Effects of Daytime Eastward and Westward Penetration Electric Fields on Low to Mid Latitude Ionosphere During Super Storms

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The daytime electric field centered over the equatorial F region, which is eastward under magnetically quiet conditions, is known to generate the equatorial plasma fountain (EPF) and equatorial ionization anomaly (EIA).
During geomagnetic storms, the daytime equatorial electric field can become strongly eastward or westward due to prompt penetration of electric field from high latitudes (and disturbance dynamo); the electric field becomes eastward for southward IMF Bz and westward for northward IMF Bz (and disturbance dynamo). The strong eastward/westward electric fields are thought to generate super forward/reverse plasma fountains, which can largely modify the low-mid latitude ionosphere both in the presence and absence of storm-time equatorward neutral winds. The super forward plasma fountain and its effects have been studied in some detail. However, the super reverse plasma fountain and its effects are not yet been studied. In this paper we present the super forward and reverse plasma fountains and their effects both in the presence and absence of storm-time neutral winds using the Sheffield University Plasmasphere Ionosphere Model (SUPIM) and observations. The study is for the super geomagnetic storms in 2000-2010. The model results show (1) strong positive ionospheric storms in electron density in the low-mid latitude ionosphere due to both forward and reverse plasma fountains in the presence equatorward neutral winds, (2) negative effects in the low-mid latitude ionosphere due to both plasma fountains in the absence of equatorward neutral winds except around the equator where the reverse plasma fountain produces strong positive ionospehric storms. The model results are compared with the observations from ionosondes, GPS-TEC networks and CHAMP satellite.