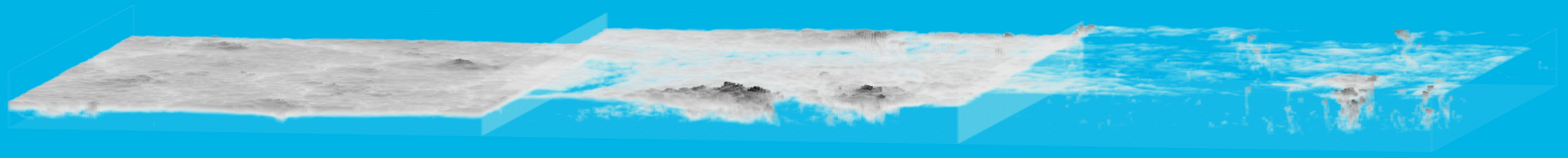
Decoupling in Stratocumulus to Cumulus transitions

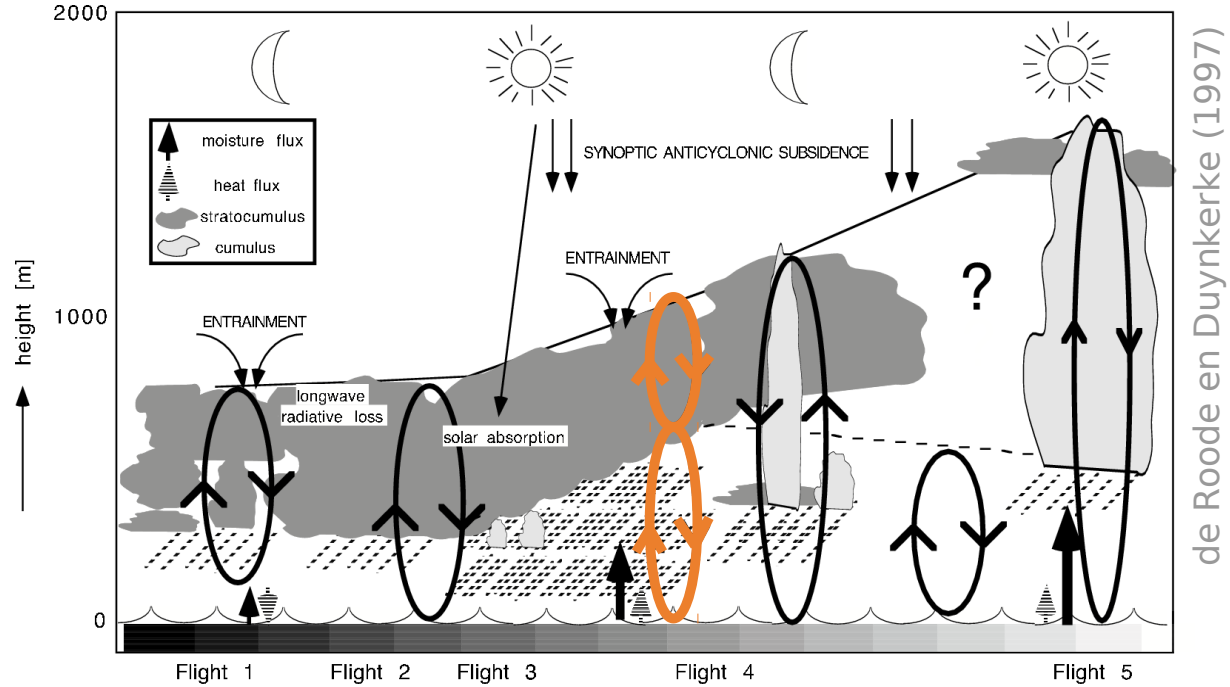
Analysis of decoupling and moisture fluxes in large eddy simulations

Johan van der Dussen & Stephan de Roode & Coen Hennipman



Decoupling

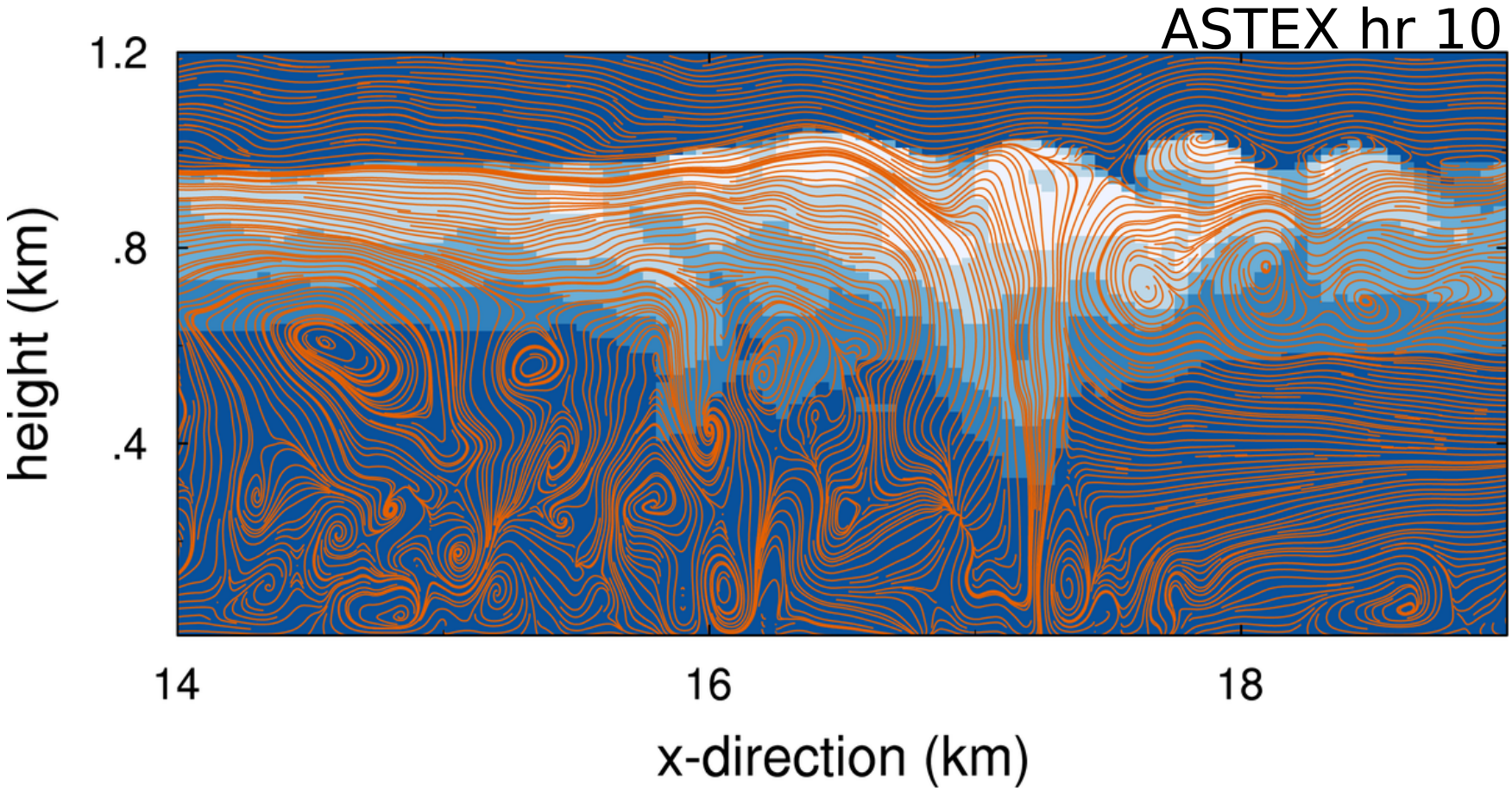
Mechanism for stratocumulus to cumulus transition



(v) There is a tendency for the eddies in the cloud layer to become distinct from those in the subcloud layer, even when the stratocumulus cover is solid and the entire boundary layer appears well mixed otherwise. (Deardorff, 1980)

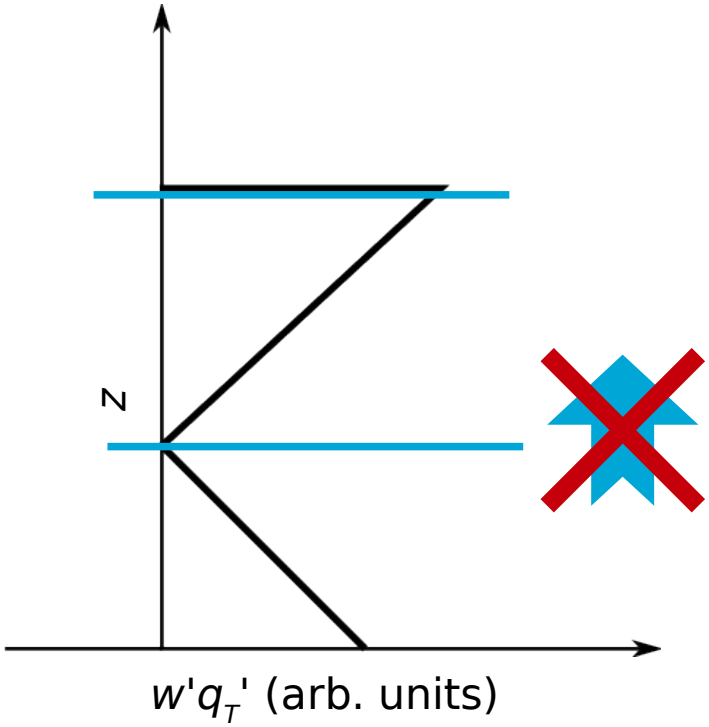
Decoupling

Eddy structures in large eddy simulations



Consequences for turbulent flux

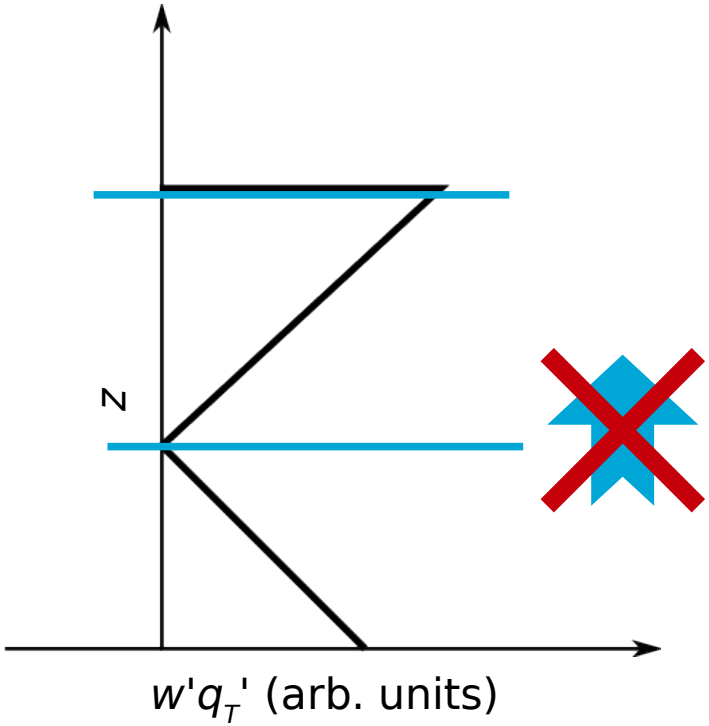
Moisture flux to cloud layer



a.o. Nicholls (1984),
in absence of precipitation

Consequences for turbulent flux

Moisture flux to stratocumulus layer



a.o. Nicholls (1984),
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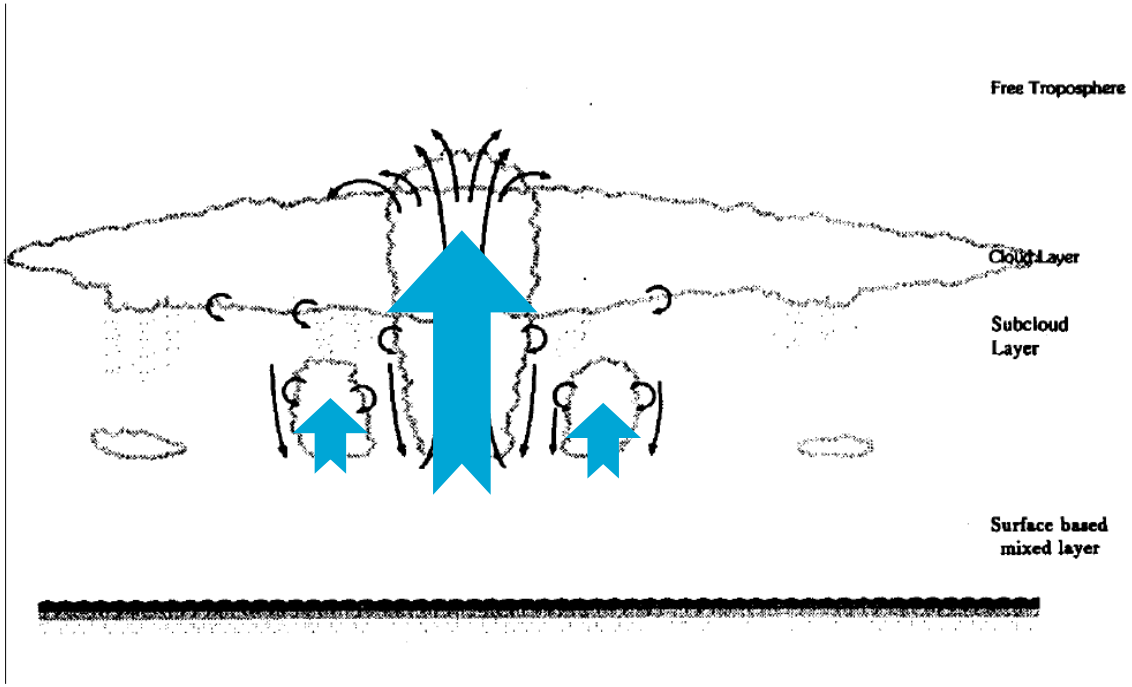
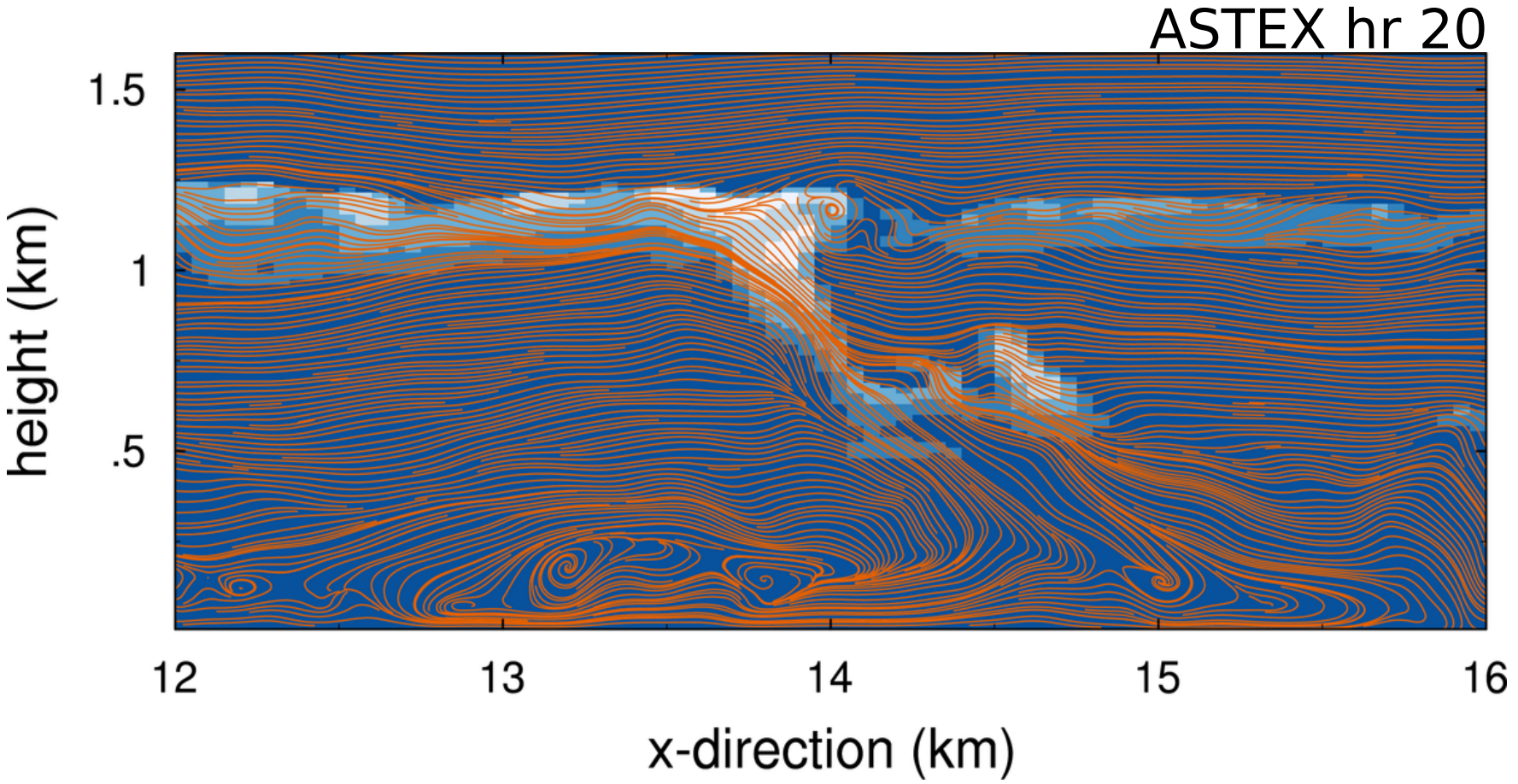


a.o. Martin et al. (1995)

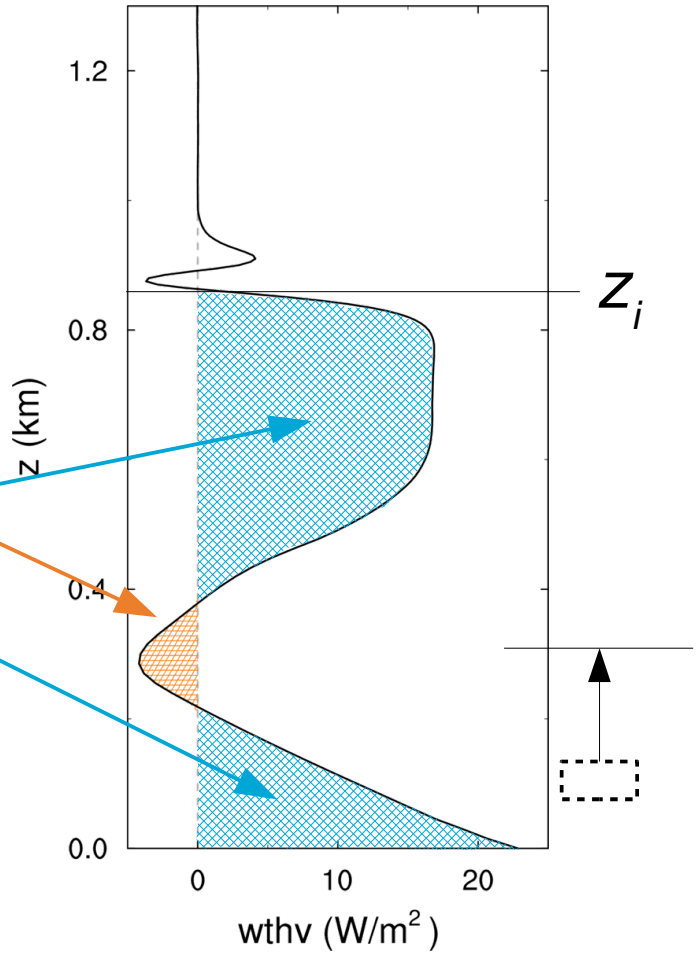
Transport by cumulus updrafts



Measure of decoupling

Buoyancy Integral Ratio

$$\mathcal{R} \equiv -\frac{\int_0^{z_i} \tilde{F}_{\theta_v} \mathcal{H}(-\tilde{F}_{\theta_v}) dz}{\int_0^{z_i} \tilde{F}_{\theta_v} \mathcal{H}(\tilde{F}_{\theta_v}) dz}$$



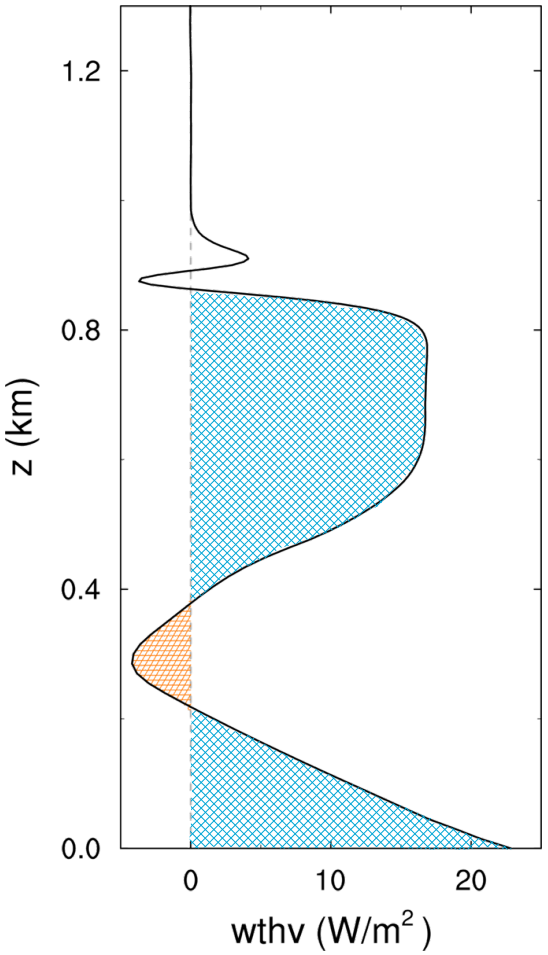
a.o. Turton & Nicholls (1987), Bretheron & Wyant (1997), Stevens (2000)

Measure of decoupling

Buoyancy Integral Ratio thresholds

Proposed critical values:

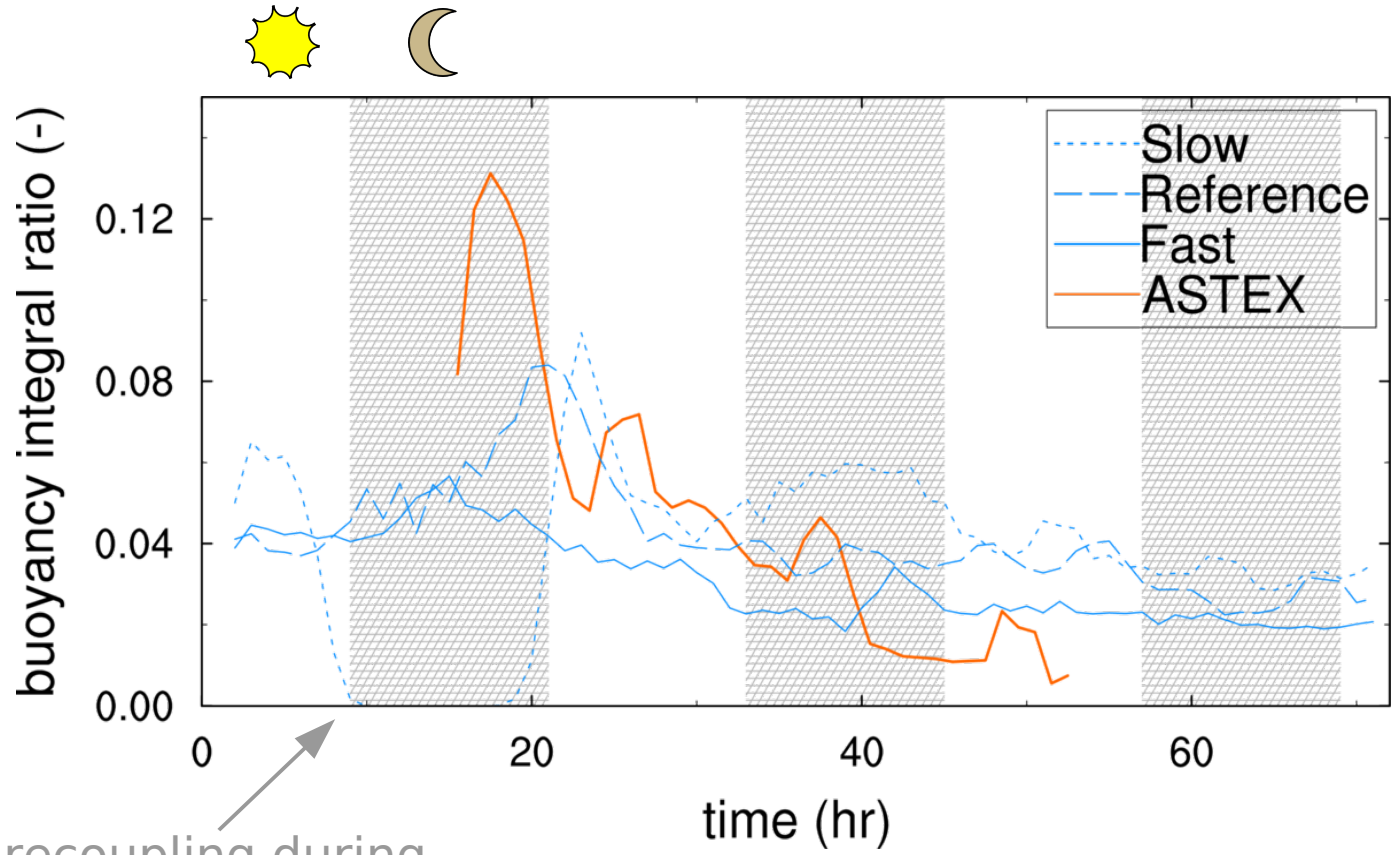
Turton & Nicholls 1987	0.4
Bretherton & Wyant 1997	0.15
Stevens 2000	0.0



a.o. Turton & Nicholls (1987), Bretheron & Wyant (1997), Stevens (2000)

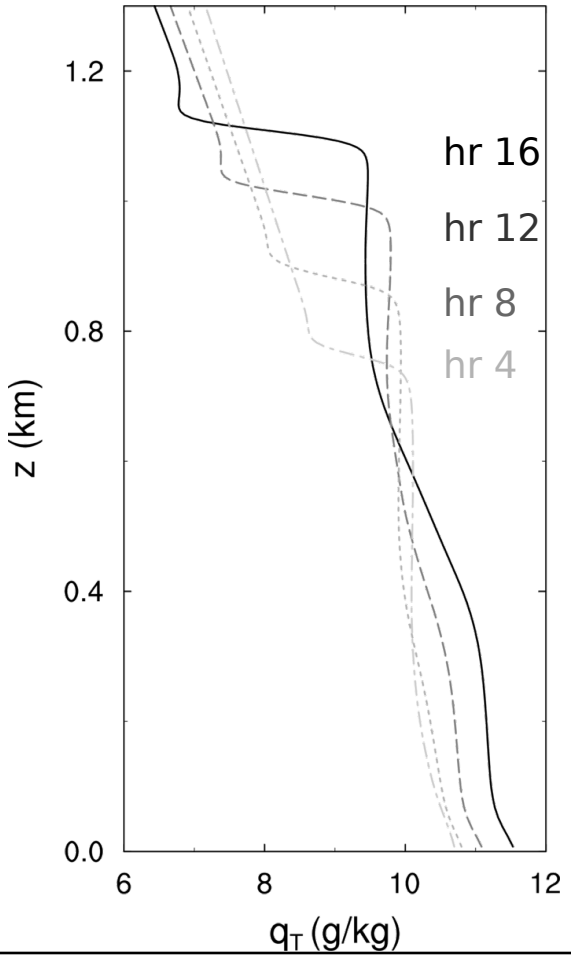
Buoyancy Integral Ratio

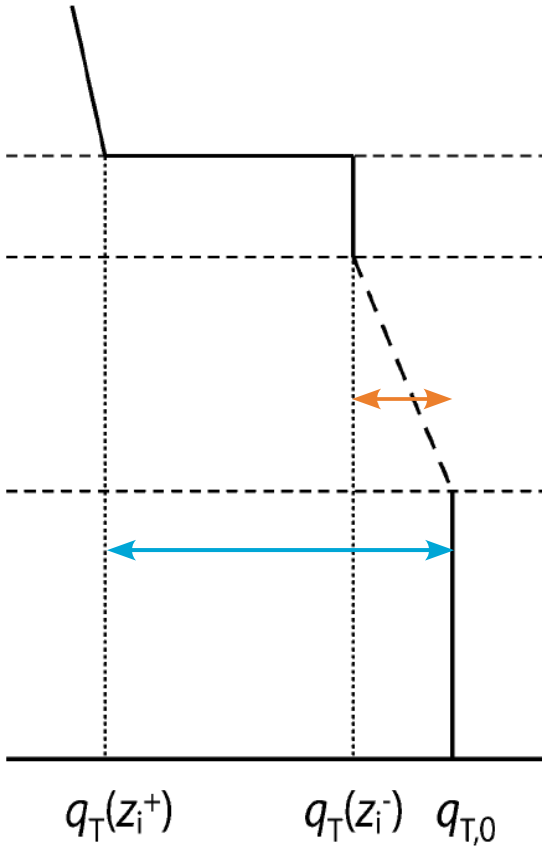
LES results show low values and decreasing trends



Boundary layer stratification

Quantifying stratification with decoupling parameter



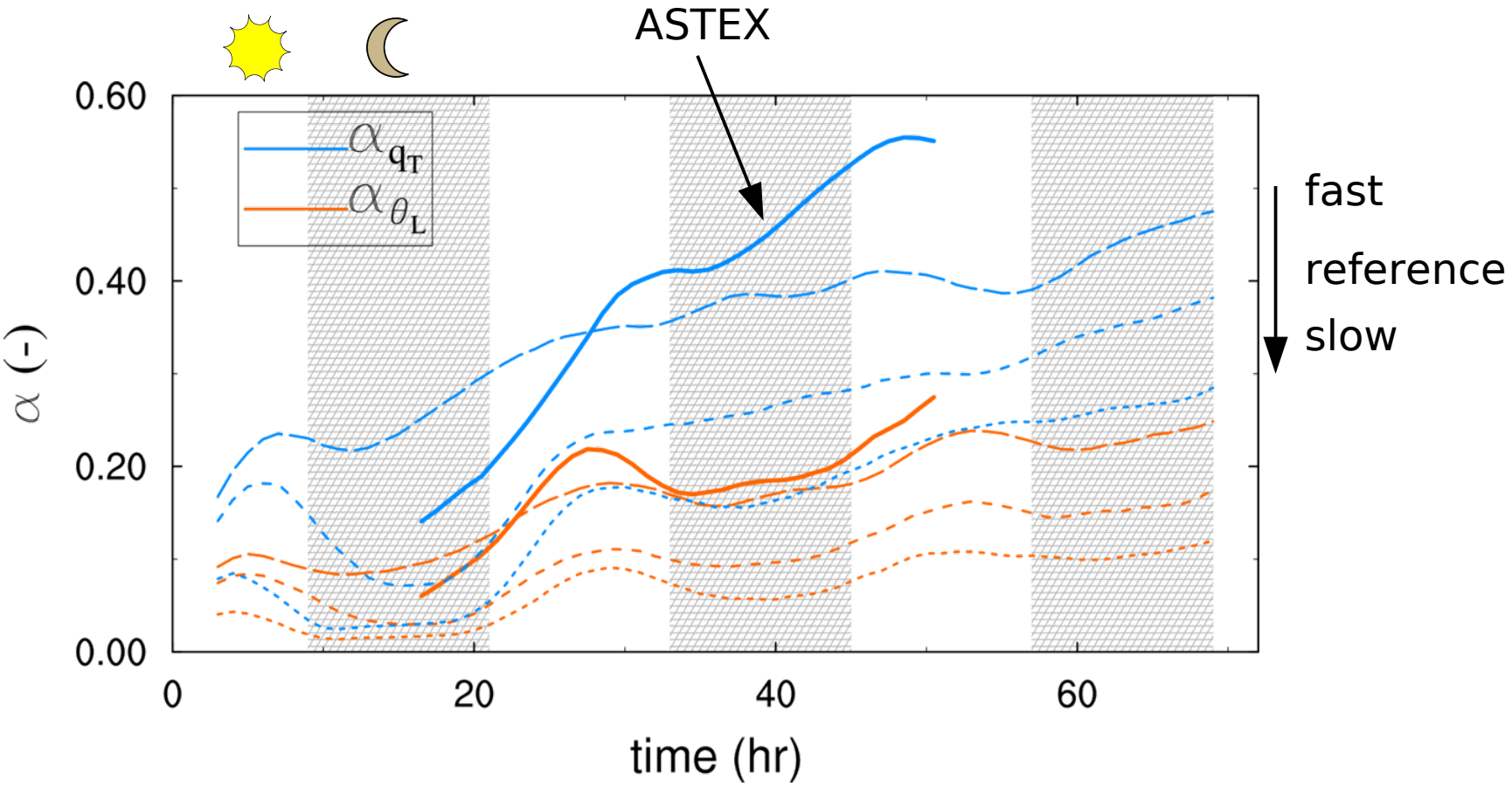


$$\alpha_q = \frac{q_T(z_i^-) - q_{T,0}}{q_T(z_i^+) - q_{T,0}}$$

a.o. Wood and Bretherton (2004), Park et al. (2004)

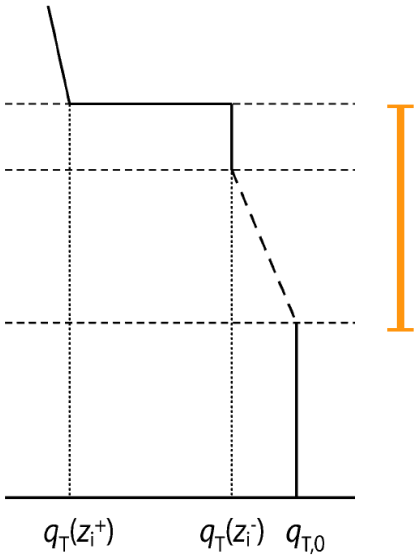
Decoupling parameter

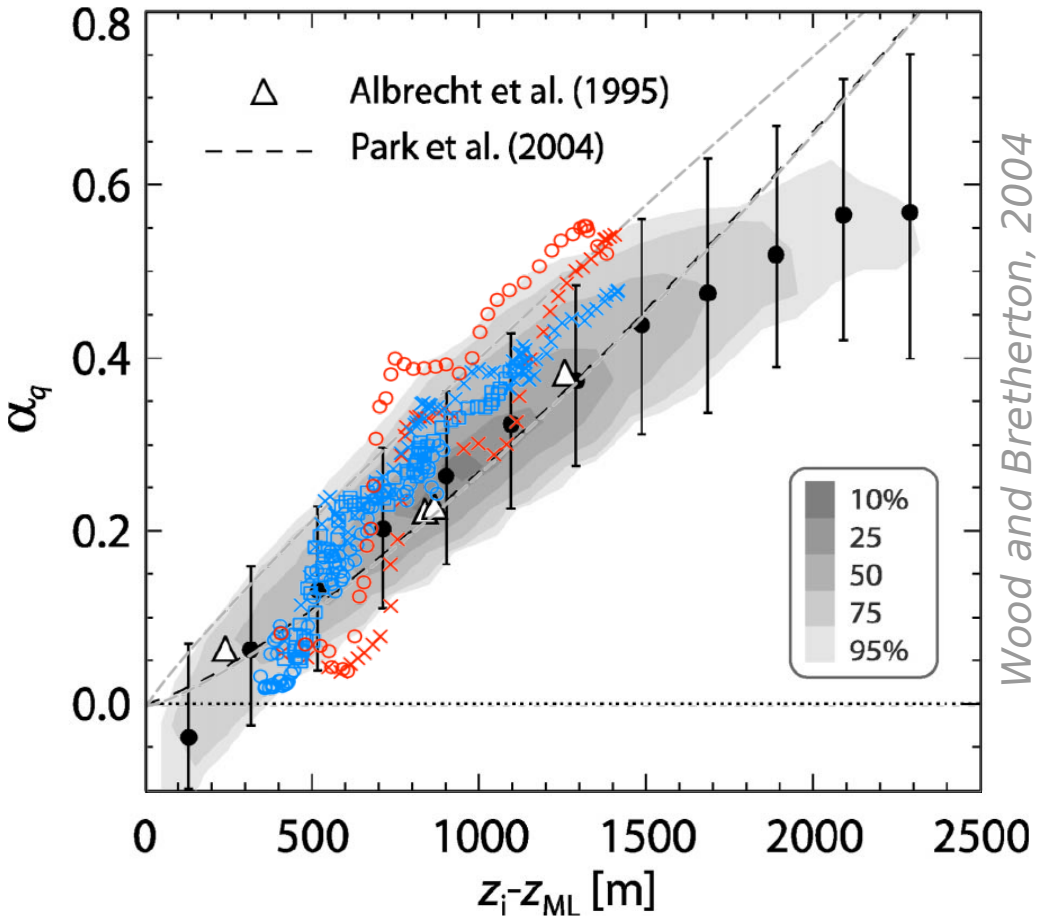
Steady increase in stratification



Decoupling parameter

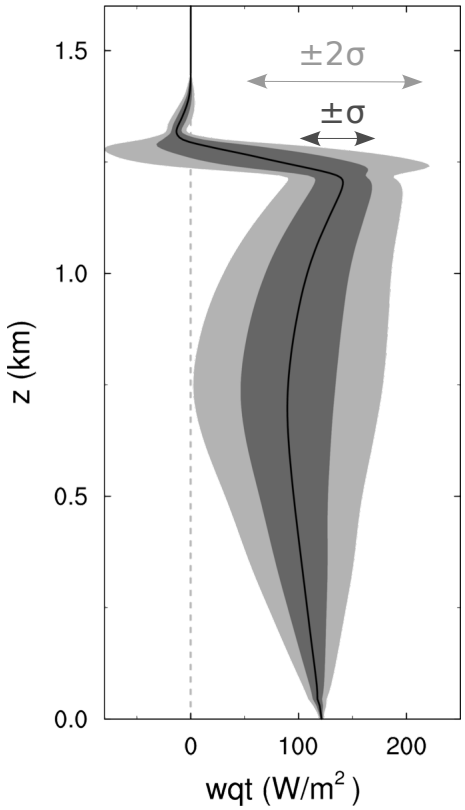
Decoupling parameter scales with layer thickness





Consequences for turbulent flux

Moisture flux from surface layer to cloud: zero??

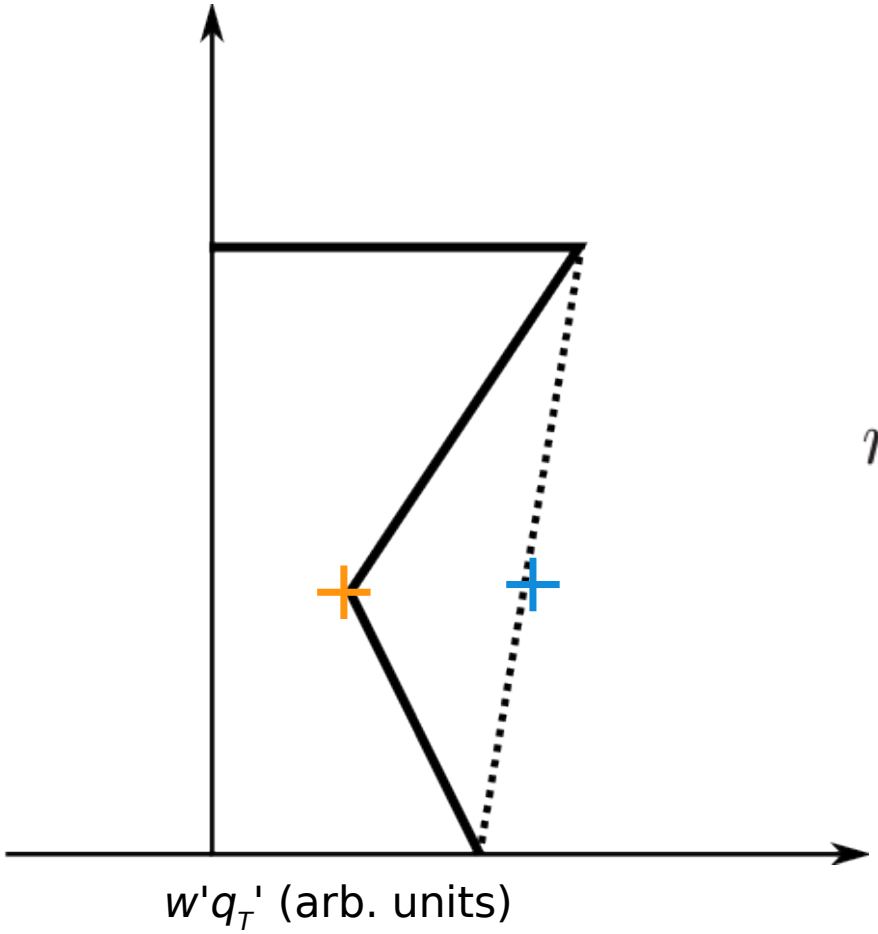


R ~ 0.08

Sandu reference case (hr 18-22)

Consequences for turbulent flux

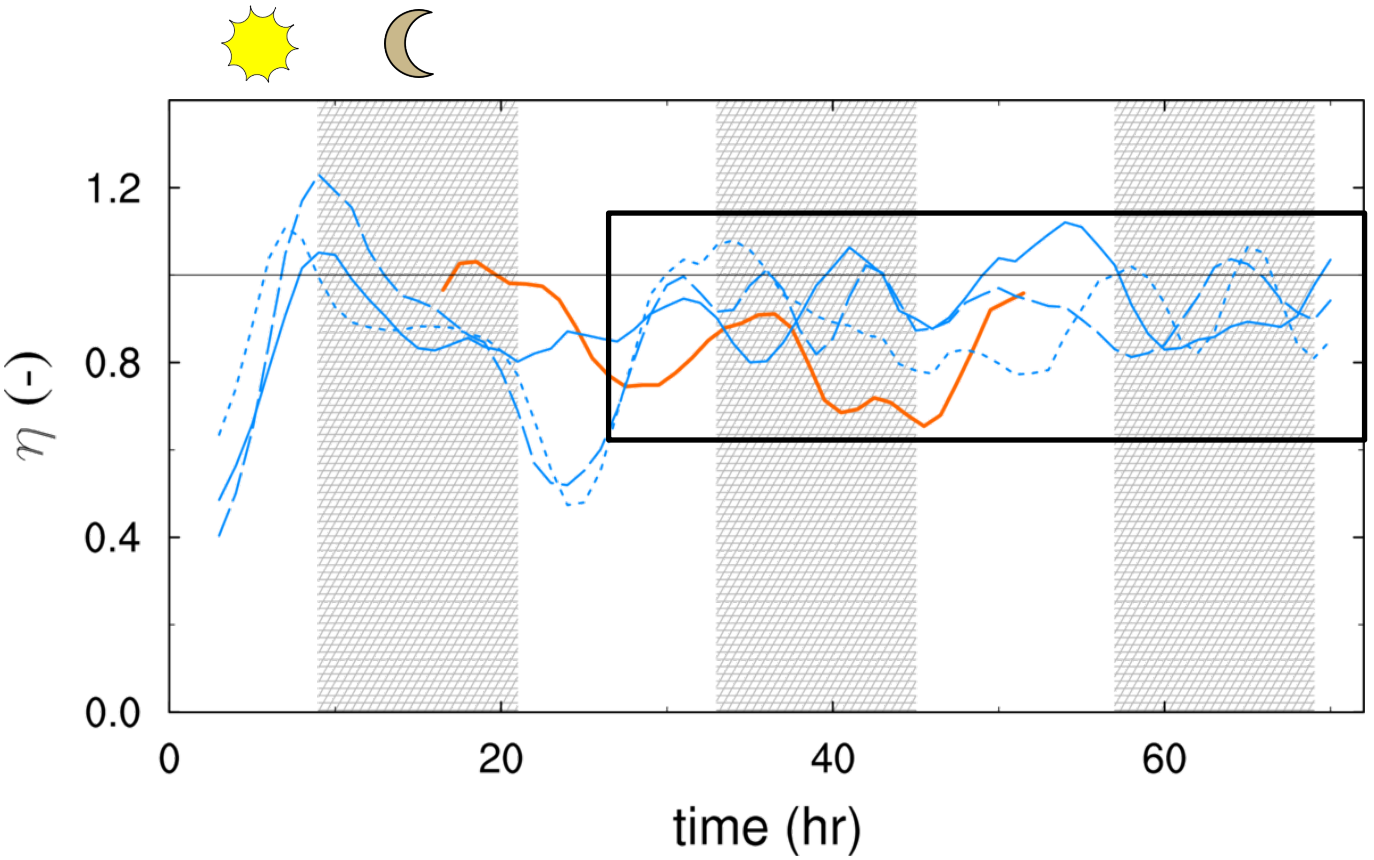
Efficiency parameter η



$$\eta = \frac{\overline{w' q_T'}(z_b)}{\overline{w' q_T'}^{WM}(z_b)}$$

Moisture flux at cloud base

Close to well-mixed in most of the simulation



transport by cumuli

Preliminary conclusions

There is no direct link between the value of the buoyancy integral ratio and the moisture flux from surface to cloud layer

During the transitions, the moisture flux to the cloud layer is never entirely suppressed
→ transition from stratocumulus to cumulus-coupled BL is very subtle

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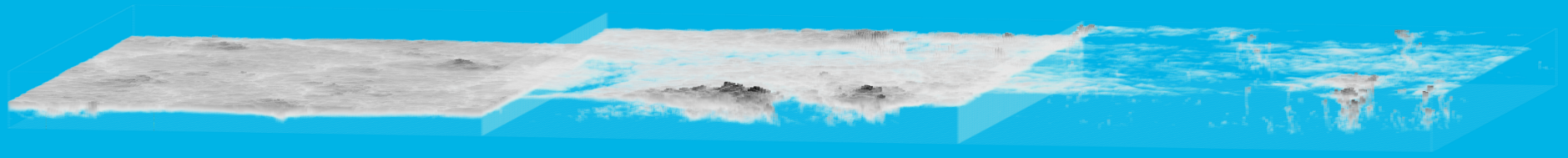
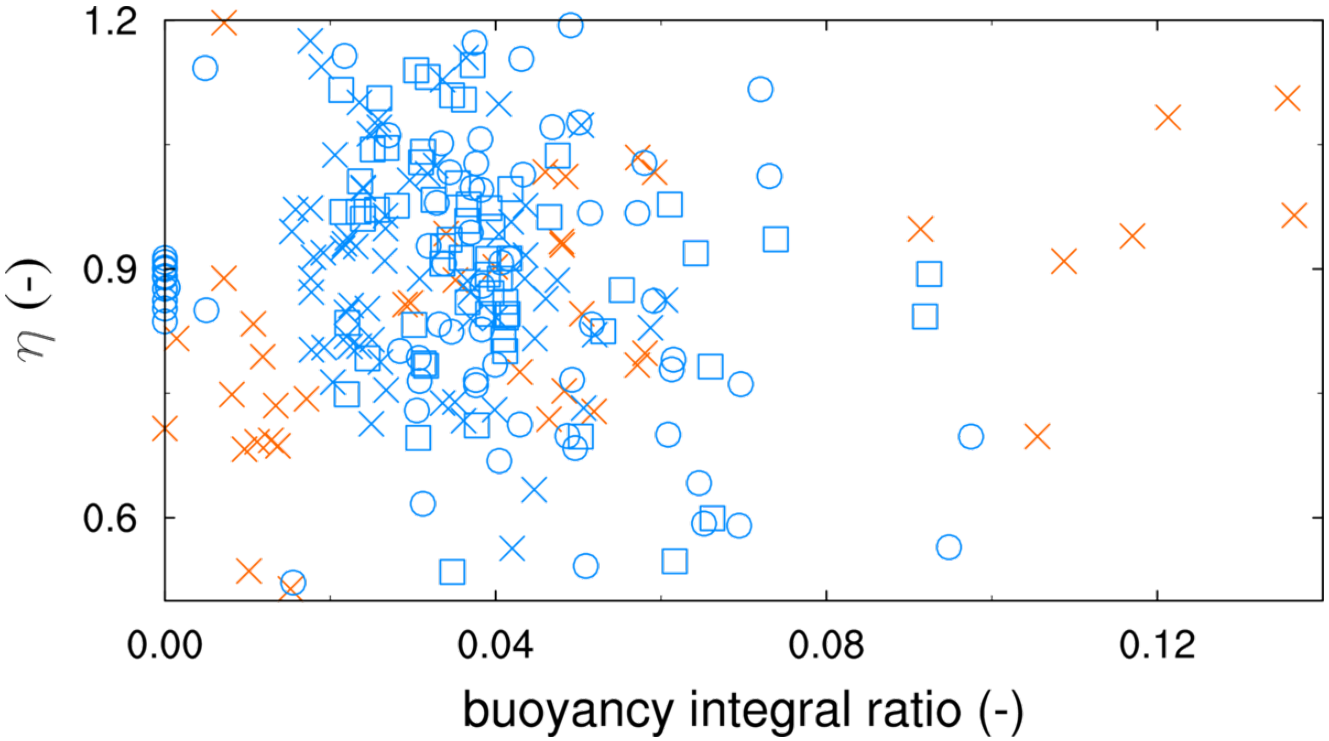
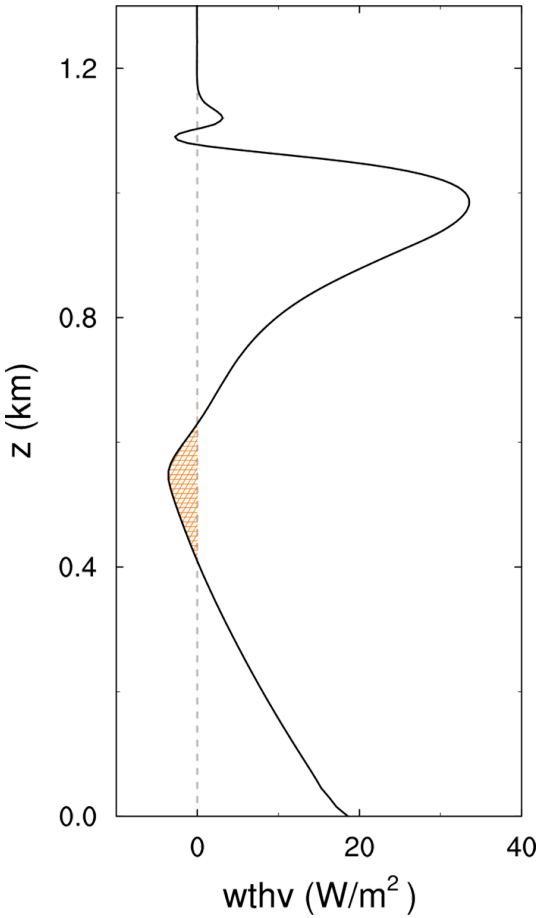


No correlation between flux and BIR



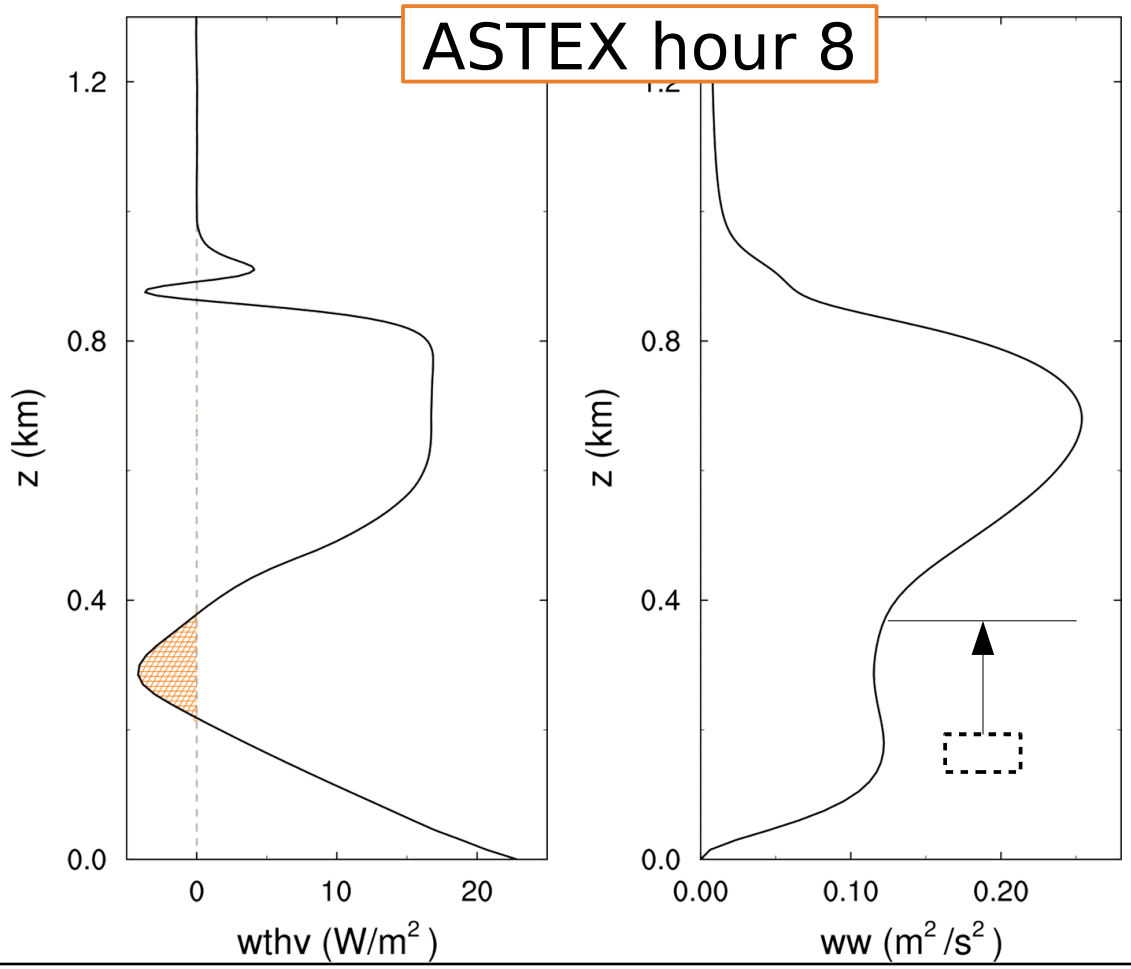
Negative buoyancy flux

Deceleration of surface updrafts

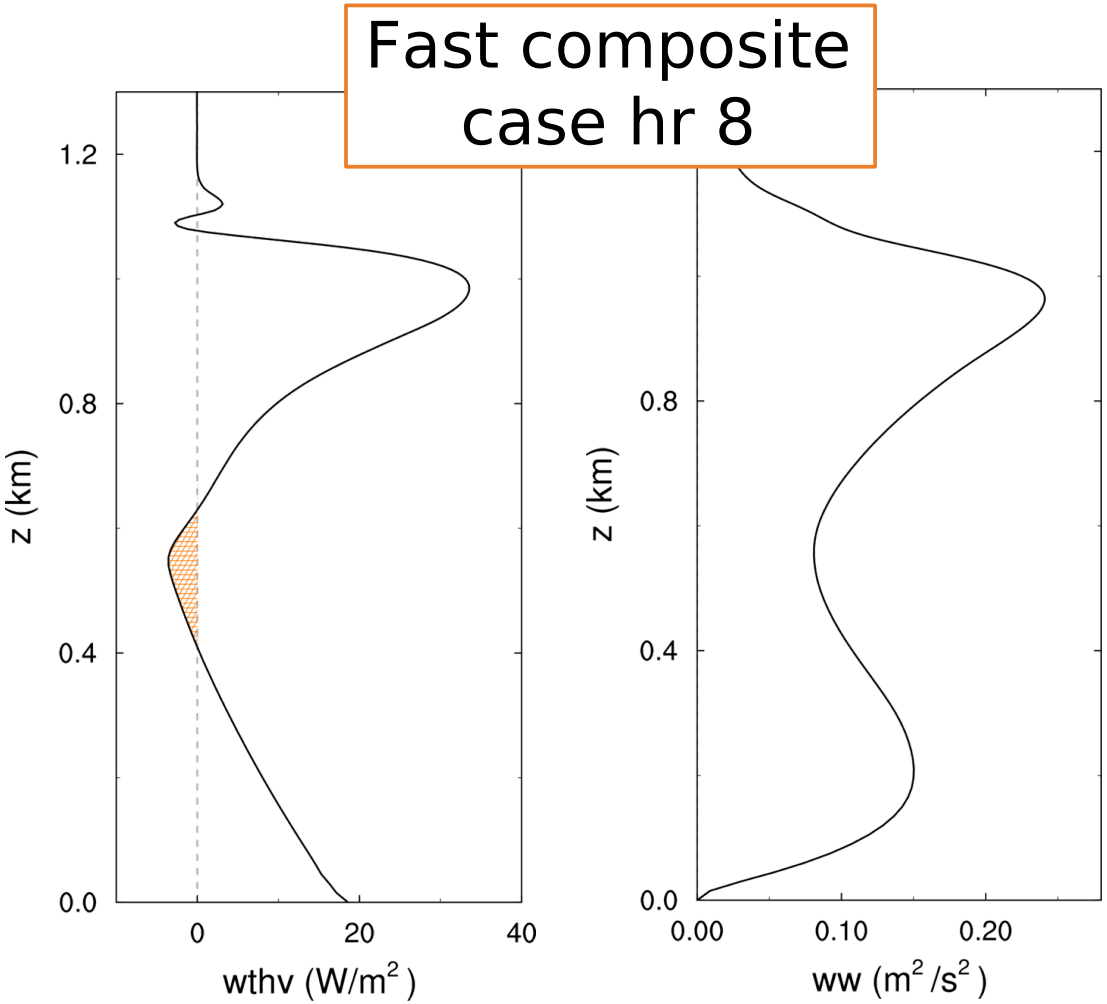


Decoupling

Double peaked structure of vertical velocity variance



Local minimum in *w'w'*



Boundary layer stratification