National Severe Storms Laboratory
February 17-19, 2009 Laboratory Research Review

Response to Review Recommendations and Implementation Plan

January 21, 2010

Submitted by Jeff Kimpel, NSSL Director, Kevin Kelleher, NSSL Deputy Director, and NSSL division chiefs and research staff

Introduction

The National Severe Storms Laboratory (NSSL) is pleased with the findings and recommendations of the Review Team. We are especially proud of the complementary remarks that we are a first rate laboratory, our staff are enthusiastic and fully engaged, our physical plant is impressive and the collocation of operational and research communities is viewed as positive. NSSL has summarized the scores NSSL received from the Review Team are presented in the matrix immediately below.

TABLE 1. NSSL Summary of Review Team findings for each science theme in their evaluation of the three focus areas (quality, relevance, and performance) for this review.

	QUALITY	RELEVANCE	PERFORMANCE
RADAR R&D	**HIGH**	**HIGH**	**VERY HIGH**
FORECAST AND WARNING R&D	**VERY HIGH**	**EXTREMELY HIGH**	**VERY GOOD**
HYDROMET R&D	**HIGH FOR QPE ONLY**	**HIGH**	**UNKNOWN AT THIS TIME**

The remaining document addresses specific findings and recommendations made by the research review panel. The responses are presented by research theme in the same format used in the reviewers' document, with the next section (Section A) addressing either overarching issues or issues that do not fit under any of the three research themes.

Section A. Additional Comments for OAR and Laboratory Management

(A.I) Workforce Plan including:

- **general recruiting (aging workforce)**
- **recruiting for specific deficiencies (e.g., engineering)**
- **increasing diversity in workforce**
- **mentoring younger workers**
- **casting a wide net when recruiting (re: close relationship with CIMMS)**

Verbatim Reviewer Recommendations:

1. Address looming manpower issues.

2. (Part A:) Management must be held accountable to recruit, motivate, and retain a cadre of multi-disciplinary, world-class scientists. NSSL should formulate and implement a viable strategy to recruit the high-caliber, diverse, and multi-disciplinary workforce needed to dramatically advance operational prediction of severe storms, heavy rains, floods, and high winds…

3. Recruiting talented, young scientists/engineers to NSSL: NSSL has an aging and minimally diverse workforce. Also, it appears that many of the new hires come over from the Cooperative Institute of Mesoscale Meteorological Studies (CIMMS). We recognize that the current NOAA environment restricts NSSL's ability to conduct open searches, but recommend that every effort be made to cast a wider and more diverse net for future hires. There has been a loss of several leading scientists, so a special effort needs to be made to recruit potential and rising stars. Efforts also need to be made to enhance interactions to universities beyond OU. Graduate fellowships should be instituted that involve students from other US universities and NSSL scientists.

4. Develop strategic goals, metrics and an execution plan for developing the next-generation NSSL technical staff population. Vet with this senior NOAA management and, where possible, resolve barriers to achieving the goals of this plan.

5. NSSL was clearly lacking in one important area – a Workforce Management Plan. This plan would address: 1) the impending retirement of senior staff (especially in radar and electrification); 2) the hiring strategy to replace these people (e.g., junior versus senior hires?, best athlete available or a disciplinary hire?); 3) strategy for introducing more diversity among the staff (e.g., currently there is little or no underrepresented groups or females among the senior leadership); 4) mentoring strategy; and 5) the possibilities of more long-term scientific visitors coming to NSSL than is currently the practice. There was a sense (which could be incorrect) that CIMMS was being used as a "grooming area" for future NSSL hires. It wasn't clear that, if true, this was the optimum hiring practice.

6. I consider the present situation at NSSL similar to a department at a university that one day finds out that all of their senior faculty are walking out the door. It is very difficult to replace these faculty (for NSSL the names include Zrnic, Rust MacGorman, Jorgensen, Davies-Jones, etc.). There are a few excellent mid-career people (e.g., Stensrud, Kain); however, you don't quite know how your junior hires will turn out. There are two recommendations that I would forward:

    1) To NSSL Management: Departments at universities often try desperately (and incorrectly) to "replace" (i.e., find a clone for) their top people. Some people are simply irreplaceable and there is nothing wrong if the emphasis of a program goes in a slightly different direction based on the new hire's expertise.

    2) To OAR Management: You may notice a low point in productivity during the transition between the senior people leaving and the junior hires trying to establish themselves. Please be patient during this period. NSSL will need time to mentor/nurture the new talent and, if they have made the right hires, the productivity will soon resume to levels that you have come to expect.

7. A summer- or semester-long graduate fellowship program, similar to that run by NASA, might be one mechanism by which NSSL could broaden its demographics over the next decade. Such a program could perhaps net the next big stars in the mesoscale or severe storms communities.

Response:

NSSL management fully agrees with the review team that essentially NSSL, and perhaps all the OAR research laboratories, have missed a generation of scientists as a result of funding restrictions and FTE management policies dating back to the 1980's. Consequently, an aggressive, comprehensive workforce management plan is needed to ensure continuity of the core science programs led by NSSL.

Background:
At its peak, NSSL had over 75 federal employees, now there are 47. The tight fiscal climate during the previous two decades precluded NSSL from hiring federal employees. Retiring employees were rarely replaced since their salary release was needed to cover mandated cost of living increases for the remaining federal employees. However, NSSL scientists have managed to compete for "soft" funds from within NOAA (usually from the NWS) and outside NOAA (e.g., the FAA, government of Taiwan). These funds have allowed NSSL to support cooperative institute research through CIMMS. At one point, the number of CIMMS researchers supported by the lab through grant funding was greater than the number of federal employees by almost two-to-one. Since 2003, however, significant reductions in NWS funding after the transfer of key WSR-88D improvements to NWS has reduced the amount of soft funding available to NSSL and the

subsequent reduction in grant funded CIMMS personnel has dropped such that the number is nearly equal to the number of NSSL federal employees.

Exacerbating the problem was a funding crisis that occurred about 10 years ago. At that time, NSSL's federal base became less than the total laboratory federal salary burden, leaving no federal base funds for operations (rent, utilities, travel, etc.) or execution of the core NSSL mission (publications, field programs, fabrication of new instruments, etc.). As a result, NSSL reduced the federal personnel such that base funds covered salaries. Today, the average age of our scientific staff is 52 and the percentage of scientific staff eligible for full retirement or early retirement is 85%.

As a first step to address this workforce problem (originally driven by the need to reduce staff), ten years ago NSSL management began a series of laboratory wide meetings called "Advances". At the first Advance, management assessed the laboratory's strengths and niche within NOAA/OAR and established three core research themes; weather radar, forecasts and warnings, and hydrometeorology. These themes are reflected in the structure of the laboratory today, in how NSSL is represented within the NOAA PPBES budget process, and in how the laboratory organized this formal review. NSSL resources are focused on advancing the science and transfer of technology within these three areas.

An increase in retirements has allowed NSSL management to hire four positions in the last few years; three in hydrometeorology and one in severe weather modeling. This action provided much needed core capability for a hydrometeorology effort previously funded with "soft" funds. It also supported NSSL's interaction with the NWS Storm Prediction Center and the Hazardous Weather Testbed, a critically important area facilitating research to operations.

Prior to these recent federal hires, the inability to afford to hire federal employees for over two decades, coupled with the availability of soft funding used to support CIMMS persons through grants, has resulted in a number of mid-career CIMMS scientists working at NSSL. Consequently, when new federal jobs became available, these CIMMS employees are highly competitive and often are selected. Understandably, this situation has led to the perception that NSSL was somewhat restrictive in its hiring practices.

<u>Current Situation:</u>
NSSL is on the verge of receiving about $1.8M annually for a research thrust called "Warn-on-Forecast" (WoF) resulting from the NOAA PPBES process. As discussed during the review, WoF was jointly conceived by the NWS and NSSL nearly a decade ago. It blends high resolution observations (e.g., radar) with high resolution storm scale models to add a predictive component to the NWS warning process. WoF essentially cuts across all three NSSL core research elements; radar, storm scale modeling, and development of tools supporting the forecasters at the local Weather Forecast Offices responsible for issuing warnings. Should the $1.8M (currently in the President's budget) be appropriated by Congress to NSSL, the laboratory will be in a hiring mode for scientists to support both the Warning Division and Forecast Division. Dr. David

Stensrud is the project leader and he is working with NSSL management to write the science plan, which will include a staffing plan, for this project.

In a parallel effort to WoF, NSSL is in line for a $1M increase for the phased array radar (PAR) research program in FY10, also as a result of the NOAA PPBES process. These two funding lines, WoF and PAR, would represent the first infusion of funds into the lab through the PPBES process. The PAR funding will allow NSSL to hire key engineers needed to support the PAR program and to help reduce the risk of the laboratory, and NOAA, losing core competency in weather radar.

On August 26-28, 2009 NSSL held a laboratory "Advance" to discuss the workforce management issues raised during the laboratory review, taking into account the two lines of funding that could become available in FY10. Four focus groups (Workforce Management, Administration Support, Facilities, and Management Structure) were formed weeks before the meeting, each charged with creating preliminary input to be used as a starting point for discussion during the Advance. Dr. Harold Brooks and Don Burgess led the Workforce Management group that presented the Report included in this document as Attachment 1.

The Report provides a number of general recommendations to NSSL management, along with a specific set of skills needed over the next 10 years to address the current and projected deficiencies within the lab. The list, which took into account the two new lab strategic priorities of Multi-function Phased Radar (MPAR) and WoF, was vetted at the Advance in August 2009 and received general support from both employees and management. Elements of the Report directly address the key points raised in Reviewer Question #5 as described next.

1) Impending Retirement of Senior Staff:

The Report specifically addresses retirement of senior staff in the context of the following key questions:

1. What skill sets need to be maintained at NSSL that have been lost due to recent retirements or may be lost to retirement in the near future?
2. What should the structure of the work force look like 10 or 20 years from now?
3. How can leaders of the large long-range efforts (MPAR, Severe Weather) have the flexibility to hire staff that are needed for a portion of those projects, particularly when currently unforeseen problems arise?
4. Are there current staff who could transition to areas of need?
5. What new areas of expertise would be most valuable for a future NSSL?

2) Hiring Strategy to Replace Impending Retirements:

A hiring strategy for replacement of key employees eligible for retirement is addressed in the report. Additional mechanisms NSSL will use to attract new scientific expertise to the lab include:

- Undergraduate Students: Continue strong support for Research Experience for Undergraduates (REU) & Hollings programs

- Graduate Students:
    - Currently support over 20 positions per year (funding permitting)
    - Upon graduation, these former students with positive experiences at NSSL are ideal applicants for vacancies
- Post Graduation:
    - National Research Council (NRC) post-doc program - currently supporting 4 per year (1 from the OAR NRC program, 3 more internally supported by NSSL)
    - Target searches for key positions historically difficult to fill (e.g., PhD weather radar engineers). Include nationwide advertisements in professional journals, personal contacts by not only Director's Office, but Division Chiefs, and working scientists to develop a list of potential candidates.
    - Utilize CIMMS (allows flexibility for short and long term positions, as well as non-US citizens)
    - Utilize newly established commercial contract for key IT and engineering positions

3) Strategy for Introducing More Diversity Among the Staff:

During a visit to the laboratory this summer, OAR EEO/Diversity Program Manager Nicole Mason, articulated the laboratory's responsibility as a National Laboratory to strive for a workforce with a diversity profile representative of not just the local community, but one reflective of the nation. The Work Force Report echoed the need for a more diverse workforce in recommendation #1. Although recent hires have improved the situation (three of the last six federal hires were women and two of the hires were of Native American origin), to address this issue more consistently in the future, NSSL is developing leadership capabilities among its minority scientists for future managerial responsibilities. NSSL will ensure involvement with OAR EEO in broad announcement of new and vacant positions. NSSL is also considering recruitment of a "Diversity Officer/Advocate" volunteer from existing federal staff.

4) Mentoring Strategy:

NSSL expects full engagement of immediate supervisors, group leaders, and division chiefs in periodic evaluation of career development for each employee. During the performance evaluation process held in early October, NSSL conducts a "lab leveling" process to discuss the performance of each federal employee and the relative scores across divisions (to address any scoring biases). During this time, the progress of each employee is discussed such that upper level management does have an opportunity to help ensure younger employees especially are being properly mentored. In addition, as follow up to this recommendation from the reviewers, we contacted the OAR EEO manager for ideas. She mentioned the concept of "On-Boarding". This program connects new employees with an established employee for up to one year to ensure they have everything they need to be successful. NSSL is looking into the various aspects of this concept to see if they would be practical and appropriate to the lab's situation.

5) Explore Possibilities of More Long-term Scientific Visitors to NSSL:
NSSL has had a number of long-term visitors over the years. However, there is no denying increasing the number of long-term visitors to NSSL is beneficial. Obstacles to consider are availability of funding, increased restrictions on foreign nationals to NOAA workspace, deemed export control issues, and reluctance of persons to participate in light of an increased number of two wage earner families. NSSL will look for opportunities to facilitate long-term visitors, including sabbaticals.

Recruiting strategies:
In addition to the report developed by the workforce group, NSSL management has already taken steps to address feedback received during the laboratory review in February 2009 to create a "Career Paths" document that was approved in April 2009 (attachment 2). The roots of the document were set in 1997 when the staff was asked to describe what expectations they have of themselves and their colleagues in terms of average annual productivity.

NSSL hired very few federal scientists during the 1980s through about 2005. Two mid-career scientists were hired, one from Naval Research Lab and one from Texas A&M, in the 1990s. In the past 5 or 6 years, there were six federal hires, one mid-career from the NWS and five from OU CIMMS. The Career Paths document explains, perhaps more clearly than was done during the laboratory review, how NSSL casts a wider net in recruiting than it may appear.

The process begins with adoption of a robust nationally and internationally competitive NRC postdoctoral fellows program. Working with NRC, each year since 2007, NSSL funds a total of 4 NRC postdocs (1 from the OAR NRC program, 3 additional from NSSL funds) for a period of 2 years each. NSSL has committed to supporting the postdocs at a very competitive stipend, while providing a significantly higher stipend for engineering candidates. As explained in the document, upon completion of the NRC program, successful postdocs may be asked to continue as CIMMS associates, subject to available funding. The NRC program has resulted in the infusion of talented individuals to the lab in the past and a few of them have successfully competed for CIMMS positions. Although there may be a number of CIMMS personnel who have competed successfully for federal positions at NSSL, it is important to consider the pre-screening that previously occurred through the NRC program. However, it is too early to tell whether this recent increase in investment in NCR postdocs by NSSL will result in an infusion of talent into key areas such as electrical engineering, stormscale modeling, and data assimilation.

In order to reach students at an early point in their education, NSSL continues to support both the NSF Research Experience for Undergraduates (REU) and NOAA Hollings Scholar programs during each summer. Support of these programs has resulted in a number of students returning for graduate work at OU, oftentimes working as research assistants at the lab through CIMMS.

NSSL has been active in requesting the NOAA Personnel Management Office modify its procedure and associated metrics for advertising federal positions. The typical two week window for candidates to submit their applications is not long enough for recruiting scientists. It is not unusual to take well over a month to get job announcements into scientific publications. As a point of reference, our university competitors often take a year to fill a vacancy. NSSL management has discussed this situation with the NOAA Director of personnel management and the suggestion was received favorably. We have recently been informed by our Headquarters it is possible to extend the window to 30 days, with unlimited extensions. We will work with Workforce Management on future federal positions to arrange for a longer period of time for applicants to apply.

Actions:

1) Adopt the "General Recommendations" set forth in the Work Force Committee Report (Attachment 1) by January 1, 2010.

2) Implement the "Specific Recommendations" proposed in the Work Force Committee Report as funding becomes available. Report on progress by July 1, 2010.

(A.II) Increasing interaction with those outside NSSL:

- **with NOAA and Academia**
- **visiting scientist program**
- **sabbatical leaves for NSSL scientists**

Verbatim Reviewer Recommendations:

2. (Part B:) …NSSL should be encouraged to expand its scientific collaborations far beyond the local community of excellence within Norman, OK. NSSL should identify mechanisms to more effectively leverage the capabilities of ESRL's expertise in atmospheric remote sensing, data assimilation, and modeling to support NOAA's challenging weather and water research objectives.

8. Develop mechanisms for increasing scientific interactions with academic community and NOAA entities external to the Norman area.

9. A visiting scientist program also could be a way to fill in some of the gaps in expertise that exist, e.g., in theoretical meteorology. Perhaps sabbatical leaves for NSSL scientists are another possibility that could be explored.

10. Establish processes encouraging cross-fertilization with researchers outside the Norman area. Possibilities include visiting scientist programs and internships for students and post-graduate researchers who do not intend to make a career in Norman. Set hiring targets for staff with degrees and/or established research affiliations outside the Norman area.

Response:

Background:
NSSL coordinated a series of laboratory "summit meetings" between NSSL and Earth System Research Laboratory Physical Sciences Division (ESRL/PSD) and ESRL Global Sciences Division (GSD) over the past few years. These meetings were intended to raise awareness of the scientific efforts at each lab and to spark collaboration between scientists across the labs. The meetings had impacts on NSSL's involvement in the Hydrometeorological Testbed (HMT) at PSD. They also provided a forum for refining the requirements needed for the Warn-on-Forecast (WoF) PPBES submission and, assuming funding will be made available, the science plan to execute the program. Subsequent meetings between ESRL/GSD and NSSL have led to cooperation and collaboration within both the Hazardous Weather Testbed (HWT) in Norman and the Developmental Testbed Center (DTC) in Boulder. More details can be found at the NSSL Laboratory Review website (http://www.nssl.noaa.gov/review/support/collaborations.pdf) on these specific interactions, along with the more than 20 international organizations, more than 10 NOAA organizations, more than 15 universities, and numerous non-NOAA US Government and foreign governments.

In addition to the specific instances of collaboration described above, for the past 7 years NSSL has funded a general topic "NSSL Scientific Seminar Series". This is an invited seminar for persons outside the area to come in and present their research. The topics are very diverse and not always related to primary core laboratory mission goals. Expenses for visiting scientists are paid by the lab.

Infusing new expertise into NSSL:
NSSL has recently helped create an OAR Scientific Fellows program. This program is designed to allow experts working outside the federal government to be appointed as "NSSL Scientific Fellows" in situations where NSSL can benefit by their expertise and counsel on key areas within laboratory core mission goals. Although this new program is not a "residency" program where visitors would stay and work at the lab for an extended period of time, it will potentially allow for an exchange of new ideas with experts from all over the world.

In the past, NSSL has had visiting scientists from a number of countries that have been at the laboratory for periods lasting from months up to a year, including:

- Dr. Sachidananda, India;
- Dr. Borowska, Doctoral candidate Tahanout, Morocco;
- Dr. Victor Homar, University of the Balearic Islands, Palma, Spain;
- Dr. Tadashi Fujita, Japan Meteorological Agency, Tokyo, Japan;
- Vagner Anabor, Federal University of Santa Maria, Santa Maria, Brazil; and
- several Korean visitors.

The cost of these visitors was borne by the visitor's organization. There have also been long-term visitors to the lab that were funded by the NSSL division which invited them.

NSSL has also arranged for several lab employees to spend time at OAR Headquarters for career enhancement to work on projects for OAR HQ. These OAR HQ "detail assignments" focused on administrative topics or involved project management and have lasted from a few months to nearly a year and a half.

Just this September we received notification that a proposal submitted to the NESDIS visiting scientist program for the GOES-R Risk Reduction program was funded. The following scientists will be visiting NSSL for various lengths of time in FY2010:

- Brian Vant-Hull (post graduate NOAA CREST/CCNY): Using Total-Volume Cloud Growth Rates in Precipitation Estimations
- Louie Grasso (research scientist CIRA, Ft Collins): Evaluation of Synthetic Satellite Imagery within the Storm Prediction Center
- John Mecikalski/Wayne MacKenzie (U. Alabama-Huntsville): Convective Initiation Nowcast Algorithm (SATCAST)
- Ralph Peterson (CIMSS, Univ. Wisconsin-Madison): Nearcast Algorithm for Forecasting Destabilization using GOES Sounder Retrievals.

However, a formal NSSL visiting scientist program has not existed in recent lab history. At the suggestion of the reviewers, NSSL management will work to create a more formal visiting scientist program. Details are being worked out now on formalizing a program supported by the lab's Director's Office that will provide, subject to funding, support for NSSL scientists to visit other locations and support for outside researchers visit NSSL for extended periods of time.

Actions: (in priority order)

1) Appoint 4 NSSL Scientific Fellows by July 1, 2010

2) Hire at least one visiting scientist by July 1, 2010, pending availability of funds

(A.III) Alternate Plan for PAR:

Verbatim Reviewer Recommendation:

11. Strategic plans/fallbacks if it appears pursuit of phased array radar research will not be productive for NOAA in the intermediate future.

Response:

III) Alternative Plan for PAR

Planning for Multi-function Phased Array Radar (MPAR) has been coordinated with the FAA and submitted into NOAA's PPBES. Planning extends from the present out through 2025. Most of the critical decision points are based on the FAA's radar needs (TDWR replacement and backup surveillance) as part of the NextGen program. There is risk in the MPAR program continuing to go forward as a multi-function, multi-agency effort.

The National Weather Radar Testbed (NWRT) which includes a Navy SPY-1 based phased array antenna has been operating in a research mode since 2004. Since that time several major hardware upgrades have been incorporated into the system. Scratch software is being written to perform weather surveillance. NSSL's experience in developing science-based algorithms identifying severe and hazardous weather features is being employed to create prototype algorithms for the NWRT. The rapid and adaptive scanning capabilities of the NWRT have given researchers an unprecedented look at the internal morphology and dynamics of severe storms. The NWRT serves as a one-of-a-kind scientific tool to further the understanding of severe storms. We expect results from the NWRT to lead to improvement of the NEXRAD algorithms and NWS performance measures.

Current funding levels for phased array radar (PAR) are adequate to provide O&M for the NWRT and to fund a modest scientific program. Additional funds are necessary to address the primary challenges that exist in the MPAR risk reduction plan; construction of a modern prototype; evaluation of dual-pol; investigation of affordability; assessment of interface (edge) between antenna plates and impact on algorithms; and evaluation of multi-functionality. If these additional funds are not forthcoming an alternate plan would be developed.

1. The alternate plan would focus PAR research and development on a weather only system for NOAA.

2. A minimal scientific program would focus on using new science learned from the NWRT to enhance the performance of the NEXRAD network and to develop and test a small dual-polarized PAR sub array for proof-of-concept.

3. Eventually the NEXRAD radars will wear out and need replacing with modern systems offering similar or enhanced capability. Ground based remote sensing systems seem to be the only option considering spatial and temporal resolution, range, and cost. NSSL's expertise at that time could be directed toward the development of a weather only system. Such a system would provide rapid and adaptive scanning capabilities as well as O&M cost savings.

4. A major goal of this R&D effort would be to develop a replacement phased array radar system at a cost equal to or less than a replacement mechanically steered system.

Actions:

1) Continue to work with the OFCM MPAR Working Group on a multiagency MPAR risk reduction program (ongoing activity)
2) Work with the NWS via the NOAA 20-Year Weather Radar Vision process to develop a weather-only phased array radar research strategy. Report status of this effort by July 1, 2010.

(A.IV) Suggestion for OAR on "Process" of laboratory reviews:

Verbatim Reviewer Recommendation:

12. A specific focus on educational activities should be made part of the general review process.

Response:

NSSL agrees with the reviewer's comments. We will bring this to the attention of OAR management such that they may consider including education as part of the review process in future laboratory reviews.

Action:

1) OAR HQ will evaluate the role of its laboratories and programs in education and how that role is appropriately evaluated in future lab reviews. Any revisions to the lab review process will be implemented by September 30, 2010.

(A.V) Support of FAA:

Verbatim Reviewer Recommendation:

13. Recommit (at the leadership level) to supporting the FAA's aviation weather program.

Response:

NSSL has enjoyed nearly three decades of interaction with the FAA. The level of activity over the years has fluctuated depending on FAA interest and project funding. Currently NSSL is deeply involved with the FAA on MPAR, NextGen planning, and aviation weather research and development.

The FAA has been a partner in MPAR for nearly 8 years. The FAA has aligned their budget process in FY11 to match NOAA's budget request for MPAR funding such that both organizations will share the expense of the project equally. Plans call for a 50/50 cost share up to first prototype and the FAA's "go/no go" decision point in FY18. The Director, Deputy Director, and Radar Division Chief are all leading the interaction with the FAA on the MPAR program.

Currently, NSSL is actively working with the FAA and NOAA/NWS to transfer into operations for aviation support the National Mosaic QPE (NMQ) 3D radar products. This application generates high resolution temporal (every 5 min) and spatial (1km x 1km) radar mosaics of not only NEXRAD radar data, but also some FAA TDWR radar data and all 32 Canadian radars for 31 vertical levels.

Since the laboratory review in February, NSSL has been participating in a number of new NextGen planning efforts, including those led by the FAA (internal FAA planning) and those led by NOAA (addressing NOAA's responsibilities to NextGen as assigned by Congress). NSSL's participation in the "NOAA 20 year Weather Radar Vision" also includes FAA requirements. With the increased focus by NOAA on NextGen, NSSL has recently assigned two NSSL Team Leaders (one from the Radar Division and one from the Warning Division) to interface with the FAA for NextGen.

Action:

1) Increase involvement of senior NSSL management with FAA. Assign two team leaders and Deputy Director to become involved with FAA NextGen planning and Aviation Weather Program (Completed August 2009)

Section B: Weather Radar Research

SUMMARY OF THEMES:

Quality:

- Both past and current research in weather radar is considered to be of high quality.
- Opinions on the publication rate ranged from appropriate but not earthshaking to excellent.
- Interactions/collaborations with NOAA entities external to Norman and interactions/collaborations with academic institutions, other governmental agencies, foreign research groups and private industry in general are considered to be not as strong as they should be. This concern not only included partnerships in basic research, but it is believed that private industry and other entities will, by necessity, need to play an important future role in engineering, software and technical aspects of future radar development.

Relevance:

- The relevance of NSSL Weather Radar Research to the NOAA mission is considered high. It is noted that the NSSL serves very well its function as a national laboratory for radar research.

Performance:

- Leadership of this research thrust is considered to be of very high quality.
- The Laboratory's activities in technology transfer to NOAA operational entities are considered to be a strong plus. NSSL research appears to be an important factor in recent improvements in weather warnings/forecasts. It was stated, however, that the efficiency of some technology transfer could be improved through more emphasis on open software architecture and software standardization. The recent work on implementing dual polarization within the 88D system was noted.
- Generally, the Laboratory is considered to have clearly defined plans. The major concern noted is associated with the research thrust in phased array radar (PAR). PAR research is considered appropriate, but a high risk. The potential cost and technical limitations associated with phased array radar may make this technology unsuitable for operational use for many years. **The reviewers are not against a high risk adventure, but reviewers were in favor of the laboratory developing a risk reduction plan with full exploitation of other technologies that might be of benefit to the operational radar system.**

Response (to text in BOLD):

NSSL is engaged in exploring related and complimentary technology (see related response given in Section A.III). This is one reason why we are examining the C band and X band polarimetric radars; these are candidates for gap filling to

augment the WSR-88D coverage. Canada is planning to deploy C band polarimetric radars along its southern border; most TV stations in the US have C band radars and some might be converted to dual polarization; CASA is studying the network aspects of X band radars. Thus, NSSL's modest studies of data from such radars are aimed at understanding polarimetric signatures and Quantitative Precipitation Estimates (QPE) at these wavelengths as well as extending NOAA expertise.

NSSL is also examining other rapid scan technologies, but to a much lesser degree than the PAR. For example, we are actively following developments in frequency scanning multi beam (probably not a viable approach because it requires too much bandwidth) and hybrid electronic and mechanical beam steering radars by gathering literature and talking to representatives from Industry. We are also keenly aware of, and monitoring the progress of, the OU-ARRC involvement in the ubiquitous radar, whereby a wide beamwidth is transmitted and upon reception parallel focusing in several directions is applied providing truly simultaneous look of weather over an extended angular region.

Verbatim Reviewer Recommendations (Note, minor editing has been done for formatting purposes):

1. While as a radar laboratory NSSL has much to offer the outside community, conversely the community has much to offer NSSL. It is not clear that there are good mechanisms for the flow of information from the outside community to the Laboratory beyond individual researchers being familiar with the research results in the external community. Having formal mechanisms for entraining external research results to help NSSL fulfill NOAA's mission is desirable. Exploiting such information should be part of the Laboratory's strategic and annual plans. One example would be to establish a visitor's program that might bring, for example, expertise in adaptive sampling to the Laboratory. Additionally, the Laboratory should investigate having their staff serve as visitors to other groups. While such visitations can be difficult to arrange due to personnel issues, the payoff can be high.

    - Flow of information from outside Community to the Laboratory

Response:

In addition to the comments made in Section A.II, NSSL actively participates in the American Meteorological Society Conferences to keep abreast of what is occurring in the field of weather radar outside of the Norman community. In particular, the radar division participates in not only the Radar Conference, but also the radar session of IIPS at the Annual Meeting. NSSL Researchers also follow new developments via the published literature.

An example of obtaining needed expertise not currently contained at the NSSL is our collaboration with the Hebrew University of Jerusalem. They have micro-

physical expertise that we are collaborating together with using their cloud model and combining it with polarimetric radar observations. This has proved to be an invaluable asset to the NSSL.

- Establish a two-way visitor's program

Response:

Although not highlighted at the review, NSSL has had a suite of visitors in the radar program – both as NRC fellows and summer employees. Examples were given in Section A.II.

In addition to visitors from other countries visiting the lab, NSSL scientists have spent time visiting other institutions. Dr. JJ Gourley at Meteo France (1 year) working on several aspects of polarimetric measurements. During the summers of 1992 to 2000, Dr. Doviak was an Affiliated Scientist at NCAR collaborating in the area of range-velocity ambiguity mitigation, and research on weather radar interferometry, and he was a lecturer at Tor University, in Rome, Italy, in June 1994, 1996, and 1998. In 1995 and 1997 Dr Doviak were invited to The International School of Atmospheric Radar**,** where they lectured on Scattering Theory and weather radar. In 2002 and 2006 Drs. Zrnic and Doviak presented tutorials, in Dusseldorf, Germany, to meteorologists from various countries. They also presented invited tutorials to the Indian Institute of Science in 1994, and most recently at the International Radar Symposium India in 2005. Dr. Doviak was an invited researcher at the National Institute for the study of Environmental Disasters (NIED), in Tsukuba, Japan from October to November, 2000.

NSSL will continue to look for opportunities to host visitors and to establish a sabbatical program (see Section A.II), as funding permits.

Action:

1) Same as Section A.II

Verbatim Reviewer Recommendation:

2. There seem to be some occasional interactions with industry as the opportunity arises, but they don't seem to be tied to long-term strategic planning. It seems this creates an opportunity for NOAA leadership in coordination with NSSL leadership to rethink creatively their approach for technological development and demonstration, which might include deliberate partnerships with industry and/or other government agencies on specific aspects of technology development that can be shared by many different applications. This might also give NSSL access to highly-qualified (already trained) engineers without having to provide them with a career-track, while freeing human resources to focus on the elements of the research that need to be done to transfer the technology to specific weather-radar operations that are the unique province of the weather radar program. I offer this suggestion with some trepidation as I am not knowledgeable enough about the

challenges in such partnerships (clearly not all NASA partnerships with the space industry are easy or equally successful for example). On the other hand, it is not clear that the R&D framework that worked so well for NEXRAD for example is optimal in the current context, especially in the light of NEXRAD success. For example, it seems unconceivable now that weather services could ever be provided without the observational advantage of a radar network. The public expects no less. This success created a market that industry may wish to lock into.

- Partnerships with industry and other government agencies

Response:

NSSL will continue to look for partnerships with industry and other government agencies in order to accomplish NOAA's mission. We would not be testing phased array technology had we not partnered with the Navy, Lockheed-Martin, National Weather Service, University of Oklahoma and Oklahoma State Board of Regents, Federal Aviation Administration and Basic Commerce Industries. These partnerships allowed NOAA to build a $27M dollar facility by investing approximately $2M. NSSL currently has a $5M contract with Basic Commerce and Industries (BCI), which also has ties to Lockheed Martin, as well as a $500K contract with Lockheed Martin for provision of SPY-1 parts and maintenance. The mobile C-Band radars are another example of partnerships. NSSL collaborated with three universities (OU, Texas A&M and Texas Tech) to provide two C-Band radars to the research community. We have had separate Cooperative Research and Development Agreements, or CRADAs, in place between NSSL and Weather Services Incorporated (WSI) Enterprise Electronics Corporation (EEC) and Warning Decision Technologies (WDT) for the last several years and are currently collaborating with Weather Solutions Incorporated (WSI/EEC). These collaborations have helped us obtain dual-polarization data from Alabama and Indiana. In addition, a newly initiated Small Business Innovative Research (SBIR) contract is in place with FreeEnt Technologies to explore an alternate way to engineer dual polarization capability into phased array technology.

NSSL has also been collaborating with the Canadians over the last four years, resulting in reciprocal visits, single and dual polarimetric radar data exchange, and joint publications.

Action:

1) Initiate dialog with at least one additional company by April 1, 2010.
2) Continue participation with other government agencies as part of the OFCM MPAR Working Group. Provide status report by July 1, 2010.

Verbatim Reviewer Recommendation:

3. The work on short-wavelength and transportable systems has the potential for diluting the efforts of key staff, especially in the engineering arena. As other

groups (e.g., CASA, DOWs, universities) are quite active in this area, any NSSL involvement should be kept modest and related to potential value to lab, NWS and NOAA missions.

- Work on short-wavelength and transportable systems

Response:

NSSL co-pioneered development and fabrication of transportable and mobile systems including the Doppler-on-Wheels (DOWS) and SMART-R mobile radars in collaboration with various entities at OU (Department of Meteorology, Atmospheric Radar Research Center (ARRC), etc). NSSL is a partner in the CASA (Collaborative Adaptive Sensing of the Atmosphere) radar development and has provided the core software used for severe weather detection. The cost of building the systems was shared. The transportable systems offer flexibility to participate in field programs at diverse locations and climate regions. Because these systems are dual polarized, they will provide important information on precipitation processes at a modest cost, allowing NSSL to meet its research mission.

Action:

1) None required

Verbatim Reviewer Recommendation:

4. I would suggest that their external collaborations could be stronger. There is a tendency for the collaborations to be internal with a strong focus on CIMMS.

- Strengthen external collaborations

Response:

This question is similar to that previously answered in Section A.II. However, to clarify our strong relationship with CIMMS, CIMMS is a joint institute that works closely with NSSL on topics of mutual interest. The joint institute obtains some funding from the NSSL for administration and a majority of its employees are funded by NSSL through a grant. Most collaborations in research come about as a desire to tackle research problems of mutual interest. Thus, a more accurate statement would be that NSSL's external collaboration has a strong focus on OU rather than CIMMS. We collaborate with: G. Zhang, Chilson, Palmer, Biggerstaff, Yeary, Tian You, Crain, Straka, Shapiro, Y. Zhang. None of these are members of CIMMS staff, but all are OU faculty.

NSSL researchers are encouraged to establish collaborations both internal and external, but it "takes two to tango". Examples of excellent external (e.g., outside Norman) collaborations include our work on phased array radar, range/velocity ambiguities, mobile radars, VORTEX-2 to name a few.

Action:

1) Same as Section A.II

Verbatim Reviewer Recommendation:

5. Prototype alternate ways of utilizing Ph.D. Electrical Engineering talent. Waiting for someone else to come up with a solution for hiring Ph.D. EE talent as federal employees appears to be hampering PAR hardware development. Accept that the next Zrnic will likely not be a federal employee. They are more likely to be an engineer at an aerospace company or a university-based engineer whose primary office it not at NWC. The current and future US workforce and economy will likely require shifts within NSSL regarding what has to be done in house versus what can be contracted offsite. Recommend delegating parts of the *[suggested]* engineering development tasks *[listed in recommendations 11 and 15, below]* to offsite commercial and university contracts.

    - Delegating parts of engineering development tasks to offsite commercial and university contracts

Response:

NSSL believes it is important for NOAA to maintain some level of internal expertise in critical areas such as electrical engineering. This expertise is needed to help set the research and development direction for the government in the field of radar meteorology, for example. The expertise must be also be maintained to help interact with the university and private sector, to evaluate grant proposals, to draft Requests For Proposals (RFPs) for engaging the private sector, and for evaluating proposals from the private sector. NSSL will continue to look for opportunities to use offsite commercial and university contracts to accomplish our mission. For example, we have partnered with the FAA in providing technical assessments for MPAR risk reduction. NSSL is partnering with the FAA to develop a technology assessment program roadmap with Lincoln Laboratory and Georgia Tech Research Institute. The main components of this assessment program are to engage industry expertise in dual polarization technology and affordability studies.

Action:

1) Report out on the progress of the joint NSSL – FAA technology assessment program by July 1, 2010.

Verbatim Reviewer Recommendation:

6. Strongly recommend the development of active collaborations with the research arms of European meteorological agencies as several of these groups already have operational networks of dual-polarization radars. Information about lessons learned and access to data for meteorological conditions that have analogs in US would be of benefit to the development and use of dual polarization in the US.

- Development of active collaborations with the research arms of European meteorological agencies.

Response:

Although the review did not allow us to touch on every detail of our collaborations.

- We are engaged with the European meteorological community and participate in European Radar Conference (ERAD) every two years to keep us informed on European radar developments.
- We are engaged in collaboration with the University of Bonn in the area of polarimetric measurements (our scientists have visited U Bonn, and their researchers have visited NSSL). U of Bonn is connected with the German Meteorological Service.
- Dr. Zrnic is a member of the advisory board of Novimet, a partnership between a private French company and Meteo France, and they are developing dual polarization QPE schemes.
- We gave seminars at Meteo France and we exchanged visitors. JJ Gourley spent a year at Meteor France and M. Tahanout from Meteo France visited NSSL. Plans are to continue this collaboration.
- We had collaborative work with the Italian researcher P.Alberoni in the area of polarimetric measurements. Dr. Zrnic was a member of advisory board on the CAPRE DIEM European project lead by Italy. Additional joint research project on polarimetric QPE between NSSL and Drs. G. Vulpiani and F. Marzano, European experts in radar meteorology, recently resulted in two formal publications.
- We are collaborating with Environment Canada in the area of polarimetric data analysis, classification of hydrometeors, and QPE. Environment Canada has a 0.5 deg C band polarimetric operational radar (24/7). Data analysis and other issues studied by authors of both organizations have been published in several papers.
- We have a new post doc from Italy that joined us in September to work on the phased array dual polarization issues.
- NSSL presented invited keynote talk at the European Conference on Radar Meteorology and Hydrology in Barcelona, Spain in September 2006 and shared in the keynote address at the European IEEE radar conference in Bordeaux, France in October 2009.
- Dr. Ryzhkov presented week-long lecture courses on weather radar polarimetry at the University of Bonn (Germany) and at the Kyoungpook National University in Daegu (Korea)
- There is a long-term collaboration established between NSSL and Korea Meteorological Agency, Kyoungpook and Pukyong National Universities in Korea (Profs. K.-E. Kim, D.-I. Lee, and G.-W. Lee) in the area of weather applications of polarimetric radar. Dr. Ryzhkov advised 4 PhD level graduate students from Korea who spent significant amount of time at NSSL during last years.

- There is a collaboration between CIMMS / NSSL and The Hebrew University of Jerusalem, Israel under the Binational Science Foundation grant on a coupling of polarimetric radar and cloud model.

Action:

1) None required. Present activity level is satisfactory.

Combined Verbatim Reviewer Recommendations 7 & 8:

7. Given the high priority of the PAR program and the large fraction of NSSL resources tied to PAR research and development, NSSL should develop risk-reduction measures. One example measure might be to organize an external PAR advisory committee

8. The MPAR effort is what would be best characterized as a moderate risk endeavor. This is not meant to imply that the effort shouldn't be undertaken. Indeed, it is entirely appropriate and exciting that NSSL is leading this program. The concern is that no Risk Mitigation Strategy was presented during the site visit (or is planned in the immediate future). This is standard procedure for any organization overseeing a large development project. Creating a detailed strategy was less of a concern with the development of the NEXRAD (WSR-88D) program; however, the risk with MPAR is greater.

- Development of risk-reduction measures

Response:

Although not highlighted at the review, the NSSL and FAA have developed a risk reduction matrix and we are proceeding in addressing the items in the matrix as funding permits. The risk mitigation plan (http://www.ofcm.gov/r25-mpar/pdf/00-opening.pdf) was developed as part of the PAR Joint Working Group (PAR JAG) Report coordinated by the Office of the Federal Coordinator for Meteorology (OFCM). It is a "living" document that was created for guiding our technology assessment program that we are collaborating on with the FAA. Having been involved in both the NEXRAD development and MPAR, both programs involve some risk with both providing potential large improvements in our radar networks.

- Organize an external PAR advisory committee

Response:

A PAR advisory committee exists through the Office of the Federal Coordinator for Meteorological Services. A Working Group has been established and this group meets quarterly to review progress and to address programs and provide guidance to the program (www.ofcm.noaa.gov/wg-mpar/).

Action:

1) None required

Combined Verbatim Reviewer Recommendations 9, 11, and 15:

9. Develop a plan for transitioning MPAR demonstration activities to a modern, active array-based testbed that will more fully demonstrate MPAR capability and implementation costs. It would be highly desirable to develop multiple MPAR testbeds so that parallel research could be conducted at other institutions around the U.S.
11. Medium risk: Weather radar phased array with modern components. There is a critical need for a prototype PAR system with modern components even if it does not include 360 deg scanning or dual polarization in the short term. This will serve both as an engineering and scientific test bed.
15. High risk: Development of dual polarization PAR with modern components.

- Plan for transitioning MPAR demonstration activities to a modern, active array-based testbed

Response:

Although not emphasized during the review, joint plans already exist with the FAA on moving to a modern, active array-based testbed. This would happen first during the technology assessment of the dual-polarized sub-array testing and then in a two/four faced prototype system.

- Develop multiple MPAR testbeds in parallel

Response:

This is a great idea if the funding profiles for development will allow us to do this.

- Develop a prototype with dual polarization capabilities

Response:

We have been working on this problem for several years and we are partnering with Lincoln Laboratories, Lockheed Martin, OU, Basic Commerce and Industries (BCI) and have funded yet a different company on a Small Business Innovative Research (SBIR) contract to address this issue. We are also supporting a post doctoral fellow from Italy to work on this in addition to the in house personnel. We are ready to build a sub-array to help minimize the risks in this area. As soon as the funding arrives, we would proceed with building a prototype.

Action:

1) Same as Section B.5

Verbatim Reviewer Recommendation:

10. Low risk: How to use data sets based on adaptive scanning at each radar site to derive standard radar products site to site across the network. An important constraint is that there are other uses of operational radar data in addition to NWS real time use. Will a low elevation angle (0.5 deg) 360 deg azimuth scan always be part of the scan strategy to address hydrometeorology and convection initiation applications? What portion of the phased array scan strategy will be proscribed and what portion should be adaptive? How low can PAR scan? Feasibility studies can be done with SPY-1 PAR.

    - Conduct feasibility studies concerning adaptive scanning

Response:

Feasibility studies are already being accomplished and modifications continue to the NWRT to support even more elaborate adaptive scanning ideas. Adaptive scans will be designed to meet the requirements for joint use of the radar and would include low level scans to address the hydrological questions.

Action:

1) Submit results of adaptive scanning studies employing the NWRT to a refereed journal by July 1, 2010.

Verbatim Reviewer Recommendation:

12. Medium risk: Related to *[#11]* above: Determine methods to increase sensitivity of PAR to current standards for WSR-88D clear air Volume Coverage Patterns (VCPs). This is needed for observations of convection initiation and snow.

    - Develop a prototype PAR with the same sensitivity as the current WSR-88D

Response:

Although the NWRT does not have the sensitivity of the WSR-88D, it is recognized that the operational replacement of the WSR-88D will be required to meet these sensitivity requirements and our goal is to meet or surpass those requirements.

Action:

1) None required

Redundant Response: Verbatim Reviewer Recommendations 13 and 14:

13. Medium risk: Obtain PAR data sets for other meteorological settings than Oklahoma in collaboration with NWS forecasters and researchers in other federal labs and at universities who have expertise on these types of storms. Clone system

in *[#11]* into a portable system (i.e. transportable in containers, it does not need to run while a truck is moving). There is a critical need to obtain data in other locations to specify NWS needs for fast updates in a variety of storm types and explore scientific/engineering issues in a wide variety of storm types and terrains. Ideally, leave the equipment in place for 3 or more months running as an internet appliance so it can be controlled at NSSL to minimize the need for on-site support. As part of this activity, collect data in a variety of locations such as: Miami, FL--small intense cellular convection, Seattle, WA--nimbostratus rainfall and mountains, Buffalo, NY--lake effect snow, Phoenix, AZ--monsoon thunderstorms and terrain, Portland, ME--hail in non-super-cell storm setting, Medford, OR--WSR-88D site on mountain top).

14. Related to *[#13]*, above: Need to determine if there are issues related to sidelobes and grating lobes when using PAR in regions with mountainous terrain.

- Make the prototype PAR transportable for testing in other areas of the US. Make it an internet appliance so it can be controlled at NSSL with minimum on site support
- Use transportable system to test effects of sidelobes and rating lobes in mountainous terrain

Response:

We agree. This will be driven by the funding profile for research and development. We already have designed the NWRT to be controlled from anywhere in the world and would carry these ideas into our development of a transportable system.

Action:

1) None required

Verbatim Reviewer Recommendation:

16. Recent and prospective hires need the space and appropriate mentoring to grow as scientists and engineers first. It was not clear to me that a couple of the small projects to demonstrate applications and products were central to the long-term core objectives/needs of the scientific and operational objectives of the weather research program, and younger scientist might be better off redirecting their efforts. Also, consider intensifying recruitment efforts at schools with strong radar research programs.

- Mentoring of young scientists and engineers

Response:

NSSL does mentor its young scientists and engineers. We will continue to make this a priority as early career scientists and engineers join the NSSL family.

- Intensify recruitment efforts at schools with strong radar research programs

Response:

We agree that we need to intensify our recruitment efforts at other schools with strong radar research programs. We will make a concerted effort this coming year to have a senior staff visit those schools, provide a seminar, and actively recruit students to come work for NOAA and especially NSSL.

Action:

1) Insert into the Performance Plan of at least one senior principle investigator the requirement to complete a recruitment visit in FY11.

Verbatim Reviewer Recommendation:

17. Increased focus is needed on the winter-weather applications of the -88D dual-polarization capability.

- Focus WSR-88D dual polarization research on winter weather applications

Response:

We currently have some effort already being applied to this problem. NSSL is collaborating with Lincoln Laboratories (LL) in detection of icing conditions. For the past two years, we have conducted a campaign to collect polarimetric radar data from winter storms in Oklahoma. A fairly good sample of various ice, freezing rain and snow cases has been collected and is being analyzed. A verification of snow amounts was by voluntary observers. We have also been collaborating with the Canadians for the last four years. They have been testing our algorithms for melting layer detection and hydrometeor classification on a huge amount of continuously collected data. They also provide us with a bounty of winter weather polarimetric data. In addition, we have increased our emphasis in this area by adding a recent post-doc to the CIMMS staff.

Action:

1) Identify a research scientist to take the lead in applying dual polarization techniques to winter weather applications by July 1, 2010.

Verbatim Reviewer Recommendation:

18. There is some concern regarding the "tuning" of QPE estimates using dual-polarization techniques in Oklahoma (e.g., the Kessler farm). While this is an important and logical first step; plans should be made to test this procedure at other locations around the United States.

- Plan to test QPE estimates from dual-polarization around the United States.

Response:

NSSL is addressing this in several ways. We are using some current field programs (i.e. Gunnison, Co; Vancouver area in support of the 2010 Winter Olympics; Debris Flow in Southern California; Hydrometeorological Testbed West; and in the near future HMT-Southeast) to gather data for analysis and we are also analyzing polarimetric rainfall data obtained in Germany. In addition, we are analyzing data from Taiwan to determine the effects of beam blockage in complex terrain. This collaboration is between the Taiwan Met Service, NCAR, and NSSL. We are also analyzing data from an X-band radar in China.

Since dual-polarization is now being implemented across the United States on the fleet of WSR-88Ds, we will continue to refine our techniques based on other locations across the United States as funding permits.

Action:

1) None required

Verbatim Reviewer Recommendation:

19. Please make sure that any new radar data archive formats that NSSL helps create are vetted in the broader community. The radar research community must be able to develop and have access to analysis tools that can easily read and synthesize the data. NSSL could facilitate (in partnership with other labs/universities) the development of common analysis tool/software packages that could be used by everyone. Hosting a workshop would be an excellent first step.

- Ensure data archive formats created at NSSL are vetted in the broader community

Response:

Radar data are archived in their raw format to preserve the most information and can then be used to recreate the radar products. We also archive radar data products using self-describing formats (i.e. NetCDF). In the past we have vetted new formats with the operational units at the NWS and FAA. An example is Message 31, the record header that was changed recently that contains the metadata for transmitting Level II WSR-88D radial information. If a new format is created in the future, NSSL will vet it with the community.

- Make access to data easy for the outside community by development of common analysis tools/software packages

Response:

We have successfully advocated for the University of Oklahoma to provide a royalty free license to U.S. Government, State Governments, university students, and non-profit researchers for the Warning Decision Support System – Integrated Information (WDSS-II) software package. Several students have used this package to develop new algorithms (many more used it to test current algorithms or view data sets) and the NSSL staff have supported them through an "on-line" forum and training packages, as well as hosting several visitors.

- Host a workshop on using NSSL data sets

Response:

We would like to host a workshop, but with the current development tasks, research, and staffing, we only have a limited amount of resources available to accomplish a workshop. Our tools are available for other researchers to use and we are committed to supporting them through the on-line forum. If future funding permits, we may see if Unidata (whose is better suited to host such a workshop) might be interested in co-sponsoring such an event.

Action:

1) Contact UNIDATA about their interest in, and financial ability to, host a radar dataset workshop. Consider alternatives if UNIDATA not forthcoming. Settle the issue and report by July 1, 2010.

Verbatim Reviewer Recommendation:

20. Update WSR-88D technology transfer processes. Specifically transition signal processing development activities to the Vaisala RVP-8 architecture in order to facilitate implementation within the ORDA. Secondly, strongly encourage meteorological algorithm developers to employ the Common Operational Development Environment (CODE) to facilitate transition of ORPG algorithms into the operational WSR-88D network.

- Transfer signal processing development activities to the Vaisala RVP-8

Response:

Up to this point, the RVP-8 did not have the power to perform some of the more CPU intensive experiments. We have now decommissioned the Research RDA (RRDA) and are using the RVP-8 connected to our research WSR-88D (OUN) radar. There are a few problems working with the RPV-8 considering it is a proprietary system.

Future endeavors will be approached on a case by case basis. We feel that science should not be constrained by the current processing systems; future requirements

should drive the future operational observing and processing systems. The primary driver of deciding the development environment for science and technology development tasks should be the one that best facilitates scientific discovery and offers the least encumbrance to the scientist.

- Encourage meteorological algorithm developers to employ CODE

Response:

NSSL believes the current process of transferring updated single radar algorithms into the NEXRAD baseline is the most efficient approach (i.e., NSSL does the science behind the algorithm, writes either software code or pseudo-code/Algorithm Enunciation Language (AEL) or makes direct changes to the baseline code, then gives it to the Radar Operations Center (ROC) for final implementation, testing, and insertion into the ORPG baseline). If the ROC would like to propose an alternate model with appropriate funding, NSSL would certainly be receptive.

Action:

1) Discuss issue with the ROC during development of FY10 joint MOU. Report outcome by July 1, 2010.

Verbatim Reviewer Recommendation:

21. Institutionalize externally monitored technical interchange meetings with national weather radar researchers to develop consensus on "best of breed" new signal processing (ORDA) and product generation (ORPG) techniques for the WSR-88D network. Validate these decisions through the NEXRAD Technical Advisory Committee (TAC).

- Formalize externally monitored technical interchange meetings concerning new signal processing and product generation techniques

Response:

Technical Interchange meetings have been accomplished concerning dual-polarization and range/velocity ambiguity mitigation. Other forums for technical interchange occur at the Radar Conferences and various AMS meetings. In addition, we serve on the NEXRAD TAC and attend the TAC meetings where technical interchange also occurs.

- Validate those decisions through the NEXRAD TAC

Response:

Decisions on changes to the operational NEXRAD WSR-88D are validated through the NEXRAD TAC.

Action:

1) None required

Section C: Hazardous Weather Forecasts and Warning Research

SUMMARY OF THEMES:

Quality:

- The quality of research under this category is considered to be very high by all reviewers with the scientific productivity meeting reviewer expectations. While there is some divergence of opinion, many reviewers state that the quality of the staff and work is very high based on awards and publication history.
- Areas of research that were thought to have been very successful were efforts on visualization and algorithm development for decision support systems, research on probabilistic weather forecasting and the warn on forecast research thrust.

Relevance:

- The relevance to the NOAA mission of NSSL's research and activities are considered to be extremely high. It is clear that the NSSL has a good relationship with the relevant operational components of NOAA.
- A new area of research that was considered to be especially relevant was the warn on forecast thrust.
- Several other areas were deemed to be relevant to the NOAA mission, but these also were considered to be under-resourced to different degrees: heavy rainfall and flooding; winter weather; impact of climate change on severe local weather; aviation meteorology, social aspects of weather forecasts/warnings, dynamics of mesoscale convective systems, non-tornadic high winds, use of satellite and lighting information.

Performance:

- The Leadership of this research thrust is considered very good. Most reviewers note well-defined objectives and strategies and the engagement of the staff in the research. One reviewer, however, observes that **this thrust is organized around activities (e.g. Spring Experiment, HWT) rather than projects. "As such, the objectives, scope and methodologies are not as clearly defined as might be the case with specific projects directed toward well-defined objectives."**

Response:

The activities mentioned (Spring Experiment, HWT) are operational beta tests of research ideas that were developed by research projects. Therefore, the activity the reviewer mentions is a research-to-operations activity that requires significant amounts of organization and resources. As such, these activities are highlighted as an important component of the NSSL research portfolio, since they allow us to test the value of our research to our NWS customers. It may be that our objectives were obscured during the discussion of these important research-to-operations activities, but we believe the research projects that lead to operational best tests have well-defined objectives, scope, and methodologies. Examples

include research related to VORTEX2, warn-on-forecast, convective initiation, derecho-producing convective systems, and short-range ensemble forecasting.

- Engagement with the operational community and technology transfer is a strength. The Hazardous Weather Testbed/Spring Experiments are considered to be an especially effective technology transfer tool.
- External connections in modeling to the university community and other NOAA laboratories were considered to not be as strong as they could be.

Response:

While external collaborations can always be stronger, collaborations require a strong interest and commitment from both organizations involved. We have strong connections to:

- NCAR in data assimilation;
- the Center for Analysis and Prediction of Storms (CAPS) and ESRL/GSD in WoF;
- the NWS Storm Prediction Center (SPC) and CAPS in HWT activities;
- the University of Oklahoma in a wide variety of research projects
- the University of Arizona in predictability research;
- Penn State in convective initiation research;
- Purdue University in severe weather and climate change;
- Purdue and Penn State in tornadogenesis research;
- North Carolina State University in mesoscale convective system research; and
- a broad coalition of universities (Penn State, Texas Tech, North Carolina State University, University of Colorado, Purdue University) are connected to NSSL via VORTEX2.

NSSL scientists also have a long history of strong participation in community activities, such as the American Meteorological Society, which can also be viewed as a type of collaboration. (See also Section A.II)

Verbatim Reviewer Recommendations (Note, minor editing has been done for formatting purposes):

1. Increase the efforts to incorporate satellite and lightning data into the mix of inputs to the warning and forecast problem; such data have potential to assist with the lead-time issue.

Response:

Satellite and lightning data already are included as part of WDSS-II to display multi-sensor observations for warning operations. The incorporation of these data into convection-resolving models is already planned, and some initial testing has been conducted. However, the majority of our work to date has been focused

upon the use of radar observations that we believe provide the foundation to increasing warning lead-time. As our ability to assimilate radar observations matures, our focus will shift to these other data sets. NSSL is also participating with the SPC and NESDIS in the GOES-R Proving Ground that may help lead to increased opportunities to incorporate satellite data into the warning and forecasting problem.

Action:

1) None required

Verbatim Reviewer Recommendation:

2. Currently and historically, the main focus of NSSL has been on tornadoes and tornado warnings, and arguably rightfully so in the early period of the lab's history. However, it is time to reassess all modes of hazardous weather since NSSL is the only NOAA lab dealing with severe storms. It is appropriate to examine current and projected statistics regarding loss of life and property for all types of hazardous weather – tornadoes, hail, lightning, flash-flood-producing storms, cold-season storms, etc. – and determine the extent to which improved forecasts and warnings can reduce losses. Priorities for basic and applied research on these phenomena can then be established, and resources redirected to tackle all societal relevant weather-hazard problems. This broader approach to severe weather research should also serve to attract a broader range of outstanding young scientists. Right now, some promising prospects shy away because they think it is a lab just for "tornado chasers."

Response:

Setting research priorities based upon current and projected statistics regarding loss of life and property loss certainly is one approach. However, our preferred approach is to set research priorities in discussion with our partners in the National Weather Service, who consider not only statistics regarding weather-related fatalities, but also operational needs and opportunities which may differ from the conclusions drawn purely from statistics. These needs must also fit with our staff expertise if the research is to be efficient and successful.

In regard to attracting younger scientists, recent NRC post-doctoral applicants have indicated an interest to work with NSSL on problems related to flash floods, ensemble techniques, radar data assimilation, and field program analyses. A recent job announcement drew applications from universities across the United States. At this time, we have no evidence that promising prospects are shying away because NSSL is "just for tornado chasers".

Action:

1) None required

Combined Verbatim Reviewer Recommendations 3 and 7:

3. NSSL also should consider whether to increase their level of basic research in mesoscale convective systems (MCS) and attendant hazards (e.g., high winds and flash floods). Most of the ongoing research on MCSs appears to be tilted more toward forecasting applications (e.g., looking for climatological sounding indicators of long-lived MCSs or damaging winds) rather than MCS dynamics (the recent research of Stensrud and Coniglio stands out as an exception). The applications research is, of course, critical to NSSL's mission, but I believe that the basic research component could be bolstered to better relate MCS dynamics to MCS-related hazards. For example, flash flood research seems largely limited to the radar detection of heavy rain and the hydrological aspects of flash floods, rather than also exploring what mesoscale dynamics produce convective systems capable of producing large precipitation accumulations.
7. There was concern that very little was presented on non-tornadic high wind warnings. In addition, there was not much emphasis placed on understanding (e.g., dynamics) of mesoscale convective systems…..a very important phenomenon that is associated with flooding and high wind damage. The focus of the presentations was clearly on tornadoes and supercells. NSSL might want to consider "balancing their portfolio" so that it includes increased research on other severe convective storm types.

Response:

MCSs certainly are an important producer of damaging non-tornadic winds and heavy rainfall. However, our publication record shows that we have been involved in research on MCSs that includes work on MCS dynamics and improved physical understanding (8 formal publications since 2000). Another 21 publications on more general MCS research have appeared in the last ten years. Work on MCSs continues, even though time was not sufficient to discuss these topics thoroughly during the review. The NSSL-enhanced COMMAS cloud model is being used to simulate mesoscale convective systems (MCSs) at high spatial resolution with an advanced, two-moment liquid and ice microphysics scheme. Our investigation of high resolution storm dynamics is needed for realistic representation of turbulence and important features such as convective updrafts, while detailed microphysics provides more accurate resolution of the diverse precipitation and electrification processes in an MCS's leading convective line and trailing stratiform region. We agree that our level of MCS dynamics research has suffered as staff retired and hope that NRC post-docs and new additions to our federal staff following the attached Workforce Committee Report (see Attachment 1) will enable us to strengthen these efforts.

Regarding the balancing of our research portfolio, we are in regular discussion with our NWS colleagues to learn where they have forecast and warning challenges and we use this knowledge to inform our choices regarding research

directions. Thus, the balancing of our portfolio is an ongoing process and occurs naturally as part of our mode of operation.

Action:

1) **None required. We believe NSSL's emphasis on MCS research is adequate at present. Interestingly, one of NSSL's 2009 PECASE Award winners *five- year research plan* is focused on damaging winds (derechos). However, see the Workforce Management Report in Attachment 1 (Position #2 in the hiring strategy portion).**

Verbatim Reviewer Recommendation:

4. While it is understandable that NSSL will continue to focus on advancing technologies such as radar, visualization etc, for **"hazardous weather**" [reviewer emphasis] forecasting, it is important that the categories and elements of hazardous weather be broadened. For instance, there should be a greater emphasis on improving the quality of precipitation estimation from radar. There should also be a clear strategy to improve the quality of QPE much like the goals set for tornado forecasting.

Response:

This comment is directly related to the research being done in the hydrometeorology group, which produces QPE every 5 minutes across CONUS. Since QPE was discussed entirely during their presentations, we refer the reviewers to responses to question 2 and 5 in the hydrometeorology Section D below.

Action:

1) Actions related to QPE research are included in Section D.

Verbatim Reviewer Recommendation:

5. This group indicated that its research efforts are relevant to four (4) of the objectives of NOAA's mission in weather and water. With respect to water," ***Increase lead-time and accuracy for weather and water warnings and forecasts"*** and ***"Improve predictability of the onset, duration, and impact of hazardous and severe weather and water events"*** are mentioned. However, reading the list of priorities for the 5 and 20 year research plans, it would be more convincing to see more specific items related to the **"water"** aspect. In my personal view, **improving the accuracy of precipitation measurement** should be a key priority. This should of course be a shared priority with the Hydrometeorology group.

Response:

We agree that improvements to QPE are needed, but note that this research effort is led by the hydrometeorology group. While all NSSL groups interact, we specifically avoided mention of water issues in this portion of the review. Please see the responses to reviewer questions 2 and 5 in the next Section D for comments.

Action:

1) Actions related to QPE and "water" research are included in Section D.

Verbatim Reviewer Recommendation:

6. Consider the inclusion of permanent social science expertise.

Response:

This suggestion is being seriously considered and was also recommended independently by an NSSL work force planning group. Note that NSSL already supports the Social Sciences Woven into Meteorology (SSWIM) group within the National Weather Center.

Action:

1) Provide copy of 2010 SSWIM Annual Report to OAR HQ by July 1, 2010.

Verbatim Reviewer Recommendation:

8. There is also some concern that at least one research project (mountain cold pools) seemed misplaced and might be considered subcritical in terms of staffing. This led to an unclear view as to how priorities are set and how decisions are made to fortify areas that are the traditional labs strengths versus diversifying the lab's research interests into other areas.

Response:

The mountain cold pool project was used to highlight a new area of work (winter weather) that is being addressed through the NRC post-doc program. All of our expertise in winter weather was lost over the past 5 years, and the post-doc program represents one way to broaden our research portfolio into winter weather once again.

Action:

1) Same as B.17

Verbatim Reviewer Recommendation:

9. Expand observation, analysis and modeling activities to the non-severe storm systems that are responsible for the majority of commercial aviation impacts, particularly in the congested airspace corridors of the eastern U.S.

Response:

We are interested in partnering more with the FAA and its collaborators on the analysis and prediction of non-severe storm systems in support of NextGen. Much of our QPE and WDSS-II system development already assists in providing real-time information on these hazards in partnership with ESRL/GSD.

Action:

1) None required

Combined Verbatim Reviewer Recommendations 10 and 11:

10. Develop at least a moderate level of staff domain-knowledge in air traffic control processes, traffic flow management decision support technologies and FAA modernization priorities (i.e. the so-called Next Generation Air Transportation System or "NextGen" initiative).
11. Assign one or two senior staff or management personnel to develop a sustained relationship with FAA's aviation weather research management team. This should be in addition to the mid-level staff assigned to execute specific NSSL projects funded by the FAA.

Response:

We have one private pilot on staff acting as our main focal person for the FAA and he is aware and well educated on air traffic control processes. We are very interested in contributing to the NextGen initiative and are working with other OAR laboratories and the NWS to explore how we can help. We believe that interactions with FAA will greatly increase as a result of NextGen. Not only is NSSL working directly with various units within the FAA on NextGen related topics (e.g., MPAR, 3D CONUS radar mosaic of precipitation, FAA's Reduced Weather Impact initiative), OAR headquarters is now organizing a Line Office level coordinated response through the recent appointment of a OAR NextGen coordinator to work with both the FAA and with the NWS, the NOAA designated lead organization responsible for NOAA's involvement in NextGen. (See also Section A.V)

We are very interested in contributing to the FAA's NextGen initiative and are working with other OAR laboratories and the NWS to explore how we can help.

We appreciate the spirit of this recommendation and are considering alternatives how we can increase NSSL's engagement with the FAA. (See also Section A.V)

Action:

1) Same as Section A.V

Verbatim Reviewer Recommendation:

12. Overall, the efforts covered under this topic are in good shape. The only concern is what appears to be a weak relationship with CAPS (and other external storm scale forecast groups). If this perception is correct, this is a substantial lost opportunity. It is recommended that NSSL management reevaluate the situation and take any needed steps to invigorate productive, collaborate efforts on storm scale numerical modeling with the external community.

Response:

NSSL has provided a stable source of funding for CAPS interactions in the past few years and is working to enhance our collaborations through collaborative external grant proposals. The Director of the NWS has requested NSSL work to infuse the scientific advances be made by CAPS into the NWS operations and we are working towards that goal. The new Warn-on-Forecast initiative currently in the President's budget will provide some funding to enhance the NSSL and CAPS collaboration. In addition, the National Weather Center Director's Forum is presently exploring convection-resolving numerical weather prediction and looking for ways to enhance collaboration across all agencies in Norman. These efforts should lead over a period of years to an increased collaboration. It is always a challenge to balance collaborations with our NWS partners and those of external groups and we constantly alter this balance to respond to new priorities and initiatives.

Action:

1) Provide a status report to OAR HQ on NSSL – CAPS partnership by July 1, 2010.

Verbatim Reviewer Recommendation:

13. Needless to say that there are many scientific challenges related to this research area which can only be solved through better observation, modeling and improved decision support systems. For instance, the goal of improving tornado forecasts beyond the current level, which has been a primary goal of the research group, will be most challenging. Judging from one of the graphs presented, it seems that since roughly 2002, the key statistics such as probability of detection and lead time have stayed at the same level. Of course time will tell, but at least the 5-year plan for the group should be examined more critically to ensure that the

combination of research and development efforts in this area are in line with the goals of improving the three statistics being monitored.

Response:

We are developing a project plan for the WoF program after examining the various needs and exploring how best to accomplish the goals set forth. The resulting plan will take into account these concerns, but we also note that it is only after 5 years that the technology will mature to the extent that we can begin to explore our ability to extend warning lead-time and improve the three statistics being monitored. A thorough discussion addressing this very point was published in the October issue of BAMS entitled "Convective-scale Warn-on-Forecast System: A vision for 2020."

Action:

1) Complete WoF project plan by July 1, 2010.

Verbatim Reviewer Recommendation:

14. Express Milestones (5-year Research Plan) in terms more definitive and subject to verification than "improve," "evaluate," "transfer up to …" and the like.

Response:

The 5-year Research Plan is a NOAA document and not within the purview of NSSL to alter independently. As opportunities arise for NSSL (and the other laboratories within OAR) to provide input to development of future plans, we will make these suggestions.

Action:

1) None required

Verbatim Reviewer Recommendation:

15. NSSL should consider how they can close the "theoretical gap". For example, NSSL lost one of the world's leading severe storms theoreticians in Robert Davies-Jones (retirement).

Response:

We agree that losing Robert Davies-Jones will weaken our theoretical expertise. Unfortunately, theoreticians in severe storms research are uncommon and it is not clear how easy it will be to replace this expertise. We will always be looking for this type of person but we cannot guarantee that this person can be found. Please see above responses to the review team concerns about developing a workforce

plan for further discussion. (See also Section A.I, which relates to development of the workforce plan, as well as Attachments 1 and 2).

Action:

1) Same as Section A.I

Section D: Hydrometeorology

SUMMARY OF THEMES:

Quality:

- The reviewers recognized that this is the newest research thrust at NSSL and probably the smallest research team. Some reviewers note this made the quality somewhat hard to judge. Others state that the publication productivity was somewhat low, but solid and of good quality.
- The research activity associated with the QPE was identified as being of high quality and importance.

Relevance:

- Relevance of this research thrust and importance of this topic to the NOAA mission was considered high by the reviewers.

Performance:

- Reviewers note the breadth of activities addressed by the hydrometeorology research group. Several reviewers, however, were concerned that the staff was not sufficient to attack all current problems and ones that likely would emerge in the future.
- The relationship of the Hydrometeorological research to that occurring in other NOAA entities was not clear to some reviewers. This includes the relationship to the HPC, RFCs, and other NOAA research laboratories. One reviewer, however, stated that NSSL was the only NOAA research laboratory that addressed both hydrometeorology and hydrology and, therefore, it fulfilled an important role.
- A theme emerged from some reviewers that due to the fact this group was supported by a high fraction of soft money, their research objectives might be diverted from NOAA goals.

(D.I) Coordination of NSSL's role and linkages with other agencies, labs:

- collaborate with ESRL on QPE and QPF
- collaborate with NWS/OHD/Academia on hydrologic modeling
- linkages with HPC, RFCs, and WFOs for flash flood prediction/warnings

Verbatim Reviewer Recommendations:

2. More effectively collaborate with ESRL to improve QPE and QPF. Partner with the NWS and the academic community to advance hydrologic forecasting. Formulate and implement a more viable strategy to focus NSSL's limited hydrologic science expertise to the overall benefit of NOAA.

3. Coordination of NSSL's role and linkages with other agencies, labs: It is not clear in this reviewer's mind what the relative roles of ESRL and NSSL are with respect to precipitation estimation and forecasting, and how NSSL links up with the Hydrometeorological Prediction Center (HPC), the River Forecast Centers (RFC), and the NWS with regard to flash-flood prediction and warnings. Activities among these various entities may already be clarified and coordinated, but I did not see it explained clearly at the review and it would be useful to define this coordination better.

    - More effectively collaborate with ESRL and NWS on QPE and QPF

Response:

NSSL continues to look for collaborative opportunities with ESRL as described in Section A.II. NSSL has been intimately involved since the late 1990's in the design, execution, and analysis of CALJET, PACJET, and HMT, contributing as members of the scientific steering committees of those projects and contributing expertise and equipment to their execution. HMT is specifically concerned with QPE and QPF and NSSL has co-authored papers on those subjects with researchers from ESRL. The Debris Flow Project implementation plan developed with the USGS had substantial ESRL involvement.

Regarding hydrologic forecasting, we have received the research version of the NWS Hydrology Laboratory's Distributed Hydrologic Model (HL-DHM). With this model, we have conducted research studies that have examined the impacts of polarimetric radar inputs on hydrologic simulations as well as multi-sensor forcing from low-earth-orbiting and geostationary satellites, radar, gauge, and combinations. Results from both these studies have been submitted to AMS journals. In addition, we have calibrated this model on the Tar River Basin in NC as part of the CI-FLOW project. This model now runs in real-time and is currently being configured to be coupled to a hydrodynamic, storm surge model.

A demonstration of CI-FLOW is currently ongoing. NSSL's Q2 multisensor QPE system is driving a research HL-DHM hydro-model for daily evaluation against stream gages. Following the first CI-FLOW season a workshop will be organized to evaluate the successes and perhaps organize a BAMS article on results.

Another strong organizing factor for hydro research is the planning process for the Integrated Water Resource Science and Services (IWRSS), a component of NOAA's Weather and Water Goal Team. OHD is leading the development of IWRSS, and NSSL is a major contributing entity.

In addition to what has been addressed in Section A.II, ESRL and NSSL collaborate on research to improve QPE though development of radar technologies and techniques. The operational units of NOAA (HPC, RFC, WSFO) are responsible for making rainfall and flash-flood predictions and they depend heavily on radar estimates of rain. NSSL conducted a major, community-wide workshop on QPE in 2005 to develop community QPE priorities and the research required to improve NOAA services. A BAMS publication describes those priorities:

Vasiloff, S.V., D.J. Seo, K.W. Howard, J. Zhang, D.H. Kitzmiller, M.G. Mullusky, W.F. Krajewski, E.A. Brandes, R.M. Rabin, D.S. Berkowitz, H.E. Brooks, J.A. McGinley, R.J. Kuligowski, and B.G. Brown, 2007: Improving QPE and Very Short Term QPF: An Initiative for a Community-Wide Integrated Approach. *Bull. Amer. Meteor. Soc*., 88, 1899–1911.

The NOAA operational units, ESRL, and academia were heavily involved in defining the approach that NSSL has been taking in research work to improve QPE and short-range QPF (<6 hours). Many sub-projects have been initiated since the workshop with large operational unit support. Examples include the development of specific QPE and radar processing algorithms in NSSL's Q2 system, evaluation of gap-filing radar technology in HMT-West using Q2, evaluation of Q2 in the development of RFC products, and the porting of Q2 to an operational entity within NCEP. Coordination of these activities involves frequent (often weekly) conference calls and regular status reports to NOAA management.

Since the review, NSSL has received funding through the NWS Advanced Hydrologic Prediction Service (AHPS) program to evaluate the primary tool called Flash Flood Monitoring and Prediction (FFMP) used by the NWS to issue flash flood warnings. This is the first study of its kind that will yield results directly applicable and useful to NWS forecasters.

Action:

1) Meet with NWS OHD to discuss improving alignment of NSSL's hydrometeorological research with OHD and ESRL under new Integrated Water Forecasting (IWF) program and report to OAR HQ by July 1, 2010

(D.II) Coordination of NSSL's role with OHD:

- stronger focus on the transition from QPE to QPF for hydro forecasting
- set milestones for progress in precipitation estimation

Verbatim Reviewer Recommendations:

4. Building on the strong relationship with the NWS and OHD, consider the potential benefits of expanding the scope of research priorities to include a stronger focus on the transition from QPE to QPF for hydrological forecasting.

5. NSSL has to work closely with OHD of NWS to set milestones for progress in precipitation estimation. It should also engage with NCEP and its hydrometeorology group with respect to QPE.

8. Targets of opportunity such as debris flow, Hydro modeling etc., while valuable, should not detract from the main mission of improving precipitation estimation. Hydro-modeling effort should be closely connected to NWS/OHD. While this aspect was discussed, I did not get a strong feeling that this collaboration was as serious as one would hope for.

    - Working with OHD and NCEP, set milestones for progress in QPE

Response:

Some aspects of OHD collaboration are stronger than others. For example, debris flow collaboration has resulted in OHD providing resources for yearly deployments on a SMART-R to burn areas to improve USGS research in defining rain thresholds for debris flow warnings and for real-time SMART-R use to the NWS/WSFO at Oxnard to improve the operational QPE for debris flow warning decisions. Other aspects of NSSL QPE research are also strongly tied to OHD collaborations including evaluation of gap-filing radars in HMT-West to create rain data sets for use in evaluating OHD's DMIP-II project. The collaborations involving hydrologic modeling still lag. Now that NSSL has the operational OHD HL-DHM model running from Q2 input, it is expected that collaboration will greatly expand.

The real-time HL-DHM simulations being run for the CI-FLOW demonstration project are driven by QPE from NSSL's Q2 system and QPF from the HPC. The benefits of utilizing QPFs in comparison to QPEs as hydrologic forcing remains a future research endeavor. Development of QPF approaches is ongoing with discussions with OHD. For example, the use of "warn-on-forecast" approaches for improving flash flood prediction (i.e., extending lead times and improving accuracy) is being explored within the context of NSSL's HWT. Many academic

scientists as well as operational units participate in annual HWT exercises. In the future when QPF becomes a stronger aspect of HWT, then OHD scientists will certainly be invited to participate to evaluate warn-on-forecast approaches to QPF and flash-flooding.

NCEP will play a larger role in helping to shape NSSL hydro research once the Q2 system has been ported to NCEP and run operationally. NSSL and NCEP will work closely to improve Q2 as the operational NWS units study more Q2 products, produced at NCEP.

NSSL has collaborated closely with OHD in evaluating several multi-sensor techniques to improve QPE using hydrologic model forecasts as a basis for evaluation. For example, see:

Kitzmiller, D. H., F. Ding, S. Van Cooten, K. Howard, C. Langston, J. Zhang, H. Moser, R. J. Kuligowski, D. Kim, Y. Zhang, D. Riley, 2008: A comparison of evolving multisensor precipitation estimation methods based on impacts on flow prediction using a distributed hydrologic model. Extended Abstracts, *22nd Conference on Hydrology*, Poster Session 3: Validation of Hydrometeorological Observations, New Orleans, LA, USA, AMS, CD-ROM, P3.4.

Action:

1) Set milestones for QPE improvement with NWS and include in NOAA PPBES budget process by July 1, 2010.

<u>(D.III) Coordination of NSSL's research with universities:</u>

- build upon relationship with OU
- seek relationships with other universities

Verbatim Reviewer Recommendations:

1. Consider strengthening interdisciplinary research activities that are central to NOAA's strategic goals but require capacity in areas outside of NSSL's core expertise in Hydrometeorology by actively seeking collaborative partnerships within and outside NOAA, specifically at research universities with ongoing programs in the same areas.

6. I admire NSSL efforts in working closely with the faculty and students at the University of Oklahoma. NSSL should capitalize on the expertise of Prof Hong Yang on making significant progress in its intended goal of combining radar/gage and satellite precipitation estimates.

7. NSSL should also extend its cooperation with other universities and ensure it brings on-board new ideas and also attract new talents from other universities. This comment applies not only to Hydrometeorology but to other areas as well.

    - Seek research partners inside and outside NOAA, leverage OU

Response:

We agree NSSL should extend its cooperation with other universities (beyond OU). We have begun to capitalize on collaborating with Prof Hong Yang in the area of hydrology. In fact, we have made excellent progress in this collaboration in a relatively short period of time. Below is a list of recently accepted and submitted publications relevant to this comment:

Liao, Z., Y. Hong, D. Kirschbaum, R. Adler, J. J. Gourley, R. Wooten, 2009: Evaluation of TRIGRS (Transient Rainfall Infiltration and Grid-based Regional Slope-Stability Analysis)'s predictive skill for hurricane-triggered landslides: A case study in Macon County, North Carolina. *ICL Landslides Journal* (in review).

Gourley, J. J., S. E. Giangrande, Y. Hong, Z. L. Flamig, T. J. Schuur, and J. A. Vrugt, 2009: Impacts of polarimetric radar observations on hydrologic simulation. *J. Hydrometeor. Special Collection on State-of-the-Science of Precipitation Research* (in review).

Gourley, J. J., J. M. Erlingis, T. M. Smith, K. L. Ortega, and Y. Hong, 2009: Remote collection and analysis of high-resolution data on flash floods. *J. Hydrol. Special Issue on Flash Flood: Observations and Analysis of Hydrometeorological Controls* (in review).

Gourley, J. J., Y. Hong, Y., Z. L. Flamig, L. Li, J. Wang, 2009: Inter-comparison of rainfall estimates from radar, satellite, gauge, and combinations for a season of record rainfall. *J. Appl. Meteor. Climatol.* (accepted).

Wang, J., Y. Hong, J. Gourley, P. Adhikari, L. Li, and F. Su, 2009: Quantitative assessment of climate change and human impact on long-term hydrologic response using an impact factor formula: a case study in a sub-basin of the Yellow River, China. *International Journal of Climatology Special Issue Hydro-climatology* (accepted).

Also, many joint proposals to NSF are under development. Several of Hong's students have Gourley on their committees.

In addition to the response in Section A.II, contacts with other groups (e.g., Krajewski's group at Iowa) are being explored that are specific to hydrometeorology. One particular area of expertise that we recognize requires more collaboration is in

the interpretation of polarimetric variables (e.g., Zdr and Kdp) and their use in calculating rainfall rate. There is a lot of expertise at S-Band within the Radar Division of NSSL, and we intend to make use of that expertise as the NWS WSR-88D national network is upgraded to dual-pol capability and those data are ingested into Q2. Gap-filling radars are at C-Band and X-Band, and for expertise at those frequencies we will have to develop collaborations with NCAR, ESRL/PSD, Iowa, and possibly French colleagues that have been working with C- and X-Band radars for QPE applications for years.

NSSL does have a history in working with colleagues in Europe, specifically at MeteoFrance, MeteoSwiss, and the University of Reading, on issues relating to QPE and polarization at C-band. Below is a list of relevant publications on this issue:

Tabary, P., G. Vulpiani, J.J. Gourley, A.J. Illingworth, and O. Bousquet, 2009: Unusually high differential attenuation at C-band: Results from a two-year analysis of the French Trappes polarimetric radar data. *J. Appl. Meteor. and Climat.*, doi: 10.1175/2009JAMC2039.1 (in press).

Gourley, J.J., A.J. Illingworth, and P. Tabary, 2009: Absolute calibration of radar reflectivity using redundancy of the polarization observations and implied constraints on drop shapes. *J. Atmo. and Ocean. Tech.,* **26,** 689-703.

Friedrich, K., U. Germann, J.J. Gourley, and P. Tabary, 2007: Effects of radar beam shielding on rainfall estimation for polarimetric C-band radar. *J. Atmo. and Ocean. Tech.,* **24,** 1839-1859.

Gourley, J.J., P. Tabary, and J. Parent-du-Chatelet, 2007: A fuzzy logic algorithm for the separation of precipitating from non-precipitating echoes using polarimetric radar observations. *J. Atmo. and Ocean. Tech.,* **24,** 1439-1451.

Gourley, J.J., P. Tabary, and J. Parent-du-Chatelet, 2007: Empirical estimation of attenuation from differential propagation phase measurements at C-band, *J. Appl. Meteor. and Climat.,* **46,** 306-317.

Gourley, J.J., P. Tabary, and J. Parent-du-Chatelet, 2006: Data quality of the Meteo-France C-band polarimetric radar, *J. Atmo. and Ocean. Tech.,* **23,** 1340-1356.

Action:

1) Demonstrate improved partnerships with OU through submission of joint publications to refereed journals by July 1, 2010

2) Seek additional partners outside of NOAA to assist with hydrometeorological research efforts and report on progress by July 1, 2010

(D.IV) NSSL's focus on year-round CONUS products:

- should NSSL focus on year-round CONUS products?
- NSSL could focus on science and forecasting of flash flooding
- extend Warn-on-Forecast concept to flash flooding

Verbatim Reviewer Recommendations:

9. Should NSSL be doing hydrometeorological research with a focus on year-round CONUS products or would another lab or NOAA office be a better fit? Unlike tornado research where NSSL has clear expertise, the case for NSSL's hydrometeorological research is less clear even taking into account that this is a relatively new area for the lab. Unlike tornadoes detection and forecast where there is one primary customer, the NWS, real-time precipitation fields and forecasts for hydrological applications have many customers within the US government. NSSL has a good working relationship and record of technology transfer to NWS. However, NSSL has not historically had strong interactions with customers other than NWS. Recommend a NWS/OAR review to address the best fit among the NOAA labs and offices for the different aspects of hydrometeorology-applied research including QPE and QPF.

10. One alternative is to more narrowly define NSSL's hydrological research away from year-round CONUS products toward applied research focused on warm season flash flood forecasts. A possible goal would be to do for the science and forecasting of flash flooding what NSSL has done for tornadoes. This research would include life cycle and trends of heavy precipitation storms that would build on related severe storm expertise within the lab. It would also require expertise on orographic precipitation, which the lab does not currently have.

11. Heavy rainfall and flash flood short-term prediction and warning: NSSL's real strength is in radar observations and short-term predictions and warnings of severe weather. It has applied these skills effectively to the tornado problem, leading to improvement of warning times for these storms. Integral to this achievement has been the development of basic theory, conceptual models, field campaigns, and numerical modeling related to tornadic storms. This same multi-pronged approach should be applied to flash-flood-producing storms so that a basic understanding is gained of the synoptic, mesoscale, and internal-storm conditions leading to extreme rainfall. Most storms do not produce extreme rainfall, so what is it about the environment and/or the internal dynamics/thermodynamics of the few outliers that make them such prolific rain-producers? This background knowledge, along with advances in theory and modeling, can then be combined with the Warn on Forecast concept to eventually aid in extending warning times for flash floods.

    - Focus NSSL hydrometeorological research on flash flooding

Response:

The word "HydroMeteorology" can have a range of meanings from understanding the classical hydrologic cycle to main stem river level forecasts to short term predictions of flash floods. The primary focus of NSSL's hydro research has been on improving QPE to allow short-term (0-6 hr) improvements to flash flood warnings. Even the debris flow project is focused on the value of gap-filling radars on warning accuracy. To be more specific about the objectives of NSSL hydro research we propose to rename the "Hydrometeorology Research Group" to the "Flash Flood R&D Group".

Improving QPE for the entire country is a huge challenge given the large differences in regional climates, weather regimes, and topography. No other organization or lab has addressed this challenge like NSSL with its Q2 system. Expanding services by linking Q2 to hydro models and other ecological models is being demonstrated in CI-FLOW. With the eminent deployment of the dual-Pol upgrades to the national WSR-88D network there will be considerable need for expertise in "getting the most bang for the buck" from this network to improve NOAA services. NSSL has this expertise. Without an "entire country" approach to improving QPE from the 88D upgrades, the research to improve services would be fragmented and delayed. NSSL has worked very successfully to transition research ideas to the FAA, Salt River Project, and Taiwan through reimbursable agreements for over a decade. Limitation on funding has prevented more interactions with groups, other than the NWS, interested in QPE.

We agree that life-cycle, phenomena-based case studies and field projects designed to improve understanding of heavy rain producing systems have their role in ultimately improving QPE and NOAA services. The analogy to improvements to tornado forecasts is a good one. In an ideal world where funding is not a concern, building a first-class QPE research staff with emphasis on observational science, numerical and hydrologic modeling, and technological development could be done. Realistically, however, NSSL must invest in the projects within our expertise base and collaborate on other aspects of hydrometeorology within the limits of current funding. QPE science at NSSL has been built on its historical expertise in radar meteorology. Other opportunities, such as field projects, will be done through collaboration.

In addition, NSSL does pursue collaborations where appropriate within the limitations of its expertise. For example, NSSL currently has an NWS/AHPS-funded project which coordinates expertise from the Office of Climate, Water, and Weather Services, OHD, Arkansas Basin RFC, and Southeast RFC to 1) collect unique and detailed observations of flash floods through the SHAVE experiment and 2) evaluate legacy flash flood guidance and new, gridded approaches for providing this guidance. It is anticipated that the SHAVE flash flood dataset will be useful for other research studies such as analyzing the environment associated with flash flood-producing storms.

Action:

1) Rename NSSL's hydrometeorological research group to "Flash Flood Group" by December 2009
2) Align Flash Flood Group research priorities working with OHD under IWF by July 1, 2010 (Same as Section D.I)

(D.IV) NSSL is spreading resources too thin:

- focus on improving radar observations and precipitation estimates
- combine radar data with satellite data

Verbatim Reviewer Recommendation:

12. Hydrometeorology is defined differently by different groups and as such may result in pursing different research directions. I recommend that NSSL try to bring more focus to this area, rather than spreading its resources too thin by trying to do too many things (such as hydrologic modeling, Debris flow etc). NSSL can play a key role in improving precipitation products and that by itself will perhaps be the most important contribution to the HYDROmeteorology. In the hydrometeorology presentation, reference is made to the NOAA 5 & 20 year plans. Take the 5-year plan quoted from the material given to us:

    "5-YEAR RESEARCH PLAN Weather and Water

    Milestones for Improving Weather Forecasts and Warnings:

    - **Improve Radar Observations and Characteristics of Precipitation**

    Milestones for Water Resources Forecasting:

    - **Improve Radar Estimates of Precipitation; Combine with Satellite Data"**

    If NSSL would place the focus of its hydrometeorology research just on the two highlighted (red, *[bolded and underlined]*) areas, it will perhaps be the greatest service to the hydrologic services (both government and private sectors). Both QPE and Z-R issues are frequently cited as areas of priority. Like the milestones for tornado warning time, NSSL has to establish milestones for degree of improvements in QPE.

        - Focus NSSL hydrometeorological research on improving radar based QPE combined with satellite data

Response:

See comments in Sections D.I, D.II, and D.IV. We agree with the review team assessment of the value of focusing on those two areas. NSSL will focus its efforts on those two areas. In particular, hydro modeling activities will be done in close collaboration with OHD as well as the use of their HL-DHM model as a means to evaluate QPE improvements. NSSL is struggling with defining suitable metrics and establishing milestones for evaluating QPE improvements, as is most of the science community. The classical flash flood GRPA goals are difficult to apply as they depend on forecasts evaluation. Most of the relevant ideas on evaluation of improvements to Quantitative Precipitation Estimation (QPE) involve some type of evaluation based on hydro model performance rather than just point or areal comparison to rain gages. Without some expertise in running OHD's HL-RDHM model it is difficult to see how new approaches to QPE (involving, for example, the new dual-pol parameters) can be objectively evaluated and transitioned to operations.

Action:

1) Same as Section D.I

Concluding Remarks

NSSL management would like to thank the reviewers for taking time out of their extraordinarily busy schedules to provide thoughtful and constructive feedback. When NSSL was asked to provide a list of names as potential reviewers, we purposefully sent in names of renowned experts in the fields of science related to NSSL's mission. We never anticipated so many of them would accept. We are honored by their participation and will work to improve NSSL based upon their input.

We would like to thank the staff at OAR Headquarters for their high quality guidance and assistance at every step of this laboratory review process. We especially want to thank Mary Anne Whitcomb, Roger Pierce, and Drs. Michael Uhart and Ward Sequin for their work on our behalf. Finally, we are grateful for the full participation of Drs. Spinrad and MacDonald during the actual review. We believe this was critically important to demonstrate OAR's commitment to the process, to convey the value of the service provided by the individual reviewers, and to show strong support for the men and women scientists at NSSL.

Table 1. Summary of Action Items taken from NSSL Response to Reviewers				
	Description of Action Item	**Milestone**	**Follow up?**	**Completion Date**
Section A				
A.I	**1) Adopt the "General Recommendations" set forth in the Work Force Committee Report (Attachment 1)**	1/1/2010		
	2) Implement the "Specific Recommendations" proposed in the Work Force Committee Report as funding becomes available. Report on progress.	7/1/2010		
A.II	**1) Appoint 4 NSSL Scientific Fellows**	7/1/2010		
	2) Hire at least one visiting scientist, pending availability of funds	7/1/2010		
A.III	**1) Continue to work with the OFCM MPAR Working Group on a multiagency MPAR risk reduction program**	Ongoing		
	2) Work with the NWS via the NOAA 20-Year Weather Radar Vision process to develop a weather-only phased array radar research strategy. Report status of this effort	7/1/2010		
A.IV	**OAR HQ will evaluate the role of its laboratories and programs in education and how that role is appropriately evaluated in future lab reviews. Any revisions to the lab review process will be implemented by September 30, 2010.**	9/30/2009/1/2009		
A.V	**Increase involvement of senior NSSL management with FAA. Assign two team leaders and Deputy Director to become involved with FAA NextGen planning and Aviation Weather Program**	8/30/2009		8/30/2009

Table 1. Summary of Action Items taken from NSSL Response to Reviewers (cont.)				
Section B	**Description of Action Item**	**Milestone**	**Follow up?**	**Completion Date**
B.2	**1) Initiate dialog with at least one additional company**	4/1/2010		
	2) Continue participation with other government agencies as part of the OFCM MPAR Working Group. Provide status report	7/1/2010		
B.5	**Report out on the progress of the joint NSSL – FAA technology assessment program**	7/1/2010		
B.10	**Submit results of adaptive scanning studies employing the NWRT in a refereed journal**	7/1/2010		
B.17	**Identify a research scientist to take the lead in applying dual polarization techniques to winter weather applications**	7/1/2010		
B.19	**Contact UNIDATA about their interest in, and financial ability to, host a radar dataset workshop. Consider alternatives if UNIDATA not forthcoming. Settle the issue and report**	7/1/2010		
B.20	**Discuss issue with the ROC during development of FY10 joint MOU. Report outcome by**	7/1/2010		
Section C				
C.6	**Provide copy of 2010 SSWIM Annual Report to OAR HQ**	7/1/2010		
C.12	**Provide a status report to OAR HQ on NSSL – CAPS partnership**	7/1/2010		
C.13	**Complete WoF project plan**	7/1/2010		

Table 1. Summary of Action Items taken from NSSL Response to Reviewers (cont.)				
Section D	**Description of Action Item**	**Milestone**	**Follow up?**	**Completion Date**
D.I	**Meet with NWS OHD to discuss improving alignment of NSSL's hydrometeorological research with OHD and ESRL under new Integrated Water Forecasting (IWF) program and report to OAR HQ**	7/1/2010		
D.II	**Set milestones for QPE improvement with NWS and include in NOAA PPBES budget process**	7/1/2010		
D.III	**1) Demonstrate improved partnerships with OU through submission of joint publications to refereed journals**	7/1/2010		
	2) Seek additional partners outside of NOAA to assist with hydrometeorological research efforts and report on progress	7/1/2010		
D.IV	**1) Rename NSSL's hydrometeorological research group to "Flash Flood"**	12/1/2009		
	2) Align Flash Flood Group research priorities working with OHD under IWF (Same as Section D.I)	7/1/2010		

Attachment 1 – Workforce Report

Work Force Committee Report
NSSL Advance
August 2009

Introduction

NSSL faces significant challenges with regards to scientific staff as it moves forward over the next decade or two. Maintaining a staff with national leaders in scientific research areas in the face of the facts that a large fraction of the federal staff is eligible for retirement at this time and there is a second, smaller grouping of staff approximately fifty years old is crucial. Potentially, these two groups could lead to waves of retirements over very short periods of time, seriously depleting the laboratory's scientific capabilities. In part, years of budgetary constraints and concomitant lack of hiring have led to this age-related demographic problem. In addition, the federal scientific staff is overwhelming white male. Although recent hiring has increased the number of PhDs on staff from historical underrepresented groups, they are still a distinct minority.

At the same time as these challenges exist, opportunities are available as well. In addition to recent and future retirements opening up funding for personnel, it appears likely that significant new funding will be coming into NSSL that could require additional personnel. In particular, the MPAR and Severe Weather Forecast Improvement efforts may lead to increases in base funding of the laboratory on the order of several million dollars per year. In addition, Integrated Water Forecasting could bring in other significant new moneys. We were told to assume that reimbursable funding from partners will continue. Obviously, changes in that assumption would require changes in the approach to hiring.

The charge to the committee was to come up with a list of ten specific federal hires. Although cognizant of the specifics of the charge, the committee viewed the task in a broader sense. Several fundamental questions need to be addressed in order to put hiring recommendations into context:

1. What skill sets need to be maintained at NSSL that have been lost due to recent retirements or may be lost to retirement in the near future?
2. What should the structure of the work force look like 10 or 20 years from now?
3. How can leaders of the large long-range efforts (MPAR, Severe Weather) have the flexibility to hire staff that are needed for a portion of those projects, particularly when currently unforeseen problems arise?
4. Are there current staff who could transition to areas of need?
5. What new areas of expertise would be most valuable for a future NSSL?

New Initiatives

Clearly, large funded efforts that are part of the PPBES process and carry with them the expectation of deliverable products will require substantial investment in personnel.

Two such projects (MPAR, Severe Weather) exist at this time and will have product requirements on the order of a decade.

For MPAR and other radar work, needs exist in Engineering Hardware (to work with Allen Zahrai) and in Engineering Systems. It is likely that relatively new PhDs within the radar group could be given the opportunity to fill the needs in the Systems area, requiring that hires be made to backfill their current duties. The arrival of post docs is likely to provide more candidates in this area. The position in Hardware is crucial to the long-term health of the radar efforts. It is likely that the person hired could become the chief Engineer upon Zahrai's retirement.

For Hazardous Weather, the needs are less well-defined. However, some needs seem very important. At present, there are no programmers/system developers involved in the effort. Scientists have to do their own programming. This limits the efficiency of the effort. Second, it is likely that an applied mathematician or statistician will be important in the development of applications of the Warn on Forecast project. Finally, it is imperative that VORTEX 2 data be analyzed thoroughly. A possible strategy for this is to utilize post-docs in the analysis. It is likely that, in the next few years, post-doc candidates will emerge from students who are working on, and thus familiar with, VORTEX 2 data collection. We anticipate that one or more of those post docs could transition to permanent employment and possibly fill some of the important skill sets that are discussed below.

Additional large projects with deliverable products should be approached with caution. We are concerned that projects such as NexGEN could lead to large demands for products that are tangential to primary NSSL activities. To the extent that NexGEN requirements match research activities at NSSL (e.g., Warn on Forecast and MPAR), it is reasonable to take advantage of possible support. The size of NexGEN, however, opens the possibility of creating extremely large demands that would require significant increases in staff that could, in effect, distract from core mission activities to improve NWS forecasts.

Important Skills for NSSL

There are certain activities for which NSSL is known and which are critical to maintain. Obviously, NSSL has centered around radar development and applications throughout its history. In large part, the discussion of MPAR above aims at maintaining those capabilities.

In addition, we are concerned about the loss of staff that could be considered experts with a holistic approach to severe storms observations from synoptic scale to mesoscale, including surface and radar observations. Historically, within laboratory staff, people such as Chuck Doswell and Don Burgess have been around with great breadth in their understanding and skills. The problem is highlighted, we believe, by the lack of federal staff that are likely to work extensively with VORTEX 2 observations. As mentioned above, post-docs may be excellent candidates to identify and grow into the next generation of experts. We have helped educate a number of the relatively recent faculty members in this area (e.g., Markowski and Trapp) and, perhaps, it is time to bring their students in.

The laboratory also has a long history of developing and using field observations. The workforce that has provided scientific leadership and technical expertise is aging. We believe that field observations will continue to be critical to NSSL and maintaining world-wide leadership in this area is essential.

Another area of traditional NSSL leadership has been in storm electricity. Much of the current staff working in the area could retire during the next decade. With the deployment of global satellite lightning detection systems and the growth of the MPAR and Hazardous Weather initiatives, it seems crucial to have in-house storm electricians.

We also believe that there are new areas of expertise that would help a wide variety of laboratory activities. Microphysics is likely to play an important role in many areas of laboratory science, from interpreting radar observations to improving forecast models to developing hydrometeorological applications. Applied mathematicians, with expertise in areas such as image processing or systems control, could also be valuable in a wide range of activities. They might have particular value by bringing in knowledge of developments from outside of meteorology.

The Hazardous Weather Testbed also requires expertise that is currently lacking. The question of whether these needs are met by federal or CIMMS hires is open, but two areas seem particularly critical to ensure maximum benefit. First, technical support and management of the HWT would provide the scientists who work in and with the HWT more time to concentrate on the scientific questions, rather than dealing with logistical and operational issues. Second, a major activity to date has been the creation and collection of survey information. None of the current staff are experts in survey creation and interpretation. The need exists to have someone on staff who is an expert.

General Recommendations

Before getting to recommendations about specific hiring needs, we offer some general statements

1. It is imperative that NSSL strive to increase the diversity of the work force. We recognize that NSSL is not alone in this problem, but NSSL should be a leader in OAR in this regard.
2. Flexibility in staffing positions is important. Keeping NSSL in a position where we are always, or almost always, just below maximum staffing limits provides an opportunity to pursue extremely valuable scientists, should they become available.
3. Leaders of funded projects that have deliverables need freedom to hire for immediate needs, using the best available opportunity (federal/CIMMS/contractor.)
4. We need to work with NOAA HR to make the hiring process easier. Although efforts to make hiring speedy are admirable, the short time that announcements can practically be "on the street" means that candidates who are not aware of the announcement before it comes out are at a distinct disadvantage. This limits the pool for any position. The time limits set by HR should apply to their portion of the process, allowing the labs to have announcements open for the time that the labs desire.
5. The post-doc program begun a few years ago is beginning to bear fruit and appears to be successful. It should be continued and, if possible, it may be desirable to expand it.

We endorse the previous guidance about using the post-doc program as part of a process that could lead to future federal hiring.

6. CIMMS remains a viable alternative for hiring non-US citizens.

7. Increasing the availability of scientific programming support would be of great benefit for the current and future scientific staff.

8. NSSL needs to explore the development of a visiting scientist program for mid- and senior career scientists to spend time on the order of several months to a year at NSSL. This could be particularly attractive for faculty members on sabbatical.

9. Similarly, NSSL needs to explore sending out NSSL scientists for short periods of time for scientific collaboration at other institutions in order to develop relationships

10. NSSL needs to explore ways to leverage non-NSSL scientists. In particular, it may be possible to get social scientists from OU and other academic institutions to do research involving the NWC by paying some portion of summer support. The Center for Risk and Crisis Management at OU may be a convenient conduit.

Hiring Recommendations

The following list is not in priority order. Quality of available candidates and changing needs will dictate hiring.

1. Radar hardware engineer

Qualifications: BS in electrical engineering with 10 years of experience or MS in electrical engineering with 5 years of experience. Knowledge of digital circuits and systems, software for real time processing and control applications, basic antennas, and radar systems. Work on radars (PAR, KOUN, X and C band mobile radars), instruments such as cameras, GPS, and other to support the radar developments. Long term prospect is to become the chief NSSL Engineer.

2. Severe Storm Observationalist/Generalist

Candidate with skills in several areas of severe convective storm research: multi-sensor observations (emphasis on radar), dynamics and morphology, forecasting, and working knowledge of storm-scale numerical modeling. This person's expertise will contribute to better understanding of storm processes that lead to improved warnings, work done in conjunction with the Warn on Forecast Program. This person will provide leadership in the decade-long analyses of VORTEX2 data and planning and execution of future field programs (e.g. VORTEX3).

3. Microphysicist

Qualification: PhD in meteorology, atmospheric physics, or physics. Depending on the topic of MS/PhD theses no experience or experience between two to 5 years. Knowledge of at least two from the following list is desirable. Cloud physics, radar meteorology, principles of radar polarimetry, in situ measurements of precipitation. Work on quantitative measurements of precipitation, classification of precipitation types, relating polarimetric measurements to storm structure (dynamics, kinematics) comparisons of polarimetric measurements with in situ observations, assimilation of polarimetric radar data into numerical models.

4. Scientific leadership for the warning side of the HWT

The candidate will lead the Experimental Warning Program, including formulating strategic plans and vision for developing, testing, and implementing improvements to severe convective weather warnings. Experience in project management, applied research, and transfer of science and technology from research to operations are required. The candidate will work closely with researchers, including both govt. and university partners, to articulate findings through publications, presentations, and interactions with key National Weather Service customers.

5. Radar systems specialist

Qualifications: PhD in electrical engineering, systems engineering, general engineering, physics. Knowledge in at least two of the following areas. Radar systems, antennas including phased array, propagation/scattering of electromagnetic waves, signal and image processing. Work as PI on remote sensing of the atmosphere, issues concerning polarimetric aspects of PAR, application of radars to warnings and forecasts, development of new radar methods and concepts, infusion of newest scientific advances to operations.

6. Hydrologic modeler

Classically trained, PhD-level hydrologist with research interests and experience in hydrologic modeling including data assimilation, model calibration, and model evaluation. Experience using radar and/or satellite data considered a plus.

7. Applied mathematician or statistician

This person will provide NSSL scientists expertise on the interpretation, design, testing, and implementation of data assimilation algorithms and advanced post-processing techniques to support the severe weather forecast improvements initiative. This person will be encouraged to bring knowledge on developments in statistical and numerical algorithms and/or image processing systems from outside of meteorology into NSSL for data assimilation and model post-processing applications.

8. Atmospheric electricity scientist

The atmospheric electricity scientist will be a national expert concerning lightning, the electrification of storms, relationships of electrical properties with other storm properties, and instrumentation for making observations relevant to these topics. Duties will include basic research concerning storm electrification and lightning production, working with others to develop operational applications of lightning mapping systems, and providing advice concerning the lightning hazard, other electrical properties of storms, and techniques for observing lightning and other electrical storm properties to NOAA and other agencies.

9. Evaluation researcher

The candidate will work closely with NSSL scientists and engineers to understand their goals in the development, testing, and transfer of new technologies, science applications, and software. This person has experience leading, conducting and managing research and evaluation projects that require mixed method qualitative and quantitative research designs and methodologies. Excellent interpersonal, writing and oral communication skills to work within and across organizational boundaries are also required.

10. Field observational systems leader

The field observing facility scientist will have expertise in making and analyzing observations with a variety of instruments other than radar, particularly from mobile ground-based platforms. Examples of facilities include mobile mesonets, mobile laboratories, and mobile balloon sounding facilities. Duties include overseeing technicians and engineers maintaining NSSL's present suite of observing facilities, making observing facilities available to field programs in accordance with NSSL policy, and providing vision for future improvements to existing facilities and for development or acquisition of new facilities.

11. HWT/EFP technical support/management

This person will provide technical and managerial support to the HWT Experimental Forecast Program (EFP). Technical duties will include the development, testing, and execution of code, software, and systems for the display and interrogation of experimental forecast products during intensive HWT activity periods in addition to management and analysis of data collected during these periods. Managerial duties will include the planning and scheduling of HWT/EFP programs and activities, coordination of visitors, and active participation in EFP experiments.

Attachment 2 – Career Paths

Guidance On

Scientific Career Paths at NSSL
(adopted April 23, 2009)

Expectations

Expectations for all research staff have been in place at the National Severe Storms Laboratory (NSSL) since 1997. During the first NSSL Advance, a group of scientists and research engineers were asked to recommend what they should expect from their colleagues in terms of annual performance metrics to ensure that NSSL remained a preeminent federal laboratory. The recommendations of this group were adopted by the majority of participants at the Advance. *The typical researcher at NSSL is expected to average two archival, refereed publications per year, generate $100,000 in research support in an average year, and participate in their fair share of educational and outreach activities on behalf of the Laboratory.*

Over the years these expectations have been broadly interpreted to allow for individual differences in opportunities to publish and generate external support, and to ensure that technology transfer goals are met. It is important to note that a significant number of NSSL researchers consistently exceed these expectations.

Initial Hiring

The single most important decision a research organization makes is in hiring talented and productive individuals into its workforce. Research staff typically begin their careers as National Research Council (NRC) postdoctoral scientists/engineers or as associates in the Cooperative Institute for Mesometeorological Studies (CIMMS) at the University of Oklahoma. Individuals can begin working at NSSL as student employees. Care must be exercised in converting student employees to full time staff. In most cases a competitive search process should be used to fill any vacancy.

Continued Employment

Continued employment of early career researchers is subject to meeting performance expectations and on the availability of funds. Annual performance appraisals are an important component of assessing successful progress. NRC postdoctoral fellows are given two years to publish their dissertations and to begin research efforts in an area aligned with the NSSL mission. Successful NRC postdoctoral fellows may be asked to continue as CIMMS associates, subject to the availability of funds. Recommendations for conversion from an NRC postdoctoral fellow to a CIMMS associate originate with the appropriate Division Chief, and are presented to the NSSL Management Team. The NSSL Director will then make a recommendation to the Director of CIMMS for final decision.

Sustained Employment

Sustained employment may occur as a CIMMS associate or by successfully competing for a federal research position, if available. *It is NSSL's intent that most federal research positions be competitively filled by individuals with a sustained record of performance analogous to those achieving tenure at a major research university in the United States.* Ideally a candidate for a federal or sustained position in CIMMS should seek to accomplish the following over a five to ten year period.

1. Average two archival refereed publications per year in areas aligned with the NSSL mission including work performed while associated with NSSL.

2. Obtained external funding in support of his/her research efforts and publish papers based on that research.

3. Demonstrated a willingness to participate in educational and outreach programs on behalf of NSSL.

4. Contribute to next generation of researchers by serving on graduate student committees, serving as mentors of undergraduate students (e.g. Hollings Scholars, REU), and occasionally teaching portions of formal graduate and undergraduate courses.

The information presented in this document is meant to serve as guidance and not be applied literally to every hiring, retention, conversion-to-federal and/or other personnel decision. Other factors may be taken into consideration from the important standpoint of building a productive, competent, creative and collegial workforce at NSSL.

Attachment 3 – Acronyms

List of Acronyms for

NSSL Response to Reviewers' Recommendations

Acronym	***Meaning***	***1st Page Referenced***
NSSL	*National Severe Storms Laboratory*	*1*
R&D	*Research and Development*	*1*
QPE	*Quantitative Precipitation Estimates*	*1*
OAR	*Oceanic and Atmospheric Research*	*2*
CIMMS	*Cooperative Institute of Mesoscale Meteorological Studies*	*2*
NOAA	*National Oceanic and Atmospheric Administration*	*2*
OU	*Oklahoma University*	*2*
NASA	*National Aeronautics and Space Administration*	*3*
FTE	*Full Time Equivalent*	*3*
NWS	*National Weather Service*	*3*
FAA	*Federal Aviation Administration*	*3*
WSR-88D	*Weather Surveillance Radar – 1988 Doppler*	*3*
PPBES	*Planning Programming Budgeting and Execution System*	*4*
WoF	*Warn-on Forecast*	*4*
PAR	*Phased Array Radar*	*5*
FY10	*Fiscal Year 2010*	*5*
MPAR	*Multi-Function Phased Array Radar*	*5*
REU	*Research Experience for Undergraduates*	*6*
NRC	*National Research Council (?)*	*6*
EEO	*Equal Employment Opportunity*	*6*
NRL	*Naval Research Lab*	*7*
NSF	*National Science Foundation*	*7*
ESRL	*Earth System Research Laboratory*	*9*
PSD	*Physical Sciences Division*	*9*
GSD	*Global Sciences Division*	*9*
HMT	*Hydrometeorological Testbed*	*9*
HWT	*Hazardous Weather Testbed*	*9*
DTC	*Developmental Testbed Center*	*9*
HQ	*Headquarters*	*10*
NESDIS	*National Environmental Satellite, Data, and Information Service*	*10*
GOES-R	*Geostationary Operational Environmental Satellite-R Series*	*10*
CREST	***C****oupled* ***R****outing and* ***E****xcess* ***ST****orage*	*10*

CCNY	*City College of New York*	*10*
CIRA	*Cooperative Institute for Research in the Atmosphere*	*10*
SATCAST	*SATellite Convection AnalySis and Tracking*	*10*
CIMSS	*Cooperative Institute for Meteorological Satellite Studies*	*10*
TDWR	*Terminal Doppler Weather Radar*	*12*
NextGen	*Next Generation Program for Federal Aviation Administration*	*12*
NWRT	*National Weather Radar Testbed*	*12*
SPY-1	*Not an acronym. Name of antenna built by Lockheed Martin for the Navy*	*12*
NEXRAD	*NEXt generation RADar*	*12*
O&M	*Operations and Maintenance*	*12*
OFCM	*Office of the Federal Coordinator for Meteorology*	*13*
DAA	*Deputy Assistant Administrator*	*14*
LCI	*Laboratories and Cooperative Institutes*	*14*
NMQ	*National Mosaic QPE*	*15*
CASA	*Collaborative Adaptive Sensing of the Atmosphere*	*17*
OU-ARRC	*Oklahoma University- Atmospheric Radar Research Center*	*17*
IIPS	*Interactive Information and Processing Systems*	*17*
NCAR	*National Center for Atmospheric Research*	*18*
NIED	*National Institute for the study of Environmental Disasters*	*18*
BCI	*Basic Commerce and Industries*	*19*
CRADAs	*Cooperative Research and Development Agreements*	*19*
EEC	*Enterprise Electronics Corporation*	*19*
WDT	*Warning Decision Technologies*	*19*
WSI/EEC	*Weather Solutions Incorporated/ EEC*	*19*
SBIR	*Small Business Innovative Research*	*19*
DOWs	*Doppler-on-Wheels*	*20*
SMART-R	*Shared Mobile Atmospheric Research and Teaching - Radar*	*20*
VORTEX-2	*Verification Of Rotation in Tornadoes EXperiment – 2nd field program*	*21*
EE	*Electrical Engineering*	*21*
ERAD	*European Radar Conference*	*22*
CARPE DIEM	*Latin for "cease the day"*	*22*
IEEE	*Institute of Electrical and Electronics Engineers*	*22*
PAR JAG	*PAR Joint Working Group*	*23*
VCPs	*Volume Coverage Pattern(s)*	*25*
NetCDF	*Network Common Data Form*	*28*
WDSS-II	*Weather Decision Support System- Integrated*	*28*

	Information	
UNIDATA	*University DATA provider*	*29*
RVP-8	***Vaisala Sigmet Digital IF Receiver and Signal Processor RVP8™***	*29*
ORDA	*Open Radar Data Acquisition*	*29*
CODE	*Common Operational Development Environment*	*29*
ORPG	*Open Radar Product Generator*	*29*
RRDA	*Research RDA*	*29*
OUN	*NEXRAD radar identification for Norman, Oklahoma radar*	*29*
AEL	*Algorithm Enunciation Language*	*30*
ROC	*Radar Operations Center*	*30*
MOU	*Memo of Understanding*	*30*
NEXRAD TAC	*NEXRAD Technical Advisory Committee*	*30*
AMS	*American Meteorological Society*	*30*
CAPS	*Center for Analysis and Prediction of Storms*	*32*
SPC	*Storm Prediction Center*	*32*
MCSs	*Mesoscale Convective Systems*	*33*
COMMAS	***COllaborative Model for Multiscale Atmospheric Simulation***	*34*
PECASE	*Presidential Early Career Award in Science and Engineering*	*34*
CONUS	*CONtiguous U.S.*	*35*
GPRA	*Government Performance Review Act*	*35*
SSWIM	*Social Sciences Woven into Meteorology*	*36*
BAMS	*Bulletin of the American Meteorological Society*	*39*
HPC	*Hydrometeorological Prediction Center*	*41*
RFCs	*River Forecast Centers*	*41*
QPF	*Quantified Precipitation Forecast*	*42*
WFOs	*Weather Forecast Office(s)*	*42*
CALJET	*CALifornia JETs experiment*	*42*
PACJET	*PACific JETs experiment*	*42*
USGS	*United States Geological Survey*	*42*
HL-DHM	*Hydrology Laboratory's Distributed Hydrologic Model*	*42*
CI-FLOW	*Coastal, Inland FLood Observation and Warning*	*42*
IWRSS	*Integrated Water Resource Science and Services*	*43*
OHD	*Office of Hydrologic Development*	*43*
WSFO	*Weather Service Forecast Office*	*43*
NCEP	*National Center for Environmental Predictions*	*43*
AHPS	*Advanced Hydrologic Prediction Service*	*43*
FFMP	*Flash Flood Monitoring and Prediction*	*43*
IWF	*Integrated Water Forecasting*	*43*
DMIP-II	*Distributed (hydrologic) Model Intercomparison Project Phase 2*	*44*

SHAVE	*Severe Hazards Analysis and Verification Experiment*	*50*
EFP	*Experimental Forecast Program*	*64*