Forecasting Ionospheric Storms Using the GPS Global Network

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Space storms (ionospheric and magnetospheric) caused by solar activity are currently poorly understood and have repeatedly impaired instruments in space, disrupted communications and power grids on Earth, and communications with satellites. Annual losses due to space storms possibly exceed $100 million and are on the increase. These costs could be significantly reduced by the development of an accurate method for near real-time forecasting of storm severity in different regions of the world, which would enable corrective actions to be taken. The GPS Global Network consists of 60+ permanent dual-frequency GPS receiver stations (operated by NASA and many international cooperating agencies) from which continuous, high-resolution global ionospheric maps (GIM) are generated. The GIM's may be used to monitor, model and ultimately help forecast space storms.

By using the GIMs we have examined and characterized 4 major storms occurring during 1994-95. Preliminary results indicate that during the main phase of the storm the Total Electron Content (TEC) significantly increases (100%-200%) relative to the quiet time ionosphere. The increases of TEC extend to the nightside. Three cases show the TEC increase mainly in the northern hemisphere, while one is in the southern hemisphere. Even though the absolute TEC change is largest along the equatorial anomaly, the highest percentage changes of TEC relative to quiet days are found at middle to high latitudes. These changes tend to be banded along geomagnetic latitude lines covering nearly all local times and spanning 5-10° in latitude. The evolution of the ionospheric storms has been animated and recorded with up to 15 minute time resolution. Potential ionospheric precursors of the storms are currently being investigated and possible mechanisms to explain the global ionospheric TEC changes are under consideration.

Plans are to characterize a number of past storms by a set of parameters describing the event such as the extent of the disturbance, spreading velocity, duration time, magnitude, reported causes and disruptions, etc. Each event would be cataloged and analyzed to identify early warnings or onset signals that could be used for forecasting the severity of the evolving storm.

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