Comments to Anonymous Referee #1 of "Permafrost-Affected Soils of the Russian Arctic and their Carbon Pools"

by S. Zubrzycki et al.

Referee #1, comments:

After reading through the manuscript, my first impression is the authors are more focused on discussing permafrost-affected soils and carbon pools of the Circumpolar North than just Russia.

The referee is right stating that our focus lies on discussing soils and their carbon pools of the Circumpolar North. This is of course of high importance to rank results while discussing the results from Russia. However, our goal was to gather as much as possible information from the area of Russia on the one hand. On the other hand we provide only some selected references from other areas (Canada, Alaska) for comparison.

Following this commentary we have modified the title to make it more precise: Permafrost-Affected Soils and their Carbon Pools with a Focus on the Russian Arctic

The authors have done an extensive literature search and review. If the focus is about permafrost-affected soils in Russia, I would like to see the information on the total area of permafrost in Russia, or the % of permafrost of the Russian land surface.

We thank the referee for this helpful comment to improve the manuscript. In the revised version of our manuscript, we will provide the requested and important information on the permafrost extent across Russian Federation. In addition, to illustrate its extent we will provide this information in the newly plotted soil map (Fig. 1).

On page 621, this sentence will be added: About 60 % of the Russian land surface is underlain by permafrost (Kudryavtsev et al., 1978; Brown et al., 1998; Kotlyakov V. and T. Khromova, 2002) (Fig. 1).

Granted, in the Russian soil classification system, Cryozem only include those permafrost-affected soils with cryoturbation, as the authors pointed out that some permafrost-affected soils lack of cryoturbation but exhibit hydromorphism, podolization, brunification, eluviations-illuviation, etc. processes are classified in Gleysols Podzols, Luvisols, Cambisols etc. (WRB). I believe that the Russian system also keys organic soils (Histosols) before

Cryozem. Thus a map showing the zonation of permafrost-affected soils in Russia would help the audience to understand the distribution of permafrost-affected soils in Russia. Such zonation map can also be used as guide to discuss the general properties and carbon distribution and stores in different soil groups. Can we find such information from the database of the Circumpolar North Soils Map and the Circumpolar North Carbon Map?

The referee is right suggesting a map showing the spatial distribution of permafrost-affected soils in Russia as well as suggesting an extension of the general discussion of soils affected by permafrost within the Russian soils classification.

In the revised version of the manuscript, we will extend the paragraph describing the Russian soil classification on page 622 and provide a map to illustrate the extent of Cryozems (Fig 1). Since the Cryozems have a really limited spatial extent, for a meaningful discussion there is a need to extend the consideration to soil types that are affected by permafrost. Assuming that soils underlain by (continuous) permafrost (see the permafrost extent line in Figure 1) can be counted to permafrost-affected soils (as Cryosols in the WRB), there are several soil types typical for those areas (Fig. 1). For details, please refer to the revised text paragraph shown below.

We will include this sentence on page 625, line 22: These carbon pools derived from small scale field work seem to be lower than the estimated carbon pools stored in the NCSCD (compare Fig. 2).

The revised version of the paragraph is:

In the morphogenetic Russian soil classification systems, permafrost is considered as being only a parameter of a soil thermal regime and not a diagnostic horizon or diagnostic property. Therefore, only permafrost-affected soils with cryoturbated soil profiles, widespread only in the far north of Russian Federation, are treated as Cryozems in a separate soil class (Fig. 1). This soil class covers about 1 % of the Russian land surface (Stolbovoi et al., 2002), whereas around 60 % of the land surface is underlain by permafrost (Kudryavtsev et al., 1978, Brown et al., 1998, Kotlyakov & Khromova, 2002). All other soils of these areas without this characteristic are allocated to other soil classes with the additional mentioning of the subjacent permafrost (such as Gleyzem with underlying permafrost (Shishov et al., 2004)). Within the permafrost-underlain areas, several soil classes can be detected in the different

vegetation zones of the Russian Federation. The polar desert is characterized by Cryozems and “Shallow weakly developed” soils (Leptosols). In the tundra zone, Gleyzems (Gleysols) dominate, followed by Al-Fe-Humic soils (Podzols). In the transition area to the taiga zone the two soil types of the tundra zone and organic rich Peat soils (Histosols) dominate. The taiga zone is dominated by Al-Fe-Humic soils, Metamorphic soils (Cambisols) and “Texture-differentiated” soils (Albeluvisols) (Fig. 1).

In the introduction part the authors summarized the distribution of permafrost and permafrost-affected soils in the world. They missed China, where the Qinghai-Tibet Plateau has the third largest area of permafrost, next to Russia and Canada.

We thank the referee this important comment. In the revised version of our manuscript we will add China with its extensive permafrost areas to the introduction.

The sentence will be as follows:

In wide areas of the high latitudes of Northern Europe, Greenland, Canada, Alaska, China and Russia, a particular group of soils has developed during the Quaternary whose diversity is based primarily on special cryopedogenetic processes within the pedosphere of the Earth system.

New references:

Brown, J., O. J. Ferrians, Jr., J. A. Heginbottom & E. S. Melnikov (1998): Circum-arctic map of permafrost and ground ice conditions. Boulder, CO: National Snow and Ice Data Center, Digital media, 1998, revised February 2001.

Kotlyakov V. and T. Khromova. In Stolbovoi V. and I. McCallum, eds. Land Resources of Russia. Laxenburg, Austria: International Institute for Applied Systems Analysis and the Russian Academy of Science. CD-ROM. Distributed by the National Snow and Ice Data Center, Boulder. 2002.

Kudryavtsev, V. A., Dostovalov, B. N., Romanovsky, N. N., K. A. Kondrat'yeva and Melamed, V. G.. Geocryology (in Russian). Moscow University Press. 464 pp. 1978.

Stolbovoi V. 2002. In Stolbovoi V. and I. McCallum, eds. Land Resources of Russia. Laxenburg, Austria: International Institute for Applied Systems Analysis and the Russian Academy of Science. CD-ROM. Distributed by the National Snow and Ice Data Center, Boulder. 2002.

Stolbovoi V., G. Fischer, V., S. Ovechkin and S. Rozhkova (Kravets), 1998. The IIASA-LUC Project Georeferenced Database of the Former U.S.S.R. 2002. In Stolbovoi V. and I. McCallum, eds. Land Resources of Russia. Laxenburg, Austria: International Institute for Applied Systems Analysis and the Russian Academy of Science. CD-ROM. Distributed by the National Snow and Ice Data Center, Boulder. 2002.

Stolbovoi V. V., I. Savin and B. Sheremet. In Stolbovoi V. and I. McCallum, eds. Land Resources of Russia. Laxenburg, Austria: International Institute for Applied Systems Analysis and the Russian Academy of Science. CD-ROM. Distributed by the National Snow and Ice Data Center, Boulder. 2002.

New figures:

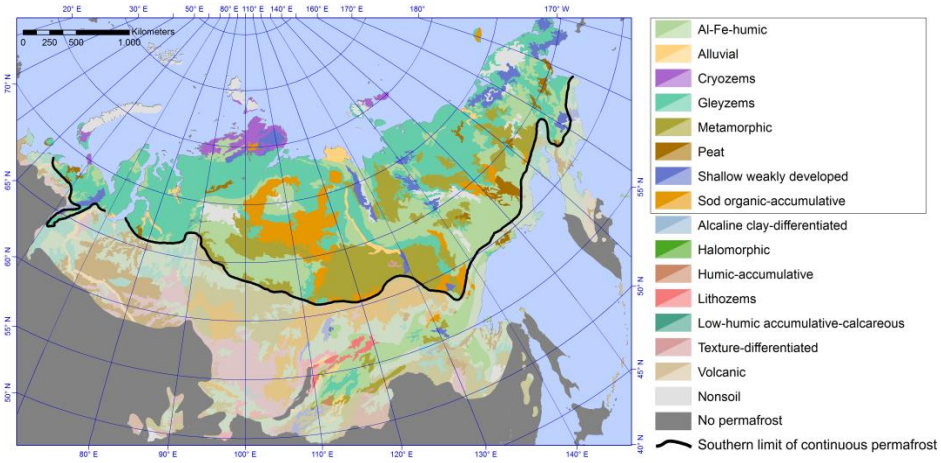

Fig. 1. Distribution of soils types across permafrost-affected parts of the Russian Federation. Soils developing within the area of continuous permafrost can certainly be assumed as permafrost-affected soils (dominating soil types in the grey box). Soils in the area of discontinuous, sporadic and isolated permafrost plotted in pastel colours (south of the black limit line of continuous permafrost) are likely to be assumed as permafrost-affected soils. Based on: Stolbovoi et al., 2002 and Brown et al., 1998.

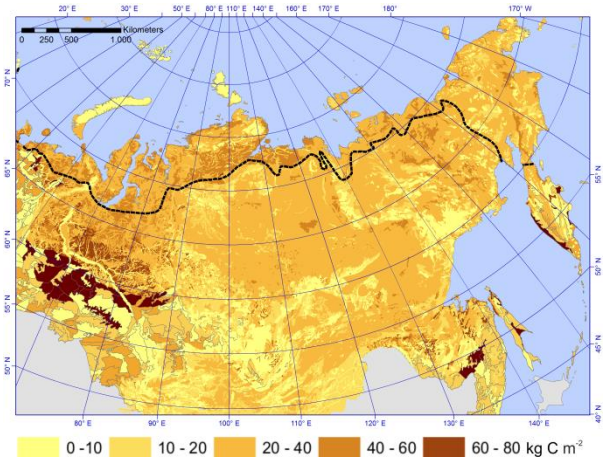

Fig. 2. Spatial distribution of the soil organic carbon contents in Russian Federation. The dashed line illustrates the tree limit. Based on: Hugelius et al., 2013a; Stolbovoi, 2002 and Brown et al., 1998.