Aerosol processing by clouds during the HCCT-2010 hill cap cloud experiment

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To study physical and chemical interactions of aerosol and clouds under natural conditions, the Lagrange-type cloud experiment "Hill Cap Cloud Thuringia 2010" (HCCT-2010) was performed in 2010 at Mount Schmücke, Germany, where a hill cap cloud served as a natural flow-through reactor.
Three measurement sites were set up (Fig. 1): An upwind site to comprehensively characterize incoming air masses, an in-cloud site on the Schmücke summit to sample the different phases of a cloud, and a downwind site to study possible modifications of the aerosol after the cloud passage.

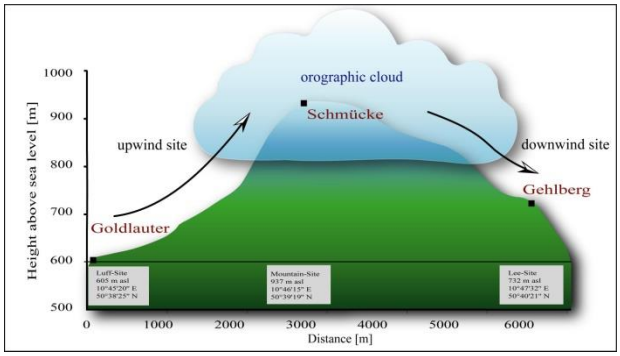

Fig. 1: Scheme of the campaign area and the 3 sites

An extended pool of various offline- and online-instruments was installed at the sites, including two 5-stage Berner impactors at the valley sites and four aerosol mass spectrometers (AMS) at both the valley and the summit sites to study in-depth possible chemical modifications of aerosol particles due to cloud processing.
A rigorous analysis of meteorological parameters and inert tracers (Tilgner et al. 2014) allowed for the identification of several cloud events where the air flow along the measurement sites was fully connected and representative air masses were sampled before, during, and after their passage through the hill-cap cloud ("full cloud events"). Similarly, "non-cloud events" with favorable flow connectivity between the sites but no cloud occurrence at the summit site were identified as reference cases.
Generally, during "non-cloud events" the chemical composition of aerosol particles was found to agree well when comparing upwind and downwind sites. During "full cloud events", downwind concentrations were consistently lower than upwind concentrations for both particle number concentration and chemical particle constituents. This concentration gradient can likely be attributed to physical loss processes such as droplet deposition along the forested area of the air flow path and/or entrainment of cleaner air masses.
When comparing the relative composition of upwind and downwind aerosol in terms of mass fraction of individual constituents, indications for a modified chemical composition of downwind particles is observed, which is likely related to aqueous phase reactions occurring in the cloud.
In an attempt to quantify such aerosol processing by clouds, the physical mass losses were corrected by normalizing the downwind concentrations using several conservative tracers (which can be assumed chemically inert and without significant sources between the sites). This resulted in estimated downwind mass additions in the order of several tenths of µg m^{-3} for sulfate, organics and sometimes nitrate.

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References

Tilgner, A., Schöne, L., Bräuer, P., van Pinxteren, D., Hoffmann, E., Spindler, G., Mertes, S., Birmili, W., Otto, R., Merkel, M., Weinhold, K., Wiedensohler, A., Deneke, H., Haunold, W., Engel, A., Wéber, A., and Herrmann, H., Atmos. Chem. Phys. Discuss., 14, 1861-1917, doi:10.5194/acpd-14-1861-2014, 2014.