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The response of GPS TEC to the sequence of September 2011 geomagnetic storms

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The behavior of total electron content (TEC) over European region was analyzed for the sequence of geomagnetic storms in September 2011. Three geomagnetic storms with similar magnitude and different time of occurrence took place during 3 week period. The sudden beginning of the first storm took place at 14 UT on September 09, 2011. Dst index was sharply changed from 0 to 17 nT and drop to -63 nT. The second storm occurred on September 17, 2011 at the moment of 9 UT, the Dst index changed from 30 nT to -58 nT. The third event began on September 26, 2011 at 16 UT, minimal Dst index was equal to -103 nT in 11 hours after beginning.
GPS TEC estimates were calculated with using data of European GNSS network. The spatial-temporal dynamics of TEC was analyzed on the base of constructed regional TEC maps and diurnal TEC variations over selected GNSS stations spaced along meridian of 20°E between latitudes of 70°-30°N.
The ionosphere's response for September 9-10, 2011 geomagnetic storm was mainly negative; the average TEC depression was about 30% at daytime over European mid-latitude stations. The short positive splash in TEC variations was observed at evening September 9 in several hours after the storm's beginning.
The distinguishing feature of September 17 storm was the strong positive effect which occurred on day-time over Europe region. The enhancement of TEC reached the factor of 1.7-2.0. Maximal effect was observed at high latitudes and slowly decreased to low latitudes. The duration of positive ionospheric effect was about 4-5 h. At high latitude stations of Kiruna (Sweden) TEC reached 30 TECU in compare with undisturbed level of 13-15 TECU. The maximal TEC enhancement was rather short-term and continued only 1.0-1.5 hour. The surge of TEC enhancement was moved from north to south, the delay between Kiruna and Noto (Sicilia) stations was 120-150 min.
The ionospheric storm occurred on September 27, 2011 was the strongest one in the considered period. The ionospheric depression (up to 60%) corresponds to the main phase of storm with minimal value of Dst index equal to -103 nT. The development of the negative ionospheric storm had classical character.
In this report we discuss the physical process in ionosphere and magnetosphere accompanied considered events and effects.