Ionospheric Variations Observed During the Solar Eclipse of August 2017

Image Courtesy of NASA
GNSS Campaign Overview for Aug 21st Solar Eclipse

5 GNSS receivers borrowed from UNAVCO, 2 borrowed from MIT
- 7 sites have been identified
  - Tom Clark (NEROC) – SC
  - Greg Earle (VT) – SC
  - Magda Moses (VT) – KS
  - John Hubbard (NRL) – MO
  - Delores Knipp (U. Colorado) – MO
  - John Swoboda (MIT) & Terry Bullett (NOAA) – WY
  - Lee Kordella (VT) – OR
- GPS data transferred back to Haystack in near real-time
UNAVCO RECEIVER SETUP
Delores Knipp’s 90 year old father
Map of ~ 3000 GPS receivers
How large is the ‘ionospheric hole’ due to the eclipse?

- The answer depends on the selection of a baseline. We tried 2 methods, empirical TEC model (NATEC, Chen et al., 2015) and observations.

- Top panel: NATEC results ($F10.7 = 87$, $Fbar = 84$, $Ap=5$). North America TEC model works well and is a good indicator of expected behavior in TEC.

- Middle panel: Observations for Aug 29, 2017, closest day with similar $F10.7$ ($F10.7 = 84$). Shows little lower TEC overall and a patch of higher TEC at 90-110W.

- Bottom panel: Observations for Aug 21, 2017; much lower TEC over entire continental US.
• Results are very similar, regardless of a choice of control day
• Largest decrease >60% is to the west of totality; shows nicely in model-data and data-data differences
Comparison of eclipse data (Aug 21) with NATEC model (left) and Aug 29, 2017 data

**TEC data-model** difference in relative difference in % (bottom); Max decrease in TEC is 6-8 TECu, 50-60%

**TEC data-data** difference in relative difference in % (bottom); Max decrease in TEC is 6-8 TECu, 50-60%
Evidence of enhanced TIDs on the western side and eastern side of the Rocky Mountain range.

In the left hand plot, the white dots represent: McBride, CA, Spokane, WA, Boise, ID, and St. George, UT and in the right hand plot, the white dots represent: Banff, CA, Jasper, MT, Jackson, WY, and Aspen, CO
Changes in Temperature

• The Great American Eclipse will start about 9 a.m. in Oregon with the path of totality crossing 14 states as it makes its way to South Carolina. The path of totality - the area that will experience the greatest periods of darkness - will also see the largest changes in daytime temperature.

• "When sunlight fades at twilight, we always notice how things start to cool down. The same is true for the temporary dimming during a total solar eclipse," NASA said.

• The amount of temperature drop will depend on factors such as time of year, cloud cover and the length of totality. In some scenarios, the air temperature can drop more than 20 degrees F, though this eclipse will more than likely see changes around the 10 degree mark.

• The change will be less dramatic in areas outside the path of totality.
You may have noticed a chill in the air as the eclipse passed by. Douglas, WY dropped 11 degrees! #SolarEclipse2017 #wywx
Differential TEC using S-G filter with a 2 hour sliding window and a linear basis function.

The 2 hr window was used because of the eclipse (partial or totality) took about 2 hrs at a given location.

Red line is noon meridian
White dot: totality location
Bow Waves

- Supersonic
  - Aircraft flying faster than the speed of sound.
- Bow wave
  - V-shape form of overlapping waves when object travels faster than wave speed.
  - An increase in speed will produce a narrower V-shape of overlapping waves.
bow waves

$W=121$, $n=1$
Conclusion

• 50-60% depletion in electron density observed, greater than models predicted
• Research into eclipse effects on ionosphere continuing

*The whole (hole) is greater than the sum of its parts*