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Ocean Science Discussions

Interactive comment on "On the Indonesian throughflow in the OCCAM 1/4 degree ocean model" *by* U. W. Humphries and D. J. Webb

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Response to Referee #4

We would like to thank the reviewer for the helpful and knowledgeable comments. Concerning individual points raised:

1. Viscosity and Tides

We agree with the reviewer that the strong internal tides generated by the ridges in the region will in turn lead to localised regions of strong and intermittent mixing. The OCCAM model did not include the effect of such mixing but the results may be of use for comparison with more sophisticated models in the future.

Recent models of the area have introduced schemes using spatially varying viscosity in order to represent the extra tidal mixing (Lee et al. 2006, Koch-Larrouy et al, 2007).

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Intermittency is also a feature of tidal mixing and needs to be considered in future. A good set of observations of internal tides and mixing in the region would also be useful.

2. Makassar Throughflow

We agree that the width of the narrows at the southern end of the Makassar Strait is too small and may be responsible for the reduced transport through the strait. We hope to test this hypothesis using a higher resolution version of the model.

3. Karimata Strait.

Following the reviewers comments we investigated the flow through the Karimata Strait in more detail. We found that the strait was responsible for most of the sea-level difference between the South China Sea and the seas to the south-east. We also found that the dominant term in the strait opposing the pressure gradient was bottom friction. This new analysis will be discussed in the revised paper.

The reviewer also queried whether the Karimata flow turned northwards and was responsible, in some way, for the reduced flow through the Makassar Strait. We have looked at this but have found no feature of the flow to support the hypothesis. However we also found nothing to indicate that the hypothesis is wrong.

4. Return flow to the Pacific

The only point that we would like to make here is that although models can have significant failings they do force the flows to be consistent on the large scale. As a result as here, in the discussion of a possible return flow to the Pacific, they are helpful when thinking about large scale connections. They are also useful for generating new hypotheses (predictions?) that can be tested experimentally.

5. Lombok Strait and Halmahera

The flow through Lombok Strait in the model is obviously wrong and as a result the flow past Timor is less than it should be. It is not clear to us that this reduced flow

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encourages extra flow southwards through the eastern Halmahera route. However it is an interesting hypothesis and one we should be able to test with the higher resolution version of the model.

6. Ombai sill

We thank the reviewer for the revised data. Unfortunately, because of cost, we cannot rerun the model with the revised sill depth but it may be possible to check the effect in later model runs.

7. Issues

We agree with the issues raised which we believe are fair and reasonable. The development of numerical models, especially global models, has to be iterative and it is often worth concentrating on 'difficult' areas like Indonesia because they are often best for highlighting areas where improvements need to be made. In this case we hope that the model results are of interest to others and that they will help to stimulate a better understanding of the region, better models and new experimental work.

8. The Godfrey Rule

We agree that the implications of the Godfrey Rule need to be followed up. The reviewer has proposed one hypothesis. Another is that the North Pacific becomes involved via the equatorial current systems. The New Guinea coastal undercurrent is a significant flow which (a) has its source in a northward flowing western boundary current in the South Pacific and (b) almost reaches the Indonesian Throughflow region. Instead of continuing westwards, on crossing the equator it turns away from the coast (Webb & King, 1989) and joins the equatorial undercurrent from which it can become part of the North Pacific flow. (Taking the ideas further, if New Guinea moved a few degrees further south, the North Pacific might be really isolated.)

Such hypotheses deserve further study.

References

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