Solar Radio Bursts and Gravity Waves Observed at HAARP, Gakona, Alaska USA

Whitham D. Reeve and Christian Monstein

Observations: Solar flares and coronal mass ejections (CME) were produced by the Sun on 30 and 31 March 2022 and their associated radio emissions were detected by the Callisto installation at the HAARP facility in Gakona, Alaska. The first image (figure 1) shows a Type II slow-sweep solar radio burst associated with a coronal mass ejection (CME). The radio sweep starts about 1735 UTC with a fundamental frequency of 60 MHz and then sweeps down to just below 20 MHz, the ionosphere's cutoff frequency at the time. Band-splitting is visible in the fundamental. A 2nd harmonic is seen in the spectrogram at 80 MHz about 1 minute after the fundamental. Band-splitting also appears to have taken place in the 2nd harmonic. A 3rd harmonic is visible at the top of the plot at approximately 1739. The irregular traces below 20 MHz are broadcast stations and other HF traffic that is seen every day in the Callisto spectrograms.

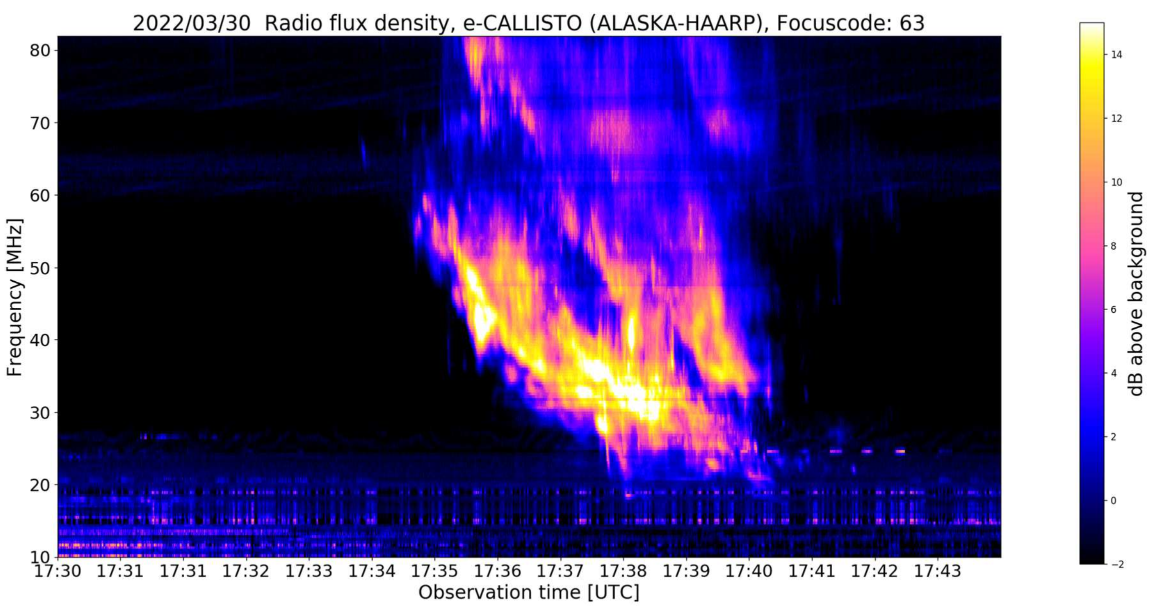


Figure 1 ~ Type II solar radio sweep with 2nd and 3rd harmonics and band-splitting observed on 30 March 2022. Credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {Callisto}

The next image (figure 2) shows another Type II slow sweep but this one was accompanied by a Type IV noise storm; these occurred almost exactly 24 hours later on 31 March. The Type II burst is much weaker than the day before, starting at about 1835 and 50 MHz. The Type IV noise storm is visible from about 1838 to 1841 and covers the frequency range from slightly under 25 MHz to the upper limit of the spectrogram at 80 MHz. Vestiges of the storm again appear in the spectrogram at 1844 at lower frequencies.

The two images discussed so far show only one polarization of the dual polarized Callisto system. Type II radio sweeps normally are unpolarized, and the HAARP Callisto data show this to be the case. On the other hand, Type IV noise storms can be strongly polarized (up to 100%), but the radio flux densities observed by the system showed the emissions were unpolarized (or very weakly polarized) in the 1830 to 1845 plots. Readers interested in solar radio emissions, may refer to a tabular summary of their characteristics at {Solar}. Also, a discussion of the source and effects of Type II bursts may be found at {Reeve18}.

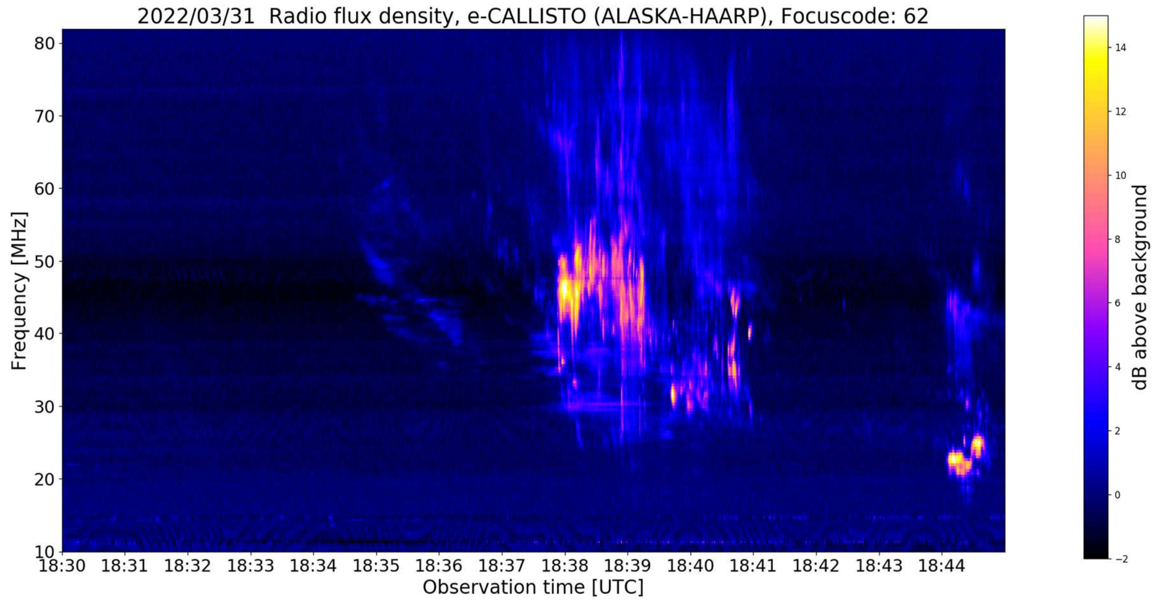
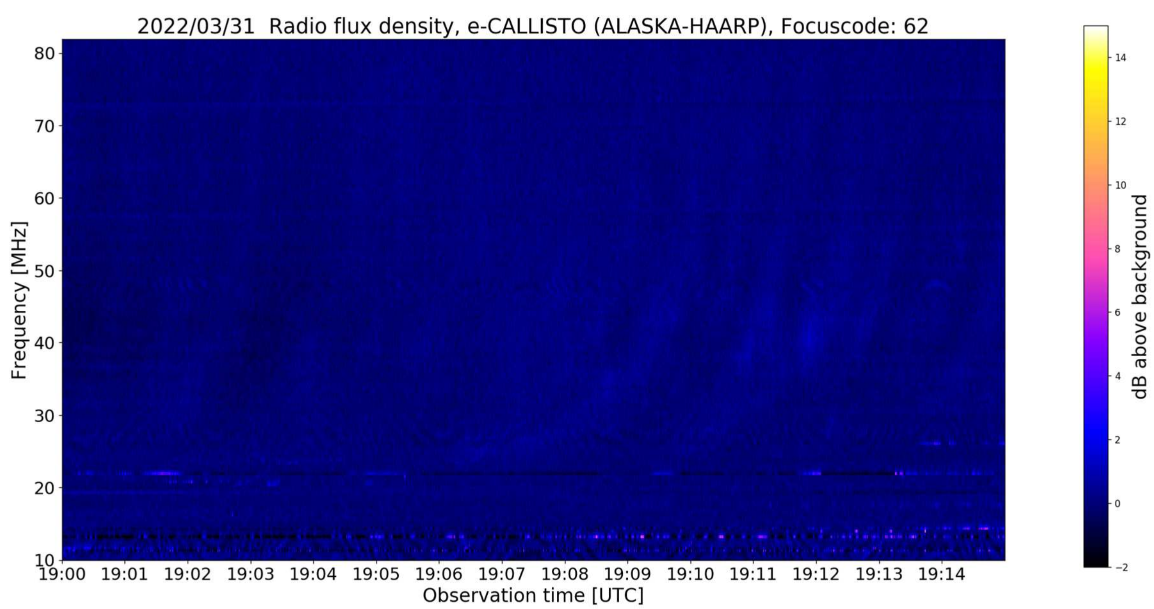


Figure 2 ~ Type II solar radio sweep accompanied by a Type IV noise storm observed on 31 March 2022. Credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {Callisto}

The last two images (figure 3) show weak atmospheric gravity waves (AGW) that manifest as slightly lighter blue, quasi-periodic bands sweeping gracefully from the lower-left to upper-right. The phenomena persisted for about 30 minutes, from 1900 to 1930 on 31 March. The gravity waves may have been caused by a traveling ionospheric disturbance (TID) that focused as spectral caustics the solar radio emissions from the Type IV noise storm discussed above. The noise storm persisted for several hours but mostly was too weak to be seen without the focusing effects. However, the storm can be seen between 20 and 50 MHz at about 1926. The plots below are for right-hand circular polarization. The plots for left-hand circular polarization show much weaker gravity waves, possibly indicating some level of polarization in the underlying radio emissions.



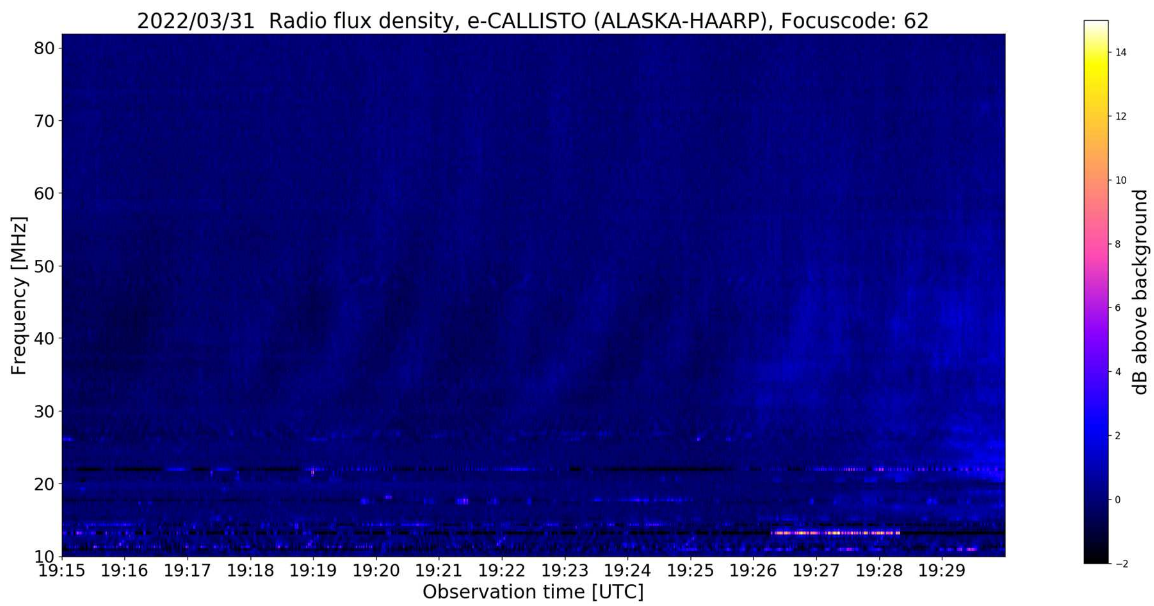


Figure 3 ~ Gravity waves observed on 31 March 2022 from 1900 to 1915 (upper) and 1915 to 1930 (lower). Weak evidence of the Type IV noise storm is seen between 1926 and 1930 UTC from below 20 to over 50 MHz. Credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {Callisto}

The source of the atmospheric gravity waves and traveling ionospheric disturbance may have been related to the geomagnetic storm conditions earlier in the day from 0600 to 1500 UTC. More complete information on the AGW and TID phenomena may be found at [Hunsucker].

Instrumentation: Active crossed-dipole (LWA Antenna) connected through an LWAPC-Q power coupler (with quadrature coupler) to a UPC-590L-M dual up-converter (5 to 85 MHz RF, 200 MHz IF) and dual Callisto instruments controlled by a PC running Callisto software. FITS data files produced by the system are automatically uploaded to FHNW in Switzerland {Callisto}.

References:

[Hunsucker] Hunsucker, R., Atmospheric Gravity Waves Generated in the High-Latitude Ionosphere: A Review, Reviews of Geophysics and Space Physics, Vol. 20, No. 3, May 1982

{Callisto} http://soleil.i4ds.ch/solarradio/callistoQuicklooks/

{Reeve18} Reeve, W., Analysis of a Type II Solar Radio Burst Observed on 20 October 2017, 2018, available at: https://www.reeve.com/Documents/CALLISTO/Reeve_TypeII-Burst.pdf

{Solar} https://www.reeve.com/Solar/Solar.htm