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A Methodology to Assess Ionospheric Models for GNSS

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Testing the accuracy of the ionospheric models used in the Global Navigation Satellite System (GNSS) is a long-standing issue. It is still a challenging problem due to the lack of accurate enough slant ionospheric determinations to be used as a reference.

The present study proposes a methodology to assess any ionospheric model used in satellite-based applications and, in particular, GNSS ionospheric models. The methodology complements other analysis comparing the navigation based on different models to correct the code and carrier-phase observations. Specifically, the following ionospheric models are assessed: the operational models broadcast in the Global Positioning System (GPS), Galileo and the European Geostationary Navigation Overlay System (EGNOS), the post-process Global Ionospheric Maps (GIMs) from different analysis centers belonging to the International GNSS Service (IGS) and, finally, a new GIM computed by the gAGE/UPC research group.

The methodology is based in the comparison between the predictions of the ionospheric model with actual unambiguous carrier-phase measurements from a global distribution of permanent receivers. The differences shall be separated into the hardware delays (a receiver constant plus a satellite constant) per data interval, e.g., a day. The condition that these Differential Code Biases (DCBs) are commonly shared throughout the world-wide network of receivers and satellites provides a global character to the assessment. This approach generalizes simple tests based on double differenced Slant Total Electron Contents (STECs) between pairs of satellites and receivers on a much local scale.

The present study has been conducted during the entire 2014, i.e. the last Solar Maximum. The seasonal and latitudinal structures of the results clearly reflect the different strategies used by the different models. On one hand, ionospheric model corrections based on a grid (IGS-GIMs or EGNOS) are shown to be several times better than the models included in the navigation messages of GPS or Galileo. On the other hand, the new gAGE/UPC GIM is shown to be several times more accurate than the previously mentioned IGS-GIMs or EGNOS grid models.

The results of this assessment suggest that current ionospheric models can be improved by using the methodology proposed in this work in conjunction with a precise STEC determination, such as the GIMs calculated by the gAGE/UPC research group. The findings underline that the temporal resolution of the techniques considered does not solely explain the different performances. In fact, it is shown how the adequate (and sometimes subtle) use of the relevant parameters to the ionospheric modelling determines the accuracy.