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Multi-GNSS Vertical Total Electron Content Estimates: A Software Evaluation Using Ionospheric Perturbations from Earthquakes

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Today, Global Navigation Satellite System (GNSS) observations are routinely used to study the physical processes that occur within the Earth's upper atmosphere. Due to the experienced satellite signal propagation effects the total electron content (TEC) in the ionosphere can be estimated and the derived Global Ionosphere Maps (GIMs) provide an important contribution to monitoring space weather. While large TEC variations are mainly associated with solar activity, small ionospheric perturbations can also be induced by physical processes such as acoustic, gravity and Rayleigh waves, often generated by large earthquakes.

In this study Ionospheric perturbations caused by four earthquake events have been observed and are subsequently used as case studies in order to validate an in-house software developed using the Python programming language. This in-house software can parse both receiver independent exchange format (RINEX) versions 2 and 3 raw data, with particular emphasis on multi-GNSS observables from GPS, GLONASS and Galileo. BDS compatibility is to be added in the near future.

Our case studies focus on four recent earthquakes measuring above a moment magnitude (Mw) of 7.0 and include: the 11 March 11 2011 Mw9.1 Tohoku, Japan, earthquake that also generated a tsunami; the 17 November 2013 Mw7.8 South Scotia Ridge Transform (SSRT), Scotia Sea earthquake; the 19 August 2016 Mw7.4 North Scotia Ridge Transform (NSRT) earthquake; and the 13 November 2016 Mw7.8 Kaikoura, New Zealand, earthquake.

We have observed ionospheric disturbances generated by all four earthquakes by looking at the estimated vertical TEC (VTEC) and residual VTEC values. The results generated from these case studies are similar to those of published studies and validate the integrity of our in-house software.