Precipitation in warm clouds and its susceptibility to aerosol perturbations

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Introduction

Decades of cloud physics research has shown that aerosol particles are likely to affect the production of rain in warm clouds. However, quantification of this effect has been elusive. We will present analyses based on modeling exercises and satellite remote sensing that indicate that not all clouds are equally susceptible to aerosol perturbations. Precipitation susceptibility is defined as:

$$S_o = \frac{-d \ln R}{d \ln N}$$

[1] where R is rainrate and N is a measure of either aerosol or drop concentration. The minus sign is applied so that a positive S_o reflects the conventional wisdom that R is inversely proportional to N.

Results

We have used output from a cloud parcel model (both adiabatic and entraining) and large eddy simulation of a field of cumulus clouds to quantify S_o. Both models include detailed calculations of droplet activation, condensation, and collision-coalescence. Results indicate the existence of 3 distinct regimes: 1) clouds with low liquid water path (LWP) that produce very little precipitation and are not susceptible to changes in aerosol; 2) clouds with intermediate LWP that exhibit progressively larger susceptibility to changes in aerosol with increasing LWP; and 3) clouds with high LWP that generate rain regardless of aerosol and experience decreasing susceptibilty with increasing LWP.

We will present new remote-sensing observations from the A-Train constellation of satellites that support the existence of these three regimes and point to regions of the Earth that are likely to be most affected by increased aerosol loading in a changing climate [2].

[1] Feingold & Siebert (2009), *Clouds in the Perturbed Climate System, Strungmann Forum report,* MIT Press. [2] Sorooshian, Feingold, Lebsock, Jiang & Stephens (2009), submitted.

Simulating the origin of sea salt aerosol at the coast of Antarctica

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Sea salt aerosols are important in a variety of atmospheric processes, affecting climate directly by scattering solar radiation and therefore affecting the radiative forcing, but also indirectly by acting as cloud condensation nuclei. Moreover, sea salt aerosols are important in atmospheric chemistry by providing reaction sites for gases like HNO_3, SO_2, and HOBr.

Very important for heterogeneous chemistry is the fact that the composition of sea salt aerosols differs according to the process of their formation. Over the open ocean the composition depends on the sea spray production mechanisms and the composition of the ocean water. In the polar coastal regions a second source are frost flowers. Frost flowers are ice crystals formed from sea water, that grow over young sea ice, on frozen leads (linear breaks in the sea ice cover) and polynyas (openings between drift ice and fast moving ice or the coast). This additional source presents higher salinity levels and lower ratios of Cl^-/Br^-. Frost flowers last normally some days before being blown away or being covered by snow.

Aerosol samples have been collected at Neumayer Air Chemistry Observatory, Antarctica since 1983. Neumayer is the only coastal station in Antarctica which delivers year-round measurements of aerosols over such a long period. The monthly variation in the concentration of aerosol ions shows more aerosols in winter than in summer. Model simulations performed with ECHAM-5.5-HAM, which resolves sea salt aerosol sizes and emissions over the open ocean, show the opposite annual cycle. This shows the importance of accounting for the additional source from sea ice.

In this work, we analyse the importance of the additional contribution of frost flowers to the sea salt aerosol atmospheric concentrations. We take into account the different meteorological conditions.