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Role of Cloud Dynamics and Microphysical Processes in Governing Stable Isotope Contents in Precipitation

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After more than 60 years of systematic isotope measurements in precipitation at global scale, there are relatively well established patterns of spatial and temporal isotope variations, but the key physical processes controlling isotope variability remain a matter of debate, preventing a fuller integration of isotope-based information in meteorology and related atmospheric sciences. The prevailing hypothesis based on temperature, amount of precipitation and the Rayleigh distillation model has been successful in explaining many of the large scale patterns, particularly at a seasonal or annual scale. However, a rigorous evaluation at the storm event or intra-storm scale, where precipitation acquires its characteristic isotope composition, does not provide a satisfactory explanation in numerous cases. Most attempts to explain these variances are done by 'tweaking' the prevailing hypothesis, which suggests that the underlying physical processes are not clearly understood.

We have conducted a year-long study with high-frequency sampling (5-30 min) of precipitation at a mid-latitude site in Vienna, Austria. More than 1200 aliquots have been analysed for δ2H, δ18O and δ17O, together with profiles of reflectivity and doppler velocity, particle size distribution in precipitation using a disdrometer, and aerological analysis of air and moisture circulation using sounding data. We will discuss these results and the light they shed on boundary layer and tropospheric moisture circulation in frontal or convective precipitation, the relative roles of vapour deposition and riming growth of precipitation on its isotopic composition, and the origin of d-excess. The agreement between meteorological observations and isotopic variability is extremely promising and may help open a new frontier in the use of isotopes for weather and climate studies.