Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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Snowfall is an important parameter for water resources. An accurate, quantitative evaluation is needed to clarify the impact of global warming on snowfall and vice versa. For that evaluation, a gridded precipitation data set based on rain-gauges is suitable, because rain-gauges measure precipitation directly. However, rain-gauge data include systematic biases due to interpolation and observation biases. For example, the long-term average, daily gridded precipitation data from APHRO_JP (P) underestimates by 30% the sum of evapotranspiration (E) and inflow (R) from dam catchments located in Northern Japan. We know this because if APHRO_JP was accurate, P should be equal to $R+E$ and it is not. It was reported that the annual mean precipitation of Japan was well simulated in the non-hydrostatic regional climate model (NHRCM, spatial resolutions 5 km/2 km) produced by the Meteorological Research Institute (MRI). From the above, we validated the interpolation bias of APHRO_JP using precipitation from the NHRCM to quantitatively evaluate winter precipitation over Northern Japan. The bias in the water balance from the dam catchments was reduced to 1% after adjusting for three systematic biases.

First, we validated and adjusted the interpolation bias. We created daily precipitation gridded data based on the distribution of the Automated Meteorological Data Acquisition System (AMeDAS) using hourly precipitation from the NHRCM (spatial distribution 2 km) and we compared it with precipitation from the NHRCM. We found that precipitation from the Mesh precipitation climatology which is used in APHRO_JP underestimated precipitation over mountain areas where rain-gauges were not set up. Because of this, APHRO_JP underestimated winter precipitation over mountain areas by approximately 3 mm/day. This daily precipitation bias over mountain areas was halved when we used climatology based on precipitation from the NHRCM instead of Mesh precipitation climatology.

Even with this adjustment, precipitation over mountain areas was still underestimated. This stemmed from the interpolation method used to predict rainfall, because the climatology indicate that the ratio of precipitation increases seasonally with elevation over mountain areas. This underestimation was controlled by an adjustment to the interpolation bias from the precipitation pattern detected by an Empirical Orthogonal Function (EOF) analysis.

On the basis of these validation results, we created daily precipitation gridded data based on the AMeDAS rain-gauge. We then applied the three adjustments from the climatology, precipitation pattern and precipitation undercatch and evaluated their contribution. We found that the annual precipitation over Japan was 2054 mm/year, which was an 18% increase on APHRO_JP. Furthermore, at the four dam catchments in Northern Japan, this adjusted precipitation explained 99% of the precipitation estimated by inflow from the dam catchments and evapotranspiration.

Finally, we measured the contribution of the systematic bias in winter precipitation in Northern Japan (138.5–141˚E, 36.8–38.8˚N). Precipitation was increased 11% by changing the climatology and increased 12% by adjusting for precipitation undercatch. The impact of the precipitation pattern adjustment was small. For extreme events, the adjustment effect was different. On average, in the four dam catchments,

precipitation was increased 18% by the change of climatology 7% by adjustment for precipitation undercatch. However, these ratios were different at each dam, and in dams where the catchments were in high mountain regions, there was a much greater effect from a change in the climatology. Because there are few rain-gauges in high mountain regions, it important to change climatology used in APHRO_JP. Furthermore, our results indicate uncertainty in precipitation from internal variability when the precipitation pattern adjustment was not used. Our application of these adjustments to APHRO_JP reduced systematic bias and improved precipitation measurements.

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