On the Dynamics, Thermodynamics and Radiation of Cumulus Topped Marine Boundary Layers

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Synopsis

Boundary layer (BL) cumulus clouds are an important feature of the Earth's climate system and are regularly observed over the tropical and the sub-tropical oceans. These clouds are intimately tied to the turbulence in the BL along with its thermodynamic and radiative structure. In this study, 33 samples of shallow cumulus cloud conditions are analyzed. They are derived from the ARM observing facility in Manus (19 cases) and from the deployment of the first ARM Mobile Facility (AMF-1) at the island of Graciosa in the Azores (14 cases). Data from the vertically pointing cloud radar operating at high temporal and spatial resolution are used to characterize the vertical velocity structure of these clouds. Additionally soundings are used to map the thermodynamic structure and a 1-Dimensioal radiative transfer model is used to analyze the atmospheric radiative structure.

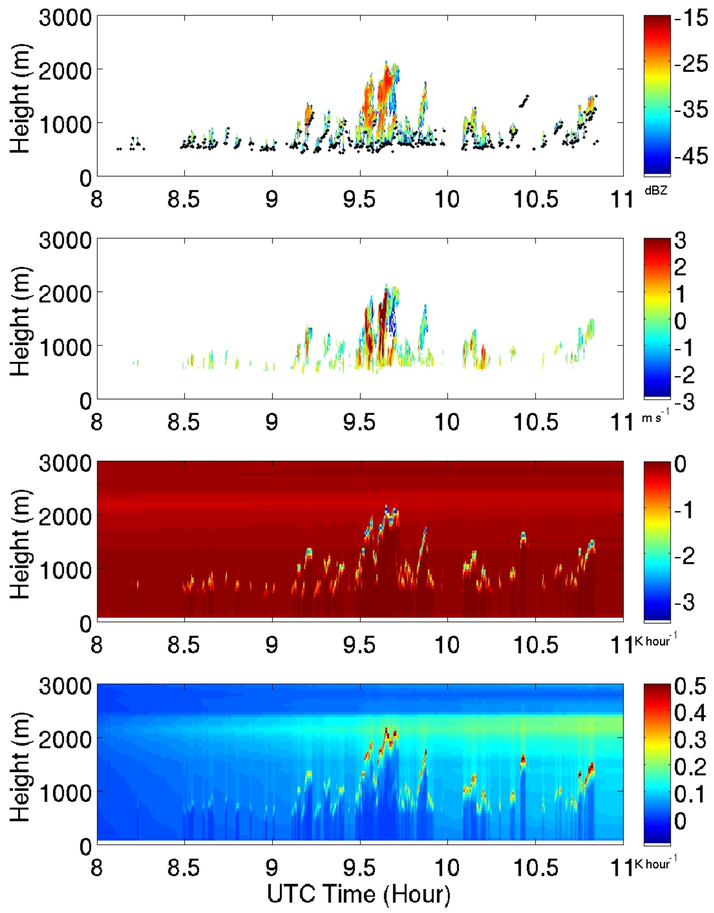

Figure 1: An example of cumulus cloud event. Shown is time-height mapping of (from top to bottom) cloud radar reflectivity, vertical velocity, longwave heating rate and shortwave heating rate. The ceilometer measured cloud base height is also shown in the top panel.

References:
Bretherton, C. S. and S. Park, 2008: *A new bulk shallow-cumulus model and implications for penetrative entrainment feedback on updraft buoyancy. J. Atmos. Sci.*, **65**, 2174-2193.
Bretherton, C.S. and S. Park, 2009: *A new moist turbulence parameterization in the community atmosphere model. J. Climate*, **22**, 3422-3448

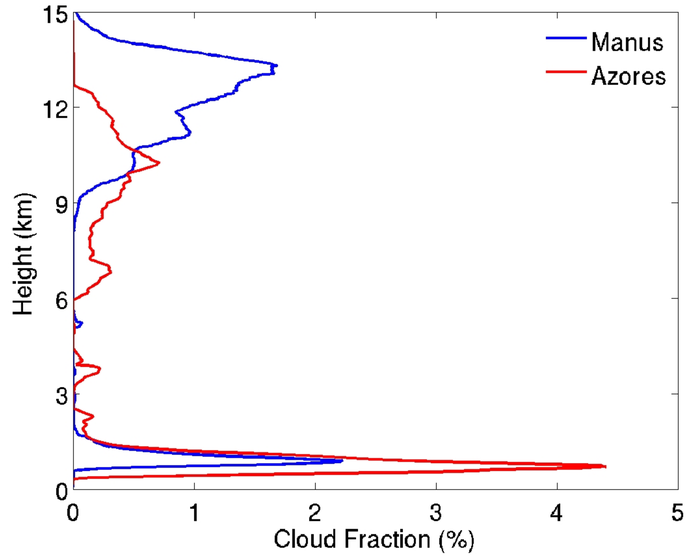

Figure 2: Averaged profile of hourly cloud fraction from all the cases for the two locations. The shallow cloud cover is higher at Azores, while the cirrus cloud cover is higher at Manus.

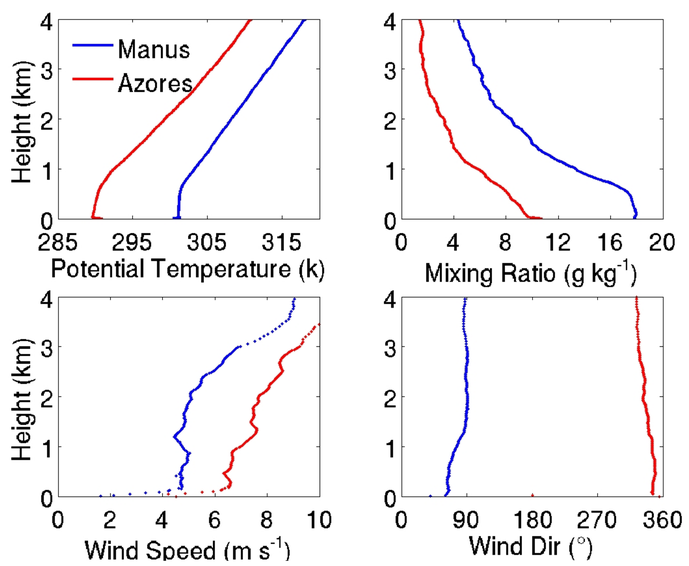

Figure 3: Averaged profile of potential temperature, mixing ratio, wind speed and wind direction at the two locations during shallow cumulus conditions.

Table 1: Mean values of parameters of shallow cumuli conditions at the two locations.

	Manus	**Azores**
Cases	19	14
Hours	272	194
Cloud Base Height (m)	758	561
Cloud Top Height (m)	1029	746
ECMWF SHF (Wm^{-2})	8.84	10.35
ECMWF LHF (Wm^{-2})	120	82.80
ECMWF Ω_{700} (mb day^{-1})	3.71	93.61
IWV (cm)	4.42	2.20

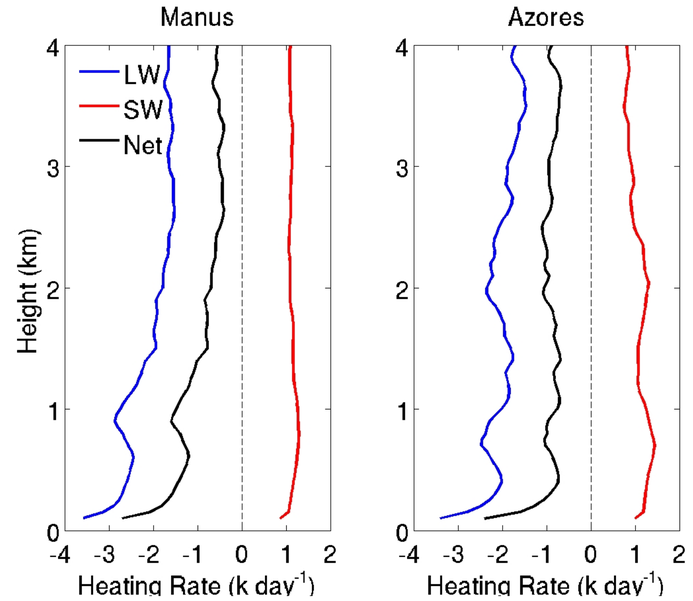

Figure 4: Averaged profile of longwave (LW), shortwave (SW) and net radiative heating rate profiles at the two locations. Radiative cooling near the BL top is little higher at Azores compared to Manus.

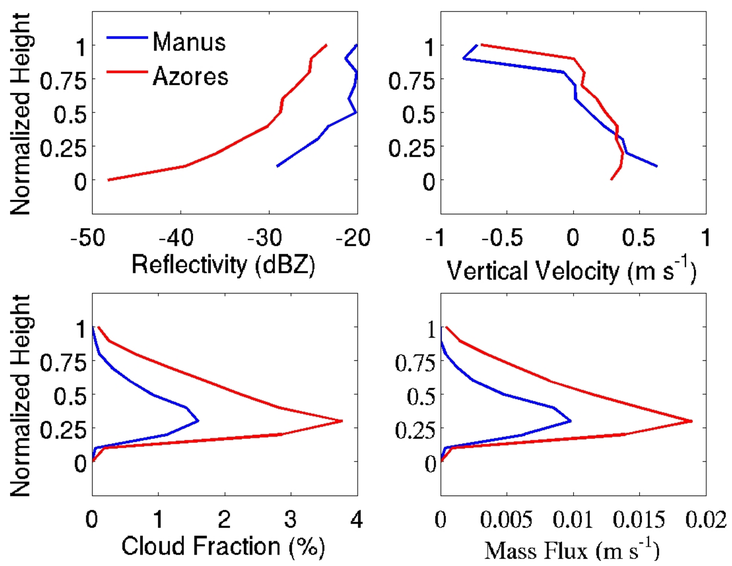

Figure 5: Averaged cloud depth normalized profiles of reflectivity, vertical velocity, cloud fraction and mass-flux for the two locations.

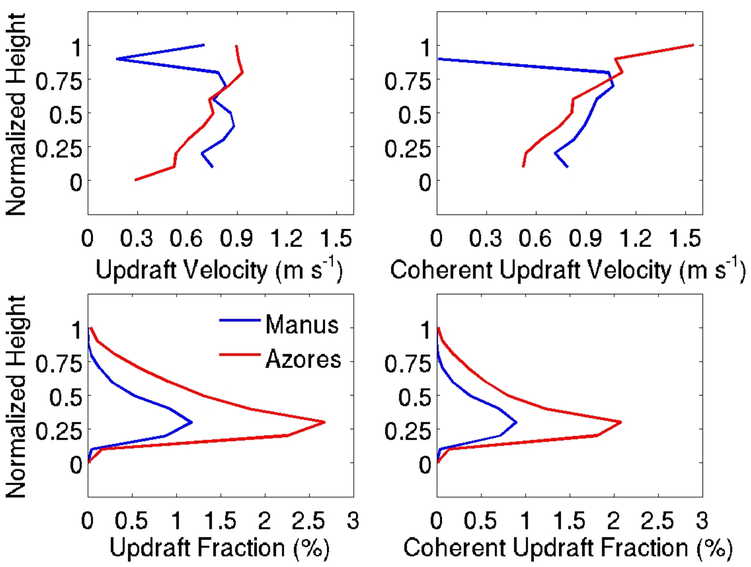

Figure 6: Averaged cloud depth normalized profiles of updraft velocity, coherent updraft velocity, updraft fraction and coherent updraft fraction for the two locations.