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Interactive comment

Interactive comment on "Analysing surface energy balance closure and partitioning over a semi-arid savanna FLUXNET site in Skukuza, Kruger National Park, South Africa" *by* Nobuhle P. Majozi et al.

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We thank the Reviewer for the positive revision of this manuscript, and for contributing to its improvement. According to their general comments, we added a discussion on the impact the exclusion of the soil heat storage term has on the surface energy balance. We tried to answer every comment in detail.

General comments The authors evaluated a 15-year EC data record of a savanna FLUXNET site in Kruger National Park. This is a great and unique dataset. The authors focus in their analysis on the surface energy balance closure and energy partitioning.

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Discussion paper

The topic fits very well into the scope of HESS, and the dataset will be interesting for a broad readership of HESS. The dataset is carefully evaluated for several aspect. The authors give interesting insight to technical problems that showed up over the 15 years, and they analyzed, among others, the effect of the season as well as the friction velocity on the EBR. My major concern is related to the measurement of the ground heat flux. Firstly, important information is missing. As far as I got it, the authors did not determine the heat storage change in the layer above the heat flux plate (HFP). Please state this clearly in the Material and Method (MM) part. Response: Thank you for your comment. The authors have included this information. Line 169-171: "We did not account for the heat storage terms in the EBR, including soil and canopy heat storage, and energy storage by photosynthesis and respiration, in this study. The significance of neglecting these storage terms will be discussed."

Moreover, it remains unclear how the three HFP readings were averaged. Two were installed under tree canopies and one at open space. How did you compute the mean ground heat flux representative for the footprint? Did you compute a weighted mean or did you compute simply the mean over the three plates. In the latter case the ground heat flux would be systematically underestimated, because the areal fraction of tree canopy is only 30%. Response: Thank you for your comment. The soil heat flux for the site was computed as a weighted mean of the three measurements, and this information has been included: Line 149-151: "Soil heat flux was then computed as a weighted mean of the three measurements, i.e., two taken under tree canopies and one on open space."

Secondly, in general neglecting the heat storage term must result to a certain extent in a systematic underestimation of the ground heat flux and hence to a systematic overestimation of the available energy and consequently to an underestimation of the EBR. From own measurements (HFP were installed in 8 cm depth) I know that this storage term can reach at unshaded surfaces 50 to 100 W/m2. Please discuss in detail the magnitude of error that might originate from your methodological approach.

Response: Thank you for your comment. In this study, the authors did not consider the heat storage terms, and have included this information in the methodology (see above response). Furthermore, we have included a discussion on the expected error that could result for this omission as suggested by the Reviewer. Line 304-317: While G plays a significant role on the surface energy balance closure, our study ignored the different energy storage terms in determining the EBR, including the soil heat storage term. The exclusion of this storage term results in the underestimation of G, as the real value of G is a combination of the flux measured by the plate and the heat exchange between the ground and the depth of the plate. This in turn contributes to overestimating the available energy, which then lowers the EBC. As reported by different studies, the omission of the soil heat storage results in the underestimation of the energy EBC by up to 7 %. For instance, Zuo et al. (2011) reported an improvement of 6 to 7 % when they included the soil heat storage in their calculation of EBR, at the Semi-Arid Climate and Environment Observatory of Lan-Zhou University (SACOL) site in semi-arid grassland over the Loess Plateau of China. In their study in the three sites in the Badan Jaran desert, Li, Liu, Wang, Miao, and Chen (2014) analysed the effect of including soil heat storage derived by different methods in the energy balance closure; their EBR improved by between 1.5 % and 4 %. The improvement of the EBR in the study in a FLUXNET boreal site in Finland by Sánchez, Caselles, and Rubio (2010) was shown to be 3 % when the soil heat storage was included, which increased to 6 % when other storage terms (canopy air) were taken into account.

Moreover, I wondered why the authors do not give any information on monthly or annual evapotranspiration rates (in mm). With that information one could get a guess of the climatic water balance of that ecosystem. I think this would be very interesting for the reader and would further strengthen the manuscript. Response: Thank you for the comment. This manuscript focuses on the surface energy balance and how solar radiation is partitioned in this savanna site. The evapotranspiration part has been covered in a different manuscript.

Specific comments Line 132: Please state which software tool (e.g. TK3 or EddyPro) was used to process the EC raw data. Response: Thank you for your comment. The information was added: Line 129-130: "The Eddysoft software was used to process the raw data collected from the eddy covariance system (Kolle & Rebmann, 2007)."

Line 135: How did you detect outliers? Please explain! Response: Thank you for your comment. The information was added: Line 144-145: "The data outliers were detected using the outlier detection procedure found in the Statistica software."

Line 170: The intention of Figure 1 is to show temperature, VPD and rainfall anomalies between the years. I think this way of displaying the data is not really optimal for this purpose. The authors should think about a better way to present these anomalies. One way could be to compute for every month the difference from the 15- year mean and list these differences in a table (rows: month; column: years). Months, for example, that were warmer than the 15-year average get a red color, months that were colder get a blue color. The larger the difference the more intensive the red and blue color. Response: Thank you for your comment. Figure 1 has been redone as shown below.

Line 198: This is a little bit data cosmetic. The very good EBR is achieved thanks to the really bad year 2013, which had an EBR of 3.76. If you remove this year as outlier the mean EBR reduces to 0.77. I suggest that the authors start this chapter with explaining the technical problems that showed up over the years with the very low EBR and the extremely high EBR in 2013. And after that the authors should refer only to the years with no data or technical issues. Response: Thank you for your comment. The authors first reported the yearly EBR, as well as the mean multiyear EBR of all years, including those with low quality data. Here we also explained the technical problems that resulted in the low EBR. Thereafter, we stated that further analysis excluded the years with low quality data (Line 232-233).

Figure 2: In the OLS approach, the dependent variable (turbulent fluxes) is plotted against the independently derived available energy. See for example Wilson et al.

(2002). If you plot it the other way round, as you did, the slope of the regression does not fit to the EBR. If the EBR is below one than the slope must also be below one. In the year 2007, for example, the EBR is 0.44 but the slope is 1.46. That does not fit together. Moreover, if you use the turbulent flux in a regression as independent variable your statistical model assumes that this variable has no error. Please correct everywhere the figures and update the numbers for slopes and intercepts! Response: Thank you for your comment. The authors have rectified this on Figures 2 to 5.

Line 205: Here it would be important for the reader to know how you modeled the incoming and outgoing longwave radiation, so that they can avoid this mistake in future. Please describe this model in more detail. Response: Thank you for your comment. The authors do not have the detailed information on the methodology used to model incoming and outgoing longwave radiation during the 2004-2008 period. However, different methods that model net radiation from climatic variables (Irmak, Mutiibwa, & Payero, 2011; Ortega-Farias, Antonioletti, & Olioso, 2000; Sabziparvar & Mirgaloybayat, 2015) and remote sensing based methods (Kjaersgaard et al., 2009; Samani, Bawazir, Bleiweiss, Skaggs, & Tran, 2007; Sun et al., 2013; Wu et al., 2017) have been developed. It would also be of interest to evaluate these models using the Skukuza eddy covariance data, as an extension to this study.

Technical comments Line 28: Avoid the wording bad and good data. Please use instead e.g. low- and high quality data Response: Corrected, thank you.

Line 40: I would not count energy stored in ground as a minor flux term (see above). Please rephrase. Response: The sentence has been rephrased as: Line 42: "…heat stored by the canopy, the ground and energy storage terms by photosynthesis."

Line 83: If you start the sentence with first I expect that there comes a second item. Response: The succeeding sentence was started as follows: Line 87: "Then, we examined how the surface energy partitioning…."

Line 150: Replace "incorrect assumption" with "simplification". Response: Corrected, Line 163.

Line 148: Introduce here the symbol “R2”. Response: Done (Line 161), thank you.

Line 158: Rewrite “4” in “four”. Response: Done (Line 173), thank you.

Line 224: Here it is unclear which storage term was included by Sanchez et al. (2010). Please rewrite! Response: Thank you for your comment. This reference has been moved to the section which explains the effect of including storage terms in the EBR.

Table 1: Why clayey? In the MM part you write that the texture ranged from sand to loamy sand. Please check! Response: Thank you for your comment. The soil type has been removed in Table 1 to avoid confusion.

Table 1: Campbell Scientific is not the manufacturer of the HFP. The manufacturer is Huskeflux. Please correct that and mention whether you used self-calibrating plates or not. Response: We used the HFT3 soil heat flux plate, which was manufactured by Campbell Scientific, not the HFP soil heat flux plate, a product of Huskeflux.

Table 1: Beside the wind speed the anemometer measures also the sonic temperature. Please add this variable to the list. Response: Added, thank you.

Fig. 2, 3 etc.: Please mention in the MM part which software you used to create these graphs. Response: Mentioned (Line 173-174), thank you.

Line 498: Replace “ground conduction heat” with “ground heat flux” Response: Corrected (Line 543), thank you.

Line 239: Typo: “if” not “It” Response: Edited (Line 262), thank you.

Line 257-258: Please rewrite this sentence. This sentence is unreadable. Response: Edited, thank you. Line 282-283: To understand the effect of friction velocity on the energy balance closure, surface energy data which had corresponding friction velocity (u*) data, were analysed.

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Discussion paper

Line 323: From here on the numbering of the figures is wrong. In this line, for example, you refer to Fig. 8 not to Fig. 9. Response: Corrected, thank you.

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-685/hess-2016-685-AC2-supplement.pdf

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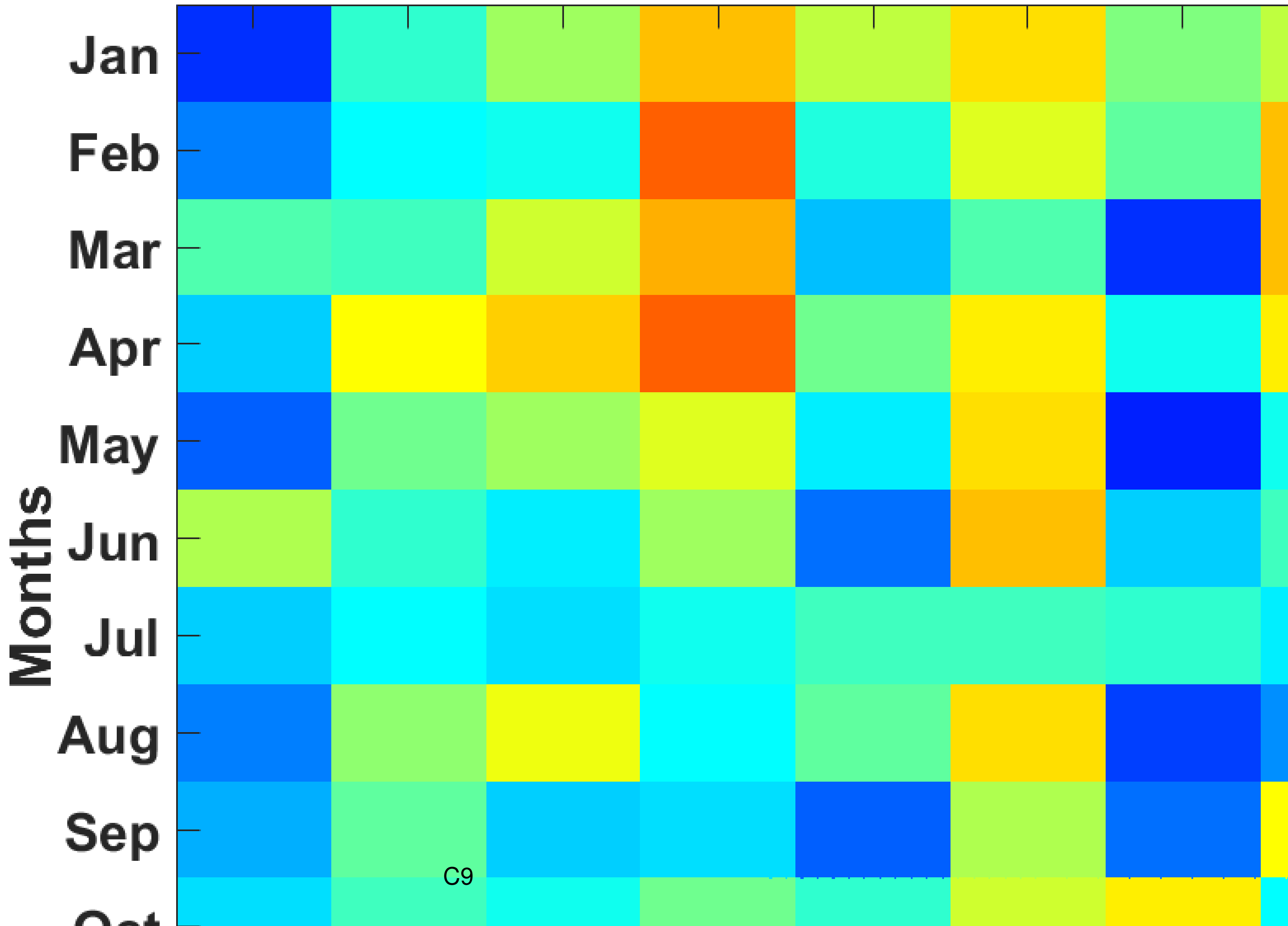
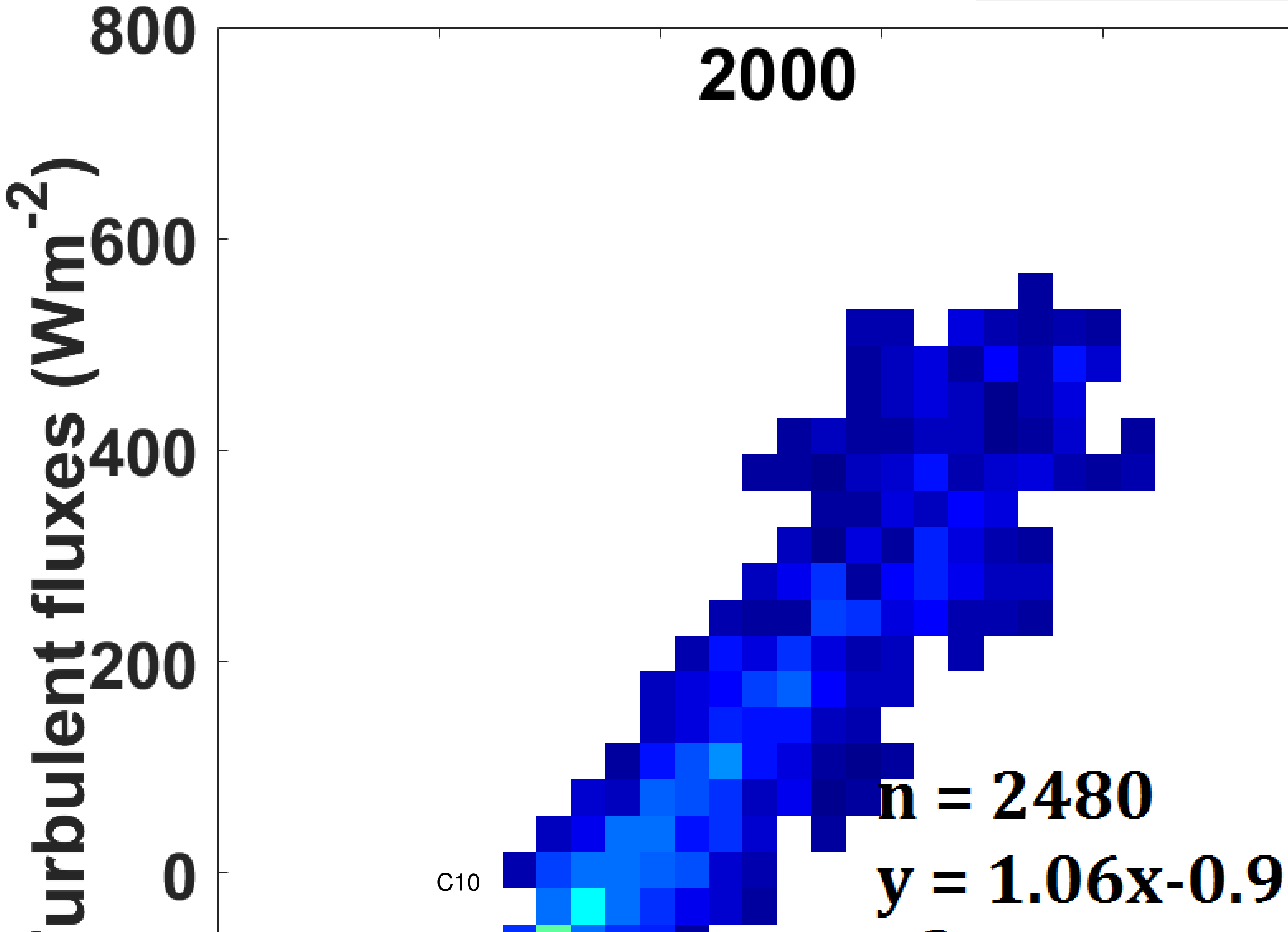
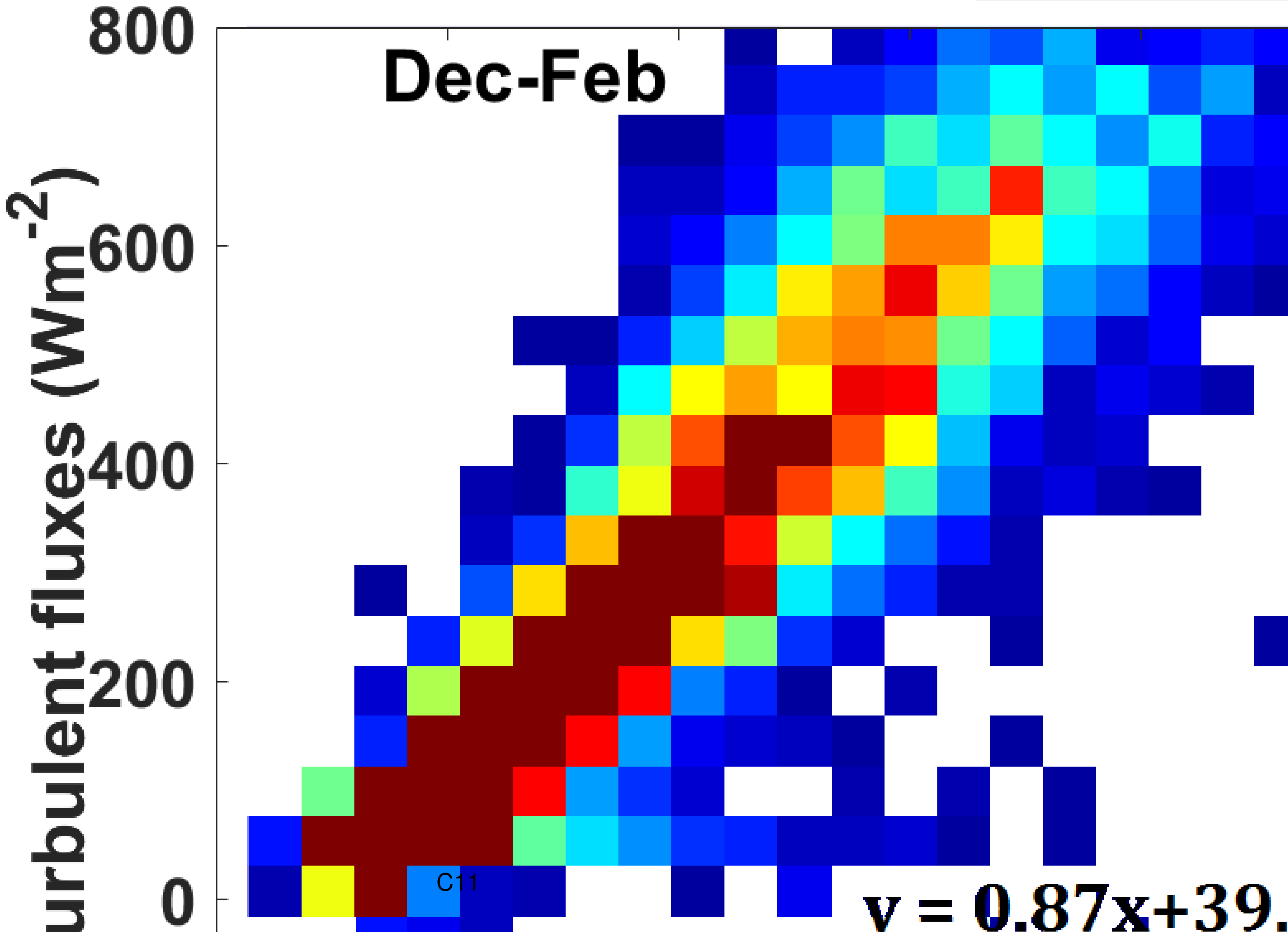


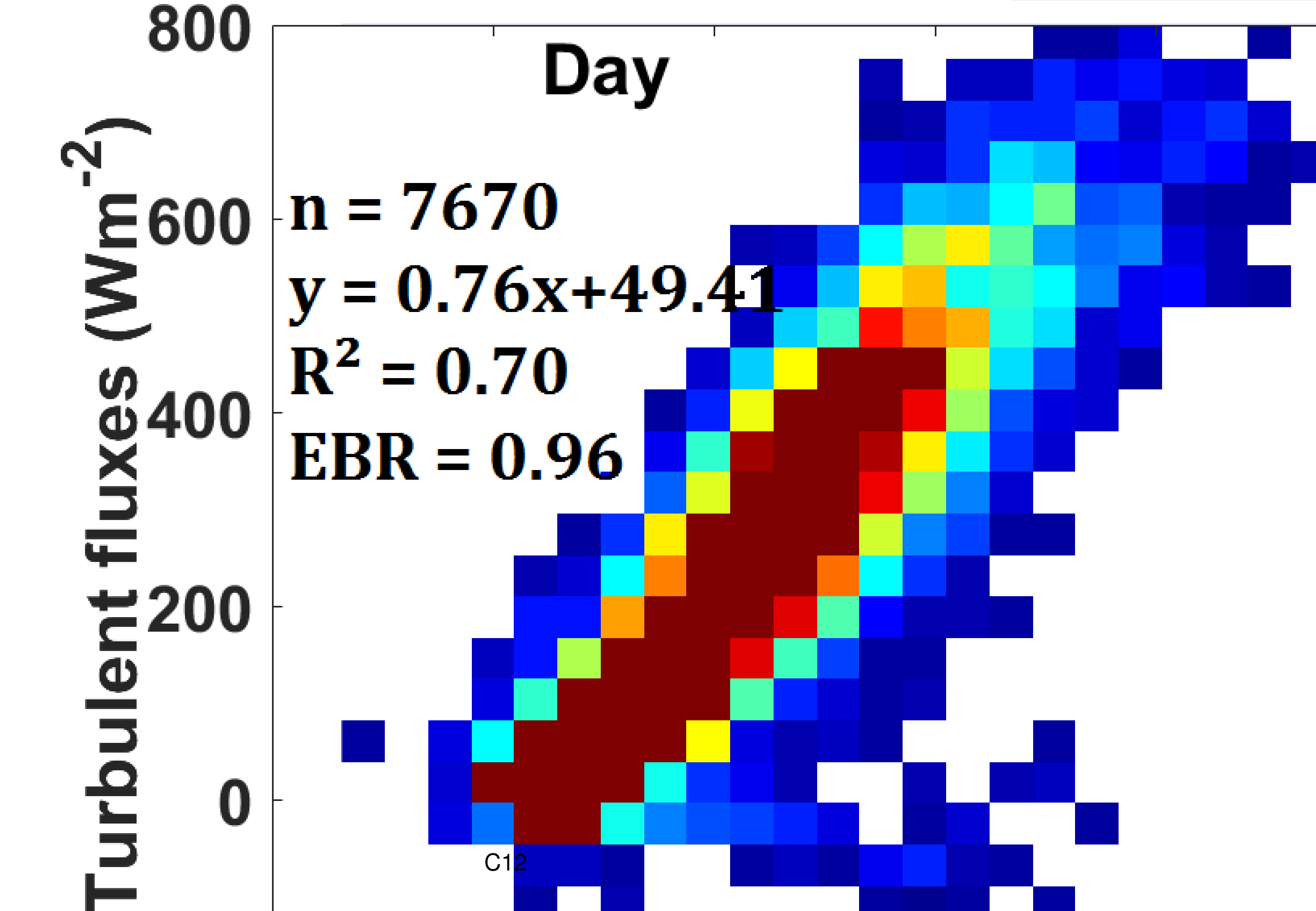
Months
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
C9



2000
800
600
400
200
0
Turbulent fluxes (Wm-2)
n = 2480
y = 1.06x-0.9
C10



Dec-Feb
800
600
400
200
0
urbulent fluxes (Wm-2)
C11
y = 0.87x+39.



Day
n = 7670
y = 0.76x+49.41
R2 = 0.70
EBR = 0.96
Turbulent fluxes (Wm-2)
800
600
400
200
0
C12

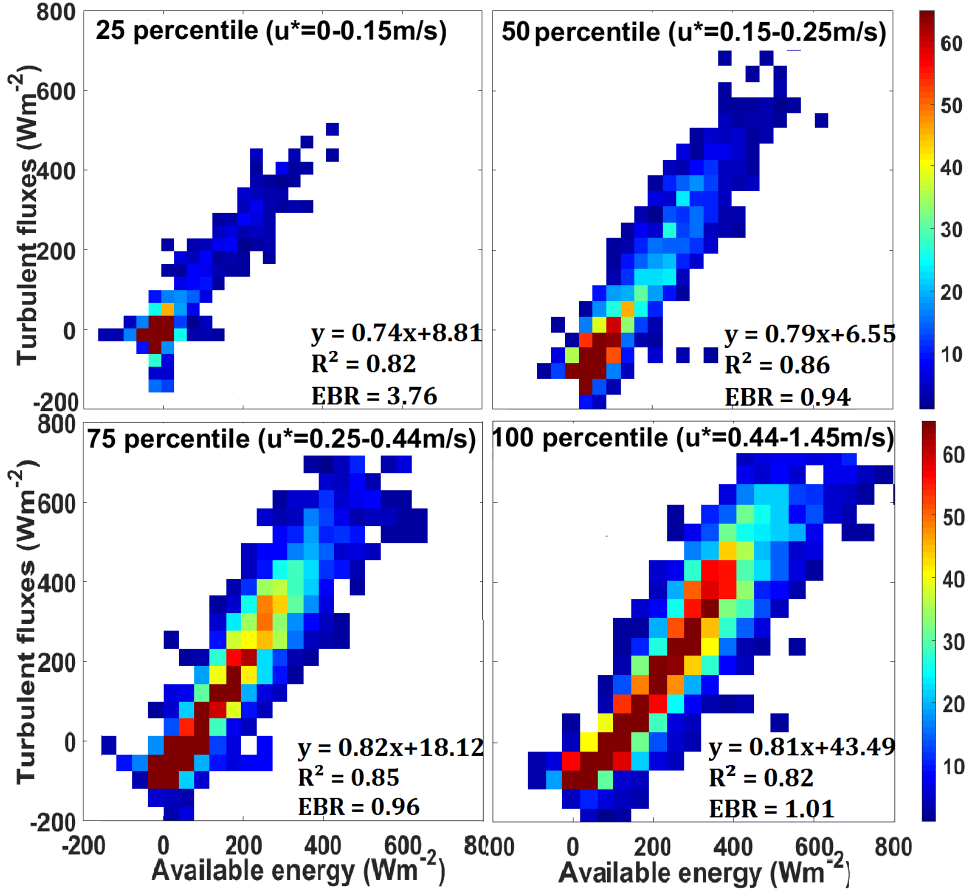


Fig. 5. OLS and EBR evaluations at different friction velocity sorted at four quartiles. The colour bar represents the count of EBR values. The colour bars represent the count of EBR values.