Solar Eclipse Effects on the Low Latitude Ionosphere

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A solar eclipse is a solar-terrestrial event during which the Moon casts its shadow on Earth's surface and atmosphere. Events like solar eclipse show a significantly short time effect on the local ionospheric properties, that's why it is of great interest for the ionospheric radio science community. During a solar eclipse, the ionospheric electron density concentration is sharply reduced to a level near night-time values. This affects radio communication through the ionosphere and produces a disturbance in satellite navigation.[1] 'Eclipses' are different based on occurrence time of the year, the solar disk occultation degree, time of the day, atmospheric weather, and location (latitude and longitude) of observations on the Earth.[2] But still, due to the rare happening of solar eclipses, reported works are limited. Hence, each solar eclipse, depending upon its time of occurrence, duration, and geographical location has a particular impact on the earth's ionosphere. A network of GNSS receivers and VLF receivers distributed over the whole globe provides a better opportunity to study the ionospheric variations.

Apart from E- and F- regions the D-region of ionosphere also changes due to solar eclipse.[2,3] In the present study, the effect of various solar eclipses on low latitude ionosphere will be presented using measurements by GNSS receivers and Very Low Frequency (VLF) receivers at various low latitude Indian stations. The VLF signals transmitted from different VLF transmitters are recorded at different low latitude Indian stations to find any significant variations in the amplitude and phase of the VLF signal. The GPS measured of DTEC is used to find oscillation observed in the ionosphere induced by atmospheric gravity waves (AGWs) generated during the period of the solar eclipse.

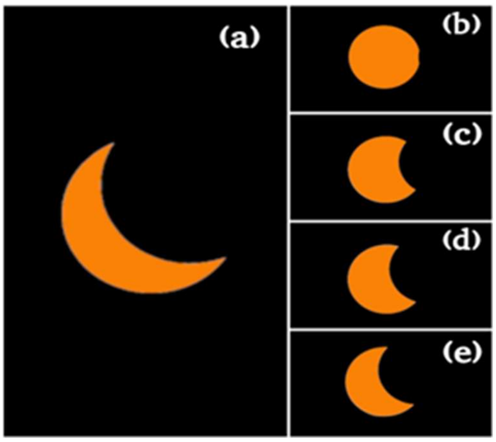

Figure 1: Images of partial solar eclipse of 21st June 2020 of different magnitudes over Varanasi.

The reflection height of the D-region ionosphere increases during the totality of eclipse and the electron concentration (electron density) decreased throughout the eclipse. The ionospheric reflection height increases from 84 km to 95 km at the totality and then decreases at the end of the eclipse. The reflection height of the D-region of the ionosphere rises to about 11 km indicating that there is a reduction in D-region ionization during the eclipse. The total electron content (TEC) variations at different stations clearly shows the presence of travelling ionospheric disturbances (TIDs) having wave-like features. The periodicity of TIDs lies in two regimes one of which belongs to a period between 20-50 minutes and the other belongs to 50-90 minutes. The analysis indicate that such oscillation observed in the ionosphere are induced by atmospheric gravity waves (AGWs) generated during the period of the solar eclipse.

Decrease in the ionospheric electron density and hence change in the reflection height of the D-region ionosphere during eclipse is demonstrated by VLF modelling and tweek analysis. The TIDs generated in the upper atmosphere regime during eclipse also confirms sudden change in ionospheric electron density.

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References

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