Comparison of aerosol properties from Lidar against the retrieved with GRASP algorithm using ceilometer and sunphotometer measurements as input

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Aerosols play a key role in the Earth climatic system because they can increase the cooling or warming of the Earth surface depending on their properties. Therefore the well knowledge about column and also vertical aerosol properties is necessary to understand the Earth energy balance. Column aerosol properties are usually well retrieved using sun/sky photometers, but they have not the capability to obtain vertical profiles of these properties. Lidar systems are generally used to obtain these vertical properties, but these kinds of systems are generally expensive and they are not usually automatic. On the other hand, ceilometers are not precise like a lidar, but they are cheaper and they are more robust and they work automatically, which implies that ceilometers are more operative. In fact, at least at Iberian Peninsula, there are more ceilometers than lidar systems. Therefore, this work aims to use ceilometers in combination with sunphotometers, in order to obtain column and vertical aerosol properties.

Sunphotometer and ceilometer measurements can be used as input in the GRASP algorithm (*Generalized Retrieval of Aerosol and Surface Properties*). GRASP is a versatile algorithm with the capability of retrieve aerosol properties (Anton *et al.*, 2013; Dubovik *et al.*, 2014). In the present study, GRASP was run using vertical range corrected ceilometer signal at 1064 nm and aerosol optical depth (AOD) and sky radiances from a sunphotometer.

AOD and sky radiances were obtained from AERONET network and AERONET-Europe/ACTRIS (Aerosol Robotic Network; http://aeronet.gsfc.nasa.gov). The vertical ceilometers profiles were given by the *Spanish and Portuguese Ceilometer Network*. This network is formed by different Spanish and Portuguese research groups, some of them uploading ceilometer data in near-real time to the network, which can be useful to detect different aerosol outbreak and its evolution, especially over the Iberian Peninsula.

In the first step of this work the GRASP retrieval of sunphotometer plus ceilometer was compared against more precise lidar measurements at a station located at Granada (Spain). This comparison has been done under different aerosol conditions. The column products of these retrievals were also compared with the provided by AERONET.

In a second step, the aerosol properties were retrieved using photometers and ceilometers at locations without operative lidar systems like Badajoz and Valladolid (Spain), Some special aerosol cases were analyzed at these locations and Granada. The obtained results help to understand the spatial and vertical aerosol behaviour during an aerosol episode over the Iberian Peninsula.

As conclusion, the GRASP algorithm can be used to retrieve vertical aerosol properties at locations without lidar systems but with one photometer and one ceilometer. The combination of both instruments at different locations helps to obtain better knowledge of spatial and vertical aerosol properties.

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