ACP-2010-438
Response to Referees

We appreciate the constructive suggestions made by Anonymous Referees 1 and 2, which have improved the revision of our original manuscript. In the responses below, the referee comments to which we are responding are given in small italics.

In revision, we have also introduced two small new corrections to the C130 dataset. The first is a upward dewpoint offset of 0.8 K and corresponding humidity/RH increase of approximately 5%. This is discussed in Section 4 and in a new Fig. 14, which argues for the offset based on consistency between subcloud LCL and lidar-measured cloud base in C130 flight legs under well-mixed stratocumulus layers. We have also added an attenuation correction to the Wyoming cloud radar reflectivity statistics that somewhat increases the inferred reflectivity and precipitation rate near the surface in regions of heavier drizzle. In addition to physical correctness, our motivation for this correction was that we were concerned that near-surface precipitation was being underestimated due to attenuation of the radar beam by the stronger drizzle in and just below the cloud. While the correction does slightly increase the near-surface drizzle rate, we still conclude that almost all drizzle evaporates before reaching the surface, even in the remote region in which drizzle cells can be fairly intense. The attenuation correction is described in a new Appendix. We hope the result of the corrections to the presented C130 data is to give modelers a more unbiased set of observations to compare with.

Response to Referee 1

Response to general comments

This manuscript presents ample lower atmosphere observations along 20 S during VOCALS-REx, demonstrating consistency between the multiplatform in situ observations and remote sensing. The analysis makes good use of the dataset to highlight boundary layer processes/properties, cloud droplet concentration and precipitation characteristics. One conclusion stresses that the drizzle is not solely dependent on droplet concentrations, but cloud depth and liquid water path are just as important. Overall, it is a generally well-written summary and analysis of the subtropical lower troposphere during austral spring and will provide a good basis for the VOCA assessment.

Thanks for the positive assessment

Response to specific comments

1. *15927, line 10: A reference for these slope flows in northern Chile would help (e.g., Rutllant, Fuenzalida and Aceituno 2003, JGR).*
Added

2. *15929, line 12: Is the 1 K difference a known, uncorrected instrument bias in the C130 radiometer? A brief comment on this difference is needed, especially if this data set will be used by others.*
We have inferred this bias from comparison of Reynolds SST to the C130 radiometric SST. We have also compared bulk estimates of surface sensible heat flux with eddy-correlation measurements from the subcloud legs (after accounting for the finite fraction of the subcloud mixed layer below the measurement level) and find this suggests a similar bias. This discussion has been expanded in Section 3.3 (see new Fig. 6 in the revision).

3. *15935, line 5: Is the increased variability in the transition zone basically linked to whether or not the continental air makes it out that far offshore or not? If so, is there a simple relationship between the wind and Nd that could be shown? Given the diverse back-trajectories it may not be a trivial matter, but it seems like an appropriate place to at least comment on this.*
Does the variability in MODIS-derived Nd also peak in this transition zone? An indication of the standard deviation around the MODIS mean in Fig. 10 would help to illustrate/corroborate the variability.
The revised paper uses a boxplot format to convey this information. The 10^{th}-90^{th} percentile variability is similarly large in the nearshore and transition zones. The text has been revised to note the large variability in the nearshore as well as the transition region.

4. *15936, line 1: A reference to these EPIC2001 observations (Bretherton et al. 2004) should be inserted here too.*
Done, including mentioning that Fig. 8 of that paper gives the comparison.

5. *15941, line 19: How often do these free-tropospheric moist layers occur? Is it a few days a month? Is there enough data to give us a decent idea?*

This is best assessed from the *Brown* sonde observations in this region in 2001-2008. Using time-height sections of mixing ratio from Serpetzoglou, we estimate that on 4 of 15 days sampled by radiosondes at 20S 85W, the vapor mixing ratio is at least 3 g/kg just above the inversion; i. e. the moist layers appear quite frequent. Text to this effect has been added near the end of Sec. 5.1.

6. *15942, lines 9-11: The writing here could be improved.*

Superfluous 'as the C130' deleted and wording of the following sentence has been streamlined to:
'In the thinner near-shore clouds, the C130 typically flew its in-cloud legs closer to the inversion than in the remote region.'

<u>Response to suggested technical corrections:</u>

1. *15922, line 10: Typo: ". . .stratocumulus with haccumulation-mode aerosol. . ."*
2. *15933, line 8: Typo: ". . . aerosol and cconcentrations"*
3. *15934, line 1: George and Wood should be 2010 not 2009.*
4. *15936, line 8: I think the authors mean Figure 11 instead of Figure 12.*
5. *15937, line 28: Reference section does not include Comstock et al. 2004.*
6. *15940, line 5: Reference section does not include Wyant et al. 2007.*
7. *15943, line 18: "with" should be "within"*

All the above corrections are made in the revision. Thanks for catching these glitches.

Figure 5 and 6: *I have a hard time seeing the dotted lines, mostly over the darker colors (like the lower panel of Fig. 6). Perhaps larger dots would help.*

Dots have been made larger.

Figure 8: *If the lettering in the bottom right of each panel is not used, it should be removed. If it is used in the final version, they should be much bigger.*

Letters have been increased in size and referred to in text and figure caption.

Figures 10-16: *Are the figure titles really necessary? It seems like these plots were at one point individual panels in a multipanel plot and were only recently separated into individual figures.*

Titles have been removed as suggested in favor of more complete y-axis labels.

Figure 10: *In the beginning of the caption there is a '(left)' but there is only one figure.*
Figure 16: *The caption indicates panels (a) and (b) show in-cloud and subcloud, while in the actual figure cloud and subcloud are indicated by red and blue, respectively.*

Both figure captions have been corrected.

Response to Referee 2

Response to general comments

The authors present the general structure of stratocumulus cloud-topped boundary layer and lower free troposphere along 20° S using observations taken during VOCALS-Rex. Their analyses include examinations of the observed thermodynamic and wind variations, cloud microphysical properties and radiative fluxes. They conduct trajectory analysis to interpret the observations. The authors are particularly good at integrating various observations to provide a coherent view of the MBL with regard to interactions among MBL turbulence, large- and meso-scale meteorology, cloud-aerosol microphysics and radiation. This is a very informative paper and should be published in ACP.

Thanks for the positive assessment

Response to specific comments

1. *Page 7, line 16. Why is 0.5 gkg-1 used for the decoupling? Does this definition result in similar results as those used in following sections, for example, LCL-cloud base difference?*

We have another paper in preparation for ACP that is all about decoupling as observed in VOCALS, where we'll fully address how to quantify decoupling in our various observational datasets. For instance, we'll show from simple thermodynamic arguments that the 0.5 g/kg threshold corresponds to a cloud base about 125 m higher than the LCL. However, we have decided to sidestep that issue in this paper by rewording the relevant sentence to:

'All of the plotted 85{\degree}\,W profiles show a moisture gradient and s_l stratification indicative of decoupling between 500~m and 1~km altitude.

2. *Page 8, line 24. It would be better to plot potential temperature instead of temperature? After all, it is potential temperature, not temperature, which determines the stability.*

The practical reason for using T rather than theta was because it halves the range in K that needs to be plotted and therefore helps bring out the horizontal gradients. It also is more directly comparable to SST. However, for internal consistency and to better capture static stability we have replotted both Figs. 4 and 5 using the theta-like variable $s/c_p = T + gz/c_p$. This still is easily comparable to SST at the surface, an advantage for boundary-layer work compared to using theta.

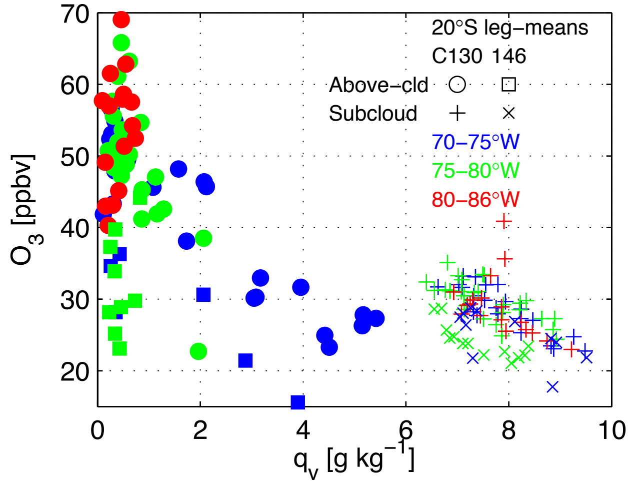
3. *Page 9, line 10. SST is still seen increasing moderately westward by about 1° C from 75° W to 85° W. This decrease should also contribute to the overall MBL stability and the westward increase of the MBL heights.*

Actually, it decreases out to 76 W then increases, with rather little net change. This can be seen in our new Fig. 6.

4. *Page 10, line 5. I am not totally convinced that the moist air is due to the mixing with the*

boundary layer (BL) air over the west slope of the Andes. The BL over the slope must be very dry. Is it possible that the moist air above the inversion near the coast may come from the northwesterly flow just above the MBL, which may originate near the equator?

The companion paper by Allen et al. (2010, ACPD, in final stages of preparation) the C130 and BAe146 measurements of humidity and ozone in the above-cloud (free tropospheric) legs. The figure is reproduced below.



The following has been added to the text:

"Allen et al (2010) hypothesize that over the west slopes of the Peruvian and Chilean Andes, moist boundary layer air is mixed into the free troposphere. Sometimes this moist air then advects offshore out to 75--80{\degree} W before subsiding into the inversion. This is particularly favored by northerly above-inversion winds, which advect air southward from the Peruvian slopes offshore across the Arica Bight. During other synoptic regimes, the moist air is trapped along the coast. They support this hypothesis using REx C130 and BAe146 ozone measurements. Ozone is generally lower in the marine boundary layer than in the overlying free troposphere. In the free troposphere within the nearshore longitude range (70-75{\degree} W), they find a correlation between low ozone and high humidity, consistent with a boundary-layer origin for the humidity. "

5. *Page 14, line 18. I have a bit difficulty in understanding the boxplots in several figures. Although I eventually figured out the meaning, many readers may have similar difficulty. Could you simply denote the mean, the first and third quartile in one of the plots?*

We have added the following text to the caption of the first boxplot (our new Fig. 6):

` In this and all following boxplots, the data (ΔT in this case) have been binned into three longitude ranges. Within each range, the plotted box extends vertically from the 25th to the 75th percentile of the data in that bin, with the median shown in the box interior, and the dashed 'whiskers' extend out to the 10th and 90th percentiles.'

To be compatible with our companion paper, Allen et al. (2010), we also have changed the whiskers on the boxplots to be the 10^{th} and 90^{th} percentiles of the binned data instead of the extrema.