



ÉCOLE DOCTORALE SCIENCES DE LA TERRE



Subject offered for a contract starting in September 2013

SUBJECT TITLE: Inversion of ionospheric signals associated to tsunamis and of atmospheric/ionospheric coupling parameters.

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Second Advisor: Emile OKAL, Pr (Univ. Northwestern, USA),

Host lab/ Team : **IPGP- Team Géophysique spatiale et Planétaire – UMR7154
University of Northwestern, USA**

Financing: Doctoral contract

*For more information go to <http://ed109.ipgp.fr>, section: Offres de these (PhD offer),
You must apply on the Doctoral School website*

Presentation of the subject: (1 or 2 pages)

Since about 10 years, observations of ionospheric signals associated to the propagation of seismic waves and tsunamis generated by large quakes have been multiplied, confirming the possibility to perform remote sensing seismology [1,2]. The modeling techniques of these signals have also been developed, and integrate now not only the coupling between the Solid Earth, the ocean and the atmosphere [3] but also between the atmosphere and the ionosphere, as the ionospheric seismic signals are corresponding to perturbations generated at more than 200 km of altitude.

The new challenges of this research field, frontier between external and internal geophysics, aim to perform inversion of the ionospheric signals, in order

- to predict the height and possibly waveform of the tsunami at the surface of the ocean from remote sensing data (GPS or airglow imagers)
- to image the rupture processes of off-shore quakes with GPS TEC data
- to invert, with joint seismic/GPS/ionospheric data, the coupling parameters between the neutral atmosphere and ionosphere and possibly other structure parameters constraining the propagation processes (e.g. viscosity, density, temperature)

These new challenges will be the main topics of this PhD, which goal will be to perform the first inversions of the ionospheric signals in order to retrieve both the amplitude of the tsunami at sea level and the coupling parameters. The thesis will be performed in the frame of a wider project, funded by the Office of Naval Research of the US Navy: TWIST (Tsunami Warning and Ionospheric Seismic Tomography) financé par l'Office of Naval Research (ONR, USA).

The data to be used in the project will be mainly GPS-Total Electronic Data and Airglow data [4], which provide integrated measurement of the electron densities between the ground and the satellite and in the 150-250 km altitude range respectively. More original data will be used through collaboration with the Office of Naval research associated to flights of ONR maritime surveillance aircrafts, aiming to demonstrate the feasibility of the tsunami inversion from the GPS onboard

aircrafts, and opening therefore new improvements in the tsunami warning systems, especially in the case of failure of the DART buoys.

The inversions, for both the tsunami amplitude or the atmospheric structure, will be performed through normal modes modeling and summations [3]. The associated theory will however be modified in order to account for the coupling between the neutral atmosphere and the ionosphere. A critical analysis will also be performed in order to quantify the importance of magneto-acoustic and Alfvén waves. Inversions will be tested and validated with the data of the ionospheric perturbations generated by the March, 2011 Tohoku earthquake and tsunami [2]

The thesis will be supervised by Pr P. Lognonné (IPGP) and E. Okal (University of Northwestern, USA). The primary location of the PhD will be IPGP, Paris, but regular stay in University of Northwestern are planned, together as strong interactions with the other US partners of the TWIST project (Los Alamos National Laboratory and University of Illinois).

A teaching activity might be associated to the thesis. This activity will be associated to the supervision of bachelor and master projects of University Paris Diderot students, associated to the development of the UnivEarth-1 3U nano satellite project and more specifically to the integration of a dual GPS receiver in this nanosat, allowing TEC measurements. As the development of this nanosat is planned between 2013 and 2016 and due to synergies with the research project, this technology activity might easily be added to the PhD project.

To apply to this thesis, send before April, 15th a motivation letter and CV to Pr. P. Lognonné (lognonne@ipgp.fr). Thesis start is expected on September 2013. The thesis is open to all candidates with strong background in Physics, or geophysics or space sciences. A Master with “magna cum laude » is generally requested. This PhD is open to single/dual nationals from USA, European Community (including Switzerland), NATO, Commonwealth, Japan or Brazil.

The French hosting laboratory is located in the Paris Rive Gauche campus of the Paris Diderot University, in the 13th arrondissement of Paris. The PhD salary will be in accordance with French rules for PhD (about 26500\$/year plus fringe benefits for a PhD with teaching activity). Due to its subject at the border of basic Earth science and Space science, the PhD will offer wide professional opportunities in both academic research and applied space research.

Références :

- [1] see for example <http://www.insu.cnrs.fr/terre-solide/catastrophes-et-risques/seismes/des-chercheurs-detectent-pour-la-premiere-fois-des-pert>
- [2] Rolland, L.M., P. Lognonné, E. Astafyeva, E. A. Kherani, N. Kobayashi, M. Mann and H. Munekane, The resonant response of the ionosphere imaged after the 2011, Tohoku-Oki earthquake, 63, 853-857, Earth Planet. Sci., 2011.
- [3] Lognonné, P., C. Clévéde and H. Kanamori, Normal mode summation of seismograms and barograms in an spherical Earth with realistic atmosphere, Geophys. J. Int., Geophys. J. Int., 135, 388-406, doi : 10.1046/j.1365-246X.1998.00665.x, 1998.
- [4] Makela, J.J., P. Lognonné, H. Hébert, T. Gehrels, L. Rolland, S. Allgeyer, A. Kherani, G. Occhipinti, E. Astafyeva, P. Coisson, A. Loevenbruck, E. Clévéde, M.C. Kelley, J. Lamouroux, Imaging and modeling the ionospheric airglow response over Hawaii to the tsunami generated by the Tohoku Earthquake of 11 March 2011, Geophys. Res. Lett., 38, L00G02, doi: 10.1029/2011GL047860