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Interactive comment on “Climate-mediated changes to mixed-layer properties in the Southern Ocean: assessing the phytoplankton response” by P. W. Boyd et al.

Anonymous Referee #1

Received and published: 17 January 2008

General Assessment of Boyd et al

In this paper the authors run a coupled carbon climate model for the period 1820 to 2100 for the A2 SRES scenario, and then compare the difference with a control run in the Southern Ocean of various physical and ecosystem properties. Time series of these differences are presented for the period 2000-2100, and then maps of standard deviation for 10 years of the control of several properties are plotted as well as their change over 20 years (2020-2029 minus 2000-2009), where the difference is greater than the sd. Changes are generally greater (both in magnitude and relative to 1 sd) in subpolar regions than in polar regions. These differences are then compared with

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results from phytoplankton perturbation experiments. The general conclusion is that expected changes over the first 20 years of this century are for the most part small relative to expected natural variability, and also too subtle to be represented experimentally at present. Finally, our knowledge of the 'plasticity' of most organisms to slow change is inadequate. I agree with the general conclusions of the paper, but the case is not made very forcefully, mostly because the different parts of the paper need to be explained more carefully and more clearly. Especially the second part needs to be presented more clearly. Table 1b give little quantitative information (lots of 'No data' entries), and the discussion is very dense and needs more careful explanation. For example, writing out what 'CCM' means in words is inadequate 8211; a few sentences clearly explaining the concept are needed.

Specific Science Issues

p 4290, l 1-5 8211; I don't understand the 2x and 4x protocol. I think it means multiplying the thermal change by 2x and 4x, but it is stated that the change in CO₂ for the A2 scenario is multiplied by 2x and 4x. This is clearly not the case in Figure 1, 4th panel on the left.

p 4290, l 12 8211; it would be good somewhere either to give the approximate latitude of the 130 Sv boundary, or to plot it on 1 panel of Fig. 3. Did the boundary change with time? There is evidence that atmospheric southern annular mode has moved poleward and will continue to do so in this century. Maybe the boundary between polar and subpolar waters will follow (see various papers by John Fyfe of CCCMA/University of Victoria, Canada and also AR4). This would also affect polar ecosystems.

Figs 1, 2 vs Fig. 3 8211; From Fig. 1 the polar MLD is expected to shoal and stratification to increase over this century. But from Fig 3, much of the change in MLD appears to be orange, i.e. positive, and stratification decreasing. Are the signs correct, or is this a short term deviation in the model results? If the signs are correct then the authors need to comment.

p 4292, l 22 8211; missing word(s) '8230; by other coupled simulated, the model 8230;' ", l 24 8211; 'for the next 20 years' seems vague. Maybe 'over the next 20 year period from present'.

p 4294, l 4 8211; if the Kfe in the model is 30 pmol/L, then for the most part, there will be little iron limitation in the model if iron levels in the model don't drop below 96 pmol/L for even the 4xA2 scenario as indicated in Figs. 1 and 2. According to Table 1b, for the most cases, the Kfe used is also lower than in laboratory studies. The authors need to comment here.

Section 3.2 8211; is dense (many refs, little exposition) and needs clearer explanation. Probably 'Q10' needs to be explained the first usage, as does 'CCM'.

p 4296, l 13 8211; need an 'e.g.' before 'icemelt, Q10'

p 4298, l 4 8211; ' Polar diatoms generally 8230;. than for P. antarctica'. Need to add 'a species of Phaeocystis'

p 4299, l 4 8211; here the authors emphasize '8230; the largest climate change signal 8211; CO2' but Table 1b only mentions 'CCM', and a reference to Riebesell et al. 2000. What about Riebesell, 2007 in Nature, where they found basically a CO2 fertilization effect for mixed communities of phytoplankton grown in enclosures in Bergen harbour 8211; presumably also (sub)polar species?

p 4300, l 9 8211; write out 'SOI' " , l 19 8211; it is true that natural interannual and seasonal variability is comparable with expected secular climate trends, but the point is missed here that extreme values will change because the natural variability will be superimposed on the secular climate trend. In terms of temperature, if the secular change is say 0.5C, and the expected 1sd deviation is 0.6C, then that deviation will be 0.5C higher, to the extent that the changes are linear and superposable.

Table 3 8211; what is 'Hmix' 8211; change in MLD? Also the structure of the Table is inconsistent. 'Interannual Variability' should be moved from being a heading to be the

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first line of the body of the table, like 'Climate Change'. Maybe 'Subpolar' and 'Polar' should be removed from the line starting with 'Climate Change'.

Interactive comment on Biogeosciences Discuss., 4, 4283, 2007.

BGD

4, S2400–S2403, 2008

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