Abstract
In the past decade, Huagapo and Pacupahuain Caves in the Central Peruvian Andes have become sources of speleothem oxygen isotope ($\delta^{18}O$) paleoclimate records. These studies identify the South American Summer Monsoon (SASM) as the main climate system controlling $\delta^{18}O$ variability. While this interpretation is verified through inter-proxy record comparisons on millennial scales, interpretation of the high-resolution variability within these records is limited by a lack of modern proxy calibration studies at these sites. Here we present results from a modern cave monitoring study undertaken to address the controls on the $\delta^{18}O$ values of precipitation at these sites and how surface and in-cave processes affect the $\delta^{18}O$ value of speleothem calcite. Speleothem calcite $\delta^{18}O$ values reflect an integrated signal of atmospheric processes (e.g., rainout, Raleigh distillation, upstream moisture recycling, changes in moisture source), evaporation and mixing during infiltration in the soil and epikarst, and in-cave processes such as degassing and evaporation. In consideration of these factors, we compare isotope trends in precipitation, cave drip water and modern farmed calcite from the two cave sites. We find that precipitation$\delta^{18}O$ values during peak monsoon activity (January -February) shows considerable inter-annual variation with averages of -16.7‰ for 2020, -18.5‰ for 2021 and -13.8‰ in 2022. We investigate the source of this variability in regional atmospheric circulation patterns using weather station data and back trajectories. The mean annual precipitation (MAP) from outside Huagapo Cave is $\delta^{18}O$ = -15.5+/- 6‰, while seasonal samples of drip water $\delta^{18}O$ = -14.5+/- 1‰, are offset from MAP possibly due to evaporation during infiltration. Cave drip water$\delta^{18}O$ has low variability over inter-annual and seasonal timescales indicating homogenization in the epikarst. Using geochemical and sensor data (e.g. cave relative humidity, temperature, and drip rate) as inputs for a karst based forward model, we simulate modern speleothem $\delta^{18}O$ to quantitatively assess the combined effects of hydroclimate processes integration to the isotope record.