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A review of our understanding of the aerosol – cloud interaction from the perspective of a bin resolved cloud scale modelling

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The review summarizes the main findings of a meso-scale cloud model for the bin resolved simulation of cloud microphysics and aerosol particle scavenging.
The work has shown that in order to analyse dedicated campaign results, the supersaturation field and the complex dynamics of the specific clouds needs to be reproduced. Only a 3D dynamics is able to simulate the variation of the supersaturation over the entire cloud, the continuous nucleation and deactivation of hydrometeors and the dependence upon initial particle size distribution and solubility.
However, general statements on certain processes can be obtained also be simpler dynamics.
We studied the importance of nucleation vs impaction scavenging inside and below cloud for warm and mixed phase clouds and the role of supersaturation.
The main influence for cloud formation results from the boundary layer aerosol, even though entrained particles at higher altitudes also contribute to their development. Generally, an increase in the number of aerosol particles and, thus, CCN inhibits rain production. Decreasing solubility of the initial aerosol particles reduces the number of activated particles and increases the most probable supersaturation value inside cloud, and thus has the same impact as a reduction in total particle number. The same sounding simulated without taking into account the ice phase experiences a quite different dynamical behaviour. In general, precipitation develops faster but not necessarily more abundant in the “all liquid” case. The scavenging properties are affected as well. An addition of giant CCN (hygroscopic seeding) in simple dynamics produces more precipitation more rapidly. Clouds are very efficient in pumping up the boundary layer aerosol.
Any change in the aerosol particle population at any time and at any location changes the developing cloud. These changes can be quite substantial. Thus, it is never possible to simulate the exact same cloud with different aerosol populations.