EMS Annual Meeting Abstracts,
Vol. 6, EMS2009-249, 2009
9th EMS / 9th ECAM

Retrieval of mixing layer depth from existing ceilometer/lidar networks in Europe

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The atmosphere boundary layer is characterized by turbulent fluctuations that induce mixing. The determination of the thickness of the layer in which turbulent mixing occurs is crucial in meteorology to study energy and water fluxes exchanges between the surface and the atmosphere, and in air quality to estimate the concentration of pollutants. It is determined either (1) using temperature, humidity and wind profiles from in-situ vertical profiles or (2) by tracing gradients in atmospheric constituents (aerosols, water vapor) or structures using remotely sensed vertical profiles (lidar, radar, sodar).

Lidars or ceilometers provide vertical profiles of backscatter from aerosol particles. Aerosols are predominantly concentrated in the mixing layer, and hence lidar backscatter signals can be used to trace the depth of the mixing layer. We reviewed more than 20 papers describing methods to retrieve mixing layer depth and find a variety of methods analyzing one-dimensional vertical or temporal gradients in lidar and ceilometer backscatter.

As Lidar/ceilometer data are 3-dimensional in nature (vertical, temporal and intensity), we reviewed 2-dimensional image processing methods. We test and implement a Canny-like 2-D image processing method on 355-nm backscatter lidar data and 905-nm backscatter ceilometer data on both clear and cloudy conditions. We show that this method has a great potential for tracking the mixing layer depth from lidar/ceilometer signals, both in stratified conditions retrieving the stable and residual layers, and in convective conditions retrieving the depth of the developing mixing layer.

We propose to test and implement this new algorithm on a ceilometer network in Europe (e.g. DWD and/or KNMI) to study both temporal and geographical variations of the mixing layer depth.