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Hydrological model of drip water d18O isotope values adjusted to 5-year drip water monitoring at Eagle Cave (Spain)

David Domínguez-Villar (1), Kristina Krklec (1), Ian Boomer (2), and Ian J. Fairchild (2)

(1) Department of Soil Science, University fo Zagreb,, Zagreb, Croatia (ddvillar@hotmail.com), (2) School of Geography, Earth and Environmental Sciences, Univerisity of Birmingham, Birmingham, UK,

When interpreting speleothem records in most cases scientists assume that the isotope composition of the speleothem resembles the variability of the d18O of precipitation. However, there are still a limited number of studies that have demonstrated such assumption. In regions with hydrological deficit, such those having a Mediterranean climate, such assumption is even more challenging and various studies have confirmed that this assumption is not valid. Additionally, a seasonal bias of the drip water has been suggested. Here we present a study on the drip water isotope composition in a Mediterranean climate, where we have 5 years of rainfall and drip water isotope values. We developed a lumped hydrological model to reproduce the isotope variability observed considering the meteorological data, the typology of discharge of different drip sites in the cave and the isotope values of rainfall and drip water.

The model considers actual evapotranspiration and assumes most of the recharge takes place after the field capacity is achieved. However, direct recharge is enabled to account for bedrock exposure over the cave. Diffuse flow is fed by recharge water, although only a percentage of recharge enters the matrix flow, whereas the rest have a preferential flow. A threshold of matrix flow is considered to account for rock assimilation capacity during large recharge events. We consider an atmospheric pressure diffuse flow, but also an overpressure diffuse flow that takes into consideration inflow of water when soil is saturated and the air is trapped in the eppikarst. The model allows lateral flow to account for the large discharge that some of this diffuse flow drip sites experience. Preferential flow is directed to two different storages, one with overflow and continuous flow and another with underflow that eventually dries out.

The isotope composition of drip waters follow the local meteoric water line and show no evaporation in the system, as confirmed by relative humidity measurements inside the cave. Most of the studied drip sites are governed by diffuse flow. The model shows that the average residence time of the water in the aquifer is of 15 months and that the drip water does not have preferential bias towards any season. Apart from some high frequency events, the model explains 67% of the variance of the drip isotope composition of the sites with diffuse flow. The drip sites that have a preferential flow are more difficult to reproduce. Their magnitude of the variability is properly captured by the model, but the timing of isotope anomalies still is challenging due to limitations in the knowledge on the precise recharge parameters. This study has confirmed that in Mediterranean sites, the isotope composition of the drips can result from the isotope composition of precipitation accounting all months of the year and with no particular bias towards any particular season.