Comment on cp-2021-184
Michiel Baatsen (Referee)

Referee comment on "Sea surface temperature evolution of the North Atlantic Ocean across the Eocene-Oligocene Transition" by Kasia K. Śliwińska et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-184-RC1, 2022

The authors present a new high quality dataset of proxy SSTs in the Northwest Atlantic Ocean spanning the late Eocene into the Oligocene. The obtained SSTs are compared to other available sites nearby, as well as adequate recent model results which spark an interesting discussion. I believe that these results can greatly contribute to our understanding of the events surrounding the EOT, covering a region where the available data is scarce.

General remarks:

- The manuscript is structurally sound, provides a balanced amount of proxy-/model-derived data as well as an extensive methodology and discussion sections. Overall, an extensive language/grammar check is needed as many small errors and typos remain in the text.
- While the comparison to model data is quite useful and important, the use of a single model makes it hard to judge which part of the results are the most model-sensitive. It is probably quite hard to find other adequate model data for this specific case, but the limitations could be highlighted more, especially considering the different deep water formation regimes. Compared to e.g. results in DeepMIP, despite representing Early Eocene conditions, it is clear that different models present a whole suite of possible overturning regimes under comparable boundary conditions.
- Although relevant, much of the discussion is rather superficial and qualitative in nature. Many of the claims/ideas would be hard to check in the available model data, but it could be helpful to have a more detailed look into some of the mechanisms that drive the changes in circulation and SST shown. This could include e.g. the radiative balance, surface/gateway fluxes, meridional temperature gradients and/or transports, and wind stresses.
Minor comments:

- The introduction cites many earlier, i.e. pre-2010 papers, so it could be useful to check for some more recent work on some of the subjects discussed here (e.g. potential Greenland glaciation or sensitivity to model boundary conditions around the EOT).
- In equation 1, the terms [37:2] and [37:3] are not explained.
- L184: rephrasing this sentence would make it more readable.
- L194: this statement may be a bit outdated, as several studies presented model simulations of comparable resolution in more recent years; e.g. Li et al. 2018, Tardif et al. 2020, Baatsen et al. 2020. Also several studies within DeepMIP, albeit for Early Eocene.
- L209: I would rephrase from using the term 'observations' for proxy data; these are proxies that give us an indication of SSTs in the deep past, but are not actual observations.
- Section 4.2: same remark as L209, also acronym NA used for North Atlantic which seems inconsistent with the previous sections, in which no acronym is used or introduced.
- L266: increased CO2 would indeed likely lead to higher temperatures and a reduced meridional gradient, but will still increase lower latitude temperatures as well. It does seems like increasing CO2 would not be very helpful if only higher latitude SSTs are underestimated by the model.
- L286: As the AMOC has not collapsed in the modern climate, this comparison is a bit odd. Some future projections show an AMOC slowdown, but this needs to be stated more carefully.
- L289: it would be helpful to have some more specifics on the actual related AMOC strengths and associated meridional heat transport to support this claim.
- L327: This may even be more important than changes in AMOC strength, as they do not induce the expected SST changes seen in the proxy record (as argued). On the other hand, the idea of this site sitting on the edge of 2 gyres shifting over time does not match well with the relatively small SST variability, as such SST changes are often strongly related to the background gradients.

Figures:

- Fig4: Not very intuitive and tough to read; many overlapping points and lines. Consider separating the pre/post-34.5Ma into 2 panels?
- Fig5: It is hard to distinguish between the different panels and see the differences, especially for the proxy SSTs. Differences are also shown in Fig6, but as of now Fig5 does not seem to be adding much information apart from an overall idea of absolute SSTs.
- Fig7: What is the added value of showing the barotropic stream function? This is rather hard to interpret, as it represents the depth-integrated flow, while the rest of the manuscript mostly discusses (near-)surface conditions. With the presence of a meridional overturning circulation, such as the AMOC in this case, it becomes quite hard to distinguish the wind-driven gyres within these fields.
Technical comments/typos:

- As noted above, a thorough language check is needed. Some examples: L95 conclude with summary, L128 as follow, L151 fifteen, L282 studies has, L304 gateway changes?, L307 require L338 provides
- Typos:
  - L90: circulation
  - L206: the the
  - L245: equivalent
  - L251: ensemble
  - Section 5.1: title SST (2x) -> EOT?
  - L293: Arctic
  - L294: it may
  - Fig2: therein
- Other small Errors:
  - L276: the model has too low polar temperatures?
  - L306: Southern Ocean Gateways?
  - L357: missing word