Warming climate-derived changes in terrestrial Arctic evapotranspiration budget and the impact to hydrological cycle

Hotaek Park and Kazuhiro Oshima
Institute of Arctic Climate and Environment Research, JAMSTEC

Evapotranspiration (ET) that is a sum of transpiration (E_T), soil evaporation (E_S), and canopy interception (E_I) is one of components constituting to global energy and water budgets. The energy and water budget is greatly influenced by changes in climate. The recent Arctic warming results in changes in the energy and water budgets, which were identified by in situ observations and model simulations. Previous results addressed increasing trends of ET dependent on the warming climates. To date, however, very few studies are available for quantitative values for changes in ET and the partition to the three constituents and the influences on river discharge. A land surface model (CHANGE) is used to assess changes in the Arctic terrestrial ET during the period of 1979–2010.

The pan-Arctic temperature and precipitation showed increasing trend from 1979–2010. The model also simulated increasing ET responding to the warming climates. The simulated pan-Arctic ET was compared with ET derived from reanalysis datasets, showing generally good agreements. We could find an interesting fact that the ET constituents indicated trends inconsistent with ET. Both E_S and E_I were significantly increased, associating with earlier soil thawing and increased canopy interception combined with increasing leaf area index. Meanwhile, E_T showed a decreasing trend, although it was not statistically significant. During the study period, air temperature and precipitation certainly increased, which can reduce stresses of heat and soil moisture deficit, respectively, consequently contributing to more E_T. The decreased E_T was related to increasing CO_2 concentration in the atmosphere, resulting in stomatal closure. This result was diagnosed by model sensitivity experiments treated the CO_2 concentration to 280 and 800 ppm. The contribution of the decreased E_T to ET was not relatively large, because the increase in both E_S and E_I did offset the decrease of E_T. The increased ET reduced the contribution of soil moisture to river discharge. However, it seems that the river discharge is primarily dependent on precipitation dynamics, because the changes of ET were not larger than those of precipitation. This study documents that changes in ET budget associated with the climate changes are likely enhanced in the future, consequently impacting the Arctic terrestrial hydrologic budget.