**Ocean Science
Discussions**

Interactive comment on "Tidal modulation of two-layer hydraulic exchange flows" *by* L. M. Frankcombe and A. McC. Hogg

Anonymous Referee #2

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General comments:

This paper presents numerical solutions for time-dependent two-layer exchange flow through a contraction. The distinguishing feature of these calculations is the relaxation of the rigid-lid assumption used in a previous study (Helfrich, 1995). This allows the tidal forcing to be specified as a free-surface height variation rather than a spatially uniform barotropic volume flux. This is motivated by the fact that tidal amplitude, not barotropic flux, is more easily found for specific oceanographic applications. The calculations require open boundaries for both the surface and internal modes. This is done with linearized versions of the characteristic variables (i.e. Riemann invariants). The principal result is that the presence of the free-surface leads to a resonant phenomena that can greatly increases the average exchange flux above the results for the rigid-lid

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at certain parameter values.

This resonance is sensitive to two things. The first is the domain, which is apparently not entirely open. This gives rise to small, "leaky" basins on either side of the strait. The second ingredient is clear from the fact that the resonance dependence on the value of the reduced gravity g', in addition to the domain size (see figure 5). The resonance is excited for large g', and is reduced as g' becomes small. Large g' increases the coupling between the surface and internal modes. The authors do not say it, but the small g' limit is also consistent with the rigid-lid assumption. The fact (figure 5) that the resonant peaks are sensitive to the time-dependent parameter γ suggests that the strait geometry may be important.

The detailed dynamics of the resonance are not explained. This leaves me wondering if the resonance has any application to the ocean (where g' is small) or the lab. This second point is relevant since the authors attempt to expain Phu's (2001) experimental results (no dependence on γ) as being affected by the resonance. However, Phu's experiments were conducted in a tank with closed basins. The connection to the leaky basins of the numerical runs is not at all clear. Also, were Phu's experiments done with such large g'? If the model is run with closed basins, does the resonance remain and can Phu's results be reproduced?

They go on to look at simulations with small L and g' to minimize the resonance and come to the same conclusions as Helfrich (1995) (e.g. fig 8b). Since the resonance is not explained, Phu's experiments are not rationalized, and the simulations reproduce earlier work, I'm not sure what has been learned.

Specific comments:

1. p 2006 line 13: The shallow water equations do admit shocks. The viscosity regularizes them.

2. p 2009 paragraph at line 10: They say that fig 8 is consistent with Phu (2001). But

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this is not the case since fig 8 shows a dependence on γ and Phu (2001) (Ivey, 2004) claim that the experiments show no dependence on γ. Helfrich's experiments showed dependence on γ in qualitative agreement with the models.

Interactive comment on Ocean Sci. Discuss., 3, 1999, 2006.

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