Integrating Seismological and Geophysical Observations for Earthquake Precursors Studies in Taiwan

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Up to the present time, it is still very hard to predict the time of occurrence, location, magnitude, and intensity of a strong earthquake, however, studies of seismic precursor are actively underway in Taiwan and the world. This research about earthquake prediction is mainly in the monitoring and analyses of earthquake precursors, broadly collect the precursor phenomenon before strong earthquake happened, included change of the groundwater level, crustal deformation and variations of the ionospheric total electron content (TEC). The Global Positioning System (GPS) has broad applications in geosciences. Recently scientists study variations of the ionospheric total electron content (TEC) to search anomalies associated with strong earthquakes. The Central Weather Bureau (CWB) has set up hundreds of GPS receivers to monitor land deformation and seismicity. This project is to combine the groundwater and GPS to monitor pre-earthquake anomalies and to also foresee the epicenter in Taiwan.

For observing the precursors of the earthquakes, CWB cooperated with Water Resources Agency to establish the real-time transmission system in 6 groundwater observation stations with sampling rate of 1 sample per second. The seismicity in eastern Taiwan is more activity than other regions of Taiwan. The groundwater station, Hualien, in eastern Taiwan has more opportunity than other stations to detect the precursors.

For investigating the relationship between seismic activities and crustal deformation in Taiwan, the Central Weather Bureau (CWB) started to set up the permanent stations for the Global Positioning System (GPS) network since 1993. The GPS has become one of the most important geodetic tools for studying crustal deformation. From 1993 to 2000, the CWB had set up 17 permanent GPS stations. To better investigate the relationship between post-seismic activities following the Chi-Chi earthquake in Taiwan and any crustal deformations, the CWB established 133 GPS stations from 2001 to 2005. Now, the CWB GPS Network includes a total amount of 150 stations with multifunction monitoring system and variable station spacing which depends on seismotectonic activity and population density, less than 50 km on average. The continuously recording GPS data collected from the CWB GPS Network were adopted to reveal the crustal deformation of Taiwan. Analyzing the time series of GPS stations in Taiwan processed by the Bernese software, the average root-mean-square (rms) values of residuals for all stations after removing the coseismic offsets, periodic variations and linear trend. GPS velocities for the stations varied from 3.2 mm/yr to 69.8 mm/yr in azimuths ranging from 33.5° to 335.6°. The area with maximum strain rate is along Coastal Range (0.24μstrain/yr). The Ilan plain, strain rate estimated from GPS velocities is 0.10μstrain/yr. Through utilizing the satellite positioning technique, each station can provide precise global coordinate for its antenna position that can be used to monitor the horizontal and vertical crustal movement at the site. It can serve as important information about the deforming crust caused by related plate motion in this area. Further studies can be explored in the fields related to seismic activities, stress accumulation and release, and the physical properties of earthquakes.

(Key words: earthquake prediction, earthquake precursor, Global Positioning System, groundwater level)

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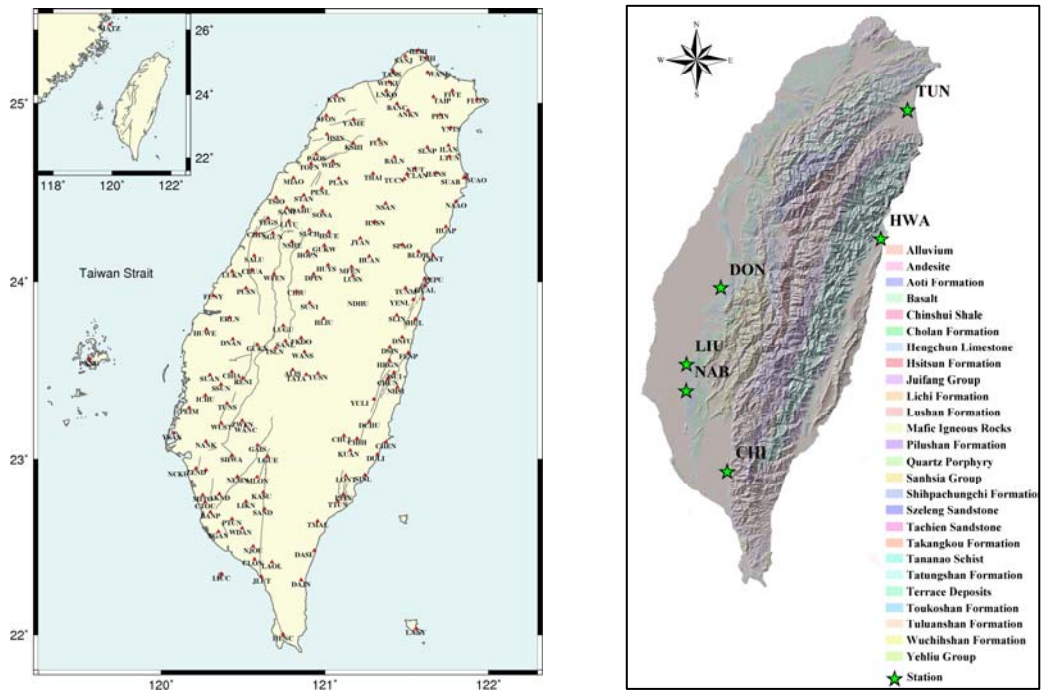
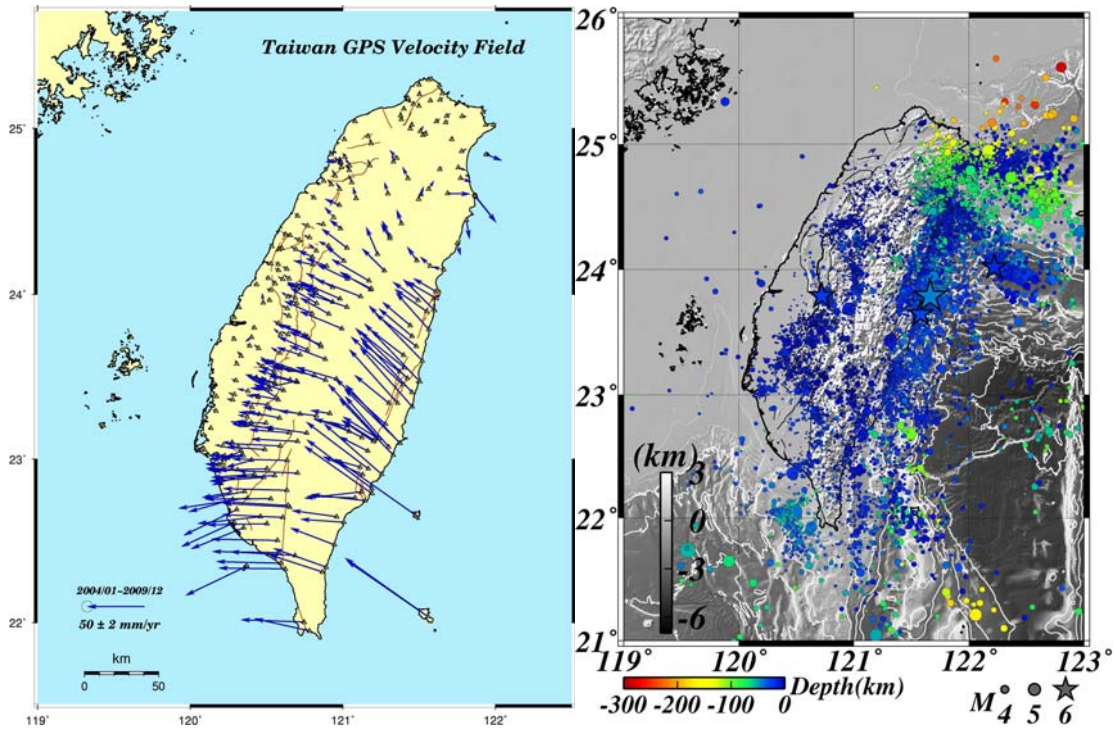


(a) (b)

Figure 1、The location distribution of CWB stations (a) GPS (b) groundwater.



(a) (b)

Figure 2、The relationship between GPS crustal deformation (a) and seismic activities (b) in Taiwan.

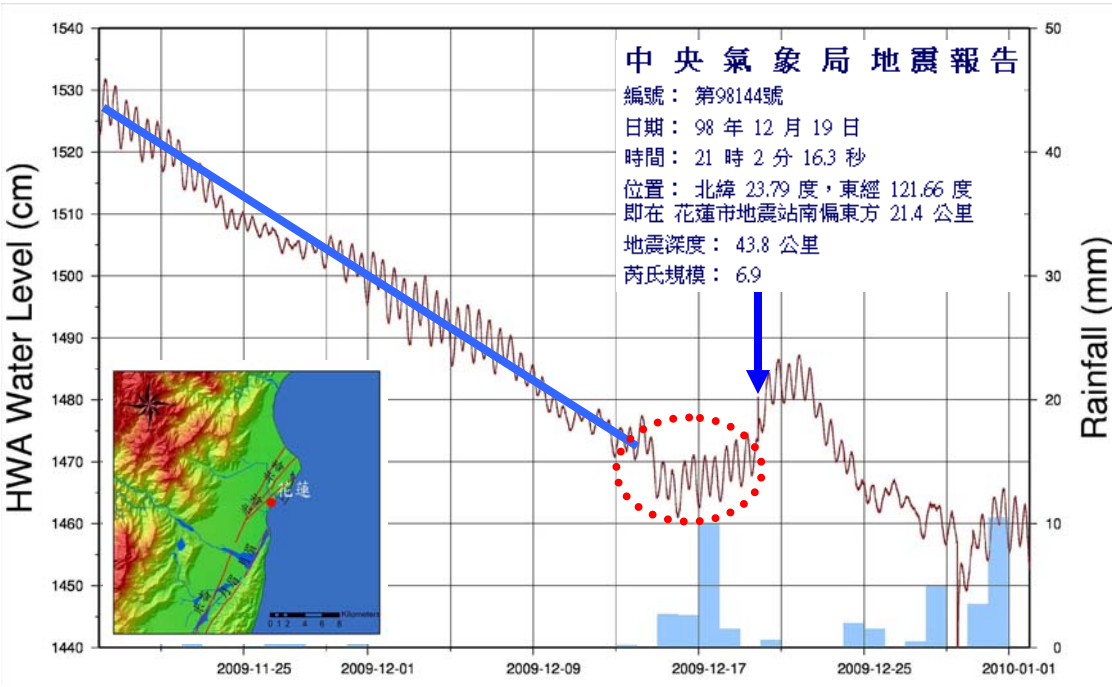


Figure 3、The earthquake precursor in groundwater for the case of December 19, 2009 strong earthquake in Hualien, Taiwan.

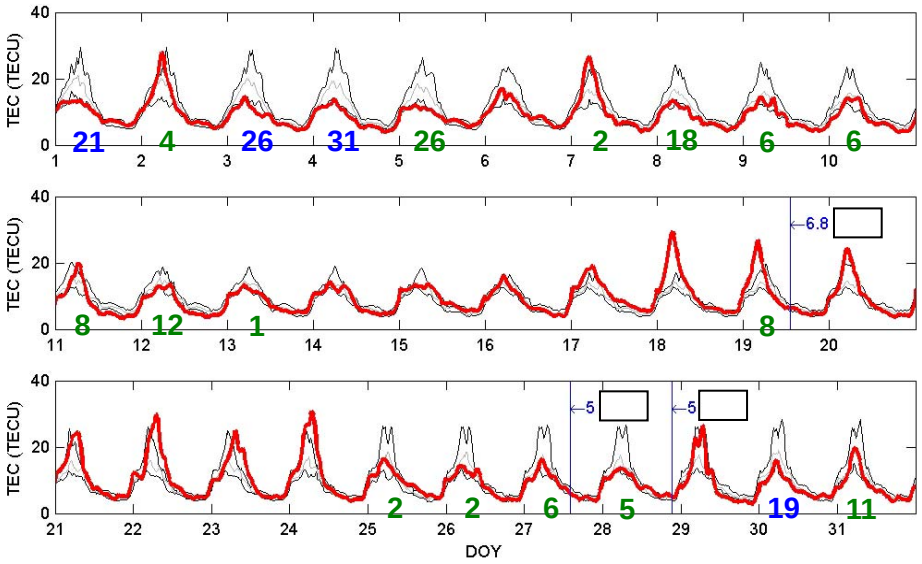


Figure 4、The earthquake precursor in ionospheric total electron content (TEC) for the case of December 19, 2009 strong earthquake in Hualien, Taiwan.