Disturbed and Undisturbed Boundary Layers Over the Tropical Ocean

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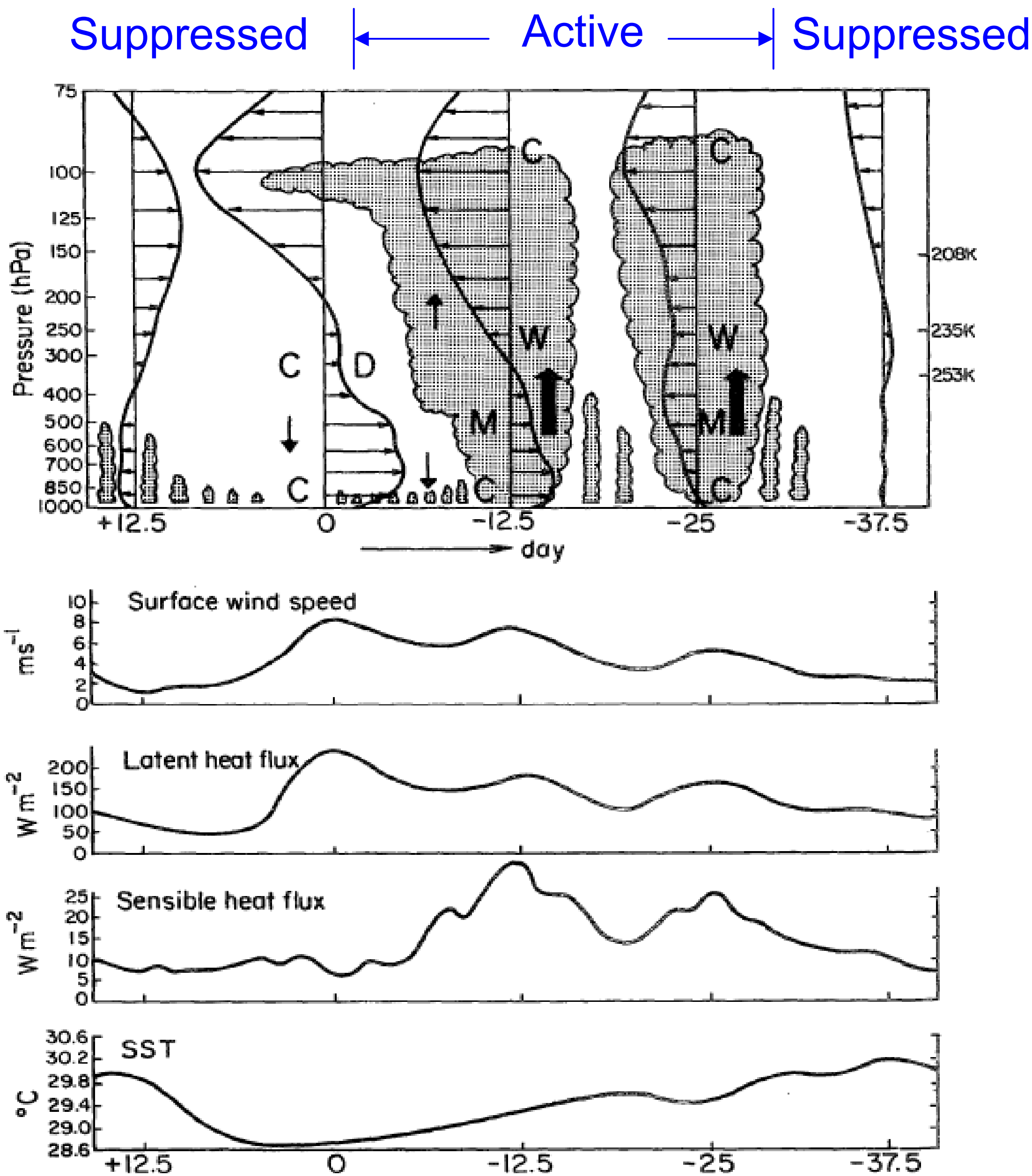
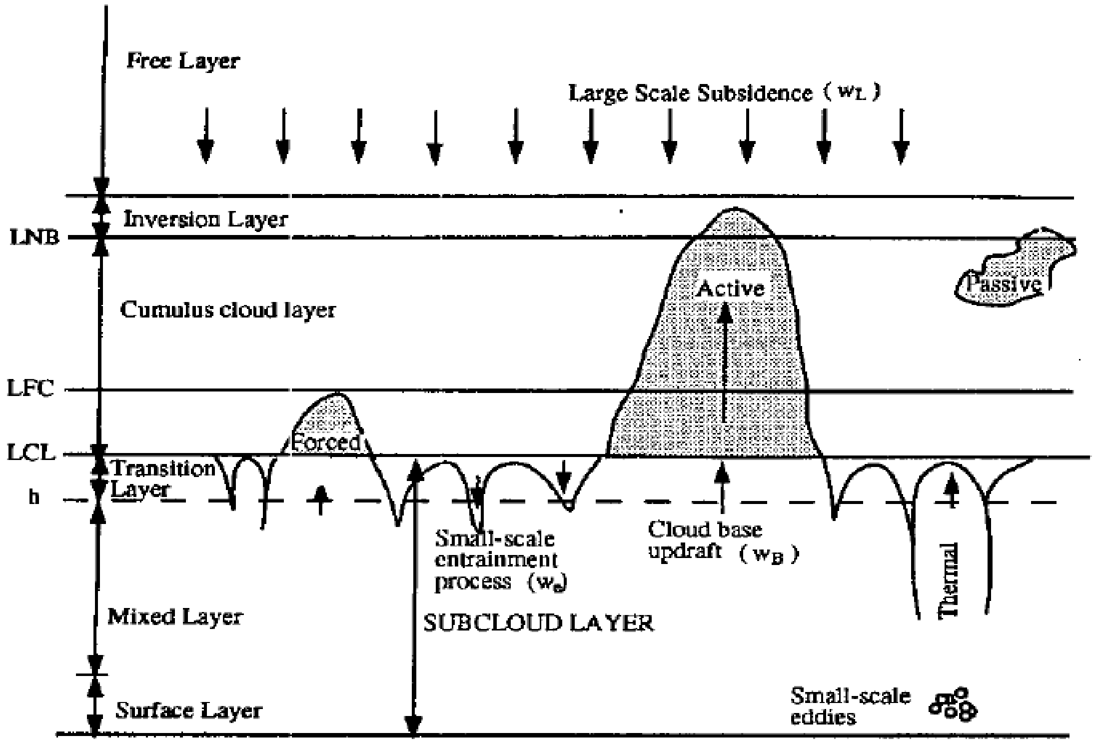
The Atlantic Tradewind Experiment (ATEX)
The Barbados Oceanographic and Meteorological Experiment (BOMEX)
The GARP Atlantic Tropical Experiment (GATE)
The Tropical Ocean–Global Atmosphere Coupled Ocean–Atmosphere Response Experiment (TOGA COARE)
The Indian Ocean Experiment (INDOEX)

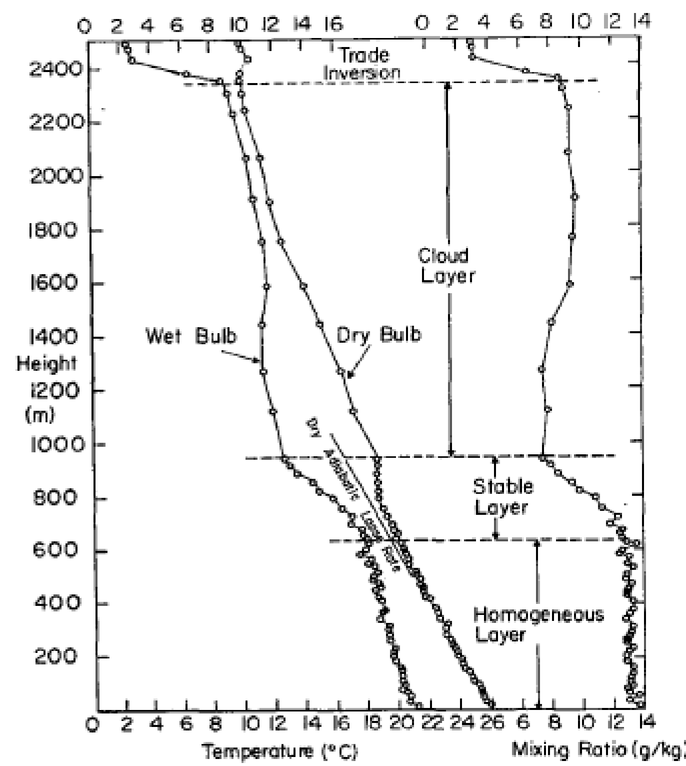


(Lin and Johnson 1996)

Shallow Cumulus Boundary Layers



Oeltes and Young 1996)



Mean Characteristics:

- A well-mixed subcloud layer (600-800 m)
- A transition layer 100-300 m in depth below cloud
- a conditionally unstable cloud layer
- a trade inversion (several hundred meters)

(Malkus 1956)

Idealized Two-layer Structure: Albrecht Model

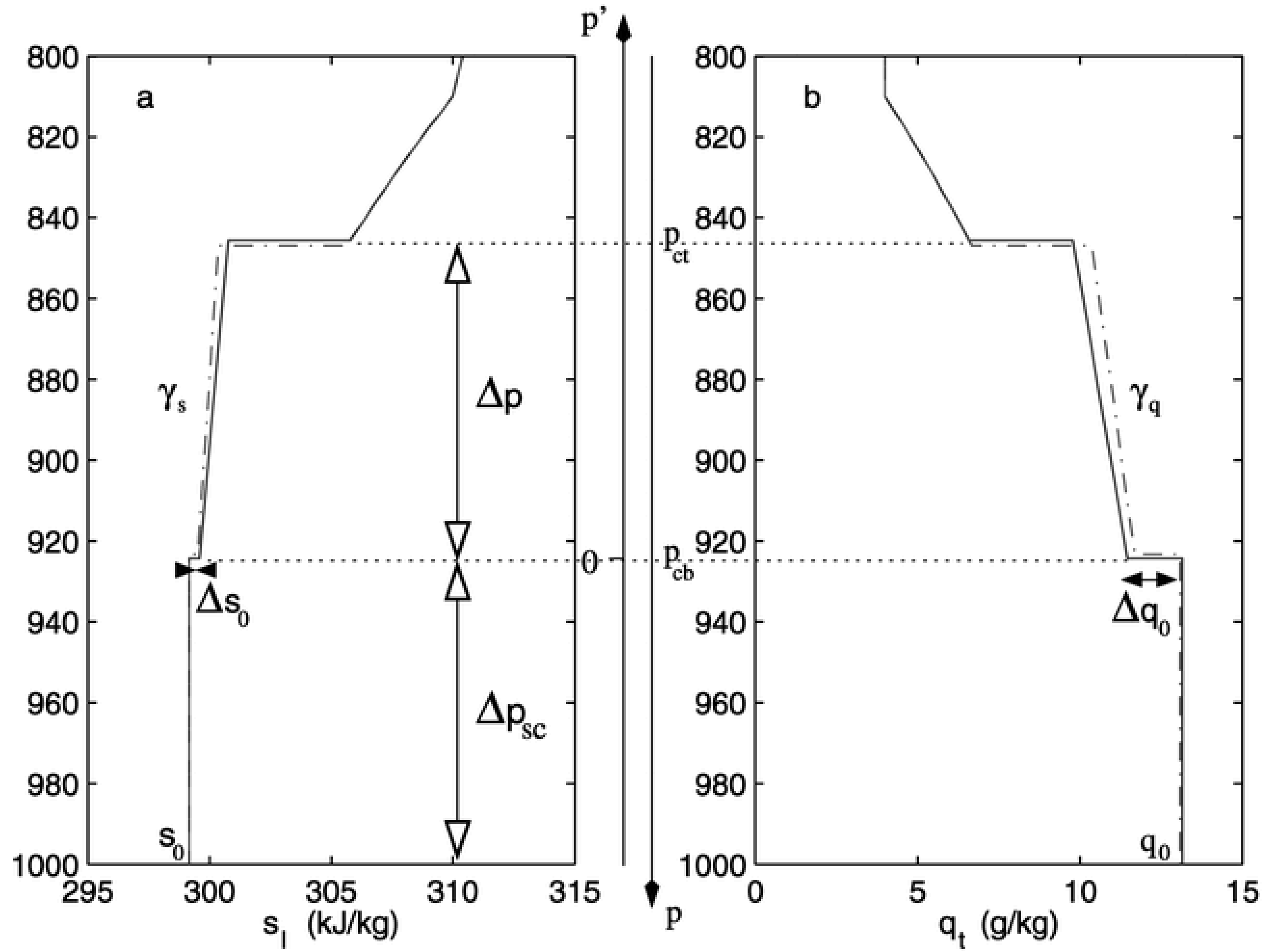
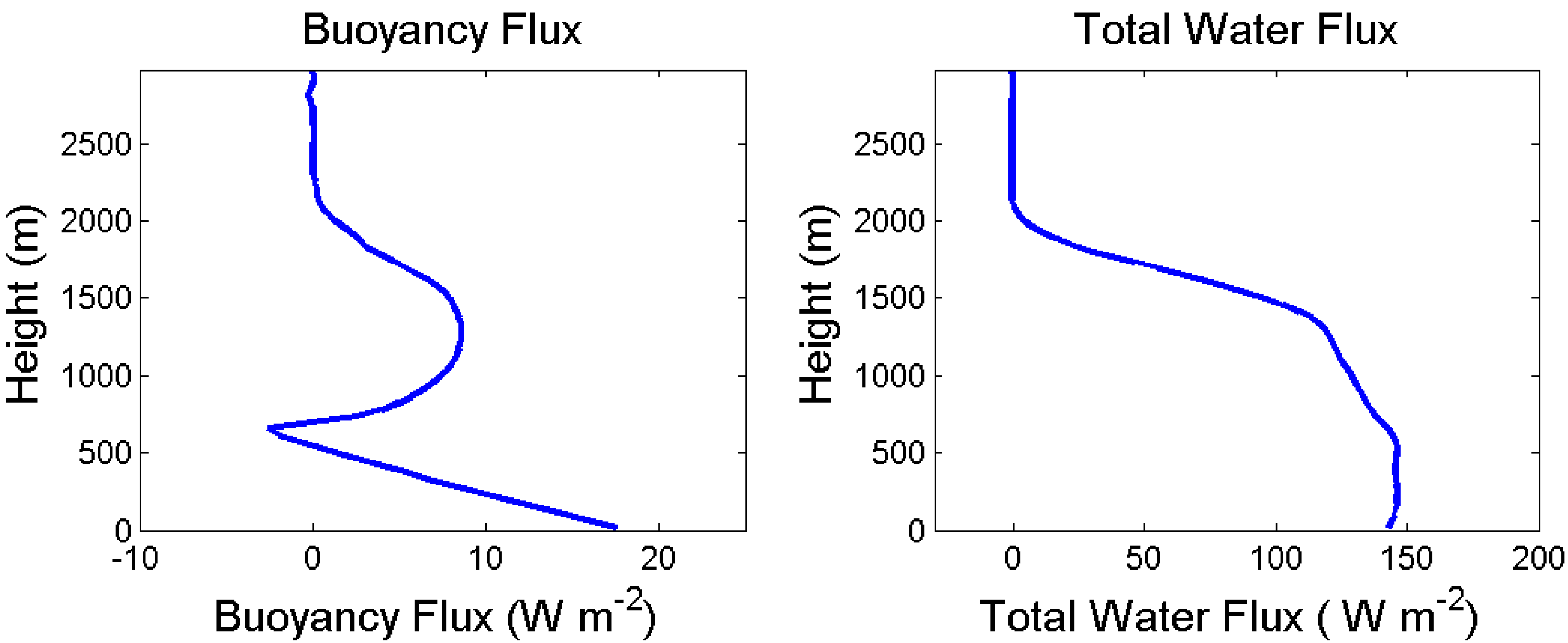


Fig. 1. Profiles of (a) liquid static energy and (b) total water produced by Albrecht model
dotted line: Albrecht model without linearization of the cloud − environment difference.

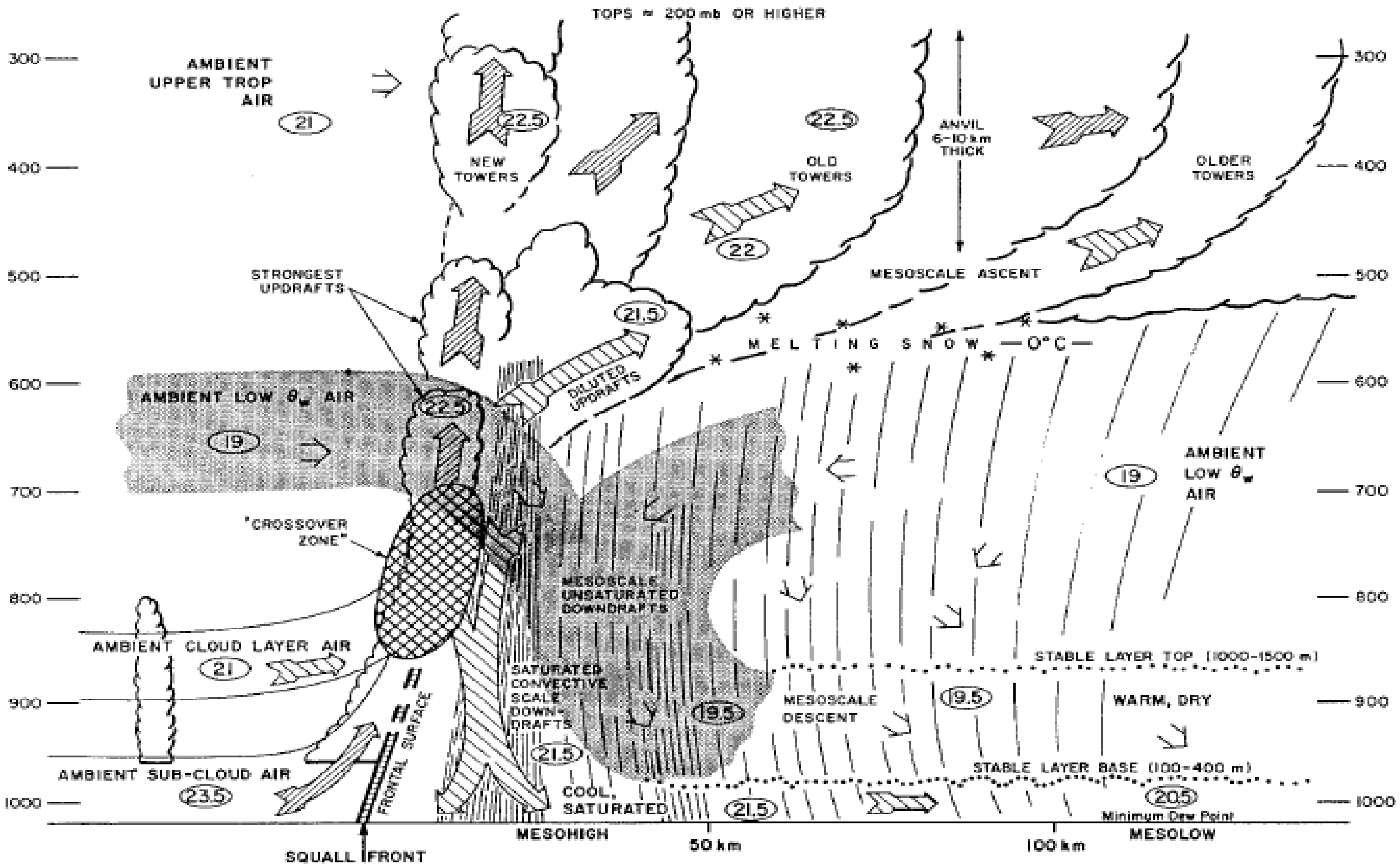
Turbulence Characteristics of the Shallow Cumulus BL



(S. Wang)

- Surface buoyancy flux drives turbulence in the subcloud layer
- Condensation in updrafts produces positive buoyancy flux in the cloud layer
- Negative entrainment buoyancy flux is present at the top of subcloud layer
- There is large latent heat flux in both subcloud and cloud layer

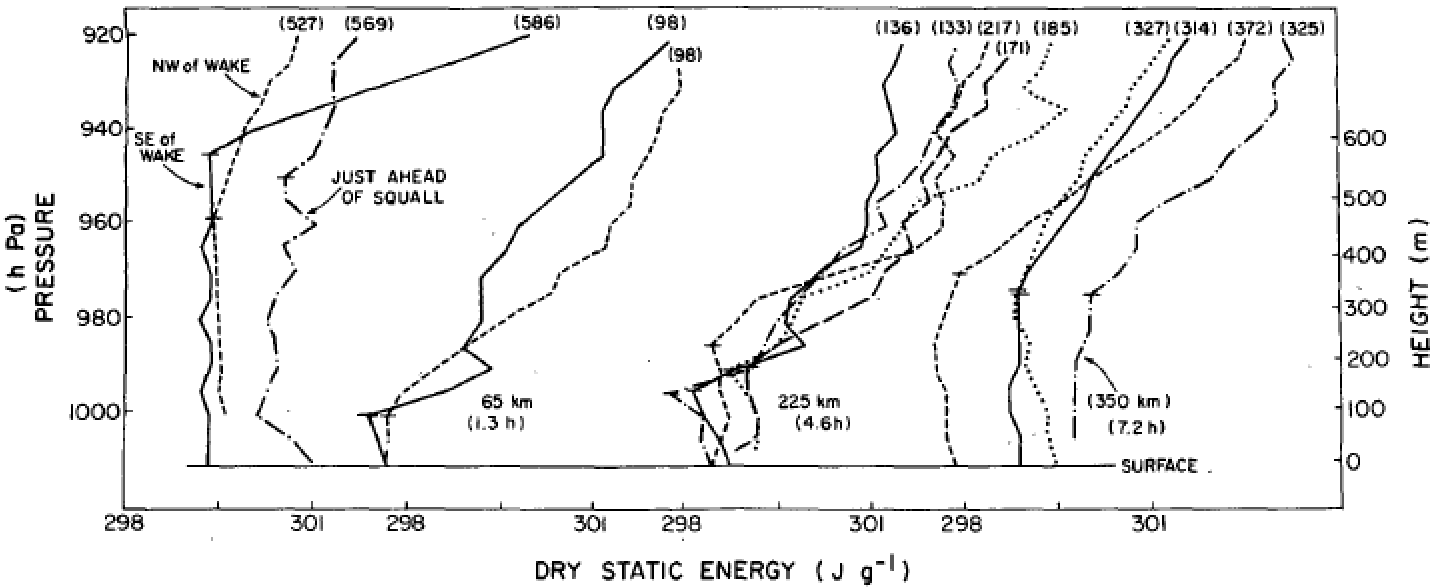
The Disturbed Boundary Layer

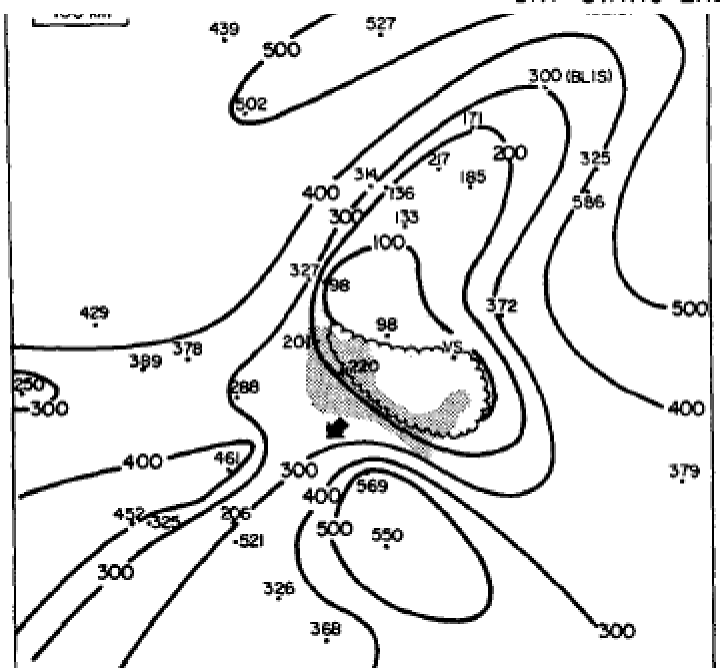


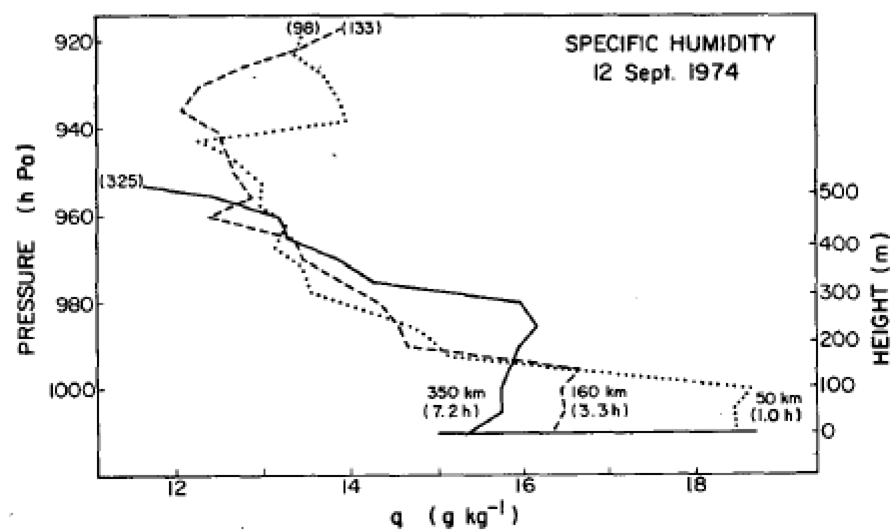
(Zipser 1977)

- Transient
- Large spatial variability

Disturbed BL behind a squall line



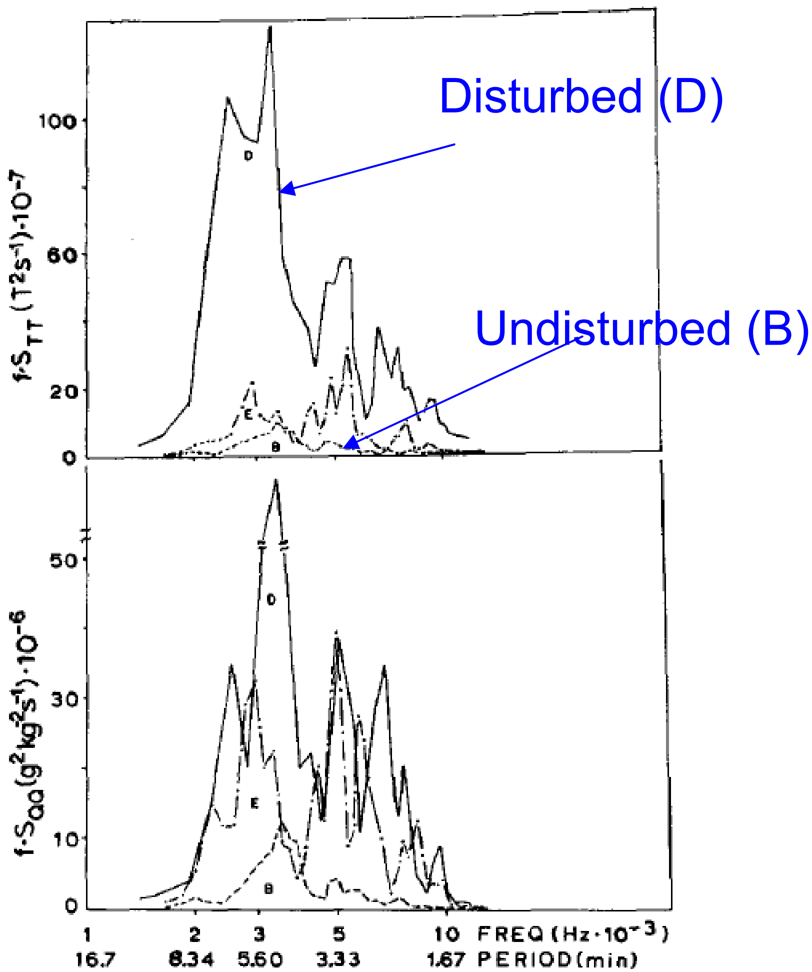




(Johnson et al 1983)

Cloud layer-subcloud layer coupling

Variance spectra in subcloud layer



Echternacht and Gartang (1976)

Findings from turbulence measurements in the upper mixed layer:

- Convectivity significantly change the subcloud turbulence characteristics
- Entrainment relationship at the subcloud layer top acts differently from the undisturbed cases.

Lack of data in the middle and upper subcloud layer to verify these results.

Measurement Needs for Further Understanding the Disturbed BL

More comprehensive sampling of the disturbed BL behind convective systems: Vertical and horizontal variations of turbulence and thermodynamics, microphysics of the evaporating precipitation, and radiation field.

Key questions:
How precipitation affects the vertical turbulent transport in the disturbed BL?

What new data analyses techniques are needed to study the transient wake BL and the larger scale effects in the BL?

Making the connection to GCMs and Forecast Models

1) meaurement-based algorithm

→ numerical forecast

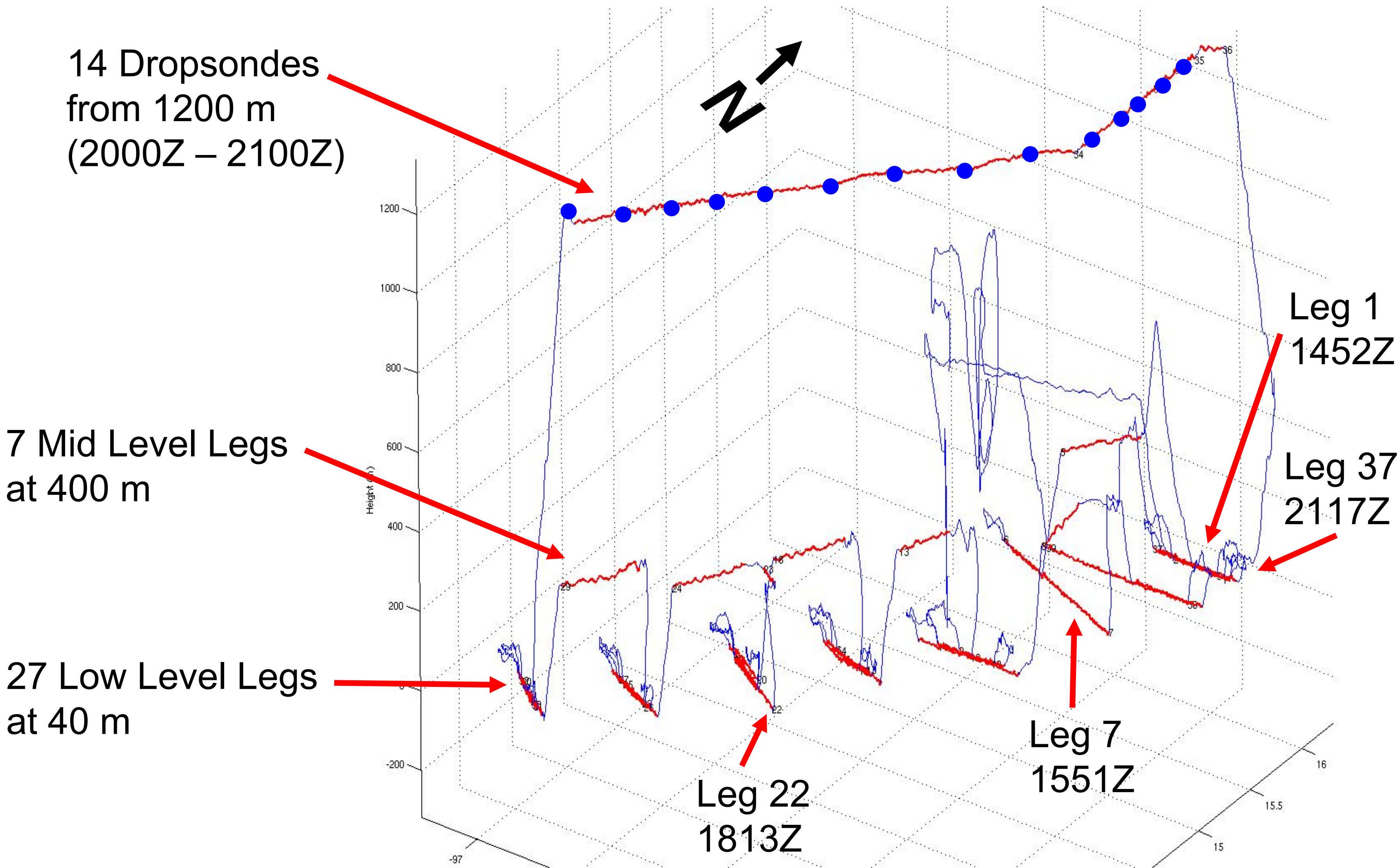
At what scale are the mean quantities are predicted?

2) Evaluation of proposed BL parameterizations in the disturbed BL (e.g., Redelsperger et. al., 2000)

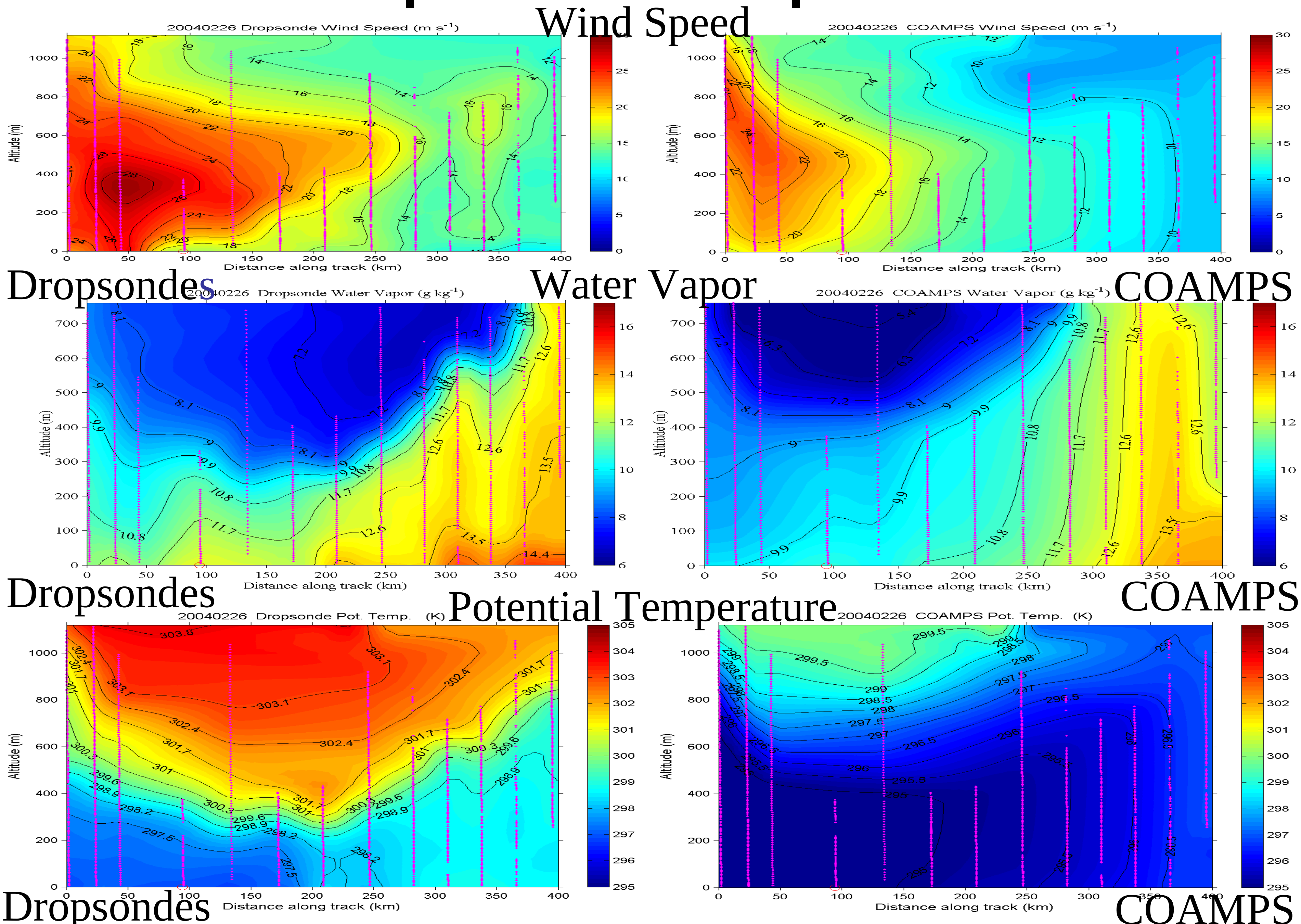
How can we make the connection between model variables (e.g. mass flux) to measurement derived quantities?

Aircraft vs COAMPS Comparisons

RF09: 14Z – 22Z 26 February 2004

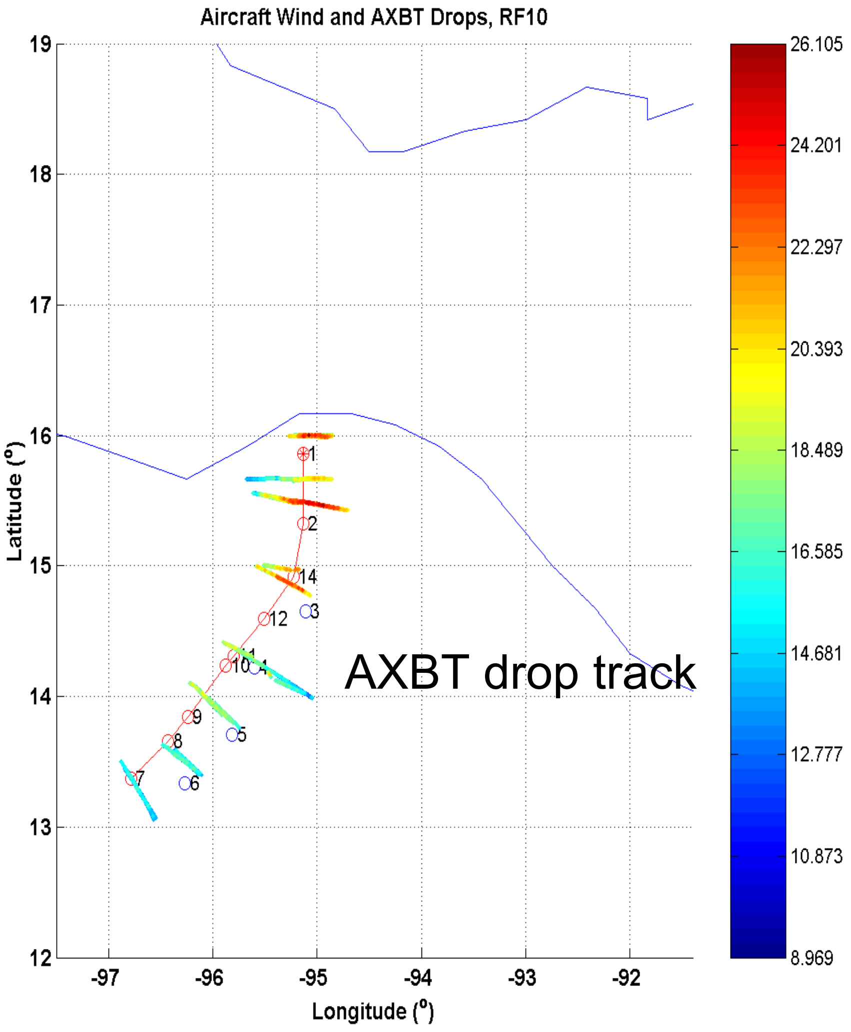


Dropsondes Comparison

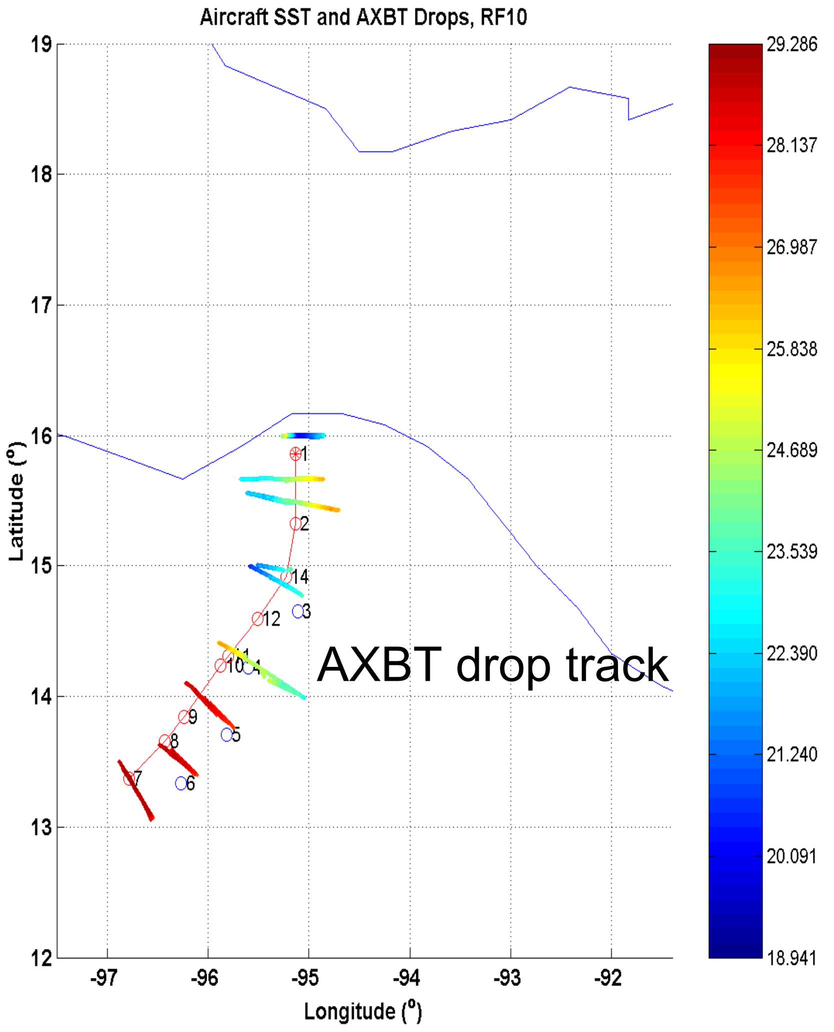


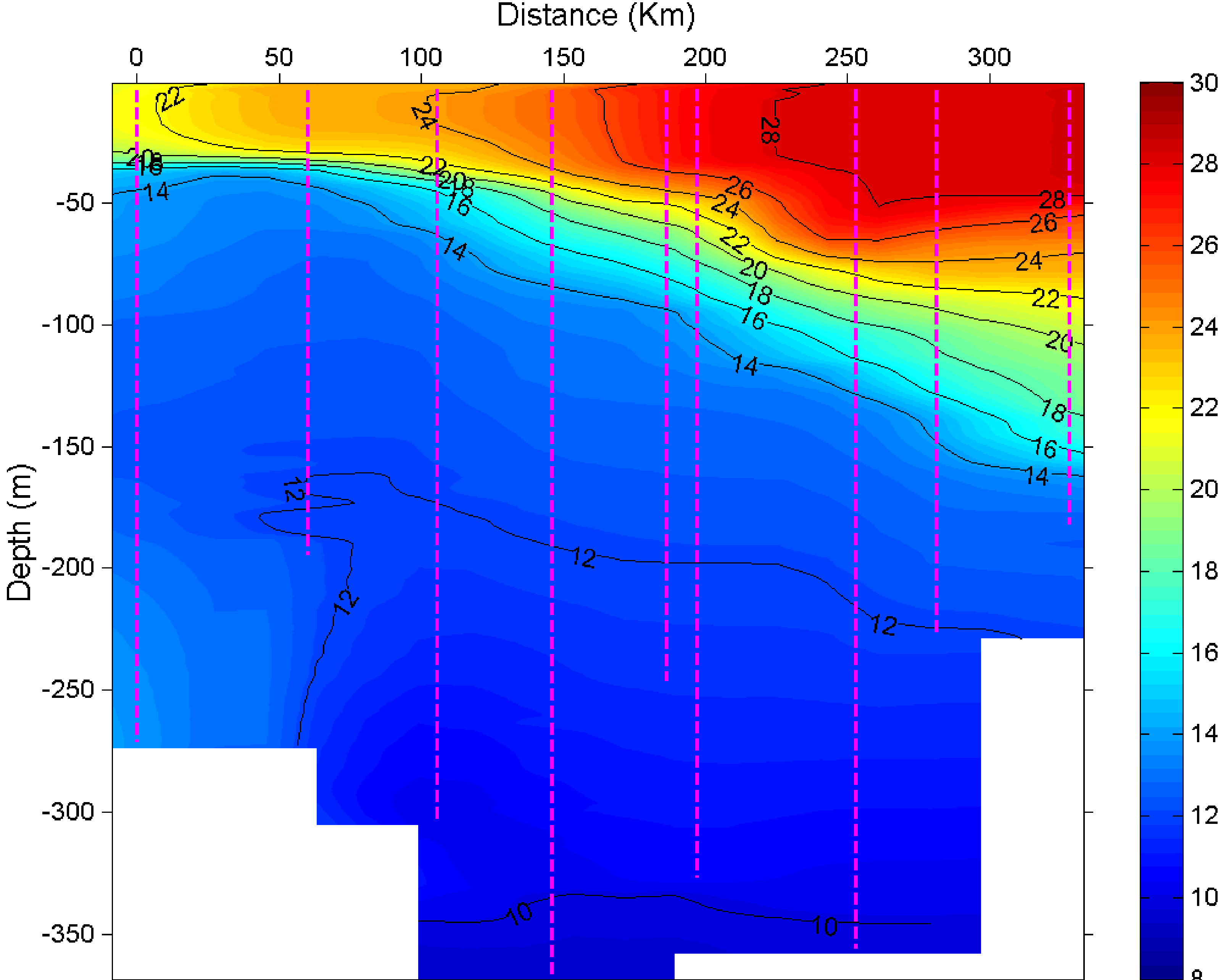
Aircraft Measurements, Feb 27

Wind Speed

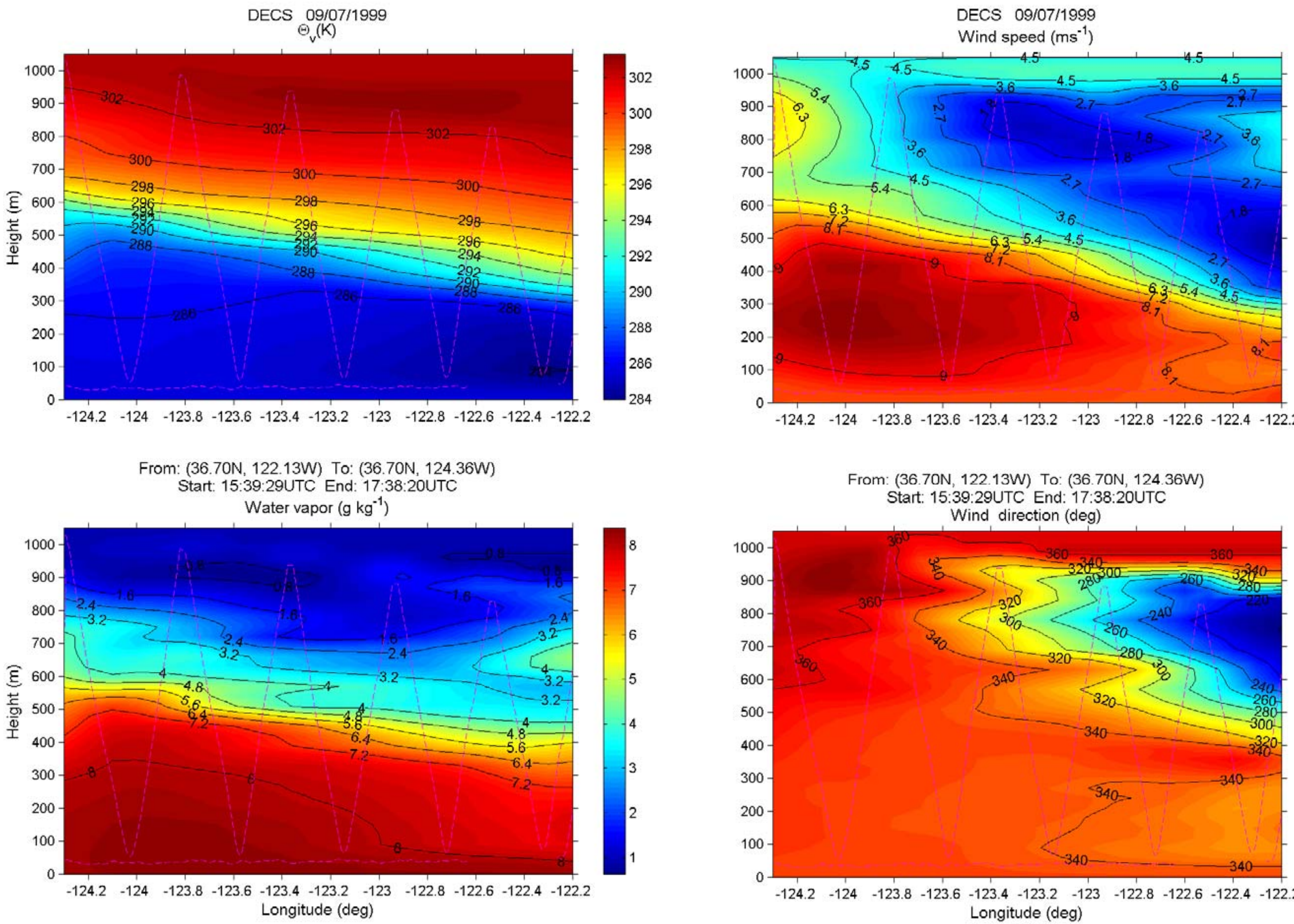


SST





Feb. 27, 2004 (RF10) AXBT Ocean Temperature (^{o}C)



DECS 09/07/1999
Θ_v(K)
DECS 09/07/1999
Wind speed (ms^{-1})
From: (36.70N, 122.13W) To: (36.70N, 124.36W)
Start: 15:39:29UTC End: 17:38:20UTC
Water vapor (g kg^{-1})
From: (36.70N, 122.13W) To: (36.70N, 124.36W)
Start: 15:39:29UTC End: 17:38:20UTC
Wind direction (deg)
Height (m)
Longitude (deg)