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Ionospheric Threat Monitoring (ITM) Mobile Application

Rajesh Tiwari [(1)], Habiba Halilu[(1)], and Mark Dumville[(1)]
(1) Nottingham Scientific Ltd. (NSL), Nottingham, United Kingdom, (rajesh.tiwari@nsl.eu.com)

Abstract

The ionospheric scintillation threat has been a major threat to GNSS users. Ionospheric scintillation occurs due to time-varying ionospheric irregularities which cause random amplitude fading and/or phase variation. In this study, there is a development of a mobile application that would be used for monitoring a space weather phenomenon namely ionospheric scintillation. The tool developed is an android mobile app to provide the user with warning maps specifically of the European region which would indicate the levels of threat and the likelihood of a scintillation event occurring. The threat levels were indicated on maps with different colors. The maps were generated using a regional alarm index which was generated using a 5-minute average of the analogous scintillation indices over the European region.

1. Introduction

Ionospheric scintillation refers to the fluctuations in the phase and amplitude of trans-ionospheric signals as they propagate due to small scale ionospheric irregularities. The characteristic used to measure the degree of scintillation is the Total Electron Content (TEC) which is the total number of electrons present in a square meter cross-section along the satellite receiver link [1]. Severe cases of scintillation cause cycle slips which lead to positional errors in signals from Global Navigation Satellite System (GNSS).
The phase advance of a GNSS (Global Navigation Satellite System) signal through the ionosphere is given by equation below.

$$\varphi = \frac{40.3}{cf} TEC \qquad (1)$$

Where c is the speed of light in a vacuum and f is the carrier frequency in Hz

$$TEC = \frac{f_1^2 f_2^2}{40.3\,(f_2^2 - f_1^2)} (P_1 - P_2) \qquad (2)$$

$$TEC = \frac{f_1^2 f_2^2}{40.3\,(f_2^2 - f_1^2)} (\emptyset_1 - \emptyset_2) \qquad (3)$$

where f_1 and f_2 are L1 and L2 GPS frequencies respectively, P- represents pseudo-ranges and Φ- represents phase observations for the corresponding frequencies [2].

2. Methodology

The 15-minute GPS 1 Hz RINEX observation files collected from the stations that produce near real time data from the European Reference Permanent Network (EPN) were utilized along with the navigation (brdc) and differential code bias (DCB) files were used to generate the TEC files. The collection of observation data was implemented using Java codes which were developed to run in a serial manner to collect the data from the stations in batch. The processing of the observation, navigation and differential code bias files to obtain the TEC files was implemented with java codes which used an executable file with C++ libraries for the data processing.

Once the TEC is generated, a mapping function is applied to it to generate the Vertical TEC (VTEC). The rate of change of the VTEC (RoT) which represents the phase fluctuations is derived and then passed through a 2nd order Butterworth high pass filter to prevent the exaggeration of the scintillation effect. The normalized standard deviation of the high pass filtered RoT is derived and finally an elevation weighted function applied as the latter is noisy at low elevations, the result of this process is analogous phase scintillation index. This procedure is applied to the data received from each EUREF station producing near-real time data. An average of analogous phase scintillation indices within a 5-minute period for the different stations utilized within a particular region gives the regional alarm index. The regional alarm index is implemented into mesh grid with different colors indicating the level of ionospheric scintillation threat.

The mesh grids will be generated on a daily basis and uploaded onto a designated server. The mobile app will be developed to provide the user with the scintillation threat levels from the server therefore providing the user with real time scintillation alerts.

3. Results

The mesh grids from the regional alarm index for a 25-minute period is shown below in Figure 1. The colors indicate the level of scintillation threat in the given locations; red (severe scintillation threat levels with possible occurrence of cycle slips), amber (moderate threat of scintillation), green (weak threat of scintillation).

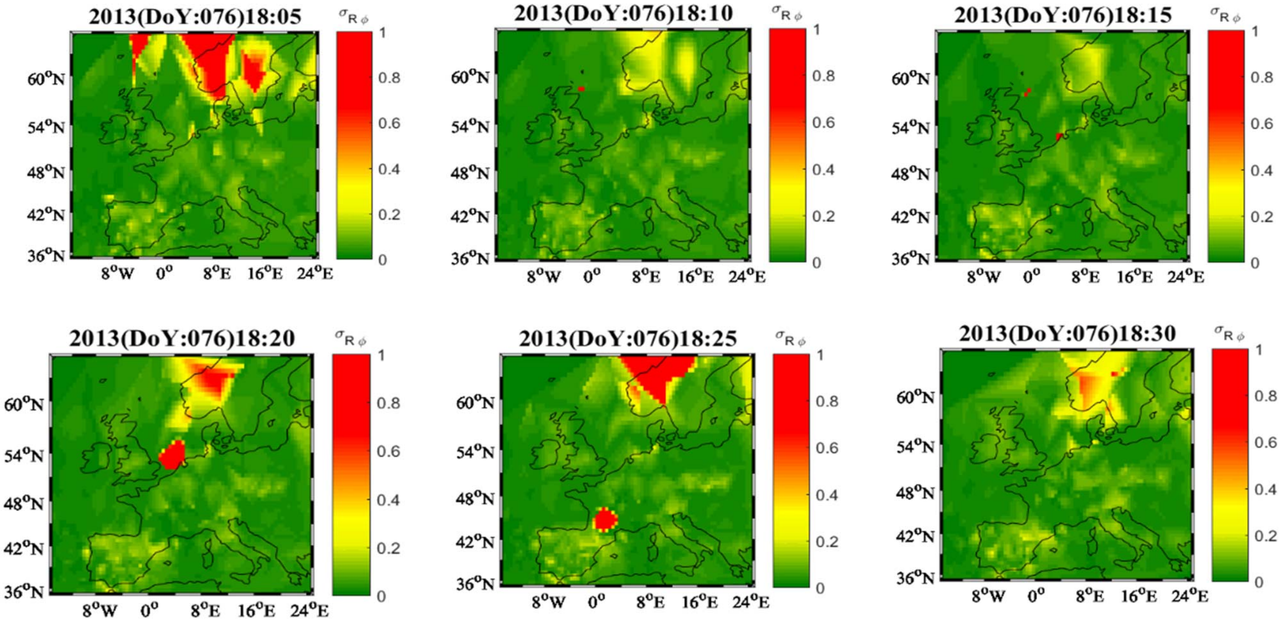

Figure 1. Scintillation threat levels shown in mesh grid for a 25-minute period [2].

4. Conclusion

The mobile app, ITM generating near real-time ionospheric scintillation alerts will be a convenient way of accessing scintillation data or monitoring the regional GNSS network. This information can be utilized by the GNSS users that depend on the reliability of data that comes from GNSS for mitigation of the effects of scintillation or to take precautionary actions.

5. Acknowledgements

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6. References

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