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Research papers

Groundwater storage inferred from earthquake activities around East Asia and West Pacific Ocean

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ABSTRACT

Groundwater is a necessary and indispensable resource in the gradual depletion of the amount in the world. Groundwater storage is an important indicator to evaluate the capability of volume of water can be released from the aquifer. This research highlights a new assessment to infer the storage of aquifer using earthquakes activated around East Asia and the ring of fire at West Pacific Ocean. Ten significant seismic events are used to evaluate the groundwater storage at an observation station. By analyzing the spectra of groundwater level and seismogram, it is evident that the period varied in 7–25 s of Rayleigh waves significantly dominate propagation from the epicenter of earthquakes to the observation station. The storage coefficient is then shown in the order of 10^{-4}–10^{-3}. The major innovation of this study suggests that to concretely deduce the groundwater storage by earthquake activity has become feasible.

1. Introduction

Groundwater storage is water existing underneath the Earth's surface for long period (USGS, 2016). It shows that about 1.7% of all of Earth's water is groundwater and about 30.1% of freshwater on Earth occurs as groundwater (Gleick, 1996). Groundwater conveys in soil matrix as an underground layer to form an aquifer which combine the soil, rock and saturated with water. If the aquifer is shallow enough and permeable enough to allow water to move through it at a rapid rate, then people can drill wells into it and withdraw water (USGS, 2016). The level of the water table can naturally change over time due to changes in weather cycles and precipitation patterns, water body in boundary, geologic changes, and even earthquake or human induced changes. The pumping of wells can have a great deal of influence on water levels of aquifer, especially in the vicinity of the well. If water is withdrawn from the ground at a faster rate that it is replenished by precipitation infiltration and seepage from streams, then the water table can become lower, resulting in a cone of depression around the well. Depending on geologic and hydrologic conditions of the aquifer, the impact on the level of the water table can be short-lived or last for decades, and the water level can fall a small amount or many tens of meter. Excessive pumping groundwater can lower the water table so much that the wells no longer supply water. An aquifer test, or a pumping test, is conducted to evaluate an aquifer by stimulating the aquifer through constant pumping, and observing the aquifer's response, or drawdown, in observation wells. Aquifer testing is a common tool that hydrogeologist uses it to characterize a system with combination of aquifers, aquitard and its boundaries. Thus storage coefficient and transmissivity can be estimated by the field testing. They indicate the capability of volume of water can be released and a function of property of both the porous medium and fluid glowing through aquifer respectively.

Many natural phenomena in the surface and subsurface of the Earth change periodically with time. It may include change in groundwater levels caused by infiltration from surface water, by the tidal effect from rivers or coasts nearby, or ocean tides affected by the interaction between astronomical bodies. For aquifers adjacent to ocean or river, the groundwater table fluctuates in response to the change of water level in nearby surface water (Roistaczer, 1988; Rotzoll et al., 2008; Shih et al., 1999, 2000, 2008; Shih and Lin, 2002, 2004). Cooper et al. (1965) studied the water level response to pressure-head fluctuations due to dilatation of an aquifer and to vertical motion of a well-aquifer system. The equation of motion in the water column was used to derive expressions for the amplification, which is defined by oscillation caused by dilatation and vertical motion. Pressure head amplification curves were plotted for different seismic waves. A storage coefficient of 10^{-4} was

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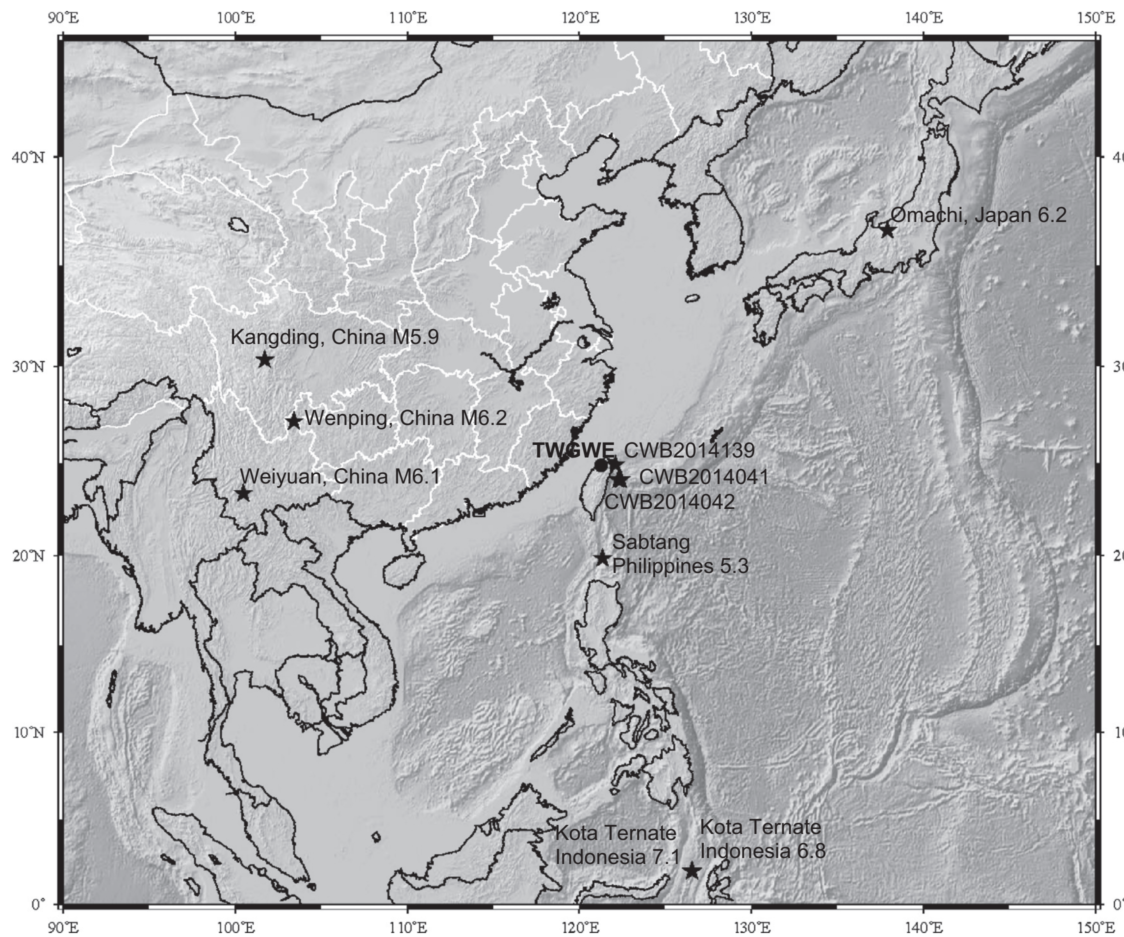

Fig. 1. Location of earthquake activities (★) and groundwater with seismology monitoring station TWGWE (●).

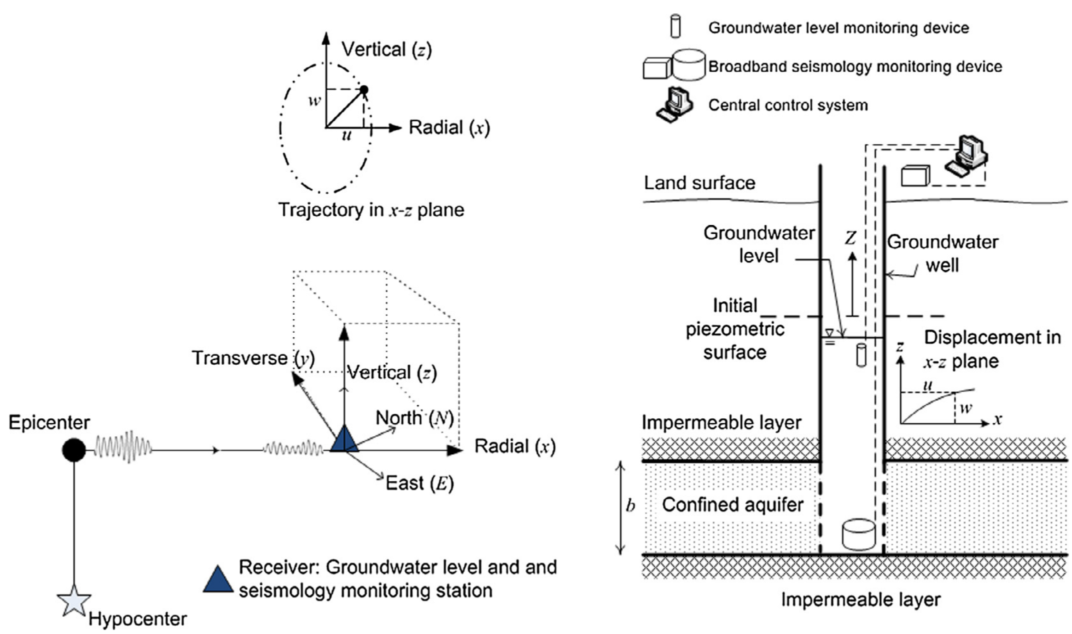

Fig. 2. Conceptual model of propagation of Rayleigh waves to groundwater and seismology monitoring station (left). Site profile demonstrates the layout for measuring groundwater level and seismic displacement (right).

assumed for all amplification curves, through which transmissivity was then determined from the form of the curve. Commonly, the storage coefficient of most confined aquifers ranges from 10^{-5} to 10^{-3} (Heath, 1983). The difference between these values and the value due to expansion of the water is attributed to compression of the confined aquifer. The total load on the top of aquifer is sup-