Real-time ionospheric tomography using GPS dense network

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The ionosphere covers the region between approximately 50 and 1500 kilometres above the Earth's surface and is characterised by the presence of a significant number of free electrons and positively charged atoms and molecules. Ionospheric influence on radio wave propagation explains its importance and research interest. Indeed, the ionosphere exerts severe influences on the propagation of electromagnetic waves, which are refracted, reflected and absorbed in various ways according to its dispersive properties.

All kinds of earth-satellite connections are hindered by the ionosphere (transionospheric communication links, satellite based navigation system, SAR (Synthetic Aperture Radar) interferometry…). For GPS/Galileo applications for example, the signal delay or advance caused by the ionosphere is the major concern because it corrupts the positioning and time transfer results. The ionosphere is also affecting earth-based communication and radars, especially those based on refraction, like over-horizon radars.

To get higher accuracy in GPS/Galileo positioning and navigation, and in SAR imagery, we need to monitor the ionospheric structure (the electron density in this layer) and its spatial and time variations. Also, the ionospheric effects could be estimated and corrected from data.

The tomography technique seems to be a good tool to produce two-dimensional cross-section maps of the ionosphere's electron density.

Dual-frequency GPS gives access to the ionospheric propagation delay that is related to the Total Electron Content (TEC) which is the integral of the local electron density along the path between the satellite and the receiver. These integrated measurements provide an image of electron density in the ionosphere.

We present here our approach to monitor the TEC using GPS data and the results from the Californian and Japanese continuous networks. The increasing number of GPS data from dense continuous networks should allow a performing real-time tomography of the ionosphere with a high spatial and temporal resolution.

The perspectives of this work are significant improvement in mono-frequency satellite measurements, and in GPS and SAR imagery of geophysical phenomena (volcano deformations or subsidence detections). Also, the precise tomography of the ionosphere will make possible to detect ionospheric disturbances like geomagnetic storms or ionospheric scintillations and eventual post-seismic perturbations.