

## ***Interactive comment on “Decadal trends in the Antarctic sea ice extent ultimately controlled by ice-ocean feedback” by H. Goosse and V. Zunz***

### **Anonymous Referee #4**

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The authors investigate positive decadal trends in Antarctic sea ice in a coupled climate (LOVECLIM) and study a possible mechanism that causes such trends in a simple 2-layer box model. It is useful to examine the multi-decadal trends or internal variability of the climate system, in comparing with the trend in the last 30 years of satellite observation. LOVECLIM seems a reasonable model for the task. The results would be interesting for a broad readership. However, I have two concerns regarding this study. First is the annual average of LOVECLIM output, and second is the treatment of the entrainment in the simple model. I recommend a revision before a publication.

The physical processes related to ice-ocean interaction in winter and summer are very different. Annual average would mix the results from those processes. For example, the top 200m would likely include both seasonal mixed layer and winter mixed layer. The

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annual average of heat content in the top 200m mixes results from stabilization of water column due to ice melt and vertical overturning due to ice formation. Annual surface salinity also reflects sea ice melt in summer and brine injection from ice formation in winter. What is the meaning of averaging the two processes? Which process primarily contributes to the positive feedback at interannual time scale? I would appreciate some discussion addressing the issue.

Regarding the simple 2-layer model, it is not quite clear how the entrainment is treated between layer 2 and the layer below. When seasonal mixed layer (layer 1) is eliminated in winter, the overturning will entrain warmer and saltier water into layer 2. The negative feedback kicks in. The process will occur even there is no deep convection. What makes the system transform from a negative feedback at seasonal time scale to a positive feedback at interannual time scale? Why S1 and S2 are reduced each year? Does the result depend on the assumption of very thin layer 2 in the model? If there is a positive feedback at interannual time scale, should we see ice thickness increasing instead of decreasing from year to year (figure 10c)? Downward salt flux is overly simplified explanation since S2 does not increase over years. Considering the exchange between layer 2 and deeper ocean, the entrainment would bring salty/warmer water into layer 2 (upward salt flux). More explanations are needed for readers understand the result.

Some detailed comments.

Page 7, and figure 3, Is the heat content at 200-500m affected by sea ice formation? It would be helpful to show the stratification of LOVECLIM as function of latitudes or spatial distribution of the winter mixed layer depth, so readers can see whether 200-500m is relevant.

Page 14. Regarding LOVECLIM simulation, “The overall trend in ice extent is of  $-38 \pm 93 \times 10^3 \text{ km}^2$  per decade”. Do you really mean a negative trend (decreasing ice extent)?

Labels in figure 3 and 7 need to be enlarged.

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Interactive comment on The Cryosphere Discuss., 7, 4585, 2013.

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