J. Cuxart et al., 2015: Estimation of the advection effects induced by surface heterogeneities in the surface energy budget

1. *Does the paper address relevant scientific questions within the scope of ACP?*
   Yes. Investigation of surface energy budget closure and estimation of the sources of imbalance, first of all the scale dependent advection, are up-to-date questions.
2. *Does the paper present novel concepts, ideas, tools, or data?*
   Yes. Quantification of scale dependent advection term for SEB.
3. *Are substantial conclusions reached?*
   Partly. The conclusions are important from a methodological point of view. but there are not sufficiently many concrete results. I suggest giving more quantitative results.
4. Are *the scientific methods and assumptions valid and clearly outlined?*
   Yes. The principle of estimation of the scale-dependent advection term with the standard deviation of temperature fields is new but requires more detail explanations. How do you estimate the standard deviation of temperature in case of no advection? How does the advection depend on the standard deviation of temperature? I think it is not really a linear assumption. Is there any intercept?
5. *Are the results sufficient to support the interpretations and conclusions?*
   Yes
6. *Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?*
   Yes (Minor comments and question are given below.)
7. *Do the authors give proper credit to related work and clearly indicate their own new/original contribution?*
   Yes. The complexity of BLLAST campaign and the hierarchy of applied models give good material for the investigation of scale dependent advection.
8. *Does the title clearly reflect the contents of the paper?*
   Yes.
9. *Does the abstract provide a concise and complete summary?*
   Yes. (See the comments below.)
10. *Is the overall presentation well structured and clear?*
    Yes.
11. *Is the language fluent and precise?*
    Yes.
12. *Are mathematical formulae, symbols,* abbreviations, and units correctly defined and used?
    Yes.
13. *Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?*
    Yes. A few comments are given below.
14. *Are the number and quality of references appropriate?*
    The most important references are in the manuscript. I suggest a few new references (see in the comments).
15. *Is the amount and quality of supplementary material appropriate?*
    Yes. The material of the paper is quite enough for understanding the messages of the authors.

After minor corrections I suggest the publication of the manuscript.

Comments

The investigation of the energy budget closure of the micrometeorological measurements and quantifying the effects of scale dependent advection are important from theoretical and practical points of view. The well written manuscript after the minor correction is suitable for publication.

Abstract.

Please give information about the eddy flux calculation methodology, uncertainty (for example in %) of calculation of energy budget components. Please give concrete results (numerical values) connected with the scale dependent effects of advection included surface heterogeneities.

Line 25-30
Conceptually it is computed for a layer of infinitesimal depth across the interface in a horizontally homogeneous area, therefore no storage or source terms are considered and, formally, the budget is expressed ...

Please clarify the sentence. I think the so called storage terms exist above horizontal homogeneous surfaces but negligabe in many cases as you mention later.

Please give the order of magnitude for additional terms in the energy budget equations above the short and tall vegetations (see for example photosynthesys, storage, etc.) Please give the estimation of order of these terms above the short and tall vegetations. (See for example Moderow et al., 2009 Theor Appl. Climatol 98. 397-412. for tall vegetation.)

Line 40-45
These terrain heterogeneities may induce turbulent eddies and change the values of the turbulent heat flux compared to a completely homogeneous area.

If it is possible please give a sentence about the underestimation of the available energy (H + LE) in the practice. The heterogeneity gives the reason of the changing the turbulent heat flux, but not enough explanation for the frequent underestimation of the fluxes.

Line 45-50
... the advection terms can be computed using the divergence of temperature across the volume limits and the missing terms can be accounted for explicitly if the information is available (see Figure 1 in that paper).

How do you interpret the effect of thermals and coherent structures in the inbalance (underestimate the fluxes in daytime)?

Line 57
Please give a few relevant citations.

Line 55-60
... not considering the internal variability of the volume (in the air and in the soil) ...

Please give more concrete information. What is meant by the variabilty of the volume air? Is it the form of the profile for example?

Line 55-60
... such as water pumped up from below by the plant roots, ..

Please clarify the effect and give a few citations.

Line 60-65
$(Imb = TT + A + S + B + Ot).$

Please use the same order as in equation (2).

Line 85-90, 135-140
Hartogensis, (2015)
Wrenger et al, 2013

Please give also the peer reviewed citations from the last few years.

Line 160-165
Lafore et al, 1998

Please check the year (1997 or 1998)

Line 160-165
The run was from June 29th at 0000 UTC to July 3rd at 0000 UTC,

Why didn't you used a spin up period for the mesoscale NH model? Please give more information about the data assimilation methodology: do you use any direct measurements in addition to the ECMWF model output?

Please give information about the differences of the turbulence parameterizations on the grid resolutions of 2 km, 400 m and 80 m. How many grid points were used in Domain 3?

Line 175-180
(Salomonson et al., 1989), (Martínez et al, 2010)

Please check the manuscript very carefully: et al or et al.?

Fig 1.
If it is possible please give a bigger map, for illustration of situation of D1 and please give also a more detailed map for D3 and surrounding. Please combine the 3 maps in one figure.

Areas for which the average LST and its standard deviation given in Figure 3 are computed for model domains D1 and D2.

Please clarify the sentences. What is meant by 'are those in green?

Line 190-195
$\rho Cp\Delta zu \approx 2500\ J(K\,ms)^{-1},$

Please give the uncertainty of the estimation (in %).

Line 200-205
(Pietersen and De Coster, 2011)

Please check the citation. I can see only De Coster and Pietersen, 2011.

Please give more detailed information about the flux calculation methodology (of the application spectral corrections, instrument specific corrections etc.) and the quality control of the fluxes.

Line 200-205
Why didn't you calculate directly the heat flux into the soil for each 30 min periods knowing the soil temperature profile, soil moisture and the soil heat flux at a depth of 5 cm?

Fig 3
Top left: evolution of the average air temperature for some levels of the model …

Please clarify the sentence. For which model domain?

Please give the date in the bottom figures same as on Fig 1.

Line 240-245
Please give an explanation to the high standard deviations of T_{surf_MSG} 29 and 30 of June (upper right panel on Fig 3). Please give information about the comparison of model runs in D1 and D2 domains. What were the average temperature differences on the D2 model run using the 2 km and 400 m space resolution? If it is informative, please give a new figure.

Line 245-250
Therefore, for scales larger than 1 km the expected contribution of the advection term to the SEB would be of the order of 10 W m^{-2} *in the daytime and of 5 W* m^{-2} *at night,*

Please give information about the sign of the estimated advection in daytime and nighttime.

Fig 4.
Please give also the measurement interval. How did you calculate the temperature field for the given time?

The red rectangle indicates the position of the small square.

What is meant by the small square? Please clarify the sentence.

If it is possible please give the scale in km in the figure of 1 and 4. This makes the analysis of the information easier.

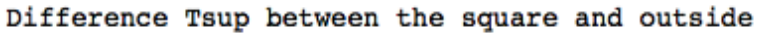
Line 270-275
How do you estimate the temperature differences depending from the Δx distance? How do you estimate the mean horizontal temperature gradient in equation 4? Please give more

detailed information about the methodology of the advection calculation based on the SUMO measurements.

… with comparable values leading to similar estimations of A …

No point.

Fig 5.



What is *Tsup*? Please clarify the headline.

Please give the algorithm in more detail for the calculation of temperature differences in fig. 5. Do you use any weighing factor depending on the distance from the small square?

If it is possible please give information about the wind speed at 65m during the SUMO flights.

Line 285-290
to 0.6 K from

One space.

Line 290-295
Figure 7

Line 300-305
How do you estimate the sign of advection?

Line 305-310
Please give the type of the soil. Please clarify the soil moisture contents in%? What are the typical maximum and minimum soil moisture contents in this case?

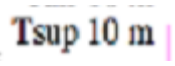
Line 325-330
The air temperature is sampled at 1 Hz, equivalent to a spatial resolution of a few meters.

Please give information about the estimation of hysteresis of the measurements and the methodology of corrections.

Line 335-340
T(5 m)

One space.

Fig. 9.

Please give the definition of 

I cannot see the abbreviation ‘sup’ in the text. Please give the explanation of the different colours in the top right figure. Please give the date and starting time for example.

Nocturnal flight pattern and LST values (bottom left) and air temperature at 5 m a.g.l. (bottom right)

Please give the date.

Line 340-345
If we just take 0.5 K for the day and 0.2 K for the night, the corresponding advection values would be 100 and 40Wm^{-2}.

Line 345-450
up to 2 K variations

Line 350-355
being a factor that may oppose to runaway cooling as it is experienced in some numerical models ...

If it is possible please give more concrete results about the measurements and the small scale modelling.

How do you estimate the sign of the advection?

Line 355-360
Garai and Kleissi (2013)

Please check the name Kleissi or Kleissl.

Line 361
Please give information about the soil (wet or dry). How do the measured inhomogeneities depend on the state of the soil? If it is possible please give a sentence?

Line 360-365
We estimate the gradient of temperature $\Delta T/\Delta x$ as $\sigma(T)/r$, where r stands for the resolution.

It is the key sentence. Please give more detailed explanation. How do you estimate the natural standard deviation of temperature? If the advection is negligible, $\sigma(T)$ goes to zero, is it true?

Table I.
Please give the height of temperature in term $\sigma(T)(K)$. (I think it is the surface.)

Line 375-380
This is in agreement with the previous argumentations of Foken (2008) ...

Please clarify the citations Foken 2008a or 2008b or both.

Line 65-70
In this work we concentrate on the importance of the advection term A in the SEB which represents the effect of the motions of timescales longer that the turbulence-averaged ones.

Please clarify the sentence and the mean goals of the paper because based on the discussion (see line 395, *Therefore the most relevant range of scales is the one comprising the hectometer and the decameter scales*.) the most relevant scales are 10-100 m, which are smaller than the calculated scale from the 30 min time scale with 1 m s^{-1} characteristic wind speed.

Line 400-405
... less than 10% ...

No space 10%.

Line 400-405
... very much in accordance with the picture provided by LES and DNS of the Convective Boundary Layer, ...

Please give citations.

References

Lafore, J. P., Stein, J., Asencio, N., Bougeault, P., Ducrocq, V., Duron, J., ... Pinty, J. P. (1997). The Meso-NH atmospheric simulation system. Part I: adiabatic formulation and control simulations. In Annales Geophysicae (Vol. 16, No. 1, pp. 90-109). Springer-Verlag.

Leuning, R., Van Gorsel, E., Massman, W. J., Isaac, P. R. (2012). Reflections on the surface energy imbalance problem. Agricultural and Forest Meteorology, 156, 65-74. 480

Lothon, M., Lohou, F., Pino, D., Couvreux, F., Pardyjak, E. R., Reuder, J., ... Augustin, P. (2014). The BLLAST field experiment: Boundary-layer late afternoon and sunset turbulence. Atmospheric chemistry and physics, 14(20), 10931-10960.

Oncley, S. P., Foken, T., Vogt, R., Kohsiek, W., DeBruin, H. A. R., Bernhofer, C., ... Lehner, I. (2007). The energy balance experiment EBEX-2000. Part I: overview and energy balance. Boundary-Layer Meteorology, 123(1), 1-28.

Please give the names of all authors.

Line 455-460
A turbulence scheme allowing for mesoscale and large?eddy simulations.

Please check the text.

Line 500-505
Bull. Amer. Meteor. Soc.

Please use the same format for the title of the journal. In other cases you used the full name, and no abbreviation.