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Energy controlling evapotranspiration from understory vegetation in an eastern Siberian boreal forest

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Introduction

Evapotranspiration (E) can be expressed by the Penman-Monteith (P-M) equation, and therefore is affected mainly by net radiation (Rn), vapor pressure deficit (VPD), aerodynamic conductance (Ga) and surface conductance (Gs). The P-M equation is rearranged by introducing the decoupling factor (Omg), equilibrium evaporation (Eeq) and imposed evaporation (Eimp) as E = OmgEeq + (1 - Omg)Eimp = (radiation term) + (aerodynamic term).

In central and eastern Siberia, some papers have shown that evapotranspiration from understory vegetation (Eu) occupied 30-50% of evapotranspiration from whole ecosystem (Eo) (Kelliher et al. 1997; Ohta et al., 2001). The driving energy for Eu has been investigated by comparing Eu and Rn, and VPD (e.g. Baldocchi and Meyers, 1991). However, there are quite few studies that use Omg, Eeq and Eimp to determine effective driving energy for Eu except for Black and Kelliher (1989). In this study, we tried to determine the primal energy to control Eu considering Omg, Eeq and Eimp.

Method

The observations took place at a larch (Larix cajanderi) forest located on the west bank of the middle reaches of the Lena River in eastern Siberia, approximately 20 km north of the city of Yakutsk. The site is situated in a continuous permafrost region and is referred to as the Spasskaya Pad experimental forest of the Institute for Biological Problems of the Cryolithozone, Russian Academy of Sciences (RAS). The dense cowberry (Vaccinium vitis-idaea) understory vegetation covered the ground completely. We applied the eddy covariance method above the forest canopy and forest floor and obtained Eo and Eu. Micrometeorological factors such as radiations, air temperature and humidity, were also observed above forest canopy and forest floor. Ga was calculated from eddy covariance data, and Gs was derived by the inverted P-M equation. In this study, data obtained during two growing seasons (from May to September) of 2005 and 2006 were analyzed.

Results and Discussion

The ratio of Eu to Eo during the growing season was 55% (2005) and 57% (2006), and the contribution of Eu was large. The aerodynamic term occupied about 80% of Eo and 70% of Eu; VPD is a primal driving energy for Eo and Eu in this site.

There were relatively large year-to-year differences in 10-days accumulated E for both whole ecosystem and understory vegetation. The year-to-year difference in E had negative relationship with that in Omg; this relationship means that increase in Omg, indicating larger contribution of Eeq to E, leads decrease in E. Year-to-year difference in E had no correlation with that in Eeq, but had clear positive relationship with that in Eimp. These results support that VPD is more important energy to control E than Rn.

In this site, Ga is significantly larger than Gs because of very sparse forest canopy of larch, and therefore Omg is small. This small Omg may be one of reasons to explain that the primal energy to control E is VPD rather than Rn. On the other hand, soil water conditions of 2005 and 2006 were rich. Since Gs can vary largely depending on the soil water condition, similar analysis will be needed for dry years to obtain more general conclusion.