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An intermediate complexity approach to modelling the ocean 231Pa / 230Th

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The non-linear interaction of ocean transport, particle flux and particle type fractionates 231Pa / 230Th in the ocean. 231Pa and 230Th are removed from the water column by a process of reversible scavenging (adsorption and desorption onto particles). Scavenging quickly removes 230Th to the sediment (in ˜ 30 years). 231Pa is less effectively scavenged and therefore has more time (˜ 200 years) in which to be transported via advection and diffusion before it reaches the ocean sediment. This allows the generation of preferential sinks of 231Pa relative to 230Th in ocean sediment, depending on the distribution of particle types and particle concentrations. 231Pa is preferentially removed in areas of high particle concentration, generating highly variable 231Pa / 230Th activity ratios in the particle flux to the sediment. Particle type also plays an important role in fractionation because of the differing affinities of particle types for 231Pa and 230Th isotopes. With a good understanding of the oceanic behaviour of these nuclides, their ratio in the sediment offers tremendous potential as a proxy for past changes in ocean circulation (e.g. McManus et al. 2004), a key component of the climate system which is present hard to reconstruct for the past. The work presented here combines particle fields (dust, opal, CaCO3, POC) derived from observations with the Bern3d intermediate complexity ocean model and an equilibrium isotope scavenging model. It is shown that a relatively simple reversible isotope-scavenging model with particle-type-dependent equilibrium partition coefficients values can explain many of the features of the global 231Pa and 230Th distribution. This model addresses the controversy regarding the importance of dust vs. CaCO3 in scavenging

230Th, clearly indicating a better fit with strong scavenging to CaCO3. The success of such a simple model at representing the global pattern of 231Pa / 230Th activity ratio strongly supports the use of this proxy in paleoceanographic studies. N. Atlantic 231Pa / 230Th activity ratios are probably more sensitive to changes in ocean circulation to the west of the basin. Multiple N. Atlantic sites should be used to deconvolve circulation effects from particle flux when considering time-dependent effects on the sediment 231Pa / 230Th activity ratios.