Geophysical Research Abstracts
Vol. 13, EGU2011-550-1, 2011
EGU General Assembly 2011

Development of a Thermokarst Lake Model for the Canadian RCM to study coupled interactions (Thermokarst Lake-Permafrost-Climate) in the Arctic

Alex Matveev (1), Laxmi Sushama (1), Rene Laprise (1), Hugo Beltrami (2), and Andrey Martynov (1)

(1) Centre pour l'étude et la simulation du climat à l'échelle régionale (ESCER), Departement des Sciences de la Terre et de l'atmosphere, Universite du Quebec a Montreal, Montreal, Quebec, Canada (matveev@sca.uqam.ca), (2) Environmental Sciences Research Centre (ESRC), Department of Earth Sciences St. Francis Xavier University, Antigonish, Nova Scotia, Canada.

Thermokarst (thaw) lakes (TKLs) form as a result of thermal subsidence within ice-rich perennially frozen soils and further deepen and expand by continuous subsidence as well as wind, wave and thermal erosion along their shores. Thaw lakes, being a common and widespread feature of the Arctic environment, form an integral part of arctic and subarctic climate systems (e.g. [Chapin et al.(2000)]). Providing that presence of TKLs lowers land surface albedo and increases its heat conductance and heat capacity, we expect that addition of TKLs in climate models will significantly alter the simulated local surface fluxes and, thus, local climate, especially in the regions with large lake area fraction. Yet, thaw lakes have been generally omitted from simulations with coupled models of high-resolution capable of delineating such small-scale individual permafrost features and/or of allocating a sub-grid fraction for them.

In order to assess the impact of TKLs on the regional climate and to study feedbacks between the TKLs and climate we develop a new TKL model for integration in the latest version of the Canadian Regional Climate Model, version 5 (CRCM5) [Zadra et al.(2008)]. We modify a relatively simple one-dimensional eddy-diffusion lake model in order to include core processes inherent to the observed TKLs (including lake geometry, dynamic water level, bathymetry, heat transfer and phase change). In addition, we extend our lake model downwards, in order to include the dynamics inherent to the soil fraction beneath TKLs. That fraction has a particular importance in the arctic and subarctic permafrost environment, where lakes deeper than annual freezing depth usually support bulbs of unfrozen ground at their bottom (taliks) which introduce a significant disturbance to the ambient permafrost thermal regime. In order to account for this disturbance, we explicitly solve the diffusive vertical heat transfer equation within the talik, and also develop a transfer function adjusting the horizontal heat flows between the lake column and the adjacent permafrost at each model layer depth (within the coupled scheme).

This paper will present results from off-line simulations with our new Thermokarst Lake Model and its validation. The validation of the model has been made possible by the multiyear survey of 46 ponds in the arctic continuous and subarctic discontinuous permafrost regions carried out in the Bylot Island, Nunavut (73N, 79W) and Nunavik, Quebec (55N, 77W) regions respectively [Breton et al.(2009)].

Upon implementation of the model in the CRCM5 we will perform the series of sensitivity experiments including interactive thermokarst lakes, in order to address the magnitude and sensitivity to perturbation of the TKL-Permafrost-Climate system and the involved timescales.

[Breton et al.(2009)] Breton, J., Vallieres, C., and Laurion, I.: Limnological properties of permafrost thaw ponds in northeastern Canada, Canadian Journal of Fisheries and Aquatic Sciences, 66, 1635–1648, URL http://dx.doi.org/10.1139/f09-108, 2009.

[Chapin et al.(2000)] Chapin, F.S., Mcguire, A.D., Randerson, J., Pielke, R., Baldocchi, D., Hobbie, S.E., Roulet, N., Eugster, W., Kasischke, E., Rastetter, E. B., Zimov, S. A., and Running, S. W.: Arctic and boreal ecosystems of western North America as components of the climate system, Global Change Biology, 6, 211–223, URL http://dx.doi.org/10.1046/j.1365-2486.2000.06022.x, 2000.

[Zadra et al.(2008)] Zadra, A., Caya, D., Côté, J., Dugas, B., Jones, C., Laprise, R., Winger, K., and Caron, L.-P.: The Next Regional Climate Model, Physics in Canada, 64, 75–83, 2008.