STEREO Space Weather and the Space Weather Beacon

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Abstract The Solar Terrestrial Relations Observatory (STEREO) is primarily a solar and interplanetary research mission, with one of the natural applications being in the area of space weather. The obvious potential for space weather applications is so great that NOAA has worked to incorporate the real-time data into their forecast center as much as possible. A subset of the STEREO data will be continuously downlinked in a real-time broadcast mode, called the Space Weather Beacon. Within the research community there has been considerable interest in conducting space weather related research with STEREO. Some of this research is geared towards making an immediate impact while other work is still very much in the research domain. There are many areas where STEREO might contribute and we cannot predict where all the successes will come. Here we discuss how STEREO will contribute to space weather and many of the specific research projects proposed to address STEREO space weather issues. The data which will be telemetered down in the Space Weather Beacon is also summarized here. Some of the lessons learned from integrating other NASA missions into the forecast center are presented. We also discuss some specific uses of the STEREO data in the NOAA Space Environment Center.

Keywords STEREO · Space weather · Coronal mass ejection · Solar wind · Forecasting

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1 Introduction

1.1 Background on Space Weather

As society becomes increasingly reliant on technologically advanced systems for many of its day-to-day functions, our ability to predict and respond to the impacts of space weather gains greater importance. Among the systems most susceptible to geomagnetic disturbances are power grids, satellites, and aviation communications—systems upon which our reliance increases dramatically every year. The use of pagers and mobile phones has become almost ubiquitous. The global positioning system (GPS) is used heavily by the military, commercial airlines, the construction and extraction industries, and the shipping and boating industry, and is being introduced into automobiles. As the use of these systems, which are vulnerable to space weather, becomes more widespread, space weather disturbances will impact a wider array of people and human activities. A comprehensive text on telecommunications and the susceptibility of such systems to space weather is that of Goodman (2005). Also, summaries on the impact of space weather on technological systems are available in Lanzerotti et al. (1999) and Lanzerotti (2001).

One example of a space weather impact was the apparent loss of a communications satellite and associated widespread loss of services due to a space weather disturbance, which was described by Baker et al. (1998). They found that the combination of coronal mass ejections (CMEs), solar flares, and high speed solar wind streams led to a prolonged period of geomagnetically disturbed conditions during which the Galaxy 4 communications satellite was subjected to an intense population of highly energetic, relativistic electrons just prior to its loss. The Galaxy 4 satellite outage affected CBS, NPR, Reuters, ATM networks and many pagers. Since our society is becoming more dependent on advanced technological systems, we are increasingly vulnerable to malfunctions in those systems. A single civilian communications satellite can cost several hundred million dollars. There are now over 300 commercial spacecraft in geosynchronous orbit and entire new constellations of satellites are being placed into a variety of Earth orbits. If even a small percentage of these satellites exhibit severe problems due to the space environment, the costs will be significant (Odenwald et al. 2006).

The need to study, forecast and mitigate space weather effects is gaining increased attention at the national level. Specifically, the need to develop a coordinated plan to improve present capabilities in specifying and forecasting conditions in the space environment has led to the formation of national programs such as the U.S. National Space Weather Program (http://www.nswp.gov), NASA's Living With a Star (http://lws.gsfc.nasa.gov/), and ESA's Space Weather Programme (http://www.esa-spaceweather.net/). As a scientific pursuit, space weather is considered analogous to atmospheric weather, having both research and forecasting elements. In some sense, our knowledge and ability to build predictive models of space weather is equivalent to, yet distinctly different from, the early stages of atmospheric weather studies (Siscoe 2006; Siscoe and Solomon 2006). For a comprehensive overview of the recent state of the art in space weather research, readers are directed to the AGU Monograph *Space Weather* (Song et al. 2001) and to the text *Space Weather: The Physics Behind a Slogan* (Scherer et al. 2005).

The ultimate source for most space weather effects is the Sun and its activity. The NOAA Space Environment Center categorizes space weather in three convenient scales which are each related to the type of solar event driving them (Poppe 2000). All three scales rate space weather disturbances on a scale from one (1) to five (5), with one being considered 'minor' and five 'extreme'. The G (Geomagnetic Storm) scale is discussed in the next section. The