Turbulence Structure of Continental Boundary Layer Clouds

Virendra P. Ghate[1], Bruce A. Albrecht[1] and Pavlos Kollias[2]

1. MPO/RSMAS, Univ. of Miami, FL; 2. McGill University, Montreal, Canada.

1. Introduction:

Boundary Layer (BL) clouds cover extensive area of the earth's surface and are efficient reflectors of the incoming solar radiation making them a significant component of the earth's radiation budget. They are also closely tied to the turbulence in the BL. Although continental BL clouds cover less area than their marine counterparts they are fundamental in regulating the vertical structure of water vapor and entropy and also affect the local weather. In this study an attempt is made to characterize the turbulence characteristics of these clouds, using data from the W-band ARM Cloud Radar (WACR) at the Southern Great Plains (SGP) site.

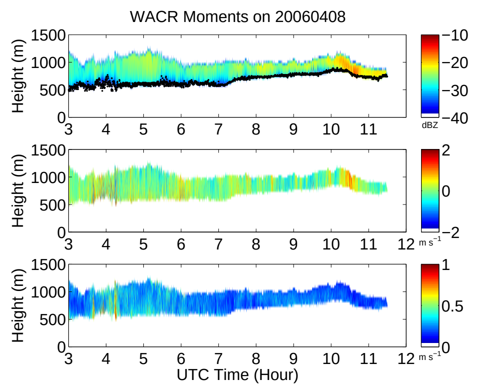

Fig 1: Time-height mapping of WACR recorded first three Doppler moments on 20060408. Also shown is the ceilometer recorded cloud base height in the top plot. This is a night-time event with decaying stratocumulus cloud which was followed by a period of clear sky for rest of the local day. Note that the local time is 6 hours behind Universal Time Constant (UTC).

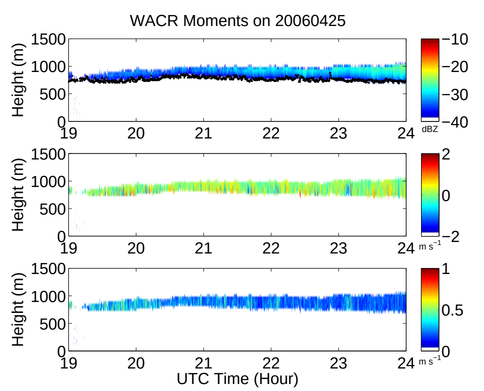

Fig. 2: Time-height mapping of WACR recorded first three Doppler moments on 20060425. This is a day-time event with developing stratocumulus cloud which was followed a by period of cloudy conditions for rest of the local day and precipitation during the early hours of next local day. Also shown is the ceilometer recorded cloud base height in the top plot.

2. Test Cases:

Shown in Fig. 1 and Fig. 2 are the two cases of continental BL stratocumulus clouds. The event on 20060408 happened at night, while that on 20060425 during late afternoon. The night-time event shows a decaying cloud which was followed by periods of clear skies, while the day-time event shows a developing cloud which was followed by periods of cloudy conditions and precipitation. The BL during both events had a similar structure with a well-mixed sub-cloud layer and weak inversion at about 1 km. Due to differences in solar heating the surface turbulent fluxes (Fig. 4) on 20060408 are negligible while those on 20060425 are considerable.

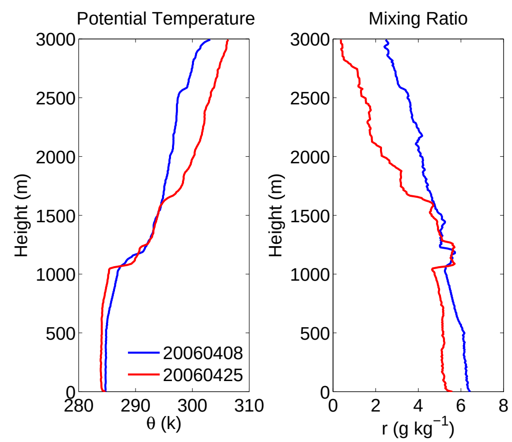

Fig. 3: Vertical profile of potential temperature (θ) and mixing ratio (r) from radiosondes launched at 0533 UTC on 8 April 2006 and 2328 UTC on 25 April 2006.

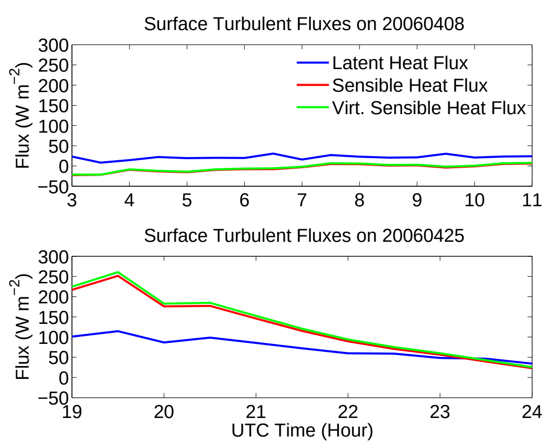

Fig. 4: Surface latent, sensible and virtual sensible heat fluxes on 8 April 2006 (top) and 25 April 2006 (bottom). Surface buoyant forcing is negligible on 8 April 2006 while considerable on 25 April 2006 due to daytime solar heating.

3. Summary & Future Work:

ARM cloud radars offer unique dataset to study BL clouds. The high resolution data from WACR and MMCR can be used to study the turbulence in these clouds. The measurements from other instruments like balloon-borne sounding system, surface met. station, surface flux measurements can be used to study the coupling of in-cloud turbulence characteristics with BL variables like PBL depth, inversion height & strength etc. and with surface forcing variables like turbulent fluxes, convective velocity scale etc. The future work will focus on expanding the analysis to a larger dataset and developing climatology of in-cloud turbulence variables for variety of conditions.

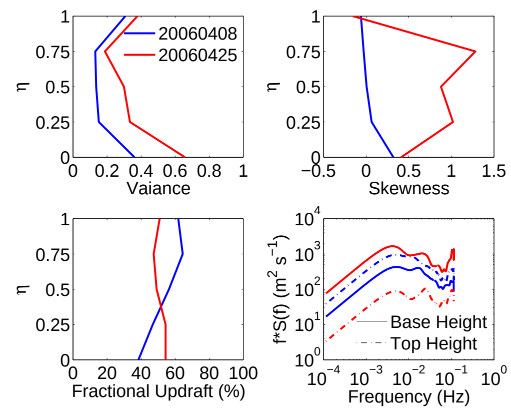

Fig. 5: Vertical velocity variance (top left), skewness (top right), fractional updraft coverage (bottom left) as a function of cloud depth normalized height (η) for 0600 UTC on 8 April 2006 (blue) and 2100 UTC on 25 April 2006 (red). Also shown is the cloud top and base height power spectra (bottom right) for the period. Please note that a bias is added to the power spectra for clarity purpose.

References:

Kollias P. and B. A. Albrecht, 2000: The turbulence structure in a continental stratocumulus cloud from millimeter wavelength radar observations. *J. Atmos. Sci.*, **57**, 2417-2434.

Kollias P., B. A. Albrecht, R. Lhermitte and A. Savtchenko, 2000: Radar observations of updrafts, downdrafts and turbulence in fair-weather cumuli. J. Atmos. Sci., **58**, 1750-1766.

Zhu, P., B. A. Albrecht and J. Gottschalck, 2000: Formation and developement of noctornal boundary layer clouds over the Southern Great Plains. *J. Atmos. Sci.*, **58**, 1409-1426.

Acknowledgement:

This research was supported by Department of Energy grant DE-F602-05SER63962.

Contact Information:

Virendra P. Ghate
MPO/RSMAS, University of Miami,
4600 Rickenbacker Causeway, Miami, FL 33149 USA.
Email: vghate@rsmas.miami.edu
Phone: 305-421-4885