, Ionospheric Detection and Mapping of the Near-field Vertical displacement of Quakes .

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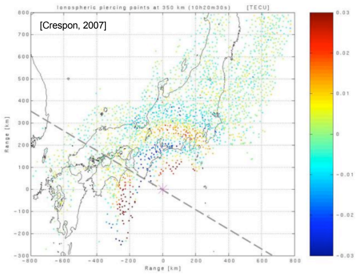
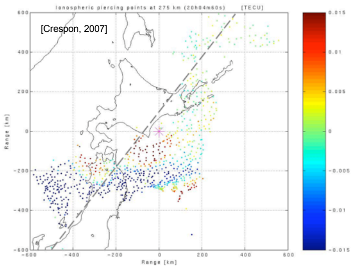
ABSTRACT:

The dense GPS networks, developed for geodetic applications, are very efficient ionospheric sensors. We use here the Slant Total Electron Content (STEC), which can be easily extracted from data provided by the dual frequency receivers. With the dense GEONET GPS , the observation of ionospheric perturbations induced by earthquakes with high time and space resolution can be achieved. In fact, earthquakes generate acoustic waves because of Earth-atmosphere coupling. We present several observations to characterize the ionospheric perturbations induced by these acoustic waves. We discriminate two types of perturbations: one at near field, due to vertical ground motion at the epicentral area, and another one at teleseimic distance, due to vertical ground displacements induced Rayleigh waves. Then, we propose to focus this presentation on the near field perturbations and to assess their local group velocities. These results are interpreted in terms of infrasonic waves disturbing the ionosphere. The acoustic generation process is analysed to constrain a few parameters of the rupture mechanisms like fault azimut and source extension. We present such results for the Tokachi-Oki M8 2003 and the Kii M7 2004 earthquakes. Finally, these results are used to discuss the usefulness of ionospheric sounding in seismology.

Energy Diagram in the ionosphere



Ionospheric perturbations for the Kii (left) and Hokkaido (righ) earthquakes are detected in TEC measurement by GPS sounding over the epicentral area. We can note directions with very low amplitude of TEC perturbations but also phase opposition for specific azimut.



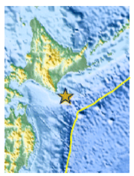
We interprate these observations as characteristics of the energy diagram radiated by vertical displacement of the ground surface. Therefore the directions found (grey dash line) can be assumed coherent with the direction of the fault of focal mechanism.

Azimut of fault for Kii: Ionospheric data → 215° ; Harvard CMT → 255° ; USGS → 234°

Azimut of fault for Hokkaido: Ionospheric data → 290° ; Harvard CMT → 277° ; USGS → 270°

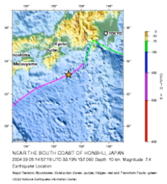
The Hokkaido earthquake 09/25/2003 Mw8.3:

On 25 September 2003, in the Tokachi Oki region, a great earthquake occurred at 19:50 (GMT) and was located at 144,1°W and 42,2°N. In this region the Pacific plate subduct beneath the Hokkaido region from the Kurile Trench at a rate of about 80 mm/year and generate large earthquakes since decades. The earthquake of the 25 September is one of them and induced strong vertical ground motion. The Centroid Moment Tensor (CMT) computed by USGS is (FP1: strike=234, slip=7, dip=103 ; FP2: strike=41, dip=83, slip=88).

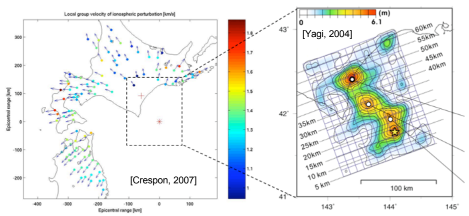


The Kii earthquake 09/05/2004 Mw7.2:

On 5 September 2004, in the South Easth of the Kii penninsula, an earthquake occurred at 10:07 (GMT) and was located at 136,6°W and 33°N. In this region the Philipine sea plate subduct beneath the Japanese Island Arc. The earthquake sequence of the 5 September was composed by two strong earthquakes but we focused on the first one. The Centroid Moment Tensor (CMT) computed by USGS is (FP1: strike=270, slip=35, dip=89 ; FP2: strike=91, dip=55, slip=91).

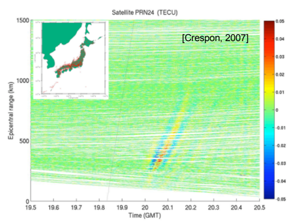


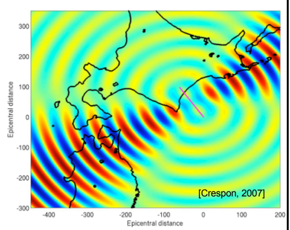
Source extension for Hokkaido



This figure (left) present local velocity of the ionospheric perturbation. The epicentre estimated by the JMA (red star) et our estimation of the source of the ionospheric perturbation (red cross) are plotted (red). We compare this results with the slip of the rupture estimated by [Yagi, 2004]. The coherence between the source (red cross) and the end of the rutpure is explained by the vertical displacement at the ground level.

This figure (righ) present time series of TEC perturbations and measurement points (red points on japan map). A very low amplitude of the ionospheric perturbation is observed for the measurement points close to the epicenter. These points are over Hokkaido island. Over Honshu, the perturbation is well detected. This difference of amplitude can be explained by acoustic interferences of an extended source (magenta line) fitting the extension of the source rupture estimated by [Yagi, 2004].





References:

Crespon, F., Tomographie 2D et 3D de l'ionosphère par GPS: application aux aléas géophysiques, Thèse de l'Institut de Physique du Globe de Paris, 2007.

Lognonné, P., C. Clévédé and H. Kanamori, Normal mode summation of seismograms and barograms in an spherical Earth with realistic atmosphere, GJI, **135**, 388-406,1998.

Yagi, Y., Source rupture process of the 2003 Tokachi-Oki earthquake determined by joint inversion of teleseimic body wave and strong motion data, Earth Planets Space, 56, 311-316, 2004