4th URSI AT-RASC, Gran Canaria, 19-24 May 2024

Near-real-time automatic detection of travelling ionospheric disturbances – dream or reality?

E. Astafyeva*(1), Q. Brissaud(2), B. Maletckii(1), I.D. Ouar(1), S. Sanchez Juarez(3), E.A. Kherani(3)

(1) Université Paris Cité, Institut de physique du globe de Paris (IPGP), CNRS UMR 7154, Paris, France; e-mail: astafyeva@ipgp.fr ; maletckii@ipgp.fr, ouar@ipgp.fr
(2) Norway Seismic Array (NORSAR), Kjeller, Norway; e-mail: Quentin.Brissaud@norsar.no
(3) Instituto Nacional de Pesquisas Espacias (INPE), Sao José dos Campos, Brazil; e-mail: saul.juarez@inpe.br, alam.kherani@inpe.br

Travelling ionospheric disturbances (TIDs) are fluctuations of plasma density that propagate through the ionosphere as waves. TIDs can be generated by numerous geophysical and man-made events: geomagnetic storms, solar eclipses, severe weather events (e.g., convective storms, tornadoes), natural hazards (e.g., earthquakes, volcanic eruptions, tsunamis), explosions, rocket launches. TIDs represent an important part of the Space Weather, because they can severely affect the propagation of radio-signals and often lead to disruption of radio-communication and degradation of precise positioning applications. Therefore, near-real-time (NRT) detection, characterization, tracking and forecast/nowcast of TIDs and other ionospheric irregularities is of greatest importance for Space Weather applications.

This contribution will present our recent developments for automatic NRT detection of TIDs of different origins in data series of GNSS-derived total electron content (TEC). Recently, our research team has developed two NRT-compatible methods. The first one captures disturbances with high TEC derivative (dTEC/dt) and determines their velocity and direction of propagation in NRT [1]. However, unfortunately, this method, fails to detect TIDs with lower dTEC/dt. The second method uses Machine Learning Random Forest technique [3] to automatically detect disturbances and to determine their arrival time [3]. This second algorithm was initially trained on co-seismic ionospheric disturbances. However, it also captures disturbances generated by other phenomena coming both from below and from above: those generated by volcanic eruptions and explosions, Rayleigh seismic waves, tornadoes, but also –partly- TIDs related to geomagnetic storms. It also detects TIDs that travel through the ionosphere without any known source action. Further work is necessary to improve our algorithms.

This work is supported by the French National Research Agency (ANR, grant ANR-22-CE49-0011) and by the French Space Agency (CNES, project "RealDetect").

References:

1. Maletckii, B., E. Astafyeva, Determining spatio-temporal characteristics of Coseismic Travelling Ionospheric Disturbances (CTID) in near-real-time. *Sci. Reports, 2021, 11:20783,* doi:10.1038/s41598-021-99906-5.
2. Breiman, L. Random forests. *Machine Learning*, 2001, 45:5–32.
3. Brissaud, Q. & E. Astafyeva. Near-real-time detection of co-seismic ionospheric disturbances using machine learning, *Geophys. J Int.,* V. 230, N3, *2022,* doi: 10.1093/gji/ggac167