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Can novel techniques using climate models aid in determining the palaeoaltimetric history of the Himalayas and Tibet Plateau?

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The Himalaya -Tibetan Plateau (HTP) is the largest and highest plateau in the world with an average elevation exceeding 4.5km. The HTP plays a fundamental role in modern climate both regionally and globally through teleconnections by perturbing atmospheric circulation and energetics. The HTP is known as the ‘Third Pole’ due to it storing more snow and ice then anywhere on Earth outside of the polar regions, making it an important source of fresh water that sustains around half the world’s human population, as well as the Asian biodiversity hotspots. Understanding the topographic evolution, in particular the height of the Himalaya and the Tibetan Plateau is crucial for understanding the development of monsoon systems, biodiversity and the wider climate through the Cenozoic (the last ∼66 million years). Several methods have been proposed to reconstruct the height of the QTP through the use of proxy-records such as fossilised plants, shells and mammalian teeth as well as carbonate minerals formed in lakes and soils. Thermodynamic approaches using moist enthalpy and thermal lapse rates utilise climate signals derived from fossil plants to produce a thermal profile at two isochronous locations, i) a priori at sea level and ii) an unknown height at elevation to be reconstructed. These approaches derive a height based on the relationship between temperature and altitude (lapse rates) and the conserved quantities of sensible and latent heat of moist air (enthalpy) which also varies with height. These approaches assume the same relationships between plants and atmospheric properties existed in fossilised plants as we observe in modern plants. A third method, stable isotopes, identifies the isotopic signature of precipitation as an airmass transgresses a topographic feature, isotopically fractionates (Raleigh distillation) and becomes increasing isotopically depleted in heavy isotopes thus providing a relationship with height. All three methods incorporate inherent uncertainties and assumptions within their methodologies with elevation estimates sometimes widely varying by as much as +/-4km at the same site in space and time. Here we show with the aid of novel paleoclimate modelling techniques how these uncertainties in each approach can be constrained allowing for an improved estimate of paleo-elevation and offer case studies showing how combined approaches of the various methodologies should be used to estimate the topographic height, extent and interpretation of paleogeography paving the way for more accurate and robust reconstructions.