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Application of a box model to investigate marine δ^{30}Si distribution

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The silicon isotope composition of biogenic opal is used as a proxy for reconstruction of the relative silicate utilization in the ocean in the geological past. During the Last Glacial Maximum, reduced riverine input of silicate, diminished overturning circulation and perhaps change of surface mixing would have had influences on the marine δ^{30}Si. Here we applied a simple box model, which is able to reproduce observed marine δ^{30}Si in different ocean basins, for testing the sensitivity of δ^{30}Si to various parameters. Our results indicate that a slower overturning circulation can result in a higher globally averaged δ^{30}Si of silicic acid, which is mainly due to a greater productivity in the surface Antarctic. Despite a decrease in subantarctic productivity, the δ^{30}Si of opal follows the increase of the Antarctic, demonstrating that changes in opaline δ^{30}Si should not necessarily be interpreted as a local signal. Stronger low-latitude mixing brings more nutrients to the ocean surface, which can benefit diatom export production that accounts for an increase in the averaged global ocean δ^{30}Si value. Nevertheless, a stronger Antarctic polar mixing does not affect δ^{30}Si very much, since the vertical mixing there is already very strong so that silicate is replete in the Southern Ocean south of the Polar Front. Furthermore, the mixing of Antarctic surface water with the huge volume of Circumpolar Deep Water tempers the signal. Another conclusion we can draw from our box model is that an addition of today's riverine input and opal burial to the model does not change ocean δ^{30}Si value much ($< 0.015‰$), because the input of silicate is small compared with opal export fluxes.