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Climate of the Past
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Interactive comment on "Model study of the circulation of the Miocene Mediterranean Sea and Paratethys: closure of the Indian Gateway" *by* A. de la Vara et al.

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General Comments

The authors of this paper use a regional ocean circulation model to study the circulation of the Mediterranean and Paratethys in the Miocene. Using different topographic boundary conditions the sensitivity of the ocean circulation and water mass properties with respect to varying Indian Gateway depth has been estimated. A shallow Indian Gateway (220m) corresponds to an effective closure of the gateway in terms of basin-scale circulation; the shoaling of the Indian Gateway leads to a saltier Paratethys.

The paper is well written and relates geological evidence to an oceanographic question: How does the closure of the Indian Gateway affect regional and global ocean circulation? Therefore, I find the paper suited for CP.

The overall structure of the paper is OK but the results section needs some work. I found some sentences and paragraphs hard to follow, especially if they were too long or consisted of too many subordinate clauses.

I recommend this paper for publication in CP after the following major concerns have been addressed.

- The study is motivated by the role closure plays for the global circulation but this is to large parts barotropic; closure is related to flow reversal in other model studies but these flows are generally barotropic (p.4388/ll.12), e.g., von der Heydt and Dijkstra (2006)
- for better evaluation of results a present-day boundary conditions setup is essential (not only mention in the discussion that results are comparable to a more comprehensive model). A comparision to the Miocene results would make the paper even more valuable.
- Deep water formation in the Mediterranean takes place mainly during winter. Therefore, the seasonal cycle is important for present-day. What is the role of the seasonal cycle in this study. If there is none, is it not important?
- The structure of Sect. 3 has some flaws and the separation between overturning and velocity/salinity does not work well in my opinion. The authors should put the focus on the individual stages of gateway closure as they did in the subsections of 3.2
- How is the Atlantic affected by the exchange? Today Mediterranean outflow water is one important source of North Atlantic Deep water which drives the Atlantic

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meridional overturning circulation.

- In the introduction, proxies records showing that closure affects temperature and salinity have been mentioned. Why not incorporating (these numbers) in the discussion of the results?

In the specific comments section I list my remarks in accordance with the paper structure

Specific Comments

Introduction:

- p.4389/l.6 new observational evidence: what kind of evidence would that be?
- l.8: What are sedimentary basins?

Model Description:

- Sponge boundary conditions are important part of the study and have to be mentioned earlier than in Sect. 2.3, i.e., in the abstract (to let the reader know what kind of experiments to be expected)
- Missing reference for Levitus data, p.4392/l.5
- Atmospheric forcing is constant in time: present-day deep-water formation during winter in Gulf of Lion (see above)

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- Evaporation is set to 0.5m/yr. The present-day seasonal cycle is large—precipitation has an amplitude of 700mm/yr and evaporation 1000mm/yr—and there is a significant east–west gradient (Mariotta et al., 2002). Why is a constant evaporation still justified?

Results:

- p.4394/ll.9-11: I cannot see this from the overturning circulation in Fig.4
- p.4396/ll.4-5 and p.4397/ll.4-7: I don't get that from the figures. Maybe add a "not shown"?
- p.4398/ll.16: The homogeneous salinity pattern with non-uniform evaporation may result from a too large decrease in evaporation. What would happens if the basin-wide average evaporation is kept the same, i.e., evaporation over the Mediterranean increases on the expense of a lower evaporation over the Paratethys.
- p.4398/ll.13: The effect is also comparable to the intermediate IG (Fig. 4b)

Discussion:

- p.4400/ll.2: Isn't that obvious? How would imposing a slightly different evaporation rate or temperature profile change the large-scale circulation with respect to the closure of an ocean gateway?
- p.4400/l.8: What is the two-level bathymetry
- p.4400/l.10 What does "very similar" mean?

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- I have difficulties to understand what the second paragraph of 4.1. is about. The aspect of a net barotropic transport needs clarification. For example, a net transport from the Indian Ocean into the Atlantic can reverse the freshwater transport across the Strait of Gibraltar (see Fig. 12e/f in Krapp and Jungclaus, 2011)
- provide a definition of "anti-estuarine" earlier in the text
- In 4.3 the authors discuss local temperature changes in response to gateway closure but this has not been shown in the results. (Also relevant for conclusion point 4)
- p.4406/ll.5: Isn't it trivial that outflow from a basin with imposed evaporation is saltier than the inflow? (Also relevant for statement 3 of the conclusions)

Conclusions:

- point 6: That Indian Gateway closure affects Indian Ocean water and, hence, the development of the East Antarctic Ice Sheet cannot be concluded from the results shown here. This point is more of a conjecture.

Tables:

- Choose one significant digit in Table 2 and 3 to facilitate readability.
- Regarding the numbers from the tables: What about variability in temperature, salinity, and stream function, for example, in terms of standard deviation (+/-)?
- The interpretation of Table 1 is difficult and more connections within the text are appreciated.

Figures

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- Dashed lines in Fig. 4 are hard to read
- I've had a hard time reading the velocities from Fig. 5. I suggest to plot velocity vector field separately with absolute values as colors.

References

Krapp, M. and Jungclaus, J. H. (2011), The Middle Miocene climate as modelled in an atmosphere-ocean-biosphere model, Clim. Past, 7, 1169-1188.

Mariotti, Annarita, Maria Vittoria Struglia, Ning Zeng, K-M. Lau (2002) The Hydrological Cycle in the Mediterranean Region and Implications for the Water Budget of the Mediterranean Sea. J. Climate, 15, 1674–1690.

von der Heydt, A., and H. A. Dijkstra (2006), Effect of ocean gateways on the global ocean circulation in the late Oligocene and early Miocene, Paleoceanography, 21, PA1011.

Interactive comment on Clim. Past Discuss., 9, 4385, 2013.