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An automatic algorithm for the detection and the characterization of cloud boundaries from BAQUNIN LIDAR signals

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The lidar LIDAR system is widely used in atmospheric aerosol and boundary layer (BL) studies, and for the detection of cloud boundaries. However automatic and accurate identification of cloud top and bottom heights and BL height is not trivial, especially for low signal to noise ratio values, and for cloud layers below the top of BL, because of the disentanglement of cloud and aerosol contribution to LIDAR signal.

In this work, a signal threshold approach is presented, starting from the Range Corrected Signal (RCS) and using its spatial and temporal variations. The approach has been tested using one year of acquisitions of the elastic LIDAR hosted in the BAQUNIN (Boundary-layer Air Quality analysis using Network of INstruments) Supersite(<https://www.baqunin.eu>) with a spatial and temporal resolution of 7.5 m and 10 s, respectively.

A minimum threshold value T_c applied to the RCS values allows detecting the presence of a cloud layer. This approach could be applied to each type of acquired LIDAR elastic signal, but depends on the specific LIDAR channel characteristics, in particular the signal to noise ratio.

RCS values obtained for each acquired profile and altitude could be considered as a two-dimensional matrix M . As first step the elements $M_{ij} > T_c$ of this matrix are labeled as possible cloud elements.

Subsequently, the algorithm excludes from the calculation the elements M_{ij} corresponding to spike values or affected by high noise considering the spatial and temporal variations of the RCS. A labeled element is confirmed to be a cloud element if the number of its labeled neighbors is above a selected percentage threshold T_{perc} . The grid of elements considered as neighbors can be defined according to spatial and temporal resolution of the LIDAR acquisition.

Finally, bottom and top of cloud layers are retrieved as the altitude of first and last labeled elements of each cloud layer and profile.

The accuracy of the results depends on the spatial and temporal resolution of the acquired signal, considering the BAQUNIN LIDAR characteristics the best accuracy is 15 m and 20 s.

The same approach could be used to distinguish aerosol from cloud layers, using a different threshold value for the aerosol.

This method was tested for different atmospheric conditions and results are discussed in this work.