The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-179-AC1, 2020

The Cryosphere Discussions

Interactive comment on "The cryostratigraphy of the Yedoma cliff of Sobo-Sise Island (Lena Delta) reveals permafrost dynamics in the Central Laptev Sea coastal region during the last about 52 ka" *by* Sebastian Wetterich et al.

Sebastian Wetterich et al.

sebastian.wetterich@awi.de

Received and published: 22 September 2020

Author's response to the interactive comment on "The cryostratigraphy of the Yedoma cliff of Sobo-Sise Island (Lena Delta) reveals permafrost dynamics in the Central Laptev Sea coastal region during the last about 52 ka" by Sebastian Wetterich et al. Anonymous Referee #1, https://doi.org/10.5194/tc-2020-179-RC1 Received and published: 25 August 2020

Wetterich et al. present a comprehensive physical and geochemical characterisation

of a Yedoma exposure on Sobo-Sise Island in the Lena Delta. Yedoma sections across the Siberian Arctic provide a unique window to look back on the Middle and Late Pleistocene and reconstruct environmental and climatic conditions based on a range of proxy indicators. This study complements previous studies of Yedoma exposures from the same region, but notably this study examines the Sobo-Sise section in very high stratigraphic/temporal detail compared to studies of other exposures. The authors discuss a number of sedimentological, cryological, isotopic and geochemical indicators to understand the environmental conditions associated with the formation of this deposit during Marine Isotope Stages 3, 2 and 1. Robust end-member mixing models are used to identify different sediment sources, and stable water isotopes of pore ice and wedge ice are used to understand the potential value of these different ice types as proxies for local climate and ice systematics. Largely I agree with the analysis and interpretations. The authors also identified chronological gaps in the record that are missing in other Yedoma sections from other sites, which provides clear evidence of a major change in regional environmental conditions that drive Yedoma accumulation. They speculate that two of these gaps may be related to major glacial-lake discharge events due to modified local drainage systems such that available source material of Yedoma accumulation was effectively impacted. It is an interesting, but still unproven point and the authors are careful to not over-interpret this. The paper itself is well written and clear. The methods and study design are scientifically sound. Overall I was impressed with the quality (and quantity) of results and discussion in this paper. In my view, this paper is well-suited for publication in the Cryosphere.

REPLY – Thank you for your time and effort to review our manuscript. We appreciate your overall positive feedback on our study.

I only have some minor points that should be addressed prior to acceptance, as follows:

REPLY – Your minor points have been carefully addressed as outlined below. We further proofread the entire ms and corrected typos in the text. We updated Figures 8 and 10 showing grain-size distributions and endmember modelling results to make

both graphical representations more easily comparable. In Figure 10, we changed the colour code of rEMs; now corresponding with that of Figure 5.

Figure 8: Grain-size distribution curves for (a) Holocene unit C, (b) MIS 2 unit B and (c) MIS 3 unit A of the Sobo-Sise Yedoma cliff. Bold lines indicate the mean value and grey shaded areas indicate the 25% to 75% quartile.

Figure 10: Grain-size distribution curves and end-member modelling (EMMA) of both Yedoma IC units A and B from the Sobo-Sise Yedoma cliff. EMMA revealed four robust endmembers (rEMs), rEM1 has its primary mode at 5.91 μm in the fine silt, rEM2 has its primary mode at 31.1 μm in the coarse silt. The rEMs 3 and 4 have their primary modes in the fine sand (76 μm) and middle sand (310 μm) respectively.

L141 – if available, please indicate somewhere what the elevation of river level is in m.a.s.l.

REPLY – Changed accordingly by adding the following statement in section 3.1 “Height measures in m arl correspond to those above sea level (m asl), given the proximity of Sobo-Sise Island at the Sardakhskaya Channel in the eastern part of the Lena Delta to the Laptev Sea (Fig. 1 b).”

L207 – “...not fully...’ it is not clear what is meant here. Please clarify this part.

REPLY – We specified the sentence as follows: “We considered only a full profile of one wedge cut and sampled perpendicular to its lateral growth direction and neglected the remaining samples of the second ice wedge, not completely captured due to its oblique exposition.”

L225 – “ballpark” please avoid this colloquialism.

REPLY – Changed accordingly to “approximate age”.

L411 – ’Unit’, in reference to specific units, is a proper noun and should be capitalized.

REPLY – Changed accordingly throughout the manuscript.

L456 – suggest using ‘relict permafrost’ instead of fossil permafrost

REPLY – Changed accordingly.

L477 – This difference would be enhanced if differences in paleo-seawater were explicitly corrected for since mean ocean water during MIS 2 was enriched in heavy isotopologues compared to MIS 3

REPLY – Indeed the difference between MIS 3 and MIS 2 isotopic signatures would be increased when considering the paleo-ocean water enrichment in heavy isotopologues during MIS 2 due to the storage of isotopically light water in ice sheets. We, however did not decide to apply this source-water correction because our wedge-ice stable isotope records from Sobo-Sise are not suitable for quantitative paleo-temperature reconstruction due to the low temporal resolution of the record based on 14C dates and the yet not satisfying relation between wedge-ice stable isotope composition and winter temperature (Porter & Opel, 2020). Reference: Porter, T. J., and Opel, T.: Recent advances in paleoclimatological studies of Arctic wedge and pore ice stable water isotope records. Permafrost and Periglac., 31, 429– 441, https://doi.org/10.1002/ppp.2052, 2020.

L506 – this is confusing since ’exceed’ typically means values are ’more positive than’. Please use other words to clarify what is meant.

REPLY – Sentence changed accordingly to “In some instances, Holocene δ18O and δD values reach the range of the late Pleistocene ice wedges (Table 2).”

L511 – please clarify what is meant. No need to describe the process in detail, but it should be clear what you are talking about. Currently it is not clear.

REPLY – We removed the unclear statement on possible isotopic diffusion within wedge ice over time that is beyond the scope of our study. Deleted sentences: “It is obvious that the horizontal profiles of late Pleistocene ice wedges are less spiky than those of Holocene ice wedges (Fig. 7). This might indicate a time-dependent smoothing of the isotope profiles due to isotopic diffusion within ice wedges but is beyond the

scope of this study.“

L529 – especially when paleo-seawater is considered, the difference is even less significant.

REPLY – Agreed. See our reply to your comment on L477.

L535-537 – following this sentence. “As such...” [please finish this thought]

REPLY – To clarify the statement, we changed the order of sentences as follows: “This might indicate that the globally cold LGM is not reflected in the Sobo-Sise ice wedge-based winter climate record and would be in accordance with both regional scale, when compared to Bykovsky Peninsula (Meyer et al., 2002a) or to other study sites in the Laptev Sea region (Wetterich et al., 2011), and also on Arctic-wide scale (Porter and Opel, 2020). In this context, we observe (1) a depositional gap temporally coinciding to peak LGM conditions for the three sites at regional scale and (2) extremely depleted LGM ice-wedge isotopes have been only found at Bol’shoy Lyakhovsky Island further east (Fig. 1; Wetterich, et al., 2011). As such it is not sufficiently resolved yet, whether this is due to a less cold LGM climate in the region or whether the LGM cold period is not captured by the studied ice-wedge profiles that do not preserve a continuous record.”

L625-626 – perhaps you can go one step further to discount direct erosion on the basis that such an event would likely remove tens of meters of sediment, and you are only missingâĹij3.5 m given the mean accumulation rate.

REPLY – Agreed. We added the following statement to the sentence: “But except for the chronology gaps no direct erosional features such as fluvial sand or pebble layers have been observed in the outcrops. Thus, direct erosion seems unlikely at the studied locations and the flooding events may here have only changed the hydrological regime (e.g. by developing new discharge paths similar to the channels in the today’s Lena Delta) for a certain time period and by doing so prevented the deposition of fluvially

transported material in the areas of the studied Yedoma IC outcrops.”

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-179, 2020.

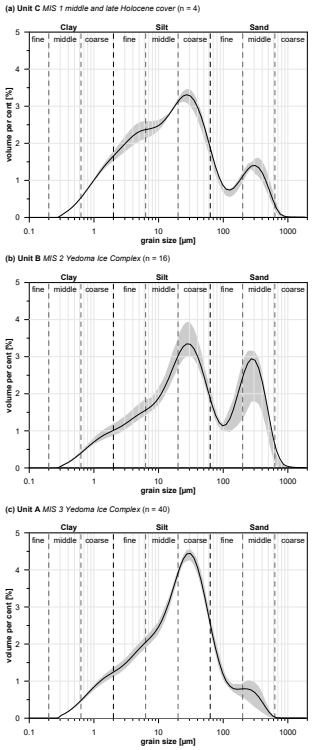

Fig. 1. Updated Figure 8

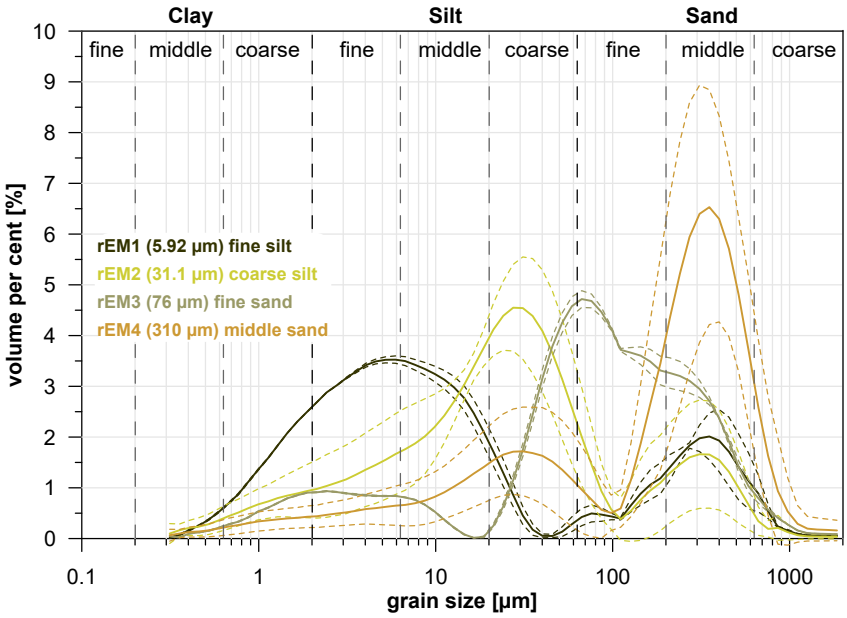

Fig. 2. Updated Figure 10