Received 06 March 2014.

Want to be part of ISWI's SID Space Weather Monitor Program?

Deborah Scherrer, Stanford University

Would your life have been different if you could have accessed scientific data from your own authentic scientific instrument in high school? Would you be willing to help students now have that experience?

Stanford University's Solar Center, with funding from NSF and NASA, has developed inexpensive space weather monitors that students can install and use at their local high schools or colleges. The instruments detect changes to the Earth's ionosphere caused by solar flares and other disturbances. Students "buy in" to the project by building their own antenna, a simple structure costing little and taking a few hours to assemble. Data collection and analysis are handled by a local PC, which need not be fast or elaborate. Stanford provides a centralized data repository where students can exchange data. Considerable accompanying educational guides are provided with the monitors.

Students at a US high school, with their SID monitor

Students in Nigeria with their SID antenna

Two versions of the monitor exist – the original SID Monitor, distributed throughout the world for the United Nations International Heliophysical Year, and SuperSID, a lower-cost, more powerful upgraded instrument being distributed by the Society of Amateur Radio Astronomers (SARA) as well as through the United Nation's International Space Weather Initiative (ISWI). Over 800 SIDs and SuperSIDs have been distributed worldwide, with a focus on Developing Nations.

Note: SID=Sudden Ionospheric Disturbance.

Newer SuperSID instrument

What is a Space Weather Monitor?

Our space weather monitors measure the effects on Earth of solar flares by tracking changes in very low frequency (VLF) radio transmissions as they bounce off Earth's ionosphere. The VLF radio waves come from transmitters set up by various nations to communicate with their submarines.

The actual communications is of no interest, but the signal strength of these VLF waves changes as the Sun affects Earth's ionosphere, adds ionization, and thus alters where the waves bounce. Our monitors track these changes in signal strength. The SID instruments are a simplified student version of the AWESOME instruments, also part of the ISWI program. The SID sample rate is significantly smaller than the AWESOMEs, so SID instruments are most appropriate for solar tracking.

The Sun affects the Earth through several mechanisms. The primary one for our purposes is energy. Whenever the Sun erupts with a flare, it is usually in the form of X-ray or extreme ultraviolet (EUV) energy. These X-ray and EUV waves travel at the speed of light, taking only 8 minutes to reach us here at Earth, and dramatically affect the Earth's ionosphere.

Right: *Solar flare, seen in UV, as captured by the AIA instrument on NASA's Solar Dynamics Observatory*

Another mechanism of affecting Earth is through the impact of matter from the Sun. Plasma, or matter in a state where electrons have been separated from the nuclei of their atoms, can also be ejected from the Sun during a flare event. This "bundle of matter" is called a Coronal Mass Ejection (CME).

CME ejection. Image courtesy NASA/SDO

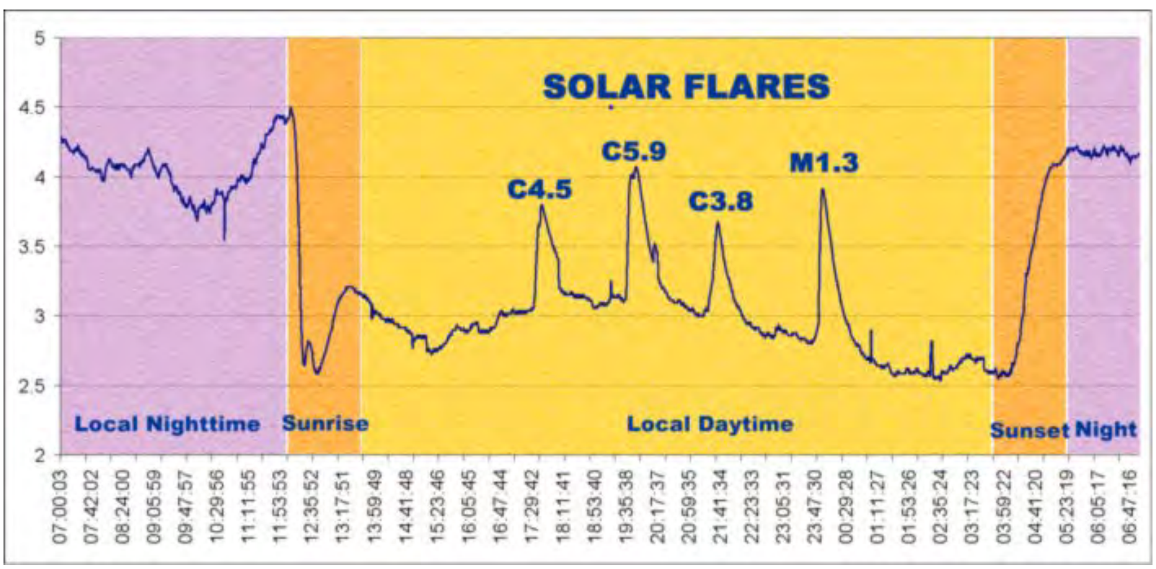
CMEs flow from the Sun at over 2 million kilometers per hour. Thus it would take a CME 72 hours or so to reach Earth. CMEs primarily affect the Earth's magnetosphere and one would need a magnetometer to track changes.

Both energy and matter emissions from the Sun affect the Earth. Our space weather monitors track only the **energy** form of solar activity.

What Do SID Data Look Like?

SID monitors track VLF signal strength over time. Each instrument monitors from 1-4 specific VLF transmitters, with a 5 second sampling rate. Below is a sample SID data graph from one station (we added the colors to make it easier to read). The y-axis of the graph indicates signal strength, and the x-axis time, in this case 24 hours, labeled in UT. Note the change of the signal strength at sunrise and at sunset. Every day has a distinctive sunset and sunrise pattern, and each receiving site has a different pattern. Note on the graph how the line slopes sharply downward at sunrise and sharply upward at sunset.

Nighttime data is of no use in SID monitoring, since the Sun has set during that time. The area between the sunrise and sunset is where we do our flare hunting. On a normal day (i.e. no flares), noon will be the highest point, because the Sun is directly overhead and producing the highest level of ionization.



Solar flares have a very characteristic shape – a swift increase in signal strength followed by a slower decrease, as in the example above. The chart shows four solar flares picked up during a single day.

Student Research

Students have undertaken a variety of research projects with SID data, including topics such as a) determining sunrise/sunset patterns and changes over time, season, latitude, distance from transmitter, site, and weather; b) identifying solar flares, tracking back to Sun, attempts at prediction; c) antenna design; d) unusual events – thunderstorms, meteor showers, CMEs, GRBs, planetary waves, earthquakes; e) electrical interference; f) eclipses; g) correlation with local events (e.g. photovoltaic power plant increases associated with flares, local hospital admissions, etc.).

The graph below shows SID data from a single transmitter graphed over a period of 1 year. The hour-glass shape is the result of dawn and dusk times during the year. Inside the hour-glass represents nighttime, outside the daytime. Transmitter maintenance outages show up fairly regularly as sold dark lines. Missing data is charted as bold white lines. Solar flares are indicated by small white occurrences. It is not clear what the darkened data showing up near the top represents. One possibility may be planetary waves.

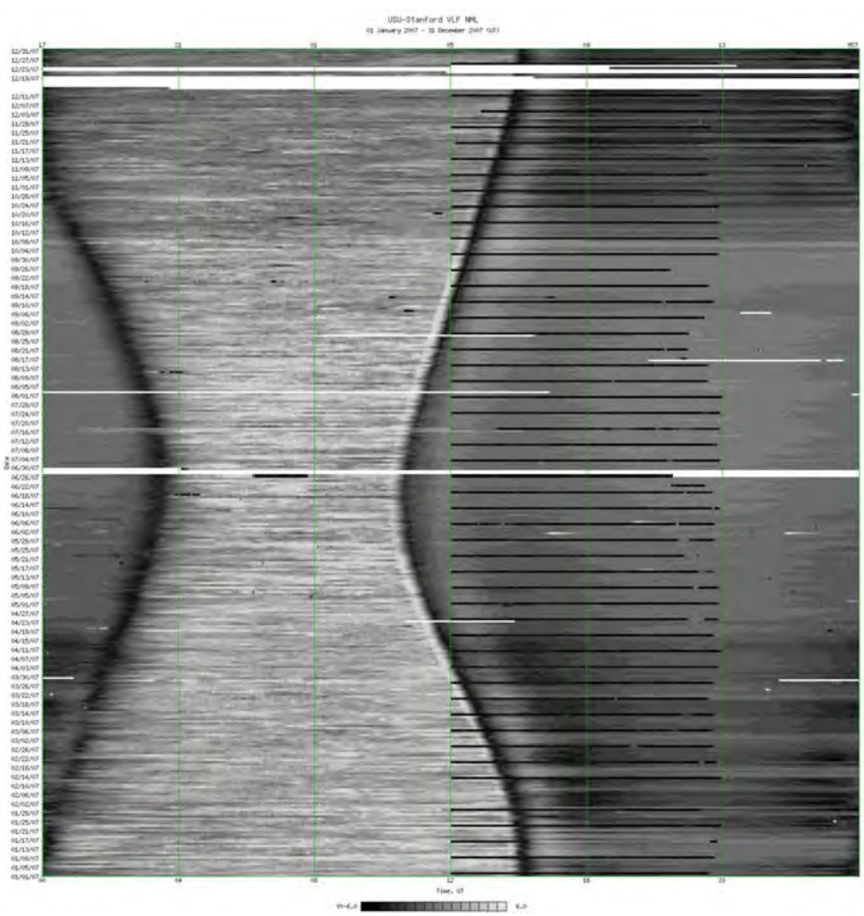
Date

Dec 2007

Planetary Waves??

Summer Solstice

Jan 2007



Transmitter maintenance outages (dark bars)

Missing data (white) ←

Flare signatures (short white lines)

Figure courtesy of Don Rice.

Nighttime UT Time (0-23) Daytime

Obtaining SID Monitors:

The Society of Amateur Radio Astronomers (SARA) has taken over distribution of the SuperSID monitors from Stanford. The goal is to place monitors in high schools and early college environments around the world. Scientists serve as Mentors to the schools. The instruments are inexpensive, about $50, and stipends are often available to schools, especially those in developing nations. You could change a student's life by giving them access to a SID monitor and serving as a Mentor. To obtain an instrument for a school, contact:

SuperSID at radio-astronomy.org

Published by SERC of Kyushu University

ISWI Newsletter

under the auspices of the United Nations

This special report was prepared by Deborah Scherrer (Stanford University) at the request of the ISWI Newsletter. It was circulated in Volume 6, No. 027, on 06 March 2014.