

Interactive comment on “Links between CO₂, glaciation and water flow: reconciling the Cenozoic history of the Antarctic Circumpolar Current” by J.-B. Ladant et al.

Anonymous Referee #1

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The authors of this manuscript study the effect of the building of an Antarctic ice sheet on the surrounding southern ocean, in particular the possible development of a (proto)-ACC. While many studies have focused on the effects of ocean circulation changes (e.g. the development of an ACC) on ocean heat transport and ice-sheet development, this study takes a complimentary angle on these issues, with the aim to better constrain the actual development of the ACC.

This is an interesting approach, and the model design seems to me reasonable. However, the analysis of the results in this manuscript is way too simple in my opinion. Firm conclusions could potentially been drawn if a lot more analysis of the model results is included in the paper.

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The main point of the paper is, that increased sea ice formation changes the meridional density structure in the Southern Ocean, which drives an ACC-like current. From the figures provided I cannot see whether this is really the case. The two (Ross- and Wedell) gyres indicated in Figure 2c, develop in areas where there is always sea ice in winter, particularly in the Tasman region (Figure 4), so I don't see why these gyres are important for the ACC flow and why they should develop? In addition, I guess that due to the buildup of an ice sheet the wind structure will change quite dramatically in some regions, this is not shown nor discussed in the paper. (The used atmospheric model might also be not sufficient to study this in detail.). The density structure shown in Figure 5 is indeed quite different for no ice sheet or a full ice sheet, but why this is, cannot be concluded from the model results shown so far.

Section 2: Models and Experiments Some information on the spinup procedure and the length of the simulations would be adequate here! Are the experiments in equilibrium? As the atmospheric model is quite low resolution, maybe a discussion about model limitations would be also in place.

In conclusion, I recommend the paper to be considerably revised and much more further analysis necessary before it can be published in *Climate of the Past* or anywhere else.

Specific comments: Page 2399, lines 1-3: There are even earlier estimates of Drake Passage openings. In fact since 50 Ma Drake Passage seems to be opening (Eagles et al. 2003, 2006).

Page 2401, lines 18-28: What would the authors define as a real ACC-flow? And when is it only a weak eastward transport?

Page 2402, lines 18-25: Here it is explicitly stated that the ACC is a delicate balance between wind-driven and buoyancy driven currents, so why only focus on the density driven part?

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Page 2405, lines 1-8: This discussion is extremely vague. The case with full ice sheet and high CO₂ is also most likely inconsistent on the long term, so the sea ice distributions are unreliable. Again also the wind pattern will change, and so will the circulation.

Interactive comment on Clim. Past Discuss., 10, 2397, 2014.

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