Total electron content driven data products of SIMuRG

Artem Vesnin¹, Yury Yasyukevich¹, Boris Maletckii¹, Alexander Kiselev¹, Ilya Zhivetiev¹, Ilya Edemskiy¹,² and Semen Syrovatskiy¹,³

¹Institute of Solar-Terrestrial Physics of Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia, 664033, PO Box 291, artem_vesnin@iszf.irk.ru
²Institute of Atmospheric Physics, Czech Academy of Science, Boční II, 1401, 14131 Prague, Czech Republic, ilya@iszf.irk.ru
³M.V. Lomonosov Moscow State University, Moscow, Russia, semen_syrovatskii@iszf.irk.ru

System for the Ionosphere Monitoring and Researching from GNSS (SIMuRG, see https://simurg.iszf.irk.ru) has been developed in ISTP SB RAS. The system servers as proxy for the RINEX data of global GNSS receivers network. SIMuRG automatically downloads, process and visualize GNSS data. Despite of the system takes routine processing task from the researches, which is valuable by itself, it provides newly developed and improved data products. All data products are based on total electron content (TEC) calculated from RINEX and global ionospheric maps GIM. The first data product is ionospheric variations (TEC variations). The variations are widely used for ionospheric studies, but SIMuRG performs calculation using the filtration that suits TEC data the best way. Before new filtration technique was applied major unphysical artifacts were detected in the data. The artifacts could even prevent from correct interpretation of processing results. The variations together with widely used ROTI index which is also implemented in the system helps to study ionospheric variability. The second data product is newly developed "adjusted TEC". For that we use GIM to force all TEC series from different site-satellite line-of-sights have one reference level. While the reference level is the same, adjusted TEC leaves all the peculiarities exhibited in different TEC series unaffected. Adjusted TEC broaden ionospheric maps capability near the GNSS stations improving time resolution up to 30 seconds and giving better space resolution. The third data product is implementation of D1 method which calculates ionospheric irregularities motion velocity. D1 shows velocity vector while variations show only amplitude of the irregularity (deviation from the background). D1 calculation is designed in the way that it possible to choose scale of the disturbance to study. It makes possible to study the disturbances of different physical origin. D1 is able to show global ionospheric dynamics and can help detect traveling ionospheric disturbances of various scales. The data described above are attribute by the interactive experimental geometry plots, which might consider as one more data product. The geometry plots might be useful since the TEC data cover area of several thousands kilometers across. The fourth data product is global and regional electron content (GEC and REC), see https://simurg.iszf.irk.ru/gec for reference. SIMuRG provides interactive plots of the GEC and REC. While TEC shows the number of electrons in a given direction (surface density), GEC and REC show amount of a plasma in a volume. GEC is weighted sum of the TEC around the globe, REC – in some geographical region. GEC and REC suits for large scale long-living ionospheric variations
studies. Using REC we detect after-storm plasma density change in equatorial ionosphere. There is an option to choose region for REC using geographic and geomagnetic coordinates. We also developed the interface for ionospheric events tracking and submission. We hope to use the events database for machine learning purpose. We hope all above newly developed and improved TEC based data products find application among researches.

This work was performed under the Russian Science Foundation Grant No. 17-77-20005.