J1.10 THE STEREO MISSION: A NEW APPROACH TO SPACE WEATHER

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1. INTRODUCTION

With the launch of the twin STEREO spacecraft in February 2006, a new capability will exist for both real-time space weather predictions and for advances in space weather research. Whereas previous spacecraft monitors of the sun such as ACE and SOHO have been essentially on the sun-Earth line, the STEREO spacecraft will be in 1 AU orbits around the sun on either side of Earth and will be viewing the solar activity from distinctly different vantage points. As seen from the sun, the two spacecraft will separate at a rate of 45 degrees per year, with Earth bisecting the angle. The instrument complement on the two spacecraft will consist of a package of optical instruments capable of imaging the sun in the visible and ultraviolet from essentially the surface to 1 AU and beyond, a radio burst receiver capable of tracking solar eruptive events from an altitude of 2-3 R_S to 1 AU, and a comprehensive set of fields and particles instruments capable of measuring in situ solar events such as interplanetary magnetic clouds. In addition to normal daily recorded data transmissions, each spacecraft is equipped with a real-time beacon that will provide 1 to 5 minute snapshots or averages of the data from the various instruments. This beacon data will be received by NOAA and NASA tracking stations and then relayed to the STEREO Science Center located at Goddard Space Flight Center in Maryland where the data will be processed and made available within a goal of 5 minutes of receipt on the ground. With STEREO's instrumentation and unique view geometry, we believe considerable improvement can be made in space weather prediction capability as well as improved understanding of the three dimensional structure of solar transient events.

2. INSTRUMENTS

The STEREO observatory carries a complement of four scientific instruments (two instruments and two instrument suites, with a total of 13 instruments per observatory) as follows:

- Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI)
- In situ Measurements of PArticles and CME Transients (IMPACT)
- PLAsma and SupraThermal Ion Composition (PLASTIC)
- STEREO/WAVES (S/WAVES)

SECCHI encompasses a suite of remote sensing instruments designed to study the three-dimensional evolution of CMEs from the Sun's surface through the corona and interplanetary medium to their eventual impact at Earth. SECCHI is composed of white light coronagraphs exploring $<1.4\ R_S$ to 15 R_S (R_S is the radius of the Sun), an extreme ultraviolet Imager to view the upper chromosphere and innermost corona, and a heliospheric imager to observe CMEs from the Sun to Earth's orbit and beyond

IMPACT will measure the interplanetary magnetic field, thermal and suprathermal solar wind electrons, and energetic electrons and ions, and the PLASTIC experiment provides in-situ plasma characteristics of protons, alpha particles, and heavy ions.

The S/WAVES instrument is an interplanetary radio burst tracker that tracks the generation and evolution of traveling radio disturbances from the Sun to the orbit of Earth.

3. ORBITS AND PHASES OF THE MISSION

To obtain unprecedented, three-dimensional measurements of the Sun, the twin observatories will be placed into solar orbits near 1 AU and they will be offset from one another. One observatory will be placed "ahead" of Earth in its orbit and the other, "behind". For the first 3 months after launch, the observatories will fly in an orbit from a point close to Earth to one that extends just beyond the moon's orbit. Mission operations personnel will synchronize the orbits of the two spacecraft to encounter the Moon about 2 months after launch. At that point, one spacecraft will use the moon's gravity to redirect it to an orbit lagging "behind" Earth. About 1 month later, the second observatory will encounter the Moon again and be redirected to its orbit "ahead" of Earth. After both spacecraft have left the Earth-moon vicinity, they will be in heliocentric orbits at nearly 1 AU. The 'ahead' spacecraft will be in an orbit slightly closer to the sun than Earth's orbit and the 'behind' spacecraft will be in a slightly larger orbit. As viewed from the sun, the two spacecraft will separate at an average of 45° per year.

The STEREO mission divides scientifically into three parts. During the first several months when the spacecraft are still fairly close together, the coronagraphs and extreme ultraviolet instrument have good overlap of their plane-of-sky viewing areas so that 3-D reconstruction of observed features is highlighted. Also during this early phase of the mission, the likelihood of both spacecraft being immersed inside the same CME/magnetic cloud is increased. Furthermore, those in situ CMEs would be Earth-directed. At the opposite extreme late in the mission, the spacecraft are at quadrature so that remote viewing of Earth-directed CMEs is enhanced. This phase of the mission is thought of as a precursor to the Living With a Star missions to be launched later. In the intermediate interval, triangulation of radio bursts with SWAVES is best.

4. SPACE WEATHER BEACON

In addition to normal data collection, the two STEREO spacecraft also broadcast continuously a low rate (~600 bps) set of data consisting of typically 1-minute summaries (or 5 minute in the case of SECCHI) to be used for space weather forecasting, much like is currently done with the ACE and SOHO data. Several participating NOAA and international ground tracking stations will collect the data and send it electronically to the STEREO Science Center where it will be processed into useful physical quantities and place on the STEREO Web page, http://stereo.gsfc.nasa.gov/. The goal is to have the processed data available within 5 minutes of receipt at the tracking stations. The STEREO mission will move space weather predictions to the next logical step, the ability to make 3D measurements.

During the early portion of the STEREO mission, many existing space weather spacecraft near Earth such as SOHO, Wind and ACE should also still be operating and the Solar-B spacecraft will also be launched the same year as STEREO (2006). Thus, there will be an impressive fleet of spacecraft dedicated to solar observations and I predict the STEREO era will become an extremely productive period in our understanding of our sun.