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Reconstruction of autumn/winter precipitation variability from a high-resolution speleothem trace element record (SW Romania)

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Speleothem records have been successfully calibrated against instrumental data, e.g., using stable oxygen isotope or annual growth lamina data considered as reliable recorders of air temperature or precipitation amount. We present the first high-resolution trace element (Mg/Ca, Sr/Ca, Ba/Ca) record providing the potential for quantitative climate reconstruction, deduced from stalagmites from Clo¸sani Cave, SW Romania.

The calibration approach relies on a precise age control - in particular for the last 250 years, where the chronology is based on three independent dating methods. Chemical lamina counting is combined with the identification of the 20th century 14C bomb peak and 230Th/U dating. Long-term cave monitoring and model simulations of drip water and speleothem elemental variability support the inference that precipitation-related processes are the main drivers of speleothem Mg/Ca ratios. Calibration against instrumental climate data shows a significant anti-correlation of speleothem Mg/Ca ratios with autumn/winter (October to March) precipitation ($r = -0.61$, $p < 0.01$), which is statistically robust when
considering age uncertainties and auto-correlation. This relationship is then used to develop a quantitative reconstruction of Holocene autumn/winter precipitation.

During the last 3.6 ka, our data suggest a heterogeneous pattern of past regional winter hydroclimate in the Carpathian/Balkan realm, along with intermittent weakening of the dominant influence of North Atlantic forcing. In agreement with other regional paleo-hydrological reconstructions, the observed variability reveals periodically occurring strong NW-SE hydro-climate gradients. We hypothesize, that this pattern is caused by shifts of the eastern edge of the area of influence of the NAO across central-eastern Europe due to the confluence of North Atlantic forcing, and other climatic features such as the East Atlantic/Western Russia (EAWR) pattern.