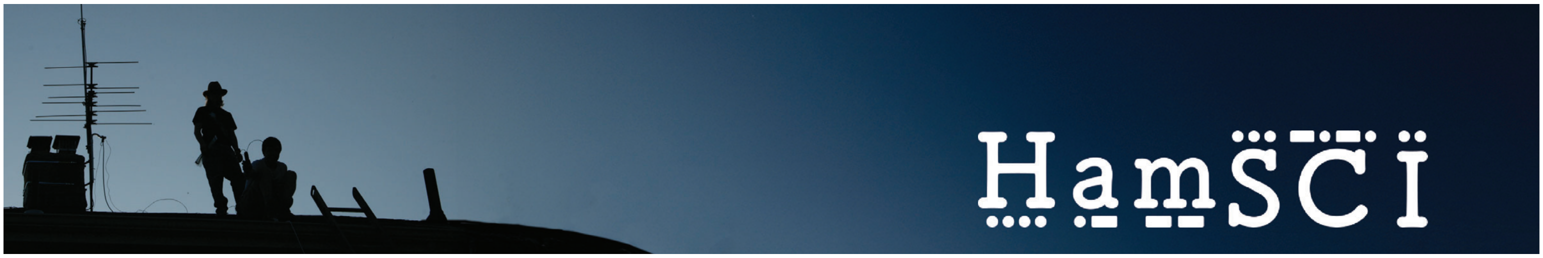


HamSCI: The Future of Ham Radio is Here

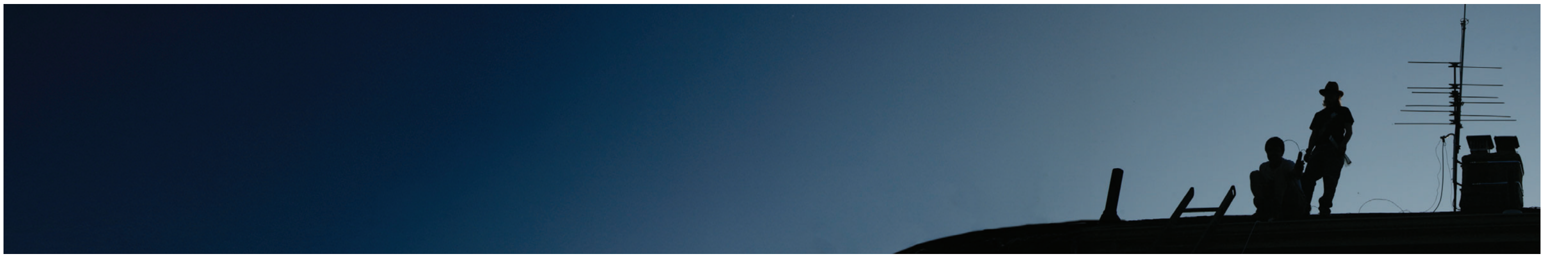
Nathaniel A. Frissell, W2NAF

Since the beginning of amateur radio, amateurs have significantly contributed to the advancement of technology and radio science. This is no accident, as the people who make up the amateur radio community are driven by a profound curiosity and passion. Equally passionate, the professional radio science community consists of scientists and engineers working to advance our understanding of the world around us. These communities share many common goals and interests, but each group has unique capabilities, resources, cultures, and perspectives. HamSCI combines these strengths.

HamSCI gathering at the 2025 Dayton Hamvention.

What is HamSCI?

Founded in 2015 in preparation for the 2017 Solar Eclipse QSO Party, the Ham Radio Science Citizen Investigation, or HamSCI, was created to bring the amateur and professional communities together for mutual benefit. HamSCI has three primary objectives. First, to advance scientific research and understanding through amateur radio activities. Second, to encourage the development of new technologies to support this research. Third, to provide educational opportunities for the amateur community and the general public. Today, the HamSCI community is engaged in multiple publicly funded projects and is recognized as an official NASA Citizen Science project.



Who Makes Up HamSCI?

HamSCI is a cooperative forum spanning both the amateur and professional communities. A number of academic institutions are represented along with amateur radio organizations (see the Acknowledgments at the end of this article). The real power of HamSCI is the ability for any individual, licensed or not, to join the community. Participation ranges from joining the group to learn something new, to helping collect and analyze data, to presenting at conferences. Participants might contribute to papers, design and build instrumentation, or even propose scientific campaigns.

Where HamSCI Data Comes From

Currently, the primary source of HamSCI data comes from real-time, global, amateur radio observing networks, such as PSKReporter, WSPRNet, WSPR-Daemon, and the Reverse Beacon Network (RBN). As an example, Figure 1 illustrates how space weather can be observed in this data. Here, a solar flare-induced HF radio blackout was observed by the RBN and WSPRNet. Figure 1a shows the 15-minute period before the flare, while Figure 1b shows the 15-minute period after. An 82% decrease in the number of HF communications paths was observed!

HamSCI members are also building a network of Personal Space Weather Stations (PSWS). A complete PSWS includes an HF receiver, a VLF receiver, and a ground magnetometer. The radio receivers utilize GPS disciplined oscillators (GPSDOs) to allow for precision frequency measurement. This capability allows the PSWS receivers to observe HF Doppler shifts.

Figure 2 illustrates one mechanism that can cause HF Doppler shift, using the 10 MHz signal from WWV in Colorado. Ionospheric processes cause the ionosphere to lower and rise in height. As the ionosphere lowers (as it does at dawn), the path length decreases causing a positive (blue) shift. As the ionosphere rises (as it does at dusk), the path length increases, causing a negative (red) shift. HamSCI PSWS HF receivers are designed to measure these shifts, which are often on the order of +/- 5 Hz or less.

PSWS HF receivers were developed at Case Western Reserve University's Case Amateur Radio Club, W8EDU, including the single-channel GRAPE 1 (See Figure 3a) and the more sophisticated three-channel

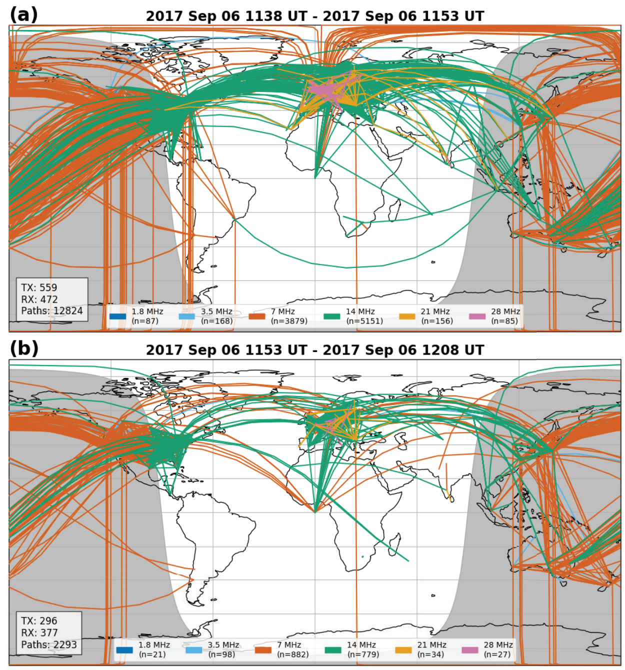


Figure 1

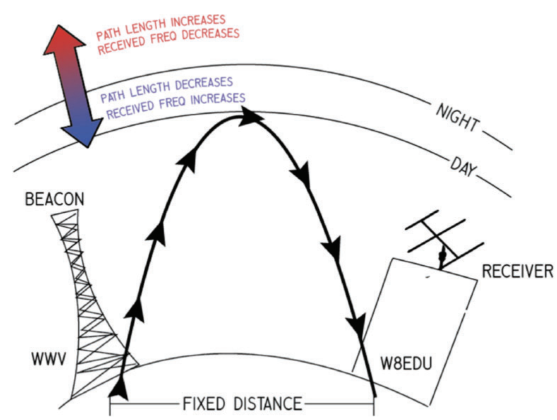
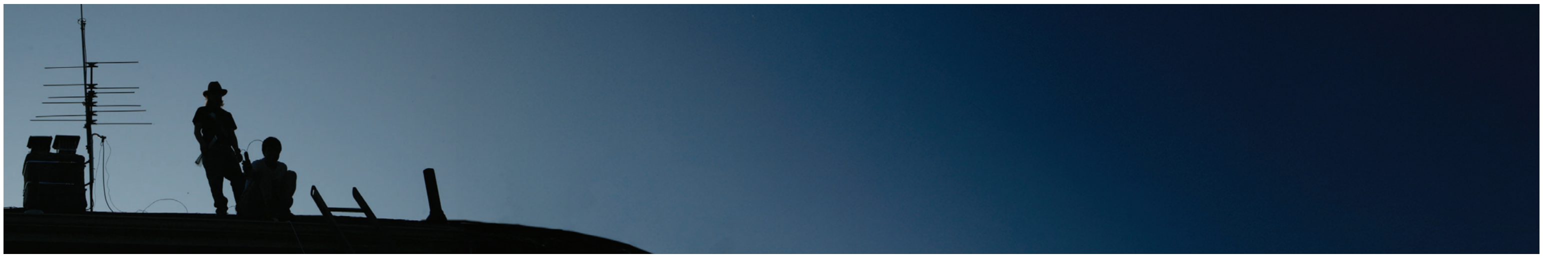


Figure 2

Figure 1 — An HF radio blackout observed by the RBN and WSPRNet on September 6, 2017. From *Frissell et al.* (2019, **https://doi.org/10.1029/2018SW002008**).

Figure 2 — A drawing showing one mechanism for HF Doppler shift. Blue indicates a positive shift and red indicates a negative shift. HamSCI PSWS HF receivers are designed to measure these shifts routinely. From *Collins et al.* (2022, **https://doi.org/10.1109/LGRS.2021.3063361**).



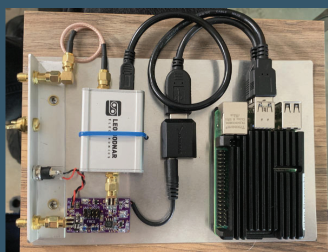


Figure 3a

Figure 3b

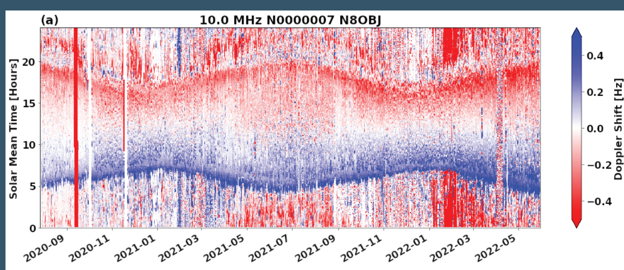


Figure 3c

Figure 4a

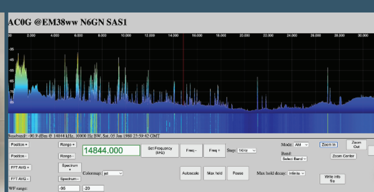


Figure 4b

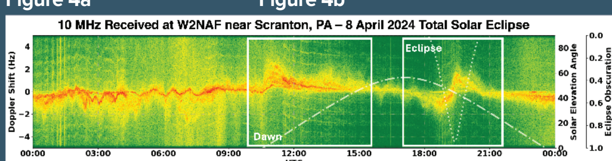


Figure 4c

Figure 3 — The (**a**) GRAPE 1 and (**b**) GRAPE 2 are receivers designed to measure the Doppler shift of signals received from stations such as WWV and CHU. (**c**) Two years of data from N8OBJ showing the Doppler shift of the 10 MHz signal produced by WWV near Fort Collins, Colorado received using a GRAPE 1. From *Collins et al.* (2023, **https://doi.org/10.5194/essd-15-1403-2023**).

Figure 4 — (**a**) An SDR-based Personal Space Weather Station consists of a Leo Bodnar GPSDO, a RX-888 SDR receiver, and a Linux computer running the *KA9Q-radio* and *WSPRDaemon* software. (**b**) The *KA9Q-web* interface allows the system to simultaneously be used as a general-coverage SDR receiver operating from 0.1 to 60 MHz. (**c**) 10 MHz observations at W2NAF on April 8, 2024, a day with a total solar eclipse traversing North America.

GRAPE 2 (See Figure 3b). Figure 3c shows almost 2 years of continuous 10 MHz Doppler observations from N8OBJ in Ohio.

HamSCI has adopted SDRs for newly deployed PSWS HF receivers, as shown in Figure 4a. This system uses the *KA9Q-radio* software by Phil Karn KA9Q, the *WSPRDaemon* data collection software by Rob Robinett, AI6VN, and the RX-888 SDR. The Linux-based system can decode WSPR/FT8 spots and observe HF Doppler shifts simultaneously across all relevant bands and channels from 0.5 – 60 MHz. The system can also be used as a web-based general coverage SDR receiver, thanks to the *KA9Q-web* interface (See Figure 4b). Figure 4c shows 10 MHz Doppler observations made using a RX-888-based PSWS receiver at W2NAF as part of the HamSCI Festivals of Eclipse Ionospheric Science (FoEIS).

How to Get Involved

First, visit **hamsci.org** and click the big, blue "Join HamSCI" button. From there, you can join the HamSCI Google Group, an open forum that facilitates discussion between the amateur and professional communities. That web page also gives links to multiple open, weekly Zoom telecons HamSCI hosts to support its various projects. You can join HamSCI on the air by participating in events such as the Meteor Scatter QSO Party (**hamsci.org/msqp**), or help collect data by installing a Personal Space Weather Station (**hamsci.org/psws**).

Acknowledgments

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