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Inter-annual variation of the timing of snowmelt runoff in the Japanese Alps region

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Global-warming-induced shift in the timing of snowmelt runoff toward earlier in the year has been observed in western North America and others. To confirm whether such a phenomenon is occurring in Japanese Alps region, inter-annual variation of river discharge was analyzed for winter and spring seasons. Using the Water Information System of Ministry of Land, Infrastructure and Transport, Japan, we selected observation data of river discharge at totally 13 gauge stations for 10 rivers, of which headwaters are located in Japanese Alps or surrounding mountain ranges. Length of available data is different among the stations with 37 years at maximum and 6 years at minimum. The ”center time” (CT), which is the flow-weighted day-of-year (DOY), was computed as a measure of runoff timing. In the present study, January 1 was assumed to be the beginning of the water year, and data after June 1 were excluded in the analysis to avoid influences of discharge increase due to Bai-u front and/or typhoons. Maximum and minimum of computed CT were DOY68 (March 9) and DOY128 (May 8), respectively. For the rivers Jinzu, Hime, Narai and Tenryu, inter-annually decreasing trend was found, suggesting that the snowmelt runoff timing did shift toward earlier. However, both linear regression analysis and Mann-Kendall rank statistic rejected the significance ($p < 0.05$) of the trend. This is probably due to insufficient length of observation records and to highly variable CT at shorter timescales (i.e., year by year). Correlation analysis for inter-annual variation of CT with those of air temperature and precipitation amount clarified different features among the rivers. For the Jinzu River (including its tributary, the Ida River) and Hime River having their sources in northern part of the Northern Alps or the Ryohaku mountains, the timing of snowmelt runoff tends to shift toward earlier, as air temperature in January is higher. For the Sai River and Narai River, which rise in southern part of the Northern Alps or the Central Alps, snowmelt runoff in late spring is increased by higher temperature or greater precipitation in April-May. Runoff timing for the Tenryu River, of which watershed covers eastern part of the Central Alps and western part of the Southern Alps, is affected by both winter temperature and spring temperature as well as spring precipitation. For the upper Chikuma River and Fuji River system (including Kamanashi River and Fuefuki River), which flow from eastern part of the Southern Alps or the Kanto mountains, river discharge strongly depends on precipitation rather than air temperature, indicating minor contribution of water from snowmelt. As a general tendency over the region, temperature in January controls not only runoff timing but also amount of discharge in spring, and in many stations significant, negative correlations was found between temperature in January and discharge in April. Thus, it is concluded that temperature rise in winter due to global warming is likely to decrease river discharge in spring over the Japanese Alps region. For rivers less sensitive to temperature (e.g., upper Chikuma River and Fuji River system), river discharge would be affected by changes in precipitation pattern, if those were altered by global warming.

Keywords: snowmelt runoff, inter-annual variation, Japanese Alps region, global warming, hydrological response