

Response to Interactive comment on “Ice sheet and palaeoclimate controls on drainage network evolution: an example from Dogger Bank, North Sea” by Andy R. Emery et al.

Anonymous Referee #2

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General comments

In the manuscript Emery and coauthors study the postglacial paleolandscape evolution of Dogger Bank by using geophysical and CPT data and try to understand the involved paleoclimate controls by utilizing paleoclimatic modeling. As they study the changes of the Earth’s surface and the influencing factors, the manuscript is well within scope of the journal Earth Surface Dynamics.

The study is well designed and based on a wealth of geophysical and geological data. The results are presented in a clear and concise manner and their interpretation is well argued in later sections of the manuscript. To summarize, the authors prepared a very interesting paper which will allow the community to better understand the postglacial environments and evolution in the North Sea. The paper undoubtedly represents a valuable contribution in the understanding of this region.

My only major concern regarding this manuscript is the lack of any chronostratigraphical data. However, as regional chronostratigraphical constraints are well established and the authors take them in account, this is not a critical limitation of the paper. There are two other minor issues that are also described in the Specific remarks. Firstly, in parts of the paper (especially in the sections describing the results of the seismic interpretation) the authors very vaguely present where a described feature is shown in figures. For example, they refer only to a figure number. These often contain 2 geophysical profiles which leaves the reader struggling with finding out to which profile the authors were referring. I suggest the authors modify the manuscript in order to make the reading a bit easier. Secondly, I have some suggestions regarding the artwork. Generally it looks very nice; I appreciate the use of uninterpreted and interpreted profiles in the same figure and I really approve of the use of “scientific colours”. However, the reader would really benefit, if locations of maps from Figs. 4 and 5 would be included in a study area figure (in Fig. 3 or 6, for example). In addition, the figures are sometimes a bit cramped (see Specific remarks for Fig. 1).

Overall, in my opinion the authors prepared a very good and interesting paper which only needs some minor modifications before publication.

We thank the reviewer for their clear, insightful, and constructive review comments. We have replied individually to specific remarks and technical corrections below.

We agree with the reviewer that a lack of chronostratigraphic control is frustrating when dealing with landscape evolution in offshore areas, and greater chronostratigraphic constraint would be beneficial. However, given the regional chronostratigraphic constraints and the high-resolution physical stratigraphy, this does not cause too much of an issue for the scope of this manuscript. We are confident that future workers will be able build on our work, employing tighter chronostratigraphic constraints.

Throughout the manuscript, we have improved both the referencing of specific parts of figures using letters to denote parts, and improved annotations on the figures themselves to draw the reader’s attention to the necessary feature.

We have cross-referenced the locations of figure 4, 5, and 9 on figure 3, and attempted to make figures less cramped by rearranging some keys and annotations. Please note the line numbers below refer to the tracked changes pdf version of the revised manuscript.

Specific remarks

L113: Maybe a reference to Fig. 3 would be suitable in this part of the manuscript to refer the reader to the CPT locations?

We have added a reference to Figure 3 (line 126)

L136-142: “The GLAC-1D ice-sheet ... representation of climate thereafter.” – this part of the manuscript could be a part of the discussion section.

We agree, and we have moved this section and integrated it into the discussion (lines 580-586)

Section 4: The results of palaeoclimate modelling are not presented in the Results section. I suggest the authors dedicate a sentence or two to these results (maybe refer the reader to Fig. 10).

We have added a section 4.5 to briefly describe results of the palaeoclimate modelling (lines 386-393): “4.5 Palaeoclimate modelling

The palaeoclimate simulation outputs for the two model runs using GLAC-1D and ICE-6G_C ice sheet reconstructions for the timespan of 26 ka BP to present are shown in Figure 10. Generally, the climate simulations show similar trends through the Holocene, but differ through the Late Pleistocene. The climate simulation using GLAC-1D has much higher precipitation than the equivalent simulation with ICE-6G_C between 26 and 18 ka BP, but the climate with ICE-6G_C shows much higher precipitation than with GLAC-1D between 18 and 11 ka BP. The temperature profiles are largely similar between the GLAC-1D and ICE-6G_C runs, except between 26 and 20 ka BP, where the ICE-6G_C run gives temperatures consistently 5°C higher.”

Section 4.1.1: The authors could refer to Fig. 2A in this part of the manuscript.

We have added references to Figure 2A (lines 182-188).

Section 4.1.2: The authors could provide the figures depicting the different appearances of Horizon Z (e.g. “... coincident with the seabed (profile A-A’ in Fig. 5).”

We have added further figure references to show the character of Horizon Z in figures 1, 3, and 5 (lines 190-196).

Section 4.1.3: Similarly to the previous comment, the authors could provide the figures depicting the different types of appearances of the channel fill on the seismic sections (for example, for the acoustic blanking). Additionally, it would be beneficial for the readers, if the authors specify more in detail, where different details of the acoustic facies can be observed. The description between L171-172 could be “(middle part between 38 and 28 ms on profile A-A’ in Figure 4)” instead of just “Figure 4”. The described details are sometimes difficult to find in the figures (for example, I don’t see the prograding fill in Fig. 4 and I don’t even know which profile to observe).

We have added references to specific parts of figures (e.g. 4B, 4C; lines 199-206) and improved annotation of the figures to draw attention to seismic facies discussed in the text.

Section 4.1.4: Again, I suggest the authors provide more in detail where the described features of the acoustic facies can be observed in the profiles.

We have added further references to figures and improved annotation on figures in this section (lines 236-238).

L189-190: "In the north of the study area, the largest elongate feature can be observed to incise through the channel-fill unit and into the basal seismic unit" I suggest the authors refer the reader to a figure with a map which demonstrates this.

We have added a part to Figure 9 that shows this, and added a reference to Figure 9 in the text here (line 247).

L293: Subdued by what process? I suggest the authors use a word that is more descriptive or also reflects the possible process (e.g. relief was eroded, compacted, leveled out...).

We agree that "subdued" implies a process, but we simply meant "it's quite flat". We have reworded the sentence to reflect this (lines 410-414): "The resulting landscape surface is likely to have been modified where the seabed and Horizon Z are coincident, and therefore reconstructing the original topographic template is challenging, although it is likely that the topography was low relief, as part of this land surface beyond the channels is planar (Figure 3)."

L305: A reference to a figure would be appropriate after "accretion".

We have added a reference to Figure 4C here (line 424), and improved annotation on that figure.

L307: Maybe "1st part of Figure 8"

We have added reference to stages 1 and 2 of Figure 8 here (line 426).

L309: Do the authors have any idea, why the widths are relatively narrow and constant? Is it possible, that they were previously confined by relief (which is not preserved?). Are there any indices in the geophysical datasets for this?

We are uncertain as to why they are relatively constant, but it is likely a topographic constraint. We have discussed this further in this section, and why it may be difficult to infer subsequent erosion in the present dataset (lines 429-434): "This relatively constant width implies the existence of a topographic constraint, such as the low-relief valleys (Figure 3D), with the possibility that these valleys were once deeper, and the surrounding higher topography has been subsequently removed through wave ravinement during marine transgression (Emery et al., 2019b). It is difficult to test whether significant erosion has taken place due to the lack of a stratigraphic datum to correlate within the proglacial lake sediments, and such a correlation would require high vertical and spatial resolution of stratigraphic detail from borehole logs and seismic data that are beyond the capability of this dataset."

L316: The authors want to demonstrate that Channel 2 was located in a valley and probably mistakenly refer to the isopach map (Fig. 2B) instead to the horizon-depth map (map in Fig. 3). Nevertheless, I am not really convinced from Fig. 3 that channel 2 is located in a valley as it seems to be located on a topographical high of Horizon Z (between -30 and -33 m).

We have added profiles to Figure 3 to show the valleys we refer to, as they are subtle and do not show well on the map in Figure 3. We have also updated the figure reference here to reflect this (line 453).

L343: On which profile and where specifically is cross-bedding visible in Fig. 4?

Figure 4C. We have updated the figure reference here (line 479) and annotated figure 4C to reflect this.

L377-378: The authors state that the warmer-climate drainage network is best developed over the proglacial lake-fill sediments, however, the largest feature (Channel 3) is developed outside the bounds of the proglacial lake.

We have extended the sentence to include this observation (lines 522-524): “This in turn led to the development of the sub-dendritic drainage network, which is most developed and best preserved over the proglacial lake-fill sediments (Figure 6), except for main channel 3, which developed over basal sub-unit 1, which are glaciotectonised and overconsolidated clays.”

L396-397: “sigmoidal to oblique reflectors in the upper seismic unit” - a reference to a figure would be appropriate in this part of the manuscript. “infill of the channels and the tidal scour features” – a figure showing a profile across the proposed tidal scours would be appropriate in this part of the manuscript.

We have added a reference to Figure 4C, and improved annotation of that figure, for the sigmoidal to oblique reflections (line 552), and added a part to figure 9 that shows the tidal scours, and added a reference to Figure 9 in the text (line 550).

L487-489: “Palaeoclimate modelling showed a cold, arid period between ice sheet retreat at 23 ka BP and 17 ka BP, when the climate became increasingly warm and wet, which correlates to marsh environments at Dogger Bank c. 14.9 – 13.5 ka BP.” – Correlates in what way? A part of the sentence seems to be missing, as a cold period is regarded as a warm period. Or should “when” be “then”?; maybe “during ice sheet retreat between” instead of “between ice sheet retreat at”

The climate warming comes after the cold period, so we have reworded this sentence to reflect this climatic change (lines 675-677): “Palaeoclimate modelling showed a cold, arid period between ice sheet retreat at 23 ka BP and 17 ka BP, after which the climate became increasingly warm and wet, which correlates to marsh environments at Dogger Bank c. 14.9 – 13.5 ka BP.”

L772-773: As this report is cited very often and is available online, I suggest the authors add the hyperlink to the report, if the journal guidelines allow.

We have added a hyperlink to the reference for this report (line 968).

Fig. 1: The font for the scale bar is disproportionately large compared to the other text on the figure. I also suggest to put the text for the depth and elevation colourbars below the colorbars. In that way, both texts are physically separated from the Forewind and Study area part of the legend and the legend becomes clearer. But these are just my personal preferences...

We have made these changes to Figure 1 to improve legibility.

Maps in Fig. 4, 5 and 9: It would be really beneficial for the readers to have the location of Figs. 4, 5 and 9 marked on one of the smaller scale Figures (Fig. 2B or Fig. 6 or...).

We have added the locations in Figures 4, 5 and 9 to Figure 3.

Fig. 3: What is the “m OD” abbreviation on the Horizon Z depth map?

Metres relative to Ordnance Datum. We have removed this reference to avoid confusion to international readers.

L786: Personally, I really appreciate the authors using “scientific colours” and hope others will follow.

Thank you! We do too.

Fig. 9: In L100 the authors mention that the reflections can be recognised up to 150 m deep. However, according to Fig. 9, the tunnel valley is more than 200 meters deep. If this is a mistake, the authors should correct the figure, otherwise I suggest you also include a reference to a previous study or a figure with a profile showing the tunnel valley (possibly 2 profiles to show the relation of the uneroded and eroded channel with the valley).

We have re-annotated the key of Figure 9 to make it clear this is depth below seabed, and the tunnel valley starts at around -66 m and extends to -226 m. We have also added a cross-section through the tunnel valley to show its relationship to main channel 1.

Fig. 11: The location of Oyster Ground is not marked on the map

We added an annotation to Figure 11 to show its location.

Technical corrections

L18: probably “represent a terrestrial” instead of “represent terrestrial”?

Yes, we have added “a” to this sentence (line 18)

L19: “comprises” instead of “comprise”

Corrected (line 19).

L28: probably “9 ka BP” instead of “8 ka BP”

More likely around 8.5-8 ka BP, this change is made here (line 28) and throughout the text to reflect this.

L108: maybe “and the extended interpretation of” instead of “and extended for interpretation of”

We have reworded this sentence for clarity (lines 120-121): “Seismic facies were identified and named based on Mitchum et al. (1977), with interpretation of glacial sediments using terminology based on Emery et al. (2019a).”

L114: “proxy for” instead of “proxy to”; alternatively you could use grain-size proxy

We have reworded this sentence for clarity and in line with comments made by another reviewer (lines 127-128): “These tests provide cone resistance (qc) measurements that were used, uncorrected, as a grain-size proxy through the sediments, with low resistance corresponding to clay and high resistance corresponding to sand, as used by Emery et al. (2019a).”

L119: “truncated. Using” instead of “truncated, using”

We have removed the second part of the initial sentence as it did not make sense and in line with comments by another reviewer.

L151: probably “Generally the area” instead of “Generally the”?

Yes, added (line 183).

L160-161: “Figure 2” should be “Figure 2b”?

Yes, added (line 191).

L186: Is “Figure 2” appropriate here? As “(Figure 2)” is placed at the end of the sentence, it seems that the authors are referring to a seismic profile and not an isopach map. If they are indeed referring to the map, I suggest they put “(Figure 2B)” after “thickest” in L185.

This sentence has been reworded to put “Figure 2B” after “thickest” (lines 242-243): “In central and northern parts of the study area, where the upper seismic unit is thickest (Figure 2B), low-frequency, low-amplitude, west to southwest-dipping sigmoidal to tangential oblique and shingled reflections are present.”