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Inferring source regions and supply mechanisms of iron in the Southern Ocean from satellite data

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In many biogeochemical models a large shelf sediment iron flux is prescribed through the seafloor over all areas of bathymetry shallower than 1000 m. Here we infer the likely location of shelf sediment iron sources by identifying where mean annual satellite chlorophyll concentrations are enhanced over shallow bathymetry ($>$ 1000 m). We show that mean annual chlorophyll concentrations are not visibly enhanced over areas of shallow bathymetry located more than 500 km from a coastline. Chlorophyll concentrations $>$ 2 mg m-3 are only found within 50 km of a continental or island coastline. These results suggest that large sedimentary iron fluxes only exist on continental or island shelves. Large sedimentary iron fluxes are unlikely to be found on isolated seamounts and submerged plateaus.

We further compare satellite chlorophyll concentrations to the position of ocean fronts to assess the relative role of horizontal advection and upwelling for supplying iron to the ocean surface. Sharp gradients in chlorophyll concentrations are observed across western boundary currents. Large chlorophyll blooms develop where western boundary currents detach from the continental shelves and turn eastwards into the Southern Ocean. Chlorophyll concentrations are enhanced along contours of sea surface height extending off continental and island shelves. These observations support the hypothesis that bioavailable iron from continental shelves is entrained into western boundary currents and advected into the Sub-Antarctic Zone along the Dynamical Subtropical Front. Likewise, iron from island shelves is entrained into nearby fronts and advected downstream. Mean annual chlorophyll concentrations are very low in open ocean regions with large modelled upwelling velocities, where fronts cross over topographic ridges. These results suggests that open ocean upwelling is unlikely to deliver iron to the surface from deep sources such as hydrothermal vents.