Séminaire

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Modeling the dynamics of lakes and ponds in lowland permafrost landscapes

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Arctic landscapes are highly sensitive to climate warming and permafrost degradation induces a large variety of landscape and ecosystem changes whose impact on the global climate system are only partially understood. Especially regions with high ground ice and high organic carbon content such lowland tundra landscapes are prone to thawing permafrost. These tundra landscapes are usually characterized by numerous lakes and ponds which play a key role in the heat, water, and carbon cycle of these ecosystems. Some permafrost landscapes show a decreasing total water surface area while growing lakes and an increasing number of waterbodies are often reported for lowland tundra landscapes. Waterbodies have a marked effect on the thermal state of the underlying and surrounding permafrost. They strongly modify the surface energy balance as well as the effective heat transport and storage which can lead to self-induced thermal erosion and accelerated lake growth. A large fraction of the total water surface in lowland tundra landscapes currently consists of small and shallow waterbodies which usually completely freeze during winter so that permafrost is preserved underneath. However, changes in water depth and surface heat fluxes might lead to a rapid transition into permafrost degrading systems. In addition, small waterbodies receive increased attention since recent studies demonstrate that ponds can strongly contribute to the CO2 and CH4 emissions of tundra ecosystems.

Predictions on future permafrost degradation are usually based on simplistic heat transfer models which do not take into account sporadic and non-linear processes such as thermal erosion and lake formation. Nevertheless, these features might strongly accelerate the overall permafrost degradation. In order to gain a better understanding of lake-permafrost interactions a coupled lake-permafrost model is developed and used for extensive sensitivity studies. In addition, we make use of a large dataset of temperature profile, surface energy, and water balance measurements from lakes and ponds in northern Siberia to ensure model validity. The overarching aim of this project is to provide new insights into non-linear dynamics of permafrost landscapes under changing climate conditions in the Arctic.