HIGH FREQUENCY ACTIVE AURORAL RESEARCH PROGRAM

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Date: November 1, 2023
To: Amateur Radio & Radio Astronomy Communities
From: HAARP Program Office
Subject: Notice of Transmission

The High-frequency Active Auroral Research Program (HAARP) will be conducting a research campaign November 4-8 UTC, with operating times specified in the table below. Operating frequencies will vary, but all HAARP transmissions will be between 2.8 MHz and 10 MHz. Actual transmit days and times are highly variable based on real-time ionospheric and/or geomagnetic conditions. All information is subject to change.

This campaign is being conducted in support of research proposals from the University of Alaska Fairbanks, Cornell University, University of Colorado Denver, the University of Florida, and the Georgia Institute of Technology. Some examples of experiments planned for this research campaign are the generation of artificial airglow and the production of ELF and VLF emissions. For more information on artificial airglow and ELF/VLF wave generation with HAARP, see the online HAARP FAQ at https://haarp.gi.alaska.edu/faq.

Transmissions at the times noted in **bold** may benefit from observers collecting receiver power and signal to noise ratio (SNR) as a function of time. These transmissions will be at 3.25 MHz with X-mode polarization and 30 seconds on, 30 seconds off cadence. Please submit data collected for this experiment to uaf-gi-haarp@alaska.edu.

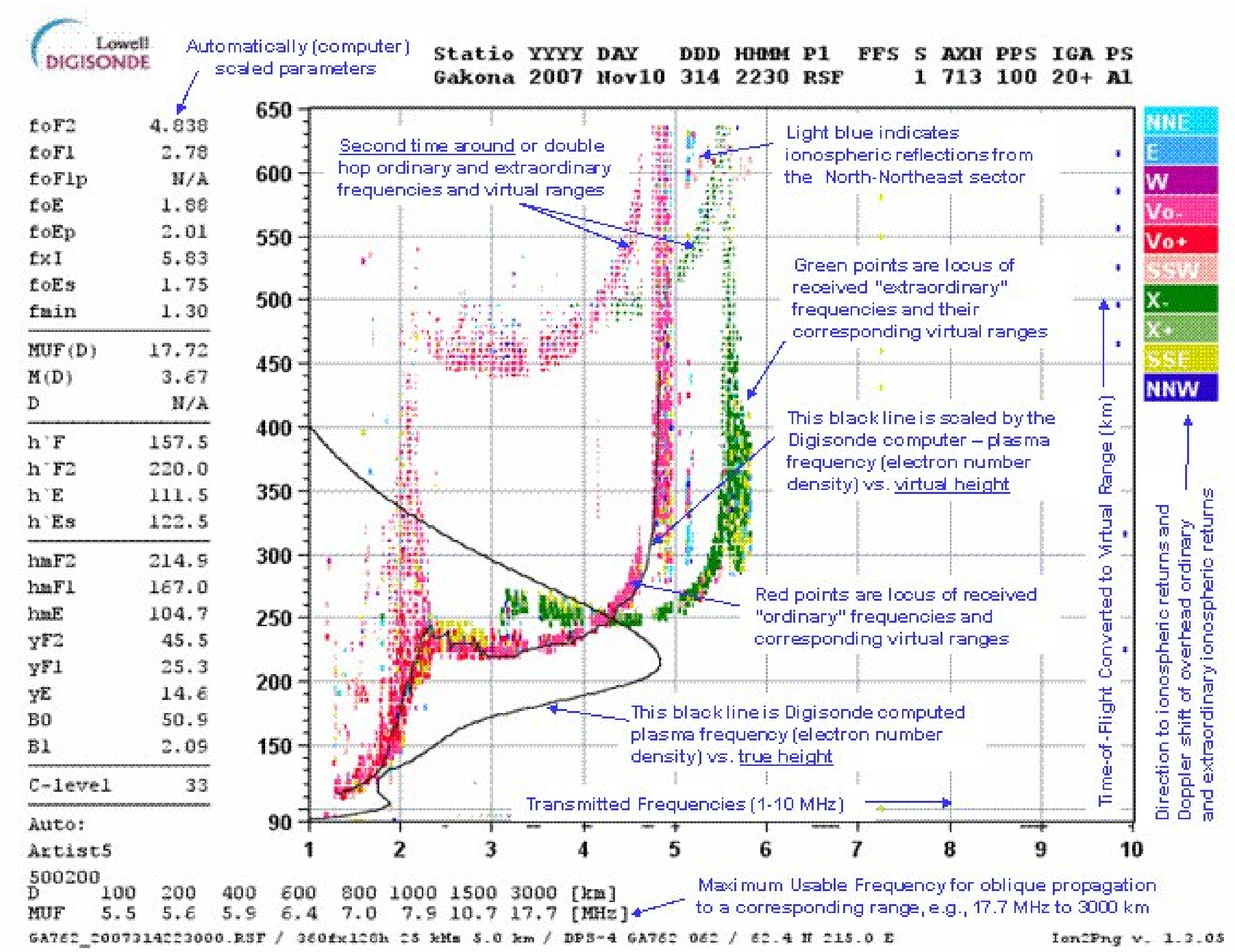
Date (UTC)	Nov. 4	Nov. 5	Nov. 6	Nov. 7	Nov. 8
Time (UTC)	2300-2400	0000-0500	0000-0630	0000-0600	0000-0600
Frequencies (MHz)	Below f_0F2	3.25, 6.8, 9.6	3.25, 5.8, 6.8, 9.6	3.25, 6.8, 9.6	3.25, 5.8, 6.8, 9.6
Notes	See Gakona ionograms for f_0F2, from HAARP Diagnostic Suite	Receiver power & SNR as function of time for **0430-0500** appreciated (3.25 MHz)	Additional transmissions at frequencies below f_0F2	Receiver power & SNR as function of time for **0430-0500** appreciated (3.25 MHz)	Receiver power & SNR as function of time for **0430-0500** appreciated (3.25 MHz)

For updates on ionospheric conditions in Gakona, please consult ionograms from the HAARP Diagnostic Suite: https://haarp.gi.alaska.edu/diagnostic-suite

Additional Resources for Reading Ionograms

Understanding HF Propagation and Reading Ionograms from Bootstrap Workbench:
https://www.youtube.com/watch?v=oTFKNCo3CI8

Reading Your Ionogram-Keeping It Simple from John (VE6EY):
https://play.fallows.ca/wp/radio/shortwave-radio/reading-your-ionogram-keeping-it-simple/



The image above is an annotated ionogram from HAARP that describes features that may be of interest. Note that f_0F2 is calculated at the top left.

f_0F2 is the critical frequency of the F2 layer of the Earth's ionosphere. This is the frequency at which radio signals stop refracting off the ionosphere and begin passing through to outer space. For certain HAARP experiments that deal with interactions in the ionosphere, transmission frequencies below f_0F2 are desirable, while for other experiments (such as those involving high-altitude satellites), staying above f_0F2 is required.

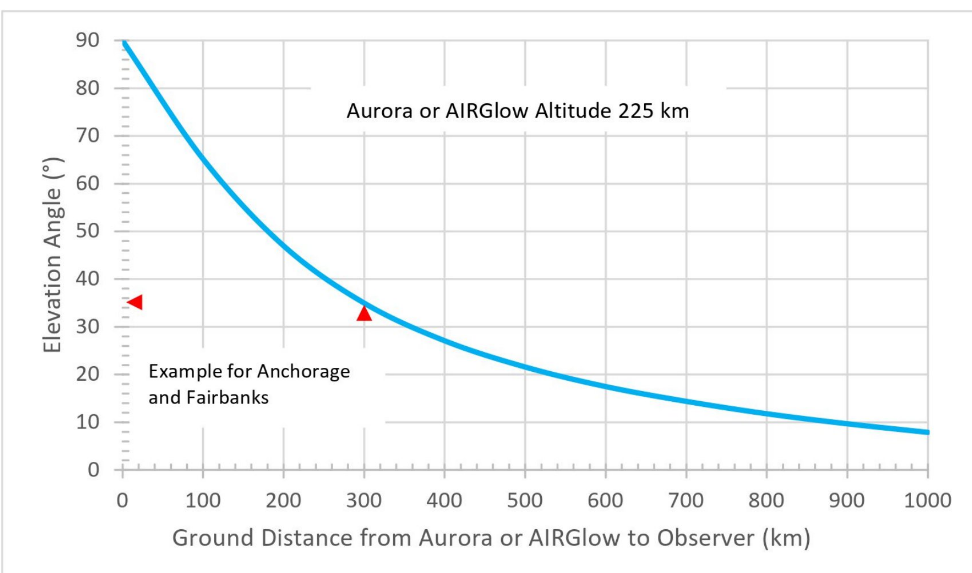
AIRGlow Observer Guide

The AIRGlow experiments pulse the HAARP transmitters on and off to create radio-induced aurora, also known as airglow and artificial aurora. The on transmissions add energy to, or excite, the gases in the upper atmosphere causing electrons to break free of their atomic bonds, a process called ionization. During the transmission off times, the electrons recombine with the molecules and atoms, and the atmosphere's gases de-excite. The de-excitation produces visible airglow between about 200 and 250 km (120 and 150 miles) altitude.

The artificial airglow can help us learn about the natural aurora and to answer questions such as: What causes the brightest airglow and why does it happen, and how do radio waves interact with ionized gases (plasma) in the upper atmosphere?

The phenomenon, if visible, will appear as a faint, red or possibly green splotch. Because of the way the human eye operates, the airglow might be easier to see when looking just to the side. The Earth's curvature prevents observations of the airglow from greater distances and, of course, the skies must be clear of clouds between the observer and the airglow. It is possible that mountains, buildings or tall trees will obstruct the line-of-sight of an observer toward HAARP. Even bright natural aurora or a bright Moon could wash out the visibility of the artificial aurora.

People within about 500 km (300 miles) of the HAARP facility can try to spot the airglow and even attempt to photograph it. The plot below shows the elevation angle (angle above the horizon) that an observer would look for the airglow. For example, say there are observers in Anchorage or Fairbanks. Both places are about 300 km from HAARP. First, find 300 km on the lower horizontal scale and then look directly above to the intersection with the blue curve. Read the elevation angle directly to the left of that intersection. In this example, the elevation angle is around 35°. Observers within 100 km (60 miles) will look almost straight up. The 500 km limit mentioned above is based on a 20° elevation angle. It is possible that some observers farther away than 500 km could have a clear line-of-sight to the airglow region above HAARP even though the elevation angle is below 20°. The opposite is true of closer observers that have mountains or tall trees in the line-of-sight.



An observer also will need to look toward the HAARP facility near Gakona, Alaska. From Anchorage, the azimuth is approximately north-west, or 60° from True North and 44° from Magnetic North as seen on a compass. An observer in Fairbanks would look south-east at approximately 154° from True North or 138° Magnetic North. Online maps or Google Earth can be used to determine the distances and azimuths for other cities in Alaska and western Canada.

Supplement to HAARP Notice of Transmission

General Information for HAARP Radio Enthusiasts:

1) The HAARP Ionospheric Research Instrument (IRI) transmits only in the frequency range 2.695 to 9.995 MHz, with certain frequencies blocked out as specified in the FCC license for call sign WI2XFX. The emission bandwidth may be up to 46 kHz wide depending on the frequency and experiment.
2) The types of modulation vary with the experiment requirements. Some emission designators are 16K0M0N, 26K0P0N, 40K5A3N, 43K0H0N, 46K0F3N, and 46K0N0N. Emission designators are not specified in HAARP experiments.
3) Most experiments depend on ionospheric and geomagnetic conditions that are mostly unpredictable. The transmission frequencies for a given experiment may change to track changes in those conditions with little or no notice.
4) A scheduled experiment that depends on certain ionospheric or geomagnetic conditions may be rescheduled or cancelled if the required conditions do not occur.
5) The IRI may be setup to simultaneously transmit two modulated or unmodulated carriers depending on the experiment requirements.
6) *To request a HAARP QSL card*, send reception reports to: HAARP, P.O. Box 271, Gakona, Alaska 99586 USA. Please note that due to the volume of requests received, it may take some time to respond to your request.
7) Additional information can be found on the HAARP webpage at: https://haarp.gi.alaska.edu/

Monitoring HAARP IRI transmissions with a Software Defined Radio Receiver:

1) Listeners with an SDR receiver capable of 8 MHz bandwidth can monitor the entire frequency band noted above;
2) Most IRI transmissions *Start* and *End* on the minute; that is, when HH:MM:SS = HH:MM:00, where HH is the UTC hour, MM is the minute and SS is the second;
3) When a carrier is seen to pop up on the SDR's displayed spectra, the listener can identify the center frequency using the SDR software and then reduce the bandwidth to further monitor, demodulate or analyze the signal;
4) If two SDRs are available, one can be used in a wideband mode to locate the signals and the other can be used in a narrowband mode to analyze, demodulate or monitor the signals;
5) Since the maximum emission bandwidth is 46 kHz (±23 kHz), SDRs with a 50 kHz bandwidth setting are able to monitor the entire modulated signal after it is located. The center frequency may be stepped through a range of frequencies or may change according to experiment requirements to another, far removed frequency;
6) Not all experiments use the full 46 kHz bandwidth, some use only a pure carrier and some use single sideband;
7) Radio propagation conditions and the IRI beam direction will affect the reception of the IRI transmissions or cause a fadeout at the receiver location. Propagation conditions and beam directions can change significantly and rapidly during an experiment;
8) Some experiments require the IRI beam to be pointed along the local magnetic zenith. This means the beam is pointed parallel to the local magnetic field lines, or approximately 75° elevation and 16° east of north;
9) Although the HAARP IRI transmits only in the HF range (see above), the transmissions can and some experiments are designed to generate SLF, ULF, and VLF emissions in the D/E-region ionosphere. Modulated heating of the D/E-region electrons by the HF transmissions in turn modulates the plasma conductivity, which generates a *virtual antenna* at altitudes between 70 and 85 km. Emissions up to 20 kHz have been demonstrated but most are below a few kilohertz. These low frequency emissions can propagate in the Earth-Ionosphere Waveguide or by other mechanisms, depending on frequency, and conceivably can travel great distances.