Ocean Sci. Discuss., 5, S174–S176, 2008
www.ocean-sci-discuss.net/5/S174/2008/

Ocean Science Discussions

Interactive comment on "On the time to tracer equilibrium in the global ocean" *by* F. Primeau and E. Deleersnijder

C. Wunsch

cwunsch@mit.edu

Received and published: 27 September 2008

The Primeau and Deleersnijder paper (hereafter PD) was apparently provoked by that of Wunsch and Heimbach (2008, hereafter WH), and so a few words of response are perhaps useful.

The WH paper was directed at the paleoclimate community (consisting principally of geologists) and their widespread assumption that injection of a tracer into the ocean leads by unexplained means to rapid homogenization. We were seeking only orders of magnitude for the time to equilibrium. As PD correctly point out, the time and pathways for achieving equilibrium for any particular tracer depends upon the boundary conditions at the sea surface. That using a flux boundary condition shortens that time as compared to a concentration one appears at least plausible.

On the other hand, in the real ocean, a Neumann boundary condition would likely rapidly saturate the mixed layer (not discussed by PD) with subsequent transfer into the vast geostrophic interior occurring through a variety of processes, very unlikely to be simply a diffusive flux. Those processes will determine the time to equilibrium of most of the ocean.

PD use an e-folding time rather than the 90% of equilibrium chosen by WH. Deciding if an e-folding time is a less arbitrary choice is a matter of taste. But more important, note that e-folding only brings the concentration to 63% of equilibrium, and is only easily interpreted if one assumes the system is describable as diffusive thereafter. One almost always uses tracers in gradients or spatial difference form, and treating a space-time varying field as in equilbrium when it is only 63% of the way there could produce very misleading results. 90% was chosen simply because 10% errors are often tolerable in real data.

As a final note, experiments with water injection (Cessi et al., 2004; Stammer, 2008) which PD focus on, suggest that the circulation does indeed control the distribution. The dynamical response to the resulting mass flux takes many decades before even the surface distribution is in equilibrium. Discussion of an active tracer (water) is far more complicated than anything that WH intended.

We await with interest water injection experiments with highly resolved models, having full mixed layer representations, accurate surface boundary conditions, both for the mass flux and for the surface dynamics, and high velocity boundary currents.

References

Cessi, P., K. Bryan and R. Zhang, 2004: Global seiching of thermocline waters between the Atlantic and the Indian-Pacific Ocean basins Geophys. Res. Letts., 31, doi:10.1029/2003GL019091

Stammer D. (2008), Response of the global ocean to Greenland and Antarctic ice

OSD

5, S174–S176, 2008

Interactive Comment

melting, J. Geophys. Res., 113, C06022, doi:10.1029/2006JC004079.

Wunsch, C. and P. Heimbach, 2008: How long to ocean tracer and proxy equilibrium? Quat. Sci. Rev., 27. doi:10.1016/j.quascirev.2008.01.006, 639-653.

Interactive comment on Ocean Sci. Discuss., 5, 471, 2008.