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Temporal variation of urban mixing layer height in Mexico City and Augsburg from ceilometer and SODAR measurements

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The mixing layer height (MLH) is assumed to be a **key parameter for the characterisation of air pollution**. The determination and modelling of the MLH has therefore found considerable interest in the recent decade (Piringer et al., 2005).

With today's availability of remote sensing devices for monitoring the structure of the atmospheric boundary layer (e.g. Emeis and Schäfer, 2006) it has been shown that the atmospheric boundary layer sometimes exhibits multiple layering (e.g. internal boundary layers, near-surface inversions and residual layers at night-time and in the morning hours). It was demonstrated that the **lowest stable layer or inversion limits the vertical exchange of primary pollutants** emitted at or near the surface (e.g. Schäfer et al., 2006). MLH information is also necessary for special kinds of satellite data interpretation, e. g. the retrievals of optical depths for the particle concentration near the surface (Sarigiannis et al., 2002).

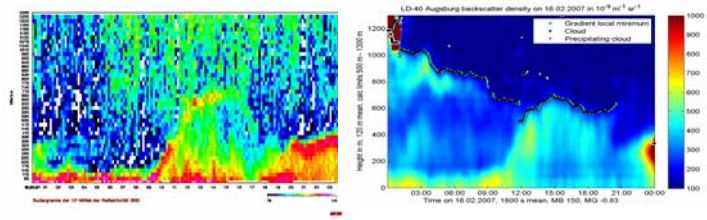
Objectives

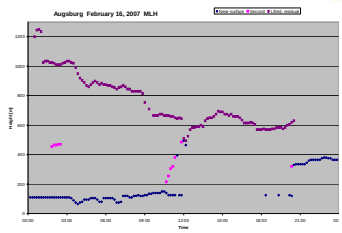
Augsburg (Germany): Determination of lower atmospheric layering to investigate **interactions between urban and regional areas**.
Mexico City: Study of conditions for **high air pollution**.

Methodologies

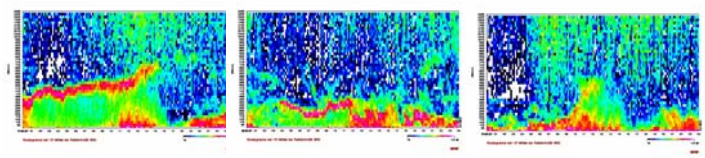
A **ceilometer was operated in Mexico City** during March 2006 and **two ceilometers and a SODAR in Augsburg** since September 2006. The Vaisala ceilometers LD40 and CL31 were used which are eye-safe commercial lidar systems. Partially a comparison was performed with parallel MLH retrievals from a Metek SODAR DSDR 3 x 7.

MLH is retrieved from SODAR data by analysing the backscatter intensity and the variance of the vertical velocity component. High backscatter intensity with low variance indicate stable layers and a sharp decrease of backscatter intensity in the vertical profile the top of the turbulent mixing layer (Emeis and Türk, 2004). The **ceilometer measurements are used routinely to determine the heights of the near surface aerosol layers** from minima of the vertical gradient of the optical backscatter intensity (Münkel et al., 2006).

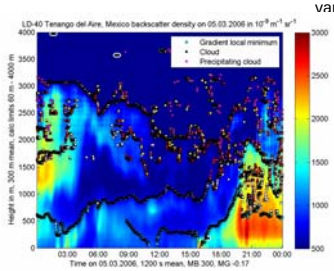




Backscatter intensities from SODAR (above left) and ceilometer (above right) in the city of Augsburg as well as several layers from ceilometer (left) on February 16, 2007; averaging: temporal 1200 s, height 120 m. Between 0:00 and 11:00 a residual layer exists above a stable near-surface layer. From 11:00 until 18:00 a convective boundary layer with a maximum height of 700 m is visible.



Backscatter intensities from SODAR on February 17, 18 and 21, 2007 clearly indicating temporal variation of MLH.



Ceilometer measurements at Tenango del Aire nearby Mexico City in 2377 m asl (left, view to Mexico City) on March 05, 2006; averaging: temporal 1200 s, height 300 m. Several aerosol layers above ground are clearly visible from the backscatter intensity plot (right).

Results

Continuous remote sensing measurements provide information about temporal variation of urban MLH. A **typical rise of MLH during a day** with strong convection in the afternoon as well as a residual layer above the mixing layer during night and early morning hours can be seen from ceilometer data together with SODAR data. Aerosol load and thus backscatter intensity are much lower in Augsburg (see above) than around Mexico City (see left).

Conclusion

In the absence of low clouds and precipitation ceilometers can estimate the mixing layer height fairly well. The **combined operation of acoustic and optical remote sensing techniques** offers the possibility to analyse the vertical structure of the atmospheric boundary layer. Because the acoustic technique observes thermal structures and the optical technique observes the aerosol distribution different layers like the stable surface layer, the **convective boundary layer and the residual layer can be easily distinguished**.

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