Clim. Past Discuss., 9, C3117–C3121, 2014
www.clim-past-discuss.net/9/C3117/2014/

Climate of the Past Discussions

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

D. Sprenk et al.

danielasprenk@gmail.com

Received and published: 15 January 2014

Thank you very much for your comments and advises. We have addressed each reviewer comment below:

"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." Reply: We thank the reviewer for the positive review. All of the highlighted grammatical errors have been corrected plus the whole manuscript was checked so that now English is hopefully used correctly.

"Reference to unpublished work: Page 4, line 1 and Page 9 lines 1-2, page 11 line 16, page 15, line 12.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." Reply: The references to the Sprenk et al. manuscript in review at Quaternary Science Reviews have been mostly removed in the revision. That manuscript discusses bulk and evolutionary spectral analysis data from core sites PS1599, PS1789, and PS1791, which are located in the same channel-ridge system. Therefore, the overlap is only marginal because of the same investigated area.

"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." Reply: Agreed. The sentences about the non-laminated sections have been removed now.

"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." Reply: The following three sentences have been included in the methods paragraph about the XRF-scanner data: ' The theoretical detection limits of the Avaatech XRF-scanner can be looked up in Richter et al. (2006). ... All XRF-scanning results are presented as non-calibrated raw counts. The theoretical limits of detection of the ITRAX XRF-scanner can be found in Croudace et al. (2006)'.

"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." Reply: Agreed. The two layers are now consistently named lighter coarser-grained and darker finer-grained layers.

"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?" Reply: The sediment core PS1795 originates from 1884 m water depth in the SE Weddell Sea, therefore it is not located in the bioproductivity zone. The biogenic opal and organic carbon contents are relatively low in the 9 m long record, i.e. in the last glacial as well as deglacial deposits (Fig. 2). Investigations showed that the sediment consists mainly of detrital material, which is transported by thermohaline currents down the continental slope. The biogenic opal and organic carbon data were retrieved every 5 cm, therefore the resolution is too low to investigate seasonal changes. Analyses of the coarse-grained fraction (>63μm) also revealed that, on average, about 80 % of the

particles coarser than 63μm are actually quartz grains. The combination of thin sections and XRF-scanner Si counts every 0.2 mm, highlights that Si counts are relatively enriched in the lighter coarser-grained layers relative to the darker finer-grained layers (see chapter 4.3.2).

"Upwelling as a mechanism 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." Reply: This type of polynya formation is usually associated with the initial formation of Circumpolar Deep Water in the Antarctic Circumpolar Current, and transport within the Weddell Gyre into the Weddell Sea before the warmer water are able to upwell in the open ocean. We see indeed strong evidence from data not reported here that, during deglaciation, Antarctic wide upwelling of Warm Deep Water is a key element in destabilizing ice sheets and overall reduction in sea ice. During the LGM, however, sea ice extended far north and the Weddell Gyre was likely more sluggish, as also indicated by modelling studies. Therefore it seems very unlikely that Warm Deep Water could have led to extensive polynya formation during the LGM, specifically not in a seasonal fashion (details see Weber et al., 2011, Science, Supporting Online Material).

"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. <1mm) 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." Reply: This is a good point but it contains – as does our interpretation – some speculation because we don't really know how the conditions were during the LGM. There are strong lines of evidence that it was colder, so in our model summer melt should not be decisive. Winter, however, should provide at least less thick sea ice or partially open water, allowing for a more effective transport of iceberg counter clockwise (due to Coriolis Force) around the Antarctic continent. So we agree that the IRD is mostly coming from icebergs not from sea ice, but it was mainly delivered during glacial winter.

"Reference order: Please ensure that throughout the manuscript all references are listed in chronological order, i.e. those in brackets." Reply: Done.

"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)." Reply: Presumed changes have been carried out in Figure 1.

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