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Integrated age modelling of numerical, correlative and relative dating of a long lake sediment sequence from Orakei maar palaeolake, Auckland, New Zealand

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Accurate and precise chronologies are fundamental for successful Quaternary palaeo-climate/environment reconstruction and correlation with global climatic events. Aside from varved lake sequences, chronologies for sediment archives typically depend on age models developed from a limited number of dated horizons, often with large associated errors, age reversals, or minimum/maximum age constraints. Whilst the approach to generating chronologies for sediment cores has moved on from linear interpolation to considering age uncertainties and developing more nuanced accumulation models, these age models rarely reach the resolution and precision desired for millennial-scale palaeo-climatic correlations, particularly beyond the limits of the more precise radiocarbon method. Bayesian modelling offers the opportunity to optimise age models by combining all available information on the depositional history of the basin.

Here we address this issue for the Orakei maar palaeolake sequence from Auckland, New Zealand. The Orakei maar sequence offers a high-resolution and continuous record of climatic variations spanning much of the last glacial cycle and is one of the few from the southern hemisphere mid-latitudes. The Orakei sequence spans ca. 120 to 10 ky; our chronology is derived from tephrochronology, radiocarbon dating, post-IR IRSL luminescence dating, relative palaeomagnetic intensity changes and meteoric Beryllium-10 flux. Prior to 40 ka, our age model relies on comparison with the global PISO-1500 palaeointensity stack and 10Be-flux. We generate our age model for the time interval ca. 50 to 10 ky using Bacon (rBacon in R), using non-normal error distribution of un-calibrated ages when necessary, facies-dependent variable mean accumulation rates and accounting for thick horizons of instantaneous deposition (i.e. tephra and mass movement deposits). This approach allows us to generate a high-resolution age model suitable for correlation of millennial-scale oscillations in our record, based on environmental magnetism and meteoric 10Be flux, with global records of past climate such as polar ice core, tropical lake and speleothem archives.