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Atmospheric Measurement Techniques Discussions

Interactive comment on "Sensitivity of large-aperture scintillometer measurements of area-average heat fluxes to uncertainties in topographic heights" *by* M. A. Gruber et al.

Anonymous Referee #3

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This paper provides a novel approach to the mathematical details of determining scintillometer sensitivity to beam height, and specifically provides a new sensitivity function for sensible heat flux with respect to the path height. In the application of scintillometry with a varying beam height, these new formulations may be useful. It is noted that the interpretation of the underlying physics is not changed compared with earlier publications and that the guidance for beam setup is also unchanged. In particular, it may be considered rather obvious (and already known) that where the beam is most sensitive to the changes in topography, then those topographic measurements should be most accurately made.

The novel work presented in this paper is in the mathematical treatment to derive the sensitivity function. However, I feel that the maths presented is outside of the scope of my knowledge to make a formal review of those derivations – therefore my comments in this review are limited to the application to scintillometry, the scintillometric assumptions made, and the results applicable to scintillometry.

Overall I welcome the approach of de-coupling the set of iterative equations which contain sensitivity to the effective beam height. In general, this approach may aid the interpretation of data by more easily recognising the inter-dependency of variables, and their sensitivities. However, the paper is confined to the sensitivity to the beam height whereas there are several other uncertainties which may be more significant. For example, it is noted that for the purposes of this paper that u* has been measured independently of the scintillometer system, which given the large sampling area of the scintillometer is in practice difficult to measure, and thus u* uncertainty may be more significant than that of the beam height. It is relatively easy to accurately survey the beam height for the case presented. The other major uncertainty in scintillometry is the application of Monin-Obukhov similarity theory, and depending on which stability function is selected, there may be large (10 to 20%) systematic differences in the calculated sensible heat flux. Whilst u* measurements and choice of stability function are not subjects of this paper, I feel there needs to some context for the determined sensitivity to beam height by judging its relative significance to the overall uncertainty in the sensible heat flux.

There are specific editorial and other queries for the manuscript:

1. Title: consider replacing ‘measurements of’ with ‘derived’, since the scintillometer does not directly measure the sensible heat flux.

2. Rephrase first sentence of abstract to something like: “Scintillometers measure the refractive index ....”

3. Abstract lines 10-11 delete “and independent friction velocity u* measurements.”

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4. P.35, L.13 define what the scintillometer beam height is measured with respect to, e.g. above the ground, vegetation canopy or zero plane displacement height?

5. P.38, L.1 u here is not the path length but the relative path position.

6. P.38, L.9 – delete “source” or explain what is meant by it?

7. Specifically, I do not agree with the concluding remark lines 7-9, P.53, where Geli et al, 2012 is cited – the authors need to justify fully how this reference supports their remark, and whether ‘uncertainty’ refers here only to the effective height used to calculate H or to all contributions to uncertainty in H?

8. Since the experimental path is relatively close to the ground, some comments and justification is required as to why the zero plane displacement height (d) is not included in the calculations, nor information on vegetation height (which may make d significant and variable along the path).

9. Lines 19-21, P.50 – I find the discussion of sensitivity versus uncertainty in H a little confusing – whilst the sensitivity is clearly shown, there is no quantification of the effect of changing sensitivity on the uncertainty in H? E.g. if there is a random difference of 0.5 m between ground truth and LIDAR topographic measurements, what is the absolute or relative error in H? How much does that reduce, if the say the measurement RMSE was reduced to 0.1 m? Some examples of this kind would guide the reader in interpreting the sensitivity function. At first sight the high sensitivity regions of the experimental path appear to have an extremely high dependence on z, which may not be physically reasonable?

10. As suggested in the paper, it is the mean whole path sensitivity that is important for the actual uncertainty in the determined H from the path average scintillometer Cn2. Considering this, and that errors in the beam height from the DEM appear random, then it seems that the mean uncertainty in H due to uncertainty in the beam height will not be very significant, compared to other errors?

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If at all possible I would suggest making the application to scintillometry more readily digestible, so that this paper will be useful to a wider audience.

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