Biogeosciences Discuss., 3, S646–S655, 2006
www.biogeosciences-discuss.net/3/S646/2006/

Biogeosciences Discussions

Interactive comment on "Towards a more harmonized processing of eddy covariance CO_2 fluxes: algorithms and uncertainty estimation" *by* D. Papale et al.

D. Papale et al.

Received and published: 25 October 2006

Thanks to the anonymous referee for the constructive comments that helped us to improve quality and comprehensibility of our paper. We try to answer to all the points:

1) *Fig. 2 (p969 line 7ff): How may the mentioned variability in the u* thresholds be explained by characteristics of the 8 measurement sites? Give concrete information/examples.*

- It is not simple to explain the variability of the u_* threshold. This is related to different factors and for sure also to sites characteristics, in particular to canopy structure that affect the capacity of the eddies to penetrate in the forest and topography that is one of the factors responsible for advection fluxes. We added this in the final text submitted to

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

BG but further in field analysis would be necessary to fully explain this variability that is interesting but out of the scope of the paper.

2) *Fig. 3 (section 3.2): The results in Fig. 3 are described but not discussed in the text! For example, explain or give possible reasons why the u* correction makes the NEE for FR01-2002 more negative! Also discuss possible reasons for the observed differences in the double-counting effect!*

- Discussion has been added to the finale version of the text. The not expected effect of u_* filtering to FR01 could be due to the small u_* threshold value that have a limited effect to annual NEE and the differences could be not significant. The double counting effect in DE03, that is opposite as expected, can be due to the high number of daytime data removed by the filtering that makes this site different from all the others. We added his comments to the final text.

3) *Fig. 5 (p971 line 3ff): Give possible reasons for the different storage correction effects of the three sites.*

- The effect is related to the magnitude of the fluxes and to the canopy structure. In FI01 for example the canopy was quite open also due to a thinning and for this reason a lower storage could be expected.

4) *Fig. 6 (p971 line 8ff): Is there a relation between the spike effect and the magnitude (diurnal variation) of the fluxes?*

- Yes, like for the storage. Added in the final version

5) *Is a bootstrapping necessary and/or recommended to determine the u* threshold?*

- Yes, it is recommended but not only to define the u_* threshold. It is very important to assess the uncertainty in the threshold value. Added in the final text

6) *How should the storage correction be harmonized including the datasets for which no profile measurements are available?*

BGD

3, S646–S655, 2006

- One possible option is to calculate the corrected storage using the relation between storage calculated with the profile system and others driving variables, like concentration on the top of the tower, wind speed, wind direction, atmospheric pressure etc. for example using Artificial Neural Networks. Added in the final text.

7) *What is concluded concerning the application of the u* filtering either to all data or only night-time data?*

- We suggest to apply to day time and night time because more conservative and also because the number of daytime data removed is not very high except for particular sites (like DE03). Added in the text.

8) *Which spike detection level is finally recommended for application?*

- We suggest to use the 5.5 threshold. Also if the conventionally used is 4, this is based on the assumption that the data are normally distributed while this is not always the case with errors in eddy covariance fluxes. (Richardson et al., 2006). Added in the final text.

9) *Considering the aim of the paper to contribute to a "harmonized" or "standardized processing" of CO2 fluxes, the entire methodology has to be described in such detail, that it can be fully reproduced by the interested reader.*

- We changed the text with a more detailed description of the methodology, following also your specific comments.

10) *The diversity of the available measurement stations concerning their representativeness for other ecosystems should be addressed. Especially for the u* filtering, it should be discussed whether the present methodology and findings for forest stations can be generalised to flux measurements over low vegetation.*

- In the datasets we used there were not grassland or cropland sites. However we are now applying this methodology to the CarboeuropeIP database where also sites from different ecosystems are available. We think that the proposed methodology can be

BGD

3, S646–S655, 2006

applied also to low vegetation and to vegetation with short growing season because both the spike and the u_* filtering are based on sub-year periods. In the final version of the text we inserted a new plot where it is possible to see the effect of the corrections to the u_*-night time NEE relation that we think can help to understand if the corrections worked or not. The same plot is available on the CarboeuropeIP database (http://gaia.agraria.unitus.it/database) for all the sites involved in the project.

11) *Throughout the text, the expressions eddy covariance "data" or "measurements" are ambiguous since they can also denote the high-resolution (e.g. 10 Hz) time series. In order to make a clear distinction against data processing and correction done on the high-resolution data, I suggest to use in the present paper the more specific terms "flux measurements" or "flux data" and for the correction applied on this data the expression "integral flux correction(s)". Also the very unspecific expression "annual sum(s)" should be replaced by "annual NEE".*

- The confusion between high resolution (10 Hz) and half-hourly data has been pointed also by the other referee. We solved it changing the suggested terms.

SPECIFIC COMMENTS:

12) *p963 line 3: What does "random measurement errors due to the technique" mean? Does it mean "instrumental errors"?*

- Clarified in the final text as in (Richardson et al., 2006)

13) *p967 line 10: Explain why a 99% threshold criterion was used in the present study and not a 95% criterion like in the cited references.*

- We changed the threshold criterion to be more conservative, however the results didn't change significantly.

14) *p967 line 16f: The formulation "...the u*-class where the night-time flux reaches more than ..." is not entirely clear. I suppose that the arithmetic averages or medians of the classes are compared. Please specify!*

BGD
3, S646–S655, 2006

EGU

- Specified. They are the arithmetic averages.

15) *p967 line 20ff: According to the method description, the u* threshold is determined as maximum of the four median values of 3-month-subsets. Was there a (systematic) difference observed between the u* values of the different seasons. If the vegetation structure really has a significant influence (as supposed in the text) the proposed procedure might be not appropriate for agricultural vegetation that changes more rapidly!*

- The differences between the 4 thresholds are variable between the sites. However we used the maximum threshold found to be more conservative and for this reason we don't see problems when the method is applied to vegetation where the structure change rapidly except that we will cut more than necessary in the others periods

16) *p967 line 24f: Does "in cases where no u* threshold could be found" mean that no result was obtained for all four seasons or for at least one season? How often did the failure cases occur?*

- Yes, if not result was obtained for all the 4 seasons. This never happened.

17) *p968 line 1f: Considering the aim for a harmonized processing of EC fluxes, the chosen minimum thresholds of 0.1 m/s and 0.01 m/s should be discussed and supported by literature references.*

- References added in the final version (Falge et al., 2001; Gu et al., 2005)

18) *p968 line 6ff: Considering the importance of the bootstrapping technique for the uncertainty estimation, and for a complete documentation of the proposed harmonized processing, the bootstrapping algorithm should be briefly explained here. Could the uncertainty of the threshold determination technique be overestimated by the bootstrapping method (due to the strong reduction/weighing of data points in each bootstrapping run)?*

- This has been explained in the new text (page 5 line 3). On the overestimation of the uncertainty, it is very unlikely that considerably less point from one season are

BGD

3, S646–S655, 2006

extracted. For example the possibility that less then 4000 points are extracted from summer is 1.14 * 10^{-11}.

18) *p969 line 9f: The meaning of the last sentence of the paragraph is not clear to me. What does "the value and the amplitude of the uncertainty" mean? Which section later in the text does the sentence refer to?*

- We reformulated the sentence (page 5 line 41) and it refers to the figure 9a discussion, where it is possible to see, e.g. that FI01 has low influence of the u* filtering in the final uncertainty also if the threshold is higher respect to other sites like FR01.

19) *p969 line 13: The statement "According to the eddy covariance data processing method, the CO2 fluxes are corrected by storage fluxes and..." is unclear and should be rephrased. It should be documented how exactly the storage correction (profile or discrete) was calculated! This might be especially important in the light of the recent publication by Finnigan (2006).*

- We changed in the text adding a full explanation about how we calculated the storage flux.

20) *p970 line 9: It is not mentioned here whether the common stationarity test (using sub-interval-fluxes), which is part of the standard EUROFLUX and CARBOEUROPE methodology, had been applied to filter the flux datasets before the integral corrections. Explain whether and why this common quality filter was not used here.*

- There are different quality check criterions proposed that are based on high frequency data (raw data) and the standard CarboeuropeIP methodology is one of these (Rebmann et al., 2005). In this paper we proposed a series of quality checks that can be applied to improve and standardize all the datasets also if raw data are not available (e.g. old datasets or sites where raw data are not stored). For this reason these quality check criterions based on raw data have not been used in this analysis. Specified in the text.

BGD
3, S646–S655, 2006

21) *p970 line 12f: Since there is only one sentence about the exemplary Fig.4 in the text, it should either be moved to the Materials and Methods section (like Fig. 1) or it can be omitted.*

- We agree, this figure has been removed

22) *p971 line 20ff: It is not mentioned (neither in the Fig. caption) which data were used for the analysis presented in Fig. 7. If the data of all stations were used, the results of FR01-2002 should lead to partially negative values in the Ust correction effect (according to Fig. 3)!?*

- To produce Fig. 7 all the sites have been used. The boxplots are based on the differences between minimum and maximum sums (daily, weekly and monthly) obtained different filtering combinations. The range can not be negative, if the different corrections have not effect on the sums, the range is 0.

23) *p971 line 26ff: It is not clear from the text how the ANOVA was performed (with annual NEE data?) and what the results of Fig. 8 specifically mean in relation (or as complement) to Figs. 3, 7, and 9.*

- The ANOVA was performed with annual NEE. It is confirmed that the u_* filtering has generally the biggest effect on the annual sum as shown in Fig. 7. In fig. 9 the effect as absolute number are shown and .

24) *p974 line 9f: The statement "We showed that we can strongly reduce the margin of uncertainties through a standardized processing by avoiding inappropriate data treatment..." is somewhat trivial. An appropriate data treatment is generally supposed to give better results than an inappropriate one. The uncertainty is mainly reduced by positively identifying the appropriate treatment among all options (e.g. show that a u* correction is necessary and gives better NEE results), but this was not the topic of the present paper.*

- The reduction of uncertainty is due not only to the appropriate data treatment but also

BGD
3, S646–S655, 2006

EGU

to the use of the same treatment for all the datasets and this was the main concept. We better reformulated the text.

25) *p974 line 20ff: The conclusion that the uncertainty of annual NEE values remains generally ("except for exceptional sites") below 100 gC/m2/yr cannot be justified with the results of this paper alone. Here only the uncertainty introduced by tree corrections techniques have been quantified. An adequate discussion (based on literature results) on the quantitative influence of the other important error sources (e.g. various types of advection, potential underestimation of daytime fluxes due to mesoscale/topographic effects, gap-filling, footprint problems) would be necessary before presenting a general estimate of the annual NEE uncertainty.*

- We completely agree that for a general estimate of annual NEE uncertainty more analysis and discussions are necessary. The 100 gC reported are relative to the three correction presented and we specified this in the final text.

26) *Fig. 9a-d, lowest panel: It is not clear, how the NEE values (and their error-bars) were calculated. Are they the result of specific correction options (e.g. best available storage correction, median u* threshold) or do they represent the average result of all correction options? The first case would be more meaningful in my opinion, but then, the error bars should show an asymmetric form (most prominently for FI01-2002 that is dominated by the storage correction)!*

- They are results of best storage, median u_* and spike 5.5. The errors bars should be asymmetric and we changed them.

27) *Fig. 9 caption: Does spike detection level 0 signify "no spike detection"? In that case the detection level z is "indefinite" instead of zero! According to Eq. 2 (incl. corrigendum) z=0 would detect all data as spikes.*

- Yes, it is true. We corrected this.

TECHNICAL CORRECTIONS

BGD

3, S646–S655, 2006

We accepted all the correction proposed, also if comment about Table 2 readability

1) *Table 2: For a better readability, additional spacing should be added between the different site-year rows (mainly in the columns with daytime and night-time results).*

and the error on the y-axes unit of figure 5 and 6

1) *Figs. 5/6: the unit on the y-axes appear in my copy as "mmol...." instead of "μmol...." (probably because of Latin instead of Greek/Symbol character)*

have to be corrected by the editor.

REFERENCES

Falge, E., Baldocchi, D., Olson, R., Anthoni, P., Aubinet, M., Bernhofer, C., Burba, G., Ceulemans, R., Clement, R., Dolman, H., Granier, A., Gross, P., Grünwald, T., Hollinger, D., Jensen, N.-O., Katul, G., Keronen, P., Kowalski, A., Lai, C. T., Law, B. E., Meyers, T., Moncrieff, J., Moors, E., Munger, J. W., Pilegaard, K., Rannik, Ü., Rebmann, C., Suyker, A., Tenhunen, J., Tu, K., Verma, S., Vesala, T., Wilson, K. and Wofsy, S.: Gap filling strategies for defensible annual sums of net ecosystem exchange, Agricultural and Forest Meteorology, 107, 43-69, 2001

Gu, L., Falge, E. M., Boden, T., Baldocchi, D. D., Black, T. A., Saleska, S. R., Suni, T., Verma, S. B., Vesala, T., Wofsy, S. C. and Xu, L.: Objective threshold determination for nighttime eddy flux filtering, Agricultural and Forest Meteorology, 128, 179-197, 2005

Rebmann, C., Göckede, M., Foken, T., Aubinet, M., Aurela, M., Berbigier, P., Bernhofer, C., Buchmann, N., Carrara, A., Cescatti, A., Ceulemans, R., Clement, R., Elbers, J. A., Granier, A., Grunwald, T., Guyon, D., Havrankova, K., Heinesch, B., Knohl, A., Laurila, T., Longdoz, B., Marcolla, B., Markkanen, T., Miglietta, F., Moncrieff, J., Montagnani, L., Moors, E., Nardino, M., Ourcival, J. M., Rambal, S., Rannik, Ü., Rotenberg, E., Sedlak, P., Unterhuber, G., Vesala, T. and Yakir, D.: Quality analysis applied on eddy covariance measurements at complex forest sites using footprint modelling, Theoretical and Applied Climatology, 80, 121-141, 2005

BGD

3, S646–S655, 2006

Interactive Comment

Richardson, A. D., Hollinger, D. Y., Burba, G. G., Davis, K. J., Flanagan, L. B., Katul, G. G., William Munger, J., Ricciuto, D. M., Stoy, P. C., Suyker, A. E., Verma, S. B. and Wofsy, S. C.: A multi-site analysis of random error in tower-based measurements of carbon and energy fluxes, Agricultural and Forest Meteorology, 136, 1-18, 2006

Interactive comment on Biogeosciences Discuss., 3, 961, 2006.