Characteristics of evapotranspiration and water balance in eastern Siberian taiga

Takeshi Ohta[1]; Taro Nakai[2]; Kazuho Matsumoto[3]; Han Dolman[4]; Shigeaki Hattori[5]; Tetsuya Hiyama[6]; Yoshihiro Iijima[7]; Yuji Kodama[8]; Trofim C. Maximov[9]; Hironori Yabuki[10]

[1] Bioagricultural Sciences, Nagoya Univ; [2] JST/CREST; [3] Grad. Bioagri. Sci., Nagoya Univ.; [4] Dept. Geo-Environ. Sci., Free Univ., The Netherlands; [5] Bioagricultural Science, Nagoya Univ.; [6] HyARC, Nagoya Univ.; [7] IORGC, JAMSTEC; [8] ILTS, HU; [9] IBPC, RAS, Russia; [10] JAMSTEC/IORGC

To clarify the features of evapotranspiration and water balance in eastern Siberian taiga, water and energy fluxes were measured at two sites (larch and pine forests) in the Yakutsk area of eastern Siberia; two sites (birch and mixed forests) in the Moshiri area of Hokkaido Prefecture, northern Japan; and one site (mixed forest) in the Seto area of Aichi Prefecture, central Japan. The Yakutsk, Moshiri, and Seto sites represent boreal, cool-temperate, and warm-temperate forests, respectively. Water balance and evapotranspiration were intercompared, and the interannual variation (IAV) of the water balance was analyzed for the larch forest in eastern Siberia.

Intercomparison of the water balances revealed the following new insights. Yakutsk had wide IAV in precipitation, but the IAV of evapotranspiration was relatively steady, even though the annual amount of precipitation was small. This feature is quite different from that found in low- and mid-latitude regions having no permafrost. The IAVs of soil water storage and runoff (estimated from the residual in the water balance equation) reflected the wide fluctuation of annual precipitation.

Next, the major factor controlling evapotranspiration was examined using the following equation:

E = A x Ep,

where E is evapotranspiration, Ep is potential evaporation, and A is the evapotranspiration coefficient. Specifically, Ep represents the atmospheric demand for evaporation under a certain meteorological condition, and A is a regulating factor of Ep based on land-surface conditions. The Yakutsk, Moshiri, and Seto sites all showed the same Ep range of 0.3 - 0.5 mm day-1. However, the A values differed significantly between the boreal (Yakutsk: 0.2 - 0.5) and temperate forests (Moshiri and Seto: 0.5 - 0.8). These results indicate that differences in land-surface processes lead to differences in evapotranspiration between boreal and temperate areas. The value of A is strongly affected by the soil water content, atmospheric water vapor deficit, and leaf area index (LAI).

Finally, the IAV of the water balance at the Yakutsk larch forest was analyzed for 7 years (1998 to 2006). More than 70% of the annual precipitation evaporated between May and September. Annual evapotranspiration, including interception loss, was relatively steady at 169-220 mm compared with the wide range in annual precipitation (111-347 mm year^{-1}). The evapotranspiration rate was 1.49-2.30 mm day^{-1}. This feature is one of the remarkable characteristics of the water balance in eastern Siberian forests where permafrost exists, as mentioned above. The thaw depth of the permafrost quickly deepened after 2004 such that the maximal thaw depth varied from 127 to over 200 cm during the study years. At the same time, the moisture content of the surface soil increased greatly. Inflow of meltwater produced by thawing at deeper layers may have contributed to the increase, which could not be explained by annual precipitation alone. Evapotranspiration showed only slight IAV, but yearly A ranged from 0.3 to 0.45. Among factors determining A, soil moisture content was the most important. This result differs somewhat from previous satellite-based findings pointing to air temperature as a major variable for plant activity. One explanation for this difference is that the IAV of the soil water content did not correspond to the IAV of the precipitation amount because of the presence of permafrost. In contrast, the soil water content was strongly affected by the precipitation of the previous summer.