

Water balance and mass balance in a mountainous river basin, Northern Japan Alps

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Abstract

We have investigated the water balance and mass balance for four years in Maekawa River basin on the eastern slope of Mt. Norikura-dake. In this region, the precipitation frequency is high from the rainy season to the autumn. The maximum base-flow discharge occurs in the spring snowmelt season. The pH and electric conductivity of the river water decline rapidly with the beginning of the snowmelt runoff and temporarily decrease when the discharge increases temporarily in the rainy season or during a typhoon event. The Cl^- concentration of the river water increases in the early stage of snowmelt season since there is a considerable amount of sea salt in the snow. In addition, the NO_3^- concentration of the river water increases when the rainfall increases the discharge. The major ion concentration of the river water, except Cl^- and NO_3^- almost synchronizes with the change in the electric conductivity. In the mass balance of cations, the runoff rate from the river basin considerably exceeds the atmospheric deposition rate to the river basin. This is because there is extremely much elution of ions from new volcanic rocks and soils. Further, the atmospheric deposition rate of NO_3^- is larger bigger with the biological consumption in the river basin than the runoff rate from the basin.

1. Introduction

For heavy-snow regions such as Japan Sea-side area, the quantity of water precipitated by a snowfall is extremely more important than rainfall as a water resource. Moreover, snow also plays a role of natural dams since it accumulates in river basins during winter time. The snowfall in mountainous regions is more than that in the lowlands; however, it is difficult to determine quantitatively. The snowfall measurement using a regular precipitation gauge requires a heater and therefore an electrical power supply. Moreover, the measurement accuracy is low because of a low capture rate of snowfalls in windy mountainous regions (Yokoyama *et al.*, 2003). For these reasons, snowfall is rarely measured using a precipitation gauge in mountainous regions during the winter season. Precipitation-gauge stations are set up by the Japan Meteorological Agency in mountainous regions only during warm periods; moreover, the number of stations is extremely small. It is crucial to elucidate the water balance by quantitatively comprehending the amount of precipitation and also including the snow in mountainous regions from the aspect of wa-

ter resources.

Further there are reports that state that the snowfall in Japan decreases in accordance with global warming (Inoue and Yokoyama, 2003). However, this result is from research based on data mainly from lowlands; therefore, it is uncertain whether this data applies to mountainous areas at high altitudes. In a snowy temperate area, where rain or temporary warming can cause frequent melting at the surface of snow cover, the snow melts due to an increase in the air temperature and the temperature determines whether the precipitation will be in the form of snow or rain. At such places, the snow turns to rain or vice versa depending on increases and decreases in temperature. In addition, it is likely that the snowfall decreases if the climate becomes warmer since snow particles melt while falling and turn into rainfall; thus, the precipitation amount is the same. However, it is also conceivable that the snowfall will increase in mountainous regions at high altitudes. This is because the saturation vapor pressure in the atmosphere increases with temperature. Therefore, snowfall will increase if the precipitable water is increased in amount and does not turn into rain. Inoue and Yokoyama (1998) predicted that the snowfall will not increase for