Beyond the Flare: An SWF-AAS Briefing on Space Weather

NASA's effort to characterize, understand and predict space weather events

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What is Heliophysics

**Heliophysics is an environmental science:**
a unique hybrid between meteorology and astrophysics

**It has an applied branch**
space weather

**And a pure branch**
fundamental physical process

![Propagation models of solar disturbances out to 2 AU](image)

![Magnetic reconnection](image)

National Space Weather Program 1995
Living With a Star 2000
International Heliosophysical Year 2007
Evolution of System Studies

**Heliophysical**: A broadening of the concept "geophysical," extending the connections from the Earth to the Sun & interplanetary space.
Sun-Earth System Science: Growth from a “consuming” science to a “producing” science for the benefit of humankind

Space Weather is no longer the domain of Earth only!

Space Weather is now Interplanetary!!

Space Weather just became Exoplanetary!!

Extreme Space Weather
The Corona is hot and controlled by magnetic fields

- X-Ray and EUV Variability at Earth (NOAA R-Scale)

High-Speed Solar Wind originates from coronal holes

- Solar Particles Impact Earth (NOAA S-Scale)

Mass from the corona is ejected into interplanetary space

- Solar catastrophic events can impact Earth’s magnetosphere (NOAA G-Scale)
Blame it on $B$ (magnetic field)

Ultra Violet and X-ray Radiation
- 8 minutes

Charged Particle Radiations
- 10-30 minutes

Magnetized Blobs of Solar Material
- 18-96 hours

Magnetic Fields

Radiation: astronaut health, aviation & satellite function

Aurora; geomagnetic storms & radio disturbances

NOAA Space Weather Scales

Satellite drag; radio blackouts

G-Scale

S-Scale

R-Scale
Space weather interacts with Earth’s B-Field and can dramatically affect the Earth.
Forecasting Space weather

- Semi-empirical near-Sun module that approximates the outflow at the base of the solar wind
- Sophisticated 3-D magnetohydrodynamic numerical model that simulates the resulting flow evolution out to Earth.

AR1429 unleashed a powerful X5-class solar flare on 7 March 2012, commencing the "St. Patrick Day storms" of 2012. The blast also propelled a massive coronal mass ejection (CME) toward Earth. NASA's Solar Dynamics Observatory recorded the flare at multiple extreme ultraviolet wavelengths.

3D CME model run from CCMC/iSWA shows how the CME would propagate through the inner solar system.
Heliophysics has 18 operating missions (on 29 spacecraft): Voyager, Geotail, Wind, SOHO, ACE, Cluster, TIMED, RHESSI, TWINS, Hinode, STEREO, THEMIS/ARTEMIS, AIM, CINDI, IBEX, SDO, Van Allen Probes, IRIS.

(Missions in red contribute to operational Space Weather.)

6 missions are in various phases of development: SET, MMS, SOC, SPP, ICON, and GOLD.
Heliophysics is an environmental science – a hybrid between meteorology and astrophysics

Weather in the mid-west today is Washington’s weather tomorrow.

Weather on the sun today is space weather in low-Earth orbit later this week

At NOAA’s SWPC, forecaster Dave Marshall sits at the crossroads.
The next frontier in space weather forecasting involves the uninterrupted tracking of storm clouds from the sun to the planets.

NASA's STEREO spacecraft and new data processing techniques have succeeded in tracking space weather events from their origin in the Sun's ultra hot corona to impact with the Earth’s magnetosphere.

STEREO includes 5 telescopes that monitor the sky at large angles from the Sun.
Since 2007-2014, we have had:

Total Students ~250
International Students ~120
PhD Level ~220
Masters Level ~30

*Jack Eddy Postdoctoral Fellowship 2010-2014, 17 appointments*

To train the next generation of researchers needed in the emerging field of heliophysics, in honor of the pioneering interdisciplinary researcher, Jack Eddy.
"Space Weather Impacts: They Happen All the Time"