Ceilometer for aerosol profiling: comparison with the multi-wavelength in the frame of INTERACT (INTERcomparison of Aerosol and Cloud Tracking)

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For the study of both climate, air pollution and its influence on health, knowledge of vertical distributions of aerosols is a key factor. This scenario has pushed the demand for continuous aerosol measurements provided by high resolution networks of ground-based instruments also to validate and improve aerosol and pollution forecasting. In order to achieve broad, high resolution coverage, low-cost and low-maintenance instruments are needed.

Despite of their differences from more advanced and more powerful lidars, low construction and operation cost of ceilometer, originally designed for cloud base height monitoring, have fostered their use for the quantitative study of aerosol properties. The large number of ceilometers available worldwide represent a strong motivation to investigate to which extent they can be used to fill the geographical gaps between advanced lidar stations and how their continuous data flow can be linked to existing networks of the advanced lidars, like EARLINET (European Aerosol research LIdar NETwork – Pappalardo et al., 2014).

INTERACT campaign

In order to make the best use of existing and future ceilometer deployments, ceilometer must be better characterized. This is the purpose of the INTERACT campaign (Madonna et al., 2014) carried out at the CNR-IMAA Atmospheric Observatory (760 m a.s.l., 40.60N, 15.72E), named CIAO (Madonna et al., 2011), in the framework of ACTRIS (Aerosol Clouds Trace gases Research InfraStructure) FP7 project.

In this paper, an overview of the results achieved during the campaign is provided. This work is the first time that three different commercial ceilometers with an advanced Raman lidar, MUSA (Multi-wavelength System for Aerosol) are compared over a period of six months

Results

The comparison reveals several limitations in the use of ceilometer observations in a quantitative way to study aerosol layers.

Ceilometers, though rugged instruments, are quite sensitive to the large changes in external temperature and collected background levels that occur on daily or seasonal bases; this generates adjustments of system parameters that affect the stability of the instrument response over the short and mid-term time period. Therefore, the use of a forward approach to calibrate a ceilometer using lidar observations or the use of a different calibration method should be frequently re-evaluated and checked.

A large instability of the ceilometer in the incomplete overlap region is also observed, in a more significant way for bi-static systems: though this instability on the retrieval of aerosol backscatter coefficient can be quantified and it is often small, overlap correction functions over extended periods of time need frequent re-evaluation.

Finally, differences in the value of aerosol attenuated backscatter (ß') among the MUSA Raman lidar and the ceilometers look proportional to the aerosol extinction coefficient (α). Changes in the values of α can be associated to seasonal changes affecting the ambient temperatures and, therefore, the ceilometer stability.

In conclusion, though differences among MUSA and ceilometers are expected by the large difference in the SNR due to the different laser sources used by an advanced lidar and a ceilometer, further technological improvements of ceilometers towards their operational use in the monitoring of the atmospheric aerosol are needed. An extension of the current analysis to daytime is foreseen. Moreover, it has been planned to study historical data available at CIAO to confirm or improve the outcome of the INTERACT campaign.

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