Mixing layer height determination by Lidar and radiosounding data

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The atmospheric boundary layer (ABL) has a thickness quite variable in space and time, ranging from hundred of metres up to a few kilometres. For convective conditions, pollutants that are emitted into the mixed layer become gradually dispersed and mixed through the action of turbulence. In this sense the mixing height (MH) is a key parameter.

Different methods can be employed to determine the mixing height. For convective conditions the radiosoundings are the most common data source based on wind, temperature and pressure profiles. A description of the determination of mixing layer by means of radiosounding is presented by Hanna (1969).

Active remote sensing systems such as Lidars use aerosols as tracers where the received energy is proportional to the aerosol content of the atmosphere. The main advantage of the Lidar technique is the possibility of carrying out a continuous monitoring of the atmosphere that permits to obtain a mixing height temporal evolution.

The energy received by a Lidar system is proportional to the backscattered signal from particles and molecules present in the atmosphere. The range-squared-corrected signal can be expressed as:

\[ RSCS = k(\beta^p(r) + \beta^m(r))P^2(r) \]

where \( \beta^p \) and \( \beta^m \) are particular and molecular backscatter coefficients, respectively, \( k \) is the system constant, \( T \) is the atmospheric transmission and \( r \) is the distance between the laser source and the target.

Three derivative methods are used to estimate the mixing height (Sicard et al, 2005):

\textbf{Gradient Method (GM)}: For the marked transition between the Mixed Layer and the Free Troposphere, the derivative of RSCS exhibits a strong negative peak. This method assigns how mixing height where occurs the absolute negative minimum of the first derivative of the RSCS.

\textbf{The Inflection Point Method (IPM)}: The mixing height corresponds to the minimum of the second derivative the RSCS just below altitude obtained by gradient method.

\textbf{The Logarithm Gradient Method (LGM)}: this height, \( h_{LGM} \), corresponds to the minimum of the first derivative of the RSCS is reached.

The mixing heights obtained on 29th June 2006 at 12:00 GMT in El Arenosillo station (Huelva, Spain, 37.1º N, 6.7º O, 0 m a.s.l.) for the different derivative methods are \( h_{GM} = 995 \pm 15 \) m, \( h_{IPM} = 980 \pm 30 \) m and \( h_{LGM} = 995 \pm 15 \) m. These results show a good agreement with mixing height obtained through the Richardson method by radiosoundings in overlap spatial and temporal, which was 1020 \( \pm 30 \) m.

Figure 1 shows the RSCS temporal evolution on 29th June. Black points correspond to the mixing heights obtained by Lidar and white diamonds correspond to the mixing height by radiosoundings.

\[ \text{Figure 1: RSCS evolution on 29th June 2006, black points and white diamonds correspond to mixing heights by Lidar system and radiosounding, respectively.} \]

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References