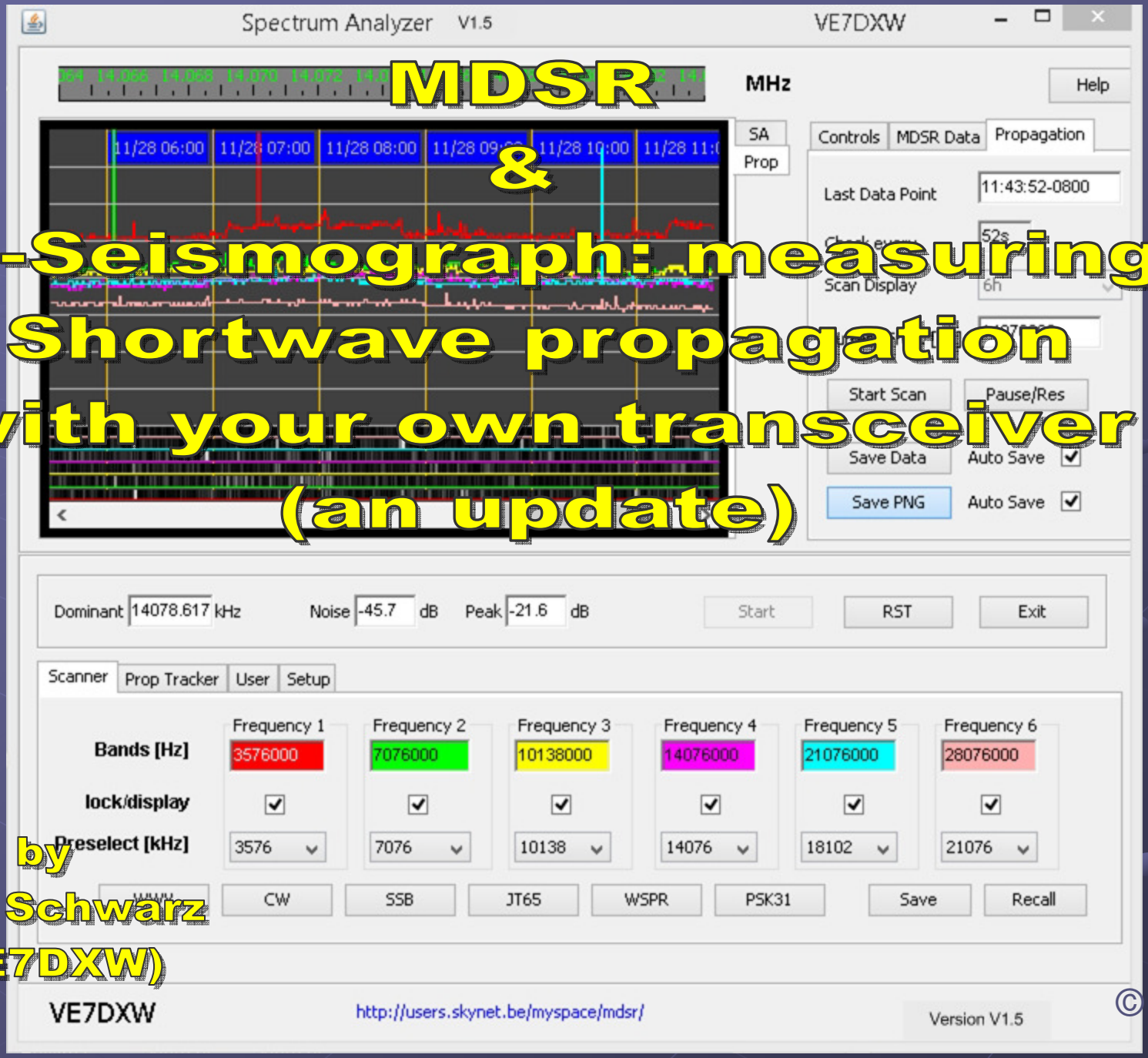
MDSR & RF-Seismograph: measuring Shortwave propagation with your own transceiver (an update)



by
Alex Schwarz
(VE7DXW)

Radiation and Particles from the Sun

- **Photons** (300000km/s ~ 8m 20s)

  radio waves, infra red, visible light, ultra violet, x-ray, galactic waves,

  - **Solar Flux** (30000km/s ~ 8m 20s)

    The 10.7 cm (2800 MHz) radio **flux** is the amount of **solar** noise that is emitted by the sun at 10.7 cm wavelengths.

- **Solar Wind** (200 to 1600km/s days to a week)

  Fast moving ionized gas particles cause Aurora in the upper atmosphere

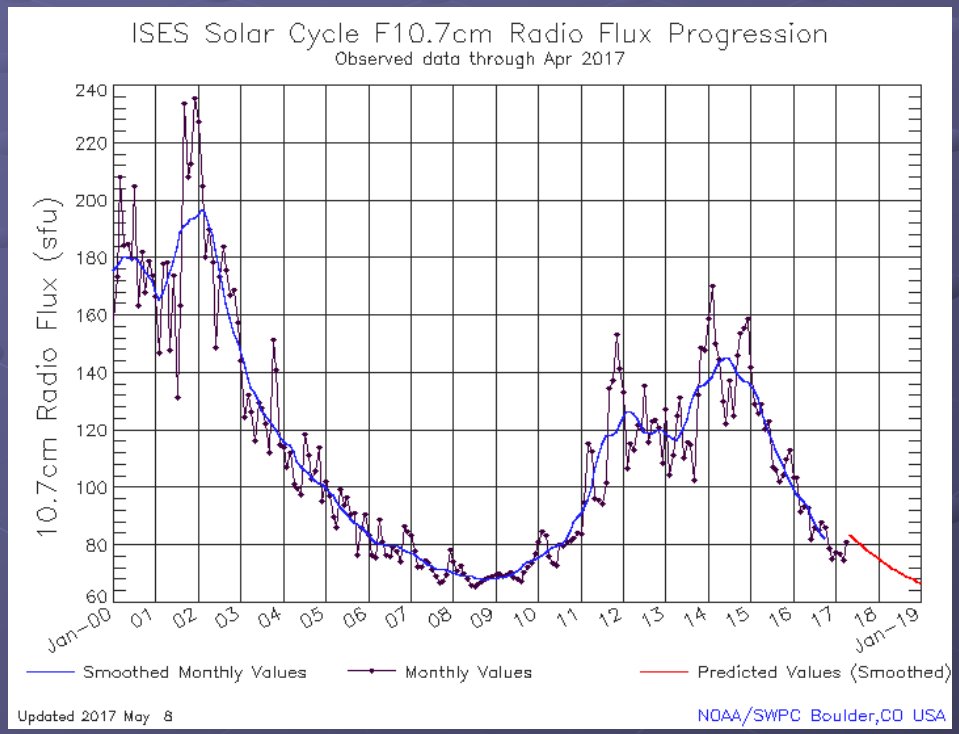
  - caused by CMEs
  - caused by coronal holes (exposed areas of the solar surface)

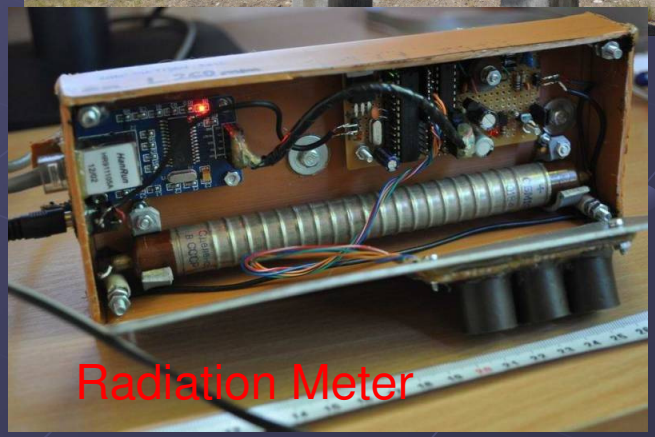
- **Magnetic Flux**

  Changes in the magnetic field are moving with the solar wind from the sun into space and can cause geomagnetic storms

Who is measuring Solar Flux?

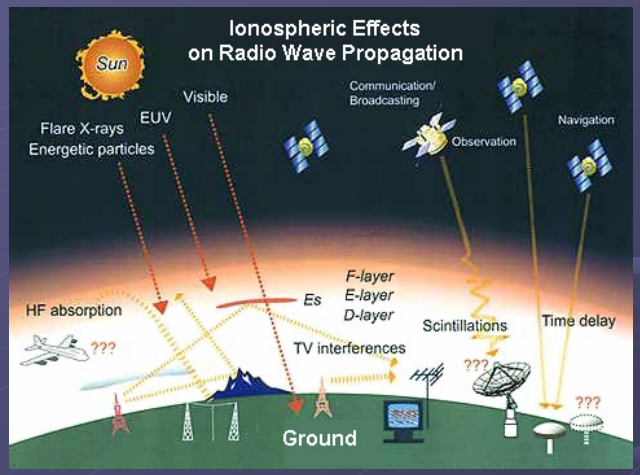
- Monitoring Stations everywhere in the world
- Space Satellites





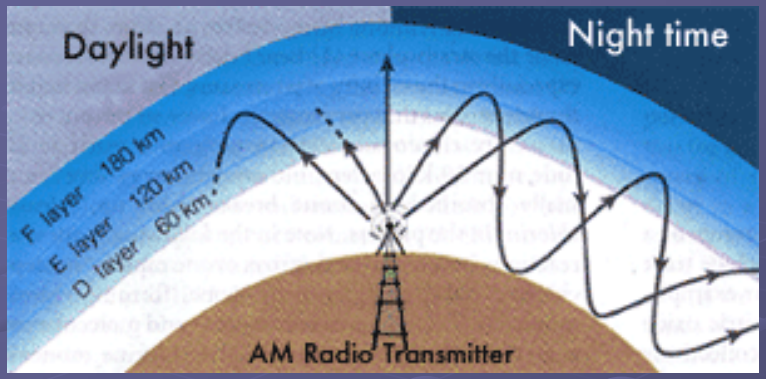
Effects of Solar Flux on Everyday Life

- Failure of Power Lines
  - Auroras can overload and damage high voltage transmission lines
- Inaccurate or no GPS Navigation
  - Bending of radio waves adds a time delay causing the location to shift without warning to the user



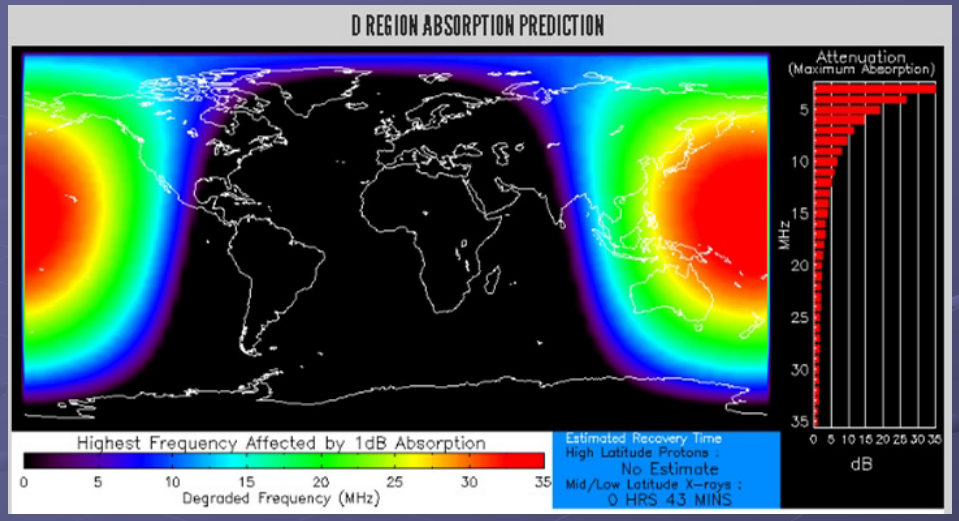
- Disruption of satellite radio and data communications
  - Interactions between radio waves and “solar flux” can cause dropouts and data loss
- Currents in pipelines cause corrosion
  - Solar radiation causes destructive electrical currents to flow
- Interference to TV and AM broadcasts
  - The reflection of VHF and UHF radio waves in the ionosphere causes interference

Effects of the Sun on HF Propagation



- **MUF** (Maximum Usable Frequency) goes up when the Solar Flux goes up. The ionosphere gets denser and reflects higher frequencies for skip. At sunrise the MUF is low, rises during the day and falls before sunset and during the night. Higher in Summer than in winter.
- **LUF** (Lowest Usable Frequency) goes up during the day and drops before sunset and during the night. It also depends on Solar Flux. As the layers get more ionized the RF hum increases making lower bands unusable. Higher in Summer than in winter.
- **MOF** (Maximum Observed Frequency) is the maximum frequency observed for a path between a transmitter and a receiver.
- **Skip** frequency and MUF are related. HF skip can happen day and night. AM skip (f < 2MHz) usually only occurs at night.

Effects of the Sun on HF Propagation

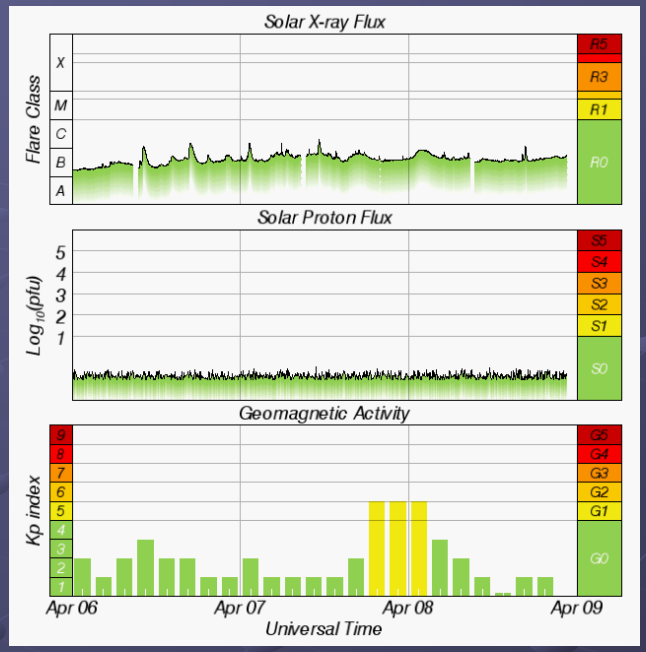


- **D Region Absorption Prediction** also takes into account the change in seasons and the angle of the radiation arriving from the sun. In the summer the northern hemisphere is illuminated more and during winter less.

- **1 dB Absorption** display is similar to the LUF and mostly affects the dayside of the planet. As the solar activity goes up an absorbing layer attenuates the radio waves. Vibrating electrons increase the noise level. Lower bands are affected first.

Effects of the Sun on HF Propagation

Solar X-ray Flux can also be viewed at the NOAA website and it shows the up to date information of the activity of the sun. In general as the SFI goes up so does the LUF and the MUF. It mostly affects the sun lit surface of the earth. SFI and sunspot activity are linked together.



Solar Proton Flux consists of particles from the sun that can ignite a geomagnetic storm. After a CME a cloud of ionized gas erupts from the solar surface and drifts from the sun into space at speeds of about 200 to 1600km/s.

All these effects change with the seasons and solar cycle as well as changes caused by the day and night rhythm.

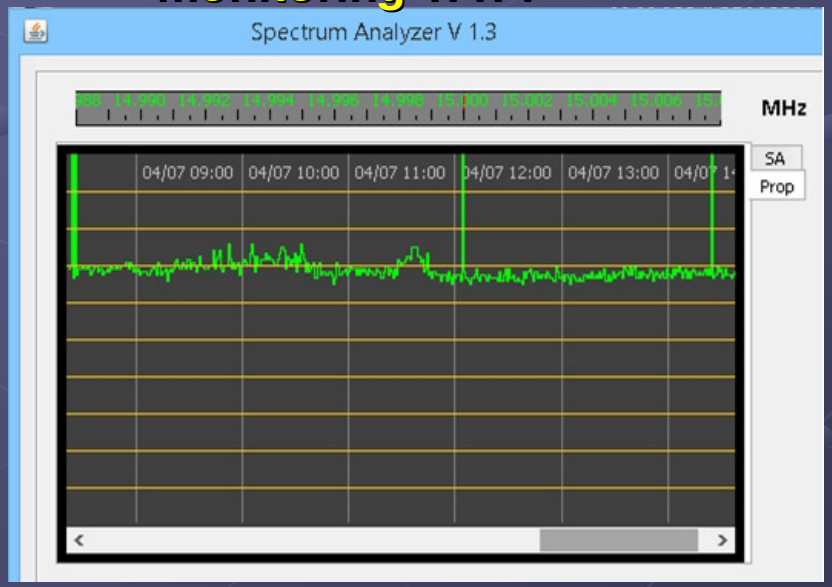
Sun and Earth Magnetic Field

- **Geomagnetic Activity** is the interaction between the solar and terrestrial magnetic fields. Important is also the polarization, a factor that describes how much energy is transferred from the solar to the earth's magnetic field. If the fields oppose each other the solar wind and particles can enter the earth atmosphere more easily. High geomagnetic activity is associated with auroras and a high sunspot count.

How does the “RF Seismograph” work?

- The “RF Seismograph” measures noise level from the RX receiver frequency.
- By monitoring the changes over a long period of time, a pattern emerges indicating the state of the ionosphere.

monitoring WWV

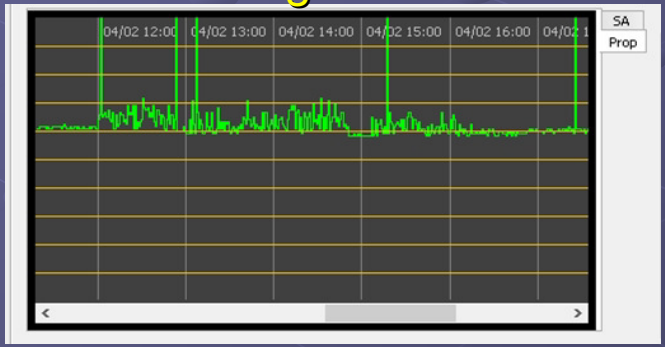


Interesting Noise Patterns

monitoring 20m

- **12:30**: the noise level dropped and DX stations were monitored
- **13:30:** noise level increased again covering the DX stations
- **14:30:** strong noise wipes out all incoming signals

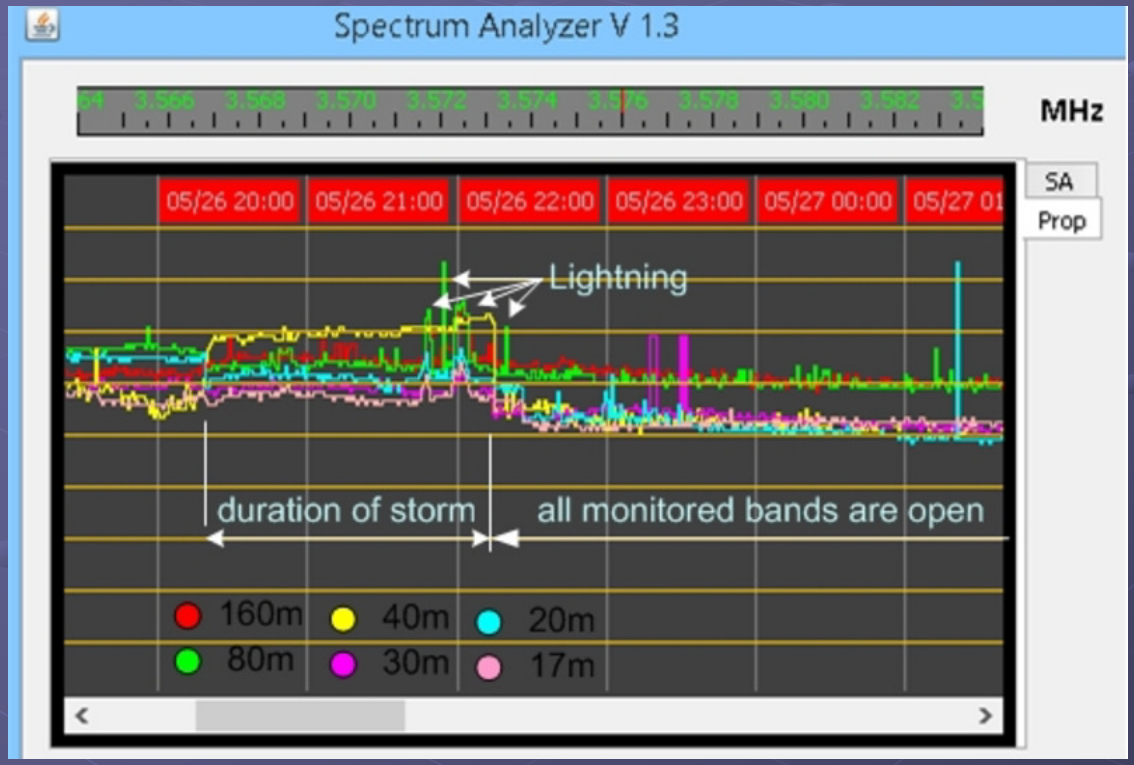
monitoring 15m



- **12:00:** a very fast changeover from a closed to an open band
- **14:50:** band closes for 20 min
- **15:10:** band reopens
- **16:00:** band fades with no signals after 16:30

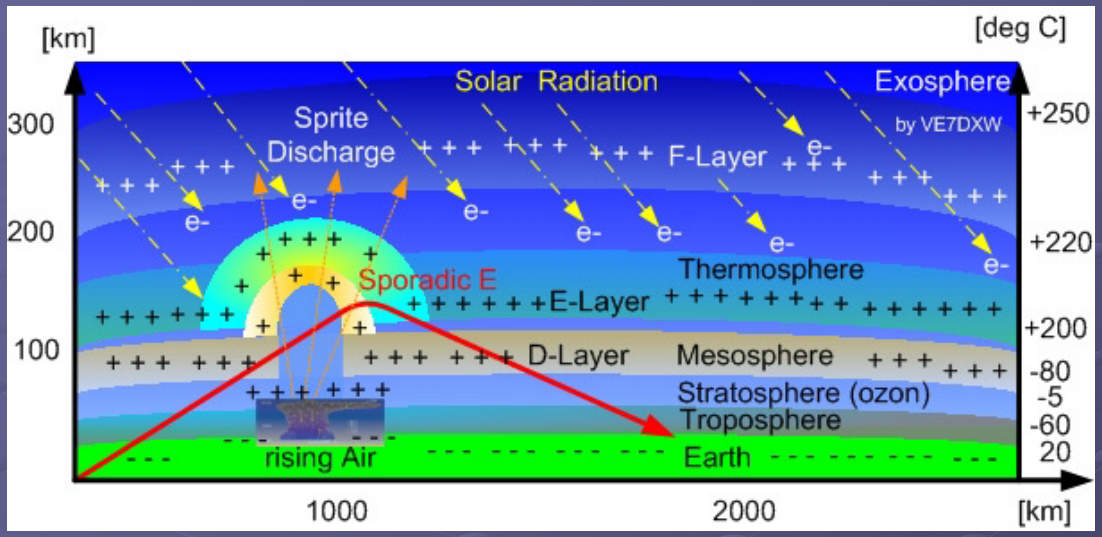
Phenomena that change Propagation

- Thunderstorms



Thunderstorms are very interesting to look at on the RF-Seismograph. The rising air creates a “noise dome” which is usually followed by lightning strikes. After the system passes the noise level drops and propagation improves.

Sporadic E Propagation caused by a Thunderstorm

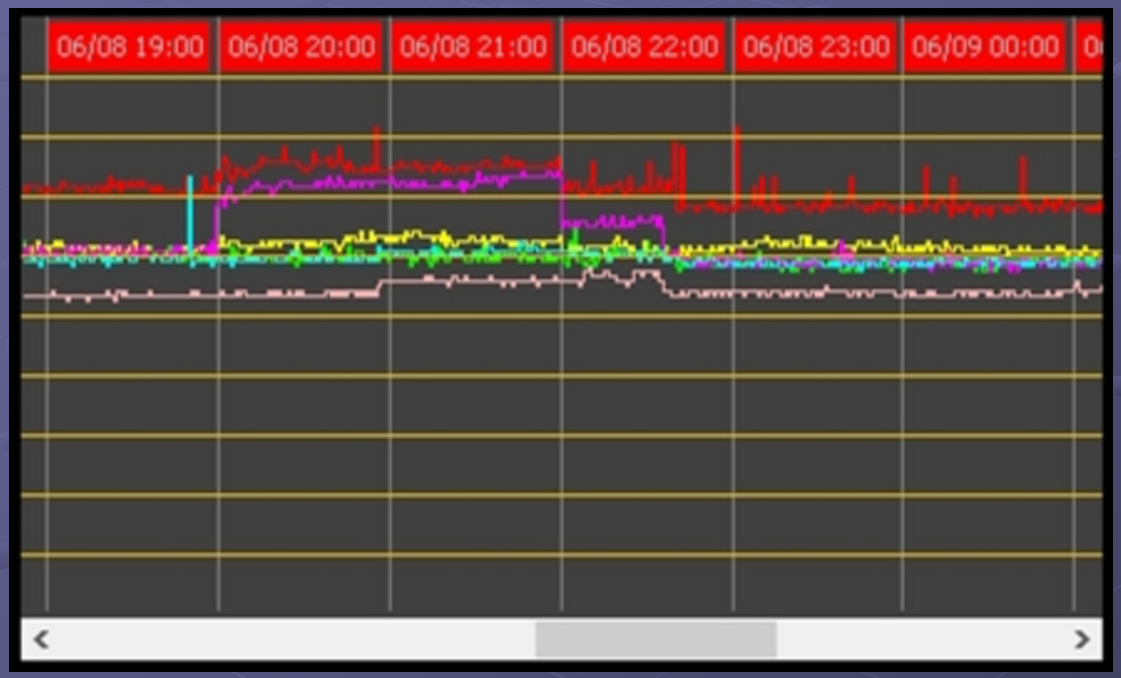


The Theory:

When the solar radiation hits the atmosphere, it knocks electrons out of the air molecules and pushes them to the ground. This will make the earth negative in comparison to the surrounding air. If my theory is correct, thunder storms mop up the negative charge on the ground and through the rising air negative ions get pushed up through the thunder storm. In the ionosphere (D-Layer) negative Ions are burning a hole into the D-Layer by combining with the positive Ions. Also, the updraft turns the D and the E layer into a dome above the storm. Thunderstorms are in essence responsible for equalizing the charges between the planet and its surrounding gas.

Phenomena that change Propagation

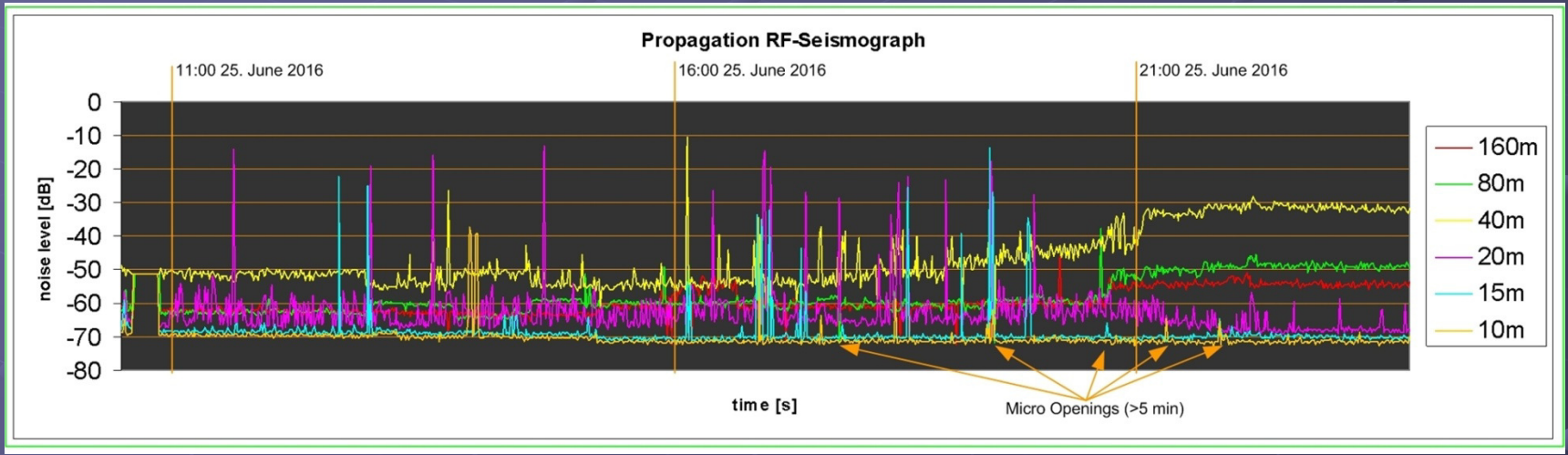
- Night Glow



“Night Glow” occurs after hot and sunny days that have clear nights. The green glow is created during the recombining action of air ionized molecules with free electrons. The energy is low but during summer month it can activate a reflective layer, mostly for the higher bands.

Phenomena that change Propagation

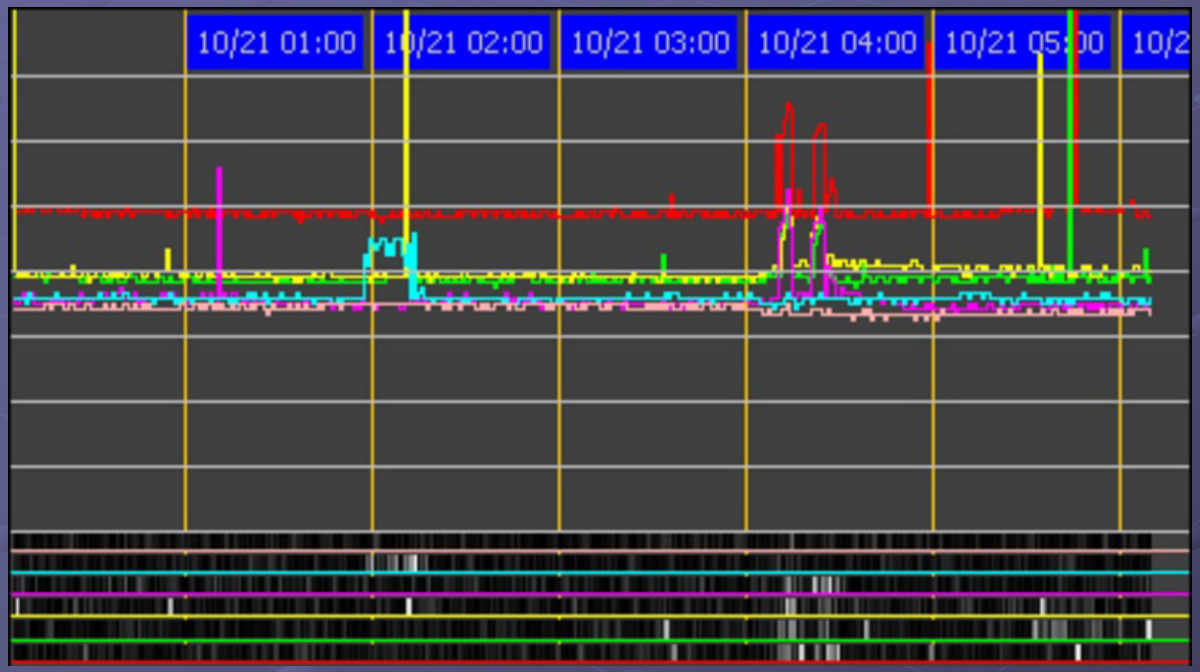
- Rising Clouds



This measurement was done during “Field Day” operations. Located in the North Shore Mountains after the weather turned from sunny to cloudy and then low overcast clouds. Propagation was rendered impossible due to high interference from RF noise created by rising clouds.

Phenomena that change Propagation

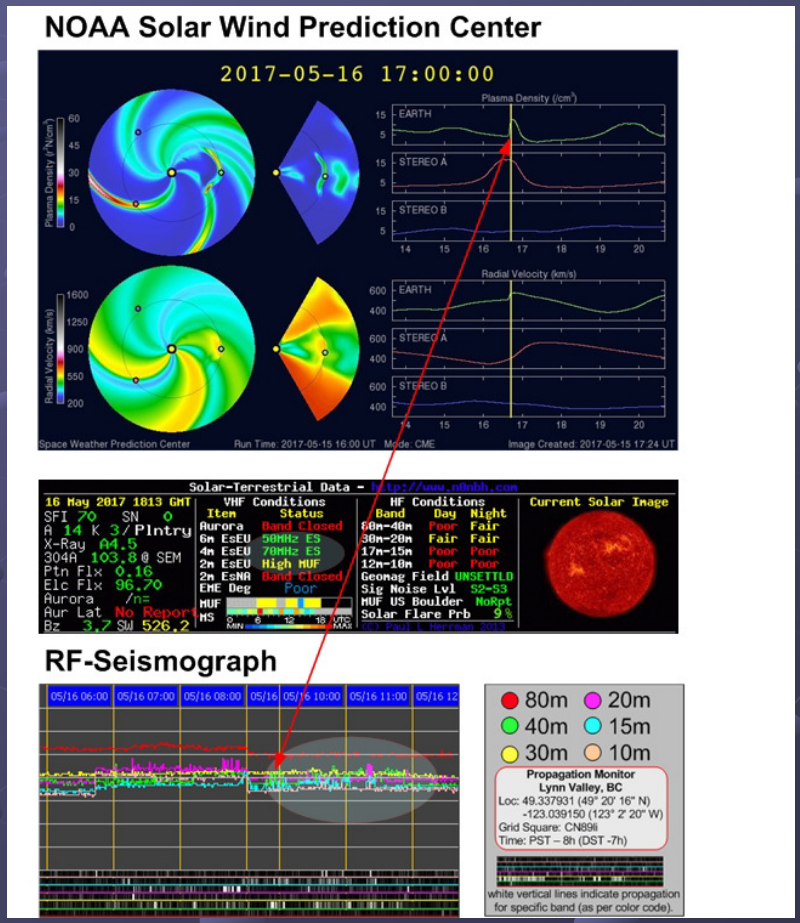
- Meteorites



Meteorites can easily be detected by the RF-Seismograph. The start with a fast rise of noise and then peak for about 5 to 10 min., followed by a steep drop back to background noise. As the earth moves though the debris field of meteorites and comets on an annual bases the rate of detected strikes goes up.

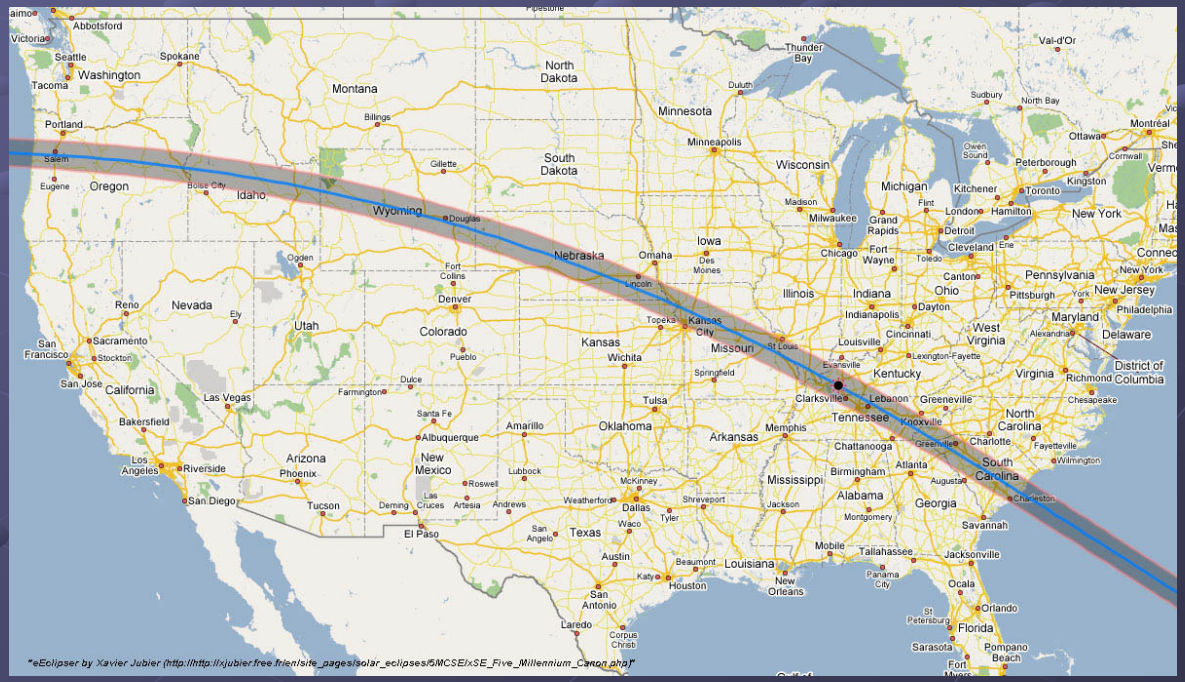
Phenomena that change Propagation

The ENLIL Plasma Stream Density indicator uses 3 satellites that are in orbit around the sun. All these satellites rotate the sun at the same speed as earth. With an offset of 120° the positioning provides a stereo (hence the name Stereo A & B) view of the solar plane. This allows detecting slower moving plasma at the speed of light and track the speed and density of particle clouds. ENLIL is the bird's eye view of escaping plasma combining the measurements of all satellites. Because the sun rotates the plasma streams bend as they fly into space, creating an effect of a rotating fan. Depending on the speed of the moving clouds, ENLIL can give us up to 3 days of warning that a plasma cloud approaches.

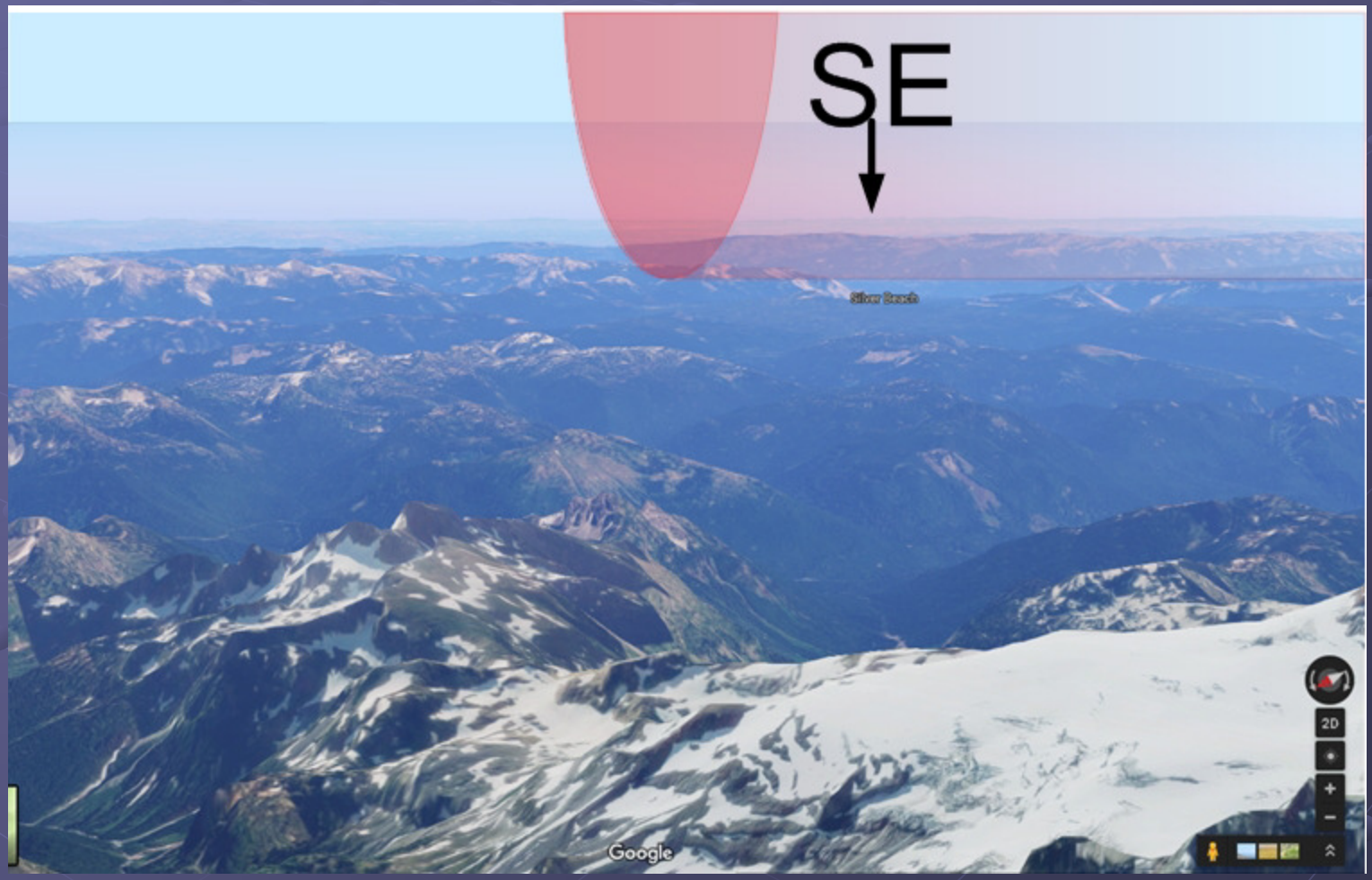


Phenomena that change Propagation

- Solar Eclipse
  - In Vancouver (southern BC) the sun will still be covered by more than 90%
    - Eclipse starts at 9:10AM
    - Totality: 10:21AM
    - Ends: 11:37AM

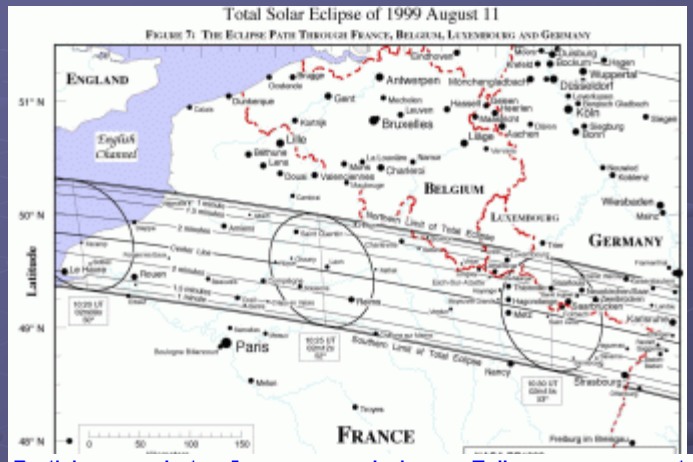


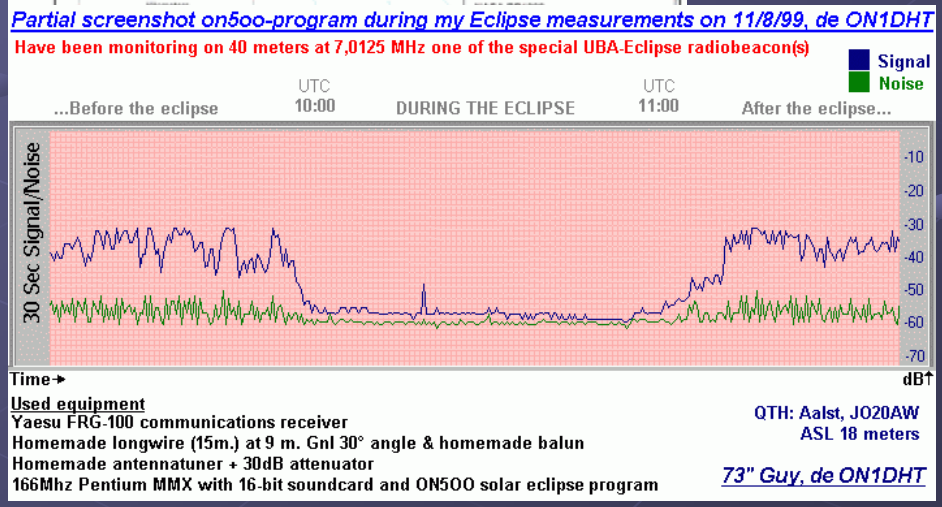
Looking into the de-ionized Canyon



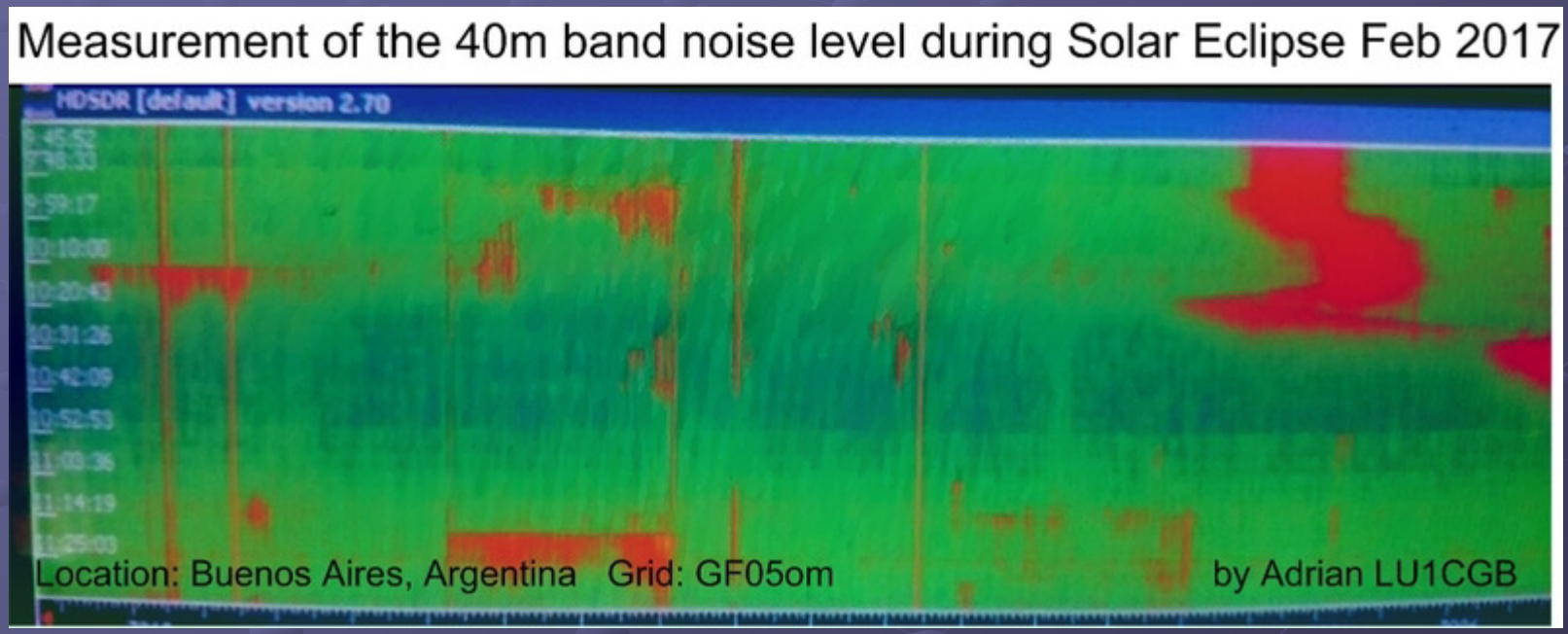
Effects of a Solar Eclipse on HF Propagation

- D Layer resolves due to lack of solar radiation.
- MUF goes down enabling continent wide communication on 160m and 80m during eclipse.
- AM (MW) radio stations all over NA will go into skip and will be heard in far away locations.





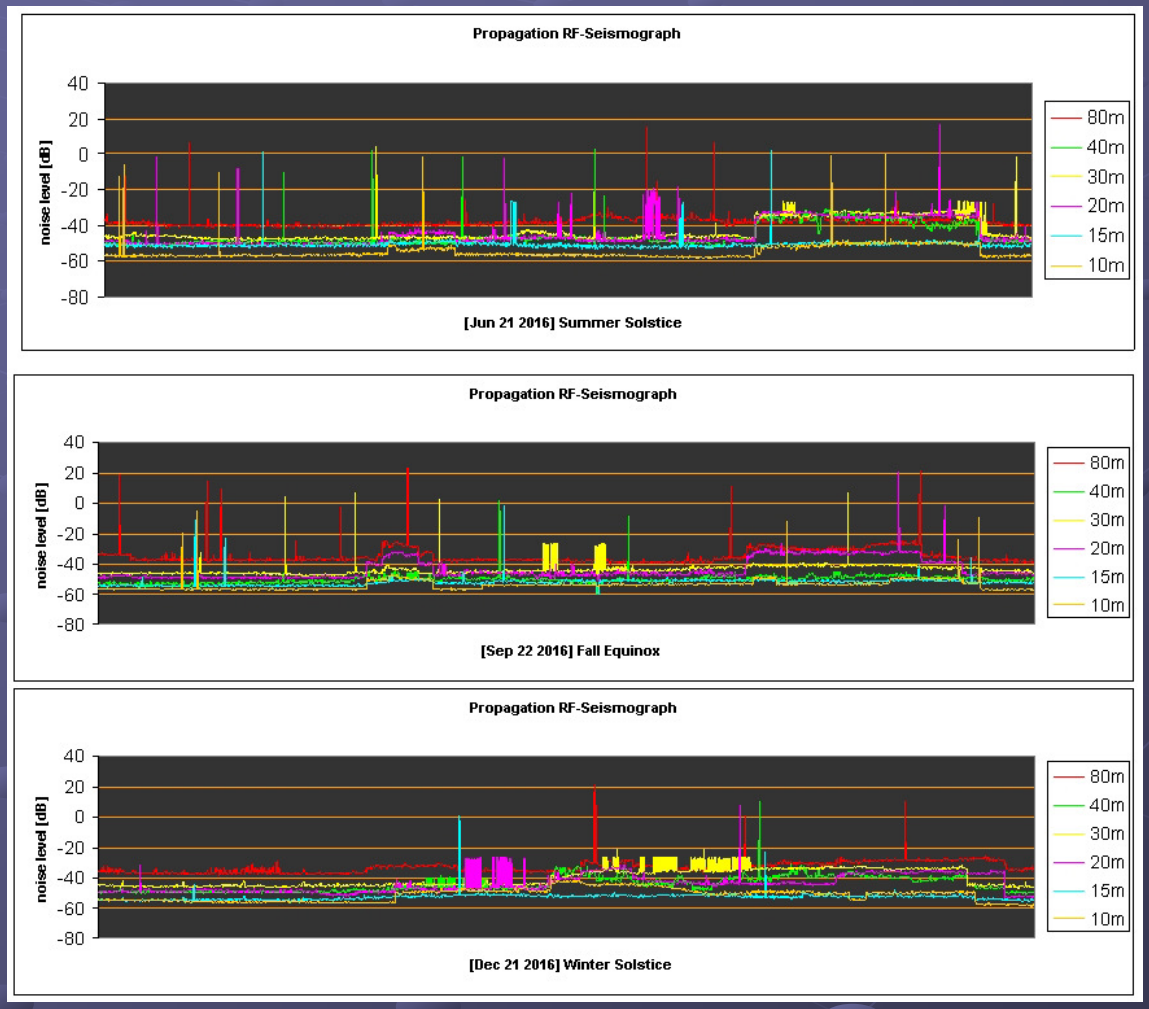
Solar Eclipse Measurement



Measurement of the noise level of the partial solar eclipse that occurred in Boenos Aires in February 2017.

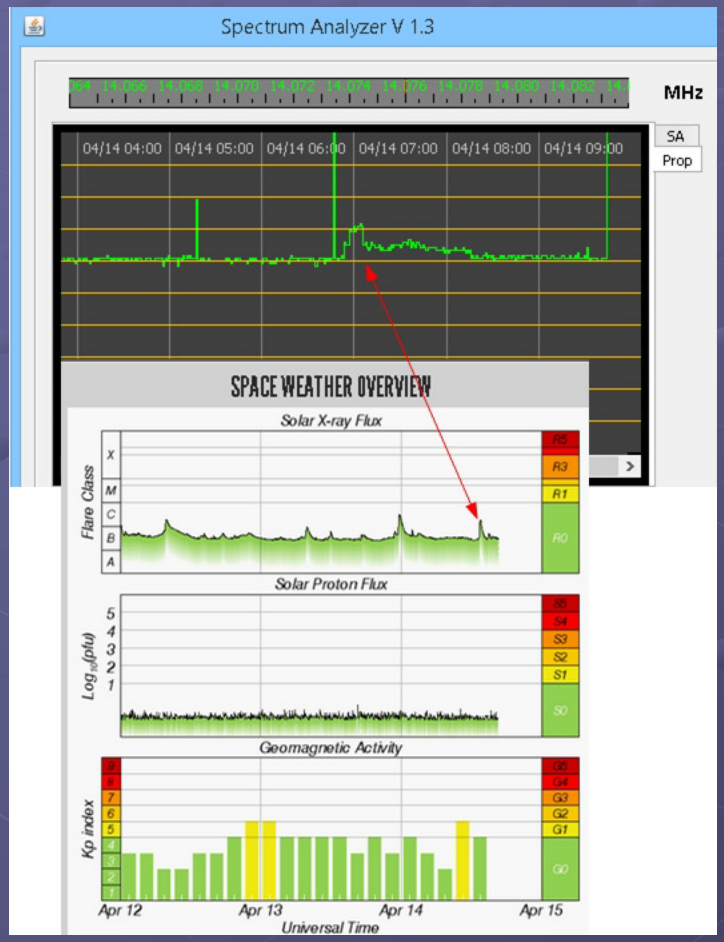
Seasonal Noise Patterns

- The count of static discharges is much reduced in the Winter.
- The grey-line propagation shifts with the rise of the sun

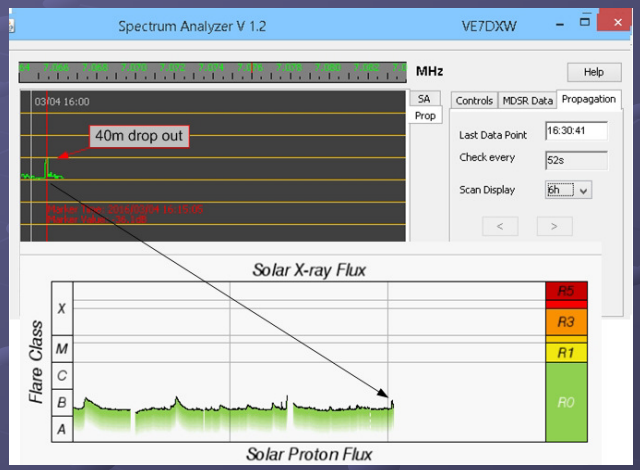


Measuring Impacts of CMEs

measuring the impact of a class C1 flare from the sun

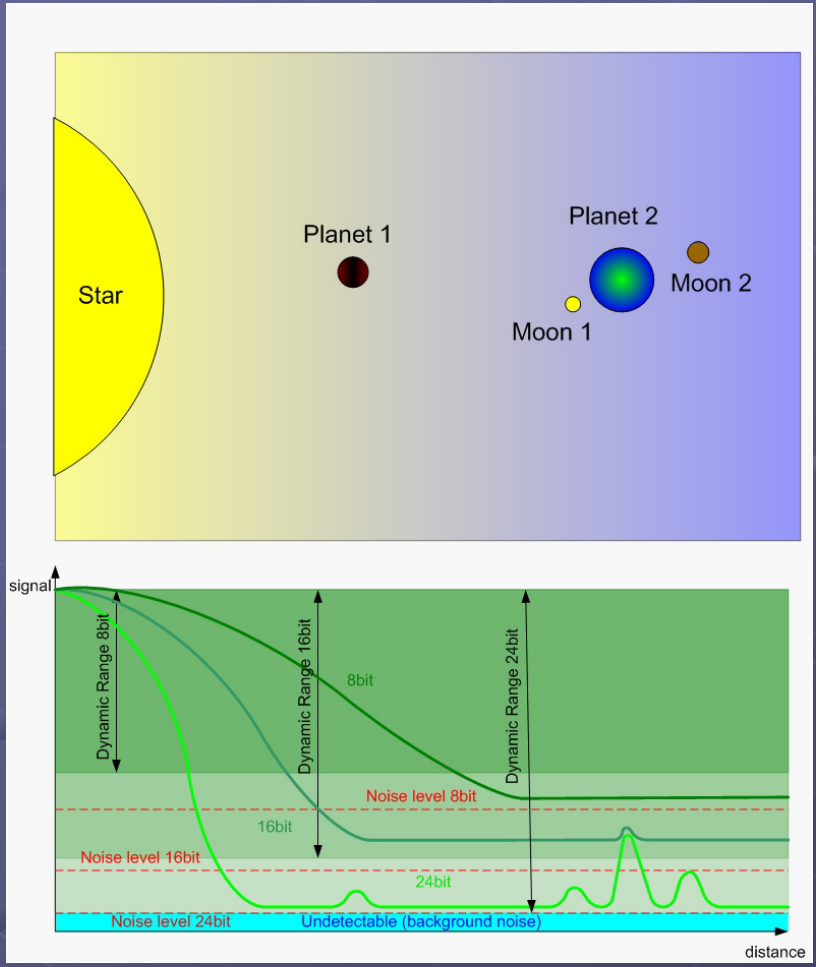


measuring the impact of a class B2 flare from the sun



- **6:50:** Incoming class C1 CME from the sun. Since this happened early in the morning the radiation angle is shallow. This has a delayed effect stretching the measured peak (compared to NOAA).
- **7:05** Highest intensity of CME and reverberations
- **8:15:** Intensity decreases by 2dB for another 1h-15min of continued vibrations of the ionosphere

The Star Problem



8bit: 256 steps, 4mV step rate @ 1V

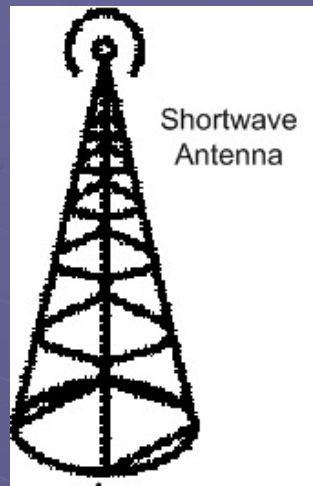
12bit: 4096 steps, 0.2mV step rate @ 1V

16bit: 65k steps, 15uV step rate @ 1V

24bit: 16M steps, 60nV step rate @ 1V

Dynamic gain is the process of taking a measurement multiple times, average it and then pass it on for processing at a lower speed. If we take 10 measurements , add them together and take the average, in theory we get more accuracy.
Dither checks the values for each measurement and makes sure that they are not too similar.
Dynamic Gain diminishes with bandwidth!

How is “RF Seismograph” connected to the Transceiver

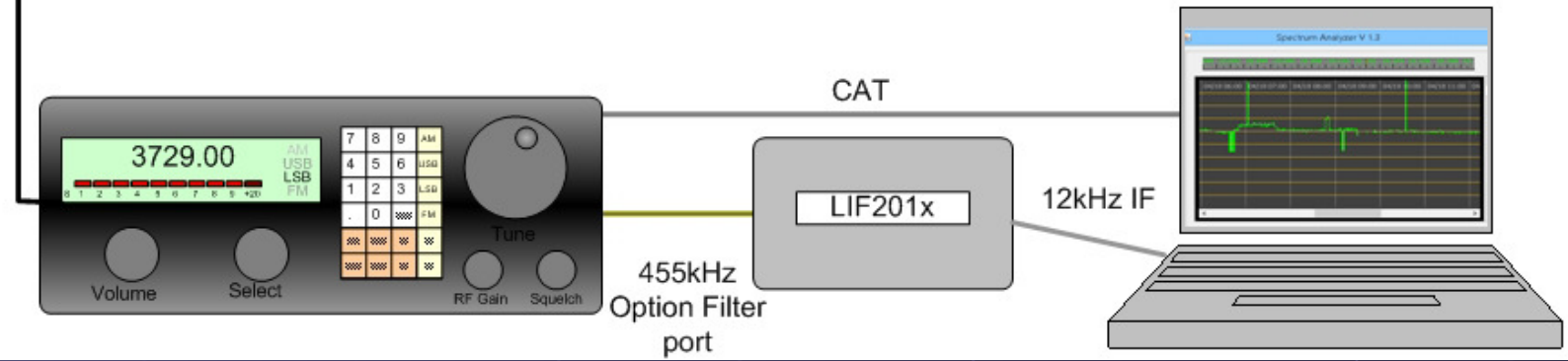


The station setup for the RF-Seismograph is exactly the same as for the MDSR. The 455kHz IF is extracted from the transceiver and then fed to the LIF converter. The LIF converts the IF to 12kHz. The output of the LIF is connected to LINE in of the Soundcard. (24-bit ADC for best performance)

The MDSR software needs to be installed.

RF-Seismograph is part of the MDSR software package.

Download at: http://users.skynet.be/myspace/mdsr/



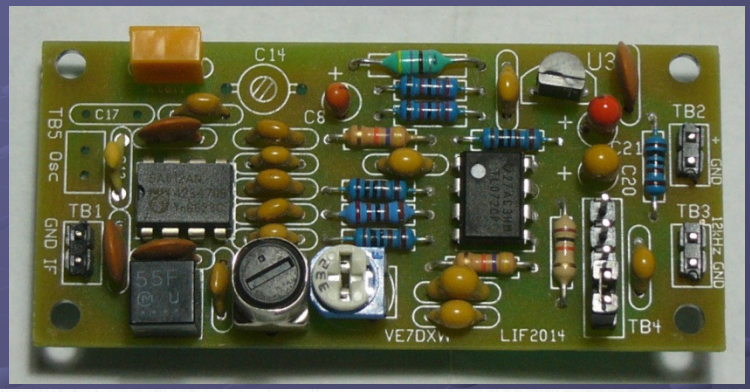
LIF and BiLIF Hardware

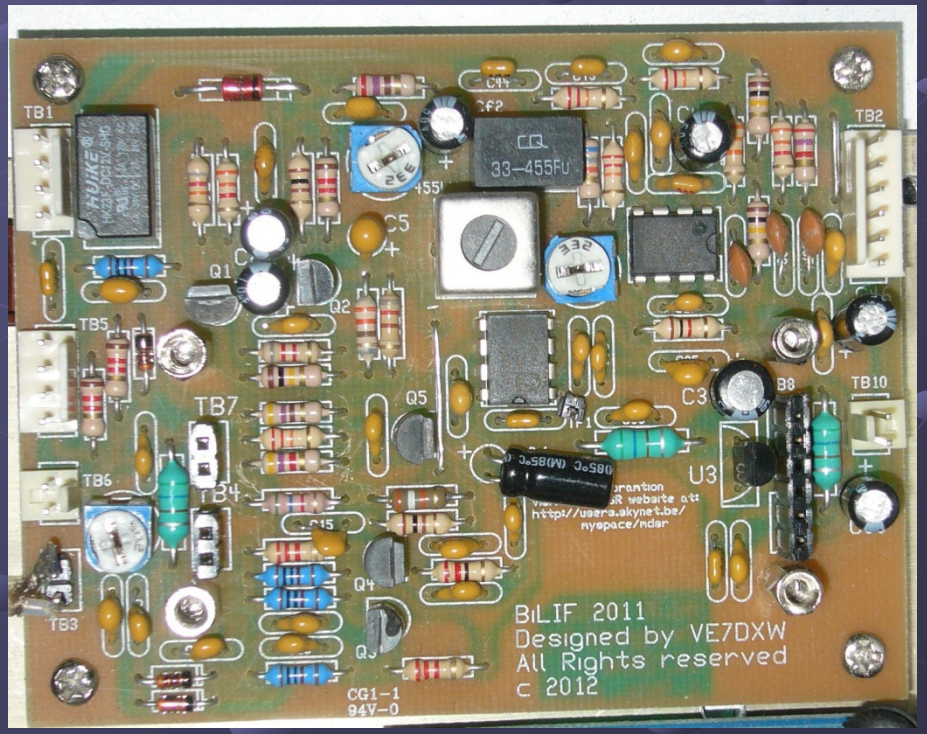
- LIF2014 PCB
  Down-converter for 450/455kHz & 9MHz to 12kHz LIF

  available as kit
- Up-converter LIF2011
  Up-converter, both kits make up the BiLIF unit for full RX/TX MDSR operation

  available as partial kit

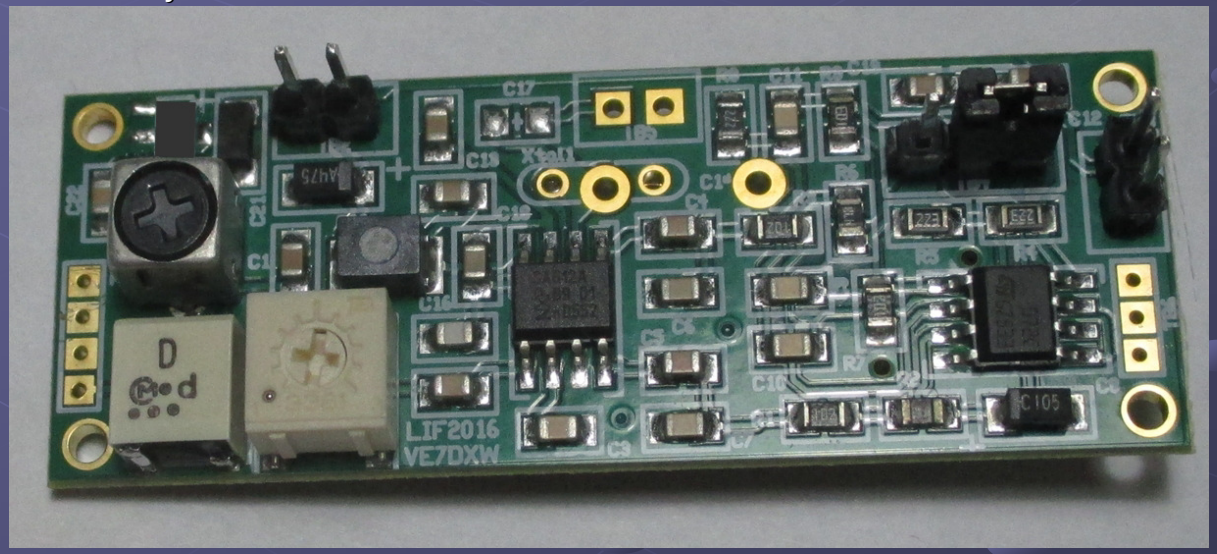
- easy to build
- easy to follow manuals
- no fancy tools are required
- only for 450 or 455 kHz IF
- online tech support





LIF 2016

- Fits into the option filter slot of many Yaesu and other radios
  - PCB size: 56 x 22mm (2.2 x 0.850”) same pin-out as option filter
- Only requires +12V to be wired from inside the radio
- 12kHz output ready for the Sound Card on TB3
  - RX only



References

Eleven Years of Sporadic E (must read!)
http://www.qsl.net/w/wa5iyx/Mar1992QST.htm

NASA Solar Eclipse Experiment 1999
http://science.nasa.gov/science-news/science-at-nasa/1999/ast04aug99_1/

Guy Roels (ON6MU) Experiment together with ON5OO Software (1999)
http://users.belgacom.net/hamradio/experiment.htm

National Research Council Canada (DRAO)
http://www.nrc-cnrc.gc.ca/eng/

NOAA Radio Communication Dashboard
http://www.swpc.noaa.gov/communities/radio-communications

Spaceweather.com
http://www.spaceweather.com/

Download MDSR software from:
http://users.skynet.be/myspace/mdsr/

Questions?

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Yahoo user group:
http://groups.yahoo.com/group/mdsradio/

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Kits are available from VE7DXW