

HF Radio Observations of X1.5 Solar Flare at Anchorage, Alaska on 3 July 2021

Whitham D. Reeve

Solar Active Region 2838 produced an X1.5 x-ray flare between 1418 and 1429 on 3 July 2021 (figure 1). The Space Weather Prediction Center (SWPC) Events report showed numerous radio emissions associated with the flare including bursts in the UHF and SHF ranges and sweeps in the HF and VHF ranges {[SWPCEvnt](#)}. The flare was reported by SpaceWeather.com as the strongest since September 2017 ([SpWx](#)). It also was the strongest so far in solar cycle 25.



Figure 1 ~ Solar flare images for 3 July. Left: SDO/AIA 094 {[SDO](#)} image shows the flare near the northwest limb at 1435 UTC shortly after its peak in extreme ultraviolet (EUV) wavelength of 9.4 nm, corresponding to a temperature of 6 million kelvin. Right: SWAP instrument on {[PROBA2](#)} almost simultaneously recorded the flare at 17.2 nm wavelength, corresponding to a temperature of 1 million kelvin. The time of this image is 1433.

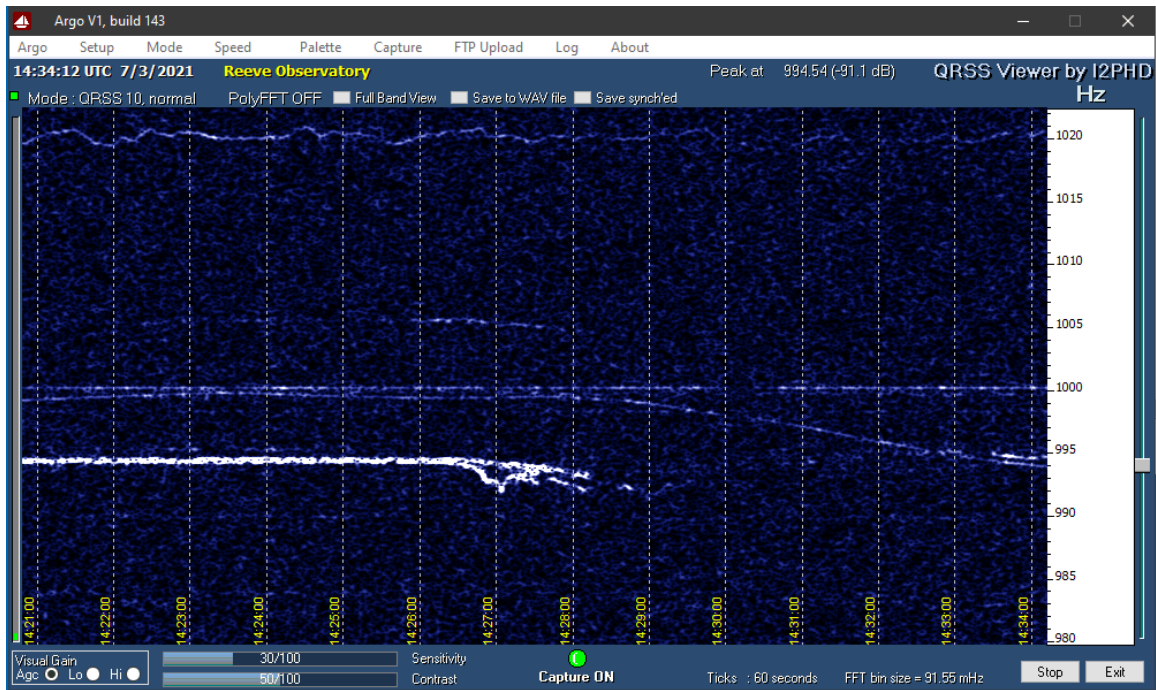


Figure 2 ~ Argos narrowband horizontal waterfall from 1421 to 1434 UTC. The white trace in the lower-left half of the image is the weak WWV or WWVH carrier at 15 MHz that has been demodulated to 995 Hz in LSB mode. A small sudden frequency deviation at 1426:30 indicates the initial disturbance in Earth's ionosphere along the path. The signal disappears entirely at 1428, indicating a radio blackout at that frequency. However, the blackout lasted only several minutes and the signal recovered to preflare levels around 1450 (not shown). The faint traces on this image are spurious signals.

The flare occurred when the Sun was over the mid-Atlantic Ocean and about 2 hours after the Anchorage sunrise. The flare's effects on HF radio propagation at 15 MHz are shown in a narrowband spectrogram waterfall (figure 2). The WWV/WWVH time-frequency transmitters supplied the signal received at Anchorage. It is not known which of the two transmitters was being received, but it probably was WWV in Colorado (about 3800 km away). The initial effect was a small sudden frequency deviation (SFD) of about 2 Hz starting at 1426:30 UTC and lasting 1 minute. The signal then disappeared altogether.

Flare radiation produced heavy D-region absorption (figure 3) leading to the radio blackout. Although propagation across the Atlantic was most affected, the radio blackout also reached propagation paths throughout the lower-48 United States and even Alaska. The flare also produced some minor geomagnetic effects but these were not evident on the Anchorage SAM-III magnetometer because of masking by the natural geomagnetic activity at higher latitudes (Anchorage is 62° N magnetic latitude).

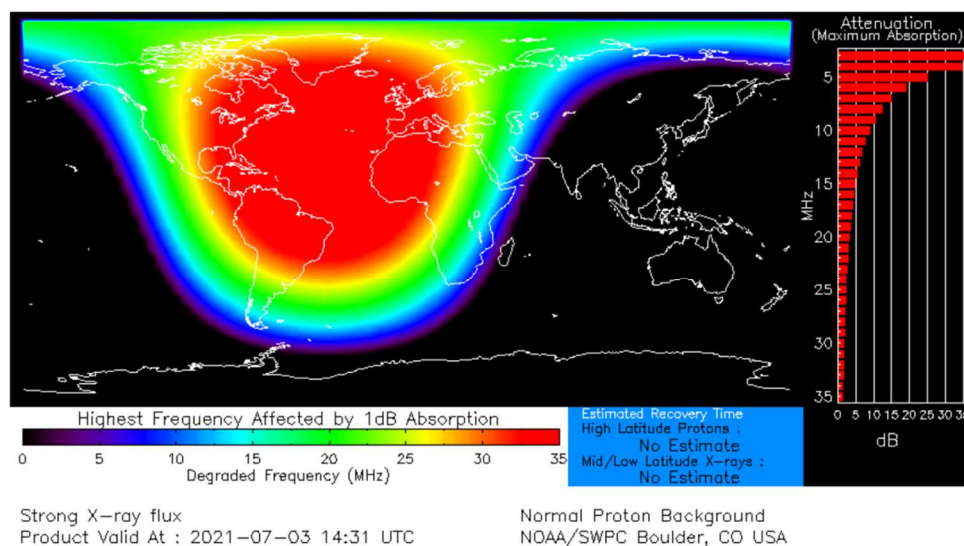


Figure 3 ~ D-Region Absorption Prediction (D-RAP) model results at 1431 UTC on 3 July. The red area shows that the D-region absorption increased at least 1 dB up to 35 MHz; frequencies below 35 MHz in this area experienced higher absorption. The green-turquoise areas along the edges correspond to at least 1 dB absorption at 15 MHz. The path from WWV near Fort Collins, Colorado to Anchorage is within this area. Image source: {D-RAP}

Instrumentation: An Icom R-8600 wideband receiver was used with a rotatable KMA-1832 log periodic dipole array antenna. The receiver was tuned to 15.000 995 MHz in LSB mode with the AGC turned off. Argo software running on an observatory PC produced the narrowband spectrum waterfall shown above.

References:

- {D-RAP} <https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap>
- {PROBA2} <https://proba2.sidc.be/ssa>
- {SDO} <https://sdo.gsfc.nasa.gov/data/aiahmi/>
- {SpWx} <https://spaceweather.com/archive.php?view=1&day=03&month=07&year=2021>
- {SWPCEvt} <ftp://ftp.swpc.noaa.gov/pub/indices/events/20210703events.txt>