Clim. Past Discuss., 9, C2485–C2491, 2013
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Climate of the Past
Discussions

CPD
9, C2485–C2491, 2013

Interactive Comment

Interactive comment on "Holocene sub centennial evolution of Atlantic water inflow and sea ice distribution in the western Barents Sea" *by* S. M. P. Berben et al.

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Received and published: 31 October 2013

We would like to thank anonymous referee #2 for a thorough and constructive feedback. Hence, we will take all corrections and suggestions into consideration in order to improve our manuscript. Therefore, we would like to respond to the comments.

General comments "it is in general not clear what the authors preferred interpretation and explanation is, or why"

We will clarify our preferred interpretations and explanations where possible. However, we might be careful with our commitment in interpretations in order to prevent any forms of over-stating.

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"Furthermore, there is a huge potential for shortening the text and clarifying the message told. The authors should go carefully through the full manuscript with the aim to get a more focused, shorter and clearer text." And related comments:

We welcome all comments and suggestions made by this reviewer regarding aspects of (a) clarification of the main messages; (b) opportunities to shorten the manuscript; (c) correction of literature citations; (d) structure of the introduction and discussion. These will be considered carefully when creating a revision of the manuscript.

"Page 4895, line 28 – page 4896, line 10: Take into consideration information gained by newer studies, e.g. by Andersson et al., 2010 and Risebrobakken et al., 2011, papers and information that you refer to later in the manuscript."

We agree and have taken these new studies into consideration. The following will be added to the revised manuscript (page 4896, line 10) : The influence of depth habitat was emphasized by Andersson et al. (2010) who suggested that discrepancies in SST records could be explained by differences in hydrographic settings (i.e sea surface versus sub surface). Risebrobakken et al. (2011) showed that a strong insolation at high northern latitudes affects temperatures within the summer mixed layer but not within the waters underneath and hence, amplifies the different roles of oceanic heat advection and orbital forcing.

"Page 4896, line 13-17: What about other suggested mechanisms behind millennial scale changes through the Holocene? And, the sentence needs to be rewritten. Also check e.g. Marshall et al., 2001 and Orvik and Skagseth 2003. Atmospheric forcing does influence the large scale and regional ocean circulation."

Superimposed on this overall trend, observations of several millennial scale changes in surface ocean circulation also exist (e.g. Bauch and Weinelt, 1997; Bond et al., 1997; Duplessy et al., 2001; Jennings et al., 2002; Jiang et al., 2002; Hald et al., 2007). These changes have been attributed to several influences such as the North Atlantic Oscillation (NAO), the Arctic Oscillation, the Scandinavian pattern and the extent of

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sea ice (Giraudeau et al., 2004; Solignac et al., 2006; Rousse et al., 2006; Slubowska-Woldengen et al., 2007; Goosse and Holland, 2005; Semenov et al., 2009). Further, Orvik and Skagseth (2003) suggest that wind stress curls affect the variability of Atlantic water inflow. Thus, atmospheric changes are important as they influence the strength of the surface water masses, the AMOC and hence, Earth's global heat distribution.

"Page 4896, line 27 – page 4897, line5: Not relevant for the introduction, should be moved to method and/or discussion. Page 4897, line 6 – page 4897, line23: Most of this information does not belong in the introduction."

The Arctic training set of planktic foraminifera and the sea ice biomarker IP25 are relatively novel, thus we favor to keep these paragraphs as part of the introduction.

"Page 4897, line 24 – page 4898, line 3: make sure that it is clear what the aim of the paper is, why, and how you will address it."

In this paper, we describe a new high resolution record of surface water properties and sea ice distribution in the western Barents Sea throughout the Holocene in order to provide a better understanding of their variability. The core site (Fig. 1) is situated close to the modern day position of the Arctic Front (Hopkins, 1991) and is situated in a glacial trough, which acts as a natural sediment trap containing relatively thick Holocene sediments (Rüther et al., 2012). As such, it represents an excellent location for carrying out such a study using planktic foraminiferal fauna, stable isotopes (d18O, d13C) and sea ice and phytoplankton biomarkers.

2 Study area "General: I suggest that you rename this section and call it Oceanography instead of Study area, since what you actually do is to introduce the oceanographic setting of the whole region."

We propose changing the heading to 'Regional oceanography'

3.1 Chronology "Page 4900, line 16: Give accumulation rate in cm/ka not mm/year. Or

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provide information on the final resolution of your records in years/cm."

Information on the final resolution (7 – 137 yr/0.5 cm) is presented in Figure 3. This is presented in yr/0.5 cm as the core is sampled every 0.5 cm. However, we can change the unit to years/cm if necessary.

"Table 1: You do not believe in those mollusc dates that do not fit with your preferred age model. Why should the other mollusk dates be more reliable?" and "Figure 1A: Include the omitted ages in the figure."

The dates which were excluded were not in line with the succession of dates, and were therefore not used. However, although we acknowledge the issues related to the uncertainty aspect of carbon dating on molluscs (e.g. Mangerud et al., 2006) we decided to use the other molluscs dates in order to get a better constrain on age model and hence, sedimentation rates. We will specify the uncertainty aspect clearer in the revised manuscript. Subsequently, all omitted ages will be included in the revised figure.

3.2 Planktic foraminifera "Page 4901, line 2-5: Consider specifying in the figures (e.g. by using different colors) which of the samples that has less than 300 specimens counted."

In the revised manuscript we will indicate all samples with less than 300 specimens within the figure.

4.2 Stable isotope analysis "Even though the main trends in the d18O and d13C are the same, the information given by the two records are different. I recommend that you restructure the information into two paragraphs, one relating to d18O and the other to d13C."

The d18O and d13C measurements of N. pachyderma (sin.) showed similar general trends throughout the record (Fig. 5). Overall, the d18O values were in the range 1.79 to 2.90‰ (Fig. 5a). Between 11 900 and 11 700 cal yr BP, d18O values showed a

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slight depletion followed by a small enrichment towards 11 100 cal yr BP. Subsequently, a sharp depletion in d18O was observed at ca. 10 500 cal yr BP (Fig. 5a), after which, d18O values gradually increased up to ca. 2.50‰ until ca. 6900 cal yr BP. Subsequently, the d18O record remained relatively stable until 1100 cal yr BP with a mean value of 2.50‰. For the last 1100 cal yr BP, the record showed slightly increased values (Fig. 5a).

The d13C record is within the range -0.30 to 0.86‰ (Fig. 5b). A slight depletion in d13C was recorded between 11 900 and 11 700 cal yr BP, followed by a small enrichment towards 11 100 cal yr BP and a sharp depletion with values of -0.26‰ towards ca. 10 500 cal yr BP. Between ca. 10 500 and 6900 cal yr BP, d13C values increased to 0.40‰. For the remaining part of the record, a relatively stable trend around a mean value of 0.40‰ was observed.

“Page 4908, line 5-8: These studies are done at different size fractions, hence the absolute values might not be directly comparable.”

One of the studies (Ebbesen et al., 2007) uses the same size fraction as the current study, hence those values are comparable. In the other study (Sarnthein et al., 2003) another size fraction is indeed used (>150 um), and caution is necessary when comparing. This will be addressed in the revised text. However, the record from Sarnthein et al. (2003) does show a relatively high % of T. quinqueloba.

“Page 4912, line 11-17: Can the selective dissolution have potential implications for the calculated temperatures?”

Yes, this is a good point. As stated in line 13 page 4912, it might change the species composition of a foraminiferal assemblage. The temperatures in the current study are calculated by transfer functions, so, depending on the foraminiferal assemblages, selective dissolution might have potential implications for the calculated temperatures. Some consideration of this will be included in the revision.

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“Page 4912, line 18: Increased early-mid Holocene d13C (relative to what?) indicates better ventilated surface water, and/or enhanced primary production (Fig. 7f).”

The d13C values are continuously increasing throughout the early-mid Holocene arguing for a gradual evolution in better ventilated surface water and/or enhanced primary production (Fig. 7f).

“Page 4912, line 24-26: Can you really say that the seasonal sea ice cover progressively decreased? The IP25 signal tells you that you had spring sea ice at the site, but can the concentrations actually tell if it was more or less?”

Previous studies have indicated that there is a positive correlation between regions known for seasonal sea ice and IP25 concentrations in the surface sediment. Temporally, directional changes in IP25 are normally consistent with corresponding changes in seasonal sea ice (Belt and Muller, 2013).

“Page 4913, line 9: These changes – specify what changes. In what direction did the front move?”

The Arctic Front shifts most likely in a north-eastwards direction.

“Page 4913, line 14-24: Merge the information given in these two paragraphs. And take a more active role in the discussion; your opinion is not clear.”

The faunal composition in Period III is marked by relatively consistent abundances of all species and a distinct dominance of T. quinqueloba (ca. 60%) possibly suggesting a stable influence of Atlantic water. However, as discussed previously for Period II, the high abundance of T. quinqueloba differs from earlier published records from this area (e.g. Sarnthein et al., 2003; Hald et al., 2004, 2007; Ebbesen et al., 2007) which might reflect regional oceanographic differences such as a more general proximity to the Arctic Front in the Barents Sea (e.g. Volkmann, 2000; Husum and Hald, 2012). The sea ice biomarker IP25 is mainly absent throughout the mid-late Holocene, reflecting predominantly ice free ocean conditions (Fig. 7g–h) meaning that the marginal ice zone was not at the core site.

“Page 4914, line 10-12: Depending on your preferred interpretation of TQ? As mentioned in first and second paragraph of this section, it can be influenced by Atlantic water/marginal sea ice zone and Arctic front.”

The abundance of T. quinqueloba is most likely influenced by Atlantic water and Arctic front conditions. This means that the transfer function-derived SST records do not incorporate the nutrition component, which is also important. We will address this point accordingly in the revised manuscript.

Interactive comment on Clim. Past Discuss., 9, 4893, 2013.