巨大地震により引き起こされた電離圏擾乱とイオノグラム・トレースの変形

丸山 隆 [1]; 津川 卓也 [1]; 加藤 久雄 [2]; 石井 守 [1]
[1] 情報通信研究機構; [2] ＮＩＣＴ

Ionospheric disturbances and deformation of ionogram traces induced by strong earthquakes

Takashi Maruyama[1]; Takuya Tsugawa[1]; Hisao Kato[2]; Mamoru Ishii[1]
[1] NICT; [2] NICT

A strong earthquake with a magnitude of 9.0 occurred off the Pacific coast of Tohoku on March 11, 2011. The earthquake induced various types of ionospheric disturbances. Among them, deformation of ionogram traces showing multiple cusps, which was induced immediately after the quake within ~10 min, was quite uncommon and almost nothing is reported but the M9.2 Alaska earthquake in 1964. The multiple-cusp trace indicates extra stratification of the ionosphere, and it was observed at Wakkanai (epicenter distance, d = 760 km), Yamagawa (d = 1330 km), and Okinawa (d = 1850 km) (the epicenter adopted is reported by USGS), while ionograms at Kokubunji (d = 390 km) closer to the epicenter did not show this type of disturbance. The real height analysis of the ionograms at Wakkanai and Yamagawa showed that the vertical scale of the structure corresponding to the adjoining cusps was 20~30 km. These ionospheric disturbances might be caused by an upward-propagating acoustic wave launched by the seismic Rayleigh wave. Assuming the mean sound speed of 500 m/s at the heights of the ionospheric disturbance, we have a wave period of approximately 1 min. Because of the smaller vertical structure (alternating compression and rarefaction) as compared with the thickness of the ionosphere, the disturbance is hard to be detected by the total electron content (TEC) measurements using GPS trans-ionospheric radio waves.

The same type of disturbance was searched in the ionogram records obtained over Japan, and we found three events. Ionogram signatures almost identical to the case of 2011 Tohoku earthquake were observed at Okinawa and Yamagawa approximately 30 min after the M9.3 great Sumatra earthquake on December 26, 2004. The distance between the epicenter and the ionosondes were 4310 and 4780 km for Okinawa and Yamagawa, respectively. Interestingly, no distortion was recognized in the ionograms recorded by the Southeast Asia ionosonde network (SEALION) closer to the epicenter.

Other two cases were found in the digital archives of historical ionogram records recently completed at NICT. An ionogram signature of earthquake-induced disturbances was first reported for the M9.2 Alaska earthquake in 1964 at Adak, Alaska, 2030 km away from the epicenter. Ionogram deformation induced by this earthquake was also observed at Kokubunji and Yamagawa, respectively 5700 and 6580 km away from the epicenter. In this event, the ionogram deformation showing multiple cusps was not reported at College, Alaska, closer to the epicenter (d = 430 km). The last one was observed at Akita, Japan, which was induced by the 1968 Tokachi-Oki earthquake (M8.2). Akita was separated from the epicenter by 310 km; no ionogram deformation was observed at faraway stations in Japan.

There observed many common features among the three strong earthquakes, viz. 2011 Tohoku, 2004 Sumatra, and 1964 Alaska earthquakes: magnitudes of those earthquakes were greater or equal to 9.0; the ionogram deformation showing multiple cusps was detected at great distances from the epicenter, while it was not detected at the closest stations; and all of those events were detected in the sunlit sector and the disturbance was significant at the F1 region heights.