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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Temperature profiles, plumes and spectra in the surface layers of convective atmospheric boundary layers" *by* Keith G. McNaughton and Subharthi Chowdhuri

Anonymous Referee #2

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General comments

The paper proposes a model of rising and falling plumes of constant temperatures with vertically varying area fractions to obtain expressions of vertical velocity variance, temperature variance, heat flux and the temperature gradient within and above the SFL. The authors then try to interpret the scales proposed by them earlier in terms of the area changes of the up and down plumes with height. However, no quantitative connection seems to be worked out between the variations proposed by the model and the observed variations. Neither are the earlier proposed scales shown to be connected to the results of the model quantitatively. These issues are so prevalent in

the paper that most of the proposed interpretations of the authors' scales seem mostly conjectures with no justification for the assumptions, or proof for the interpretations or connection to the model proposed by the authors. In addition, to make matters worse, the model itself is physically suspect, as shown in Specific comments 1. Further, even though the paper is mostly free of typos and grammatical errors, it is overly verbose, especially all the sections subsequent to § 4, with many a times the same ideas being repeated over and over, to make it a drudgery to read. I detail some of these issues below. Due to these issues, I do not think the paper in its present form is suitable for publication.

Specific comments

1. Equation 9 is not physically correct since it is not volume that is conserved but mass. Hence the terms must be multiplied by the corresponding densities of the upward and downward regions. This would imply that all the subsequent relations that use (9), like (13) are erroneous.
2. The origin of (11) and (15) and the steps leading to (12) and (16) are not clear.
3. Line 199 : 'On average the up-plumes.....'. Is this information available from earlier research?; if so, please cite.
4. There must be far more discussion in § 3.2 about the relationship of $\sigma_{\langle w \rangle}, \sigma_{\langle w \rangle}, H$ and $d\theta/dz$ with f_u and f_d.
5. I am puzzled by the interpretation of fig 2 in § 5.1 by the authors. Figure 2 shows the probability density function of $\theta - \theta_p$ obtained from point-wise measurements over time in SLTEST. LHS of the peak value of the pdf shows the probability of occurence of $\theta < \theta_p$, while the RHS of the peak value shows the probability of occurrence of $\theta > \theta_p$. Since θ_p is the peak temperature measured from various measurements over time at a point, a temperature less or more than θ_p does not

imply that the mass of air is falling down or rising up, as the authors assume. Masses of air with $\theta < \theta_p$ could as well be rising and vice versa at any point of time since all rising or falling masses of air do not have the same temperature in these measurements, unlike that in the case of the 2T model. So to interpret this experimental PDF based on the assumption in 2T model would be wrong, since the experiments do not satisfy the assumptions made in the model.

Even if we ignore this error, the interpretations of fig 2 based on the 2T model is again problematic. Firstly I do not see that the area of the PDF to the left of the peak is larger than the area to the right of the peak, as the authors state, since the right hand side extends over a much larger range of $\theta - \theta_p$. Neither is it obvious that the areas of the PDF to the right of the peak decrease with increase z since the height of the peak also increase with increase in z.

More importantly, the authors make the leap of faith, in line 261, of relating the areas of PDF to the fractional areas of plumes. This connection cannot be made since the fractional areas that the authors speak are the horizontal areas occupied by rising and falling regions of plumes in a horizontal plane. The PDF obtained by point wise measurements over time only reflects the time of duration that the point has the particular temperature by being within a rising or falling plume and not the horizontal area of the rising or falling plume. Even application of Taylors frozen turbulence hypothesis will only give the vertical extent of the plume, and not the horizontal areas, since the flow is predominantly vertical.

6. Line 303: How is it obvious that the plume velocity scale is $(z\epsilon)^{1/3}$ when the T variance scale is $H^2(z\epsilon)^{-2/3}$? Line 304: How does the w variance scale being same identify the larger eddies shape the plume? Line 289, 305:Further, what physical model or scaling argument shows that when a larger eddy process with a length scale l_1 organises a smaller plume with a length scale l_2, the resultant process has a length scale of $\sqrt{l_1 l_2}$?

7. In line 311, the authors say that the T variance scale $H^2(z\epsilon_o)^{-2/3}$ is incompatible with $(\theta_u - \theta_d)$ and then conjecture another reconciliation by proposing, without any proof, composite plumes above SFL. The 2T model's prediction (16) is then anyway in contradiction with the observation, which the authors justify by saying that, had the reality had what the 2T model assumed then we would have obtained the prediction of 2T model!! So even when the model's prediction contradicts observation, it is because the actual situation is not following the assumptions in the model, and not the deficiency of the model!! In para starting at line 318, the proposed T variance scale is shown to suggest a plume aggregation process which results in having a $(z/z_s)^{-1/3}$ variation of the plume area fraction. Is there any proof for such an area variation? Does the 2T model suggest such a variation of plume areas? No answer is given.

8. Second para page 14: The authors argue that the length scale $\sqrt{\lambda z}$ of T spectrum is consistent with the -1/2 power law of the mean temperature profile, if the area of plumes vary as $(z/\lambda)^{-1/2}$. The up plumes are suggested to be embedded in outer eddies so that horizontal convergence and hence the plume area scales as $(z/\lambda)^{-1/2}$, without making it clear why the horizontal convergence (what does this term mean?) should scale as suggested. This argument is hence based on many unverified assumptions and no proof for the proposed variation of area of plumes is given. Later, it is suggested that even when the aggregation properties change to change the spectral length scale to λ at lower wave numbers, the same power law is said to hold; this is contradictory since the argument for mid wave numbers was based on the spectral scale and when the spectral scale changes the power law of mean temperature profile is also expected to change. All of the above is just conjecture with no proof for the assumptions made or the results proposed shown.

Same is the case with the argument for the scales of wT cospectra in the next paragraph, which is again based on the argument that two process of length scales $l_1 = \sqrt{\lambda z}$ and $l_2 z$ when interact create a process of length scale $\sqrt{l_1 l_2}$; what is the physical justification for such an assumption? Why cant the new length scale be some other dimensionally consistent power law combination, like say, $l_1^{1/3} l_{2/3}$

9. Line 409:Taylor frozen turbulence using mean wind speed is not valid when there are rising and falling plume regions. No justification to show that the hypothesis is valid in convective turbulence is given. The issues pointed out above for the above SFL interpretations hold for § 6 on interpretation of scales within the SFL.

10. § 6.4 is just a rephrasing of all the ideas described earlier in the previous sections. As pointed out earlier, these are just conjectures with no justifications for the assumptions or proofs of the results being given. Mixing length models do not work in convective turbulence, here it is assumed to be valid.

Technical corrections

1. Kinematic heat flux must be defined in line 45 (page 2), same is the case with potential temperature in the caption of figure 1.