Estimation of Net Precipitation over the Three Great Siberian River Basins Using Atmospheric Reanalyses

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Net precipitation is the difference between precipitation (P) and evapotranspiration (E), that is, the net input of water from the atmosphere to the land surface. In principle, when calculated as an average over a long time period, the net precipitation integrated over the river basin area should be nearly equal to the river discharge at the mouth of the river.

River discharges from the three great Siberian rivers are a large source of freshwater inflows into the Arctic Ocean. The freshwater budget in the Arctic Ocean is important for local sea ice formation and for the ocean conveyor belt, which affects climate in Europe and several other regions. Sources of the freshwater inflow include river discharges from the land, net precipitation from the atmosphere, and ocean currents from the ocean. The river discharges from the three great Siberian rivers account for about 60% of the total river discharge into the Arctic Ocean and they also account for about 20% of the total freshwater inflow into the Arctic Ocean.

We used monthly mean river discharges observed near the mouths of the Lena, Yenisei and Ob Rivers from the ArcticRIMS archives, and 4 times daily specific humidity and winds from several atmospheric reanalyses (JRA25/JCDAS, ERA40, ERAI, NCEP2, CFSR and MERRA). Because it is difficult to estimate net precipitation (P-E) from direct observations of P and E on large spatial scales, in our analysis, we estimated net precipitation on the basis of atmospheric reanalysis data without using P and E datasets. We calculated vertically integrated moisture flux using the atmospheric reanalysis and then estimated the net precipitation from the moisture flux and precipitable water by means of the atmospheric water budget method.

On average during 1980-2008, the amounts of net precipitation over the basins of the Lena, Ob and Yenisei Rivers were found to be comparable in magnitude to the river discharges at the mouths of each river. Our previous studies already produced good estimates of net precipitation over the Arctic and Antarctic regions (Oshima and Yamazaki 2004) and over the Amur River basin (Tachibana et al. 2008). Therefore, all these results indicate that the estimation of net precipitation by using atmospheric reanalysis is an effective way to evaluate and quantify the atmospheric and terrestrial water cycles of a large river basin or at larger spatial scales.

We further examined the seasonal and interannual variations of the river discharges and of the net precipitation for the Lena, Yenisei and Ob River basins, and in addition, how these variations are related with the atmospheric water cycle, that is, the moisture transport and associated large-scale atmospheric circulation. Some results are as follows. The Lena River discharge shows a maximum in June due to river ice melting. While the precipitation over the Lena River basin shows a maximum in July, the net precipitation shows a minimum at nearly zero flow in July. This indicates that the evapotranspiration is as large as the precipitation in the warm season. These seasonal cycles are almost the same as in the Yenisei and Ob Rivers. The net precipitation over the Lena River basin is mainly caused by transient moisture flux associated with cyclone activity; in contrast, over the Ob it is caused by stationary moisture flux associated with the mean flow, while over the Yenisei it is caused by both of stationary and transient fluxes. The summer and winter mean discharges of the Lena River are positively correlated with the net precipitations over the basin in each season, respectively. These variables do not show any significant trends during the past three decades (1980-2008).

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