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Assessing and modeling sediment mobility in estuarine and coastal settings due to extreme climate events from natural short-lived isotope distribution

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Climatic events (e.g. floods, storminess) and management activities (e.g. dredging) may result in the burial or removal and re-suspension of sediments in estuaries and coastal areas. When such sediments are contaminated, such processes may either help restoring better chemical environments or lead to their long-term contamination. Geochemical signatures in surface sediments may help identifying such sedimentological events. However, short-lived isotope data are generally required to set time-constraints on their occurrence. Whereas 210Pb and radioactive fallout isotope contents can help setting time constraints at $\sim$50 to $\sim$100 yr-time scales, natural disequilibria in the 232Th-228Ra-228Th sequence do provide information on processes which occurred within the last 30 yrs, as illustrated in the present study. Box-cored sediments from the Saguenay Fjord and lower estuary of the St. Lawrence (Canada) as well as from estuaries and lagoons from the Sinaloa Coast (Mexico) are used to document the behavior of these isotopes either under relatively steady conditions (St. Lawrence estuary) or under high-frequency extreme climate events (storms and floods; Saguenay Fjord, Coastal Sinaloa). 228Th/232Th activity ratios were determined by chemical extraction of Th and alpha counting of unspiked samples, rapidly after sampling (228Th/232Th). The activity of the intermediate isotope 228Ra was then estimated based on replicate measurements on aliquot samples made a few years later. Under steady conditions, core-top sediment shows an excess in 228Th vs 232Th (AR $\sim$ 1.6), whereas the intermediate 228Ra depicts a deficit vs its parent 232Th (AR $\sim$0.6). Downcore, radioactive decay carries rapidly 228Th-activities to those of the parent 228Ra within about 10 yrs (i.e. $\sim$ 5 half-lives of 228Th), then both move during the next $\sim$20 yrs ($\sim$ i.e. $\sim$ 5 half-lives of 228Ra, when added to the 10 yrs of 228Th-excess) towards secular equilibrium with the parent long-lived 232Th. A few algorithms provide simple models governing these processes under relatively high sedimentation rates, i.e. when Ra-diffusion from the sediment towards the water column may be neglected. In sites characterized by extreme sedimentologival events, 228Th/232Th profiles depict departures from this model, thus bearing information on the timing and processes involved. Examples from the Saguenay Fjord (Canada) illustrate the case of fast-deposited layers due to floods, whereas examples from estuaries and coastal areas of Sinaloa show evidence for re-suspension and/or erosion events linked notably to storminess and/or land use changes. In the first case, the fast accumulation of flood layers has sealed most of the early 20th-century contamination, whereas in the second case, erosion and re-suspension events led to either some removal of sediments contaminated by heavy metals, or their secondary release into the environment.