Review of Oschlies et al. (2010)

This is a nicely written paper analyzing the impact of ocean iron fertilization over the entire Southern Ocean. There are several new elements to this paper that have not been considered in previous studies:

(1) Iron fertilization was simulated by increasing the phytoplankton maximum growth rate to correspond to the behavior seen in the natural iron fertilization experiments at Kerguelen and Crozet. Previous such studies either depleted nutrients completely or added iron in models that have complex biological and iron cycling models that are difficult to verify. I like the approach taken in this study.

(2) The model used in this study is a simplified earth system model that includes terrestrial biosphere processes and climate, which makes it possible to include the feedback from the land biosphere on the removal of carbon into the ocean. This feedback is comparable to the oceanic back flux of CO_2 from regions outside the Southern Ocean that results from reduced atmospheric CO_2.

(3) Simulations were carried out to determine that the reduction in fossil fuel emissions that would be required to achieve a reduction in atmospheric CO_2 equivalent to that achieved by iron fertilization is 20% greater because of the CO_2 loss from the land biosphere and ocean that results from the reduced fossil fuel emissions.

(4) The impacts of the iron fertilization on ocean acidification were evaluated.

There were two points that I would like to see a further discussion of:

(1) The authors reference the Marinov et al. (2006) biogeochemical divide paper, but I didn't see that it was discussed anywhere in the paper. It is clearly of considerable interest and importance that many of the remote effects of iron fertilization would be greatly reduced if fertilization were confined to the regions poleward of the biogeochemical divide. A discussion of this would be good. Even better would be a sensitivity study to see how results change when this is done.

(2) There is no discussion of the seasonality of the response. I am pretty sure that the extreme 10 day^{-1} sensitivity study discussed in Appendix A must deplete nutrients during the summertime period of shallow mixed layers. In this connection, it is interesting that the total atmospheric CO_2 response from the 10 day^{-1} sensitivity study is -73.3 ppm (Table A1), which is almost exactly equal to the -72 ppm "standard model" result obtained by Sarmiento & Orr (1991) in their year-around nutrient depletion scenario. By contrast, the Oschlies et al. study obtains an increase of export production of only 408 Pg C over 100 years compared with S&O's result of ~14 Pg C/yr x 100 yr ~ 1,400 Pg C over 100 years (see S&O Figure 4), so it looks like the actual magnitude of the export production is not the key here. It is interesting that it seems possible to obtain most of the drawdown of CO_2 by nutrient

depletion during only a portion of the year when the mixed layer is shallow – in fact, Marinov in her PhD thesis showed that 3 mo nutrient depletion gave two-thirds of the response, and our recent 2009 Sarmiento et al. BGD paper shows we got pretty much the same response in a model that just depleted nutrients in the summer months.

As and aside, it is interesting that the CO2 reduction we got in our Sarmiento et al. 2009 BGD paper is only 39 ppm in the KVHISOUTH study. I am pretty sure this is due to the fact that we fixed CO2 at 280 ppm in that study. Allowing the atmospheric CO2 to increase as per the SRES A2 scenario in the Oschlies et al. study, and something comparable in the S&O study, makes a big difference to how much CO2 the ocean takes up. It might be worth point this out.

Finally, as Oschlies et al. point out in this paper, we did a simulation very much like this one in Sarmiento and Orr (1991). It may be worth noting that the macronutrient, oxygen, and export production responses in the S&O nutrient depletion study are quite similar to those discussed in sections 3.1 to 3.3 of this paper, including the fact that the oxygen actually increases in the low oxygen thermocline waters of the tropics and subtropics.

Nice study!

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