Long-term runoff analysis of the Lena River basin using a distributed hydrological model

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In order to understand the current status of the water cycle in the Northern Regions, and predict future variation due to environmental changes, the authors have constructed a hydrological model for the Lena River basin, which enables precise estimation of the long-term stream discharge.

This research uses a distributed hydrological model to take into account the fact that there is significant spatial variation in precipitation in the subject basin. This hydrological model is comprised of two models: a land surface model (LSM), and a runoff model.

LSM used in this study is that described in Yamazaki et al. (2004). It includes the three sub models; vegetation, snowpack and soil. LSM applied to north-eastern Siberia including the Lena River basin. The horizontal grid spacing is 0.5 deg x 0.5 deg. Daily forcing meteorological data of each grid were reconstructed based on Baseline Meteorological Dataset of Siberia of 77 stations. Park et al. (2008) shows LSM results of the region.

The runoff model uses the optimal channel routing scheme for flood routing in unit channels (Lu et al., 1989), and routing of flood flows up to the basin outlets is performed via a channel network created from 5 min x 5 min digital elevation data. More specifically, water from soil in a unit grid calculated with LSM is divided, at a fixed ratio, into a direct runoff component and a base flow component, and the base flow component is given as an input value to the grid for the channel network, together with the direct runoff component, via a linear storage function model. Stream flow in the channel network is modeled using kinematic wave approximation and Manning's equation. River ice growth was estimated from the accumulated freezing degree-days, and ice decay was estimated from the accumulated degree-days and maximum ice thickness during the ice formation period.

The stream discharge was calculated for the period from 1986 to 2003 using the above hydrological model, and as a result, it was possible to almost exactly reproduce the actual measured flow rates throughout the entire period. Previously, there have been no examples of reproducing the stream discharge for 18 years, and thus these results are especially noteworthy. The results show that the hydrological model used in this study is effective for simulation of the water cycle in the Northern Regions.