Determination of GNSS instrumental biases for total electron content study using isolated single receiver

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Extended Abstract

L-band signals transmitted from GNSS satellites are widely used for the study of ionospheric total electron content (TEC). For this purpose, differential propagation delay between two frequencies in the dispersive medium is measured. However, there is a basic problem of signal delays in the electronics of satellites and receiver, being different between two different frequencies, which is often referred to as instrumental biases. Thus it is necessary to estimate the instrumental biases for calculating the ionospheric propagation delay and thus slant TEC.

Various algorithms have been proposed to estimate instrumental biases and TEC products are provided from many organizations. Most of them are based on the global or local networks consisting of many GNSS receivers. However, it is still required to determine receiver biases in areas of the globe isolated from global or local dense receiver networks. Most of the proposed techniques for estimating the receiver bias of a single receiver rely on the outputs of the network technique more or less, i.e., spatially interpolated or extrapolated TEC values and/or satellite biases.

In this paper, we present an alternative method to determine instrumental biases and TEC for isolated single receiver without relying on other products. The technique used data obtained for a whole day and the TEC was assumed to be expressed by surface harmonics of angular local time ($\phi$) and geographic colatitude ($\theta$), with degree and order of 5 ($n=5, m=5$). Traditional thin layer approximation was used to convert the azimuth and elevation of the satellite from the receiver into the parameters at the ionospheric pierce point; ($lon_{ipp}$, $lat_{ipp}$) and zenith angle ($\chi$). The longitudinal parameter $\phi$ was calculated from $lon_{ipp}$ and time (UT). The surface harmonics fitting is illustrated in Figure 1, which is an orthogonal function network and an additional network without input for the bias estimation. The weights ($w_i$) and biases ($b_r, b_s$) were calculated to minimize the quadratic error by using the gradient descent algorithm.

![Figure 1. Orthogonal network to obtain GNSS instrumental biases and TEC.](image)

The technique was applied to the data obtained on 26 April 2014 by the receiver located at Beijing, China, and Figure 2 shows resultant local-time variation of TEC for the latitude range $\pm 5^\circ$ of the receiver.

![Figure 2. Local time vs. latitude variation of TEC at Beijing (39.61°N, 115.90°E), China on 26 April 2014.](image)