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Characterising the atmospheric boundary layer based on ceilometer observations

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Long-term statistics of atmospheric boundary layer (ABL) dynamics are required for the interpretation of seasonal variations and trends in surface air quality observations and for the evaluation of chemistry transport models. Using aerosols as tracers, attenuated backscatter recorded by e.g. automatic lidars and ceilometers (ALC) can portray the various layers in the ABL. Especially in cities, where aerosol loading is often high, even sensors with a lower signal-to-noise ratio (SNR) can be used successfully to track the mixed layer depth (DML). As ALC operate automatically and require only little maintenance, they are most suitable to continuously monitor profiles of attenuated backscatter with high temporal and vertical resolution.

Atmospheric boundary layer characteristics are determined based on a long-term dataset (2011-2016) of Vaisala CL31 observations collected in central London, UK. As the CL31 has the advantage of reaching complete overlap already at 70 m range, it is possible to detect DML even during stable night-time conditions. A new algorithm was developed to detect the mixed layer depth, with a specific focus on the near-range. To facilitate the interpretation of DML under different atmospheric conditions, days are classified by cloud cover, cloud type, and duration of precipitation - all being solely estimated based on observations from the ceilometer. Given surface rain gauges are insufficient to flag rainfall in attenuated backscatter profiles when rain evaporates above the surface or rain rates are low, a rainfall flag was developed based on the ALC attenuated backscatter. Using the ABL classification, systematic differences between ABL dynamics are identified and their impact on the mixed layer depth climatology is estimated.

With the expansion of ALC networks in Europe and across the world, the demand for harmonised ABL detection increases. Several tools have recently been developed or expanded (such as STRAT+, Pal and Haeffelin, 2013; pathfinderTURB, Poltera et al. 2017). Pursuing collaborations facilitated by the COST action TOPROF, it is being evaluated how advantages of various available algorithms may be combined.

References

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