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Interactive comment on "River flooding as a driver of polygon dynamics: modern vegetation data and a millennial peat record from the Anabar River lowlands (Arctic Siberia)" *by* R. Zibulski et al.

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Anonymous Referee #2 Received and published 01. May 2013

We thank reviewer #2 for the valuable comments which have contributed to the improvement of the article.

Reviewer comment: General comments: However, my main concern with this study is the overall suitability of the presented sediment cores for palaeoenvironmental investigation. The sedimentation process in the polygon might have been disturbed by at least two processes. Firstly, it is severe river ïňĆooding events (the evidence of which is discussed by the authors); secondly, it is the ice, which certainly touches the sedi-

ment surface in winter and therefore disturbs it. In addition, there is a high possibility that thermokarst processes have also affected sediment formation. The 14C dates are clearly not accurate, so there is no conïňĄdence at all that the process of sediment formation in this shallow pond has been undisturbed. The authors need to be able to prove ïňĄrst that the sediment stratigraphy is reliable before proceeding with the discussion of the results. I do not think that the manuscript may be published before the sediment sequences'suitability as palaeoenvironmental archive is reliably proved.

Our response: We have added new text in sub-section 5.4 (first paragraph) explaining why we are confident that the original stratigraphy has been preserved in the sediment cores and hence why the sediments can be used to interpret the environmental history, as follows:

Previous studies have shown that sediment cores from the thawed layer of polygons in arctic landscapes provide usefully archives for palaeoenvironmental studies (Ellis and Rochefort, 2004; De Klerk et al., 2011).

And pointed it out in the section 2-Geographic setting (second paragraph) for the location: The study area is underlain by 500 to 600 m of permafrost (Yershov et al., 1991). Temperature increases at the beginning of the Holocene initiated thermokarst processes that led to permafrost degradation and widespread subsidence (Czudek and Demek, 1970). The study area is characterized by meander terraces, polygon mires and in a wider surrounding thermokarst lakes and alas depressions. The uppermost parts of the soils are wet and organic-rich, and are classified as Histic Fluvisols (Jones et al., 2010).

We also believe that the presented sediment core is suitable for such palaeoenvironmental studies for the following reasons: (a) Well defined layers could be observed in both cores B and C, characterized by a specific fossil composition, grain-size, or elemental composition, suggesting that the stratigraphy within the cores had not been disturbed by the reworking of sediments (e.g., due to freezing/thawing, thermokarst, or

fluvial influences). (b) A strong correlation was observed between the layering in cores B and C, providing additional evidence that the spatial pattern had been preserved. (c) Our investigations revealed that fossils within these cores had been preserved in a very good condition (e.g., with no broken diatoms and with fragile moss fossils still identifiable). The geographical position of the investigated polygon within an abandoned meander on the river's floodplain and the fact that most of the movements in ice-wedge polygons occur on their rims (Mackay, 2000), may have combined to preserve the polygon's history within the sedimentary record in the polygon centre.

Reviewer comment: Generally, it is well established that 14C dating is not entirely suitable within the last 500-1000 years. Since humans started burning coal, the older carbon became incorporated in the younger sediment layers that has obviously lead to the occurrence of older dates in younger sediments; that phenomenon was also clearly shown in this study. It is therefore advisable to apply other dating techniques, for instance, 210Pb analysis, to date recent sediment sequences. I strongly suggest that the authors attempt to date the upper part of their sequence using 210Pb. There are also several minor comments, please see below and the attached copy of the manuscript.

Our response: We agree with the reviewer that the use of AMS 14C dating for the last 1000 years is complicated due to occurrence of various CO2 plateaus. However, previous investigations on polygons (Ellis and Rochefort, 2004; De Klerk et al., 2011) have yielded reliable chronologies using this method. We consider the use of 210Pb dating not to be appropriate for our core due to the very low sedimentation rate (as indicated not only by the 14C results but also by other comparable polygon records) relative to the sample resolution. Finally, our interpretation of the sediment record and conclusions concerning the drivers of polygonal change are not dependent on an age-depth model. We have therefore presented what is, to our knowledge, the most reliable age-depth model but have also critically discussed this in the text.

We have pointed out in Section 5.2 (Age-depth relationships) the problems with 14C

dating, as follows: The range of radiocarbon dating results is very narrow over the whole of Core C, except for those samples with a fluvial influence. Various explanations have been previously proposed for such narrow radiocarbon dating ranges: Kilian et al. (1995) suggested reservoir effects in bulk sediments as a possible explanation, whereas Price et al. (1997) found that mosses growing under wet conditions contain a proportion of recycled CO2 from older sediment layers. Our own field observations suggest that the submerged moss Scorpidium scorpioides can reach a length of several tens of centimetres down to the sediment in water-filled polygon centres. Thus some of the dated material was probably older than the layer in which it was collected, as the whole length of the moss may have been subsequently covered by sediment.

Furthermore, contamination with carbon-rich Tertiary deposits is thought to be highly unlikely since the area surrounding our site is entirely covered with Quaternary sediments. The dated samples were also pretreated with HCl and KOH before being submitted for radiocarbon analysis. We therefore believe that the possibility of contamination with carbon-rich Tertiary deposits can reasonably be excluded. The low population density in the Anabarsky district ($\sim$0.02 /km2; Federal State Statistics Service Russia, 2009) is also unlikely to result in any significant effects from burning coal on the 14C dating.

Specific comments: Reviewer comment: Page 4069, lines 6-9: "Since these polygons have an important role in the arctic carbon cycle (Hobbie et al., 2002); although the mires of the arctic tundra only cover about 3 % of the arctic land area, they contain more than 15 % of the world's soil carbon (Post et al., 1982)." Awkward phrase, needs re-writing

Our response: We accept the reviewer's comment and have changed the paragraph as follows: Although these mires only cover about 3 % of the arctic land area, they contain more than 15 % of the world's soil carbon (Post et al., 1982); hence they play an important role in the arctic carbon cycle (Hobbie et al., 2002).

Reviewer comment: Page 4069, lines 25-27: “Especially in the Lena River Delta (Samoylov Island) which is also located in an area of river inïňĆuence form and sediment characteristics have been investigated (Boike et al., 2012; Fiedler et al., 2004).” Awkward phrase, needs re-writing

Our response: We accept the reviewer’s comment and have changed the paragraph as follows: Investigations into the shape and sediment characteristics of river-influenced polygons in northern Russia have mainly been carried out in the Lena River Delta (Boike et al., 2013; Fiedler et al., 2004).

Reviewer comment: Page 4070, line 1: “In the last decade studies with a special focus on the carbon content (Zubrzycki et al., 2013) and the net ecosystem CO2 exchange have been done, e.g. in low-centred polygons on Samoylov Island (Runkle et al., 2013). replace with ’conducted”’

Our response: We accept the reviewer’s comment and have changed the paragraph as follows: During the last decade studies have been conducted with a special focus on the carbon content (Zubrzycki et al., submitted), and on the net ecosystem CO2 exchange, for example in low-centred polygons on Samoylov Island (Runkle et al., 2013).

Reviewer comment: Page 4072, line 10. Reference is required to Braun-Blanquet classes and ïňĆoristic approach

Our response: As explained in our response to Reviewer #1, we have now added the following:

[...] according to the Braun-Blanquet ïňĆoristic approach (Braun-Blanquet, 1964) [...]

Reviewer comment: Page 4072, line 11: “The materials were transported to the Alfred Wegener Institute in Potsdam, Germany and stored at 4°C. replace the highlighted word with ’samples”

Our response: We accept the reviewer’s comment and have changed the sentence

as follows (adding the word soil): The soil samples were transported to the Alfred Wegener Institute in Potsdam, Germany, and stored at 4°C.

References Ellis, C. J. and Rochefort, L.: Century-scale development of polygon-patterned tundra wetland, Bylot Island (73 N, 80 W), Ecology, 85(4), 963–978, 2004. Isaev, A. P., Protopopov, A. V., Protopopova, V. V., Egorova, A. A., Timofeyev, P. A., Nikolaev, A. N., Shurduk, I. F., Lytkina, L. P., Ermakov, N. B., Nikitina, N. V., Efimova, A. P., Zakharova, V. I., Cherosov, M. M., Nikolin, E. G., Sosina, N. K., Troeva, E. I., Gogoleva, P. A., Kuznetsova, L. V., Pestryakov, B. N., Mironova, S. I. and Sleptsova, N. P.: Vegetation of Yakutia: Elements of Ecology and Plant Sociology, in The Far North, vol. 3, edited by E. I. Troeva, A. P. Isaev, M. M. Cherosov, and N. S. Karpov, pp. 143–260, Springer Netherlands, Dordrecht., 2010. Kilian, M. R., Van der Plicht, J. and Van Geel, B.: Dating raised bogs: new aspects of AMS 14C wiggle matching, a reservoir effect and climatic change, Quat. Sci. Rev., 14(10), 959–966, 1995. De Klerk, P., Donner, N., Karpov, N. S., Minke, M. and Joosten, H.: Short-term dynamics of a low-centred ice-wedge polygon near Chokurdakh (NE Yakutia, NE Siberia) and climate change during the last ca 1250 years, Quat. Sci. Rev., 30(21–22), 3013–3031, doi:10.1016/j.quascirev.2011.06.016, 2011. Mackay, J. R.: Thermally induced movements in ice-wedge polygons, western arctic coast: a long-term study, Géographie Phys. Quat., 54(1), 41, doi:10.7202/004846ar, 2000. Matveev, I.A. (ed.): Agricultural Atlas of the Republic Sakha (Yakutia), Nauka, Moscow., 1989. Price, G. D., McKenzie, J. E., Pilcher, J. R. and Hoper, S. T.: Carbon-isotope variation in Sphagnum from hummock-hollow complexes: implications for Holocene climate reconstruction, The Holocene, 7(2), 229–233, doi:10.1177/095968369700700211, 1997.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/10/C2560/2013/bgd-10-C2560-2013-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 10, 4067, 2013.