Multispectral Airglow Observations during the August 2017 Total Solar Eclipse

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Abstract

It has been well established that eclipses induce atmospheric gravity waves. However, where these waves originate, how they propagate, and the speed of propagation have not been quite resolved. Furthermore, it is also not completely understood how long the disturbance caused by an eclipse lasts. To answer these questions, OI 557.7 nm (green line, peak altitude ~150 km) and OI 630.0 nm (red line, peak altitude ~250 km) emissions were observed on the night before and on the night of the eclipse from Carbondale, IL (in the path of totality). Wavelet analysis of data obtained ~ 8 hours after totality show wavelike brightness perturbation with a dominant period of around 1.5 hours in both red and green lines. These results could represent the long term effect of the eclipse on the upper atmosphere.

Background

- Moon's shadow moving at supersonic speed blocks solar radiation that leads to localized cooling and reduction in photo-ionization

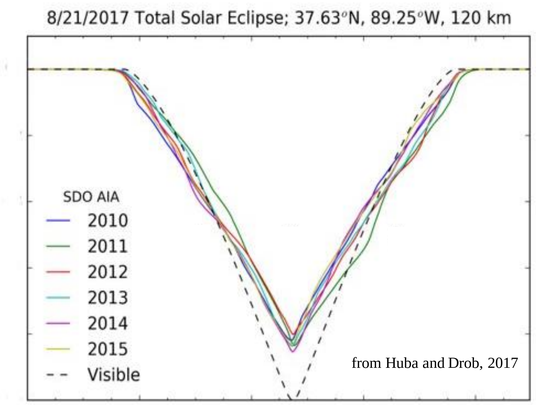


Fig I. Reduction of UV radiation incident on earth during eclipse. This leads to a short duration rapid cooling and a reduction in photoionization [Huba and Drob, 2017]

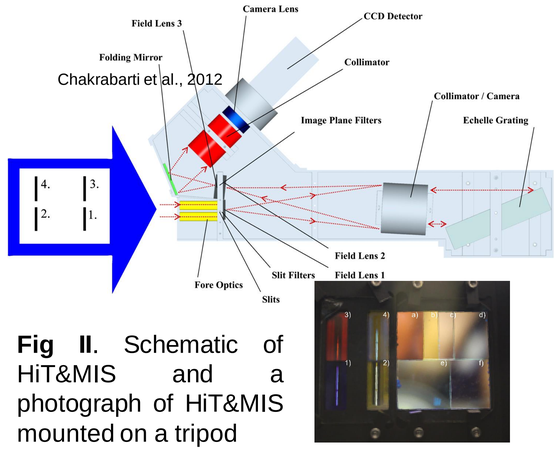
- Based on atmospheric cooling early simulations predicted the formation of bow waves immediately following an eclipse [Chimonas, 1970]
- Simulations based on both atmospheric cooling and a reduction in photo-ionization have predicted TEC reduction in conjugate hemisphere [Huba and Drob, 2017]
- Observations have also confirmed the presence of Atmospheric Gravity Waves (AGW) following a eclipse (Liu et al., 1998 for example)

Early Results from August 2017 Eclipse

- Enhanced TEC structure along the Rocky mountains as the eclipse passed through them [Coster et al., 2017]
- Upward plasma drift above the F2 peak height immediately following the maximum obscuration (60 %) at Westford, MA [Goncharenko et al., 2018]
- Differential TEC measurements mimicking UV obstruction gradients pointing that the large scale TEC perturbation immediately following the eclipse is a result of direct EUV modulation [Mrak et al., 2018]

All of these are immediate effects of the eclipse. There have been very few studies on long term effect of eclipse. We are presenting brightness perturbation in prominent nightglow emissions hours after the eclipse.

HiT&MIS: High Throughput and Multi-slit Imaging Spectrograph



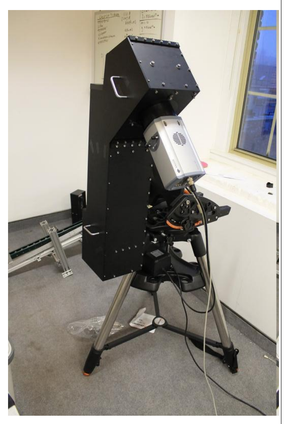


Fig II. Schematic of HiT&MIS and a photograph of HiT&MIS mounted on a tripod

- HiT&MIS is an imaging spectrograph that can simultaneously observe six prominent upper atmospheric emissions
- It has already been used to derive energy and flux of precipitating electrons during an geomagnetic storm [Aryal et al., 2018]

HiT&MIS Observation

- HiT&MIS looked at a fixed area in the sky at two airglow features from Carbondale, IL, which was in the path of totality

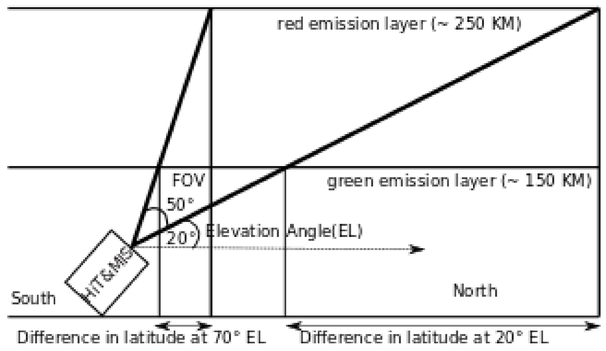


Fig III. Viewing geometry of HiT&MIS. Notice different latitudes are traced by red and green lines.

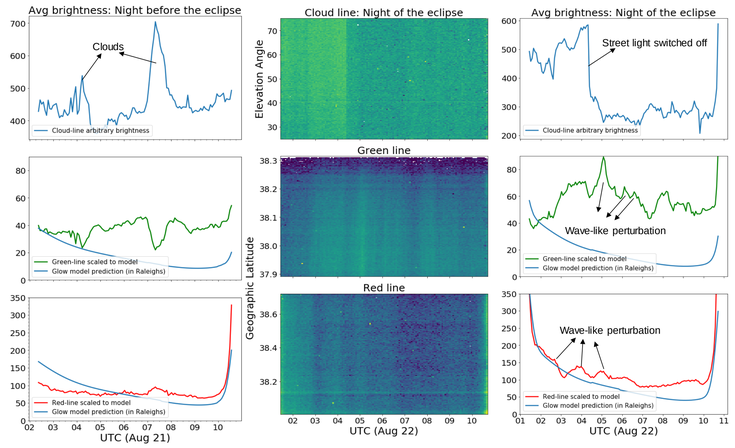


Fig IV. Brightness in red, green lines and a cloud diagnostic line (Ne I 630.5 nm) as a function of local time the night before and the night of eclipse. Notice periodic change in brightness on the night of the eclipse.

Results

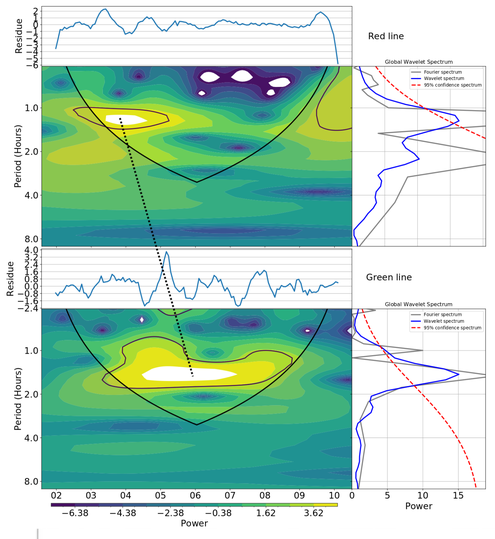


Fig V. Wavelet analysis on the residual (brightness data subtracted with a 2 hour running average) of red and green lines. Both red and green lines have a dominant time period of around 1.5 hours but they peak at different times.

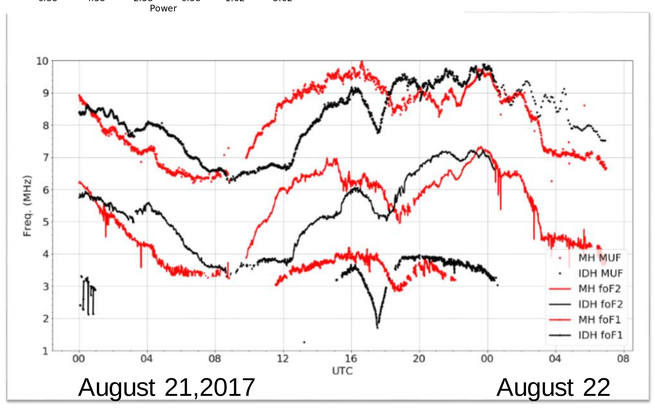


Fig VI: Supplementary digisonde ionospheric parameters at Idaho National Lab (labeled as IDH, 99.6% peak obscuration) and Millstone Hill (labled as MH, Westford, MA, 60% peak obscuration) both show disturbed ionosphere well after the eclipse

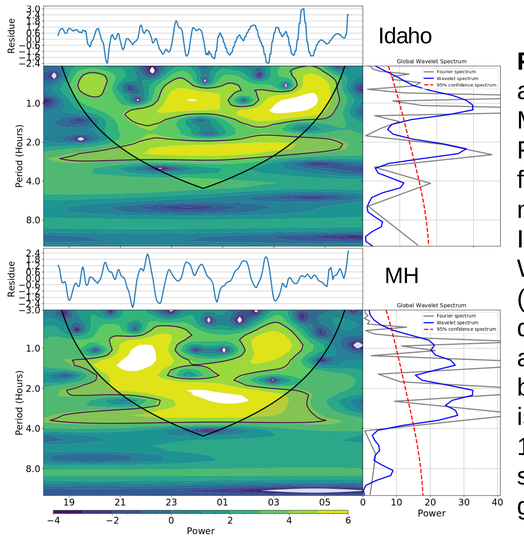


Fig VII : Wavelet analysis of the Maximum Usable Frequency (MUF) from digisonde measurements at Idaho (top) and Westford, MA (bottom) showing dominant time period around 1 hour at both locations. This is comparable to the 1.5 hour periodicity seen in red and the green airglow lines.

Summary

- Upper atmospheric optical emission were measured in red and green line airglows hours after the total solar eclipse of 2017 at Carbondale, IL
- These post-sunset measurement show wave-like brightness perturbation with a dominant time period of about 1.5 hours
- This could represent long term effect of eclipse on the state of the upper atmosphere

CEDAR, 2018

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