Atmospheric boundary layer height estimation by different methods: Application to lidar measurements

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The Atmospheric Boundary Layer (ABL) is the lowest part of the troposphere which is directly influenced by the Earth surface. Factors like the season, the orography, the time of the day and the weather act over the ABL.

The determination of the ABL height is decisive for pollution dynamic studies and weather forecasting modelling. Radiosoundings, typically used for this purpose, are launched in a 1-2/day basis, at best. Then they cannot provide a suitable evolution of the ABL along the day.

Higher concentrations of aerosols are usually present in the ABL respect to those are in the Free Troposphere (FT). This fact is used to estimate the ABL height by means of lidar measurements. Indeed, a sharp difference in backscatter signal is found by 'crossing' from BL to FT altitude. In addition, since lidar systems can be in full-time operation, they appear to be the most appropriate instrumentation for a continuous ABL top detection.

There are different methods to calculate the ABL top height from lidar signals. They are based on two approaches: 1) the vertical distribution of the aerosol concentration, as used by the Derivative Methods (DM) (Flamant, 1997), i.e. the Gradient Method (GM) and Logarithm Method (LGM), and the Wavelet Covariance Transform (WCT) (Brooks, 2003); and the statistic analysis as used by the Centroid/Variance Method (VM) (Hooper and Elorata, 1986). A new procedure combining both these approaches is also used in this work: the Cluster Analysis (CA). The goal of this work is the comparison of the results obtained from the application of each one of those methods to lidar measurements. Differences found are analysed in order to establish the most reliable method for ABL top height determination.

Daily measurements are performed by a Micro Pulse Lidar (MPL) system in routine operation at the subtropical station of AEMET/Sta. Cruz de Tenerife Observatory (SCO, 28ºN 16ºW, 52 m a.s.l.). Raw signal profiles are acquired with 1-min integrating time and vertical resolution of 75 m. Then, these 1-min profiles are averaged over 10 minutes, obtaining thus 6 profiles/hour (144 profiles/day). This study is focused on two scenarios: dusty and non-dusty cases. An example of the ABL top height calculated by the GM, VM, WCT CA methods is shown in Figure 1 for a dusty case (9 November 2005). The same by the LGM and IPM methods is shown in Figure 2.

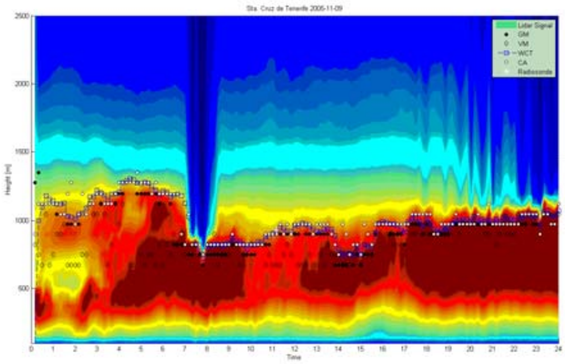

Figure 1. Daily range-corrected lidar signal on 09 November 2005, where the temporal evolution of the ABL top height calculated by GM, VM, WCT and CA methods (see legend) is shown. Radiosounding ABL estimation (11:00 UTC) is also included (white star) for reference.

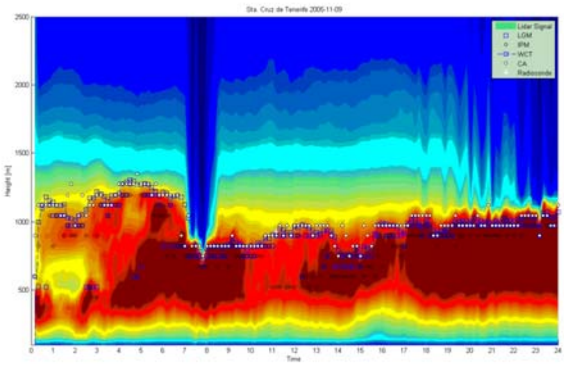

Figure 2. The same as Figure 1, but ABL top height is calculated by LGM, IPM, WCT and CA methods (see legend).

Results show that ABL heights determined by CA, WCT and LGM methods present the lowest differences respect to the radiosounding reference. VM provides a higher dispersion at the beginning and the end of the day. IPM shows, in general, lower height values than those obtained by all other methods.

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