NASA SHORT-TERM PREDICITON RESEARCH TRANSITION CENTER

SCIENCE ADVISORY COMMITTEE REPORT & RECOMMENDATIONS

~December 2016~

NASA SPoRT
320 SPARKMAN DRIVE
HUNTSVILLE, AL 35805

SPORT

MISSION

Apply NASA and NOAA measurement systems and unique Earth science research to improve the accuracy of short-term weather prediction at the regional and local scales.

GOALS

Evaluate and assess the utility of NASA and NOAA Earth science data and products and unique research capabilities to address operational weather forecast problems

Provide an environment which enables the development and testing of new capabilities to improve short-term weather forecasts on a regional scale

Help ensure successful transition of new capabilities to operational weather entities for the benefit of society

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I. Introduction

This report summarizes opinions, observations, and recommendations of the Ninth NASA SPoRT Science Advisory Committee (SAC) meeting, held July 26-28, 2016 at the National Space Science and Technology Center in Huntsville, Alabama. The meeting included the following SAC members and invited experts:

- Will McCarty, NASA Goddard Space Flight Center GMAO
- Joe Santanello, NASA Goddard Space Flight Center, Hydrological Sciences Lab
- John Haynes, NASA HQ, Public Health/Air Quality Applications Program Manager
- Walt Petersen, NASA Marshall Space Flight Center
- Andy Edman, NOAA/NWS Western Region Science & Technology Infusion Division
- Dave Radell, NOAA/NWS Eastern Region Scientific Services Division
- Kim Runk, NOAA/NWS Operations Proving Ground

- SAC Member Greg Mandt of the GOES-R Program was unable to attend
- Tsengdar Lee, NASA Weather Focus Area Lead, attended as an invite guest

In preparation for this meeting, SPoRT provided read-aheads, including their 5-year Strategic Plan dated February 6, 2015; the 2014 Annual Report; and the most recent SPoRT Quarterlies.

The SAC was charged with providing feedback on SPoRT strengths, accomplishments, key opportunities, and potential threat areas. This feedback will be used as input for decisions concerning program direction and strategic planning to advance the SPoRT mission.

Toward that end, the meeting agenda consisted of project overview presentations of major activities undertaken since the last SAC meeting (August 2014); a session featuring end-user feedback on SPoRT Research to Operations (R2O) partnerships; and a generous amount of time for questions and discussion between the SAC and SPoRT team members. The recommendations herein were drawn from those presentations and interactions.

II. Commendations

NASA SPoRT has a well-deserved reputation for excellence in working together with partners to transition new science into operations. The direct engagement and collaborative, iterative development process for developing solutions to real operational problems has been key to its success in this arena.

NASA SPoRT is also to be commended for its culture of innovation. It is obvious that SPoRT has created an environment in which team members feel it is safe to take calculated risks and explore new applications that show potential for improving decision making connected to short-term weather prediction and associated impacts. Such an environment is critical to the process of testing and refining ideas, yet it is relatively rare. This innovation culture should be celebrated and protected.

Finally, the committee applauds SPoRT on its continuing commitment to invite an external group to review its projects, ideas, and plans. Given the extent to which they have implemented recommendations from previous SAC Reports, it is clear that SPoRT is dedicated to the

advisory committee concept. For any organization to expose its work to external scrutiny in such an open and vulnerable manner, and then commit to act on that group's recommendations in order to improve its operations and services, is admirable and courageous.

III. Mission Drivers

An expected reduction in new weather-related space missions over the next five to ten years may threaten the long term viability of some traditional SPoRT focus areas. However, this also presents opportunities to pivot into other promising project areas.

Examples include:

- Water-related missions (GPM, SMAP, GRACE/FO, SWOT) in connection with the National Water Center, including adding value through land surface expertise
- Atmospheric composition missions
- Ice missions
- SAR
- Earth Venture
- Disaster Response sector services

With that reality as a backdrop, it is possible that NASA SPoRT would benefit from a fresh look at its mission statement. While its current mission is inspiring and representative of SPoRT's overall thrust, it may not accurately reflect the unique niche SPoRT fills in NASA. In addition, its explicit focus on weather prediction could be construed as too restrictive.

The challenge for SPoRT is to identify and articulate its distinctive areas of strength, expertise, and value-added contributions to the R2O transition process. One possible consideration would be to focus on becoming *the* group in NASA that identifies the most promising environmental data sets, experimental products, applied research, etc., and shepherds them through the "last mile" to operations in a variety of decision support systems. A slight change in emphasis that encompasses all environmental prediction fields (i.e., hydrology, water resources, climate, ice, disaster response, etc.) broadens the potential subject areas, while the emphasis on Technical Readiness Level (TRL) 7-9 (i.e., mature; nearly ready for operations) projects might serve to narrow the focus toward implementing new science, tools, and capabilities in operations.

Regardless of SPoRT's decision on a mission statement rewrite, if "Short Term Prediction" and "Research Transition" remain critical to the SPoRT mission, these can be used as practical filters for investment decisions. In other words, before pursuing funding, it may be useful to ask questions such as:

- Does this project meet the definitions for both of those criteria?
- Are benchmarks for short term prediction and operational transition incorporated into the success metrics established for this project?

The value of such questions comes in the form of focus. In order to ensure organizational excellence, deciding what not to do is sometimes just as important as deciding what to do.

IV. Feedback and Recommendations

Presentations delivered to the SAC were all thorough and professional, with excellent content and sufficient time for follow-up questions and discussions. This format worked well, and we recommend continuing such a structure for future SAC Meetings.

From a strategic standpoint, the SAC strongly supports SPoRT's efforts to build new partnerships and strengthen advocacy for its R2O portfolio. However, as with previous SAC Reports, we recommend doing so at a measured and thoughtful pace. Much of SPoRT's success can be attributed to its paradigm of direct interaction and iterative development with end users. It would be unfortunate if overly aggressive project expansion were to jeopardize that model.

The following sections highlight comments, questions, and recommendations that ensued for each of the seven themed sessions.

a. Modeling and Data Assimilation

The land surface modeling and assimilation work SPoRT is involved in shows significant potential for multiple applications. Among the most promising is the opportunity to collaborate with the NOAA Water Center to operationalize the National Water Model (NWM). The coupling of Land Information System (LIS) and WRF-Hydro is being leveraged across multiple products (NEMS, Navy/COAMPS, NWC, and NASA ROSES (Santanello-Kumar-Gochis). One motivating aspect of this coupling is to perform integrated hydrological prediction and data assimilation (soil moisture and streamflow).

Overall, SPoRT has done an excellent job demonstrating the capabilities of LIS, particularly with respect to using novel approaches for application to real-time events and impacts. A prime example of this is the SPoRT-LIS soil moisture product that is being used widely across NWS offices. The Greenness Vegetation Fraction (GVF) product and its growing use across the community is another noteworthy achievement for SPoRT. All LSMs are moving toward real-time vegetation products. SPoRT should consider other products like LAI, albedo, emissivity, or crop/irrigation related measures that would help improve Noah-MP simulations.

With regard to soil moisture modeling, new funding and major NLDAS developments are being planned, including new hydrological data assimilation (DA), new LSMs, irrigation schemes, higher resolution, and improved forcing. The GSFC LIS team will perform these improvements and transition them into the NLDAS system. As a result, NLDAS soil moisture products will encroach on the scales and novelty of the LIS-SPoRT product, possibly rendering it obsolete. SPoRT should, therefore, monitor and incorporate some of these advances going forward, and consider what value-added soil moisture products might be useful to the operational community in the near future.

It will also be important for SPoRT to closely monitor developments in SMAP downscaling. Radar loss (and 3km, 9km products) is a relevant factor for SPoRT scales of interest. Significant improvements are on the horizon due to DA on 3km scale. The SMAP program and SUSMAP proposals will move quickly to generate new high-resolution SMAP products based on downscaling approaches and Sentinel radar data.

Land DA is a moving target – imperfect and very much still an art form. In addition, the impact of soil moisture DA on coupled prediction is still unproven. New projects will undoubtedly help to address the potential value of hydrologic DA to the operational user community. Multiple ongoing developments, including major overhauls of DA and bias correction, are ongoing at GSFC. These issues raise the importance of being mindful to avoid developmental efforts in isolation. The committee suggests that the SPoRT team actively cultivates collaborative

relationships in its projects related to SMOS/SMAP DA, as well as other variables such as snow, LST, and groundwater.

The work in exploring downscaling of seasonal/climate range forecasts raised some questions about effective return on investment. The science of seasonal prediction is immature and advancements will come primarily through incremental improvements in 2-week to 3-month modeling skill. Downscaling a marginally useful forecast does not improve the quality of the original, inherently flawed forecast. This particular time and space skill is a challenge for the modeling community. Scientifically based progress over the next several years is unclear. Thus, this may be an area where SPoRT monitors and participates as appropriate, but does not pursue this as one of their critical, core mission projects.

Recommendations for Modeling and Data Assimilation:

1. Strengthen direct connections to the GSFC LIS team to ensure the group is apprised of, and invested in of ongoing developments in NLDAS, LSM, NU-WRF, LIS/WRF-Hydro, etc. Due to the lack of core funding for LIS, it might be helpful to formalize the LIS-SPoRT connection, both in terms of personnel and of some nominal FTE support to enhance the development and transition activities between the two groups.
2. Pursue collaborations with the NOAA Water Center to couple LIS/WRF-Hydro and integrate other NASA data sets and DA approaches into the National Water Model (NWM), and accelerate its operational implementation. SPoRT should have a primary seat at the table in order to support the LIS-NWC-SPoRT collaborative connections, and could play a role in enabling LIS to more formally become considered in the NWC paradigm (via DA capabilities). In order to fully exploit NWM opportunities, SPoRT may need to consider altering or augmenting its staffing profile to increase and strengthen its hydrology expertise.
3. Continue investigations of modeling land surface responses in major wildfire burn areas (i.e., changes in albedo, feedback on weather/water event evolution and attendant impacts).
4. Emphasize applications connected to GPM, SMAP research – flood extent, vegetation anomalies, drought monitoring, cross-calibrated passive microwave brightness temperatures, ideal approaches for operational GPM use, and impacts of SMAP DA on short term forecasts.
5. Consider the changing landscape of the operational modeling community at-large, both in terms of LSMs (Noah-MP, RUC) and coupled models (WRF, RAP/HRRR), particularly as the more traditional paradigm of NWS running local WRF experiments is going away.
6. SAC agrees with the proposed de-scoping of atmospheric DA with a focus on numerical weather prediction, specifically of retrieved profiles, since the operational community has settled on radiance centered assimilation. (It is worth noting, however, that there may still be a role for atmospheric assimilation as an extension of the aerosol and air quality remote sensing expertise at SPoRT.)
7. SPoRT should consider how its strengths will need to adapt to the changing landscape of atmospheric modeling – specifically as the models evolve from limited area domains to global models with adaptive and non-uniform grids.

b. Lightning Applications

Lightning research is clearly a strength of the SPoRT program. Through collaborations with NWS WFOs, NOAA Testbeds, and Emergency Management partners, they have achieved numerous successes in application development, forecaster training, and visualization.

Many NWS offices are excited about GOES-R Global Lightning Mapper (GLM) because of the enthusiasm shared by WFO forecasters who are located within LMA areas and have worked with NASA SPoRT. Practical applications range from local to national, and from routine decision support services (e.g., as a tool for providing public safety information to event managers) to assisting with warning decisions for severe weather (e.g., the occurrence of a lightning jump in concert with other intensification signals). In addition, SPoRT has developed excellent training resources that NWS forecasters have praised as useful, engaging, and applicable to their jobs.

Aside from serving as outstanding precursor work to GLM availability, some of these projects have led to discovering new areas of opportunity, such as exploring the use of lightning as a proxy for radar offshore (especially valuable to the Aviation community, or data sparse international partners); and research into a lightning initiation algorithm.

The SAC applauds SPoRT's ongoing efforts to develop a quality-controlled data set of Total Lightning Climatology. This work will represent an invaluable resource for researchers to use in data mining and comparing with other environmental parameters.

The SAC notes and appreciates SPoRT's continued responsiveness to user needs for visualizations that enhance forecaster situational awareness and decision making. The mobile device display of lightning information superimposed on shapefiles of LMA areas is a particularly promising tool for IDSS, since it is usable and accessible anywhere – whether at an Emergency Operations Center (EOC) or an outdoor public venue. For similar reasons, the work being done to develop a Web Mapping Server that uses GeoTiff and integrates observations into a single visualization tool is very exciting. Other notable examples of valuable SPoRT visualization work include the development and baseline deployment of the AWIPS Tracking Meteogram Tool, and several experimental Pseudo-GLM plan view displays. All these examples highlight SPoRT's awareness that users are not necessarily enamored by availability of new data if they are not provided tools and guidance on the use and interpretation of those data. This special attention to the latter is a key factor in SPoRT being held in such regard among end users.

Recommendations for Lightning Applications:

1. Continue collaborations with NOAA/NWS to prepare forecasters for effective use of GOES-R (GOES-16) GLM.
2. Foster new partnerships with National Centers and International stakeholders. Areas which seem particularly promising include applications for aviation, wildfire initiation, IDSS in data sparse regions, development and calibration of physically-based lightning jump algorithm for identifying probabilities of hazardous storms. Potential U.S. Government partners include FAA, USFS, NPS, FEMA, and the National Wildfire Coordination Group. On the international front, SPoRT could serve as Subject Matter Experts for SERVIR hubs to assist with exploiting lightning for DSS in data sparse areas.
3. Enhance collaborations with Kennedy Space Center and Mission Launch Working Group to apply lightning initiation/cessation for real-time monitoring of developing storms. It may also be worth exploring whether there is practical value in electrification modeling for mission planning.
4. Continue ongoing efforts in Total Lightning Climatology. The potential value of a comprehensive quality-controlled lightning climatology data set for data mining and research is tremendous.
5. While much of the emphasis will be placed on GLM in coming years, there may still be a significant and meaningful role for LMA research. For instance, LMAs may be used to

validate or explain what is being observed from the GLM and, perhaps more importantly, to understand what the GLM cannot observe.

c. Remote Sensing

As with lightning, the work done by SPoRT in the area of applied remote sensing is a key strength. SPoRT is engaged in a wide variety of remote sensing activities that span the electromagnetic spectrum. Their research and R2O/O2R collaborations have led to numerous satellite-related products being adopted by the operational forecasting community.

Several examples were shared, including:

- The use of passive microwave imagery to discriminate deep convection embedded in cirrus shields, or to estimate near-surface winds over the ocean;
- GPM Level 2 rain rates for nowcasting over radar-void areas
- GPM IMERG rain rates and precipitation accumulations, as well as passive microwave snowfall rates, used to supplement guidance for warning and forecast decisions

Two promising new areas are:

1) Development of aerosol optical depth (AOD) products for both diagnosis and data assimilation; and
2) Continued refinement of Red-Green-Blue (RGB) composites to assist in identifying targeted atmospheric phenomena.

AOD – By presenting a near-global representation of spatial aerosol distribution, the AOD product retrievals offer improved capability to identify large scale dust storms, high concentrations of pollutants, and areas where long-range transported aerosols are interacting with atmospheric rivers. Such improvements are not only useful to the accurate analysis and forecasting for these phenomena, but effective assimilation of this information into global models may result in enhanced predictability as well. The SAC strongly supports SPoRT efforts to explore and develop such applications.

RGB – SPoRT has been a leader in the U.S. in the area of combining spectral channels and/or multi-spectral differences into RGB imagery. They have also created some of the best training modules for understanding how to use those products operationally. Over the next several years, the threat of data overload will be enormous as forecasters become inundated with high-resolution models and data sets. The capability to combine data and imagery judiciously, in order to extract actionable intelligence from those data will be increasingly important. The SAC appreciates that SPoRT has taken the approach to build on the experience and success of EUMETSAT in choosing its RGB recipes. If EUMETSAT, JMA and NOAA adopt the same recipes for some of the fundamental composites (e.g., True Color, Natural Color, Airmass RGB, Dust RGB, Nighttime Microphysics, etc.), the result will be a uniform global alignment that can be used for practical diagnostic challenges and, perhaps more importantly, for data assimilation into global models.

It came to the group's attention that there is some discrepancy as to whether those recipes will be baselined into AWIPS. The SAC engaged the NWS Operations Advisory Team to resolve these issues and move toward a collection of baseline RGBs that are consistent internationally. As of this writing, those issues seem to have been resolved favorably. As a related side note, the SPoRT/NWS EPDT 24-bit processing plug-in could be useful to accommodate normalization of these baseline composite recipes.

As mentioned earlier, there is significant potential to leverage SPoRT achievements and expertise in land surface remote sensing and modeling. Although SPoRT has traditionally provided land surface composites to benefit the LIS, areas related to hydrologic modeling, such as improving runoff responses in burn areas, warrant investment and investigation. In addition, high resolution land surface information from sensors aboard Landsat 7/8 and Sentinels may offer the prospect of further collaborations with the NOAA Water Center in their efforts to implement the NWM.

Information derived from NUCAPS hyperspectral soundings shows some promise but field forecasters generally feel that its value is limited unless considerable improvements can be made to improve its representation of the lowest 200mb above the surface. It is not certain whether this opportunity rises to the level of a primary effort by the SPoRT team.

A note of recognition is warranted concerning SPoRT's use of the Early Adopter role to test and innovate, then parlay lessons learned into new collaborations, such as those partnerships which emerged from Early Adoption in GPM and SMAP missions. The SAC encourages exploration of comparable opportunities, such as end user evaluations of TEMPO, and use of products derived from ICESat-2.

Recommendations for Remote Sensing:

1. Continue the outstanding work in collaborative development and successful R2O transition of satellite imagery and products that directly benefit operational analysis and forecasting. The use of passive microwave, AOD retrievals, RGB composites, hyperspectral soundings, and Land Surface Information are all rich with potential benefit for enhancing forecaster performance and increasing the accuracy of numerical guidance through improved data assimilation.
2. Maintain involvement in the development of focused, practical, interactive training that enables forecasters to understand how to interpret and use satellite imagery and products correctly and effectively.
3. Assume an Early Adopter role for missions that may reveal promising new opportunities for the future. Perhaps applications related to Landsat, Sentinel, ICESat-2, and Earth Venture missions fall into this category.
4. Continue to develop in-house expertise in remote sensing with a focus on new and upcoming observing platforms. Develop strategies to utilize new data within the constraints and/or shortcomings beyond the control of SPoRT (e.g., data latency).
5. Consider what role SPoRT can play in NASA mission development. This may, in part, include being co-investigators on NASA mission or instrument proposals (e.g., through Earth Venture) to fulfill explicit applications requirements included in future announcements of opportunity.
6. Continue to think innovatively in terms of data usage. Non-primary mission data products such as OCO-2 meteorological parameters, may have utility that can be exploited to the benefit of SPoRT.

d. Training and Assessment

NASA SPoRT has remained committed to the practice of cultivating long-term relationships with interested parties in the operational forecast community. This continual 2-way engagement is extremely valuable to both sides. For end users, it provides an opportunity to work directly with researchers who desire to improve the forecasters' capabilities. For developers, it yields a

stronger awareness of the operational needs, concerns, and challenges, which can in turn be used to refine products, algorithms, training resources, etc. This paradigm takes considerable time and effort but it has proven itself to be a productive formula. If the definitive metrics of success are actual transition to operations and enthusiastic endorsement by forecasters, SPoRT has several accomplishments to its credit (e.g., Snow/Cloud RGB, Blended TPW, Total Lightning in areas with LMA, Airmass RGB at National Centers, NTMicro).

The SAC commends SPoRT for the diversity of training methods it is employing. SPoRT has demonstrated skill and reliability in producing professional quality teletraining materials. Its recent decision to expand into shorter, more focused training is commendable because it meets an expressed need by numerous operational forecasters. Job demands and protracted staffing shortages have made time for training somewhat of a premium. Forecasters are interested in training that is job-relevant, application-oriented, and easily accessible when they need it. Well-designed Interactive Quick Guides and Micro-Lessons that are available within the AWIPS environment, coupled with a focus on specific learner-centered objectives, will garner high approval ratings from NWS forecasters. In fact, early feedback from participants who tested the use of these materials at the OPG indicated extremely favorable opinions.

The SAC is also strongly supportive of SPoRT's proposal to build out a framework for an AWIPS Applications Library. With the large number of new products being added to the forecaster tool box from GOES-R and JPSS, a mechanism that forecasters can use to develop and share local applications would meet a crucial operational need. With GOES-R, forecasters will have a unique opportunity to contribute to the body of the science. A system that facilitates creation of, and access to, operational examples will assist forecasters and researchers alike in developing cases that improve knowledge and understanding.

This library is envisioned to emphasize short formats – practical local and regional examples – created by users, for users. It would house a combination of short, 1-minute "picture and paragraph" quick guides; some 3-5 minute You Tube "how to" videos; and a lesser number of more detailed 5-8 minutes micro-lessons – all linked to the AWIPS2 Integrated Training (AIT) Tool using VLab. The exact nature of production tools, and the manner in which proposed cases are vetted, must be resolved but the overall goal is worthwhile.

The SAC advocates for SPoRT to occupy a prominent seat at the table as the NWS Office of Learning maps out its strategy for development of GOES-R applications training, Just-in-Time training modules, and a process for vetting Applications Library entries. It would be foolish not to leverage their experience and expertise with RGB development and training, as well as the successful prototyping of the AIT Tool. Initial discussions have already taken place to explore archetype structures and processes with NWS (i.e., OCLO and OSTI – specifically, MDL and OPG).

Recommendations for Training and Assessment:

1. Preserve the paradigm of developing and maintaining relationships with end users in the operational community to develop, refine, and transition new tools; and in creating appropriate training for using those tools correctly and effectively.
2. In terms of training development, place strong emphasis on the focused, applications oriented, just-in-time modes. These are continually the ones forecasters rate most highly.
3. Collaborate with NWS to refine and baseline the AWIPS Integrated Training Tool, and build out a framework for an AWIPS Applications Library.

4. Seek advocacy for a seat at the table when NWS plans its strategy for development and implementation of GOES-R applications training.

e. Applied Science Activities

The SAC commends SPoRT for its Early Adopter work in Applied Sciences. The demand for expertise in disaster assessment and response is growing rapidly. This is, in fact, one of the chief drivers of impact-based decision support services. SPoRT Applied Sciences activities are impressive and promising.

The "SPoRT Paradigm" of working directly and collaboratively with end users is well-aligned to support the use of NASA mission products and modeling outcomes to customize solutions for partners. An excellent example is the work to employ remote sensing and numerical modeling for severe weather monitoring and damage assessment as a SERVIR partner in India and Nepal. This type of activity will likely lead to new collaborative partnership opportunities.

SPoRT's efforts to use VIIRS DNB imagery and other ancillary data sets to assist with the challenge of identifying impact areas associated with large scale, long duration power outages was another extremely innovative venture, and undoubtedly useful to regional risk management decision makers. Other examples cited, such as use of remote sensing data to analyze flooding events, and an entire new portfolio of projects made possible via use of synthetic aperture radar in diagnosis and post mortem, make it clear there are many opportunities ahead for SPoRT to pursue in disaster applications. SPoRT is encouraged to continue its engagement with NOAA/NWS and FEMA in an effort to explore other opportunities to leverage remote sensing in support of their disaster response activities.

SPoRT's contributions to provide timely access to high-resolution imagery and data for the NWS Damage Assessment Toolkit represented a significant enhancement to that platform. That tool is used hundreds of times each year, and NWS offices have already reported dozens of cases in which tornado damage tracks were refined by adjusting end points, path width segments, and specific areas of impact. This capability is not just important for its contribution to accurate damage survey results, it has also proven valuable for a number of emergency management concerns, such as positioning of response resources, disaster declaration and compensation qualifications.

It is clear there is now a strong organizational effort to form a structured disaster response coordination plan, in which SPoRT will play a prominent role. This is prudent and should be expedited, since disaster response is a potentially rich area for expanded opportunities, both at home and abroad.

SPoRT is encouraged to continue its engagement with NOAA/NWS to support their disaster response activities; and to build collaborations with new partners, such as FEMA, EPA, CDC and the US Coast Guard. However, SPoRT should ensure appropriate collaborators and end users are involved in the design and execution of projects outside SPoRT expertise (e.g., public health).

SPoRT's successes with GPM and SMAP prove it can leverage Early Adopter status into effective collaborations. Their expertise in R2O/R2A and their experience in cultivating healthy, productive end-user partnerships, position them well to support other Early Adopter activities. For new missions, it is recommended they begin activities as early as possible.

Recommendations for Applied Sciences Activities:

1. SPoRT is encouraged to continue its engagement with NOAA/NWS to support their disaster response activities; and to build collaborations with new partners, such as FEMA, EPA, CDC, and the US Coast Guard.
2. SPoRT's successes with GPM and SMAP prove it can leverage Early Adopter status into effective collaborations. Their expertise in R2O/R2A and their experience in cultivating healthy, productive end-user partnerships, position them well to support other Early Adopter activities. For new missions, it is recommended they begin activities as early as possible.
3. Expedite the formulation of an organized plan that defines unique roles and contributions NASA SPoRT makes to the overall National Response Framework, and specifically to the efforts involved with Disaster Assessment and Response Coordination.

f. Data Delivery and Data Visualization

SPoRT has provided development, technical aid, custom configurations, specific applications, and professional training for a remarkable number of decision support systems. They have proven themselves an invaluable resource of experts with fluency in AWIPS, AWIPS-II, NAWIPS, Google Earth, as well as numerous data formats and non-standard data sets.

Much of the R2O work conducted by the NWS, at NOAA Testbed sites, such as HWT and OPG, could not have been accomplished if not for the expertise, initiative, and extraordinary problem-solving skills of the NASA SPoRT team. They are directly responsible for several innovations which could improve both system performance and forecaster capabilities. For example, the client-side generation of RGB recipes tested at the OPG calculates RGB channels on the fly using single-band source data, with the benefits of greater color fidelity, reduced latency caused by external product providers, less load on central servers, and the flexibility for users to modify the recipes.

A second example is the AWIPS Integrated Training Tool, alluded to in the Training section of this report, provides product-specific training from within AWIPS-II CAVE, and received rave ratings from all forecasters who tested it.

Their sponsorship of the EPDT program has resulted in many useful operational plug-ins which have been incorporated into the AWIPS baseline: the LMA Decoder, the Tracking Meteogram Tool, and the GLM Decoder, to name a few. The SAC applauds and endorses the excellent but often unsung work that this group does on behalf of the operational forecasting community.

On the web interface side of the house, plans to pursue a robust Web Map Service capability are strongly supported. The advantages are self-evident: greater interaction with data and products; geo-referenced, geo-rectified data that are available to be layered with other data; and enhanced capability for utility by other tool sets (ArcGIS, Qgis, etc.). In general, the move toward more dynamic content, coupled with a focus on intuitive, interactive user experience is laudable and very exciting.

One noteworthy post-script on this topic: While web interfaces for near real-time products are excellent resources for education and outreach, the question of scalability of these services is of concern as a public tool. For example, the existing SPoRT/MSFC GOES interfaces are very popular during the Atlantic hurricane season. Will these more advanced methods be able to

manage such surges during periods of intense interest, or will they be limited to specific customers rather than the general public?

Recommendations for Data Delivery and Data Visualization:

1. Stay committed to open, flexible, extensible, scalable, design for data delivery and visualizations, both in AWIPS-II and web development
2. Adopt the use of RPMs to simplify/automate implementation of configuration changes and system modifications
3. The committee strongly endorses plans for development of Web Map Service capabilities. Responsive web development may play a role in the applicability to end-users in the field, since they are increasing accessing information for critical decision making from tablets and/or smartphones.

g. Open Forum Discussion with End Users

SPoRT arranged for six collaborators to provide a short briefing to the SAC, covering their impressions as to the key strengths and benefits of their ongoing partnership with SPoRT, and any opportunities for improvement. Contributors included representatives from WFOs and a National Center, with experiences in working with SPoRT ranging from two years to almost ten.

Although their individual experiences differed, there were certain recurring themes. One was that the ongoing, two-way exchanges are extremely valuable. Forecasters are enthused about having the opportunity to experiment with new data sets and tools, to communicate ideas and concerns, and above all, to learn through the process of direct interaction with experts.

In general, recommendations for improvement took the form of better communication of assessment results, and the need for more training and examples to reinforce learning.

Specific thoughts, taken verbatim from the briefings, follow:

STRENGTHS

- SPoRT collaborations have given WFOs a chance to be directly involved in R2O, and even in customizing solutions to local problems.
- Forecaster feedback has been very positive about the usefulness and usability of SPoRT products, and the helpful, collaborative relationship with SPoRT personnel.
- Forecasters enjoy engaging in the R2O process and contributing to SPoRT Assessments.
- Forecasters find many of the experimental products valuable. Some specific examples cited were: LMA Total Lightning, VIIRS Day-Night Band, Nighttime Microphysics, LIS soil moisture, SST composite, Airmass RGB, GOES-R CI, GOES-R FLS, and CIRA LPW. While some of these are not specific to SPoRT, SPoRT has been helpful in coaching them on appropriate interpretation and usage.
- The SPoRT assessments are well organized, and characterized by good interaction and reliable follow-up support.
- It is easy to collaborate with SPoRT. They are very accessible, knowledgeable, open to new ideas and responsive to needs. They are *the* reason why we still have an LMA.
- SPoRT products have aided forecast decisions.

CHALLENGES

- More forecaster training is needed, including case studies to show operational utility. Some products are not available in AWIPS. Data are sometimes unavailable due to SPoRT outages.
- Setup requires some time. Is an RPM-style or other method possible? We would like to see improvement in follow-up on assessment results, what and how a product was transitioned, etc.
- A few SOOs admitted it can be a struggle to get feedback on the new products from forecasters at times. They like to use products but you have to keep pushing them to document cases, provide details necessary to assess utility, value, application, etc.
- Some collaborators shared a candid concern that SPoRT may become stretched too thin to maintain its paradigm of personal coaching and assistance in developing practical solutions to specific operational problems – a practice which has characterized its successful partnerships since its inception.
- Several WFO collaborators expressed desire to see NASA SPoRT expertise leveraged in the GOES-R training development. Their impression was that NOAA has primarily focused on CIMSS, CIRA, COMET, etc., and that NASA SPoRT is not always utilized as an expert resource.
- At least two collaborators shared a desire to see better communication of assessment results, lessons learned, important applications, and transition plans.
- SPoRT is sometimes seen as a provider of operational products.

V. Conclusion

SPoRT has earned a reputation as an innovative leader in R2O, with a heart for both science and service. This reputation is well deserved, and they are encouraged to preserve the paradigm which has defined its success and growth to date – namely the practice of direct engagement with end users to better understand their needs and challenges, then work with them to develop solutions, transition those solutions to operational use, and co-create training that facilitates performance-based learning.

SPoRT has traditionally worked with NOAA/NWS using NASA weather satellite data (e.g., MODIS, AIRS, VIIRS, CrIS) but NOAA has developed a robust proving ground and many of these instruments will be operational within the next year. However, the SAC encourages SPoRT to continue engaging with its NWS partners on use of new datasets and on the investigation of value-added products, tools, algorithms, and practices. The fact that GOES-R will be operational in 2017 does not negate the need for operational forecasters to obtain training and guidance on effective uses of those data for critical decision making.

The SAC strongly supports SPoRT's cultivation of relationships with the NWC. There is great potential to leverage these relationships and SPoRT expertise into an important role by accelerating transition of NASA data sets into the NWM, especially in the area of linking LIS to water forecasting.

SPoRT is also urged to foster opportunities for new collaborations and partnerships, among U.S. government agencies, and in the international arena. However, as opportunities for growth and expansion emerge, it may become increasingly important for SPoRT to assess ROI risks more carefully by filtering new potential project areas through the lens of its vision, mission, core values, and key strengths.

Close working relationships among researchers, developers, modelers, and the operational community require a distinctive blend of knowledge and skills – a blend which the SPoRT team possesses. The SAC believes SPoRT's true calling is to capitalize on its unique strengths and bridge the gap between research and operations in the environmental sciences. SPoRT is *the* team within NASA that specializes in facilitating transition of the best, most promising scientific and technological advancements into operational practice. This is a function for which SPoRT can assert proven success, and they are uniquely positioned to stake their claim on that space. The committee strongly encourages SPoRT to remain true to this mission.

Finally, the SAC would be remiss if we did not express our gratitude to SPoRT for the way they planned and conducted the committee proceedings. The SPoRT team was, to a person, friendly, welcoming and accommodating. Their hospitality created a wonderful environment that directly contributed to a very productive meeting. Our sincere thanks to each of them for being such generous and gracious hosts.

Appendix A. – Composite Summary of SAC Recommendations

Modeling and Data Assimilation:

1. Strengthen direct connections to the GSFC LIS team to ensure the group is apprised of, and invested in ongoing developments in NLDAS, LSM, DA, NU-WRF, LIS/WRF-Hydro, etc. Due to the lack of core funding for LIS, it might be helpful to formalize the LIS-SPoRT connection both in terms of personnel and of some nominal FTE support to enhance the development and transition activities between the two groups.
2. Pursue collaborations with the NOAA Water Center to couple LIS/WRF-Hydro and integrate other NASA data sets and DA approaches into the National Water Model, and accelerate its operational implementation. SPoRT should have a primary seat at the table in order to support the LIS-NWC-SPoRT collaborative connections, and could play a role in enabling LIS to more formally become considered in the NWC paradigm (via DA capabilities).
3. Continue investigations of modeling land surface responses in major wildfire burn areas (i.e., changes in albedo, feedback on weather/water event evolution and attendant impacts).
4. Emphasize applications connected to GPM, SMAP research – flood extent, vegetation anomalies, drought monitoring, cross-calibrated passive microwave brightness temperatures, ideal approaches for operational GPM use, and impacts of SMAP DA on short term forecasts.
5. Consider the changing landscape of the operational modeling community at large, both in terms of LSMs (Noah-MP, RUC) and coupled models (WRF, RAP/HRRR). The urgency of this need is underscored by the fact that the paradigm of NWS field offices running local WRF experiments is rapidly going away.
6. SAC agrees with the proposed de-scoping of the atmospheric DA with a focus on numerical weather prediction, specifically of retrieved profiles, since the operational community has settled on radiance centered assimilation. (It is worth noting, however, that there may still be a role for atmospheric assimilation as an extension of the aerosol and air quality remote sensing expertise at SPoRT.)
7. SPoRT should consider how its strengths will need to adapt as numerical models evolve from limited area domains to global models with adaptive and non-uniform grids.

Lightning Applications:

8. Continue collaborations with NOAA/NWS to prepare forecasters for effective use of GOES GLM.
9. Foster new partnerships with National Centers and International stakeholders. Areas which seem particularly promising include applications for aviation, wildfire initiation, IDSS in data sparse regions, and the development and calibration of a physically-based lightning jump algorithm for identifying probabilities of hazardous storms. Potential U.S. Government partners include FAA, FEMA, USFS, NPS, and the National Wildfire Coordination Group; on the international front, SPoRT could serve as Subject Matter Experts for SERVIR hubs to assist with exploiting lightning for DSS in data sparse areas.
10. Enhance collaborations with Kennedy Space Center and Mission Launch Working Group to apply lightning initiation/cessation for real-time monitoring of developing storms; research value of electrification modeling for mission planning?

11. Continue ongoing efforts in Total Lightning Climatology. The potential value of a comprehensive, quality-controlled lightning climatology data set for data mining and research is tremendous.
12. While much of the emphasis will be placed on GLM in coming years, there may still be a significant and meaningful role for LMA research. For instance, LMAs may be used to validate or explain what is being observed from the GLM and, perhaps more importantly, to understand what the GLM cannot observe.

Remote Sensing:

13. Continue outstanding work in collaborative development and successful R2O transition of satellite imagery and products that directly benefit operational analysis and forecasting. The use of passive microwave, AOD retrievals, RGB composites, hyperspectral soundings, and Land Surface Information are all rich with potential benefit for enhancing forecaster performance and increasing the accuracy of numerical guidance through improved data assimilation.
14. Maintain involvement in development of focused, practical, interactive training that enables forecasters to understand how to interpret and use satellite imagery and products correctly and effectively.
15. Assume an Early Adopter role for missions that may reveal promising new opportunities for the future. Perhaps applications related to Landsat, Sentinel, ICESat-2, and Earth Venture missions fall into this category.
16. Continue to develop in-house expertise in remote sensing with a focus on new and upcoming observing platforms. Develop strategies to utilize new data within the constraints that are beyond the control of SPoRT (e.g., data latency).
17. Consider what role SPoRT can play in NASA mission development. This may, in part, include being co-investigators on NASA mission or instrument proposals (e.g., through Earth Venture) to fulfill explicit applications requirements included in future announcements of opportunity.
18. Continue to think innovatively in terms of data usage. Non-primary mission data products such as OCO-2 meteorological parameters, may have utility that can be exploited to the benefit of SPoRT.

Training and Assessment:

19. Preserve the paradigm of developing and maintaining relationships with end users in the operational community to develop, refine, and transition new tools, and in creating appropriate training in how to use those tools correctly and effectively.
20. In terms of training development, place strong emphasis on the focused, applications oriented, just-in-time modes. These are continually the ones that forecasters rate most highly.
21. Collaborate with NWS to refine and baseline the AWIPS Integrated Training Tool, and build out a framework for an AWIPS Applications Library.
22. Seek advocacy for a seat at the table when NWS plans its strategy for development and implementation of GOES-R applications training.

Applied Sciences Activities:

23. SPoRT is encouraged to continue its engagement with NOAA/NWS to support their disaster response activities; and to build collaborations with new partners, such as FEMA, EPA, CDC, and the US Coast Guard. However, SPoRT should ensure

appropriate collaborators and end users are involved in the design and execution of projects outside SPoRT expertise (e.g., public health).

24. SPoRT's successes with GPM and SMAP prove it can leverage Early Adopter status into effective collaborations. Their expertise in R2O/R2A and their experience in cultivating healthy, productive end-user partnerships, position them well to support other Early Adopter activities. For new missions, it is recommended they begin activities as early as possible.
25. Expedite the formulation of an organized plan that defines unique roles and contributions NASA SPoRT makes to the overall National Response Framework, and specifically to the efforts involved with Disaster Assessment and Response Coordination.

Data Delivery and Data Visualization:

26. Stay committed to open, flexible, extensible, and scalable, design for data delivery and visualizations, both in AWIPS-II and web development.
27. Adopt the use of RPMs to simplify/automate implementation of configuration changes and system modifications.
28. The committee strongly endorses plans for development of Web Map Service capabilities. Responsive web development may play a role in the applicability to end-users in the field, since they are increasing accessing information for critical decision making from tablets and/or smartphones.