

Authors' response to the Referee's comment

First of all, we would like to thank the Referee for the positive evaluation of our revised manuscript. We appreciate the comment, which helped us further improve the manuscript. Below, the Reviewer's suggestion is shown in black, while our response is shown in blue.

Thank you to the authors for addressing most of my concerns and clarifying numerous details. The manuscript has been substantially improved compared to the initial submission, but I have one remaining concern that should be addressed. L255–259: I remain unconvinced by the authors' decision not to exclude data from wind directions where the tower structure is expected to distort the airflow and potentially influence the turbulent flux measurements (Fig. R2). While the empirical approach described in Lines 255–259 may help to correctly identify and interpret the wind direction sectors, it does not, in my view, directly address the issue of flow distortion caused by the tower structure itself. Such distortion can alter the turbulence field near measurements and thus affect the representativeness of the measured fluxes. Therefore, I recommend excluding flux data originating from the affected wind sectors or, alternatively, providing a more detailed justification for why such filtering is not considered necessary.

We thank the Reviewer for returning to this point. We agree that our previous reply addressed the correction of the measured wind direction, but did not address the effect of the distortion of the turbulent field behind the body of the tower in case of southerly winds. We have now estimated the influence of the tower body effect on the reported results, and whether the affected data should be removed from the analysis.

We have investigated the potential effects of the flow distortion within the wind sector in question, which we determined to be between 155° and 215° (see Fig. R2 in the previous response to Referees: <https://egusphere.copernicus.org/preprints/egusphere-2026-1077#AC1>).

First, we investigated the effect of the wind distortion on the representativeness of the fluxes (possible footprint geometry distortion).

Three of the six input parameters of the FFP model are influenced by the sonic anemometer data directly or indirectly (σ_v , u^* and L). Among these 3 parameters, σ_v is strongly affected by the flow distortion caused by the tower body for wind directions between 155° and 215° (southerly wind). Within the affected sector we calculated 39% increase in σ_v . The other two parameters are only slightly affected by the flow distortion.

We propagated these biases through the footprint model. The quantity on which the data selection depends is unchanged. The σ_v governs the crosswind spread of the footprint, whereas the selection criterion (the fraction of the footprint lying within a 5 km radius) is radial, so widening or narrowing the plume moves mass almost tangentially to that circle rather than across it. The share of the measured flux within 5 km changes by less than 0.1% even if σ_v is halved.

We also quantified the effect of using only the subset of data (rejecting the fluxes associated with southerly wind) on the final results using the April–September time period highlighted in the abstract. We made calculations to check if excluding the CO flux data from the affected sector influences the mean CO fluxes significantly. This was achieved using a paired block bootstrap (Künsch, 1989) approach. We made 2000 iterations for the analysis. The results indicated that the difference between the two datasets (original and wind direction filtered CO flux dataset) is statistically indistinguishable from zero. The results are demonstrated in Table A.

Table A: Statistical indicators derived from the bootstrap experiment. CI stands for confidence interval.

quantity	value
95 % CI, percentile	[-0.125, +0.128]
basic CI	[-0.231, +0.023]
normal CI	[-0.178, +0.076]
SD of the all-data estimate	0.080 nmol m ⁻² s ⁻¹
SD of the excluded estimate	0.095 nmol m ⁻² s ⁻¹
Precision loss	19%

The confidence intervals in Table A are derived from subtracting the filtered and full dataset. The resulting difference has CI of [-0.125, +0.128], which includes zero. The conclusion is unchanged if the interval is constructed by the basic (so-called reverse percentile) method with CI of [-0.231, +0.023], or by the normal method with CI of [-0.178, +0.076]. These results indicate that the mean difference between the two datasets cannot be statistically distinguished from 0.

We also quantified the underlying precision loss due to the filtering (subsetting). The sampling standard deviation of the April-September mean rises from 0.080 to 0.095 nmol m⁻² s⁻¹ due to the applied filtering, which is an increase by 19%. This clearly means that the subsetting increases uncertainty, so keeping all data supports a more statistically sound estimation. In other words, via wind direction filtering, we would reach the same statistical conclusion that is presented in the original manuscript but with measurably larger uncertainty associated with it.

Based on the above reasoning, we have retained the full dataset, and state the logic explicitly in the revised manuscript rather than leaving the filtering question unaddressed.

We have extended the 2.5 Flux footprint calculation section to explain the data handling method considering the wind flow distortion (lines 362-372 in the revised manuscript):

„As it was mentioned above, the tower body structure affects the airflow sampled by the eddy covariance system in the case of southerly winds (see Fig. 2.12 in Barcza, 2001). Although the wind direction correction aligns the footprint well facing the mean wind direction for a given hour, the distorted turbulence might affect the source region detection and also the measured CO flux itself due to possible modification of the spectral properties of the vertical wind speed. We have quantified the potential effects of the flow distortion within the wind sector in question (between 155° and 215°). It was found that although σ_v is systematically affected by the tower body within the sector, the footprint geometry remains largely unaffected (the width of the footprint changes slightly but does not affect our data selection). We also tested the option to drop all CO fluxes measured from wind directions between 155° and 215°. Statistical analysis indicated that CO flux filtering inevitably increases uncertainty but leads to the same conclusions, so keeping all data supports a more statistically sound estimation. It is important to note that southerly winds bring information from the (quasi)natural areas where the fluxes are considerably smaller than those originating from the populated areas (see Results).”

References

Künsch, H. R. (1989). The jackknife and the bootstrap for general stationary observations. *The Annals of Statistics*, 1217-1241.