Sudden Ionospheric Disturbances (SID) and Personal Space Weather Stations

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Purpose of Sudden Ionospheric Disturbances (SID) Project

8th Grade Capstone Project
Congressional School, Falls Church, VA

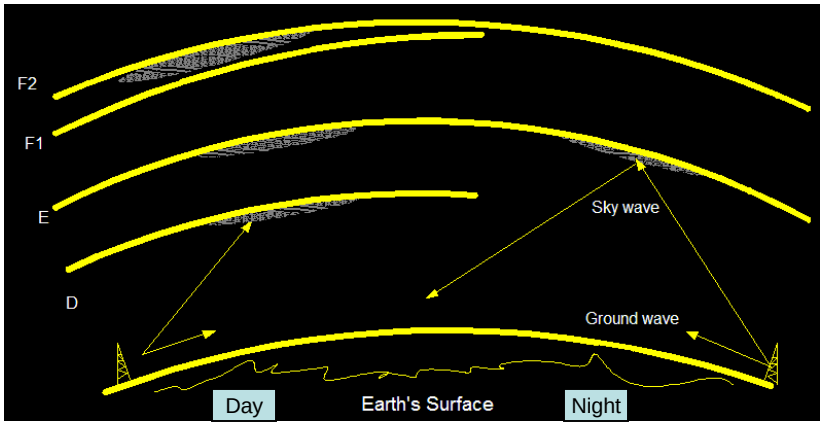
CONGRESSIONAL SCHOOL 1939

Learned about ionosphere studies associated with Eclipse Project in 2017.

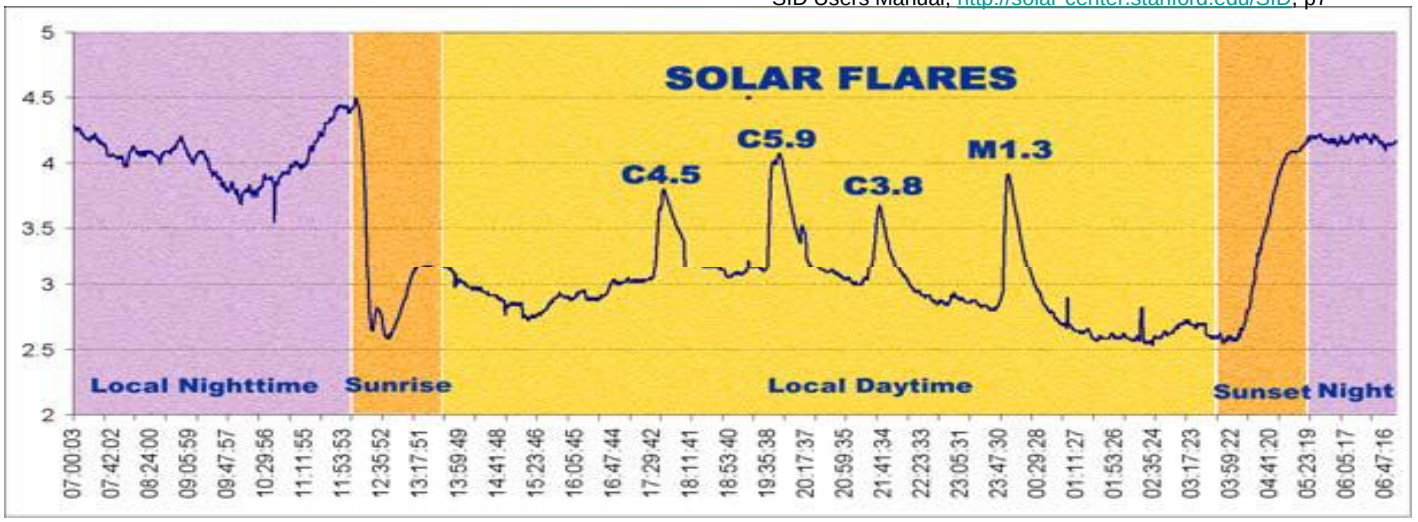
SID project was an opportunity to learn more about Sun Activity and Radio Wave Propagation.

Solar flares of Extreme Ultraviolet and X-Rays interact with the Ionosphere creating an observable change in received VLF signal strength.

SID monitoring system consists of a VLF (3-30 KHz) receiver and a signal strength monitor/recorder. Military VLF transmitters provide the signal to be monitored.

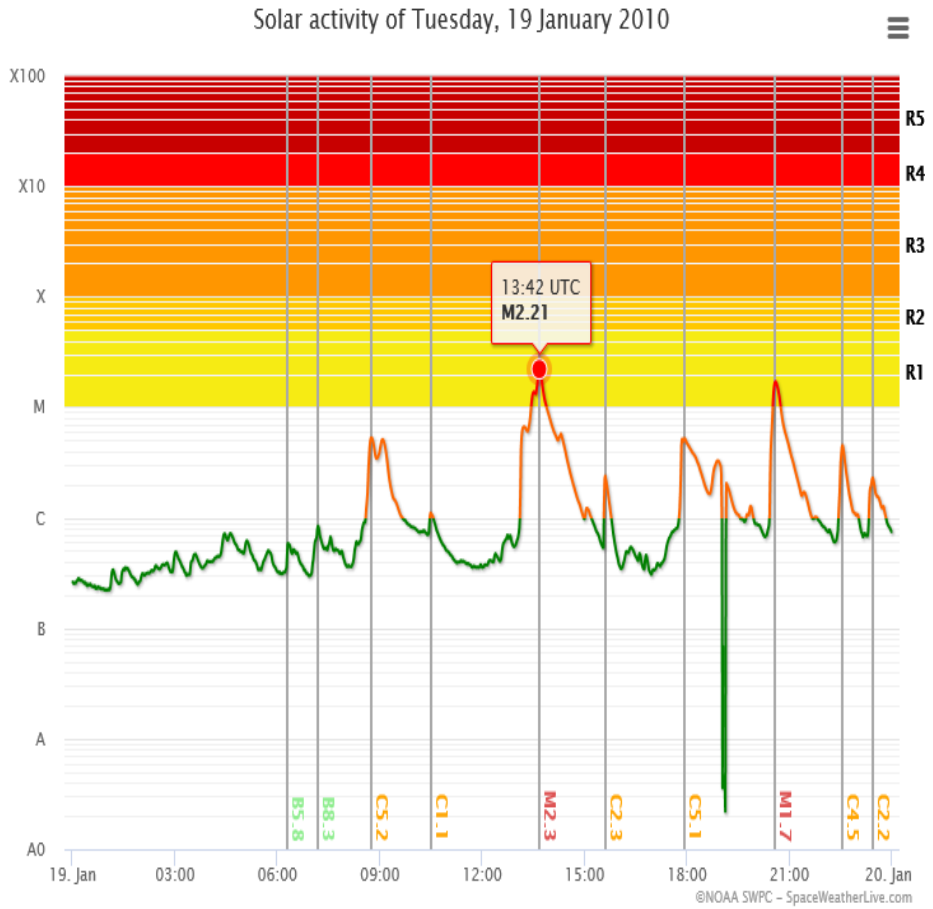


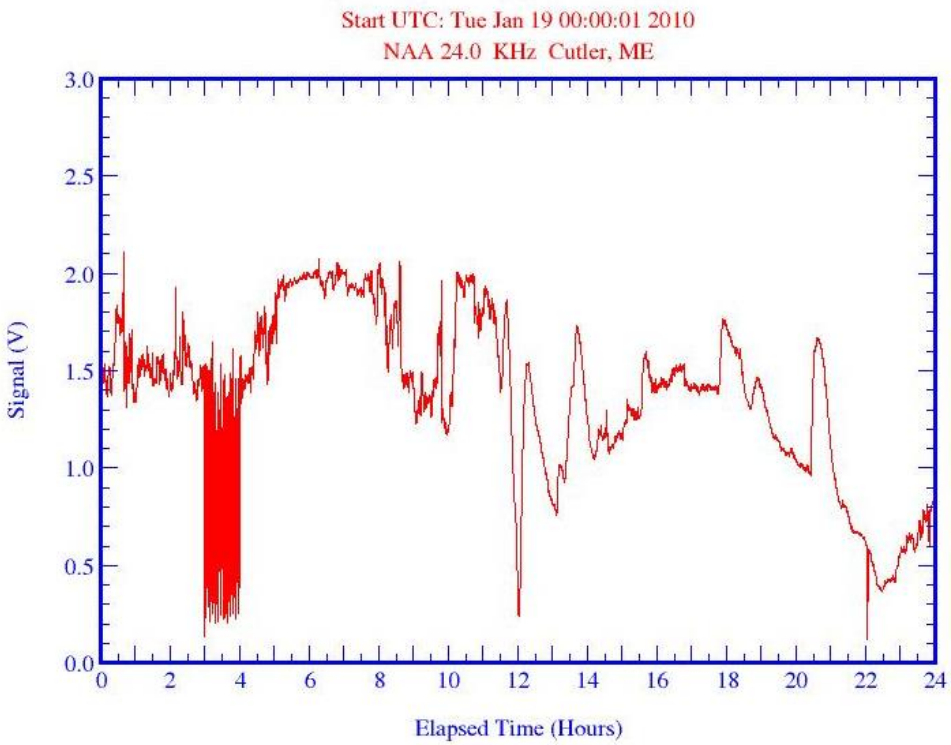
SID Users Manual, http://solar-center.stanford.edu/SID, p7



Variation in VLF station signal strength during multiple sun flares
Examples from SID Users Manual, http://solar-center.stanford.edu/SID, p8

Example Solar Activity 19 Jan 2010





X-Ray Data from GOES Satellite
(Geostationary Operational Environmental Satellite)
From:
SpaceWeatherLive.com

https://www.spaceweatherlive.com/en/archive/2010/01/19/xray

Signal strength of VLF transmitter in Cutler, ME, monitored near Louisville, KY.

http://moondog.astro.louisville.edu/naa/archive/plots/2010/20100119.jpg

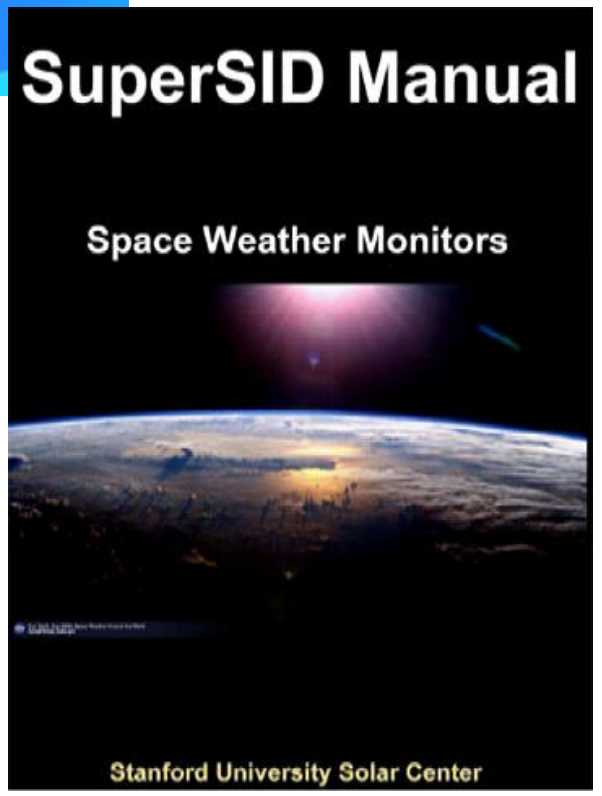
Resources:

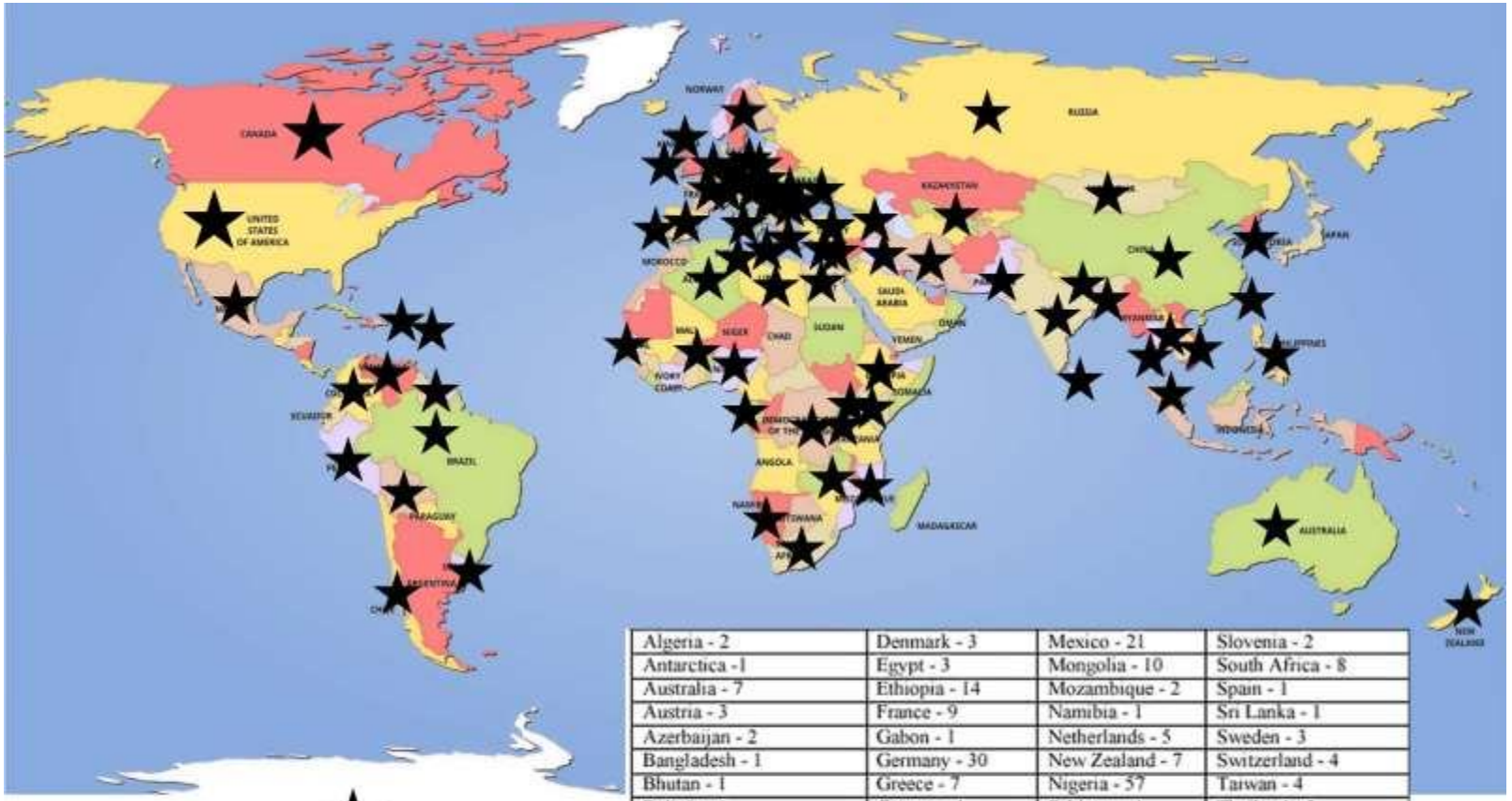
Sudden Ionospheric Disturbances (SID) Monitor

Collaboration of Society of Amateur Radio Astronomers (SARA) and Stanford Solar Center

http://solar-center.stanford.edu/SID/

http://solar-center.stanford.edu/SID/DOC/SuperSID-Manual.pdf





Stanford
SID Monitor Distribution by country
~1078 instruments
82 countries
7 continents

Algeria - 2	Denmark - 3	Mexico - 21	Slovenia - 2
Antarctica -1	Egypt - 3	Mongolia - 10	South Africa - 8
Australia - 7	Ethiopia - 14	Mozambique - 2	Spain - 1
Austria - 3	France - 9	Namibia - 1	Sri Lanka - 1
Azerbaijan - 2	Gabon - 1	Netherlands - 5	Sweden - 3
Bangladesh - 1	Germany - 30	New Zealand - 7	Switzerland - 4
Bhutan - 1	Greece - 7	Nigeria - 57	Taiwan - 4
Bolivia - 1	Guyana - 1	Pakistan - 4	Thailand - 5
Bosnia-Herzegovina - 2	Hungary - 1	Peru - 10	Tunisia - 9
Brazil - 11	India - 33	Philippines - 3	Turkey - 2
British Virgin Islands - 1	Indonesia - 2	Poland - 2	Uganda - 5
Bulgaria - 2	Iran - 4	Portugal - 3	UK - 32
Burkino Faso - 1	Iraq - 1	Rep of Congo - 3	Uruguay - 9
Canada - 33	Ireland - 9	Romania - 4	US Virgin Islands - 2
Chile - 1	Italy - 42	Russia - 3	USA - 491
China - 38	Kenya - 23	Rwanda - 1	Uzbekistan - 2
Columbia - 9	Korea (South) - 2	S Africa - 4	Venezuela - 2
Croatia - 7	Lebanon - 11	Senegal - 1	Vietnam - 1
Cypress - 1	Libya - 1	Serbia - 1	Zambia - 2
Czech Republic - 1	Malaysia - 19	Singapore - 3	
D Rep of Congo - 4	Malta - 1	Slovak Repub - 2	

http://www.radio-astronomy.org/node/276 http://solar-center.stanford.edu/SID/map/#satellite_map

SARA/Stanford SID Receiver, Antenna Kit, and Software

(software and manual available as free download)

Example

SARA SID Antenna

Antenna instructions and materials provided

1 to 2 Meters

#18-26

25-50 Turns

Coax cable (RG-58)

to preamplifier

http://solar-center.stanford.edu/SID/DOC/SuperSID-Manual.pdf (p13)

Alternative ‘DIY’ SID Receiver System

USB Audio Digitizer Gift from from SARA booth at Dayton Hamfest
96 ksps 16 bit
SID Recorder bandwidth 48 kHz

Purchased used computer for data recording

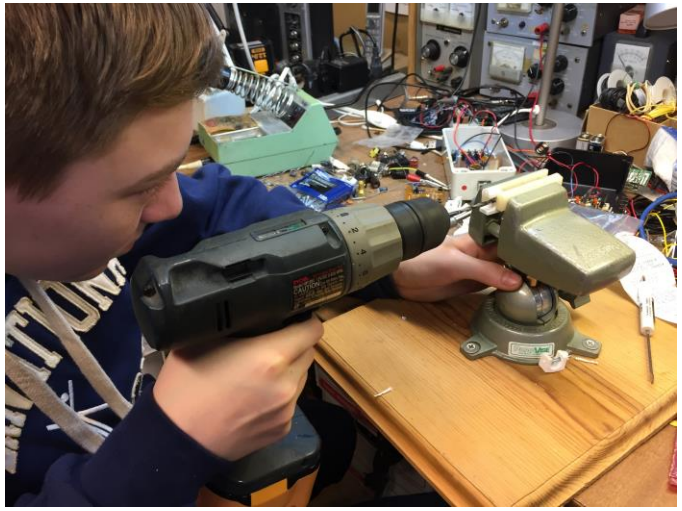
Loop antenna made from available materials

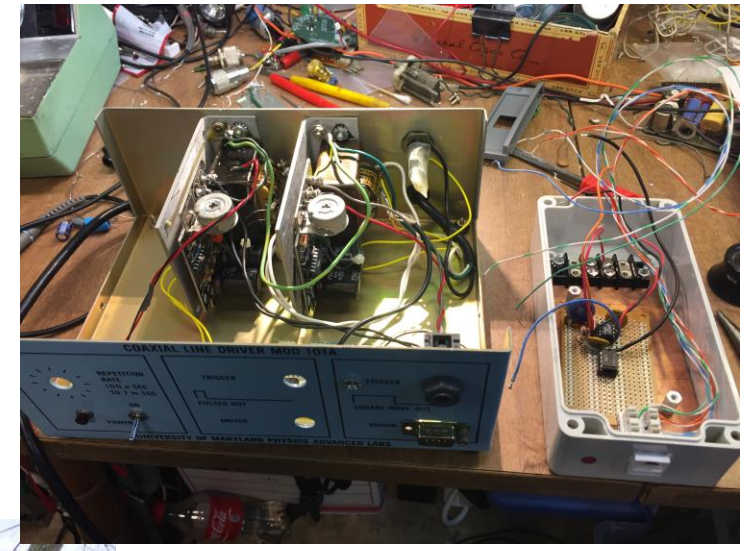
Antenna Preamplifier at loop terminals
Preamplifier allowed Cat 5 cable for lead-in to computer

Reception of VLF stations using USB Audio Digitizer shown

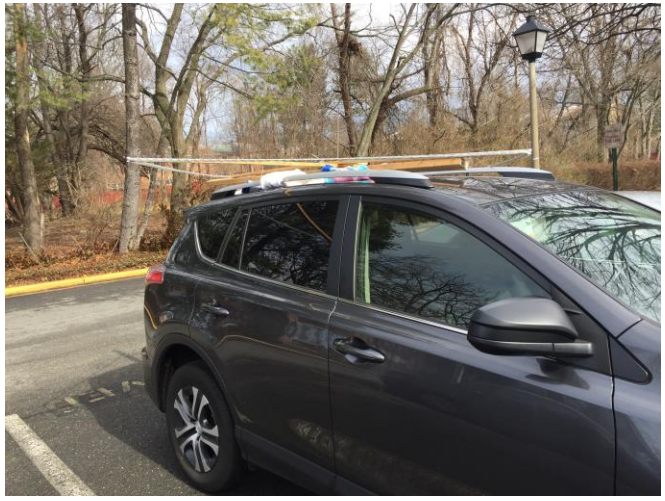
Data recording and analysis using Stanford Univ. SID Software and MS Excel

Antenna and Antenna Amplifier Construction

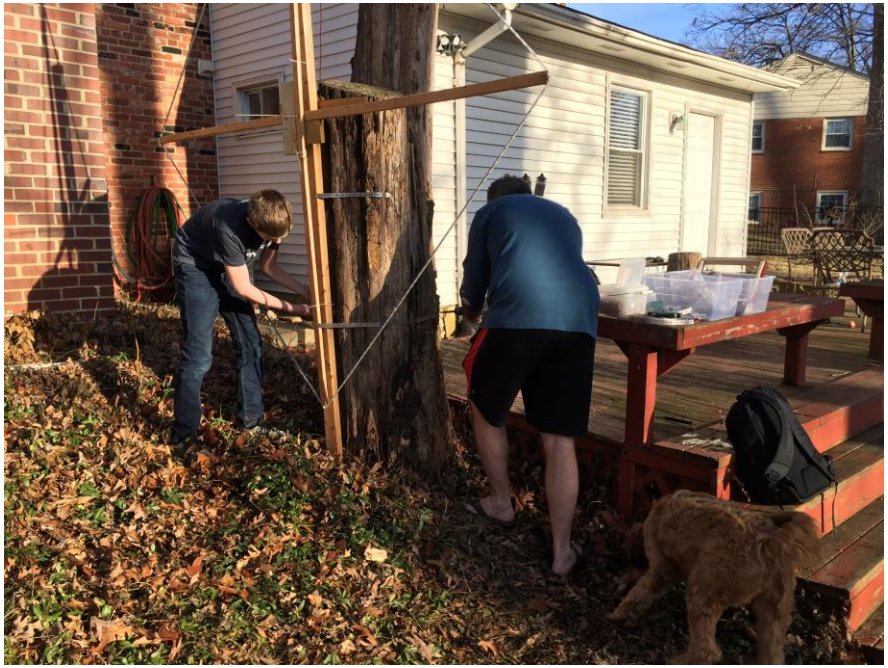


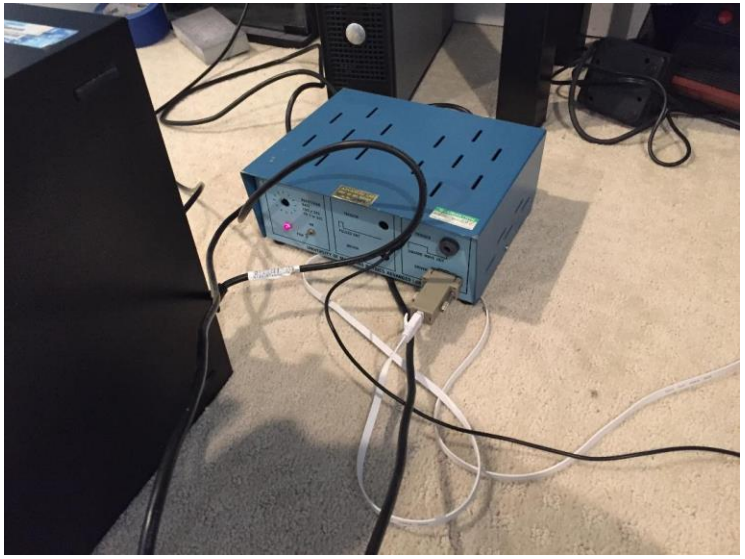


Preamp and
Power Supply



Antenna installation and test

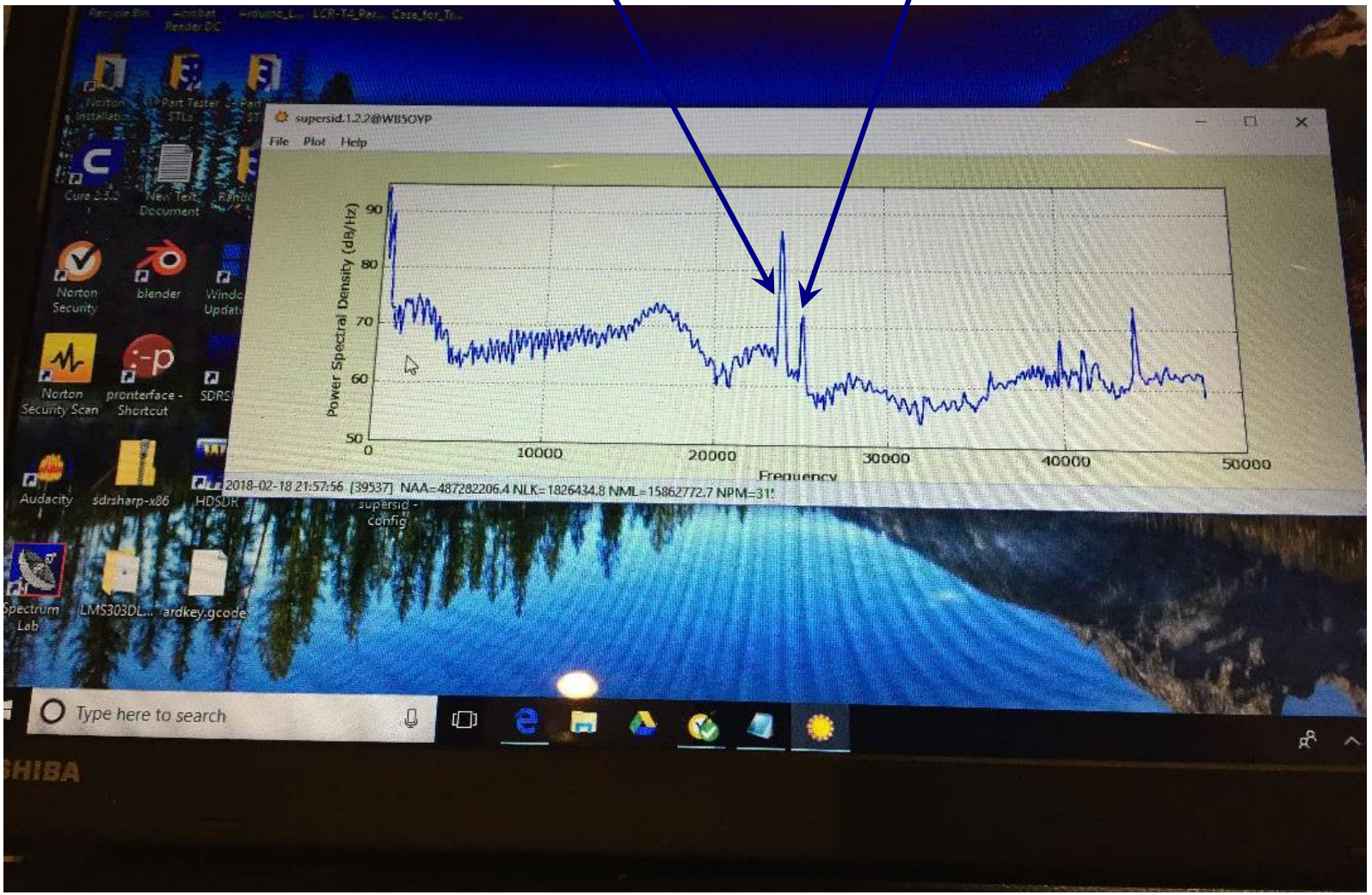




Antenna initial test

NAA Cutler, ME 24.0 KHz

NML LaMoure, ND 25.2 KHz

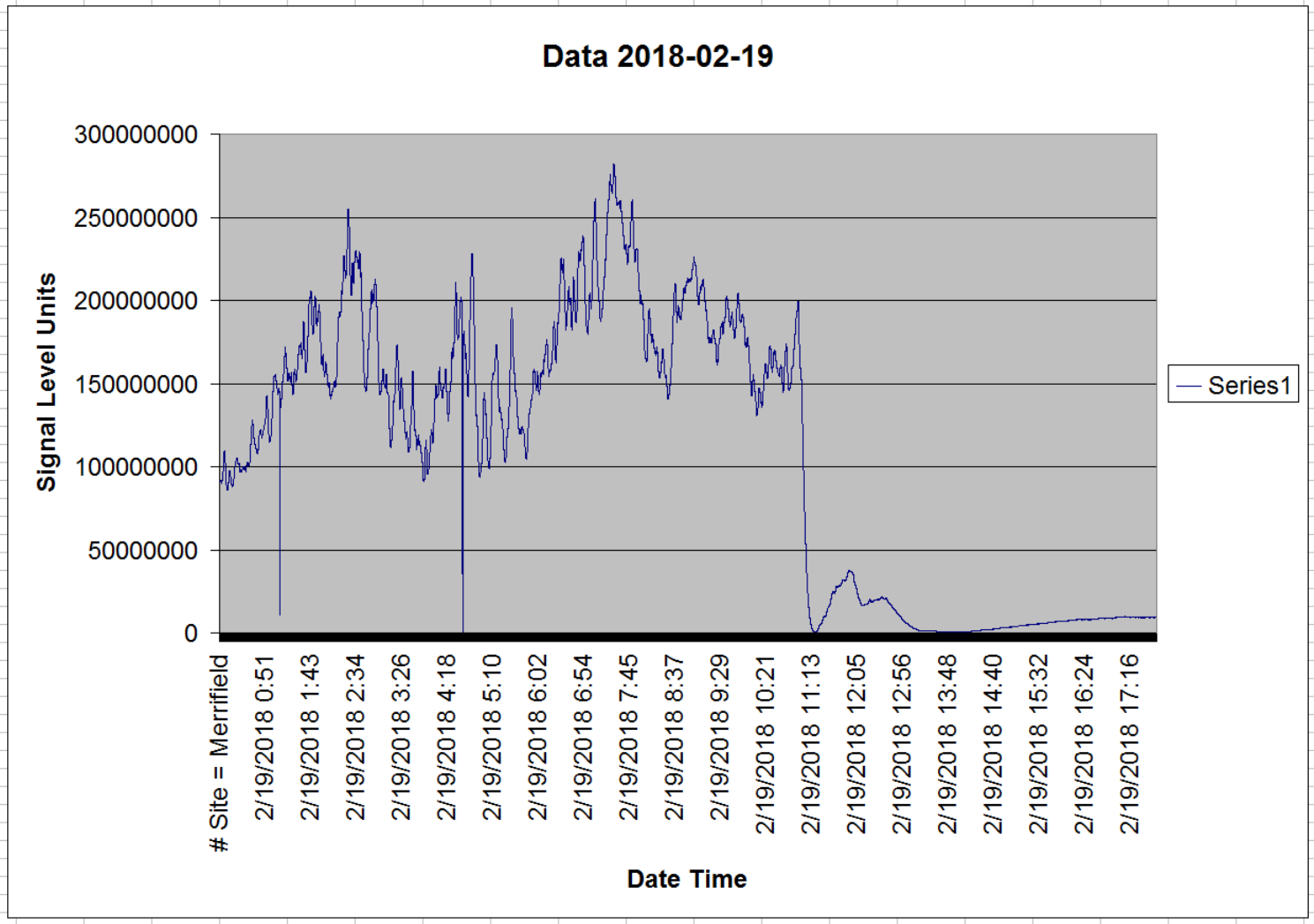


Example file output showing setup parameters

File Edit View Insert Format Tools Data Window Help

C52

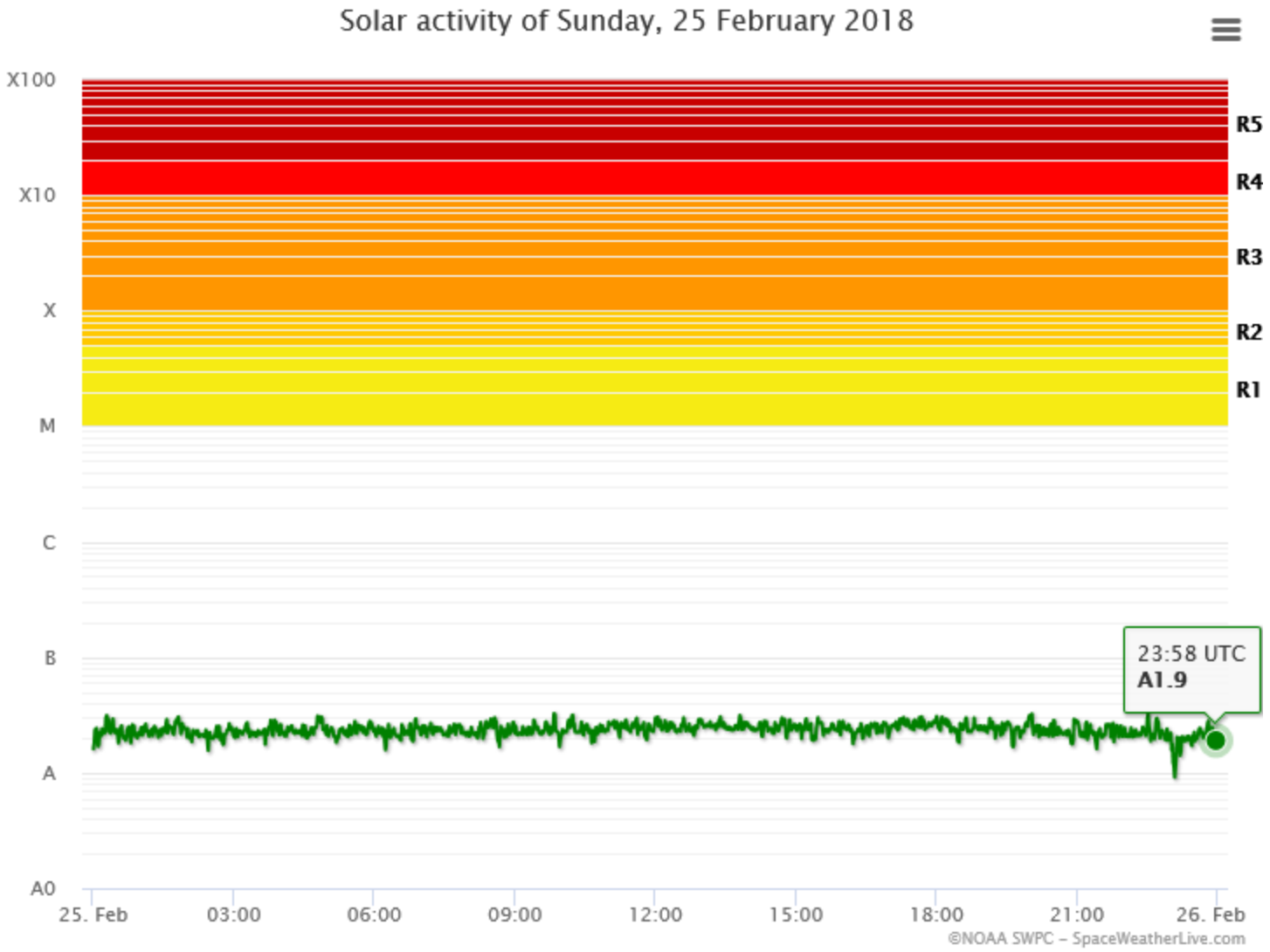
	A	B	C
1	# Site = Merrifield		
2	# Contact :		:e@gmail.com
3	# Country = USA		
4	# Longitude = -77.220464		
5	# Latitude = 38.883177		
6	#		
7	# UTC_Offset = -5		
8	# TimeZone = EST		
9	#		
10	# UTC_StartTime = 2018-02-19 00:00:00		
11	# LogInterval = 2		
12	# LogType = filtered		
13	# MonitorID = 100		
14	# SampleRate = 2		
15	# StationID = NAA		
16	# Frequency = 24000		
17	2/19/2018 0:00	90764647	
18	2/19/2018 0:00	90764647	
19	2/19/2018 0:00	90764647	
20	2/19/2018 0:00	90764647	
21	2/19/2018 0:00	90764647	
22	2/19/2018 0:00	90764647	
23	2/19/2018 0:00	90769727	
24	2/19/2018 0:00	90774806	
25	2/19/2018 0:00	90779885	
26	2/19/2018 0:00	90784965	
27	2/19/2018 0:00	90790044	
28	2/19/2018 0:00	90836519	
29	2/19/2018 0:00	90882993	
30	2/19/2018 0:00	90929468	
31	2/19/2018 0:00	91016372	
32	2/19/2018 0:00	91103275	
33	2/19/2018 0:00	91190179	
34	2/19/2018 0:00	91277082	
35	2/19/2018 0:00	91347732	
36	2/19/2018 0:00	91382773	
37	2/19/2018 0:00	91417814	
38	2/19/2018 0:00	91452855	
39	2/19/2018 0:00	91487896	
40	2/19/2018 0:00	91522937	
41	2/19/2018 0:00	91516582	
42	2/19/2018 0:00	91510228	
43	2/19/2018 0:00	91503873	
44	2/19/2018 0:00	91457090	
45	2/19/2018 0:00	91377454	
46	2/19/2018 0:00	91297818	
47	2/19/2018 0:01	91210651	
48	2/19/2018 0:01	91139738	
49	2/19/2018 0:01	91099354	
50	2/19/2018 0:01	91058970	
51	2/19/2018 0:01	91018586	
52	2/19/2018 0:01	90959708	



Merrifield_NAA_2018-02-19_00000

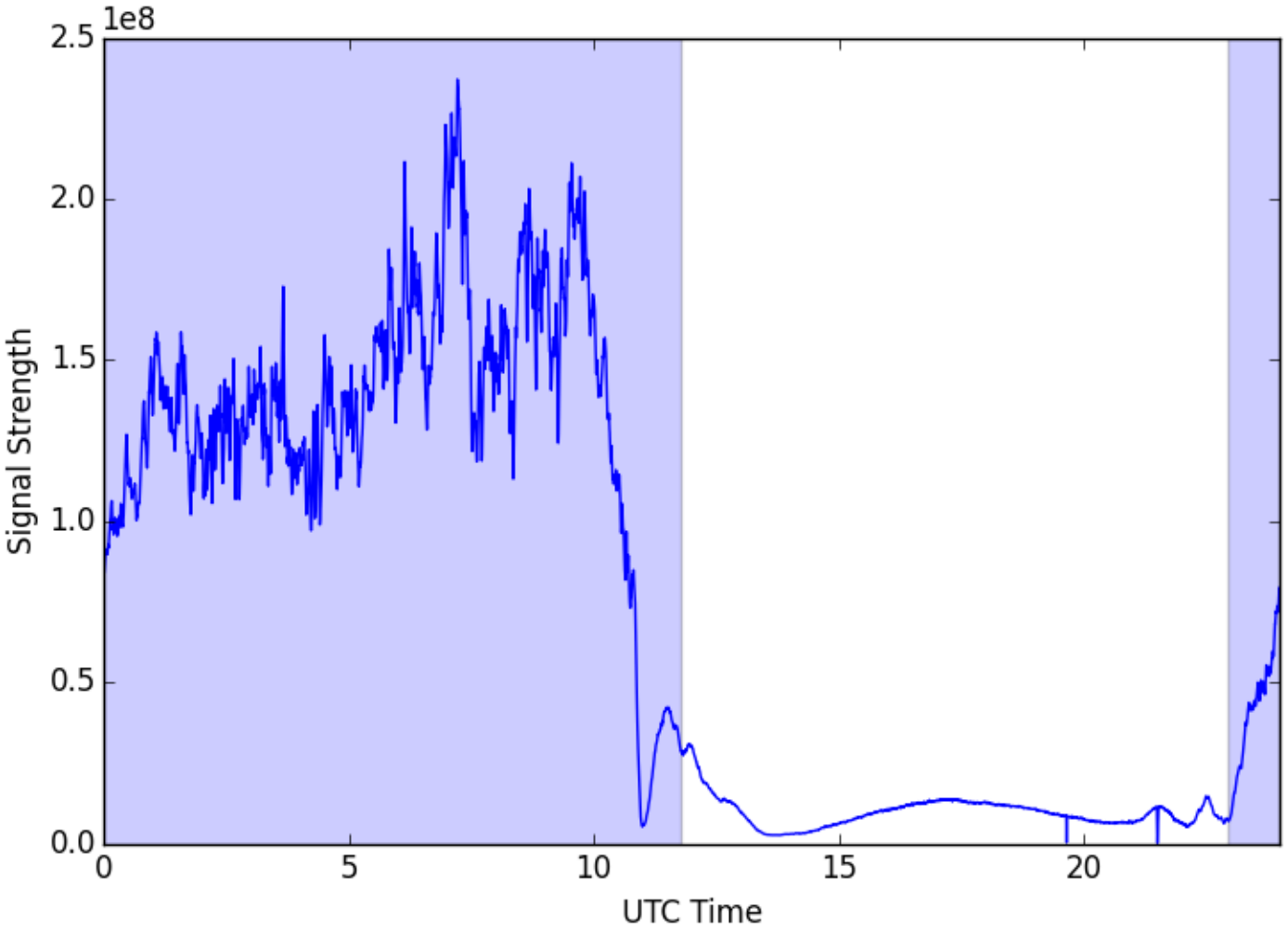
Software can be configured for automatic uploads to Stanford Solar Center

Solar Activity 25 February 2018

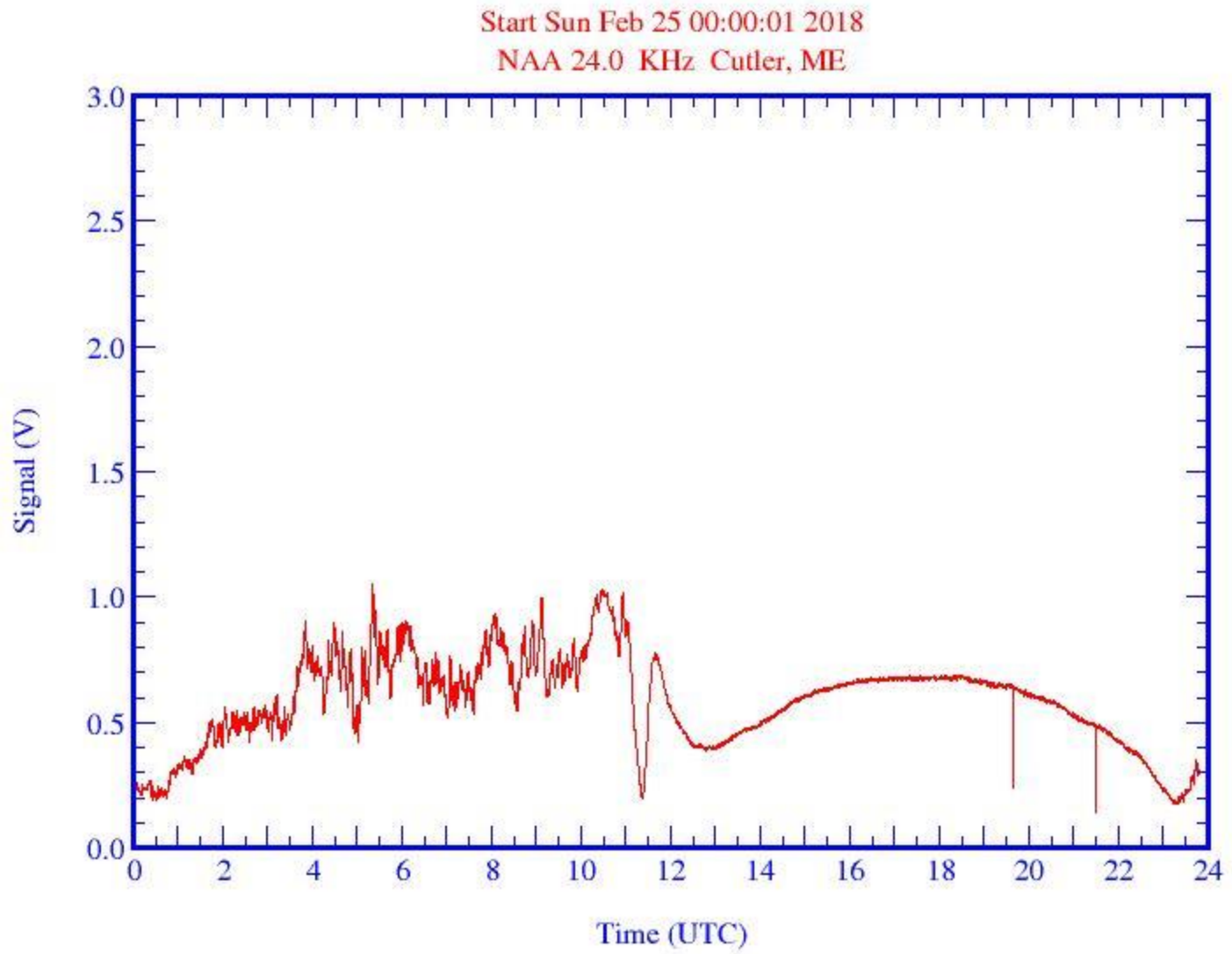


X-Ray Data from GOES Satellite
From: SpaceWeatherLive.com

25_Feb_2018 SuperSid Plot NAA Cutler, ME @ Falls Church,VA

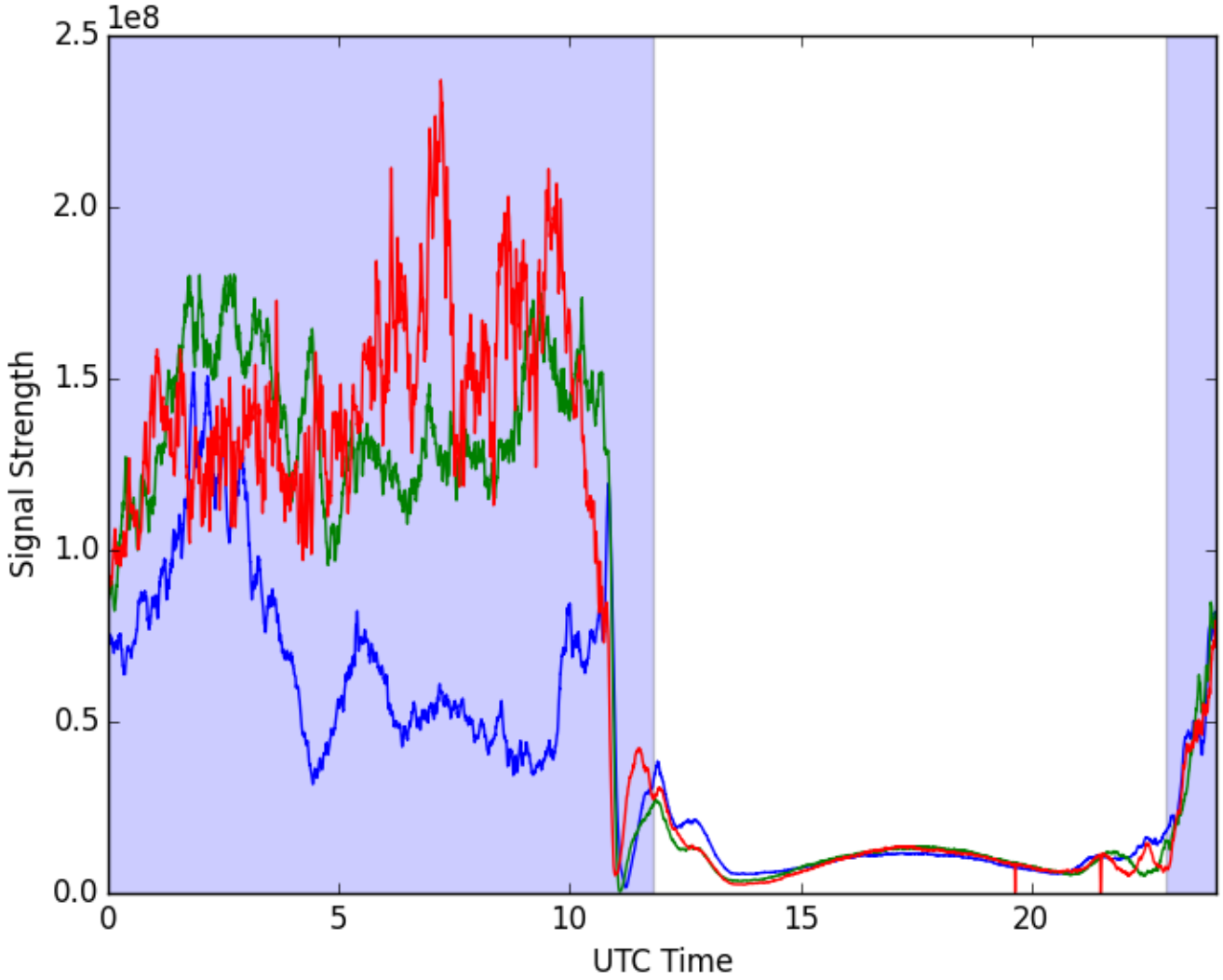


25 Feb 2018 University of Louisville NAA Monitor Collection



http://moondog.astro.louisville.edu/naa/archive/plots/2018/20180225.jpg

Example:
Stanford software allows overlays:
23, 24, 25_Feb_2018 SuperSid Plot NAA Cutler, ME @ Falls Church,VA



Red = 25 Feb Green = 24 Feb Blue = 23 Feb

Conclusions

A SID Monitor can be a part of a personal Space Weather Station

SID Monitor stations can be built with Stanford’s kit or ‘DIY’ antennas/receivers

VLF antenna and receiver were satisfactory for monitoring VLF stations.

Data charts collected appear very similar to recordings at Univ. of Kentucky.

Sun was relatively quiet during the recording period in 2018.