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Improved late-Holocene dating models for eutrophic lake sediment cores: combining radiometric dating, tephrochronology, spheroidal carbonaceous particles, instrumental data and documentary records.

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Short-lived radio isotopes (^{210}Pb, ^{137}Cs, ^{241}Am) are a widely-used method to date lake-sediment cores over the late-Holocene. However, in some shallow (<2 m) eutrophic (>50 μgL^{-1}TP) systems, the level of unsupported ^{210}Pb is often low and is limited by its calibration to the ^{137}Cs peak in 1963, resulting in chronologies that are short and have high associated errors. Where precisely-dated, multi-centennial records are required to identify short-term, abrupt and/or anthropogenic impacts on catchments, a lack of robust dating is problematic. Here, we present a case study comprising a suite of sediment-cores from the same inter-connected catchment. For cores with low unsupported ^{210}Pb and a truncated chronology, a more robust and extended dating model has been achieved by comparisons with well dated cores, and combining radiometric dating with tephrochronology, spheroidal carbonaceous particles (SCPs), instrumental data and documentary records. The unsupported ^{210}Pb profiles of the cores have low isotopic abundance with the majority calibrated to the ^{137}Cs peak, giving precise dates for only half the core length. Cryptotephra, microscopic volcanic ash, down-core of the radiometrically dated section, have suggested abrupt changes in sedimentation rate, suggesting deposition of tephra shards prior to the extrapolated date. The presence of SCPs, fly ash particles produced from the high temperature combustion of fossil-fuels, has the potential to extend a truncated ^{210}Pb record to the industrial revolution ~1850 AD, and the start of the SCP record. The beginning of the SCP record can be used to validate sedimentation rates inferred from the constant rate of supply (CRS) and the constant initial concentration (CIC) dating models, and in some un-dated intervals, the co-occurrence of tephra shards and SCPs improves the constraints on tephrochronology by limiting the chronology to the industrial-revolution. In combination, these methods have extended the chronology of the cores, and highlighted errors associated with the extrapolation of radiometrically derived sedimentation rates down-core, especially where increased sedimentation rates have occurred with increasing eutrophication. The ability to improve chronologies for eutrophic lakes using a combination of radiometric dating, SCPs and tephrochronology is an important step in increasing our understanding of short-term changes in these environments.