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Station based GPS Slant Total Electron Content (STEC) Prediction

M. M. Hoque and N. Jakowski

Institute of Communications and Navigation, German Aerospace Center, Kalkhorstweg 53, 17235 Neustrelitz, GERMANY.
(E-mail: Mainul.Hoque@dlr.de, Norbert.Jakowski@dlr.de)

ABSTRACT

The orbit configuration of the Global Positioning System (GPS) space segment is such that the same satellite appears in the same part of the sky at the subsequent day delayed by approximately 4 minutes. During this period the Earth completes one revolution whereas a GPS satellite completes exactly two revolutions in inertial space creating the same ray path geometry when looking to the same satellite from a fixed location on Earth. This repetition of receiver-satellite geometry can be used for mitigating local multipath noises as well as for Slant Total Electron Content (STEC) prediction along receiver-satellite links. A GPS signal travelling through the same part of the sky to the same location on Earth experiences nearly the same geophysical conditions for STEC computation. Considering quiet ionospheric conditions we assume that during a 1 day period, more precisely 4 minutes less than one day, the STEC varies primarily with solar radiation changes. Since the solar radiation varies during this period and influences the level of the total ionization, STEC along a phase-connected arc for the same receiver-satellite link would not be the same as measured the previous day. Accordingly STEC compared with the previous day needs to be adjusted to the current solar radiation level. We found that by recording the GPS dual-frequency measurements for one or more hours and comparing them to the previous day measurements, the differences in the solar activity level between consecutive days can be successfully derived. However, the GPS differential measurements are biased by satellite and receiver inter-frequency instrumental biases and these biases must be corrected for. It is assumed that the GPS satellite and receiver biases do not change significantly during consecutive days and therefore we considered them unchanged during consecutive days.

For validating the discussed STEC prediction approach we have selected a geomagnetically quiet period of 17 consecutive days 15-31 Jan 2011 and a perturbed period of 17 consecutive days 23 Oct - 8 Nov 2011. We processed dual-frequency GPS data from International GNSS Service (IGS) stations separately for both the quiet and perturbed periods and computed daily satellite and receiver differential code biases (DCBs) and corresponding STECs at numerous GPS stations (2011a, 2011b). Our investigation shows that during quiet ionospheric condition the approach can predict STEC at a mid-latitude station, as for example at wtzs (49.9° N, 12.9° E), with mean and standard deviations from reference values of about 0 and 1.6 TECU (1 TECU = 1.e+16 el/m^2), respectively. During perturbed condition the mean and standard

deviations are found as about -0.1 and 4.4 TECU, respectively. At a low-latitude station, as for example at adis (9° N, 33.8° E), the mean and standard deviations are found as about 0.3 and 3.7 TECU, respectively during quiet ionospheric condition. During perturbed condition the mean and standard deviations are found as about 0.7 and 11.2 TECU, respectively. The following Figure shows prediction performance at IGS stations wtzs and adis during quiet and perturbed ionospheric conditions in histogram plots.

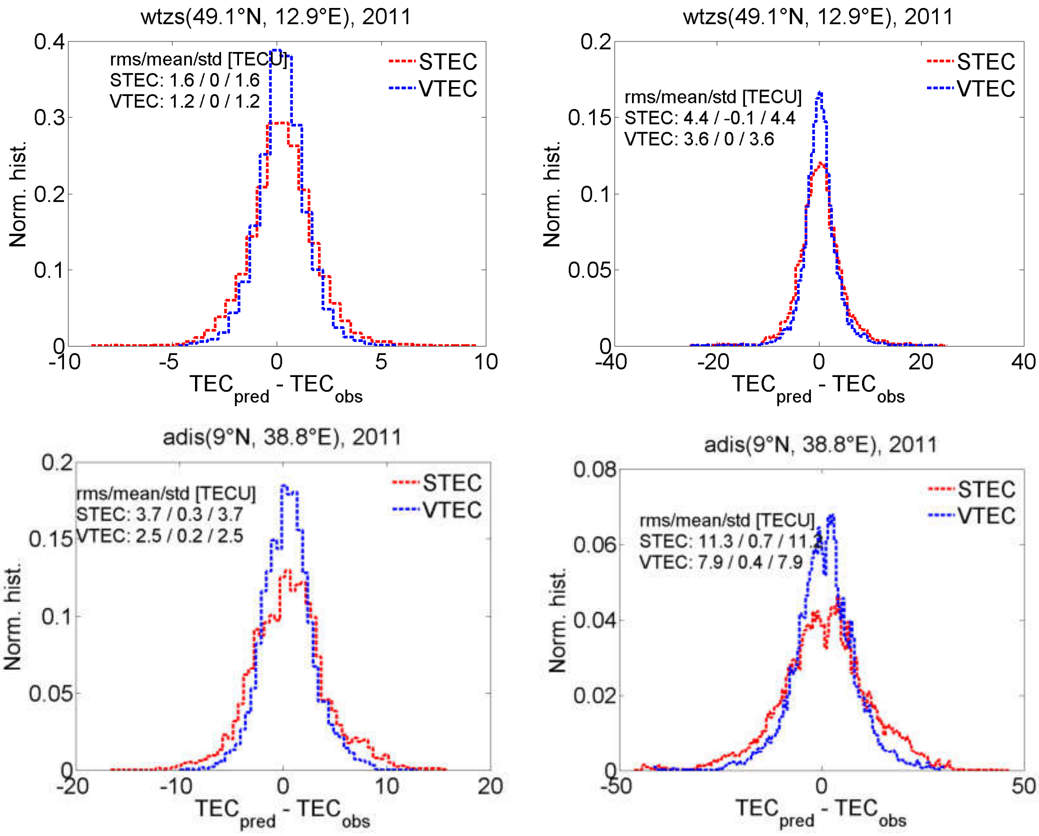

Figure 1: Prediction performance at wtzs and adis stations during quiet (left panels) and perturbed ionospheric period (right panels)

We have utilized the diurnal repetition property of a GPS satellite that creates the same ray path geometry when looking to the same satellite from a location on Earth. The method is free from mapping function errors that appear if vertical TEC models are used. We found that our new approach can successfully predict slant TEC several hours in advance if severe ionospheric storms are excluded especially at a mid-latitude station.

References:

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