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CCN activation and cloud processing in sectional aerosol models with low size resolution

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Abstract. We investigate the influence of low size resolution, typical to sectional aerosol models in large scale applications, on cloud droplet activation and cloud processing of aerosol particles. A simplified cloud model with five approaches to determine the fraction of activated particles is compared with a detailed reference model under different atmospheric conditions. In general, activation approaches which assume a distribution profile within the critical model size sections predict the cloud droplet concentration most accurately under clean and moderately polluted conditions. In such cases, the deviation from the reference simulations is below 15% except for very low updraft velocities. In highly polluted cases, the concentration of cloud droplets is significantly overestimated due to the inability of the simplified model to account for the kinetic limitations of the droplet growth. Of the profiles examined, taking into account the local shape of the particle size distribution is the most accurate although in most cases the shape of the profile has little relevance. While the low resolution cloud model cannot reproduce the details of the out-of-the-cloud aerosol size distribution, it captures well the amount of sulphate produced in aqueous-phase reactions as well as the distribution of the sulphate between the cloud droplets. Overall, the simplified cloud model with low size resolution performs well for clean and moderately polluted regions that cover most of the Earth's surface and is therefore suitable for large scale models. It can, however, show uncertainties in areas with strong pollution from anthropogenic sources.

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