Solar Eclipse QSO Party Update

Results poured in and we're starting to crunch the numbers.

Ward Silver, NØAX

On the day of the solar eclipse, August 21, 2017, the HF bands were busy from the first minute of the Solar Eclipse QSO Party (SEQP) at 1400 UTC to the closing bell at 2200 UTC.

Propagation was excellent for mid-August. The Sun held off on generating any flares or Coronal Mass Ejections, so conditions were relatively quiet until well after the SEQP was done and the eclipse was no longer visible in North America. During the SEQP, the smoothed sunspot number (SSN) was 44, solar flux hit 83, and K_P was 3 or less — pretty good in summer near a solar minimum. These quiet geomagnetic conditions made the contact data more valuable because the effect of disturbances was minimized.

The automated receiver networks were busy, as Table 1 clearly shows. This is a *lot* of data! In a presentation[1] at the ARRL/TAPR Digital Communications Conference the following month by a HamSCI (**hamsci.org**) team, it was obvious that the Reverse Beacon Net (RBN; **reversebeacon.net**) receivers captured many signals crossing the path of totality. Figure 1 gives you an idea of the locations for contacts in SEQP logs with the different colors indicating different bands.

Table 1
SEQP Statistics as of September 29, 2017

SEQP Logs	656
SEQP QSOs	31,252
SDR Recordings	More than 50 Tb of data
Reverse Beacon Net	618,647 measurements
PSK Reporter	1,291,090 measurements
WSPRNet	631,685 measurements
EclipseMOB	191 recordings
Unique Calls	27,488 calls (raw data) from all sources

You can also clearly see a signature of the eclipse in the number of spots recorded on each band throughout the day. Figure 2 shows that, as expected, contacts on a higher-frequency band fell and rose on a lower-frequency band as the eclipse weakened the ionosphere's D and F regions. Other bands followed this general pattern.

The number of 14 MHz contacts decreases because signals at that frequency, which prior to the eclipse were cutting through the D region but still being refracted by the F region, were escaping into space because the F region was suddenly too weak. Conversely, the number of 3.5 MHz contacts increased because the D region disappeared, allowing the 3.5 MHz signals to reach the F region, which in spite of being weaker, still had enough density to refract lower signals back to Earth. When the eclipse finished and solar illumination returned, propagation returned to what it was before the eclipse.

The depth of de-ionization is shown in the *total electron content (TEC)* map shown in Figure 3. The MIT Haystack Observatory measured the electrons liberated by the solar ultraviolet at several sites along the path of the eclipse. The map shows the difference in TEC at 1815 UTC (when the shadow was on Missouri) from that at 1645 UTC (when the eclipse had just started for Oregon). Blue indicates a decrease in TEC caused by the decrease in solar illumination.

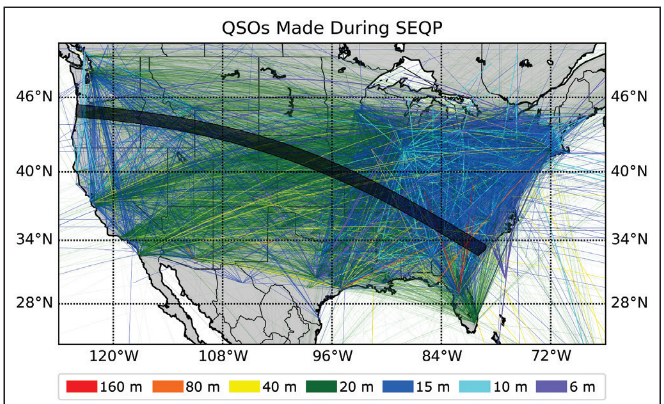

Figure 1 — A map of contacts made during the SEQP. Different bands are represented by the color legend shown under the map. [Graphic by Spencer Gunning, K2AEM, NJIT]

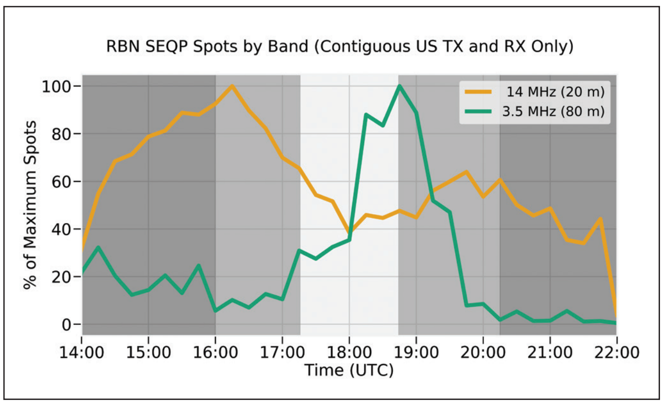

Figure 2 — Reverse Beacon Net (RBN) observations as a percentage of the maximum spots per band during the SEQP. The three shaded regions indicate the level of eclipse present on the continental US: dark (no eclipse), light gray (only partial eclipse), and white (total eclipse). [Graphic by Joshua Vega, WB2JSV, NJIT]

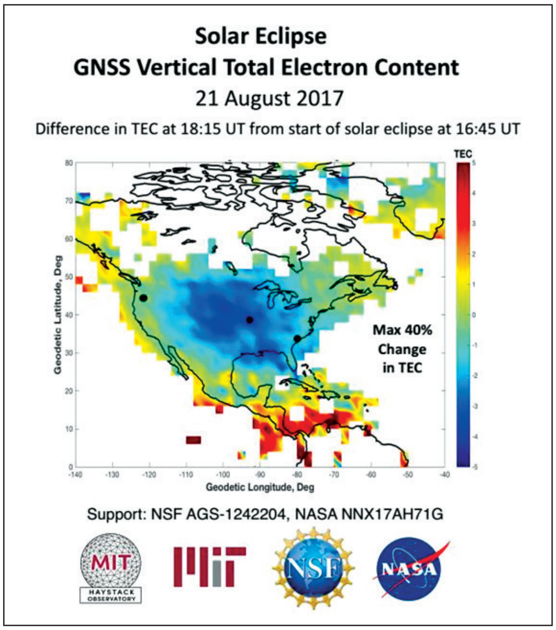

Figure 3 — The difference in total electron content (TEC) caused by the eclipse over Missouri. [Map generated by Anthea Coster, supported by NSF and NASA grants]

This does make a big difference for lower-frequency signals, especially the D-layer changes. Ethan Miller, K8GU, analyzed the RBN spots on 40 meters for 2 days, as shown in Figure 4. The top figure is a non-eclipse, "control" day (all magenta). As the Sun rises above the horizon (positive solar elevations), the D layer forms and short skip dominates with most contacts below 1,500 kilometers toward the upper right of the chart. On eclipse day, however, the Sun was high in the sky when the Moon blocked it (blue shades). During that time, contacts lengthened dramatically, indicating a loss of the D layer during the eclipse. The D layer rapidly reformed after the eclipse and short skip returned.

Not all of the data was so dramatic. Because the solar flux was relatively low, not much effect was seen above 14 MHz. A trio of receivers for the RF Seismograph (**www.nsarc.ca/hf/rf_seismo/main.html**) saw little effect on background noise levels. Measurements showing no effect are important, too, as the history of science makes clear.

It was conclusively demonstrated that the shadow of the eclipse stops ion production in the ionosphere. Amateurs observed Doppler shifts, phase shifts, and amplitude changes in WWV, WWVB, and AM radio station reception. The SEQP observations suggest the F layer rose and the D layer was depleted during the eclipse. While these effects weren't unexpected, they have been observed in far greater detail than ever before. This will allow a finely detailed validation of ionospheric and geomagnetic models against the recorded data, and that is where "new science" often happens as unexpected subtle behavior of a natural phenomenon is examined and explained.

A lot more graphics and measurements were made during the SEQP. Watch for more detailed articles online at the HamSCI website and in future issues of *QST* and *QEX* as the ionosphere gives up its secrets.

What's Next for HamSCI?

A workshop on the SEQP will be held at the New Jersey Institute of Technology on February 23 – 24, 2018. The research community is awakening to the use of amateur capabilities. For example, work is proceeding on the design of the HamSCI Amateur Radio Communications (HARC) database to help us transfer recorded data to the research community in a standardized way.[2] This is a great help to experiment design and reduces the cost of acquiring and analyzing the data.

This initial HamSCI event echoes the success of amateur-research collaboration reaching back nearly a century to the Listening Tests of the early 1920s that established the ionosphere's existence. Stay tuned for the next opportunity to contribute your skills as we advance the radio art.

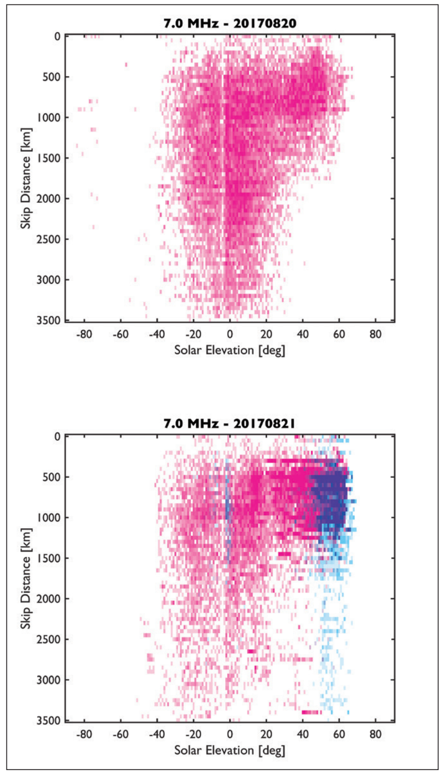

Figure 4 — RBN reception report distance versus solar elevation on 40 meters. Each bin counts spots, with darker bins having more spots. Magenta shows contacts made at non-eclipse times. Blue indicates contacts made during partial or total eclipse conditions. [Graphic by Ethan Miller, K8GU]

Notes

[1]Nathaniel A. Frissell, W2NAF (New Jersey Institute of Technology, NJIT), William Engelke, AB4EJ (University of Alabama, UofAL), Joshua D. Katz, KD2JAO (NJIT), Spencer W. Gunning, K2AEM (NJIT), Joshua S. Vega, WB2JSV (NJIT), "HamSCI and the 2017 Total Solar Eclipse," ARRL/TAPR DCC 2017.

[2]J. Katz, KD2JAO (NJIT), W. Engelke, AB4EJ (UofAL), N. Frissell, W2NAF (NJIT), "The H.A.R.C. Database and Visualization Utilities," TAPR DCC 2017.

You can contact Ward Silver, NØAX, at **n0ax@arrl.org**.