Quantitative Comparison of Ionospheric Storms over North America in Solar Cycles 23 and 24 from a WAAS Perspective

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An ionospheric storm is a disturbance of the upper atmosphere that generates regions of enhanced electron density and lasts typically several hours. Such storms can be a major source of positioning error for users of the Global Navigation Satellite Systems (GNSS). Consequently, satellite-based augmentation systems (SBAS) have been implemented to improve the accuracy and to ensure the integrity of user position estimates derived from GNSS measurements. Such systems provide a means of monitoring storm magnitudes over each system's region of coverage.

The ionospheric storms that have occurred during the current solar cycle (solar cycle 24) have been much weaker in magnitude than the largest storms of the previous solar cycle. In this paper, we provide a quantitative assessment comparing the magnitudes of the ionospheric storms in solar cycles 23 and 24. The metric used to measure the magnitude of each storm is derived from observations of the Wide Area Augmentation System (WAAS), the United States' augmentation of the Global Position System (GPS).

Ionospheric storms are observed frequently in conjunction with magnetic storms, *i.e.*, periods of geophysical activity as measured by magnetometers. Since no generally recognized index exists for quantifying the regional level of ionospheric activity, various geomagnetic indices, such as D_{st} and k_p, are often used to identify periods of increased ionospheric disturbance. However, since this level of disturbance (as represented, for example, by enhancements in total electron content) does not always scale directly with the level of the geophysical disturbance in a coincident magnetic storm, an independent ionospheric storm index proves useful when attempting to rank ionospheric storms by their magnitudes.

The WAAS storm magnitude metric is based upon estimation of vertical total electron content (TEC) on a grid at regularly spaced intervals of latitude and longitude, derived from measurements of slant TEC collected at WAAS receivers. The standard χ^2 goodness-of-fit parameter associated with each vertical TEC estimate has been found to scale reliably with the local level of ionospheric disturbance. The maximum value that this parameter assumes over the entire grid serves as a robust metric reflecting the instantaneous level of regional ionospheric disturbance. To take into account the temporal duration of the storm, we introduce the concept of a *storm profile*, *i.e.*, a function that represents, as a function of the metric value x, the maximum duration over which the disturbance metric remains *continuously* above x during the storm. The storm magnitude metric used to rank the storm can then be defined as the area under this curve. We apply this metric to rank the most significant storms of the last two solar cycles.