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On the horizontal homogeneity of aerosol distributions

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Aerosol particles play a significant role in atmospheric radiation and chemistry. However, the resources for observational programs of aerosols are still limited, and models often consider aerosols only in simplified approaches. As a consequence, experimental and modelling efforts must be intensified. Observations should be organized in form of networks to provide significant temporal and spatial coverage.

In this context, even the probably most basic information on aerosols is beneficial, i.e., the height of that layer where aerosols are concentrated. This layer can be considered as the mixing layer. Its height, z_{ml}, is in particular relevant for studies of the air quality, but also for the validation of chemistry transport models, or for parameterizations of the aerosol optical depth using visibility data. Parameterizations can be used for correcting satellite data for atmospheric masking, if no direct measurements of the optical depth or the vertical profile of the extinction are available.

The range resolved assessment of optical properties of aerosols can best be provided by lidars. As a by-product, the extent and the structure of the mixing layer can be derived from the vertical aerosol distribution. As the derivation of z_{ml} is relatively simple, it certainly is the most promising candidate for automated data evaluation and for monitoring purposes. Several instruments such as ceilometers or small, unattended lidars, but also different methodologies such as sodars and wind profilers have been used for monitoring z_{ml}. However, it has to be quantified where the limits of these systems are, e.g., with respect to measurement range, temporal and spatial resolution and accuracy. The benchmark should be a lidar.

The establishment of a groundbased network for aerosol characterization – and the determination of z_{ml} as a spin-off – will necessarily include only a limited number of stations. Consequently, the question of the representativeness of their data sets must be

addressed, and a careful selection of these sites is essential. To know the area, which is represented by the point measurements, will also help to validate satellite retrievals, which often refer to areas of several tens of square-kilometers.

An opportunity to investigate the horizontal distribution of aerosols and their temporal development was given by the ICAROS-NET (Integrated Computational Assessment of Air Quality Via Remote Observation System; Schäfer et al., 2004) campaign. This campaign was run in May 2003 and December 2003, in each case for two weeks, in and around Munich. The mixing layer height was observed for a few days by two lidars of the Meteorological Institute of the Ludwig-Maximilians-Universität; one of which (MULIS) was located in central Munich, the other (POLIS) was moved in a van between Maisach (25 km west of Munich) and Ebersberg (30 km east). In addition, several other instruments were operated at different locations near Munich, among others a ceilometer of the Institut für Meteorologie und Klimaforschung, Atmosphärische Umweltforschung (IMK-IFU), at Frankendorf, 38 km north of Munich.

Evaluation of the data gave good insight in the spatial aerosol distribution over an area of about 50 km in diameter and the potential of different remote sensing techniques to derive the mixing layer height. It was found that the horizontal aerosol distribution was relatively homogeneous in and around Munich, so that the Munich area seems to be a good test bed for satellite validation. It was further found that in particular in winter the aerosol distribution could be extremely shallow: during Foehn episodes, the aerosols were confined to the lowest 300-400 m. As a consequence, special care is required for the lower limit of the measurement range of the respective lidar system.

The latter point is also relevant if the potential of a lidar to determine extinction coefficient profiles – a quantity that is beyond the capabilities of the other instruments involved in ICAROS-NET – should be exploited. As the lowermost layers of the troposphere contain most of the aerosols, the missing of these layers would introduce significant errors in the integrated optical depth.

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