Characterization of Equatorial Ionosphere in South East Asia in the ERICA Project: a case study

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ABSTRACT

The ERICA study is a project funded by the European Space Agency within the Alcantara Initiative, a programme of the Agency aimed to foster the cooperation between European and extra-European research groups on space-related topics.

The main objective of the ERICA study is to monitor the ionosphere over South East Asia (SEA) region in order to identify signatures of the interplay between ionosphere and the geomagnetic field, with a specific focus on the impact this interaction may have on performance of radio systems such as Global Navigation Satellite Systems (GNSS). In particular, the project is centered on the study of the variations of the plasma electron density in correspondence of the southern and northern crests of the Equatorial Ionospheric Anomaly (EIA) and over the dip equator identified by the Equatorial Ionospheric Trough (EIT).

South East Asia has been selected as a sector of interest for this study given the scarce and uneven availability of observations and the lack of relevant scientific information in the existing literature, as highlighted here [1]. The actual understanding of the scintillation conditions and of the TEC gradients origin and evolution in that area has to be completely achieved yet. Thus, the capability to correctly forecast the ionospheric conditions in the area and to put in place mitigation techniques to improve the availability and reliability of GNSS-based services is limited in the area.

In order to carry out the study, the ERICA team set up an ad-hoc measurement campaign, which was supported by the contribution of local experts in Indonesia and Vietnam, who managed the data collection with ground-based instruments deployed in the footprints of EIA and EIT. The set of instruments used in the campaign included GNSS based scintillation and Total Electron Content (TEC) monitors, magnetometers, and (in Indonesia only) ionosondes. The data campaign started on 1st March 2015 and ended on 9th October 2015. Collected data enclose raw and processed data

from GNSS scintillation monitor receivers as well as variation of the components of the geomagnetic field. To support the assessment of the ionospheric electron density distribution, data from International GNSS Service (IGS) receivers installed in the area were used as well. Specifically, IGS RINEX files were used to obtain calibrated TEC during selected case events, as described in [2]. Raw GNSS datasets were collected with a custom front-end which was built with off-the-shelve components and deployed at the Navis Centre in Hanoi. There, a software receiver constantly monitors the local scintillation activity and triggers the data recording when the estimated amplitude scintillation index S4 is above a predefined threshold. Raw data processing with the software receiver was envisioned to complement the measurements obtained from professional receivers. The collected datasets are stored in a database set up at Istituto Superiore Mario Boella, Italy, and are freely available for not-for-profit purposes.

The collected data were used to assess the ionospheric features that characterize the upper atmosphere over Vietnam and Indonesia. The adopted approach is twofold: an overall climatology of the ionosphere in the considered region and an in-depth analysis of specific weather conditions on specific events. The results of the climatological analysis are described in [4], while in this paper the effect of the geomagnetic storm occurred on 3-9 October is analysed. This event was characterized by the occurrence of several decreases of the H component of the geomagnetic field, as shown by the variation of the Disturbance storm time (Dst) index in Figure 1.

Figure 1. Dst variation along the period 3-9 October 2016

The presence of several geomagnetic perturbations along the selected period was analyzed by means of the diverse range of measurements available. Rate of TEC (ROT) variations showed a re-enhance on 6th of October at the southernmost stations of the network, followed by a decrease to then grow again on October 8 and 9. A similar behavior was also observed in the level of S4. Calibrated VTEC mapped together with the scintillation occurrence showed the inhibition of the post-sunset increase of S4 on the 3rd, 4th, and 5th of October, an enhancement of S4 on the 6th October, a new decrease on the 7th October and the restart of the expected scintillation increase on the 8th and, mainly, on the 9th of October.

It was found that equatorial and southern stations result the most affected by phase scintillations. The comparison between the amplitude scintillations recorded at Phu Thuy and NAVIS (Figure 2) shows a weak level of scintillation at both locations. During the selected time window the losses of lock on L1 and L2 were rare.

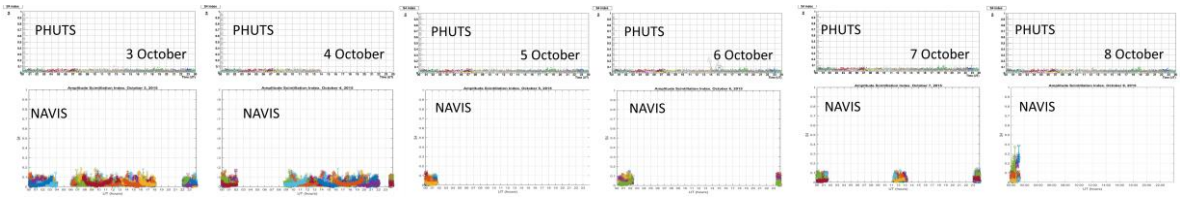

Figure 2. Comparison of S4 derived from professional receiver (above) and software-radio (below) on the selected period.

The overall climatology and the case studies investigation performed on the ERICA data confirm the peculiarities of the SEA ionosphere underlying the indispensable need to rely on a regional assessment of the ionospheric plasma. The campaign and the related analysis provide interesting insights on the impact of geomagnetic storms on the local ionosphere, contributing to the scientific understanding in the field.

Key words: Ionosphere, GNSS, Scintillation, South East Asia, Low Latitudes.

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