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On the importance of cumulus penetration on the microphysical and optical properties of stratocumulus clouds

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Abstract. Owing to their extensive spatial coverage, stratocumulus clouds play a crucial role in the radiation budget of the earth. Climate models need an accurate characterisation of stratocumulus in order to provide an accurate forecast. However, remote sensing as well as in-situ observations reveal that on several occasions, cumulus clouds present below the stratocumulus, often have a significant impact on the main stratocumulus microphysical properties. This was observed during the ACE-2 (Aerosol Characterisation Experiment-2) campaign designed to study the impact of polluted continental air on stratocumulus formation. In this paper we used a detailed micro-physical chemical parcel model to quantify the extent of this cumulus-stratocumuls coupling. In addition, we made extensive use of microphysical observations from the C-130 aircraft that was operated during ACE-2. For the ACE-2 case studies considered in this paper, our analysis revealed that the chemical, microphysical and optical characteristics of the main stratocumulus cloud deck had significant contributions from cumulus clouds that often penetrated the stratocumulus deck. The amount of fine mode ionic species, the average droplet number concentrations, the effective radii and the optical depths during the flight A562 (when cumulus clouds interacted with the main stratocumulus) were estimated and model runs that included this effect yielded microphysical and optical properties which compared more favourably with the observations than the runs which did not. This study highlights the importance of including these cumulus effects in stratocumulus related modelling studies.

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