Observations in Alaska of Solar Radio and Magnetic Activity During February 2023

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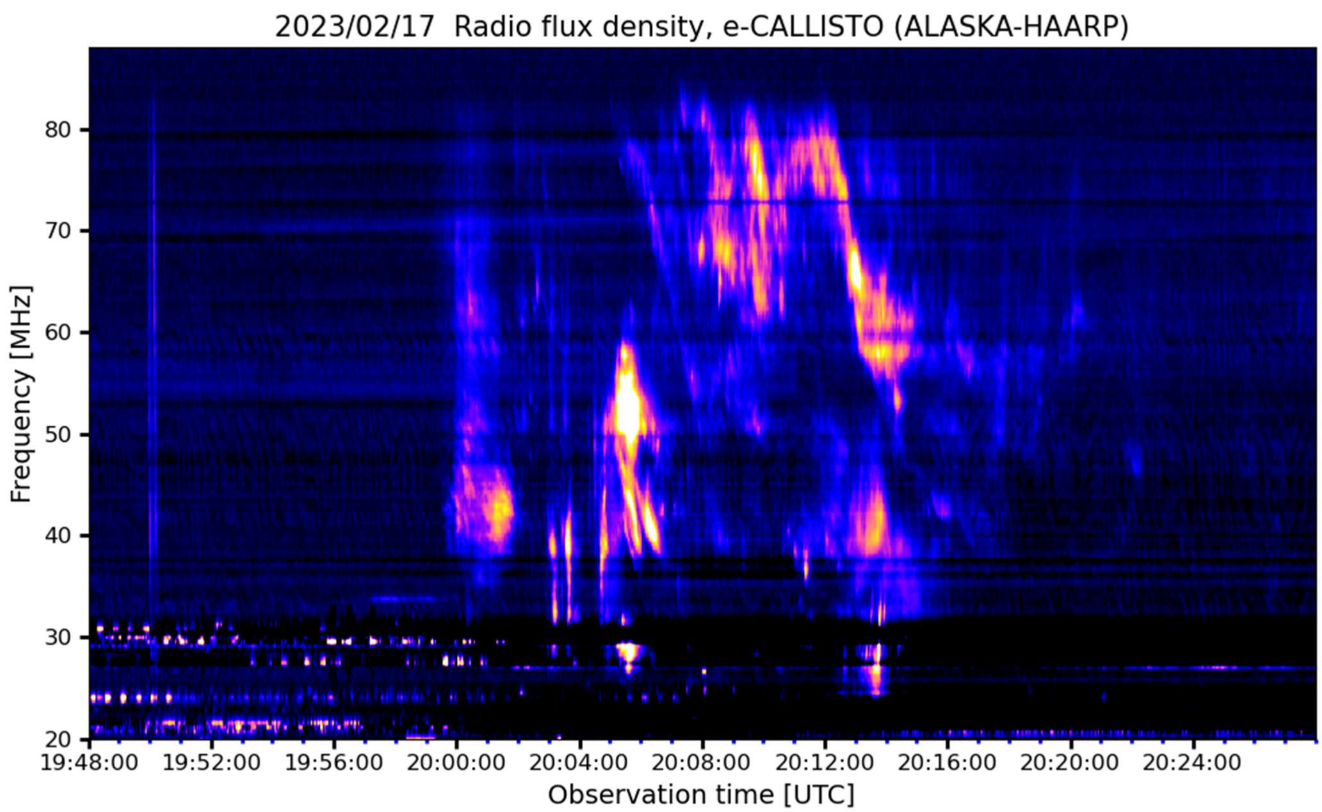
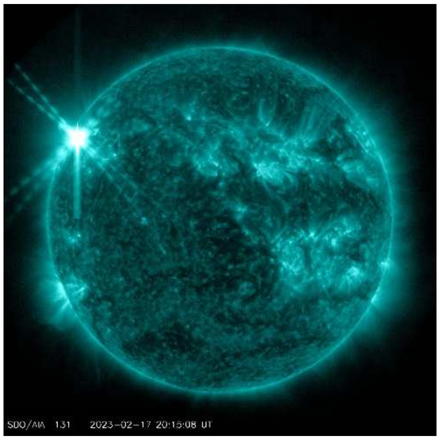
Type II Slow Radio Sweep on 17 February: The radio sweep was observed at the HAARP and Cohoe Radio Observatories by Callisto spectrometers and LWA Antennas but the associated received spectra are shown only for HAARP in the image below. The radio event started at 2000 and ended at about 2020. Harmonics usually accompany Type II sweeps in ratios of about 1.8 to 2.0 and some are visible in the image. The received spectra have a complicated structure and may include overlapping Type III and other radio phenomena. A double Type III radio burst is visible in the spectra at about 1950. See https://reeve.com/Solar/Solar.htm for burst definitions. The Sun position from HAARP was 153.3° true azimuth and 12.9° elevation at the time of reception.



Space Weather Prediction Center (SWPC) reported that solar active region 3229 produced an X2.2 x-ray flare at 2016 (see image of the Sun below). The flare, in turn, produced a coronal mass ejection (CME). Type II radio sweeps are very often observed with CMEs. In addition to the Type II, the flare produced radio emissions over a very wide bandwidth.

Based on CME imagery and the radio sweep characteristics, SWPC estimated the CME velocity to be 2,407 km s^{-1}. Assuming the estimate was along the Sun-Earth line, the CME would arrive at Earth in 17.3 h, or approximately 1343 on 18 February. However, the actual arrival time was 1039 on 20 February, a time of flight of 62.1 h. Therefore, the average speed toward Earth was closer to 671 km s^{-1}. The interplanetary shock from the CME arrived at the DSCVR spacecraft at 0952 on 20 February, 47 minutes before a sudden impulse was observed at Earth's magnetosphere. The DSCVR spacecraft is approximately 1.5 million km inside Earth's orbit in a line with the Sun. Assuming the magnetosphere's radius was $8R_E$ (51 thousand km), the distance the shock traveled from the spacecraft to the magnetosphere (to produce the sudden impulse) was approximately 1.45 million km. Therefore, the average speed in that segment of travel was about 514 km s^{-1}. The difference in calculated speeds most likely is due to the assumptions and approximations.



Solar Dynamics Observatory (SDO) image of the Sun at 13.1 nm wavelength showing the flare near the northeast limb at 2015. This wavelength emphasizes a spectral line emitted by iron atoms that have lost 19 and 22 electrons at temperatures of 10 000 000 K and is used to study solar flares and other high-energy solar phenomena. Image source: NASA

<u>Geomagnetic Sudden Impulse on 20 February resulting from the 17 February CME</u>: The sudden impulse mentioned above was recorded on the HAARP SAM-III magnetometer at 1039; see magnetogram below. The magnetometer sensors are located about 50 m from the LWA Antenna used to capture the radio sweep. The sudden impulse was strongest on the x-axis (east-west, blue trace) but also recognizable on the y-axis (north-south, red trace). A small negative deflection on the z-axis (vertical, green trace) barely exceeded the background noise level. A geomagnetic storm sometimes follows a sudden impulse but not in this case. An almost identical magnetic response was recorded on the Anchorage SAM-III magnetometer about 300 km southwest of HAARP. HAARP magnetograms may be viewed in real-time at: https://reeve.com/SAM/SAM-HAARP/SAM-HAARP_simple.html .