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Intercomparison of aerosol measurements performed with multi-wavelength Raman lidars, automatic lidars and ceilometers

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The use of automatic lidars for the profiling of the boundary layer and of aerosol properties in the free troposphere has reported continuous progress over the last years. The scientific community is working to understand to what extent automatic lidars and ceilometers (ALCs) are able to provide an estimation of the aerosol geometric and optical properties and fill in the geographical gaps of the existing advanced lidar networks. To this purpose, intercomparison experiments must be designed to assess the performances of commercial systems with respect to advanced multi-wavelength lidars and to ensure comparability between different instruments, measurements and retrieval techniques. Recommendation outcome from these experiments can also strongly support the design of current and future aerosol observing networks for measuring pollution. Within this scenario and in continuity the effort spent during the INTERACT (INTERcomparison of Aerosol and Cloud Tracking) campaign, the INTERACT-II campaign used multi-wavelength Raman lidar measurements to assess the performance of an automatic compact micro-pulse lidar (MiniMPL) and two ceilometers (CL51 and CS135), respectively, to provide reliable information about optical and geometric atmospheric aerosol properties. The campaign took place at CIAO, the CNR-IMAA Atmospheric Observatory (760 m asl, 40.60° N, 15.72° E), in the framework of the ACTRIS-2 (Aerosol Clouds Trace gases Research InfraStructure) H2020 project. Co-located simultaneous measurements involving a MiniMPL, two ceilometers, and two EARLINET (European Aerosol Research Lidar NETwork) multi-wavelength Raman lidars were performed from July to December 2016.

The comparison between the MiniMPL and the CIAO EARLINET lidars showed an agreement within 10-15 % in the values of the Range-Corrected signal, with a good stability of the MiniMPL during the whole duration of the campaign. The CL51 ceilometer showed a much better performance than the previous generation of Vaisala ceilometers. The CL51 appeared to have the capability to detect the molecular signal in the free troposphere over an integration time of 1-2 hours. Nevertheless, signal distortions can have a large effect on the molecular calibration even after dark current subtraction. The CS135 showed improvements compared to the prototype tested during INTERACT-I. Its performance was similar to the CL51 in the region below 2.0 km asl (within 20-30% of the MUSA/PEARL attenuated backscatter). Both the ceilometers were corrected for the effect of the water vapor absorption bands at their operating wavelengths.

The experience gained during INTERACT-I and INTERACT-II confirms that ceilometers' good performances in the qualitatively monitoring of aerosols in the boundary layer with enhanced profiling capabilities in the free troposphere only for the most advanced models. Nevertheless, the retrieval of aerosol attenuated backscatter (and of any related optical properties) appears to be often affected by the instrumental issues which must be improved by the manufacturers in cooperation with the scientific community. It is therefore possible to argue that, compared to automatic (backscatter) lidars, more expensive but more powerful, the capability of ceilometers to fill in existing observational gaps within lidar networks is in continuous growth but it is still limited.