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Regional short-term forecasting model to predict ionospheric scintillation and TEC at low latitudes

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The regular behavior of the electrodynamics of the low latitude ionosphere makes the scintillation on GNSS signals a daily phenomenon, occurring after the local sunset. The solar activity changes ionospheric conditions. In the specific, a solar storm hitting the Earth may change the ExB drift, leading to a suppression or to an intensification of the Equatorial Fountain. This result into a change in the mechanism regulating the formation of the plasma bubbles, and has strong dependence on the local time of the storm development. The regular and irregular behavior of the low latitude ionosphere in producing scintillation-effective irregularities pose then a challenge to model and predict the disruption of GNSS signals [1]. Mitigation of the degradation of the GNSS performance due to presence of ionospheric irregularities, i.e. the equatorial plasma bubbles, is of paramount importance for high-precision applications, such as precision agriculture.

A regional empirical model able to predict TEC and scintillation indices from seconds to minutes in advance has been implemented and tested for the Brazilian region during the CALIBRA project (http://is-cigala-calibra.fct.unesp.br/is/) [2,3] and is now under improvements. The parameters used for input are the values of TEC, S_4 and SigmaPhi in the Ionospheric Pierce Point (IPP) - TEC and scintillation data acquired by Septentrio PolaRxS receivers deployed in Brazil in the framework of FP7 CIGALA and CALIBRA projects [2]. The basic idea of the model is to apply continuity equation to the parameters of interest (S_4, σ_Φ and TEC), assuming velocity field and source terms don't change during forecasting procedure (reconstruction and prediction steps). The model uses finite volume (FV) discretization over triangulation formed by ionospheric pierce points (IPP).

This paper describes the recent developments of the model, which cover improvement of the numerical scheme and the fine tuning of the algorithms to speed-up the computation time. In addition, this work presents the comparisons between the first formulation of the model and the improved one by using data from the September 2017, when two of the largest solar storms of the last 10 years disturbed the ionosphere, with impact in radio communications [4].

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