INTRODUCTION

August 21, 2017 provided a unique opportunity to investigate the effects of the total solar eclipse on high frequency (HF) radio propagation and ionospheric variability. In Marshall Space Flight Center's partnership with the US Space and Rocket Center (USSRC) and Austin Peay State University (APSU), we engaged students and citizen scientists in an investigation of the eclipse effects on the mid-latitude ionosphere. Activities included implementing and configuring software, monitoring the HF Amateur Radio frequency bands and collecting radio transmission data on days before, the day of, and after the eclipse to build a continuous record of changing propagation conditions as the moon’s shadow marched across the United States. Post-eclipse radio propagation analysis provided insights into ionospheric variability due to the eclipse. We report on results, interpretation, and conclusions of these investigations.

OBJECTIVES

• Engage students and citizen scientists to participate in, and contribute to, a solar eclipse radio science investigation.

• Observe the propagation of HF radio signals that may be influenced by changes in the ionosphere during an eclipse.

• Investigate the way eclipse radio propagation conditions evolve in a manner similar to day/night transition scenarios that occur at the dawn and dusk terminators (Smith and Silver, 2016).

• Explain changes in radio propagation in terms of evolving ionospheric conditions as the eclipse shadow marches across the U.S.

• Have Fun!

HYPOTHESIS

It has long been known that the Earth’s ionosphere responds to changes in solar illumination during a lunar eclipse (e.g., Chapman, 1933; Hulburt, 1941; Mitra, 1952; Davies, 1990).

• Changes in the ionosphere during an eclipse would influence the propagation of HF radio waves traversing the ionosphere, and could be explained by observing the behavior of HF radio propagation.

• The most dramatic changes in radio signal strength during the eclipse should occur in the mid-latitude D-region (e.g., Nichol, 2015).

BACKGROUND

Radio propagation at low HF frequencies (30 meters, 3.5-4.0 MHz) and 40 meters (40M, 7.0 – 7.3 MHz), are typically good during the night, but during the day, the D-Region ionospheric density increases due to ionization, and the lower frequency waves are attenuated via wave absorption.

In the ionospheric D region, radio wave absorption per unit path length is roughly proportional to \( n_i \eta \), where \( n_i \) is electron density, \( \eta \) is collision frequency, and \( \varphi \) is the wave angular frequency as solar illumination and ionization decreases in the shadow of the eclipse, electrons recombine with ions at a faster rate than they are produced. The result is a decrease in \( n_i \) and the product \( n_i \varphi \).

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WL7C Reverse Beacon Network Receive Node APSU Farm in Clarksville, TN 38439, 87.3496 South of eclipse centerline, 82-foot dipole antenna

KDDR Reverse Beacon Network Transmitter North of Hopkinsville, KY (37.34N, 87.30W) On eclipse centerline, 80 watts feeding "L" antenna

NNSA Weak Signal Propagation Reporter Transmitter NASA Marshall Space Flight Center Huntsville, AL (34.64N, 86.86W) Partial eclipse, 5 watt transmitters on 80M and 40M

Propagation paths of stations received by WL7C August 21, 2017 between 1400-2000 UT. WL7C is at the apparent radiant point.

Preliminary results from analysis of WL7C RBN data collected on eclipse day indicate an increase in propagation distance on the 40M band during the eclipse. On the 80M band, WP8V7 receives from hundreds of kilometers away reported RNN data transmissions, whereas this was not the case on the day after the eclipse. These results point to decrease of absorption in the D region during the eclipse and suggest F region ionospheric propagation, and/or multi-hop modes. Numerical simulations using the PM model support these assumptions.

REFERENCES


Daniell et al., 1995, Radio Sci., 30, 1489-1510.

Frisold et al., 2015, Space Weather, 13(12), 10-15.


WSPR Signal to Noise Ratio vs Time 3.5 MHz

All 40M spots reported by WL7C on eclipse day. Bubble size represents Signal-to-Noise (SNR). Negative distances show stations south of WL7C.

Processed data of stations receiving NNSA signals.

Weak Signal Propagation Reporter Circles represent stations receiving NNSA signals.

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