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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

Anonymous Referee #4

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This is a very good paper, a well written with thorough presentation. It should be published. While there are [possibly] a few discrepancies with observed aspects of the ITF, overall the model results are surprisingly realistic. The overall ITF transport of 11.7-13 Sv agrees nicely with the INSTANT total ITF [3 year] of ∼13 Sv. The thermocline maximum speeds in Makassar and the near surface maximum speeds for the outflow in the Sunda Passages are fully consistent with INSTANT and earlier work.

The model has 0.2' [1/4] degree spatial resolution, ∼28 km. The bottom topography used is 0.5', ∼55km res. The width of critical constrictions in the channels that lead the ITF to the Indian Ocean are about this value or less. Another aspect related to the topography has to do with side wall viscosity, which is likely tied to tidal dissipation; the model does not have tides. I suspect that there is must be spatial non-homogeneity in

the viscosity, being higher in areas of tidal dissipation [see Ray 2005 TOS issue]. While the sill depth at the southern end of Makassar strait is around 680 m, the real constriction is in deeper water around 3S where the passage narrows ∼40-50 km in the upper 500 m, the layer that carries the bulk of the throughflow. The model has the channel as 28 km wide, which is too constrictive, and may account for the reduced Makassar transport. This must side wall friction attenuate the model Makassar throughflow to less than observed.

The model has 1.7 Sv [1.2 Sv with ECMWF] entering the Java Sea from the South China Sea, with seasonal fluctuations of ∼5 Sv amp. The section crosses the wide part of the SCS, but all of this transport must pass through Karimata Strait, which is ∼70 km wide and 40 m deep. Might the local dissipation make such a large transport unrealistic? I do see that most other models also have a large transport for Karimata, but there are no measurements to validate these numbers. Also, other model studies [Qu et al 2005 and 2006 GRL, others too] show that the Karimata flow [which occupies the upper ∼40 m] turns northward in Makassar. Might the OCCAM model 5.7 Sv results for Makassar be the sum of 7.4 - 1.7 Sv?

Observations do show that South Pacific water enters the Indonesian seas via Halmerhera, mainly in the lower thermocline layers [see: Ilahude, A.G., and A.L. Gordon (1996) Thermocline Stratification Within the Indonesian Seas, J. Geophys. Res., 101(C5): 12401-12409; Gordon, A.L., and J.L. McClean (1999) Thermohaline Stratification of the Indonesian Seas - Model and Observations. J. Phys. Oceanogr., 29 (2): 198-216]. These is some evidence in the water properties that at least some of this water passes back to the Pacific along the eastern Molucca Sea, but I think the model numbers of 1.6 Sv [3.4 Sv] for Halmerhera water reaching the Indian Ocean cannot be ruled as unrealistic, as there are no observations for comparison [the Cresswell and Luick are far from adequate for the job]. I like the ∼2 Sv for the deep Lifamatola overflow into the Banda Sea, a value close to the new INSTANT data, which is slightly more than 2 Sv.

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Lombok Strait at ∼5.7 Sv is far larger than observations by Murray and the recent INSTANT data [2.2 Sv]. Effectively the model has all of the Makassar transport exiting via Lombok, obs clearly show this does not happen. Might this model result 'leave room' for the eastern Halmahera route? Closing Lombok a bit, widening Makassar a bit might yield more realistic model results.

While I don't think this is an important point: The model uses 2000 m for the Ombai sill. I thought that the sill of the Sunda arc is more like 1500 m, see: Gordon, A.L., C.F. Giulivi, and A.G. Ilahude [(2003) Deep topographic barriers within the Indonesian Seas, In: Physical Oceanography of the Indian Ocean during the WOCE period, F. Schott (ed), Deep-Sea Research II (50): 2205-2228].

So my main problem with the model has to do with topography and tidal related dissipation issues, primarily for western channels [inflow and outflow] transports.

On a more general issue why is the North Pacific at all involved in the ITF? The Godfrey Island rule does not need the North Pacific involvement, the South Pacific flow has access directly into the Indonesian seas. Usually when faced with this type of 'why' question, I think- what would happen if the ocean did what models say they do. In the ITF situation, the North Pacific water above ∼1000 m would essentially become isolated from the rest of the ocean, even of 1 Sv entered from the south to make up for the Bering Strait loss. If it were so isolated it would become less and less dense, as P>E for the North Pacific. This might then dominate the interocean pressure gradient force through the Indonesian sea and drive the ITF, drawing 'replacement' South Pacific water into the North Pacific. I suppose this would be a considered as a thermohaline process, not part of the Godfrey Island rule.

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