p>	<p>APPROPRIATE</p>
<p>11. Does the program portfolio have appropriate participation of underrepresented groups?</p>	<p>APPROPRIATE</p>

<p>Comments:</p> <p>The program officers are appropriately concerned about diversity in their awards. The committee's view was that the success rates provided for these categories may have been influenced by incompleteness of data owing to the option of self-reporting, and to the demographics of the individual research community. Getting a better representation from these groups will require an effort that is broader than these programs or this section and would require involvement at a higher level in the organization. Refer to section C for recommendations.</p>	
<p>12. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports.</p> <p>Comments:</p> <p>Inasmuch as the NSF Mission is driven by NSF and GEO strategic plans, the US Climate Change Science Program, NRC strategic guidance, and the IPCC and other international assessments, this section has responded well. Guidance is also received through workshop reports and the research interests of principal investigators. For example, climate process themes, which have been coming increasingly to attention of the nation and world, are critical elements of the LARS programs, and pursuit of new directions and retention of longer term research efforts are consistent with the priorities and mission of the program drivers. The program is intrinsically linked to priorities of weather, climate, and air quality.</p>	<p>APPROPRIATE</p>
<p>13. Additional comments on the quality of the projects or the balance of the portfolio:</p> <p>This COV echoes the comments of the previous (2001-2003) COV, in that the strength of the LARS program lies in good part in the quality of its program officers and their ability to pay attention to and address both emerging and established needs of the program. The collegial spirit observed among program officers further adds value to the program and care should be taken not to compromise this in any management decisions that might ensue. We find the human component involved in evaluating and approving proposals to be critical to the success of the mission. That individual reviewers do not always agree, computers cannot evaluate risk, and science is driven in good part by individual initiative and grass-roots efforts, speaks to the need for this element in decision-making. There are many instances in the material the COV reviewed where the wisdom and experience of the program officer in making tough decisions has led to positive results.</p>	

A.5 Management of the program under review. Please comment on:

1. Management of the program.

Comments:

At the programmatic level, the COV was extremely impressed with the management and leadership demonstrated by all of the program officers. There is a striking collegiality among program officers within LARS. Such a close working relationship promotes the sharing of funds and ideas and fosters cross-fertilization among programs. All program officers are experts in their fields, which enables them to identify appropriate reviewers and panelists (as required). Moreover, their expertise allows them to critically evaluate and synthesize the external and panel reviews to make well-reasoned decisions. In certain circumstances, the program officers gave the PIs an opportunity to address reviewer and panel comments if the proposal appeared high risk, yet has the potential for high impact. This helps decrease the number of submissions overall.

An important aspect of the management of the section and programs is the allocation of budget. The Paleoclimate budget is conspicuously low when compared to the budgets of the other programs. This was also noted in the NRC report "Strategic Guidance for the National Science Foundation's Support of the Atmospheric Sciences" (2007, page 66). This smaller budget faces proposal pressure (defined here as "dollars awarded per submitted proposal") greater than that faced by other programs within LARS.⁷

Recommendation: The COV is not in a position to comment on the appropriateness of the size of the budgets with the LARS programs. However, the committee does feel that in the same way that LARS prides itself in the transparency of the process associated with proposals it should also pride itself in the transparency of the process associated with the distribution of funds amongst programs. LARS should put in place an ordered process for deciding how it distributes funds amongst the programs. This process should be transparent and justified.

Another important aspect of the management of the section is decisions associated with large field campaigns. The COV found the processes employed and decisions made by the program officers to be excellent, but the COV is concerned that the community views many of these decisions to be arbitrary.

Recommendation: There is a need for transparency and improved communication to the community regarding funding decisions for large field campaigns.

Management at the Division and Section levels benefits from permanent and rotating staff in that each program continues to have a good organizational memory and a continuous influx of fresh perspectives and ideas. The merger of the Large-Scale Dynamic Meteorology and Climate Dynamics Programs, and the merger of the Mesoscale Dynamical Meteorology and Physical Meteorology Programs both appear to be working well; the COV agreed with the program officers that the desired effect of increased flexibility was attained within these areas. The COV also found that that both these programs are now benefitting from the combination of long-term and rotating staff, which provides the desired balance.

⁷ Using statistics provided to the COV, the dollars awarded per submitted proposal was calculated for each program. The amount for each program was then normalized by the average amount for the other three programs (ESH was not included). Averaged over the 3 years, the awarded dollars per submitted proposal for Atmospheric Chemistry was 125% the average of the other three programs, Physical and Dynamical Meteorology was 100% the average of the other three programs, Paleoclimate was 72% the average of the other three programs, and Climate and Large Scale Dynamics was 107% the average of the other three programs.

2. Responsiveness of the program to emerging research and education opportunities.

Comments:

Emerging research and education opportunities are well addressed through several avenues. Investments are driven by the LARS community. Major field campaigns and SGER, REU, and CAREER grants were funded throughout LARS. The COV notes that the ability to respond swiftly and adequately is, however, dependent on budget constraints.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments:

Program planning and prioritization within LARS are influenced by several internal and external factors. Solicitations and guidelines were targeted at the program level. At the community level, workshops and conferences were organized (e.g., the Holocene Initiative Workshop, the Hadley Circulation: Present, Past and Future conference, Post-ESH planning meeting, etc.). Several guiding organizations at the national and international levels include the NSB, CCSP, IPCC, CLIVAR, and other agencies listed in Section A.4.12. Further guidance is drawn from synergy with other agencies and by interactions at conferences and informal feedback from the community, symposia, and in community white papers.

4. Additional comments on program management:

As with the previous COV, there was concern with the gap in staffing during periods of transition of rotating staff. LARS does an excellent job balancing the institutional knowledge and experience of senior employees with the new ideas and attitudes of rotating staff.

PART B. RESULTS OF NSF INVESTMENTS

The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award "highlights" as well as information about the program and its award portfolio. Since relevant aspects of the Stewardship goal are included in Part A, the COV is not asked to respond to that goal in Part B.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 OUTCOME GOAL for Discovery: "*Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.*"

Comments:

There is a valuable mix of projects within LARS that has stimulated innovative collaborations across disciplines and involve cutting-edge science. There are abundant examples of important research discoveries/elements that have arisen from LARS funding. Examples of these discovery award highlights identified by the COV or the four LARS programs are listed below. Based on these awards and other past and current awards, the expectations for future progress are high, provided that funding is adequate. LARS is supporting fundamental research that has great potential benefits to society through improved understanding and prediction of earth's atmosphere and climate.

1. Atmospheric Chemistry

The Megacity Initiative: Local and Global Research Observations (MILAGRO) was a major field campaign in 2006 sponsored by NSF that brought together researchers, scientific agencies, and countries to study the impacts of pollution from major metropolitan areas on the atmosphere at the regional and global scale. With multiple aircraft, as well as other ground, remote sensing, and

airborne instrumentation, MILAGRO was one of the largest atmospheric chemistry field campaigns ever conducted. Early results encompass both new scientific findings and confirmation of hypothesized results. Researchers found that pollution in the Gulf of Mexico is persistent, and from diverse sources over the southeastern United States, Mexico, and Central America. They also found that the pollution plumes downwind from Mexico City exhibited enhanced levels and production of ozone. An unexpected finding was that aerosol absorption at ultraviolet wavelengths may be stronger than expected from current understanding. This field campaign fostered research that will advance the frontiers of knowledge and in addition cultivated a world-class, broadly inclusive science and engineering workforce and expanded scientific literacy of all citizens.

Barry Huebert, University of Hawaii, studied aerosols during the Asia-Pacific Regional Aerosol Characterization Experiment (ACE-Asia) held in May of 2001 (ATM 0002604). Results from this NSF-supported field program showed that above 2 km, the concentrations of organic carbon were 10 to 100 times higher than the computer models predicted. The underestimation of organic carbon is now thought to be due to the formation of secondary organic aerosol. These particles are long lived and can therefore play a large role in the intercontinental transport of pollution and the radiative forcing of climate.

William Simpson, University of Alaska, was funded with a SGER award to study the chemistry of Arctic snow (ATM 0420205). The PI sampled snow surfaces in the Arctic and found that bromide, which is a component of sea salt, is preferentially removed from snow. This is consistent with conversion of bromide sea salts into reactive bromine gases that are major players in ozone depletion and mercury deposition. The researchers also found very high levels of mercury in snow and ice in the immediate vicinity of surrounding leads and frost flowers. This work is helping to explain the high levels of mercury found in humans and animals in the Arctic region.

2. Physical and Mesoscale Dynamic Meteorology

During the period of this review, the COV could cite many incremental advances in the understanding of tornadoes, hurricanes, lightning, trade wind clouds, boundary layer structures, mesoscale convective systems, and orographic systems. Continuing research from prior major field campaigns, such as the Mesoscale Alpine Programme (MAP), Bow echo And Mesoscale vortex EXperiment (BAMEX), and the Severe Thunderstorm Electricity and Precipitation Studies (STEPS), to name just a few, has moved the frontier of knowledge appreciably forward in these areas. For orographic studies, this is evidenced, in part, by a special issue of nine review articles covering "MAP Findings" published by the *Quarterly Journal of the Royal Meteorological Society* (April 2007). A special issue of the *Journal of Climate* (May 2007) included 22 research articles from the LARS-funded North American Monsoon Experiment (NAME) in 2004. The major advances in atmospheric electricity are evidenced, in part, by the expanding use of lightning mapping arrays to better study volcanoes, urban meteorology, and mesoscale convective systems. Across the subdisciplines of PDM, LARS is supporting fundamental research that has great potential benefits to society through improved understanding and prediction of the atmosphere.

Hurricane prediction: The Hurricane Rainband and Intensity Change Experiment (RAINEX) was a field program held in 2005 that sampled two of the strongest hurricanes ever recorded in the Gulf of Mexico. A multi-investigator collaboration, led by **Robert Houze** (University of Washington, ATM-0432623) and **Shuyi Chen** (University of Miami, ATM-0432717) is analyzing radar measurements and wind, pressure, moisture, and temperature from multiple aircraft during the rapidly developing stages of hurricanes Katrina and Rita. This study is leading to a better understanding of how rainbands and multiple eyewalls interact to affect hurricane intensity. Another study of hurricane intensity (**Lynn Shay**, University of Miami, ATM-0444525) is examining the effect of water temperature, salinity, and current properties in the Gulf of Mexico's Loop Current. The northward

extent and depth of the Loop Current may be valuable indicators for predicting hurricane intensity changes. **James Kossin**, University of Wisconsin-Madison, and **Wayne Schubert**, Colorado State University, have conducted a collaborative project on internal small-scale dynamics within the hurricane eyewall (ATM-0435694, ATM-0435644). Their computer model simulations show that when there is extra forcing within the hurricane eyewall, it becomes less well coupled with the eye. Mixing between these two regions is reduced, and intensification of the entire hurricane is temporarily suppressed. **Isaac Ginis**, University of Rhode Island, has improved the understanding how of ocean surface waves impact atmosphere-ocean fluxes and, in turn, has improved the way these fluxes are represented in a hurricane model. This project (ATM-0406895) has already shown results in improved predictions of both the track and intensity of hurricanes, particularly strong ones, and it has been implemented in an operational hurricane forecasting model.

Tornado damage estimates: A computer model study led by **David Lewellen**, West Virginia University, has quantified some effects of debris on tornado structure and maximum wind speeds (ATM-0236667). The work has shown that debris size and type, which are related to the surface characteristics of the land, can be important factors in the structure of the tornado up to several hundred meters above the surface. Although the presence of some types of debris reduces the maximum wind speed, the calculated damage potential of the tornado is greater due to the increased momentum of the air plus the debris. A collaborative study by researchers at the University of Oklahoma, Pennsylvania State University, and The Center for Severe Weather Research (**Donald Burgess**, ATM-0437898; **Yvette Richardson**, ATM-0437512; **Joshua Wurman**, ATM-0437505) has calculated the range of possible human casualties that would occur if an F5-level tornado crossed a densely populated region. This work, which combines Doppler radar data from intense tornadoes with population data for metropolitan areas, gives estimates of up to 45,000 human deaths from a single tornado impacting a city like Chicago.

Warm rain processes: The Rain in Cumulus over the Ocean (RICO) field project included more than 100 scientists, students, and technicians studying trade wind cumulus clouds, with an emphasis on the warm rain process. Investigators from the University of Wyoming (**Bart Geerts**, PI, ATM-0342957) were funded by LARS to collect vital data for the experiment with the Wyoming King Air aircraft and the Wyoming Cloud Radar. **Bruce Albrecht**, University of Miami, (ATM-0342623) led a collaboration with the University of Colorado and the NOAA ETL to collect ship-based data with two short wavelength radars and a scanning Doppler lidar as well as instrumentation to measure fluxes from the ocean surface. Shallow cloud systems are present over tropical oceans around the world, but it is not known how they produce rain twice as quickly as the current theoretical calculations indicate it should take. **Robert Rauber**, University of Illinois at Urbana-Champaign, (ATM-0346172) is using RICO data to help quantify the parameters that control the structure and coverage of shallow tropical cloud systems. This work is leading to a better representation of the exchanges of energy, moisture, momentum, and trace constituents between the atmosphere and ocean for use in models of global weather and climate. Another RICO dataset includes measurements of the concentration of hydrogen peroxide and methylhydroperoxide inside and in the vicinity of clouds. **Brian Heikes**, University of Rhode Island, (ATM-0342386) is using these data to estimate cloud age, the amount of environmental air entrained into the clouds, and the character of the oxidization that occurs in cloud droplets. This work is leading to better understanding of the chemical processes that control the structure of clouds and the interactions of clouds with the climate system.

THE COV has high expectations for future contributions toward the Discovery outcome goal from the current portfolio of projects. Continued data analysis and results from recent field campaigns will lead to improved understanding regarding, e.g., evolution of the boundary layer in closed basins (METCRAX), evolution of orographic convection (CuPIDO), anthropogenic impacts on land-surface heat and moisture fluxes (BUFEX), terrain-induced atmospheric rotors (T-REX), and volcanic electricity. Of particular importance to the public will be the findings from projects such as RAINEX

in which data from the 2005 hurricane season were collected: these are expected to greatly improve forecasting of hurricane intensity changes. Beyond the major field campaigns, the LARS portfolio of awards [in PDM] is exemplary and leads the COV to expect the future contributions toward *Discovery* will be broad and impressive.

3. Paleoclimate and Earth System History (ESH)

Highlights over the COV period include the presentation of the National Medal of Science to **Lonnie Thompson** of Ohio State University, supported by the Paleoclimate Program, in 2005. Another important highlight is that the Paleoclimate Program Director and associates were invited to the White House (2006) by the National Science Advisor to present and discuss program results on abrupt climate change and implications of past climate conditions for understanding current and future climate change. A project headed by **Matthew Kohn**, University of South Carolina Research Foundation, (Timing and Magnitude of Climate Change across the Eocene-Oligocene Transition, Northern Great Plains, USA, ATM-0400532) investigates how fossils can hold clues to major temperature changes 33 million years ago. Another key result was a study by **Edward Cook** of long-term aridity in the western USA using gridded drought reconstructions developed over the past 1200 years, published in *Science* (Cook et al. 2004, Lamont-Doherty, 0322403, SGER: Development of a North American Drought Atlas). This is a timely project, given the severity of ongoing and expected future drought in the western USA. Several innovative, 5-year projects are also notable within Paleoclimatology: a current project on reconstructing the climate of Monsoon Asia using tree rings (**Tree-Ring Lab, Lamont-Doherty**, ATM-0402474), the EdGCM project (**M. Chandler et al**, educating students on use of GCM models in the classroom), and PALEOVAR (**Pisias et al**, Oregon State University, 0602395, Past Climate Variability: Understanding Mechanisms and Interactions with the Mean State).

4. Climate and Large-Scale Dynamics

In recent years much of the focus of the climate research community has been on the possibility of climate change due to anthropogenic causes. Evidence has been coming from theory, numerical models, and more recently, from observations indicating that such changes are actually occurring. As is appropriate for a topic of such scientific interest and potential societal impacts a significant number of the studies in the Program deal with this issue. We highlight here three of several important contributions funded by the Program.

The first two illustrate how theory and observations can be combined to study the existence and attribution of climate changes. Webster (ATM-0328842) is a very well publicized, and somewhat controversial, study that found that the number of Category 4 and 5 hurricanes worldwide has nearly doubled over the past 35 years. The percentage of hurricanes that reached Category 4 or 5 status rose from 20 percent in the 1970s to 35 percent in the past decade. In a second, and more theoretically-based approach, Emanuel (ATM-043209) describes hurricane intensity in terms of a power dissipation index. This is an index of the potential destructiveness of hurricanes based on the total dissipation of power, integrated over the lifetime of the cyclone. This index has increased markedly since the mid-1970s. The author found that the trend is due to both longer storm lifetimes and greater storm intensities. Both studies attribute the change to increased sea-surface temperatures.

Dr. Mark Schwartz of the University of Wisconsin-Milwaukee (ATM-0085224) and his colleagues performed the first large-scale analysis of a warming trend and its effect on the spring growing season. The researchers compiled a database of temperatures throughout the Northern Hemisphere and used this data as an input for a Spring Indices (SI) model to simulate the phenology of representative plant species. The output from the model was shown to be highly correlated with

actual bloom and leaf-in measurements taken at various gardens or forest research sites throughout North America. The first leaf date, first bloom date, and last spring freeze are all found to occur earlier, at the rate of at least 1 day per decade.

B.2 OUTCOME GOAL for Learning: “Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.”

Comments:

Across the LARS portfolio, the COV found many examples of the recognized value of cultivating the S&E workforce. The importance placed on training the next generations of atmospheric scientists is reflected in the relatively high percentage of dollar support provided to undergraduate and graduate students by LARS awards. In particular, involvement of undergraduate students in field programs, either via REU support or other mechanisms, was evident in many of the programs and subdisciplines. This participation is vital for the LARS community and is one essential component of improving the STEM "pipeline" problems across ATM, GEO and NSF.

The world-class nature of LARS-supported scientists is reflected in some of the major, peer-selected awards they have recently won:

- **Inez Fung**, University of California Berkeley, received the Roger Revelle Medal from the American Geophysical Union (AGU) in 2004. Her most recent NSF award (ATM-0628678) is a “Carbon & Water in the Earth System” collaborative and multidisciplinary project “to investigate a series of hypotheses via numerical modeling experiments linking carbon and hydrologic cycles across the globe, linking land and ocean, low and high latitudes.”
- **James Randerson**, University of California Irvine, received AGU’s James B. MacElwane Medal in 2005. His most recent NSF award (ATM-0628637), also in the “Carbon & Water in the Earth System” program, is a collaborative project to improve the Community Climate System Model by examining “the direct modulation of fire effects by precipitation, drought, soil moisture, together with a host of human activities...[and] a range of biogeochemical and ecosystem feedbacks.”
- **David Thompson**, Colorado State University, received AGU’s James B. MacElwane Medal, in 2004. Thompson is a LARS-supported CAREER awardee (ATM-0132190) for a project “to improve our understanding of large-scale climate variability in the Southern Hemisphere in the context of the Southern Hemisphere “annular oscillation” (AO)” and to develop a new curriculum in large-scale climate variability. His most recent NSF award (ATM-06013082) is aimed at improving “understanding of large-scale climate variability in both hemispheres ranging from weeks to longer timescales.”
- **Barbara Finlayson-Pitts**, University of California Irvine, was one of 90 scientists elected to National Academy of Science in 2006. Her most recent NSF award (ATM-0423804, supported jointly by Atmospheric Chemistry and Analytical and Surface Chemistry programs) is a project “to develop quantitative understanding of the mechanisms and kinetics of reactions involving sea salt particles under conditions relevant to the atmosphere in order that such processes can be accurately incorporated into numerical models of atmospheric chemical processes”
- **Lonnie Thompson**, Ohio State University, was one of 90 people elected to the National Academy of Science in 2005. Through his recent NSF award (ATM-0502476), he will recover ice cores and “produce a long, high resolution multi-proxy climate history” of the western Tibetan highlands. Thompson also was awarded the National Medal of Science in 2005.
- **Peter Webster**, Georgia Institute of Technology, was awarded the AMS Rossby Award in 2004. His most recent NSF award (ATM-0531771) aims to 1) investigate the large-scale

circulation and thermodynamic aspects of the tropics, 2) study the prediction of tropical intraseasonal variability and its interannual variability, and 3) study the variability of long-term relationships in the tropics.

- **Robert Houze**, University of Washington, was awarded the AMS Rossby Award in 2006. His most recent NSF award (ATM-0505739) investigates the physical mechanisms of orographic enhancement of precipitation in a representative variety of storms, under different regimes of stability, type of storm, and topography.
- **Natalie Mahowald**, National Center for Atmospheric Research, was awarded the AMS Houghton Award in 2006. Her most recent NSF award (ATM-0628472) is part of the NSF Carbon and Water in the Earth System solicitation and aims to improve the representation of fire and fire-related processes within the specific framework of the Community Climate System Model (CCSM) Common Land Model Carbon and Nitrogen (CLM-CN) model,
- **Amy Clement**, University of Miami, received AGU's James B. MacElwane Medal, in 2007. Clement is a CAREER awardee (ATM- 0134742) for a project in "the creative integration of paleoclimate research and educational outreach to better understand the interplay of low- and high-latitude climate processes in Earth's natural climate evolution and to describe this interplay in a manner useful to social scientists engaged in the economic and policy aspects of global climate change." Her most recent NSF award (ATM-0500275) is aimed at improving "understanding of the mechanisms of drought over the last few millennia."

In addition to the above individual awards, **COMET** (Cooperative Program for Operational Meteorology, Education and Training) received the Excellence in Geophysical Education Award from the AGU in 2006. The award honors "a sustained commitment to excellence in geophysical education..." The citation (available on the AGU web site) states that COMET began in 1990 to help train operational meteorologists to apply the latest science and incorporate new data sources in weather forecasting. COMET now "reaches university faculty and students, emergency managers, broadcasters, and the general public with its ever-expanding list of educational materials on a variety of topics in geophysical disciplines. Over 400 universities and colleges have accessed the COMET training Web site." Many LARS-supported researchers are among the contributors to COMET, which has been funded by 10 federal agencies at various levels and times. In his acceptance speech, Tim Spangler, director of COMET, included an acknowledgement of support from the NSF.

The world-class nature of LARS projects is reflected, for example, in the large number of people involved in extended collaborations on international field programs, such as MAP, RICO, RAINEX, MILAGRO, and ACE-Asia. Awards for multidisciplinary, interdisciplinary, and collaborative research represent a healthy percentage of the LARS projects; these types of projects broaden the perspectives of the scientists and students involved and contribute toward long-term improved linkages throughout ATM, GEO, and NSF. As the statistics show, new investigators and under-represented groups are leading or are involved in many LARS projects; this helps to indicate the programs are broadly inclusive. The LARS support of several new CAREER awards each year is also helping NSF reach this outcome goal. Scientific literacy is being impacted through outreach aspects of many individual LARS-supported projects. In particular, the large field programs have received positive media attention and public coverage of the science under investigation. LARS programs are reaching out to the public in significant ways in the U.S. (e.g., the RICO project in Puerto Rico) as well as in places as disparate as Mexico (via MILAGRO's Windows to the Universe website, with 25% of its millions of users being Spanish-speaking visitors); East Africa (via The Nyanza Project, associated with IDEAL); and Norway (via undergraduate research projects in Svalbard). A few of the recent CAREER awardees are working directly in K-12 and informal education venues. LARS has also supported a project aimed at enhancing scientists' skills for communicating their findings to the public. Overall, the COV was impressed by the extent and success with which the LARS portfolio is truly integrating research and education to improve the S&E workforce and scientific literacy.

Noteworthy Learning Achievements Based on NSF Awards:

From the exemplary portfolio of LARS awards, the COV has chosen some examples that are achieving significant results toward the Outcome Goal for *Learning*. These achievements are described briefly below.

Cultivating the S&E Workforce

- **Michael Evans**, University of Arizona, has a CAREER award in dynamical paleoclimatology (ATM-0349356) in which he is working to derive multi-century proxy climate records from the terrestrial tropics. He is also developing a course on weather and climate to enhance the science program at a community college attended primarily by Native American students.
- **J. Curt Stager**, Paul Smith's College of Arts and Sciences, received a Research at Undergraduate Institutions (RUI) grant (ATM-0117170) to study environmental changes of Lake Victoria, East Africa, on the decadal time scale over the past millennium. His work is providing a new understanding of how Earth's climate functions and how it is influenced by extraterrestrial forces.
- Through an RUI grant (ATM-0213248), **Varavut Limpasuvan**, Coastal Carolina University, has shown that mid-level stratospheric gravity waves can be correctly simulated with the Advanced Regional Prediction System (ARPS) model, even though ARPS was developed specifically for tropospheric weather forecasting purposes. This project has also provided the first direct demonstration that mountain-induced gravity waves strongly interact with the polar vortex by decreasing the circumpolar wind speed. Limpasuvan has involved four undergraduate students in the work, and they presented their research at various meetings. Two of these students are now pursuing graduate studies.
- **Petra Klein**, University of Oklahoma, is heavily involving undergraduates in an innovative urban meteorology project as part of her CAREER award (ATM-0547882). Students serving as summer fellows have helped to install various instruments on towers, buildings, and local sites in and around Norman, OK. So far, about 55 students in a junior-level meteorology course have undertaken hands-on projects with the data acquired by these instruments.
- A project led by **Robert Rauber**, University of Illinois at Urbana-Champaign, involved thirty students from various universities in the U.S., including Puerto Rico, in the field phase of The Rain in Cumulus over the Ocean (RICO) experiment (ATM-0346172). The combination of a seminar series, three student-planned airborne missions, and subsequent data analyses, gave students the opportunity to organize and conduct research on aerosols and microphysics in trade wind clouds. An article is planned for the *Bulletin of the American Meteorological Society* to describe the educational component of RICO. Several students have continued working on data post-analysis with Rauber and with scientists at NCAR.
- **Athanasios Nenes**, Georgia Tech, has a CAREER award to study cloud formation processes over the ocean (ATM-0349015). NSF-supported work has shown that over a large area of the Southern Ocean, phytoplankton blooms are correlated in space and time with increased cloud droplet number and decreased cloud droplet radius. Through modeling studies, Nenes has found that these changes in cloud properties were due to oxidation of isoprene emitted by the oceanic phytoplankton. Further, he discovered that the resulting indirect effect on climate was comparable in magnitude to the indirect effect over highly polluted regions. The PI trains graduate and undergraduate students at Georgia Tech and is active in outreach efforts.

Several LARS-supported Research Experiences for Undergraduates (REU) awards are especially noteworthy for their efforts to broaden the S&E workforce.

- **Al Werner**, Mount Holyoke College, has established an REU site on Svalbard, Norway, to study climate change in the high Arctic. This project (ATM-0244097) involves a multidisciplinary educational research experience that integrates the fields of geology, oceanography, meteorology, biology, physics, chemistry, ecology, biology and mathematics.
- In another REU grant (ATM-0223920) **Andy Cohen**, University of Arizona, has coordinated the

interdisciplinary Nyanza Project to study tropical lakes as a part of the larger “International Decade of East Africa Lakes” (IDEAL). The project provides an interactive season of research, training, and cultural experiences for American undergraduate, graduate, and secondary school teachers with their African counterparts.

- **David Cocker**, University of California Riverside, is studying the formation of secondary organic aerosols with the help of six undergraduate students supported by an REU award (ATM-0449778). Each student had an individual project, including development of particle instrumentation, training for operation of diverse instrumentation, modification of a new environmental chamber, measurement of jet aircraft exhaust and development of in-house chemical characterization tools for secondary organic aerosols. Several of the students have presented their work at conferences and have won awards for their research.
- **William Brune**, Pennsylvania State University, has trained undergraduates in atmospheric chemistry laboratory and field work through an REU award (ATM-0209972). Notably, all eight of the students involved in his program have since enrolled in or applied for admission to graduate school.

Expanding Scientific Literacy

- **Paul Voss**, Smith College, is leading an extensive outreach effort as part of the Megacity Initiative: Local and Global Research Observations field campaign (MILAGRO). MILAGRO was a major LARS-supported field mission held in 2006 to study the impacts of pollution from large population centers on the regional to global atmosphere. NSF sponsored a Research Experience for Teachers award to Smith College (ATM-0511833) that, in addition to involving teachers, also allowed a K-12 science administrator to participate in the field campaign and share his experiences with his home district. This award has thus far provided research training for six undergraduate women at Smith College.
- **John Seeley**, Oakland University, has focused part of his CAREER award (ATM-0094185) on outreach to high school students and teachers by developing laboratory experiments that allow them to measure atmospheric species with relatively inexpensive and simple techniques. In addition to training the teachers and students in these measurement methods, he has also devised some research activities specifically for them to help them better understand atmospheric ozone.
- **Mark Chandler**, Columbia University, has used LARS support (ATM-0231400) for “EdGCM,” a project that has extended a global climate model (GCM) for use in teaching and training in K-12 and university classrooms. A user-friendly interface, including database and teacher management module, ports the full-scale three-dimensional GCM to any desktop computer. Added software allows teachers to provide instructional materials and web links relevant to their particular lesson plans. Students at many levels can thus familiarize themselves with one of the basic tools of climatology and some of the concepts of climate change science.

LARS has also continued its commitment to assisting scientists with communicating their discoveries to the public. **Jackleen de La Harpe**, **Sara C. Hickox**, and **Morris Ward**, University of Rhode Island, received support to improve climate research communication between scientists and the news media (ATM-0433415). In partnership with the American Geophysical Union, several media communication workshops were organized to train scientists in effectively disseminating climate change information that results in accurate reporting of such information. One example of a positive outcome of these media communication workshops is **Curt Stager’s** (Paul Smith’s College of Arts and Sciences), weekly radio show on climate change.

In summary, the COV finds that LARS performance during the review period toward *Learning* is excellent. The many *Learning* outcomes presented in the “highlights” and described in the other materials that were made available to the COV clearly show that the Section places a high priority on this Goal.

Expectations for Future Performance Toward *Learning*:

Based on the long-standing importance placed on involvement of students in research projects and field campaigns, the COV is confident that the impact of LARS-funded projects and people on the *Learning* Outcome Goal will continue to be strong. We expect that the support for current REU and CAREER awards (some of which we have noted above), along with the evident high caliber of these programs and awardees, will continue to bear significant *Learning* results. The COV further expects that more recent and future awardees in these and other highly competitive LARS programs will continue toward this goal. Thus, the COV believes there is every indication that its high expectations for future LARS performance in this category are well-founded.

B.3 OUTCOME GOAL for Research Infrastructure: “*Build the nation’s research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools.*”

Comments:

A significant part of the LARS mission involves development of new research tools, new databases that form the basis of research work (termed “*research infrastructure*”). These developments can take many forms, including instrumentation, model development, computer resources, databases, or sampling networks and they can be resourced as MRIs or simply parts of research projects. What makes them valuable is their potential for broader application by the community to achieve greater results. Several examples here demonstrate the breadth of these applications and their potential use by the community

LARS has supported several moderate to large-sized field campaigns during the period covered by the COV review that have led to the collection of unique and extensive datasets available to the community. In addition, 12 MRI grants have led to new observational facilities and instruments as well as new observational capabilities that will enable studies covering a wide range of lower atmospheric phenomena. Below are highlighted **six** field campaigns, **one** multidisciplinary award, and **4** funded MRI proposals that illustrate the breadth of new observational capability and the richness of data collected as part of LARS grant activities.

1. Exemplarity Field Campaigns

The data bases produced by the field projects address critical problems in atmospheric science and should provide important sources of validation data to testing of hypotheses and evaluation of numerical simulation studies associated with small cloud dynamics, atmospheric rotors, boundary layer processes, and hurricane intensification mechanisms.

A) Precipitation Studies in Trade Wind Clouds - The Rain In Cumulus over the Ocean (RICO) Experiment - 16 awards worth \$1,186,212 in 2004 (R. Rauber, U Ill. - Lead)

The "Rain in Cumulus over the Ocean" (RICO) experiment, a multi-institutional collaborative project involving more than 15 institutions studied trade-wind Cumulus clouds in Nov 2004 - Jan 2005. The studies covered four key areas: (1) the processes that lead to rapid onset of precipitation in tropical cumulus clouds; (2) the transition from initiation to mature precipitating system in such clouds; (3) the effect of tradewind Cumuli on the properties of the tradewind layer; and (4) the role of precipitation in the energy balance in the tradewind regime. A focus of the study was an investigation of the rate at which rain forms in warm clouds, which appears to be faster than

predicted by models or calculations. The investigators tested several hypotheses that were advanced to explain this rapid onset of precipitation, including the roles of giant particles, turbulence, and entrainment. In the study, they used recently developed observational capabilities, including new radar techniques for detecting the nature of precipitation formation and new instruments for measuring the size distributions of cloud droplets and aerosol particles. The investigators studied larger-scale characteristics and effects of tradewind Cumuli, eventually leading to improved understanding of the roles of these regions and of precipitation in the climate system. RICO was executed during 2004 and was focused on large gaps in our knowledge concerning the microphysical properties and life-cycle of trade-wind cumulus clouds and mesoscale cloud lines with an eye toward improving their handling in climate models. In order to study the life-cycle of these clouds a complete description of the environment, including aerosol characterizations that had to be obtained via aircraft profiles. The evolution of the precipitation and microphysics was studied using aircraft penetrations (microphysics instruments) and S-Pol radar dual-polarized radar observations.

B) Tropospheric Rotors Experiment (TREX) - 9 awards worth \$2.1 million in 2006 (V. Grubisic, DRI - Lead)

TREX took place in 2006 and focused on mesoscale airflow phenomena in the lee of the Sierra Nevada, including terrain-induced waves, rotors, and attendant downslope windstorms, and their interaction with cold air pools and thermally-forced flows in a deep lee-side mountain valley. Atmospheric rotors, intense low-level horizontal vortices that form along an axis parallel to, and downstream of, a mountain ridge crest, most frequently in conjunction with large-amplitude mountain waves, pose a significant hazard to aviation. Despite the significance of rotors, and because of their spatial complexity and intermittency, knowledge of rotor size, internal structure, turbulence intensity, and predictability is still limited. The main observational objective of this study was to document the full three-dimensional structure and temporal evolution of mountain waves and rotors under a wide range of environmental conditions and wave/rotor strengths. The research was conducted using both field observations and numerical simulations. Comprehensive observational T-REX data sets from ground-based and airborne, in situ and remotely sensed instruments, including measurements obtained by the mesonet network of automatic surface stations established during a precursor Sierra Rotors study, were collected in the central portion of Owens Valley, in the lee of the southern Sierra Nevada. The southern Sierra Nevada is the tallest, steepest, quasi-linear topographic barrier in the contiguous United States. The mesonet network surface observations were collected before, during, and after the two-month intensive T-REX observational period. This study's numerical modeling effort consisted of high-resolution simulations with two state-of-the-art mesoscale numerical models, the Coupled Ocean-Atmosphere Modeling Prediction System (COAMPS) and the Weather Research Forecasting (WRF) modeling system. Dynamical explanations for the evolution, structure and interaction of rotors and waves with cold air pools and thermally forced flows, were sought through synthesis of high-resolution state-of-the-art numerical model simulations and high-resolution observations. Additionally, longer-term records from the Owens Valley mesonet network were used to compile a climatology of the Sierra Nevada windstorms and patterns of thermally forced flow in Owens Valley.

C) Meteor Crater Experiment (METCRAX) - 4 awards worth \$400k in 2006 (A. Muschinski, U. Mass - Lead)

METCRAX focused on the meso- and micro-scale structure and evolution of the stable boundary layer (e.g, diurnal behavior of cold pools) in the vicinity of an ideal, simple-shaped, small, closed basin (the Arizona meteor crater) within a nearly homogeneous horizontal plane. A four-week experiment was conducted in the fall of 2005. Research equipment was set up on the floor,

sidewalls, rim, and in the vicinity of the crater and all equipment inside the crater, except for tethersondes, operated continuously. Instruments include three Integrated Surface Flux Facilities (ISFF), three Campbell Scientific automatic weather stations, two lines of 30 HOBO temperature dataloggers per line, Five Vaisala digital barometers, and a 15-m, portable, extensible mast instrumented with 6 thermocouples. Researchers interested in transport and mixing in the stable boundary layer would benefit from examination of this database.

D) BUFEX (Bunny Fence Experiment) - 1 awards worth \$190.5k in 2006 (U. Nair, U. Alabama/Huntsville - Lead)

BUFEX focused on investigations of the land use effects on cloud formation and atmospheric circulation patterns near boundary between crop lands and the undisturbed vegetation areas in SW Australia. The drastic nature and large spatial extent of the land surface heterogeneity is conducive to the formation of secondary atmospheric circulations that can impact cloud formation. A rich data set of satellite and aircraft observations, surface measurements, and radiosonde observations is available to study surface energy and moisture fluxes, atmospheric profiles and cloud formation as a function of land use.

E) RAINEX (Hurricane Rainband Experiment) - 2 awards worth \$892,615 in 2004 (R. Houze, U. Washington and S. Chen, U. Miami, Leads)

RAINEX focused on hurricane intensity changes in relation to inner-core vortex dynamics, formation of secondary wind maxima in the outer rainband region, eyewall replacement cycles, and dynamic/thermodynamic feedback of outer rainband using aircraft, especially Doppler radar and dropsonde equipped aircraft. RAINEX was extraordinarily successful in the summer of 2005 in collecting high quality data sets in two category 5 storms (Rita & Katrina) as well as a developing storm (Ophelia). These data sets should provide information for model validation of hurricane intensity change hypotheses for decades to come. Rainbands are major sources of asymmetric heating outside of the hurricane inner core. This asymmetric heating leads to localized potential vorticity (PV) features, which may in turn be "axisymmetrized" by the radial shear of the tangential wind. The eyewall dynamics are then restructured and the overall storm intensity changes. Thus, the detailed evolution of the structure of the rainbands is integrally involved in storm evolution. The internal structure of the rainbands will be examined by subdividing the bands into convective and stratiform regions where the vertical distributions of heating and thus PV generation patterns are different. By simultaneously examining the eyewall and rainband structures, the PV features of the rainbands can be related to storm intensity changes. The PV features generated in the convective and stratiform regions of rainbands will be examined in relation to the formation of secondary wind maxima in the rainbands. As the secondary wind maxima take shape, they will be examined for how they may intensify and axisymmetrize and eventually take over as the main eyewall.

F) Megacity Impacts on Regional and Global Environments-Mexico City Pollution Outflow Field Campaign (MIRAGE-Mex City) – Over 30 awards totaling over \$8 million from 2004-2008

This multi-PI project was designed to investigate the contribution of biomass and biofuel burning to the overall air quality of Mexico City as part of the MIRAGE-Mex (Megacity Impact on Regional and Global Environment) campaign. Urban-rural sources of pollution were characterized by deploying airborne and ground-based Fourier Transform Infrared (FTIR) trace gas measurement systems. The compounds measured by these systems include carbon monoxide, carbon dioxide, nitrous oxide,

ammonia, ozone, oxygenated volatile organic compounds, and hydrocarbons. To facilitate measurements of biomass burning sources, both forest and domestic fires, one of the FTIR systems was mounted on a van for rapid deployment to off-road sources. Another FTIR was mounted on a cart and could be brought directly to the emission sources. Signature emission factors and emission ratios were measured for these sources, while corresponding plume samples were recorded from a small aircraft. The recorded emissions were combined with available biofuel use inventories to create a new, speciated emissions inventory for cooking fires in the Mexico City area and nationwide. Integration with measurements in Zambia and Brazil updated the recommended emission factors for global biofuel use, and an improved assessment of the health effects of these fires resulted from the first-ever comprehensive measurement of the emissions. The award provided training opportunities for a postdoctoral associate, and enhance collaborations with a Mexican University.

2. Data sets produced by a grant activity.

Measurements of Atmospheric Ozone in the Marine Boundary Layer from Ocean Buoys - 1 award worth \$532,285 over 2002 - 2004.

Eric Hints and Edward Sholkovitz of Woods Hole Oceanographic Institution developed and deployed near surface-level ozone sensors for relatively autonomous long-term measurements from ocean buoys and used the data acquired to study oxidation chemistry within the marine boundary layer, long-term trends in ozone concentration far from local sources, and the regional and intercontinental transport of atmospheric pollution. The accomplishments were published in the *Journal of Atmospheric and Oceanic Technology*. The application of this technology will result in improved characterization of the diurnal and seasonal cycles of ozone in the marine boundary layer and enhanced assessments of air transport across the ocean. The project involves a synergistic meld of engineering and technology application with highly topical fundamental studies of relevance to the global atmospheric environment.

A rather unusual example of a grant that produced an interesting multidisciplinary data set that is available on the internet is the following:

Volcanic Lightning Observations - S. McNutt, U. Alaska/Fairbanks - 1 award worth \$54,227 in 2005.

A comprehensive literature search and a survey of DoD satellite observations on the global occurrence of volcanic lightning found a strong association of lightning with many eruptions. A web-based interactive database on volcanic lightning for use by other researchers has been established noting the location, timing, timing uncertainty, volcanic plume height, and volcanic "explosivity index" have been tabulated.

3. Major Research Instrumentation (MRI) Awards – 3-year total 12 awards worth \$6,002,305

The COV noted an upward trend in MRI grants for instrumentation in the years 2004 (2); 2005 (3); 2006 (7) . A few examples indicate the high-quality of these investments.

Development of Microwave and Lidar Instrumentation to Enhance the University of Wisconsin Facilities for State-of-the Art Cloud Observations – 1 award worth \$1,118,055

PI Steven Ackerman and colleagues will adds a High-Spectral Resolution Lidar (HSRL) and a 3-

band microwave profiler to an existing suite of instrumentation to greatly extend the University of Wisconsin-Madison Space Science and Engineering Center's (UW SSEC) ability to remotely sense the atmosphere from its rooftop and from its mobile weather lab. SSEC has developed and deployed Atmospheric Emitted Radiance Interferometers (AERIs) around the world; AERI is a ground-based instrument that routinely measures the downwelling infrared radiance at high spectral resolution. Other existing instrumentation includes a rawinsonde launch and receiver system. A Multi-Filter Rotating Shadowband Radiometer (MFRSR) and Total Sky Imager (TSI) are being acquired using other resources to provide solar derived aerosol optical depth and cloud fraction respectively.

It is expected that these investments will enhance studies for years in 1) Collaborating with other institutes in lidar measurements of aerosol properties and transport as part of the Regional East Atmospheric Lidar Mesonet (REALM), an air quality monitoring program; 2) Combining ground-based and satellite observations to study cirrus cloud properties; 3) Resolving differences between GPS integrated water vapor retrievals, and microwave and infrared ground-based passive observations; 4) Enhancing the development of meteorological thermodynamic and cloud property retrieval algorithms using combined passive and active observations; 5) Improving forward radiative transfer model calculations to support data assimilation studies by using the microwave radiometer to provide calibrated radiances within the microwave region; and 6) Expanding knowledge of remote sensing cloud microphysical and macrophysical properties.

Acquisition of Instrumentation for Measurement of Airborne Organics and Fine Particulate Matter – 1 Award worth \$357,972

Through the Major Research Instrumentation Program, an interdisciplinary group of Science and Engineering faculty at led by Allen Robinson at Carnegie Mellon University acquired two research grade instruments – a Proton Transfer Mass Spectrometer (PTR-MS) and an Aerosol Mass Spectrometer (AMS) for use in collaborative projects addressing issues of high importance to atmospheric chemistry and air quality. These projects include laboratory and field studies characterizing the chemical production, growth, transformation, and fate of atmospheric gas-phase organic compounds and fine particulate aerosols. The instruments have been used thus far to study secondary organic aerosol (SOA) formation and the investigators have developed a method for measuring SOA production at low total concentrations of organic compounds. These two instruments allow the principal investigators, along with all collaborators, to measure important organic compounds and aerosols in the atmosphere.

Acquisition of Instrumentation for Quantification of Organic Compounds Responsible for Aerosol Formation – 1 Award worth \$545,445

This Major Research Instrumentation award to PI Paul Wennberg supports the acquisition and development of state-of-the art instrumentation for aerosol research. It will enable simultaneous characterization of the chemistry occurring in the gas and condensed phases as secondary aerosol forms and evolves in a laboratory setting. A benchtop instrument for gas chromatography - time-of-flight mass spectrometry (GC-TOF-MS) will be purchased to provide rapid chemical analysis of hydrocarbons and oxygenated volatile organic compounds. A triple quadrupole mass spectrometer will be coupled to an ion chemical ionization front end (TSQ-SICIMS) for real-time analysis of short-lived, reactive compounds. A preparative capillary gas-liquid chromatography (PCGC) instrument will be used to isolate larger quantities of volatile organic compounds for subsequent analysis with a broad array of instruments. Finally, an aerosol trap / concentrator will be developed for use as a front end to the mass spectrometers for rapid analysis of the chemical composition of aerosol. Studies using these new instruments will provide improved constraints on the mechanisms responsible for

production of organic aerosol in Earth's atmosphere. This instrumentation, in combination with the aerosol instrumentation currently available on the Caltech environmental chamber, will enable significant progress in addressing questions such as: - How important is the formation of low volatility oxidation products in the gas phase to the budget of organic aerosol and how does this chemistry influence the physical properties and environmental effects of atmospheric aerosols? - How important are aerosol-phase reactions relative to gas-phase oxidation followed by gas-to-particle uptake for determining the chemical composition of the aerosol? - What are the molecular mechanisms and kinetics of the processes involved in aerosol production? - What are the most important chemicals leading to aerosol formation (organic acids, oligomers/polymers, etc.) and what are their physicochemical properties (functional groups, molecular mass, stability, volatility, solubility, hygroscopicity, optical absorption, etc.)? - How do the gas phase and the aerosol composition evolve in the presence of atmospheric oxidants?

Development of the Thunderstorm Energetic Radiation Array (TERA) – 1 Award worth \$771,123.

This award to PI Joseph Dwyer will support the development of a new monitoring array for measuring energetic radiation associated with lightning. Recent observations have shown that X-rays and gamma rays are produced by lightning, through mechanisms that are not yet understood. These investigators will install an array for measuring such radiation at the International Center for Lightning Research and Testing, a facility operated by the University of Florida. The new instruments will be placed around a tower at this facility where rockets are launched to trigger lightning. The 32-element array will measure X-rays produced by dart leaders and return strokes associated with rocket-triggered (and occasional natural) lightning, and they will also monitor gamma rays and cosmic rays (which may be deflected by the high fields present in thunderstorms). Complementary measurements already made at the Center include electric and magnetic fields, electric currents, and optical emissions. The combination of existing and new sensors will provide comprehensive characterization of the electromagnetic radiation from lightning. The new instruments, like the existing Center, will be made available to outside users and visitors.

Expected results from this development project include: 1) new capabilities for characterizing the broad spectrum of electromagnetic radiation from lightning, including the poorly understood high-energy components; 2) the ability to collect observations that document the nature of the breakdown process involved when lightning is initiated and so constrain theoretical models of that breakdown process; and 3) support for an emerging new community of scientists interested in these new phenomena. The installation of this instrument array at a widely used center for lightning research will advance the study of newly discovered and largely unexplored kinds of radiation produced by lightning and will also provide opportunities for many investigators to integrate these observations into their studies of the properties and nature of lightning.

In summary, the COV finds that LARS performance during the review period toward *Research Infrastructure* is outstanding. The many outcomes presented in the “highlights” and described in the other materials that were made available to the COV clearly show that the LARS places a high priority on this Goal.

Expectations for Future Performance Toward *Research Infrastructure*:

Based on the quality of its research projects, MRI grants, and field campaigns during the time period covered by this COV, the COV is confident that the impact of LARS-funded projects in providing new tools and databases for future research work will continue to be very strong. We expect that the support for current awards (some of which we have noted above), along with the evident high caliber of the results of programs and awardees, will continue to bear significant results. The COV further

expects that more-recent and future awardees in these and other highly competitive LARS programs will continue to mine the valuable resources within this goal. Thus, the COV believes there is every indication that future LARS performance in this category will be high-quality and high-impact.

PART C. OTHER TOPICS

C.1 Please comment on any program areas in need of improvement or gaps (if any) within program areas.

In section A the committee commented on the adequacy of the section's program areas. We found no serious gaps or weaknesses. Section A.5 comments on areas of program management we feel are in need of improvement.

C.2 Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

The view of the committee is that previous sections adequately addressed the important aspects of the section's performance.

C.3 Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

The committee is satisfied that LARS program officers strive to include underrepresented groups in their portfolio of reviewers and PIs. However, a significant barrier to increasing participation of these groups is the small pool from which to draw.

Recommendation: NSF must continue its efforts to increase the participation of underrepresented groups in science and engineering across all education levels.

It was found that many PIs and reviewers pay little attention to the broader impact section of proposals and reviews. The COV feels that this is likely because the NSF has done an inadequate job communicating the importance and meaning of the broader impacts criterion to the community.

Recommendation: The NSF should make clear the relative importance of Intellectual Merit and Broader Impacts to the community and encourage program officers to make and communicate funding decisions in accordance with that relative importance.

C.4 Please provide comments on any other issues the COV feels are relevant.

The merger of the Large-Scale Dynamical Meteorology program with the Climate Dynamics program and the merger of the Physical Meteorology program with the Mesoscale Dynamic Meteorology program effectively removed an artificial barrier and provided program officers with greater flexibility in their ability to make awards. The COV was impressed by the benefits afforded by this increased funding flexibility.

Recommendation: While significant co-funding already exists amongst LARS programs, and the Section already has a small amount of discretionary funds, we ask the section to explore mechanisms for adding additional funding flexibility.

C.5 NSF would appreciate your comments on how to improve the COV review process, format and report template.

The COV commends LARS and the NSF for the effort expended on the COV review process. Program officers and staff were incredibly responsive to requests and generous with their time. The committee's only substantive concern about the COV review process involved Part B – Results of NSF Investments. The only information available to assess the quality of NSF investments comes in the form of annual and final project reports. The committee recognizes that the full impact of research cannot be fully appreciated after 1-3 years, but we feel that a sense of the quality of the work can potentially be gleaned from these reports provided PIs are conscientious about their content and level of completeness. The NSF does not keep relevant metrics to quantitatively evaluate performance from its granting activities (e.g., papers published, conference presentations made, etc.). The COV understands the reasons for this policy (i.e., manpower requirements to search out these records) and so has adopted a qualitative approach of highlighting relevant projects and grants that likely will produce significant advances in the science covered by LARS.

Recommendation: LARS should explore mechanisms to quantitatively assess the results of the section's investments at the time of submittal of annual and final project reports. The COV anticipates that much like the reviewer scores for proposals the "quality of investment" metric will sometimes be misleading. But like the reviewer scores for proposals the "quality of investment" metric will provide rough guidance for both program officers and future COVs.

The committee also *recommends* the following fine-tuning to the COV process, format and report template.

- 1) It would be helpful to have information such as Months in ATM and Total Score made available in the eJackets.
- 2) While all of the documents in the COV folder were made available in electronic form it would be helpful if information in tables were stored in spreadsheet form rather than PDFs. This would enable simple statistical information to be calculated and communicated quickly and easily.
- 3) It was noted that some of the review statistics provided to the COV only included reviewers who scored proposals. It was not uncommon for a reviewer to provide a text review but no score. These reviews should be enumerated in the summary statistics.
- 4) Questions A.5.1 and A.5.5 are identical. A.5.5 should be removed or changed.
- 5) The information provided to the COV in binder form was very useful, but a lack of page numbers made it difficult to point committee members to common pages. Please provide page numbers for each section.
- 6) Ask program officers to provide lists of proposals that they feel are i) transformative/innovative, ii) high-risk, and iii) multidisciplinary/interdisciplinary.
- 7) The COV found the computer and software system inadequate. We recommend that a solution be found that enables committee members to swivel their monitors so that program teams can more easily share information. We also recommend that software solutions be implemented that i) enable committee members to easily share documents created and edited on individual machines, ii) enable committee members to edit a common document (similar to the software currently used by panels), and iii) enable the contents of any monitor to be projected onto a screen and viewed by all.

SIGNATURE BLOCK:

For the LARS COV

A handwritten signature in black ink, appearing to read 'J. Hansen', written over a light gray rectangular background.

James A. Hansen
Chair