Reply to comments

Baseline characteristics of climate, permafrost, and land cover from a new permafrost observatory in the Lena River Delta, Siberia (1998–2011)

by J. Boike et al.

L.D. Hinzman (Referee)

lhinzman@iarc.uaf.edu

Received and published: 12 November 2012

I believe this is a useful paper that will be cited often by scientists who conduct research at this station, but I don't think it is a really important paper, which is a shame, because it could be. The authors state several times that the purpose is just to provide a summary of the conditions at this site and to provide information for others to make comparisons. I find no problems with the presentation of that information, but I don't think this paper will be valued by readers who are not specifically interested in conducting research at that site. This paper could much more. One of the main questions most readers would ask is "Why Samoylov Island?" Why is this site important? Does this site actually represent northern Siberia? Is it so dominated by the marine influence that it does not represent continental Siberia? Or is it uniquely situated such that it can be considered as model for both the Laptev Sea and northern Siberia? I also wonder about the consequences of a site on a delta? Does it just represent a delta site? Does the deposition of so much sediment make this site uniquely different from the highly organic soils of non-fluvial plain sites? I hope my questions do not imply that I question the value of a site at Samoylov Island; I just think this paper could be of more value if it went beyond simple numeric comparisons of temperatures or rainfall and addressed the more important question of representativeness. What does this site represent and why is that important? At present, the paper does accomplish what the authors intended, but it could do so much more if they attempted to go beyond a simple iteration of measurements into an analysis of what they mean.

We thank Larry Hinzman for his valuable comments.

Section **6.2 Climate and permafrost** gives an overview of the climate (air temperature, precipitation, net radiation) and the thermal state of the permafrost in relation to other Arctic sites. Furthermore, we use the Köppen-Geiger classification (climate classes based on vegetation groups and defined in terms of rules applied to variables derived from long-term mean monthly temperatures and precipitation measurements) to obtain a qualitative assessment of the circum-Arctic representativeness of this site. Under the Köppen-Geiger climate classification system Samoylov is classified as polar tundra and is thus representative of the climate found around the northern margins of the North American and Eurasian land masses, and on nearby islands (page 13648). It therefore does not represent a major climatic zone; in fact the "polar E" climate zones (of which the tundra is a part) only represents 3.8 % of Asia and 11% of North America (Peel et al., 2007). The most dominant climate type by far in terms of areal coverage is the "cold D" zone, which represents 43.8 % of Asia and 54.5% of North America.

Well-expressed low-centered polygonal tundra covers only a small part of the Arctic landmass. Estimates range from 3 % (Minke et al., 2007) to 7.9 % (Walker et al., 2005).

While the location of this research site was originally chosen because of the existing infrastructure and logistical feasibility, rather than following strict spatial guidelines, the unique value of the site has subsequently become evident. Clearly the small areal coverage of this ecosystem makes it representative of a small, pristine ecosystem that is likely to face marked changes in the future due to environmental change.
Hoffmann et al. (Representativeness-Based Sampling Network Design for the Arctic, *Landscape Ecology*, in review) used multivariate spatial clustering to define current and future ecoregions for Alaska. For the North Slope of Alaska, which is analogous to the (polygonal tundra) wetlands of Samoylov Island and lies within the Köppen-Geiger "polar E" climate zone, a significant reduction to near extinction of this ecozone (reduction to about 0.78 % of its present area) is predicted by the end of the century. Such a modern computer based clustering algorithm, including assessments of climate change, would also be useful in representative analysis studies for Siberia.

As well as offering a pristine ecosystem, the site is unique because of its location within the largest river delta in the Arctic, between the Eurasian continent and the Arctic Ocean. The Lena River transports vast quantities of water and riverine material, and its catchment area is almost completely underlain by permafrost. Future changes over this huge catchment area may be detectable at its outlet into the Arctic Ocean.

On a much smaller scale, this site provides a key laboratory in which to study hydrologic, geochemical, and flux processes within the polygonal tundra. For example, the importance of small water bodies (Small ponds with major impact", Abnizova et al., 2012) with respect to water, energy, and carbon balances can provide useful analogies and guidance in the study of similar processes in other ecosystems.

In summary therefore, we are convinced that our paper will be of major importance to a broad research community.

We have made the following alterations and additions to the paper:

Section **6.1**
The polygonal tundra on Samoylov Island lies within ice-rich permafrost terrain that is characterized by ubiquitous water bodies. Similar wetland landscapes cover about 3-8 % of the Arctic landmass, mostly located in the Arctic coastal plains of Alaska, the Canadian Mackenzie delta, and the low-lying wetlands of Northern Siberia (Mackay, 1972, 2002; Washburn, 1979; Gersper et al., 1980; Ping et al., 2004; Tarnocai and Zoltai, 1988; Naumov, 2004; Minke et al., 2007; Webber, 1978; Webber and Walker, 1975; Webber et al., 1980, Walker et al., 2005).

Section **6.2**
According to the Köppen-Geiger classification, this polar tundra climate is representative of the climate found around the northern edges of the North American and Eurasian land masses, and on nearby islands (Peel et al., 2007). Using this classification, the "polar E" climate zone only represents 3.8 % of Asia and 11% of North America (Peel et al., 2007).

Section **7 Summary and conclusions**
Added to the end of this section:
Because of its small areal coverage (around the margins of the North American and Eurasian land masses), this ecosystem faces potential extinction in a future changing climate. Located between the Arctic Ocean and the Siberian Continent, it also serves as a "sentinel" for changes within the Lena River catchment area. Finally, this site provides a unique opportunity for the study of small scale processes that are important for large-scale predictions (for example, small ponds have a large impact on the CO_2 *balance, Abnizova et al. 2012).*

There are a few other minor issues that I think may make the paper more reader friendly. I would suggest adding a figure of the soil profile(s) that indicate soil properties and characteristics. Perhaps they could make one plot that shows the temperature max and min range and then for various depth ranges, label thermal conductivity, carbon content, heat capacity, etc: : : Also, I think some of the tables are a bit much for the article. I am not certain if Biogeosciences allows appendices, as some on-line journals now do, but if so, I would suggest moving detailed tables like 4, 5 and 6 to an appendix and just present the essential information in the text.

Following this suggestion, we have moved tables 4, 5 and 6 to the Appendix and they are now relabeled as Appendix A1, A2 and A3, respectively. Since the article is already rather long, we would prefer not to include an additional figure. The cited literature includes photos of typical soil profiles on Samoylov Island:

Sanders, T., Fiencke, C., and Pfeiffer, E.-M.: Small-scale variability of dissolved inorganic nitrogen (DIN), C/N ratios and ammonia oxidizing capacities in various permafrost affected soils of Samoylov Island, Lena River Delta, Northeast Siberia, Polarforschung, 80, 23–35, 2010.
Zubrzycki, S., Kutzbach, L., and Pfeiffer, E.-M.: Böden in Permafrostgebieten der Arktis als Kohlenstoffsenke und Kohlenstoffquelle (Soils in arctic permafrost regions as carbon sink and source), Polarforschung, 81, 33–46, 2012a.

I think there are a few more meaningful comparisons that could be made: : : with respect to water balance, it would be good to consider these:
Killingtveit, Å., Pettersson, L.E. and K. Sand, 1994: Water balance studies at Spitbergen. In: Sand, K. and Å. Killingtveit (Eds.), 1994: Proceedings of the Tenth International Northern Research basins Symposium and Workshop, Spitsbergen, Norway, August 28 – September 3, 1994. pp. 77-94.
Kane, D. L., and D. Yang. 2004. Overview for Water Balance Determinations for High Latitude Watersheds. Int. Assoc. of Hydrological Sciences Publication 290. pp. 1-12.
Mendez, J., L.D. Hinzman, D.L. Kane. 1998. Evapotranspiration from a wetland complex on the arctic coastal plain of Alaska. Nordic Hydrology. 29(4/5):303-330.

The article by Killingtveit et al. (1994) only includes data from glaciered catchments on Spitsbergen, which is why we did not include it in our comparisons. There are, in general, few published water balance studies available for low gradient polygonal landscapes (with pronounced microtopography and underlain by permafrost) that also include lateral runoff measurements. The overview article by Kane et al. (2004) summarizes basin watershed characteristics between 44°N and 80°N for a broad range of areas, permafrost coverage, topography, and surface characteristics. Our site supports the analysis by Kane et al. (2004), whose data set indicated decreasing precipitation and evapotranspiration with increasing latitude. With regards to the evapotranspiration ratio (average annual evapotranspiration/average annual precipitation), the ratio of 0.8 at Samoylov Island plots at a higher latitude on the latitude versus ratio diagram.
Using the criteria from our study site (continuous permafrost, low gradient topography, location within “polar tundra E” climate zone, non-glaciered, average annual precipitation and evapotranspiration) our site is comparable to the Putuligayuk River catchment area (471 km^2) located on the Alaskan North Slope, with similar climate characteristics (Köppen Geiger classification, summer evapotranspiration exceeds rainfall) and surfaces (wetland with ponds and lakes). The average summer rainfall- runoff ratio for the Putuligayuk River watershed was 0.36 for 1999-2007, with a range from 0.1 to 0.64 (Kane et al. 2008). For the summer period between July 25 and August 20, 2008, the rainfall- runoff ratio for Samoyloy

Island was determined to be around 0.1, which is at the lower end of the values given by Kane et al. (2008).

We have added the following text:

6.3 Hydrosphere: thermal characteristics of ponds and thermokarst lakes, and their water budgets
The summer water balance on the catchment scale was found to be mainly controlled by vertical fluxes (precipitation and evapotranspiration). On the other hand, pronounced redistribution of storage water due to lateral fluxes takes place within the microtopography of polygonal tundra (Liljedahl et al., 2012; Helbig et al., 2013). Averaged daily summer evaporation rates of 1.3 mm day^{-1} are comparable to those for other sites in the Arctic. Evaporation rates are 1 mm day^{-1} at Ny-Alesund, Spitsbergen (Lloyd et al., 2001), 1.3 mm day^{-1} in the Kevo area in northern Finland (Harding et al., 2002), 1.4 mm day^{-1} in the Zackenberg valley, Greenland (Soegaard et al., 2001), and 1.5 mm day^{-1} in Happy Valley, Alaska (Vourlitis and Oechel, 1999). Higher evaporation rates of 2.3 mm day^{-1} were reported by Mendez et al. (1998) at Prudhoe Bay, Alaska. There are, in general, few published water balance studies available for low gradient polygonal landscapes (with pronounced microtopography and underlain by permafrost) that also include lateral runoff measurements. A site with similar characteristics (Köppen Geiger climate classification, summer evapotranspiration exceeds rainfall) and similar surfaces (wetland with ponds and lakes) for which water balance data are available is the Putuligayuk River watershed, located on the North Slope of Alaska, although it covers a much larger area (471 km^2). The average summer runoff ratio for this site from 1999-2007 is 0.36, with a range from 0.1 to 0.64 (Kane et al. 2008). For the island of Samoylov the runoff ratio for July 25 to August 20, 2008, was determined to be around 0.1, and thus at the lower end the values given by Kane et al. (2008).

Other concerns: : :
Page 13631, line 28: : : What about Tiksi? Is that not considered the delta? Probably still worth mentioning there are several stations relatively near.

Tiksi is located on the continent, not within the delta. While air temperatures are similar, the precipitation shows distinct differences due to its proximity to the Laptev Sea and a location that is surrounded by mountains. Tiksi generally has much higher precipitation than Samoylov, in both winter and summer.

There are no weather stations currently operating within the delta (as stated on page 13631 in our paper). The only other nearby station, which is not yet automated and is currently maintained by the Hydrometeorolgical Centre of Russia, is Stolb, from which forecast data are provided (http://wmc.meteoinfo.ru/weather/russia/republic-saha-yakutia/stolb).

We have added the following in section 2:

The closest weather station (about 110 km east from Samoylov, located on the continent) is Tiksi where data are collected as part of the Regional Basic Synoptic Network (World Meteorological Organization: www.wmo.in. While air temperatures are similar compared to Samoylov, the precipitation shows distinct differences due to its proximity to the Laptev Sea and a location that is surrounded by mountains.

Page 13631, line 14: : : You say "in summer" but obviously more true in winter

The word "summer" has now been omitted.

Page 13633, line 28: : : You say “polygon rims”, but this is true for the whole network.

The term “polygonal rims” has now been replaced by “polygonal network”.

Finally, there are some minor mistakes, which I suspect the editor will catch, but I’ll point them out for completeness: : :
Page 13638, line 10: : : The word “under” is confusing.
Page 13643, line 28: : : Pond should be capitalized
Page 13652, line 16: : : obvious problem

These have now all been rectified.

Additional literature that was added in the revised paper:

Helbig, M., Boike, J., Langer, M., Schreiber, P., Runkle, B. R. K., Kutzbach, L. 2013. Spatial and seasonal variability of polygonal tundra water balance, Lena River Delta, northern Siberia. Hydrogeology Journal, DOI 10.1007/s10040-012-0933-4 (published online).

Kane, D.L, Gieck, R., Boudreau, L. 2008. Water balance for a low gradient watershed in northern Alaska. In: Kane, D.L., Hinkel, K.M. (eds) Proceedings of the Ninth International Conference on Permafrost, University of Alaska, Institute of Northern Engineering, Fairbanks, AK, 883–888.

Liljedahl, A.K, Hinzman, L.D, Schulla, J. 2012). Ice-wedge polygon type controls low-gradient watershed scale hydrology. In: Hinkel, K.M (ed) Proceedings of the Tenth International Conference on Permafrost, vol 1: International contributions. The Northern Publisher, Salehard, Russia, 231–236.

Mendez, J., Hinzman, L.D., Kane, D.L. 1998. Evapotranspiration from a wetland complex on the arctic coastal plain of Alaska. Nordic Hydrology. 29(4/5):303-330.

Walker, D., Raynolds, M., Daniels, F., Einarsson, E., Elvebakk, A. and co-authors. 2005. The circumpolar Arctic vegetation map. J. Veg. Sci. 16(3), 267-282.