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Remote sensing methods to investigate boundary-layer structures in proximity of urban areas

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The vertical stratification of thermal and mechanical properties of the lower side of atmosphere are described by atmospheric turbulence conditions and at each time of day they have some well defined characteristics. Remote sensing systems are often used to study boundary layer structures. One of the very attractive remote sensing tool is the ceilometer, which is based on the measurements backscattering (BS) derived from the aerosol concentration that are in the different layer of the atmosphere. As known, the aerosol particles are related to the depth of mixing height and they are linked to the optical depth of the atmosphere. Some works attempt to connect the measurements of the optical depth with the depth of the mixing layer. Another tool which can be used are the SODAR-RASS systems. Back reflection of acoustic and electromagnetic pulses are used to derive wind and temperature vertical profiles to investigate boundary layer structures.

In Italy, and above all for urban sites, it could be very difficult to determine PBL parameters such as mixing height, using only by the observed meteorological variables (such as temperature and wind velocity profiles). As an example, during high convective conditions, often the mixing height can easy greater than 1000m, that represents the maximum height that can be achieved by Sodar-Rass systems. An alternative optical remote sensing tool, as the ceilometer, can reach easily several kilometres in altitude, also in urban area. In particular, we adopt a Vaisala ceilometer CL31 to investigate an area close to the urban site of Rome during some intense campaigns during the calendar years 2010. We investigated the heights up to 4000m and we compared the backscattering signal from aerosol both with Sodar-Rass and the atmospheric stability measured at ground station using the direct turbulence measurements by means of sonic anemometers.

From all data set, we select some stationary situations related to well defined stability conditions. PBL structures were detected from both SODAR-RASS and ceilometer systems especially during nightime, when stability conditions are prevalent and cooling mechanisms produce thermal stratifications well detected by both systems. At daytime, when convection prevails, the ceilometer is found to be able to detect the PBL evolution, which is instead missed by the SODAR_RASS. Some results are presented to show the agreement between these two techniques and their complementarities.

In addition, different methods have been investigated to determine the vertical structure of atmosphere using the BS signal, from statistical approaches up to the methods based on the profile of the vertical gradient of the BS signal. All above methods presents some difficult during the presence of the clouds at medium-low levels, difficulties that are related to the presence of multiple peaks along the vertical profile. Results obtained with different methods are presented.