Space Weather Aspects of the STEREO Mission

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Introduction

The STEREO Space Weather Group consists of scientists associated with the STEREO teams interested in space weather aspects of the mission. We operate a public web site at http://wwwsolar.nrl.navy.mil/STEREO/swx/swindex.html, where anyone from the scientific community can follow efforts to prepare computer programs, modeling efforts and research studies in preparation to use the STEREO observations as tools for Space Weather. Our activities are coordinated with the STEREO PI Teams and the STEREO Science Center (SSC) at GSFC. *The list of tools and projects below shows the kind of ideas being pursued. We invite scientists from outside the STEREO teams to join in our efforts.* Our group interacts closely with the SECCHI 3D Reconstruction and Visualization Team; some of the 3D tools listed here overlap with science tools being developed by the 3D R&V team: http://wwwsolar.nrl.navy.mil/STEREO/3drv/scisoft/pasadena_replies.pdf.

The STEREO Beacon is the main STEREO effort focused on Space Weather; its main purpose is to provide low resolution, low cadence, near-real-time imaging and in-situ data to NOAA's Space Environment Center (SEC) for forecasting. *The Beacon and its content are also described in this poster.* In addition to the real-time Beacon data, the full science data stream will be downloaded to the SSC each day. These data will also be important for space weather, both for predicting and in improving our understanding of CME's and related phenomena.

NOAA/SEC is always looking for products which will improve space weather forecasts. STEREO is a mission which has obvious forecasting benefits, but is by no means the only mission. Researchers who have developed tools or methods to improve these products are encouraged to contact NOAA/SEC. *Also shown in this poster are the forecast products which are most needed.*

NOAA/SEC's BIG LIST

NOAA Space Environment Center forecasting needs.

Highest Priority

- Solar Energetic Particle event forecasts, including start time, end time, peak flux, time of peak flux, spectra, fluence, and probability of occurrence
- Energetic electron flux prediction for International Space Station
- Regional geomagnetic nowcasts and forecasts (e.g., Auroral electrojet maps)
- Ionospheric maps of TEC and scintillation (real-time and future)
- Geomagnetic Indices (A, K, Dst) and Probability forecasts

High Priority

- Geomagnetic activity predictions (1-7 days) based on CME observations, coronal hole observations, solar magnetic observations, and ACE/EPAM observations
- Geomagnetic storm end-time forecast
- Real-time estimates of geomagnetic indices
- Real-time quality diagnostics (verification) of all warning/watch/forecast products
- Routine statistical and/or numerical guidance for all forecast quantities (e.g., climatological forecasts of flares, geomagnetic indices and probabilities, and F10.7—similar to NWS Model Output Statistics)
- Improved image analysis capability (e.g., for SXI, STEREO, SMEI)
- Short-term (days) F10.7 forecasts
- Short-term (days) X-ray flare forecasts
- Magnetopause crossing forecasts based on L1 data
- EUV index

Notes:

1. Items in each grouping are not necessarily in order
2. Required product lead-time and needed product quality (skill, accuracy, etc.) depend on specific user needs

Real-time Beacon

The Beacon and Data Flow

633 bps – real-time continuous broadcast (no record capabilities)

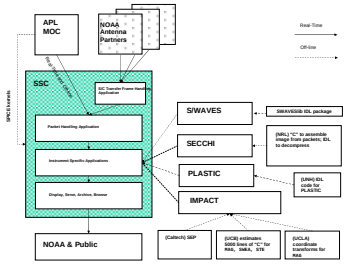


Figure courtesy of W. Thompson

The Beacon Data

IMPACT – numbers in parentheses denote # energy bands

- MAG *(Magnetometer)*
  - ***B*** vectors at 3 samples/minute
- STE *(Suprathermal Electron Telescope – e 2-20keV)*
  - ***e*** flux in 2 look directions, 8 energies, 16 samples/minute
- SWEA *(Solar Wind Electron Analyzer – e eV-several keV)*
  - ***e*** density, bulk velocity, temperature at 13 samples/minute
  - pitch angle distributions at 2 energies, 24 samples/minute
- SEPT *(Solar Electron Proton Telescope – e 20-400keV; p 20-7000keV)*
  - ***e***(2) and ***p***(2) flux in 4 look directions (and summed); 1 minute avg.
- LET *(Low Energy Telescope – p & He 1.5-13 MeV/nuc.; heavy ions 2-30 MeV/nuc.)*
  - ***p(1)*** flux in 2 look directions (and summed); 1 minute avg.
  - He(2) flux in 2 look directions; 1 minute avg.
  - He(1), ^{3}He(2), CNO(3), Fe(4) fluxes; summed over all look angles; 1 minute avg.
- HET *(High Energy Telescope – e <5 MeV; p & He <100MeV/nuc.)*
  - ***e***(1), ***p***(3), He(3), CNO(2), Fe(1) fluxes; 1 minute avg.
- SIT *(Suprathermal Ion Telescope – 30 keV/nuc. – 2 MeV/nuc.)*
  - He(4), CNO(4), Fe(4) fluxes; 1 minute avg.

PLASTIC

- 1 minute resolution
  - Solar Wind H density, bulk H velocity
  - Solar Wind H+ temperature and heat flux tensors
  - Solar Wind He++ peak distribution, position, deflection step, energy step
- 5 minute resolution
  - Selected Solar Wind charge states
  - Suprathermal rates

S/WAVES

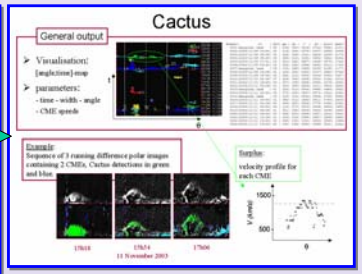
- 1 minute averages; 8 channels/octave from 16 kHz to 16 MHz

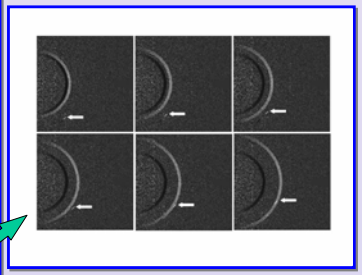
SECCHI

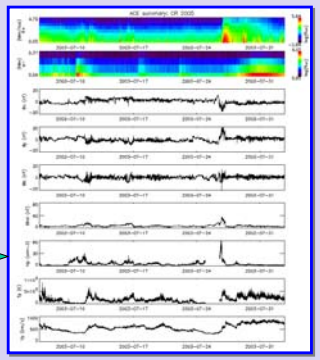
- 7 256x256 pixel images (w/lossy compression) per hour, including:
  - 4 COR2 images
  - 1 HI1/HI2 alternating
  - + 4 byte sum of EUVI total intensity; CME detection flag

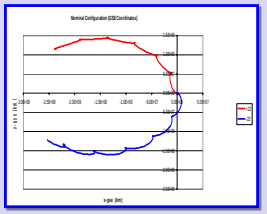
Tools and Projects Being Developed for STEREO Space Weather Purposes

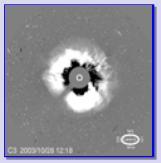
Title	Leaders/Institutions	Brief Description
GENERAL SCIENCE TOOL		
LOS Tool for SECCHI White Light Images	P. Liewer, J. Hall, J. Lorre JPL, NRL	Create synthetic white light images from 3D density data cube. Use with simple CME models.
AUTOMATED DETECTION and IDENTIFICATION		
Computer Aided CME Tracking (CACTus)	E. Robbrecht, D. Berghmans, G. Lawrence, R. van der Linden Royal Observatory Belgium	Near-realtime tool for detecting CMEs in SECCHI images. Outputs: QL CME catalog w/measures of time, width, speed; NRT CME warnings. Successfully tested on SOHO LASCO CMEs. Test version available at http://sidc.oma.be/cactus.
Computer Aided EUVI Wave & Dimming Detection	O. Podladchikova, D. Berghmans, A. Zhukov ROB	NRT tool for detecting EUV waves & dimming regions. To be tested on SOHO EIT images.
Velocity Map Construction	J. Hochedez, S. Gissot ROB	Program to analyze velocity flows on SECCHI images; detect CME onsets & EUV waves; NRT warnings of fast CMEs; reconstruct 3D velocity maps of CMEs from 2D maps from each STEREO.
Automatic Solar Feature	D. Rust, P. Bernasconi, B. LaBonte, JHU/APL	Tool for detecting and characterizing solar filaments and sigmoids Recognition & Classification in solar images. Goal is to meas. magnetic helicity parameters & forecast eruptions using filaments & sigmoids.
3-D IMAGING TOOLS		
Tie Point Tool	E. DeJong, P. Liewer, J. Hall, J. Lorre JPL	Manually create tiepoints between features in SECCHI image pair & solve for 3D location in heliographic coordinates.
Geometric Localization Of STEREO CMEs	V. Pizzo, D. Biesecker NOAA	Tool utilizing a series of LOSs from two views to define the location, shape, size and velocity of a CME. To be automated & used to decide whether and when a CME will impact Earth.
3D Structure of CMEs	V. Bothmer, H. Cremades, D. Tripathi MPI, Ger.	Program to compare analysis of SECCHI images on the internal magnetic field configuration & near-Sun evolution of CMEs with models based on SOHO observations. Forecast flux rope structure; 3D visualization of CMEs.
HELIOSPHERIC STUDIES		
SECCHI HI Beacon	R. Harrison, C. Davis RAL, MSSL	For space weather purposes the prime HI data product is the images sent in the beacon mode The HIs will observe CMEs along the Sun-Earth line from Cor2 to beyond Earth.
Structural Context of Heliosphere Using SMEI Data	D. Webb, B. Jackson BC/AFRL, UCSD	Assuming an extended SMEI mission, use analyses of SMEI images, including 3D reconst. mapping, to provide structural context of the heliosphere for STEREO HI observations. Also provide complementary observations of transient disturbances, especially CMEs.
Identifying & Tracking CMEs with the Helio-spheric Imagers	R. Harrison, C. Davis RAL, MSSL	Produce simulations to show that model CMEs can be identified & tracked with the HIs. Test wavelet & other techniques for extracting CME signatures. Use triangulation to measure speed & direction of CMEs & forecast their Earth arrival.
Interplanetary Acceleration of ICMEs	M. Owens BU	Construct acceleration profiles of fast ICMEs over a large heliocentric range using multi-point HI observations of the leading edges to understand the forces acting on ejecta in interplanetary space, & improve predictions of arrival times of ICMEs at Earth.
Relationship between CMEs and Magnetic Clouds	S. Matthews, MSSL	Assess the potential geoeffectiveness of CMEs based their association with magnetic clouds. What particular characteristics lead to production of a magnetic cloud? Combine SECCHI images with in-situ measurements from both STEREOs & ACE.
Comparison of WSA Model Predictions with STEREO in-situ Data	N. Arge, J. Luhmann, D. Biesecker AFRL/UCB/ NOAA	The Wang-Sheeley-Arge and ENLIL 3D MHD solar wind models will be integrated to provide routine predictions of vector s.w. velocity, polarity, IMF, s.w. density & temp. anywhere in heliosphere. Place model into in-situ STEREO displays (see next).
DATA BROWERS and VIEWERS		
Solar Weather Browser	B. Nicula, D. Berghmans, R. van der Linden ROB	User-friendly browser tool for finding & displaying solar data & (SWB) context information. Uses fast internet access & caching. Test version available at http://sidc.oma.be/SWB/.
STEREO Key Parameters	C. Russell & IMPACT, PLASTIC & SWAVES teams UCLA	An easily browsable Merged Key Parameter data display including the in-situ & SWAVES radio data from STEREO.
Carrington Rotation In-situ Browser	J. Luhmann, P. Schroeder UCB	Browser for identifying in-situ events & their solar sources at CR-time scales. Includes near-Earth (ACE) data sets for third point views, & image movies from SECCHI & near-Earth (SOHO) s/c. See: http://sprg.ssl.berkeley.edu/impact/data_browser/index.html.
JAVA-3D Synoptic Information Viewer	J. Luhmann, P. Schroeder UCB	JAVA-3D applet for viewing 3D Sun & solar wind sources based on synoptic solar maps & potential field models of the coronal magnetic field.











STEREO