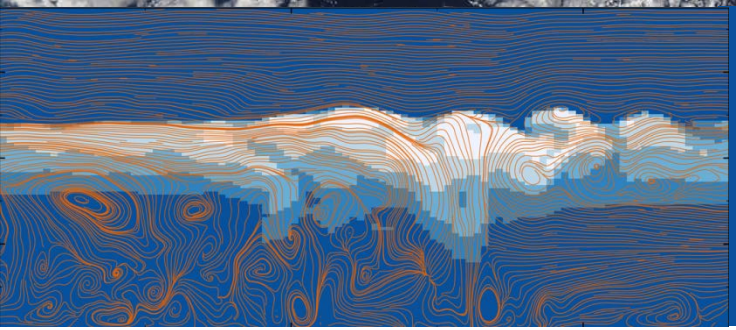
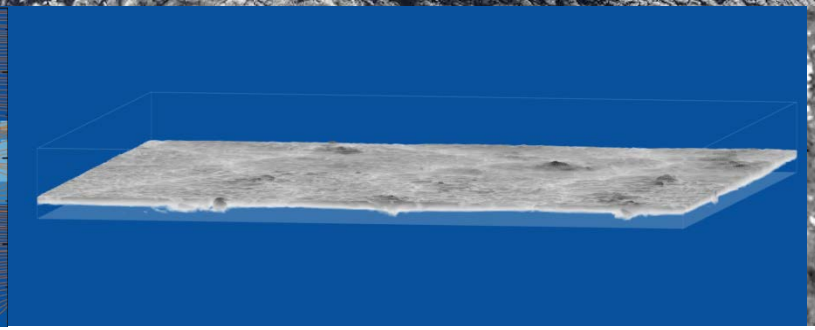
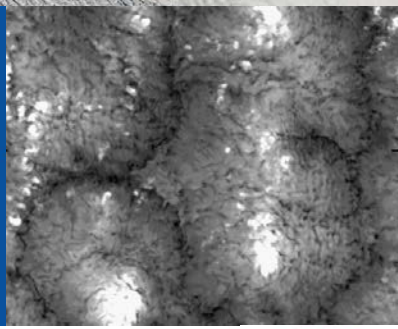
# LES of Response of Stratocumulus Clouds to a Climate Perturbation

Johan van der Dussen | Sara Dal Gesso | Stephan de Roode | Pier Siebesma







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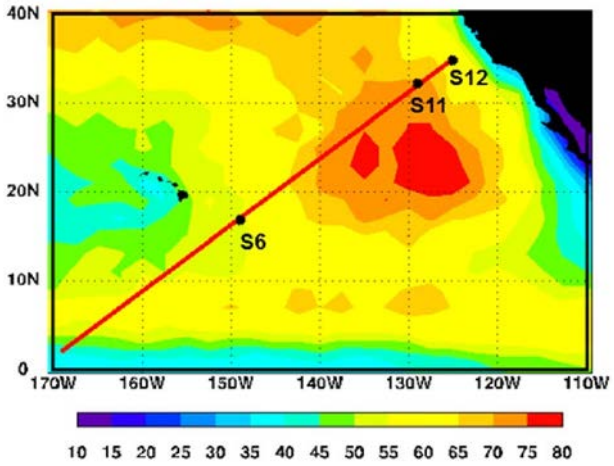
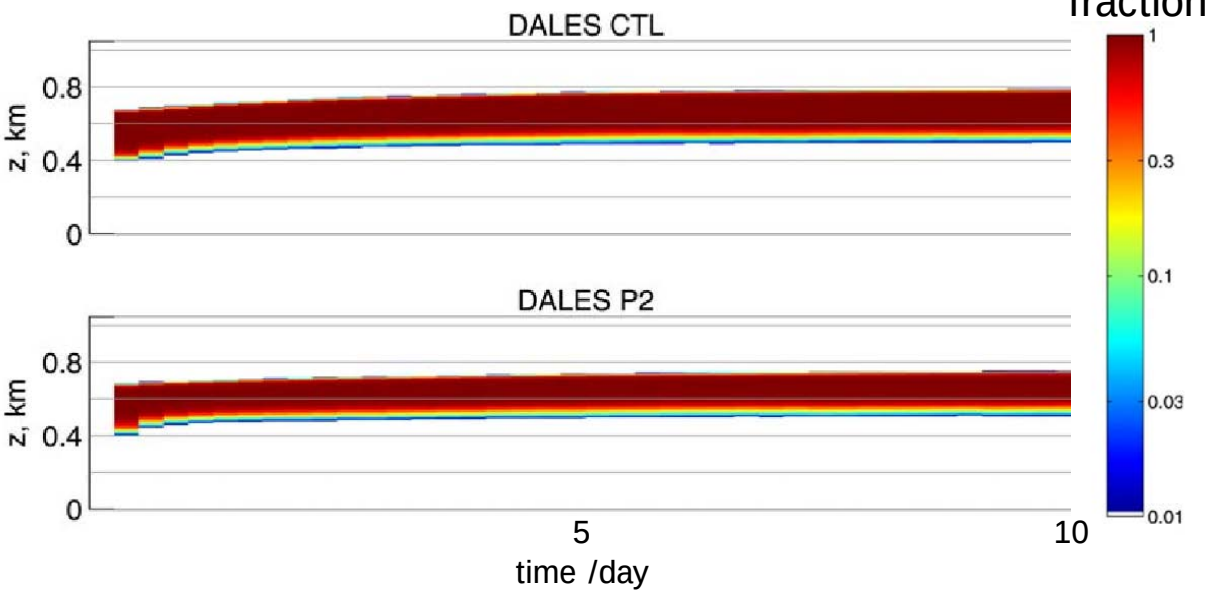
# Motivation

## CGILS response to perturbed climate using LES




cloud cover

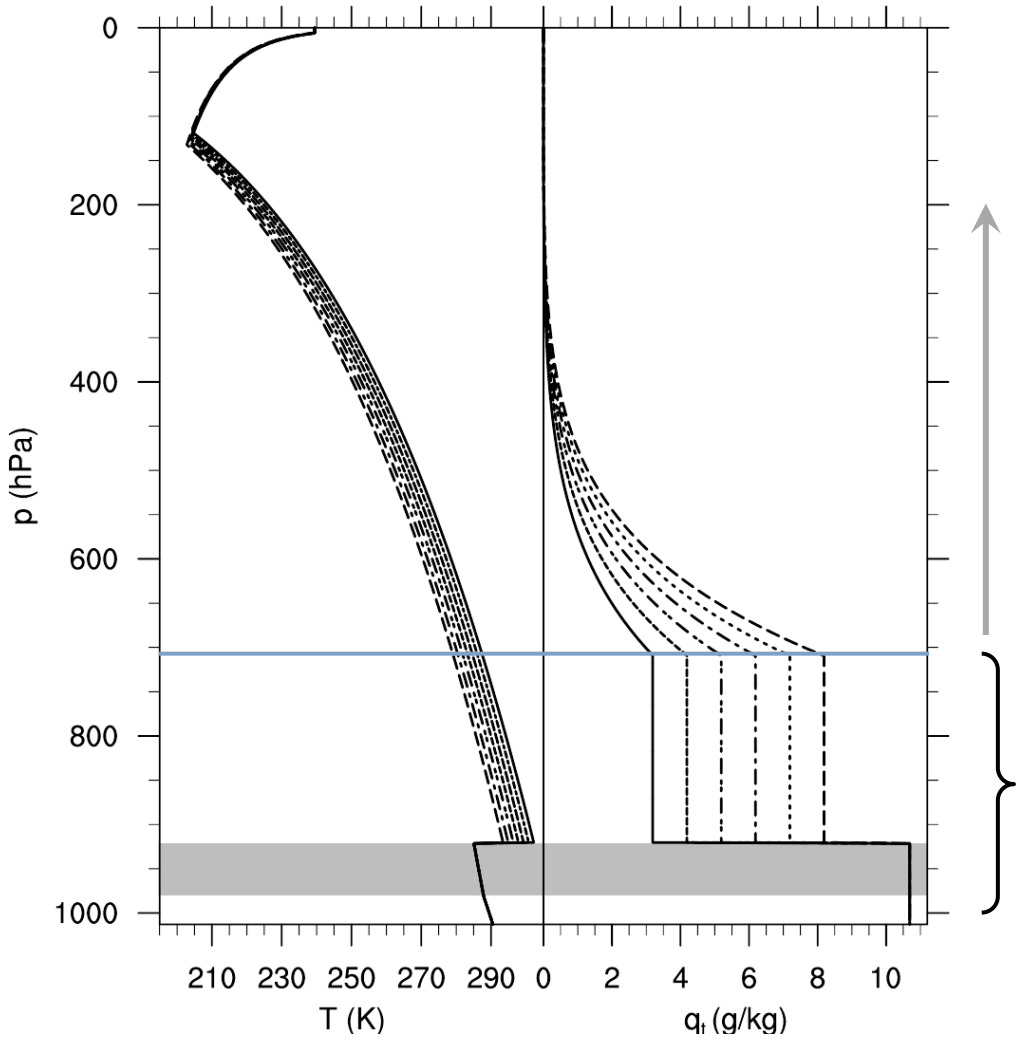



How will stratocumulus clouds change in a future climate?



Zhang et al. (2013); Blossey et al. (2013)

# Case setup

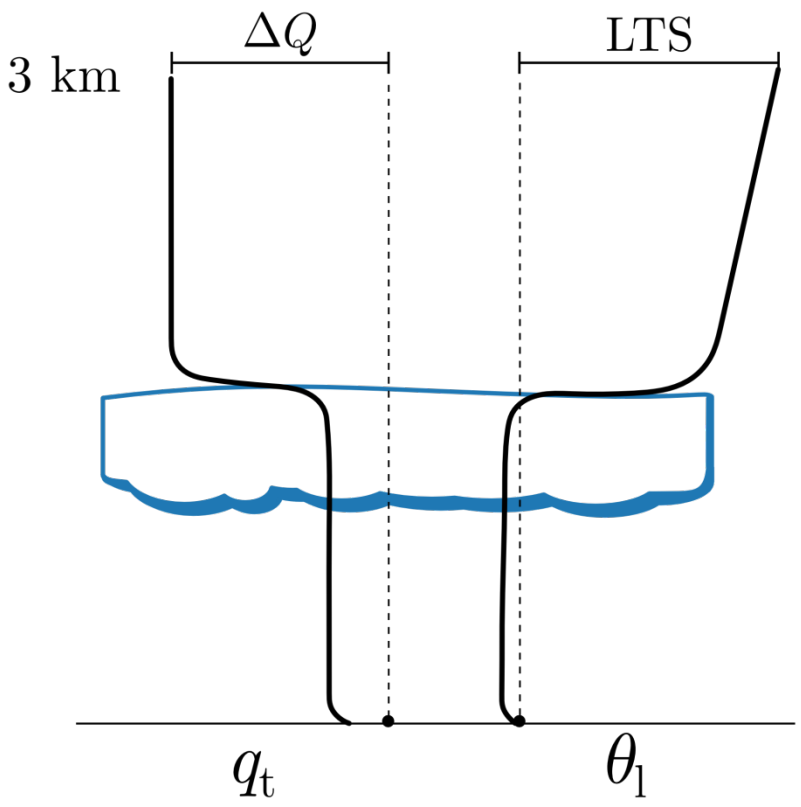


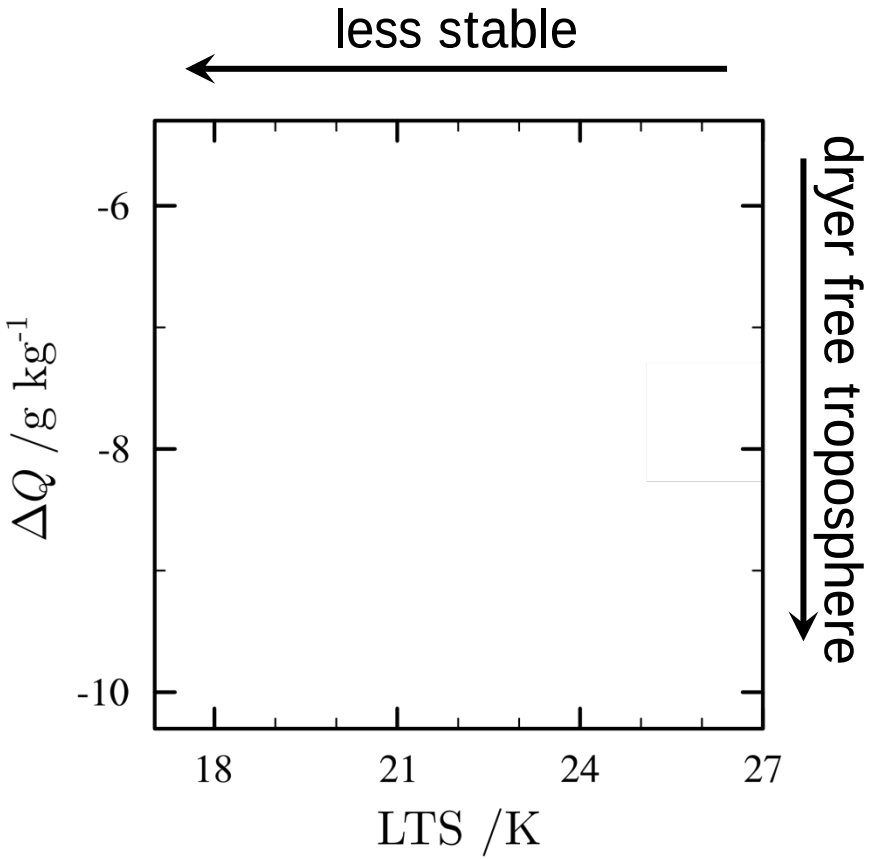

Radiation only

LES domain

# Case setup

## Bulk humidity and potential temperature difference



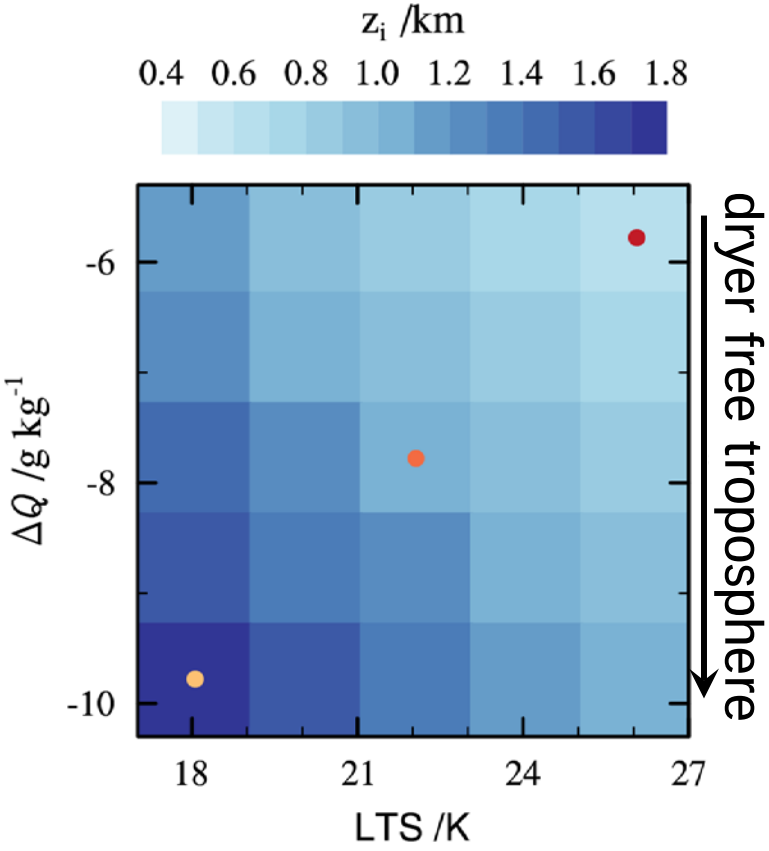
# Simulation details

| | |
|---|---|
| Model | DALES 4 |
| number of simulations | 25 (x2) |
| simulation time | 10 days |
| domain size | 6 x 6 x 3 $km^3$ |
| $\Delta z$ | 10 m |
| $\Delta x = \Delta y$ | 50 m |
| $N_z$ | 219 |
| $N_x = N_y$ | 120 |

# 1. Control Climate

# Results - control

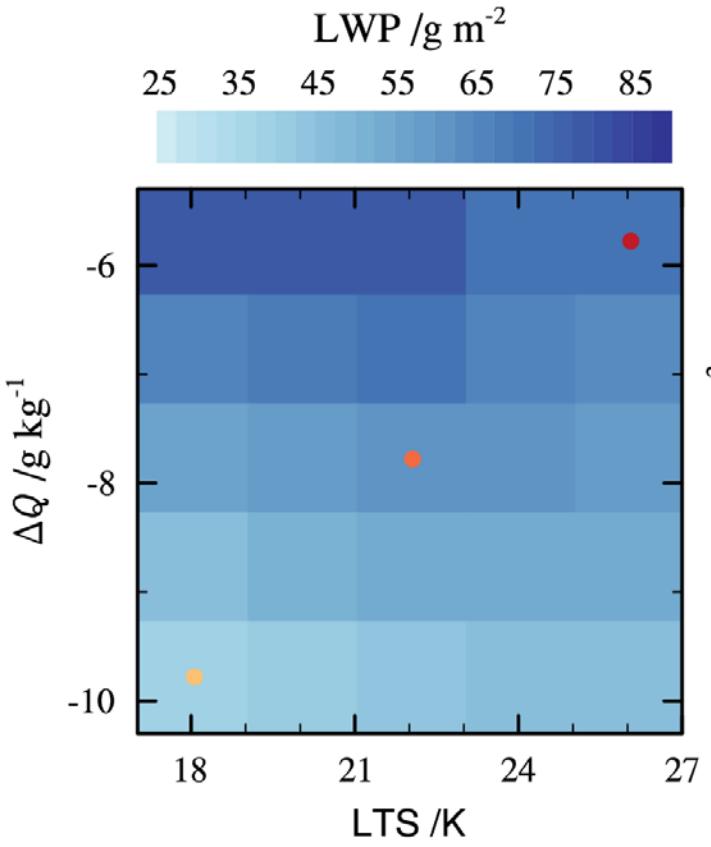
## Inversion height

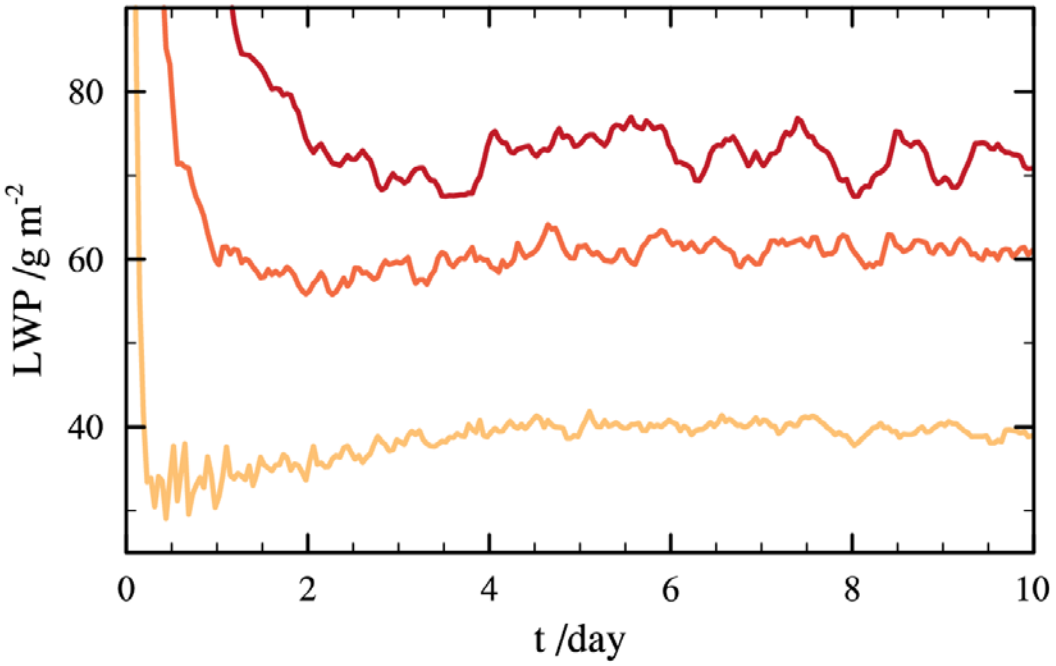



Cloud cover is 100% everywhere

# Results - control

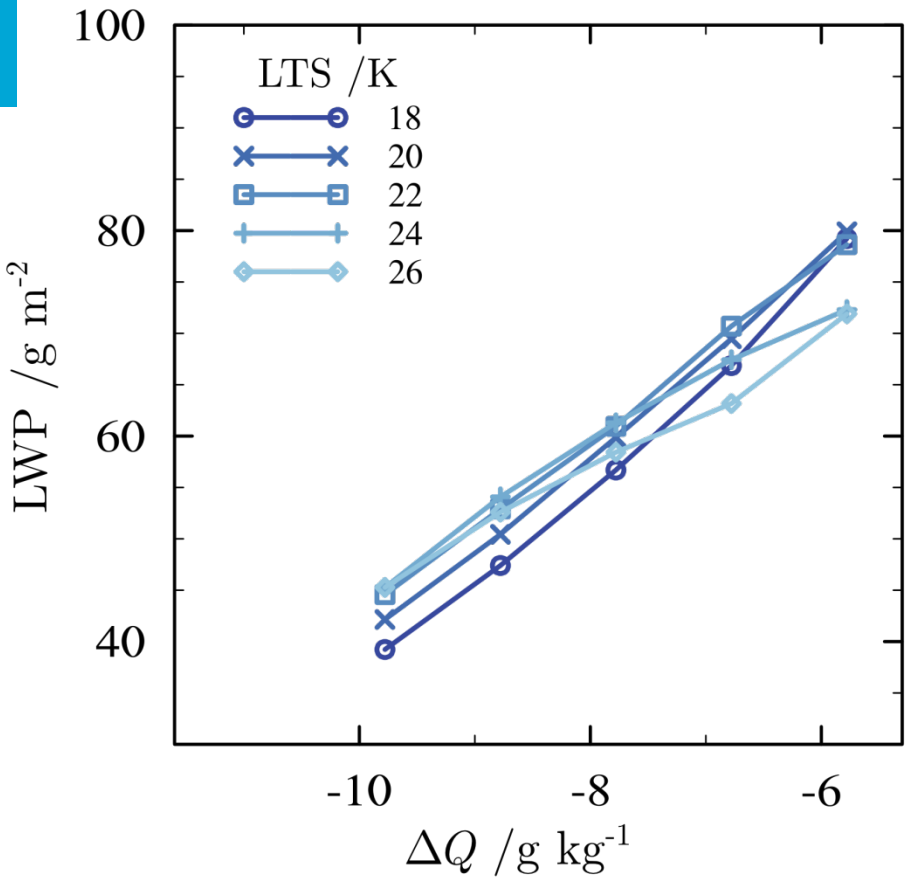
## Liquid water path



# Results

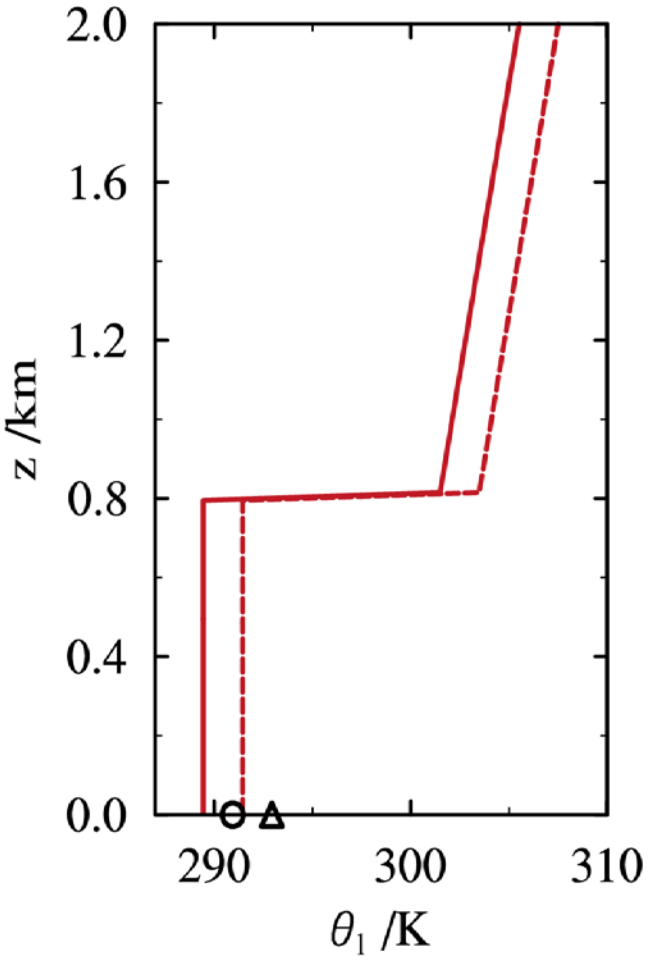
## LWP mostly depends on free tropospheric humidity



# 2. Perturbed climate

# Climate perturbation

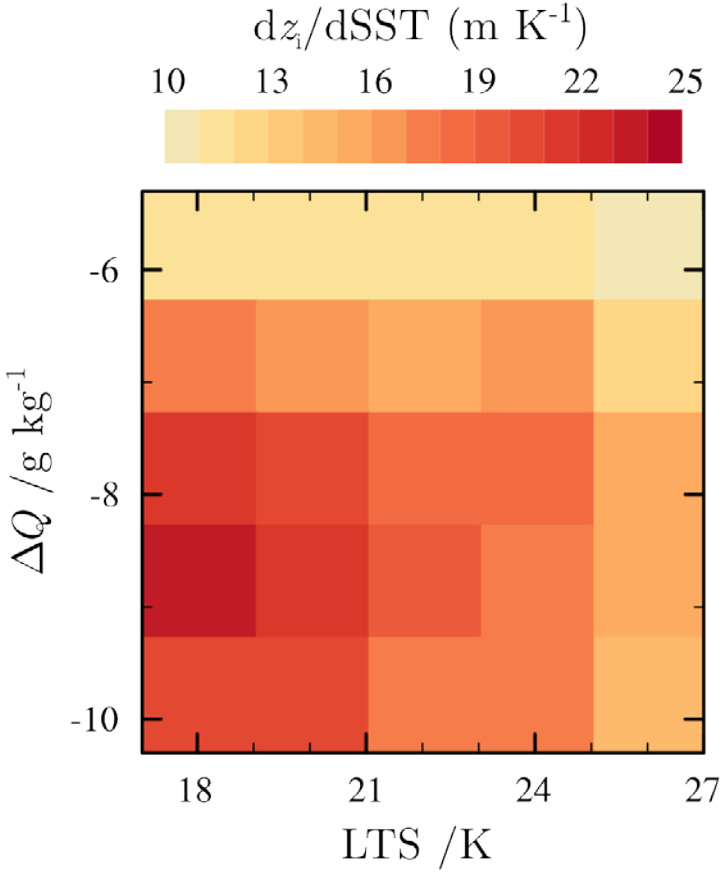
## Temperature increase at constant relative humidity




$|\Delta Q|$ increases by up to 1.4 g kg$^{-1}$!

# Response to perturbation

## Inversion height increases



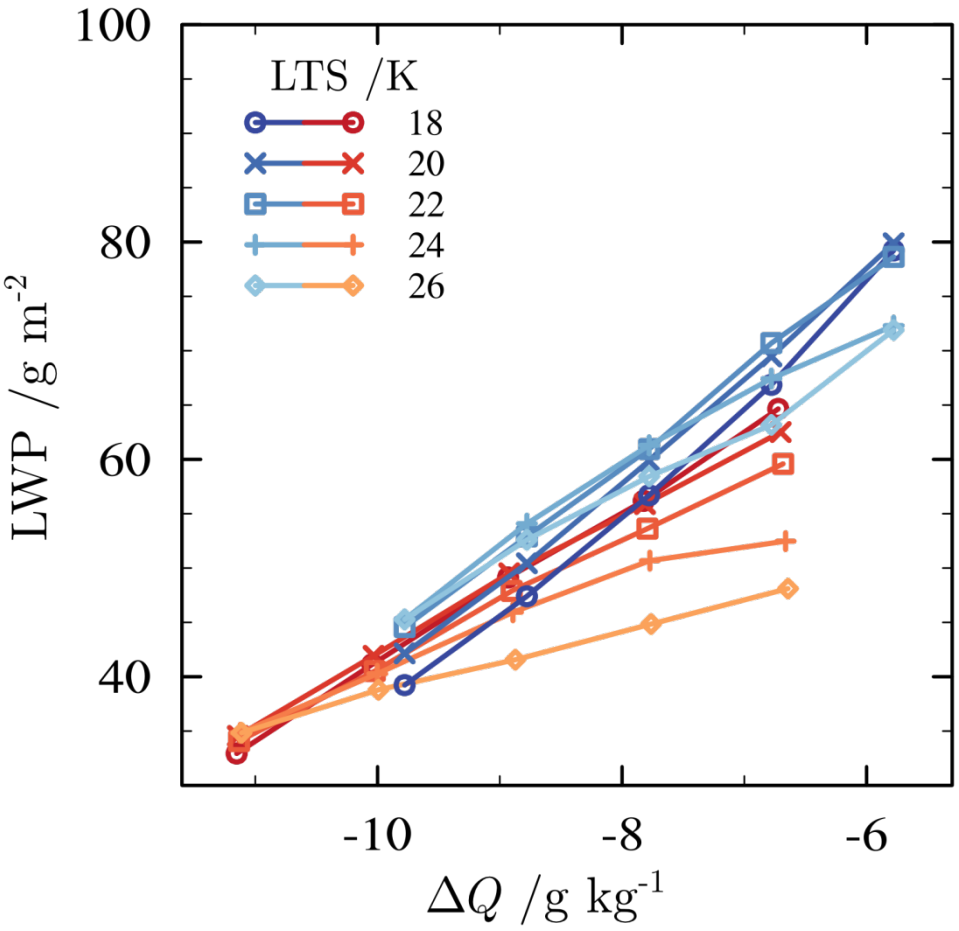

Two competing processes

- increased surface flux: $z_i \uparrow$
- increased downwelling longwave radiative flux: $z_i \downarrow$

Cloud cover remains 100% everywhere

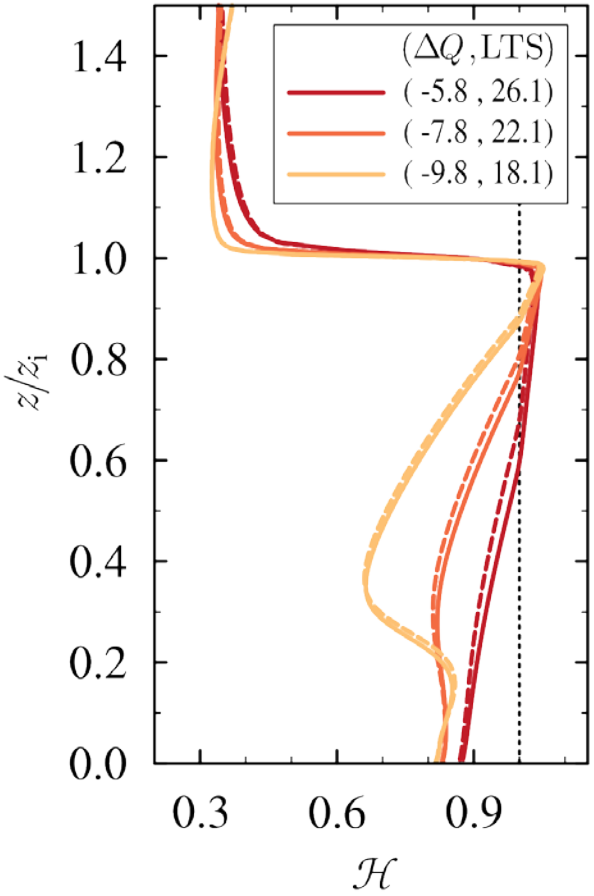
# Response to perturbation

## LWP response partly related to change of $\Delta Q$



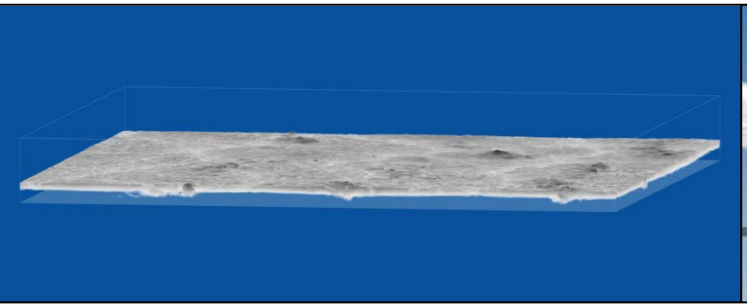
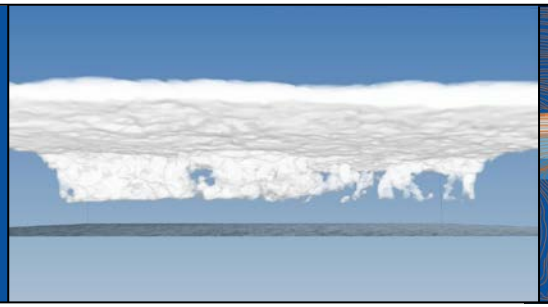
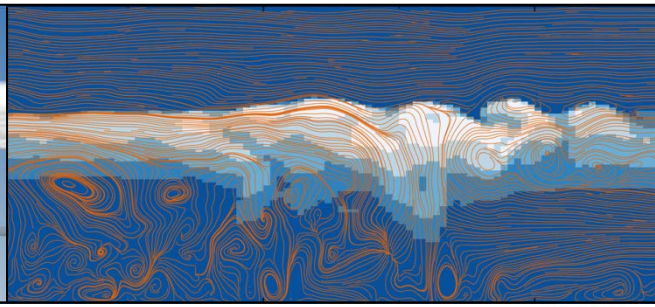
# Response to perturbation

## Relative humidity decreases



# Conclusions

- Climate feedback is positive for all cases
- LWP response mainly result of by change of $\Delta Q$
- Cloud thinning response mainly due to drying of cloud layer

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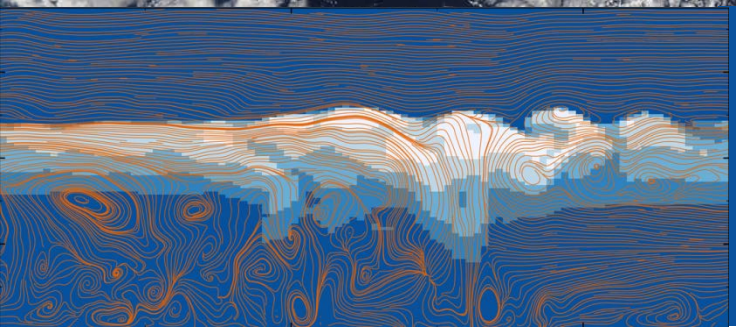

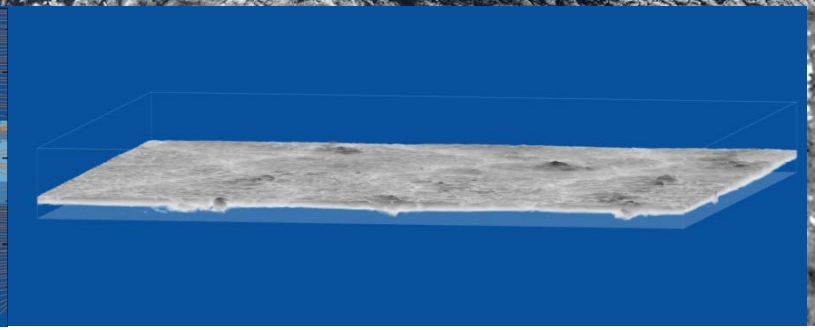

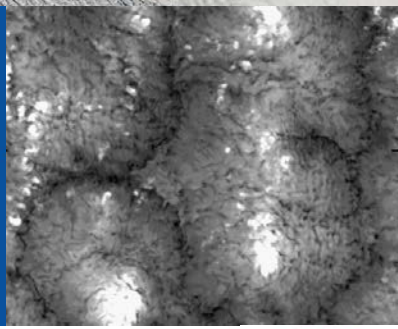

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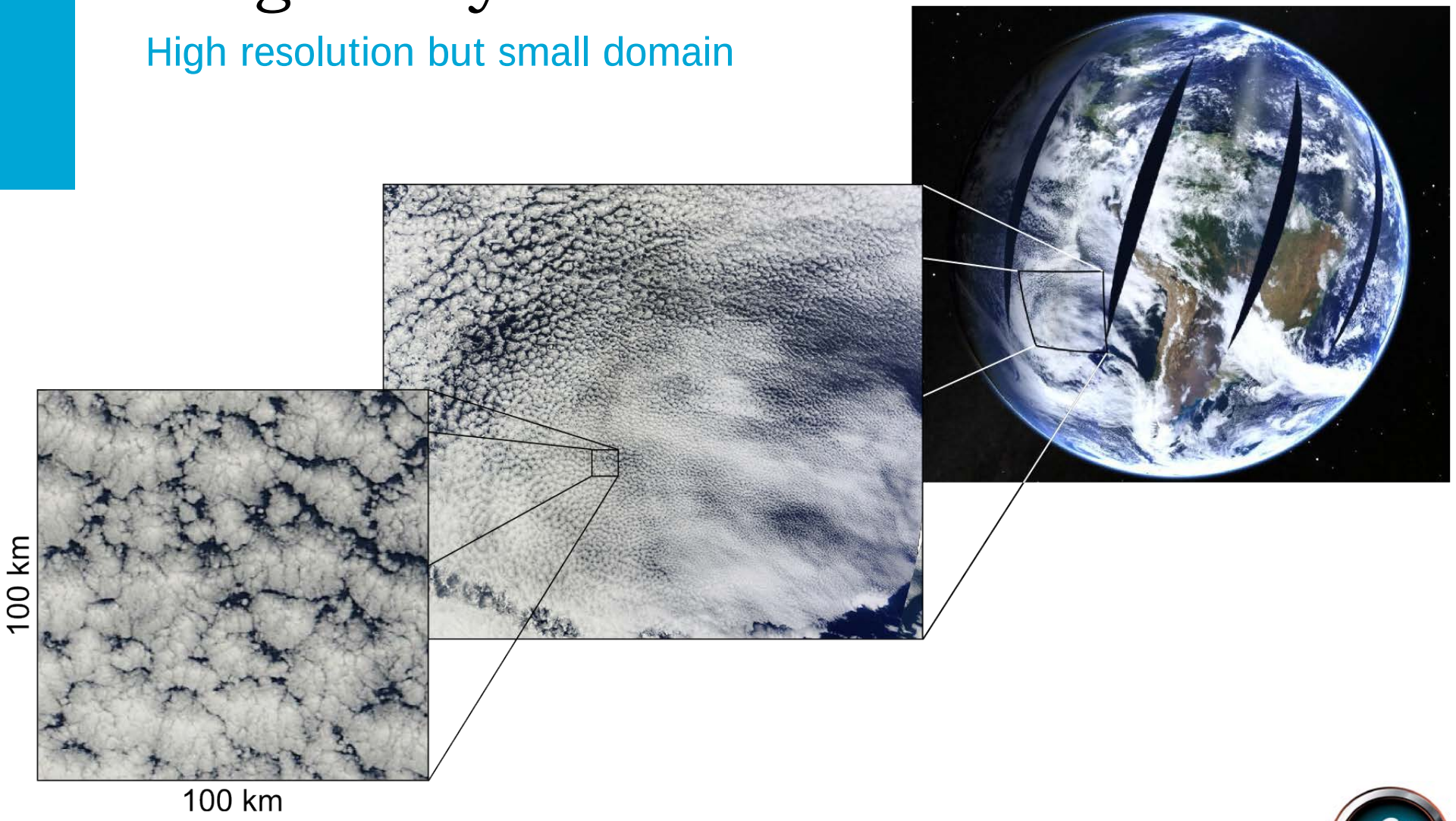
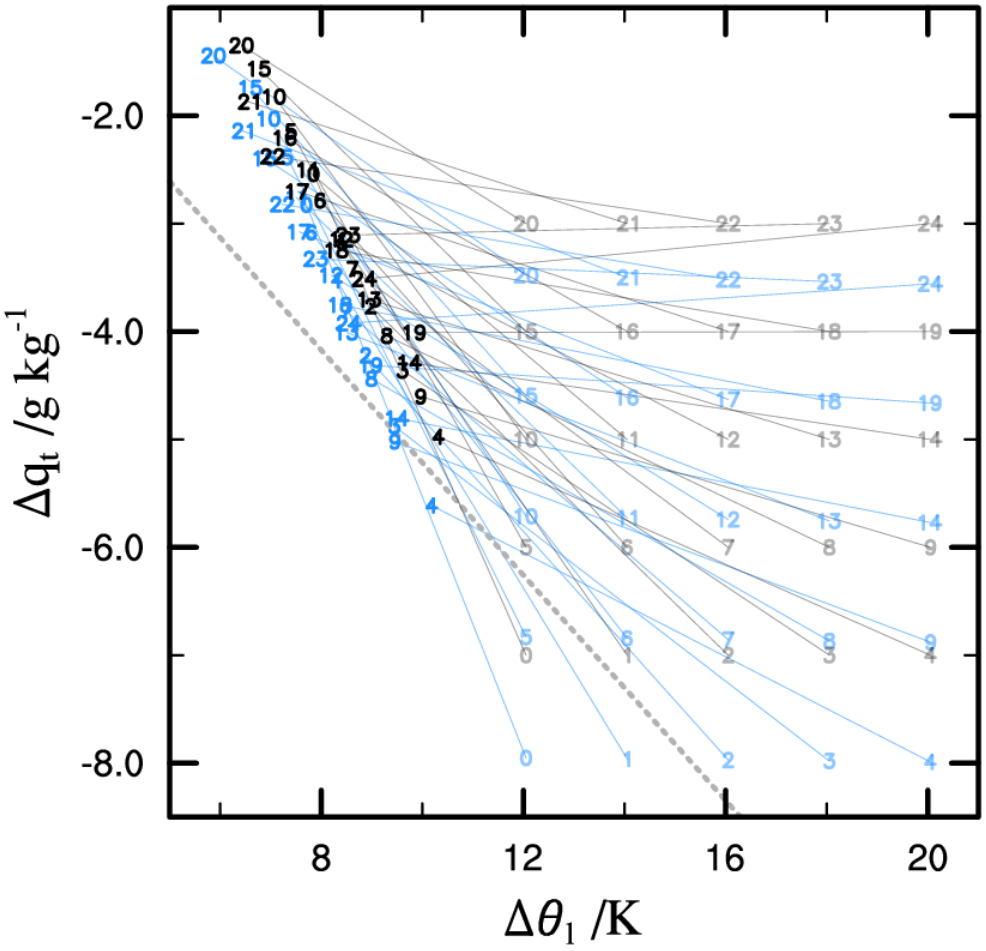
# Large-eddy simulation

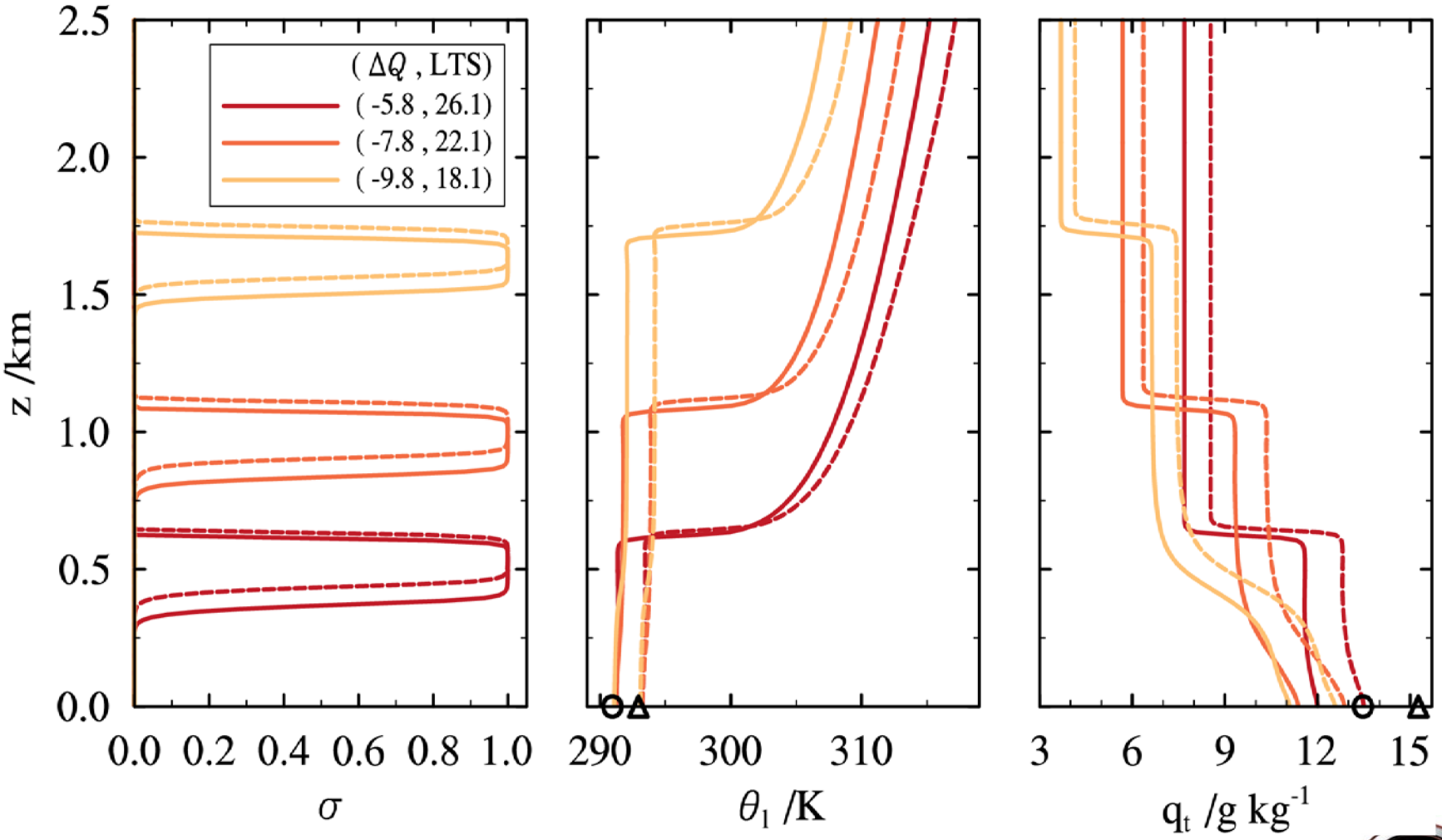
## High resolution but small domain



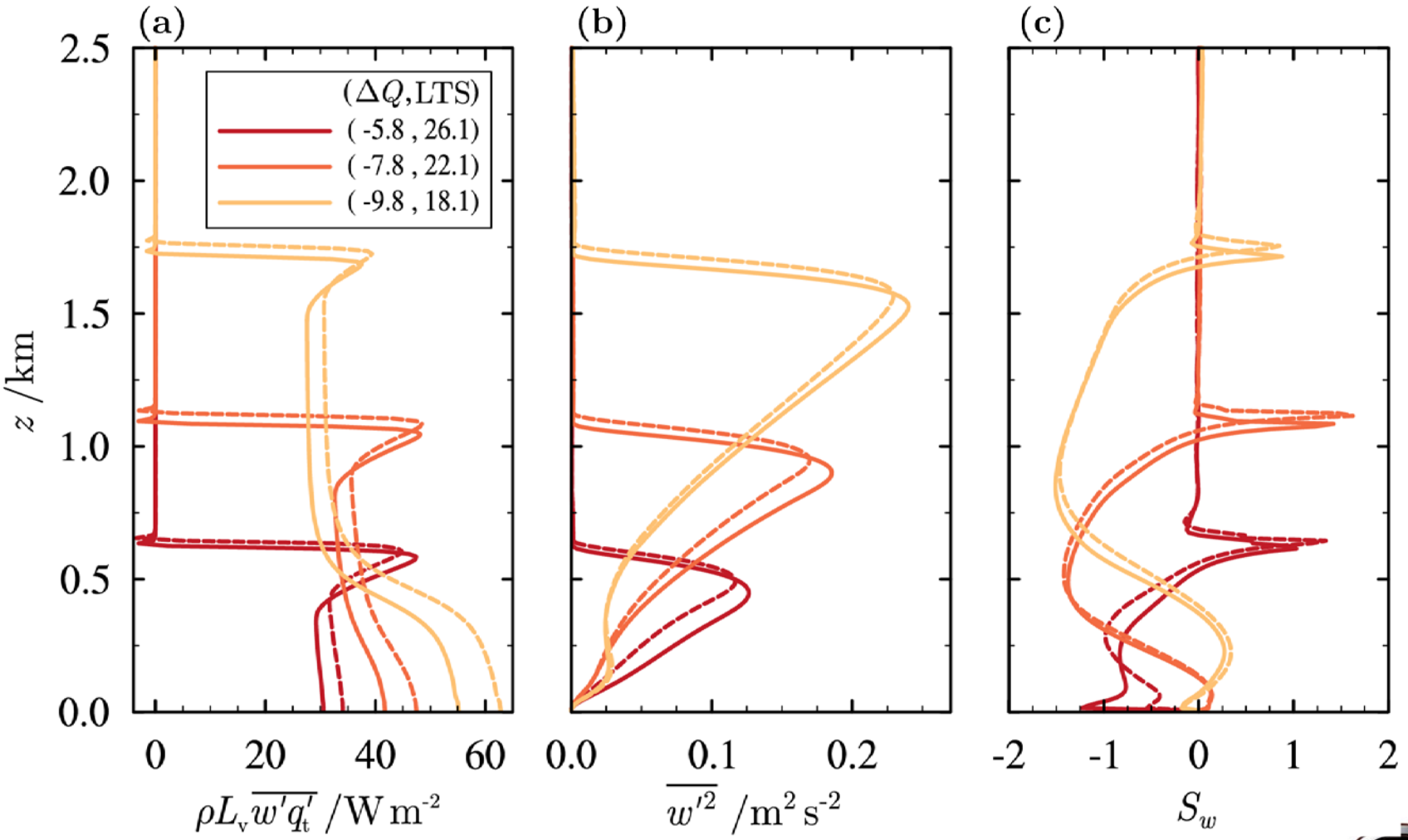
# Inversion jumps



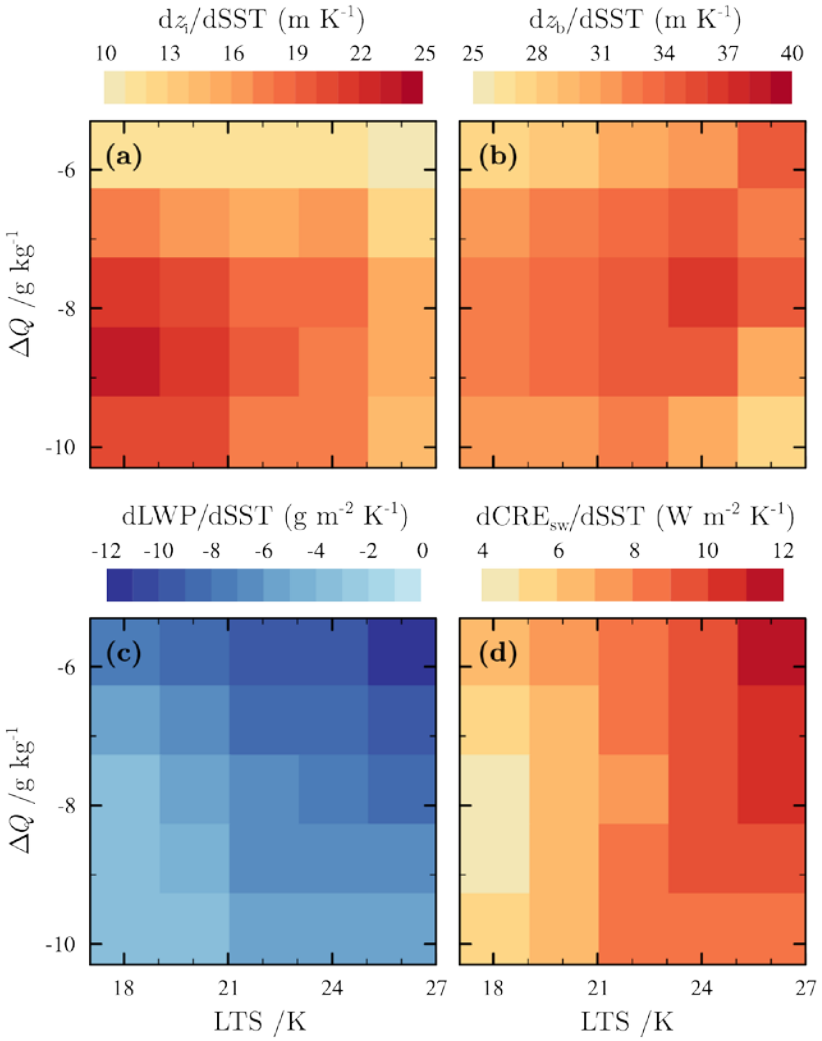
# Mean state profiles



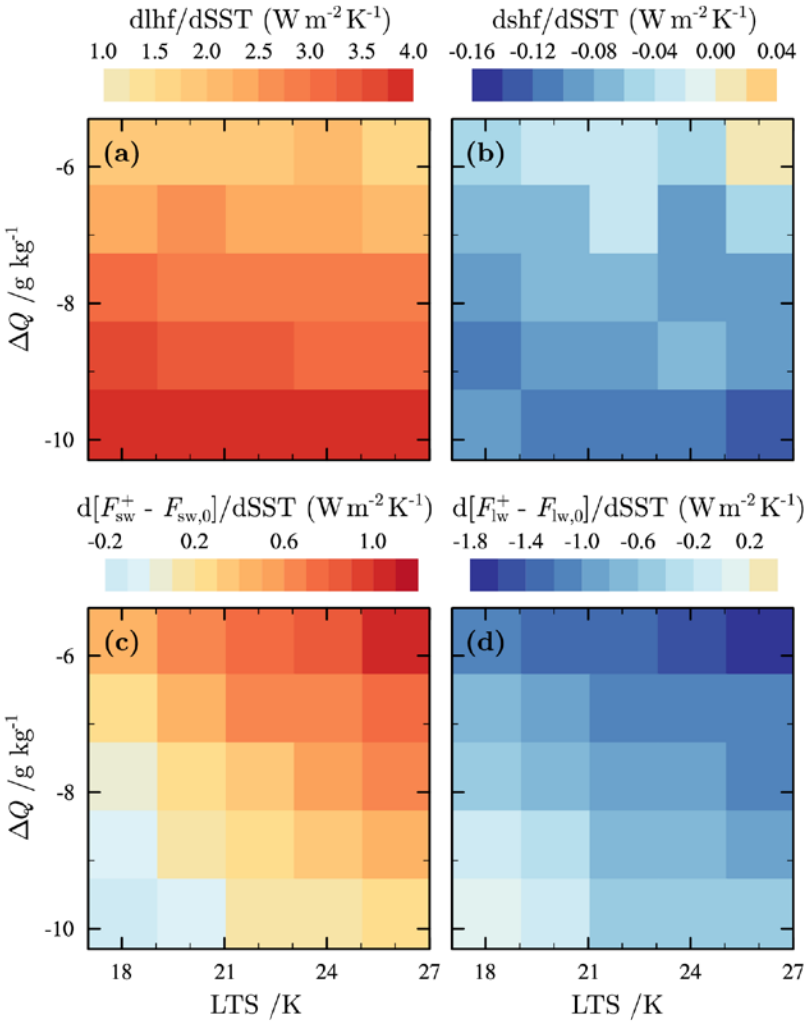
# Turbulence state profiles



# Climate response



# Climate response – source/sinks



# Entrainment-liquid flux adjustment