

Interactive comment on “The efficient global primitive equation climate model SPEEDO” by C. A. Severijns and W. Hazeleger

Anonymous Referee #3

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General comments

This paper introduces the coupled climate model SPEEDO, and describes four experiments: a 1000yr control (preindustrial) simulation, an ensemble of experiments simulating the period 1800–2100, a CO₂ doubling experiment and a scenario experiment with enhanced CO₂. The paper certainly falls within the scope of Geoscientific Model Development, and is generally well written, clear and concisely covers a lot of material. The model appears to be a useful addition to the suite of coupled models currently in use and is likely to generate significant scientific results in the future. The component atmosphere and ocean models are well known and well regarded. The source code is freely available. On all these counts I recommend that this paper is accepted for publication. However I have a few concerns which I would like the authors to address

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before publication. The model has four features which I think deserve further explanation, these are 1) lack of ENSO, 2) weak AMOC/NADW production 3) very low summer ice concentration and 4) centennial scale oscillations in Antarctic sea ice concentration. Whilst I do not expect to see full explanations in a paper of this nature it would be useful to have some indication or even speculation as to what is going on. I would be wary about using a model with only 8Sv AMOC and 0.5PW Atlantic heat transport to study climate related processes in the Atlantic for example unless I had some idea of what causes this. Is ocean convection very weak? Is the Gulf Stream too broad and diffuse? Is Denmark Strait too deep/too narrow? What are the coefficients of vertical diffusivity and viscosity? The authors show very little in the way of ocean diagnostics apart from the ubiquitous MOC. For the low summer sea-ice concentration the authors could at least look at the seasonal cycle of surface heat fluxes/air temperatures/SST. ENSO is always difficult to reproduce of course, but is the lack of ENSO due to deficiencies in simulating the Walker circulation or does the ocean model have trouble reproducing the east-west tilt in the thermocline in the Equatorial Pacific? I am reasonably happy with the explanation of the centennial oscillations in Antarctic Sea-ice (p1125), but in the other cases I would like to see at least a similar level of explanation (including more Figures if necessary), otherwise the reader is in some doubt about how the model handles some of the fundamental features of the climate system.

Specific comments

Page 1118 line 25 “the model was tuned such that...” How was the model tuned to ensure the energy loss affects only the top of the atmosphere?

P1119line 16 “pole problem” – jargon – probably best to rephrase this.

P1120 line 4 “was spun up for a period of 2000 years” What was the initial state used to initialize the spinup?

P1120 line 25 “all quantities the drift is smaller than the standard deviation” – only just smaller in the case of ocean temperature, salinity and sea ice. Without seeing time

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series it is difficult to assess if the model is in equilibrium or even if it is tending towards equilibrium. Time series of global mean sst and sss would be helpful.

P1120 line 26 “energy loss of 1.5 W m^{-2} ” – This is quite a substantial loss of heat and would be a concern over millennial scale runs even if it is confined to the top of the atmosphere (stratospheric level). Is this a common problem with atmosphere models?

P1121 line 8 “salinity in the ocean is not constant because CLIO is a constant volume model” – please explain further

P1121 line 25 – “ensemble mean” – the simulations are for 300 years so can they be compared to the literature values? Shouldn’t the time average be taken over the same period as in the observations?

P1122 line 8 “ after correcting the TOA and surface budgets. . .” What is the rationale behind doing this and what does it show?

P1123 line 9 “typical features of coarse resolution climate models” examples?

P1123 line 15 “CMIP multi-model ensemble” – reference?

P1123 line 22 “probably associated with low production of..” – almost certainly I would have thought.

P1124 line 1 “heat transport to vary by 0.05 PW ” – Atlantic or global heat transport – what does the atmospheric heat transport look like?

Page 1126 line 20 “ Fig 16 shows that the model is close to equilibrium although the deep ocean still warms” The surface ocean is perhaps in equilibrium, not the whole model. The figure does not show that the deep ocean is still becoming warmer.

Technical corrections

P1119line 16 “pole problem” – jargon – probably best to rephrase this.

P1127 line 22 “decreases” should be “increases” I think.

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P1130 line 2 “gasses” should be “gases”

P1130 line 3 “beard” should be “borne”

Figures 3, 5, 16, 17 and 18 also have no colour scale

Caption of Figure 14 is confusing (is this a plot of correlation coefficient?) and it is not clear what the colour scale units are. Overturning is not measured in units of s^{-1} .

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