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Opposite Hemispheric Asymmetries in the Ionospheric F- and Topside Regions Observed During the Geomagnetic Storm of 29-31 August 2004

Abstract:
We use multiple ground-based and space-borne instruments to study ionospheric and thermospheric variations during the moderately intense geomagnetic storm of 29-31 August 2004 (minimum Dst excursion of -128 nT). Although this storm was far from the strongest in solar cycle 23, it provoked quite interesting effects in both the ionosphere and thermosphere, showing a very complex behavior: 1) A positive storm in vertical TEC (vTEC) and NmF2 started to develop at low-latitudes with the beginning of the main phase and persisted until the recovery phase. The large dayside low-latitude enhancement was also seen in the topside ionosphere, as shown by the GRACE and CHAMP satellites, and reached as high as 840 km of altitude, as seen in data of the F13 and F15 DMSP satellite. 2) Data of ground-based GPS-receivers and ionosondes revealed a strong positive storm in the ionospheric F-layer in the southern hemisphere (SH) in the American and European-African sectors; at the same time, in data from the northern hemisphere (NH), we observed no or a very small and short-term positive effect, followed by larger negative deviations during the main phase of the storm. 3) The satellites' data covered the topside region and detected opposite asymmetry than it was observed in the F-layer, i.e. larger vTEC and electron density (Ne) values in the NH, and no or small storm-time enhancement in the SH. This phenomenon was observed in both late afternoon (17-18LT) and post-sunset (~20:30-21:30 LT) sectors, and it was also shown to reach at least 840 km of height. 4) The hemispheric asymmetry can also be seen in the data of the neutral density, but only in the post-sunset region (CHAMP measurements at 385 km altitude), while in the evening sector GRACE data showed rather "even" increase throughout all latitudes with no asymmetry (at 485 km). Overall, the thermospheric storm in the post-sunset sector was found to be much stronger than in the evening sector. 5) In the post-sunset sector, we observed a strong storm-time reinforcement of the equatorial ionization anomaly (EIA), also known as a super-fountain effect. At the end of the main phase of the storm, about an hour after a further intensification of the IMF Bz component, TEC and Ne within the crests of the post-sunset EIA increased up to 250-400%; this effect further strengthened during the next 4-5 hours and lasted until the beginning of the recovery phase. The contribution of the topside ionosphere was estimated to be significant (about 3:7). DMSP observations showed a rise of the ionospheric plasma to at least 840 km, and simultaneously the O+ ratio density increased in the equatorial region and in the NH, also indicating the hemispheric asymmetry.