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# The L-WAIVE campaign over the Annecy lake: An analysis of water vapor variability in complex terrain

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The vertical structure of the water vapor field in the lower troposphere is only sparsely documented in mountainous regions and particularly above Alpine lakes. This may in part due to the complexity of the system, being intimately linked to the orography surrounding the lakes and the forcing of the topography-induced winds. The question arises as to how the vertical extent of evaporation processes over the lakes and how these are influenced by larger scale forcing, in particularly with regard to the vertical dimension.

In order to gain understanding on the vertical structure of atmospheric water vapour above mountain lakes, the L-WAIVE (Lacustrine-Water vApor Isotope inVentory Experiment) field campaign was conducted in the Annecy valley in the French Alps in June 2019. This campaign was based on a synergy between ground-based lidar measurements and ship-borne as well as airborne observations. Two ultra-light aircraft (ULA) were equipped with remote sensing and in-situ instruments to characterize the vertical distribution of the main water vapour isotopes. One ULA embarked a backscatter lidar to monitor the horizontal evolution of the vertical structure of the lower troposphere above and around the lake, and the other one carried an L2130-i Picarro isotope analyser for the in-situ measurement of the $H_2{}^{16}O$, $H_2{}^{18}O$ and HDO concentrations, an iMet probe for the measurement of thermodynamic properties (T, RH, p), as well as a pre-cleaned Caltech Active Strand Cloud Water Collector which was modified to efficiently collect cloud water at the speed of the ULA. Offset calibration of the Picarro analyser was carried out for each flight before take-off and after landing. Three-dimensional explorations of the lake environment up to 4 km above the mean sea level (~3.5 km above the ground level) were conducted with the ULAs. Simultaneous vertical profiles of water vapour, temperature, aerosols and winds were acquired from two co-located ground-based lidars installed on the shore of the southern part of the Annecy Lake named “petit lac”, in the commune of Lathuile (45°47' N, 6°12' E). Finally, ship-borne profile measurements of the lake water temperature, pH, conductivity and dissolved $O_2$ as well as water sampling for isotopic analyses were accrued out across the lake of Annecy.

The campaign period included several cases of weather events leading to variability between dry and humid conditions, cloudy and cloud-free conditions, and regimes dominated by weak and strong winds. Flight patterns have been repeated at several times in the day to capture the diurnal evolution as well as variation between different weather regimes. Additional flights have been conducted to map the spatial variability of the water vapour isotope composition with regard to the lake and topography. The scientific strategy of the experiment will be presented, and the first observational results will be described with emphasis on the vertical structure of the lower troposphere and its relationship to orography, including the characterisation of the water vapour isotopologues variability in, above and around the Annecy lake.