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On the NeQuick model capability to represent the Winter Anomaly

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NeQuick [1] is an empirical model conceived to represent the climatological behavior of the ionospheric electron density and it is particularly designed for transionospheric propagation applications. The ionospheric Winter Anomaly (WA) is defined as the situation where, over a given middle-latitude location, the (daytime) maximum vertical Total Electron Content (vTEC) is greater in winter than in summer, for approximately the same solar activity condition. In this work the NeQuick model capability to represent the WA effects is analyzed. For this purpose, the attention has been devoted to the regions over the 50°N and 50°S geographic parallels. The vTEC daily patterns, representative of the month of June and December during the years from 1993 to 2019, have been calculated at selected locations with NeQuick model driven by the average solar flux for the relevant month/year. The events where the maximum vTEC is greater in winter than in summer have therefore been identified as WA occurrences. For each location, the model calculated vTEC daily patterns and WA occurrences have then been compared to the corresponding experimentally derived TEC patterns and WA occurrences. For locations over mainland, vTEC data have been obtained from ground-based GNSS receivers; for locations over the sea (specifically the 50°S geographic parallel), vTEC daily patterns have been retrieved from altimeter satellites (TOPEX, Jason1, Jason 2 and Jason 3) data using a novel technique [2] recently developed. As an example, Figure 1 displays the vTEC computed with NeQuick model (panel a) and experimentally derived (panel b) for June (red) and December (blue) during more than two solar cycles at the site with coordinates (50°S, 120°E). From the same figure it is possible to recognize that NeQuick data exhibit WA effects in 1993, from 1999 to 2003, in 2012 and 2015; while experimentally derived data WA effects are noticeable only for years from 1999 to 2002.

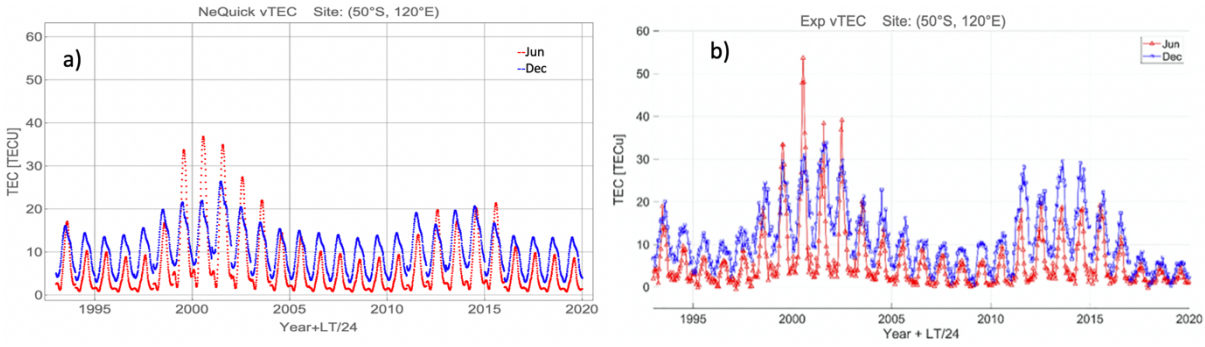

Figure 1. vTEC daily patterns computed with NeQuick model (panel a) and experimentally derived (panel b) for June (red) and December (blue) during the period 1993-2019 at the site with coordinates (50°S, 120°E).

The comparative analysis of modelled and experimentally derived vTEC data has indicated that NeQuick is capable to represent the WA effects over the analyzed middle latitude regions (in spite of some discrepancies in TEC ranges). Nevertheless, in some cases the model tends to over-represent the WA, by overestimating its effects or by showing WA effects where they should not be present in accordance to the experimental evidence.

References

[1] B. Nava, P. Coïsson and S.M. Radicella, "A new version of the NeQuick ionosphere electron density model", *J. Atmos. and Solar-Terr. Phys*, **70**, 15, Dec. 2008, pp. 1856–1862, doi: 10.1016/j.jastp.2008.01.015.
[2] F. Azpilicueta, and B. Nava, "Studying the winter anomaly with altimeter-derived TEC data", *Advances in Space Research*, **68**, 8, 2021, pp. 3391-3402, doi: 10.1016/j.asr.2021.06.008.