WP22- JRA3: A framework for cloud-aerosol interaction studies

Deliverable D22.4: Report on observation procedure for the classification of aerosol - cloud interaction

The aim of this work package is to establish a strategy for cloud – aerosol interactions observation. In the Task 22.4 we focus on forming an optimal observation method of aerosol-cloud interactions. Below we present a short overview of currently used methods.

1. Measurement of aerosol and water clouds with Raman lidar RAMSES (Reigert, 2014)

Lindenberg observatory performs observations with Raman lidar RAMSES (Primary quantities measured include: Elastic backscatter signal, Water vapor (408nm), Temperature, Nitrogen, Depolarization). It can provide measurement products to characterize aerosols and clouds, as well as water vapour measurement (relative humidity). Lindenberg provides a vast amount of additional data and synergy with other measurement systems. RAMSES is a stationary instrument.

2. Dual field of view lidar method (Schmidt et al., 2014)

Dual-FOV Raman lidar technique retrieves profiles of cloud microphysical properties. It has possibilities of investigating aerosol-cloud interactions from the objective of microphysical processes and radiative effects. Based on the measurements from the Dual-FOV Raman a statistical analyses of aerosol-cloud interactions was performed. It showed the ACI decrease with increasing penetration depth. The radiative forcing calculated according to Twomey over central Germany is around -1.4 +/- 1.6 W/m^2. Dual-FOV Raman lidar is a stationary instrument.

3. Radar and lidar direct observables method (Sarna et al., 2014)

In this method we use direct observables from the widely available instruments. This approach enables to process data quickly and find out whether changes in the aerosol environment below the cloud influence the cloud itself. In order to properly quantify this effect we need to have information about both aerosol and cloud properties.

For an aerosol proxy we propose to use attenuated backscatter and to obtain information about changes in the cloud we use radar reflectivity factor combined with an extinction coefficient at the cloud base. To retrieve extinction coefficient we use a stable lidar profile inversion (Klett, 1981). We perform a series of tests on the retrieved extinction in order to assure an optimal penetration in the cloud. In addition, we make a correction for the multiple scattering. The extinction coefficient is used to estimate the size of cloud droplets in the lower part of the cloud only. This approach is based on observing changes in the proxies and identifying process that causes them.

We expect to observe aerosol-cloud interaction when the attenuated backscatter below the cloud is increasing at the same time as the radar reflectivity factor is increasing. To make sure that the increase in the reflectivity factor is caused by an increased number of cloud droplets and not by the droplets size, we have to introduce a third parameter - in this case extinction coefficient - that will provide information about the size of particles. In case of the influence of aerosol on cloud droplet size, we expect to see a decrease in the extinction coefficient at the cloud base. A number of factors, such as meteorology or cloud drop microphysical properties, can influence changes in cloud. For that reason, we put a constraint on the liquid water path, as suggested by Twomey (Twomey, 1974). This limitation ensures that the variability in the cloud will be primarily due to changes in microphysical properties associated with variation in aerosol. Further, we limit the cases only to non-precipitating clouds with no drizzle present by putting a constraint on the value of the radar reflectivity factor (we only process data if it is smaller than 20dBZ). In the next step we will divide processed data into aerosol activation zones. This will be done by identifying updrafts and downdrafts close to the cloud base with the Doppler velocity.

Although this method is also based on a synergy of remote sensing instruments, we use widely available systems for a quick and efficient evaluation of aerosol influence on cloud. The main advantages of this method include fast data processing and a possibility to apply this framework easily at new or existing observational sites. Moreover, this approach enables to process large time series of data and is less restrictive in cases selection than most microphysical cloud properties retrieval algorithms used to obtained cloud droplet size in previously performed studies.

From the classification of aerosol - cloud interaction it is important to use a method that can be applied in all ACTRIS stations that have capability of observing cloud and aerosol parameters. The method based on the direct radar and lidar observables is more easily applicable than methods using Raman lidars. It is mainly due to using measurements from ceilometer, that can be obtained during both day and night-time. Moreover, ceilometers are available at the majority of ACTRIS observatories.

References:

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