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Climate of the Past Discussions

Interactive comment on "Application of sediment core modelling to understanding climates of the past: An example from glacial-interglacial changes in Southern Oceansilica cycling" *by* A. Ridgwell

Anonymous Referee #2

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General comments A. Ridgwell presents here a novel approach to explain the opposite evolution of opal in Southern Oceans sediments south and north of the Antarctic Polar Front (APF). Although this idea is potentially interesting it is not developed enough in the paper to tease the reader. Indeed, the main conclusion is that sea ice is the main process forcing the opal sedimentary patterns north and south of the APF. It is far from being new, although, to my knowledge, this has not been computed yet. In the late 80's, Lloyd Burckle explained the diatom ooze belt spreading south of the APF "by the damping effect of sea ice on diatom productivity to the south" and "reduction in diatom growth rate to the north due to elevated temperatures" (Burckle and Cirilli, 1987). Since then, many studies argued that reduced productivity in the Antarctic Zone coupled to

a northward shift of diatom communities to follow their preferential habitat where they feed on a larger silicon pool are responsible of the migration of the diatom ooze belt during glacial times (cf. Burckle, 1984). The trigger is the drop in temperatures that induced a larger sea ice cover (Gersonde et al., 2000; Gersonde et al., 2005) limiting production to the south while leaving more silicon to be consumed to the north (Bareille et al., 1998; Anderson et al., 1998; Brzezinski et al., 2002) where diatom can bloom in colder waters. The cyclic migration of the diatom ooze belt represents the antagonism depicted in the paper.

I am therefore concerned by the true reaching of the manuscript. To me, the most important output/conclusion of the present study is about the inter-sector differences (page 1378, lines 15-20). This part is unfortunately not detailed nor plotted. Looking at diatom-based reconstructions little is known about sea ice distribution in the Pacific sector of the Southern Ocean over the last climatic cycles (Crosta et al., 1998; Gersonde et al., 2005). One way to greatly improve the manuscript will be to reproduce opal records from the 3 sectors of the Southern Ocean and to determine what are the best fit in winter and summer sea ice extents. The best fit in the Atlantic and Indian sectors of the Southern Ocean can be confronted to geological evidences and, if acceptable, can provide a best guess of sea ice evolution in the Pacific sector. It will be even more interesting if maps of sea ice distribution at key periods can be provided.

The paper is apparently a slightly modified version of Nature/Science contribution. Although I have no problem with this, I believe that the paper suffer from lack of details both in the methodology and the results/interpretations. The model methodology is not detailed enough. A 3D cartoon of the model with initial conditions and resulting conditions during glacial and interglacial periods is necessary (circulation, upwelling, nutrient contentĚ). As being the centre part of the study, this part should be precise enough not to oblige the reader to shuffle between several papers presenting the previous versions of the model.

Specific comments Even though the model has a low spatial resolution, I don't un-

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derstand why the author still uses spurious input data such as CLIMAP seasonal sea ice extent. Burckle et al. (1982) demonstrate that the CLIMAP summer sea ice limit was wrong, which was further supported by diatom-based reconstructions (Crosta et al., 1998; Gersonde and Zielisnki, 2000; Gersonde et al., 2005). The author states page 1379 lines 1-10 that using more accurate winter and summer limits results in little changes in the modelled cores. So, why not using accurate limits?? Is it because "the CLIMAP reconstruction enables the better fit to the opal data"?? One needs to know that CLIMAT limits in the Pacific sector are just lines prolonging the reconstructions in the Atlantic and Indian sectors weighted by the modern position of the APF. The computation of such limits may not be too difficult and will prove beneficent to document inter-basinal differences. Similarly, the author uses Vostok temperatures and monthly insolation to calculate seasonal sea ice limits. These limits may at least been confronted to geological evidences of winter and summer limits (Gersonde and Zielinski, 2000; Crosta et al., 2004; Stuut et al., 2004; Wolff et al., 2006). A first glance points out to noticeable differences in MIS 4.

Records of opal content in core RC13-259 and RC13-254 from the Atlantic sector of the Southern Ocean. There are old records and are not corrected for lateral advection which is known to strongly affect down-core records north of the Weddell Sea. Records of preserved opal (i.e. corrected for focusing and dissolution) from the Indian sector of the Southern ocean are totally different than the one presented here with little changes in the northern Subantarctic Zone, continuous increase between 5 and 35 kyr BP in the Polar Front Zone and a sharp decrease during the last glacial in the Antarctic Zone (Dézileau et al., 2003). If I understood well, the model does not take into account lateral transport and remobilization at the water-sediment interface. It therefore estimates the preserved opal as in Dézileau et al (2003) or corrected %opal rather than the RC13-259 and RC13-254 opal records that are affected by secondary processes. Won't it be more sensible to compare model outputs to records of corrected opal content?

Page 1375, lines 10-12. Please note that new and higher resolution ice records indicate

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that the increase in CO2 is concomitant to the drop in dust fluxes (Gaspari et al., 2006).

Page 1376, lines 10-15. If there is a 35% increase in opal export during glacial times south of the APF, why is there no imprint in the sediment? Greater dissolution at the water-sediment interface?? More explanations are needed. Similarly, what cause the continuous increase of the modelled opal record in core RC13-259 (Figure 1)?

Anderson, R.F., Chase, Z., Fleisher, M.Q., and Sachs, J., 2002, The Southern Ocean's biological pump during the Last Glacial Maximum: Deep Sea Research, part II, v. 49, p. 1909-1938. Anderson, R.F., Kumar, N., Mortlock, R.A., Froelich, P.N., Kubik, P., Dittrich-Hannen, B., and Suter, M., 1998, Late-Quaternary changes in productivity of the Southern Ocean: Journal of Marine Systems, v. 17, p. 497-514. Bareille, G., Labracherie, M., bertrand, P., Labeyrie, L., Lavaux, G., and Dignan, M., 1998, Glacial-interglacial changes in the accumulation rates of major biogenic components in Southern Indian Ocean sediments: Journal of Marine Systems, v. 17, p. 527-539. Brzezinski, M.A., Pride, C.J., Franck, V., Sigman, D.M., Sarmiento, J.L., Matsumoto, K., Gruber, N., rau, G.H., and Coale, K.H., 2002, A switch from SI(OH)4 to NO3- depletion in the glacial Southern Ocean: Geophysical Research Letters, v. 29(12), p. 5-1 to 5-4, doi: 10.1029/2001GL014349. Burckle, L.H., 1984, Diatom distribution and paleoceanographic reconstruction in the Southern Ocean - Present and Last Glacial Maximum: Marine Micropaleontology, v. 9, p. 241-261. Burckle, L.H., and Cirilli, J., 1987, Origin of the diatom ooze belt in the Southern Ocean: implications for the late Quaternary paleoceanography: Micropaleontology, v. 33, p. 82-86. Burckle, L.H., Robinson, D., and Cooke, D., 1982, Reappraisal of sea-ice distribution in Atlantic and Pacific sectors of the Southern Ocean: Nature, v. 299, p. 435-437. Crosta, X., Pichon, J.J., and Burckle, L.H., 1998a, Application of modern analog technique to marine Antarctic diatoms: Reconstruction of the maximum sea ice extent at the last glacial maximum: Paleoceanography, v. 13(3), p. 284-297. Crosta, X., Pichon, J.J., and Burckle, L.H., 1998b, Reappraisal of seasonal Antarctic sea-ice extent at the last glacial maximum: Geophysical Research Letters, v. 25(14), p. 2703-2706. Crosta,

X., Sturm, A., Armand, L., and Pichon, J.J., 2004, Late Quaternary sea ice history in the Indian sector of the Southern Ocean as recorded by diatom assemblages: Marine Micropaleontology, v. 50, p. 209-223. Dezileau, L., Bareille, G., and Reyss, J.L., 2003, The 231Pa/230Th ratio as a proxy for past changes in opal fluxes in the Indian secor of the Southern Ocean: Marine Chemistry, v. 81, p. 105-117. Dézileau, L., Bareille, G., Reiss, J.L., and Lemoine, F., 2000, Evidence for strong sedment redistribution by bottom currents along the southeast Indian Ridge: Deep-Sea research I, v. 47, p. 1899-1936. Dézileau, L., Reyss, J.L., and Lemoine, F., 2003, Late Quaternary changes in biogenic opal fluxes in the Southern Indian Ocean: Marine Geology, v. 202, p. 143-158. Gaspari, V., Barbante, C., Cozzi, G., Cescon, P., Boutron, C.F., Gabrielli, P., Capodaglio, G., Ferrari, C., Petit, J.R., and Delmonte, B., 2006, Atmospheric iron fluxes over the last deglaciation: Climatic implications: Geophysical research Letters, v. 33, L03704, doi: 10.1029/2005GL024352. Gersonde, R., Abelmann, A., Brathauer, U., Becquey, S., Bianchi, C., Cortese, G., Grobe, H., Khun, G., Niebler, H.S., Segl, M., Sieger, R., Zielinski, U., and Fütterer, D.K., 2003, Last glacial sea surface temperatures and sea-ice extent in the Southern Ocean (Atlantic-Indian sector): A multi-proxy approach: Paleoceanography, v. 18(3), 1061, doi:10.1029/2002PA000809, p. 6.1-6.18. Gersonde, R., and Zielinski, U., 2000, The reconstruction of late Quaternary Antarctic sea-ice distribution - the use of diatoms as a proxy for sea-ice: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 162, p. 263-286. Gersonde, R., Crosta, X., Abelmann, A., and Armand, L.K., 2005, Sea surface temperature and sea ice distribution of the Southern Ocean at the EPILOG Last Glacial Maximum - A circum-Antarctic view based on siliceous microfossil records: Quaternary Science Reviews, v. 24, p. 869-896. Stuut, J.B., Crosta, X., Borg, K.v.d., and Schneider, R., 2004a, Relationship between Antarctic sea ice and southwest African climate during the last Quaternary: Geology, v. 32(10), p. 909-912. Wolff, E.W., Fisher, H., Fundel, F., Ruth, U., Twarloh, B., Littot, G.C., Mulvaney, R., Röthlosberger, R., Angelis, M.d., Boutron, C.F., Hansson, M., Jonsell, U., Hutterli, M.A., Lambert, F., P.Kaufmann, Stauffer, B., Stocker, T.F., Steffensen, J.P., Bigler, M., Siggaard-Andersen, M.L., Udisti, R., Becagli, S., Castel-

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lano, E., Severi, M., Wagenbach, D., Barbante, C., Gabrielli, P., and Gaspari, V., 2006, Southern Ocean sea-ice extent, productivity and iron flux over the past eight glacial cycles: Nature, v. 440, p. 491-496.

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