# Observations of turbulence properties in coupled and decoupled stratocumulus-topped marine boundary layers

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TROPOS
Leibniz Institute for Tropospheric Research

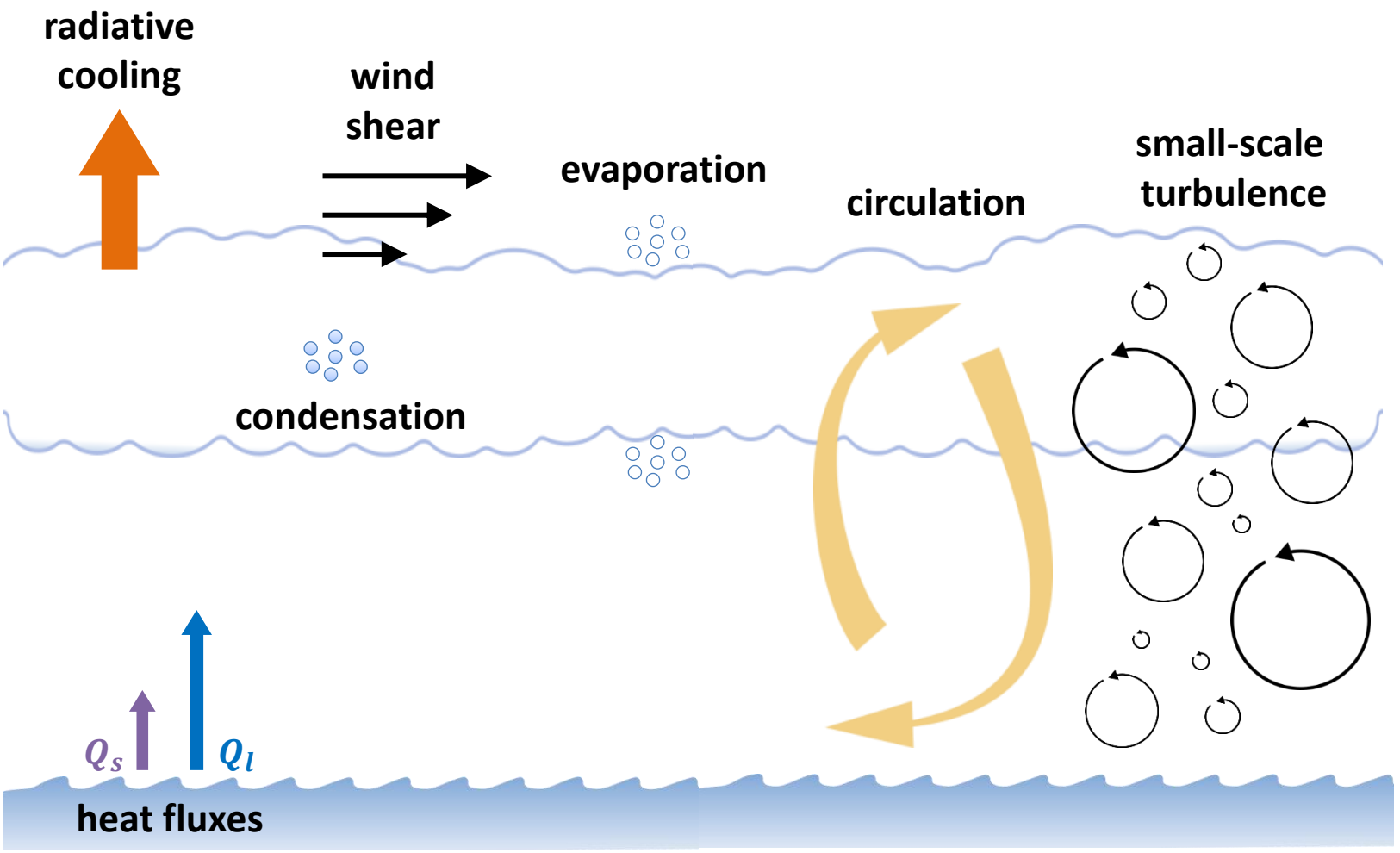
EMS Annual Meeting, 9.09.2022

# Stratocumulus clouds

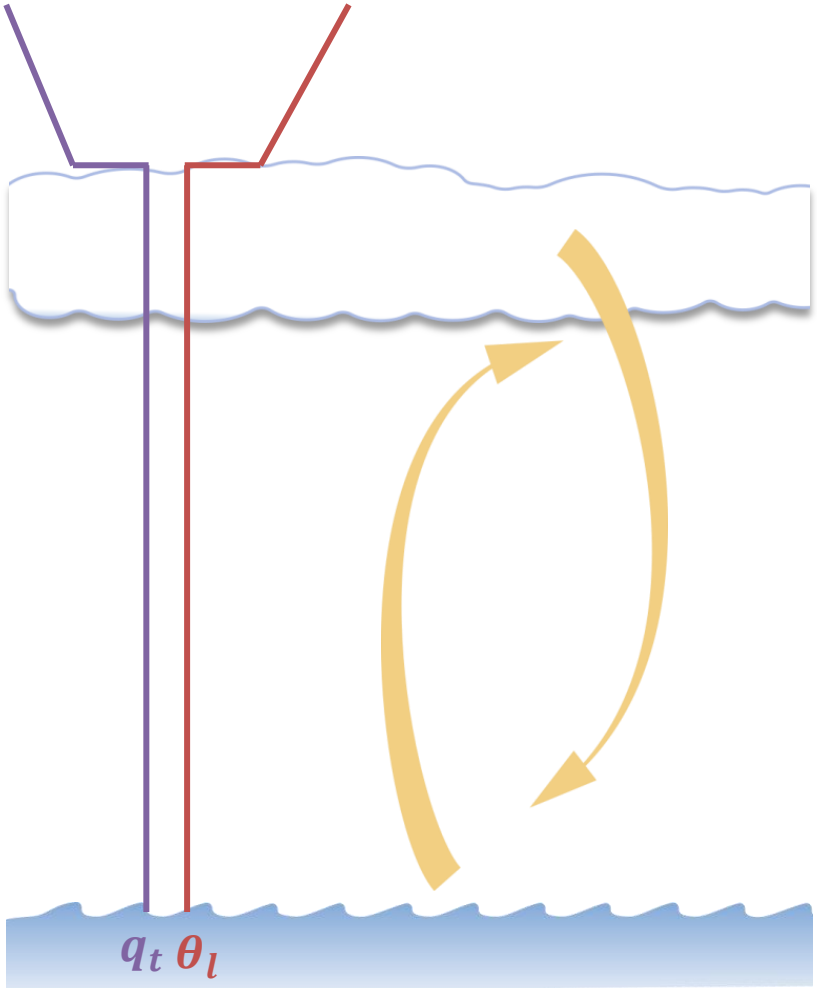


Stratocumulus over northeastern Atlantic, 9.07.2017

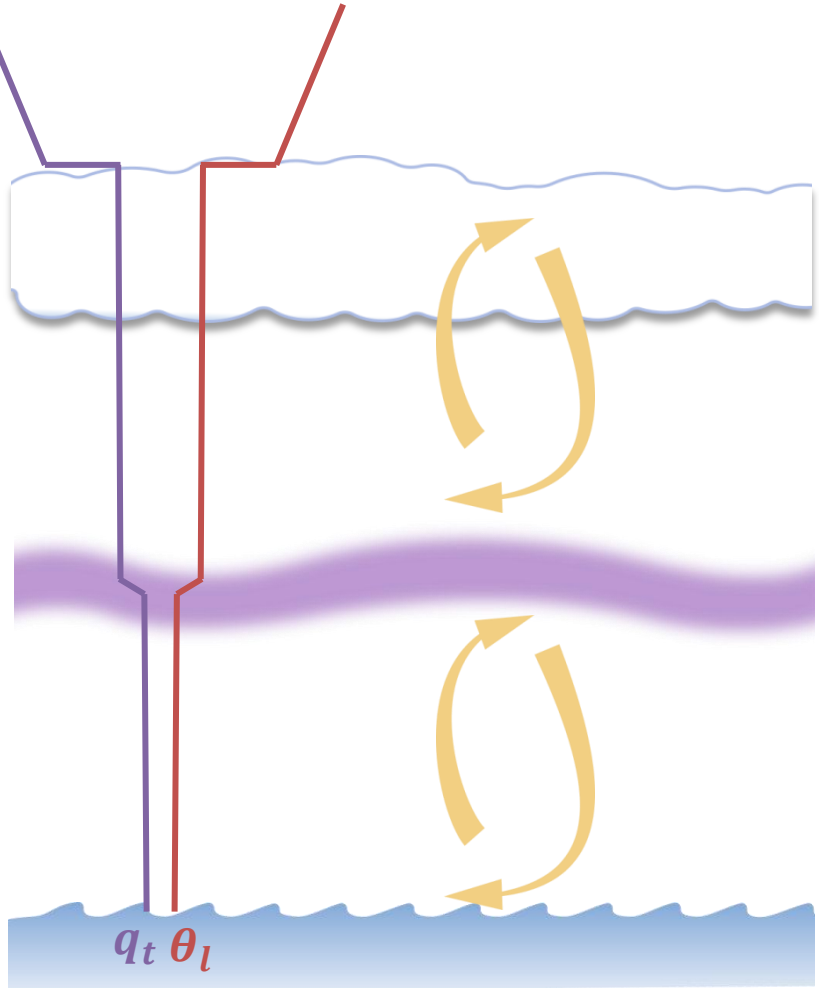
# Stratocumulus-topped boundary layer



# Coupling/decoupling of a boundary layer

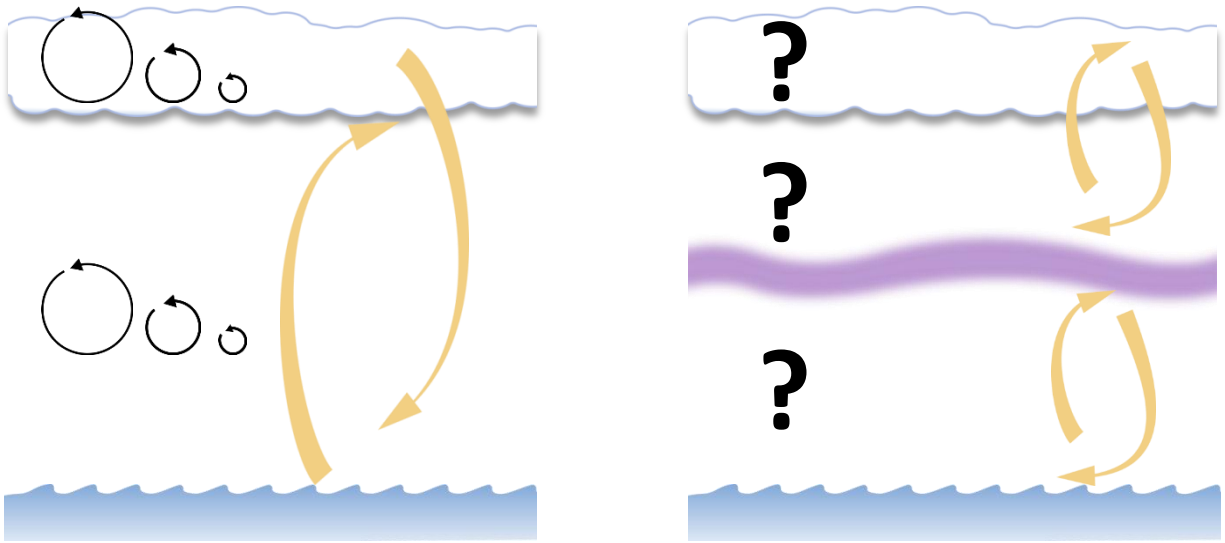



Coupled boundary layer




Decoupled boundary layer

# Research objectives



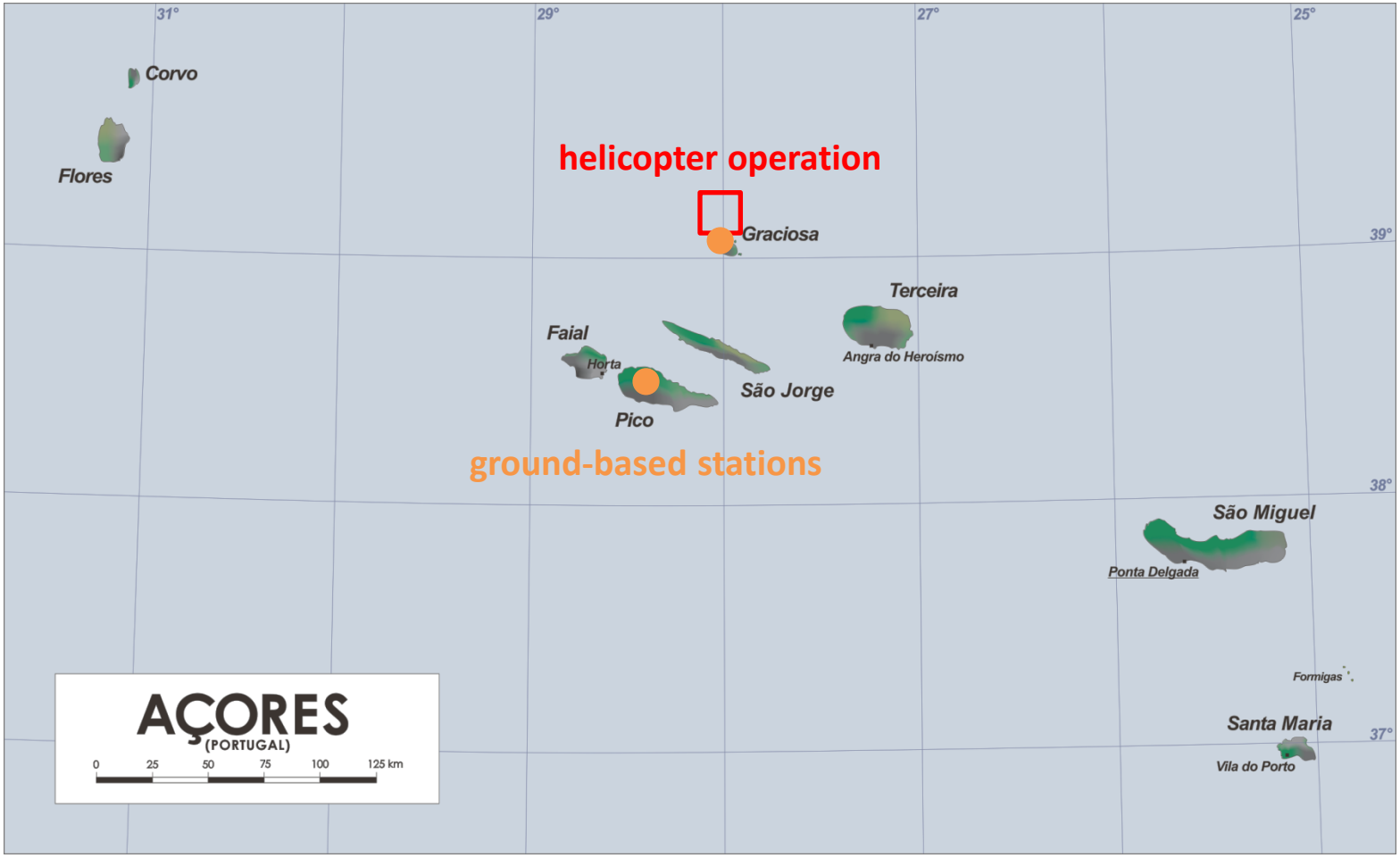

What are the properties of turbulence
in a decoupled stratocumulus-topped boundary layer?

$$Q_s, Q_l, B, S, \epsilon, s, p, A, L, \lambda, \eta$$

Do they differ between the sublayers?

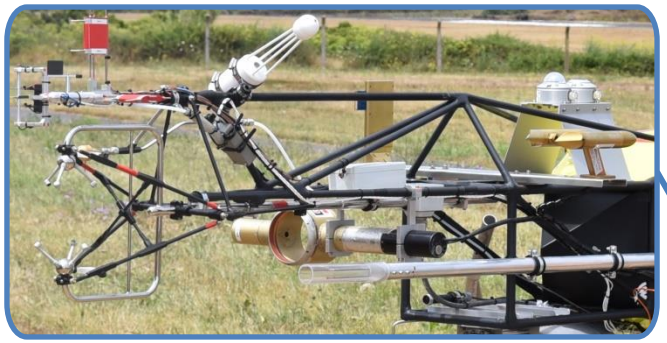
# Field campaign ACORES

Azores stratoCumulus measurements Of Radiation, turbulEnce and aeroSols
2-22 July 2017



# Sampling strategy

Closely collocated (~30 cm)
high-resolution instruments



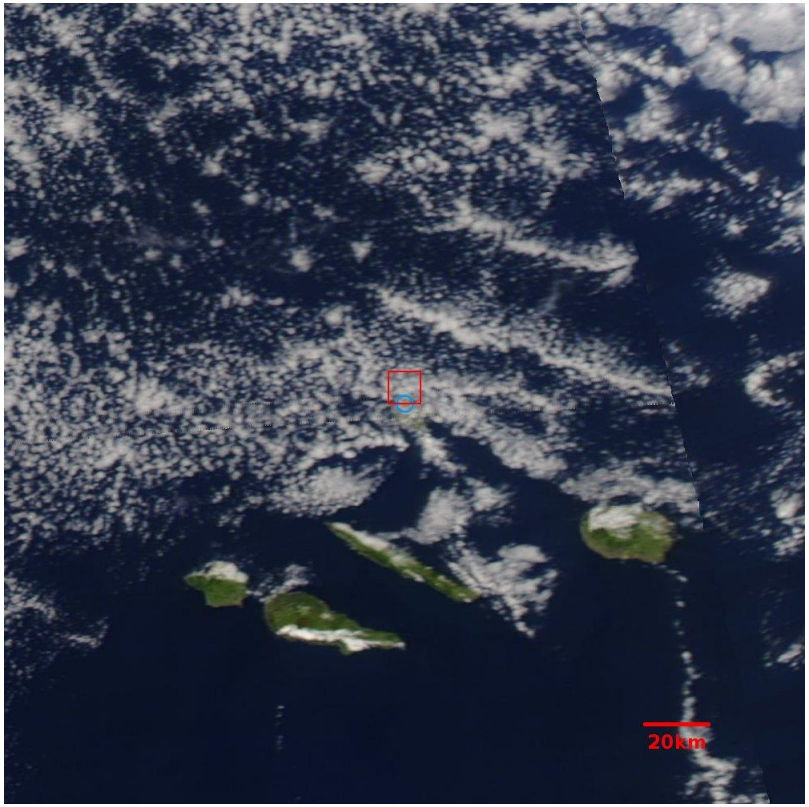
Moderate TAS (~20 m/s)




Siebert et al. 2021

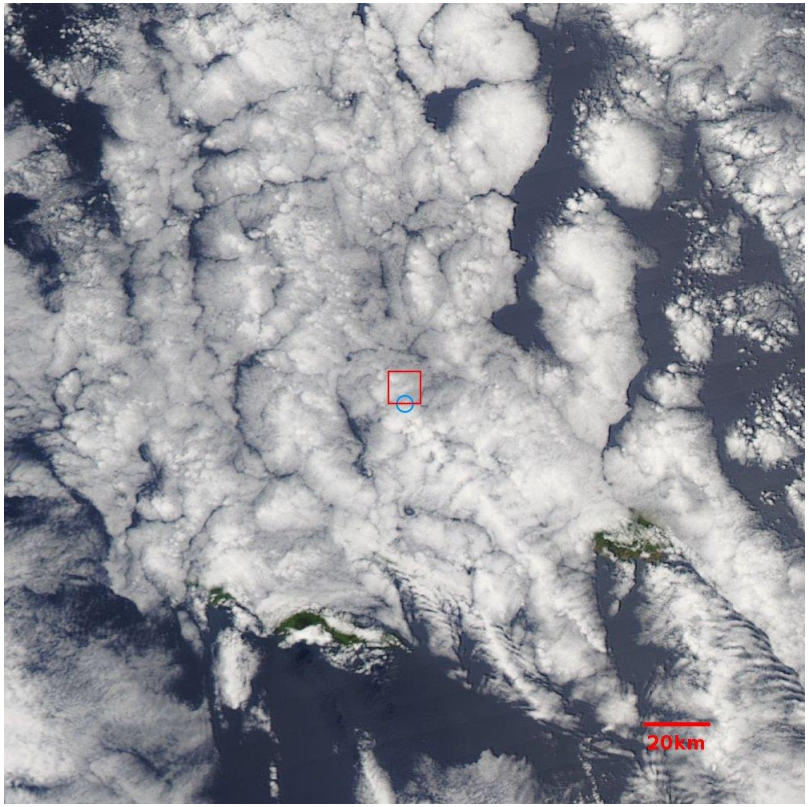
# Selected observations

Flight #5, 8 July 2017
coupled boundary layer




15:45 UTC

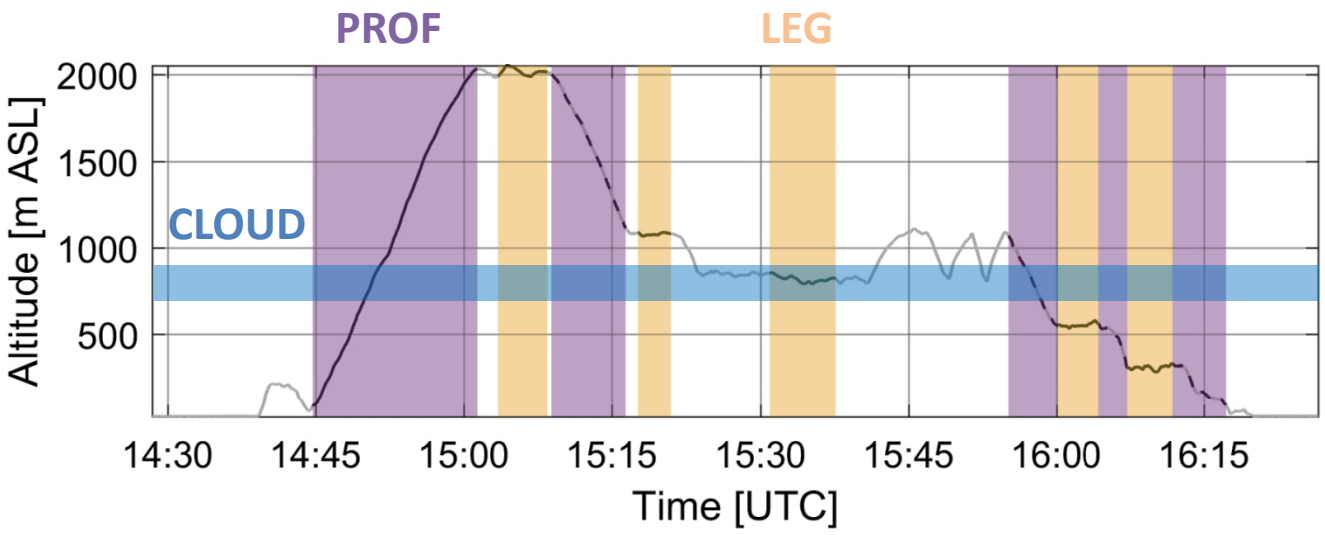
Flight #14, 18 July 2017
decoupled boundary layer



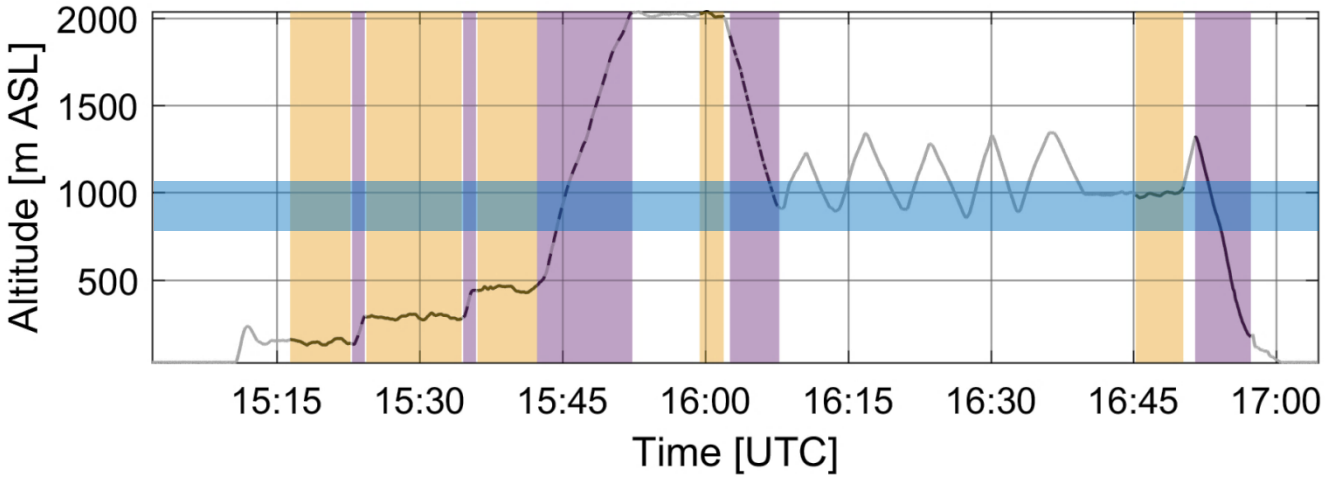

14:43 UTC

MODIS Aqua, NASA Worldview Snapshots

# Flight segmentation

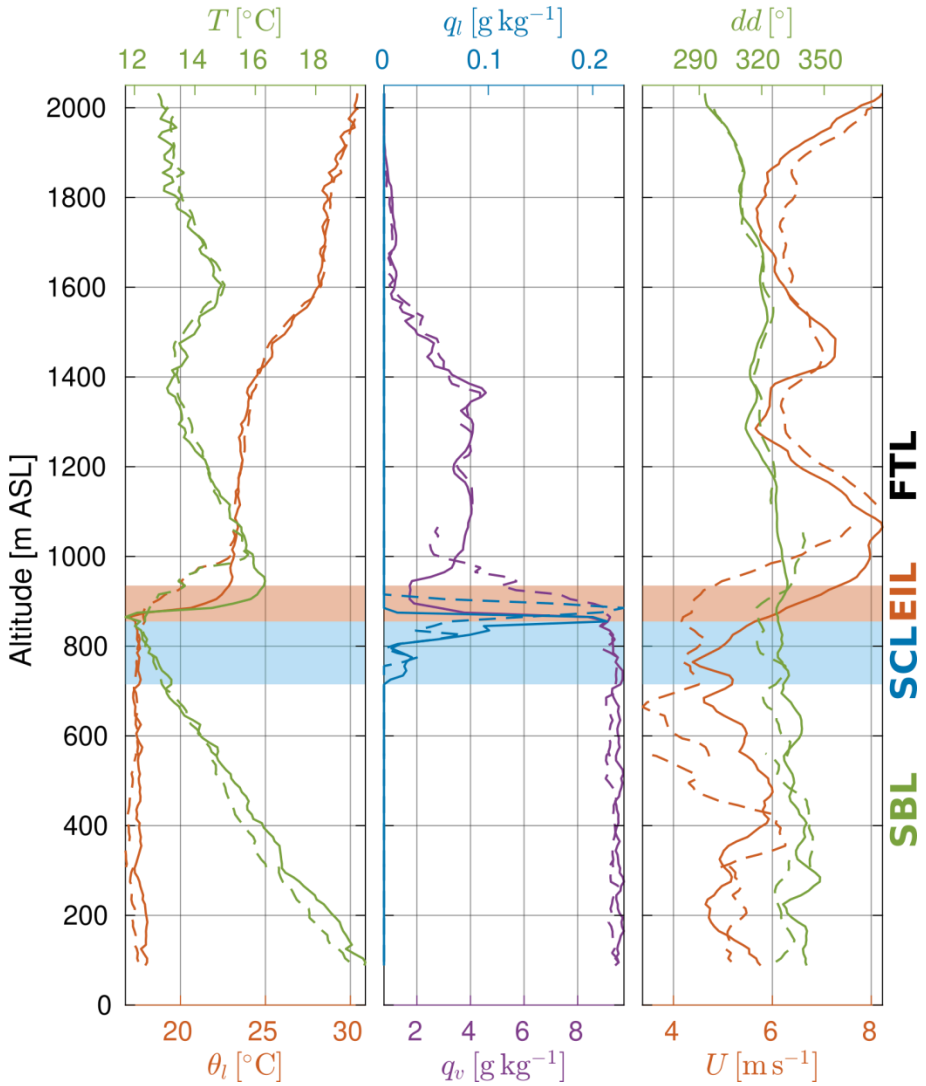



Flight #5, 8 July 2017
Coupled BL




Flight#14, 18 July 2017
Decoupled BL

# Stratification




Free Tropospheric Layer

Entrainment Interface Layer

Stratocumulus Layer

Subcloud Layer

Coupled boundary layer

# Stratification

**Free Tropospheric Layer**

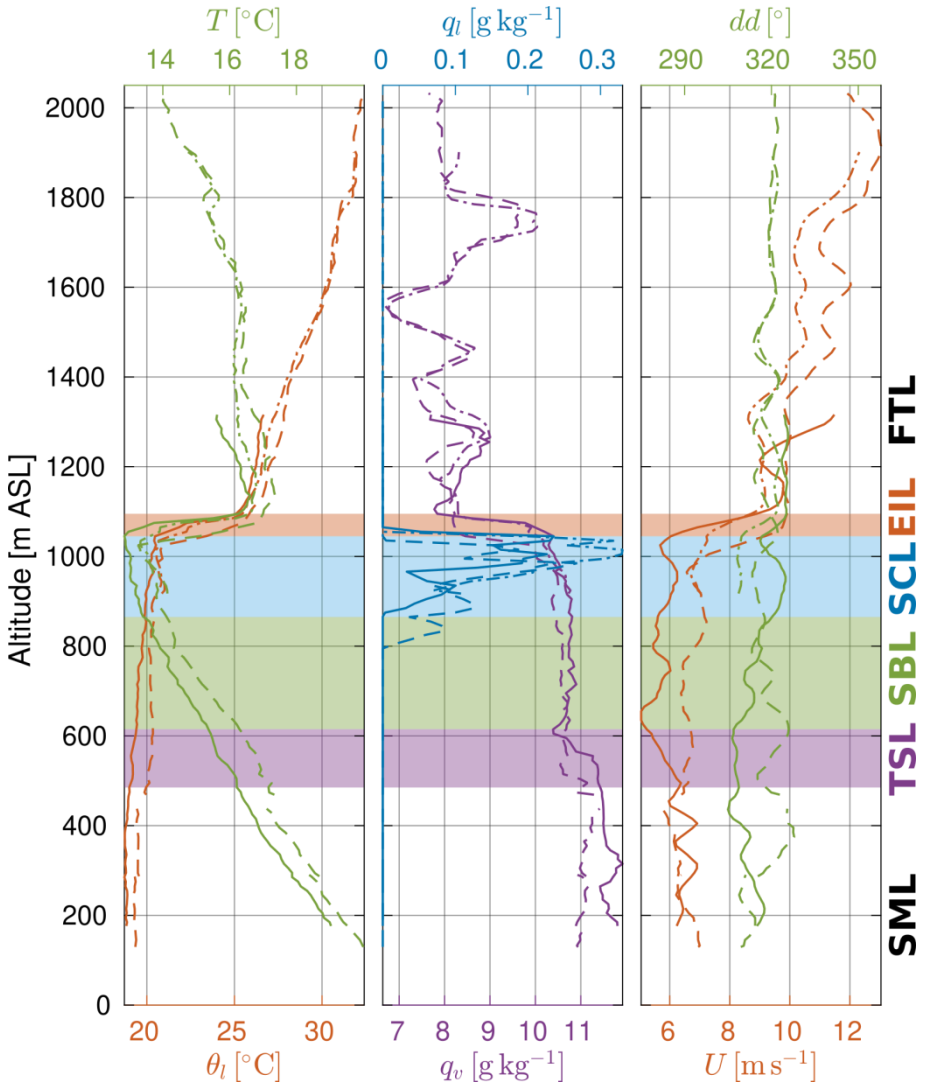
**Entrainment Interface Layer**

**Stratocumulus Layer**

**Subcloud Layer**

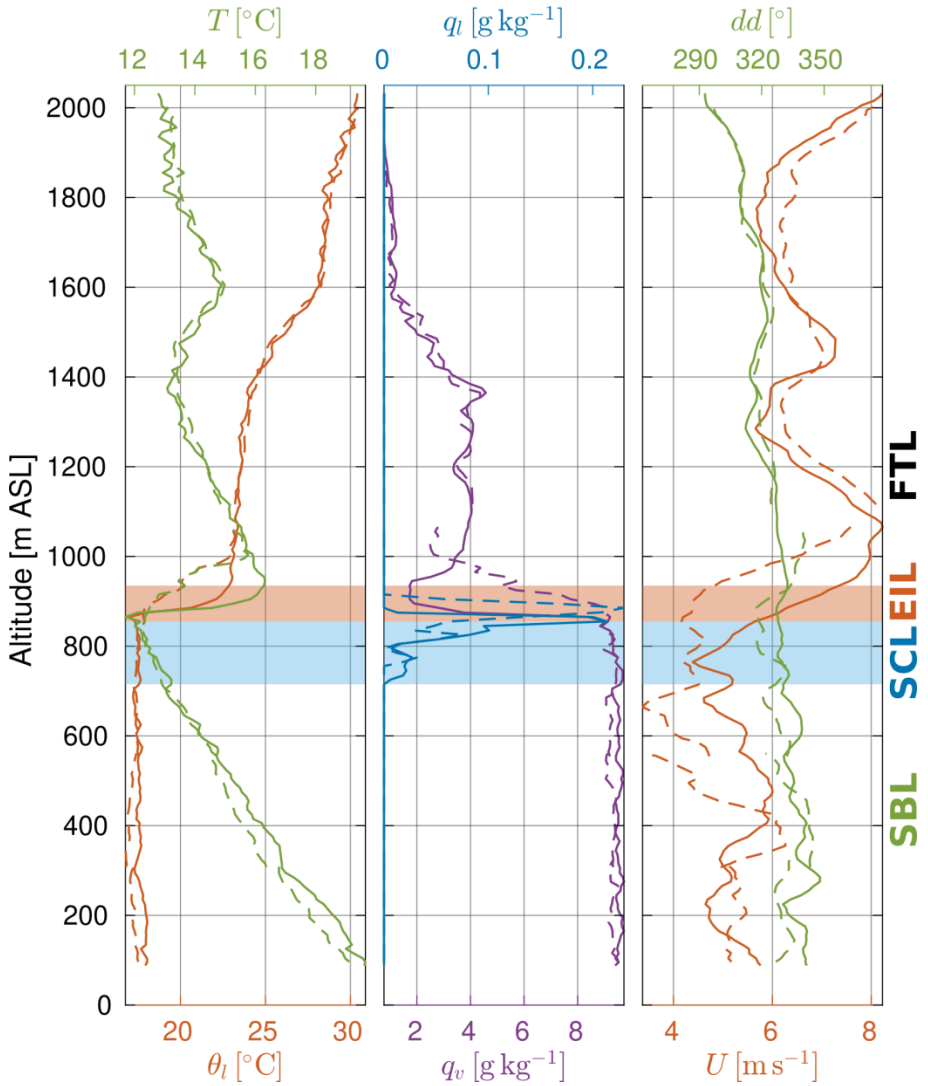
**Transition Layer**

**Surface Mixed Layer**

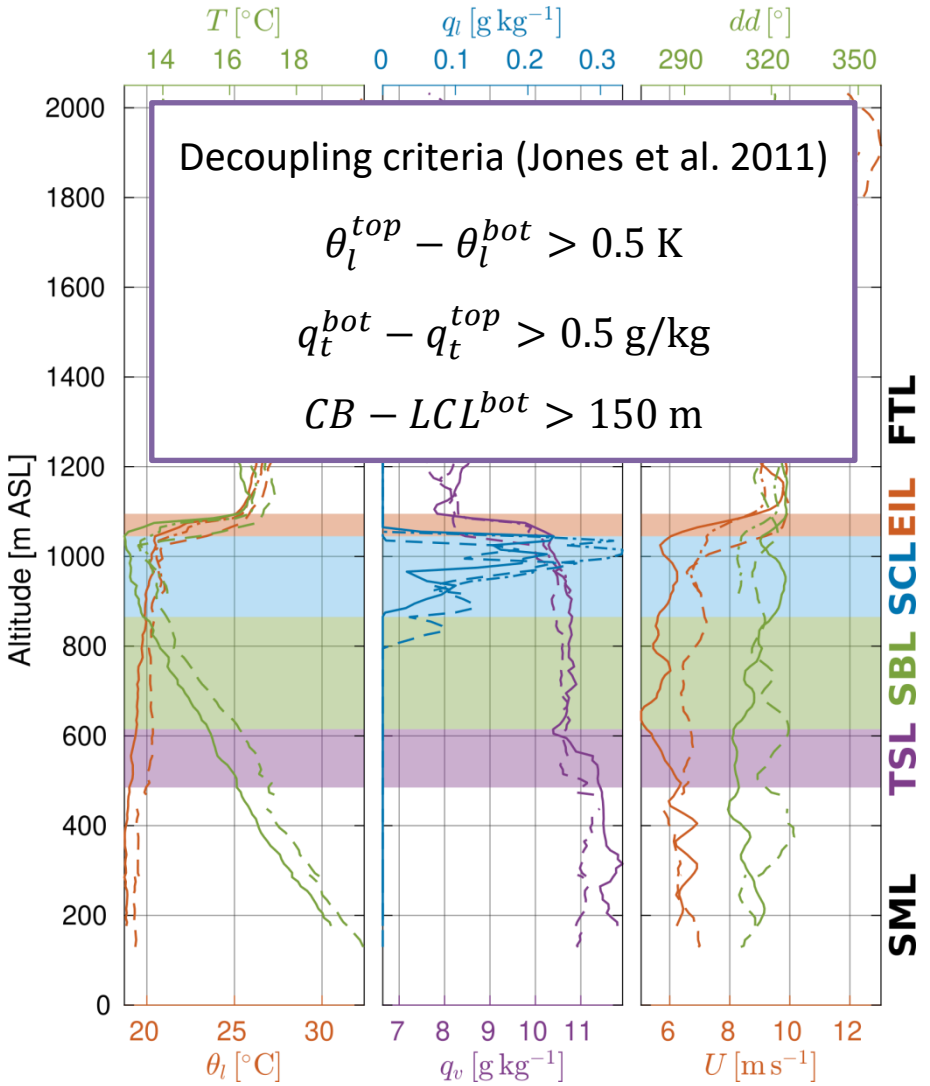



Decoupled boundary layer

# Stratification

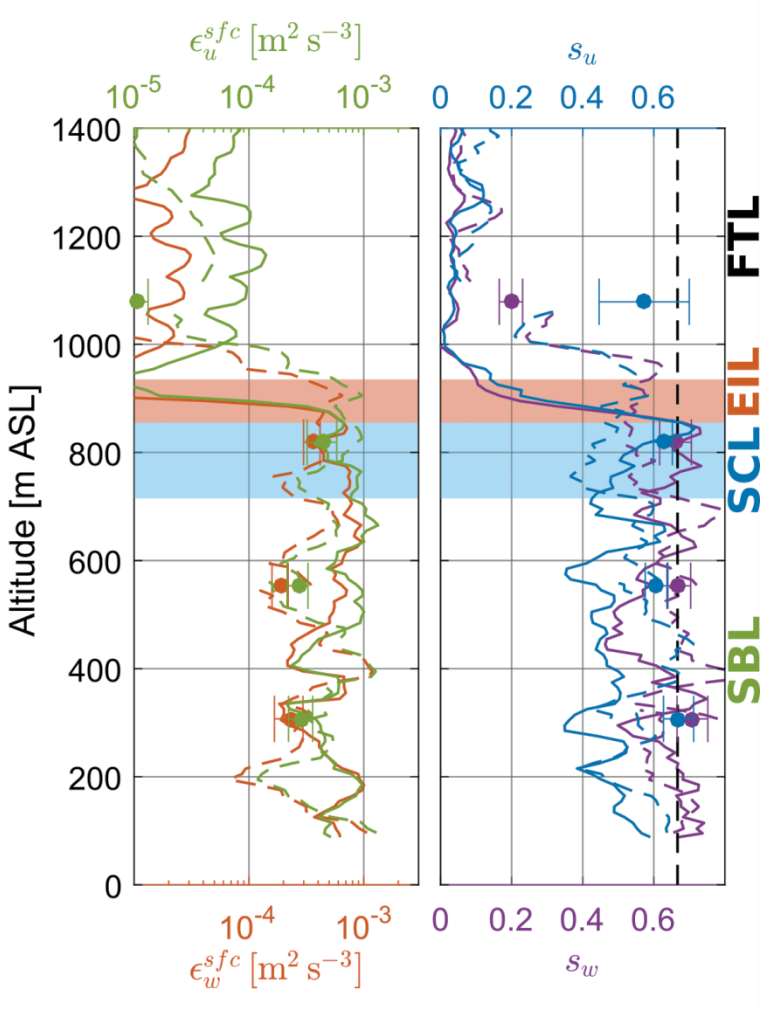


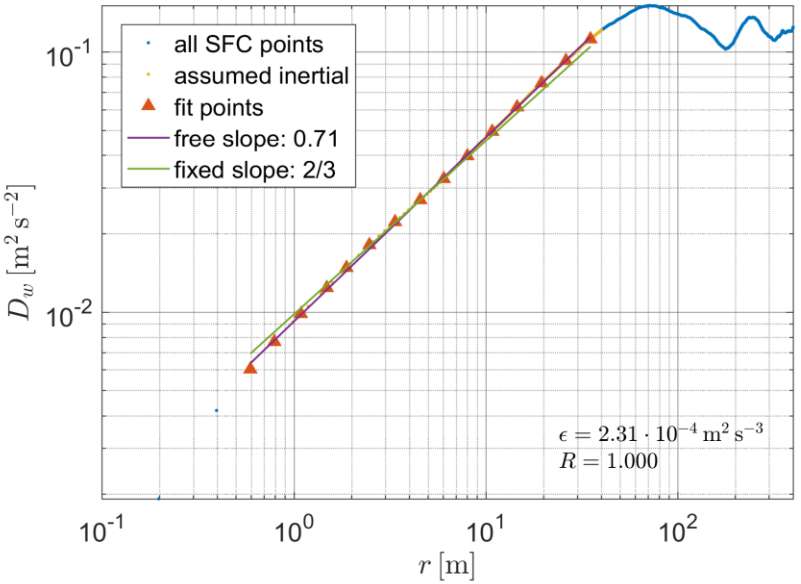

Coupled boundary layer




Decoupled boundary layer

# TKE dissipation rate and inertial range scaling (1)



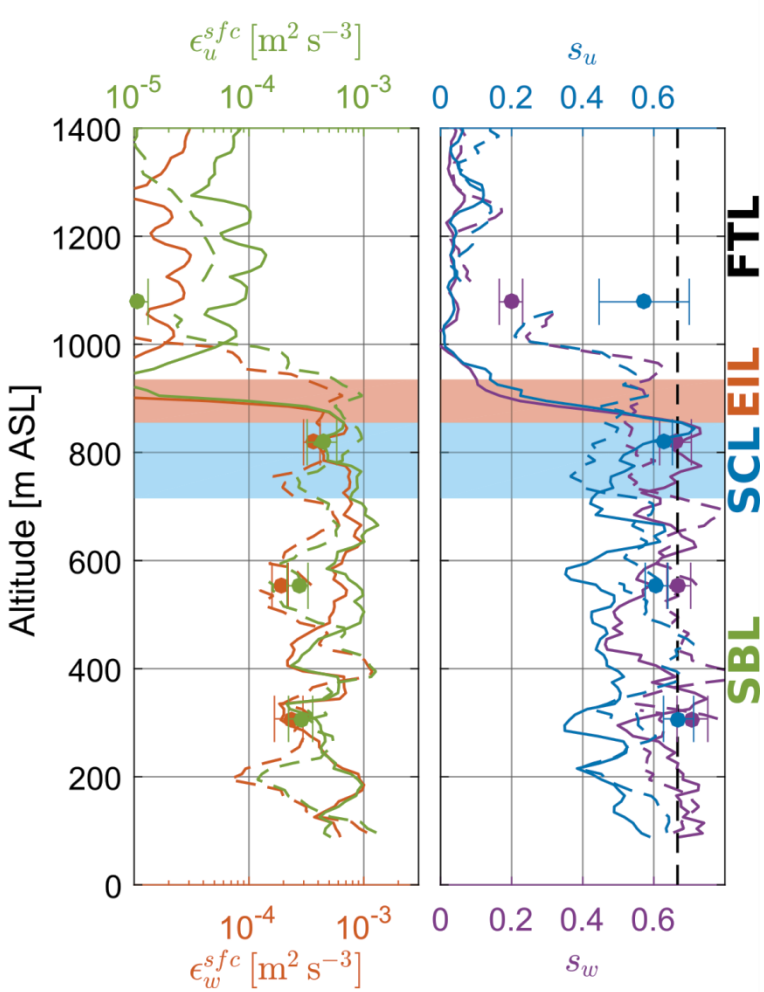

$$\mathrm{D(r)} = C_{sfc}(\boldsymbol{\epsilon} r)^{\frac{2}{3}}$$

$$\mathrm{D(r)} = C^*_{sfc} r^{\boldsymbol{s}}$$

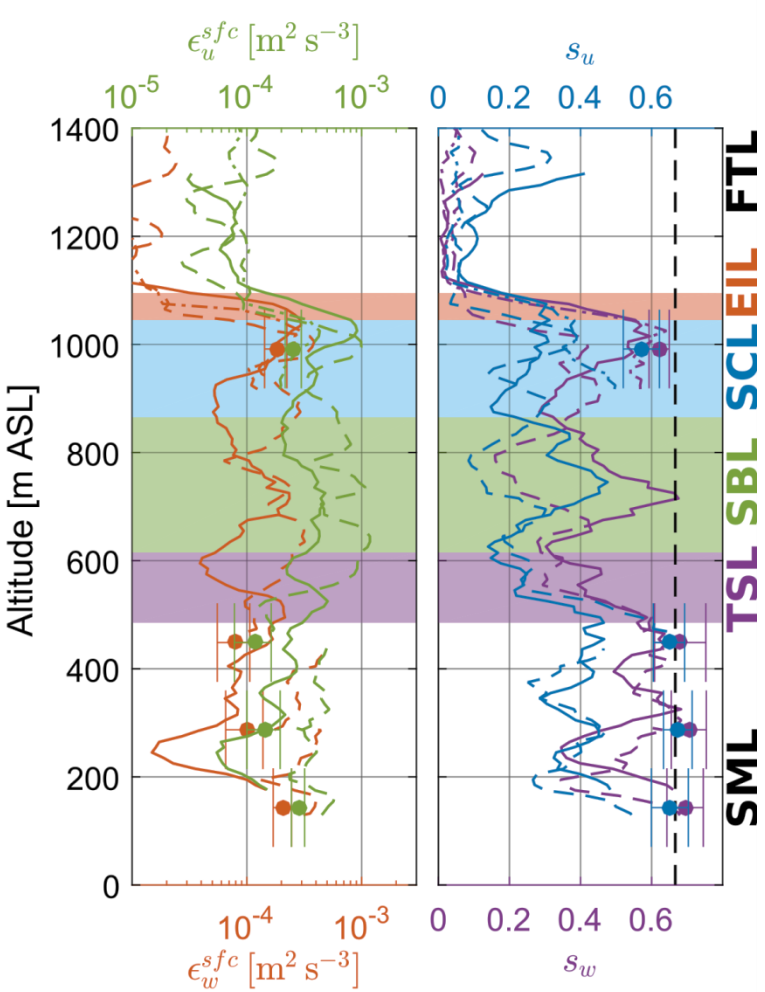
$$D_u \rightarrow \epsilon_u^{sfc}, s_u \quad D_w \rightarrow \epsilon_w^{sfc}, s_w$$

Coupled boundary layer

# TKE dissipation rate and inertial range scaling (1)

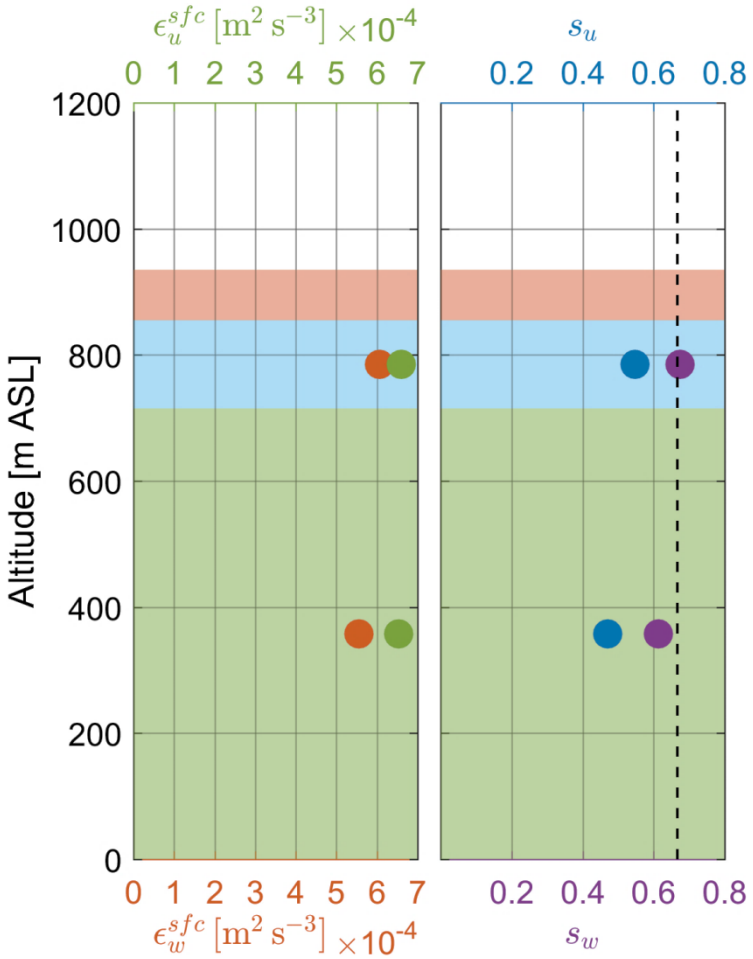



Coupled boundary layer

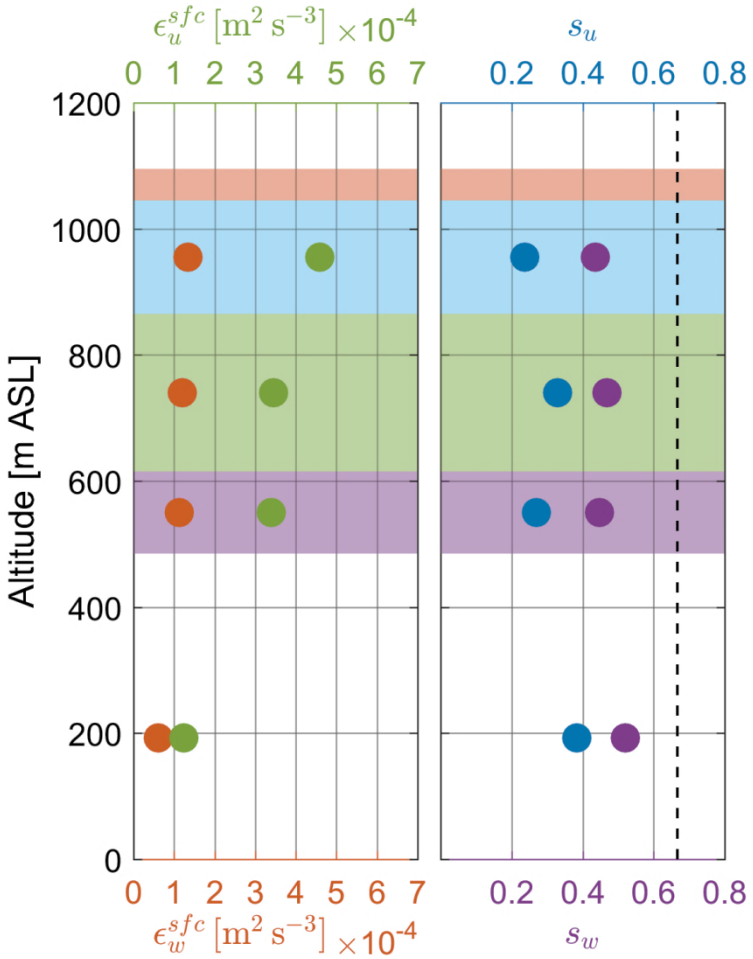



Decoupled boundary layer

# TKE dissipation rate and inertial range scaling (2)

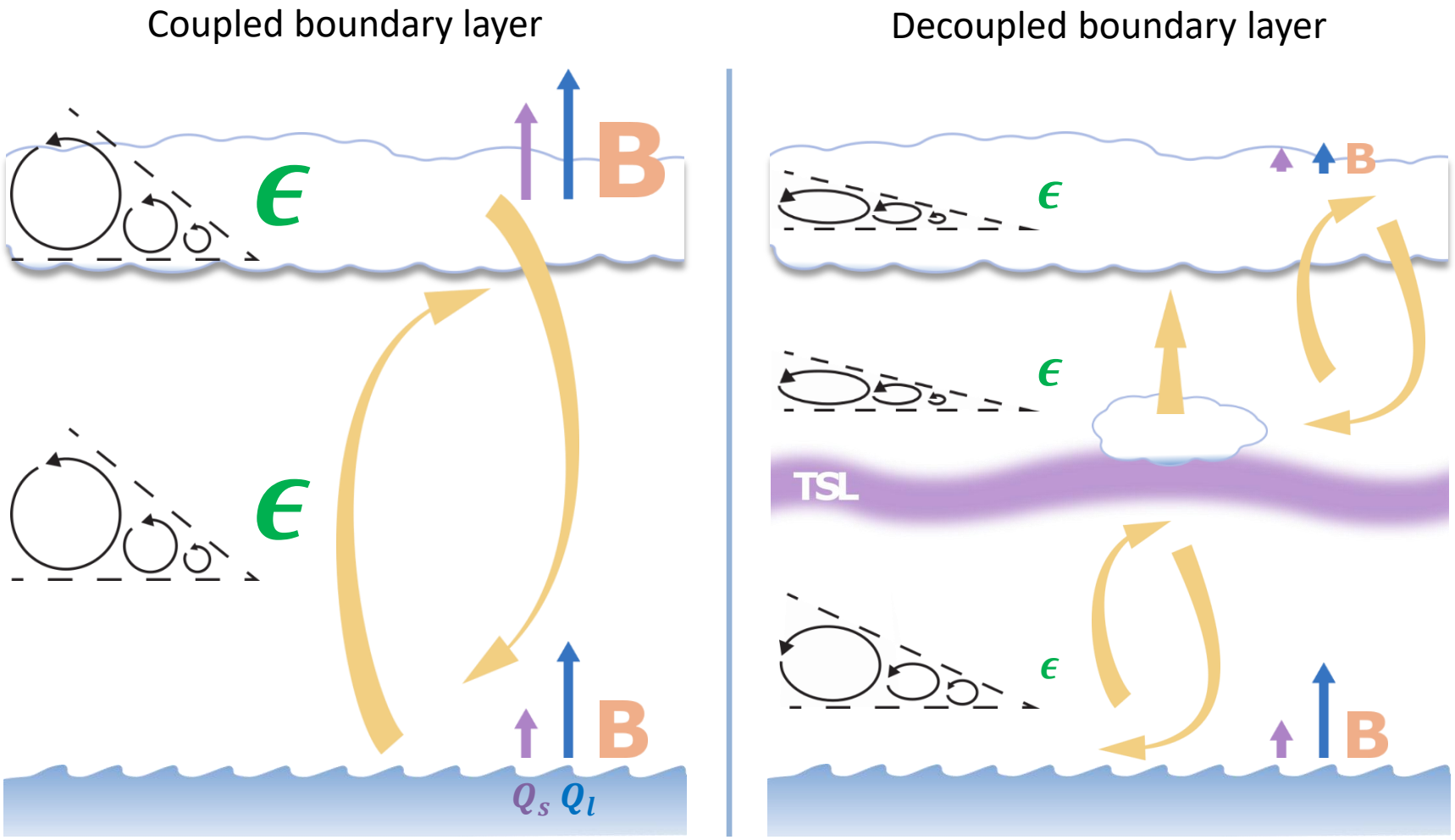



Coupled boundary layer




Decoupled boundary layer

# Summary of turbulence properties




Nowak et al. 2021, Atmos. Chem. Phys., 10.5194/acp-21-10965-2021