Evaluation of subsurface warming in the Tokyo metropolitan area, Japan

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Three-dimensional subsurface temperature distribution and its long-term change were examined by repeated observations of temperature-depth profiles at monitoring wells from 2000 to 2016 and groundwater temperature monitoring from 2007 or 2012, to evaluate effects of regional groundwater flow and environmental changes due to urbanization on subsurface thermal environment in the Tokyo metropolitan area, Japan.
Subsurface warming has been found at shallow depths in the whole study area by our previous study (Miyakoshi et al., 2010). Especially, subsurface temperature beneath the city center was particularly high not only at shallow part but also deep part. In contrast, relatively low temperatures were found beneath the suburban area. Comparison result between past subsurface temperature data (2003 to 2005) and present subsurface temperature data (2013 to 2016) shows that subsurface warming is found at the shallow part in the last 9 to 10 years. Subsurface temperature increase in the city center is larger than the suburban area, and the temperature difference between both areas shows an increasing tendency. Additionally, subsurface warming in the present data was recognized deeper than the past data. This result suggests that distribution of subsurface warming is expanding toward the deeper part.
Subsurface monitoring data showed constant warming rates at observatories in the southeastern area of Saitama Prefecture and the eastern area of Tokyo Metropolis. These observatories are located in the alluvial lowland, and the warming tendency was formed by effects of surface warming due to urbanization. On the other hands, subsurface warming was not a constant rate at observatories in the southwestern area of Saitama Prefecture and the western area of Tokyo Metropolises. These observatories are located in the Musashino Uplands, and the warming rate show a time and a depth variation. Additionally, subsurface temperature changes were found at not only the shallow part but also deeper part than 100m in this area. These complex subsurface temperature changes are recognized around areas where significant changes of hydraulic heads were observed, and it was considered that subsurface thermal environment was affected by artificially-induced groundwater flow changes. Results of this study suggest that mechanism of subsurface warming is able to be evaluated by combined analysis of geological condition, groundwater flow and subsurface temperature changes.
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