Geophysical Research Abstracts
Vol. 19, EGU2017-5185-4, 2017
EGU General Assembly 2017

Evaluation of operational forecast model of aerosol transportation using ceilometer network measurements

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Due to technical improvements of ceilometers in recent years, ceilometer measurements are not only limited to determine cloud base heights but also providing information on the vertical aerosol distribution. Therefore, several national weather services implemented ceilometer networks. These measurements are e.g. valuable for the evaluation of the chemical transport model simulations.

In this study, we present comparisons of European Centre for Medium-Range Weather Forecast Integrated Forecast System (ECMWF-IFS) model simulation of aerosol backscatter coefficients with ceilometer network measurements operated by the German weather service (DWD) . Five different types of aerosol are available in the model simulations which include two natural aerosols, sea salt and dust. The other three aerosol types, i.e. sulfate, organic carbon and black carbon, have significant anthropogenic contributions. As the model output provides mass mixing ratios of the above mentioned types of aerosol and the ceilometers measure attenuated backscatter (β^*) provided that calibration took place, it is necessary to determine a common physical quantity for the comparison. We have chosen the aerosol backscatter coefficient (β) for this purpose. The β-profiles are calculated from the mass mixing ratios of the model output assuming the inherent aerosol microphysics properties. It shall be emphasized that in the model calculations, all particles are assumed to be spherical.

We have examined the sensitivity of the intercomparison on the hygroscopic growth of particles and on the role of particle shape. Our results show that the hygroscopic growth of particle is crucial (up to a factor of 22) in converting the model output to backscatter coefficient profiles whereas the effect of non-sphericity of dust particles is comparably small ($\sim$44%). Furthermore, the calibration of the ceilometer signals can be an issue. The agreements between modeled and retrieved β-profiles show different characteristic in terms of absolute values and in the height of the mixing layer under different circumstances.