HamSCI

Ham Radio Science Citizen Investigation

ARRL The national association for AMATEUR RADIO

Ionospheric Impacts of the 2017 Total Solar Eclipse

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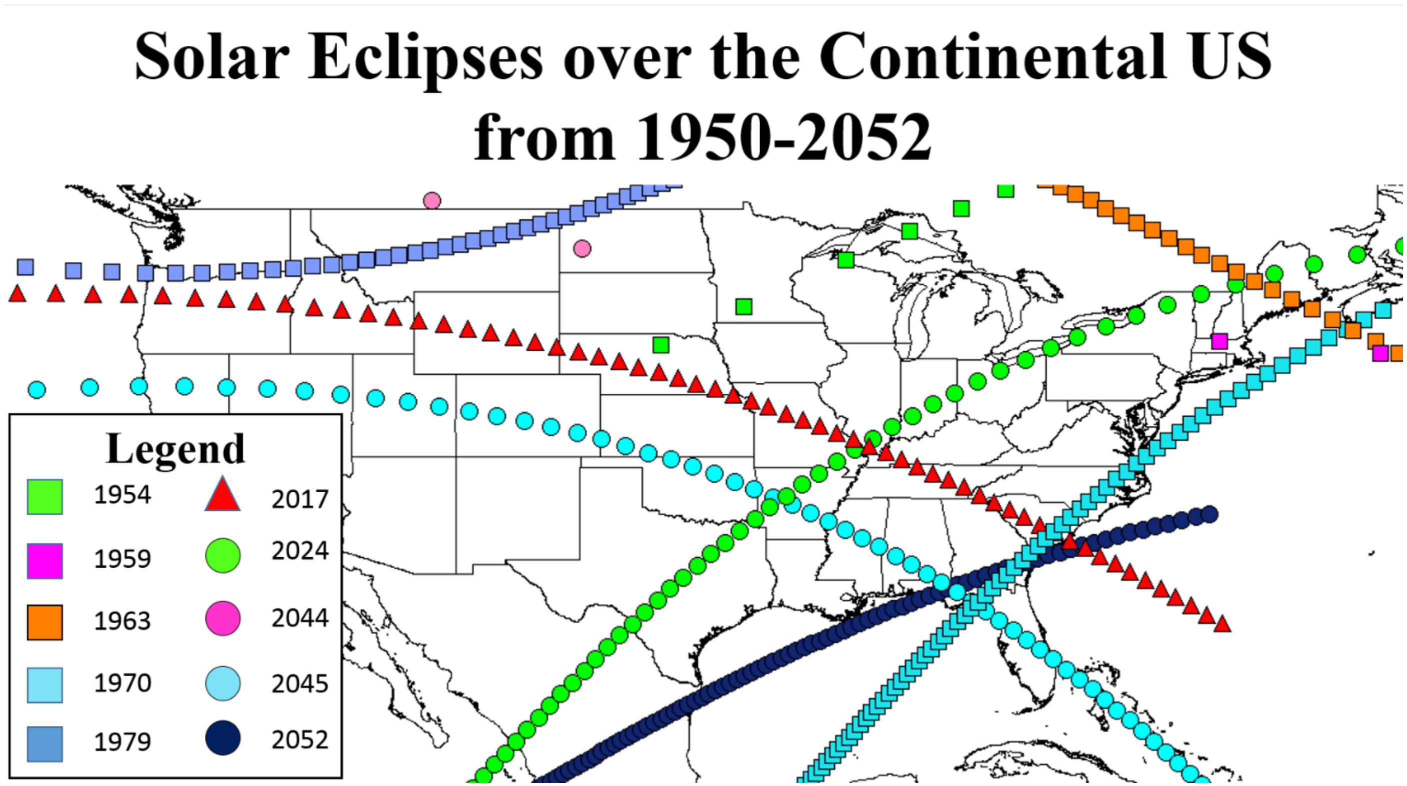
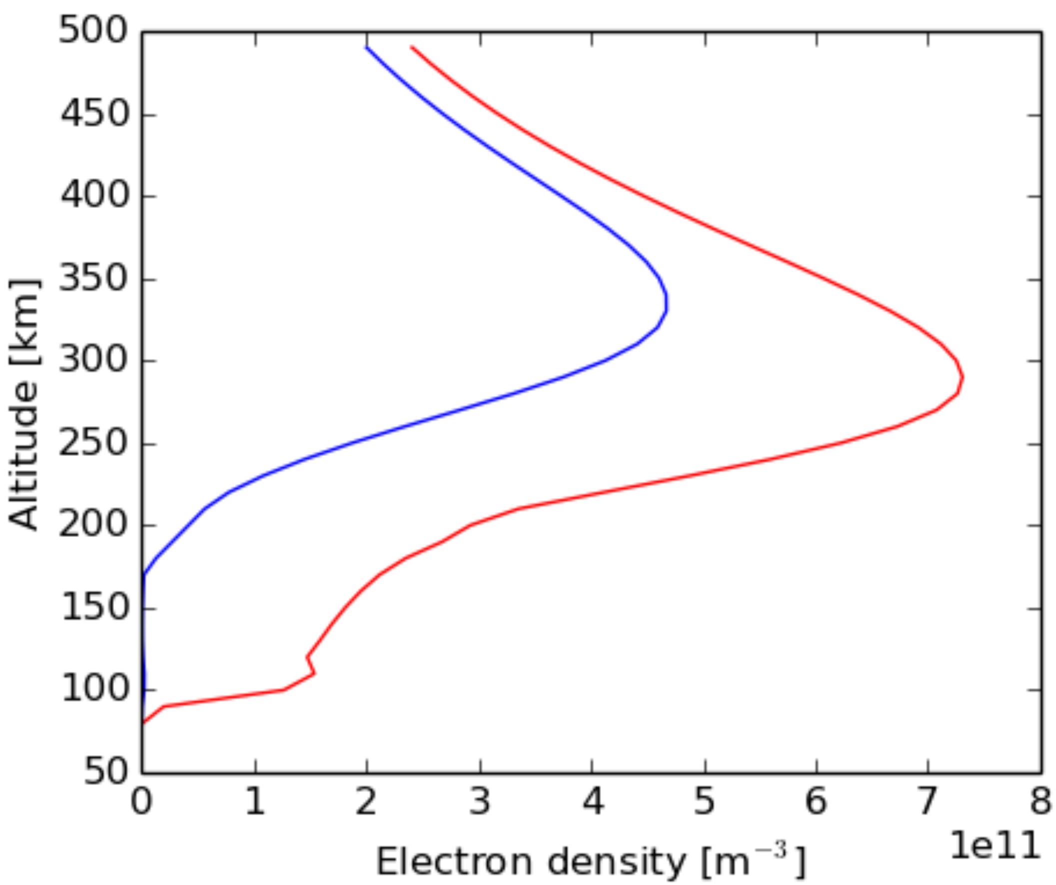
NSF

2017 “Great American” Eclipse



- 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 Dependence on Sunlight



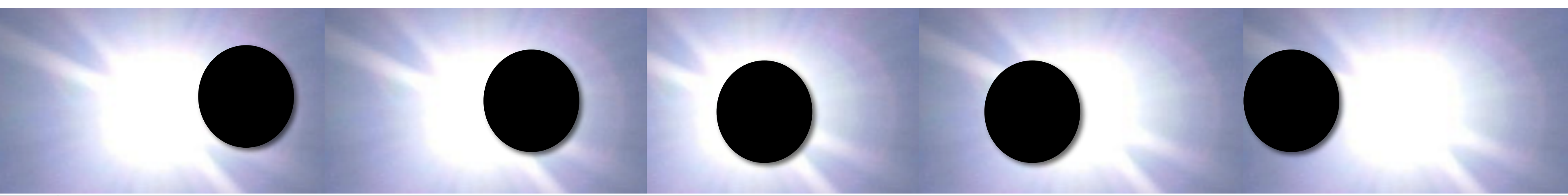
The ionosphere's density is very dependent on sunlight. At night all layers of the ionosphere experience a large decrease in electron density.

What May Happen During an Eclipse?

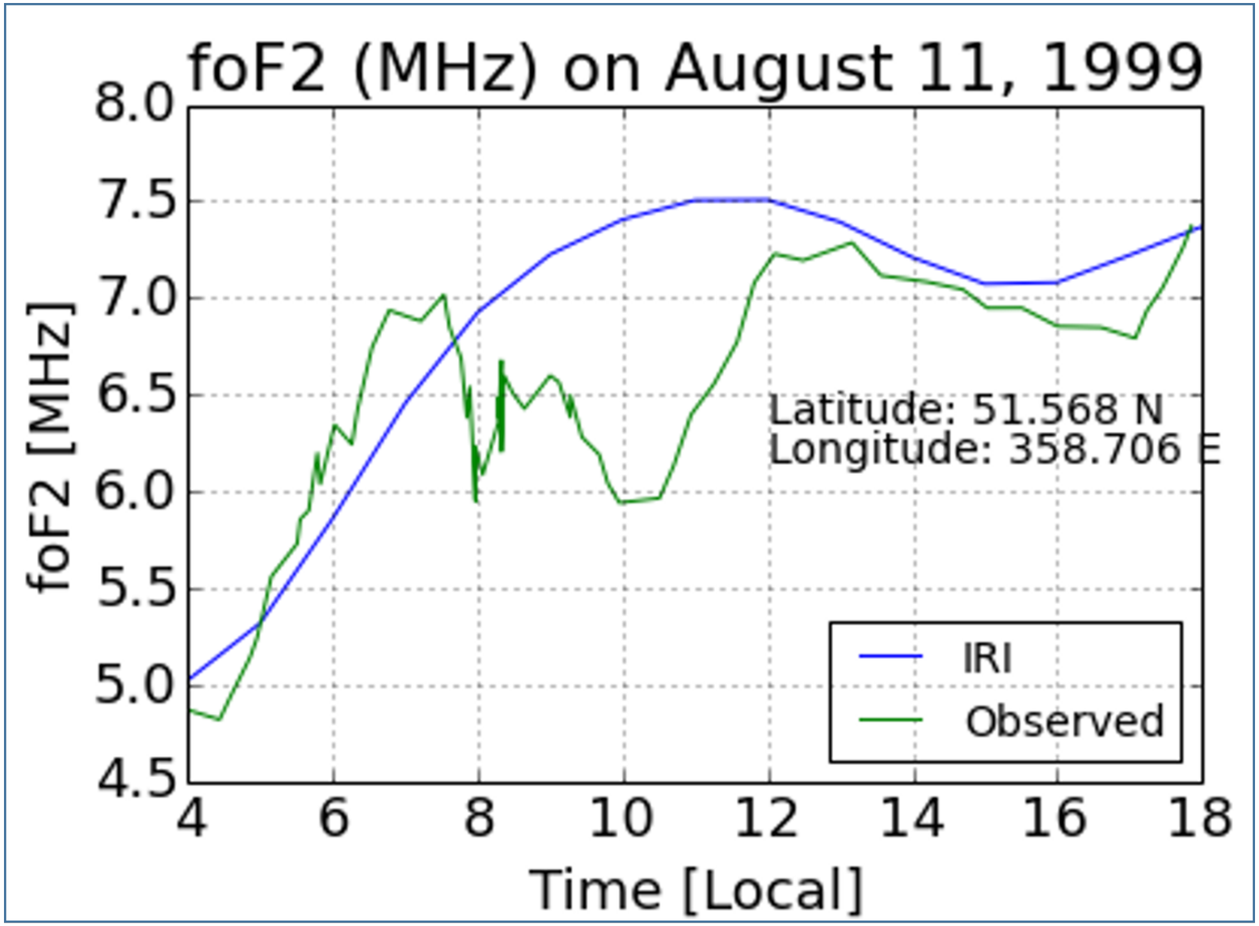
From the onset of the eclipse to the end takes only ~ 3 hours, and the solar disk is fully blocked by the moon for only ~2 minutes. So the effect of an eclipse on the ionosphere will be unlike the effects of sunset & sunrise.

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.



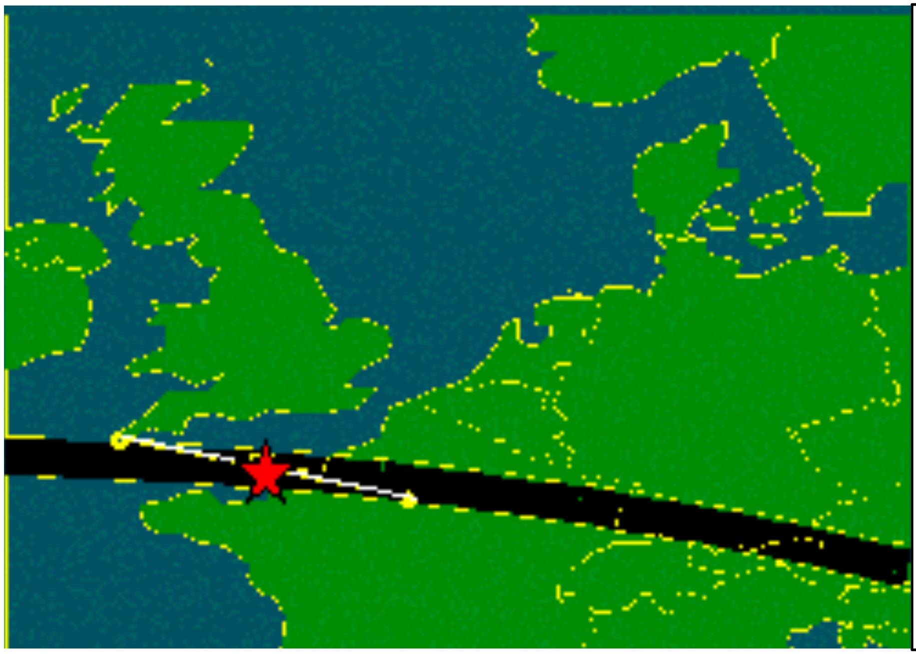
Previous Eclipse Observation

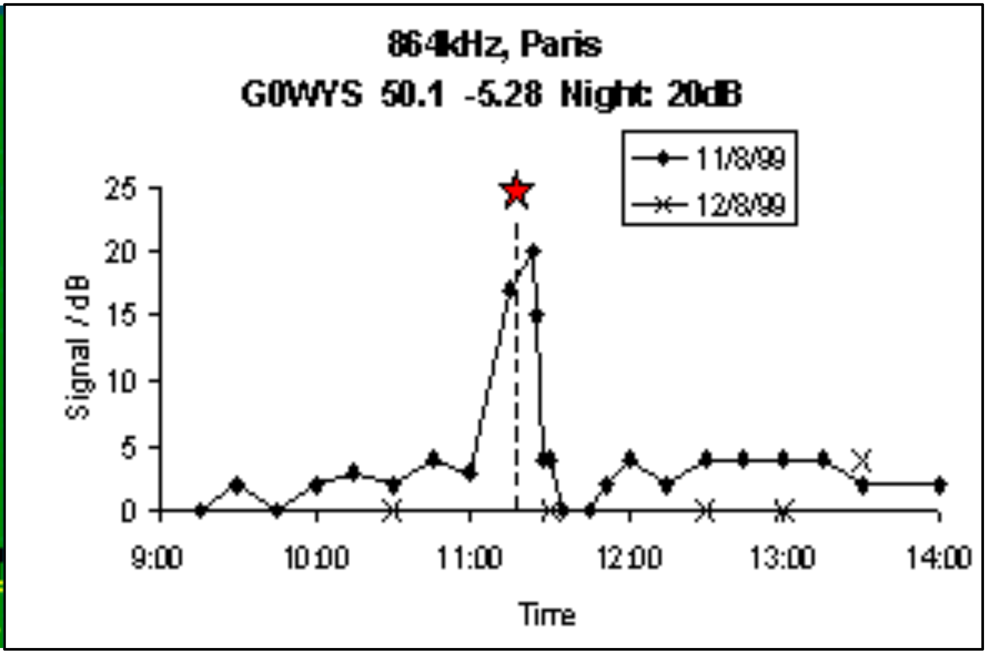


(*Afraimovich et al.*, 2002)

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

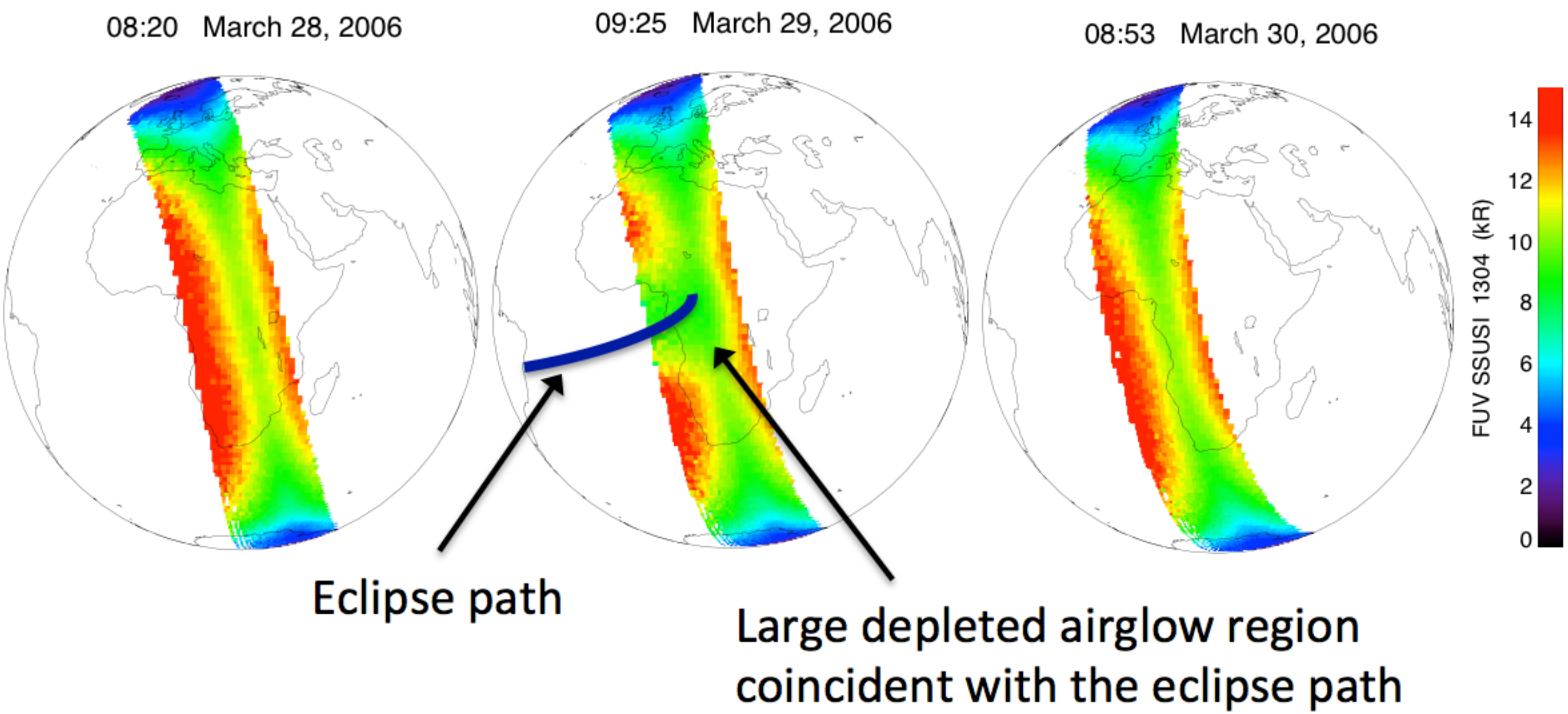
1999 Ham Eclipse Observations





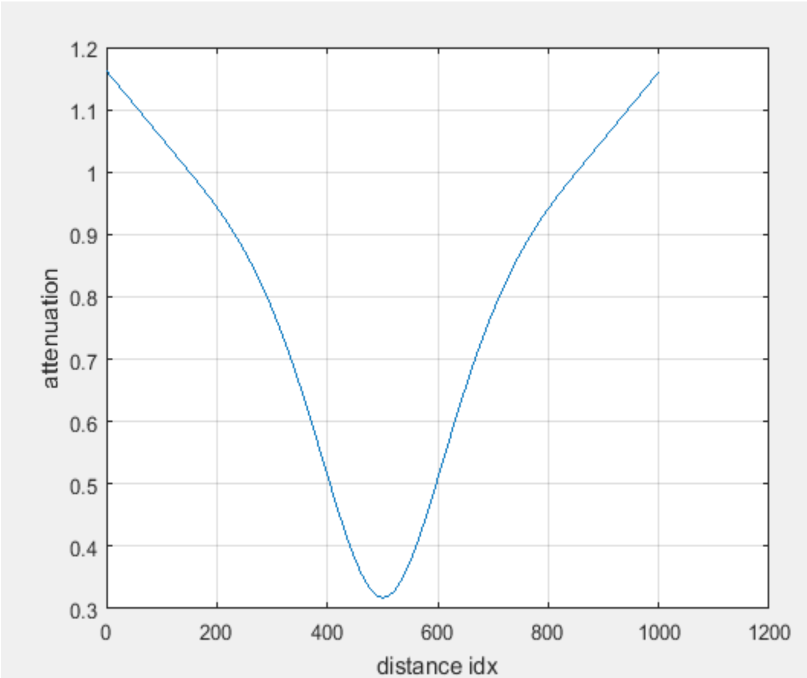
(Bamford, Radio and the 1999 Total Solar Eclipse, 2000)

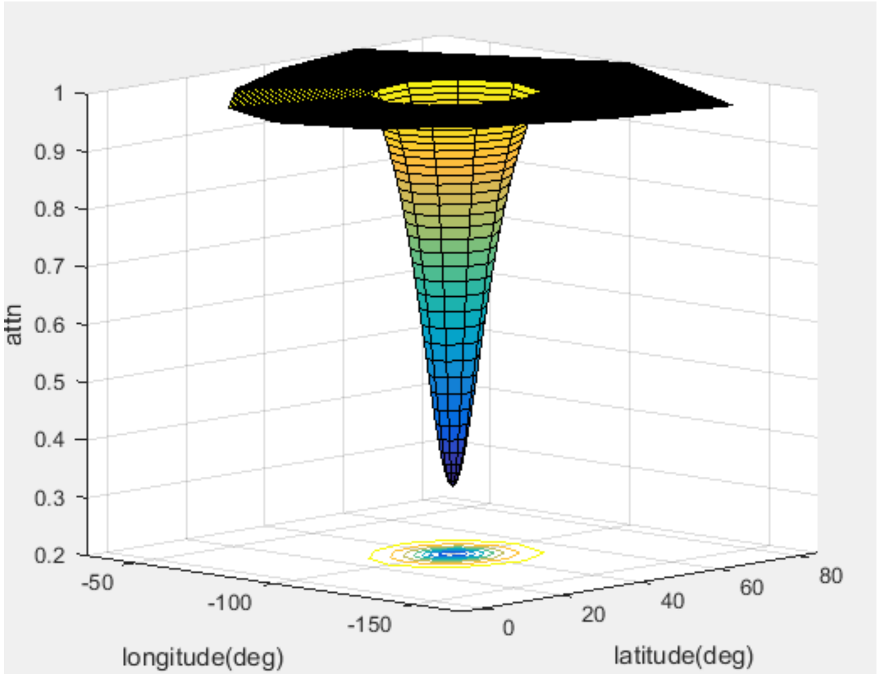
SSUSI Data - 2006



The area affected by the eclipse is about 1100 km in diameter, but the umbra region of the eclipse is only ~100 km wide.

Modeling Eclipse HF Propagation

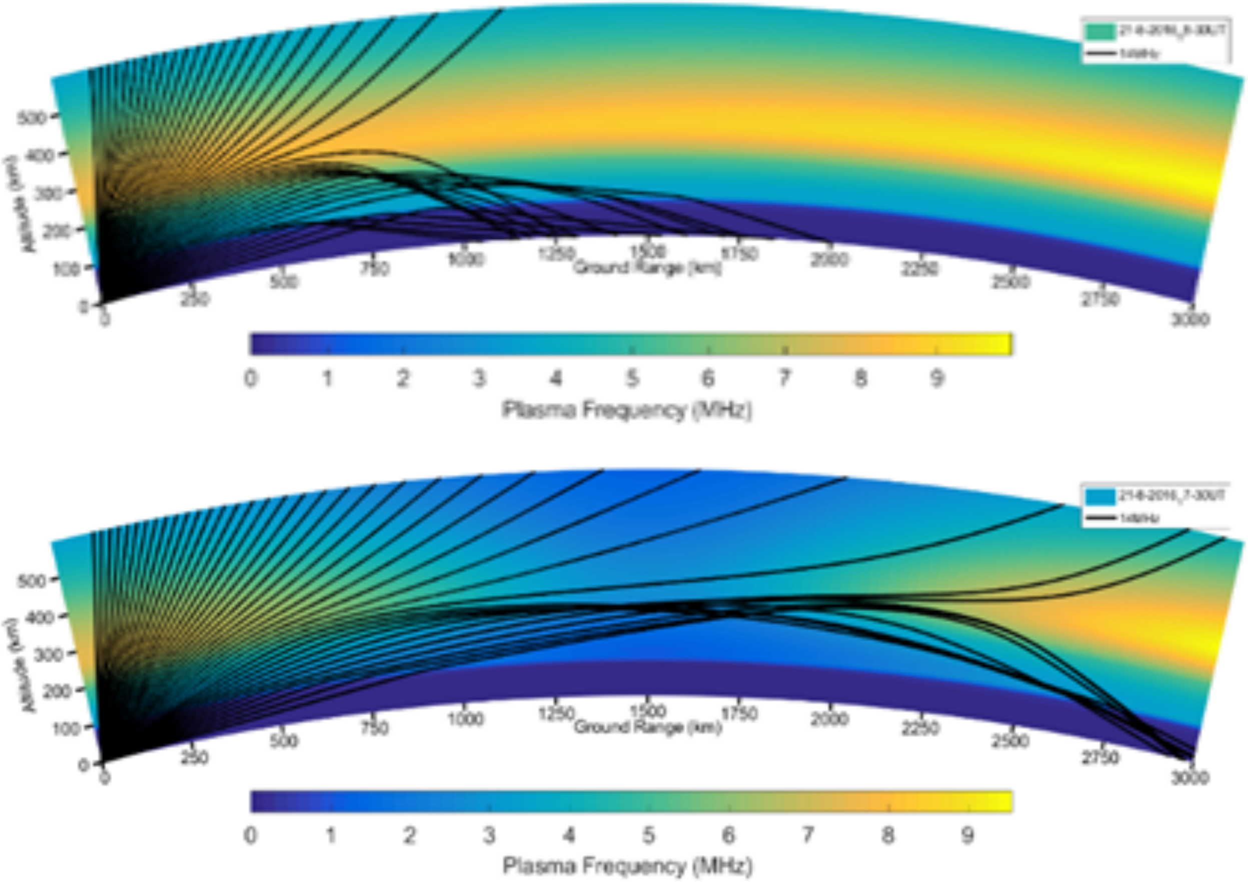




(Burujupalli, Ray-tracing to study the Ionosphere during Eclipse, 2017)

❖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.

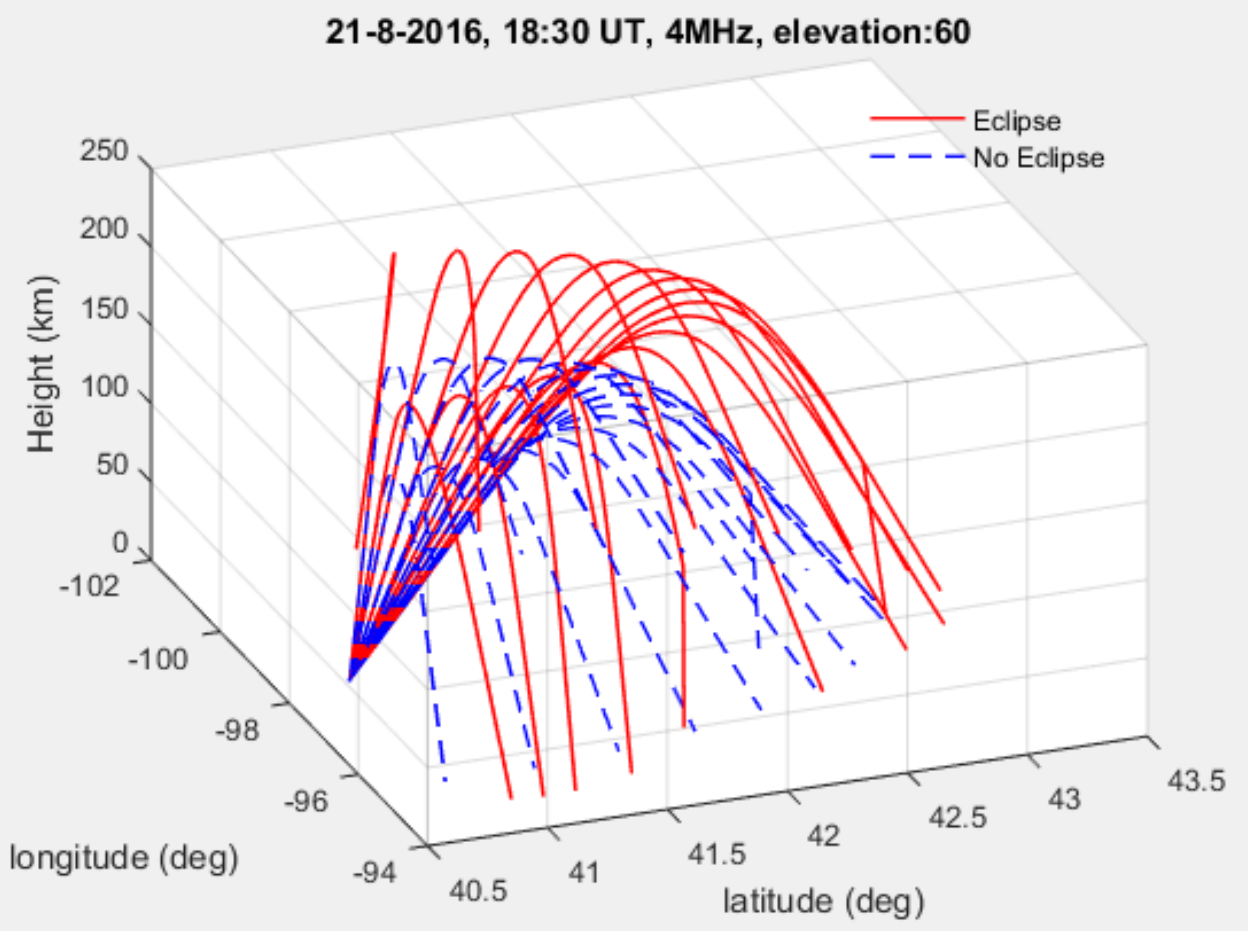
Raytracing In 2D Along the Path



(Burujupalli, Ray-tracing to study the Ionosphere during Eclipse, 2017)

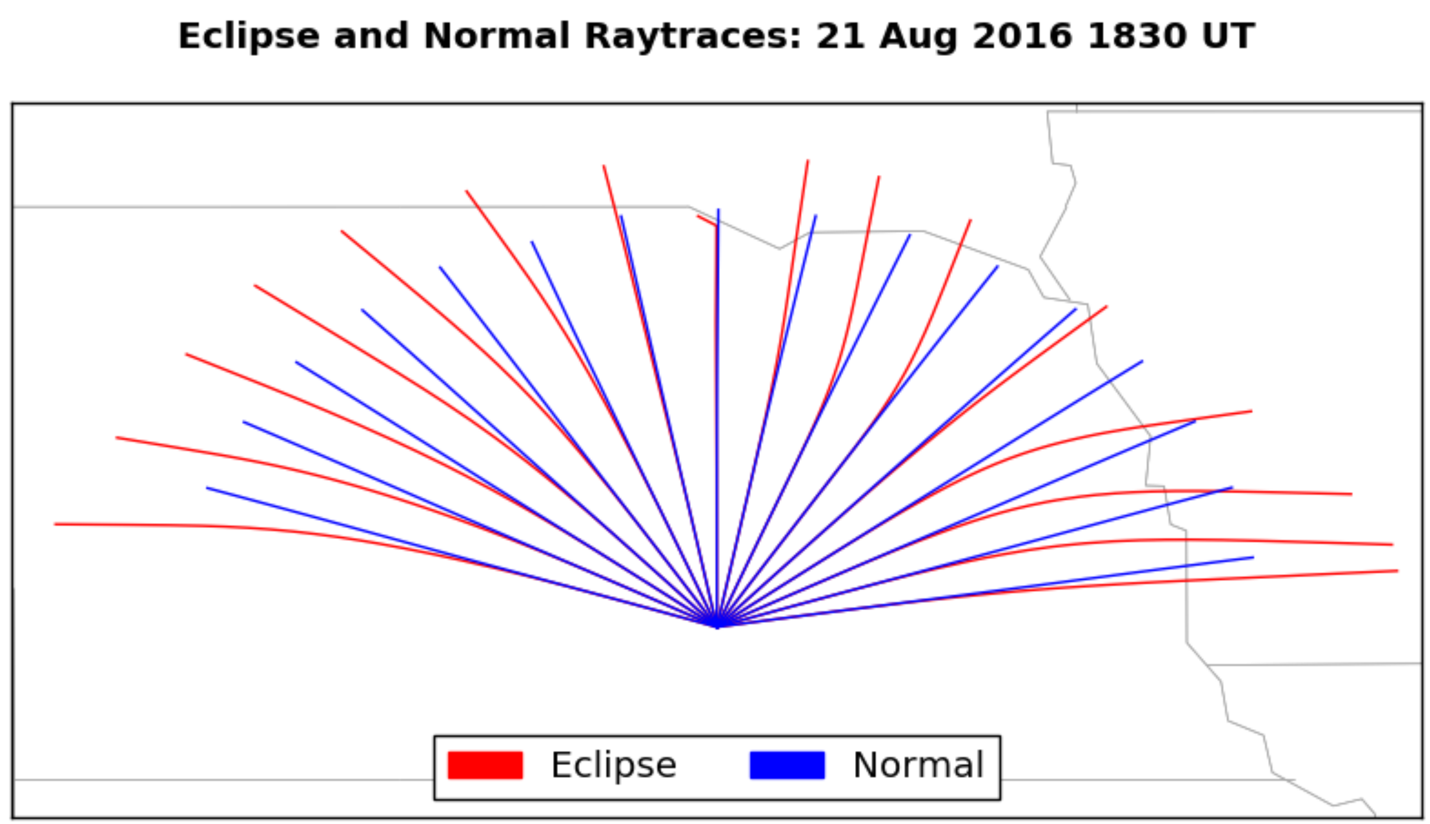
- We use the PHaRLAP ray tracer with our plasma model in order to predict the behavior of HF radio waves propagating through the ionosphere along the eclipse path.
- Rays that do not escape are ducted as they pass through the ionosphere's eclipsed region, resulting in a longer path than under pre-eclipse conditions.

Raytracing in 3D Across the Path



(Burujupalli, Ray-tracing to study the Ionosphere during Eclipse, 2017)

Raytracing In 3D Across the Path



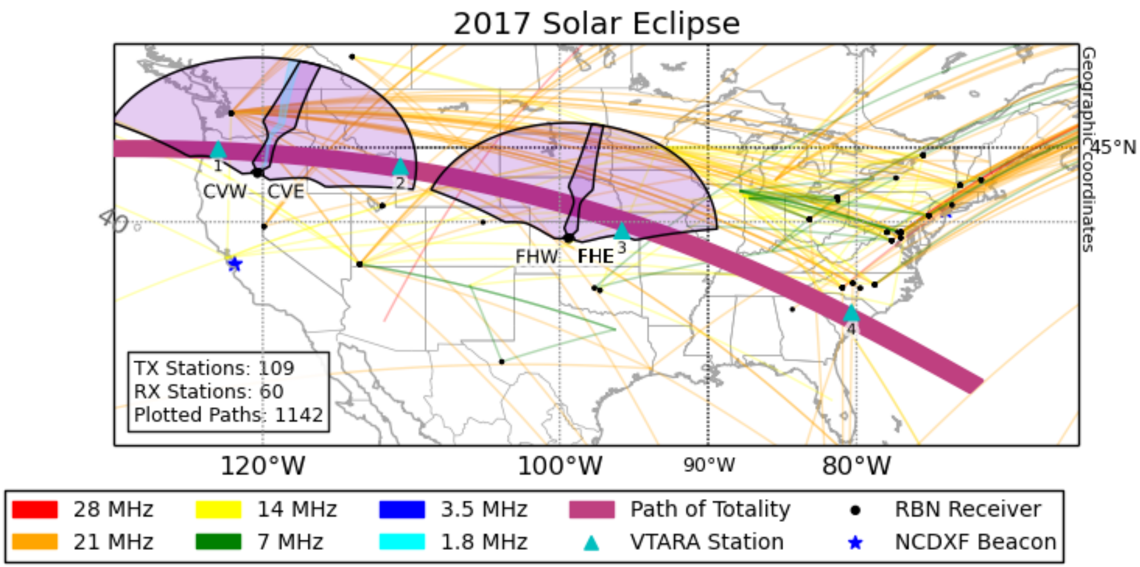
Three-dimensional raytracing shows a “lensing effect” for rays directed at different angles across the eclipse path that pass through the eclipsed region due to refraction.

Some Science Questions to be Addressed

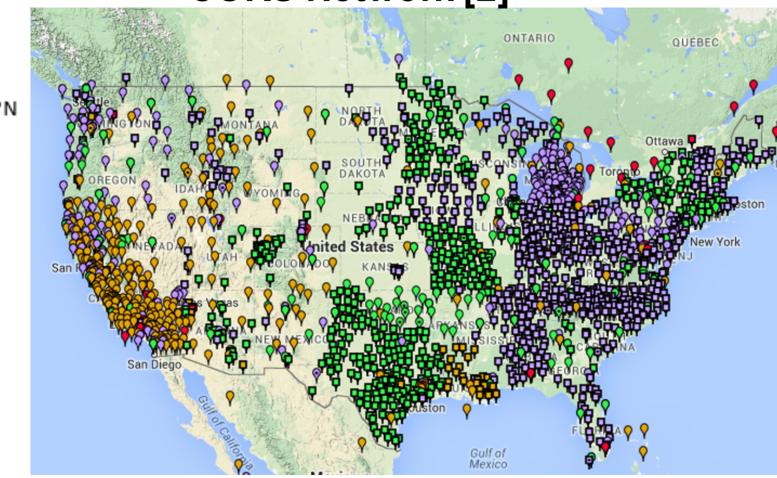
- How much of the ionosphere is affected by a solar eclipse?
- For how long is the ionosphere affected by a solar eclipse?
- What causes these spatial and temporal scales?

In order to answer these questions we need good data from multiple observing platforms.

Eclipse Experiment Overview



CORS Network [2]



- 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.