

Interactive comment on “Observational constraints on entrainment and the entrainment interface layer in stratocumulus” by J. K. Carman et al.

Anonymous Referee #2

Received and published: 7 March 2012

This manuscript reports on the analysis of observations from 16 flights of the CIRPAS Twin Otter during the Physics of Stratocumulus (POST) field campaign off the coast of Monterey, CA during the summer of 2008. A sawtooth flight pattern was used for each of these flights within a layer ± 100 meters from cloud top in order to best sample the vertical structure of the entrainment interface layer (EIL) near the stratocumulus cloud top.

These observations are first used to determine the boundaries of the entrainment interface layer using the turbulent kinetic energy (TKE), θ_{v} and total water mixing ratio (section 3.1). The TKE and θ_{v} based estimates are robust and agree well with

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each other while the EIL boundaries determined using the profile of total water mixing ratio are much more uncertain and lead to inconsistency in the location and vertical extent of the EIL.

Use these observations to estimate the entrainment efficiency, which represents the fraction of the TKE produced by net cloud-top radiative cooling that is consumed by doing work against stably-stratified air by entrainment/detrainment, to provide observational constraints for modeling studies.

I would recommend that this manuscript be accepted for publication after a few revisions:

Major comments:

P834-Lines 13-25 – Could surface analyses or satellite observations be used in order to investigate some of the differences between boundary layer characteristics for the different flights? For example, is the strength of the sub-tropical high weaker on days where the humidity jump is smaller? Are the cloud characteristics (e.g., cloud fraction, cloud size) noticeably different between these cases?

P-836 The contribution of buoyancy fluxes more than 100m below the cloud top to the “boundary layer integral” represents a possibly large uncertainty in this quantity. I believe that it is important to offer some estimate of this contribution. Could the atmospheric profiles from 30 meters to 1000 meters done at the beginning and end of each sawtooth patterned flight be used to make some estimate of the positive buoyancy fluxes that are not accounted for in the entrainment efficiency calculations? While this would not be perfect, it might at least give an idea of the errors in the calculation. In general, some estimate of the uncertainties in the numerator and denominator of eq. (5) (including those due to filtering) would make the calculated values more useful for interpretation. This may also help justify (P838, Lines 14-15), “We have eliminated these cases from further examination due to the potential for large uncertainty in the calculation” which has little justification as currently stated. Could this be impacting the

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correlation between the “entrainment integral” and the boundary layer integral”? This could directly impact the conclusion in section 3.2.3.

Minor comments:

P819 Line 28 – Should be “. . . observations by a number of studies. . .”

P820 Line 6 – Should be “. . . as one mechanism for the formation. . .”

P821 Equation 2 - For completeness and clarity, please define all of the variables in equation (2)

P822 Line 1 – TKE was already defined

P822 Line 4 – Remove the word “and” at end of line.

P823 Line 17 – LES was already defined

P823 Line 18 – “the the”

P824 Line 3 – Define CIRPAS

Figure 1 – Needs a legend explaining what the black (aircraft altitude) and blue(LWC) lines are.

P827 Line 3 – Define F/PDI

Table 1 – It would be helpful to the reader if the flights shown in Figures 2 – 5 were indicated in this table (perhaps shaded?)

P827 Line 23 – “. . . with a range of approximately 3 to 10 K.” How are you defining the “top” of this jump?

P827 Line 28 – Should be “. . . sphere, to roughly constant values. . .”

P830 Line 19-23 – “That the filtered flux is only somewhat smaller than model predictions of the total buoyancy flux is consistent with the notion that entrainment tends to be a small-scale event, with typical length scales on the order of ~ 10 to 30 m based on

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high resolution observations of liquid water and temperature near the tops of stratocumulus (Gerber et al., 2005; Haman et al. 2007).” – Is this because your averages are over a much smaller length scale for which entrainment events would have a potentially larger impact? Please explain.

Figure 6 – Needs an y-axis label

P835 Line 5 – “Observations are not able to identify Z_{mix} . . .” Should Z_{mix} be Z_{mgd} ?

P835 Line 9 – Define DMF (or just spell it out)

Figure 7 (and all subsequent figures) – To help the reader, the caption should clearly indicate that the numbers near each point represent the date of the flight. This was not immediate clear to me.

P840 Line 3 – $d(\theta_v)/dz$ should be $\Delta(\theta_v)/\Delta(z)$ (as in figure 10)

P840, Line 6 – “results” should be “resulting”

P840, Line 13 – Should be “. . . this qualitative relationship could be used as. . . .”

P840, Line 14 – Should be “. . . in the STBL”

P842, Line 7 – Remove the second “both” on this line.

Figure 14-15 – There is no discussion of these figures in the text. Either remove figures or add discussion.

P843 Line 19 – “EII” should be “EIL”

P843, Line 25 – “. . . (within 10m) of cloud top. . .” should be “. . . (within 10m) to cloud top. . .”

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 817, 2012.

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