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2013 年 3 月 1 日に発生した磁気嵐における中緯度域まで拡大するプラズマバブルの磁気共役性

#惣宇利　卓弥 [1)], 大塚　雄一 [2)], 新堀　淳樹 [3)], 西岡　未知 [4)],PERWITASARI　SEPTI[5)]
[(1] 名大　ISEE,[(2] 名大・宇地研,[(3] 名古屋大学宇宙地球環境研究所,[(4] 情報通信研究機構,[(5]NICT

Geomagnetic conjugacy of plasma bubbles extending to mid-latitudes during a geomagnetic storm on March 1, 2013

#Takuya Sori[1)], Yuichi Otsuka[2)], Atsuki Shinbori[3)], Michi Nishioka[4)], SEPTI PERWITASARI[5)]
[(1]ISEE, Nagoya Univ.,[(2]ISEE, Nagoya Univ.,[(3]ISEE, Nagoya Univ.,[(4]NICT,[(5]NICT

After sunset, a plasma density depletion (plasma bubble) often occurs at the bottom of the F region over the equator. It is widely accepted that plasma bubbles are caused by the Rayleigh-Taylor instability mechanism. It is well known that plasma bubbles have been generated by eastward electric fields after sunset during the main phase of geomagnetic storms. Since plasma bubbles are formed along magnetic field lines and extend to higher altitudes and latitudes, they have been observed in both hemispheres at geomagnetic conjugate points. On the other hand, conjugate observation of storm-time plasma bubbles extending to mid-latitudes has not yet been performed although storm-time plasma bubbles often extend to mid-latitudes. In this study, we report the geomagnetically conjugate structure of a plasma bubble extending to the mid-latitudes and the asymmetrical structure of the decay of the plasma bubble during a geomagnetic storm. We investigated the temporal and spatial variations of plasma bubbles in the Asian sector during a geomagnetic storm on March 1, 2013, using global navigation satellite system (GNSS)-total electron content (TEC) data with high spatiotemporal resolutions. The first important point of our data analysis results is that the plasma bubble extended from the equator to the mid-latitudes with geomagnetic conjugacy along the magnetic field lines. The TEC data showed that the plasma bubbles appeared in the equatorial regions near 150o E after sunset during the main phase of the geomagnetic storm. From ionosonde data (h'F: virtual height) over both Japan and Australia, they suggest that a large eastward electric field existed in the Asian sector. Finally, the plasma bubbles extended up to the mid-latitudes (~43o geomagnetic latitude) in both hemispheres, maintaining geomagnetic conjugacy. The second point is that the mid-latitude plasma bubble disappeared 1 – 2 hours earlier in the northern hemisphere than in the southern hemisphere at close to midnight. In the northern hemisphere, the ionospheric virtual height decreased near midnight, followed by a rapid decrease in the total electron content and a rapid increase in the ionospheric virtual height. These results imply that the mid-latitude plasma bubble disappeared as the background plasma density decreased after midnight due to the recombination resulting from the descent of the F layer. Therefore, we can conclude that mid-latitude plasma bubbles can be asymmetric between the northern and southern hemispheres because of the rapid decay of plasma bubbles in one of the hemispheres.