Mesoscale motions mute trade cumulus feedback to warming

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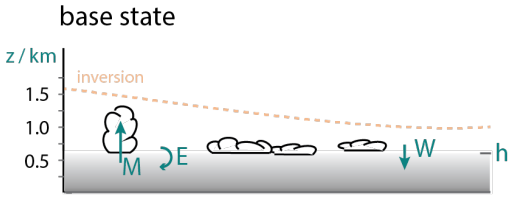
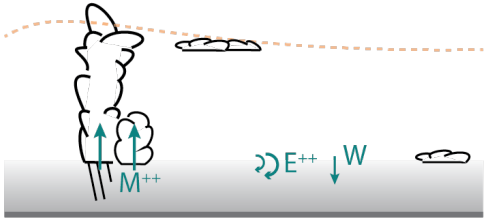
Mixing-desiccation mechanism - *a hypothesis for a large positive trade cumulus feedback*

A Mixing-desiccation mechanism (β<0)





h: sub-cloud layer top
M: mass flux
E: entrainment rate
W: mesoscale vertical velocity
C: cloud-base cloud fraction

$$\frac{Dh}{Dt} = E + W - M$$

consistent with high-sensitivity climate models & idealized large-eddy simulations of non-precipitiating trade cumuli *(Sherwood et al. 2014, Rieck et al. 2012)*

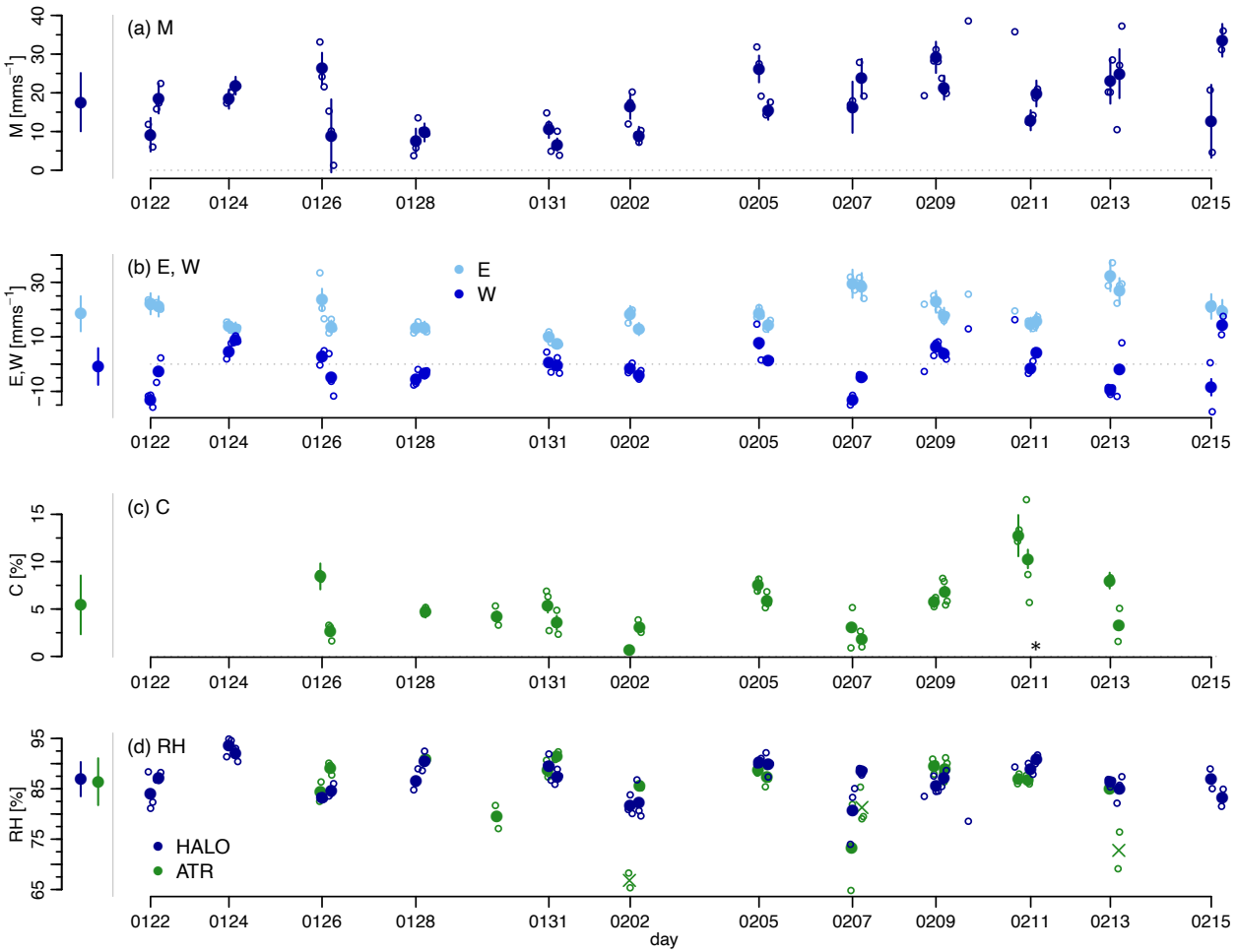
→ $C \propto M^{\beta}$, with $\beta < 0$

(Bony et al. 2017, Stevens et al. 2021)

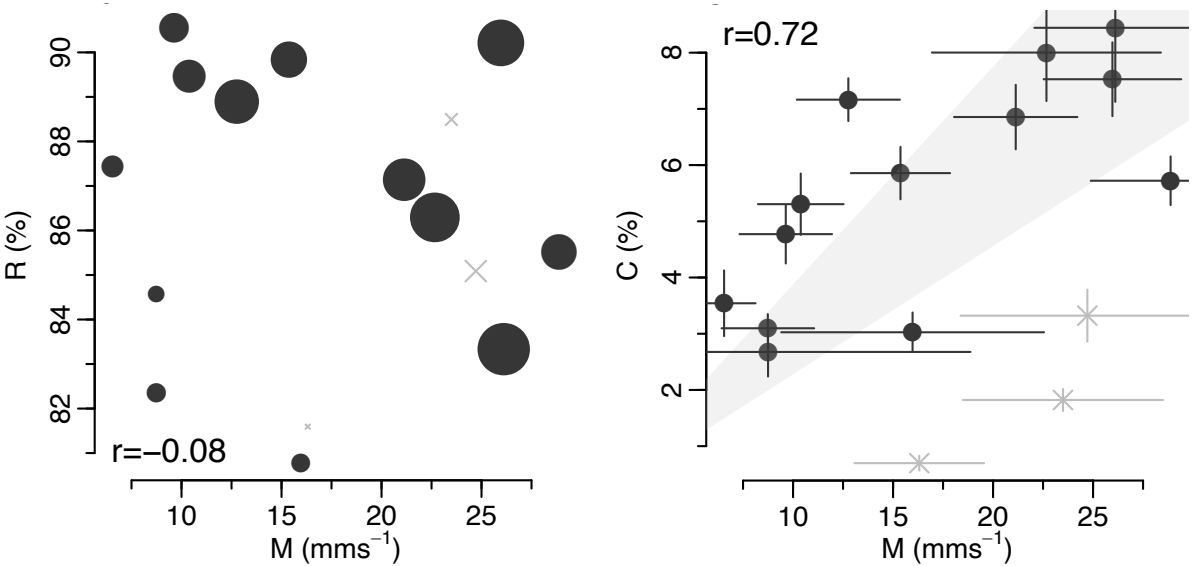
... but never tested with observations!

First measurements of M, C, and RH co-variations

- Jan-Feb 2020 upstream Barbados
- Clouds @Barbados representative for trades *(Medeiros & Nuijens 2016)*
- Robustness assessed with independent data



EUREC^{4}A data refute mixing-desiccation mechanism

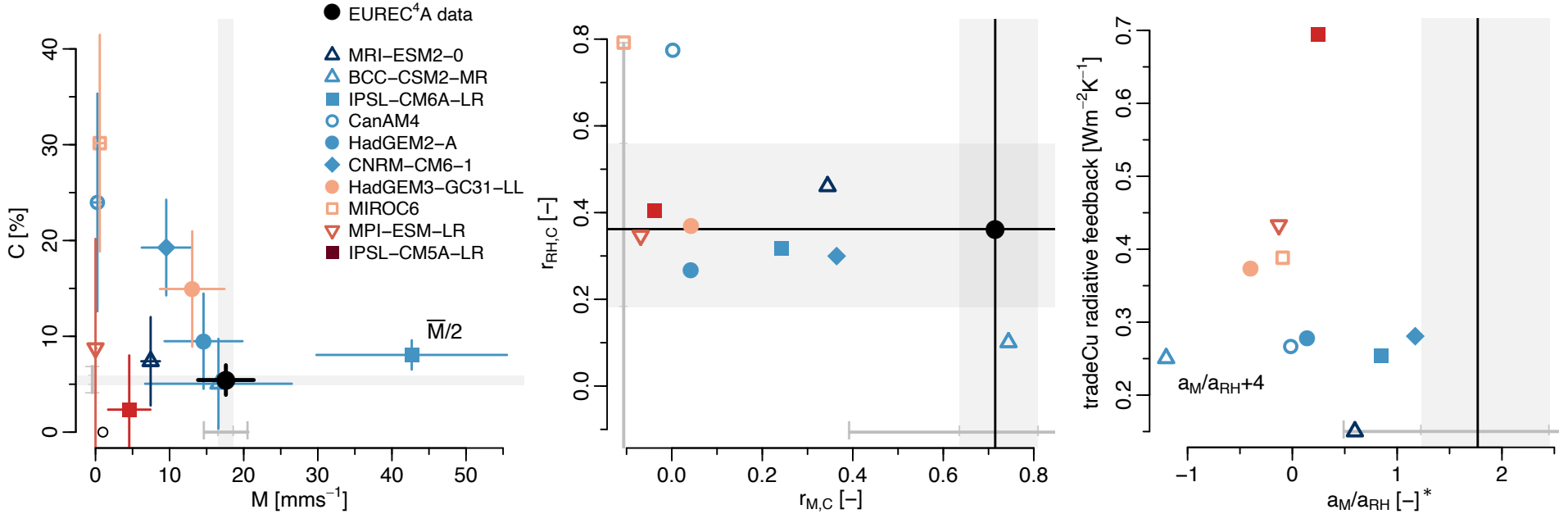


W & E contribute equally to variability in M, but have opposing relations to relative humidity (R)

→ negligible desiccation effect of M!

M alone explains 50% of C variability

Process-based constraints render strongly positive trade cumulus feedbacks implausible



Magnitude, variability, and coupling of M, C and RH in CFMIP models differs drastically from EUREC⁴A data

Models with largest positive feedback represent refuted mixing-desiccation mechanism and particularly exaggerate variability of C and coupling of C to RH instead of M (small a_M/a_{RH})

*a_M/a_{RH} from $\hat{C} = a_M\tilde{\mathrm{M}} + a_{RH}\widetilde{\mathrm{RH}}$

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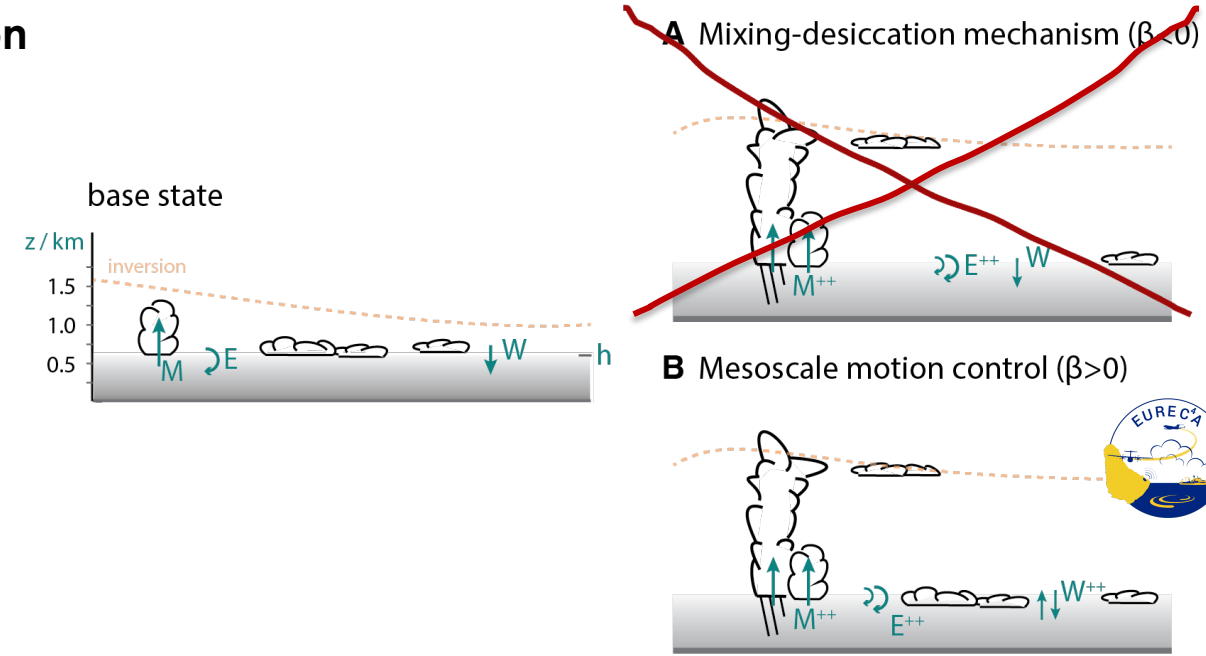
Conclusion



By refuting the mixing-desiccation mechanism with the EUREC⁴A observations...

... we disprove an important mechanism for a strongly positive trade cumulus feedback

... we both support *(Myers et al. 2021, Vogel et al. 2016)* and explain at the process scale a weak trade cumulus feedback