Temporal and spatial variations of midlatitude trough during geomagnetic storms based on Arase and GNSS-TEC observation data analysis

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In order to investigate characteristics of temporal and spatial variations of the midlatitude ionospheric trough and plasmasphere during a geomagnetic storm which occurred on 4 April, 2017, we analyze the 5-min average Global Navigation Satellite System total electron content (GNSS-TEC) data together with solar wind, interplanetary magnetic field, geomagnetic field, and electron density in the inner magnetosphere and ionosphere obtained from Arase High Frequency Analyzer observation data. The electron density in the inner magnetosphere along the Arase satellite orbit is determined with high time resolution of 1 or 8 seconds from the upper limit frequency of the upper hybrid resonance (UHR) waves. In calculating the electron density, we use 8-sec spin-average total magnetic field intensity data obtained from the Magnetic Field Experiment instrument. On the other hand, to find the location of the mid-latitude trough minimum during geomagnetic storms, we first subtract an average TEC data of 10 geomagnetically quiet days every month from the TEC data for each storm event. As a next step, we identify a minimum value of the subtracted TEC in the midlatitudes as a trough minimum in a TEC keogram. As a result, the location of the mid-latitude trough minimum moves equatorward from 60 to 48 degrees in geomagnetic latitude within several hours after the onset of the main phase of the geomagnetic storm. The movement speed is in a range from 1.3 to 3.5 degrees of geomagnetic latitude per hour. The location of the nighttime mid-latitude trough shows good agreement with that of an abrupt drop of electron density in the inner magnetosphere detected by the Arase satellite. The location of the plasmapause also moves earthward from L=4.49 to L=2.34 associated with the geomagnetic storm. The geomagnetic longitude distribution of the location of the mid-latitude trough minimum shows a significant variation with a scale of 1000 – 2500 km. The feature can be found during a quiet time, but the pattern of the longitudinal variation is different between the storm and quiet times. This phenomenon has not yet been reported by previous studies due to limitations in the coverage density of GNSS receiver networks. After the start of the recovery phase of the geomagnetic storm, the location of the mid-latitude trough minimum rapidly moves poleward back to the quiet-time location within several hours. The speed of the poleward movement is different from a different geomagnetic longitude.