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Statistical analysis of thermospheric and ionospheric response to solar flares in solar cycle 23

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In the present study, we first explored the thermospheric response to all X-class solar flares during 2001-2006 by analyzing CHAMP and GRACE measurements. The observed results show that X5 and stronger solar flares can induce an average enhancement of 10-13% in thermospheric density in latitude 50°S-50°N within ∼4 hours after the flare onset. Many important lines and continua in solar EUV region are optically thick, thus EUV enhancements are smaller for flares located near the solar limb due to absorption by the solar atmosphere. Limb flares induce smaller thermospheric responses, due to the limb effect of solar EUV. The thermospheric density enhancement is much more correlated with integrated EUV flux than with peak EUV flux, with a high correlation coefficient of 0.91, which suggests that thermospheric response is strongly dependent on the total integrated energy into the thermosphere. Then we studied the ionospheric responses to solar flares during 1999-2006 by using the GOES 0.1-0.8nm X-ray, 26-34nm EUV, and GPS/TEC in the worldwide. The statistical results show the TEC enhancements are highly related to the solar zenith angle (SZA). The smaller SZA would result in the greater TEC responses. The TEC response is not highly related with the X-ray flux (the correlation coefficient 0.6), which is due to that the ionospheric response is not only related to the X-ray flux level, but also related to the flare location on solar disc. The limb flare has less effect on the ionosphere than the central flare. The reason for this is that the main ionization source EUV flux has such flare location dependence. The statistical results show that the flare location effect decreases with decreasing flare X-ray class. The results also show that the TEC enhancement does not linearly increase with X-ray flux. Its uprising amplitude increases with X-ray flux. The TEC response also has slight latitude dependence: it decrease with latitude. And the TEC response has significant seasonal dependence. The maximum response occurred at equinox and the minimum response at summer.