Comparison of water and heat balance on grassland and forest in Central Yakutia, East Siberia.

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Abstract

Siberian region is an area dominated by taiga forest but the percentage of it is 70%, other being bare land, grassland and water bodies such as rivers and lakes. In order to better understand the water and energy cycle on this region, water and heat characteristics were compare the forest and grassland. The field observation was carried out from April to September 2000. The tower and mast were used 1-D scale flux observations of forest canopy and grassland, respectively. Both sites have separated as a distance about 2km. Air temperature and humidity were measured at 22m and 17m in forest site, and 2m and 0.5m in grassland site, respectively. We measured the downward and upward short-wave/long-wave radiation on top of tower and upward short-wave/long-wave radiation at grassland. Latent heat and sensible heat fluxes were obtained by the Bowen ratio method. And those flues were compared with between forest and grassland sites. At the grassland the sensible heat flux was smaller and latent heat flux larger than those at the forest site. PAI in forest and grassland were 3.5 and 3.2, respectively, this value of the grassland was smaller than that of the forest site. However, the area of trunk and branch at forest were big, LAI of the forest which contributes to the evapotranspiration was 2.0, this value was smaller than grassland. The difference of this LAI seems to appear the difference in the latent heat of the forest and the grassland.

Keywords: Siberia, alas, latent heat flux, forest, grassland.

1. Introduction

Siberian region is an area dominated by taiga forest but the percentage of it is 70%, other being bare land, grassland and water bodies such as rivers and lakes. These regions were underlain by permafrost. Especially, in right bank of the Lena River region, which is the opposite side of the Yakutsk City, there are many concave landforms called "alas". An alas is formed after the forest has been cleared by natural collapse and forest fire, cultivation in an area where the ice content of permafrost was high. The alas occupying up to 20% of this area. Most alas have lakes and marshes near the center, and the surround of lake is covered in the grassland. When we consider the water and heat circulation of this region, it is necessary to clarify water and heat characteristics of the forest and grassland. In this study, the water and heat flux observation was carried out in the forest and grassland area, and the water and heat balance characteristics was compared. Until now, the simultaneous measurement of sensible heat and latent heat fluxes in forest and grassland was little, where weather condition seemed to be almost similar.

2. Observation Site

Observation site in the right bank of the Lena River is called "Ulakhan Sykkhan"(62.15^{o}N, 130.51^{o}E), which is located at 50km north east part of the Yaktusk city, being on the middle reaches of the Lena river in a permafrost region (Fig1). This region is interminglement region of grassland called "alas" and Taiga forest. The observation was carried out in grassland and taiga forest. In forest site, we install observation tower in a flat larch forest. The stand density was 4200 tree ha-1. The mean basal diameter of tree was 7.6cm. The mean stand height was 7.6m. The maximum stand height was 17.3m. In grassland site, we installed observation mast in the center of alas. This alas has oval shape and 0.64km^2 area including a 0.1km^2 lake at the center. The tower and mast were used 1-D scale flux observations of forest canopy and grassland, respectively. Both sites have separated as a distance about 2km. The field observation was carried out from April to September 2000.

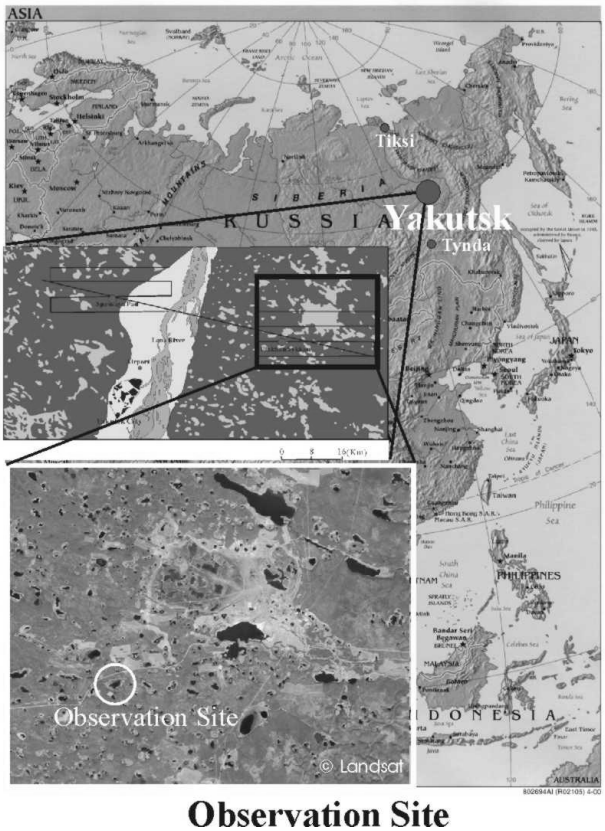

Fig.1 Location map and satellite image of Observation area

3. Observation

3.1 Forest Site

Figure 2. illustrates a schematic diagram of the

observation system installed in right bank forest station on Rena river. A temperature and moisture sensor has ventilation fan, which moves from the before two minutes of the measurement for the reducing power. Air temperature, relative humidity and wind speeds are measured at three levels. Accurate temperature measurement used thermocouple in respect of the temperature gradient. Short wave radiation, long wave radiation and photosynthetically active radiation (PAR) are measured above the canopy and on the forest floor with the upward and the downward radiations. The humidity and temperature data that measured after two minutes ventilation collected 10 minutes interval. The radiation carried out the measurement every 5-second, and it recorded the average for 10 minutes.

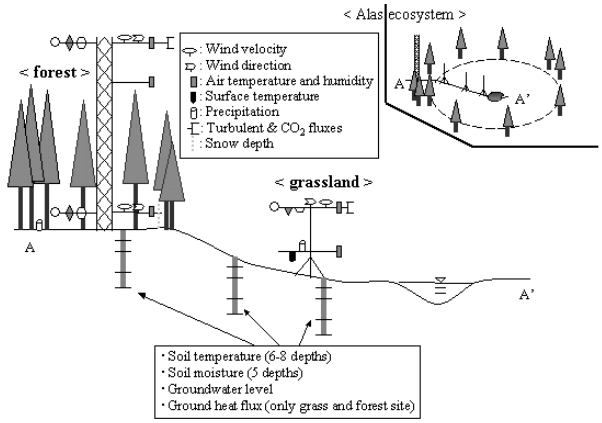

Fig2. Schematic map of alas observation

Picture1 .Forest conditon

Picture 2. Grassland conditon

3.2 Grassland site

The observation system of the center of grassland is composed of two parts. One is the radiation system, and others is Bowen ratio system. Radiation system measured upward short wave, long wave, photosynthetically active radiation (PAR) and net radiation. The eddy covariance system can be measured sensible and latent heat directly. The eddy covariance system consists of three sensors that measure the fluctuations in vertical wind speed, air temperature, and water vapor density. K style sensor is three-dimensional sonic anemometer / thermometer. K style sonic array has path length of 15cm. The KH-20 is an ultraviolet krypton hygrometer, which is similar in principle to the Lyman-alpha hygrometer, except that the source tube contains krypton gas. The KH-20 has a frequency response of 100 Hz. All devices will be operated by storage batteries power that is charged by the solar cell.

4. Result and discussion

4.1 Forest site

It was required sensible heat and latent heat by the Bowen ratio method in the forest site. The energy balance is estimated the Bowen ratio method. According to this method, sensible heat H, and latent heat lE, are presented as follows;

$$H = \frac{(Rn - G)}{(1 + (1/\beta))} \qquad (1)$$

$$lE = \frac{(Rn - G)}{(1 + \beta)} \qquad (2)$$

where Rn is net radiation, G is ground heat flux and β is the Bowen ratio. The Bowen ratio is defined by following equation.

$$\beta = \gamma \frac{(T_2 - T_1)}{(e_2 - e_1)} \qquad (3)$$

where γ is humidity coefficient, T_1, T_2 and e_1, e_2 were air temperatures and relative humidity at the heights with z_1 and z_2, respectively.

The equation of the following was used in order to obtain the daily mean flux.

$$\beta = \frac{\overline{H}}{\overline{lE}} = \gamma \frac{\overline{(T_2 - T_1)U}}{\overline{(e_2 - e_1)U}} \qquad (4)$$

where U is wind speed.

The seasonal variation of sensible and latent heat flux calculated by Bowen Ratio method shown in fig. 3. This figure showed also the seasonal variation of net radiation and ground heat flux and Bowen ratio and forest condition.

The forest is covered in the snow by 3 May, and the open and leaf is done from middle of May. The Bowen ratio decreased with arriving leaf and open leaf of the forest, and the latent heat increased.

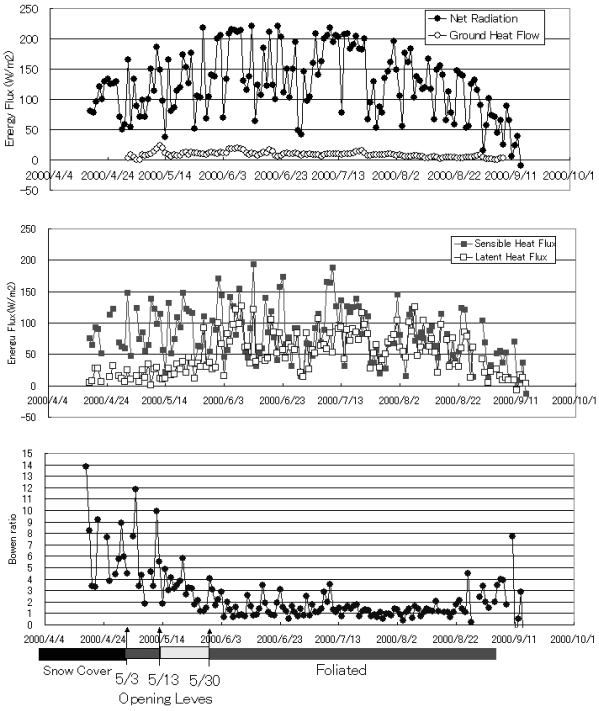

Fig.3 The seasonal variation of net radiation and ground heat flux, sensible and latent heat flux, Bowen ratio and forest condition

4.2 Grassland site

Though it would be to obtain the sensible and latent heat fluxes by Bowen ratio method in grassland site, the observation in the whole period was not possible in the trouble of the machine. And it used the result by the eddy correlation method. The heat balance required by the equal method is important in order to compare 2 sites.

The Bowen ratio was made using the ratio of sensible and latent heat required by the eddy correlation method. And sensible heat and latent heat were required using this Bowen ratio. The Bowen Ratio used by eddy correlation method compared with Bowen ratio calculated from air temperature and vapor pressure (Fig. 4). We had good relation, Sensible heat and latent heat of the grassland were required using the Bowen Ratio used by eddy correlation method. The seasonal variation of sensible and latent heat flux calculated by Bowen Ratio method shown in fig. 5. This figure showed also the seasonal variation of net radiation and ground heat flux and Bowen ratio and grassland condition.

The grassland is covered in the snow by end of April, and the grass began to grow in first of June. The grass land in this region was natural condition to end of July, The mowing was carried out in the end of July, since it is used as the feeds.

When the grass starts the growth, the latent heat increases. Bowen ratio in the summer is almost 0.1, and it is very small. In the grassland, Rn-G used as a latent heat.

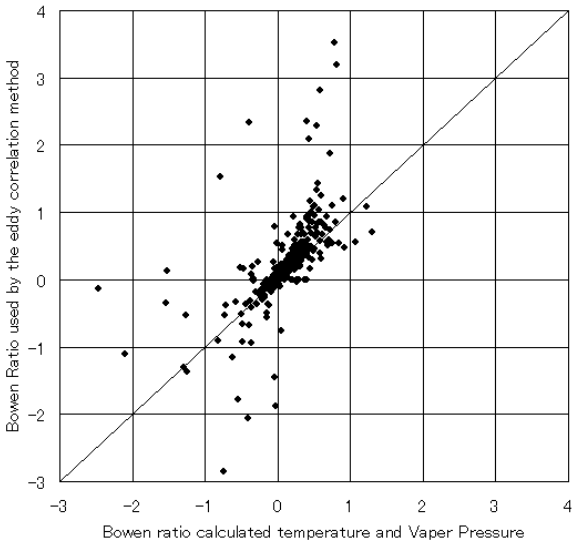

Fig 4. The relationship of Bowen ratio used by eddy correlation method compared with Bowen ratio calculated from air temperature and vapor pressure.

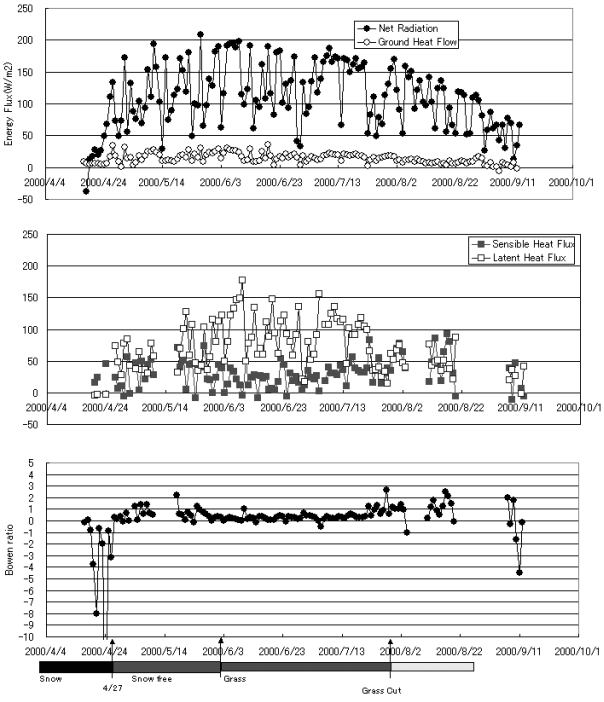

Fig 5. The seasonal variation of net radiation and ground heat flux, sensible and latent heat flux, Bowen ratio and grassland condition

The figures 6 shown the result of sensible and latent heat compare grassland and the forest. At the grassland the sensible heat flux was smaller and latent heat flux larger than those at the forest site. LAI of the grassland was shown in Table4. LAI of the grassland did the measurement in 2 sites. LAI of the grassland becomes 3.2 on 2 July. LAI of the forest of the measurement in the same time became 2.0.

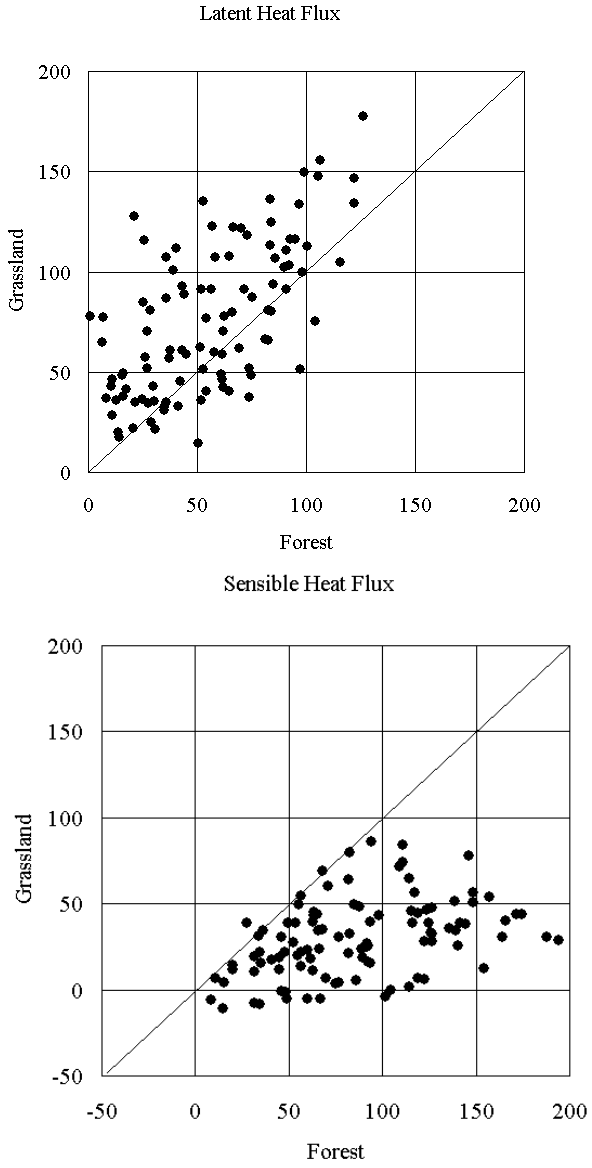

Fig 6. The comparison of latent and sensible heat flux with forest and grassland

Table 1. LAI of the grassland

LAI	Point 1	Point 2	Average
2000/5/26	0.5	0.8	0.7
2000/6/6	1.5	1.5	1.5
2000/6/16	2.9	2.9	2.9
2000/7/2	3.4	3.0	3.2

PAI in forest and grassland were 3.5 and 3.2, respectively, this value of the grassland was smaller than that of the forest site. However, the area of trunk and branch at forest were big, LAI of the forest which contributes to the evapotranspiration was 2.0, this value was smaller than grassland. The difference of this LAI seems to appear the difference in the latent heat of the forest and the grassland.

5. Conclusion

At the grassland the sensible heat flux was smaller and latent heat flux larger than those at the forest site. PAI in forest and grassland were 3.5 and 3.2, respectively, this value of the grassland was smaller than that of the forest site. However, the area of trunk and branch at forest were big, LAI of the forest which contributes to the evapotranspiration was 2.0, this value was smaller than grassland. The difference of this LAI seems to appear the difference in the latent heat of the forest and the grassland