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Biogeosciences Discussions

Interactive comment on "Thermal and haline effects on the calculation of air-sea CO_2 fluxes revisited" *by* D. K. Woolf et al.

Anonymous Referee #2

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This paper describes a host of issues involved in proper boundary conditions for estimating the air-sea flux of CO2. The emphasis is on the impact of near-surface gradients in water temperature and salinity associated with socalled cool-skin/warm-layers driven by the net interfacial heat flux and salty skin driven by evaporation. The paper synthesizes recent literature on the topic and corrects (I think) the notion that the cool skin effects are significantly reduced by the thinness of the CO2 diffusion layer. The authors attempt to settle the issue of errors associated with using bulk water temperature (say m deep) verses skin or radiative temperature. A considerable effort is devoted to the carbon-chemistry effect and how the time scale of those reactions adds uncertainty.

The paper is fairly long and wordy and reviews a lot of basic material about the layered structure of the upper ocean. Most of this review is well-known to physical oceanog-

raphers, but considering the BiogeoDisc audience, it is likely appropriate. The paper draws heavily on McGillis and Wanninkhov (2006), so its length is excessive considering how little it adds to that paper. One big finding is the error in MW06 about the effects of the cool skin. I find myself convinced by the authors arguments so I think that is a valuable contribution. Also, they make clear the uncertainties in several factors that make a definitive answer impossible at this time. The question of the balance of carbonate reaction time scales and the mixing time scale is new to me and should be resolved. On balance this is a worthy contribution and I recommend publication. I strongly urge the authors to tighten the text and make the MS much more readable. I consider myself an expert on the physical issues and I puzzled for days over the terminology and the figures. The multiple figure dealing with the same issue seemed to add more confusion that clarity. Personally I would like to see some discussion in terms of conservation principles, conserved variable, and turbulent-diffusive transport in a system with a source. Also, the discussion about monthly/seasonal variations is a distraction – I suggest essentially removing it and focusing on the vertical gradient issues.

*Since we are interested in the flux, please give an equation for the flux at the interface with the proper variables from your discussion –with all temperature dependent factors including Schmidt number. *I suggest eliminating Fig. 1 and adding an additional line in Fig. 3 that shows the conservative carbonate chemistry variable. *I think I understand Fig. 4 but Fig. 5 is confusing and does not seem to add. Also, Fig. 4 is poorly representative. Should not the rapid and equilibrium lines approach each other as you go down the water column. Why are there two scales with Cm, Ct, Ci, etc? Please put horizontal marks at the appropriate depths. *I suggest coming Figs. 2 and 6 and adding a curve for Scˆ(-1/2) if appropriate. I think the temperature dependence of Scˆ(-1/2) is comparable to that for solubility. MW06 dismiss this, but do not explain why. I note the standard k coefficient used in these applications represents an integral over the diffusion sublayer, so it isn't obvious what temperature to use.

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