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Biogeosciences Discussions

Interactive comment on "Equatorward phytoplankton migration during a cold spell within the Late Cretaceous supergreenhouse" *by* Niels A.G.M. van Helmond et al.

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We thank the referee for his/her detailed review of our manuscript. We reply to the comments below and aim to revise the manuscript accordingly.

Referee's comment: This study establishes a link between the first consistent occurrence of dinoflagellate cysts grouped in the Cyclonephelium compactum-membraniphorum (Ccm) morphological plexus with the Plenus cold event during OAE 2. Whereas most data were literature derived one additional section was added which represents a locality in northern Alberta. This locality is presented as a High Latitude northern hemisphere site. Data for this locality are shown in Figure 3, which is not very informative. The segment of the featured carbon Isotope curve can be anywhere within

the Cretaceous history. No correlations to biostratigraphic zones that are mentioned in the text are indicated. No lithostratigraphy is mentioned either. Since this is the only new data point, more information would be desirable.

Author's Reply: Despite the distinctive, >2‰ positive excursion in δ13Corg which is indicative for the OAE2 interval, we agree with the reviewer that more information for the Pratts Landing outcrop locality is desirable. We will aim to put the Pratts Landing section in a broader, regional stratigraphic framework. We will also add the lithostratigraphy to Figure 3. Unfortunately no planktonic foraminifer or ammonite zonation is available for Pratts Landing. This explains why they are not indicated in Figure 3 and 6. The only biostratigraphic data that is available for Pratts Landing is based on inoceramid bivalves, we mentioned this in the main text but it did not come forward in any figures. In the revised version of the manuscript we will add this information to Figure 3.

Referee's comment: The Ccm occurs throughout and shows an increase within the OAE 2, but not only during the interval that was designated as the Plenus Event. Two other peaks occur above which would indicate that the increased productivity signal prevalent throughout this interval and the possibly increased preservation potential of organic matter during this interval could also be regarded as causes for these occurrences.

Author's Reply: We treat the post-Plenus occurrences of the Ccm at lower latitudes in section 3.2 of the manuscript with the following text: "The sustained presence of Ccm after the PCE at all sites, except Bass River (Fig. 6), suggests that, in addition to sea surface temperature, other environmental and paleoceanographic factors became dominant in determining the distribution of Ccm once it had occupied niches at lower latitudes. For example, salinity and proximity to the shoreline may have been important (Harris and Tocher, 2003)."

The reviewer suggests that productivity may have been more important than the fac-

tors we mention to explain sustained presence of Ccm after the Plenus Cold Event. Based on modern analogue paleoecology and empirical information, we do not expect this taxon to be particularly sensitive to sea surface water nutrient budgets. We would expect other taxa, notably peridinioid dinocysts, to more strongly respond to such changes (e.g., Sluijs et al., 2005; Earth-science Reviews). We do not note these, nor other productivity indicators along with the additional Ccm occurrences (Van Helmond et al., 2014; Geology and 2015; Climate of the Past) and therefore surmise that productivity was unlikely a dominant factor. However, to accommodate the comment by the reviewer, we will include productivity (i.e. enhanced nutrient availability) as a potential factor.

Preservation of the palynomorphs is variable within sections and between sections but is unrelated to the occurrences of Ccm. We will include this information in the revised manuscript.

Referee's comment: This illustration is then repeated in Figure 6, which is unreadable in the small format as presented.

Author's Reply: We fully agree. In fact the handling editor, Christoph Heinze, raised this point after the initial upload of the manuscript as well. We then uploaded the figure in landscape, but unfortunately the new template used by Copernicus does not allow landscape format of complete pages.

Referee's comment: In Figure 6 five localities are compared, all in the northern hemisphere of which Pratts Landing from Alberta is the only locality that shows the Ccm throughout the Cenomanian. Other localities show the first occurrence within the Plenus Event, but several sections show increased abundances during the warmer interval of the OAE 2 further up section. These occurrences do not confirm the interpretation presented here namely that this species group is a marker for a cold spell. This species group appears to range throughout the Cenomanian to Turonian. The Plenus Cold Event is near the base of the OAE 2 interval, where a number of global

paleoenvironmental changes take place. The distribution of this fossil as shown here does not convince me that it is indeed the cold spell that is the main control.

Author's Reply: We agree with the referee that the base of OAE2 marks a phase of global paleoenvironmental change, and that the migration of Ccm could therefore be the result of a wide range of paleoenvironmental parameters. However, as stated on Page 2, lines 33-38, for two of the five locations, Bass River (van Helmond et al., 2014; Geology) and Wunstorf (van Helmond et al., 2015; Climate of the Past) the FCO of Ccm co-occurs with a pronounced cooling in sea surface temperatures, reconstructed using the biomarker-based proxy TEX86 (e.g., Schouten et al., 2002; EPSL). For the Eastbourne succession the FCO of Ccm occurs in the interval where a Boreal fauna was found (Pearce et al., 2009; Palaeo3), i.e. colder conditions. While for the Iona-1 core the FCO of Ccm occurs in a period of reoxygenation, e.g. minima in sedimentary organic carbon and redox sensitive elements (Eldrett et al., 2014; Geology), which previously have been shown to correlate with a phase of cooling (e.g., Sinninghe Damsté et al., 2010; EPSL).

Only at Bass River the occurrence of Ccm is strictly confined to the interval of lowered sea surface temperatures (Figure 6, van Helmond et al., 2014; Geology). We therefore suggest that once Ccm arrived in the mid-latitudes other paleoenvironmental factors became important in controlling its distribution, as discussed above and more elaborately in the revised manuscript.

Referee's comment: Page 1, Line 41: Jenkyns et al. is the wrong reference, their work addressed Arctic sections of Campanian age, not late Cenomanian.

Author's Reply: In the revised version of this manuscript we will remove this sentence and reference.

Referee's comment: Figure 1: Occurrences of Boreal fauna: Hamulus sp., sp should not be italicized. Why does the carbon curve leave some dots out?

Author's Reply: We will correct Figure 1. The carbon isotope curve in Figure 1 is based on two different records. The high resolution line is based on the data derived from Paul et al. 1999 (Palaeo3), while the low resolution dots are derived from Pearce et al., 2009 (Palaeo3). We will clarify this in the caption of Figure 1.

Referee's comment: Biostratigraphic and lithostratigraphic information should be added. Figure 3: See comments above. In addition, what is the wavy line, normally indicating a disconformity. Is that the case here? Its meaning should be added to the legend.

Author's Reply: As indicated above we will add the lithostratigraphy and the available biostratigraphy to Figure 3. In addition we will adapt the legend.

Referee's comment: Page 4, Line 23: The genus of a species named for the first time, should be spelled out. Page 6, Line 22: zone should be plural.

Author's Reply: We will correct both issues in the revised version of the manuscript.

Sincerely,

On behalf of all authors,

Niels van Helmond

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