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Biogeosciences Discussions

Interactive comment on "Modelling the effect of boundary scavenging on Thorium and Protactinium profiles in the ocean" *by* M. Roy-Barman

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General comments:

This paper gives a most welcome extension of our understanding of the process of boundary scavenging. By modeling the effect of horizontal mixing on all depth levels a better explanation of concentration profiles is obtained than could be given by traditional box models. The modeling results are especially revealing in the Arctic Ocean where low particle fluxes and small dimensions of the basins make an extreme case of boundary scavenging. The author finds at 2000m a 230Th sedimentation flux only 29% of in situ production in the inner ocean compared to 409% in the margin. These

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analyses support the suggestion already made by Moran et al. (2005) that boundary scavenging in the Arctic is as high for 230Th as for 231Pa, resulting in a lack of fractionation between the two isotopes in the Arctic basin.

Previous work:

In principle, global circulation models that include scavenging would provide a numerical alternative for the equations derived here. But it may be that the resolution of particle flux and scavenging in such models is not sufficient to fully model the effect of boundary scavenging on tracer distributions. E.g. Henderson et al. 1999: "Boundary scavenging is not explicitly incorporated into the model presented in this paper. The scale at which it occurs is too fine to be well mimicked by the resolution of the model, and our primary interest in this study is the open-ocean advection and scavenging of 230Th rather than near-shore processes". But I think that the attempts of Bacon et al. (1977) and Spencer et al (1981) to model the horizontal distribution of 210Pb in the ocean deserve to be mentioned in the present analysis. It is in these papers that the concept of boundary scavenging was first applied to horizontal transport toward lateral ocean boundaries.

Specific comments:

There is in my view an inconsistency in the treatment of ocean bathymetry. On page 7856 line 18 it is explained that the exchange is assumed to be horizontal and that "the flux is homogeneously distributed throughout the water column". The author concludes that the residence time of the water (with respect to horizontal mixing) is constant over depth. However, if we realize that the margins include a slope, as depicted in figure 1 and discussed for the Arctic situation on page 7869 line 18, the horizontal area in the margin box decreases with water depth, and so must the residence time of water in the margin box. I think it is acceptable for the purpose of this paper to use a water residence time that is constant with depth, but this should then be mentioned explicitly and figure 1 should be changed accordingly.

BGD

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Details and typos:

Page 7866 line 11,12 (eq. 10a,b, cf A27a,b): exchange first two terms in right-hand part of equations

Page 7866 line 24: “high” should be “low”

Page 7869-6870: Use consistently the term CESAR for the Arctic Ice station.

Page 7882 line 6 (A27a, cf. A 25a): F/SmVmKm should be F/SiViKi

Page 7870 line 25. does the author mean sedimentation rate or settling velocity?

References:

Bacon, M.P., 1977. 210Pb and 210Po results from F. S. Meteor cruise 32 in the North Atlantic. Meteor Forschungs-Ergebnisse 19, 24-36.

Henderson, G.M., Heinze, C., Anderson, R.F., Winguth, A.M.E., 1999. Global distribution of the 230Th flux to ocean sediments constrained by GCM modelling. Deep Sea Research Part I 46 (11), 1861-1893.

Moran, S.B., Shen, C.-C., Edwards, L.R., Edmonds, H.N., Scholten, J.C., Smith, J.N., Ku, T.-L., 2005. 231Pa and 230Th in surface sediments of the Arctic Ocean: implications for 231Pa/230Th fractionation, boundary scavenging, and advective export. Earth and Planetary Science Letters 234 (1-2), 235-248.

Spencer, D.W., Bacon, M.P., Brewer, P.G., 1981. Models of the distribution of 210Pb in a section across the north Equatorial Atlantic Ocean. J. Mar. Res. 39, 119-138.

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