Comparison of controlling factors of streamwater mean residence time across headwater catchments using water stable isotope

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The estimation of mean residence time (or mean transit time) with stable isotope is conducted based on the phenomena that the tracer output signal (groundwater and/or streamwater) is damped and lagged compared to the input signal in rainfall as the result of water transport within the catchment. The long-term and continuous isotope data is necessary to apply this method for precise estimations in each catchment. This fact is sometimes a difficulty for the inter-comparison of mean residence time between the sites. To overcome this difficulty, the inverse transit time proxies (ITTPs) were proposed by a simple metric of isotopic tracer damping, using the ratio of standard deviation of d18O in streamwater to the standard deviation of d18O in precipitation, and applied in some studies. The smaller ITTPs stand for the longer mean residence time. In this study, we applied this index for 25 headwater catchments from 8 sites in Japan to compare the controlling factors of streamwater mean residence time across the catchments considering geomorphic and hydrological parameters. The weak relationship between catchment area and ITTPs was found that the ITTPs varied between the smaller catchments and converged to smaller ITTPs values in the larger catchments. We considered the relationship between ITTPs and relative height, mean slope gradient G, flow path length L, L/G, and topographic index TPI as geomorphic parameters, although the availability of these parameters were different between the sites. The parameter values were similar in each site and we could not find the clear relationship between ITTPs and these parameters. Within them, the relationship between ITTPs and L/G, which was available in three sites, were similar to that with the catchment area; the ITTPs varied between the smaller L/G and converged to smaller ITTPs values with the larger L/G. As the G values were similar within the same site, this relationship was mainly controlled be the L values. On the other hand, the relationship between ITTPs and the standard deviation of annual daily discharge showed that the ITTPs were relatively constant regardless of discharge fluctuation. Generally, the discharge patterns are controlled by the bedrock geology. However, it is implied that the variation of discharge rate less effect on the variation of isotope values, and accordingly on the difference of the mean residence time. In the next step, we will consider if we can find some common controlling factors, and/or the key mechanisms, of mean residence time across the sites.

Keywords: Headwater catchments, Mean residence time, Water isotope, Inverse transit time proxies, Geomorphic parameters, Hydrological parameters

