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Deep Water Cycling and Sea Level Change Since the Breakup of Pangea

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The sea level record shows cyclic-variations with amplitudes of approximately 200 m that coincide with those of supercontinental cycles (200-300 Myr). Proposed mechanisms for this sea level change include processes that change ocean basin container volume and the thermal elevation of supercontinents due to trapping of heat beneath them. Here we investigate how unbalanced exchange of water between Earth's surface and interior can cause sea level changes as a result of fluctuations in tectonic rates. Previous modeling studies of subduction water fluxes suggest that the amount of water that can go beyond the sub-arc depths is well correlated with the velocity and age of the subducting plate. We propose an improved parametrization of subduction water flux by introducing age- and velocity-dependent slab water retention. By applying parameterizations of regassing and degassing to data from tectonic reconstructions we estimate the water fluxes between the Earth's oceans and the mantle through space and time for past 230 Ma, and compute the associated sea level change. Our model predicts a sea level drop over this period to be equivalent of at least 40 m, and possibly as large as 150 m, caused mainly by the 150 Ma rift-pulse that opened the Atlantic and forced rapid subduction of old oceanic lithosphere in the Pacific Basin. This indicates that deep water cycling maybe one of the more important sea level changing mechanisms on the supercontinental time scale, and provides a more complete picture of the dynamic interplay between tectonics and sea level change. Our predictions of the deep subduction water flux through space and time can also be used to infer water-dense regions in the mantle, which could potentially help to constrain the heterogeneous distribution of water in the mantle. Due to the strong dependence of mantle viscosity on water-content, maps of the mantle water distribution could help us to link tectonic and magmatic surface processes with deep mantle convection dynamics.