Boundary-Layer Decoupling as Observed in VOCALS-REx

Christopher R. Jones, Department of Applied Mathematics, University of Washington, Seattle USA Christopher S. Bretherton, Departments of Atmos. Sci. and Applied Math, University of Washington, Seattle USA David Leon, Department of Atmospheric Science, University of Wyoming, Laramie USA

Objective

Use comprehensive airborne profile/remote sensing dataset from VOCALS-REx to study key factors regulating decoupling and early-morning cloud cover in SE Pacific cloud-topped boundary layers (CTBLs).

Importance of CTBL decoupling

- CTBLs can *decouple* into separate turbulent layers driven by surface fluxes and by cloud processes.
- Vertical structure of CTBL important to ... Cloud cover
- Vertical mixing processes
- Precipitation
- Subtropical Sc-Cu transition Decoupling allows CTBL to deepen without cloud thickening.



FIG. 4. A schematic of the transition from stratocumulus to trade wind cumulus



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A typical VOCALS flight













 Δz_{B} = Leg-mean lidar cloud base – 150 m LCL

Leg and profile measures are consistent



 $\Delta \theta_L \text{ and } \Delta q_T \text{ correlated } \quad \Delta z_B \text{ and } \Delta q_T \text{ correlated }$

Testing decoupling mechanisms

Diurnal – inadequate midday sampling Drizzle – cloud radar gives drizzle proxy Moisture flux – bulk estimates from subcloud legs Deepening – correlate with depth of cloud layer



Drizzle and stronger LHF promote decoupling, but are not required.

Inversion jumps, cloud cover & decoupling

Inversion jumps: calculated objectively in non-POC profiles; visually in POCs.

Moist jump parameter $\kappa = 1 + c_p \Delta \theta_L / L \Delta q_T$ Cloud fraction: for pre-10 LT profiles with adjacent subcloud legs.



Inversion jump results



- Broken cloud sometimes seen with κ > 0.3, but cloud cover mostly larger than LESpredicted range from Lock (2009, QJRMS)
- Many decoupled CTBLs with κ < 0.4 are 100% cloudy.
- 3. POC and non-POC distributions overlap.

Learn more in our submitted paper:

http://www.atmos-chem-phys-discuss.net/11/8431/2011/

Conclusions

• Aircraft lidar/radar/LCL and profile measurements show early-morning Sc-capped boundary layers in which 'well-mixed' cloud thickness

 $\Delta z_{M} = z_{inv} - LCL > 400-500 \text{ m}$

- are typically decoupled; otherwise they are typically well mixed.
- Drizzle formation promotes, but is not required, for decoupling.
- Early-morning cloud fraction is loosely correlated to inversion stability ratio κ in this region.