VARION extension to GEO satellites: application to recent tsunami induced TIDs events

Michela Ravanelli[1], Giorgio Savastano[1], Augusto Mazzoni[1] and Mattia Crespi[1]

[1]Geodesy and Geomatics Division, DICEA, Sapienza University of Rome, Rome, Italy

It is now established that the VARION (Variometric Approach for Real-Time Ionosphere Observation) algorithm can effectively detect sTEC (slant Total Electron Content) variations connected to TIDs (Travelling Ionospheric Disturbances) in real time [1]. In this work, VARION algorithm was applied to geostationary satellite (GEOs) observations (VARION-GEO) in order to analyse TIDs connected to M_W 7.9 earthquake occurred 288 km South-East of Chiniak, Alaska [2] and to the M_W 7.5 earthquake registered 165 km East-South-East of Tadine, New Caledonia [3]. In particular, observations coming from GEO satellites, belonging respectively to WAAS (Wide Area Augmentation System) [4] and Beidou constellations, were employed. Beidou GEOs are playing an increasingly important role since they are the only orbiting dual-frequency GEOs.

The main advantages of applying the VARION algorithm with GEO observations are the possibility to remove all the geometry effects, to keep the observation noise level as much constant as possible and to provide continuous time series.

Although GNSS stations tracking GEOs are still few, the results show the effectiveness of the VARION-GEO technique in detecting TIDs. Indeed, these analyses confirm a good improvement in reducing the observed background noise, since geostationary satellites are almost motionless relative to a point on Earth. As a result, the IPPs (ionospheric pierce points where a notional ionosphere intercepts a receiver to satellite line-of-sight) may be assumed to be stationary in the sky. For all these reasons, the introduction of GEO satellite observations in the VARION algorithm may represent a further significant step for the real-time ionosphere monitoring.

Thus, VARION-GEO may also find an application in detecting TIDs induced by complex tsunamis event: for example, the recent tsunami generated by the collapse of the Anak Krakatau volcano in the Sunda Strait [5]. In this background, countries very subjected to geohazard, like Indonesia, could also benefit from the use of GEOs from Beidou constellation, which already cover the area.

Nonetheless, VARION-GEO does not intend to be the alternative to “traditional” VARION, which employs standard GNSS observations, but its application is expected to be complementary to the classic method.

In conclusion, VARION-GEO can potentially increase the reliability of natural hazards detection based on ionospheric remote sensing observations, contributing to the enhancement of already existing tsunami early warning systems.

References

[1] Savastano, G., Komjathy, A., Verkhoglyadova, O., Mazzoni, A., Crespi, M., Wei, Y., & Mannucci, A. J. (2017). Real-time detection of tsunami ionospheric disturbances with a stand-alone GNSS receiver: A preliminary feasibility demonstration. Scientific reports 7

[2] https://www.tsunami.gov/previous.events/?p=1-23-2018_Kodiak

[3] https://earthquake.usgs.gov/earthquakes/eventpage/us1000i2gt/executive

[4] https://www.nstb.tc.faa.gov/

[5] https://en.wikipedia.org/wiki/2018_Sunda_Strait_tsunami#cite_note-Guardian2018-12-23a-5