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Spatial-temporal distribution of the ionospheric perturbations prior to Msâ[U+0089]¥6.0 earthquakes in China main land

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Recently, earthquake precursor in the ionosphere is becoming one of the most challenging issues both in earthquake science and ionospheric science field. Based on the analysis of ionospheric data before strong EQs, some perturbations have been found in D, E, F layers respectively over the epicentral areas, including case and statistics studies. For the earthquake monitoring and prediction, we need to understand the evolutional features both in temporal series and spatial distribution in order to build their relationship with earthquakes.
In this study, using GPS TEC data (from Jet Populsion Laboratry), we have statistically analyzed the ionospheric perturbations prior to the Ms$\geq$6.0 earthquakes in China main land from November 1st, 1998 to December 31st, 2010. For each earthquake, LB=M-1.5(M-LQ) and UB=M+1.5(UQ-M) were selected as the threshold to abstract the disturbance from 0 to 15 days around the epicenter, and then we summed all the earthquakes results. The obtained results indicated that the GPS TEC had the same variation trend above the epicenter and eastern, southern, western, northern directions 15 days before earthquakes, and decrease occurred in all the 5 directions from 3 days to 5 days. Through different space scale analysis of $\pm$10°, $\pm$20°, $\pm$30°, it was found that the maximum seismo-ionospheric disturbance didn't appear just above the epicenter, but shifted to the magnetic equator, and it was worth to point out that the effected region in ionosphere was about $\pm$15°. Besides this, prior to earthquakes, positive anomalies appeared in the southwestern direction before 14th, 10th days, and there were obviously negative anomalies in the southeastern direction before 5th day. At last, a hypothesis of electrostatic field channel in lithosphere-atmosphere-ionosphere coupling was used to explain the observed phenomena. If there is penetration or secondary electric field in the ionosphere, it will move upward along the magnetic lines, causing E$\times$B motion, and leading to electron movement to equatorward and also to east and west directions under down and up electric field.