Clim. Past Discuss.,
doi:10.5194/cp-2017-14, 2017
doi:10.5194/cp-2017-14-RC1, 2017

Reply to the **Interactive comment on "Regional seesaw between North Atlantic and Nordic Seas during the last glacial abrupt climate events" by Mélanie Wary et al., by Anonymous Referee #1, Received and published: 13 March 2017**

REV#1: This paper presents interesting reconstructions of sea-surface conditions in the North Atlantic and Nordic Seas for Marine Isotopic Stage 3, based on dinocyst assemblages and planktonic forams, as well as climate modelling. This is a very well written paper, well presented and argued, with little to fault. The only aspect I would like to have seen being discussed is the possible forcing of productivity on dinocyst assemblages, in particular the high abundance of I. minutum, which is recognized as a tracer of sea-ice cover, but also abundant in high nutrient environments (see Zonneveld et al 2013). Further studies by Heikkilä et al (2014, 2016) also suggest a more complex response of this species to sea-ice environments. Based on these ecological findings, how would it affect your interpretation?

Heikkilä, M., Pospelova, V., Forest, A., Stern, G.A., Fortier, L., Macdonald, R.W. Dinoflagellate cyst production over an annual cycle in seasonally ice-covered Hudson Bay (2016) Marine Micropaleontology, 125, pp. 1-24
Heikkilä, M., Pospelova, V., Hochheim, K.P., Kuzyk, Z.Z.A., Stern, G.A., Barber, D.G., Macdonald, R.W. Surface sediment dinoflagellate cysts from the Hudson Bay system and their relation to freshwater and nutrient cycling (2014)

We are grateful to reviewer 1 for his / her review of our paper and for pointing out the interesting role of productivity on dinocyst assemblages in sea-ice covered environments.

The highest abundances of *I. minutum*, and especially abundances as high as those recorded during GI in our Norwegian Sea cores, are systematically encountered in cold and sea-ice covered environments (Figure S2, re-enclosed below). Nonetheless, in these areas, this heterotrophic taxon can exhibit a complex spatial and temporal dynamic tightly linked to nutrient and prey availability, as highlighted by Heikkilä et al. (2014, 2016) for the Hudson Bay and Hudson Strait where this factor appears as the primary controlling factor. We will for sure add a mention about that in the Supporting Information Section S2.

However, in our case, we think that sea ice, stratification and nutrient/prey availability changes are directly related to each other and play in concert.
During GS, our dinocyst assemblages closely resemble those of the Eastern Hudson Bay as described by Heikkilä et al. (2014; i.e. *P. dalei*, *O. centrocarpum*, *S. ramosus*), with the exception of *B. tepikiense* being additionally reported in our Norwegian Sea cores (see Eynaud et al., 2002 and Wary et al., in press, The southern Norwegian Sea during the last 45 ka: hydrographical reorganizations under changing ice-sheet dynamics. Journal of Quaternary Science). Heikkilä et al. (2014) related this assemblage to productive stratified waters related to large meltwater inputs and a relatively long open-water season. These findings are in agreement with our interpretations for GS. The occurrence of *B. tepikiense* in our assemblages reinforces the stratification pattern (together with a strongest seasonality), and dinocyst-derived (through MAT transfer function) primary productivity reconstructions for core MD99-2285 (see Fig. 6 in Wary et al., 2016, enclosed below) support the high productivity pattern.
During GI, our dinocyst assemblages are dominated by heterotrophic taxa, with the strong dominance of *I. minutum* ('sea-ice indicator') and the lesser occurrence of *Brigantedinium* spp. ('nutrient indicator') in cores MD95-2009 and MD95-2010 (Eynaud et al., 2002). Heterotrophic taxa usually feed on diatoms, and Hoff et al. (2016) indeed reported higher diatom fluxes during GI. If not related to a better preservation effect (less dissolution), this could indicate more favorable conditions for diatom proliferation, and especially in the present case likely for sea-ice diatoms proliferation (higher IP25 abundances are indeed reported during GI in core MD99-2285, see Wary, 2015). Our records indicate the absence of stratification during GI (with longer sea-ice cover limiting iceberg calving and subsequent meltwater inputs, see Wary et al., 2016 and

references therein), which is reported by Heikillä et al. (2014) in the Hudson Strait as a factor favoring diatom proliferation and disfavoring competitive autotrophic dinoflagellate development. Hence during GI, sea-ice, stratification and nutrient/prey availability appear directly related to each other, and could all together provide optimal conditions for *I. minutum* and *Brigantedinium* spp. seasonal proliferation: longer sea-ice cover durations, colder SST, likely less (compared to GS) but still substantial nutrient-rich meltwater inputs (from the seasonal melting of sea-ice and from continental freshwater inputs likely enhanced under warmer atmospheric conditions), less stratification (less iceberg melting), more (sea-ice) diatoms/i.e. heterotrophic dinocyst preys, less autotrophic dinoflagellates, … and more heterotrophic taxa typical of cold, seasonally ice covered, nutrient- and sea-ice diatom-rich, but low primary productivity (likely due to grazing; see Fig. 6 in Wary et al., 2016) environments.

Figure S2 (Supporting Information from the present reviewed paper):

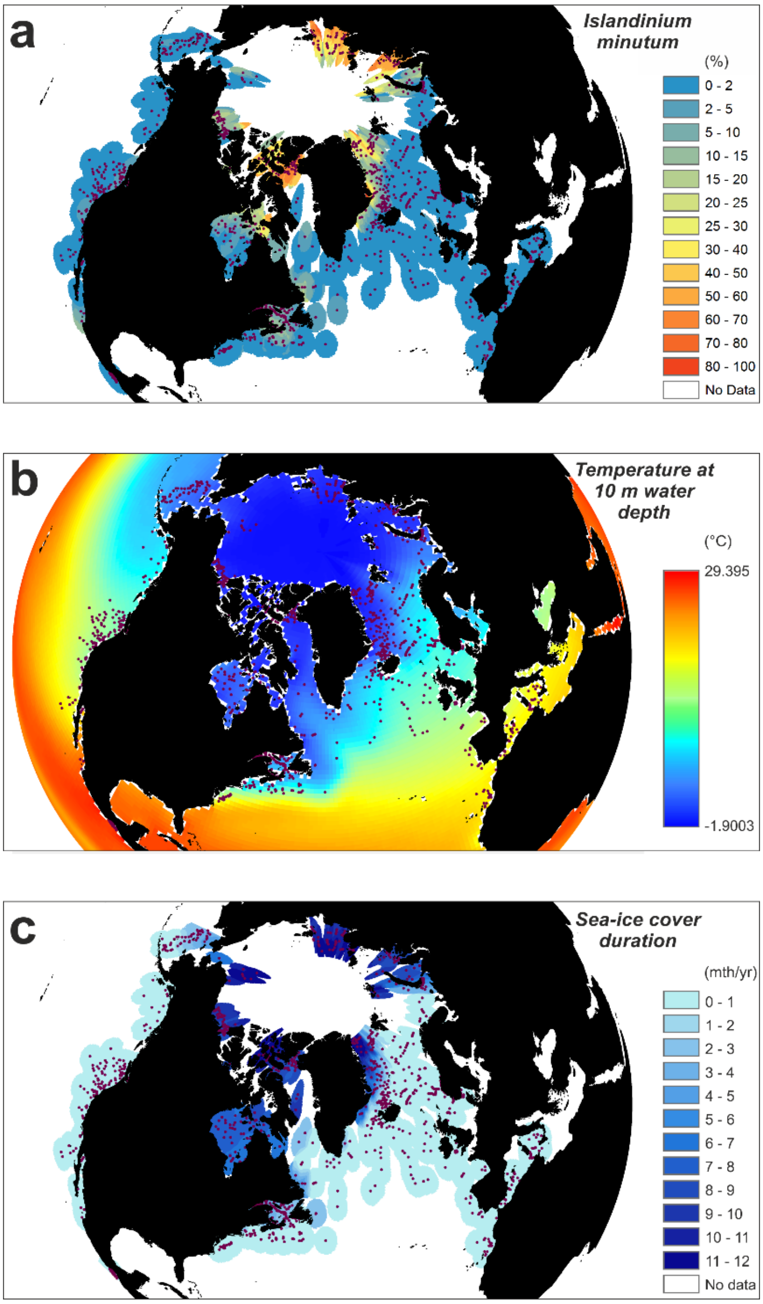

Figure S2. Islandinium minutum distribution and ecology. (a) Islandinium minutum distribution within the modern dinocyst database made of 1207 points. (b) Oceanic temperatures at 10 mbsl (WOA09 data; Locarnini et al., 2010). (c) Sea-ice cover (with concentration greater than 50%) duration within the modern dinocyst database made of 1207 points (after data provided by the National Climate Data Centre in Boulder). These maps demonstrate the strong link of this dinocyst taxon with cold and seasonally sea-ice covered surface environments.

Fig. 6 from Wary et al., 2016:

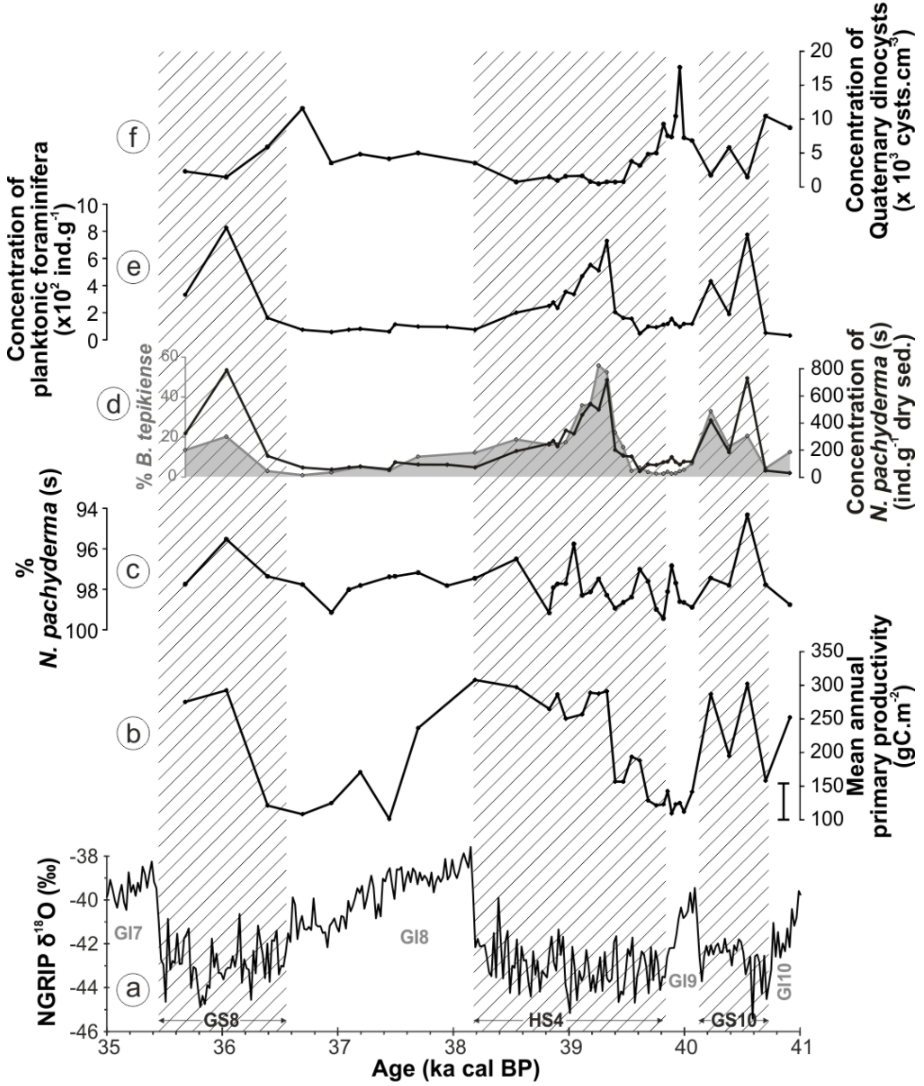

Fig. 6. Interpretation of NPS absolute abundance signal in core MD99-2285. (a) NGRIP d18O regional stratotype. (b) Dinocysts-derived mean annual primary productivity. (c) NPS relative abundance (plotted with a reverse scale ranging from 94 to 100%). (d) NPS absolute abundance, compared with B. tepikiense relative abundance. (e) Total planktonic foraminifera absolute concentration. (f) Total dinocyst absolute concentration. Hatched bands highlight stadial intervals (age limits after Wolff et al., 2010).