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Stalagmite growth and palaeo-climate: An inverse approach

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The growth of stalagmites is controlled by climatic conditions such as temperature, soil activity, and precipitation. Hence, a stalagmite stratigraphy reflects fluctuations of palaeo-climate conditions on various timescales, from annual variations to ice-age cycles. However, no attempt has been made to infer palaeo-climate fluctuations from the stratigraphy itself. We describe the complicated growth of a stalagmite with a simple mathematical model, in which both the growth rate and the equilibrium diameter of stalagmites are functions of palaeo-climate variables. Hence, inverting a given stalagmite stratigraphy in terms of growth rate and equilibrium diameter can in principle recover the palaeo-climate signal. The strongly non-linear dependence of these two geometrical parameters, however, limits the success of a formal inversion of stratigraphical data. In this paper, we explore the resolving power of both growth rate and equilibrium diameter data for the palaeo-climate signals temperature, carbon-dioxide concentration, and precipitation. We use numerically generated stalagmite stratigraphies as observational data, thus we know beforehand the palaeo-climate signal contained in the stratigraphic record. Our results indicate that both variations in carbon-dioxide concentrations (as a proxy of soil cover) and drip interval (as a proxy of precipitation) can be recovered from the stratigraphy. However, temperature variations are poorly resolved.