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Quantitative Effect of Solar Flares on Global Thermospheric Neutral Dynamics: First Kind Analysis

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Even though there have been numerous studies on the effect of solar flares on ionosphere [1] , there have been little understanding on the dynamic variability of the thermosphere in conjunction with the solar flare phenomenon. The present study unveils the global variability of thermospheric mass density, neutral wind components and thermospheric wave perturbations associated with X-class solar flares using GOCE satellite observations.

The analysis reveals that the thermospheric neutral mass density is higher (global average of ~ 4.3 x 10^{-11} kg/m^3) in solar flare days compared to non-flare days (global average of ~ 3.62 x 10^{-11} kg/m^3) in global context. In flare (or non-flare) days maximum density is observed at 270° longitude and (0 – 25°) latitude bin with value 5 x 10^{-11} kg/m^3 (or 4.5 x 10^{-11} kg/m^3). The latitudinal gradient of thermospheric mass density is stronger in flare days (0.027 x 10^{-12} kg/m^3/deg). The increase in thermospheric mass density in solar flare days can be related with the increase EUV (associated with solar flares) and hence increase the joule heating rate at high latitudes. This increases the temperature and scale height of the thermosphere, which accounts for the increase in mass density observed.

The zonal component of thermospheric neutral wind is observed to be increased in solar flare days (300 m/s) compared to non-flare days (200 m/s), especially in the polar regions. This indicates that the solar flare enhances the zonal wind at the polar regions by ~ 100 m/s. The pole-to-pole gradient of zonal component of thermospheric neutral wind is ~ 0.33 m/s/deg. The analysis also shows a notable enhancement of the Polar component of thermospheric neutral wind in polar region which has stronger northern component on flare days. The maximum value of northern component of thermospheric neutral wind in north pole is 200 m/s (or 100 m/s) on flare days (or non-flare days). The influence of strong northern component extends to vast longitude bin at polar region on flare days. In addition to both zonal component and Polar component of thermospheric neutral wind, we have observations that X class flares induces an overall increase in vertical component of thermospheric neutral wind also. The global average of vertical component is about 5 m/s upwards on flare days and about 10 m/s downwards on non-flare days. The latitude gradient of vertical component is also observed as little bit higher on flare days.

The latitudinal perturbation in thermospheric mass density is subjected to wavelet analysis to extract the major wave pattern generated in associated with solar flares. Variation with 500 -1000 km wavelength is observed to be present along Indian longitude sector at thermosphere during intense X-class flares.

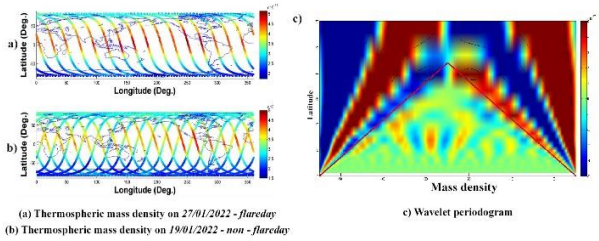

Figure 1. Thermospheric mass density observations and Wavelet periodogram

1. Grubor D, Šulic D, Zigman V " Influence of solar X-ray fares on the Earth ionosphere waveguide" *Serbian Astron* , 2005, J 171:29–35.