The stable isotopic complexity of thunderstorm precipitation – First results of the IAEA *HiRise21* experiment

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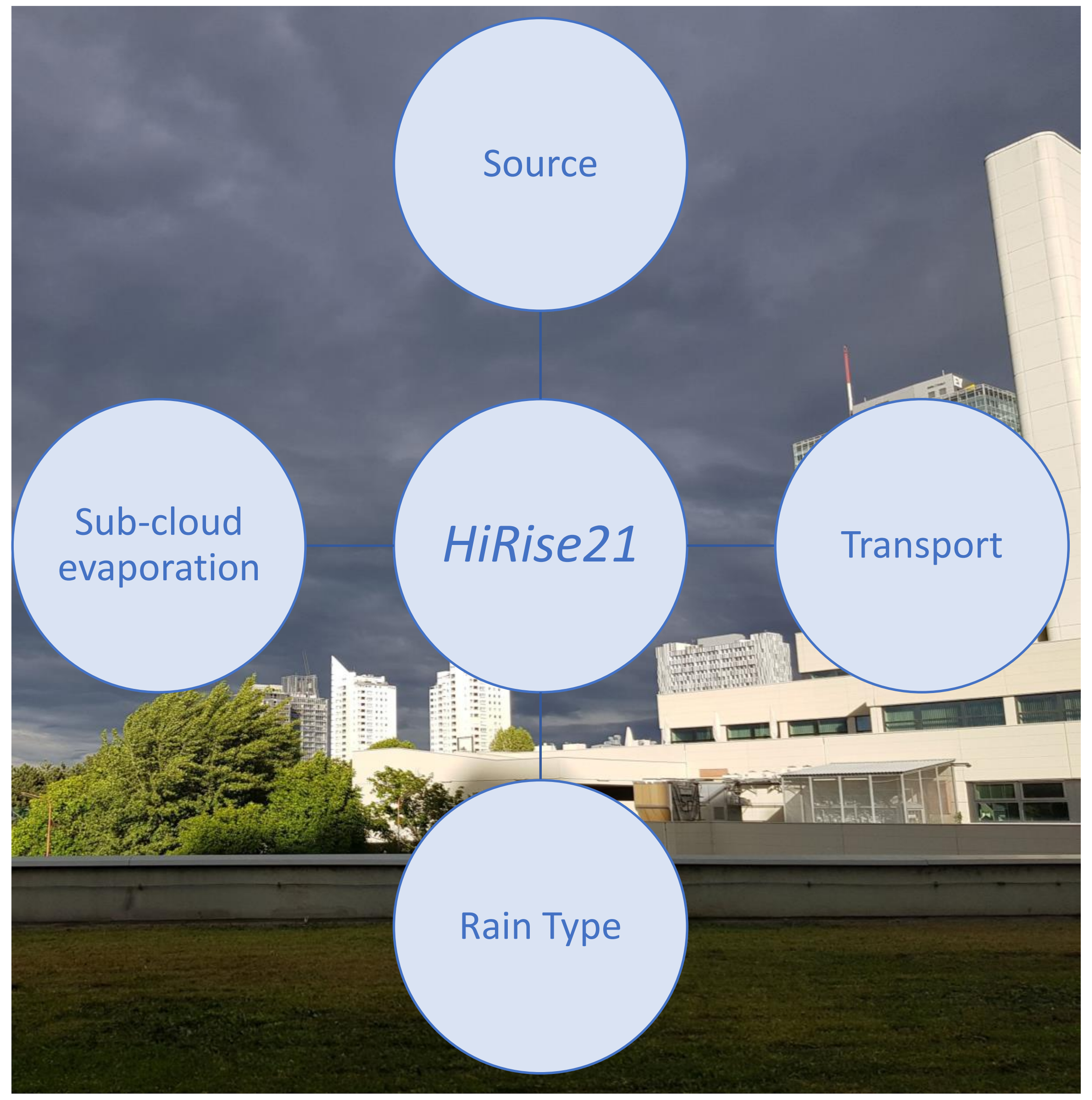
The IAEA HiRise21 (High-Resolution Isotope Sampling Experiment 2021) was designed to apportion the influence of vapor source regions on the precipitation process as well as sub-cloud evaporation over the May-October 2021 summer/fall period.

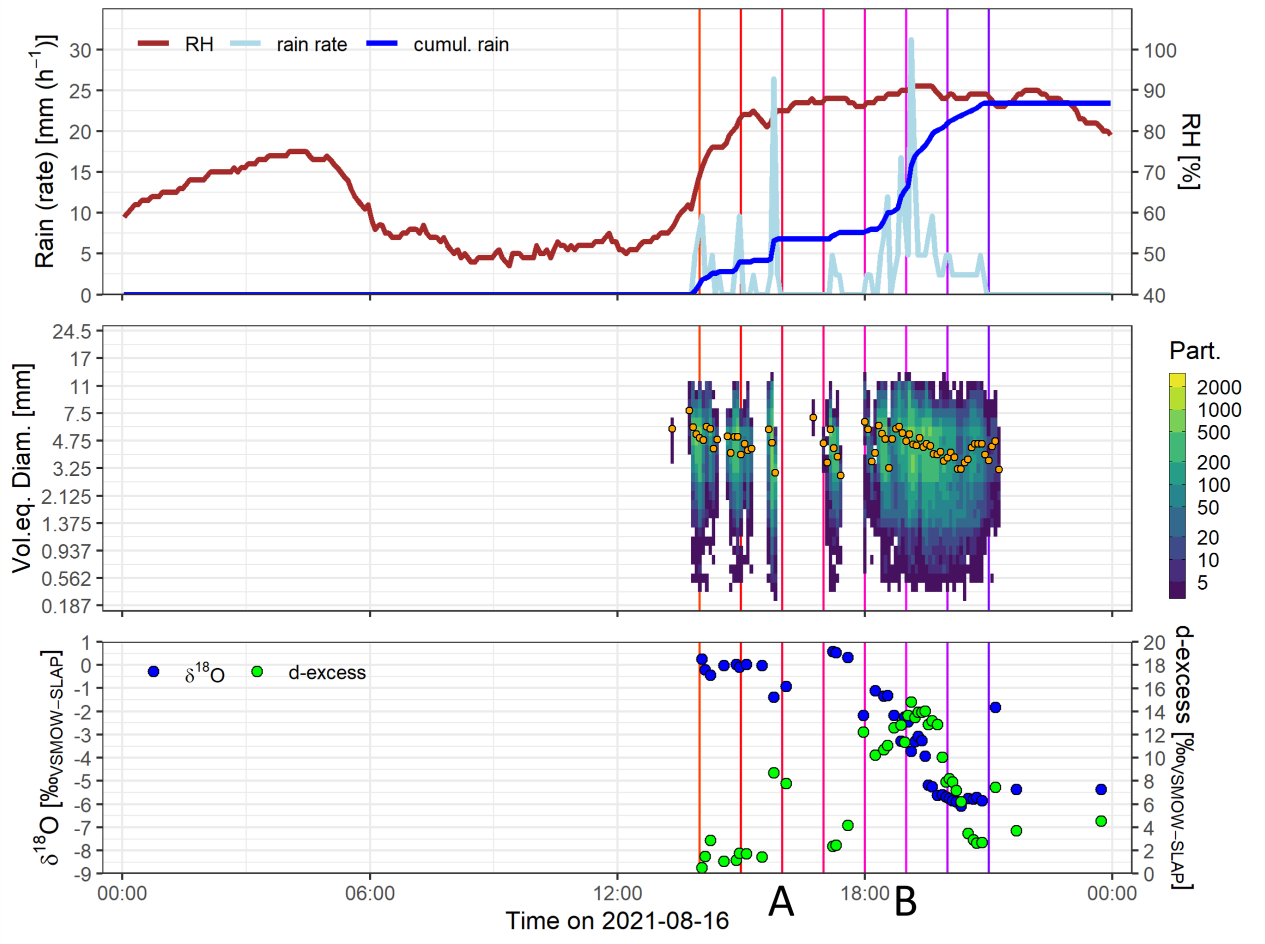
At the study site in Vienna, Austria, we captured the evolution of stable isotopes during thunderstorms by sampling at intervals of 5 minutes or 0.2 mm of precipitation using an automated rain collector (640 samples from 43 precipitation events). We recorded meteorological information and drop size distribution (size vs. terminal velocity matrix) and used 96h backwards trajectories at the 0° isotherm to identify source regions and travel paths.

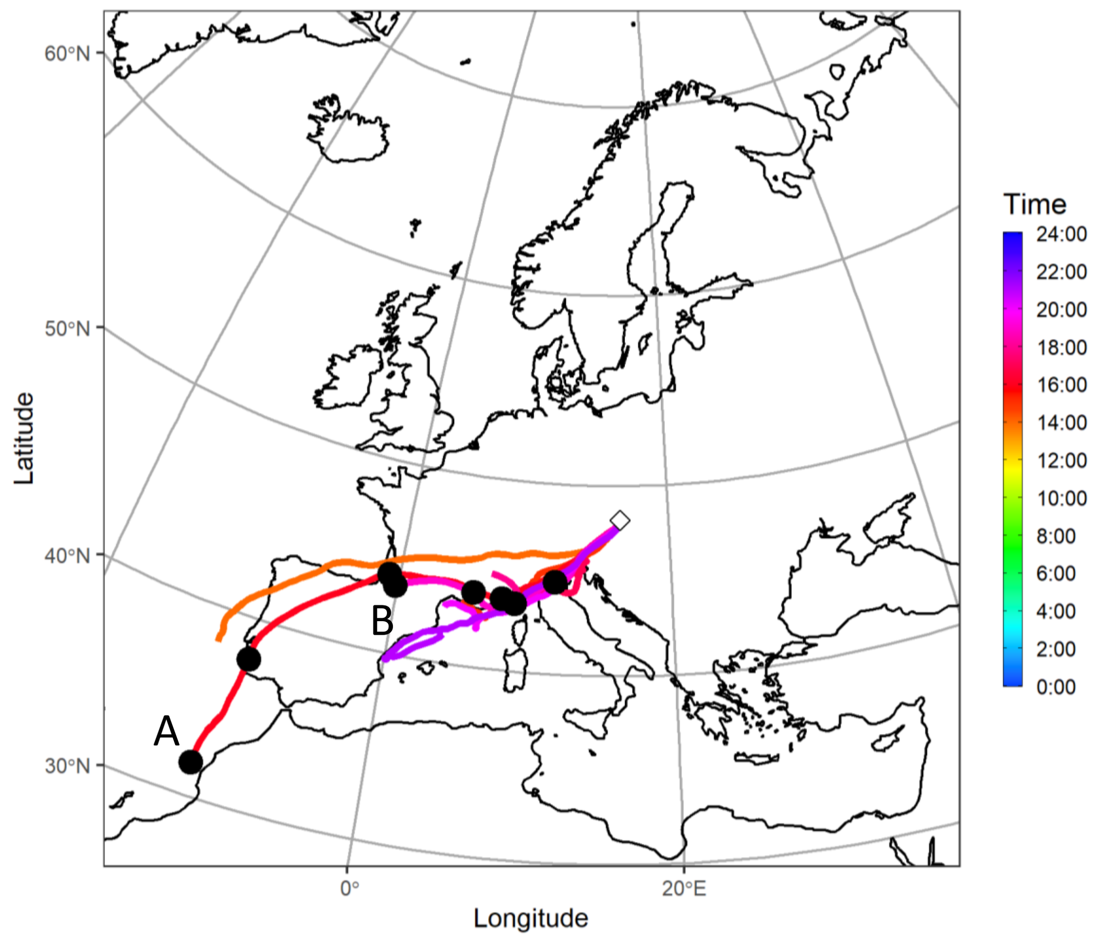
Here we present two selected events of "Mediterranean" source yet different isotopic variability.

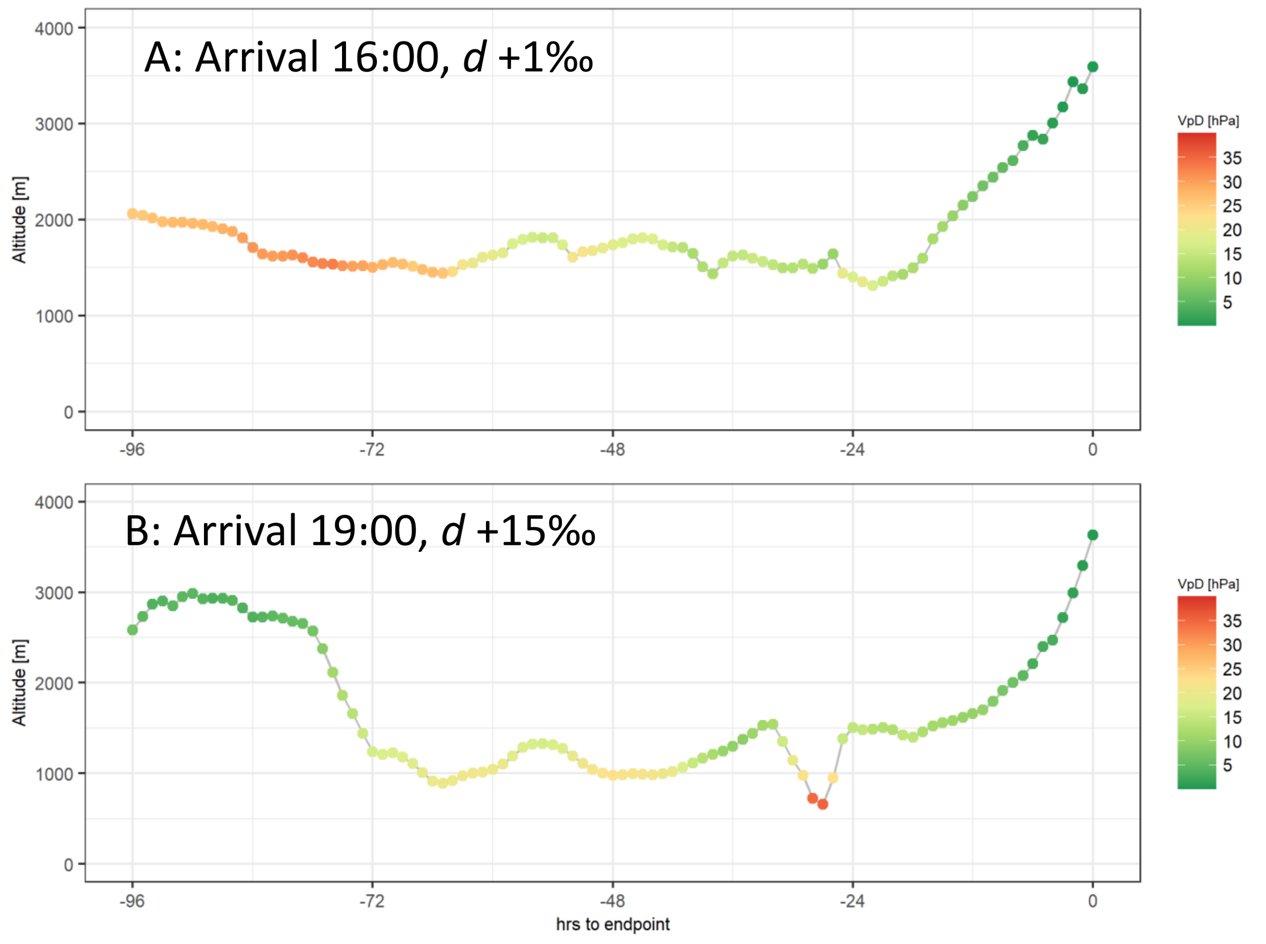


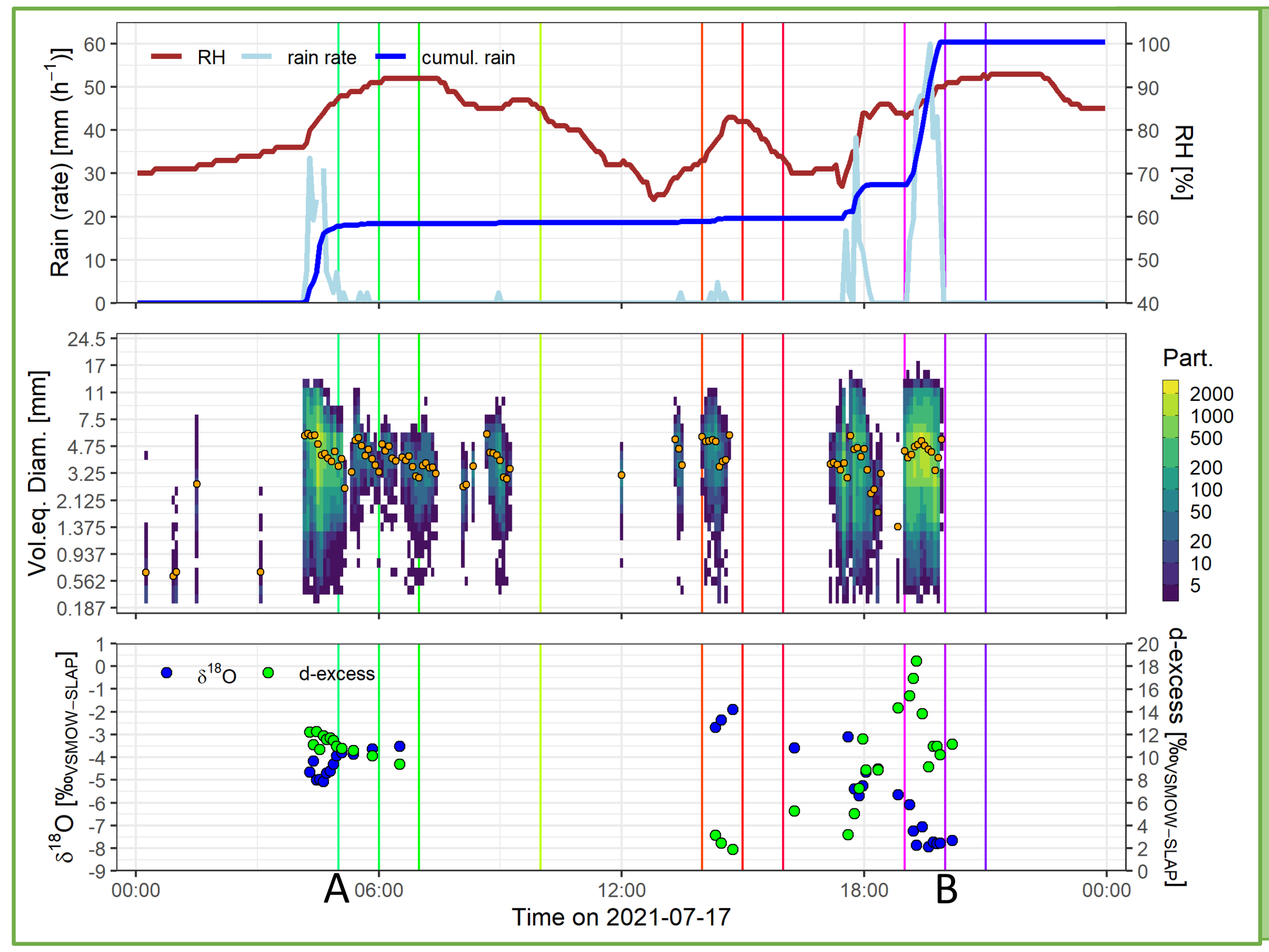
August 16 – 2 events totaling 22 mm.

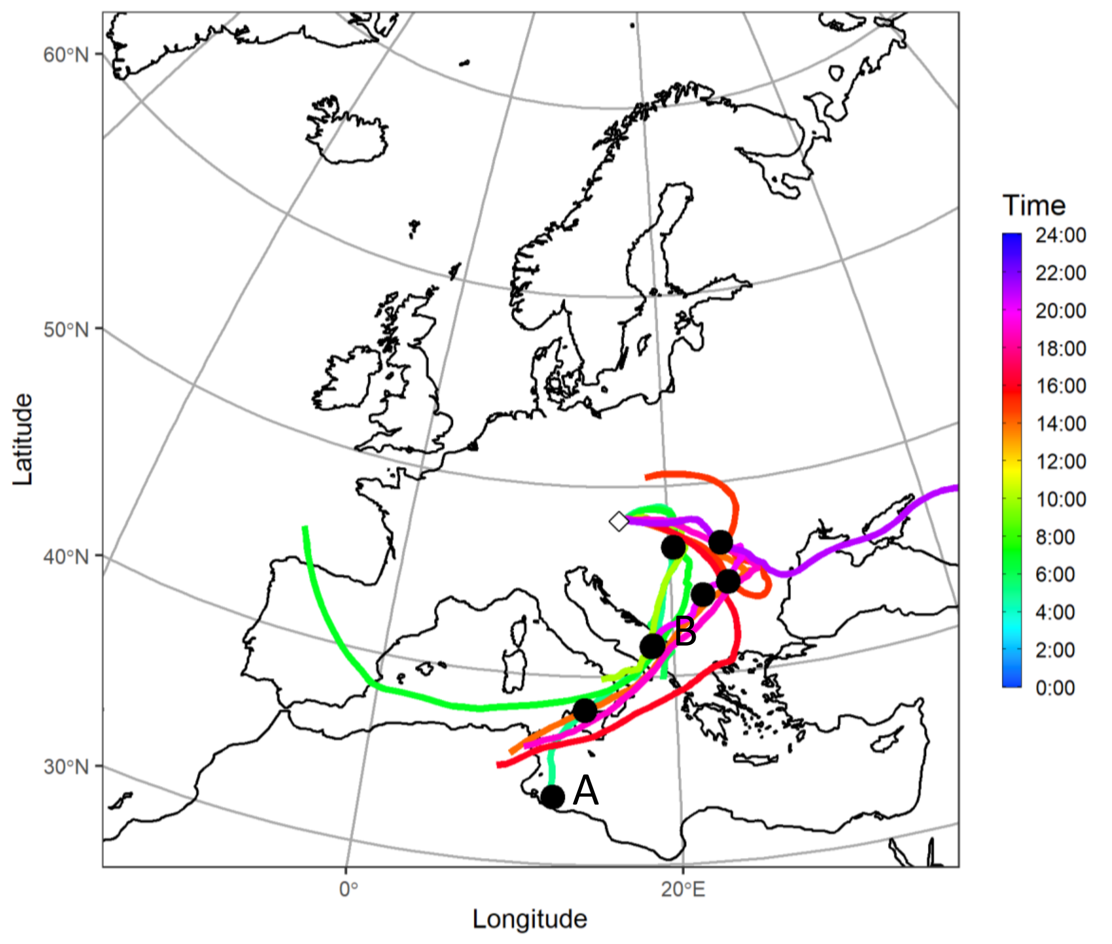
- 16:00 – the 96h trajectory reveals an origin in the subtropical Atlantic. D-excess is rather low (0 to +5 ‰) and $\delta^{18}O$ rather enriched (-1 to 0 ‰). The alleged source region shows a low-lying trajectory with a high vapor pressure deficit.
- Intermediate rain showers mark the transition to Western Mediterranean influences (d-excess increasing).
- 19:00 – this trajectory seems to follow a similar path, but potential moisture uptake areas are different: over the Western Mediterranean basin, and with a marked "dive" into the Gulf of Venice ca. 28h prior to arrival boosting moisture. The d-excess peaks at +14 ‰. Later trajectory paths do not exhibit this "dive"-associated d-excess peak (though passing over the same area) and follow a Rayleigh-type rainout depletion pattern.

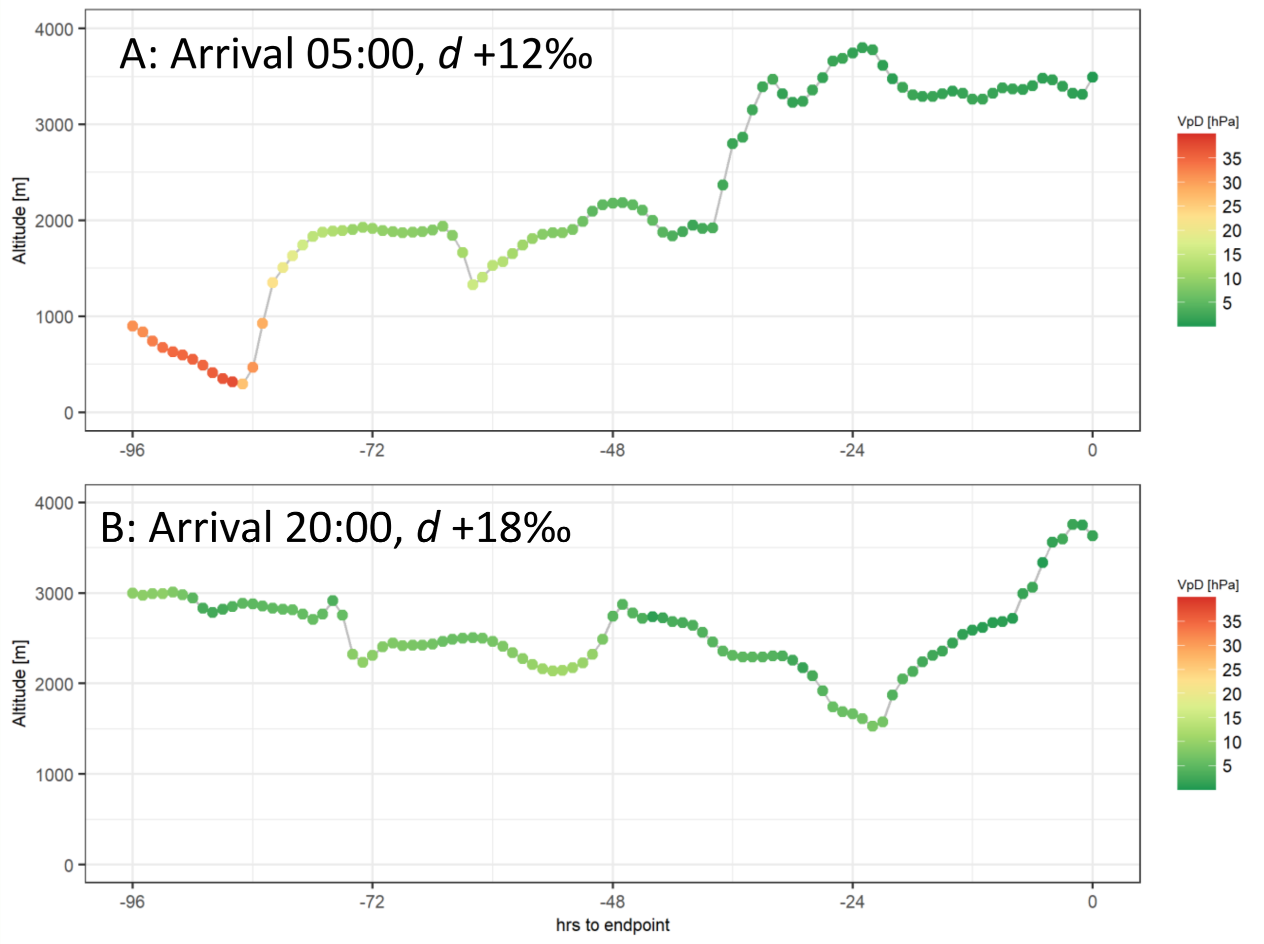












Jul 17 – 3 events totaling 60 mm during 18 hours.

- The first event (04-05:00, 20 mm) originated in the South-Central Mediterranean basin along a low-lying trajectory. The d-excess is above the GMWL (+11 to +13‰) and $\delta^{18}O$ does not show a marked evolution.
- An intermediate rain shower (14-15:00) presents an evaporated signature, obviously due to RH.
- The next event (10 mm, 18:00) passes over the Adriatic, however without the characteristic isotopic signature. It is followed by the final event (19-20:00, 30 mm) which strongly peaks in d-excess (+18‰) without touching the Adriatic at low height.

Conclusions & Outlook

- Neither source-based nor process-focused approaches were able to systematically explain the observed isotopic variabilities. Multiple competing processes during sourcing and advection of air masses impeded the systematic identification of d-excess signatures expected for convective processes (or they weren't sufficiently deep).
- Source and transport path analysis revealed a remarkable influence of the Adriatic Sea, including a „boost" for d-excess after this passage often concomitant with higher rain rates. Decreases in d-excess through sub-cloud evaporation occasionally correlated with relative humidity, but not to drop size, and were often masked by source/transport effects.
- Further data interpretation will focus on identifying conditions for and effects of "Adriatic boosts". The interplay with northern Atlantic sources could hardly be studied because of absence of such events in summer 2021.

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