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Intercomparison of Methods for the Determination of Mixing-Layer Heights Using a New Network of Advanced Ceilometers in Germany

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The mixing layer height (MLH) is one of the most relevant parameters for modeling and assessing the atmospheric spreading conditions for all kinds of constituents in the boundary layer. For this reason, it has become more and more important to operationally detect and determine MLH with networks of sophisticated observing systems. Such networks can either be used for validation of the output from NWP models, or for the direct assessment of the atmospheric conditions (*if the measurements are cost-effective and the results can be proven to be reliable*). Typically, MLH is determined from vertical profiles measured with radiosondes, lidar, sodar/RASS, or WPR/RASS. While time resolution of radiosondes is strongly restricted, remote-sensing systems are mostly facing deficits with respect to height coverage or range. Apart from combinations of systems, ceilometers show considerable advantages for monitoring the full daily cycle of the MLH from the surface layer up to more than three kilometers. In 2007, the German Meteorological Service started to install a network of new ceilometers which are being used among other objectives also for MLH detection. In contrast to the previous systems, the new type of ceilometer (JENOPTIK CHM-15K) is based on a diode-pumped Nd:YAG laser and a single-photon-counting detector with considerably higher sensitivity than standard analog-detection systems. Apart from a description of the new type of ceilometers, this contribution focuses on the presentation of a new mathematics-based method for the determination of MLH.

In principle, MLH detection is a pattern recognition problem. The basic assumption which is usually made is that the vertical distribution of aerosol can be used as a tracer for finding boundaries. The absolute value of the backscatter is typically not needed since the relevant information seems to be completely coded in the gradient (but possibly of different orders) of the backscatter profile. Currently, two major types of algorithms for MLH detection from lidar or ceilometer exist:

- The peak technique, being invented for detection of the top of multiple aerosol layers from backscatter profiles; it bases on the analysis of collocated minima of the backscatter gradient and maxima of the backscatter variance, and
- the wavelet method, which utilizes the wavelet transform of the backscatter profile.

This latter method has gained a great amount of popularity during the last years. Typically, the Haar wavelet transform is used because it is easy to implement and a powerful gradient locator and therefore a very promising mathematical tool. However, recently published wavelet-based methods do not take full advantage of the wavelet theory. Here, we present results of our efforts to develop an advanced version of the wavelet algorithm and, thus, a reliable MLH detector.

First, the new MLH retrieval technique is described, demonstrated in a case study, and its results are compared to those obtained with the standard peak technique. Then, a comparison to MLHs derived from radiosonde data will be presented. Emphasis is also put on the assessment of the new ceilometer technology in comparison with other remote-sensing systems like a Ka-band cloud radar. Furthermore, a first impression of the spatial MLH variability over Germany is given by showing results from different ceilometer network sites. Finally, the potential for further improvements of the new profiling technique using the new type of ceilometer is discussed.