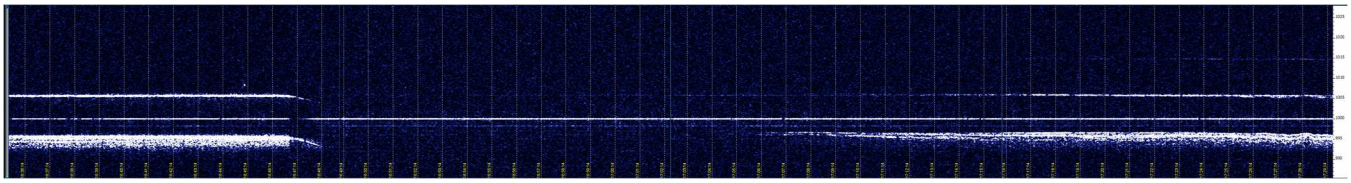
X8.7 Flare Observed at Radio Frequencies

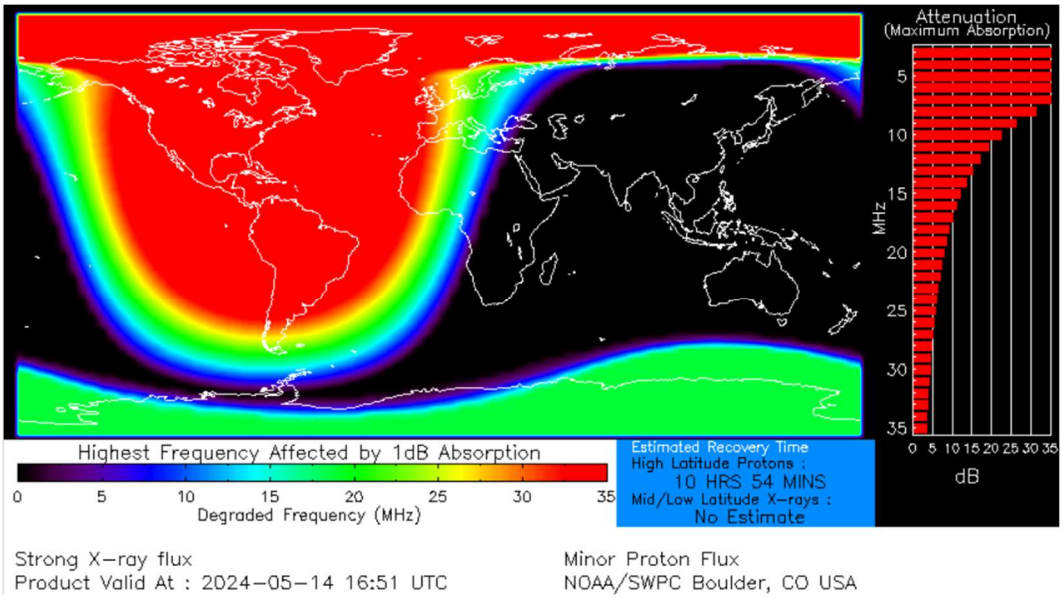
Whitham D. Reeve

An x-ray flare with magnitude X8.7 was observed on 14 May 2024. It was the strongest flare during solar cycle 24 up to that time. The flare radiation increased the electron density in the ionosphere's D-region, producing heavy absorption of HF radio signals and an HF radio blackout on Earth's sunlit side. Of particular interest was the almost instantaneous blockage at 1646:45 UTC of signals propagating from the time-frequency stations WWV in Fort Collins, Colorado and WWVH in Kekaha, Kauai, Hawaii to Anchorage, Alaska. The received signals at 15 and 20 MHz started to recover about 20 and 30 minutes later, respectively. The image below shows the event's time sequence in a narrowband horizontal waterfall spectrogram.



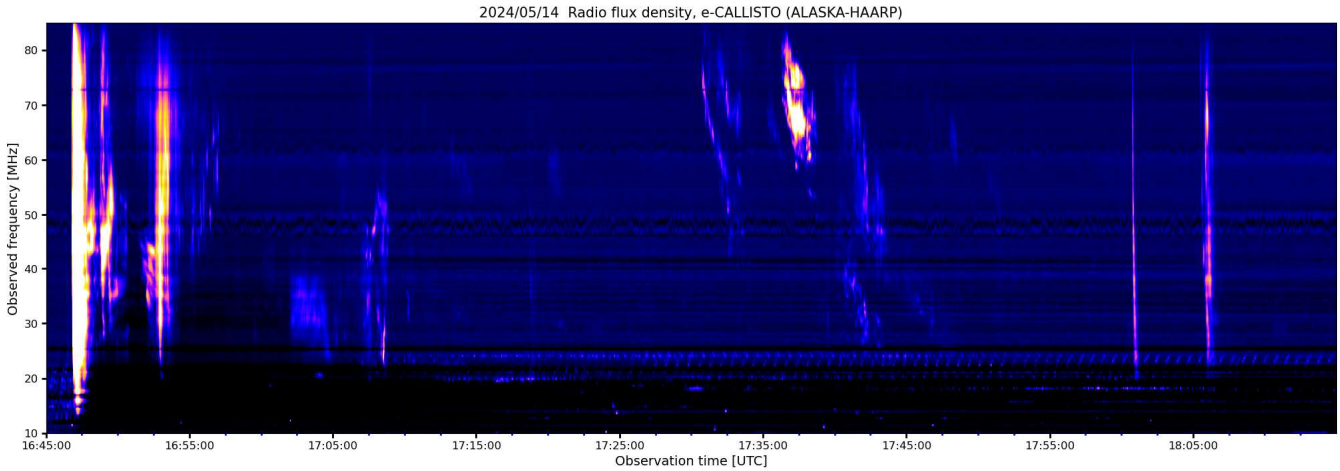
Narrowband spectra from 1636 to 1729 on 14 May 2024 UTC as observed at Anchorage, Alaska. Time is measured left-to-right with 1 minute tick-marks (faint vertical yellow lines). The frequency of the demodulated carrier is shown on the right vertical scale and extends from 985 at the bottom to 1030 Hz at the top. The receivers were tuned nominally 1 kHz above the carrier frequency and set to the LSB mode. The lower white trace at 995 Hz corresponds to a carrier frequency of 15 MHz, and the somewhat narrower trace at 1005 Hz near the middle of the frequency scale corresponds to a carrier frequency of 20 MHz. The thin continuous trace between 995 and 1005 Hz is a spurious signal. Note the almost instantaneous nature of the radio blackout and the relatively slow recovery. The receivers were Icom R-8600 *Communications Receivers* and the antenna was an 8-element KMA-1832 log periodic dipole array. The waterfall spectra was produced by Argo software and consists of four 13 minute images that have been spliced together.

Another representation of the radio blackout phenomena on the sunlit side of Earth is seen in the D-Region Absorption Prediction (D-RAP) plot below. This plot is based on spacecraft data and a rather simple model.



The D-RAP plot at 1651 UTC shows absorption at low- and mid-latitudes exceeding 35 dB at low frequencies (right-hand scale) from flare radiation. Persistent and similarly heavy absorption was predicted earlier in the day for high latitudes from energetic particle precipitation (mostly protons) into the high-latitude ionosphere. The high-latitude absorption was associated with preflare solar activity. Image source: https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap

The Callisto radio spectrometer and LWA Antenna at the HAARP facility near Gakona, Alaska captured solar radio bursts at the time of the flare and are shown in the spectrogram below. Space Weather Prediction Center (SWPC) reported the flare "*produced Type II and Type IV sweeps, a 10 cm burst and a Castelli-U signature*"; however, the U-signature is not apparent in any of the e-CALLISTO spectrograms that captured this particular flare event. The U-signature phenomenon may have been observed by SWPC at frequencies above those being observed by the e-CALLISTO network but SWPC did not specify the frequency range of their observation.



Callisto radio spectra from 10 to 85 MHz for the period 1645 to 1900 on 1 June 2024 shown in a broadband horizontal waterfall spectrogram. Strong Type III fast radio sweeps are seen at the time of the flare on the left side of the plot and banded Type II slow radio sweeps at about 1735 near the middle. The Type II was caused by a coronal mass ejection associated with the flare. Additional Type III sweeps can be seen near the right side of the chart. Image courtesy of Christian Monstein who used data archived at FHNW Brugg/Windisch and IRSOL Locarno, Switzerland.