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Potential and limits of luminescence dating for establishing late-Holocene cyclone and tsunami chronologies

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Long-term recurrence intervals of coastal hazards such as tropical cyclones and tsunamis can be reconstructed on the basis of geological evidence of prehistoric events. These geological records have the potential to extend the period under observation beyond historical time scales. In addition to radiocarbon datings, optically stimulated luminescence (OSL) dating is used for the establishment of late-Holocene event chronologies. Here we discuss the potential and limits of applying OSL to sandy storm and tsunami deposits based on case studies from SW Thailand and NW Australia, where quartz luminescence properties (i.e. high sensitivity, thermally stable signal components dominated by the easily bleachable fast component, no mineralogical impurities) are favourable. Potential uncertainties and age offsets due to (i) incomplete signal resetting and (ii) spatial and temporal variations of dose rates that are supposed to be characteristic for deposits of coastal flooding events are evaluated. Incomplete bleaching of the OSL signal is evident in most deposits but can be corrected by statistical analysis of small aliquots or single grains using the minimum age model. Although the dating of modern analogues such as deposits from the 2004 Indian Ocean Tsunami revealed residuals, these uncertainties are insignificant compared to the respective local recurrence intervals. Further potential uncertainties arise from the complex coastal stratigraphies recording tsunami and cyclone deposits, such as variations between peat layers and sand sheets as well as differing concentrations of heavy minerals, but are comparably small if the geometry of different strata is adequately addressed. In contrast, errors introduced by temporal variations of environmental radiation fields may be much more significant. Especially changing water contents or radioactive disequilibria due to element mobility in marine carbonates are frequent in coastal settings and may lead to large uncertainties. However, in the absence of significant radioactive disequilibria OSL ages of cyclone and tsunami deposits from Thailand and Australia are in good agreement (within 1 sigma) with independent chronologies. Our case studies show that the OSL dating precision is sufficient to discriminate late-Holocene events with recurrence rates of several centuries during the last millennia (400-600 years for strong tsunamis in SW Thailand) as well as events with decadal recurrence during the last centuries (cyclone records of the last 200-300 years from NW Australia). Compared to radiocarbon dating, OSL provides adequate resolutions even on very recent time scales (i.e. the last 300 years) and avoids potential errors due to reworking and contamination.