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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Exploring aerosol cloud interaction using VOCALS-REx aircraft measurements" *by* Hailing Jia et al.

Anonymous Referee #1

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article

1 Overview Comments

This paper uses data from a field campaign in the south eastern Pacific to investigate the aerosol dispersion effect and entrainment in stratocumulus clouds. The cases have been described in other work previously and so the new aspect here is to analyse those data in a new way to look at different properties.

The paper is well structured, and the limited information in the data and methods section is mitigated by previous published work. Some reference to entrainment in stra-

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Discussion paper

tocumulus clouds specifically should be added.

The changes made from the original document have improved the manuscript, and it is much closer to publication. Where I still have comments or questions they are within the body of this report. The manuscript would still benefit from being more specific in places for clarity - some occasions identified in technical corrections.

2 Specific Comments

2.1 Section 2

I would like to see more information on interstitial aerosol observations. The size looks very large.

2.2 Results Section 3.1

It is interesting and somewhat unusual that the number concentrations increase with height above cloud base, rather than remaining relatively constant. I suggest noting this comparing to some of the VOCALS cloud observations perhaps.

2.3 Results section 3.2

Section 3.2, paragraph one. In the south eastern Pacific most of the aerosol optical depth will be within the marine boundary layer and so the assumption from the satellite studies is probably good here, as the aerosol and cloud layer are not well separated. Is there anything specific about the satellite studies that results in a large bias in this region? Otherwise it is not that relevant. Line 145 onwards: What altitude is the level

of decoupling in these clouds? Is it below the level where sub-CCN measurements are made? In the case of Nd and LWC,and cloud base even the "other" cases look well correlated apart from 2 - possibly the ones with precipitation? The decoupling will only have an impact if it is above the level where you make the sub-CCN measurements. Do you have measurements of the decoupling altitude?

2.4 Results Section 3.3

October 18th Case study: do all results here apply to this case? Is it possible to get aerosol particle size distribution for the sub-CCN layer, and the interstitial aerosol? It is a surprise that the unactivated aerosols are larger than 1 micron in size (for example in Figure 7. Is this because they are in a saturated environment? For example, during the VOCALS measurements (for example Twohy ACP2013, Impacts of aerosol particles on the microphysical and radiative properties of stratocumulus clouds over the southeast Pacific Ocean) observed much smaller interstitial aerosols of 150 nm, and below cloud 135 nm.

It looks as though the vertical velocity effect is limited for low total aerosol concentrations which seems interesting. Is this worth noting? Is the effect limited by low aerosol number?

Line 208. Is the average here for the whole flights worth of data for October 2018? Again - is it possible to show aerosol size distributions?

Why do some flights show a reduced effect, e.g. 22nd Oct, 29th, 30th, 4th Nov, 8th. Are the data able to explain?

2.5 Results Section 3.4

I still do not think there are strong difference in the vertical velocity PDFs between the well mixed and other cases. The grey shading does not help in figure 9, it might be easier to see if the shading is removed, and those cases are identified with a symbol above the axis. The standard deviations do not look different within the other category compared to well mixed, and if the skewness is not different, then what is? If anything I might expect the skewness to be the parameter that varied, when in a decoupled boundary layer, dominated by turbulence from cooling at cloud top, rather than the ocean surface thermals.

A see that the correlation reduces when the other cases are included, and so the dynamics are important (in Figure 9), but again - it looks like there are two strong outliers - which are these? Do they have to most skewed w PDFs or most different standard deviation of w? Or else precipitation, or wind shear?

2.6 Results Section 3.5

This section is interesting and appears to show some evidence for inhomogeneous mixing. It is difficult to isolate this, and I wonder if there is enough precision in the observations to look at 20 m deep layers. However the size distributions in Figure 11 show some reasonably convincing evidence. Does the degree of change in the size distribution correlate with the AF_{ent}^{d} fraction in Table 2? For a quick look it appears to - is there a way to quantify this?

There are a number of references to entrainment in cumulus clouds, but these are not relevant here. The clouds are not still developing vertically at the inversion level, whereas in cumulus, at cloud top,the clouds are still growing. Lateral entrainment is important in cumulus, but not here.

Some reference include Malinkowski ACP2012 Physics of Stratocumulus Top (POST): turbulent mixing across capping inversion, Wood Monthly Weather Review 2012 Stratocumulus Clouds, and Stevens QJ2002, Entrainment in stratocumulus-topped mixed layers.

Line 285 - you suggest that entrainment of above cloud aerosol could be important, but elsewhere state it isn't, and showed this with the previous Figure 4. Line 287 - probability of what? Line 288 onwards - drier air would also case reduction in size. Line 312 - is this the increase in LWC from increased sub-CCN?

line 325 - do dynamical considerations mask the dispersion effect or is the effect lower once vertical velocity is considered? Line 334, 335 - the stratocumulus entrainment references may assist here. At cloud top vertical velocities will tend towards zero, and entrainment will dry the cloud and evaporate particles. There will not be much cloud nucleation here.

3 Technical corrections

There are numerous errors of tense and grammar that should be corrected.

Line 122, attributable Line 130, aerosols in, not on. Line 153, replace figure omitted with not shown line 163, As the certain... suggest re-writing for clarity line 164, replace contributed with controlled line 186, remove more, replace with spurious? As those extra aerosol area an artefact. line 196, Since part of.. suggest: Since part of the aerosol population has activated, or similar. line 200, and thus THEY activate line 209 Those aerosol, not that line 210 for INTO larger cloud droplets(Twohy

There are others to consider as well.