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Interactive Comment

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

F. Primeau and E. Deleersnijder

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Response to Carl Wunsch:

"...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."

Our original goal was to study the tracer equilibration timescales associated with the ocean circulation and not with the air-sea gas exchange process. In the revised manuscript we have included a new section in which we consider the tracer equilibration timescale for a Robin boundary condition. This allows us to study the tracer equilibration time as a function of the air-sea gas exchange rate.

"...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."

First of all, it is not correct to say that an e-folding timescale is only easily interpreted if one assumes that the system is diffusive thereafter. Eigenmodes are used to characterise all kinds of dynamical systems that have nothing to do with diffusion. For our specific application, the spatial pattern associated with the most slowly decaying eigenmode depends on the combined effects of both diffusion and advection.

The difference between 90% and 63% is not an important issue when one is dealing with an exponentially decaying function – it is easy to change the base of the exponential function from e to 10 by multiplying the e-folding timescale by log(10) and so estimate the time for the disequilibrium to decrease by 90% instead of 63%. In contrast, given t90 alone, one cannot determine how much longer the implied equilibration time would be if the threshold had been chosen to be 95% instead of 90%. It is possible however to use the e-folding timescale of the most slowly decaying mode to determine the sensitivity to the choice of threshold. (At least for our model, the tracer evolution is dominated by the most slowly decaying eigenmode by the time t90 is reached.) The difference between t95 and t90 is then given by tau*(log(10)-log(5)) where tau is the e-folding decay timescale of the most slowly decaying eigenmode. Characterising the equilibration timescale using the e-folding timescale has the advantage of not depending on an arbitrary threshold. Nevertheless we have removed the offending sentence

"To avoid the arbitrariness of the 90\% threshold associated with the t_{90} timescale, we will use the e-folding decay timescale of the most slowly decaying eigenmode of the system."

and replaced it with

"A natural timescale for characterising the rate at which a system approaches equilibrium is the e-folding decay timescale of the most slowly decaying eigenmode of the system."

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

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