

# Episodes of *warm-air advection* causing cloud-surface *decoupling* during the MARCUS

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# ***What is the definition of “decoupling” of a cloud-topped boundary layer (CTBL)?***

- Definition # 1 (commonly used):

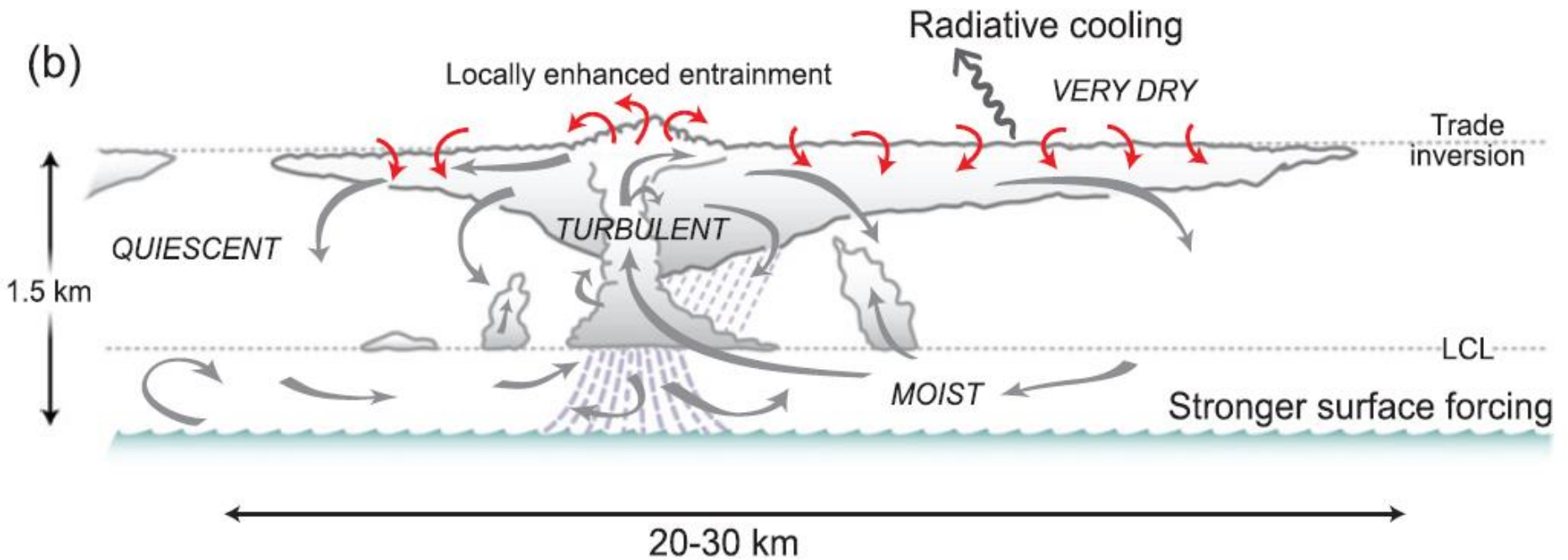
Thermodynamically stratified (poorly mixing).

Nicholls 1984

- Definition # 2 (more intuitive):

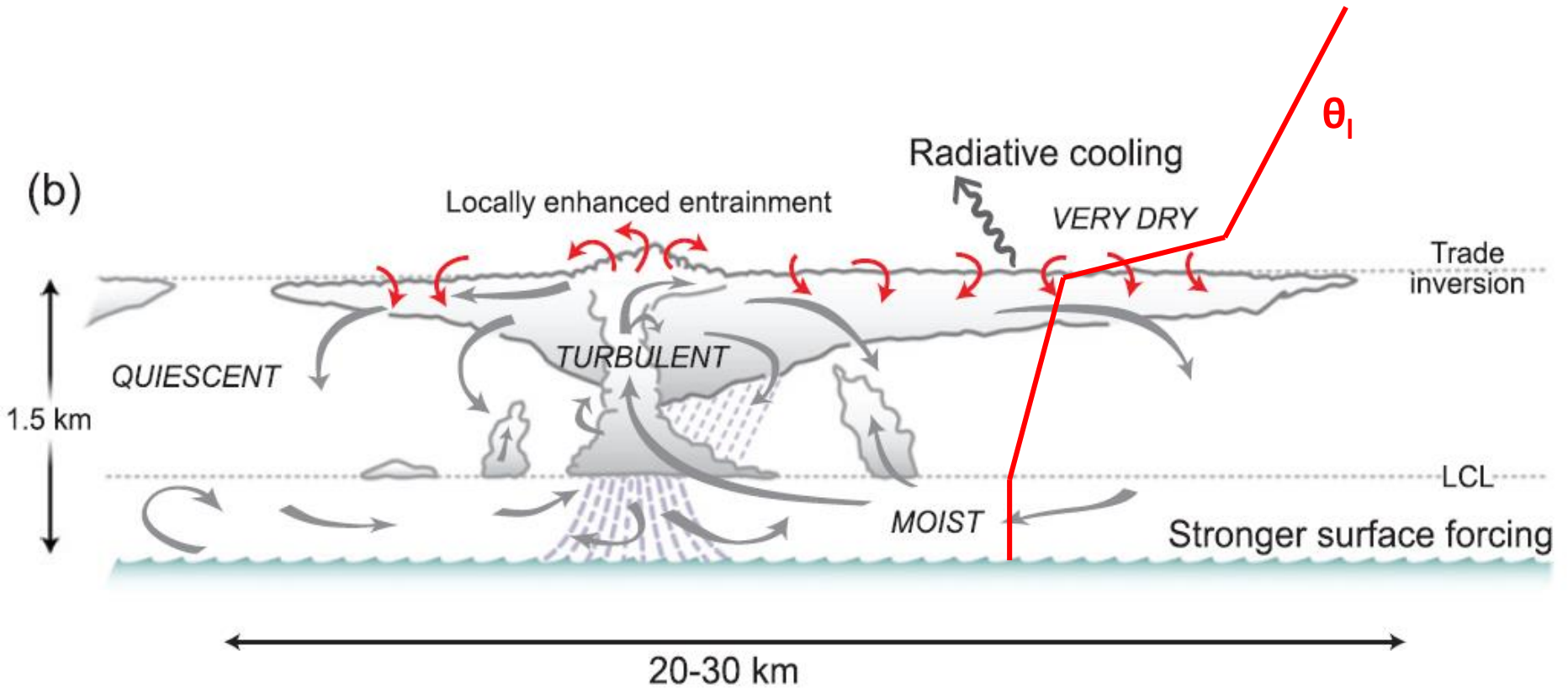
A shut-off of exchanges between cloud-containing layers and the surface.

# Cumulus-fed stratocumulus: coupled or decoupled?



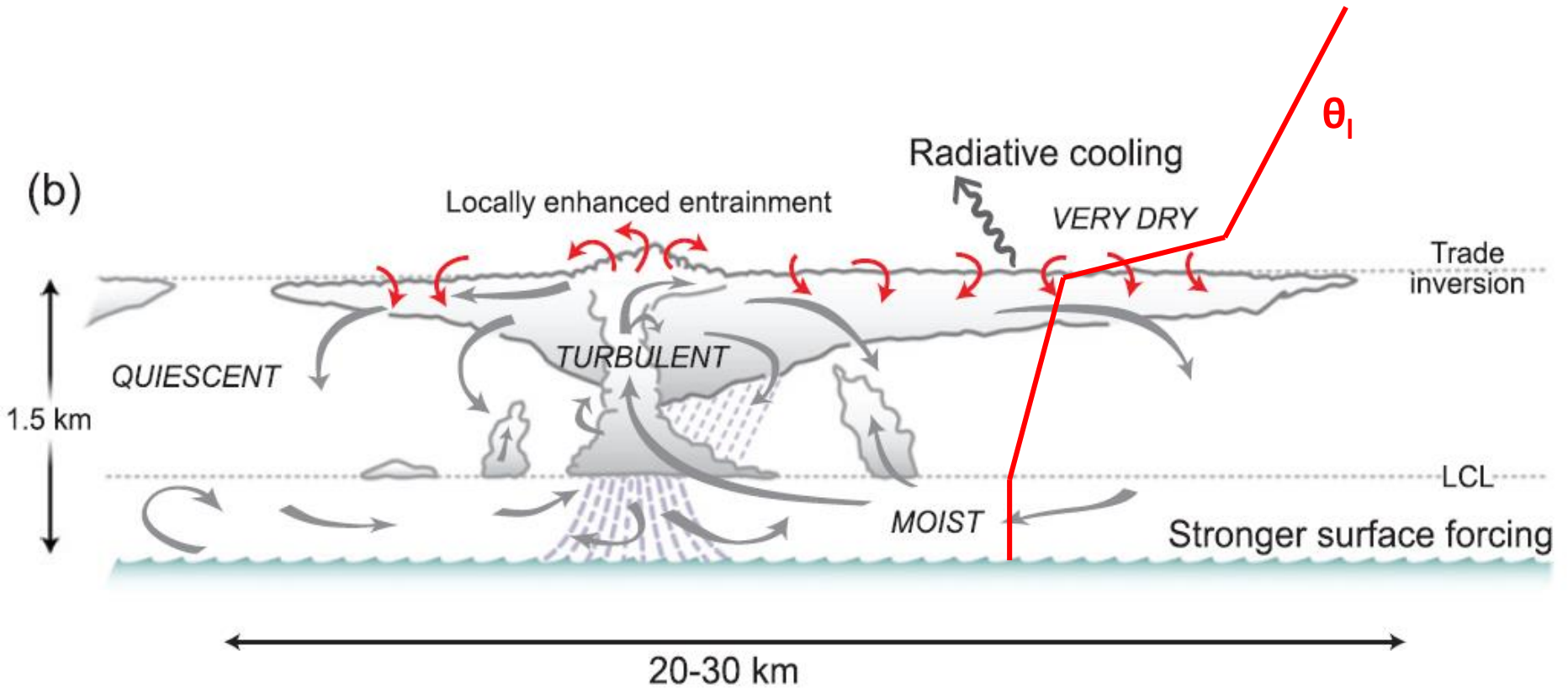
Wood 2012

# Cumulus-fed stratocumulus: coupled or decoupled?



Wood 2012

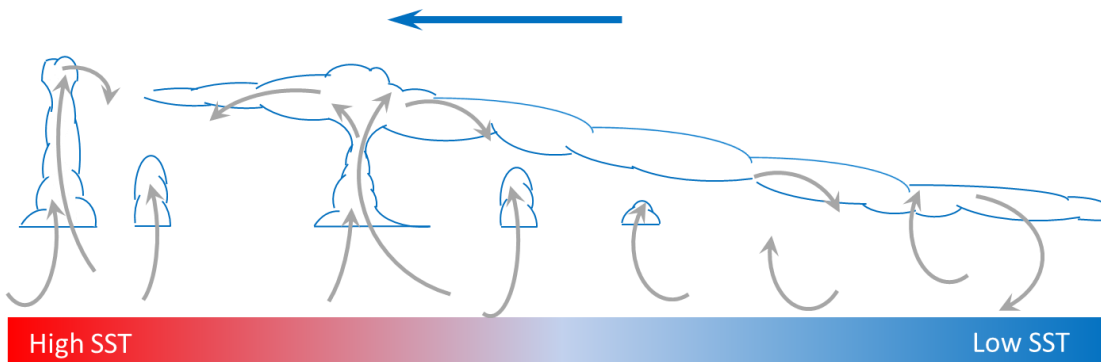
# What is the key influential factor that modulates the cloud-surface interactions?



Wood 2012

# Importance of low-level temperature advection

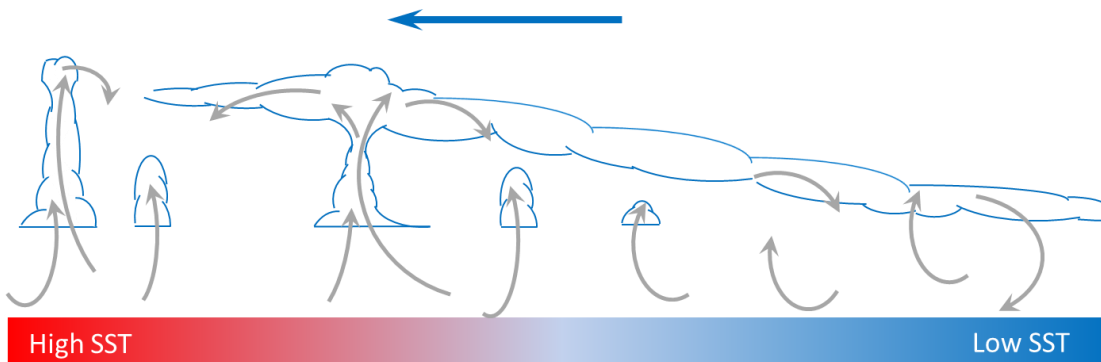
Low-level cold air advection (CAA)



“Deepening warming” decoupling  
(Bretherton and Wyant, 1997)

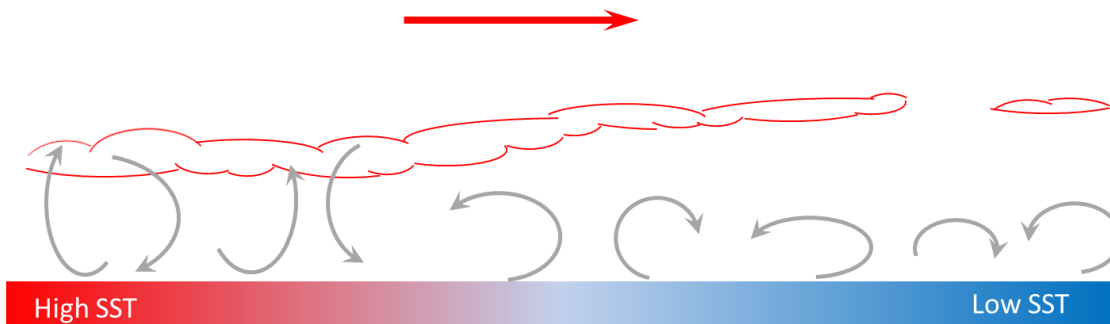
# Importance of low-level temperature advection

## Low-level cold air advection (CAA)



“Deepening warming” decoupling  
(Bretherton and Wyant, 1997)

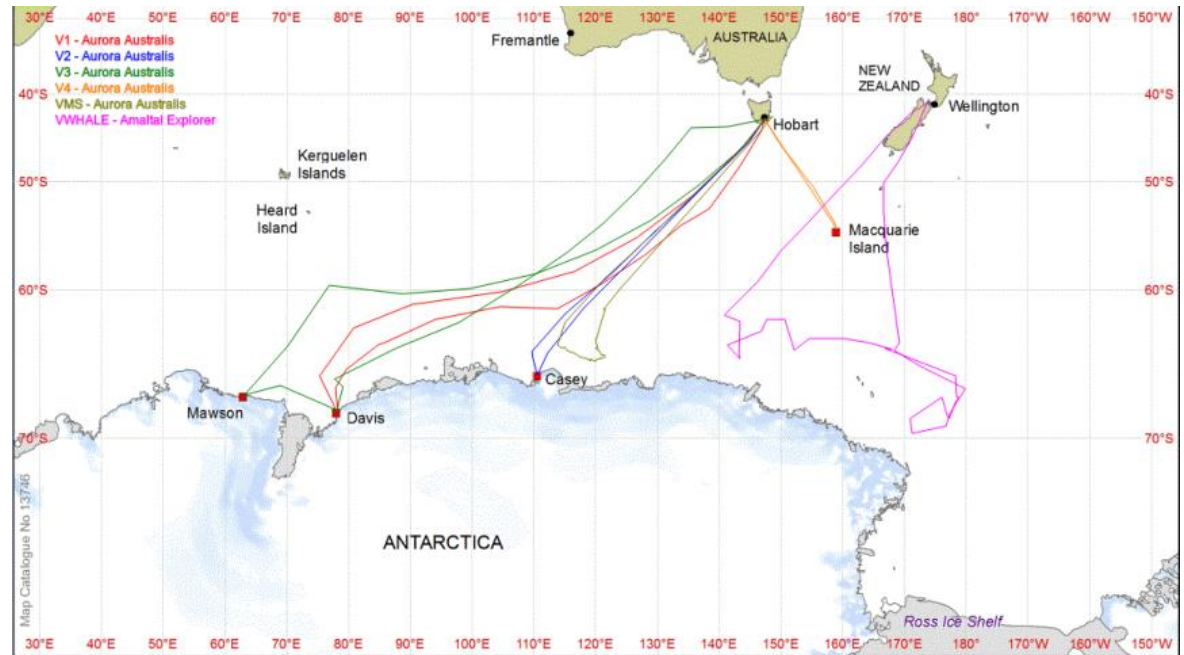
## Low-level warm air advection (WAA)



Zheng et al., 2018b, JGR  
Zheng and Li, 2019, submitted to JGR

# Measurements of Aerosols, Radiation, and Clouds over the Southern Ocean (MARCUS)

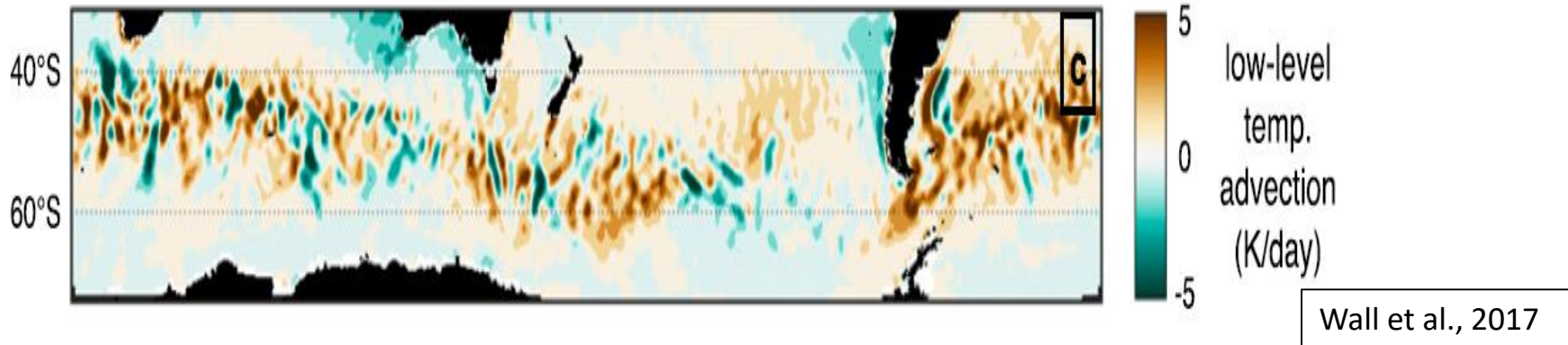
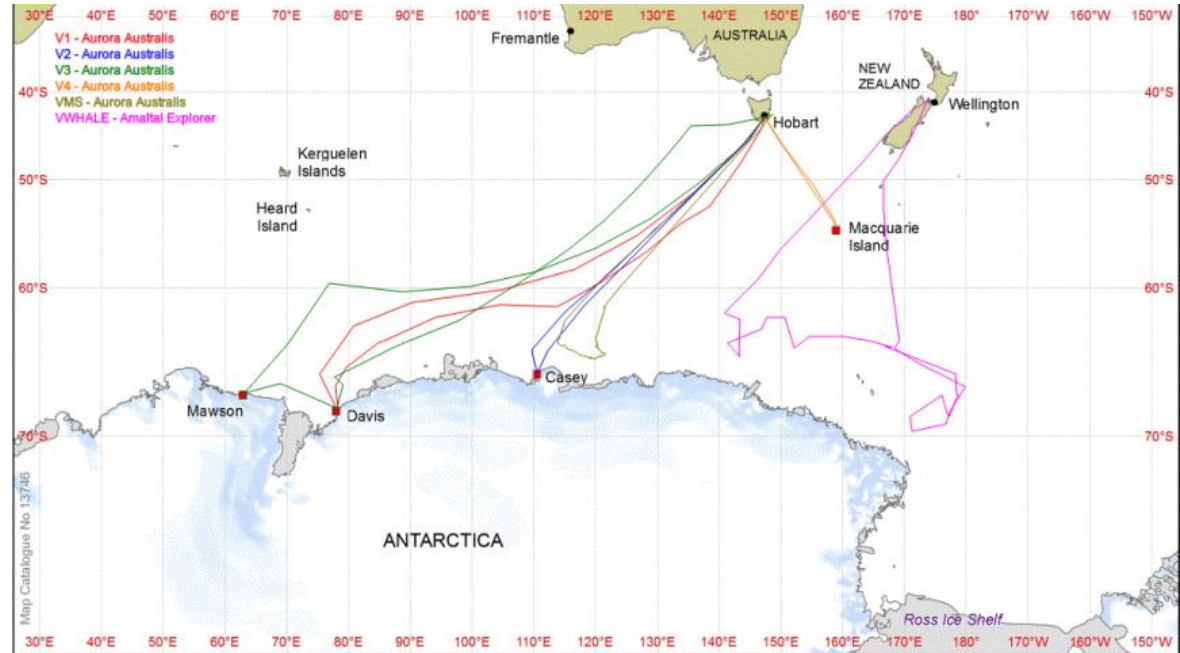
- U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM)
- Sep 2017 – April 2018
- PI: Greg McFarquhar





# Measurements of Aerosols, Radiation, and Clouds over the Southern Ocean (MARCUS)

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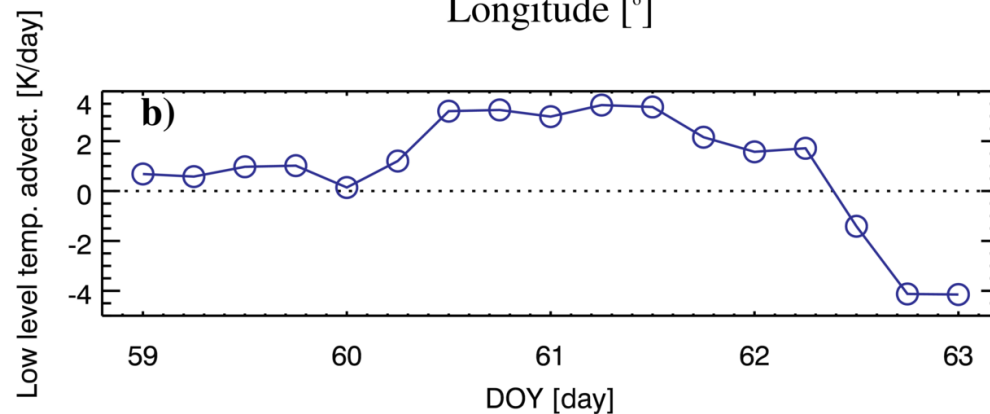
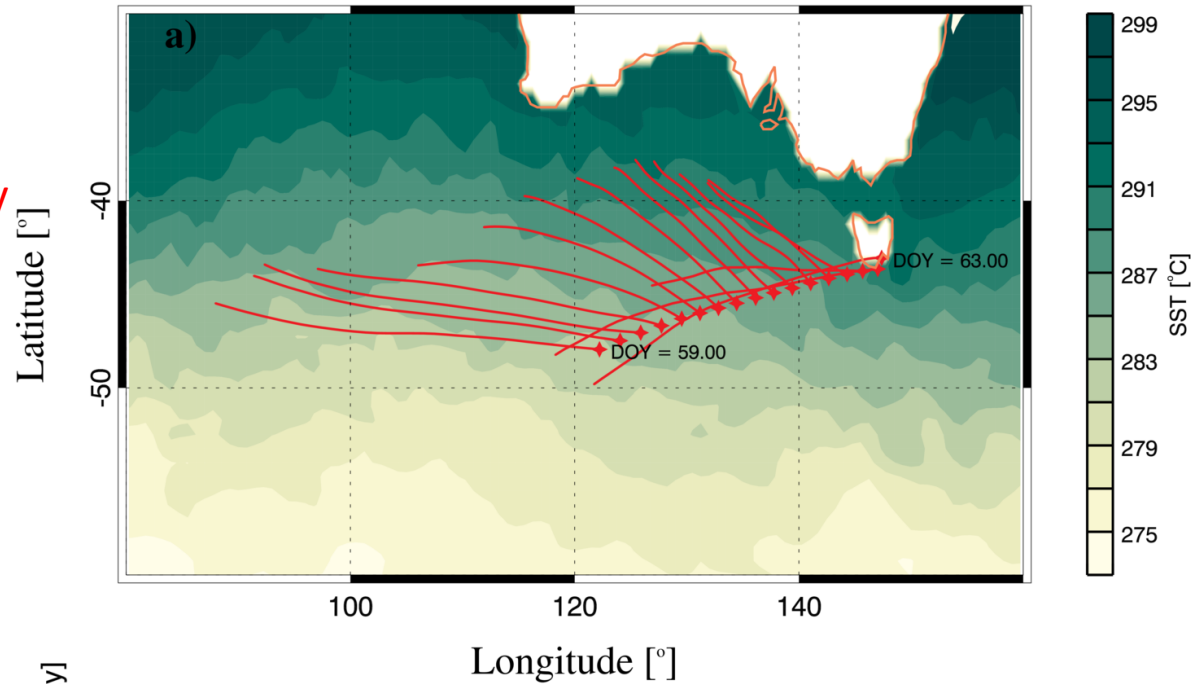


# An example of CTBL under LLWAA influence during MARCUS

Feb 28 – Mar 3, 2018

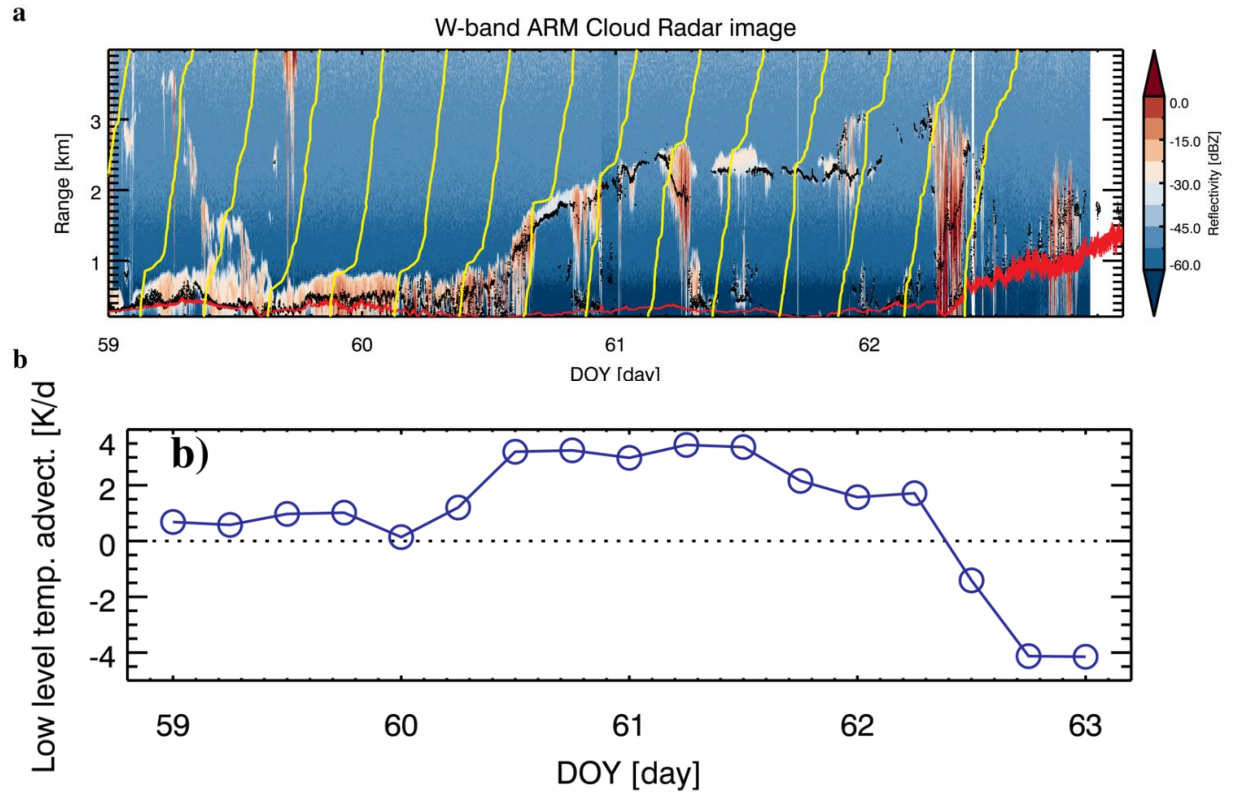
★ Ship location

— 36-h back trajectory



# An example of CTBL under LLWAA influence during MARCUS

Black = cloud base height  
Red = LCL  
Yellow =  $\theta$  profile



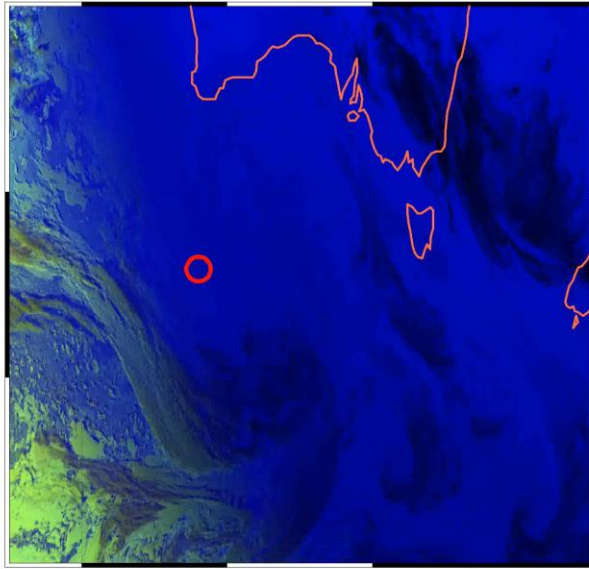
## Common characteristics of CTBL under WAA:

- The MBLs are **highly stratified** to the extent that the penetration of cumulus into the inversion, which is common for subtropical decoupled MBLs, is non-existent
- Sea surface temperature (SST) lower than the near-surface air temperature, indicating a **negative surface fluxes**
- Decoupled clouds manifest stratiform with lifetime as long as **several tens of hours**
- They locate in **warm sectors of middle-latitude cyclones** where the lack of strong large-scale subsidence is favorable for their maintenance (lack of subsidence-induced drying)

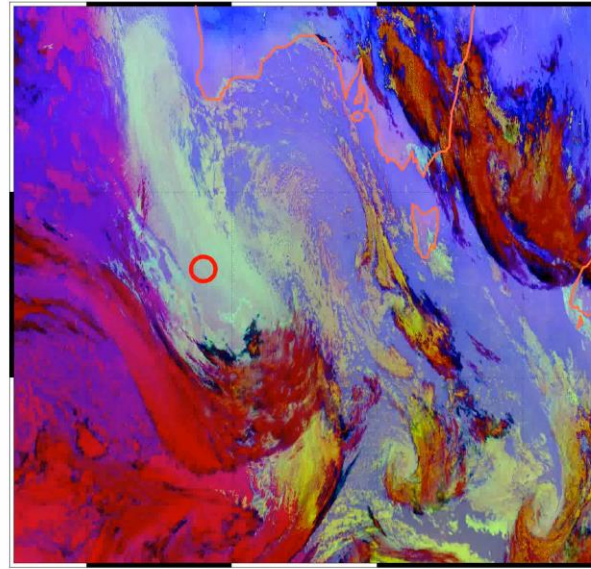
# Himawari-8 RGB imagery

-24hr, 2018-01-08T12:00:00Z

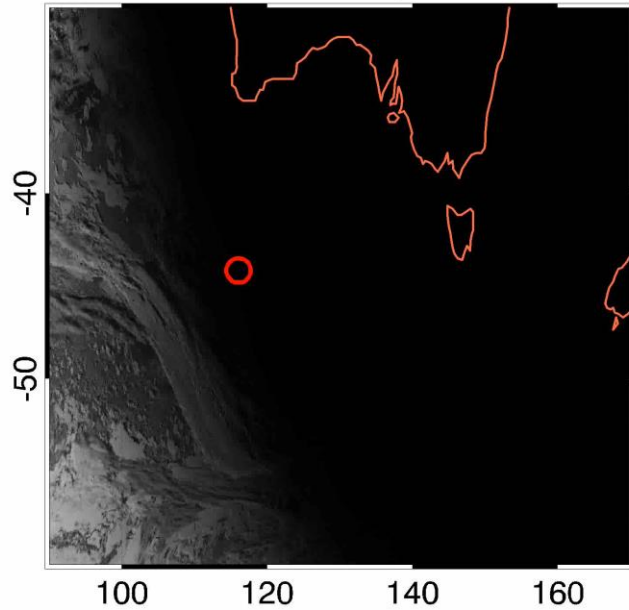
Daytime Microphysical RGB



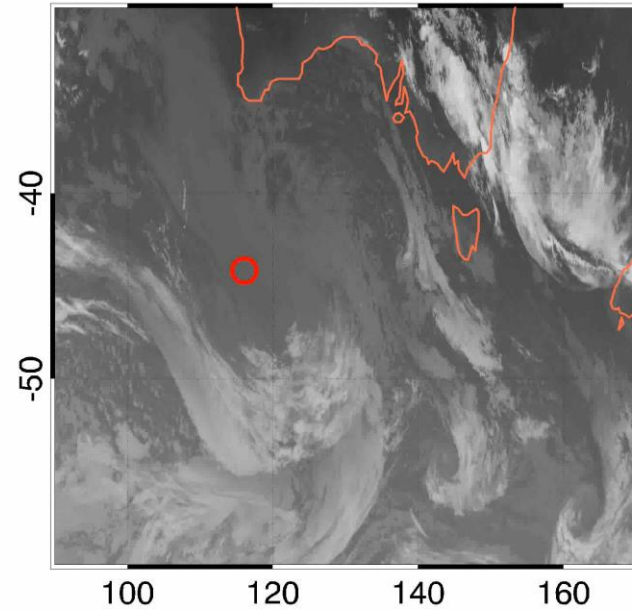
Nighttime Microphysical RGB



Visible 0.64  $\mu\text{m}$



Infrared 10.4  $\mu\text{m}$





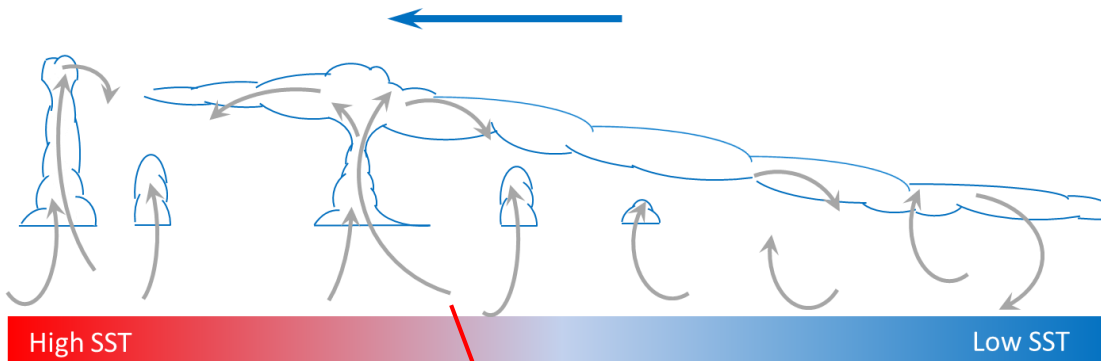
## Take-home message:

- The conventional definition of “decoupling” (Nicholls, 1984) fails to reveal the “coupled” nature of cumulus-fed stratocumulus regime over subtropics.
- The decoupled MBL caused by the “deepening warming” mechanism is less stratified/decoupled than that in warm air advection (WAA). The latter has been receiving less attention.
- The WAA-induced decoupled clouds can be quite persistent with lifetime as long as several tens of hours.
- The WAA-induced decoupled clouds may influence the pathway through which surface-generated aerosols affect the clouds.

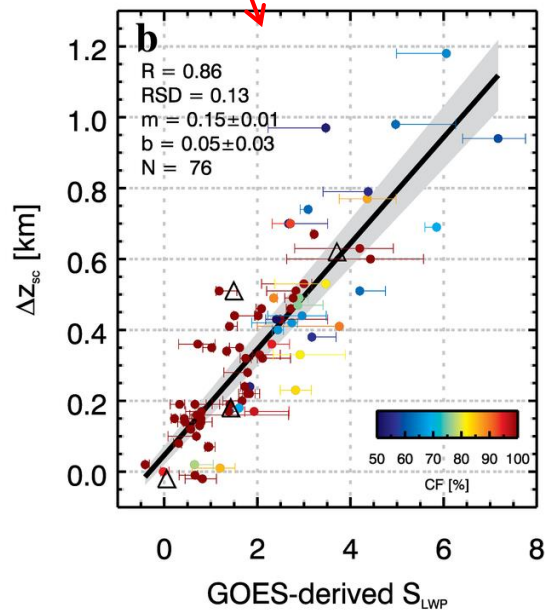
Supplementary slides

# Importance of low-level temperature advection

Low-level cold air advection (CAA)



“Deepening warming” decoupling  
(Bretherton and Wyant, 1997)



Zheng et al., 2018a, GRL



# *An example under LLWAA influence during MARCUS*

