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Characteristics of Heat and Water Budget of Arctic Permafrost Sites: Dominant Processes and Observed Changes

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Permafrost plays a significant role in the land surface energy and moisture balance, and thus in the climate and hydrologic system. The goal of our group is to establish spatial and temporal linkages between water and energy fluxes at the plot and landscape scales at different permafrost affected ecosystems.

We chose typical Arctic ecosystems spanning contrasting bioclimatic zones with different climate and landcover conditions: (i) warm, maritime conditions with low above ground biomass (Spitsbergen) and (ii) cold, continental conditions with medium biomass (Lena River Delta, Siberia) and (iii) medium to cold continental conditions with high biomass (upper Lena-Viluiy catchment). At these sites, weather stations have been operated for at least 10 years.

Spitsbergen has a mild, maritime winter climate due to the influence of the Atlantic currents and is underlain by warm permafrost (mean annual ground temp. (MAGT): -2.9 °C; mean annual air temp. (MAAT): -6.3°C). Warming is observed in permafrost temperatures, due to recently warmer winter air temperature and an increase of snow depth.

The island Samoylov located in the Lena River Delta is characterized by wetland polygonal tundra, thermokarst lakes and cold permafrost (MAGT: -9.2 °C, MAAT: -13.6°C). Latent heat fluxes, such as sublimation of snow during spring and evapotranspiration during the summer are important components of the energy balance. Overall, the water balance is more or less equilibrated, i.e. the precipitation (rain and snow) input equals loss through evapotranspiration. Only during years of extreme dryness, where summer evapotranspiration exceeds precipitation, the pond water level falls below the ground surface.

The study site in Central Yakutia shows a 30 yr warming trend with an increase of about 0.1 °C/year. Summer and winter precipitation shows a large spatial and temporal variability, with an increase at most stations. The analysis of satellite images using Landsat and Soyus data shows distinct changes in the land surface cover between 1976 and 2002. During this period, the aerial coverage of lake bodies increased by about 100 % which is due to the infilling of previous dry/drier thermokarst basins. From 2002 to 2009, an increase of only 2% is observed.