Ionospheric Impacts of the 2017 Total Solar Eclipse

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On August 21, 2017 there will be a total solar eclipse over the United States that will travel from Oregon to South Carolina.

The next total eclipse over the US is in 2024 and there will not be a comparable one for 28 years.
The ionosphere’s density is very dependent on sunlight. At night all layers of the ionosphere experience a large decrease in electron density.
What May Happen During an Eclipse?

From the onset of the eclipse to the end takes only ~3 hours, and the solar disk is fully blocked by the moon for only ~2 minutes. So the effect of an eclipse on the ionosphere will be unlike the effects of sunset & sunrise.

Since the moon blocks out the solar disk during an eclipse, the 2017 eclipse will produce a short-lived “artificial night” visible across most of the US:

- At low altitudes the plasma recombination rate is high, so the plasma in the ionosphere will disappear quickly.
- At higher altitudes the plasma will never completely disappear.
- The artificial nighttime produced by the eclipse will likely change radio propagation through the eclipse region.
Previous Eclipse Observation

- Data from an ionosonde observation during a total solar eclipse in the UK.
- The ionospheric peak plasma density decreased by ~35% during this event.

(Afraimovich et al., 2002)
1999 Ham Eclipse Observations

(Bamford, Radio and the 1999 Total Solar Eclipse, 2000)
The area affected by the eclipse is about 1100 km in diameter, but the umbra region of the eclipse is only ~100 km wide.
Our preliminary models based on ionospheric production/loss models and the 1999 eclipse observations map the decrease in plasma density as a function of distance from the eclipse center at a given time.
We use the PHaRLAP ray tracer with our plasma model in order to predict the behavior of HF radio waves propagating through the ionosphere along the eclipse path.

Rays that do not escape are ducted as they pass through the ionosphere’s eclipsed region, resulting in a longer path than under pre-eclipse conditions.

(Burujupalli, Ray-tracing to study the Ionosphere during Eclipse, 2017)
Raytracing in 3D Across the Path

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Raytracing In 3D Across the Path

Eclipse and Normal Raytraces: 21 Aug 2016 1830 UT

Three-dimensional raytracing shows a “lensing effect” for rays directed at different angles across the eclipse path that pass through the eclipsed region due to refraction.
Some Science Questions to be Addressed

- How much of the ionosphere is affected by a solar eclipse?
- For how long is the ionosphere affected by a solar eclipse?
- What causes these spatial and temporal scales?

In order to answer these questions we need good data from multiple observing platforms.
Our experiment relies on several existing networks to collect data on the changes in radio propagation over the course of the eclipse including:

- Continuously Operating Reference Station (CORS) GPS receivers
- Super Dual Auroral Radar Network (SuperDARN)
- Amateur radio networks (RBN, WSPRNet and PskReporter)
Summary

• The 2017 eclipse offers unprecedented opportunities to study propagation in the ionosphere.

• We more instrumentation available to study this eclipse than any previous eclipse.

• Our experiment will encompass
  - GPS TEC
  - Ham Radio Propagation
  - HF radar
  - Scintillation Measurements

• We will interpret all of these data to answer our fundamental science questions.