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Physical and biological regulation of the soft tissue carbon pump

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We examine the relationship between aeolian iron deposition, ocean circulation and atmospheric CO_2 in the context of a global ocean circulation and biogeochemistry model with a coupled atmospheric reservoir of CO_2. In common with previous models we find only a small reduction of atmospheric pCO_2 in response to an enhanced aeolian iron source consistent with Last Glacial Maximum conditions. We show this to be due to a combination of limiting factors including control of deep ocean iron concentrations by complexation to an organic ligand, regional compensation in changes to export production, and the maintenance of high pre-formed nutrient concentrations in deep water formation regions. We also demonstrate a signficant sensitivity of atmospheric pCO_2 to changes in the residual mean overturning circulation of the Southern Ocean dominated by its regulation of the accumulation of biogenic carbon in the deep ocean. Although it is not enough to explain the full draw down of pCO_2 to glacial levels, a reduction in overturning can lead to significant reduction in atmospheric pCO_2, providing mechanistic basis for the control by "vertical mixing" inferred from box models.