Assessment of first Real-Time IGS global VTEC maps

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Abstract

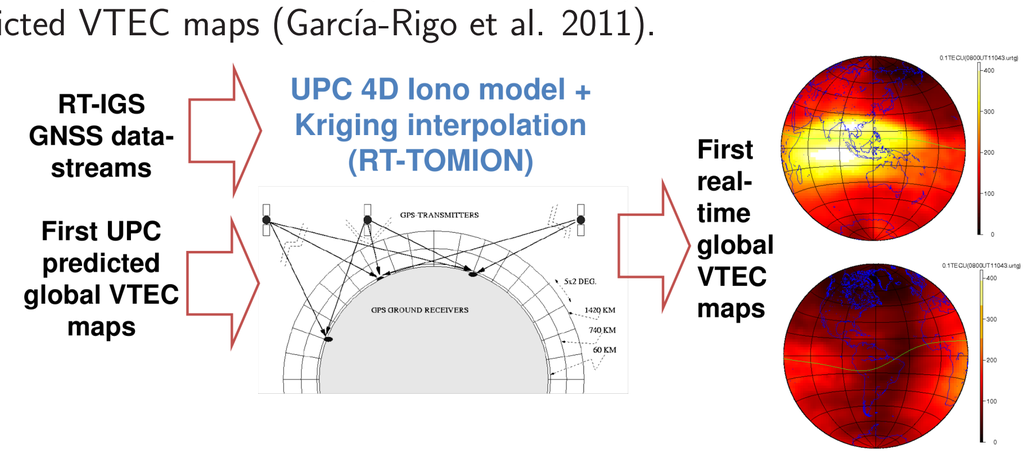
The assessment of the first Real-Time (RT) IGS global VTEC maps computed by DLR and UPC, against JASON-1 (during 2011) and JASON-2 altimeter VTEC measurements (2012), is presented in this work. Indeed, within the International GNSS Service (IGS), Associate Analysis Centres (ACC) produce specialized or derived products. Two examples of Real-time ACCs are the Universitat Politècnica de Catalunya (UPC) and the German Aerospace Center (DLR). They have participated in the IGS Real Time Pilot Project (RTPP) and continue to collaborate on the development of a combined global IGS RT-VTEC product. This collaboration is occurring under the umbrella of the IGS Ionosphere Working group (IGS Iono-WG) currently lead by the University of Warmia and Mazury in Olsztyn, Poland. RT-VTEC information is used to support earth observation missions and space weather monitoring and forecast. RT-VTEC information can improve single-frequency positioning on a global scale and in smaller regions where the ionosphere may be well sounded. RT-VTEC information is known to improve RTPPP accuracy results for single-frequency users. Through the use of iono-geodetic techniques, phase quality dual-frequency RTPPP results are being improved by reducing the convergence time for phase ambiguity fixing. The JASON comparisons are considered pessimistic for the overall global VTEC product accuracy because the land-based tracking stations are generally located quite far from the location of the JASON measurements. The importance of a reliable globally distributed and sufficiently dense real-time GNSS tracking network will be shown. Moreover the RT-VTEC results are quite compatible with the rapid and final IGS VTEC maps for a significant fraction of time. These results suggest that it may be feasible to combine real-time VTEC products from several centres into a robust IGS real-time IONO product. Additional work to compare both solutions is underway with the goal of finding optimal ways to assess and combine these products into an IGS RT- VTEC product. Future efforts will include working with RTCM to ensure that the IGS RT-VTEC product is compatible with ionosphere correction information proposed for the RTCM-SSR standard.

Introduction

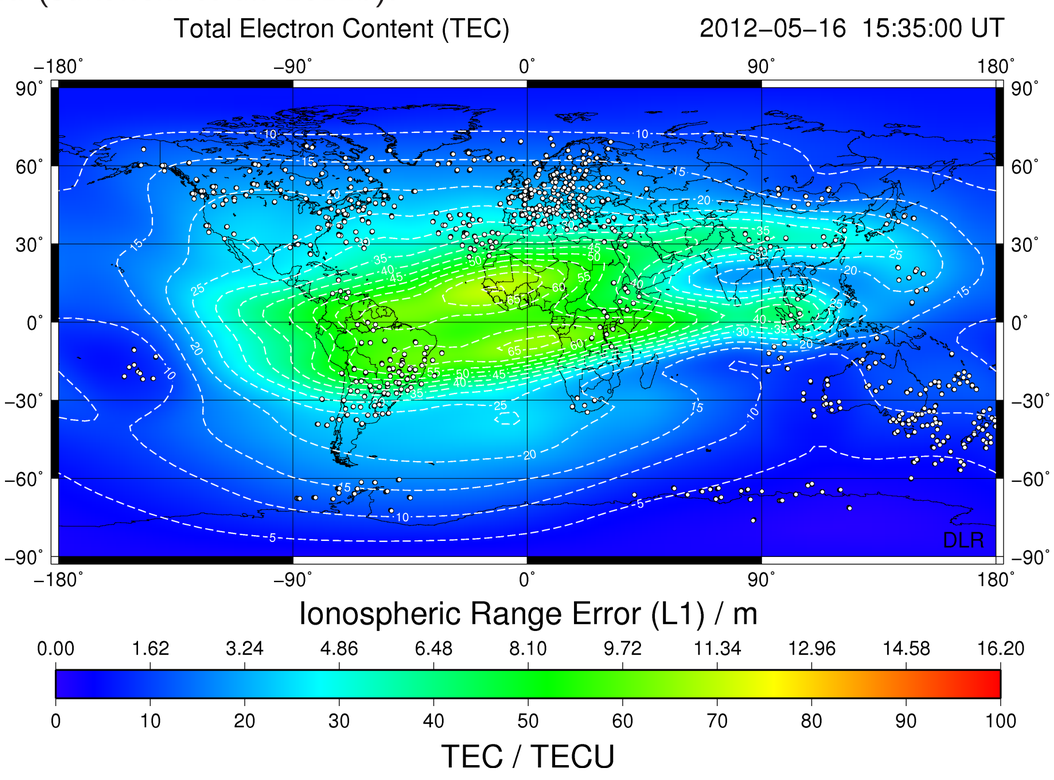
- The generation of real-time global IGS ionosphere VTEC maps is a new challenge within RTIGS project (Caissy et al. 2012).
- So far: final, rapid and predicted global VTEC maps are generated with latencies of about 12, 1, -1 and -2 days (Hernández-Pajares et al. 2009).
- Applications at short and long terms: Space Weather (see http://swaciweb.dlr.de), GNSS navigation (single freq., PPP-RTK or Fast PPP Juan et al. 2012).
- Performance of first global RT-VTEC maps of UPC and DLR is summarized.

Models

- UPC RT-TOMION software directly fed by the RTIGS datastreams, estimates the TEC with two layers of voxels (Juan et al. 1997), with Kalman filtering and further Kriging interpolation (Orús et al. 2005) of the residuals regarding to predicted VTEC maps (García-Rigo et al. 2011).

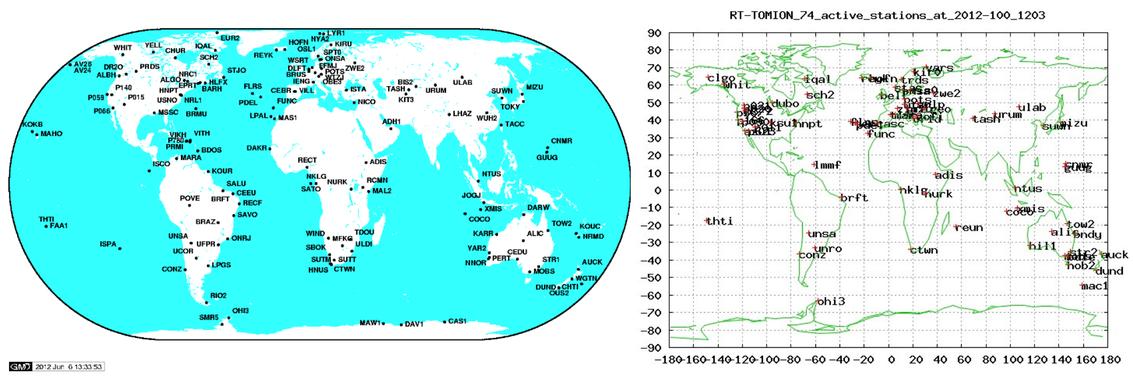


- DLR VTEC maps are generated by assimilating GNSS data into a global TEC model (Jakowski et al. 2011a). The model is used to forecast TEC 1 hour ahead (Jakowski et al. 2011b).



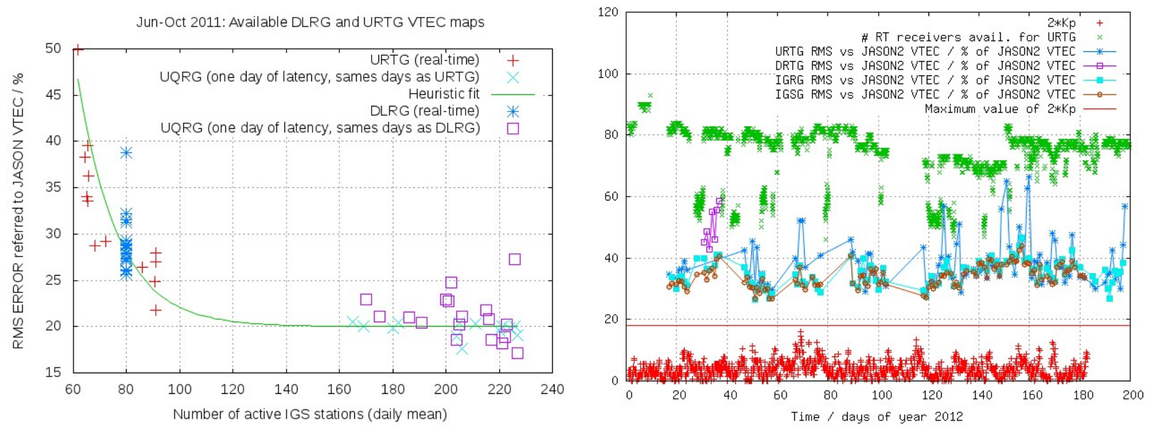
Main limitation: global lack of RT receivers

- Degradation of the RT-VTEC quality over oceans and large areas outside Europe, North America and Australia due to the limited RT coverage (see complete set of present RT IGS receivers at left-hand plot). See below (right-hand plot) a typical map representing the worldwide-selected RT active receivers for RT-TOMION (74 receivers for day April 9th, at 1203UT):



First assessments of global Real-Time DLR and UPC against JASON altimeter data

- RT global VTEC maps of DLR and UPC (hereiafter DRTG and URTG) computed each 15 min. are compared (left-hand plot) with rapid VTEC maps of UPC computed each 15 min. (UQRG and 1 day of latency).
- The reference is the VTEC directly observed by the dual-frequency altimeter JASON-1 on the oceans (see for instance Orús et al. 2002) in Jun.-Oct. 2011.
- The importance of a reliable globally distributed and sufficiently dense real-time GNSS tracking network is evident. These results suggest that it may be feasible to combine real-time VTEC products from several centres.



- The assessment of global RT DLR and UPC VTEC maps has been extended to RT runs in 2012, but using JASON-2 (instead of JASON-1, which was not available in part of that period). The RT results are plotted along with rapid and final IGS VTEC performance results, as well as the Kp index of geomagnetic activity and the number of available receivers (above-right plot):
  - For a significant number of days, the relative RMS of the RT-VTEC error vs. JASON-2, is only slightly worse that those of the final and rapid IGS (combined) VTEC maps.
  - Typical RT error seems related to higher geomagnetic activity (like day 69, with Kp=8) and affects the corresponding quality of the predicted map.
  - A few huge error values for UPC RT-VTEC are due to wrong runs of the system after re-initialisations (two instances running in parallel).
  - Other error peaks for UPC RT-VTEC seem to be associated with sporadic problems in the generation of the reference predicted VTEC maps "U2PG" (under investigation).
  - An update to the number of available receivers seems necessary to improve the UPC RT input data (there has been a decreasing number of maximum available streams with time).

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Conclusions

- The importance of a reliable globally distributed and sufficiently dense real-time GNSS tracking network is shown. These results suggest that it may be feasible to combine RT VTEC products from several centres into a robust IGS RT IONO product, when a high enough number of worldwide distributed RT stations is available.
- The real-time results are sufficiently close, for a significant number of days, to those of the rapid and final IGS VTEC.
- Work to compare DLR and UPC RT solutions is underway with the goal of finding optimal ways to assess and combine these products into an IGS RT-VTEC product.
- Future efforts will be focused on an improvements to the apriori background VTEC model (UPC), and on working with the RTCM community to ensure that the IGS RT-VTEC product is compatible with the ionosphere correction information proposed for the RTCM-SSR standard.

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