Evaluation of a mixed-layer height detection algorithm using two case study days from the urbisphere-Berlin campaign

Russell Glazer[1], Sue Grimmond[1], Lewis Blunn[2], Humphrey Lean[2], Daniel Fenner[3], Andreas Christen[3], Will Morrison[3], Matt Clements[1], Fred Meier[4], Janet Barlow[1]

[1]University of Reading

[2]MetOffice@Reading

[3]University of Freiburg

[4]Technical University, Berlin

As part of the ERC urbisphere project, field campaign measurements were taken during 2021-2022 in the Berlin region with 24 ALCs (ceilometers) deployed in three concentric rings (A Inner city, B Outer city, and C Rural). The three rings centered on the city centre are derived using detailed urban form and function data (Fenner et al. 2024). Hectometric (100 m) numerical weather prediction (NWP) is undertaken with Met Office Unified Model (UM) v13 for two IOP days (1) 4 August 2022 during a heatwave, and (2) 18 April 2022 during early spring, with clear skies. The ALC attenuated backscatter data is used with STRATfinder (Kotthaus et al. 2020) and CABAM (Kotthaus et al. 2018) to derive mixed-layer height (MLH). Here, we present a new algorithm (MMLH) to analyse MURK single-species aerosol (Clark et al 2008) to derive the modelled MLH. Following CABAM and previously MURK ALC analyses (Warren et al. 2018,2020, 2022), the data are analysed considering the distinct diurnal regimes of the ML (e.g. growth period between morning and afternoon). MMLH derived MLH suggests the UM100 performs well on both days (r2 ~0.9). The largest discrepancy occurs during the morning transition period when the UM100 overestimates the MLH. This may be explained by the strong residual layer present in the morning simulations, which MMLH misdiagnoses as the MLH. Urban-rural differences in MLH are very similar between the observations and model. The model simulates an urban plume effect on both days but in the observations it is only seen on the Spring day.

Clark, P.A., Harcourt, S.A., Macpherson, B., Mathison, C.T., Cusack, S. and Naylor, M. (2008) Prediction of visibility and aerosol within the operational Met Office Unified Model. I: Model formulation and variational assimilation. Quarterly Journal of the Royal Meteorological Society, 134(636), 1801–1816. https://doi.org/10.1002/qj.318

Fenner, D. and coauthors, 2024: urbisphere-Berlin: Multi-scale urban impacts on the atmospheric boundary layer. Bull. Am. Met. Soc. (In review)

Kotthaus, S. and Grimmond, C. S. B., 2018a: Atmospheric Boundary Layer Characteristics from Ceilometer Measurements Part 1: A new method to track mixed layer height and classify clouds. Q. J. R. Meteorol. Soc. 144 (714): 1525-1538. https://doi.org/10.1002/qj.3299

Kotthaus, S. and Coauthors, 2020: Tailored Algorithms for the Detection of the Atmospheric Boundary Layer Height from Common Automatic Lidars and Ceilometers (ALC). Remote Sens. 12 (19): 3259. https://doi.org/10.3390/rs12193259

Warren E et al. 2018: Evaluation of forward-modelled attenuated backscatter using an urban ceilometer network in London under clear-sky conditions. Atmos. Env., 191, 532-547,1352-2310, https://doi.org/10.1016/j.atmosenv.2018.04.045

Warren E et al. 2022: Spatial variability of forward modelled attenuated backscatter in clear-sky conditions over a megacity: Implications for observation network design. Q J R Meteorol Soc, 148(744), 1168–1183. https://doi.org/10.1002/qj.4253

Warren E et al. 2020: Observed aerosol characteristics to improve forward-modelled attenuated backscatter in urban areas. Atmos. Env., 224, 1352-2310. https://doi.org/10.1016/j.atmosenv.2019.117177.