Towards a consistent eddy-covariance processing: a comparison between EddyPro and TK3

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1. Introduction

- The eddy-covariance (EC) processing sequence is complex, depending on the instruments of choices and their deployment, the site characteristics, and the atmospheric turbulence peculiarities. Available EC software support different implementations and often the same procedures are implemented in different ways, or different order. In addition, many groups use "in-house" collections of scripts that may include customized implementations. It is often found that these differences show up to the researcher who attempts a software inter-comparison, as either systematic or random differences in resulting fluxes.
- We present a comparison of two popular EC software, EddyPro (licor.com/eddypro) and TK3 (Mauder and Foken 2011). The aim of the comparison is threefold:
  - *Compare calculated fluxes and related quality flags;*
  - *Individuate the sources of residual differences;*
  - *Stressing on the complexity of performing a fair rigorous software comparison.*

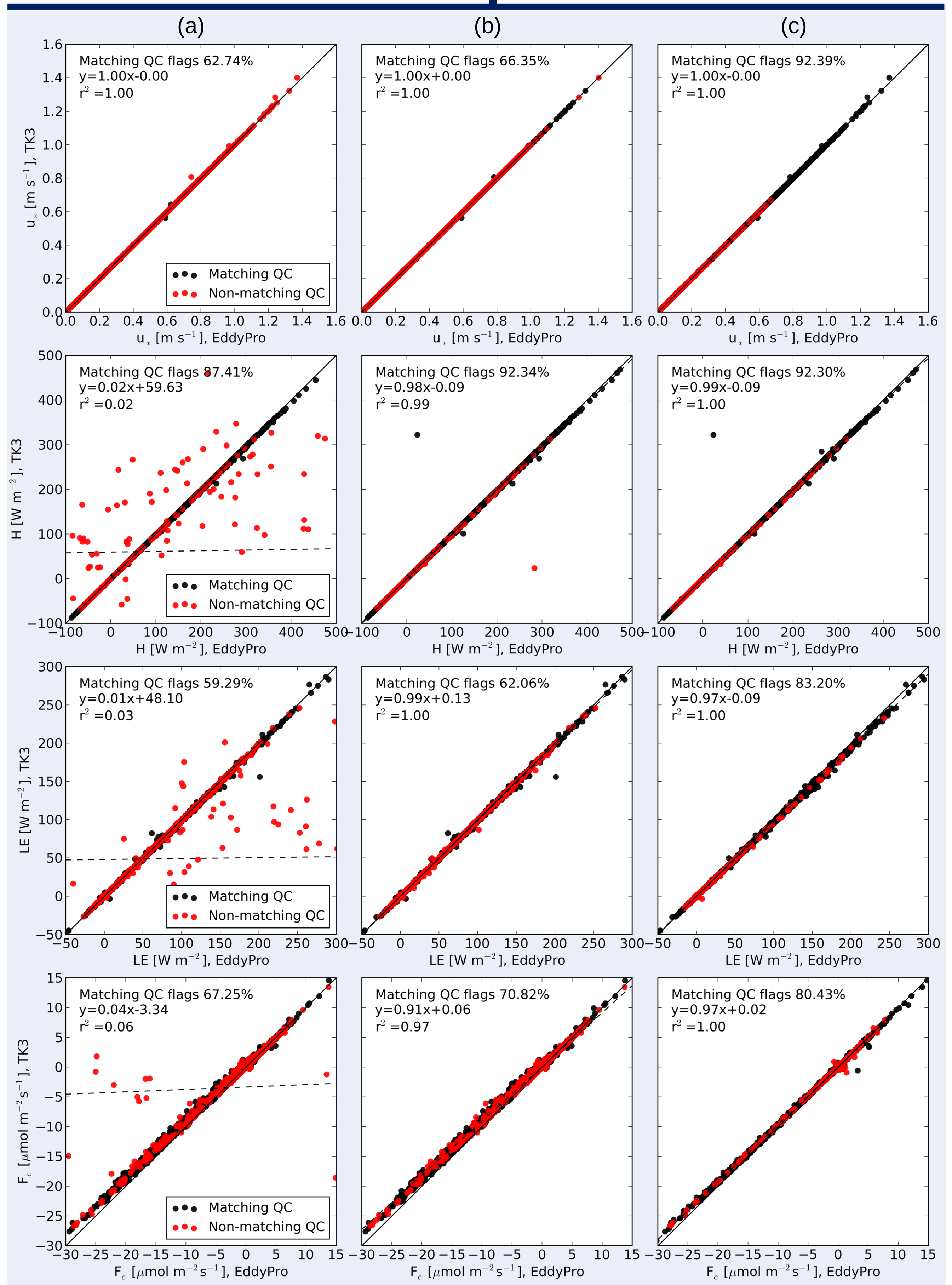
2. Comparison strategy

- We used data from an open-path and a closed-path system, and looked at friction velocity, mass fluxes, energy fluxes, and all corresponding quality flags according to the 0,1,2 scheme (Foken et al. 2004).
- We intentionally started the comparison with a superficial definition of the processing steps (Table 1) to be performed, and then repeated the comparison two times, introducing refinements after looking at the results obtained at the previous *rounds*, for a total of 3 rounds.

		open-path	*closed-path*
dataset	*duration*	38 days	49 days
	variables	u, v, w, Ts, CO_2, H_2O, P	u, v, w, Ts, CO_2, H_2O
	instruments	CSAT3/LI-7500	Solent R3/LI-6262
	ecosystem	grassland	forest
	measurement height	3.1 m	19 m
Despiking		yes	yes
Block averaging		yes	yes
Tilt correction		double-rotations	planar-fit
Time lag compensation		circular correlation	circular correlation
WPL terms		yes	yes
Spectral corrections		yes	yes

Table 1. Datasets used in the comparison and processing sequences

3. Results closed path

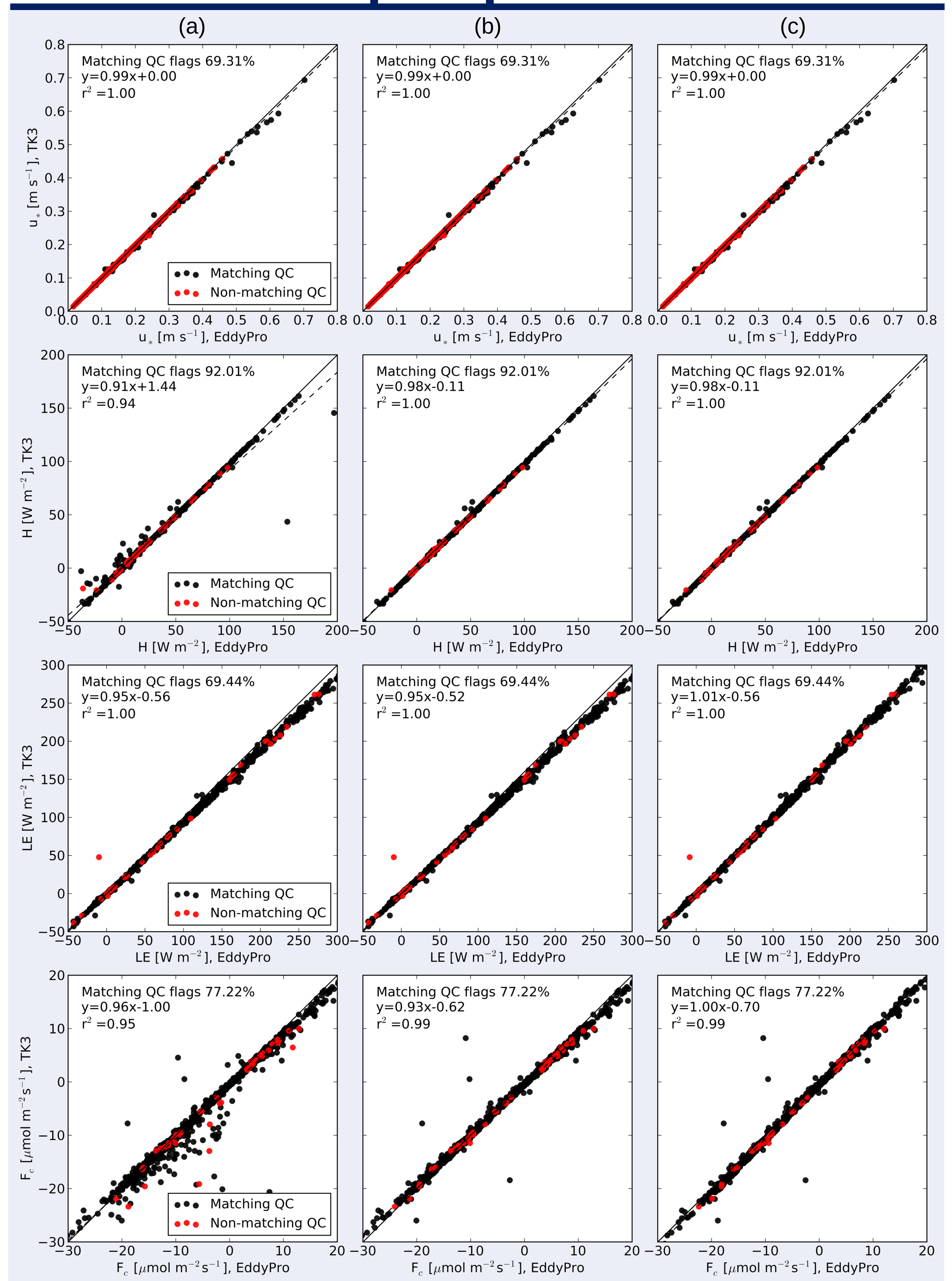


(a) In the first round, a relatively large number of scatters (i.e. large difference in the results) was found. F_c showed a large systematic bias (9%) and match of calculated quality flags was poor.

(b) We were able to completely eliminate major scatters. The reason was identified in different algorithms used for the raw data despiking: Mauder et al. (2013) in TK3 and Vickers and Mahrt (1997) in EddyPro.

(c) The systematic bias in Fc was reduced to 3% with a proper consideration of the WPL terms in both software. Consideration of WPL worsened the comparison of LE, which in round (b) appeared perfect as a result of the compensation of the difference in WPL and in the spectral corrections. The match of the quality flags was greatly improved by reconsideration of the quantities involved in the flags definition, and of the sequence of operations, i.e. in which point of the processing sequence the test are evaluated. Residual differences in Fc and LE (about 3%) is due to different spectral correction methods.

4. Results open path



(a) The scatter observed in the first round is due to using or not the pressure data available among the raw data. Significant systematic differences is observed for both Fc and LE.

(b) A refined agreement on the variables to be used (in particular, usage of high frequency data of air pressure) helped eliminating most of the scatter.

(c) To evaluate the quality of the WPL implementation for open path data, we needed to artificially match the spectral correction factors, as the methods available in the two software do not provide satisfying agreement (Moncrieff et al. (1997) in EddyPro and Moore (1986) in TK3). Once this was done, the match improved for all fluxes. It is to be noted, however, that the agreement visible in (c) is not achievable to the software user who cannot modify the source code to force – as we did in here – the spectral correction factors to match, before the WPL terms are calculated.

5. Conclusions

- When properly configured, the two software provide **satisfying (yet not perfect) agreement** in calculated fluxes and related quality flags.
- Initial comparisons showed some discrepancies due to misinterpretation of the selected processing sequence. After a few **rounds of refining the configurations** of the two software packages, **almost perfect agreement** was achieved for the values of the different fluxes.
- Residual differences in quality flags is mostly due to different algorithms used for the "well developed turbulence" test (Foken et al. 2004).
- Particularly, **the spectral correction procedures are quite differently implemented** between EddyPro (Moncrieff et al. 1997) and TK3 (Moore 1986). This is the processing step that caused the largest differences in flux values depending on the applied settings.
- We conclude that discriminating among actual errors in the implementations ("bugs"), intentional differences and inaccuracies in the software configuration may be **beyond the possibility of the researcher who does not control the source code**; in particular, the present comparison did not highlight any bug; all differences are explained in terms of different implementations.
- We thus warn against "quick and dirty" inter-comparisons as a means to validate EC software. To the aim of assuring consistency and inter-comparability of centralized flux databases, we also warn against the proliferation of "in-house" software. **We rather suggest researchers to rely on established software**, notably those that have been extensively validated in documented inter-comparisons (e.g. Mauder et al., 2008).

6. References

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