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Biogeosciences
Discussions

Interactive comment on "Local flux-profile relationships of wind speed and temperature in a canopy layer in atmospheric stable conditions" *by* G. Zhang et al.

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Answers to the comments of referee 2:

-pp 3, last two lines: I think could be more subtle here and make a distinction between idealistic and non-idealistic cases: from direct numerical simulation of the Navier-Stokes equations Van de Wiel et al. (2008) show that in true homogeneous and stationary conditions the log-linear Phi-m,h remains valid even for strong stability (!). However, as indeed indicated by Mahrt (2007), in atmospheric practice the functions tend to level off (in a non universal way) mainly due to effects on non-stationarity and non-homogeneity.

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A: (pp 4507 lines 12-15) It has been revised as: From direct numerical simulation of the Navier-Stokes equations, van de Wiel et al. (2008) showed that in true homogeneous and stationary conditions the similarity functions remain valid even for strong stability. However, it has been shown that, as the stability parameter ξ increases, the similarity functions tend to level off, i.e., in very stable conditions, stability tends not to control the momentum and heat fluxes (Grachev et al., 2005; Yagüe et al., 2006). As indicated by Mahrt (2007), the "leveling off" is mainly due to non-stationarity and non-homogeneity.

-pp 5, line 7: “It suggests that,. . . .measurements”. Indeed, probably you also refer to the fact that in the unstable boundary layer (mainly aimed for when formulating MO originally), fluxes are generally large and gradients of mean variables small (thus Phi vs. z/L works better than Phi vs Ri) , whereas for stable boundary layers the reverse is true (thus Phi vs Ri works better). . . see indeed Baas et al. (2006).

A: (pp 4508 line 19) At the end of the paragraph, the following has been added: Baas et al (2006) also indicated that in the stable boundary layer, fluxes are generally small and gradients of mean variables are large, and thus a gradient-based scaling might be more suitable than a flux-based scaling. The latter is usually used for the unstable boundary layers with large fluxes and small gradients.

-pp 7: I just wonder: by using discretized version of the local Ri, one generally somewhat overestimates the actual value. Did you look into this, or do you think the number of observational levels is sufficient? At least this might explain some quantitative deviations from other studies mentioned later in the paper.

A: By using discretized version of the local Ri, the calculated Ri is an estimate of mean value in the layer. With the sonic anemometer measurements at 0.08, 0.2, 0.5, 0.6, 0.9, and 1.0 h, we think the number of observational levels is sufficient.

-pp10, figure 2. This figure really would benefit from two extra graphs viz. U(z) and Theta(z). Now immediately gradients are given. In the paper you often implicitly refer to the shape of those (not shown) graphs.

A: We have added the profiles of U(z) and θ(z) into original Fig. 2, and revised the related text. (Position of Fig 1, i.e., revised original Fig. 2)

Pp12, line 14: "preventing the loss of long-wave radiation from the ground". To my opinion radiation itself cannot be limited by stability, probably you refer to the fact that exchange of cold air from below (generated indeed by radiative cooling) is limited.

A: (pp 4514 lines 16-19) The sentence has been changed as: This suggests that the crown functions as a lid and limits the exchange of above-crown warmer air and below-crown colder air.

Pp12, line 18, figure 2D: In this figure I observe a large amount of scatter in the very stable case (large error bars). In the very stable case one expects some kind of reversed (convective) boundary layer within the canopy, indeed with counter-gradient transport (sinking cold air from top canopy). I recall from a study by Jacobs et al. that they showed that for those cases convective scaling with w* (based on canopy height and turbulent heat flux, or alternatively net-radiation/or alternatively ground heat flux), worked much better than u* scaling (u*-scaling indeed is more applicable for weakly stable cases). Could you check if this type of scaling (using either is indeed more physical in the very stable case and reduces the scatting.

A: We have tried the convective scaling with w*, but it seems to not decrease the scatter. The comparison of (averaged) u'w' and (averaged) w'T' normalized by w* and Tf with those normalized by u*(h) and T*(h) are presented below, for cases with (averaged) w'T'>0 at 0.08 h in strongly stable (1<h/L(h)<3) conditions. (Position of Fig. 2)

-same lines: the way figures 2d and 2c are presented seem a bit in contra-diction. Where does the counter gradient transport come from (as gradient of temperature seems positive even at top of canopy? I think the result is blurred by averaging. The very stable class could be subdivided in: -cases with negative dT/dz at the top (sinking cold air-counter gradient possible in the middle) -cases with positive dT/dz (as in the weakly stable case) Or at least discuss this point in the text.

A: The counter gradient transport usually happens in the middle and lower layers (not at the top layer) of the canopy in strongly stable conditions. In strongly stable conditions, the mid- and lower-canopy becomes decoupled from the above-canopy. The upward heat flux might come from the soil heat released at night.

-pp14 lines13-22: wording is a bit unclear to reader; could use clarification

A: (pp 4516 lines 5-12) We have revised the wording.

-pp18, lines 20-22: I really appreciate this comment, as the reader suspects a remark on this.

-pp21, lines 15-17: "This suggests . . . .otherwise valid local phih and Ri relationships.". This is a serious issue: to my opinion if SBL scaling between Phih and Ri does not work because of counter gradient turbulence (which I can understand) it cannot still apply to Phim (why should it then physically speaking). Please give your opinion on this interpretation.

A: It may imply that the heat transport is different from the momentum transport when counter-gradient transport occurs in strongly stable conditions. Mahrt (2007) showed that the eddy-Prandtl number (i.e., phih/phim) increases from near unity for nearly stationary flows to about 5 for strongly nonstationary flows. In other words, the momentum transport is much more efficient than the heat transport for strongly nonstationary flows. The counter-gradient transport within the canopy in strongly stable conditions might correspond to strongly nonstationary flows.

-pp22-23: this section really improves the credibility of the results!

Interactive comment on Biogeosciences Discuss., 7, 4505, 2010.

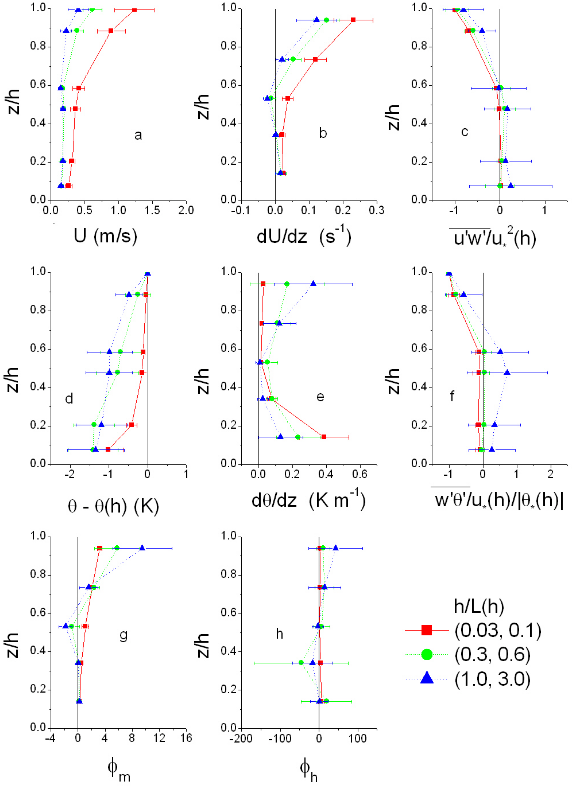

Fig. 1. Profiles of variables (new version of original Fig. 2)

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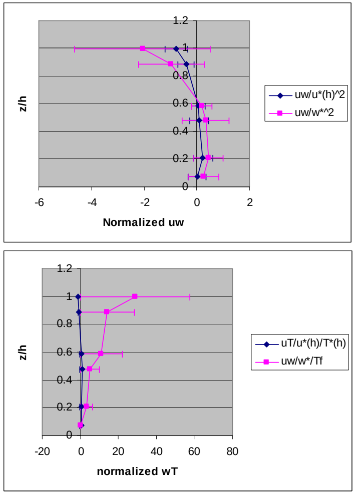

The comparison of $\overline{u'w'}$ and $\overline{w'T'}$ normalized by w* and Tf with those normalized by u*(h) and T*(h), for cases with $\overline{w'T'}$ >0 at 0.08 h in strongly stable (1<h/L(h)<3) conditions.

Fig. 2. Comparison for scaling with w* and with u*

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