Geophysical Research Abstracts
Vol. 21, EGU2019-11069, 2019
EGU General Assembly 2019

Factors governing the nocturnal stratocumulus to diurnal shallow cumulus transition on LES

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The Southern West Africa is known to be a problematic region for climate models to properly represent its diurnal cycle and evolution of clouds, particularly boundary-layer clouds. This leads to significant biases in the radiation budget that cause further errors and deviations between models for current forecast and future climate projections. Based on observations taken during the DACCIWA campaign in 2016 in Southern West Africa, we designed an idealized case using a LES simulation. The case describes a frequently observed phenomenon on a daily scale: an overcast sky during the night with homogeneous stratus or stratocumulus and low cloud base (e.g. 200 m); after sunrise the cloud base rises faster than the cloud top, leading to a rise and thinning of the cloud layer; few hours later shallow cumulus appear below the stratocumulus layer, eventually remaining as the only cloud layer while the stratocumulus above have disappeared. The experiment couples boundary layer dynamics, radiation and a plant-physiology-based land surface scheme.
First, we discuss the characteristic vertical profiles and evolution of relevant variables along the different cloud phases of our case. Secondly, and taking advantage that the whole mixed layer, including the initial stratocumulus clouds, is well-mixed, we apply mixed-layer equations to analyse the LES results. We therefore are able to quantify the impact of different processes (radiation, entrainment and subsidence) and relate their contributions to the growth (or decrease) of the boundary layer height over time. We subsequently analyse the liquid water path tendency on a similar method, assuming that the cloud layer is also a well mixed layer itself. This assumption holds at least for the first hours where we observe a homogeneous and prototypical stratocumulus cloud layer. Our preliminar results show that the entrainment is the leading factor for the rising of the cloud layer, with the radiative effect being about half of the entrainment one. Subsidence contributes negatively to the boundary layer growth.