Final response to the following Referee Comment

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Anonymous Referee #3

Referee comment on "Options to correct local turbulent flux measurements for large-scale fluxes using a LES-based approach" by Matthias Mauder et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-126-RC2, 2021

The manuscript by Mauder et al., seeks to correct the local turbulent flux measurements based on a non-local parametric model from a set of LES. The authors used three different experimental sites. They showed that the accuracy of the turbulent flux estimates is improved after use the LES-based SEB closure correction method. These results are important for a better approximation of the closure of the SEB. The manuscript is well written. The text is clear and easy to read. Figures are very explanatory and aid understanding the manuscript. However, I have some minor concerns with the authors' methodology, which I feel should be resolved before publication.

1) As the LES simulations performed by De Roo et al. (2018) were an important part of the methodology used in this manuscript, I suggest that the authors create a subsection in the "Methodology" to inform readers the main steps in the work of De Roo et al. (2018) were used by the authors in this manuscript. If the authors do this, all the equations in the introduction would go into this subsection;

- ➔ We have followed this recommendation of Referee #3 and created a new subsection in the Methodology, which includes partially the equations from the introduction (section 2.1).

2) The experimental measurements performed in this study were carried out with very similar instruments/methodologies, for the three different experimentais sites investigated. Except for one of them: the height of the boundary layer. Sometimes the authores used a ceilometer data and sometimes they used the slab model (Batchvarova and Gryning (1990)) to identify the BLH. What is the impact on the results presented by the authors if one of these devices/methodologies does not adequately represent the height of the convective boundary layer?

- ➔ The sensitivity of the correction with respect to the value of the boundary-layer height zi can be directly seen from the correction equations F2H and F2E according to Eq. 5 and 6 of the revised version of this manuscript. Thus, the correction scales linearly with z/zi, i.e. the ratio between the measurement height and the boundary layer height. In general, zi is typically much larger than z, and the correction amounts only to roughly 5-30% of the flux. As a consequence, a large absolute error in zi (e.g. 100 m) will only result in a relatively small error in z/zi, and even a smaller relative error in the resulting flux. Therefore, the resulting flux is relatively robust to inaccuracies in zi. Nevertheless, zi should be determined as accurately as possible. For the DK-Sor site, no continuous ground-based remote sensing data were available. Hence, we applied the method of Batchvarova and Gryning (1991), and the improvement in the energy balance closure, both by reducing the random and systematic deviations, shows that this method worked sufficiently well. This is not unexpected since they have shown in their original paper for two different sites that the model is able to predict zi with an error on the order of 10%, and this has been confirmed in many other studies that have used this model for different sites around the world. Moreover, the DK-Sor site is located in relatively flat terrain at the scale of 100 km, where this model is expected to be applicable.

On the other hand, the DE-Fen and DE-Gwg sites are located in the Alpine foreland, which is highly complex terrain in comparison to the Danish site. For these sites, the Batchvarova and Gryning (1991) model is not applicable. Therefore, we used a method top determine zi from ground-based remote-sensing at these complex-terrain sites, which does not require the assumption of a flat homogeneous surface. The only main assumption of this method is well-mixed conditions in the boundary layer. Again, the improvement in the energy balance closure, particularly in reducing the random deviations, shows that the method works sufficiently well for this purpose. Similarly, to the method of Batchvarova and Gryning, the original paper by Münkel et al (2007) shows that the accuracy of this method is typically on the order of 10% or better in comparison to radio soundings.

We have added a paragraph along these lines at the end of the discussion section:

For a site with flat terrain on the landscape and regional scale, this important nonlocal scaling variable z_i can be modelled from standard in-situ measurements in combination with radio-sounding data that are freely available worldwide. For study areas that are located in mountainous regions, such as the TERENO Pre-Alpine sites DE-Fen and DE-Gwg, it is advantageous to use continuous remote-sensing measurements of z_i based on ceilometers. Both methods are expected to provide an accuracy on the order of 10% of z_i, which may lead to an error in the energy balance closure of the same magnitude, since it depends linearly on z/z_i. This correction only amounts to 5-30% of the fluxes. Hence, the resulting error of the flux is less than 5-30% of 10%, i.e. 0.5-3%. Moreover, the improvement in the energy balance closure, particularly in reducing the random deviations, shows that both methods work sufficiently well for this purpose.

Technical corrections;
L138: of 4x4 km;

- ➔ This typo has been corrected.

L200: ...(Emeis et al., 2011; Münkel et al., 2007). This method is...
- ➔ Thanks, we have added the full stop behind the references in brackets.

L211: 1.4 m
- ➔ We have added a blank space between the number and the unit.

L246-248: Isn't that logical? Hdis depends on H and the latter has higher values in summer
- ➔ We agree and have added that this can be explained by a combination of smaller sensible heat fluxes and less unstable conditions during the months October to December.