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Late summer carbon export and remineralisation in the Southern Ocean determined with the combined 234Th and particulate biogenic Ba tracers

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As part of the Bonus-GoodHope expedition (late summer 2008; Feb-March) in the Atlantic sector of the Southern Ocean, we present combined 234Th and biogenic particulate barium (Baxs) results. These data are used to estimate the export of particulate organic carbon (POC) from the upper mixed layer and the impact of twilight zone remineralisation on the carbon export.
Total 234Th activity in surface waters is depleted relative to its parent nuclide 238U (234Th/238U ratio ranging from 0.74 to 0.91), while equilibrium is reached at the base of the surface mixed-layer. The export fluxes of 234Th from the 100m horizon, as estimated using steady state (SS) and non steady state (NSS) models, reveal different latitudinal trends. SS 234Th export varies from 496 dpm m-2 d-1 in the subtropical domain of the Cape Basin to 1195 dpm m-2 d-1 close to the Polar Front (PF). NSS export representative for a 15 to 22 day period preceding the cruise, is consistently less than SS export in the sub-Antarctic Zone (SAZ, 150 dpm m-2 d-1) and the Polar Frontal Zone (PFZ, 440 dpm m-2 d-1) but is similar further south in the Antarctic Zone (AZ, 1217 dpm m-2 d-1) and the northern Weddell Gyre (N-WG; 757 dpm m-2 d-1). This reflects temporal variability of export north of the PF, while south of the PF the export system appears to be in steady state during this late summer situation. The POC:Th ratio of large (>53 μm) particles collected below the surface mixed layer increases from 1.7 μmol dpm-1 in the STZ to a maximum of 4.8 μmol dpm-1 at the Southern Antarctic Circumpolar Current Front (SACCF), suggesting a southward increase of the contribution of larger cells, such as diatoms, to sinking material. Using these POC:Th ratios we calculate that the POC SS export from the 100m horizon reaches 0.9-1.7 mmol m-2 d-1 in the STZ and the SAZ, 2.6-4.7 mmol m-2 d-1 in the PFZ, and 3.3 mmol m-2 d-1 in the N-WG.
Below the export layer, in the mesopelagic zone (100-600 m), 234Th activities generally reach equilibrium with 238U, but sometimes also are in large excess (234Th/238U ratio > to 1.1). Such activity excesses reflect intense remineralisation/disaggregation of 234Th-bearing particles which is estimated to attenuate the original POC export flux by close to 100%. Increased biogenic particulate Ba (Baxs) contents in the mesopelagic zone, indicate enhanced remaineralisation of organic matter, and in general overlap with the areas of excess 234Th. Excluding two outliers, we found a general positive correlation for mesopelagic waters between POC remineralisation estimated from Baxs inventories and from 234Th excess. Our results indicate that POC export production in the Southern Ocean is strongly attenuated in the mesopelagic waters.