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Quantifying how model assumptions affect aerosol-cloud interactions in large-eddy simulations of warm stratocumulus clouds

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Subtropical low-level marine stratocumulus clouds effectively reflect downwelling shortwave radiation while having a small effect on outgoing longwave radiation. Hence, they impose a strong negative net radiative effect on the Earth's radiation balance. The optical and microphysical properties of these clouds are susceptible to anthropogenic changes in aerosol abundance. Although these aerosol-cloud-climate interactions (ACI) are generally explicitly treated in state-of-the-art Earth System Models (ESMs), they are accountable for large uncertainties in current climate projections.

Here, we present preliminary work where we exploit Large-Eddy-Simulations (LES) of warm stratocumulus clouds to identify and constrain processes and model assumptions that affect the response of cloud droplet number concentration (N_d) to changes in aerosol number concentration (N_a). Our results are based on simulations with the MISU-MIT Cloud-Aerosol (MIMICA, Savre et al., 2014) LES, which has two-moment bulk microphysics (Seifert and Beheng, 2001) and a two-moment aerosol scheme (Ekman et al., 2006). The reference simulation is based on observations made during the Dynamics and Chemistry of Marine Stratocumulus Field Study (DYCOMS-II, Stevens et al., 2003) which were used extensively during previous LES studies (e.g., Ackerman et al., 2009).

Starting from the reference simulation, we conduct sensitivity experiments to examine how the susceptibility ($\beta = d\ln(N_d)/d\ln(N_a)$) changes depending on different model setups. We run the model with fixed and interactive aerosol concentrations, with and without saturation adjustment, with different aerosol populations, and with different model parameter choices. Our early results suggest that β is sensitive to these choices and can vary roughly between 0.6 to 0.9 depending on the setup. The overall purpose of our study is to guide future model developments and evaluations concerning aerosol-cloud-climate interactions.

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