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Water/Energy/CO2 exchanges on the twe larch forests in easten Siberia

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Evapotranspiration, energy flux and meteorological conditions has been measured in a larch forest near Yakutsk (YLF) at eastern Siberia from 1998 to understand the water-balance characteristics and its long term variation. Recently, environmental change such as increasing soil water and its influence on forest canopy was observed, and construction of a new insight to forest response is under way. On the other hand, observation at the other larch forest located at Elgeeii (ELF), in which some environment such as precipitation is different from YLF, was started to develop understanding in response of larch forest to environmental variability.

1. Water balance over 9 years

Annual evapotranspiration including interception loss was relatively steady at 169-220mm compared with the wide range in annual precipitation (111-347 mm) in YLF. This fact contradicts to world-wide (but not including permafrost region) observation result, in which the response of annual evapotranspiration to annual precipitation was remarkable at annual precipitation below 500 mm (Zhang et al. 2001).

A very large increase in the temperature and moisture content of the surface soil was observed since 2004, while there was no clear trend in meteorological condition such as air temperature and radiation. At the same time, the thawing depth of the permafrost has been rapidly deepening. The rapidly increase of soil water storage in 0-100cm depth, which cannot be explained only by precipitation, indicates input of melting water from the deeper layer.

2. Controlling factor on annual evapotranspiration

During the same period, the yearly evapotranspiration coefficient (the ratio of evapotranspiration to potential evaporation) ranged from 0.30 to 0.45, and this fact indicates that the interannual variation of evapotranspiration is controlled by regulation of the land surface rather than by atmospheric demand. Soil water content was the most important variable among the factors determining evapotranspiration coefficient at this time scale. Interannual variability of soil water content is found to be related to the summertime precipitation at previous year, which indicates that rain water precipitated during summer was stored in frozen soil till melting at the next summer.

3. Plant response to increasing soil water ? concept of elastic and plastic stress

Some forest around YLF has experienced withered dead of larch trees during 2007 and 2008. Following increase of the soil water since 2004 as mentioned above, evapotranspiration rates increased till 2006. They turned to drop in the summers of 2007 and 2008, although we found no significant change in atmospheric demand for evaporation and soil water content had maintained high values since 2005. During this period, no decrease of understorey evapotranspiration was observed. These tendencies imply that only the overstorey vegetation suffered severe damage due to the extremely high soil water content because, unlike the understorey, the overstorey cannot rapidly adapt to wet conditions. Based on these results, we will propose a conceptual model of ”elastic” and ”plastic” stresses for evaluating the tolerance and/or tipping point of vegetation to unexpected ambient conditions.

4. Regional characteristics in water and carbon cycle

A new flux station was constructed at Elgeeii (ELF) located at 300 km of southeast from Yakutsk in 2009. Although it was found no clear difference in meteorological condition and evapotranspiration at these two sites during the growing season (May to September), net absorption of carbon dioxide (net ecosystem exchange, NEE) was 1.8 times larger at ELF compared to YLF. Under high light condition, following increase of vapor pressure deficit, NEE at ELF increased while that at YLF was restrained. This result indicates possibility that dryness of the atmosphere does not necessarily restrain exchange process as reported in the several works of Siberian forest.

Keywords: water balance, energy balance, CO2 balance, plastic stress, elastic stress