Understanding Space Weather Effects in the Upper Atmosphere Using Global Map of Ionospheric Irregularities and Scintillation

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1. Introduction

Using dual-frequency GNSS signal phase data collected from ground-based geodetic receivers, one can compute the rate of TEC index (ROTI) to measure ionospheric irregularities [1]. The nominal GNSS data from these receiver networks have been collected in real-time, near real-time and daily basis. By processing these data snapshot global maps of ionospheric irregularities and scintillation (GMIIS) with 5-minute cadence have been produced at the Jet Propulsion Laboratory. GMIIS can be compared with multi-diagnostic measurements of space weather and aeronomy to investigate physics processes and conditions under which ionospheric irregularities develop [2]. This presentation will show that GMIIS is useful in understanding and monitoring space weather effects in the upper atmosphere.

2. GMIIS and Comparison between ROTI and Traditional Scintillation Indices

An example of GMIIS is shown in Figure 1. ROTI measurements are different from the traditional ionospehric scintillation measurements, i.e., S_4 and σ_ϕ indices, in several aspects. For example: (1) ROTI measures ionospheric irregularities directly; (2) the measurements are independent of radio frequency; (3) the measurements are not susceptible to receiver local oscillator quality so that the measurements can be made from thousands of ground-based GNSS receivers that are already deployed. A detailed comparison between ROTI and S_4 as well as σ_ϕ indices are referred to [2] and will also be further reviewed in this presentation.

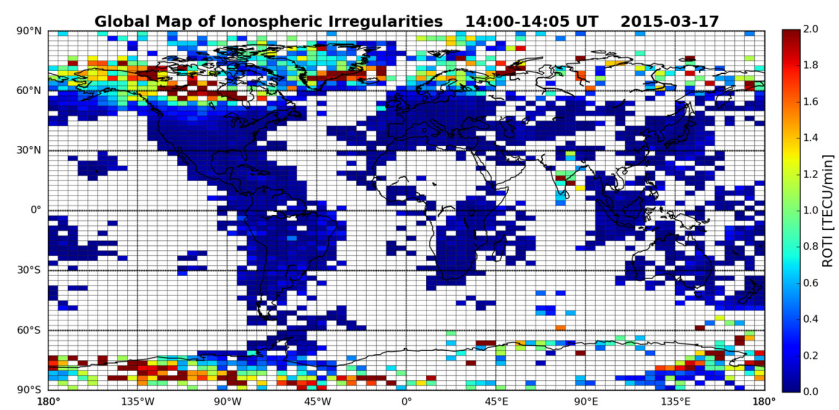

Figure 1. An example of Global map of ionospheric irregularities and scintillation.

3. Space Weather Effects Revealed in GMIIS

In the past a global picture of ionospheric irregularities and scintillation (IIS) can only be obtained schematically based on long term observations made from individual sites. Now using GMIIS one can observe activities of global IIS continuously every 5 minutes. In this presentation, characteristics of IIS in different latitude regions will be shown through GMIIS. Some major IIS events during space weather disturbances and geomagnetic storms will also be presented to show applications of GMIIS in understanding the physics process of M-I-T coupling during space weather events.

4. References

1. X. Pi, A. J. Mannucci, U. J. Lindqwister, and C. M. Ho, "Monitoring of global ionospheric irregularities using the worldwide GPS network," *Geophys. Res. Lett.*, **24**, 1997, p.2283, DOI: 10.1029/97GL02273.

2. X. Pi, A. J. Mannucci, B. Valant-Spaight, R. Viereck, and Y. Zhang, "Middle-Latitude Ionospheric Irregularities and Scintillation During Geomagnetic Storms," *Proc. ION GNSS+*, Portland, Oregon, September 2016, pp.1657-1663.