Dear authors,

Thanks for the detailed comments to the three reviews of your paper.

All three reviewers have provided constructive comments, as well as major questions and concerns with regards to your results and conclusions. Please find my summary of the most important points, as well as additional editorial comments below.

If you can provide sufficient clarification on these points, please provide a point to point reply, as well as a revised version of your paper (tracked change modus). Your reply and revised version will potentially be reviewed again.

Many thanks,

Julia

Text in *italics and blue* refers to the reply of the authors to the reviewers‘ comments or the original paper.

1. **Additional radiation sources, such as bedrock or dust layers**

The request by reviewer 1 was to give more thought to the calculation of dose rate and the meaning of the optical age for basal sediment including additional radiation sources from (1) bedrock or subglacial sediment and (2) from dust layers in the core.

Based on results from Greenland ice core (Willerslev et al., 2017) and dust layers from a different ice core (on the Chongce ice cap), you come to the conclusion that the dose rate contribution from the underlying bedrock and dust layers are negligible.

Authors reply: Yes we fully agree that the dose rate is determined by many factors, including the potentially two additional sources of radiation as indicated above…… the moment, assume that its contribution to the dose rate was insignificant.

Editor comment: Please also provide further information on your sampled core and the dose rate methods:

- If bedrock is incorporated in the basal glacier, these bedrock fractions might still influence the sample to some extend; please discuss this with respect to your glacier site and sampling depth.
- Information on dust layers from your core; if these are located close to sampled material

(in “normal” sediment 30 cm, in ice more), then this contributes to the dose rate and needs to be measured or considered.

- The process of embedding grains in ice is important. The radiation sources (radionuclides) may be separated from quartz/feldspar grains by ice increasing the distance between radiation source and dosimeter and, hence, reducing the dose rate by an extent that cannot be covered by measuring gamma-spec dry/unfrozen material.
- How are the high ice content/layers/lenses accounted for (varying densities)?
- It is not clear why “dehydrated” dose rates and respective ages are calculated considering that the material is an ice core (see also point 3).
- Please provide further clarification on the dose rate modeling using attenuation due to water and whether this can be transferred to the effect of ice, and how this dose rate measurement is representative of the natural condition within the ice core. Assuming water instead of ice for corrections of the dose rate efficiency may induce errors. The effective dose rate could also be (largely) overestimated and ages could be older (see also point 3).

2. Sources of the dated material (glacial erosion and eolian mixture) and relationship to age of ice cap

This concern is raised by all reviewers and you do not provide any further details in your response.

Reviewer 1: The authors suggest that the sand-sized quartz grains are sourced from subglacial erosion. If true, it seems likely that some of the silt-sized quartz is also derived from subglacial erosion. Thus, it is conceivable that the dated aliquots are a mixture of eolian quartz and subglacially derived quartz.

Author’s reply: This suggests that even some of the silt-sized quartz is also derived from subglacial erosion, its portion might be very small. Thus the dated aliquots are mostly an eolian origin.

Editor comment: This explanation is weak, because no big distance is needed to produce silt sized grains, it also could happen in just a freeze-thaw-cycle. It is thus important to investigate their equivalent dose distributions. If silt is only or predominantly from eolian transport, one distinct, normally distributed population can be expected. Grains from grinding material below the glacier was not bleached before getting into the basal glacier part and hence would form an different population.
Please provide further clarification.

Reviewer 1: If the ice flow at the core site is dominated by downward vertical motion, then the OSL age of the eolian component of the dated aliquots would represent the time for the ice to move from the surface to the bed, not the age of the ice cap itself.

Author's reply: Yes we agree with the comment, and this will be clarified in the revision.

Editor comment: The ice cap may have existed at this place over a longer period of time and OSL ages give only a sort of transition/travel time of ice portions/sediment particles from top/incorporation to the bottom layer. As a result, a minimum age estimate can be given, but the age of the ice cap could be much older. Please provide further details.

Reviewer 1 and 3: If the ice flow at the core site is dominated by downward vertical motion, then the OSL age of the eolian component of the dated aliquots would represent the time for the ice to move from the surface to the bed, not the age of the ice cap itself.

Editor comment: In your reply to reviewer 3 you confirm that that the 4 -11 µm fine quartz grains used for the dating are mostly of eolian origin. The OSL age of the eolian component would represent the time for the ice to move from the surface to the bed, which is younger than the ice cap.

Author's reply: The OSL dating results of the coarse grain (90-150µm) quartz are shown below. Water content is assigned an absolute uncertainty of ±7%. The slightly older ages of the coarse grains in comparison to the fine grain quartz may imply that the former were more affected by the local scoured particles that were partly bleached. Another disadvantage for the coarse grain aliquots is that their medium and slow components accounts for a significant part of the natural OSL signal.

Sample	U (ppm)		Th (ppm)		K (%)		Water content	Dₑ	Dose rate	Age
	Gamma[1]	NAA	Gamma	NAA	Gamma	NAA	(%)	(Gy)	(Gy/ka)	(ka)
CCICE	3.66±0.15	3.45±0.12	11.21±0.42	11.40±0.32	3.52±0.10	3.48±0.08	0	238±51	5.25±0.45	45 ±11
CCICE	3.66±0.15	3.45±0.12	11.21±0.42	11.40±0.32	3.52±0.10	3.48±0.08	30	238±51	3.85±0.24	62 ±14

Editor comment: (1) Are those assumed to be eolian, too? Or what is the assumed incorporation process and, hence, bleaching? After reading the above comments, I would have expected that only the fine grained fraction can represent eolian sediments and, hence, no basal material, and consequently the coarse grained fraction should be much older. If the coarse grains have different properties (i.e. medium and slow components) then they are likely derived from a different source. (2) Table above: how can the water content be 0% in this type of sediment?

Author's reply: Yes the 4 -11 µm fine quartz grains used for the dating are mostly an eolian origin. The OSL age of the eolian component would represent the time for the ice to move from the surface to the bed, which is younger than the ice cap. In fact, this OSL age, as an upper limit, does not imply for an ice-free region in the Chongce region, but for an retreat of the ice cap above the elevation of the bottom at the drilling site during a (or more) warm period (or periods) since the upper limit age (e.g., MIS3, the Bølling-Allerød period, Holocene Climate Optimum). Because only limited results are gained, and many processes (each with its uncertainty) are involved in affecting the final age, we are cautious to avoid over-explaining the results at this moment.

Editor comment: This is contractionary, because above you say the OSL ages refer to eolian grains travelling from the ice top to the bottom, which happens without ice retreat?

3. Water/ice content (issues raised by reviewers 1 and 3)

Reviewer 3: The actual sample came from sediment embedded within ice. The authors should calculate a dose rate for the real situation of sediment in ice.

Editor comment: This comment has not been addressed in the reply. The authors calculate two extreme ranges (dry to 30% water content). Why would the dehydrated scenario be realistic for any time slice of the sediment's age? How was the 30% water content chosen?
You should explain under which conditions the sediment was dehydrated and how likely this conditions persisted - as long as the cold ice/glacier is on top the sediment is frozen or retrieves melt-water from the glacier.

Author's reply: no water under the frozen condition and 30% water content if the sediment is saturated with water.

Editor comment: Please be specific and correct in your wording. Does frozen mean subzero temperatures with no liquid water or ice content? Please differentiate between the phases water and ice and consider that water also exists in ice-sedimentary material at zero and sub zero temperatures.

Author's reply: The latter case (with high water content) results in a lower dose rate. Thus our upper limit age may be over estimated.

Editors comment: Why? Because the 30% water content are unrealistic?

4. **Further editorial comments**

- I would prefer "maximum or minimum ages" instead of "upper limit".
- Reference to Adamiec and Aitken (1998): This is a standard procedure and not specifically addressing samples in/under ice.

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- Drilling of the 2012 ice cores is described in the introduction, as well as the two 2013 cores. It should be clearly described which data are presented from which core and which cores are used for illustrative purposes. For example, an image of the basal core material is shown for core location 2, but dating has been carried out with cores 3 and 4. Was dating done on the basal material of both cores?
  This detailed information needs to be included in the method section.

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- "*Electron microscope of the sediment of coarse grain quartz might have scoured from bedrock, but the finer grained quartz was chosen as appropriate for luminescence dating of our sample (hence excluded the coarse grain quartz from further calculation). In the end, 8 fine grain quartz aliquots were used for OSL age calculation, resulting in an average equivalent dose (De) of 178 ± 9 Gy (Table 1).*"

Why not use the coarse grain quartz if this is the material clearly defined as bedrock? Please clarify.

Please also do not use phrases such as "*, we believe that only the fine grained…*", instead use data to support your statement.

- "*Only the aliquots with recycling ratios within the acceptable range were used for further analysis. Among these, one additional aliquot was also excluded because its De value fell outside 2σ of the distribution (Fig. 3).*"

Can you give further information about this sample? Is it usual to remove a sample if the value falls outside 2σ of the distribution (Fig. 3)?

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- Table 1 provides results from sample CCICE – please clarify the abbreviation. Where do you provide the information on the 8 aliquots?
- Figures, Tables and legends (in Paper and Supplement)

  All figures and tables need to include the information for understanding the figure. Please provide detailed figure and table legends. For example, Figure S1 shows 5 coring locations. When were they drilled? What results are used from which core in the paper? The paper mentions 4 ice cores, what about core 5?

  The data shown are from which ice core specifically?