

Interactive comment on “Seasonal changes in glacial polynya activity inferred from Weddell Sea varves” by D. Sprenk et al.

Anonymous Referee #1

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Overview and General Comments

This manuscript presents new sedimentological and geochemical data from an annually resolvable LGM sediment record from a channel overflow levee on the continental slope of the SE Weddell Sea. The authors characterise two different alternating sediment layers with high resolution analyses of physical properties (wet-bulk density, compression wave velocity, and magnetic susceptibility), colour components, water content, inorganic and organic carbon contents, nitrogen and sulphur contents, biogenic opal contents, and XRF scanning (Si, Ca, K, Fe, Ti, Rb, Sr, Zr). They additionally scanned cut sections by X-ray permitting for IRD counts, and produced thin sections of target intervals for scanning and mineral-specific particle-size distributions, and also carried out automated and visual counting of sediment layers. The age model of the

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sediment core is based on five AMS ¹⁴C ages. The authors identify brighter sediment layers that are denser and contain higher amounts of Si, Zr, Ca and Rb, more IRD and silt-sized quartz grains, and darker layers that contain finer-grained clay-sized particles, and more Fe, Ti, Rb and K. Based on previous studies and the findings presented here, the authors conclude that these alternating layers are seasonal varves, and represent changes in sedimentation associated with seasonal variations in the production of dense bottom waters and subsequent transport of sediment downslope, with stronger brine rejection and more intense coastal polynya formation during winter months. Lighter coarser-grained layers are interpreted to represent winter conditions with stronger katabatic winds opening more polynas offshore of the advanced ice sheet edge, leading to increased brine rejection and stronger transport velocities and hence increased overflow, and stronger transport of icebergs. Conversely, the authors interpret darker finer-grained layers as a summer signal with weaker katabatic winds and comparatively less polynya formation, and hence lower bottom current velocities and less levee overflow. However, the authors concede that lighter-coarser grained layers may also represent summer conditions, with increased ice melt and meltwater production taking place.

Overall, I found the paper to be well structured, with excellent discussion of relevant results and good use of references to support the interpretations presented in it. I found the study to be particularly novel in its utilisation of a wide array of different sedimentological and geochemical tools, some of which are relatively new approaches. The interpretations presented within the paper agree well with existing studies into the Weddell Sea region during the LGM, and provide new insights into seasonal dynamics of sea ice/ocean circulation in the eastern Weddell Sea area. I therefore recommend this manuscript for publication, subject to minor revisions I set out below. Additionally, I would like to encourage the authors to ensure that English, including punctuation, is used correctly throughout the final version of the manuscript. I have attempted to highlight some of the more serious grammatical errors in the line by line review comments below.

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Specific Comments 1) Reference to unpublished work: Page 4, line 1 and Page 9 lines 1-2, page 11 line 16, page 15, line 12. Reference to (Sprenk et al. 2013 in review) is not helpful at all. Either remove this reference and discussion of it throughout this manuscript, or include a more thorough discussion of this work at each relevant point, or wait to publish this manuscript until the referenced manuscript is available to access by readers. In fact, without even seeing this other manuscript, there does appear to be some overlap between the interpretations/data presented in this manuscript and the other manuscript, which is a concern for the novelty of this particular study. The authors need to clarify to the editors if there is any overlap. 2) Results section: The authors go into a lot of detail describing results for non-laminated sections of the core (e.g. page 9 lines 18-25 and page 10 lines 1-15) but do not provide interpretations about them later on. Leave them out if they do not contribute to the final interpretations of the varve seasonality, which is the main focus of the manuscript. 3) XRF calibration: For data quality assessment, please clarify if any calibration was carried out during measurements? Using standards and/or independently measured elemental oxide concentrations of sediments by ICP-AES for example? If so, the authors should report this information, and if not, they should clarify that none has been carried out and should stress the uncertainties associated with the data. 4) Naming of sediment layers: Use of different names for the two layers is confusing, the authors should be consistent with the naming of sediment layers. For example, the authors could use 'lighter coarser-grained' vs. 'darker finer-grained', or 'lighter' vs. 'darker', or 'coarser-grained' vs. 'finer-grained'. Alternatively, the authors could consider naming them type 'A' and type 'B'. Whatever they decide to use, please use the same throughout the manuscript. 5) Low biogenic opal and carbon contents: Low opal and organic carbon content would point towards reduced productivity, but why was this the case? Large coastal polynas such as those formed by advection of sea ice by katabatic winds are today and in the past sites of enhanced productivity – how do the authors reconcile the low opal and organic carbon contents of the sediments with an interpretation of polyna formation, as low biogenic content could indicate reduced open water conditions? 6) Upwelling as a mechanism

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of polyna formation: The authors must also discuss upwelling of warm deep waters (e.g. the WDW) as a mechanism to drive polyna formation, either as an alternative to katabatic-wind driven advection of pack-ice or as a combination of both. 7) Winter vs. summer interpretation of coarser-IRD laden layers: This reviewer finds it difficult to envisage how increased IRD deposition took place during glacial winter months, even if polynas were plentiful. The authors even concede that open water probably did not stay open for long due to low temperatures during winter months, so how were the icebergs transported? Perhaps increased iceberg mobility did take place during winter months when there was more open water, but accordingly the authors need to clarify why IRD deposition was reduced during warmer summer months when iceberg melting rates would be increased. Also, the coarser sized IRD is almost certainly iceberg rafted and not sea ice carried, and it is important to note that finer-grained (i.e. <1 mm) detrital components often compose the majority of ice-rafted fractions, so it is feasible that a large proportion of the lighter sediment layers are ice-rafted in origin. 8) Reference order: Please ensure that throughout the manuscript all references are listed in chronological order, i.e. those in brackets.

Figure 1: Left map: Caption - Black 'box' not 'square', ACC blue arrows; Bathymetry map: use different colours to distinguish between HSSW/ISW and WSBW – perhaps a different shade of blue for WSBW? Also the blue arrows are currently difficult to see on top of the blue contour lines; Right map: make main study site clearer, i.e. distinguish the site from others. Add arrows to blue lines indicating direction of flow. Caption: Weber et al 1994 should not be in brackets, i.e. Weber et al. (1994).

Line by line comments: Page 3, line 6: refer to Fig 1 for location. Page 3, line 8: remove reference to chapter 2, unnecessary – also, throughout manuscript, change 'chapter' to 'section'. Page 3, line 19: edit flow of sentence to 'therefore, glacial bottom-water production was likely very different to today, as...'. Page 3, line 25 to 28: you introduce the laminated sediments for the first time here, it is written like the reader knows about their existence already. Please rewrite this sentence. Page 4, line 21:

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remove comma. Pag 4 line 22: change 'is' with 'was'. Page 4 line 23: watch wording: change to 'Final retreat of the EAIS was around...'. Page 5, first paragraph: this manuscript focuses almost entirely on PS1795, so why treat all sites with the same level of detail? This also applies to Figure 1. Page 5, line 17-18: Remove 'brine rejection and supercooling' as it is discussed in the next paragraph. Page 5: Optional: could the circulation system be better shown in a figure? Page 5 line 25, west should not be capitalised. Page 6, line 6: please use correct nomenclature: 'west' not 'left'. Page 6, lines 7-10: sentence does not make sense, change to 'However, a current meter mooring in the northeastern prolongation of the channel-ridge system shows ...'. Page 9 line 11. Not true for upper 2m of core. Please clarify this. Page 10, line 14-15: the authors claim that less ice-transported sediment was deposited in the upper section of the core, but this is in direct contrast to the increase in IRD counts shown in F2 and discussed in the paragraph above (e.g. line 7). Page 10 lines 17-18: watch unscientific language: remove 'labour-intense' and 'managed'. Page 10 lines 26-28: watch language: change to 'The first age-model was for undisturbed sediments and relied only on the AMS 14C ages, and the second includes a hiatus at ...'. Page 11, lines 5 and 6: remove 'the material can be identified as varved sediment' as this is the topic of the next sentence. On line 6, change to 'the material can be considered to be varved'. Page 11 line 8 and line 11: either LSR or linear sedimentation rate, but be consistent. Page 11 lines 12-13: re-emphasise that this hiatus refers to the boundary between the top of the varved section and the base of the bioturbated section. Any idea what caused this unconformity? Page 12, lines 24-26: does not make sense, rewrite '...and that the radiographs were taken from a different interval compared to where the XRF-scanner data were measured, both...'. Page 13, line 2: change to 'where Rb, similar to K, Fe and Ti, is enriched in 'clayey' layers. Page 15, lines 11-19: see above comment – impossible to confirm this as this work is not published. Page 17, line 5-7: on the previous page the authors discuss that today polyna formation is important in the Weddell Sea, but here they state that bottom water is today mainly formed on the continental shelf under ice shelves. Please clarify why polyna formation is important

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for bottom water production today.

Interactive comment on Clim. Past Discuss., 9, 5123, 2013.

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