Ionosphere Modelling for Galileo Single Frequency Users

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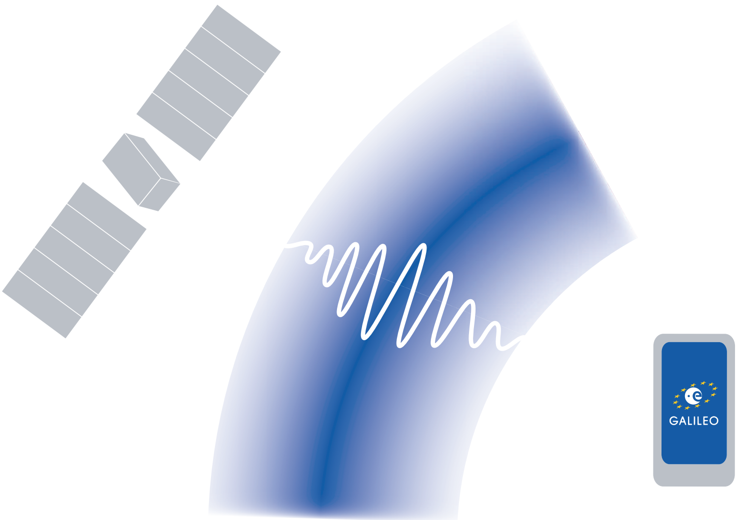

Nowadays the ionosphere constitutes one of the most often modelled natural media. Indeed each GPS receiver among nearly two million units sold daily throughout the world runs a model to mitigate the ionospheric effect affecting the signal propagation from the satellites. This propagation is delayed by the free electrons in the atmosphere so that the navigation signals appear to travel distances larger than actual ones by $7m$ on average. Hence this delayed propagation deteriorates the positioning accuracy deemed on a $10-m$ level for mass-market applications mainly involving single frequency users.

Tomorrow the European navigation system Galileo will offer a new mitigation strategy to single frequency users. This strategy will rely on the NeQuick ionospheric model and associated broadcast information. To be properly implemented, it must be extensively described to future Galileo users. These users will also wonder about its effectiveness in accounting for the ionospheric delay.

The PhD research covered by the present thesis has built on Belgian expertise in ionosphere monitoring to investigate the NeQuick model and its use for Galileo. It began with the collection and handling of ionosphere measurements including GPS data. It analysed various situations at different places in the world encompassing a whole year (2002).

This PhD thesis provides the ins and outs of the Galileo Single Frequency Ionospheric Correction Algorithm. It gathers an algorithm description, a performance evaluation and a variant investigation. In the shape of a paper collection, it discloses many figures as visual entry-points into the juxtaposed text and includes many references allowing to dig into the details.

The algorithm performances are usefully characterised both in terms of delay mitigation and positioning accuracy. On the one hand, the residual ionospheric delay reaches 31% for the chosen sites and year. On the other hand, the positioning accuracy amounts to $6m$ horizontally and $9.3m$ vertically.

The performance evaluation allowed to emphasise several aspects of the Galileo ionospheric correction. This correction depends largely on the modelling of the topside, the upper part of the ionosphere, which hosts more complex physical processes. It owes its good performances to data ingestion, the model adaptation technique to actual measurements underlying the Galileo algorithm. It does not necessarily provide highly correlated correction levels in terms of delay on the one hand and positioning on the other. It enables the definition of alternative regional procedures following a compatible design but coping with its weaknesses.

The present thesis paves the way for future work related to ionosphere modelling for Galileo single frequency users. It supplies comparative information for the algorithm assessment in the framework of successive phases of Galileo deployment. It establishes a conceptual basis for an Assisted Ionospheric Correction Algorithm (A-ICA) disseminating more flexible ionospheric information thanks to the integration of Global Navigation Satellite Systems and telecommunications.

A thesis submitted in partial fulfilment
of the requirements
for the academic degree of
Philosophiæ Doctor in Sciences
at the University of Liège

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October 25^{th}, 2012

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