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Interactive Comment

Interactive comment on "Spatial and temporal variations in the sea surface pCO$_2$ and air-sea CO$_2$ flux in the equatorial Pacific: model sensitivity to gas exchange and biological formulations" *by* X. J. Wang

Anonymous Referee #1

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This paper examines the potential influences of (1) parameterization in gas transfer coefficient, and (2) biological model on the sea surface pCO2 and air-sea CO2 flux in the equatorial Pacific. This is an important subject worthy of investigation given the importance of equatorial Pacific in global carbon cycle. The approach is to compare the model results with (1) different gas exchange formulations or (2) with and without inclusion of a DON component. The model results seem interesting. However, the paper as written is asking the readers simply believe the results and conclusions without an in-depth analysis of why the results are reasonable. For example, why inclusion of a DON pool would lead to much stronger inter-annual variability of co2 flux? From the only comparison with observations (primary productivity, Table 2), one cannot judge which model (DON vs Non-DON) is better. I had reviewed an earlier version of this paper. This version has significantly improved in writing, but my major concern has not been addressed.

My major problem lies in sections 5.2 and 6.2, which compare the results of a model without a DON component (non-DON model) and one that has (DON model). Specifically, the author concludes that inclusion of a DON component leads to a 6-10% increase of net community production (NCP) in the tropical Pacific, which in turn leads to a 14-20ppm decrease (or 16-42%) of air-sea pco2 difference (dpco2) (Table 4).

Both models (DON and non-DON) produce very similar NCP in terms of spatial magnitudes and patterns (Fig.8). However, the resulted dpco2 and net air-sea CO2 flux are very different, largely in the central equatorial Pacific (Figs. 4-7). Now can the small difference of NCP (6-10% see Table 4) between these two models explain the 14-20 ppm pco2 difference? If yes, then biology perhaps plays a large role in regulating the pco2 in the equatorial Pacific. For the surface layer of the Basin as defined in Table 2, the total DIC inventory should be governed by,

dTotalDIC/dt = - advection + upwelling - AirSeaFlux - Export

where I have added signs so that each term is positive. Vertically, we assume integration down to 50m. Equatorial Pacific is a divergent zone and hence I assume a net export of carbon to subtropics or further west of 140E. In steady state (or approximately average over long-time such as 1990-2003), dTotalDIC/dt can be assumed as zero. And since in both experiments, physical processes are the same and the DIC at the base of euphotic zone can be assumed to be same as well, this implies that differences of CO2 upwelling can be neglected. Therefore, the difference between the two models should follow,

(Advection1 - Advection2) + (AirSeaFlux1 - AirSeaFlux2) = - (Export1 - Export2)

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Or

d(Advection) + d(AirSeaFlux) = - d(Export)

Now again in steady state, biological export should be balanced by net community production. Therefore,

d(Advection) + d(AirSeaFlux) = - d(NCP)

Now, since DIC concentration is not reported, I cannot calculate the first term. Let us look at the second term, which is reported as 0.26 PgC/yr, which is equivalent to 1.3 mmolC/m2/day. This is about 3 times the 0.5 mmol/m2/day NCP difference reported. So, even if we assume the advection contribution is zero, the reported NCP change cannot balance the total CO_2 flux change.

Of course, one might think it is possible that with more biological export, subsurface DIC may be higher, which would lead to higher upwelling flux back to the surface. But I would suspect that term is quite small. In any case, I cannot have an estimate without seeing the model upwelling and DIC.

In summary, I feel the model somehow exaggerates the impact of DON effect on air-sea CO_2 flux by 2-3 times. But I cannot be sure without seeing more information or a detailed analysis. Even if this is rejected, it would be important to include an analysis of why inclusion of a DON pool would lead to weaker NCP inter-annual variability (and hence stronger CO_2 flux variability).

Interactive comment on Biogeosciences Discuss., 7, 3879, 2010.