

# Nature's 4<sup>th</sup> of July Fireworks Observed in Alaska

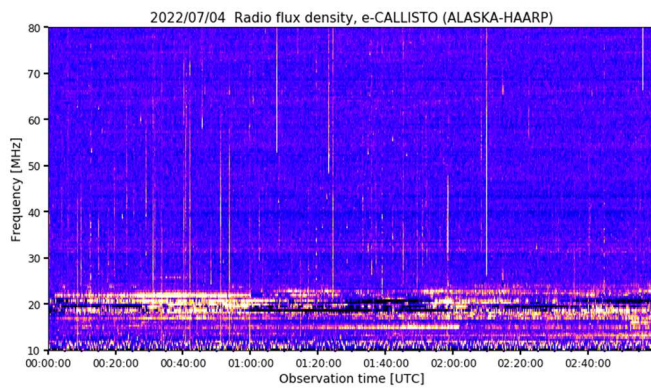
Whitham D. Reeve

Nature celebrated the USA's greatest holiday, Independence Day – July 4<sup>th</sup>, with plenty of electromagnetic fireworks. The Sun produced numerous flares and radio bursts. The collision of a coronal mass ejection with Earth disturbed its magnetic field, producing aurora radio reflections. Terrestrial lightning produced broadband radio emissions. These were observed at three locations in Alaska – Anchorage Radio Observatory, Coho Radio Observatory and HAARP Radio Observatory – and discussed below. See Instrumentation section for information on the site locations and a brief description of the instrumentation and Resources section for internet links to explanations of the phenomena.

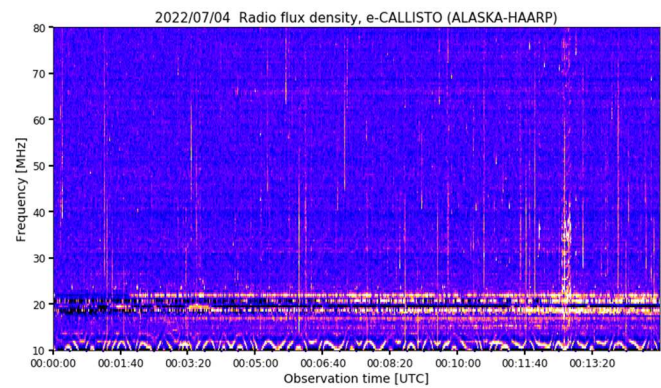


Thunderstorms developed during the local afternoon above the broad plain on which the HAARP Radio Observatory is located. The images below show the associated lightning activity as bright vertical lines over the frequency span of 10 to 80 MHz on two time scales. The left image spans the 3-h period from 0000 to 0300 UTC and the right image spans the 15-min period from 0000 to 0015. Note that the spectra appear very similar at both time scales. The bright horizontal lines below about 22 MHz are terrestrial HF transmissions.

HAARP lightning: 0000-0300 UTC

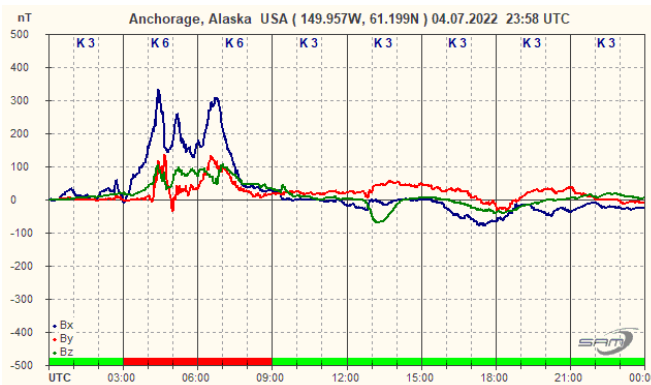


HAARP lightning: 0000-0015 UTC

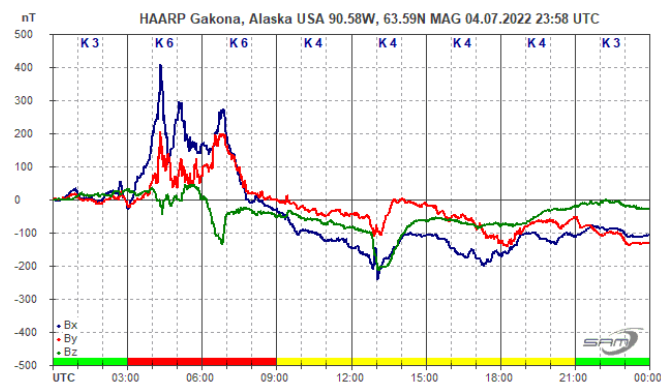


The two 24-h magnetograms below show geomagnetic activity observed at Anchorage Radio Observatory and HAARP Radio Observatory. The disturbances are quite pronounced in the 0300 to 0600 and 0600 to 0900 UTC synoptic periods. These were caused by merging of Earth's magnetic field with the solar magnetic field embedded in a coronal mass ejection from 29 June, altering the currents in the auroral electrojet and the magnetic field measured on the ground. The magnetograms show broad similarities but subtle differences.

Anchorage SAM-III Magnetogram



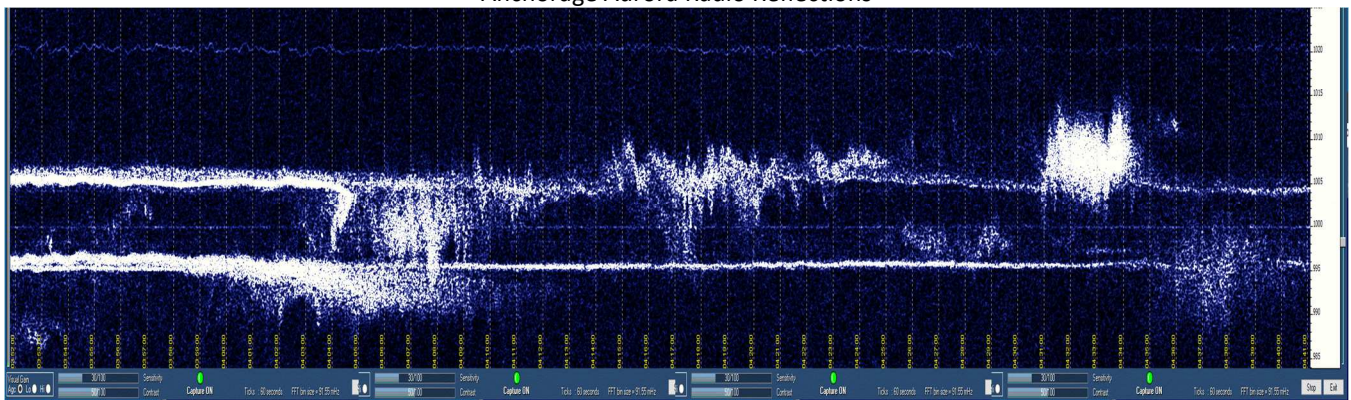
HAARP SAM-III Magnetogram



The separation in geomagnetic latitudes of the two observatories can explain some of the differences seen in the plots. The geomagnetic coordinates are 61.72° N, 94.41° W for Anchorage and 63.95° N, 90.58° W for HAARP, a difference of about 2° in latitude. The magnetometer at HAARP was installed only a few days before the measurements and the buried sensors were still acclimating to the underground temperatures over the holiday and showed some temperature related drift.

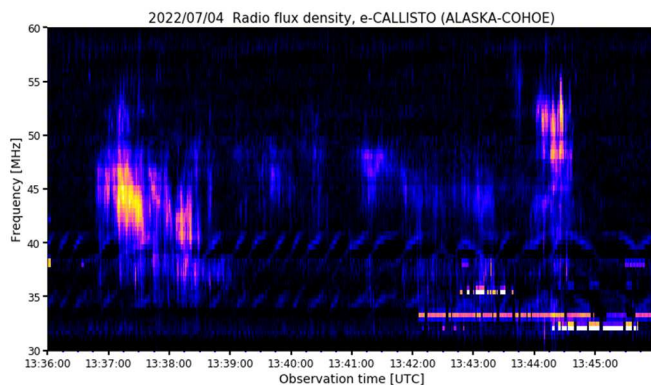
The narrowband spectrogram image below shows HF aurora radio reflections received at Anchorage Radio Observatory. The vertical frequency scale spans 40 Hz, and the horizontal time scale is the 50-min period between about 0350 and 0440 UTC. The 1-minute time stamps are seen as faint vertical yellow lines. The lower and upper traces correspond to demodulated WWVH carriers on 15 and 20 MHz, respectively, propagated to and reflected by enhanced electron density regions associated with aurora estimated to be 500 to 1000 km north of Anchorage. The reflections are related to the geomagnetic disturbances previously described. Four Argo spectrogram images were stitched together and then stretched vertically to visually enhance the reflections.

Anchorage Aurora Radio Reflections

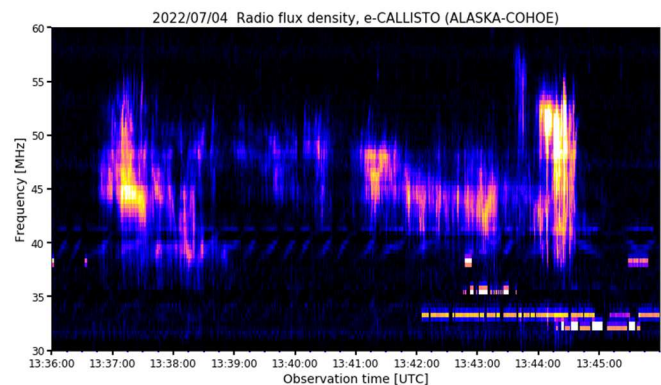


The spectra below from 30 to 60 MHz appear as *curtains of fire* and were obtained by the Callisto spectrometer instrumentation at Cohoe Radio Observatory and HARRP Radio Observatory in left- and right-hand circular polarizations (LHCP and RHCP, respectively). The spectra span the 10-min period from 1336 to 1346 UTC and show continuum radio emissions (possibly Type IV flare continuum) from the Sun. Space Weather Prediction Center reported a C5.1 x-ray flare and a Type II slow radio sweep during this time period but the sweep is not obvious in the spectra. The spectral structures are slightly different between the two observatories as are the polarizations. The bright horizontal lines below 36 MHz late in the Cohoe Radio Observatory spectra are radio frequency interference of unknown origin.

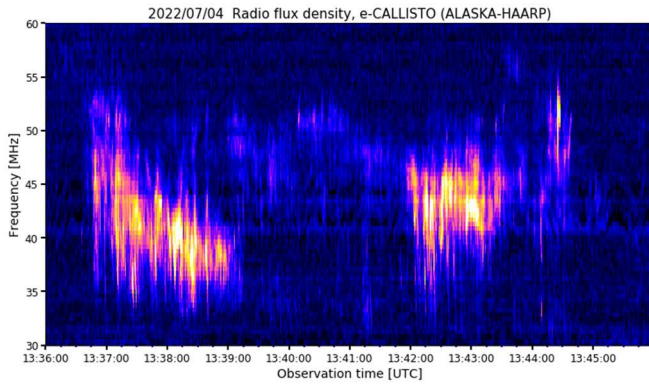
Cohoe Solar Radio LHCP



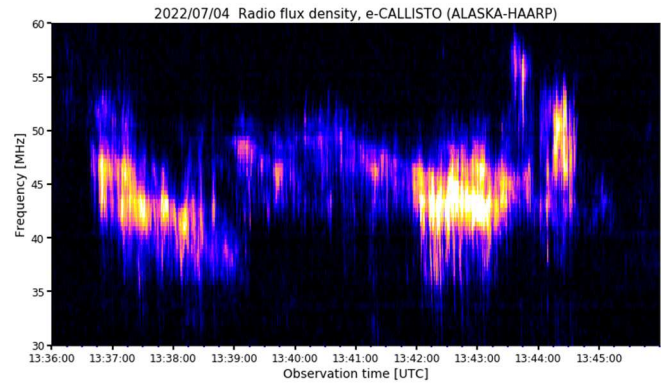
Cohoe Solar Radio RHCP



HAARP Solar Radio LHCP



HAARP Solar Radio RHCP



LWA Antenna at HAARP Radio Observatory on 1 July 2022, just before the holiday. The HRO equipment is collocated on the science pad with the Modular UHF Incoherent Radar (MUIR). Image © 2022 W. Reeve.

Instrumentation:

- ⚙ Anchorage Radio Observatory, Anchorage, Alaska: 61° 11' 57.62" N, 149° 57' 23.49" W, 22 m AMSL
  - 8-element log periodic dipole array connected through a multicoupler to Icom R-8600 wideband receivers (LSB mode and carrier frequency offset) with audio outputs connected through an analog audio mixer to a PC soundcard, Argo software
  - SAM-III 3-Axis Magnetometer, SAM\_VIEW software;
- ⚙ Cohoe Radio Observatory, Cohoe, Alaska: 60° 22' 5.04" N, 151° 18' 55.74" W, 22 M AMSL
  - LWA Antenna connected through a quadrature coupler and RF power splitters to a dual up-converter and two Callisto instruments, Callisto software;
- ⚙ HAARP Radio Observatory, Gakona, Alaska: 62° 23' 20.93"N, 145° 8' 15.51" W, 562 AMSL
  - LWA Antenna (shown above) connected through a quadrature coupler and RF power splitters to a dual up-converter and two Callisto instruments, Callisto software
  - SAM-III 3-Axis Magnetometer, SAM\_VIEW software.

Resources:

- ⚙ Aurora radio reflections: HF Aurora Radio Reflections Observed at Anchorage, Alaska USA:  
[https://reeve.com/Documents/Articles%20Papers/Reeve\\_AuroraRadioObsrv.pdf](https://reeve.com/Documents/Articles%20Papers/Reeve_AuroraRadioObsrv.pdf)
- ⚙ Geomagnetism Tutorial: <https://reeve.com/Documents/SAM/GeomagnetismTutorial.pdf>
- ⚙ Solar radio burst types: <https://reeve.com/Solar/Solar.htm>
- ⚙ Space Weather Prediction Center: <https://www.swpc.noaa.gov/>
- ⚙ Type II Slow Sweep Radio Bursts: [https://www.reeve.com/Documents/CALLISTO/Reeve\\_Typell-Burst.pdf](https://www.reeve.com/Documents/CALLISTO/Reeve_Typell-Burst.pdf)

Acknowledgements:

Callisto FITS files, credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {[Callisto](#)}