Interactive comment on “The role of East-Tethys seaway closure in the middle Miocene climatic transition (ca. 14 Ma)” by N. Hamon et al.

Anonymous Referee #2
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The presented and discussed model outcomes are very interesting, and contribute towards the ongoing discussion on the causes of the Middle Miocene Climatic Transition (MMCT) and consequences of the closure of the eastern Tethys seaway – the connection between the Indian Ocean and the (proto-)Mediterranean. The author’s also try to use their model outcome to constrain the timing of the closure of this seaway, linking the end of Tethyan Indian saline water (TISW) production to the MMCT (Woodruff and Savin 1989 and other references giving in the manuscript), but the identification of TISW in Indian Oceans isotopes is, to date, controversial (e.g. Smart et al. 2007). The manuscript would benefit greatly from re-structuring and re-writing the results and discussion in such a way that the focus is more on the TISW and AMOC, the actual outcome of the modeling experiments, and that the closure had very little effect on the global climate. In this sense, many details concerning previously published model outcomes and the Middle Miocene climate should be part of the Introduction/Background. Consequently, I suggest a moderate to major revision for this manuscript. I have the following comments concerning Hamon et al.’s manuscript.

We thank Referee #2 for his comments and suggestions on our manuscript. In the future version, we will rewrite the introduction in order to better explain what motivated our study. In particular, we will include more detailed reviews of previous modelling work, tectonic events of the East-Tethys seaway closure, and Miocene oceanography.

• A reference and discussion on the oceanic box model and ocean circulation model by Karami 2011 and Karami et al. 2011 (see references below) is entirely missing even though these are relevant for the presented model data and results. Karami 2011 finds a flow reversal between the western Mediterranean and the Atlantic Ocean when introducing a sill of 500m in the eastern Tethys connections. This flow reversal is found here in the shallow eastern Tethys experiment (Mio250), which is suggested to intensify the MOC (AMOC?)

We will include a discussion on the results of Karami (2011) in our introduction, as well as a presentation of previous modelling studies on the middle Miocene. Moreover, the comparison of our results with those of Karami (2011) will be made briefly in the discussion.

• I advocate to use ‘Paratethys’ for the northeastern geographic extend, an intercontinental sea following Rögel 1998, Rögel 1999, Harzhauser et al. 2007, Harzhauser and Piller 2007, de Leeuw et al. 2011 and many more. The region of the present-day Mediterranean during the Miocene is referred to as the Mediterranean basin or Proto-Mediterranean (see Rögel 1999, Harzhauser et al. 2007, Harzhauser and Piller 2007). As a consequence, the author’s draw incorrect conclusions and use incorrect citations in the discussion of their model results. For instance, on page 2127, line 21, the reference de Leeuw et al. 2013 is incorrect in this context. De Leeuw et al. 2013 dated the onset of the Badenian salinity crisis at 13.82 Ma, which is triggered by the glacio-eustatic restriction of the connection between the Central Paratethys and the Mediterranean and not the Paratethys and the Indian Ocean as written in the text. Again, the Paratethys-Indian Ocean connection differs significantly from that of the (proto-)Mediterranean and the Indian Ocean (see Harzhauser et al 2007). See also Karami et al. (2011) for modeling experiments concerning the (proto-)Mediterranean and Paratethys disconnection during the Miocene.

We agree that the use of the name Paratethys is not sound in our manuscript and led to misinterpretation of the literature. Actually we are rather studying the Proto-Mediterranean, as the TISW comes from this basin (salinity in the Paratethys is actually very low and this basin cannot be considered as the source of TISW). Moreover, the seaway we are studying, the Eastern Tethys seaway, connected the Mediterranean and Indian basins. Therefore we will correct this mistake in a future version of our manuscript.

• The link between the closure of the seaway and the demise of the TISW should be emphasized more as this is a very important result. Previous work should be summarized and additional references included, such as Ramsay et al. 1998 and Smart et al. 2007 that pick up the hypothesis of Woodruff and Savin (1998). In particular Smart et al. (2007) argue that the published stable isotope data from two Indian Ocean DSDP sites (from Woodruff and Savin 1991) do not unequivocally show the presence of TISW/TOW between 17 and 5 Ma in the Indian Ocean. It is still a very interesting point, which the authors should address in more detail and could potentially suggest that identifying and dating the end of TISW production could date the most significant step in the closure of the eastern Tethys seaway. But for this, they need to discuss all available published data on the TISW production and TOW into the Indian Ocean.

We will improve our introduction in the future version of our manuscript. In particular, we will include more detailed discussion of oceanographic data and summarize what we know on the TISW, the Eastern-Tethys seaway closure, and the MMCT.

• The intensified AMOC when the eastern Tethys seaway is shallow (Mio250) and closed (MioC) is a very interesting model result and needs to be discussed in more detail in terms of the effects on the palaeoceanographic circulation and on Middle Miocene climate (see also Holbourn et al. 2013, Ramsay et al. 1998, but also Karami 2011 etc). See Holbourn et al. 2013 on the importance of meridional overturning circulation (MOC) and orbital forcing of the Middle Miocene Climatic Transition.

We will include a more detailed discussion on the consequences of enhanced AMOC in our manuscript.

• All description and results of previously published models should be summarized in the beginning of the paper in order to show the need of the here presented model and model outcome.

This has also been suggested by Dr. Herold (referee #1), and we agree that such a presentation of previous modelling studies is necessary in the introduction. This will be done in the future version of the manuscript.

• Also, all information on the Miocene climate, tectonic and oceanographic changes should be part of the Introduction/Background.

> – The authors should discuss the Monterey event, which has been attributed to contribute to the Middle Miocene climatic change.
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> *We will include a discussion on the Monterey hypothesis in the part dealing with the possible causes of the MMCT (CO2 vs seaway closure).*
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> – Also, a discussion on the Langhian transgression and its implications for the eastern Tethys seaway is missing.
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> *We will rewrite our introduction for a better understanding of the timing of East-Tethys seaway closure. Here, we consider that the “final closure” is the end of the Langhian*

transgression, during which water exchanges occurred between the Indian, Mediterranean and Paratethys basins (Rögl, 1999). When we discuss the closure of the Tethys seaway, we do not directly refer to tectonic events, but to the end of water exchanges between basins. We will include a review of tectonic events of the closure of the East-Tethys seaway, as well as the evolution of its constriction in our introduction.

• A more detailed summary of the significant tectonic event (e.g. diachronous collision of Africa with Eurasia, i.e. Robertson 2000, Golonka et al. 2004 and many more) and the evolution of the restriction of the eastern Tethys seaway as described by Harzhauser et al. 2007, Harzhauser and Piller 2007, Rögel 1998, Rögel et al. 1999, Reuter et al. 2007 etc. - including the timing of mammal migration (gomphotherium landbridge) - should from part of the Introduction/Background and should be later referred to in the Discussion, in particular on the timing of the closure.

As indicated above, we agree with this comment, and we will modify the manuscript consequently.

• A short description of the four chosen model set-ups, including water depth, width of gateway and location of gateway is missing but would help the reader.

We included a table indicating the depth of the Eastern-Tethys seaway. As we performed sensitivity experiments, width and location of the seaway are identical in the three experiments with open seaway (Mio4000, Mio1000 and Mio250). We will add this precision in our manuscript.

• A more detailed discussion on (the implication of) the width of the gateway is missing as other models have shown to be an important factor.

As we do not test the impact of the width of the seaway, but only its depth, we do not include such a discussion. However, we agree that it should be interesting to mention that this factor can have an important impact in the conclusion.

• Please show all four models configurations at least once in a figure.

As indicated above, the four experiments were performed with the same geographic configuration (shown on Fig. 1). We only modified the depth of the Eastern Tethys seaway. As this is not clear in our manuscript, we will rewrite the description of experimental settings. However, we do not think that a figure showing the four configurations is necessary.

• The authors should integrate their model results also with biogeographic and tectonic evidences of the gateway closure

– If the isotope data does not unambiguous point towards TISW production and TOW in the Indian Ocean (Smart et al., 2007) between 17-5 Ma, then a temporal link to the timing of separation of bioprovinces, and the gomphotherium landbridge cannot be ruled out and the main step in the disconnection, the shallowing to ~250m of the eastern Tethys seaway is not unambigeouly linked to the MMCT. The authors do argue that the closure has very little impact on ice sheet build-up and therefore climatic cooling.

Our results emphasize the link between Eastern-Tethys seaway shoaling and the end of TISW production. We also find strong modification of oceanic circulation, in particular a reinforcement of the AMOC. However, we cannot directly link the MMCT to the closure of the East-Tethys seaway, and we indicate that the climatic changes between our simulations are not sufficient to explain the Antarctic ice-sheet growth.

What we can conclude is that, if data-based reconstructions can unambiguously date the termination of TISW, our work suggest that this corresponds to the shoaling of the East-Tethys seaway to approximately 250m (this depth being model-dependant)

• A discussion on the link between TISW production/TOW in the northern Indian Ocean and the Middle Miocene Climatic Transition is missing, but would greatly improve the manuscript. In particular, considerung the model finding that the closure of the eastern Tethys seaway, which stopped TISW production, has very little influence on the cooling, precipitation and ice sheet growth over Antarctica, which, in turn had been argued to be the trigger (Woodruff and Savin 1989, Wright et al. 1992 etc.).

We will discuss this in more detail in the next version of our manuscript. The important point is that the Eastern Tethys seaway closure strongly modifies the oceanic circulation. Although climatic changes induced by the closure of the seaway are not sufficient to initiate the MMCT, we argue that the oceanic changes due to this closure could have played an important role. However, our results are not consistent with the hypothesis according to which TISW termination was the trigger of the MMCT.

• An entire paragraph (4.3 The cause of the Middle Miocene Climatic Transition) is dedicated to the discussion on the effect of changing pCO_2 on the Middle Miocene Climate Transition, which is purely based on previously published data, while the model experiments neither take pCO_2 into consideration, nor provides any insight into this issue. I advise to describe the effects of changing pCO2 in the Introduction/Background, while only in the conclusion refer to it as one of the most likely trigger for the Middle Miocene climatic cooling in the author's opinion.

This paragraph will be modified in the future version of the manuscript: we will delete the discussion about pCO2 in experiments performed with slab ocean models (which results will be presented in the introduction). However, we will discuss the climate sensitivity, as we noted that it was higher for the Miocene than for present-day experiments. We suggest that this can be due to oceanic changes, and we will discuss this point. Moreover, we will include here a discussion on the respective roles of CO2 and seaways in global cooling events (Eocene/Oligocene and Pliocene).

• Concerning the reference Allen and Armstrong (2008): The suggested mechanisms explaining pCO_2 drawdown, in particular total organic carbon storage, is referring to the Maykop and Menilite units in the Paratethys, not Mediterranean basin.

We thank *Referee N#2 for this remark. We made a mistake here and will correct it.*

• Use capital letters for the Middle Miocene Climatic Transition, and Middle Miocene Climatic Optimum as they are the names for these events.

It will be corrected in the future version of the Manuscript.

• In Figure 5, upper panel, the (proto-)Mediterranean basin is labeled Tethys Sea, while in the figure caption it is referred to as the Paratethys. Please be consistent in naming the oceanic basins. Again, it is not the Paratethys, but the (proto-)Mediterranean basin. The Paratethys Sea was already partly separated from the (proto-)Mediterranean basin during the early Miocene, and in particular during the Middle Miocene (see e.g. Harzhauser et al. 2007, de Leeuw et al. 2011).

As indicated above, we will change the names we use, as we are studying the Proto-Mediterranean and not the Paratethys basin. We also will modify this in the figures.

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