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Geoscientific Model Development Discussions

Interactive comment on "Downscaling the climate change for oceans around Australia" *by* M. A. Chamberlain et al.

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Interactive comment on "Downscaling the climate change for oceans around Australia" by M. A. Chamberlain et al. Anonymous Referee 1

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The paper by Chamberlain et al. introduces results from a downscaling experiment, in which fluxes obtained with a coupled ocean-atmosphere simulation of the 'A1B' climate change scenario are used to drive an ocean-only model with higher resolution in the Australian region.

I found the paper interesting and certainly worth of publication. The paper is well written, clear and thorough. The technique and results presented are innovative and

useful for a variety of applications.

My only comment is that there seems to be little analysis on the differences between the coupled and downscaled experiments in terms of 'marine impacts of climate change on regional and local scales' (line 5, page 443). Providing maps of SST, SSS and stratification does seem a bit preliminary. Ideally, one would like to see the biogeochemical response in the high-resolution area around Australia, and whether resolving the mesoscale has a clear impact on 'marine life in Australian waters' (line 4, page 427).

RESPONSE: Text in the introduction and discussion has been modified to clarify that the purpose of this paper is to present a novel methodology to downscale ocean projection. Several studies using the projections from this method are underway: one study focusing on the changes in the Australian ocean boundary currents have been published (Sun et al., 2012), the other one focusing on ecological impact (Cheung et al., 2012) is also published, and another focusing on the biogeochemical response has just been submitted (Matear et al., 2012).

You say that 'the magnitude of differences in SST change is $\sim$ 0.5 C and SSS change $\sim$ 0.1 psu between the downscaled and the coupled model projections' (line 11, page 442). Are these differences worth the downscaling exercise? Do these differences lie outside the spread of multi-model simulation in the Australian area? You actually use two very different versions of the same ocean model (MOM2.2 in the CSIRO Mk3.5 climate model and MOM4.0 in OFAM); could this potentially affect your upper ocean response?

RESPONSE: Differences in SST have not been compared to differences with other models. Although the projected SST changes by ODM is likely to be within the multi-model spread (given its modest magnitude), a very interesting result is its spatial pattern is different from the climate model projections. For example, warming of the EAC extension within the Tasman Sea is a common feature in climate models, while SST

warming in the ODM is more prominent at the EAC seperation point further north. Discussion of this distinctive difference is the subject of Matear et al. (2012).
Model biases exist in both models due to different parameterisations, different resolutions, coupling or lack of coupling, etc, as with any ocean models. By comparing the changes between the future and present simulations by each model, the impact of model biases on the analysis is likely to be reduced. Therefore, we focus on the projected changes by the two models. The hypothesis is that by resolving the mesoscale dynamics in the new projections, we could study boundaries currents, eddies and their effects with more confidence. By resolving mesoscale features (like eddies and boundary) we simulate a change in the character of the warming. This is a key result of the work and suggests the need to resolve mesoscale features to assess impact on climate change on the marine environment.
Discussion of these points is added throughout the paper.

Minor comments:

What are the changes in upwelling (vertical velocity)?

RESPONSE: Good question, but this diagnostic has not been looked at extensively because the large spatial variability in the vertical velocities due to eddies in the ODM makes it difficult to extract trends from simulation. Further, the lack of direct observations make it a difficult quantity to assess in the simulation too.

(page 430, line 13) 'coarser resolution outside this region'. How coarse is the model outside the Australian region?

RESPONSE: The range of resolution of model is now quantified in the text, "telescoping to 2 deg resolution far from the region of interest."

(page 438, line 7) 'despite the different amplitudes ...'. I understand the point here, but the amplitude is crucial too in order to assess whether high-res is important or not in climate change simulations of marine life in Australian waters. The effects of climate

change on the marine environment must be a function of both spatial patterns and magnitude of warming. The feedback parameterization proposed does change both SST and SSS response in a non-trivial way. In the abstract you say that 'While the magnitude of the climate change differences may vary with the feedback parameterization used, the patterns of the climate change differences are consistent ...' (line 14, page 426)'. But I think one of the main points of the downscaling and the paper is the feedback parameterization, so it's importance, and control over the ocean response, should be highlighted.

RESPONSE: Initially, our conclusions were focusing on the mechanism driving the difference in the ocean's response to climate, and the ODM simulations show a consistent difference in the SST warming which suggests that resolving mesoscale features has altered the climate change projection in a robust way. But yes, feedback is evidently playing an important role, also modifying the impact. We now include this in the discussion, where we present the projection with restoring as our best estimate of the future climate, and the range of experiments give some indication confidence. Also, we recognise that feedback has been handled here in a rather simple way and that this is one area of further research and development.

References:

Cheung et al. 2012. Climate-change induced tropicalisation of marine communities of Western Australia. Marine and Freshwater Research, 63, 415-427.

Matear et al. 2012. Climate change projection of the Tasman Sea from an eddy-resolving ocean model, Global Change Biology, submitted.

Sun et al. 2012. Marine downscaling of a future climate scenario for Australian boundary currents. J. of Climate, 25, 2947-2962.

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