Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

ACC03-P12 会場:コンベンションホール 時間:5 月 22 日 18:15-19:30

Energy and mass exchange in a larch forest on permafrost in Central Siberia, Russia

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Summary.

Daily, seasonal and annual dynamics of energy and mass (water and carbon dioxide) exchange between the atmosphere and larch ecosystem was analyzed from eddy covariance measurements obtained during growing seasons of 2004, 2005, 2007, 2008. Ecosystem was found to be a carbon sink of a different strength: -53, -60, -67 and -107 g C m^{-2} $season^{-1}$ at these years respectively.

Abstract

Systematic long-term annual eddy covariance measurements in mature *Larix gmeilini* (Rupr.) Rupr. stand in permafrost area of Central Siberia, Russia (64^{o}16'N, 100^{o}12'E) were initiated in 2004 by the Institute of Forest, Krasnoyarsk, Russia and FFPRI, Tsukuba, Japan. Energy, water and CO_2 fluxes were analyzed from eddy covariance measurements obtained during growing seasons (June?early September, approximately 90 days).

Eddy covariance tower was installed in study area. Various meteorological parameters were measured by corresponding meteorological instruments and carbon dioxide and water vapor concentrations were measured by infrared gas analyzers. The sensors were installed at a height of 20 meters. Data for all meteorological and CO_2 parameters were registered every 10 sec and averaged for 30 min. The fluxes were calculated as covariances of 30-min. high-frequency time series of vertical wind velocity with air temperature, H_20, or CO_2 atmospheric concentrations. Half-hourly values of each parameter were elaborated using criteria the eddy covariance method (Baldocchi et al. 1988, Foken and Wichura 1995, Baldochhi et al. 1996, Nakai et al. 2008).

Found that daily average air temperature and relative air humidity were 10-15^{o}C and 50-70% respectively. Under these conditions daily maximum half-hourly NEE reached 9-11 mcmol m^{-2} s^{-1} in 2007 and 2008 years and 5-6 mcmol m^{-2} s^{-1} in 2004 and 2005. It was observed in mid July and associated with maximum of precipitation in these months. Daily CO_2 flux dynamic has similar pattern for years we studied. Comparing to another ecosystems our data are close to *Larix cajanderi* Mayr in Central Yakutia (-7 mcmol m^{-2} s^{-1}, Schulze et al. 1999) and *Picea mariana* (P. Mill.) B.S.P. in North America (-9 -10 mcmol m^{-2} s^{-1}, Jarvis et al. 1997; Pattey et al. 1997). Established that flux dioxide rate has positive correlation with relative humidity (R=0,51) and negatively correlated with air temperature (R=-0,47).

Daily averages CO_2 assimilation in the beginning of growing season were 1 g C m^{-2} day^{-1}. At the end of June it increased up to 4 g C m^{-2} day^{-1}, in July ? up to 4,6 g C m^{-2} day^{-1} (with peak values reached 7,7 g C m^{-2} day^{-1}). August is characterized by decreasing of assimilation rate to 2,5 g C m^{-2} day^{-1}. Ecosystem daily average emission slightly increases from 0,8 g C m^{-2} day^{-1} at growing season beginning to 3-4 g C m^{-2} day^{-1} at its end. Carbon dioxide NEE decreases during growing season from 3 g C m^{-2} day^{-1} to 1,2 g C m^{-2} day^{-1}. In wet seasons (2007, 2008) daily averages values of assimilation and emission increases as much as 2-4 times when net exchange increases as much as 1.5-2.5 times only.

Thus, seasonal NEE in northern larch ecosystem on continuous permafrost varies from -53 to -107 g C m^{-2} $season^{-1}$ increasing according to the amount of precipitation.

The data obtained were compared with that of Scots pine ecosystem located on frostless area (Tchebakova 2006). Larch forest is characterized by CO_2 exchange maximal rate of 9-11 mcmol m^{-2} sec^{-1}, emission of 86,6 g C m^{-2}, assimilation of -159,1 g C m^{-2} and NEE of -72,5 g C m-$^{-2}$ versus that of Scots pine forest being equal to 10-12 mcmol m^{-2} sec^{-1}, 372 g C m^{-2}, -534 g C m^{-2} and -156 g C m^{-2} respectively.

The estimations of seasonal ecosystem carbon dioxide exchange obtained in Gmelin larch ecosystem appeared to be the lowest among both Siberian larch forests and boreal ecosystems worldwide.

キーワード: CO2 exchange, permafrost, Siberia, larch ecosystem, eddy covariance
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