RIMT: A tool for Regional Ionospheric Mapping and Tomography using GPS data

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Abstract

The ionosphere is about 60-1000 km above the earth's surface, which is actually plasma of ionized gas of the upper atmosphere by solar radiation and high-energy particles from the Sun. The ionized electrons concentrations change with height above earth's surface, location, time of the day, season, and amount of solar activity. The total electron content (TEC) and electron density profiles are two key parameters in the ionosphere. Therefore, imaging the TEC and electron density profile is very crucial to determine the status of the ionospheric activities. In addition, the TEC in the Earth's ionosphere and plasmasphere is important for estimation and correction of propagation delays in satellite positioning, and predicting space weather and ionospheric disturbances due to geomagnetic storms and solar flares, etc.

In the past decades, different observing instruments have been developed and used to gather information on the ionosphere, such as ionosonde, scatter radars, topside sounders onboard satellites, in situ rocket and satellite observations and LEO (Low Earth Orbit) GPS occultation measurements. However, most instruments are expensive and also restricted to either the bottomside ionosphere or the lower part of the topside ionosphere (usually lower than 800 km), such as ground based radar measurements. Nowadays, GPS satellites in high altitude orbits (~20,200 km) are capable of providing details on the structure of the entire ionosphere, even the plasmasphere. Moreover, GPS is a low-cost, all-weather, near real time, and high-temporal resolution (30s) technique. Therefore, GPS has been widely used to investigate the ionospheric and its related solid earth activities recently. In order to sufficiently and conveniently use GPS in the ionosphere by more uses, in this paper, we develop a software tool, called Regional Ionospheric Mapping and Tomography software (RIMT), which can monitor TEC and map 3D ionospheric electron density distribution using GPS measurements. Some cases results are obtained from the RIMT tool with regional GPS networks, which compare well with the ionosonde. The software using GPS data suggests a way to provide ionospheric total electron content (TEC) and 3-D electron density profiles at any specified grid, which can monitor ionospheric activities and states as well as direct application to single frequency instrument calibration. In addition, this tool with GPS-based 3D ionospheric tomography has the potential to complement other expensive observing techniques in ionospheric mapping, such as ionosonde and radar.

The RIMT tool is also able to extend global ionospheric mapping and tomography when using global GPS data. In the future, it is expected to further improve the RIMT tool by combining more data from the dense ground-based and space-borne GPS, VLBI, Jason, TOPEX/Poseidon, GLONASS, and Galileo across the concerned region for ionosphere mapping and tomography. The higher resolution density profiles can be achieved. At that time, the RIMT will be more powerful useful tool in monitoring the ionosphere and relevant research.

Keywords: GPS, ionosphere, TEC, electron density, tomography