Particle-bound materials (carbon, nutrients, transition and trace elements) that originate within the watershed and are transported via rivers to the ocean, undergo many transformations en route. Knowledge of what transformations take place (and where these transformations occur) is crucial to our understanding of river-ocean systems and their response to global change. Uranium isotopes are sensitive indicators of the spatial and temporal extent to which terrestrial materials are altered during sedimentation and diagenesis cycles en route to the ocean. In concert with other shorter-lived naturally occurring radioisotopes ($^{7}$Be, $^{210}$Pb), uranium isotopes provide valuable information about the residence time, pathways and fates of particle-bound terrestrial materials. Studies within the lower (tidal fresh) Mississippi River and adjacent ocean margin and on the Amazon Shelf provide insights as to the relative role of the lower river and the open margin as sites for intensive sediment processing. Preliminary results indicate that the net loss of particle-bound constituents such as Fe, Mn, U and organic carbon (due to sedimentation/diagenesis processes) is much greater within the lower Mississippi River than on the adjacent shelf. In contrast, more limited data suggests that the lower Amazon may be the site of net gain in particle-bound constituents and the adjacent shelf the site of net loss of terrestrial signal.