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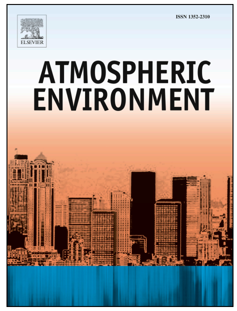


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# Evaluation of forward-modelled attenuated backscatter using an urban ceilometer network in London under clear-sky conditions

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***Abstract***

Numerical weather prediction (NWP) of urban aerosols is increasingly sophisticated and accurate. In the absence of large particles (e.g. rain, cloud droplets), information on atmospheric aerosols can be obtained from single wavelength automatic lidars and ceilometers (ALC) that measure profiles of attenuated backscatter ($\beta_o$). To assess the suitability of ALC profile observations for forecast evaluation and data assimilation, a forward operator is required to convert model variables into the measured quantity.Here, an aerosol forward operator (aerFO) is developed and tested with Met Office NWP data (UKV 1.5 km) to obtain synthetic attenuated backscatter profiles ($\beta_m$). aerFO requires as input the profiles of bulk aerosol mass mixing ratio and relative humidity to compute $\beta_m$, plus air temperature and pressure to calculate the effect of water vapour absorption. Bulk aerosol characteristics (e.g. mean radius and number concentration) are used to estimate optical properties. ALC profile observations in London are used to assess $\beta_m$. A wavelength-dependent extinction enhancement factor accounts for the change in optical properties due to aerosol swelling. Sensitivity studies show the aerFO unattenuated backscatter is very sensitive to the aerosol mass and relative humidity above ~60-80 %. The extinction efficiency is sensitive to the choice of aerosol constituents and to ALC wavelength.Given aerosol is a tracer for boundary layer dynamics, application of the aerFO has proven very useful to evaluate the performance of urban surface parameterisation schemes and their ability to drive growth of the mixing layer. Implications of changing the urban surface scheme within the UKV is explored using two spring cases. For the original scheme, morning $\beta_m$ is too high probably because of delayed vertical mixing. The new scheme reduced this persistence of high morning $\beta_m$, demonstrating the importance of surface heating processes. Analysis of profiles at five sites on 12 clear-sky days shows a positive, statistically significant relation between the differences of modelled and measured near-surface attenuated backscatter [$\beta_m$ - $\beta_o$] and near-surface aerosol mass. This suggests errors in near-surface attenuated backscatter can be attributed to errors in the amount of aerosol estimated by the NWP scheme. Correlation increases when cases of high relative humidity in the NWP model are excluded. Given the impact on aerosol optical properties demonstrated, results suggest the use of a fixed, bulk aerosol for urban areas in the UKV should be revisited and the lidar ratio should be constrained. As quality of the observed attenuated backscatter is demonstrated to be critical for performing model evaluation, careful sensor operation and data processing is vital to avoid false conclusions to be drawn about model performance.