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Temporal and spatial variability of water vapor isotopic composition in the lower troposphere: insights from ultralight aircraft measurements

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The lower troposphere is where the surface evapotranspiration flux has a strong impact on the atmospheric water vapor isotopic composition, enabling the investigation of the hydro-ecological features of a specific study area. Even though several studies investigated in the last decade the spatial and temporal variability of tropospheric water vapor isotopic composition with ships, aircrafts, satellites and at fixed locations at ground level, vertical profiles and spatial observations acquired within the same time window in the lower troposphere (<3000 m) are still rare. As part of the ground validation of the EU H2020 LEMON project, we used an UltraLight Aircraft (ULA) equipped with a flight-enabled CRDS water vapor isotopes analyzer to probe the vertical and spatial structure of the lower troposphere in Ardèche, Southern France, between 17 and 23 September 2021. In total, 16 flights with different flight strategies were performed for a total flight time of ~20 hours. The flight patterns were mainly designed to obtain representative vertical profiles of the water vapor column below 3000 m for comparison with ground-based LIDAR and to obtain precise estimates of the humidity and water vapor isotopic composition at specific altitude levels, spanning an area of approximately 10 km x 10 km. Due to the flexibility of the ULA, it was also possible to fly several times throughout the day, allowing to study the daytime temporal evolution of the water vapor column within the boundary layer. In general, vertical profile measurements showed evidence of strong mixing process throughout the lower atmospheric column, with both input from free tropospheric layer and surface evapotranspiration. Water vapor stratification, characterized by a large vertical gradient of the isotopic composition, was observed during early morning flights with increased steepness of the vertical isotopic profile along the day. In some cases, flights focused on horizontal and spatial gridding of water vapor isotopic composition showed variation of more than 10‰ for dD in ~5 km^2 and in less than 0.12 hours. We

hypothesize this large horizontal variability to be related to development of thermals within the boundary layer. Our next step will be to summarize the spatial and temporal variability of water vapor isotopic composition for allowing a fair comparison between high-resolution isotope-enabled general circulation models, remote sensing and water vapor observations in the boundary layer.