Continued lessons from the RF-Seismograph

Matching HF noise and Propagation to the US Geological Survey's earthquake catalog.

Goups.io user group: https://groups.io/g/MDSRadio

MDSR website: https://www.qsl.net/rf-seismograph/

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Earthquake vs. Propagation

A discovery that belongs to all Amateur radio operators.

Everybody gets frustrated when you turn on a shortwave radio and propagation is poor. And right now propagation cannot get any worse, we are at the bottom of the solar cycle and even though there are some promising signs, the new solar max is at least 5 years away. Even propagation is down and the solar flux is around 70, there is still a lot of propagation especially below 20 m, but it is sporadic. What we need is software that records these openings and can display them on the web, freely accessible to anyone; this was the idea of the RF-Seismograph. With the RF-Seismograph we have instant access to propagation records and now we have more than 4 years of data!

When the sun is quiet, information on propagation becomes pseudo science, unless you start to look at a different cause of propagation, such as earthquakes. There are always at least small earthquakes. With the usual 5 or more significant quakes daily, the changes in propagation can be much better modeled and understood. This idea came via a Scientific American article “Earthquakes in the Sky” and it described the piezo electric effect of Bruce’s (N7RR) article in his QST article. So the idea was, to look for changes in the recorded data during time of earthquakes. The best record of worldwide earthquakes can be found at the USGS website. At first we looked at events bigger than M6.0, and sure enough from the 160 quakes that were looked at, 70% did have an effect. That was a year ago and we posted our findings and as you can imagine, there are a lot of critics. The difference to previous attempts was, that with HF (short wave radio), we were able to measure the S/N ratio of random stations at a global scale. If there is a change in the ionosphere, we would be able to pick up the modified propagation from almost any quake, anywhere in the world! Thanks to all operators that keep their shortwave radios on and in TX mode, so that our test station was able to pick it up. This is why the discovery of the propagation vs. earthquakes should belong to all active Ham operators! It was a global problem and everyone worked together to solve it.

Setting up and developing the RF-Seismograph has been a challenge

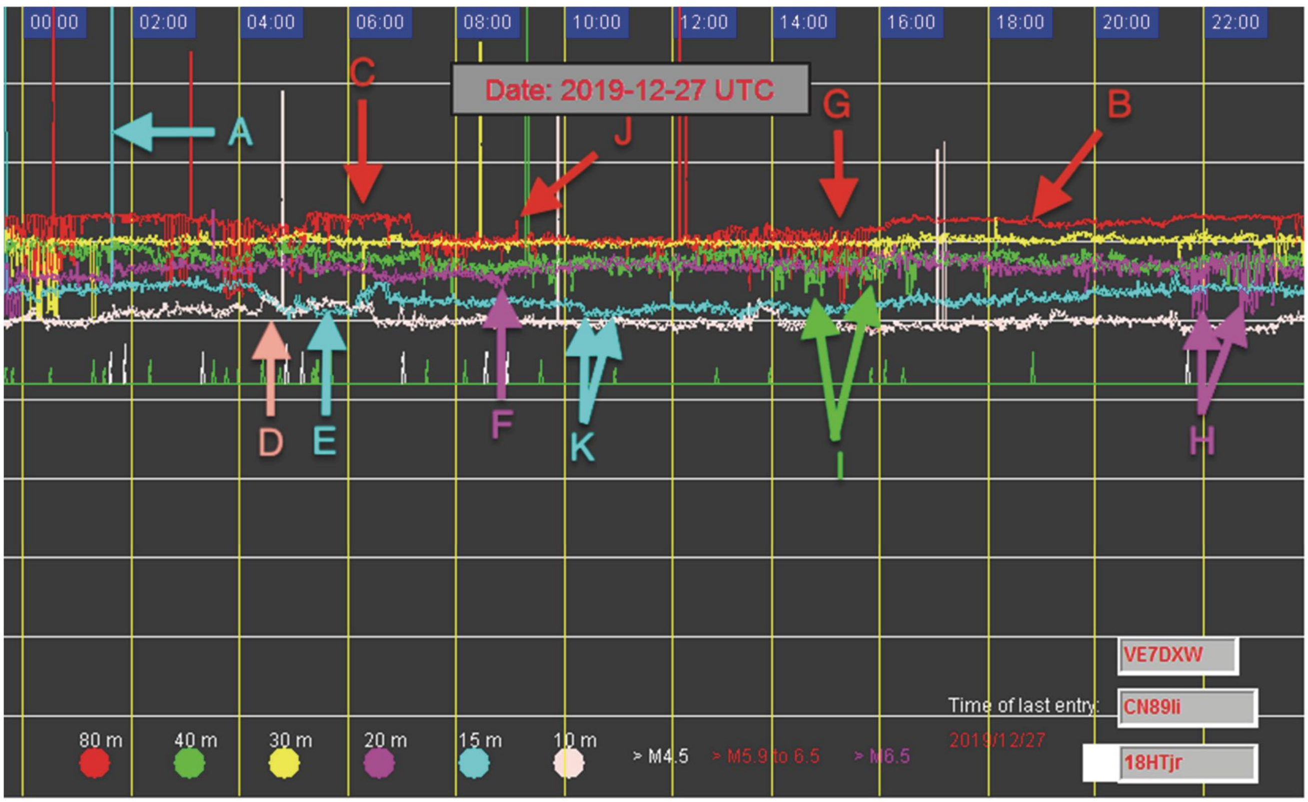
The RF-Seismograph has been developed with interference in mind and the RF-Seismograph separates noise from propagation. This is done by measuring S/N noise level and not just noise. When the RF-Seismograph receives a signal, the S/N ratio is displayed as a vertical line below the noise level. Regular noise is displayed as spikes that go above the noise floor. When there is no signal, the RF-

Seismograph displays a thin line that moves up and down as the noise level changes. The RF-Seismograph operates in North Vancouver (CN89) on a 24by7 basis and has been in operation since August 2016.

Discussion of a day of RF-Seismograph measurements

Recognizing Earth Quake Indicators:

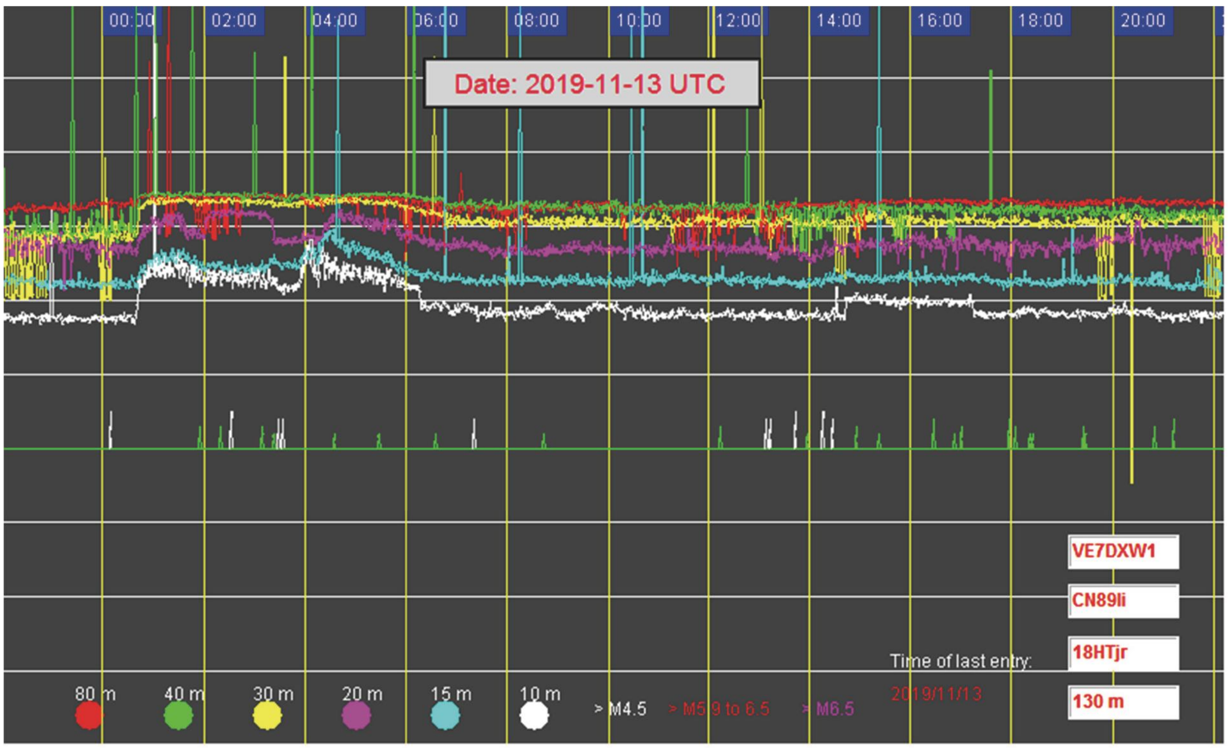
This is a "dictionary" of showing received signals on an RF-seismograph and what each bump, attenuation, spike, etc. is called and what is causing them. (**Note:** for viewing in B&W – the normal noise level distribution is highest for 80 m and then goes down as the bands go up – for better viewing in color use the web version). The daily graphs are also available in our group at: https://groups.io/g/MDSRadio



A spike – caused by braking magnetic field lines (seen on all bands)
B increased long term noise (mostly on 80 m) – ongoing earth quake activity
C noise dome – can be caused by a single or multiple quake (shows ongoing quake activity)
D bump (mostly on 15 m and 10m) – caused by either fast flowing solar wind or if none present by the interaction zone between quakes (check the NOAA website for fast lowing solar wind)
E dip (mostly on 15 m and 10m) – caused by quakes
F small Dip – caused by quakes

G propagation — shown as vertical lines (when propagating is very strong the line goes below the noise level)
H sporadic propagation – caused by scattered ionosphere clouds
I sporadic propagation – transition waves with fast noise transitions (mostly seen on 40 m and 30 m)
J small spike – human caused interference
K Noise floor reduction – show a transition between different earthquake intervals

Graph of RF-Seismograph for Nov. 13. 2019 in UTC time (-7 h for PDT – 17:00 PDT = 00:00 UTC :



When the RF-Seismograph picks up earthquakes, there are two distinct ways it is displayed and it is dependent on the size of the quake. The graph above uses the USGS database to query the size, location and time of the quakes (green and white spikes) and then matches the times of the quakes with the noise record. All the measured data and the daily summaries are archived at our MDSRadio.io group. All group members receive a summary at the end of the day. For a better display of the graph, please join the https://groups.io/g/MDSRadio and check the messages and the file section.

Quakes below M4.9 usually do not have a precursor or a large effect on the ionosphere and the S/N of the received signal does not change, but they do create spikes and noise level changes. Good examples are the 10 m spikes that can be seen at 07:15 UTC, 09:00 UTC, 12:10 UTC, 13:10 UTC, 14:45 UTC, 18:00 UTC and 21:00 UTC. Seeing this many time correlations makes it very difficult to assign the measured spikes to random events. We still would like establish more monitoring stations to collaborate these findings, but the initial measurements look very promising; especially the fact that we see so many of these events and not just on Nov. 17, 2019, but every day!

Quakes above M4.9 do have a distinct effect on propagation as measured by the RF-Seismograph

Note: A synopsis of the given band conditions and earthquake activity as stated below is given with each daily report that is available from the group and mailed to all members after 24:00 UTC every day.

The quake that occurred at 00:10 UTC bends the ionosphere, to allow 30 m propagation at 00:00 UTC for about 15 min. Then the precursor of the quake starts to increase the noise level on all bands starting at 01:00 UTC. This also creates sporadic conditions on 80 m. The spikes go below the noise floor of the signal, so we know that this is not noise, but a real signal. As we can see on the 80 m graph the reception is sporadic starting at 01:00 UTC lasting until 03:00 UTC, with a distinct gap just before the green quake indicator at 02:00 UTC. This day (Nov. 17) was especially interesting, because one can see two quakes interfering with each other! The quake that released at 2:30 UTC started the effect on the ionosphere at 01:00 UTC and it lasts to 06:15 UTC. The two additional quakes that release at 3:00 UTC and 03:05 UTC actually create a noise drop on 20 m, 15 m and 10 m! The quake at 07:15 UTC can be seen because it attenuates 80 m. At 06:00 UTC the 80 m band can be seen trying to open up, but then stops. This is due to the effect of this quake also and 0.5 h after 80 m returns. At 12:15 UTC a minor quake can be seen attenuating 80 m again, which had opened at 11:00 UTC. At 13:00 UTC, two quakes in short succession create another short opening on 80 m. The quake at 13:45 UTC created a short opening on 40 m as well. The double quake that occurred at 14:45 UTC creates 30 m propagation for 5 min only. The 10 m noise increase from 15:00 UTC to 17:15 UTC was created by the clusters that started to release at 14:45 UTC until 17:00 UTC. The 30 m band on this day did come up after 19:45 UTC, but was disrupted by two quakes and only came back just before 23:45 UTC.

Because it is autumn, the daylight and nighttime propagation changes are minimized. The RF-Seismograph is located on the west coast of Canada in Vancouver and the time zone is PST, which is -8 h from UTC. The date change occurs at 5:00 PM during daylight saving time and 4:00 PM in the winter, so the early hours of UTC reflect the nighttime of the location CN89.

What's next?

The RF-Seismograph team is hard at work to develop a real time Propagation vs. Earthquakes monitor that will run on a PC, a RbPi and a java enabled phone and Mac computer. This will allow everyone interested to monitor RF-conditions on real-time basis and to report their own findings in the IO group. In the mean time we are putting out a daily report that allows us to familiarize us with the way the ionosphere behaves and how quakes change propagation. To share these findings we put out a daily report that is accessible through the group.

Long term goal is still to get other operators to set up their own monitoring station, by using Raspberry Pi4 and the LIF2016 units that are still available through our website. If you are planning to offer your location and equipment for monitoring, please contact me. We also have a solution for areas that are in lightning danger zones, with our special grounded balun and lightning arrestor antenna system.

Why Use a Vertical Antenna

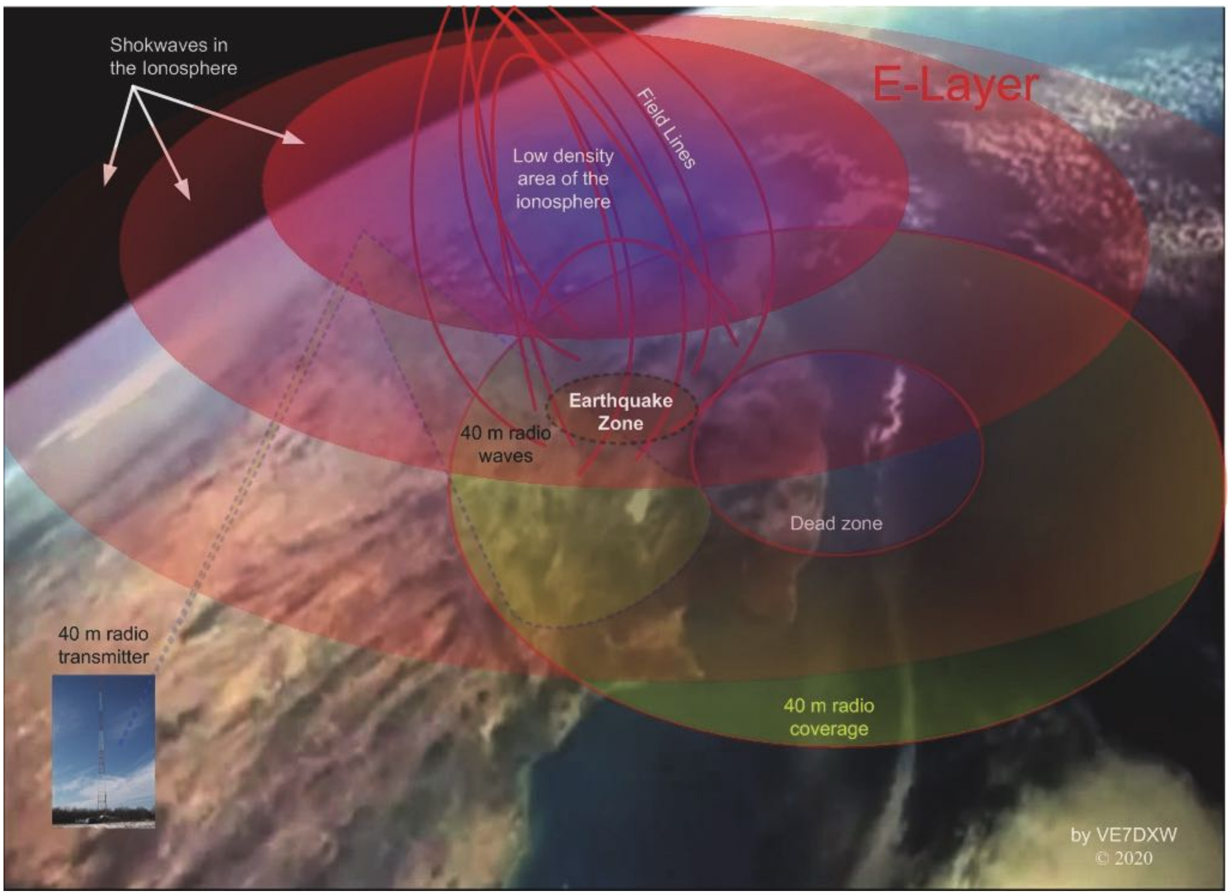
The antenna system (model: 18HTjr) has been specifically chosen as the best antenna and cost-effective omni directional solution for this application. It is 12 m (36 ft.) tall and has resonators for 40 m, 20 m, 15 m and 10 m. With the height of the antenna the takeoff angle is very shallow, which makes it more resilient to local noise. The 80 m part uses NVIS shooting the beam straight up. Below is the image of the antenna on top of a 30 ft townhouse; ground is provided by a 4” copper water pipe, which is also grounded at the basement.

Conclusion

Now we have a good understanding, why propagation is so sporadic during solar minimum; it is caused by the changes of the magnetic fields created by earthquakes that affect the ionosphere. With digital modes and their superior low signal characteristics, amateur operators can keep using their shortwave radios even in the lowest solar flux conditions. By using the RF-Seismograph to catch these signals and detecting how they propagate, is helping, to solve one of the big mysteries in Earth quake science. It seems like it is more beneficial to monitor the USGS earthquake reports for propagation, than to watch solar flux indicators – or just build your own RF-Seismograph.

If we update our repertoire and accept quakes do be more than a movement of soil, the implications will have a very positive and long lasting effect on the world and not just for shortwave radio.

<u>An illustration on how the Ionosphere changes in response to an Earthquakes</u>



References

Scientific American Oct. 2018: “Earthquakes in the Sky”

http://www.ep.sci.hokudai.ac.jp/~heki/pdf/Scientific_American_Vance2018.pdf

Earthquakes Canada**:**

http://www.earthquakescanada.ca

U.S. Geological Survey

https://www.usgs.gov/

Access to Study for 2017, 2018 (2019 is part of 2018)

http://www3.telus.net/public/bc237/MDSR/Matches-RF-Seismograph and Seismic data for 2017.pdf

http://www3.telus.net/public/bc237/MDSR/Earthquakes visible with RF-Seismograph 2018.pdf

Download and Install RF-Seismograph for Linux and Raspberry Pi

https://groups.io/g/MDSRadio/wiki/home

Download MDSR software for PC from:

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

Many thanks to Joe Joncas (WA7MHB) for the input and the definition of the earthquake signatures.