We thank both reviewers for their constructive and thoughtful comments, which have helped to strengthen the manuscript. In response, we have clarified the complementary roles of the *abrupt-127k* and *lig127k* experiments and expanded the guidance on their joint interpretation. We have strengthened the description of the required ocean and sea-ice diagnostics to ensure consistency with the CMIP7 data request, added and updated key references, and revised Table 3 to include the newly incorporated ocean variables. All suggested textual revisions and figure-caption corrections have been implemented.

In addition, we have added new appendix figures showing HadGEM3 Arctic Ocean stratification diagnostics (SST, SSS, and mixed layer depth). These directly address Reviewer 2's questions regarding near-surface ocean processes relevant to sea-ice change, and on the physical mechanisms discussed.

RC1: 'Comment on egusphere-2025-3531', Anonymous Referee #1, 23 Nov 2025

This manuscript provides a clear and well-organized protocol for the CMIP7 Assessment Fast Track abrupt-127k experiment. The scientific motivation, experimental design, and HadGEM3 example are well presented.

Thank you for this comment.

I have two brief suggestions:

1. **The manuscript distinguishes abrupt-127k from the quasi-equilibrium lig127k experiment, but it would benefit from clearer guidance on their complementary roles and how their results should be jointly interpreted.**

The lig127k experiment tests how well climate models simulate this past warm period by benchmarking their responses to known forcings against palaeoclimate evidence from across the globe, whereas the shorter abrupt-127k experiment focuses specifically on Arctic adjustments. The close relationship between lig127k and abrupt-127k helps ensure traceability of model-development impacts across simulation generations.

Text modified on page 4: *The abrupt-127k protocol draws heavily on the previous CMIP6/PMIP4 lig127k protocol (Otto-Bliesner et al., 2017). We note that the lig127k experiment tests how well climate models simulate this past warm period by benchmarking their responses to known forcings against palaeoclimate evidence from across the globe, whilst the shorter abrupt-127k experiment focusses solely on the Arctic. The close relationship between the lig127k and abrupt-127k helps ensure traceability of the impact of model development cycles on the simulations.*

In appendix B we add text:

\textbf{Tier 2: \emph{lig127k}}. ... groups may also find it useful to extend their initial 100-year runs until they reach quasi-equilibrium. This would enable them to have also

completed the PMIP4/7-lig127k, fully spun-up, 127k experiment. See also \citet{Otto-Bliesner2017lig127k,Otto-Bliesner2021Large-scalePMIP4}.

The \emph{lig127k} permits groups to further model responses to changes in orbital forcing, greenhouse gases, ice sheets, and feedbacks within the climate system \citep{Otto-Bliesner2017lig127k}. By benchmarking output against reconstructed temperatures, hydrology, sea ice, ice sheets, and ocean circulation during past warm climates, groups can further (i) assess model skill and structural uncertainty, (ii) improve understanding of key climate feedbacks and regional responses, and (iii) increase confidence in future climate projections under continued warming. In particular, the \emph{lig127k} and other PMIP interglacials simulations provide critical insight into polar amplification, ice-sheet stability, sea-level sensitivity, and the behaviour of the coupled atmosphere–ocean–cryosphere system under climates comparable to or warmer than today \citep{Otto-Bliesner2017lig127k}.

2. The protocol includes only insolation and greenhouse gas forcings. Given the availability of the lig127k experiment, additional forcings—such as Greenland Ice Sheet changes, meltwater fluxes, and sea-level variations—should also be considered, as they are important for Arctic sea-ice conditions.

These additional forcings are included within the lig127k experiment but are not part of the abrupt-127k protocol by design. We anticipate that the diagnostics and analysis framework described here will also be applied to CMIP7 lig127k simulations, where these additional boundary conditions are incorporated.

RC2: ['Comment on egusphere-2025-3531'](), Anonymous Referee #2, 22 Jan 2026

General Comments

This manuscript presents an experimental protocol for a "rapid" Last Interglacial simulation to assess how CMIP7 models would perform under 127 ka orbital forcing. The experimental protocol is well motivated by the fact the Arctic Ocean in the LIG likely had some periods of being completely sea ice free, or close to it. Investigating that phenomenon could help constrain how well CMIP7 models might represent future sea-ice free summers in the Arctic. As it's mostly about designing new experiments, I have mostly minor comments.

Thank you for this comment.

The one area which I found a bit disappointing was the lack of requirement for ocean metrics. Since this is an evaluation of fully coupled GCMs, it would seem sensible to have a decent collection of ocean variables as a standard feature of these experiments. The authors only request an 'optional' variable of daily sea surface temperature ('tos' in CMIP terms). I would recommend having a

requirement for monthly outputs of enough variables to enable a decent analysis of the ocean, for example:

- **Temperature (3D)**

- **Salinity (3D)**

- **Velocities (3D)**

- **Horizontal transport vectors (3D) – since these can be difficult to reconstruct directly from velocities**

- **Barotropic stream function**

- **Meridional overturning circulation**

- **Sea surface height**

- **Surface fluxes on the ocean grid**

- **Evaporation and precipitation**

- **Runoff**

(It's at the authors' discretion to think of a suitable set of ocean metrics, but I think there should be some ocean metrics.)

Part of the motivation for such metrics is that sea ice formation (and destruction) is closely tied to near-surface stratification. Sea ice formation requires the near-surface to be salt-stratified. If the near-surface becomes too salty this can inhibit sea ice. Thus, 3D outputs of temperature and salinity are essential to gain an understanding of the interplay. Likewise, the horizontal circulation and the meridional overturning circulation are critical to understanding how the North Atlantic and Arctic regions behave in terms of temperature and salinity.

Thank you for pointing this out. We take the opportunity to add the reference: Fox-Kemper, B., DeRepentigny, P., Treguier, A. M., Stepanek, C., O'Rourke, E., Mackallah, C., ... & Vancoppenolle, M. (2025). CMIP7 Data Request: Ocean and Sea Ice Priorities and Opportunities. *EGUsphere*, *2025*, 1-58. This presents the full CMIP7 ocean and sea ice data request, developed through an international, community-based process to prioritize variables for model output.

On line 6 we revise the text to read: *Required monthly variables for the recommended subsequent analyses are given in Tables \ref{tab:Amon_request} (atmospheric variables) and \ref{tab:SImon_request} (sea ice and ocean variables). These are primarily drawn from \citet{fox2025cmip7}, who present the full CMIP7 ocean and sea ice data request; modelling groups who are interested in having their \emph{abrupt-127k} simulation embedded in the wider PMIP framework are invited to consider this full*

PMIP data request. See also \citet{juckes2025baseline} for further information on baseline CMIP climate variables.

Table 3 has been modified to include the following additional ocean variables:

baseline_monthly   & mlotst   & ocean mixed layer thickness & N \\

baseline_monthly   & sos   & sea surface salinity & N \\

baseline_monthly   & tos   & sea surface temperature & Y \\

These additions provide the minimum set of near-surface ocean diagnostics required to assess stratification and its role in sea-ice evolution, directly addressing the reviewer's concern. The number of newly requested variables has intentionally been kept small; this (i) maintains the abrupt-127k experiment as a streamlined, light-weight, and broadly achievable protocol, and (ii) it fully preserves the clear one-to-one relationship between the requested variables and the analyses performed. See also below.

Line Comments

L57: "Analyse supports assessment…" Grammar is wrong

Corrected

L127: "ice decline is rapid (Fig. 3)". This should be Fig. 2.

Corrected

L141-142: Here one wonders, what about the ocean variables? As in my general comments.

Corrected

L146: "1 °latitude." Here there should be space between the degree symbol and "latitude".

Corrected

L191-214: I think all these numbered objectives ought to have new lines to make them clearer. Perhaps also use bold type on the letter and numbering to help clarify that is a numbered item. Having the objectives somewhat written like normal paragraphs, while being interrupted all the time by the "O3.1" and "O4.1" etc doesn't fit very well in my opinion, as if it's only going half-way to a proper list.

Corrected

Figure 5 caption, first line: "for example HadGEM3…", I think "for the example…" might be helpful.

Corrected

Figure 5 caption, "We use years 50-100". I thought it stated clearly in the text that it's years 51-100, not 50-100.

Corrected

Figure 6 caption, again "years 50-100", I thought this should have been 51-100?

Corrected

L237: Acronyms SIA and SIM are defined only the Figure captions and the appendix. I would also re-define them when using for the first time in the main text.

Corrected

L239: "Gt x 10^3". It seems very strange to put the power of 10 before the unit. I would state this as "10-15 x 10^3 Gt".
Corrected

L249: "the (i) the …" repeated "the".

Corrected

L250-251: "SAT increase values for which the model…" seems a bit garbled grammatically, please clarify this sentence.

Corrected

In keeping with my general comment, there are no Figures from HadGEM3 presented for Arctic Ocean near-surface stratification (e.g. temperature and salinity) and I think those are quite pertinent to the sea ice story.

To address this we include three additional seasonal-cycle plots from HadGEM3 showing Arctic Ocean sea-surface temperature (SST), sea-surface salinity (SSS), and mixed layer depth (MLD), showing piControl to abrupt-127k changes.

During the melt season (May–September), abrupt-127k is characterised by substantially warmer SSTs, slightly fresher surface waters, and a consistently shallower mixed layer relative to piControl, indicating enhanced near-surface stratification consistent with reduced sea-ice cover. Outside the melt season (January–April), differences are small: abrupt-127k shows marginally higher SSS and a slightly deeper mixed layer, but anomalies remain weak.

These ocean diagnostics demonstrate that abrupt-127k Arctic stratification changes are seasonally focused and closely aligned with the simulated summer sea-ice reductions.

To reflect this additional analysis, new Table 3 variables, we also write a new appendix:

\subsection{Further details, Arctic Ocean near-surface stratification}

To characterise upper-ocean adjustments in the \emph{abrupt-127k} simulation, we include additional seasonal diagnostics of Arctic Ocean near-surface temperature and salinity structure (Figs. \ref{fig:ocean_supp_fig_1}--\ref{fig:ocean_supp_fig_3}). These diagnostics use monthly data from years 51--100 and are calculated as area-weighted averages over 70--90\textdegree N, with no land mask applied, consistent with the surface energy budget calculations described above.

We indicate the relevant ocean variables from the \texttt{baseline_monthly} output in \underline{\textit{underlined italics}}.

Sea surface temperature (SST; \underline{\textit{tos}}) provides a measure of the upper-ocean thermal state. Sea surface salinity (SSS; \underline{\textit{sos}}) reflects freshwater forcing and stratification changes. Mixed layer depth (MLD; \underline{\textit{mlotst}}) characterises the vertical extent of active mixing and therefore the strength of near-surface stratification.

During the melt season (May--September), \emph{abrupt-127k} is characterised by substantially warmer SSTs, slightly fresher surface waters, and a consistently shallower mixed layer relative to \emph{piControl}. Together, these features indicate enhanced near-surface stratification consistent with reduced sea-ice cover and increased surface heating. Outside the melt season (January--April), differences are small: \emph{abrupt-127k} shows marginally higher SSS and a slightly deeper mixed layer, but anomalies remain weak.

These ocean diagnostics demonstrate that Arctic stratification changes in \emph{abrupt-127k} are strongly seasonally focused and closely aligned with the simulated summer sea-ice reductions described in the main text.

New figures: