Correlation between surface displacement and groundwater level displacement in the periods before and after the 2018 Northern Osaka earthquake

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It is known that displacement of groundwater level sometimes occurs around an epicenter or in a wide area immediately after an earthquake. For example, in the Kumamoto earthquake in 2016, some areas of the groundwater level increased due to the inflow of groundwater stored at the foot of the mountain. On the other hand, other area of the groundwater level decreased due to the groundwater flowing into the fracture area in the deep underground. It is widely known that displacement of ground surface is caused by such displacement of groundwater level. Land subsidence due to the lowering of the groundwater level is generally recognized and a model for it has been developed. However, in some areas, rising ground surface due to rising groundwater level has been observed as a phenomenon, but its model is not fully understood. It is important to examine which parameters contribute to rising ground surface when the groundwater level rises, such as speed and acceleration of the groundwater level.
In the periods before and after the Osaka Northern earthquake on June 18, 2018, the rises of the groundwater level have been observed at several groundwater wells in the Hanshin area, Japan. Therefore, the ground uplift due to the rise of the groundwater level may have occurred. In this study, we first estimated the amount of long-term change in ground surface displacement in the Hanshin area in the periods before and after the 2018 Osaka Northern Earthquake, and then discussed the correlation between surface displacements and groundwater levels. Finally, we discuss a simple model for uplift of the ground surface due to rising groundwater levels. PSInSAR analysis was used to estimate surface displacements because it can calculate displacements over a wide area. By combining the surface displacement from the PSInSAR analysis with the groundwater level displacement data, It will be possible to discuss changes in displacement of groundwater level and ground surface due to earthquakes, the magnitude of seasonal displacement of groundwater level and ground surface, and changes in two-dimensional displacement of groundwater level. The satellite data was obtained from the European Space Agency's Sentinel-1 northward orbit for the period April 2015 to April 25, 2019. For the groundwater level data, we used the groundwater level stations of the hydrological water quality database operated by the Ministry of Land, Infrastructure, Transport and Tourism, the groundwater level stations operated by the National Institute of Advanced Industrial Science and Technology, and the groundwater level stations operated by Osaka City.
As results of PSInSAR analysis, surface displacements in the direction of satellite line-of-sight shortening were observed in the vicinity of Takarazuka City and the eastern part of the Osaka Plain in the period before and after the earthquake. The direction of these displacements is westward or uplift direction in terms of actual displacements. These results are consistent with the groundwater level displacement at the groundwater level point near Takarazuka City because the groundwater level rose in the periods before and after the earthquake. On the other hand, in each observation point of groundwater level in the eastern part of the Osaka Plain, the displacement trend of groundwater level depends on the location. Specifically, some observation points showed seasonal changes in groundwater level due to increases and decreases in precipitation, while others showed no seasonal changes. This indicates that displacement of groundwater level and ground surface cannot be modeled simply, and that it is necessary to study the geological structure and aquifer characteristics of each site.

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