REAL TIME APPLICATION OF TOMION MODEL: FIRST GLOBAL RESULTS


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1. INTRODUCTION

Since the first introduction of the TOMION (Tomographic Model of the Ionosphere) in 1985, gAGE/UPC has been improving its performance and reliability of this technique. The TOMION model relies on the computation of the ionospheric electron density profiles using a 4D model of the ionosphere. At the beginning, the technique was mainly limited to the ionospheric phenomena observed in a single very precise ionosonde station. Further developments led to the use of TOMION as a global ionospheric model, see [1], also allowing for the production of regionaltomographic ionospheric Maps (GIMs) for the International Global Navigation Satellite Systems (GNSS) constellation, with CORD, University of Bath, UK (Energy Mines and Resources, MRCAN), ESA (European Space Agency) and JASON (Joint Project Office) as activities. In short terms, TOMION maps have been improved, increased, and the use of more than 5 layers was a natural extension of the model, see [5]. However, some aspects were introduced, and as a result of that after the improved Abel technique, the electron density retrieval, was developed, see [7]. This technique was based on the separability hypothesis, which overcame the limitations of the original hypothesis for electron density retrieval.

In the last years, the TOMION has been improved in all the mentioned fields by gAGE/UPC. This includes the improvements of Abel techniques (e.g. new ionospheric time series), and the ionospheric global interpolation by means of Kriging techniques, see [8] and more recently the inclusion of precipitation capability to 2 days ahead, see [3]. Along with these techniques, the capability of the gAGE/UPC to verify and test the new improvements has been highly increased, developing techniques from GNSS data itself and using external data, such as allinmter, ionosondes and Langmuir probes.

Therefore, the natural step forward for the TOMION group was to add real time capability for ionospheric determination. In this sense, the use of the IGS Real Time network, jointly with the BGK faster software, opens the possibility to merge all the know-how to develop a real time open product of the ionosphere for the scientific community.

2. IMPROVED TOMION APPLICATIONS

2.1. Testing the ionospheric products of TOMION

Since 1998 the gAGE/UPC is participating in the IGS ionospheric working group as a computation and analysis centre. The use of different algorithms to test the GIMs has become a routine task inside the working group. These tests are generally done using static data (TODPS, JASON and INGV/ENAV missions) and with the GPS data itself, using the so-called self-consistency test developed in gAGE/UPC. However, in order to test the different capabilities of the TOMION, for instance the electron density profiles, other approaches to compute the goodness of the method have been used. Thus, since the TOMION only gives electron density profiles in the region where an ionosonde is present, an alternative solution has been the use of ionosonde maps, which can be use to evaluate the parameters of the ionosphere that can be obtained from the electron density profiles, see Figure 1. In this sense, with the tools provided by the separability hypothesis the extension of the limits is valid to the neighborhood (few thousands of km) of the reference data.

2.2. Real Time Ionosphere

The real time streams, containing the permanent GPS receiver measurements, are retrieved from the IGS and EUREF real time services coordinated by the IGS and the EUREF Real Time Working Services respectively and provided by the BGK network software of the Federal Agency for Cartography and Geodesy (BGK) http://www.bgk bund.de. In this sense, for this first prototype, about 50 stations (see map distributed in Figure 2) were gathered in order to compute the new fast voxel model of the ionospheric electron content, with a resolution of 7°x1° in local time and latitude.

After the data have been preprocessed the first coarse ionospheric map is computed, and then the UPC predicted GIM is based in order to refine the residuals where the TOMION results have been computed, see Figure 3.

Figure 3: TEC maps for 11 UT of the day 34 of year 2010. (Left-top panel) Real time integrated voxel determination, (Right-top panel) UPC prediction and (Bottom panel) Kriging based global TEC maps.

As a result, the kriging technique will be used in order to derive the final GIM at 9x2.5° in longitude and latitude by means of using the above mentioned residuals, see Figure 3.

2.2.1 Real Time Ionosphere preliminary assessment

In the first runs of the prototype computations, large continuous assessments are difficult to perform. However, a preliminary assessment along with the UPC rapid and predicted ionospheres are done in order to cope with the performance of the new ionospheric product. As it has been done in previous works, the assessment will be done with the alliterative ionospheric JASON TEC data. The first results indicate that the Real Time UPC ionosphere can achieve comparable performance, as the other ionospheric products, but at this moment the stability and real time coverage are important issues to solve. So the global performance is affected. In the Figure 4 there is an example on how the Real time map behaves better than the base (predicted) map.

Figure 4: JASON comparison, (Left-top panel) UPC rapid ionosphere, (Right-top panel) UPC predicted ionosphere and (Bottom panel) Kriging based Real Time ionosphere for the day 34 of year 2010.

The day in Figure 4 represents the TOMION performance of a continuous full day of actual real-time data where the overall error for the different maps are 40.5%, 14.1%, 28.3% and 32.2% for the Predicted (upg), Rapid (upg), Final (upg) and Real Time (upg) respectively.

3. CONCLUSIONS

The TOMION real time capabilities have been presented. It is clear that the performance is more related with the stability of the real time algorithms but as well with the coverage of the real-time data. In this sense, the large data gaps over the Pacific ocean and Asia compromise the overall performance through the remaining day. The real-time interpolation of the TEC data is highly affected. However, in the region where data is available covering the partial Real Time maps present good performance. Moreover, the interpolation of the TEC data over the Asia can be done more efficiently using the UPC public product as the Real Time ionosphere data. The improvement of the TEC data over the Asia can be done more efficiently using the UPC public product as the Real Time ionosphere data. The 3D-voxel model of the ionosphere that provides the storm-time behaviour of the ionosphere is an alternative to the Global Space Weather System (GSWS) and other related tools.

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