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Temporal change of SF6 age in spring during rainstorms in a forested headwater catchment, Fukushima, Japan

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Time variant water age in catchments can fundamentally describe catchment function, controlling rainfall-runoff generation, groundwater flow pathway, and water storage. We observed sulfur hexafluoride concentration in the stream and groundwater with 1 - 2 hours interval during rainstorm events in order to reveal temporal variations of rainfall-runoff water age. Target's spring is perennial in a forested headwater catchment with an area of 0.045 square km, Fukushima, Japan. The observed hydrological data and tracer data of water in the catchment (stable isotopic compositions, inorganic solute concentrations) were used for clarifying rainfall-runoff processes related to water age variances.
The storm hydrograph and groundwater table clearly responded to rainfall especially with more than 30 mm per day throughout the monitoring period (May 2015 - October 2016). Large variations of SF6 age in spring ranging from zero to 14 years were found in the short period during rainstorms. In particular, the SF6 age in spring was evidently old when the runoff was over 2 mm per day. At the high runoff condition, the SF6 age in spring positively correlated with discharge rate: the spring age became older as the discharge rate increased. With regard to spatial distributions of SF6 age in groundwater, the old groundwater age (9 - 13 years) in the shallow subsurface area along the valley was confirmed after heavy rainfall. This groundwater age was similar age to the deep groundwater at no-rainfall conditions. In addition, inorganic solute concentrations such as chloride ion, sodium ion, and silica in spring water showed dominant levels in the deep and ridge groundwater. All facts suggest that the old groundwater, stored in the ridge or deeper subsurface area, replaced the shallow groundwater in the vicinity of the spring due to heavy rainfall, then it contributed to the spring discharge. Therefore, rainstorm events play important roles as triggers for discharging older water stored in the catchment, causing dynamic changes of groundwater flow system.