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Vertical profiling of aerosol properties with two-wavelength polarization Raman lidar over the Vipava valley

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Presence of atmospheric aerosols affects the Earth's radiation budget and thus also atmospheric thermal structure, which in turn affects cloud and planetary boundary layer (PBL) dynamics. We combine in-situ and remote measurements to determine aerosol properties in a representative hot-spot for air pollution in a complex terrain configuration. Vertical profiles of aerosol properties were investigated using a two-wavelength polarization Raman lidar system in the Vipava valley. Using lidar-obtained particle depolarization ratio, lidar ratio and backscatter Ångström exponent (355 nm / 1064 nm), which depend on aerosol shape, size and refractive index, thus the aerosols can be identified and the roles of different aerosol types in the observed atmospheric processes were investigated. In addition, aerosol absorption coefficients were measured in-situ by Aethalometers (AE33, Magee Scientific / Aerosol d.o.o.) on the valley floor and on the adjacent mountain range, 850 m above the lidar site.

Our primary goal was to study the variability of aerosol types within and above the Vipava valley, which was performed using the entire lidar dataset from August – December 2017. Primary anthropogenic aerosols within the valley is mainly emitted from two sources: individual domestic heating systems, which mostly use biomass fuel and traffic. Natural aerosols, transported by long-range transport, such as mineral dust and sea salt, were observed both above the PBL and entering into the PBL. Vertical distributions of aerosol properties, in particular the particle depolarization ratio, indicated atmospheric stratification with different aerosol types occupying different height ranges. In the presence of Bora (strong down-slope wind), Kelvin-Helmholtz instabilities were observed between the PBL and the free troposphere. Using aerosol type identification capability of our system, we discovered that this instability was responsible for ejecting aerosols from the PBL up to 2 km into the free troposphere.

In addition, we improved the reliability of aerosol identification in vertical profiles using absorption coefficient measured by Aethalometer. Combining it with the aerosol extinction coefficient at 355 nm derived from lidar data, we derived aerosol single scattering albedo (SSA), which is an important parameter for aerosol characterization.