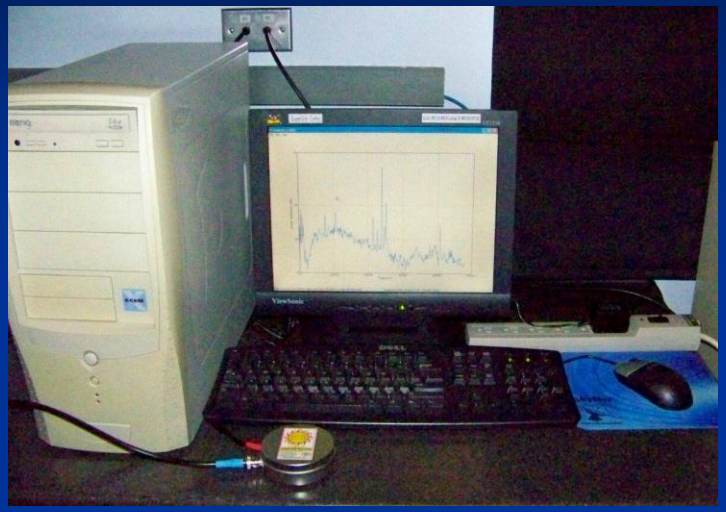
SuperSID - a small-version AWESOME for educational and research use

By Deborah Scherrer
Stanford University
Solar Center

Overview

- What is this project?
- What can the instrument do, and not do
- SuperSID data
- Tracking solar phenomena
- SuperSID research
- Obtaining instruments

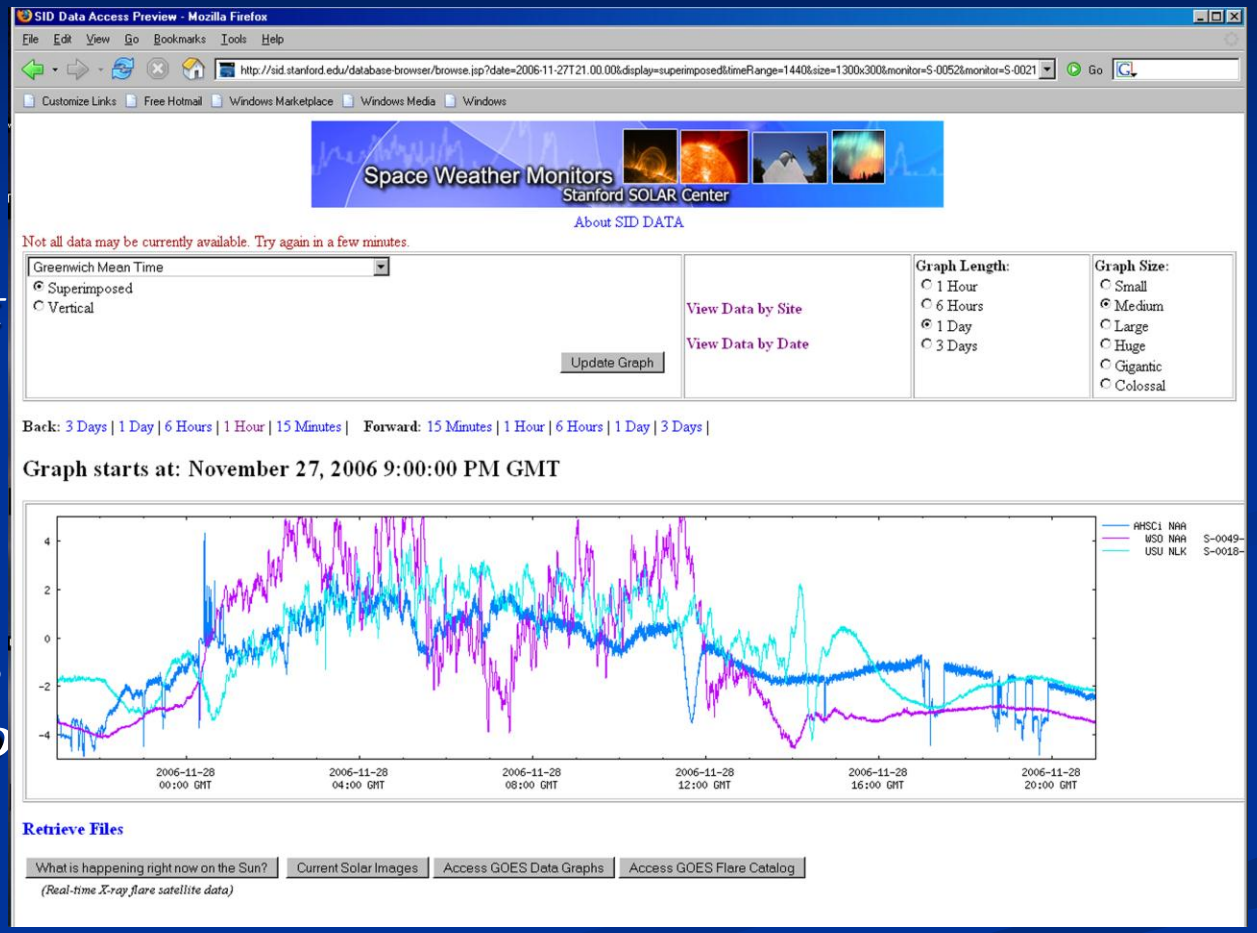


The Project

- Built upon previous SID - inexpensive space weather monitoring instruments for high schools
- Development funded by NSF – Center for Integrated Space Weather Modeling
- Distribution funded by NASA – International Heliophysical Year
- Complement to AWESOME research instruments
- 500 distributed worldwide

Centralized Data Repository

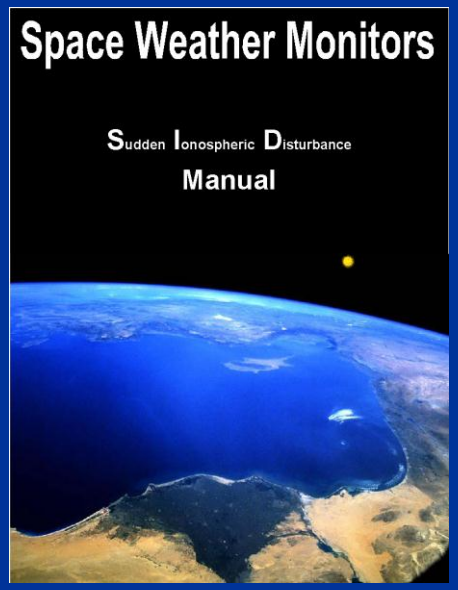
- Hosted at Stanford
- Accessible to anyone with internet
- Sites ftp data (software provided)
- Data freely available to all and valuable to solar & ionospheric researchers

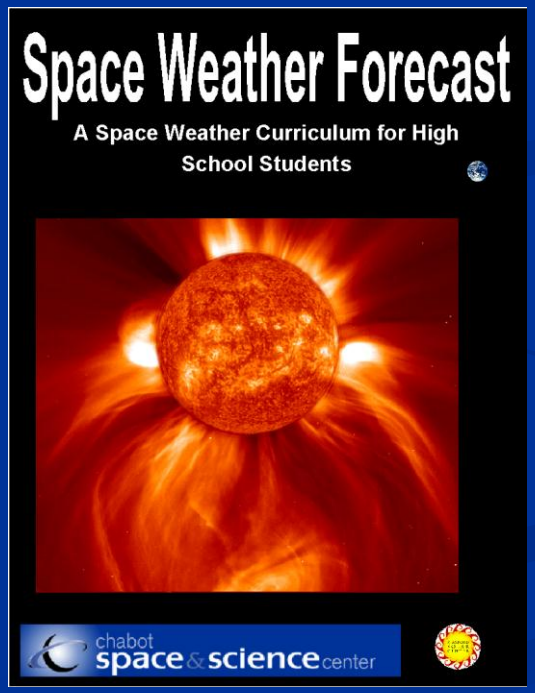


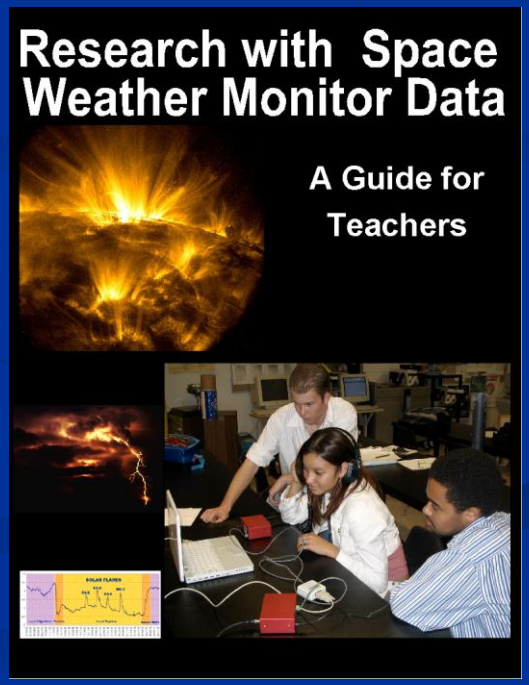
http://sid.stanford.edu/database-browser

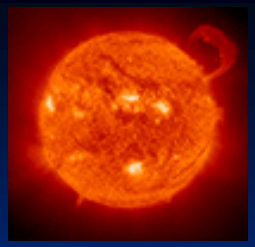
Package includes extensive educational resources

- Manual, installation CD, presentations, etc.
- Curriculum Guide
- Research Guide



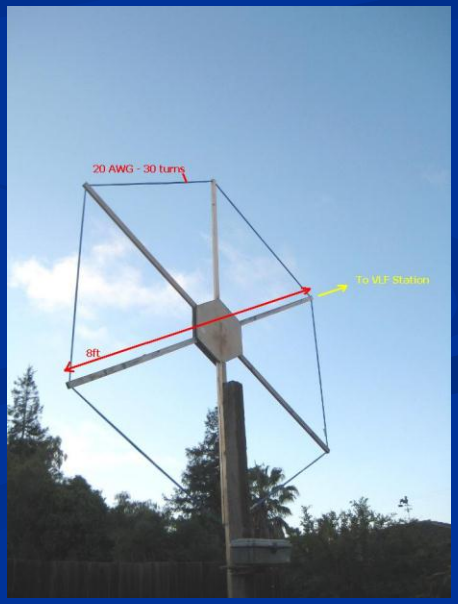






SuperSID Instruments

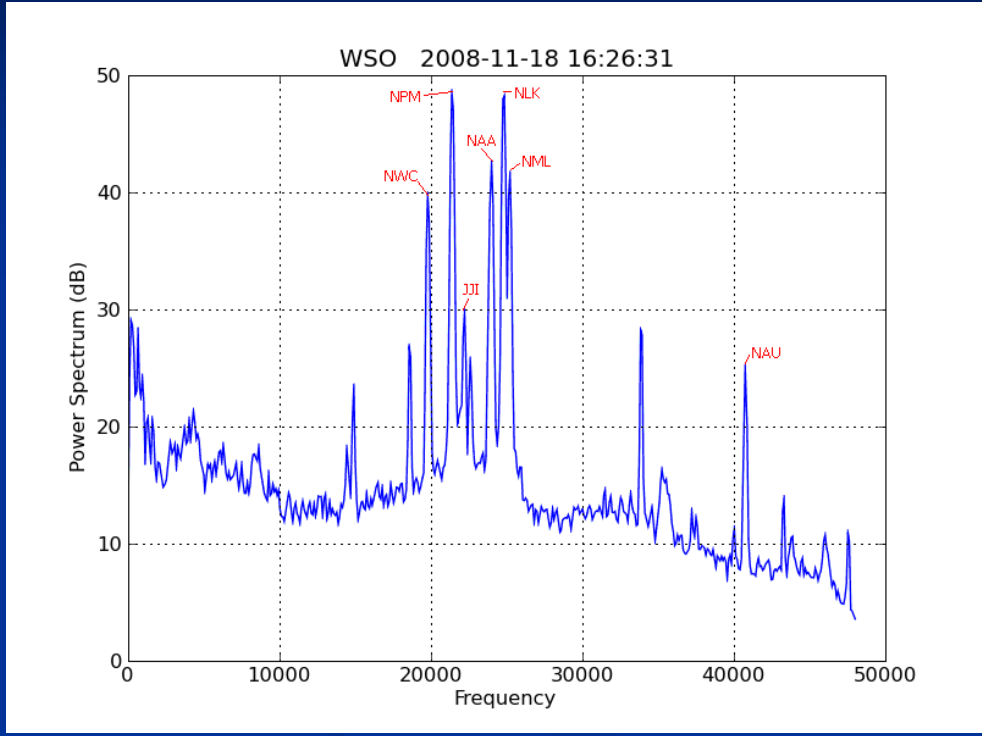
- Simple VLF radio receivers that track same VLF transmissions that AWESOME does
- Similar to AWESOME although smaller sampling rate, less sensitive
- Relies on computer sound card to handle sampling
- Narrowband data only
- Inexpensive (~$50)
- Designed to primarily track solar-induced changes to the ionosphere, but adaptable to other ionospheric phenomena as well



SuperSID Data

- *SuperSID takes 96000 samples/sec, calculates the spectrum, extracts the signal strength at interesting frequencies (~5-7 data points), then drops the 96000 samples in the buffer (to save disk space and hard drive, because SuperSIDs run continuously for months).*

- *Once every 5 seconds, SuperSID samples and saves signal strength for each interesting transmitter*



SuperSID receives VLF signals from multiple transmitters, as does AWESOME

Keeping Time

- AWESOMEs use GPS for time stamps
- SuperSIDs use the system clock
  - However, some high-end audio cards have trigger inputs that could be synchronized with an external clock (GPS)
  - One could also expand SuperSID capabilities to work with National Instrument boards (needs additional ~$300). This would not be difficult to add.

SuperSID vs. AWESOME

- AWESOME 's hardware is superior to SuperSID, but is costly
- SuperSID is inexpensive and suitable for enhancing an AWESOME network or for use as educational instruments in high schools and universities
- SuperSID software taps into several important open sources (e.g. Python, MatPlotLib) for numerical analysis, graphics, and networking – making it inexpensive and extensible for academic environments.

Site Requirements

A loop antenna to pick up VLF signals reflected from the ionosphere

A PreAmp to raise very small signals to a level can be captured by a PC sound card.

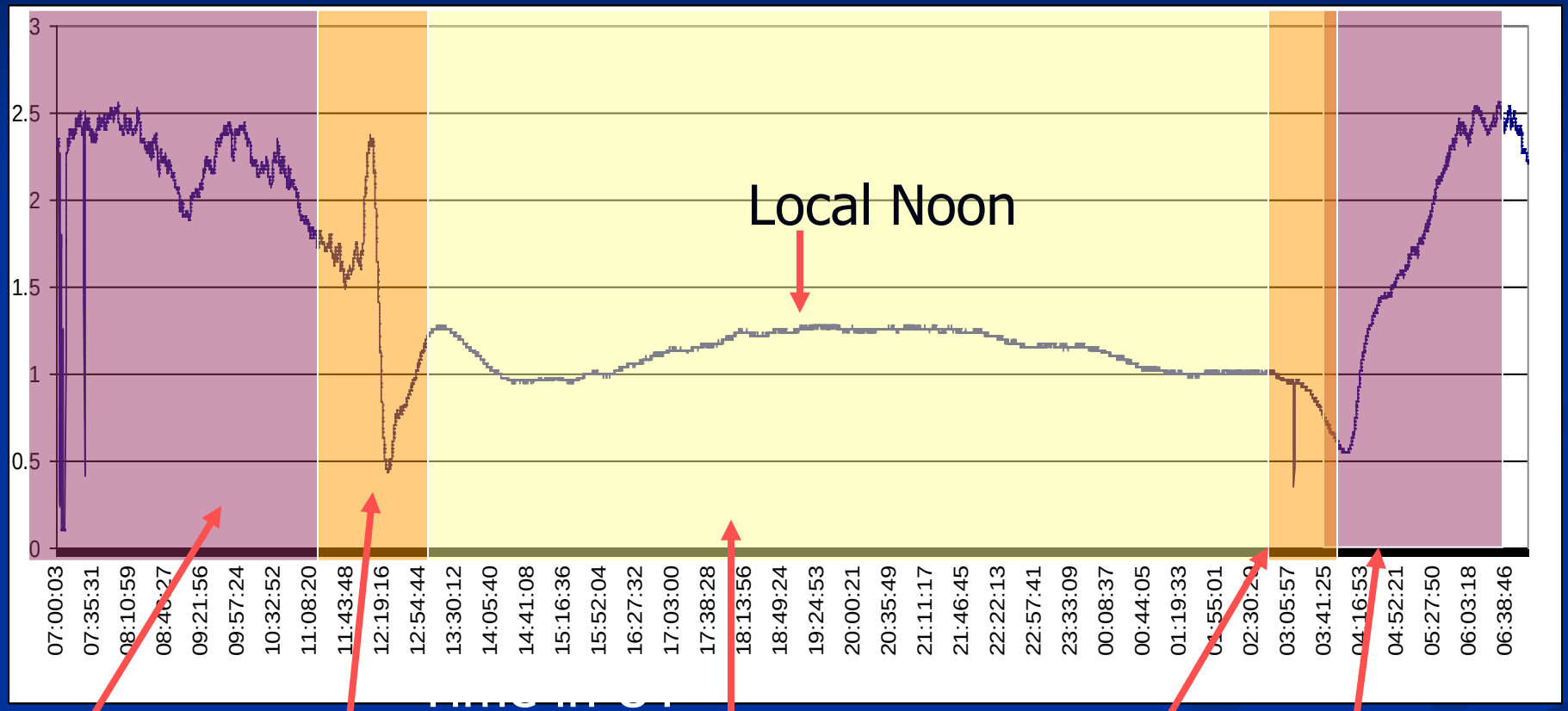
A sound card to convert signal from analog to digital.

A PC to process data and estimate signal strengths though a day. Sudden Ionosphere Disturbance indicates Solar Flare on the SUN.

- *SuperSID consists of a preamp, an antenna, plus a computer with sound card*
- *Access to power*
- *PC with 1 gHz CPU, 128 meg RAM, CD reader, MS Windows (W2000 or newer) or Linux operating system*
- *HD (96kHz) sound card desirable but will work in Europe, Asia, Africa with 48 kHz*
- *Simple antenna*
- *Relatively quiet site (but not as quiet as needed for AWESOME)*

Normal 24 Hr. Data (No flares)

Data from a single transmitter



Nighttime

Sunrise

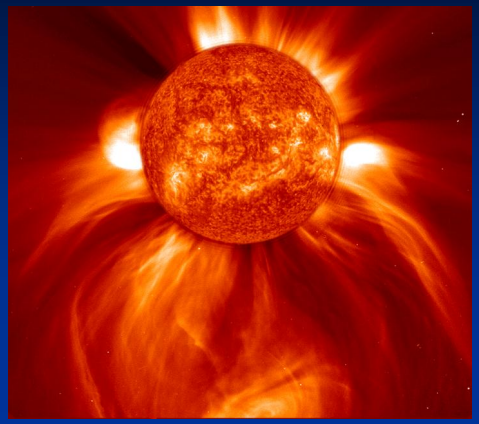
Daytime

Sunset

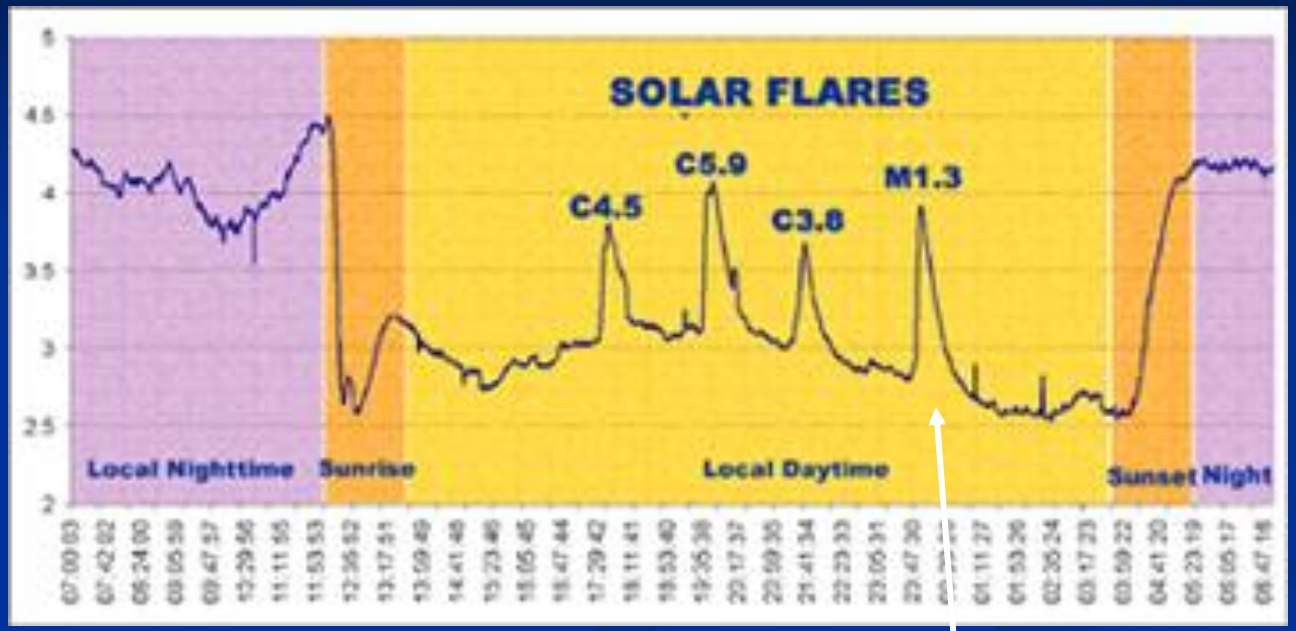
Nighttime

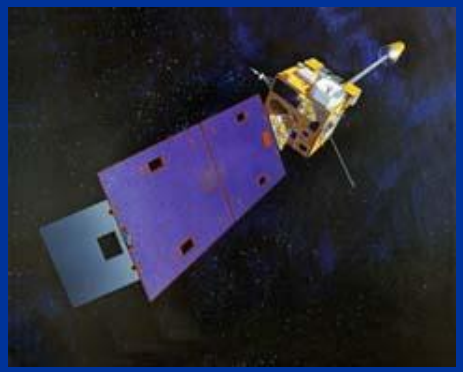
Colors and labels added

Data indications of solar flares

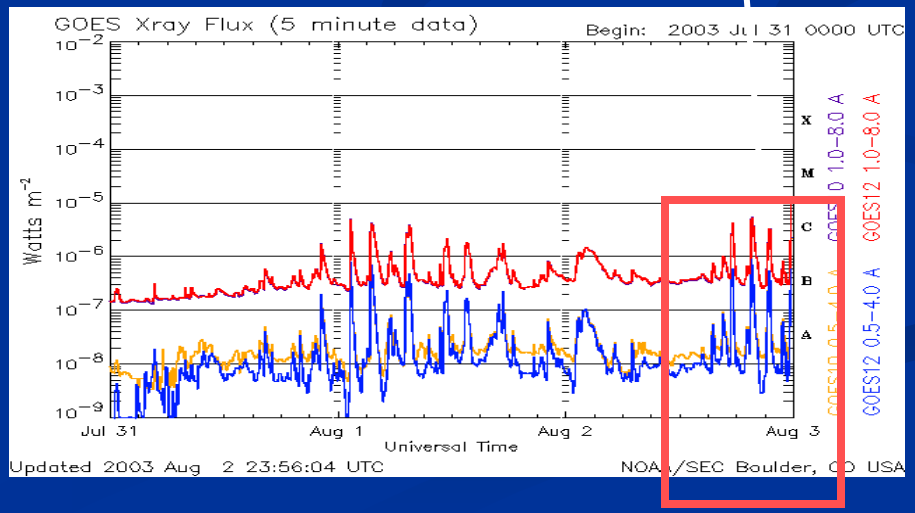


Unlike AWESOME, the SuperSIDs usually detect flares as an increase in signal strength

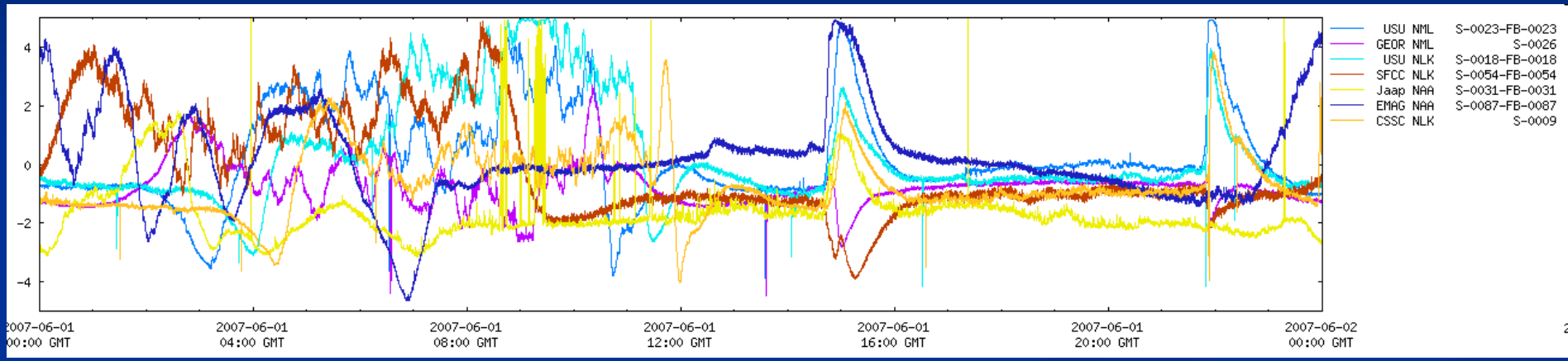




GOES-12 weather satellite – detects X-rays directly from Sun



Solar Flare Detection



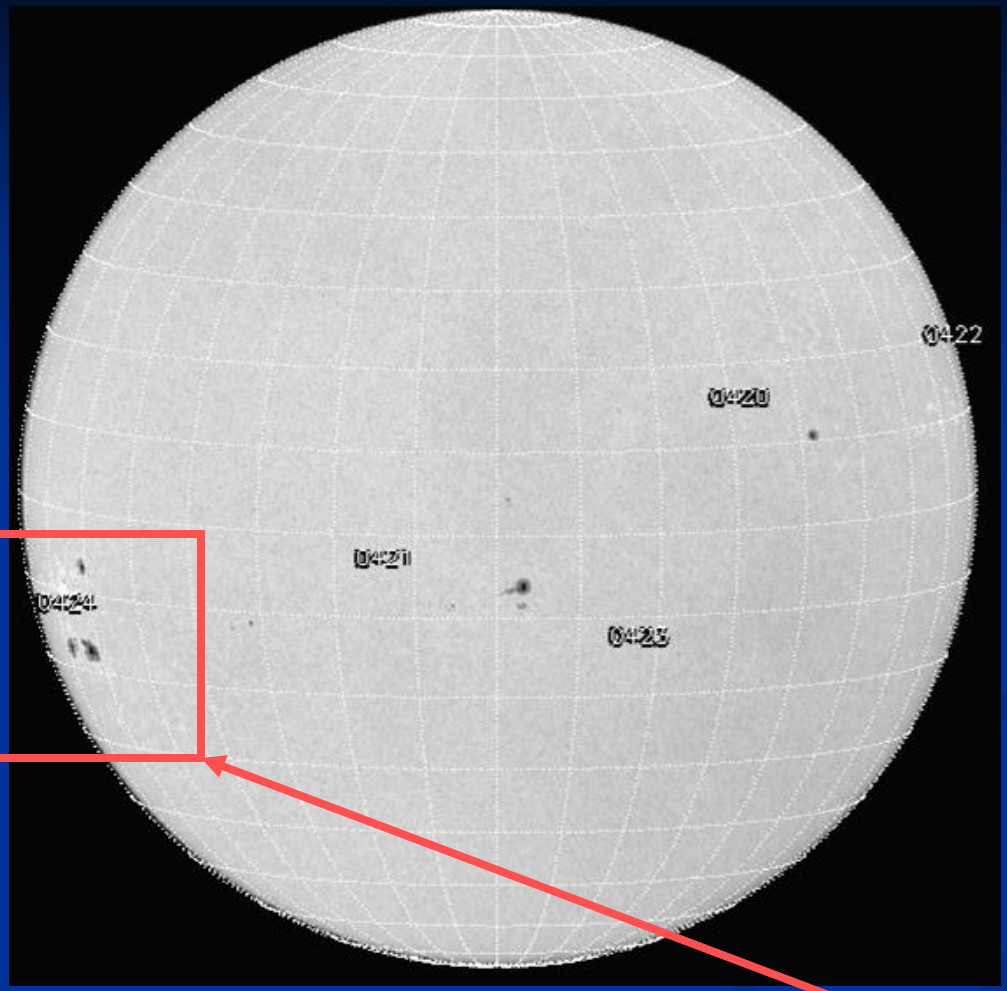
7 sites picked up this flare

M2.8 class solar flare on 1 June 2007

Note that 2 sites picked up the flare as a decrease, rather than increase, in signal strength. This is due to destructive interference of the VLF waves.

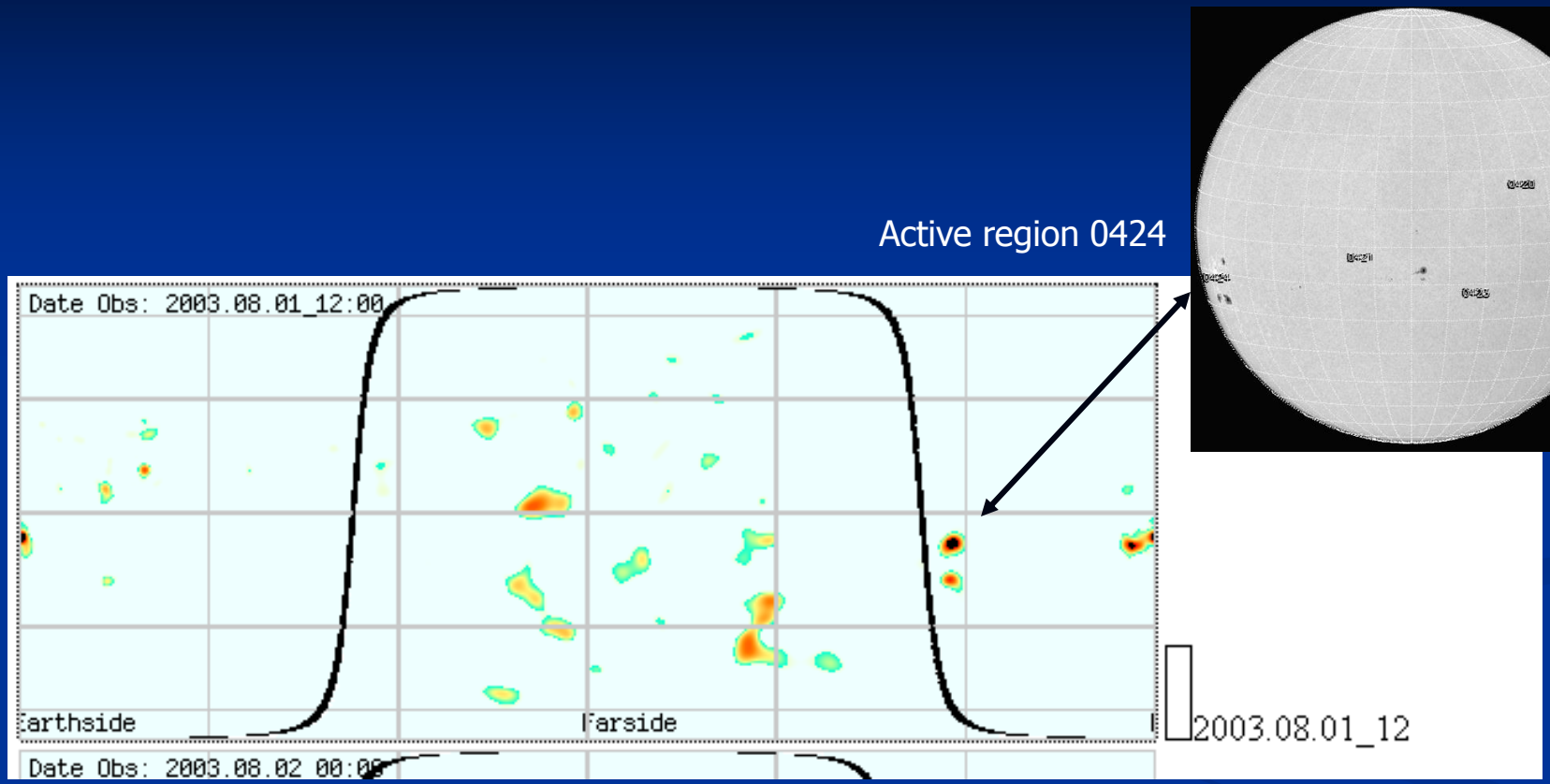
Problem – very little solar activity in last 2 years because of long minimum in solar cycle

Flares can be tracked back to the solar active region that produced them



#Event	Begin	Max	End	Obs	Q	Type	Loc/Frq	Particulars		Reg#
1960 +	1727	1736	1744	G12	5	XRA	1-8A	C4.5	3.1E-03	0424
1990 +	1930	1946	1954	G12	5	XRA	1-8A	C5.9	5.9E-03	0424
2000 +	2112	2134	2140	G12	5	XRA	1-8A	C3.8	3.1E-03	0424
2040 +	2341	2354	0002	G12	5	XRA	1-8A	M1.3	8.5E-03	0424

…and even tracked back to



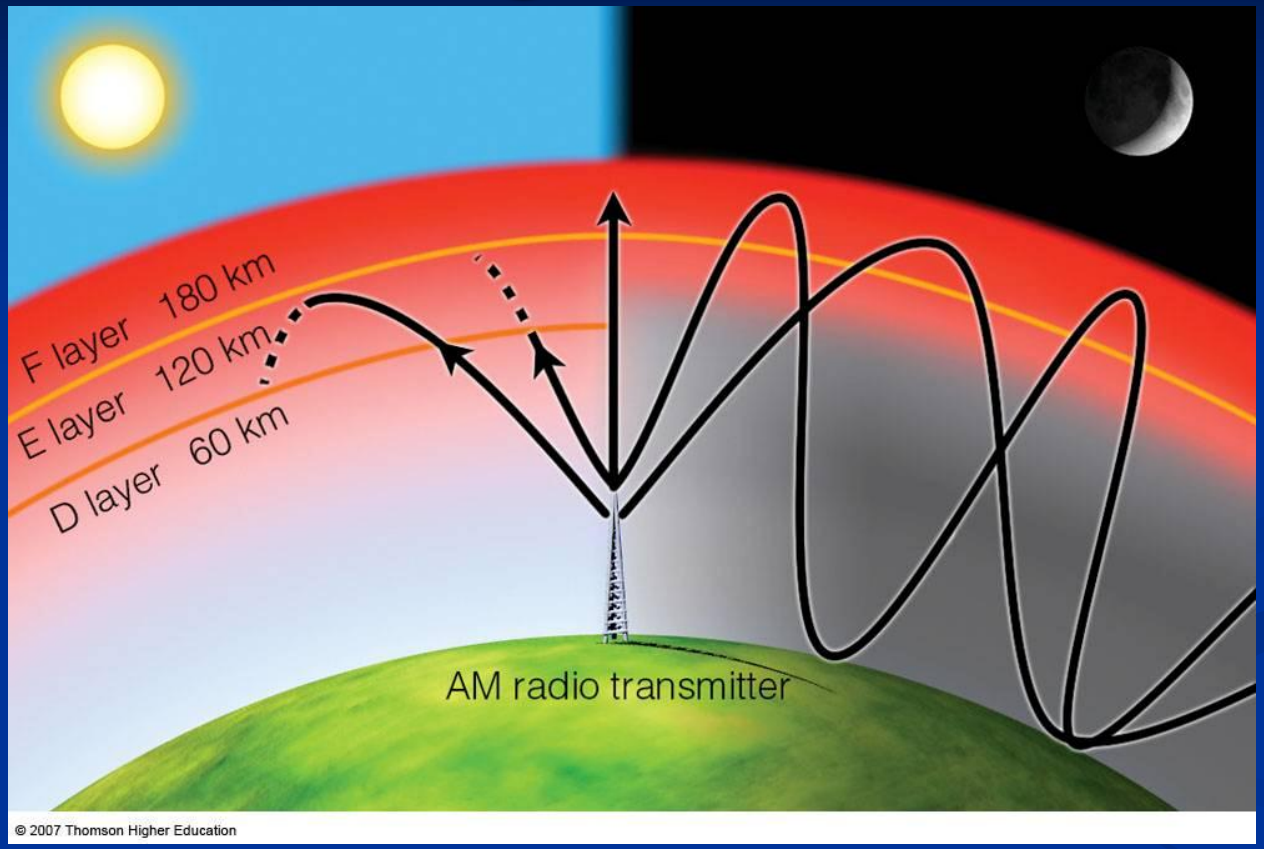
the Farside (backside) of Sun

Farside data from the MDI instrument on board NASA/ESA's SOlar & Heliospheric Observatory (SOHO) spacecraft

How does the Sun affect the ionosphere & magnetosphere?

- Through normal day-night ionization
- Through solar flares
- Through the solar wind
- Through coronal mass ejections (CMEs)
- The solar cycle affects all these

Day- Night Ionization

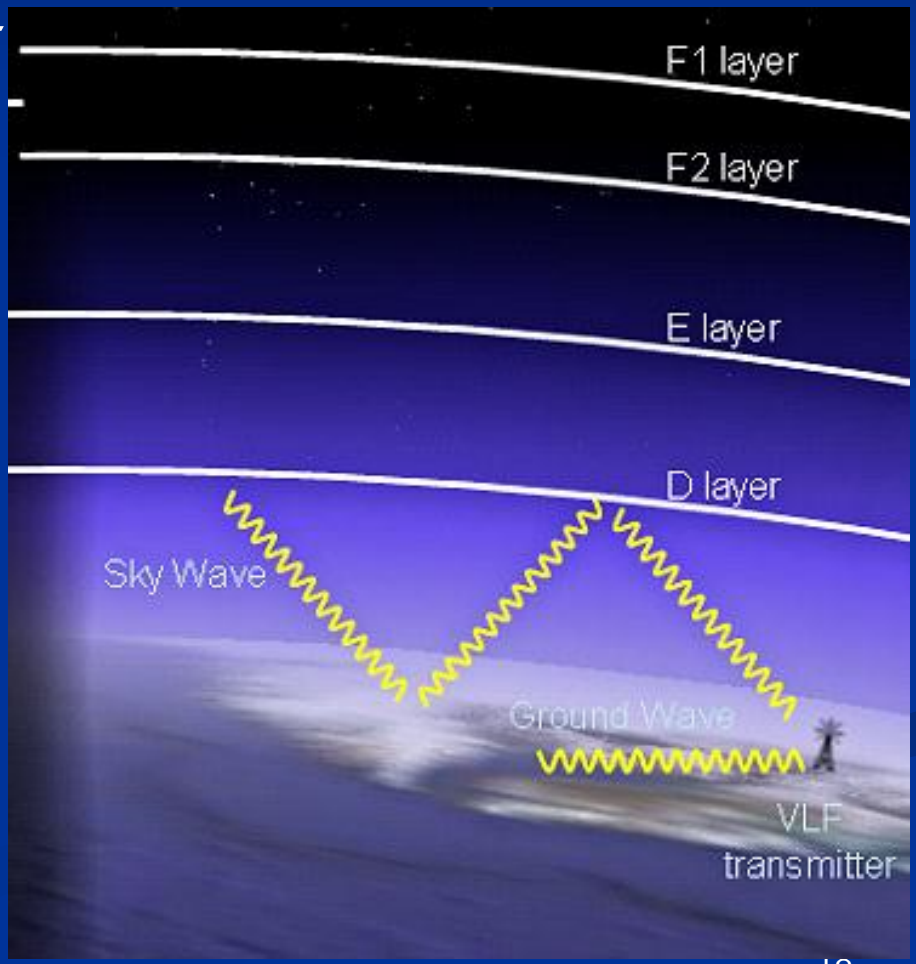


During the daytime, the Sun ionizes the F and E layers, and creates the D layer. Hence, during the day, VLF waves bounce off the E layer but lose energy penetrating the D layer. The VLF signal is weakened.

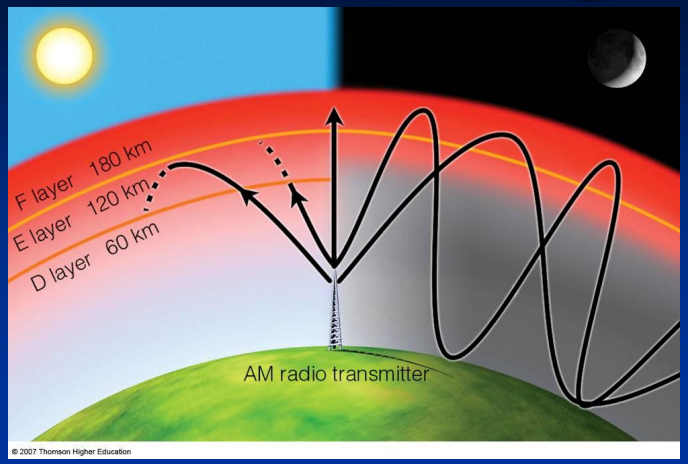
During the nighttime, when the Sun is down, cosmic rays ionize only the F layer. Hence, at night, VLF waves bounce off the F layer. Produces good, strong VLF signal.

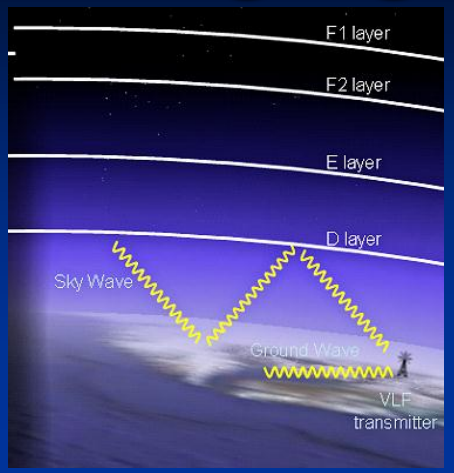
Solar Flares disrupt this normal pattern

- Solar flare consists of X-ray and UV energy
- This high energy ionizes the D layer
- VLF waves now bounce off D, without losing energy penetrating through the D layer
- Produces stronger VLF signal



Day, night, and flares changing ionization





Day

Weak VLF signal – energy lost while transitting D layer

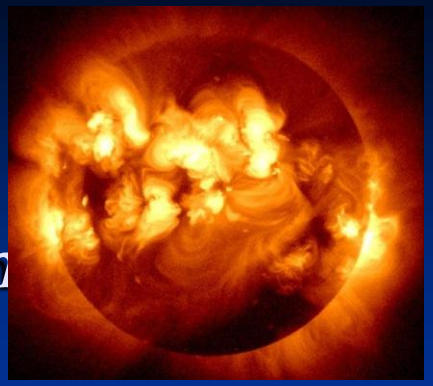
Night

Strong VLF signal

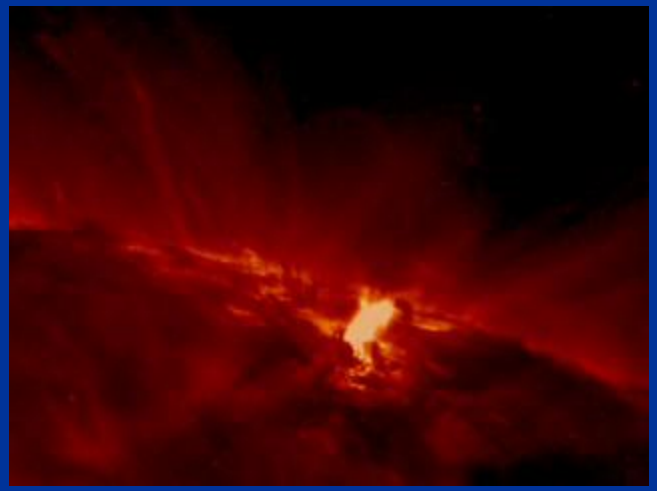
Solar Flare (daytime)

Strong VLF signal

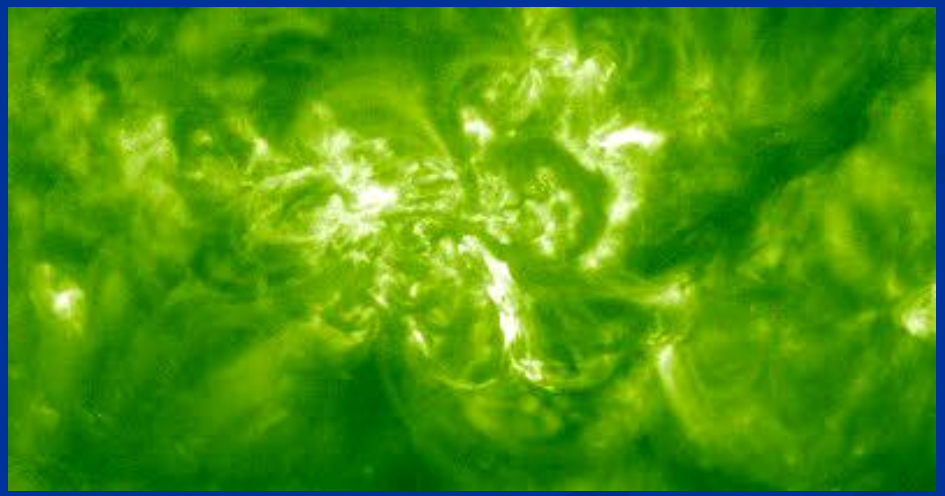
Solar Flares



When magnetic fields associated with Active Regions erupt through the Sun's surface, then tangle, disconnect, and reconnect, they can release solar flares bright in EUV, X-rays, and particle radiation.



Solar flares affect the Earth's ionosphere



Huge flare of 28 October 2003

"Speckles" are high energy particles hitting the CCD

What causes solar flares?

Caveat: according to current understanding

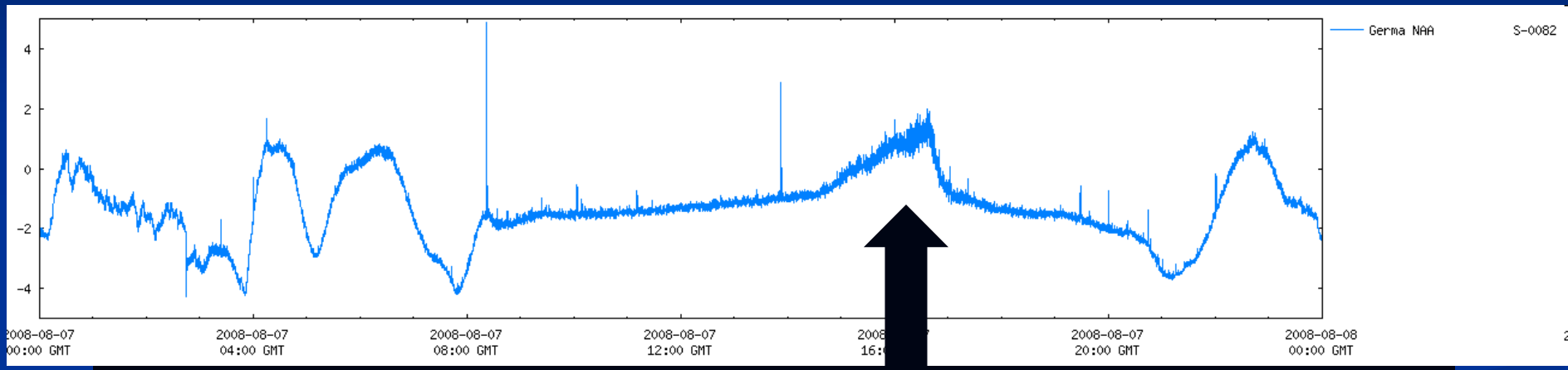
Magnetic field lines poke through the solar surface, producing sunspots. The field lines tangle and disconnect, producting Coronal Mass Ejections. When the field lines reconnect, energy is transferred to the surface and a flare may appear.

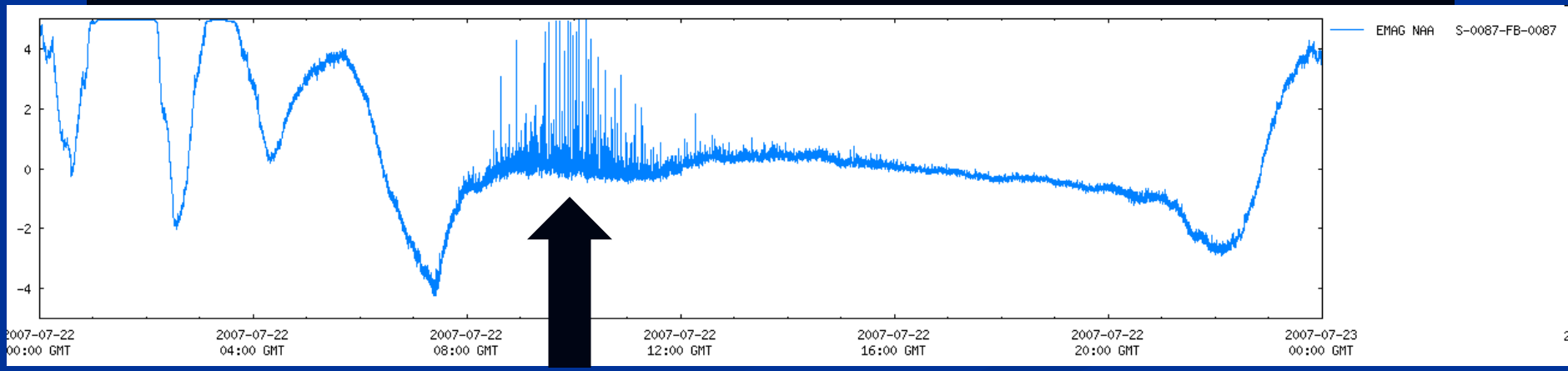
Sample Research Projects

- Sunrise/sunset phenomena & changes over time, season, latitude, distance from transmitter, site, weather, etc.
- Identifying solar flares, tracking back to Sun, perhaps predicting
- Antenna design
- Unusual events – thunderstorms, meteor showers, CMEs, GRBs, planetary waves, earthquakes
- Electrical interference
- Eclipses
- Correlation with local events (e.g. photovoltaic power plant increases associated with flares, local hospital admissions, etc.)

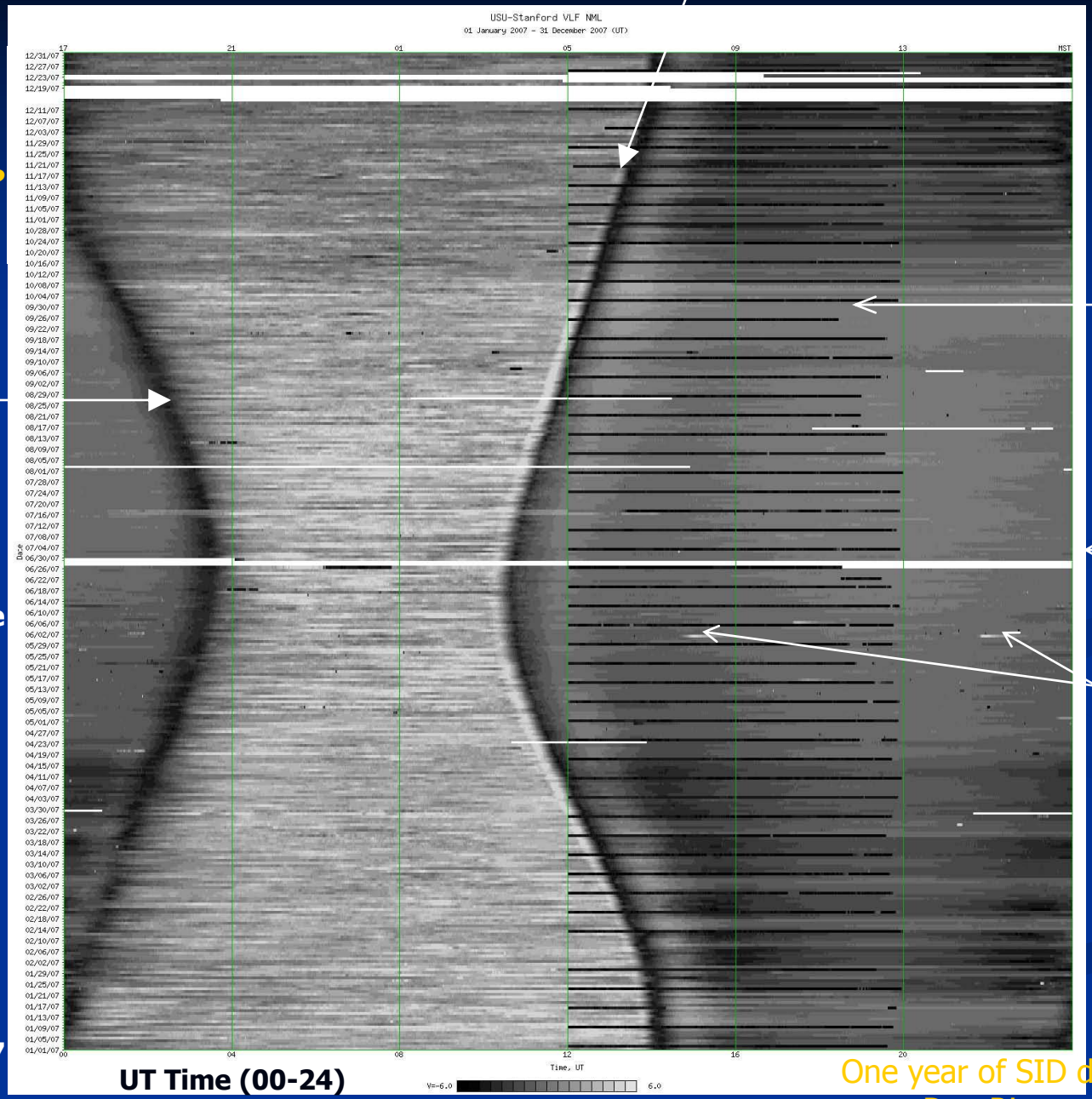
Thunderstorms

Thunderstorms detected by German students (with a short distance between the transmitter, DHO, and school)





Ionospheric Research



One year of SID data, collected by Don Rice, solar researcher

Obtaining Instruments

- Distribution through the Society of Amateur Radio Astronomers (SARA)

- Send email to supersid@radio-astronomy.org

- Attendees of the ISWI/MAGDAS Summer School can obtain a SuperSID instrument at no cost (only the cost of shpping)

What are your questions?

Thank You