The Impact of a Humidity Inversion on the Persistence of a Decoupled Arctic Mixed-Phase Stratocumulus

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In collaboration with:

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*ASR PI on this project

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Outline of Talk:

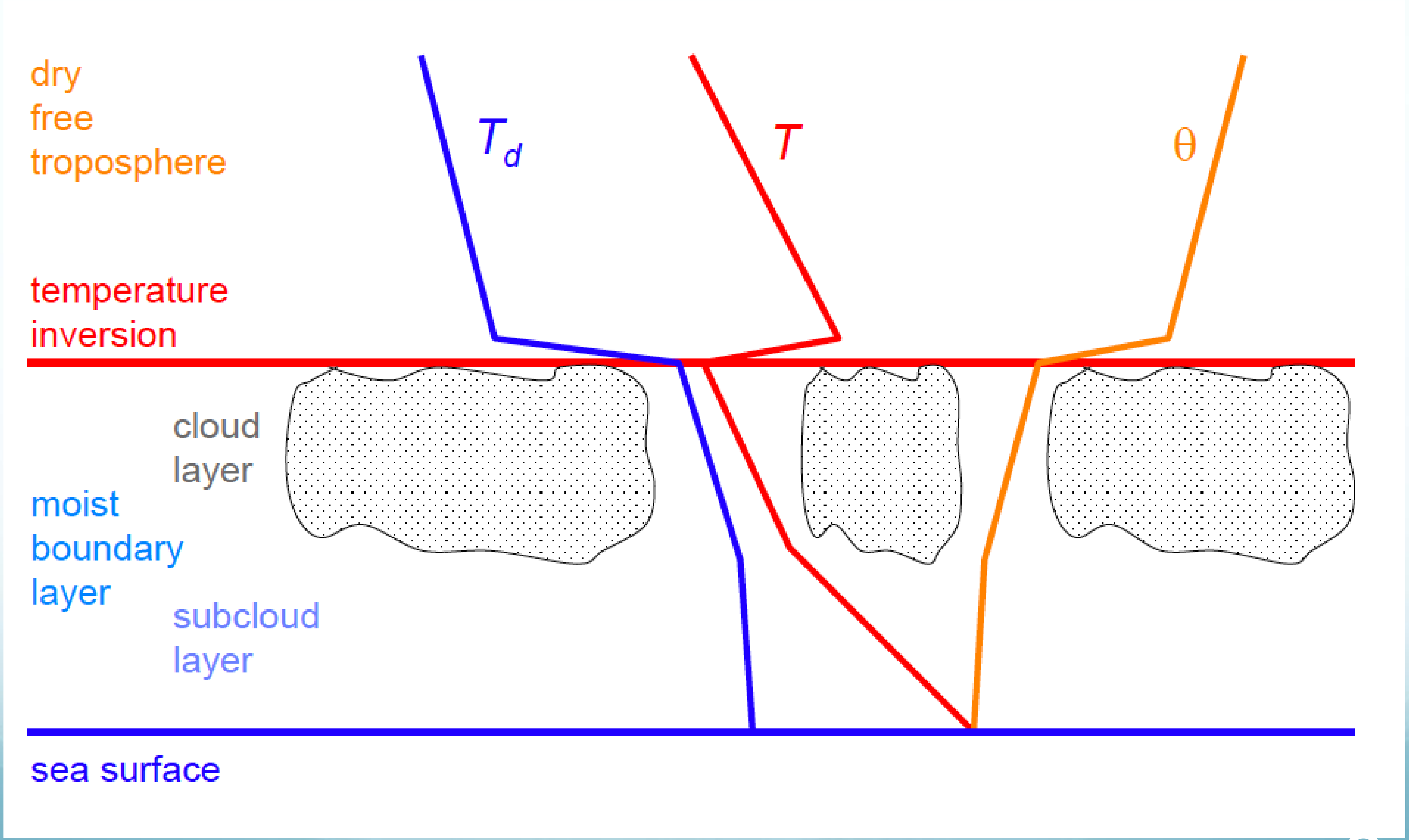
1)Comparison of Arctic Mixed-Phase Stratocumulus to Subtropical Stratocumulus Topped Boundary Layers

2) Nested LES Simulation of Decoupled AMPS

--- Case Study ISDAC Golden Day 8 April 2008

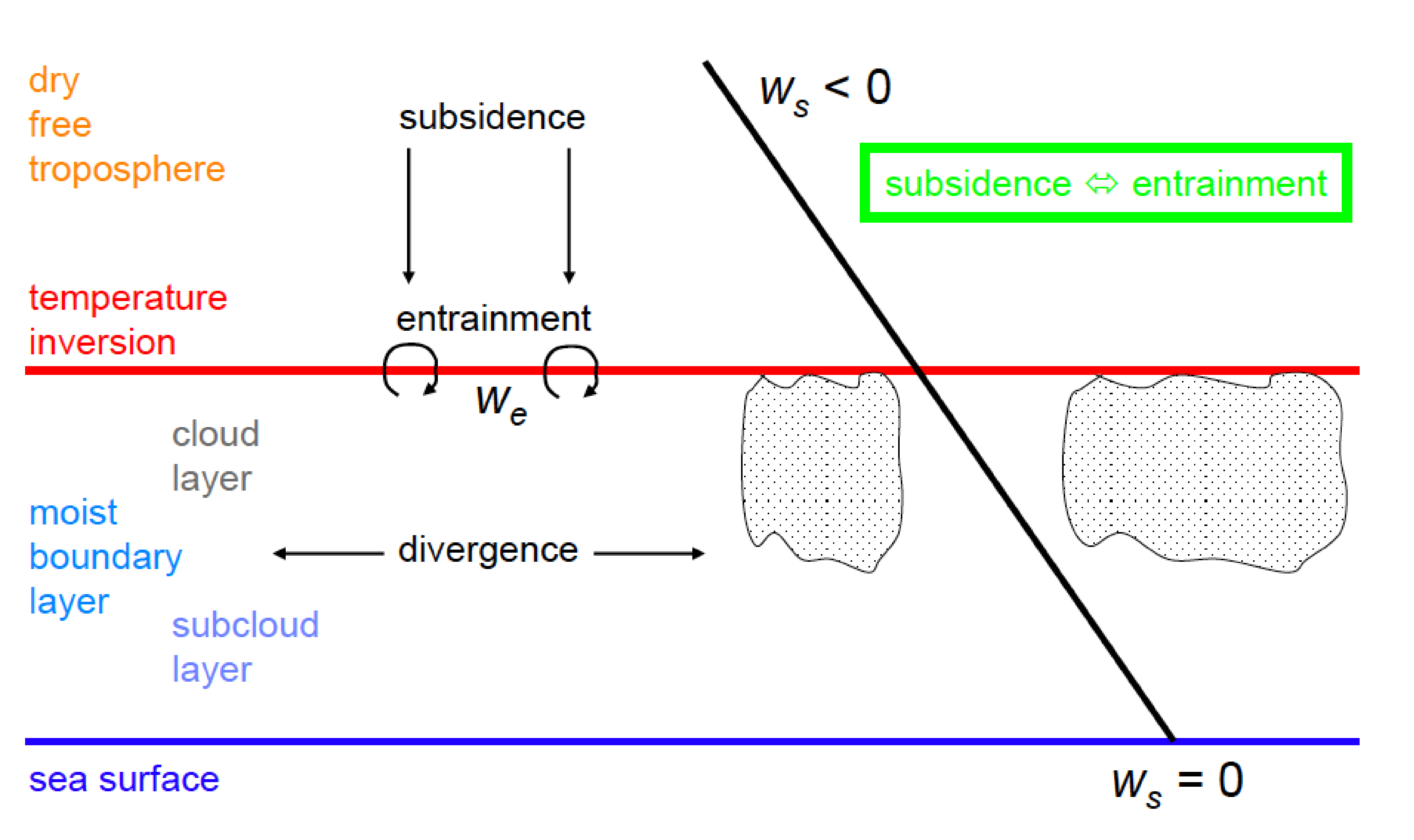
3)Conceptual Model of AMPS

Idealized Marine Stratocumulus-topped Boundary Layer



After Norris (2010)

Idealized Marine Stratocumulus-topped Boundary Layer



After Norris (2010)

Sounding and Retrievals at Barrow at 17.6Z 8 April 2008

Different from MBL:

Humidity Inversion:
QV doesn't decrease at cloud top (θe increases within the cloud layer)

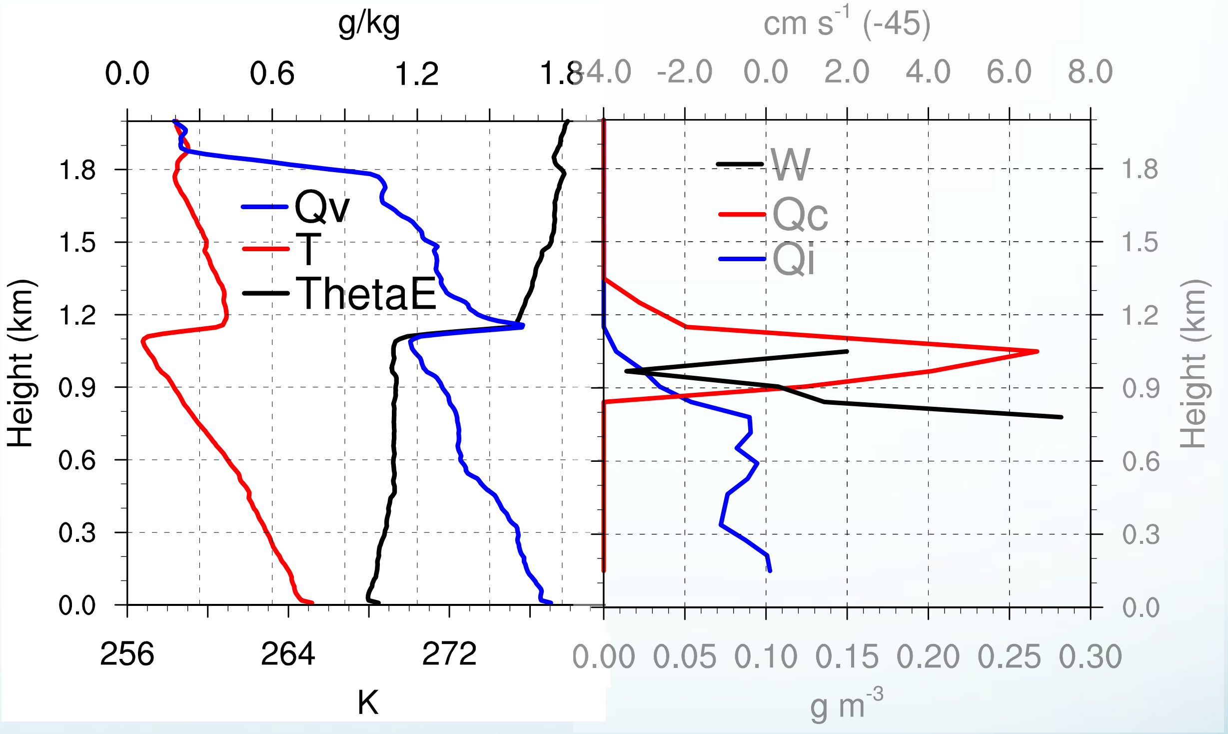
Cloud extends ~100m into inversion

Large-scale subsidence?

Stable surface layer (decoupled)

Much less precipitation

Role of ice?



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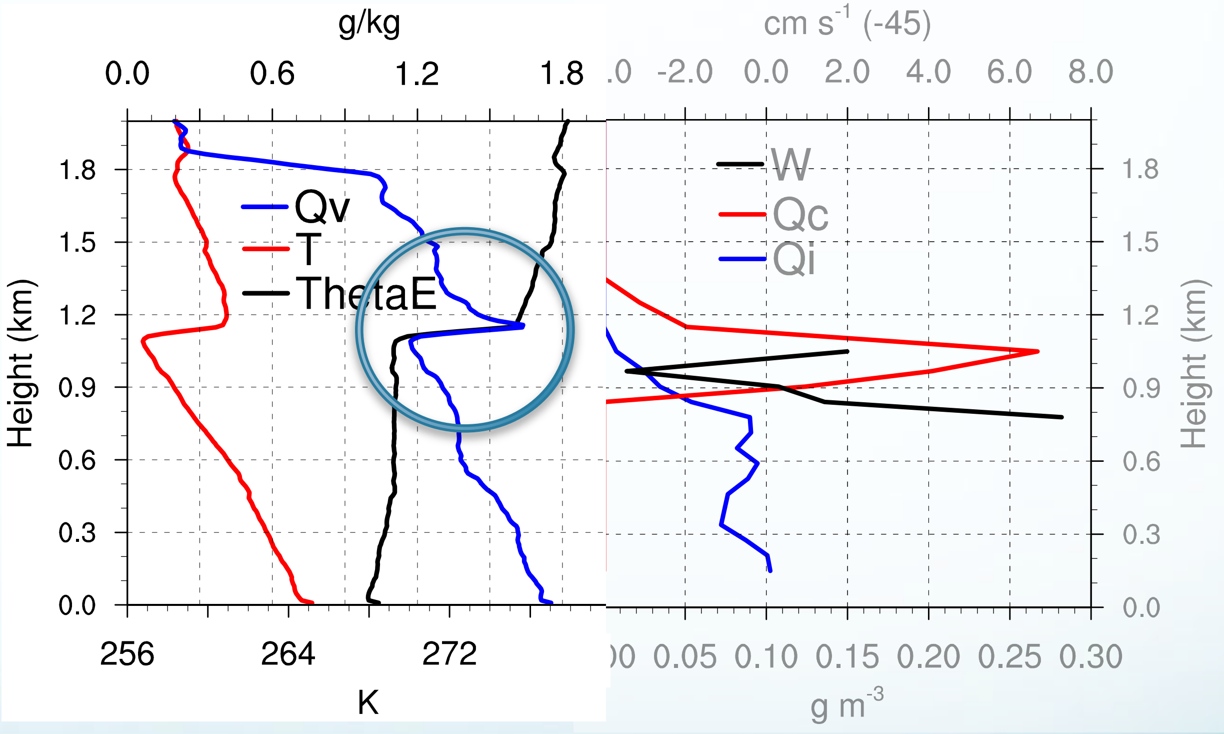

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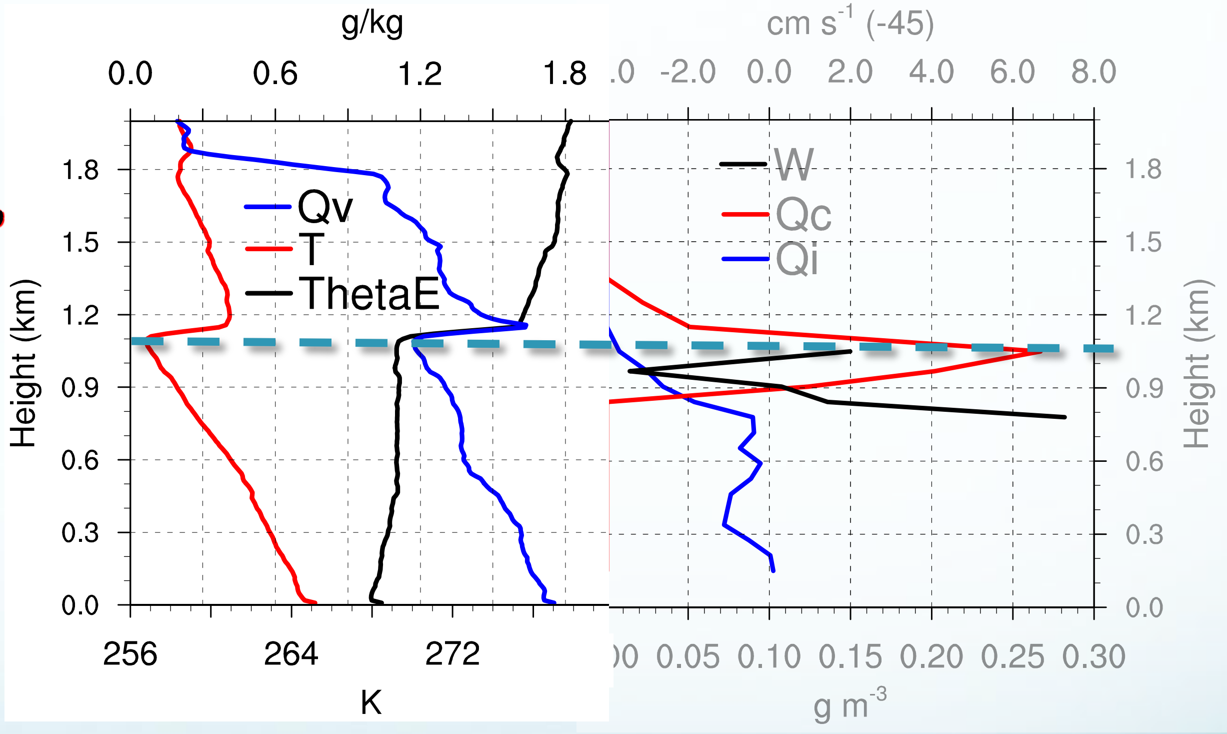

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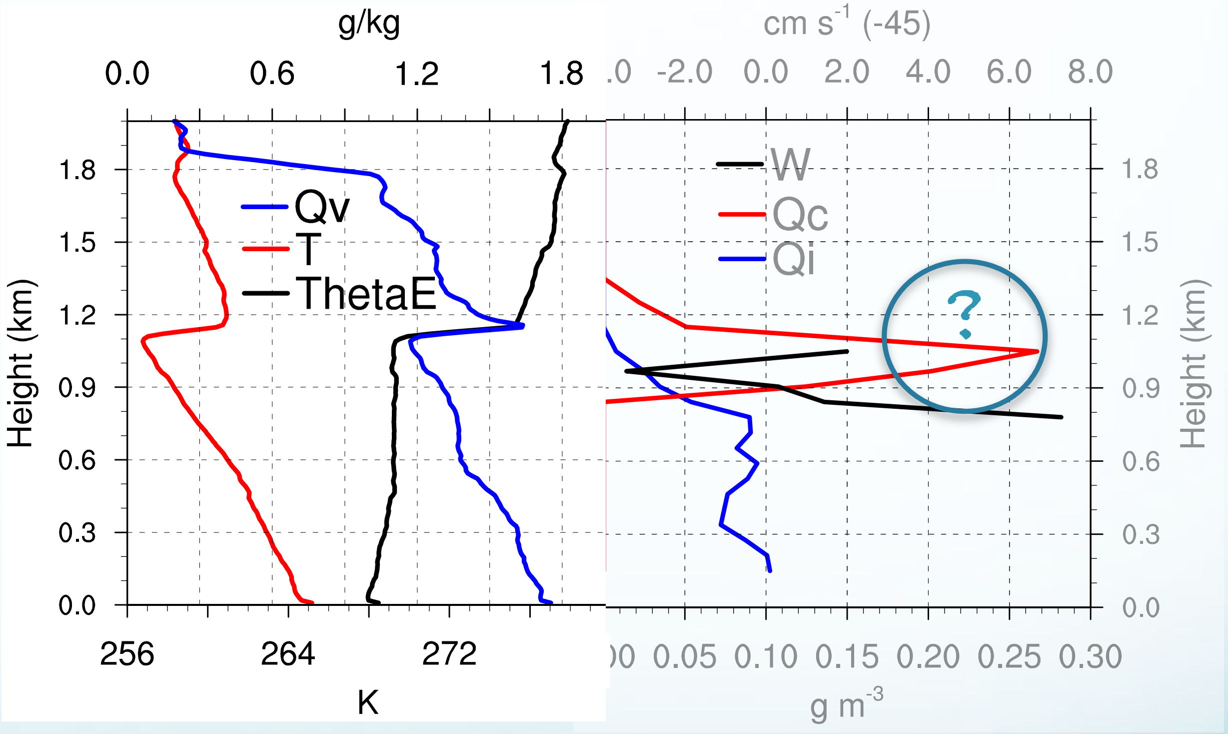

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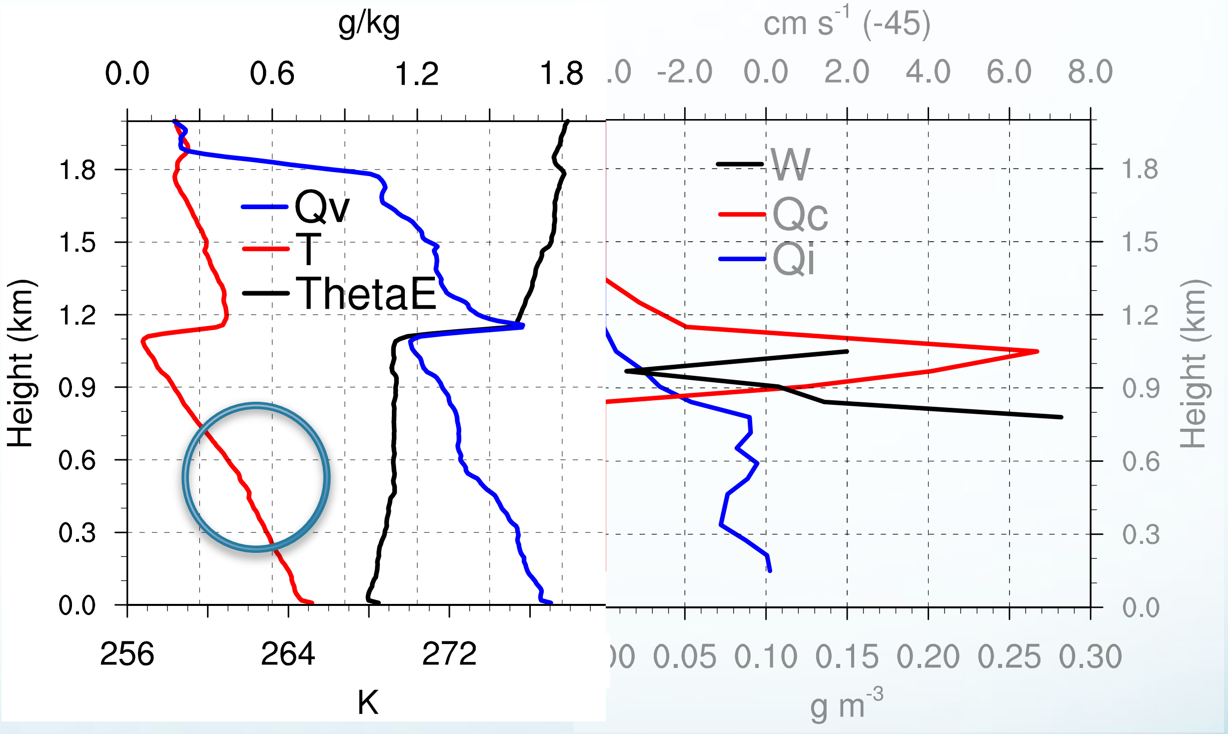
Large-scale subsidence?

Stable surface layer (decoupled)
Limited surface moisture sources

Much less precipitation
Role of ice?



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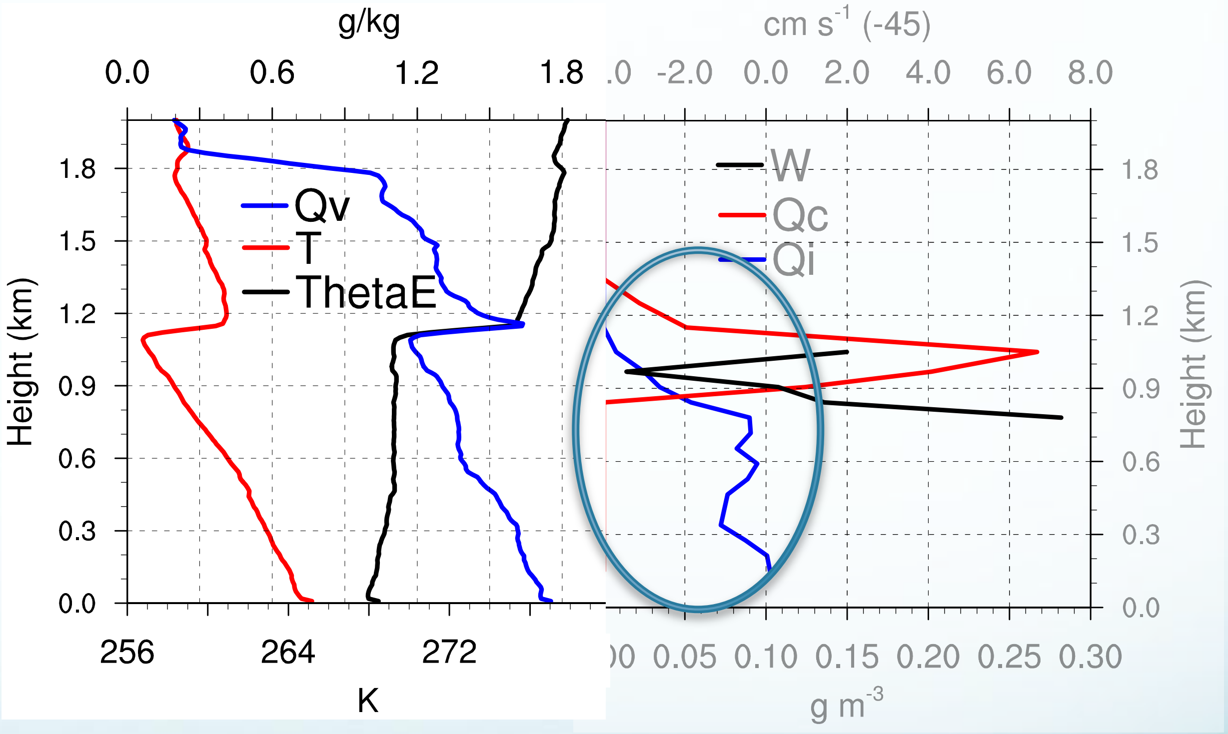


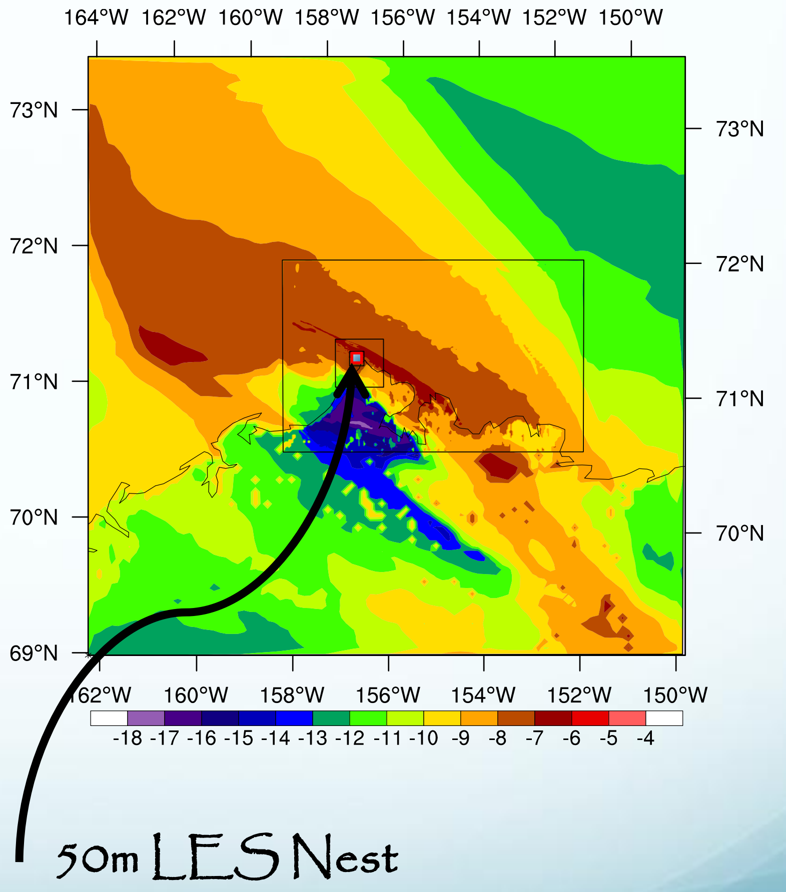
Much less precipitation

Role of ice?

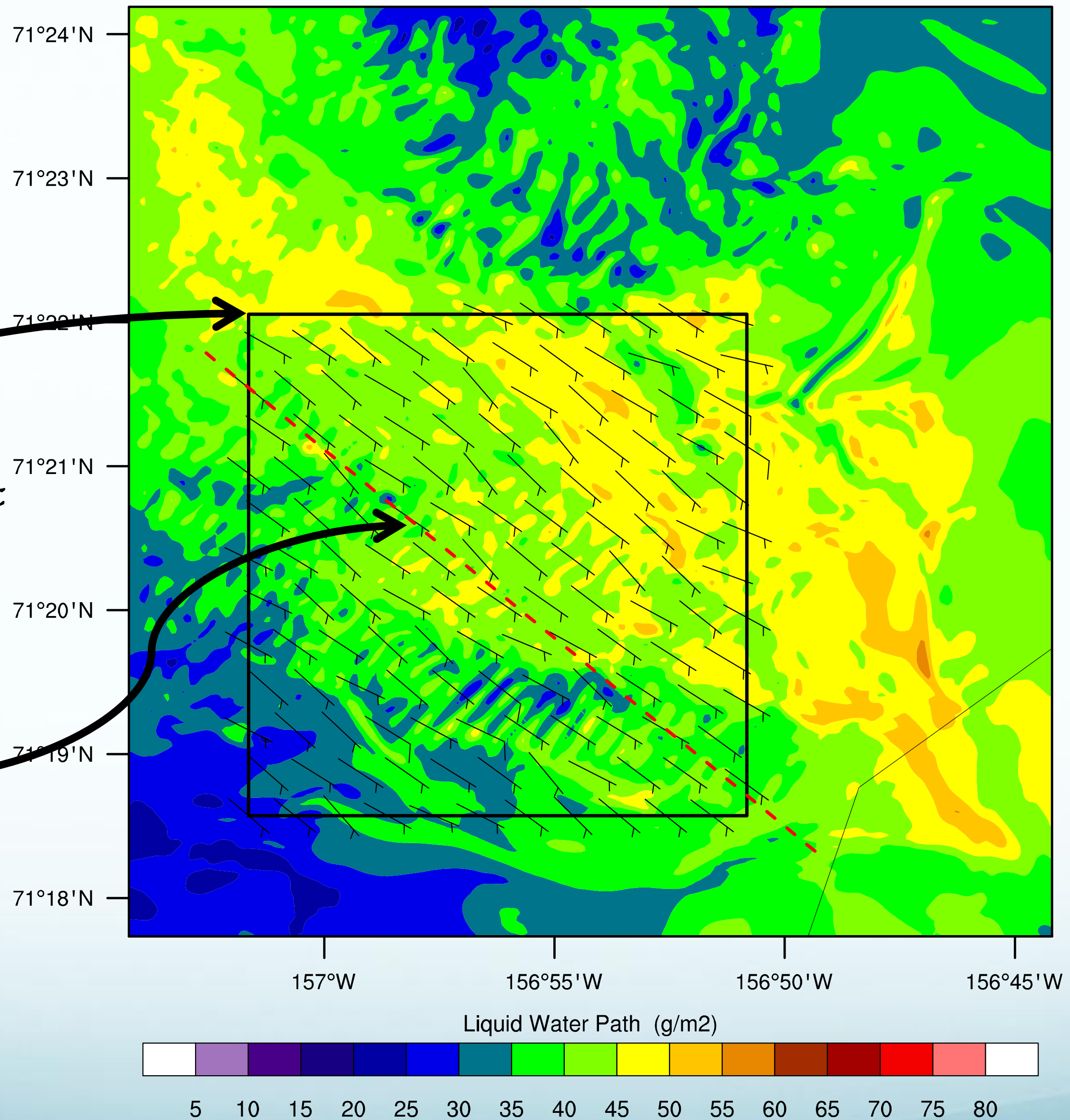
Experiment Design

- WRF Version 3.1
- Two-way nesting using 25km, 5km, 1km, 200m, 50m nests
- 16m vertical resolution in mixed layer, 8m resolution in entrainment zone
- Morrison 2-moment liquid and ice microphysics
- Uniform sea-ice surface
- ECMWF 6 hourly forcing at the 25km lateral boundaries
- Aerosols fit to ISDAC measurements

Surface Skin Temperature



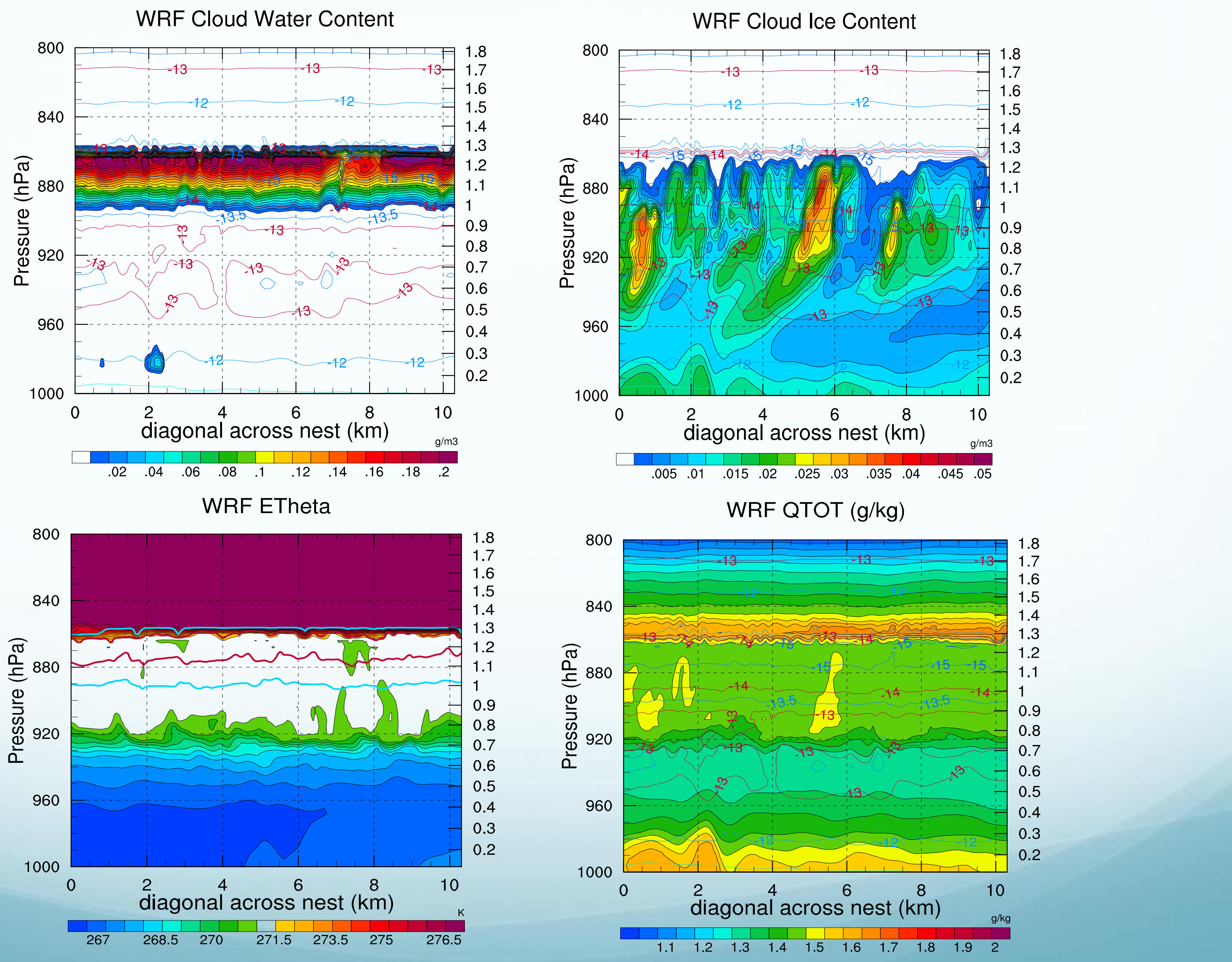
Square Domain:
130x130 gridpoint
Area of Analysis



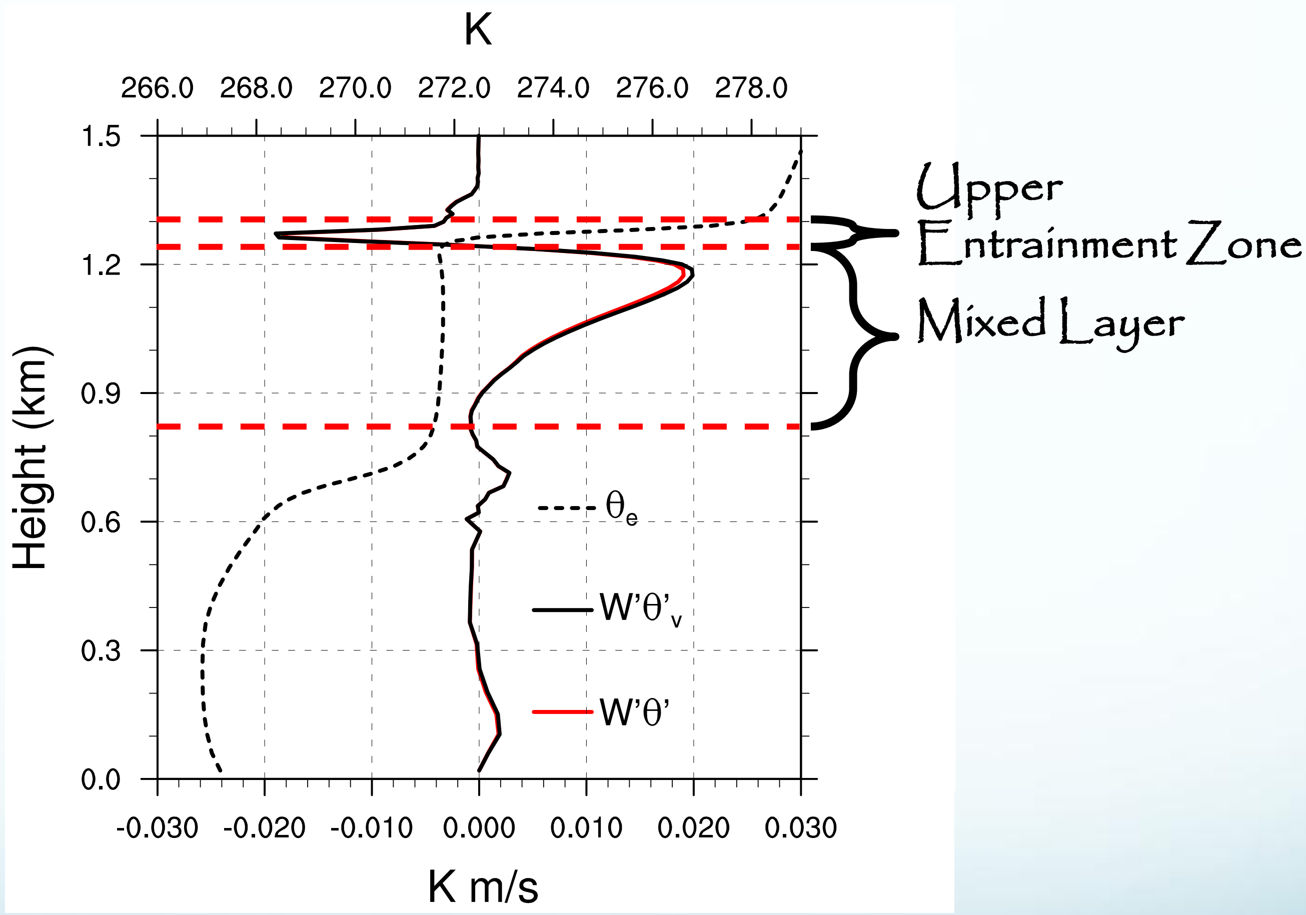
Cross-section
Along Mean
Mixed Layer
Winds

Barrow, Alaska

Boundary Layer Structure Along Mean Mixed Layer Winds



Domain Averaged θe and Buoyancy Flux



Domain Averaged Water Tendencies and Mean Fields

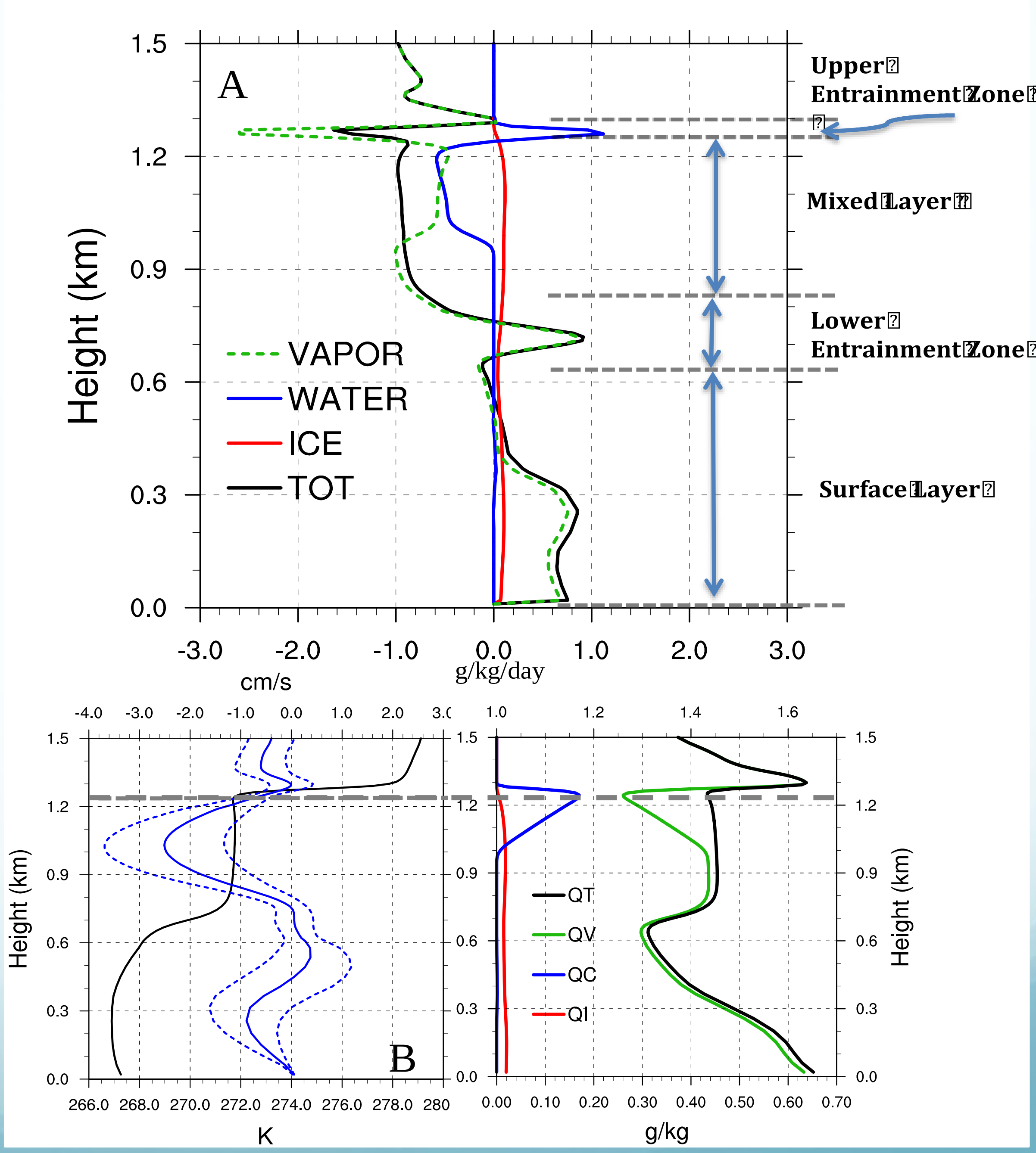
In Upper EZ:

- Depleting Vapor while maintaining Cloud Water
- Cloud layer in Inversion
- W = 0 at Top

In Mixed Layer:

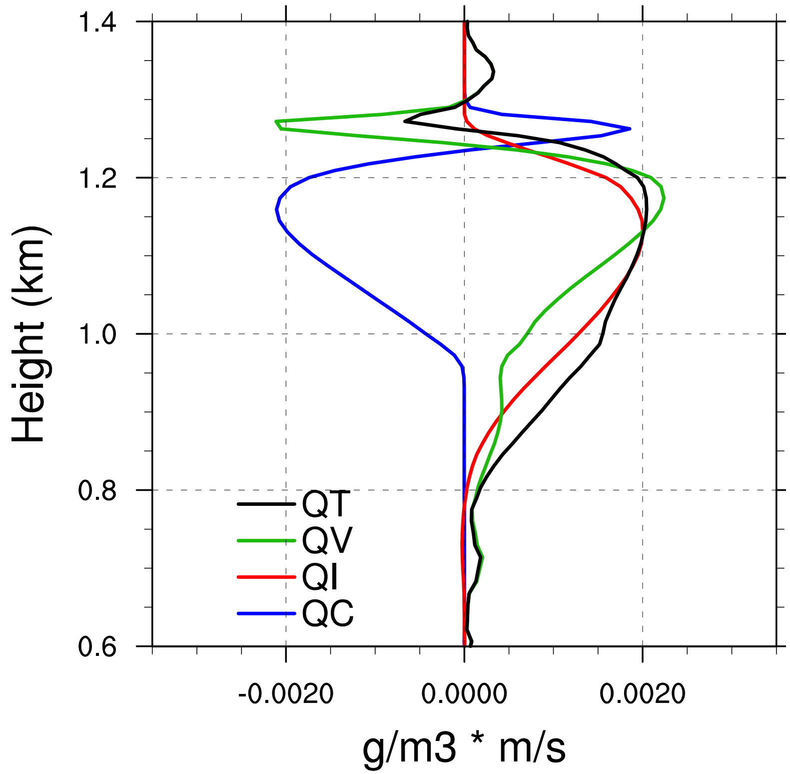
- Role of Ice?
- Depletion of both Vapor and Cloud Water

W ≈ -0.5 cm/s above Inversion

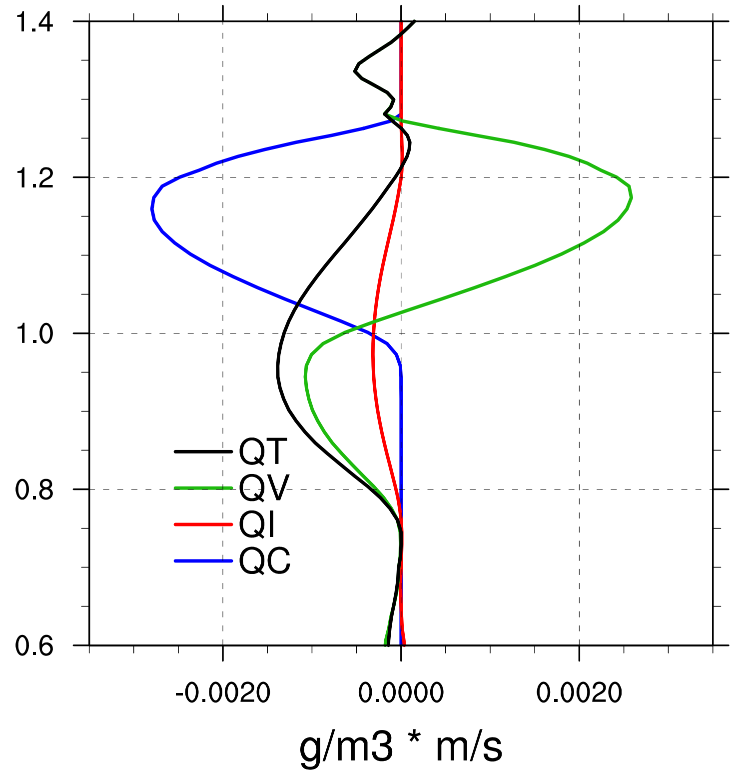


Domain Averaged Water Fluxes

Resolved Turbulent Water Fluxes



Mean Water Fluxes

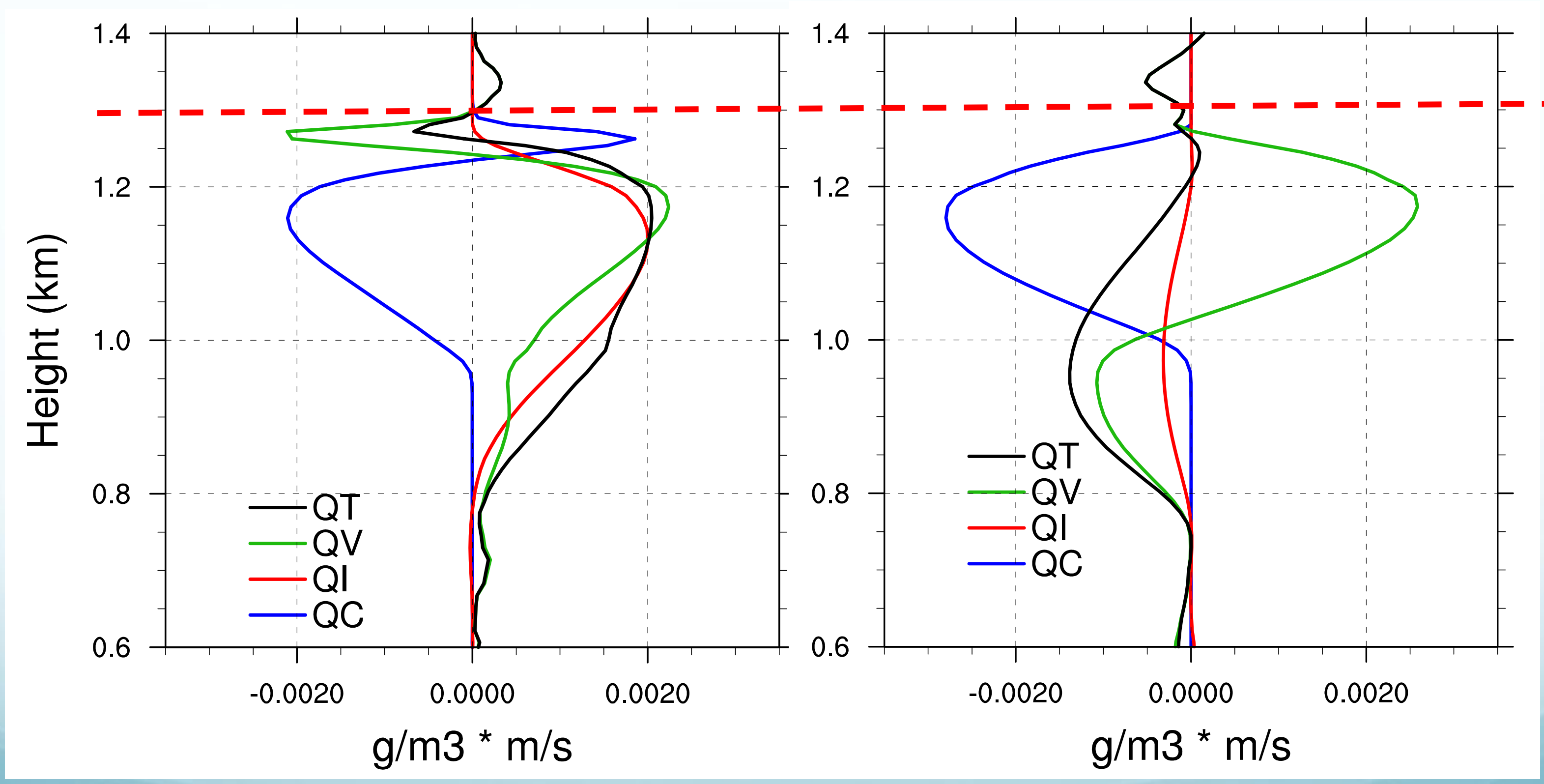


Domain Averaged Water Fluxes

At the Top of the Upper Entrainment Zone:
Mean and Turbulent Vertical Fluxes ≈ Zero

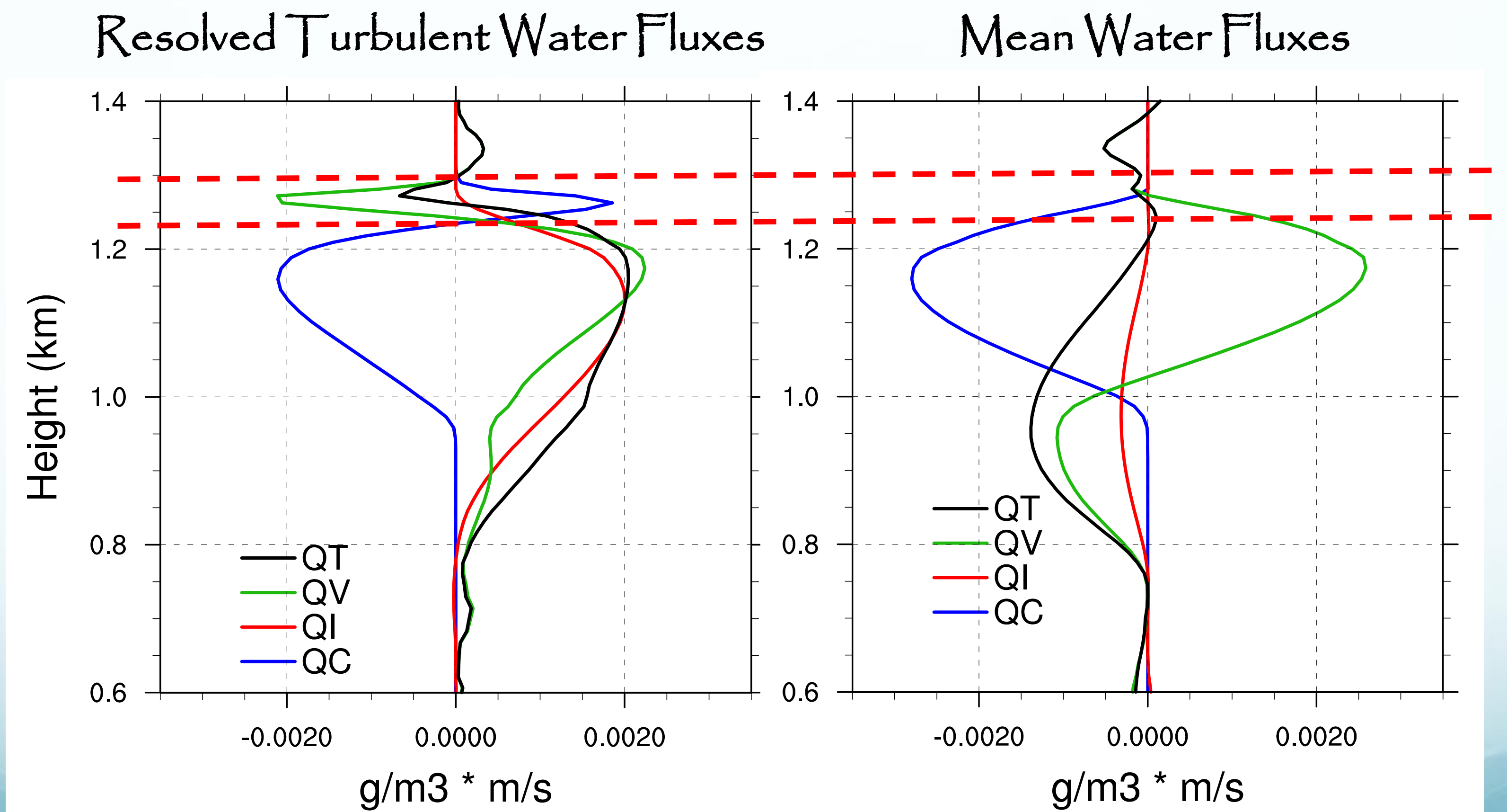
Resolved Turbulent Water Fluxes

Mean Water Fluxes



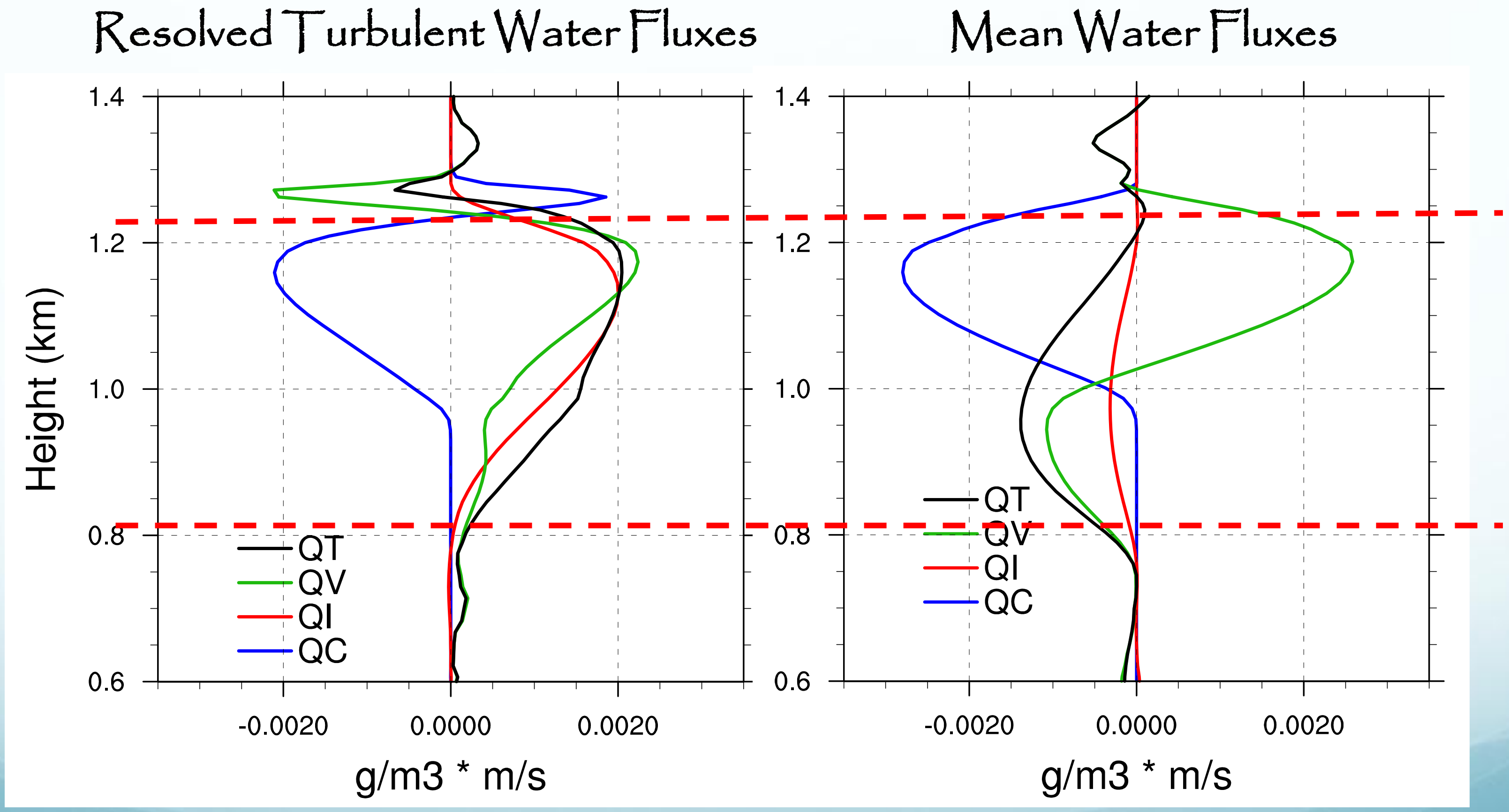
Domain Averaged Water Fluxes

Within the Upper Entrainment Zone:
Turbulent Fluxes Transport Water Vapor to EZ Base



Domain Averaged Water Fluxes

Fluxes at Mixed Layer Top are Larger than at the Base:
Sedimentation is the Primary Sink of Water from the Mixed Layer

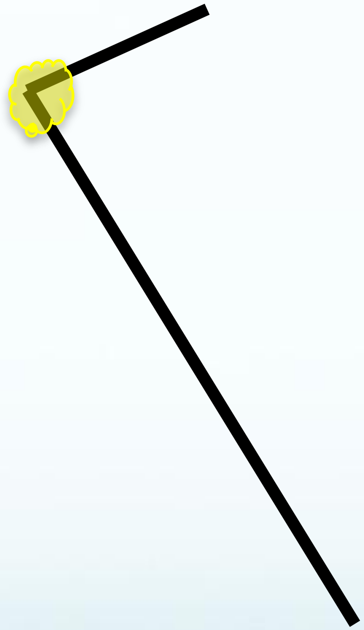


AMPS Conceptual Model

Given a temperature + humidity inversion…

AMPS Conceptual Model

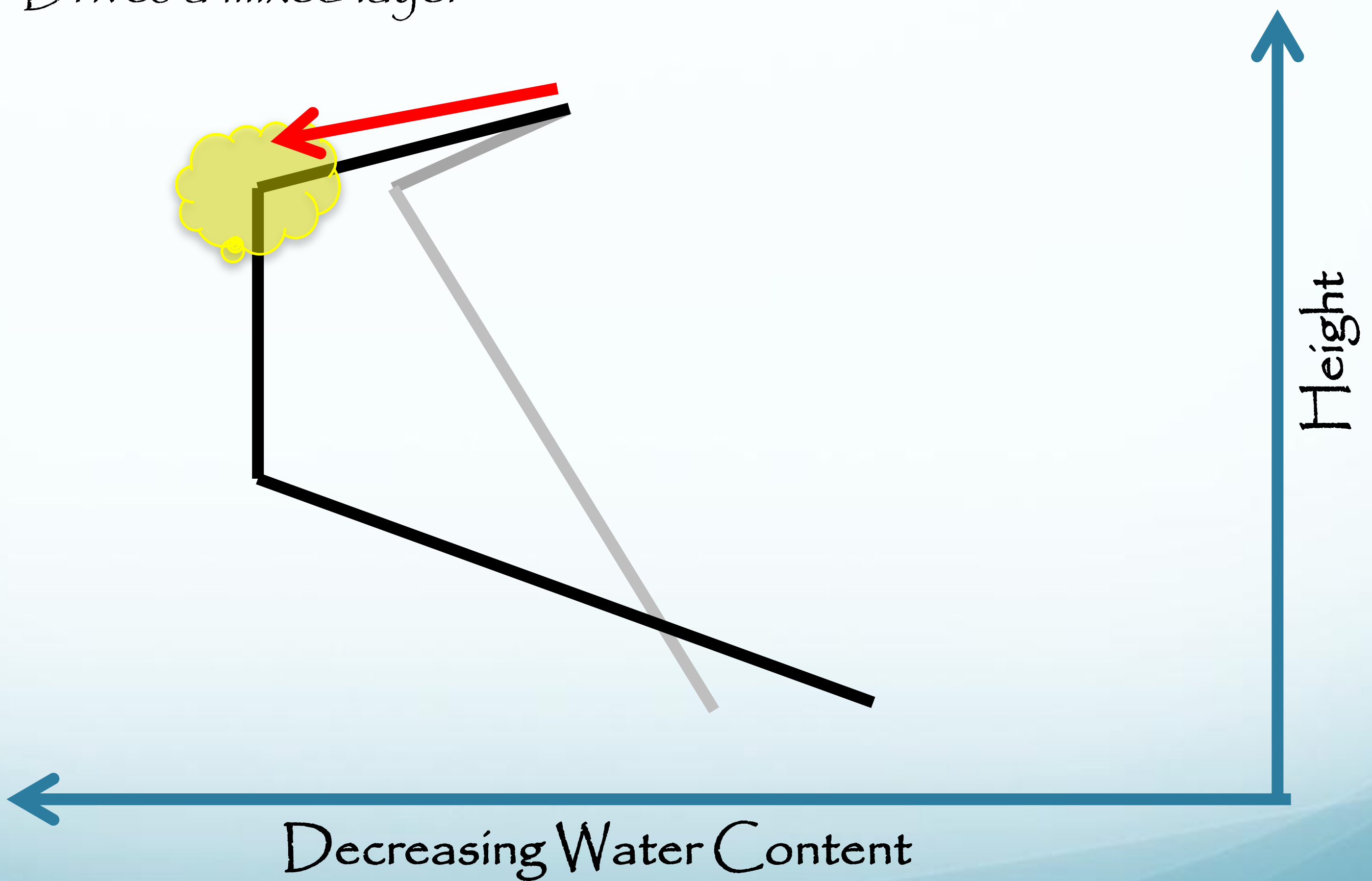
And liquid water forming at the base of the inversion



AMPS Conceptual Model

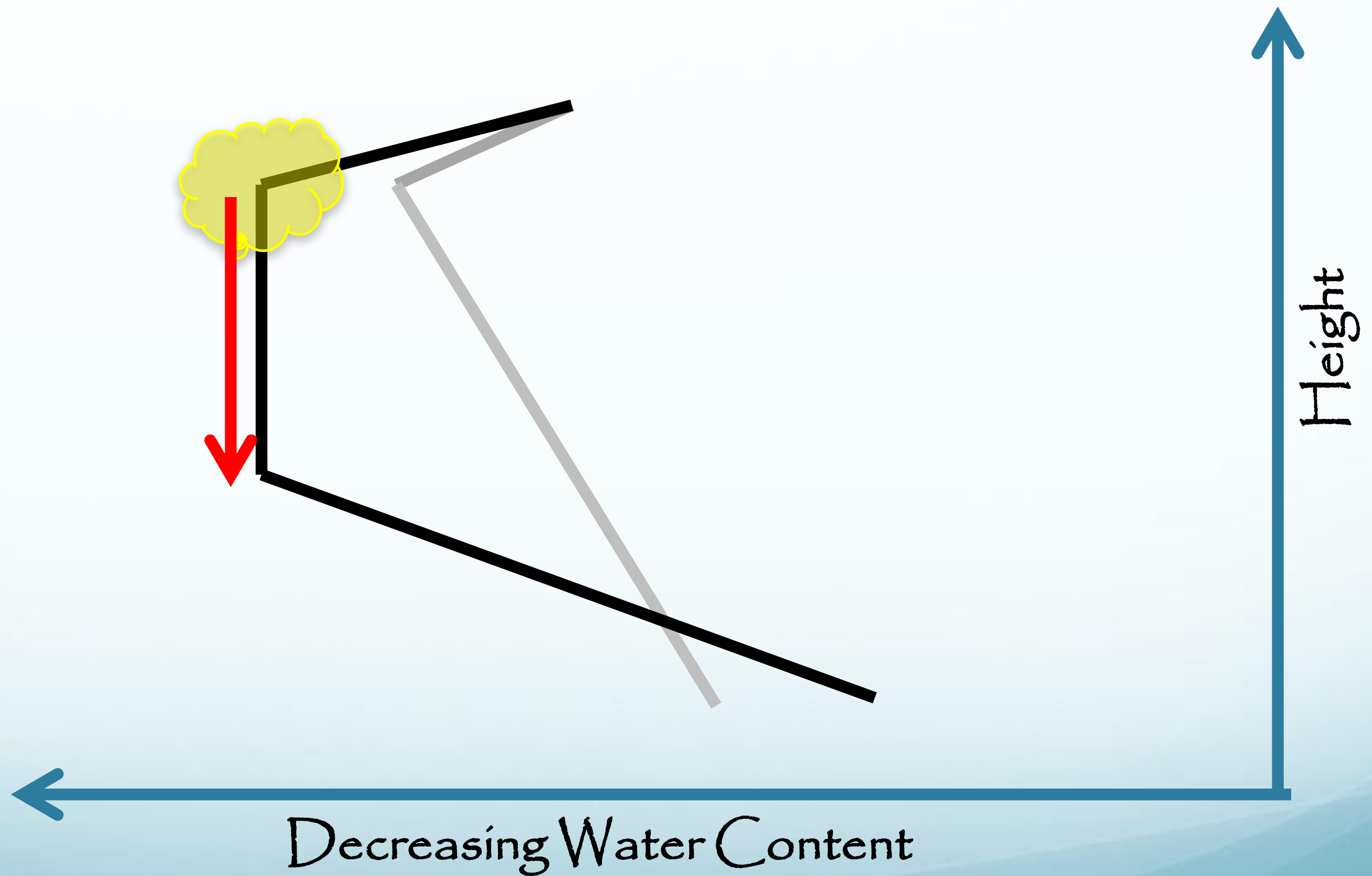
Longwave cooling forces turbulence that

1) Mixes water vapor downward --that increases the inversion and maintains the cloud layer--
2) Drives a mixed layer



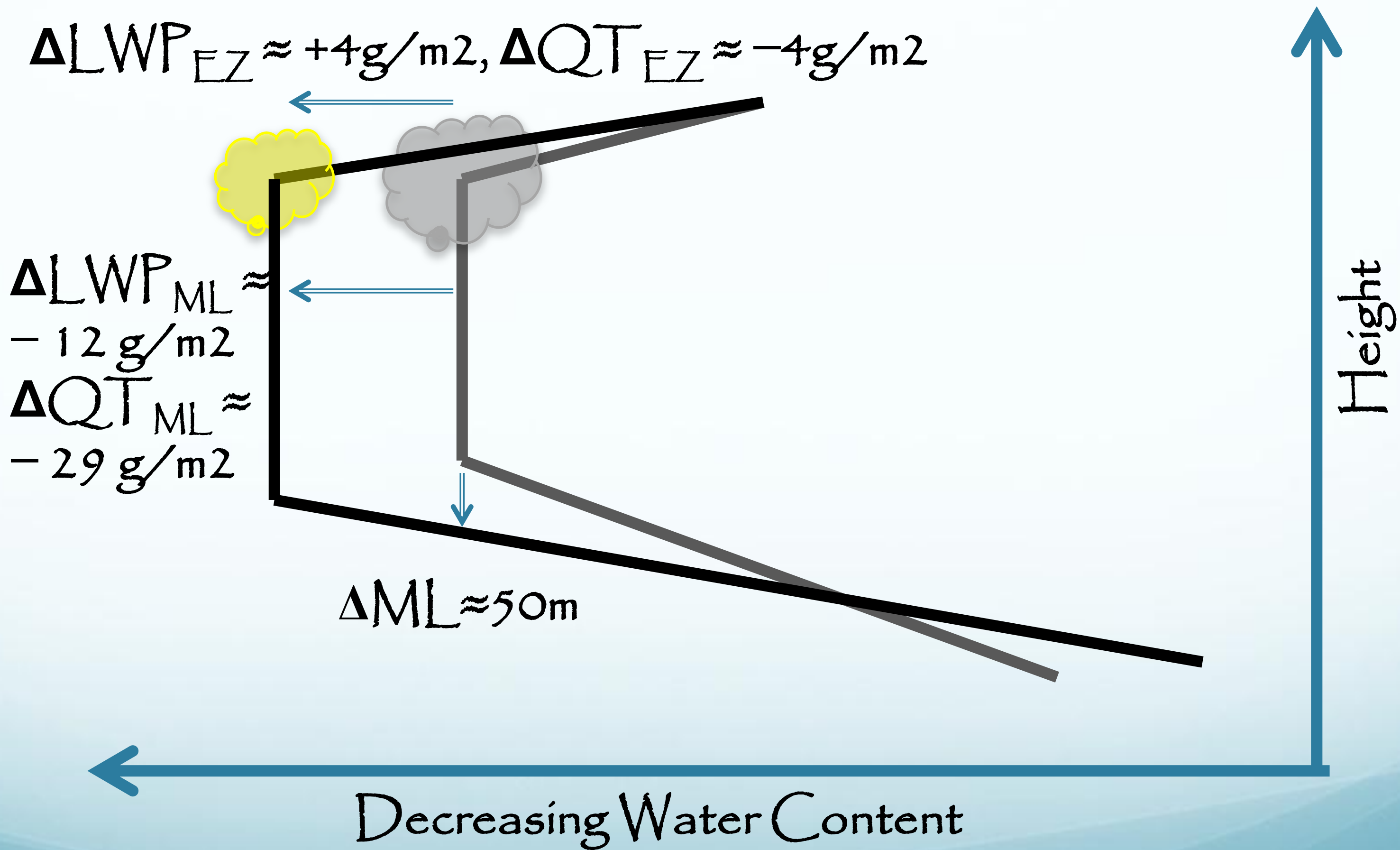
AMPS Conceptual Model

And mixes the cloud water into the mixed layer where it evaporates



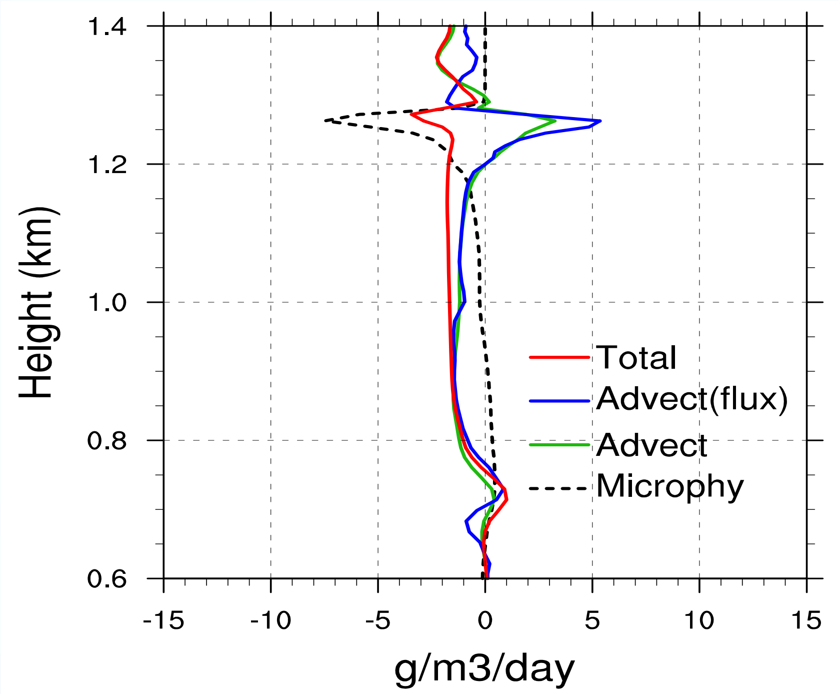
AMPS Conceptual Model

Over an hour…

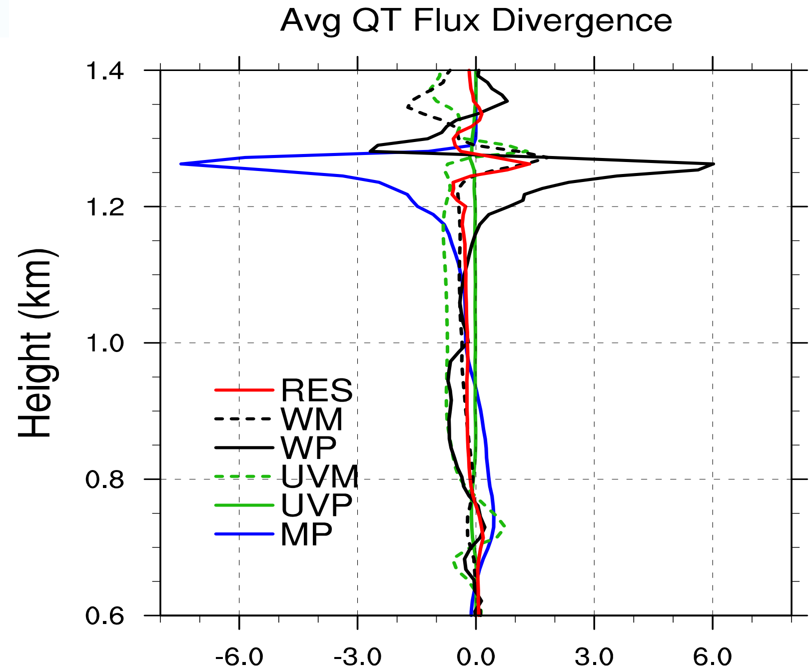


Thank you for your attention!

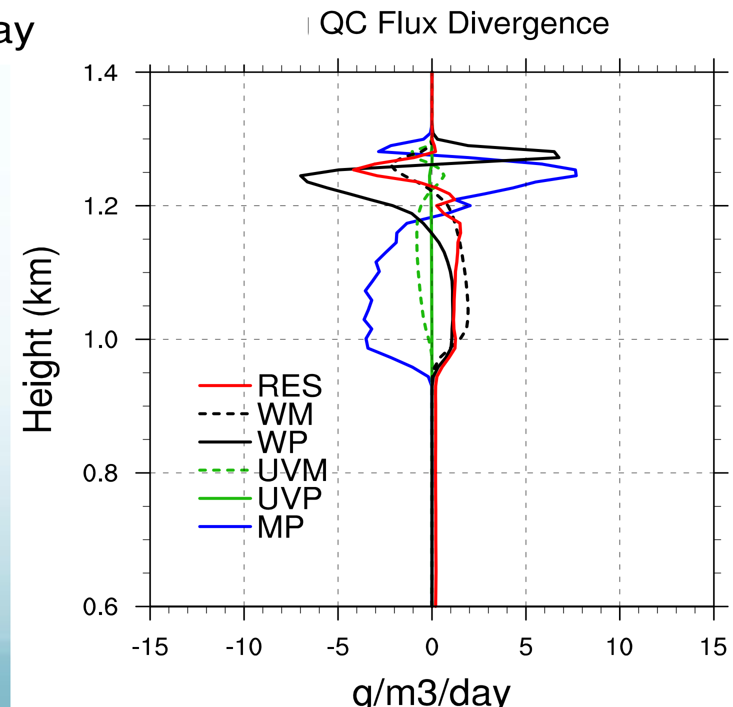
...Questions?



1.4
1.2
1.0
0.8
0.6
Height (km)
-15
-10
-5
0
5
10
15
g/m3/day
Total
Advect(flux)
Advect
Microphy



Avg QT Flux Divergence
1.4
1.2
1.0
0.8
0.6
Height (km)
-6.0
-3.0
0.0
3.0
6.0
RES
WM
WP
UVM
UVP
MP



QC Flux Divergence
1.4
1.2
1.0
0.8
0.6
Height (km)
-15
-10
-5
0
5
10
15
g/m3/day
RES
WM
WP
UVM
UVP
MP