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Study of Droplet Activation in Thin Clouds Using Ground-based Raman Lidar and Ancillary Remote Sensors

Marco Rosoldi, Fabio Madonna, Pilar Gumà Claramunt, and Gelsomina Pappalardo

Consiglio Nazionale delle Ricerche(CNR), Istituto di Metodologie per l'Analisi Ambientale (IMAA), Tito Scalo, Italy (marco.rosoldi@imaa.cnr.it)

Studies on global climate change show that the effects of aerosol-cloud interactions (ACI) on the Earth's radiation balance and climate, also known as indirect aerosol effects, are the most uncertain among all the effects involving the atmospheric constituents and processes (Stocker et al., IPCC, 2013). Droplet activation is the most important and challenging process in the understanding of ACI. It represents the direct microphysical link between aerosols and clouds and it is probably the largest source of uncertainty in estimating indirect aerosol effects.

An accurate estimation of aerosol-clouds microphysical and optical properties in proximity and within the cloud boundaries represents a good frame for the study of droplet activation. This can be obtained by using ground-based profiling remote sensing techniques.

In this work, a methodology for the experimental investigation of droplet activation, based on ground-based multi-wavelength Raman lidar and Doppler radar technique, is presented. The study is focused on the observation of thin liquid water clouds, which are low or midlevel super-cooled clouds characterized by a liquid water path (LWP) lower than about 100 gm^{-2}(Turner et al., 2007). These clouds are often optically thin, which means that ground-based Raman lidar allows the detection of the cloud top and of the cloud structure above. Broken clouds are primarily inspected to take advantage of their discontinuous structure using ground based remote sensing. Observations are performed simultaneously with multi-wavelength Raman lidars, a cloud Doppler radar and a microwave radiometer at CIAO (CNR-IMAA Atmospheric Observatory: www.ciao.imaa.cnr.it), in Potenza, Southern Italy (40.60N, 15.72E, 760 m a.s.l.).

A statistical study of the variability of optical properties and humidity in the transition from cloudy regions to cloud-free regions surrounding the clouds leads to the identification of threshold values for the optical properties, enabling the discrimination between clouds and cloudless regions.

Furthermore, a statistical study of the Doppler radar moments allows to retrieve droplet size and vertical velocities close to the cloud base. First evidences of a correlation between updrafts and downdrafts and aerosol effective radius have been found.