Geophysical Research Abstracts
Vol. 12, EGU2010-14260-1, 2010
EGU General Assembly 2010

Impact of Aerosol Processing on Orographic Clouds

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Aerosol particles undergo significant modifications during their residence time in the atmosphere. Physical processes like coagulation, coating and water uptake, and aqueous surface chemistry alter the aerosol size distribution and composition. At this, clouds play a primary role as physical and chemical processing inside cloud droplets contributes considerably to the changes in aerosol particles. A previous study estimates that on global average atmospheric particles are cycled three times through a cloud before being removed from the atmosphere [1].

An explicit and detailed treatment of cloud-borne particles has been implemented in the regional weather forecast and climate model COSMO-CLM. The employed model version includes a two-moment cloud microphysical scheme [2] that has been coupled to the aerosol microphysical scheme M7 [3] as described by Muhlbauer and Lohmann, 2008 [4]. So far, the formation, transfer and removal of cloud-borne aerosol number and mass were not considered in the model. Following the parameterization for cloud-borne particles developed by Hoose et al., 2008 [5], distinction between in-droplet and in-crystal particles is made to more physically account for processes in mixed-phase clouds, such as the Wegener-Bergeron-Findeisen process and contact and immersion freezing. In our model, this approach has been extended to allow for aerosol particles in five different hydrometeors: cloud droplets, rain drops, ice crystals, snow flakes and graupel. We account for nucleation scavenging, freezing and melting processes, autoconversion, accretion, aggregation, riming and selfcollection, collisions between interstitial aerosol particles and hydrometeors, ice multiplication, sedimentation, evaporation and sublimation.

The new scheme allows an evaluation of the cloud cycling of aerosol particles by tracking the particles even when scavenged into hydrometeors. Global simulations of aerosol processing in clouds have recently been conducted by Hoose et al. [6]. Our investigation regarding the influence of aerosol processing will focus on the regional scale using a cloud-system resolving model with a much higher resolution. Emphasis will be placed on orographic mixed-phase precipitation. Different two-dimensional simulations of idealized orographic clouds will be conducted to estimate the effect of aerosol processing on orographic cloud formation and precipitation. Here, cloud lifetime, location and extent as well as the cloud type will be of particular interest.
In a supplementary study, the new parameterization will be compared to observations of total and interstitial aerosol concentrations and size distribution at the remote high alpine research station Jungfraujoch in Switzerland. In addition, our simulations will be compared to recent simulations of aerosol processing in warm, mixed-phase and cold clouds, which have been carried out at the location of Jungfraujoch station [5].

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