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Software intercomparison

Data preparation

The software intercomparison (hereafter SI) was performed using two months of raw Eddy Covariance (EC) data, one month referring to a Gill R3/Li7000 EC system (closed path dataset) and one month referring to a Gill R3/Li7500 setup (open path dataset). Data were provided by MPI, collected in the Wetzstein forested site and referring both to the days 108 to 138 of 2006. The dataset was comprised of 30-minutes files containing raw wind components (u, v, w), speed of sound in ambient air, and CO2 and H2O mole fractions. Concentration data were actually provided as raw signals. Hence, before distribution, they have been converted into physical units and formatted as plain text, space-separated values. The dataset was completed by the relevant meteorological data, used in the typical EC processing, i.e. ambient air temperature, pressure and relative humidity, provided as 30-minutes averages. Dataset were chosen so as to allow a thorough comparison: they refer to a period of relevant fluxes for all variables of interest, while containing a meaningful amount of spikes and sporadic malfunctioning periods that should be detected by the data-quality criteria of the processing software.

Participating software and comparison strategy

The SI was carried out, completely or partially, as a one-by-one comparison between ECO_2S (Eddy COvariance COmmunity Software) developed by University of Tuscia with contributions from the EC community, and the following software:

1) BARFlux, developed by the Finnish Meteorological Institute (Finland).
2) UniHels, developed by University Of Helsinki (Finland)

3) LundFlux, developed by University of Lund (Sweden)
4) EddySoft, developed by MPI-Jena (Germany)
5) EdiRe, developed by University of Edinburg (UK)
6) RCPM/sas developed by Risø (Denmark)

Each SI was carried out using both open and closed path datasets, but processing setups were different, based on the implementation available in each specific software and, when multiple choices were available, according to the “common practice” of the software user/developer, who actually carried out the comparison. In each case, ECO2S was adjusted to replicate implementations of the comparing software. In some cases (e.g. sensible heat correction in BARFlux, high-frequency spectral corrections in RCPM/sas and 2D rotation formulation in LundFlux) this involved a development effort to include these special implementations in ECO_2S.
Datasets were processed to obtain, as a minimum, the most relevant EC fluxes: CO_2, sensible and latent heats. However, in some cases other results (or partial calculations) were compared in addition, with the aim of going in depth into the cross-comparison of implementations, or when it was needed to recover a satisfying agreement, when preliminary comparisons did not succeed.

Intercomparison setups
Hereafter, the processing setups are listed, that were used for the SI.

ECO2S *vs* BARFlux

Despiking	yes
cross-wind correction for sonic temperature	no
angle-of-attack correction for wind components	no
detrending method	block-average
tilt correction method	2D rotations
scalars time-lag detection method	automatic (covariance maximization)
WPL method	Webb et al. 1980
sensible heat correction method	customized
high-frequency spectral correction method	experimental
low-frequency spectral correction	yes
meteorological variables used	yes

ECO2S *vs* EddySoft

Despiking	yes
cross-wind correction for sonic temperature	yes
angle-of-attack correction for wind components	no
detrending method	block-average
tilt correction method	planar-fit
scalars time-lag detection method	automatic (covariance maximization)
WPL method	Webb et al. 1980
sensible heat correction method	Schotanus et al. (1983)
high-frequency spectral correction method	mixed (experimental/analytical)
low-frequency spectral correction	yes
meteorological variables used	yes

ECO2S *vs* UniHels

Despiking	yes
cross-wind correction for sonic temperature	no
angle-of-attack correction for wind components	no
detrending method	linear detrending
tilt correction method	2D rotations
scalars time-lag detection method	automatic (covariance maximization)
WPL method	Webb et al. 1980
sensible heat correction method	Schotanus et al. (1983)
high-frequency spectral correction method	Horst (1997)
low-frequency spectral correction	No
meteorological variables used	partly

ECO2S *vs* RCPM/sas

Despiking	yes
cross-wind correction for sonic temperature	yes
angle-of-attack correction for wind components	yes
detrending method	linear detrending
tilt correction method	2D rotations
scalars time-lag detection method	automatic (covariance maximization)

WPL method	Webb et al. 1980
sensible heat correction method	Schotanus et al. (1983)
high-frequency spectral correction method	Ibrom et al. 2007
low-frequency spectral correction	No
meteorological variables used	yes

ECO2S *vs* LundFlux[1]

Despiking	yes (not substituted with interpolation)
cross-wind correction for sonic temperature	no
angle-of-attack correction for wind components	no
detrending method	linear detrending
tilt correction method	2D rotations (custom implementation)
scalars time-lag detection method	automatic (covariance maximization)
WPL method	Webb et al. 1980
sensible heat correction method	Schotanus et al. (1983)
high-frequency spectral correction method	no
low-frequency spectral correction	no
meteorological variables used	no

ECO2S *vs* EdiRe[2]

Despiking	yes
cross-wind correction for sonic temperature	-
angle-of-attack correction for wind components	-
detrending method	-
tilt correction method	-
scalars time-lag detection method	-
WPL method	-
sensible heat correction method	-
high-frequency spectral correction method	-
low-frequency spectral correction	-
meteorological variables used	-

[1] Comparison with LundFlux was carried out with a previously chosen dataset, consisting of 1 week closed-path and 1 week open-path data.
[2] A very detailed intercomparison was ongoing with EdiRe, evaluating differences arising after each single processing step. However, the comparison was not finished at the moment this report was written, thus results are not shown in the following summary tables.

Note that the implementation of high-frequency spectral corrections as in RCPM/sas, required a much broader and detailed comparison of the two software, that involved processing one year (2005) raw data from Sorø and comparing many partial and final processing outputs.

Results of intercomparison

Overall results of SI are presented in the following table, expressed as parameters (slope, y-intercept and R^2) of the linear regression for fluxes of CO_2 (F_c), sensible heat (H) and latent heat (LE), as calculated with ECO2S and other software. Note that no filter was applied to results before calculating regressions.

	OPEN PATH DATASET		
	F_c	**H**	**LE**
	slope / y-interc. / R^2	**slope / y-interc. / R^2**	**slope / y-interc. / R^2**
ECO_2S *vs* BARFlux	1.023 / 0.027 / 0.9807	0.986 / -0.327 / 0.9949	0.998 / 1.125 / 0.9955
ECO_2S *vs* UniHels	0.972 / -0.235 / 0.9166	1.012 / 7.440 / 0.9933	0.960 / 4.641 / 0.9899
ECO_2S *vs* EddySoft	0.979 / 0.091 / 0.9929	0.991 / 3.249 / 0.9965	1.016 / 0.609 / 0.9977
ECO_2S *vs* RCPM/sas	1.023 / -0.375 / 0.9971	0.970 / -1.003 / 0.9985	0.989 / -0.392 / 0.9998
ECO_2S *vs* LundFlux	0.988 / 0.037 / 0.9933	0.995 / 0.351 / 0.9999	0.981 / -0.160 / 0.9934

	CLOSED PATH DATASET		
	F_c	**H**	**LE**
	slope / y-interc. / R^2	**slope / y-interc. / R^2**	**slope / y-interc. / R^2**
ECO_2S *vs* BARFlux	1.013 / 0.010 / 0.9998	1.026 / 0.139 / 0.9998	1.017 / 1.270 / 0.9932
ECO_2S *vs* UniHels	1.033 / 0.086 / 0.9992	1.019 / -5.11 / 0.9947	1.039 / 2.683 / 0.9798
ECO_2S *vs* EddySoft	0.987 / 0.011 / 0.9991	0.984 / 0.229 / 0.9992	1.047 / -1.819 / 0.9866
ECO_2S *vs* RCPM/sas	0.985 / -0.016 / 0.9997	0.976 / 0.275 / 0.9994	0.987 / -0.113 / 0.9990
ECO_2S *vs* LundFlux	0.981 / 0.013 / 0.9997	0.992 / 0.043 / 1.0000	0.957 / -0.110 / 0.9993

Results show a general acceptable agreement, with differences narrowed within ±5% (often smaller) and R^2 always higher than 0.98, except for two cases (min 0.92).

None the less, it is also evidenced that, even if identical processing steps are declared, it is nearly impossible to achieve a perfect agreement between two software, even after intense and detailed exchange of information on each implementation. This highlights that, in addition to uncertainties deriving from the availability of different processing choices, sources of uncertainties in the eddy covariance chain derive also from the fact that the same conceptual steps may (and actually are) interpreted differently from different developers. The reason is mainly related to the fact that some procedures (either specific to EC or of general use in data processing) are described in literature with a certain amount of indefiniteness, or are actually available in different versions, leaving the developer with a certain degree of arbitrariness. As an example, the comparison with EdiRe within this activity, evidenced that the de-spiking procedure described in Vickers and Mahrt (1997), and widely used in EC packages, is prone to different interpretation in both the definition of the spikes and in the spike enumeration, leading to (somewhat surprising) differences in the assessment and removal of spikes in raw files.

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