

Interactive comment on “Northward advection of Atlantic water in the eastern Nordic Seas over the last 3000 yr: a coccolith investigation of volume transport and surface water changes” by C. V. Dylmer et al.

Anonymous Referee #2

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General comments

The authors present a reconstruction of the northward flow of Atlantic Water (AW) within the eastern Nordic Seas since 3000 cal. yrs BP. The results are mainly based on coccolith proxies (both absolute concentrations and relative abundances) and come from 3 sediment cores located along the axis of the Norwegian Atlantic Current (NAC). The main conclusion is a general increasing volume inflow of AW during the investigated time interval, which is linked to “atmospheric processes driven by dominant modes of North Atlantic Oscillation” (NAO).

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The paper is clearly written, well-structured and added by adequate figures. I am a bit confused about the term “volume” transport of AW – Sverdrup is a unit of measure of volume transport and this term is almost exclusively used in oceanography and is of course not used here since no data is given concerning the transport of ocean current. Usually “strength” of current is used. There are a lot of interesting data in this manuscript but the outcome is a bit arbitrary and the conclusions are to my opinion not always supported by the data. In particular, the episode assumed as the Little Ice Age (LIA) influenced by arctic/polar surface waters and severe sea-ice conditions seems to be a bit over-interpreted.

Methods:

I like the idea of using single coccolith proxy records as a tool for the reconstruction of late Holocene variations in surface water flow, but I have some general comments. Since the authors deal with %-abundance changes in the order of 5% (for *G. muellerae* and *C. leptoporus*), it is important to quantify errors and possible error sources. In addition, it would be worth indicating on how much census counts the concentrations and relative abundances are based. Usage of %-abundance is fine, although %-occurrence of one species effect the %-occurrence of the other species, but I doubt that coccolith concentrations are biased by terrigenous sediment transport (which certainly doesn't come from river transport) in a way that this data cannot be used for paleoceanographic interpretations. Otherwise, the distribution of the species as shown by Baumann et al. (2000) wouldn't make any sense. The sedimentation rates at the two northernmost sites are rather comparable and the authors also show that the concentration data seem to work for *G. muellerae*. So at least some of the main conclusions are drawn from this kind of data!

Species-selected coccolith proxies:

Actually, only *Emiliana huxleyi* is occurring in high cell densities in the Nordic Seas dominating extant populations. All other species, including *C. pelagicus*, quite some

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syracosphaerids, and others, only occur in lower cell densities (Samtleben and Schröder, 1992; Baumann et al., 1997; Baumann et al., 2000) and most of them mainly thrive in NAC waters. And their occurrence and distribution are certainly influenced by ecological parameters (temperature, salinity, nutrients, turbulence, . . .) within this water mass and not by variations in its volume. The distribution of *E. huxleyi* and *C. pelagicus* in sediments differs slightly from their occurrences in the plankton. Both species are mainly concentrated in the eastern Nordic Seas with *C. pelagicus* being a bit more prominent in the vicinity of the summer position of the Arctic front. Both absolute numbers drastically decrease by nearly an order of magnitude towards the west with *C. pelagicus* being relatively bit more abundant (Baumann et al., 2000). This change in the ratio of *E. huxleyi* vs. *C. pelagicus* (E/C) occurs at about the summer position of the Arctic front. However, this only works out in the central Nordic Seas, whereas further to the north *E. huxleyi* is dominating the assemblages. This may be due to the influence of surface waters from the Barents Sea, which also could influence the present core locations. Those water masses (of the ESC and PC?) are indicated in Figure 1, but they are not mentioned in the oceanography chapter. What is their influence in terms of salinity, temperature, sea-ice, etc.? *Gephyrocapsa muellerae* and *Calcidiscus leptoporus* are thought to exclusively drift from the temperate North Atlantic, possibly from their main area of occurrence in the eastern North Atlantic. I am not convinced of this kind of transport from about 50°N to nearly 80°N! The species *G. muellerae* was already found thriving in the Nordic Seas, though occurring only in low numbers, and was placed into a Norwegian-Sea group (Samtleben et al., 1995). Both species are relatively robust concerning destruction by zooplankters and may therefore be enriched in the surface sediments (e.g., Samtleben and Schröder 1992). They possibly form early or regional blooms in the Nordic Seas, which so far only seldom have been sampled. In particular, *G. muellerae* is also described from sediment traps dominating coccolith fluxes in a short time interval (June – early July) at 900m water depths in the central Nordic Seas (70°N, 0°W; Andruleit, 1997). Giraudeau et al. (2010) have related this to lateral transport of fossil assemblages, which is quite difficult to explain given the fact

that most of the coccoliths were transported to the sediment surface within weeks by fecal pellets (e.g. Samtleben and Bickert, 1990; Samtleben and Schröder, 1992; Andrulleit, 1997). In what way are all the other coccolith species than influenced by lateral drift from the far south? It shouldn't only affect *G. muelleriae* and *C. leptoporus*, but all species living south of the Iceland-Scotland Ridge. The different abundance patterns of these species might therefore not been enigmatic but could perhaps been related to different ecological adaptations of the species to changing water mass conditions in the study area! At least this should be discussed in a bit more detail.

Advection of AW and fluctuations of the AF:

Changes in the coccolith record are used to infer an overall increase in the “volume” transport of AW and in “the nature” (?) of the surface waters (Arctic vs. Atlantic). Again, the discussion is lacking as how changes of the ecological conditions that may have occurred independent of any changes of the NAC inflow might have influenced the assemblage composition. The increased E/C ratios at site MD95-2011 are due to increased abundances of *C. pelagicus*, which, f.e., would well fit with the lowest sea-surface (alkenone) temperatures occurring at that site in this time interval (Calvo et al., 2002). Most of the discussion and interpretations are focussed on the absolute concentrations of *G. muelleriae*, and is therefore based on only slight variations (of mostly less than 5% in abundance). Trends in the abundances of *C. pelagicus* and *E. huxleyi* are not taken into consideration, as the increase in *E. huxleyi* (or decrease in *C. pelagicus*!) during the Medieval Warm Period in the Svalbard core, or the divergence of both species after about 1200 cal yr. BP in the Barents Sea core. However, for both cases it is not clear whether *E. huxleyi* increased in numbers or whether *C. pelagicus* decreased in their concentration – absolute concentration data could clarify this! And what would be the influence of the NAO on these species? In general, the comparison and linkage of the coccolith record (mainly *G. muelleriae*) to NAO seems a bit arbitrary and only fits in some parts of the record and not in all cores. In addition to this, I am a bit critical to the interpretation of the LIA, which is assumed as a period of strong

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cooling, influenced by arctic/polar surface waters and severe sea-ice conditions off western Svalbard and in the western Barents Sea. These harsh conditions are not well represented by the coccolith records. Neither changes in the abundance of the dominant species occur nor any obvious shift in the *G. muelleriae* record at around 650 cal. yr. BP, except in the Norwegian Sea site. Variations in the strength of the AW inflow may also influence slightly the pathway and the spatial extension of the NAC as has been reconstructed for time-slices of the last 350 ka (Henrich, 1998; Mar. Geol.).

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