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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The monsoon effect on energy and carbon exchange processes over a highland lake in southwest of China" *by* Qun Du et al.

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Many Thanks for reviewer's valuable comments and suggestions, which help a lot to improve our manuscript. All the revisions have been marked with red color in the manuscript. The responses point by point are as following:

General comments The paper presents interesting measurements of lake energy and CO_2 fluxes from a high altitude monsoon site. The site location adds novelty to the study and further advances our understanding of regional differences and similarities in terms of lake-air interaction. The comparison of temporal patterns during, after and before monsoon is novel and interesting to see. The reasoning and explanation of the

behavior is physically sound However, my main concerns is the analysis regarding the fluxes. In my opinion the correlation analysis does not add anything to our physical understanding of the forcing mechanisms for the energy and CO_2 fluxes. It is for instance well established that both U and the gradient controls H and E. This does not need further investigation. For CO_2 the situation is slightly more complicated, but to say anything meaningful about the flux variation the CO_2 concentration of the water would have to be measured. The gradient is thermodynamic forcing and the efficiency of the exchange is determined by the transfer velocity. In term of H, the variation in U is very small so there is no surprise that the variation in sensible heat flux is due to variations in the temperature gradient. E is determined by both dq and U, here dq and U seem to be well correlated (you can calculate the correlation coefficient) which then explains your results. My suggestion is, instead of the correlation analysis, compute the Stanton and Dalton numbers for the different cases, and analyze these results. You also need to add more references on the CO_2 lake fluxes in the introduction/background and discuss your results in terms of these previous findings. Also, add background on e.g. transfer velocity, surface renewal etc. to at least conceptually put your results in this context. In general, I also think that the figures showing results for all years should be combined into one single plot as they mostly are very similar. Are there any statistical significant difference between the years? Some measure of variation would also be interesting to include.

Answer: Thanks for your valuable comments and suggestions. Although it is well understood that latent heat fluxes and sensible heat fluxes are primarily controlled by wind speed and water vapor or temperature gradients, the factors controlling turbulent fluxes vary among lakes and lake-air interaction could be affected by the lake characteristics, including lake sizes, lake depths, lake dimensions, as well as geographic location (Liu et al., 2009). A weak correlation between U and latent heat flux was found over Ross Barnett Reservoir (Liu et al., 2012) and a small lake in Finland (Nordbo et al., 2011) but a positive correlation was observed for the Great Slave Lake for wind speeds larger than a particular threshold value (Blanken et al., 2003). Water vapor gradient was found to play a dominant role in determining energy fluxes under conditions involving large water vapor gradients, while atmospheric stability becomes significant under small water vapor gradients (Zhang and Liu, 2014). A close correlation was found between net radiation and evaporation (Yao, 2009) but a weak correlation was also found in some lakes (Liu et al., 2012). Lakes with different characteristics may respond differently to various physical forcing. Therefore, more deep study is needed to improve understanding of process controlling lake-air turbulent fluxes. For CO2 fluxes, EC technique could provide long-term continuous measurement compared to traditional methods, e.g., floating chamber and boundary layer techniques. EC measurements have been used also to develop new empirical models of gas transfer velocity k using simultaneous measurements of CO2 partial pressure at the water surface (Mammarella et al., 2014). However, due to the lack of measurements of CO2 partial pressure in our present observation, we didn't study the gas exchange rate. In future, measurements of CO2 partial pressure will be supplemented to develop further study on the variation of gas exchange rate and its controlling meteorological variables. We don't think the poor correlation between U and Hs is attributed to the variation of U is small. Although U is found to have a weak effect on Hs, a strong effect of U on LE is observed. We have calculated the correlation coefficient between U and deltae and the results show large variation, which is not in agreement with the correlation coefficient between U and LE. Therefore, so we don't think the close correlation between U and LE could be explained by the correlation between U and deltae. Some studies have reported the large effect of U on LE especially in some small lakes (Assouline et al., 2008; Wang et al., 2017). This has been added in the manuscript. The correlation between U and âŰşe, and LE are shown in a table, which has been uploaded.

Correlation analysis is a widely used statistical method. Plenty of scientists have applied this method to investigate the relationship between lake-atmosphere turbulent fluxes and meteorological variables (Nordbo et al., 2011; Liu et al., 2012; Zhang and Liu, 2014; Goldbach and Kuttler, 2015). In order to compare with other studies on lake and atmosphere interaction, we retain the results analysis with the use of this method.

Besides, the Stanton and Dalton numbers have been estimated and the analyzed in the manuscript (Figure 8). More references on lake CO2 fluxes have been added in the introduction and compared with our results in discussion. Meantime, the introduction on transfer velocity has been added in background too. All figures have been changed by combining four years into a single plot. The average and the standard error of meteorological variables and fluxes for four years period have been calculated and shown in individual figures. A boxplot is also added to show the variation of turbulent fluxes in different years (Figure 9), and the results have been analyzed in the manuscript.

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Yao, H. X. (2009), Long-term study of lake evaporation and evaluation of seven estimation methods: Results from Dickie Lake, South-Central Ontario, Canada, J. Water Resour. Prot., 1(2), 59–77

Zhang, Q., and H. Liu (2014), Seasonal changes in physical processes controlling evaporation over inland water, J. Geophys. Res. Atmos., 119, 9779–9792, doi:10.1002/2014JD021797.

Specific comments Page 4, Line 4: water level should be stated as water depth, not height above sea level as is stated now (?)

Answer: The water depth of Lake Erhai has been introduced in the last paragraph "The water depth of the lake varies from 10 and 20.7 m". "Water level" here indeed means the height above sea level.

P4, L 10, how large is the annual precipitation, and in average how much during the different periods (pre, during, after monsoon)?

Answer: The average precipitation of the whole year and three different periods has been added in the manuscript.

P4 L15: How are the booms oriented on which you placed the eddy covariance sensors? Did you consider any flow distortion effects from the platform (it is a quite solid construction)?

Answer: The EC sensors are mounted on a pipe orienting to the prevailing wind direction (southeast) at the height of 2 m above the platform. This has been added in the manuscript. The platform is about 1 m above the water surface with a radius of 1 m. The platform is supported by three piers distributing in triangle shape in order to make the air flow pass conveniently (Figure 1). As the air flow could pass the platform easily due to the structure of the platform, the effect of flow distortion is minor and could be neglected. These measurement details could also be referred to our previous studies (Liu et al., 2015).

P4, L 22: CS616 cannot be correct, this is a water content reflectometer

Answer: The temperature probes should be "model 109-L (Campbell Scientific, Inc)". The mistake has been corrected.

P4 L24 : Ts seem to be defines as skin temperature. How does this compare with the standard bulk water temperature at 0.5 m depth?

Answer: We compared Ts and the water temperature at 0.5 m (T0.5) depth for the year of 2012. The result shows Ts and T0.5 have similar temporal variation and T0.5 is slightly higher than Ts. the average of 30-min Ts and T0.5 in 2012 are 17.2$\pm$4.5âĎČ and 17.6$\pm$4.6âĎČ respectively.

P 4, L26: Was the entire field of view located over water for the net radiation sensor? You can estimate this with the measurement height and the length of the boom. It appears from the photo in Fig 1 that the sensor might include also some parts of the platform which would affect your Ts values.

Answer: A figure is uploaded in the attachment which could show the position of the radiation sensors more clearly. The sensors are marked with red circle in the figure.

The radiation sensors are entirely over the water surface. Figure The observation system over Erhai Lake

P4 L31, specify that it is cup anemometer.

Answer: Thanks for your suggestion. This information has been supplemented.

P5 L 4: what do you mean by “also filtered”? AGC 40 is quite low limit, why not set a higher limit?

Answer: It means not only the data points outside the normal range but also those flagged with AGC larger than 40 are filtered. The threshold of AGC is determined by analyzing the relationship between AGC and precipitation. The results show the AGC is usually more than 40 when there is precipitation, indicating the lower data quality in this case.

P5, L6, what is the averaging time?

Answer: The averaging time is 30 minutes, which has been added in the manuscript.

P5, L8: if you are using block average you are not detrending. What do you mean by“circular correlation procedure”?

Answer: Sorry for the mistake about detrending, it has been corrected . The circular correlation procedure is selected to compensate time lags between anemometric variables and gas analyzer measurements. This method determines the time lag that maximizes the covariance of two variables, within a window of plausible time lags (Fan et al., 1990). This has been added in the manuscript.

P5 L11: Add reference for the high frequency correction method. Was this a severe problem?

Answer: The high frequency correction method is referred from Moncrieff et al. (2004), which has been added. The cospectrum analysis shows a rapid decline for the turbulent fluxes at high frequency, indicating the minor effect of small eddy vortex.

P5 L24: It would be useful with a wind rose to illustrate the prevailing wind direction.

Answer: Thanks for your suggestion. The wind rose during daytime and nighttime has been added (Figure 2).

P6 L4: how many data is included in the final data set? How are the data distributed over the different years? Is there any season that has significantly less data than the others?

Answer: After the data quality control, about 66

P6 Section 3: This text is very compact, please separate into paragraphs.

Answer: It has been separated into two paragraphs.

P7, L6: Do you have any more supporting evidence that it is a sea/land breeze circulation? Any land site in the vincinity? Is there any previous studies on this for this site? A single surface observation is in my opinion not enough to support this, it is indicative but not complete shown. As you state on line 11 that strong synoptic (?) west wind during night, this might be explanation for the night wind direction and not land breeze.

Answer: Yes, there is a local meteorological observation site (Dali National Climatic Observatory) near the lake site, with a distance about 4 km between them. The local circulation over Lake Erhai has been analyzed by our another study, which mainly focused on the comparison of atmospheric boundary layer characteristics between pre-monsoon (30 March to 30 April, 2012) and monsoon period (30 June to 31 July, 2012) by conducting sensitivity experiments with the lake-atmosphere coupled model WRF v3.7.1 (Xu et al., 2018). The study has observed the lake breeze circulation during daytime and land breeze circulation during nighttime respectively by analyzing the spatial distribution of horizontal wind. This has been supplemented in the manuscript.

Xu, L., Liu, H., Du, Q., Wang, L., Yang, L., and Sun, J.: Differences of atmospheric boundary layer characteristics between pre-monsoon and monsoon period over the erhai lake. Theor. Appl. Climatol., https://doi.org/10.1007/s00704-018-2386-8, 2018.

P9 L1, “resulted in a lower abledo” compared to what?

Answer: The albedo of Lake Erhai is lower compared to terrestrial land surfaces. This paragraph (the diurnal pattern of radiation components) has been deleted according to another reviewer’s opinion.

P9 L8 The Katsaros reference in the reference list is wrong, please use the correct one.

Answer: Sorry for the mistake. This paragraph has been deleted as it’s not so interesting to authors according to another reviewer’s opinion.

Sections 3.4 to 3.8 please see the general comments

Answer: Thanks for your valuable suggestion. The detailed replies see above.

Figure 8: No data for monsoon and post monsoon for 2014?

Answer: Yes, The instrument failure has resulted in a long data gap for 3 months in this year. This information has been added in the manuscript.

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-14/acp-2018-14-AC2-supplement.pdf

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Fig. 1. The figure of radiation sensors’s position

Table The correlation between U and Δe, and LE are listed as following:

Correlation coefficients	30Min			Daily			Monthly		
	pre-monsoon	monsoon	post-monsoon	pre-monsoon	monsoon	post-monsoon	pre-monsoon	monsoon	post-monsoon
U and Δe	0.149**	0.090**	0.244**	0.006	0.442**	0.390**	-0.482	0.505*	0.183
U and LE	0.502**	0.741**	0.723**	0.634**	0.798**	0.687**	0.791*	0.765**	0.568

Fig. 2. The table of the correlation coefficiency between U and âŰşe, and LE