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The Cryosphere Discussions

Interactive comment on "Spatial analyses of thermokarst lakes and basins in Yedoma landscapes of the Lena Delta" *by* A. Morgenstern et al.

Anonymous Referee #1

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I greatly enjoyed reading this article describing thermokarst lakes and basins of the Lena Delta region of Northern Yakutia of Siberia. This is a fascinating area to study post-glacial landscape-scale degradation of permafrost and thermokarst processes. The authors conducted a comprehensive analysis using geospatial techniques applied to Landsat imagery to calculate lakes and basin shape metrics, with statistical analysis comparing morphological characteristics of lakes and basins of the third Lena Delta terrace and subgroups. The study was supplemented by a more intensive and comprehensive terrain analysis of the smaller key area of Kurungnakh Island using a high-resolution DEM (5-m horizontal resolution) and bathymetric data from several lakes.

The data sources were appropriate for the stated objectives, although the ∼6m vertical accuracy of the ALOS PRISM DEM seemed rather large for this low-relief terrain. Data processing and the analytical methods used were appropriate and clearly explained, the writing was concise, and the overall presentation is well organized. Although I am not familiar with the Russian-language literature, the references cited are appropriate.

The authors derive several substantial conclusions. First, they clearly demonstrate the importance of stratigraphic (cryolithological) control on thaw susceptibility. At Kurungnakh Island, an ice-poor sand unit of fluvial origin underlies thick (30m) Yedoma deposit with excess ground ice. The contact is at 17m asl. The younger Ice Complex has experienced thermokarst since the early Holocene, and large thermokarst lakes developed at the surface where low slopes promoted water detention and ponding. In time, as the lakes grew in size and the talik penetrated the ice-rich sediments, the lakes deepened. However, once the talik reached the ice-poor lower unit, further ground subsidence was halted. This is evidenced by the concordance of basin and lake bed elevations at ∼17m in Figure 11; about 70% of the lakes and basins on Kurungnakh Island have subsided to the base of the Ice Complex. The authors present a useful conceptual model (Figure 13) that describes lake, basin and landscape evolution.

Unlike large areas of Arctic North America, thermokarst lakes are not extremely abundant and cover only ∼5% of the study area. By contrast, total basin area exceeds lake area by about a factor of four. From this and other evidence, the authors conclude that lakes in the past were much larger owing to the uniformly flat terrain lacking integrated surface drainage.

Although thermokarst development on the Ice Complex is ongoing, there have been changes to the landscape that affect future rates of degradation. As basins coalesced and streams developed in this dynamic deltaic environment, the local relief increased. Thermo-erosion channels have developed on basin slopes that enhance drainage of the thaw-susceptible uplands. Over the Holocene, the extension and integration of the stream drainage system, combined with thermal degradation of the landscape,

has reduced the overall potential for ponding across the region; it is largely limited to higher elevations with slopes < 2°. Currently, only about 1/3 of Kurungnakh Island is vulnerable to future thermokarst and associated mobilization of old soil organic carbon.

The authors have presented a compelling case for thermokarst evolution over time and space. Some of the observational data could not be definitively explained (e.g., inconsistencies in lake and basin orientation, the consistent displacement of pingos and residual/secondary lakes to the north or south of the basin center), and warrant further research. This manuscript is so professionally prepared that I have only a few very minor suggestions:

Use of the term “Island” to describe the Yedoma uplands is somewhat misleading and should be clearly noted early in the paper.

Figures 1b, 4 and 10 are busy, with labels and boundaries somewhat difficult to discriminate.

Interactive comment on The Cryosphere Discuss., 5, 1495, 2011.