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Satellite and aircraft measurements of vertical cloud microphysical profiles and their relations to aerosols during EUCAARI IOP of May 2008

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During EUCARRI (European Integrated project on Aerosol Cloud Climate and Air Quality Interactions) intensive observation period over the Netherlands and adjacent sea, which lasted during the month of May 2008, 25 flights were conducted with the SAFIRE ATR-42 research aircraft, on which aerosol and cloud microphysics probes were mounted. Out of the 25 flights, only 6 penetrated clouds systematically. From these 6 flights, we were able to construct 8 different (rather shallow) vertical profiles of cloud droplet properties that covered both pristine and polluted conditions, and put them in global perspective.

We used the shape of the vertical evolution of the droplet size distribution in convective cloud elements (including in layer clouds) to parameterize the impacts of activated aerosols. The number of activated aerosols was estimated with the help of CCN and updraft measurements under and near the cloud base, as well as with the measurement of the cloud droplet concentration in adiabatic cloud parcels. Similar characterization was done by satellite retrieval of the vertical profiles of cloud top particle effective radius, using both geostationary and polar-orbiting satellites. These satellite inferences were validated by the aircraft measurements, which showed that the higher the number of activated aerosols, the smaller is the increase in the cloud droplet sizes with altitude and the higher the clouds have to develop before they can start producing large enough droplets to precipitate - although the profiled clouds were just not deep enough to produce any significant precipitation.

These results can be better appreciated when compared to our measurements, analyzed with similar methods, which were applied to deep convective clouds in other parts of the world such as the Amazon, Thailand, Argentina, the US, and recently in Israel and India. Those other clouds were sufficiently deep to reach the height of the onset of precipitation, thereby revealing the impacts of aerosols on the precipitation forming processes. The similarity of the EUCAARI dataset with the lower part of the vertical profiles of the deep clouds, together with comparable CCN concentrations, allows us to extrapolate the vertical profiles of the EUCAARI clouds to the deeper clouds that were quite abundant according to the satellite observations over Western Europe during parts of the observation period, and put the EUCAARI observations it in a global perspective.