Evaluation of NeQuick model performance using ATS-6 STEC satellite data

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ABSTRACT

Slant Total Electron Content (STEC) measurements from the ATS-6 Radio Beacon Experiment (RBE) have been used to evaluate the performance of NeQuick 2 ionospheric model in the stations of Bozeman, Boulder and Dallas, US [1].
The geostationary ATS-6 satellite launched in 1974 and in orbit until 1979, gave a unique opportunity to use the group delay effect simultaneously with Differential Doppler and Faraday effects observations. The ATS-6 RBE provided the first VHF/UHF coherent beacons especially designed for ionospheric and plasmaspheric research [2].
The values of STEC corresponding to the station of Boulder (40.13°N, 254.76°E) for December 1974 have been reproduced by using NeQuick 2 under different modes: climatological, driven by daily solar flux (F10.7) and ingested with STEC values registered for the same month at the station of Bozeman (45.66°N, 248.95°E).
The capability of NeQuick 2 (daily solar flux and ingested) model in reconstructing the ionosphere electron density at the selected ATS-6 station has been validated in terms of a statistical comparison between experimental and modeled STEC values. The results indicate that the model after the ingestion procedure improves its ability to compute STEC in comparison to its climatological version up to about 70% during night hours.
A supplemental analysis taking into account the mismodelings of the plasmaspheric contribution to the columnar electron content will be discussed.

Keywords: Beacon satellite, Ionospheric models, Data ingestion, Total Electron Content.

Data and Methodology

The multifrequency radio beacon onboard the ATS-6 was designed to measure the total columnar electron content (NT) between transmitter and receiver and the Faraday (or ionospheric) columnar content (NF) along the ray path between the receiver and a height of about 2000 km [3, 4]. For this study, the STEC data from the group delay measurements of 140 MHz from ATS-6 satellite during December 1974 at the stations of Bozeman and Boulder has been used as experimental values to validate the performance of the last version of NeQuick ionospheric model [5], as a climatological model and when is driven by solar flux of the day. In [6], a simple method to ingest the NeQuick model with ground and or space based data has been proposed. We checked then the ability of the model in reconstructing the 3D ionosphere electron density when STEC from an ATS-6 station data (Bozeman) is incorporated into it and the effective level of ionization (Az) thus obtained is applied to a near station (Boulder).

Results

The validation carried out comprises statistical results of the differences obtained between ATS-6 STEC (NT and NF) and STEC calculated with the NeQuick model when is driven by daily F10.7 and after the ingestion procedure already mentioned. The histograms of the differences are shown in Fig 1.

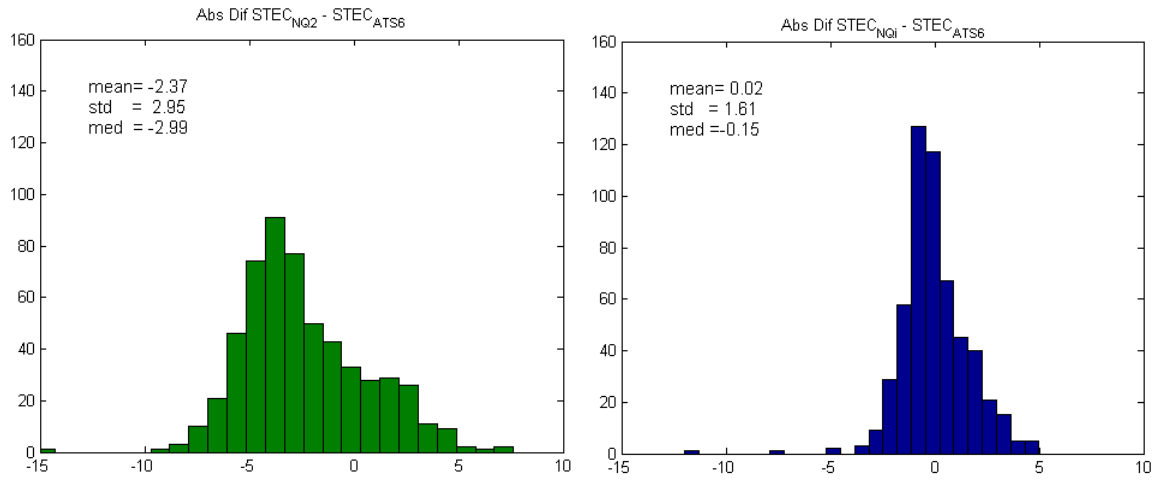

Figure 1. Histogram of differences in TECU of: NeQuick2 – ATS6 (NT) STEC (left-pannel) and NeQuick ingested – ATS6 STEC (right-pannel). Mean, standard deviation and median values are included.

As can be seen from Fig.1, when NeQuick model is ingested with STEC from Bozeman station and the resulted effective parameter used to drive the model in Boulder, the performance of the model clearly improves with respect to the same model driven by daily F10.7.
An analysis on the day-to-day variation of the measured and modeled TEC reports a good agreement of the ingested version of the model, while the climatological and the version driven by daily F10.7 present a constant underestimation during the night hours.

The variations of the monthly median hourly STEC ATS-6 and NeQuick values (in different modes) at Boulder for December 1974 are shown in Fig. 2.

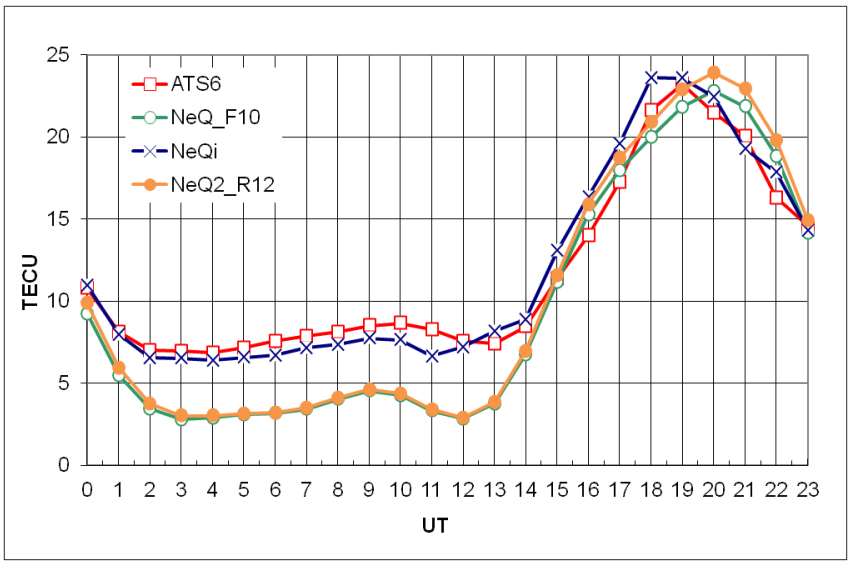

Figure 2. Monthly median hourly STEC values (ATS-6, NeQuick driven by daily F10.7, NeQuick ingested and NeQuick climatologic version) at Boulder, for December, 1974.

Further comparisons by taking into account the NF and NP values given by ATS-6 were realized to better understand the source of the mismodelings. The necessity of a revision of the slab thickness representation of the NeQuick model, as well as the underestimation of the topside electron density beyond 2000 km will be discussed.

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