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**ON THE  
NATIONAL PRIORITIES FOR SOLAR AND SPACE PHYSICS RESEARCH AND  
APPLICATIONS FOR SPACE WEATHER PREDICTION**

**COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE AND AERONAUTICS  
U.S. HOUSE OF REPRESENTATIVES**

**NOVEMBER 28, 2012**

**Introduction**

Good morning Mr. Chairman and Members of the Committee. My name is Laura Furgione and I am the Acting Director of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) in the Department of Commerce. Thank you for the opportunity to testify at this hearing about space weather.

NOAA plays a critical role to ensure our Nation is warned of natural hazards and prepared to respond should such an event occur. While probably best known for our role in hurricane, flood, and tornado forecasts and warnings, NOAA also has operational responsibilities for space weather forecasts and warnings. Today I will discuss how NOAA integrates National Aeronautics and Space Administration (NASA) research and observations and National Science Foundation (NSF) funded research into operations and then focus my testimony on NOAA's efforts to predict space weather impacts for the Nation and the world, in the context of the 2012 National Research Council (NRC) report, "Solar and Space Physics: A Science for a Technological Society."

NOAA is the U.S. Government official and definitive source of civilian space weather forecasts, warnings, and alerts to the general public, industry, and government agencies. The NOAA Space Weather Prediction Center (SWPC), which is one of nine national environmental prediction centers within the NWS, has a mission to deliver space weather products and services that meet the evolving needs of the Nation. SWPC operates 24 hours a day, 7 days a week (24x7), and provides real-time forecasts and warnings of solar and geophysical events. This is becoming even more important as our society increases its reliance on technology that is vulnerable to the impacts from space weather.

## **Critical Observations**

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) operates the Geostationary Operational Environmental Satellite (GOES) and Polar-orbiting Operational Environmental Satellite (POES) spacecraft, which provide critical observations of solar and geophysical events that are incorporated into NOAA's forecasts and satellite anomaly assessments for use by the Nation. The NOAA GOES spacecraft provides critical data in support of our Nation's technological infrastructure. Indeed, multiple activities associated with our industry, economic, and defense sectors depend on our ability to monitor and predict the space environment using critical measurements from GOES. NOAA issues space weather alerts, warnings, and forecasts using GOES data to thousands of customers worldwide, including airlines, satellite companies, NASA, and the Department of Defense (DoD). In fact, 80% of DoD space weather alerts and warnings rely on GOES data. The GOES-R series satellites, NOAA's next generation geostationary satellites, will continue and extend space environment measurements begun almost forty years ago. GOES-R will introduce new solar imagery capability, and an expanded range of energetic particle measurements, that will improve our products and meet growing national needs for space weather services.

NOAA POES satellites include the Space Environment Monitor (SEM) - a suite of instruments that measure energetic particles in lower Earth orbit. The SEM provides measurements of Earth's radiation belts and the increases of charged particles associated with solar eruptions. This information has long been used to assess space weather impacts on communications, satellites operations, radar systems, and the International Space Station.

NOAA is currently working with NASA to refurbish the Deep Space Climate Observatory (DSCOVR) spacecraft to provide space weather measurements from the L-1 position which is between the Sun and the Earth, 1 million miles upstream of Earth. A satellite at this L-1 position provides approximately one hour of warning for a space weather event that will impact Earth. When these space weather events impact Earth, they cause geomagnetic storms which can result in significant electric power grid problems. Satellites, airlines, GPS, radio communications, and other systems can be seriously affected as well.

NOAA's National Geophysical Data Center provides scientific stewardship of NOAA's space weather data. They are responsible for the archive and access of operational solar and space environmental data and derived products collected by NOAA and DoD observing systems.

NOAA also uses data from several NASA research satellites to augment its warnings and forecasts. SWPC uses data from the Advanced Composition Explorer (ACE) satellite to issue warnings on geomagnetic storms. ACE was launched in 1997 with a 2-year design life and is a single point of failure for these critical measurements. SWPC also relies on the coronagraph data from the Solar and Heliospheric Observatory and the Solar Terrestrial Relations Observatory missions to see coronal mass ejections (CMEs) erupt from the Sun, allowing NOAA to issue geomagnetic storm watches, which provide 1-3 day advance notice of a geomagnetic storm. These critical observations also provide the initial input to geomagnetic storm forecast prediction models.

## Research to Operations

NOAA has extensive experience transitioning research to operations, best illustrated by the NOAA hurricane program. In this instance, NOAA research and development activities work hand in glove with operations staff to define requirements for improvement and develop new techniques and models, which are then evaluated in a test-bed environment before adjustments are made and finally implemented into operations. NOAA uses a similar process to bring space weather research to operations. NOAA defines operational data requirements and space weather prediction model requirements, which are made available to NASA and the broader research community. NASA develops new space weather prediction models, and NOAA transitions NASA research into operations as efficiently and effectively as possible. NASA works with NOAA to define needs and requirements, develops models in conjunction with partners in academia, and assists as NOAA integrates the model into operations. In 2011, NOAA successfully transitioned the first physics-based space weather prediction model into operational use. This model was largely developed by NSF funded research and transitioned into operations from NASA. This model helps forecasters understand when an eruption on the Sun may impact Earth and result in a geomagnetic storm.

SWPC maintains a close working relationship with its user community and adjusts its products and services to meet the growing and changing needs of its customers, including emergency responders, power grid, satellite, aviation, and GPS industries. As new requirements are defined by the user community, SWPC works to develop products and services to meet those needs, and works with NASA and the broader research community to ensure SWPC requirements are met.

Recognizing the importance of 24x7 forecast and warnings, in 2005, NOAA transferred its space weather prediction program from an applied research environment into NWS operations. NOAA believes that NASA provides important research capabilities that, once proven, could be useful to NOAA's operational mission. As I will discuss later, the NRC report calls for NOAA to re-establish and support applied research efforts in space weather. NOAA and NASA have distinct roles in the national space weather program with NASA focused on research and NOAA on forecasts, operations, and applied research. NASA provides its experimental data to NOAA to be incorporated into operational space weather predictions.

There are extensive interagency actions and planning already underway to ensure continuity of solar wind data. NOAA and the Air Force have been appropriated funding to refurbish, launch, and operate the DSCOVR satellite to provide continuity of solar wind measurements after the ACE research satellite fails. This option was developed consistent with the recommendations of the nineteen-agency review which was conducted under the auspices of the Office of the Federal Coordinator for Meteorology at the request of the Office of Science and Technology Policy. This review recommended that NOAA, NASA, and the Air Force collaborate to refurbish and launch DSCOVR. NOAA and Air Force have received appropriations and work is underway. NOAA, in consultation with its operational partner, the Air Force, is assessing plans for continuity of such data after DSCOVR. We are evaluating the best value options for continuity for our requirements for solar wind observations and the initiation of operational coronal mass ejection imagery in the post-DSCOVR era. We will consider interagency and international partnerships as well as the

use of commercial services to meet these requirements. NOAA will focus on operational space weather observations needed to meet operational forecasting requirements.

## **Decadal Survey Report**

The NRC Decadal Survey report emphasizes the importance of space weather for society and therefore the value of the work conducted by NOAA to provide services that protect life and property and to provide economic benefits for the Nation. The report's number one science goal for the next decade is to "determine the origins of the Sun's activity and predict the variations in the space environment." Promoting NASA and National Science Foundation (NSF) research programs in directions that will lead to improving space weather predictive capabilities will ultimately benefit NOAA's ability to provide the Nation with improved services. This report sets the stage for NOAA to continue fulfilling its critical leadership role in space weather operations and applying forecasts and services to benefit society.

The report provides an excellent assessment of the state of heliophysics and provides a roadmap for moving NASA into the next decade. The importance of space weather is highlighted throughout the document and many of the proposed missions and research that are highlighted would provide key information for improving modeling and forecasts. As emphasized in the report, it is important that space environment research and data be transitioned to operations. The multi-agency effort required to accomplish research to operations is well recognized and the report calls for more resources to take full advantage of current research. Furthermore, the report recommended several times that NOAA should increase its internal applied space weather research capability to enhance the research to operations activities.

The survey highlights NOAA's role in operational forecasts to support society and civilian customers. The importance of NOAA observations in supporting the operational needs of customers is also clearly stated. NOAA and NASA are currently updating roles and responsibilities regarding space weather programs.

This report contains many pertinent recommendations for the National Space Weather Program which is a coordinating program involving numerous Federal agencies. Below are NOAA's views of the recommendations that affect our operational space weather forecast mission.

The report identifies the need for NOAA to establish a space weather research program to effectively transition research to operations. Before SWPC was transferred to the NWS in 2005, there was an applied research program in NOAA's Office of Oceanic and Atmospheric Research. With the transition of SWPC to the NWS, NOAA transitioned its focus to operational space weather forecasting resulting in reduced emphasis on applied research, which is needed to advance operational space weather prediction. NOAA still supports space weather research, including evaluating space weather prediction models for operational use and developing satellite algorithms to take advantage of future satellite observations. The report also states that this will require growing the research programs at NSF, NASA, Air Force Office of Scientific Research, and Office of Naval Research. As the agency responsible for integrating research into operations, NOAA looks forward to working with our federal and non-federal partners to ensure the latest successful research is available to be transitioned.

The report states, “It is critical that we develop predictive capabilities for space-weather events while maintaining comprehensive measurements for nowcasting solar-wind and energetic-particle inputs into geospace” (motivation M2 in the report). The report provides a plan for a NASA Heliophysics Systems Observatory. While we agree these types of observations are required to advance our collective understanding of space weather, requirements for “operational” observations are typically not the same as for “research” observations. NASA typically flies sensors that go beyond true operational needs; however, we must ensure operational needs continue to be met.

The report also discusses distribution of essential, operational data. NOAA believes that as the operational agency it should continue to distribute these observations. NOAA currently has the responsibility for distributing operational measurements and should continue in this role.

In general, we also agree that synergy exists between NOAA and NASA and can be enhanced by the space weather community, especially when NASA’s research and observing expertise is combined with NOAA’s operational expertise and forecast capabilities. However, agency strengths, roles, and responsibilities have not been addressed in the report’s recommendation.

Our Nation remains vulnerable to space weather and needs improved forecasts providing more timely and accurate forecasts to help mitigate potential impacts from such events. The NRC report is an excellent first step and identifies critical research activities that are necessary to expand our comprehensive understanding of heliophysics and space weather as well as to improve our nation’s forecast and warning capabilities.

In conclusion, the nation requires ongoing research and development that will inform operations. As such, NASA plays an important role to explore new technologies that NOAA can assess for use in its 24x7 operations. The NRC has provided critical insight into the areas that NOAA, NASA, the Department of Defense, and the larger space weather community will continue to assess in years to come.