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The response of shallow convection and momentum transport to the wind profile in Large Eddy Simulations

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Convective momentum transport (CMT) is hypothesized to play an important role in explaining patterns of near-surface wind in the tropics and subtropics. In light of the uncertainties in (shallow) convective mixing in global models, and its link to the large-scale Hadley circulation, which is strongly defined by the trade-winds, our study focuses on how shallow cumulus convection and horizontal winds in the trades interact. In particular, we ask, what is the structure of CMT by shallow convection, and how does it depend on the background wind profile?

Using the Dutch Atmospheric Large Eddy Simulation (DALES), we simulate idealized cases for shallow cumulus and congestus clouds typical for the subtropics. We impose idealized geostrophic wind forcing with varying shear – informed by reanalyses – and first show how shear influences convection and cloudiness.

A robust and known signal is that shear increases cloud cover, just by slanting clouds, but for very large shear it can also increase cloud fraction at cloud base. Furthermore, in the presence of wind shear, clouds grow less deep despite the fact that they are more buoyant. Yet, this does not always imply larger vertical velocities.

We also observe considerable heterogeneity in the horizontal winds related to the patterns of clouds. Cloudy volumes generally have lower (horizontal) wind velocities than clear sky volumes, as updrafts presumably carry air with lower momentum from near the surface upwards. But also, in clear sky volumes in the vicinity of clouds wind speeds tend to differ from the mean wind.

In this presentation, we will explain these changes in horizontal winds with convective organization, and show the impact on total and convective momentum transport. To unravel the influence of changing thermodynamics and of the organization of clouds, we also repeat simulations with fixed surface fluxes and without precipitation, removing feedbacks that involve changes in the near-surface wind.