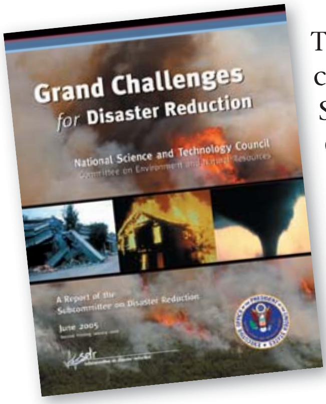


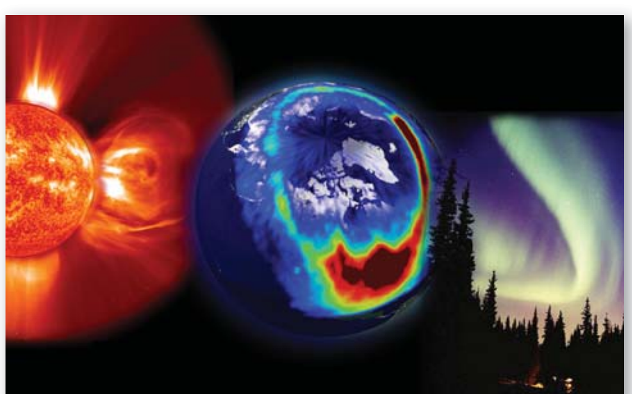
The *Grand Challenges for Disaster Reduction* is a ten-year strategy crafted by the National Science and Technology Council's Subcommittee on Disaster Reduction (SDR). It sets forth six Grand Challenges that, when addressed, will enhance community resilience to disasters and thus create a more disaster-resilient Nation. These Grand Challenges require sustained Federal investment as well as collaborations with state and local governments, professional societies and trade associations, the private sector, academia, and the international community to successfully transfer disaster reduction science and technology into common use.

To meet these Challenges, the SDR has identified priority science and technology interagency implementation actions by hazard that build upon ongoing efforts. Addressing these implementation actions will improve America's capacity to prevent and recover from disasters, thus fulfilling our Nation's commitment to reducing the impacts of all hazards and enhancing the safety and economic well-being of every individual and community. This is the space weather-specific implementation plan. See also **sdr.gov** for other hazard-specific implementation plans.

What is at Stake?

DEFINITION AND BACKGROUND. Space weather refers to dynamic conditions on the Sun and in the space environment that can influence the performance and reliability of space-borne and ground-based technological systems, and can endanger human life or health of astronaut crews outside the magnetosphere, as well as aviation flight crews and passengers on trans-polar flights. Adverse conditions in the space environment can cause disruption of satellite operations, communications, navigation, and electric power distribution grids, leading to severe socio-economic losses. The growing importance of space to security and economic well-being requires that the United States Government develop and maintain capabilities to mitigate the deleterious effects of severe space weather.

Space weather forecasts are issued by the NOAA Space Weather Prediction Center (SWPC) and the Air Force Weather Agency (AFWA) Space Weather Flight (SWF) based on data from ground and satellite monitoring systems operated by DOD, NASA (through missions involving research spacecraft), NOAA, USGS and other partners. Space weather specification and forecast services are based on four strategic elements: observations, data access and display, predictions and product dissemination. All of these activities in turn are supported by research and technology advancements communicated through a comprehensive education program which facilitates the transfer of knowledge to operations. The Office of the Federal Coordinator for Meteorology (OFCM) works with the Office of Science and Technology Policy (OSTP), the Office of Management and Budget (OMB), and other U.S. Government departments and agencies to advance the interagency National Space Weather Program (NSWP). Established in 1995, the program provides coordination and oversight in support of space environmental forecasting, research, data acquisition, model development, technology transition, operations, education, and public outreach.



SPACE WEATHER

A report of the Subcommittee on Disaster Reduction
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IMPACTS. Space weather presents a variety of hazards to technical systems and human life depending on the type, strength, timing, and location of the disturbances.

During the massive space weather storm in March 1989, rapid fluctuations in the Earth's magnetic field induced electric currents in Quebec's hydroelectric power grid, leading to a system-wide outage that left 6 million people without power for 9 hours. The space weather storms of October 2003 caused many satellites and deep-space instruments to be put into safe mode. Had astronauts been en route to the Moon or Mars at that time, they may have suffered from acute radiation sickness. The Wide Area Augmentation System (WAAS) used by commercial airlines for precision navigation was disrupted for more than 10 hours on two consecutive days. A series of solar flares in early December 2006 resulted in widespread loss of Global Positioning System (GPS) signal acquisition over the US. Several commercial airline flights in the polar regions were ordered to fly at lower altitudes to reduce radiation hazards to passengers.

In the future, the number of technical systems vulnerable to space weather effects will continue to grow. Many of these systems are critical to the Nation's ability to respond to other emergencies. Most space weather effects are global in nature. Therefore, space weather threats can be compounded with those associated with other disasters.

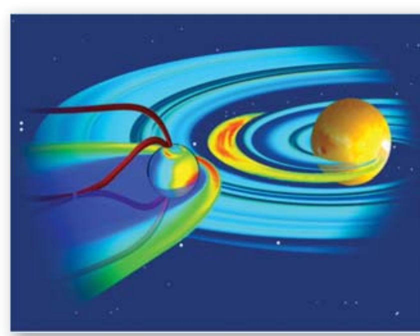
Grand Challenges for Disaster Reduction: Priority Interagency Space Weather Implementation Actions

GRAND CHALLENGE #1: Provide hazard and disaster information where and when it is needed.

- ■ Enhance the capabilities of space weather operational centers (NOAA SWPC and AFWA SWF) to ensure timely, accurate, and advanced space weather warnings, specifications, and forecasts;
- ■ Identify critical measurements and plan for strategic investments in the development of ground- and space-based systems;
- ■ Continue to validate the adequacy and reliability of space weather data sources;
- ➤ Foster efforts within the growing commercial sector for space weather services and products to enable this sector to flourish as a vital part of the national space weather enterprise;
- ➤ Establish processes by which measurements from space-based research assets are effectively made available to space forecasters;
- ➤ Investigate the use of arrays of ground-based instruments with real-time data capabilities for use in space weather forecasting;
- ➤ Accelerate the transition of advanced space environmental models to space weather forecasting applications;
- ◆ Develop advanced technologies and deployment strategies to achieve longer early warning lead times; improved accuracy in space weather forecasts;
- ◆ Enhance the seamless exchange of international data and information.

GRAND CHALLENGE #2: Understand the natural processes that produce hazards.

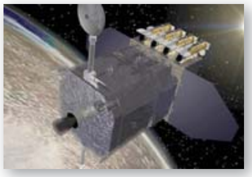
- ■ Support basic heliophysical and geophysical research aimed at understanding the fundamental physical processes that affect space weather;
- ■ Support the development of targeted, innovative instrumentation, concepts, and hardware for space weather research;
- ➤ Evaluate and promote space weather modeling progress through a set of well-defined space weather metrics;
- ➤ Encourage a broad perspective of processes affecting the entire Sun-Earth system in space weather research and education;
- ◆ Incorporate and demonstrate new physical understanding using evolving model chains, which cover the entire Sun-Earth domain.



Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

GRAND CHALLENGE #3: Develop hazard mitigation strategies and technologies.

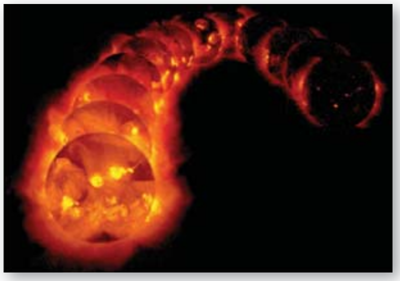
- ■ Streamline and improve the ability of the operational centers to rapidly implement state-of-the-art space weather forecast tools;
- ■ Investigate approaches for innovative operational data sources (e.g., micro-satellites and miniaturized sensors) capable of capturing space weather precursors and extremes;
- ■ Develop comprehensive models of historical space environmental data to better understand the full range of space environmental parameters and their extremes;
- ➤ Develop and/or adopt standards for modeling frameworks in order to facilitate inter-model coupling, and flexible model execution;
- ➤ Implement data assimilation techniques for space weather models;
- ➤ Develop approaches to expedite the transition of research to operations;
- ◆ Disseminate space weather information and develop products and decision-aid processes to enhance rapid and effective responses.



GRAND CHALLENGE #4: Reduce the vulnerability of infrastructure.

- ■ Perform post-event analyses to understand and mitigate future vulnerabilities through engineering solutions or other strategies as appropriate;
- ■ Establish an open and accessible database of impacts for use by system developers and operators;
- ➤ Encourage exchange of information among space weather customers identifying vulnerabilities and new technological solutions;
- ◆ Establish engineering standards to ensure uniform specifications are applied to technical systems;
- ◆ Develop comprehensive and cost-effective mitigation and recovery plans;
- ◆ Support development of plans for stockpiling replacements for sensitive infrastructure components subject to space weather damage.

GRAND CHALLENGE #5: Assess disaster resilience.



- ■ Initiate periodic reviews of space weather impact studies addressing the primary topics of concern to at-risk communities;
- ➤ Conduct regular exercises using teams of economists, scientists, engineers and practitioners to simulate the effects of space weather events and the effectiveness of mitigation strategies;
- ➤ Work with the private sector to understand better the economic and social benefits of space weather services;
- ◆ Develop risk-analysis techniques to guide loss reduction efforts at the Federal, state, and local levels.

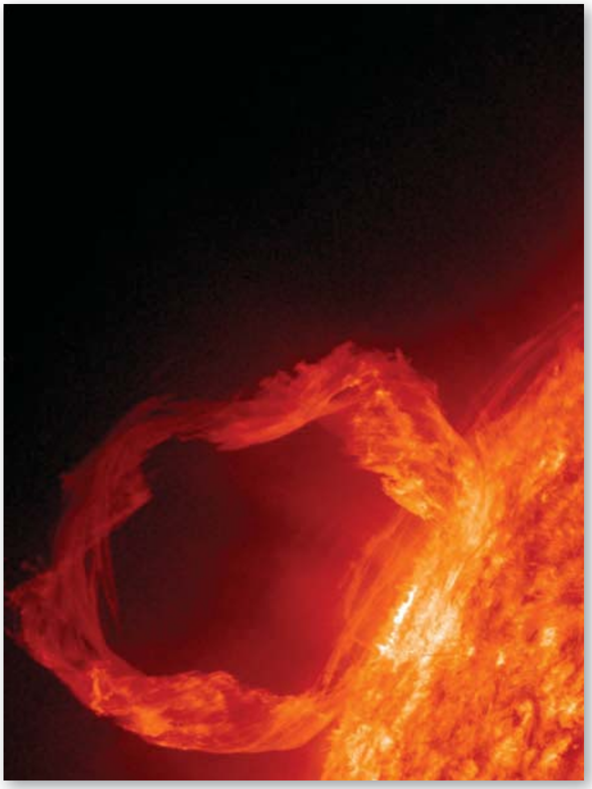
GRAND CHALLENGE #6: Promote risk-wise behavior.

- ■ Enhance awareness across the U.S. Government, technical communities, and the general public to promote familiarity with space weather dangers and hazard prevention;
- ■ Foster the exchange of ideas and information through space weather workshops that bring together researchers, customers, and service providers from government, academia, and the commercial sector;
- ➤ Conduct further studies to assess radiation exposure hazards to humans in aviation and space travel;
- ◆ Promote public policy to address space weather challenges and security risks;
- ◆ Create and strengthen international collaborations to enhance global awareness of and coordinated responses to space weather hazards.

Key: ■ Short Term Action (1-2 years) ➤ Medium Term Action (2-5 years) ◆ Long Term Effort (5+ years)

Expected Benefits: Creating a More Disaster-Resilient America

Fulfilling the space weather-specific implementation plan will create a more disaster-resilient America. Specifically:



Relevant hazards are recognized and understood. A strong space weather research program and technology development, key elements of the Grand Challenges, will produce essential scientific data and understanding of the source processes of space weather dangers. This research will enable effective forecasting and mitigation. Furthermore, it will also provide the means to recognize the danger levels associated with harmful environmental factors such as radiation, ionospheric effects on communication and navigation, and electric current induction in power grids. A solid communications and information program will ensure that these science results are disseminated to space weather interests and to the general public. Effectively communicating space weather science will provide the broad level of understanding which is required for appropriate preparation for hazardous events, and for appropriate action and mitigation when threatened by space weather.

Communities at risk know when a hazard event is imminent. Addressing the Grand Challenges will lead to a new, heretofore unobtainable, level of space weather forecasting capability. A broad dissemination system, primarily government-based, but also benefiting from private enterprise, will assure easy access to space weather warnings. This transformational advance in capability will result from (1) enhancing the capabilities of our space weather forecasting centers, (2) providing for and sharing operational data sources, and (3) a robust process to transfer research models to operational use. Resolving the Grand Challenges will foster reliable forecasts, increasingly in advance of the actual event, that enable operators of space weather-sensitive equipment or humans in danger of radiation exposure to take the proper mitigating measures at the appropriate time.

Individuals at risk are safe from hazards. Reliable space weather forecasting is helpful in mitigating the potential loss of strategic communications and in enhancing situational awareness. Individuals are affected by space weather in two ways. First, space radiation effects are harmful to astronauts and the crew and passengers on trans-polar flights. Second, space weather damage to essential equipment or systems such as GPS and the North American Power Grid can threaten large segments of the population over extended periods of time. Safety of humans in both categories, while minimizing economic or operational impacts, has to rely on appropriate action at the appropriate time. Hazard mitigation will be possible because of improved understanding and timely warnings. Mitigation strategies will ensure the safety of humans while directly or indirectly exposed to space weather dangers. Resolution of the Grand Challenges will provide confidence that humans are well protected from space weather hazards.

Disaster-resilient communities experience minimum disruption to life and economy after a hazard event has passed. By addressing the Grand Challenges, endangered communities are enabled to prepare properly and to react appropriately in the case of an impending space weather event. Critical knowledge of the danger levels and of the event timing derived from solutions to the Grand Challenges provides mitigation solutions with minimum socio-economic impact. Systems will be engineered with greater resilience to space weather effects, and replacements will be available for vulnerable components. Guided by that knowledge, services disrupted by the event itself, or turned off as a mitigation measure during the event, can be resumed rapidly so that normal life is affected minimally or not at all.

References

1. http://www.ofcm.gov/r24/fcm-r24.htm