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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Turbulent dispersion in cloud-topped boundary layers" *by* R. A. Verzijlbergh et al.

Anonymous Referee #1

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This manuscript presents an analysis of plume dispersion characteristics in several cloudy boundary layers (namely: smoke cloud, stratocumulus and shallow cumulus), which are in turn compared with the Convective Boundary Layer (CBL) reference case. This study represents a nice and timely extension of previous studies on dispersion in the CBL, by providing an interesting contribution to the understanding of the processes governing plume dispersion in conditions that have been rarely studied in the literature and that, on the other hand, represent a case of significantly practical importance.

The manuscript is well written and reads easily, and deserves eventual publication in ACP after making some minor revisions listed below.

1. Methodology: I would extend shortly this part by including, for instance, some com-

ments as how the position of each particle is calculated within the grid cell, and, especially, whether in this calculation the sub-grid component of the velocity has been used or not.

2. Also, it is not completely clear to me how the particles are released. In the text I read that 1024ˆ2 particles are released in a 256ˆ2 grid. Does it mean that 16 particles are released in each grid? Or did you perform several releases at different times? Moreover, the height of the releases should be clearly mentioned somewhere here, I guess.

3. Finally, I haven't seen mentioned anywhere the speed of the mean wind, which, although not extremely Important In this context, is the main driver for the horizontal motion of the particles. Also it would be interesting to show vertical profiles of u in the different BLs, which may be relevant in the following discussion.

4. Eq 2. pag 19645. Something between the equation and the text is not consistent. I guess that 'L_z' in the text (line 11) should be replaced with 'z_i'. As the text later explains, (line 15) the integration is then done over all the domain 'L_z'.

5. Line 19: The definition of the dimensionless time t_* is usually given as: t_*=(w_*/z_i)t . The time defined in eq 3 is not dimensionless.

6. Results and Discussion: Fig 1: the sketches in Fig 1 are very nice and useful for the following discussion: however, I would find more helpful to visualize in this figure also the plots of the PDF of w, as shown in Fig6, 8, 10, and 13, since it would give a more quantitative insight of the vertical velocity distribution in the boundary layer in exam.

7. Figure 3 is not very clear when printed, but it may be a problem of my printer. However, it would be really interesting to plot here also similar pictures for the other releases at different heights. In fact, although the main discussion is based on plume statistics as shown for instance in fig 4, 7, 9, and 12, the plots of the concentration would definitely help to visualize the behaviors of the plume in the different conditions,

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making it easier then to the reader to interpret the other figures.

8. Fig 4: why the skewness of the plume position is shown only for release at z=0.5z_i? I would expect that the shape of the skewness depends on the release height.

9. I don’t' think Figure 5 is very relevant. As explained in the text, a Gaussian distribution in the horizontal direction in the CBL is a very well known fact.

10. Figure 6: if the authors follow my suggestion to move the upper part of Fig 6 (w PDF) in Fig 1, then the remaining part of this figure could be easily attached at the bottom of Fig 4.

11. Fig. 7. The resemblance of the smoke cloud case with an 'inverse' CBL is very interesting and effective. I notice only a small discrepancy, namely the tendency of the plume released at z/z_i=0.2 (?) to remain close to the ground for a long time (t/T_*=0.5) before being lifted up, whereas in the CBL the plume release near the top of the CBL is immediately transported down. A comment here would be appreciated.

12. Paragraph 3.4.1: Here, it is very interesting to note, as the authors do, that the stratocumulus case is a sort of mixture between a pure CBL and the smoke cloud case, as illustrated by Fig 2. Therefore, in my opinion, it is essential here to distinguish between the release below and inside the cloud layer. Especially because it seems that the release at around 350m coincides almost exactly with the bottom of the cloud layer. Moreover, the authors themselves point out that the skewness in this case changes with height. Therefore, I would definitely show here the concentration plots as a function of the release heights and also, the PDF of w at the release height. This would help to better understand the behavior of the plume as Illustrated in Fig 9. Also, the release at 350m is furthermore striking: In fact, although the mean plume height remains fairly constant with time, from Fig 3 and Fig 9b one can see that after t/t_*=1 the plume tends to be transported upwards very rapidly. This may be due to the plume entering the cloud layer, but a short comment from the authors would be welcomed.

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13. Fig. 11 I would personally scale the figures with either the dimensionless time, or the same units used in the other figures (i.e. seconds) to be more consistent.

14. Fig 12: It seems to me that something is wrong here with the labeling. In all the other similar figures, the continuous line represented the lowest release, and the dotted line the upper one. Here it seems to be the other way round. However, in the second panel, labeling seems again different. This makes in turn impossible to distinguish between the different releases in the third panel (dispersion parameter).

15. I have three general remarks about this section, which is without any doubt the most original: I) given your explanation of the plume behavior in terms of the different velocity distribution as a function of the distance form the cloud, would it be possible to distinguish between releases (at the same release height) within and outside the could? I would expect very different behaviors in the plume characteristics if this distinction was made; II) The value of the dispersion parameter in this case is extremely different than the ones in the CBL and the other cloud cases. Therefore, it would be very interesting to plot, as a reference, the value of the dispersion parameter of the CBL case in figure 12c. III) The value of the plume skewness in this case is very high, as much as three times the CBL case. Do the authors have a comment on this? Is this value depending on the release height?

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