

On the definition and experimental use of ionospheric indices to evaluate space weather effects on GNSS positioning

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Relevant Topic(s):

G02a: Ionospheric effects on radio systems

Abstract:

It is well recognized that the space weather can induce severe ionosphere perturbations and can cause serious technological problems in the Global Navigation Satellite Systems (GNSS). On the other hand, the ionosphere also plays an active role in the complex Sun-Earth relationship and the space weather manifestation. Highly dynamical and strong deviations of the ionosphere electron density structure may cause range errors by rapid phase and amplitude fluctuations of the satellite signal. Therefore, in order to efficiently operate and further improve the functionality of such systems, key information on the ionosphere condition is needed, particularly when the ionosphere is disturbed.

The ionosphere / space weather monitoring, modelling and forecast refer to activity indices such as the Zurich sunspot number R_z and the 10.7 cm radio flux index $F_{10.7}$ for the solar activity or the indices K_p , A_p , and Dst for geomagnetic activity. There is a serious practical reason for using such indices because they provide simplified proxy estimates of complex phenomena. The enhanced activity, i.e. the enhanced intensity level or enhanced variability of a given physical parameter, is simply given by the biggest index value. However, the majority of the abovementioned indices are so-called 'planetary' indices which are not always suitable for all phenomena and all applications. From this aspect, a quick evaluation of the current GNSS signal propagation conditions effectively expressed in a suitable Ionospheric Perturbation Index, would be of great benefit to GNSS users.

The aim of this publication is to discuss the possibility of introducing ionosphere perturbations/disturbances indices for use in practical applications such as precise navigation by differential GNSS techniques. Presented here is the analysis of selected events of strong disturbances. As a result of this analysis, proposed is a new ionospheric perturbation index for possible use in the satellite based navigation and positioning. Discussed are potential applications of the index and its relation to the traditional geomagnetic activity indices.

It is believed that the standardization and the use of the proposed perturbation index can prove helpful to many users in their task of reducing the adverse space weather effects on the GNSS-based navigation and positioning.