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Application of IBIS [Integrated Bayesian approach for unique Initial thorium corrections and age-depth models in U-Th dating of Speleothems] to Hato Cave, Curaçao speleothems

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Proxies recorded in speleothems offer insight into past patterns of rainfall and other components of the terrestrial climate system. Uranium-thorium dating is commonly applied to create chronological models for speleothems from present-day to ~650 ka. Making accurate and precise corrections for initial thorium (i.e., ^{230}Th that is not a result of in-situ decay of uranium within the sample) can be the limiting factor in building robust speleothem age models. Two methods are broadly used to correct for initial thorium: (1) direct estimation using isochron techniques; or (2) assuming a constant, model value of the initial ^{230}Th/^{232}Th ratio. However, isochron approaches are resource-intensive, while corrections made using a single, assumed initial thorium value with arbitrary uncertainty may fail to characterize significant variations in initial thorium.

IBIS is a Bayesian model that uses a probabilistic approach to constrain the initial thorium isotopic composition of each sample, thereby facilitating the derivation of accurate U-Th ages and robust age-depth models for speleothems. The model formulates a speleothem-specific prior for initial ^{230}Th/^{232}Th ratios using simple a priori constraints and applies a likelihood that penalizes violations of stratigraphic order. As a case study, we have employed IBIS to estimate sample-specific initial thorium values and U-Th ages in Holocene speleothems hosted in an uplifted Pleistocene coral terrace from Hato Cave, Curaçao. We also performed isochron analyses of multiple layers from two Hato Cave speleothems, which yield initial thorium ratios consistent with the independent IBIS estimates. We then use the IBIS estimated U-Th ages to generate robust age-depth models for multiple Holocene speleothems in this challenging geochronological environment. The ability of the IBIS modeling framework to make accurate and unique corrections of the initial thorium for each sample within a speleothem has the potential to extend the application of U-Th dating to more complex speleothem systems.