Response to reviewer #2

General comments:

The main aim of this study is to assess the comparisons of latent (LHF) and sensible (SHF) heat fluxes from the high quality Yongxing air-sea flux tower (YXASFT) and OAFlux data. YXASFT LHF and SHF are calculated from bulk variables derived from instrument measurements, while OAFlux fluxes are available as global daily re-analyses with a spatial resolution of 1° in longitude and latitude. The authors handled interesting and needed work aiming at the estimation of heat fluxes. However, the paper requires scientific improvements. I would suggest to further clarify the study objective and the main new findings. The main results, shown in this paper, deal with straightforward comparisons of YXASFT and OAFlux daily flux estimates, with few insights in the physics and the spatial and temporal scale impacts on the comparison results. The paper does not investigate the quality of YXASFT heat fluxes. The results showing the comparison between YXASFT and ECF fluxes are not convincing. The comparisons between the two sources are quite poor. OAFlux flux estimates have been investigated in several papers, including in papers published by the authors. For instance, the bias characterizing mean difference between moorings and OAFlux LHF are quite small. In this study, the LHF biases exhibit "outstanding" values. It would of great interest for scientific community to understand the source of differences between the previous published results and those shown in this manuscript. I am feeling very sorry. I cannot recommend the publication of this paper. However, I strongly encourage the authors to consider the comments aforementioned and listed hereafter for a new enhanced version.

Response: Thank you very much for your review and objective comments on this study. First of all, we should acknowledge that this study focuses more on the in situ measurement techniques and less on the relevant physical processes or other scientific questions. Actually, for a long time in the past, we have been devoted to the construction of YXASFT by installing a varity of observational sensors and uninterrupted maintenance work, with the aim of making it a unique, fixed, multi-parametric and long-term observational tower of air-sea interaction that is still running normally in the open water of the SCS. This study focuses on the introduction of the YXASFT and presenting some preliminary results. To prove the reliability of these in situ observations, we compared the two observational results of high frequency (ECF turbulent flux) and low frequency (bulk flux) at the beginning. In general, the results of LHF in the two sources are in good agreement. Note that some obvious mismatches can be found, which is mainly due to the effect of precipitation of ECF flux data. However, for SHF, variations in the two sources are quite different and big discrepancies exist in them. This partly due to the deficiency of the ECF sensors in the measurement of air temperature, and on the other hand it is related to the defect of the bulk formula in the SHF calculation. We have explained this with more detail under the response to Specific comments No.6. As one of the most representative flux products, the OAFlux datasets was chosen and compared with full year observations at YXASFT. The YXASFT observations and OAFlux estimates coincide relatively well. On the one hand, this enhanced our confidence on the reliability of YXASFT observations. On the other hand, it helps to find problems in the present flux product and find ways to improve them.

Generally speaking, we presented all the problems found in the comparisons and gave possible explanations for every mismatch, which can provide references for YXASFT and OAFlux data users. However, considering the fact that the nature of AMT is focused more on the observation technology, we have not made a deep analysis of the reasons for these problems and related scientific issue. In the future work, with the continuous accumulation of high quality YXASFT observation data, we will focus more on the scientific issues related to the air-sea boundary layer interaction.

As the technical director of the YXASFT for its design and maintenance, I have received many requests for data sharing of YXASFT in different private (E-mails, messages from CAS, NUSIT, OUC et al.,) and public occasions (EGU, AGU and AOGS exhibitions). And the publication of this article can greatly enhance our confidence and promote efforts to obtain the in situ observations which are very important to air-sea interaction scientific research around the SCS.

At last, we have studied the comments carefully, gave explanation for each questions list below and made some corresponding corrections which we hope meet with your approval.

Specific comments:

1. Page 3, Line 23: The correction procedure used for the estimation of Tau, SHF, and LHF should be explained.

Response: Thanks for your suggestion, due to the limited article space, we did not give a detail description of EC data processing step in the paper. The turbulent flux was calculated by an online program named EasyFlux_DL, which was developed by Campbell Scientific Inc, each EC data processing steps we adopted in EasyFlux_DL are as follws: despiking (Vickers et al., 1997), Coordinate rotation (van Dijk et al., 2004), frequency correction (Moncrieff et al., 2004), WPL compensation (Wallace et al., 2006). As suggested by reviewer, we added **Figure 3** (Page 22 in the revised paper) to show the EC data correction procedure. And also, in Page 6, Line 11-14, we have added a description of the EC data processing, as follows:

"The EC method is mathematically complex, significant care is required to set up different processing steps for different sites, measurements and study purposes. In this paper, the EC program running on CR3000 was based on the processing steps shown in Fig. 3. "

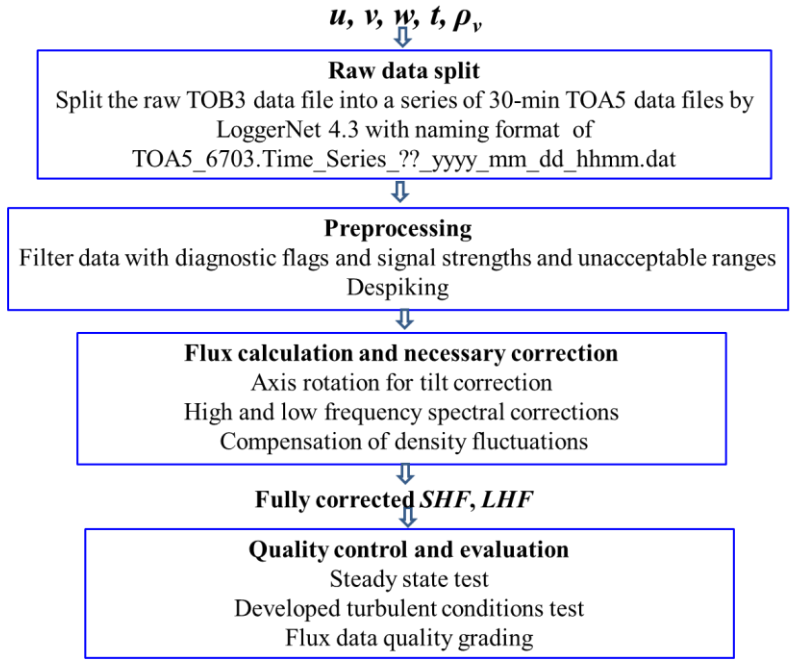

Fig.3 (in the revised paper). EC turbulence data processing and quality control flow chart

2: Page 4: Are bulk variables measured at 20m, 12m, or 10m? The manuscript shows all these values, but does not mention any height correction.

Response: The *U* in YXASFT used for comparison were measured in 10m, this is the same height with surface layer *U* in the OAFlux. The T_a and Q_a adopted in YXASFT were measured at 5m, while the measurement height of T_a and Q_a in the OAFlux are both 2m. Thus, prior to conducting a comparison, we used the height correction algorithm for bulk variables provided in COARE3.0 to correct the YXASFT observed data to the same height as the bulk variables in OAFlux. This was already explained in the paper (marked by red color), in Page 4, Line 18-20, as follow:

"The measurement heights of T_a and Q_a in the OAFlux dataset are both 2m, while the measurement heights for these two parameters on the YXASFT are both 5m. Thus, prior to conducting a comparison, we corrected the corresponding heights of the in situ data to correspond to the variable heights in the OAFlux dataset using COARE3.0. "

3. Page 3, Line 13: OAFlux are not measurements. They are estimates.

Response: Thank you for reminding us. Yes, OAFLux is an estimated product with the synthesis of reanalysis and satellite inputs. The improper expression and all the similar problems found in the manuscript have been corrected.

4. Page 5, Lines 18 – 25: It is not clear. Are these calculates handled by the authors or by dedicated online software. The authors mention above the use of Easy-flux software.

Response: In recent years, many EC data processing methods has been developed and updated, which are mainly divided into two kinds: one is the post-processing software, such as EdiRe, EddyPro, TK3 and so on. The users can use these software to process the direct measured high frequency turbulent data, the built-in correction algorithm module can be selected with purpose to adapt the location and environment of the observation site. The other is online processing program, such as the Easy_flux developed by Campbell Scientific Inc, which requires the user to preset the adaptive correction algorithm in the program according to the site location and the surrounding environmental condition, the program can calculate the turbulent flux in 30min or 60min in real time. The built in algorithm modules of the online program and post-processing softwares are universally accepted around the world, the calculation results are also very similar.

In this paper, we directly use the flux calculation results of the Easy_flux online program to compare with bulk heat fluxes. Further, considering the special location of the island reef and the underlying surface of sea water, we preset a suitable data correction algorithm in order to assure the reliability of the observed data, such as we select planar fitting method for axis correction of sonic wind sensor. A detailed response has been made in Specific comments No.1 in regard to the correction procedure.

5. Page 6, Lines 19 – 24: Do the authors assume that ECF LHF observations are overestimated for rain events? Does it result from instrumental and/or measurement issues?

Response: Yes, due to the limitation of the measurement principle of EC sensors, precipitation has great influence on the measurement of high frequency of Q_a and T_a (T_a was indirect measured by the ultrasonic, however the principle of ultrasonic measurement of T_a will be seriously affected by precipitation). So, this is a technical problem that has not yet been solved well around the world. Due to there is no direct precipitation observation in the YXASFT, we plot the time series of the 30 min mean variables of U, T_a and Rh in Fig.1 (but this figure was not added in the revised article). As we can see from Fig.1, the time window of four possible precipitations were in 2016/02/03, 2016/02/07, 2016/02/25, 2016/03/26 (marked by dashed ellipse), respectively, which could be obviously shown from a sudden increase in Rh and a sudden drop in T_a.

Strictly speaking, the ECF data in these four time windows must be eliminated before compared with COARE3.0. In this paper, we didn’t eliminate the possible data polluted by precipitation, but it almost does not affect the validation of LHF. The LHF comparison between ECF and COARE3.0 shows a good consistency except for the above mentioned possible precipitation windows. We agree very much that if the ECF data during precipitation days were eliminated, the comparison between CAORE3.0 and ECF will be more consistent, which will further demonstrate the reliability of the COARE3.0 algorithm in SCS.

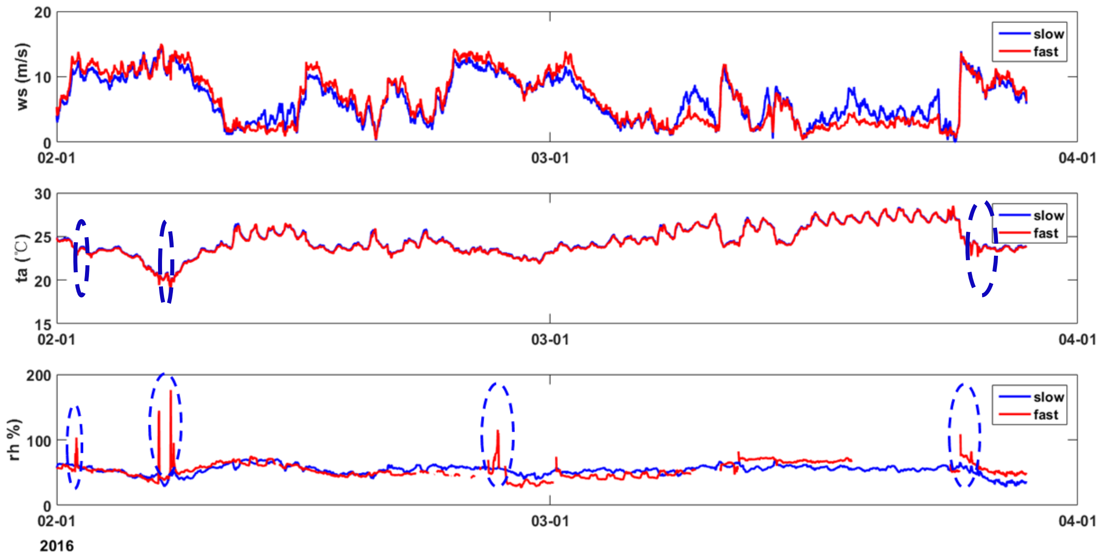

Fig.1 Time series of observed wind speed (U), air temperature (Ta), air relative humidity (Rh) by the slow and fast response sensors, respectively. The time windows for possible precipitation were marked by dashed ellipse.

6. Page 7, Lines 25 – 28: Convincing scientific and/or technical reasons should be provided for explaining the difference between observed and estimated SHF.

Response: The big difference of SHF between ECF and bulk method can be attributed to both the technical and theoretical reasons.

Technical aspects: As we mentioned in the answer of the last question, the T_a was indirectly measured using ultrasonic principle rather than directly physical measurement, so it was easily affected by the precipitation and surrounding environment **(Zhang et al., 2016)**. Further more, T_a was the key factor of SHF calculation and can directly affect the accuracy the SHF in ECF system. So, inaccuracy measurement of T_a by ECF system is a technical problem to be solved.

Theoretical aspects: The present bulk method still has large uncertainties in SHF calculation (for example, the uncertainty and limitations of parameterization schemes), which can affect the calculation accuracy of SHF by bulk method. To solve this problem, joint efforts by the scientific community are needed to improve and optimize the parameterization scheme

So, on the basis of the technical and theoretical problems mentioned above, the comparison results show that the SHF calculated by ECF and Bulk method is so not consistent with each other. Actually, this problem is well understood as: you can not expect that neither of the two results is accurate enough to have good match with each other.

Further, from Fig.9 in the revised paper we can find that the SHF deviation of YXASFT observation and OAFlux is mainly come from spring and winter, but it showed high consistency in the summer_autumn period. This is also consistent with the T_s comparison in Fig.7, which are further affected by the cloud cover in different seasons.

Reference:

Zhang R., J. Huang, X. Wang, J. A. Zhang, and F. Huang, 2016: Effects of precipitation on sonic anemometer measurements of turbulent fluxes in the atmospheric surface layer. J. Ocean Univ. China, 15(3), 389-398.

7. Page 7, Lines 11-13: How the YXASFT and OAFlux consistency has been determined?

Response: One side, we try to understand your question from the aspect of spatial matching of the compared datasets. Reply as follows:

The YXASFT observation is a signal point, and the OAFlux is a gridded datasets. In order to minimize the uncertainly caused by the location difference, we have adopted the method introduced by **(Sun et al, 2003)**. The representative OAFlux data used for comparison with YXASFT is derived by bilinearly interpolated (inversely weighted by distance) from values of the surrounding four grid points.

On the other side, we try to understand your question as how to quantify of data consistency from the comparison, and reply as follows:

We gave both the time series and the scatter plots of each compared variables in Fig.5 and Fig.7 (in the revised paper), respectively. From Fig.7, the consistency of the two variables can be quantitative analyzed by value of both line coefficient and R^2, the bigger value of line coefficient and R^2 indicates a better consistency.

Reference:

Sun B, Yu L, Weller RA (2003). Comparisons of surface meteorology and turbulent heat fluxes over the Atlantic: NWP model analyses versus moored buoy observations. Journal of Climate 16:679–695.

8. Page 8, Lines 1-2: The OAFlux U biases are quite high compared to those obtained from moored buoys and OAFlux U10 comparisons. Does this result relies on YXASFT location and/or on OAFlux spatial and temporal resolutions?

Response: Overall speaking, the U10 of OAFlux is in good consistent with the YXASFT observation, with bias of 0.96m/s in Spring, 1.19m/s in Summer_Autumn and 0.67m/s in Winter, and a R^2 of 0.90 in Spring, 0.79 in Summer_Autumn and 0.92 in Winter, respectively. However, as shown in Fig.5 and Fig.7 (first row), the U10 in OAFlux is slightly higher than YXASFT observation, and the U10 difference between OAFlux and YXASFT is more obvious in summer. The reason for this may be related to the onset of the summer monsoon and the environmental factors became more complex during this period. The problem of the larger U10 difference between OAFlux and YXASFT during the monsoon period remains to be further studied.

On the other hand, the mismatch in temporal and spatial resolution may also affect the high biases in U. OAFlux is grid data and YXASFT is a single point observation data, the two datasets for comparison can bot be fully spatial matched. So this spatial difference may also lead to the mismatch between of OAFlux and YXASFT observation. The observed daily average data were derived from the average of 48 high-frequency (30 min) observations, but the temporal resolution of the OAFlux's daily average data is not so high (6 hours satellite remote sensing data), so the temporal resolution difference may also lead to the mismatch in their daily average data.

9. Page 8, Lines 22-24: The cloud impact on OAFlux T_s (from NOAA OI SST) should be found everywhere, and especially along tropical are. The previous published studies aiming at the assessment of OAFlux daily data, did not provide T_s results shown in this study.

Response: Yes, this suggestion (the available OLR reanalysis data download) has also been given by a Short Comment during the public discussion period. And, we downloaded the daily mean OLR data from NOAA through this web link: https://www.esrl.noaa.gov/psd/cgi-bin/db_search/DBSearch.pl?Dataset=NOAA+Uninterpolated+OLR&Variable=Outgoing+Longwave+Radiation, also we plotted the OLR time series as Fig 2. But from OLR time series, we can not infer that the cloud cover of the sky in winter and spring is more than that during the summer monsoon period (2016/5-2016/9). Then we used DLR (downward longwave radiation) observed from YXASFT to estimate cloud cover indirectly instead of OLR. As we know, DLR is mainly depends on the air temperature, which can be affected by cloud cover. When the sky was covered with large clouds and thick clouds, the probability of rising air temperature will be bigger, which will further increase the DLR. We plotted the curve of observed DLR in Fig.8 (in the revised paper) in the revised paper, from Fig.8 we can see that there is an evidently greater fluctuation in the DLR during the winter and spring periods than in the summer_autumn period, indicating that the winter and spring seasons possess greater probabilities of cloudy days.

Yes, as shown in the previous study, with the onset of the summer monsoon, the sky cloud cover should increase, and the T_s retrieved via the AVHRR should correspondingly exhibit a lower quality. But in this study, we found a different result that the data quality of T_s in OAFlux during the monsoon period is better than that in spring and winter season. And also we have tried to use the observed DLR to explain this phenomenon was caused by the less cloud cover during the summer monsoon period. This interesting phenomenon may be caused by the fact that the intensity of the summer monsoon in 2016 was weaker than those in preceding years, which remains further explored.

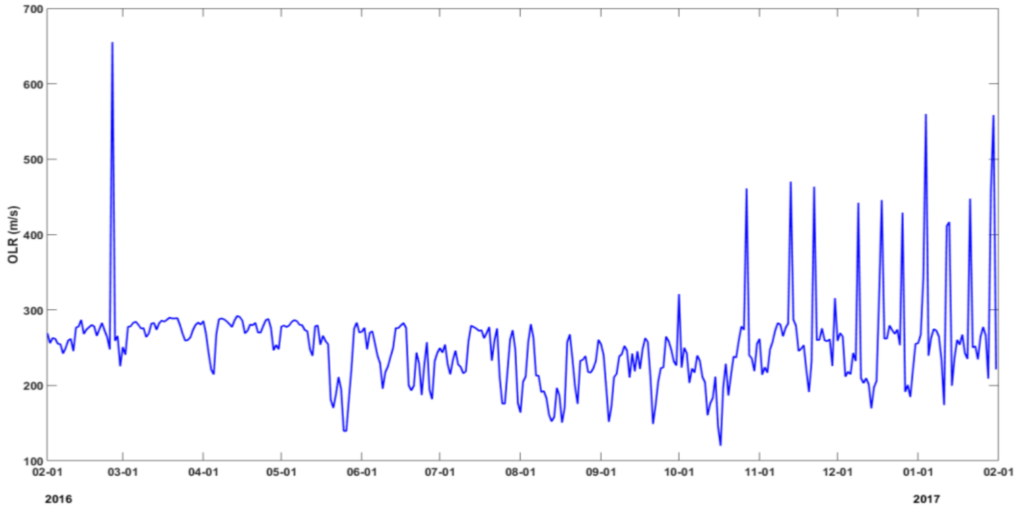

Fig 2. Daily mean of NOAA OLR from 2016//02/01-2017/01/31

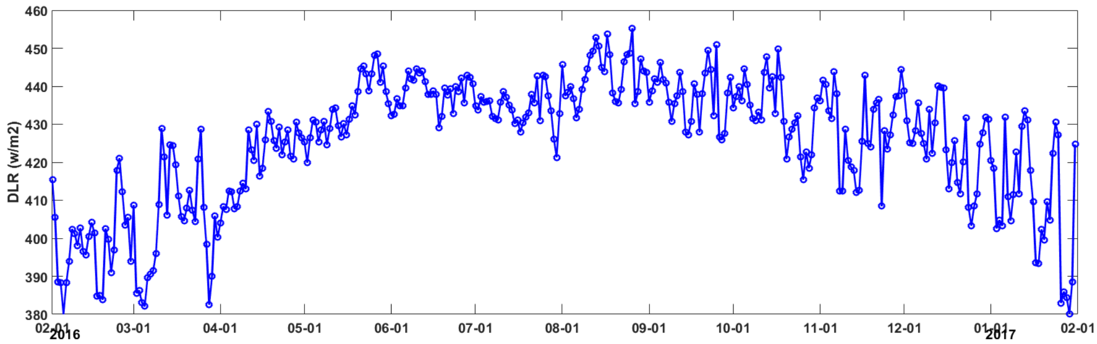

Fig 8 (in the revised paper). Daily mean time series plots of the YXASFT-observed downward long radiation (DLR) over the study period (2016/02/01-2017/01/31).

10. Page 10: The section on top only confirms the results published in several papers. It does provide any new findings dealing with the assessment of LHF and SHF quality or accuracy. Figure 9 and 10 show some interesting results. For instance, the relationship between ΔLHF and ΔTa for winter, would be investigated. Furthermore, the figures show significant scatter. The latter would be investigated as study cases.

Response: Yes, in terms of biased factor that determine the biased heat flux, we have got some conclusions similar to previous studies. Such as, the biases in T_s were the key factor dominating the biases in SHF and the biases in LHF is mainly caused by the biases in Q_a. This does not seem redundant in the article, but proves the credibility of both previous and the present studies. And, we further analyzed the bias factors that dominate the biase of heat flux in different seasons. For example, from Fig.10 (in the revised paper), it can be seen that the LHF bias between YXASFT and OAFlux mainly caused by biased Q_a in Spring, biased U and Q_a in Summer_Autumn, and bised Q_a and T_a in winter, respectively. These dominate factors that cause the seasonal biases in heat flux are new findings in this article. Thank you for your suggestions, we have revised this chapter in Page 9&10, Line 26-33 & 1-3, as follows:

△ LHF: The biases in Q_a are the most dominant factor in determining the biases in LHF during the spring with relatively high R^2 values of 0.38 compared with the other biased bulk variables (Fig. 10 (first column)). Both of the Q_a and U biases are responsible for controlling the biases in LHF during the summer_autumn period with R^2 values of 0.36 and 0.32, respectively (Fig. 10 (second column)). Both of the Q_a and T_a biases are the dominate factors in determining the bias in LHF during the winter period with R^2 values of 0.43 and 0.16, respectively (Fig. 9 (third column)). The biases in T_s is negligible control factors on the biases in LHF, since their R^2 values are all relatively small during the three periods compared with those of Q_a (Fig. 9 (third and fourth rows)). In general, the result revealed that the Q_a is the most dominated factor controlling the biases in LHF throughout the year is similar to those reported in previous studies (Wang et al., 2013, 2017). Additional, these dominate factors that cause the seasonal biases in LHF are new findings in this article.

Yes, it is true that we can find some special phenomena from scatter plots in Fig.10 and Fig.11 (in the revised paper). As you mentioned, from Fig.10, we can see that the relationship of biased LHF and biased T_a in winter is very different from that in spring and summer_autumn, this can be further investigated as a phenomenon study case. This is a good advice, but the main purpose of this paper is to compare the YXASFT observation data and the OAFlux reanalysis data, present the results of comparison objectively, prove the reliability of the observation data, provide references and suggestions for data users. Any in-depth analysis of phenomena or physical process is not described in this paper, but will be further explored in the follow-up research work.