The structure and role of the wind in trade-wind convection

Louise Nuijens

CloudBrake

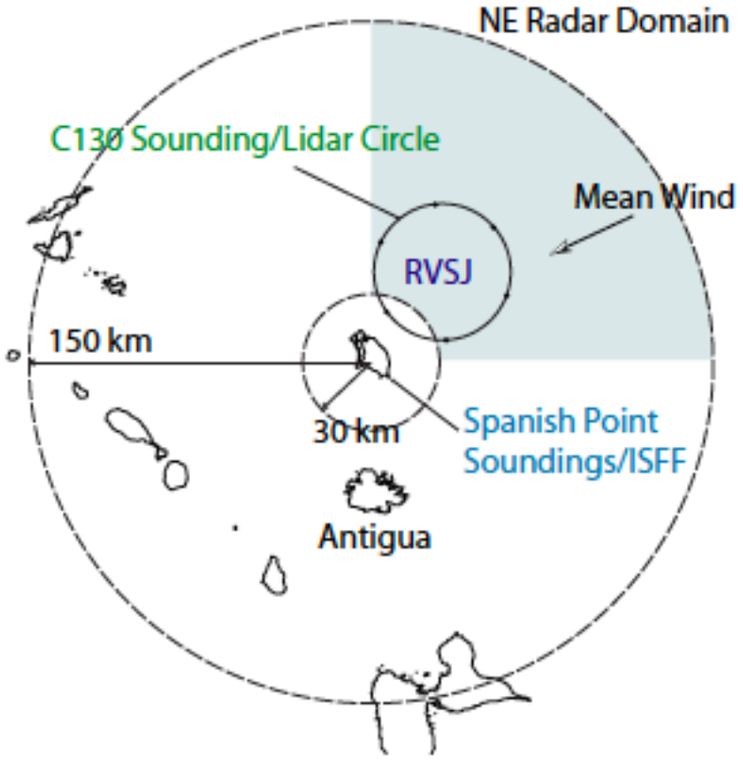
erc

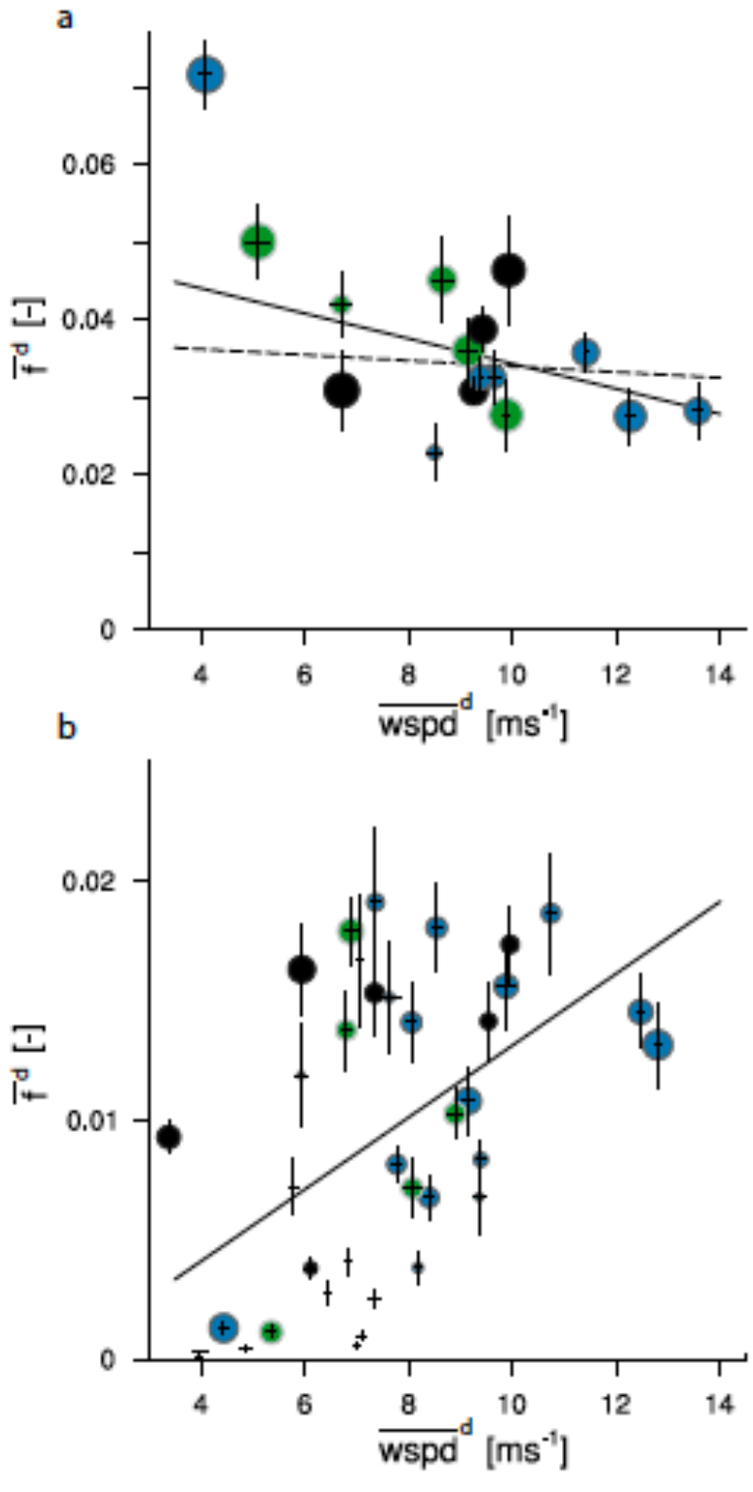
TU Delft

I was young enough for RICO

(photo by Bjorn)

Stronger winds, more rain, during RICO



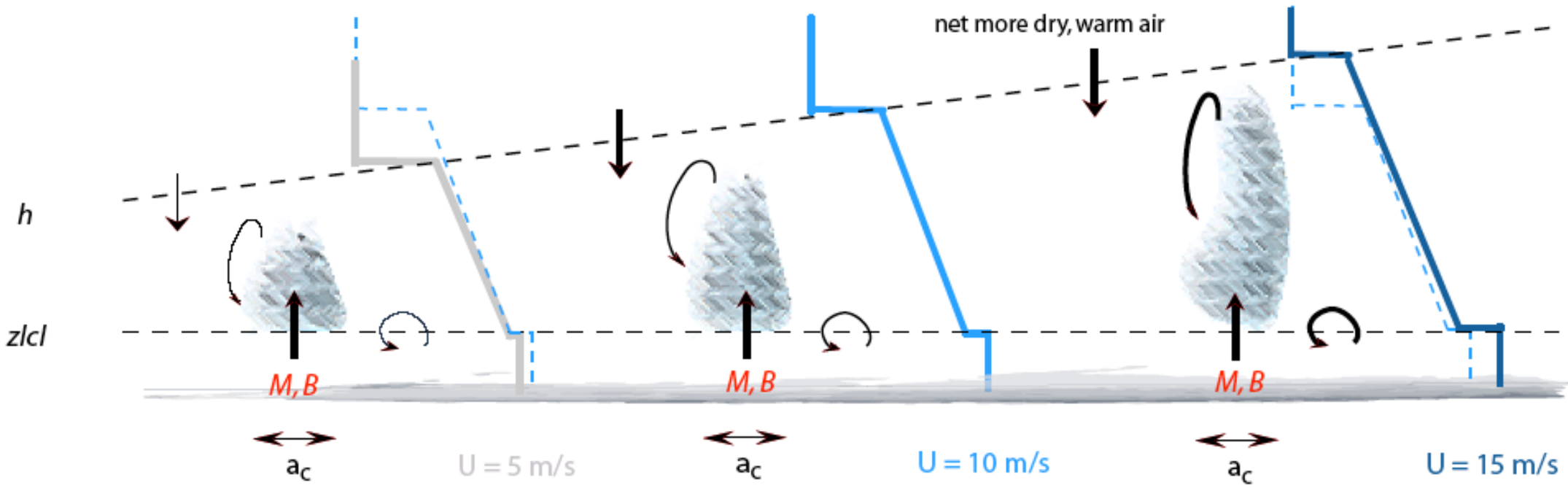


Nuijens, Stevens and Siebesma (2009)

How do clouds and winds interact?

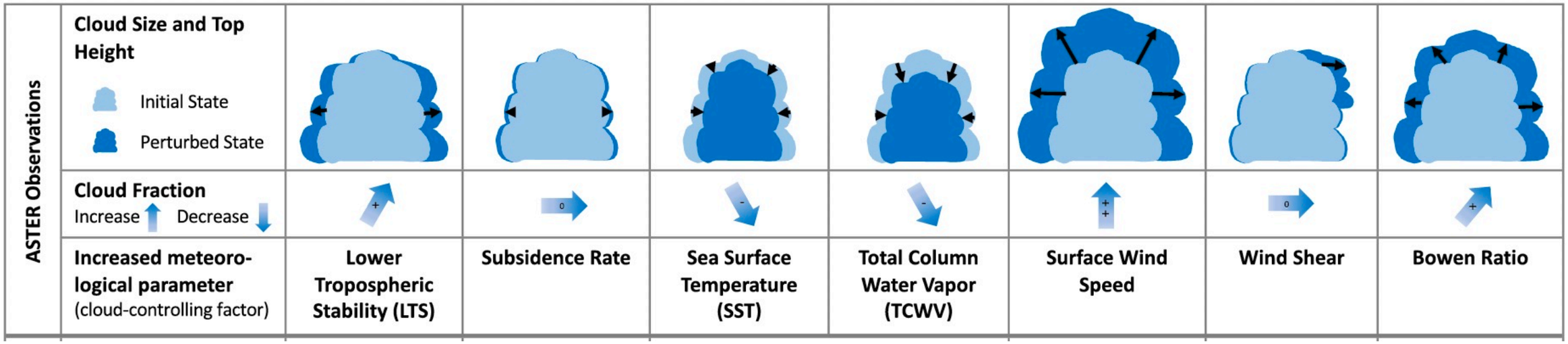
- ✦ ***Wind speed influence on clouds***
- ✦ ***Wind shear influence on clouds***
- ✦ ***Cloud influence on wind speed and shear***
- ✦ ***Role of convection in wind biases in the IFS operational model***

Stronger winds, more surface latent heat flux, deeper clouds



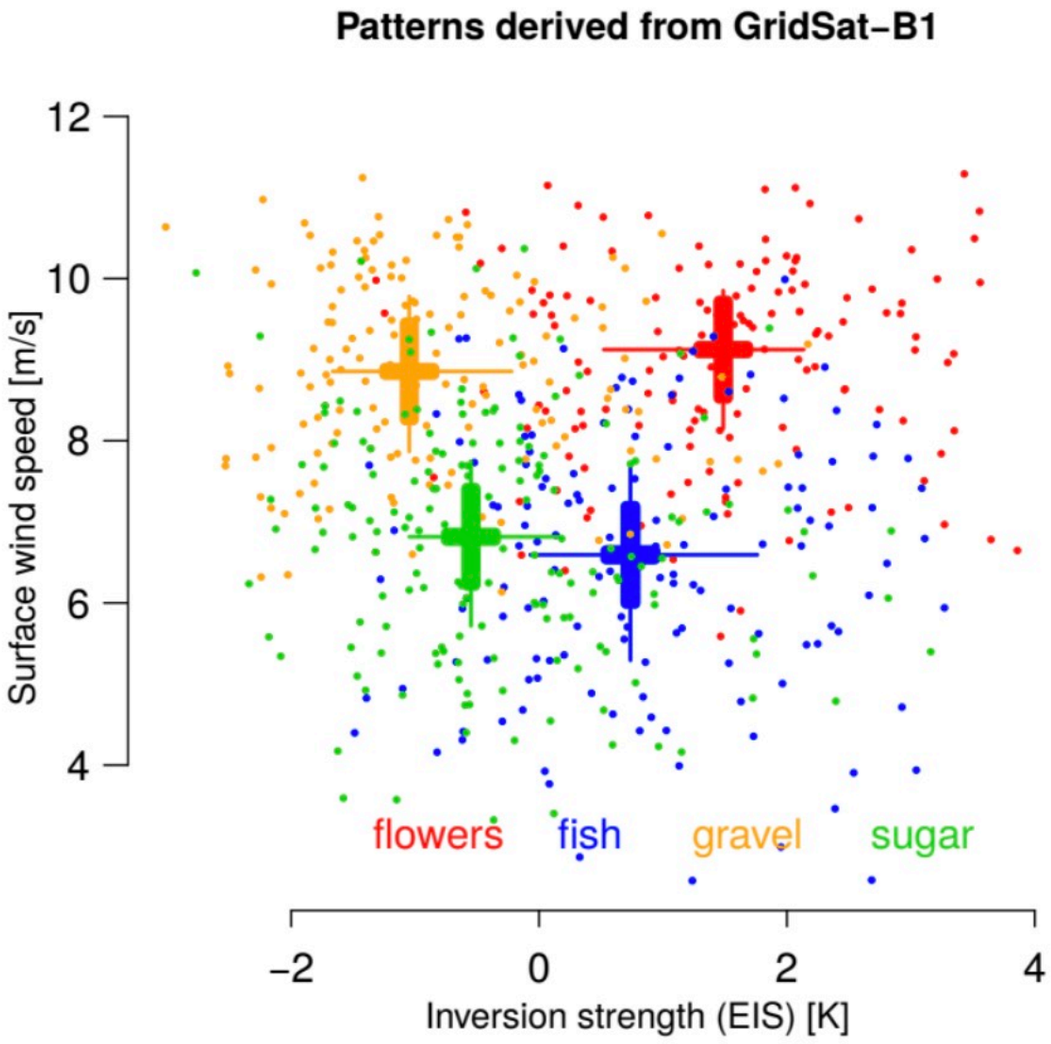
Nuijens and Stevens (2012)

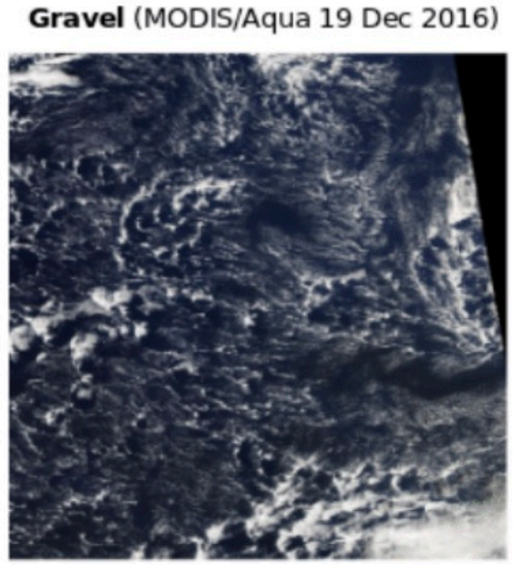
In satellite and BCO climatology, surface wind speed is the best predictor of low cloud amount

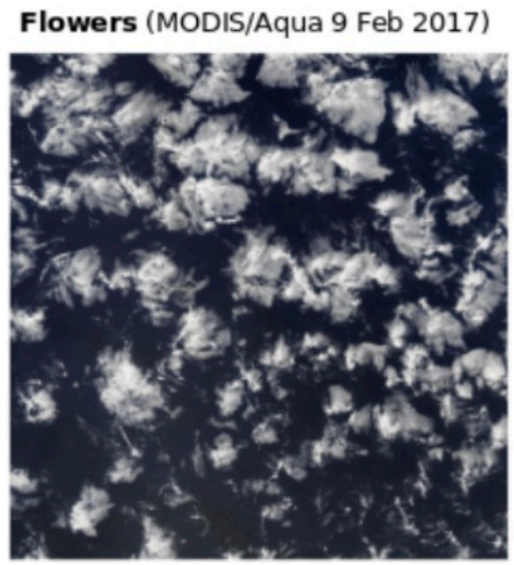


Klein (1997), Brueck et al (2014), Nuijens et al (2015), Mieslinger et al (2019), Sakradzija and Klingebiel (2019)

Strong winds, more gravel and flowers







Bony, Schulz, Vial and Stevens (2020)

Strong winds, more cloud …

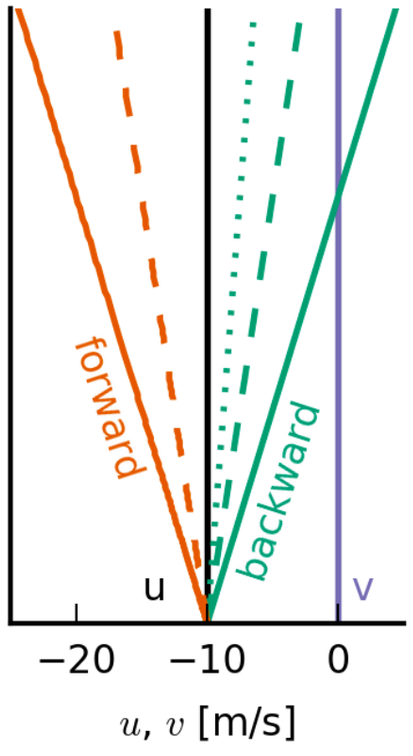
But overcast, no wind

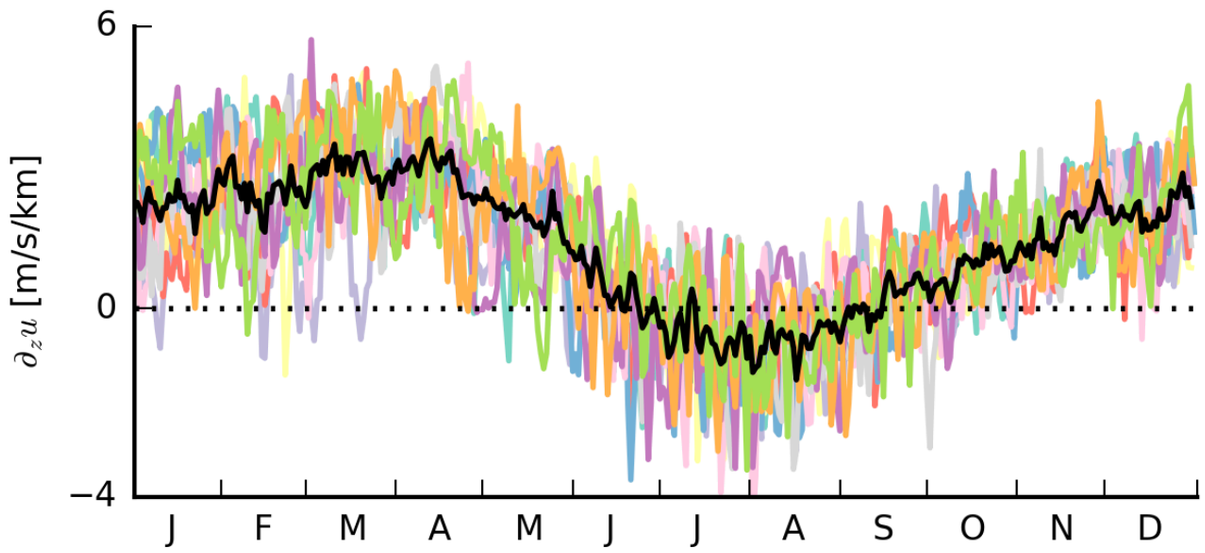

Hobie

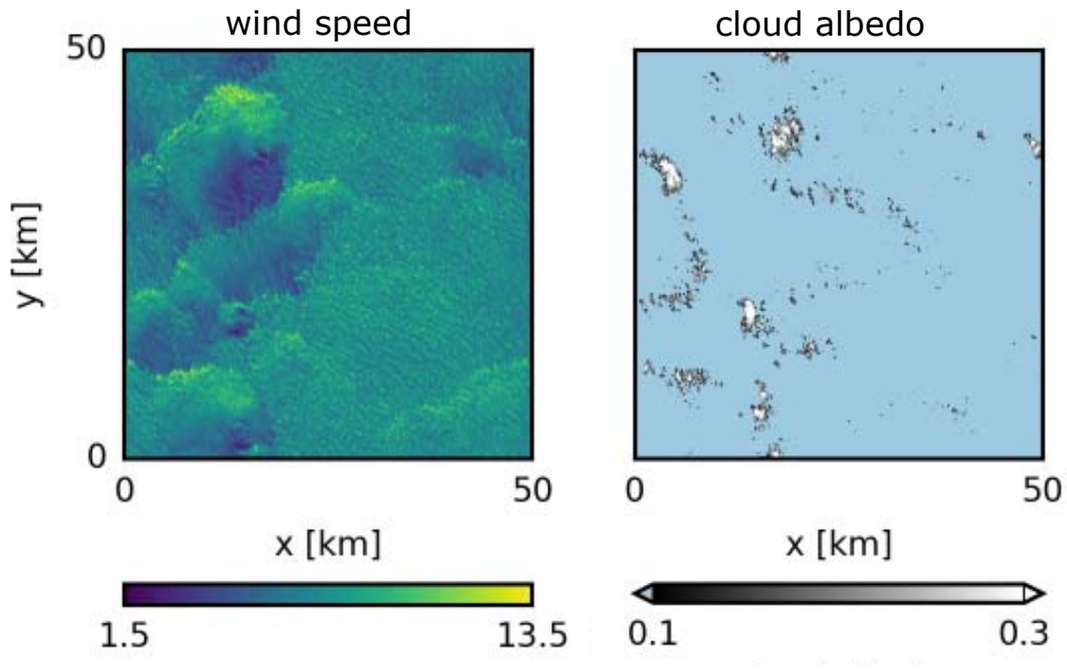

Hobie

What about winds higher up?

Trade-wind convection simulated with DALES subjected to different shear in the zonal wind

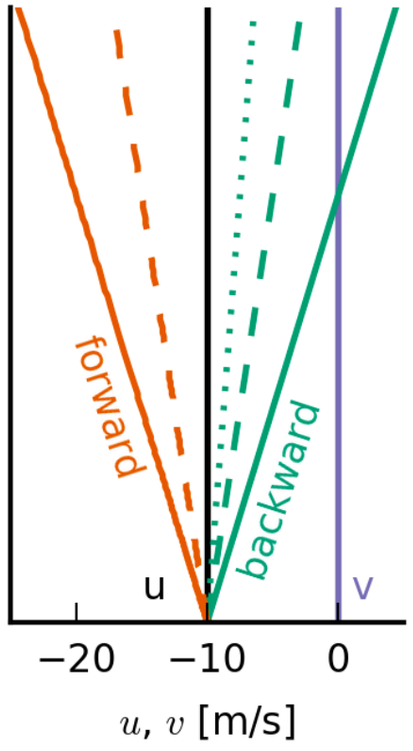


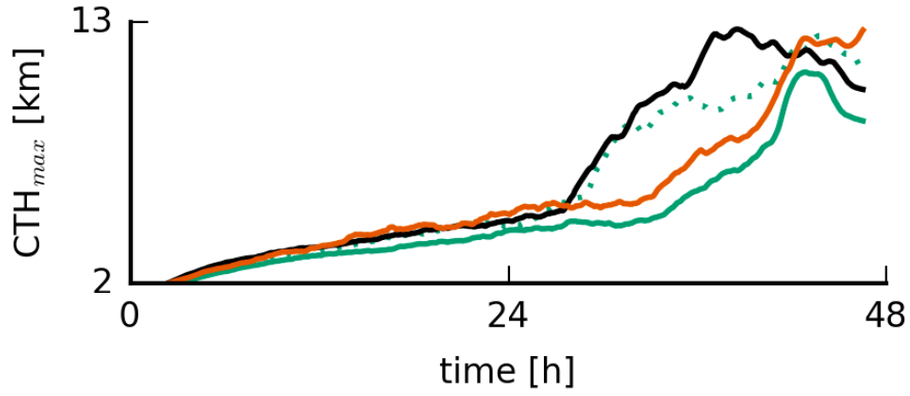


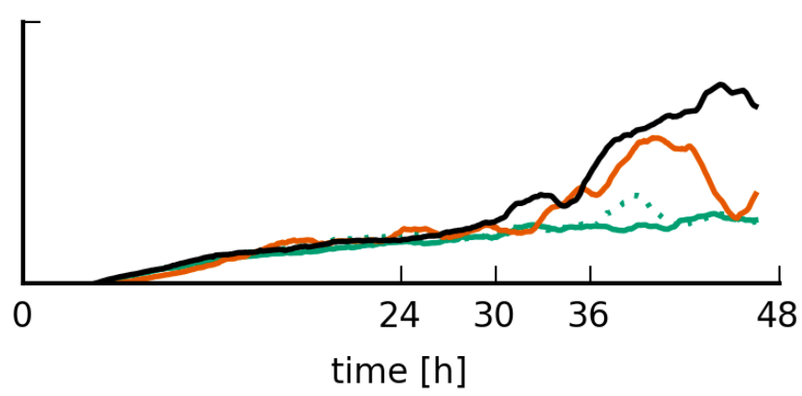


set up after Vogel, Nuijens and Stevens (2016, 2018)

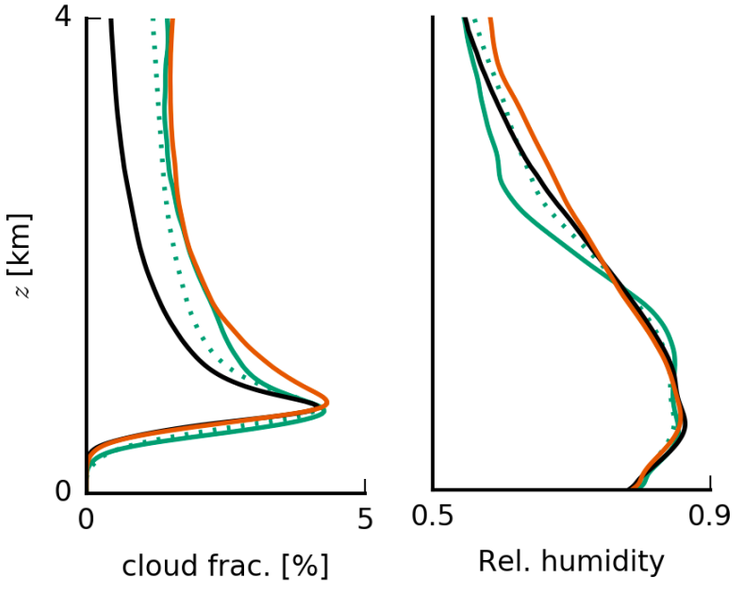
Backward shear leads to shallower convection and a shallower, moister trade-wind layer



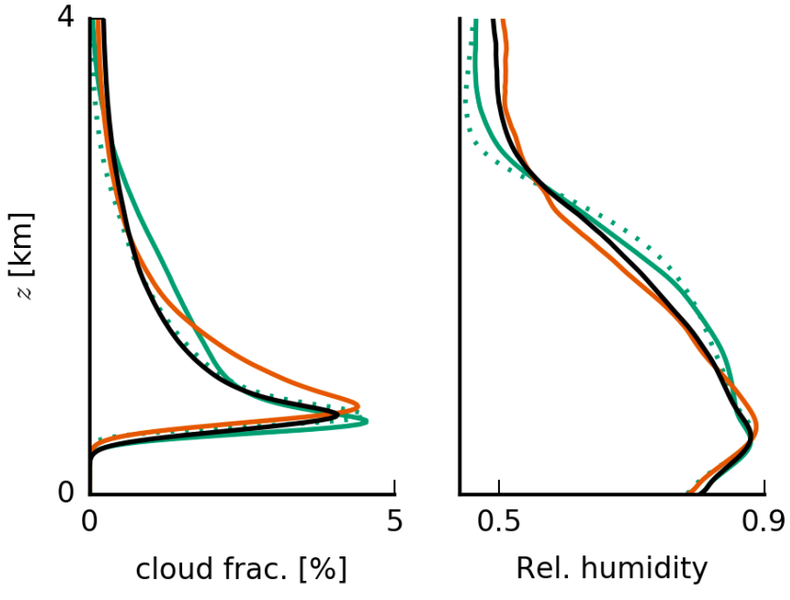




interactive surface fluxes

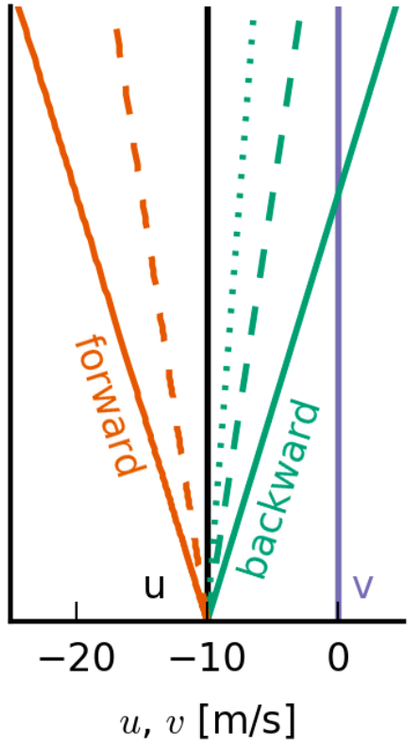


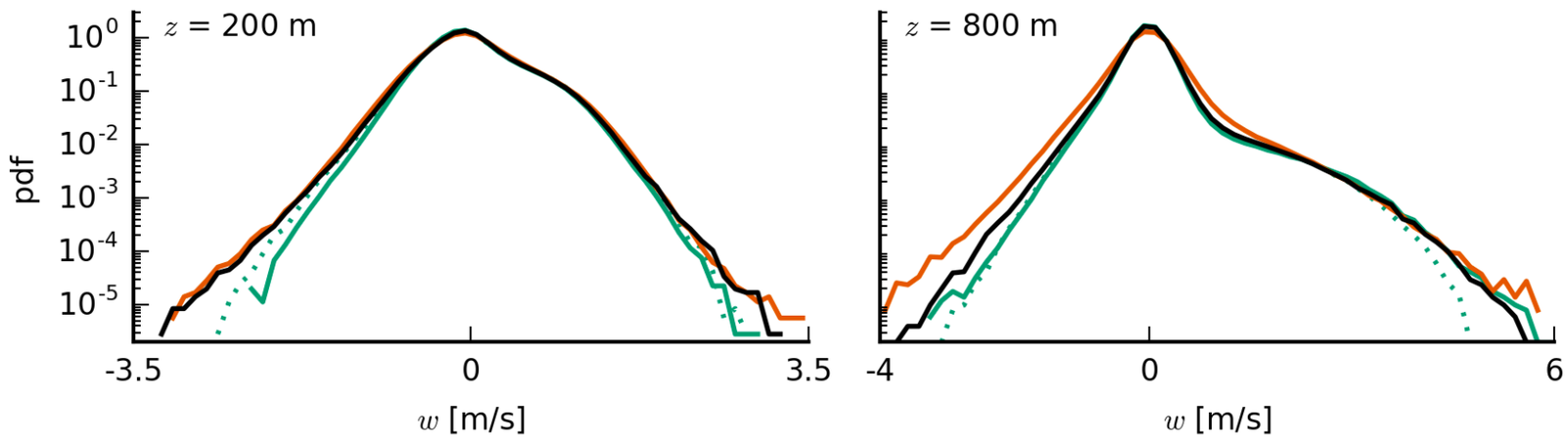
fixed surface fluxes



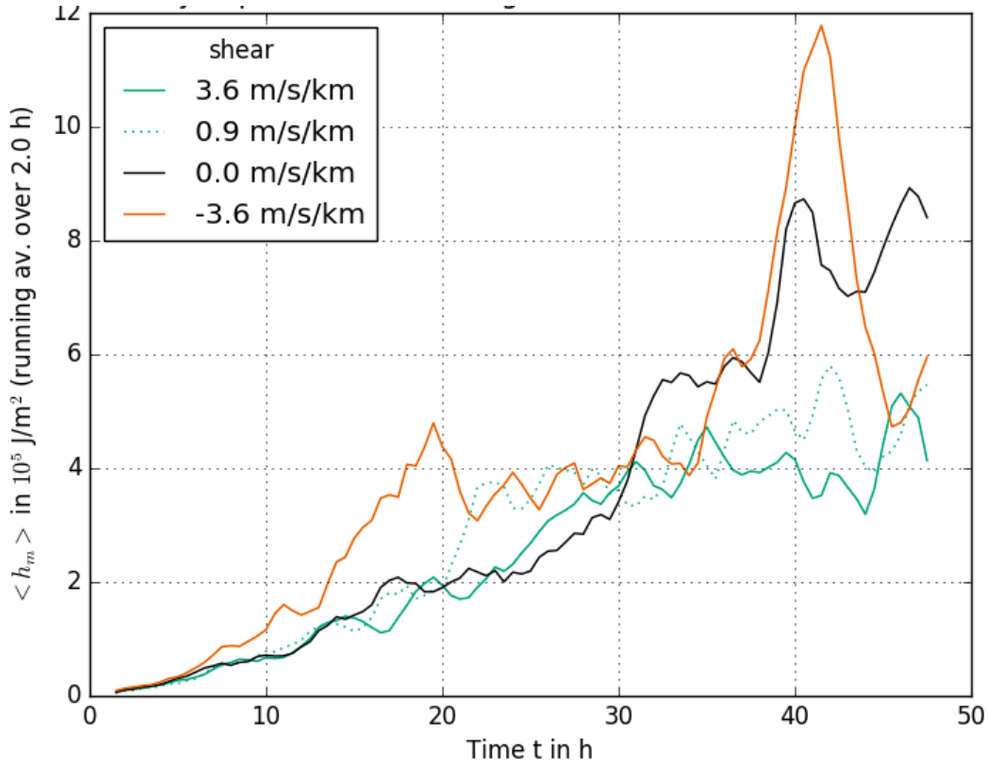
Helfer et al (in prep)

No shear / forward shear promotes moisture aggregation and larger sub-cloud vertical velocities



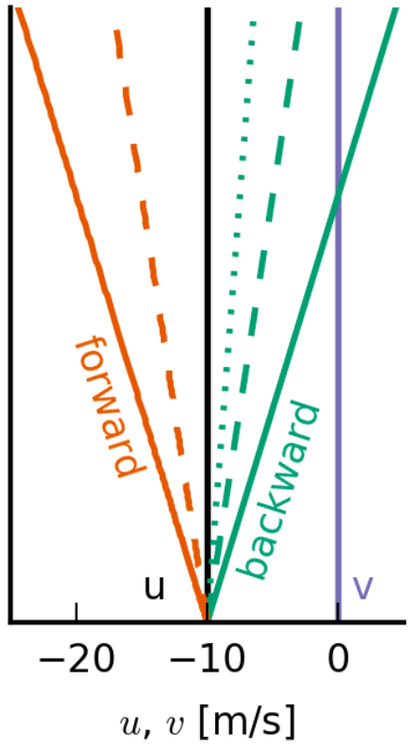


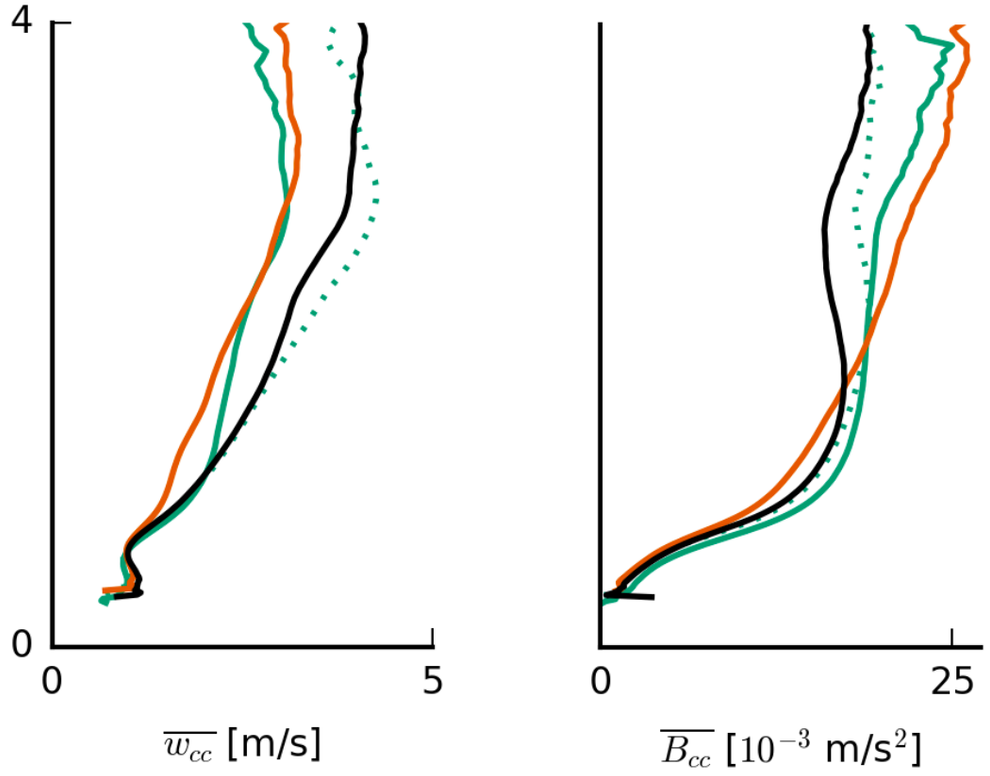
fixed surface flux



Helfer et al (in prep)

Shear in general limits updraft speeds in clouds



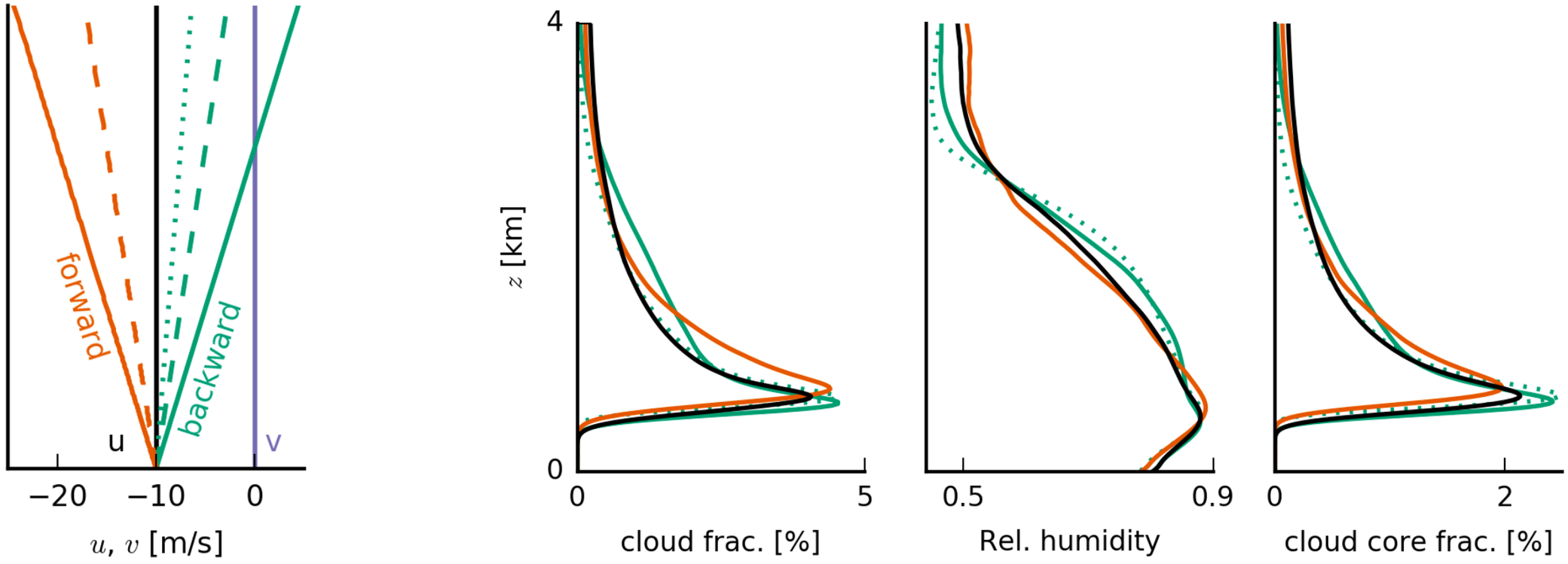


fixed surface flux

Helfer et al (in prep)

Peters et al (2019), Tian et al (2019), Morrison and Peters (2018)

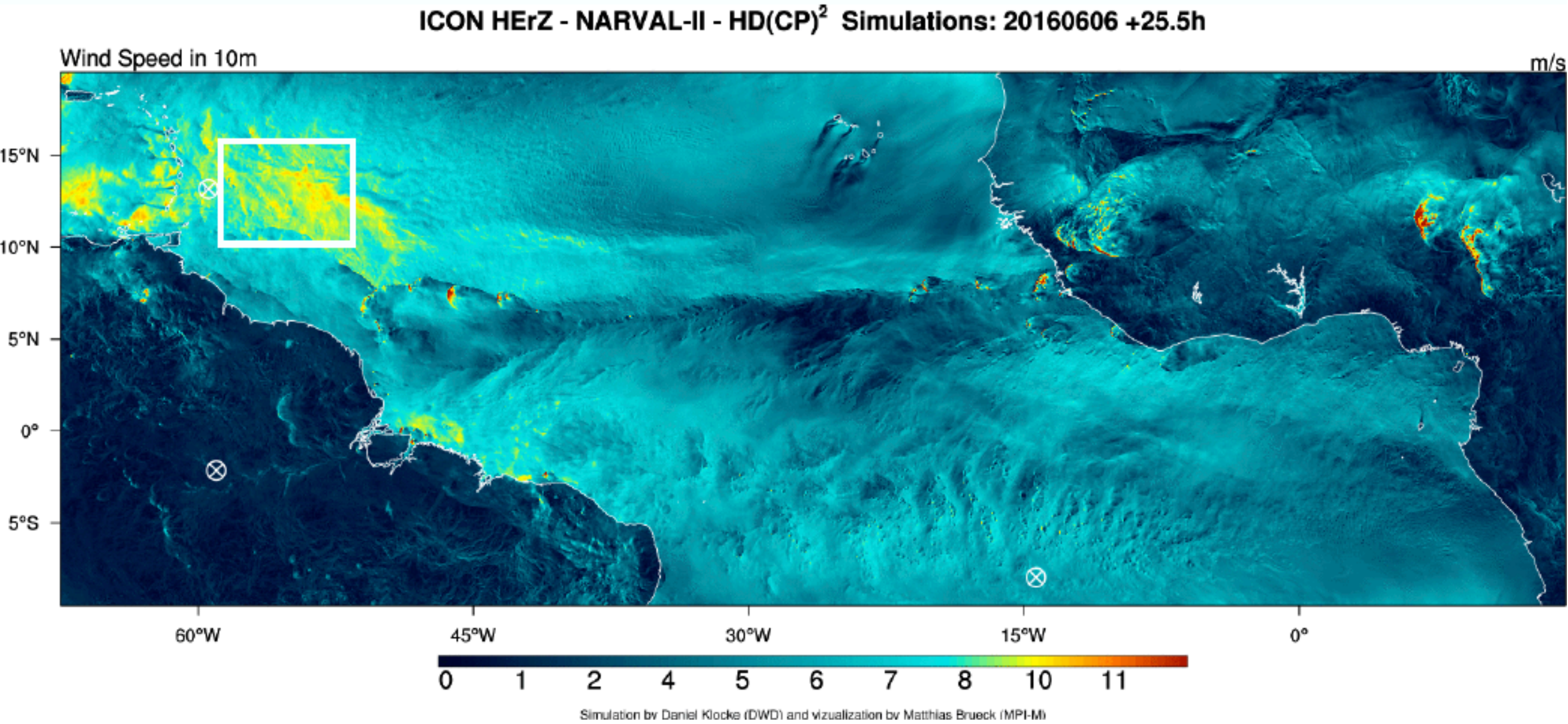
Shear enhances the fraction of active cloud fraction (backward) and passive cloud fraction (forward)



fixed surface flux

Helfer et al (in prep)

ICON-LES over the North Atlantic allow a glance into the momentum transported by turbulence and convection



Simulations by Klocke and Brueck (MPI-M)

A cumulus friction effect? Subgrid turbulence dominates momentum tendencies in the lower cloud layer

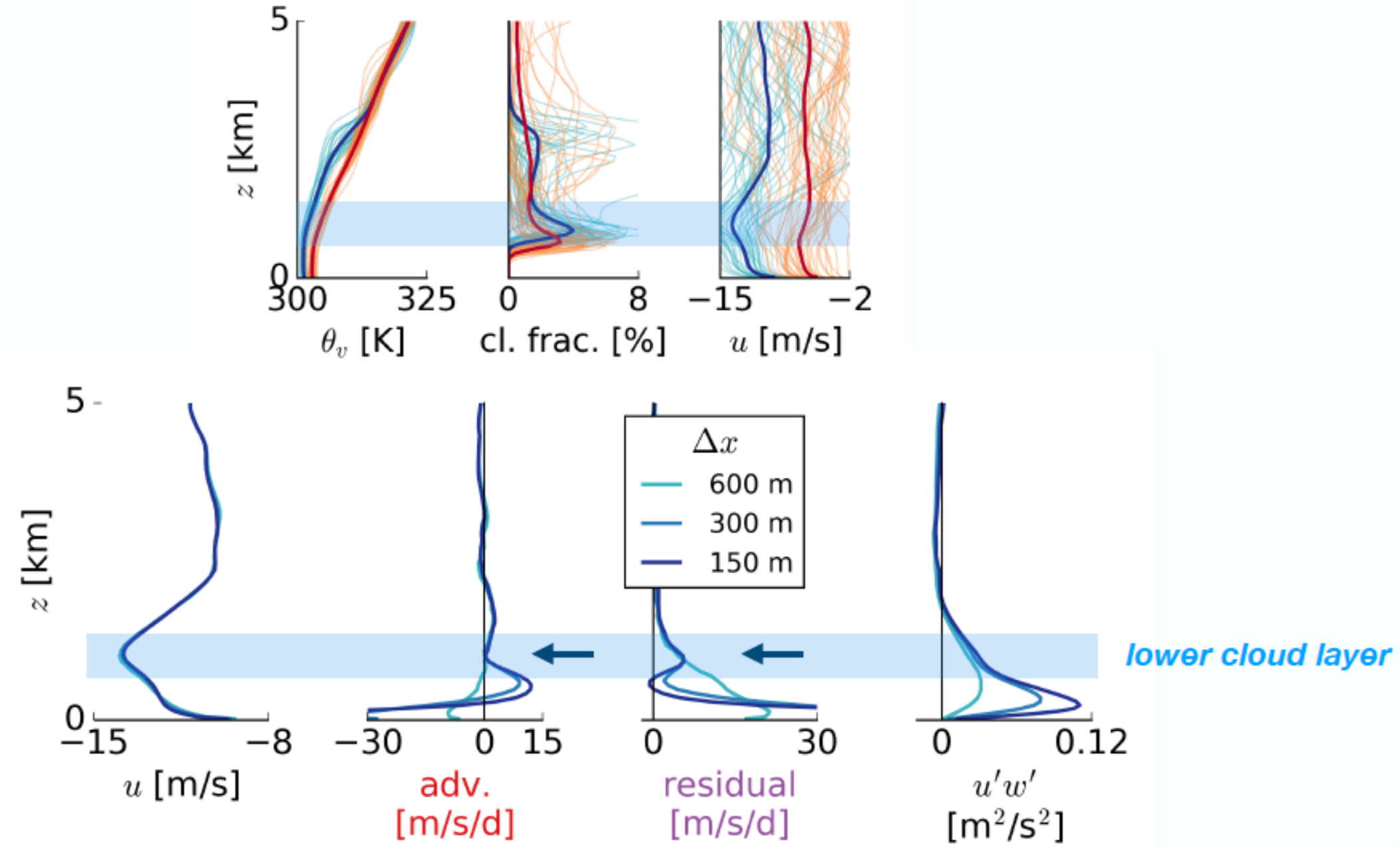
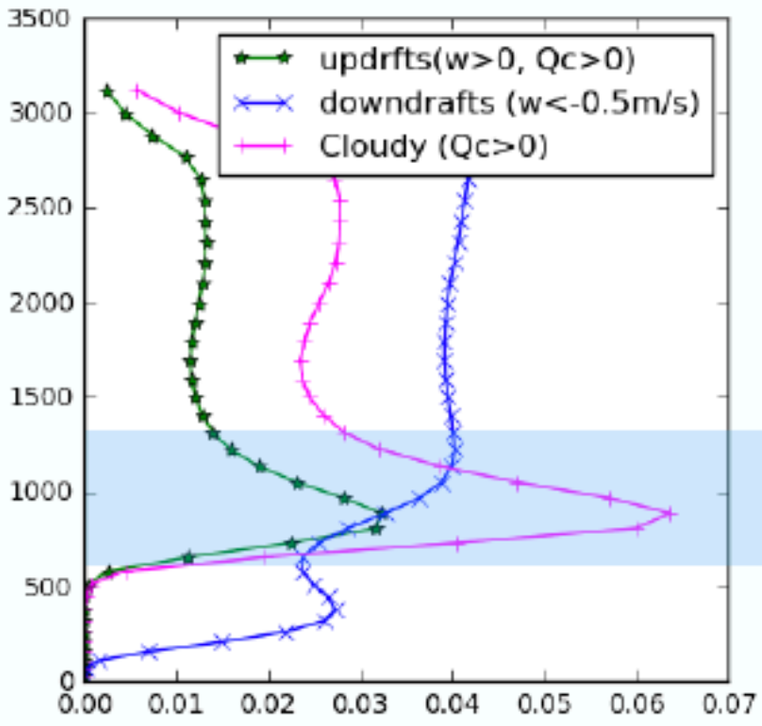
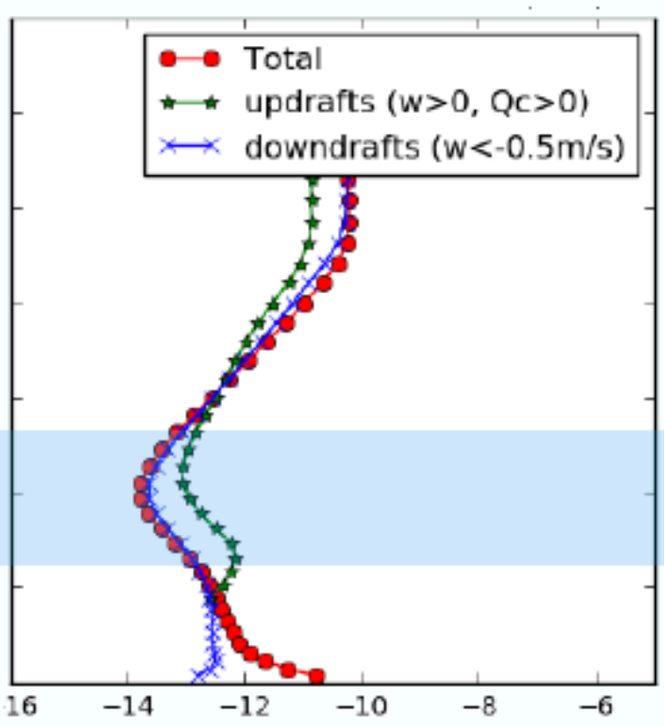


Figure by Kevin Helfer

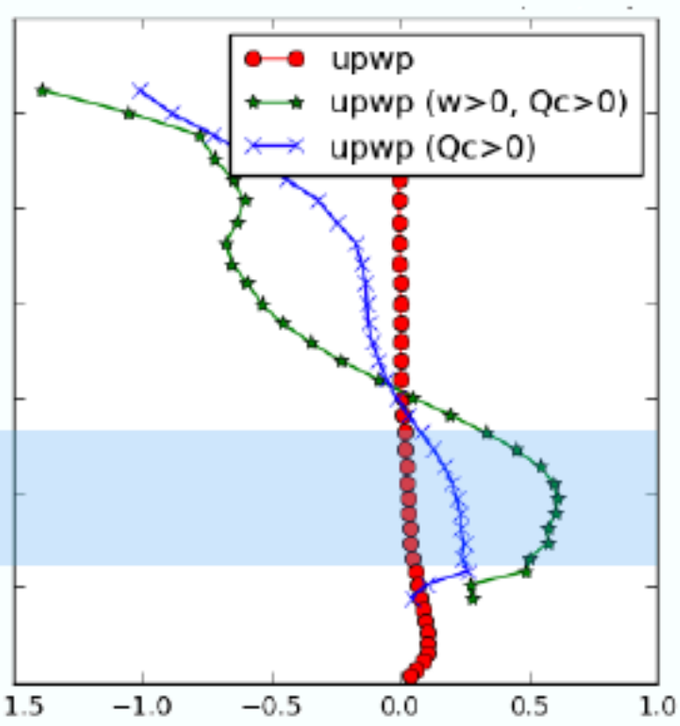
If anything, convective momentum fluxes accelerate easterly flow in the lower cloud layer



fraction of cloud, updrafts, downdrafts



zonal wind speed [m/s]



zonal momentum flux [m^2/s^2]

Figure by Vishal Dixit

In Summary

- ***Shear influences convective deepening via the effect of momentum transport on the surface wind speed and surface fluxes***

- ***Backward shear leads to a shallower and moister trade-wind layer***

- ***Backward (B) and forward (F) shear reduce in-cloud updraft speeds, while enhancing the fraction of active cloud (B) respectively passive cloud (F)***

- ***The zonal wind jet is determined to first order by thermal wind. Momentum flux divergence by convection does little to slow it down***

- ***Counter-gradient turbulent momentum transport slows down zonal winds***