ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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Subject title: Development of novel methods for near-real-time automatic detection and assessment of natural hazards from the ionosphere

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Financing: ½ bourse par l'Académie Spatiale

Presentation of the subject:

Development of novel methods for near-real-time automatic detection and assessment of natural hazards from the ionosphere

Large offshore earthquakes (EQs) can generate strong tsunamis with devastating consequences for coast populations. EQs are traditionally monitored using their seismic signature that can be recorded at the ground to provide timely alerts. However, assessing an EQ's tsunamigenic potential is a difficult task with distant seismic data. Fortunately, seismic energy can couple to the ocean and atmosphere and propagate up to high altitude in the ionosphere (~200-400 km altitude) as acoustic and gravity waves. Such waves reach the ionospheric altitudes at about 8 min (acoustic waves) or 15-60 min (gravity waves) carrying information about the source that generated them. The exploitation of this information in acoustic and gravity waves could enable the retrieval of source parameters and assess the tsunamigenic potential of an EQ from the ionosphere by using GNSS-sounding methods.

In addition to EQs, near-real-time (NRT) monitoring of tsunami propagation in both near-field (<500 km from the source) and far-field (>500 km away from the source and trans-oceanic propagation) remains very challenging. Therefore, it is of highest importance to develop new and more accessible methods that will enable to monitor tsunami propagation and to assess the risk of tsunamis of any origin. Because tsunamis generate gravity waves that propagate upward and trigger atmospheric/ionospheric perturbations, one can detect co-tsunamic disturbances in the ionosphere. Then, by analyzing the features of these disturbances, it should be possible to assess the parameters of the tsunamis that generated them, merely, the tsunami wave heights, but also the propagation speed. The ultimate idea is to contribute in the improvement of the existing tsunami early warning systems, by assessing parameters of EQs and tsunamis from the ionosphere in NRT.

The main aim of this PhD thesis is to develop methods allowing for 1) automatic NRT detection of ionospheric disturbances in data of total electron content (TEC), by using ionospheric GNSS data, and for 2) assessment of EQs and tsunami parameters based on the analysis of the features of detected ionospheric disturbances.

Since the ionosphere is sensitive to a large variety of geophysical and man-made events, numerous disturbances can travel through the ionosphere at any time. Therefore, the first major and important step is to detect the disturbances and then to confirm their origin. Once these steps are done, we can proceed with assessment of the parameters of parameters of EQs and tsunamis from the ionosphere.