IGS ROTIPOLARMAP: product, service and applications

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The ionosphere plays an important role in GNSS applications because it influences on the radio wave propagation through out. The ionosphere delay is the biggest error source for satellite navigation systems, but it can be directly measured and mitigated with using dual frequency GNSS receivers. The navigation signals fading due to presence of the plasma irregularities in the ionosphere can decrease an operational availability of navigation systems [1]. This effect can be estimated by measuring of its impact on phase of the received GPS signal. So, observation and analysis of the ionospheric irregularities at the high latitudes using GPS measurements represent very actual task for both scientific point of view and Global Navigation Satellite Systems (GNSS) applications,

The new IGS ionospheric fluctuation maps product (ROTIPOLARMAP) is based on estimates of the TEC rapid changes. For an overall representation of the spatial evolution of the ionospheric irregularities, which caused the GPS signal fluctuations over the Northern Hemisphere middle and high latitudes, there is produced a daily map of the ROTI (rate of GPS TEC change) index [2] basing on data derived from a representative set of 700 representative permanent GPS stations in the Northern Hemisphere. The Earth's magnetosphere and ionosphere are strongly coupled and the most intense ionospheric irregularities are observed during geomagnetic storms that occur as a result of significant increase of the auroral particle precipitation and high latitude ionospheric electric fields and currents. By this reason for ROTI maps representation we use the corrected geomagnetic (CGM) coordinates with DGRF/IGRF models. For daily ROTI maps, we averaged and binned all ROTI values collected during 00–24 UT period of a considered day. The grid size is 8 min MLT by 2° MLAT, with the latter covering 50° - 90°. The averaged ROTI value in each MLAT-MLT bin corresponds to probability of the GPS signals phase fluctuations caused by passing of radio signals through the ionospheric irregularities. The ROTI maps allow to estimate the ionospheric plasma gradients distribution and auroral oval evolutions. In general the ROTI values are corresponded to the probability of GPS signals phase fluctuations and amplitude scintillations. The resulted ionospheric fluctuation product is represented in the ASCII IONEX-like data format and can be visualized. The ROTIPOLARMAP s data format is described in details.

We demonstrate the IGS ionospheric fluctuation map product performance for scientific research application on set of test-cases (geomagnetic storms occurred in the years 2013-2015) for comparative analysis of the resulted daily ROTI maps for quite and geomagnetically disturbed periods. Occurrence of the ionospheric irregularities is driven by forces of the space weather phenomena, and considered case studies demonstrate the ability to retrieve information about the ionospheric irregularities structure, position, and duration. We found that during quiet ionospheric conditions the fluctuation events are mainly observed during geographic or magnetic local night and day cusp sector time within the area of 70° MLAT. Obtained results show clear dependence of the ionospheric fluctuation activity, described by ROTI, on solar wind and IMF parameter variations. Intense phase scintillations depicted in the diurnal ROTI maps can provide an important information about development of the severe storm-induced gradients in the ionospheric plasma density, both caused by auroral particle precipitation and plasma flows. It is possible to conclude that IGS ionospheric fluctuation maps product can be effectively used for monitoring of the plasma irregularities with different origin. The independent ground-based and satellite measurements supported our results and conclusions. The indices and maps, based on TEC changes, can be effective and very perspective indicator of the presence of the plasma irregularities in the high-latitude and midlatitude ionosphere. We expect the high potential of the new IGS service and its products.

References

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