

Interactive comment on “Turbulence Kinetic Energy budget during the afternoon transition – Part 2: A simple TKE model” by E. Nilsson et al.

Anonymous Referee #1

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Using time series of the observed surface fluxes of sensible and latent heat, the near-surface wind and the boundary layer depth, the authors construct a simple model of the TKE budget of the boundary layer, giving expressions for the profiles of each term in the budget as functions of the timeseries. The predictions of the simple model are compared with a wider selection of observational data and the model is then used to investigate how the rate of decay of TKE through the evening transition varies with different forcing scenarios.

Traditionally, transitional boundary layers have been comparatively neglected in the literature, so the current focus on these cases, involving field experiments such as BLLAST, is to be welcomed and this paper makes a useful contribution to this growing literature. However, I feel that the clarity of presentation could be improved in several

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respects and so I recommend publication subject to major revision.

1 Major Comment

1. In its current form, the paper is quite long and hard to absorb. I think some restructuring and subdivision of the longer sections would improve the clarity of the presentation.
 - (a) Since the various terms in the model are taken from the preceding paper (Part I), I suggest introducing the model first, before discussing the observational data. It will then be more obvious what features of the data are relevant.
 - (b) Either at the end of the introduction or early in the section on the model, there should be a statement of what the inputs are (B , u and z_i) and what it is intended to predict (profiles of terms in the TKE equation): this will give the reader more sense of direction in reading the description of the model. The inputs to the model are indeed mentioned at the beginning of the abstract, but it is not clear what is meant by the TKE budget at that stage – a profile, a quantity integrated over the whole boundary layer, or something else – either way, repeating this just before introducing the model will do no harm. I would include the fact that the model is initialized at the morning transition, and I would also consider whether the formulae for the various terms of the budget could be presented more directly for readers who wish to refer back to the paper. Equation 16 is ideal, but the expressions for T could be presented more concisely. (See also below.)
 - (c) Section 6, and to some extent section 4, are very long and would be better divided into subsections. This will make it easier to locate information when referring back to earlier parts of the paper on rereading. In the case

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of section 4, a separate section for each term in the budget would be appropriate and in the case of section 6, there might be subsections for each scenario, then one on the rate of decay of TKE and finally one about the simple equilibrium model.

- (d) The comparison with Lenschow's (1974) model could be integrated more effectively into the paper. There are sporadic references to this from section 3.3.1 onwards. It would be useful to discuss differences of formulation from Lenschow's model at the end of the section on the model, where the forms of each term could be compared and contrasted. Figures A1 and A2 should show both Lenschow's profiles and yours.

2 Minor Comments

1. p29809 L5. Is this the best reference? Emanuel himself refers back to Stull (1988) in his discussion of the mixed layer.
2. p29810 L10. Please insert one sentence on the aims of BLLAST.
3. p29818 L9. This is just a standard iterative approach to obtaining u_* . Would it not suffice simply to say that u_* is obtained iteratively from u and B ? Figure 1 could then be deleted.
4. p29820 L20. Please state the actual number of the equation.
5. Section 3.3.3. If I have understood the model for T_b correctly, $z_{i0}/z_i = \sqrt{2}$. It would be useful to state this. An immediate consequence is that the depth of the entrainment zone is 40% of that of the mixed layer. Similarly, $T_{b_{max}}$ is completely determined by $B_0(t)$.

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6. p28923 L22. I tend to feel that this is excessively elaborate, given the scatter in your data and the apparently systematic difference between the morning and afternoon data, and that a constant value of about 0.4 would be equally good. In fact you yourselves make just this approximation in section 6. The only real justification for the more elaborate expression seems to be that it is derived from terms from Part I.
7. Sections 3.3.5 and 3.3.6. Should these not be swapped? You need initial conditions before you can determine the evolution of the TKE.
8. Section 3.3.6. The initial condition requires more justification. During the morning transition (eg. Angevine, Baltink Bosveld (2001) ‘Observations of the morning transition of the convective boundary layer’, BLM, 101, pp. 209–227) a shallow mixed layer develops within the stable boundary layer and deepens rapidly when its potential temperature attains that of the residual layer. At that point the buoyancy flux is not 0. Since you later take the initial value of z_i to be 150 m you probably intend to start the model from just before this point. That said, since, as you subsequently show, the TKE remains close to its quasi-equilibrium value, the initial conditions may not matter too much.
9. p29828 L21. The implication here is that the gradient is the main source of error in predicting the TKE. Perhaps it’s worth actually saying this. In one way, that’s a bit surprising since u_* is derived from the gradient.
10. p29828 L24. Because the source of TKE depends on w_*^3 , it is likely that missing periods of high wind speeds will systematically underestimate the generation of TKE. The importance of these excursions will depend on how quickly departures from quasi-equilibrium are damped.
11. p29838 L25. The success of the simplification of ignoring the time dependence is interesting and possibly worth stating more prominently (abstract/conclusions).

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- Although, on the other hand, it's worth bearing in mind that by using prescribed functions of z for each term, you force all levels of the boundary layer to respond together. It's possible that this may underestimate the role of time-dependence in the real boundary layer.
12. p29839 L5. This equation seems to predict rather low values of TKE near the surface in very convective conditions. E appears to scale on $z^{2/3}$, which is what would be expected for the variance of vertical velocity, but the variances of the horizontal velocities show little variation with height in the mixed layer. Have you compared the profile of TKE with published results, such as Caughey and Palmer (1979), "Some aspects of turbulence structure through the depth of the convective boundary layer", QJRMS, vol. 105, pp. 811-827?
 13. p29839 L10. A dependence of the TKE on z_i in the CBL is not surprising, since it must scale on w_*^2 and so on $z_i^{2/3}$. I take it that you mean specifically the first term in Eq. 40.
 14. Figures. Red and magenta can appear very similar when printed. Consider using green for data at 14.30 UTC in figures 2–4 etc.
 15. Figure 3. The data for 14.30 UTC are not well represented by the fit. Do you have any comment?
 16. Figure 5. A minus sign is required before z/L throughout the caption.
 17. Figure 8. The last sentence of the caption is interpretation and belongs in the text.

3 Typographical Comments

1. p29809 L10. Delete "the" before "atmospheric".
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2. p29810 L 5. "slower decay of the TKE"?
3. p29821 L20. "is decaying" → "decays".
4. p29823 L 6. Perhaps f_T would be preferable to T_f notationally.
5. p29823 L 6. "solved for" → "obtained"
6. p29823 L 15. "spreads the transport" is a poor phrase. The TKE is spread. It would be better to say that TKE is transported from the surface layer to the upper part of the boundary layer.
7. p29824 L 16. "compare" → "compares"
8. p29824 L 20. "on" → "at"
9. p29824 L 21. "differ" → "differs"
10. p29825 L 16. "maxima" → "maximum"
11. p29826 L 18. "has" → "have"
12. p29828 L 18. "more smooth" → "smoother"
13. p29832 L 15. Do you mean capped in value or in height?
14. p29840 L 5. You "predict"; "days" do not.
15. p29841 L26. "supports" → "suggests".
16. Figure 12, caption. "shown legends applies" → "legends shown apply".
17. Figure 13, caption. "is showing" → "shows".

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