Ionospheric Density Irregularities, Turbulence, and Wave Disturbances during the Total Solar Eclipse over North America on 21 August 2017

Rezy Pradipta, Endawoke Yizengaw, and Patricia H. Doherty

Boston College, Institute for Scientific Research

NEROC 2nd Annual Radio Science Symposium
MIT Haystack Observatory
8 November 2017
We studied some ionospheric effects associated with the passage of total solar eclipse over North America on 21 August 2017.

Data from ionosonde as well as GPS TEC measurements were analyzed in the study.

45% reduction in TEC, 33% reduction in foF2, and a 50% reduction in foE occurred during the eclipse.

Midlatitude spread-F echoes and wave disturbances were observed during the 21 August 2017 North American total solar eclipse.
A Total Solar Eclipse during Solar Minimum

The 21 August 2017 total solar eclipse: a total solar eclipse over a midlatitude region during a generally quiet geomagnetic condition at a solar minimum.

Left: Background TEC over North America on 21 Aug 2017 from IRI-2012 model
Right: Gridded GPS TEC data over North America on 21 Aug 2017 from Madrigal
Visible Effects of the Total Solar Eclipse in TEC
Setup for the Ionosonde and TEC Data Analysis

21 Aug 2017 — 18:17 UTC

TECU

Latitude (deg)

Longitude (deg)

Mer Cut #1
Mer Cut #2
Mer Cut #3
Parallel Cut

trajectory of eclipse totality

Digisonde IF843
ca position of lunar shadow
Ionosonde Data Analysis: FTI/RTI Summary Plots
Spread-F Echoes and TIDs during Solar Eclipse

Total Echo Ampl Count, Digisonde Station IF843 – 21 Aug 2017

Virtual Height (km)

UTC (decimal hours)

17:00 UT
17:36 UT
17:42 UT

Spread echoes
TID signatures
maximum eclipse
solar eclipse

0 500 1000 1500 2000 2500 3000 3500 4000

[Graph showing data plots at different times during the solar eclipse, with indicators for spread echoes and TID signatures.]
Doppler Vel. from Ionosonde during the Eclipse
TEC Reduction during the Total Solar Eclipse

Madrigal TEC – 21 Aug 2017, Lat=44 N Lon=113 W

(a) moving average (w/ cubic spline)
7-day median (± 1 quartile)
max eclipse
solar eclipse

(b) max eclipse
solar eclipse
Reductions in \( \text{foF}_2 \) and \( \text{foE} \) during Solar Eclipse
TEC Reductions along Different Longitudes

(a) TEC – 21 Aug 2017, Mer Cut #1 (115°W)
(b) ΔTEC – 21 Aug 2017, Mer Cut #1 (115°W)

Latitude (deg) vs. Universal Time (hours) for different longitudes.
TEC Reductions along the Totality Trajectory
Perturbations in Equiv Vert TEC --- TECP (TECU)

21-08-2017 / 00:00 UTC
(Integr. 23:55 -- 00:05)
Summary and Conclusions

- We studied some ionospheric effects associated with the passage of total solar eclipse over North America on 21 August 2017.
- Data from ionosonde as well as GPS TEC measurements were analyzed in the study.
- 45% reduction in TEC, 33% reduction in $f_{oF2}$, and a 50% reduction in $f_{oE}$ occurred during the eclipse.
- Midlatitude spread-F echoes and wave disturbances were observed during the 21 August 2017 North American total solar eclipse.