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Energy and water exchange in various ecosystems in central Siberia (from eddy covariance measurements)

Nadja Tchebakova (1), Almuth Arneth (2), Luca Belelli (3), Chiara Corradi (3), Julia Kurbatova (4), Elena Parfenova (1), Natalia Vygodskaya (5), Ernst-Detlef Schulze (6), and Riccardo Valentini (3)

(1) V.N. Sukachev Institute of Forest, Russian Academy of Sciences, Krasnoyarsk, Russian Federation (ncheby@ksc.krasn.ru), (2) Lund University, Lund, Sweden , (3) University of Tuscia, Viterbo, Italy, (4) A.N. Sevetsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russian Federation, (5) , Jan Kochanowski University, Kielce, Poland, (6) Planck Institute for Biogeochemistry, Jena, Germany

Our goals were to evaluate and compare energy and water fluxes in various ecosystems (a tundra patch, a pine forest, a bog, a steppe patch) along the 90o E meridian in central Siberia from eddy covariance measurements during the EuroSiberian arbon Flux project (1998-2000) and TCOS-Siberia project (2002-2004).

Components of the energy balance for the growing season (May-September) in a pine forest and a Sphagnum bog located as close as 500 m to each other differed due to the type of underlying surface. The average daily Bowen ratio was always below 1.0 in the Sphagnum bog. The transparent pine forest with its large gaps in forest cover resulted in a higher Bowen ratio 2-3 on average up to 8-10 in warm days in early spring. In steppe, the Bowen ratio was on average higher than 1.0; in tundra it was less than 1.0 and only on warm summer days could exceed 1.0. The proportion of latent and sensible heat in the energy balance of steppe and tundra depends correspondingly on available moisture and heat. The comparison between the energy balance components in Siberian ecosystems based on our eddy covariance measurements and earlier gradient measurements derived from literature showed that they are comparable except in two cases. In the tussock tundra with unlimited water for evaporation, the monthly Bowen ratio is less than 1.0, but in the dry stony tundra it was significantly greater than 1.0. The seasonal water balance of these ecosystems was evaluated as the difference between rain and evaporation. Water evaporation from the bog was equal to precipitation during 1998-2000. In the pine forest, the seasonal water balance overall was positive although it could be negative in some summer months. In steppe, the water balance was negative in spring because evaporation of water accumulated during the winter exceeded April precipitation. In tundra, the water balance was significantly negative during July-September because with evaporation was more than double rainfall amounts. Water available for evaporation was not limited by rain and came in addition from thawing permafrost and flooding in the Kolyma flood-plain. Relative evaporation, showing the proportion of actual evaporation to potential evaporation, was 0.3-0.4 in summer and 0.2-0.25 in spring in the pine forest. In Siberia, relative evaporation did not exceed 0.5 even in the bog possibly because of a mulching effect of surface peat drying for a growing season and thus decreasing the evaporating surface. For comparison, relative evaporation in European deciduous and mixed forests reached 1.0 because of the larger leaf area index and soil moisture in Europe than in Siberia. In Siberia, the climate at the end of the twenty-first century is predicted from GCMs to be much warmer and dryer in terms of a greater difference between potential and actual evaporation. Thus, the energy balance would be partitioned in favor of sensible flux that would exceed latent flux resulting in an increasing Bowen ratio. These conditions would not favor some plants and especially trees to grow. To survive unfavorable conditions, plants of a given vegetation type would first drop production and then would die out and be replaced by a more drought resistant vegetation type. So, climate warming would initiate such effects as vegetation shifts; change of forest structure and functions; a shorter snow cover period etc. which feedback each other and all together would change surface albedo. Albedo change would in turn affect surface energy balance resulting in both positive and negative feedbacks to the climate system accelerating/slowing down climate warming.