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Spatial variability of river thermal imprint on permafrost through combined in situ measurements and 2D hydro-thermal modeling – A case study in Central Yakutia

Eric Pohl (1), Christophe Grenier (1), Antoine Séjourné (2), Albane Saintenoy (2), Alexander Fedorov (3), and Pavel Konstantinov (3)

(1) LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, Gif-sur-Yvette, France (eric.pohl@lsce.ipsl.fr), (2) GEOPS/IPSL, Geosciences Paris Sud, Université Paris-Saclay, Orsay, France, (3) Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Sciences

A key aspect of global warming in permafrost regions is the associated transport of heat into the ground and its impacts onto permafrost properties, especially in the presence of ground ice. Melting of ground ice in excess induces the formation of thermokarst lakes and their connecting rivers, which, in return, increases the complexity of such natural systems. Such processes primarily affect active layer depth evolution and heat transport into the ground through the presence of water affecting heat transport. Knowledge about these processes is crucial to assess impacts and feedback mechanisms involved in global warming, in particular with respect to carbon transfer. While lakes and related heat transport into the ground have recently gained a lot of attention, the role of river systems and their intricate hydrological characteristics is hardly addressed. However, such river systems play a significant role in the redistribution of heat and water and associated mass transport processes. They also provide a great opportunity to specifically investigate how meteorological variability and resulting river flow, and changes in landscape morphology affect heat transport into the ground and how the river influences the thermal state of a valley. To address these issues, a study site in form of a river valley between two thermokarst lakes was initiated in Central Yakutia in 2012. Measurements include thermal and hydraulic state variables, active layer depths, various soil properties, and were recently complemented by ground penetrating radar and electrical resistivity measurements. We used these data to first calibrate and validate a 2D hydro-thermal model of the soil. In a second step, we investigated how changes in river width, either through variability in meteorological forcing, or in river valley morphology affect the evolution of active layer depths and heat transport into permafrost. The results highlight an intensive spatial variability along the course of the river that could not be assessed by the spatially limited in situ measurements alone.