



Interpretation of Groundwater Level Variations in Jeju Island by Principal Component Analysis

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Groundwater in Jeju volcanic Island is the major source of fresh water due to the absence of any perennial streams. Currently, a total of 133 monitoring wells has been operated by the government of Jeju Special Self-Governing Province, and each monitoring well is equipped with an automatic data logger that measures the water level every hour. We analyzed groundwater monitoring data from 116 selected wells in Jeju Island of the year 2017 by principal component analysis (PCA). In the year of 2017, the annual average rainfall was just 1,054 mm (61% compared to normal), and it was the third lowest precipitation since 1961 (when all 4 stations began observations). This study used the PCA to investigate the patterns of changes in the groundwater level. In addition, time-series analysis and cross-correlation were also conducted to understand the relationships between precipitation, tide level, artificial pumping, and groundwater level. The results are as follows: (1) the major two components account for 71~84 % of the variance in the water level data for each time resolution (month: 83.6%, day: 78.5%, hour: 71.3%) and PC 1 is a more influential factor affecting groundwater level fluctuation than PC 2 (PC1: 53.8%, PC2: 29.8%, based on monthly data); (2) the PC 1 scores hydrographs show a downward trend, except in the summer with a lot of rainfall, and mainly show high values in the northern and western regions. The groundwater level fluctuation strongly affected by pumping for agriculture, industrial usage. These results are completely different from groundwater level fluctuation, in 2016, when PC 1 showed a well-reflected pattern of seasonal variations; and (3) the PC 2 scores hydrographs indicate a close relationship of the seasonal variation and the tidal cycle. The PC 2, which has high values in the southern and eastern regions, shows seasonal variation (e.g., precipitation, relative humidity) in all-time resolution data. Especially, in the eastern region, groundwater level for hourly time resolution was sensitive to the tidal cycle. The cross-correlation between the hourly water level and the hourly tidal level showed a very close correlation with $r = 0.89$ after 2 days. But, in the southern region with the same high PC 2 score distribution, groundwater level fluctuation is not influenced by the tides because of low permeable Seogwipo Formation which is situated above sea level, not like other regions in Jeju Island and is just affected by seasonal variation as a whole. Through this study, we can obtain comprehensive information for groundwater level fluctuation patterns using PCA and the results of this study indicate that PCA can be a useful tool to summarize information in large data sets of groundwater monitoring networks.