For the selected flare event, maximum D-layer absorption is shown:

Tracking a Class-X Solar Flare with WSPR

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Abstract

WSPR data for North America is summarized to examine the impact of a reported x-class solar flare on High Frequency propagation. The data is divided into distance categories to examine impact on different propagation methods, assuming that distance indicates the most likely propagation method. Very short distance (under 40 mile) for non-ionospheric, short distance (40 to 500 miles) for NVIS, medium distance (500-1500 miles) for E-layer propagation and longer distance (1500-300 miles) for F-layer and multi-hop (over 3000 miles). Signal to noise ratio is plotted by hour and tenth hour for the date of the flare. The impact of the flare is shown as a sudden decline in SNR for all distance ranges but the lowest.

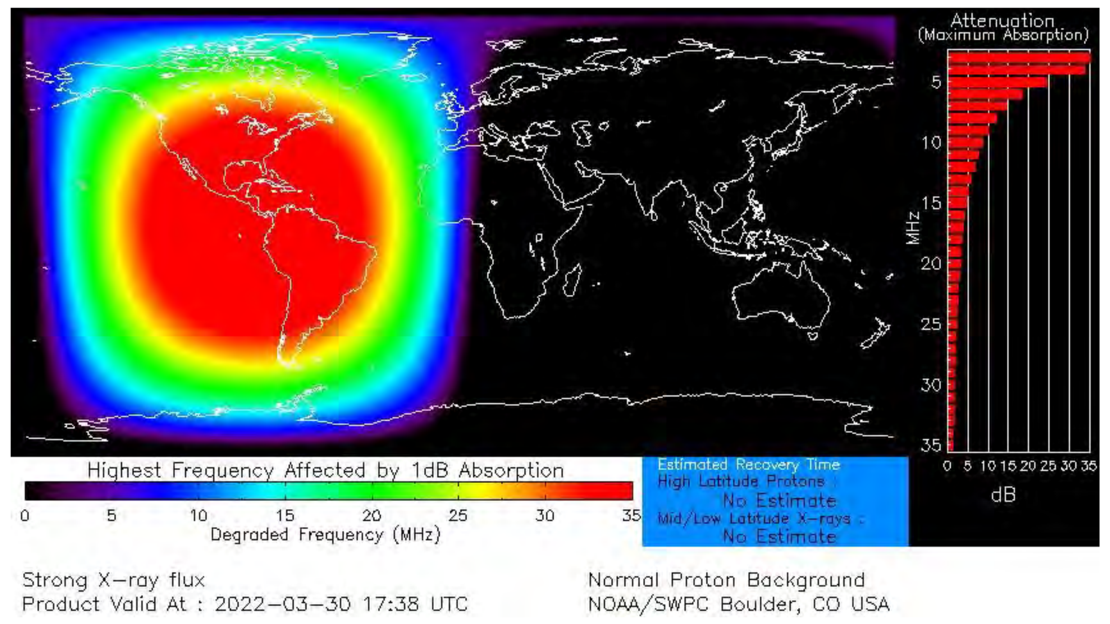
Introduction

Weak Signal Propagation Reporting (WSPR) is a radio beaconing system provided by Amateur Radio operators. WSPR stations transmit digital frames periodically and specific frequencies. Receiving stations log these transmissions, uploading information about the transmitter and received signal characteristics to Internet-based servers. Files containing all reports for each day are provided as zip compressed files.

WSPR operations occur throughout the world, and can thus be used to determine radio propagation at the various frequencies represented by amateur radio allocations. WSPR is an entirely voluntary effort with station configurations varying widely. Using a large number of observations for a portion of a day was done to counter local configuration idiosyncrasies.

Method/Experiment

Focusing on the year 2020, dates with a significant solar flare were selected for having maximum impact on radio propagation and hence greatest visibility in selected metrics. On March 30, 2022 an X1.3 solar flare occurred between 17:21 and 17:46 UTC (9:21 AM – 9:46 AM PST). This flare occurred during daylight in North America making it a good candidate for demonstrating the impact on amateur radio communications. [https://www.spaceweatherlive.com/en/archive/2022/03/30/xray.html]. Solar flares affect HF radio propagation primarily through increased ionization of the ionosphere's D-Layer. D-Layer ionization absorbs RF energy, rather than refracting it. By increasing D-Layer ionization, solar flares can cause HF radio backouts.



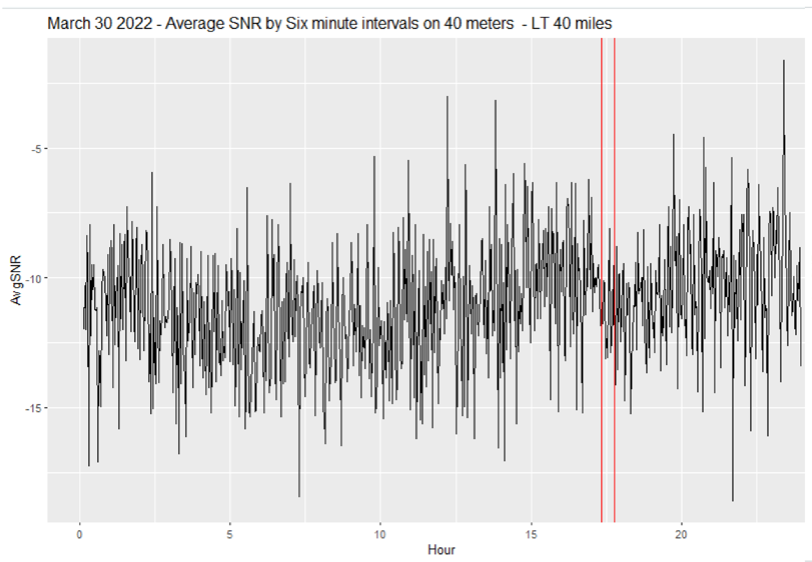
To examine this impact, extracts of WSPR data was downloaded for March 30, 2022. The Signal to Noise Ratio (SNR) was averaged by six-minute (tenth of an hour) increments. These intervals are short enough to define the flare over its 25 minute duration and contain enough observations to yield useful average values.

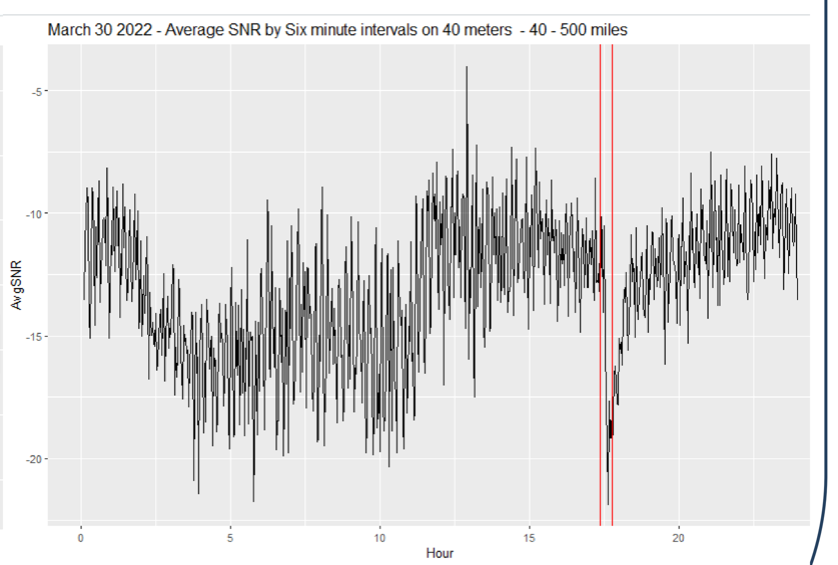
WSPR data extracts were downloaded and filtered with a Python script, selecting 7 MHz records for North American Maidenhead Fields. Further analysis including generating plots was performed using the R Language. Details of the processing including Python and R code are available on request.

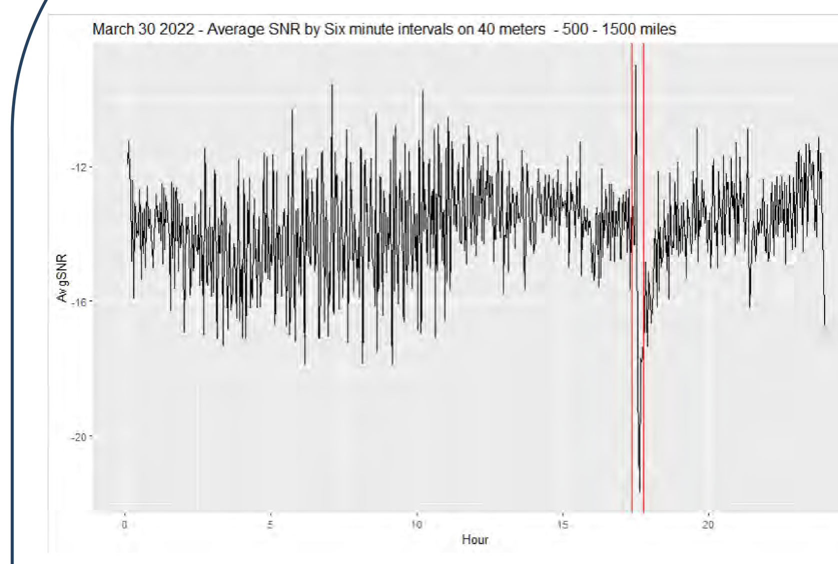
Data and Analysis

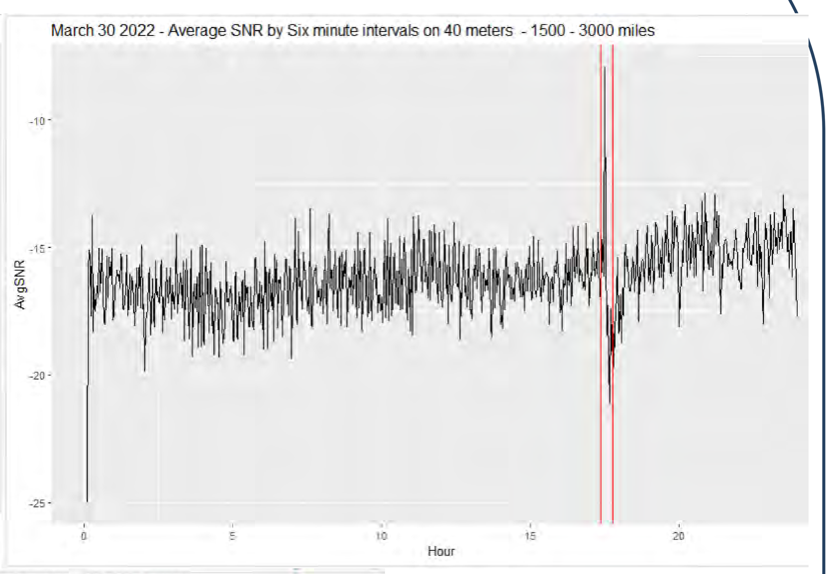
The propagation metric chosen is SNR vs. tenth of Hour (6-minute intervals). The time interval is a compromise between smoothing out random fluctuations while maintain information related to flare progress. Using an interval greater than the length of the flare will "wash out" flare impacts, by including them in a running average with observations before and after the flare. Using too small an interval will cause averages to reflect the unique characteristics of individual observations, rather than overall impact of flare-induced propagation changes.

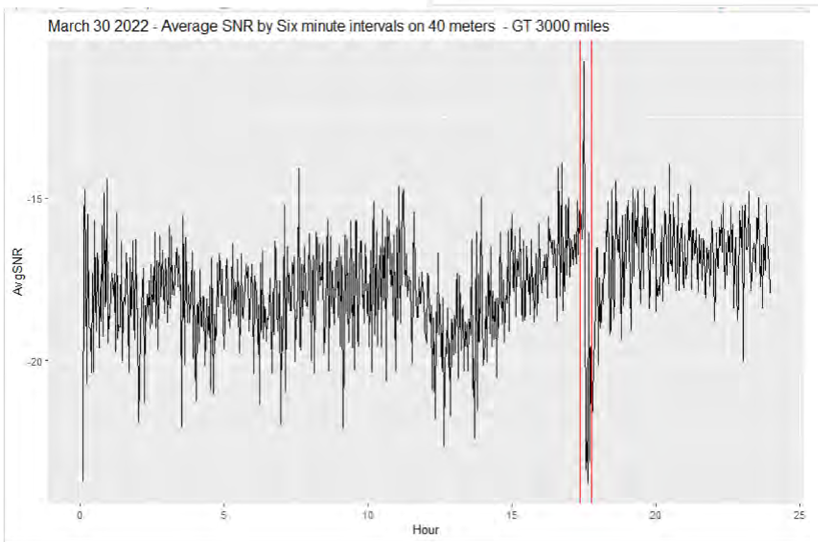
The following are the SNR vs. time plots for each distance range. The duration of the x-class flare is shown by vertical red lines:











The graphs show an immediate impact of the X1.3 class flare for all distance ranges except the "under 40 miles"

Conclusion

WSPR SNR data, when summarized for a large area affected by a major solar flare, provides dramatic evidence of the impact on propagation. This allows tracking the progress of the flare and subsequent recovery. Note that graphs for all distances over 500 miles show an initial sharp decrease in SNR, suggesting a transient propagation enhancement.

References

In addition to previously noted citations, the following articles were used in developing this analysis:

- https://www.swpc.noaa.gov/phenomena/solar-flares-radio-blackouts
- https://www.spaceweatherlive.com/en/archive/2022/03/30/xray.html
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