HamSCI and the 2017 Total Solar Eclipse

Nathaniel A. Frissell, W2NAF
Joshua D. Katz, Spencer W. Gunning, Joshua S. Vega, Andrew J. Gerrard, Greg D. Earle, Magda L. Moses,
Mary Lou West, Philip J. Erickson, Ethan S. Miller, Robert Gerzoff, H. Ward Silver, and the HamSCI Community

1New Jersey Institute of Technology, K2MFF
2Virginia Tech
3Montclair State University
4MIT Haystack Observatory
5Johns Hopkins University Applied Physics Laboratory
6HamSCI Community
7American Radio Relay League

frissell@njit.edu http://hamsci.org
Outline

I. What is Ham Radio & HamSCI?

II. Eclipse Experiments
   I. 2017 Total Solar Eclipse & The Ionosphere
   II. Ham Radio Data Sources
   III. Observations

III. Summary & Conclusions
Amateur/Ham Radio

• Hobby for Radio Enthusiasts
  • Communicators  • Builders  • Experimenters

• Wide-reaching Demographic, Technically Able
  • All ages & walks of life
  • Over 730,000 US hams  [http://www.arrl.org/arrl-fact-sheet]
  • ~3 million World Wide

  - Hobbyists routinely use HF-VHF transionospheric links.
  - Often ~100 W into dipole antennas.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 MHz</td>
<td>160 m</td>
</tr>
<tr>
<td>3.5 MHz</td>
<td>80 m</td>
</tr>
<tr>
<td>7 MHz</td>
<td>40 m</td>
</tr>
<tr>
<td>10 MHz</td>
<td>30 m</td>
</tr>
<tr>
<td>14 MHz</td>
<td>20 m</td>
</tr>
<tr>
<td>18 MHz</td>
<td>17 m</td>
</tr>
<tr>
<td>21 MHz</td>
<td>15 m</td>
</tr>
<tr>
<td>24 MHz</td>
<td>12 m</td>
</tr>
<tr>
<td>28 MHz</td>
<td>10 m</td>
</tr>
<tr>
<td>50 MHz</td>
<td>6 m</td>
</tr>
</tbody>
</table>
Total Solar Eclipse

21 August 2017

Partial Start: 1604 UT
Total Max: 1716 UT
Partial End: 1834 UT

Expected ionospheric effects
[M. Moses after Afraimovich et al., 2002]

Partial Start: 1720 UT
Total Max: 1851 UT
Partial End: 2013 UT

Figure: W. Strickling, Wikipedia
HamSCI Eclipse Research Questions

• What are the temporal and spatial scales of eclipse-induced ionospheric effects?
• How does the eclipse affect HF propagation?
HF Propagation & The Ionosphere

15.0 MHz

10.0 MHz
Solar Eclipse QSO Party (SEQP)

- Ham Radio Contest-Like Event
- Generate a quasi-random dataset
- Point-to-point contact (QSO) data from automatic [RBN, PSKReporter, WSPRNet] and manual sources [Logs]
SEQP Observations

Observations from 21 August 2017 1400 – 2200 UT

<table>
<thead>
<tr>
<th>Network</th>
<th># Spots / QSOs</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBN</td>
<td>618,623</td>
</tr>
<tr>
<td>WSPRNet</td>
<td>630,132</td>
</tr>
<tr>
<td>PSKReporter</td>
<td>1,287,855</td>
</tr>
<tr>
<td>Participant Logs</td>
<td>31,151</td>
</tr>
</tbody>
</table>
Solar Eclipse QSO Party

• 593 parsed logs
• 31,151 QSOs
• 5,045 unique callsigns
• 656 4-char grid squares
• 81 DX Entities

(from logs submitted to hamsci.org)
Ham Radio Eclipse Data

21 Aug 2017 1400 UT - 21 Aug 2017 1405 UT
QSO/Spot Midpoints; 300.0 km Obscuration Alt

SEQP Logs

WSPR

PSKReporter

RBN

Frequency [MHz]

frissell@njit.edu
SEQP RBN Spots

RBN SEQP Spots by Band (Contiguous US TX and RX Only)

- **28 MHz (10 m)**
- **21 MHz (15 m)**
- **14 MHz (20 m)**
- **7 MHz (40 m)**
- **3.5 MHz (80 m)**
- **1.8 MHz (160 m)**

# Spots

<table>
<thead>
<tr>
<th>Time (UTC)</th>
<th>Partial</th>
<th>Total</th>
<th>Partial</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>14:00</td>
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<tr>
<td>16:00</td>
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<tr>
<td>18:00</td>
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<tr>
<td>20:00</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>22:00</td>
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</tbody>
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frissell@njit.edu

http://hamsci.org
WE9V 14 MHz RBN Rx, Wisconsin

WE9V RBN Pairs
20 m Eclipse
21 Aug 2017 1400 UT - 21 Aug 2017 2159 UT

- WE9V (13026)
- AA2MF (2991)
- N4BP (1731)
- K7VT (1355)
- N1MD (1340)
- N1XF (1155)
- W7SE (1052)
- W1UJ (099)
- KS7T (864)
- AA3B (841)
- W6RW (798)
Ground Eclipse Times
Bristol, WI:
• Start partial: 1653 UT
• Max: 1818 UT
• End partial: 1940 UT

Clear drop in 20 meter propagation during temporary ‘nighttime’ conditions
7 MHz RBN: Great-Circle Range vs Obscuration

Eclipse

Control

SNR [dB]

20 25 30 35 40 45 50

Midpoint Obscuration at 300 km Altitude

Great Circle Distance [km]
7 MHz RBN: Great-Circle Range vs Obscuration

Eclipse

Control

Great Circle Distance [km]

Midpoint Obscuration at 300 km Altitude

Solar Local Time [hr]

N: 39223

N: 28917
Eclipse vs Control

14 MHz RBN: Great-Circle Range vs Obscuration

Eclipse

Control

SNR [dB]

20  25  30  35  40  45  50

Midpoint Obscuration at 300 km Altitude

Great Circle Distance [km]
14 MHz RBN: Great-Circle Range vs Obscuration

Eclipse

Control
RBN SNR and GPS TEC Waves

14 MHz Scaled RBN SNR Overplotted on Coster et al. [2017] Figure 3 GPS dTEC

(a) 14 MHz Scaled RBN SNR Overplotted on Coster et al. [2017] Figure 3 GPS dTEC

(b) Map of the United States

AA4VV
W6RW
K7VIT
KUTT
NOUV
KBTE/F
W6EW

Time [UT] on 21 Aug 2017

Longitude [deg]

-120 -115 -110 -105 -100 -95 -90

-3 -2 -1 0 0.1 0.2 0.3

dTEC(10^8/m)

frissell@njit.edu

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Summary & Conclusions

• **Ham Radio Science Citizen Investigation**
  - An organization that allows university researchers to collaborate with the amateur radio community in scientific investigations.

• **2017 Solar Eclipse QSO Party**
  - Number of HF Spots During Eclipse
    - Increases on 1.8 to 7 MHz.
    - Decreases on 14 MHz
  
  - With increasing obscuration
    - 7 MHz path length increases
    - 14 MHz SNR decreases; second-hop propagation goes away.

  - This shows temporary “night-like” propagation conditions of the ionosphere.
Thank you!

THIS WORK WAS SUPPORTED BY NSF GRANT AGS-1552188/479505-19C75.
References
