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Atmospheric Measurement Techniques Discussions

Interactive comment on "Note on the application of planar-fit rotation for non-omnidirectional sonic anemometers" *by* M. Li et al.

Anonymous Referee #1

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General Comments

This short manuscript deals with eddy covariance measurements of the vertical fluxes of momentum and sensible heat, using two types of "asymmetrical" sonic anemometers. It has long been known that "vertical" fluxes ought to be measured perpendicular to the mean streamlines if they are to be taken as representative of the underlying surface fluxes. To that end, wind vectors measured in an instrument-defined coordinate system need to be rotated into a coordinate system defined by the mean streamlines. In other words, wind vector rotation removes a "tilt" angle that would lead to contamination of vertical fluxes by their horizontal counterparts. It is not a trivial matter, though, to accurately determine the mean streamlines from measurements at one point in a

turbulent flow field, both conceptually and practically, and a number of methods are in use for this purpose. One of these is the planar-fit method. The present authors apply this method in two ways: either using data from all wind directions in a single planar fit, or using separate planar fits for "disturbed" and "undisturbed" wind direction sectors, where "disturbed" refers to flow distortion from the sonic anemometer probe and its mounting/support structures. They claim that the latter approach (separate planar fits) yields better estimates of the momentum fluxes than the former (single planar fit), while for sensible heat fluxes the differences between the two approaches are negligible. Based on this single study, they then recommend separate planar fits for general use.

In my opinion, the suggested approach is wrong. Wind vector tilt at the point of measurement can be caused by a) terrain slope, b) non-vertical alignment of the sonic anemometer, c) bulky mounting parts under the sonic, or obstacles in the vicinity, d) flow distortion by the sonic probe elements. Only for causes a) and b) does the tilt angle show a sinusoidal dependence on wind direction that can (and should) be corrected by the planar-fit method. The distortion effects c) and d) are likely to cause additional tilt, with a different dependence on direction and, possibly, speed. Thus, they need mount- or probe-specific empirical correction approaches, which should be applied separately, and not confounded with the correction for a) and b). However, this is exactly what the authors do, by defining separate sectors determined by the geometry of the sonic probe and then applying a planar fit for each sector. The planar fit enforces a tilt correction dependent on the sine of wind direction, but where the tilt originates from flow distortion by the probe and/or mount there is no physical basis for this.

Specific Comments

p.2 L2f: The planar-fit method assumes that the mean streamlines from all wind directions define a single plane. This is true for sloping but otherwise flat terrain. But there are infinitely many "heterogeneous landscapes" where this is not true, and then the planar-fit method is not appropriate.

p.2 L8: I disagree that the planar-fit method "replaced" the double-rotation method. The latter is still in widespread use, and for good reasons, because the planar-fit method works properly only where the tilt angle has a sinusoidal dependence on wind direction.

p.4 L4: "incline < 2°": it may be useful to provide a topographical map of the surroundings, to see whether topography (which would be the justification for applying a planar fit) is likely to explain any features in Fig. 2.

p.4 L17ff "Furthermore, the front sector..." Better state clearly earlier in this paragraph that for the CSAT-3, three and not two sectors were distinguished, and why.

p.4, Results section. Can the planar-fit rotation angles be given (alpha and beta in Wilczak et al.)? How (in-) consistent are they between sectors and between sonics?

p4 L.27f, "Singular and negative... of 140°": looks like 130° in Figs. 2 and 3.

p.5 top paragraph, discussion of Figs. 2 and 3. While Fig. 2d suggests a sinusoid as the main trend in the tilt vs direction dependence (tilt = arctan (w/u), why not use that variable on the vertical axis?), Figs 2e and f do not. As a consequence, the success of the planar-fit rotation is limited, and Figs 3b, c, e, f all show significant structure which is clearly not sinusoidal.

p.5 L 14f, "reduced ... especially in the front sector": True, but this is because the narrower a sector, the more effective is any regression method to bring the mean tilt to near-zero. There is absolutely no basis for prescribing that the tilt vs direction dependence in this sector should follow a (small segment of) a sine wave. Fig. 3f shows strong discontinuities at the sector limits, suggesting that the fit is inappropriate.

p.5 L22, "hardly any irregular": still looks like a considerable proportion to me!

p.5 L25ff. It is impossible to judge by eye whether Fig. 4e is "better" than 4b, or 4f better than 4c.

p.6 L3, "front and side sectors should be rotated separately". I agree, but not with a pla-

nar fit, because it is the CSAT geometry and not the terrain slope (or sonic alignment) that causes the differences between the sectors.

p.6 L8, "friction velocity was improved": it was changed, and more often increased than decreased, but whether that is an improvement is unclear.

p.6 L12: "not significantly affected": how was significance tested?

p.6 L17, "no significant effect": probably because neither method addresses the underlying physics of flow distortion correctly.

p.7 L4ff, "A separate..." I would agree with this sentence if the words "planar fit" were removed. An appropriate fit is required, but there is no justification for it to be planar.

Table 2 and Fig. 5. Please note that standard linear regression is not symmetrical (except for cases of perfect correlation!). The result for the slope depends on which variable is taken as the "dependent" one. It should thus be mentioned what happens in Fig. 5a if the axes were reversed. Or if a symmetrical regression was used instead. Same applies to other regressions that are not shown but summarised in the table.

Fig. 1b. The $\pm 10°$ sectors are drawn for directions into which the flow is going, not where it is coming from. This is a bit confusing. Also, the probe should be the origin for drawing the angles.

Figs. 2 to 4. In my view, the main message from these figures is that the planar-fit method, in either variant applied here, is not very successful in removing tilt. Hence, run-by-run coordinate rotation (which enforces zero tilt) may not be a dumb idea. Comparing the planar-fit to the double-rotation method for momentum and heat fluxes may provide more useful insights than comparing single planar-fit to sectorial planar-fit!

Technical Comments

p.3 L18: replace "about unclear" with "unexplained". p.6 L4: replace "rotation" by "planar fit". Table 2 caption: replace "increment" by "intercept".

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 7323, 2012.