Dear Reviewer:

We appreciate very much for the valuable comments of our manuscript. Thses opinions help to improve academic rigor of our artical. Based on your suggestions, we have responded the comments one by one as listed below, which is also revised in our revised manuscript.

Minor：

1. **Line 91 : 'scientists' to be replaced with 'studies'**

We appreciate it very much for the suggestion, and we have replaced 'scientists' with 'studies'.

2. **Line 93: Citations needed for definition**

Thank you for the reminder, and the citations have been added. (Rao and Sivakumar, 1999; Kumar et al., 2009; Rao et al., 2015)

3. **Line 183-195 : Quite repetitive writing. Rephrasing needed.**

We have revised the text to address your concerns and it is much clearer now. The revised text reads as follows: "The contribution of SHF to $\frac{\partial T}{\partial t}$ ranged from 0.11°C/5 day to 0.34°C/5 day (Figure 4), always playing a heating role. From April to early May, the contribution of SHF to temperature was around 0.3°C/5 day, indicating that SHF provided substantial thermal support for the increased temperature. By early June, the contribution of SHF to temperature dropped below 0.2°C/5 day. The effect of SHF on warm pool temperature can be divided into two parts that are caused by net surface heat flux ($SHF_{Q_{net}}$) and the penetrating shortwave radiation at the bottom of the mixed layer ($SHF_{Q_{loss}}$). In the upper layer of the mixed layer, the temperature change is related to the heat exchange between the surface seawater and the atmosphere, so it is related to net heat flux at the sea surface ($SHF_{Q_{net}}$). In the lower layer of the mixed layer, the heat flux that can penetrate the bottom of the mixed layer is mainly shortwave radiation. Therefore, the heat loss at the bottom of the mixed layer is mainly related to penetrative shortwave radiation ($SHF_{Q_{loss}}$). The contribution of gradually increased from 0.41°C/5 day to 0.50°C/5 day in April. It increased slowly but remained at a relatively high level. Then it gradually decreased to less than 0.2°C/5 day. Similar to , also gradually increased to –0.17°C/5 day in April and then decreased."

4. **The paper is loosely written. At many places, it seems authors meant something else but have written something else.**

We have now worked on both language and readability. We really hope that the language level have been substantially improved. Thanks so much for your useful comments.

5. **Line 292 : based on a 0.5 sigma criterion .**

Thank you for your suggestions, and we have changed the above as suggested.

6. **Figure 13, and its caption : N should be capital In Niño and in all other places.**

We are very sorry for our incorrect writing, and we have corrected the errors in the whole paper.

7. Line 328 : Please rewrite the descripition of IOD if needed in correct tense. This is grammatically incorret.

Thank you for pointing out the error, and we have revised it as: "The IOD is an inherent interannual climate mode in the TIO. During a positive phase, warm waters are pushed to the Western part of the Indian Ocean, while cold deep waters are brought up to the surface in the Eastern Indian Ocean. This pattern is reversed during the negative phase of the IOD (Saji et al., 1999; Kumar et al., 2020)".

8. Rewrite section 5 with more conciseness and clarity.

Thanks for your comments. According to your suggestions, we have revised the summary and discussion of section 5 of the paper to make them more concise and clear.

Major :

1. Section 2.3 : Are the units consistent in this formulation of Heat budget? The units of ENT1 and ENT2 is degC/s. The units of ENT3 is deg C-m/s. Kindly check and clarify.

After careful checking, we confirmed that the units in this formulation of the heat budget were consistent (°C/s). In our study, since the time interval of the SODA data set used in this paper is 5 days, in order to ensure the accuracy of calculation and the units are consistent, we converted the unit into °C/5 days when calculating and drawing.

2. Line 139 : What is advection of mixed layer depth and how is it different from advection : ADV? Please explain. This is very confusing. What is tendency of MLD? Is it the tendency of how depth changes?

"Advection of mixed layer depth" refers to the horizontal variation of the mixed layer depth caused by the horizontal flow of seawater, with an emphasis on the distribution of the mixed layer depth in the horizontal direction. However, the advection term "ADV" refers to the horizontal variation of seawater temperature caused by the horizontal flow of seawater, with an emphasis on the distribution of seawater temperature in the horizontal direction. "tendency of MLD" refers to the trend of changes in mixed layer depth over time, which corresponds to variable $\mathrm{ENT2} = -\mathrm{H}\frac{\partial h}{\partial t}\frac{T-T_h}{h}$ in the formula (line 128), indicating the change in mixed layer temperature caused by local changes in mixed layer depth.

3. Section 2.3 Line154 ; Wh is the bottom of mixed layer? Is it the depth? I understand it is the vertical velocity at the base of the mixed layer from the calculation. However, please write it carefully. It is important for the readers to understand this.

Thank you for pointing this out. The reviewer is correct, and we have corrected it as " W_h is the vertical velocity at the base of the mixed layer"(line 138).

4. Why do you need a dimensionless number H in the heat budget equation?

H is the dimensionless number in the vertical entrainment, which involves the temperature change caused by the local change of mixing depth ($\frac{\partial h}{\partial t}$). When $\frac{\partial h}{\partial t}$>0, H is 1; When $\frac{\partial h}{\partial t}$≤0, H is 0. The calculation formula used here is consistent with that of Kurian and Vinayachandran (2007).

5. Figure 1 & Figure 2 : You define warm pool by 30deg C, but in figure 1, there is no cold pool after 26 May. How do you plot the maximum temperatures in figure 2, it is not clear what area did you choose for it? In Line 151, it is mentioned that area of warm pool has been chosen, but there is no warm pool on those dates.

Thank you for pointing out this problem in our manuscript. According to the revised content, we have redrawn Figure 1 and 2, and added a clear description of the definition: "This article defined a rectangle range of 55.25°E-77.25°E and 5.25°N-20.25°N based on the regional distribution of sea surface temperature in the Arabian Sea (As shown in Figure 1, marked with a dashed rectangle). ASWP was defined as the sea area within the rectangular range with a SST greater than 30°C" (line 156-158). Therefore, it can be seen that there are still small areas of sea temperature above 30℃ along the western coast of the Indian Peninsula after May 26th (i.e., May 31st, June 5th). When calculating the highest temperature, we calculate the highest temperature of the sea area with SST greater than 30℃ within the rectangular sea area. Corresponding modifications have also been made to Figure 1 and 2.

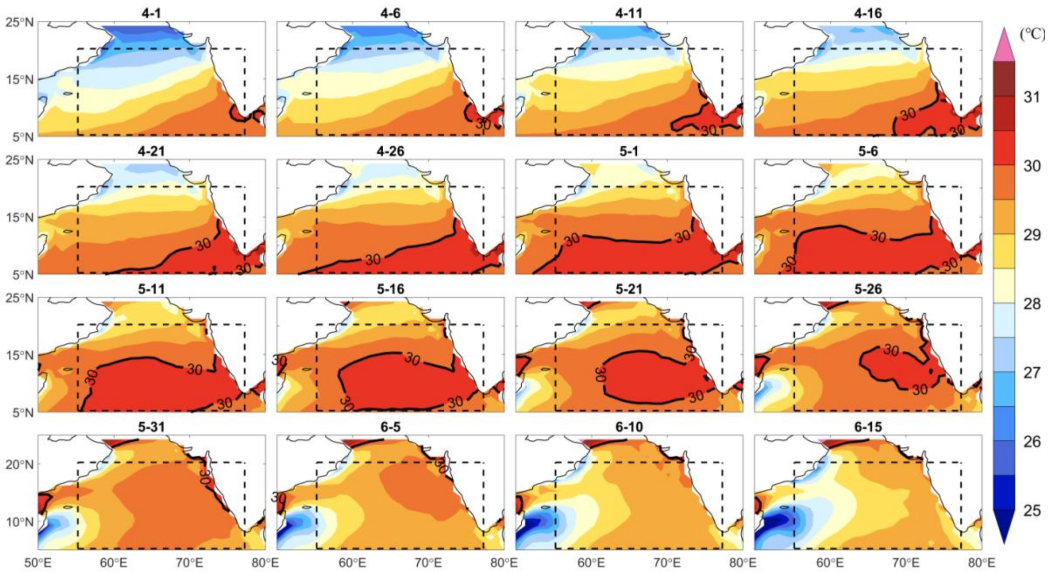

Figure 1: Climatological SST (1980–2016) in April–June, where the black contour is the 30°C contour. The dashed rectangle represents the selected warm pool range.

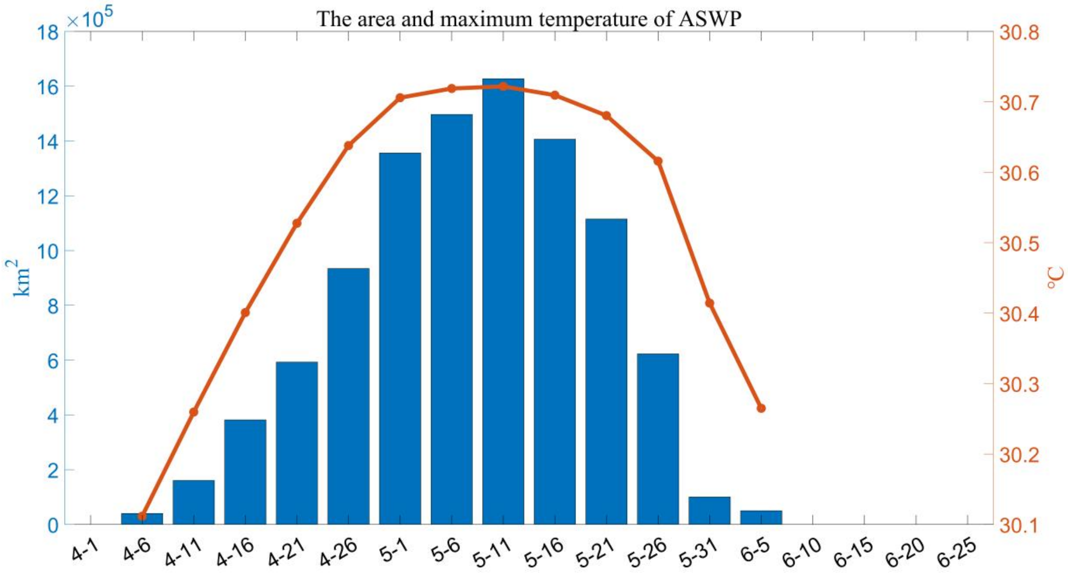

Figure 2: Climatological time series of the area and maximum temperature of ASWP, where the blue bars represent the warm pool area (km^2) and the solid line represent the maximum warm pool temperature (°C).

6. The ASWP is defined historically in the SEAS, from 31 May onwards the pool seems to be shifting to extreme North of coast. Did you use a latitudinal boundary to define the warm pool, or have the authors taken June 5 contour of 30deg C to calculate area and temp of warm pool?

We apologize for the vague expression of the definition. The definition of ASWP in this article is the sea area with sea surface temperature greater than 30°C within the rectangular area of 55.25°E-77.25°E and 5.25°N-20.25°N. The delineation of this rectangular area is based on the spatial extent of the warm pool when it reaches its maximum area (May 11th). Following your suggestion, a box defining the area has been added to Figure 1, and a detailed description of the ASWP definition has been added to the text (lines 156-158).

7. Line 195: This is anyway clear from blue line in Figure 3.

Thanks for pointing it out. Since this conclusion has already been illustrated in Figure 3, it will not be repeated here at your suggestion.

8. Line 188 : How do authors say that Qnet is due to air sea interaction and Qloss is due to SWR penetration. Qloss is due to all factors of Heat flux – Sensible, latent, longwave etc and not only because of reduced SWR penetration. If the authors are too confident about SWR reduction, it should be explained more. Always : Q = Qnet + Qloss, so saying the SWR penetrated less is not always correct.

We are very sorry for some confusing descriptions. As mentioned by the reviewer, strictly speaking, both Q_{net} and Q_{loss} are indeed related to all factors of heat flux (such as latent heat, sensible heat, longwave and shortwave radiation). In the upper layer of the mixed layer, the temperature change is related to the heat exchange between the surface seawater and the atmosphere, so it is related to net shortwave radiation, longwave radiation, sensible heat, and latent heat at the sea surface. In the lower layer of the mixed layer, the heat flux that can penetrate the bottom of the mixed layer is mainly shortwave radiation (Liu Zhiliang, 2007). Therefore, the heat loss at the bottom of the mixed layer is mainly related to penetrative shortwave radiation.

Therefore, in the calculation formula, $Q_{net} = \frac{Q_{sw} - Q_{lw} \pm Q_{sh} \pm Q_{lh}}{\rho_0 ch}$, $Q_{loss} = \frac{Q_{sw}[re^{-\frac{h}{\beta_R}} + (1-r)e^{-\frac{h}{\beta_B}}]}{\rho_0 ch}$.
According to your suggestions, we have revised the paper to make it more clear (line 195-200).

9. Line 200 onwards : Here SWR penetration is explained. It is not clear at what level have the authors taken SWR in their calculation. Is it at the TOA or Surface of the ocean?

SWR can affect the temperature change of the mixed layer through two aspects, one is the absorption of shortwave radiation in the ocean surface layer, and the other is the loss of shortwave radiation at the bottom of the mixed layer (Li et al., 2016). Therefore, this article reflects the calculation of SWR in two aspects: one is in Q_{net}, which calculates the net shortwave radiation absorbed by the ocean surface layer; the other is in Q_{loss}, which calculates the shortwave radiation that penetrates the bottom of the mixed layer. We corrected it clearly in the revised paper.

10. Is the MLD response to reduced SWR immediate? Or is there a difference in the rate of decay of MLD temperature due to SWR reduction?

Thank you for pointing this out. The revised it as follows: "In addition, although the variation of SST was roughly in line with the trend of SWR, the variation of SST had a lag time of about one month compared with SWR. This trend occurred because seawater has a large specific heat capacity and there is a lag of one month in the variation of SST." The results also show a one-month lag (Figure 3).

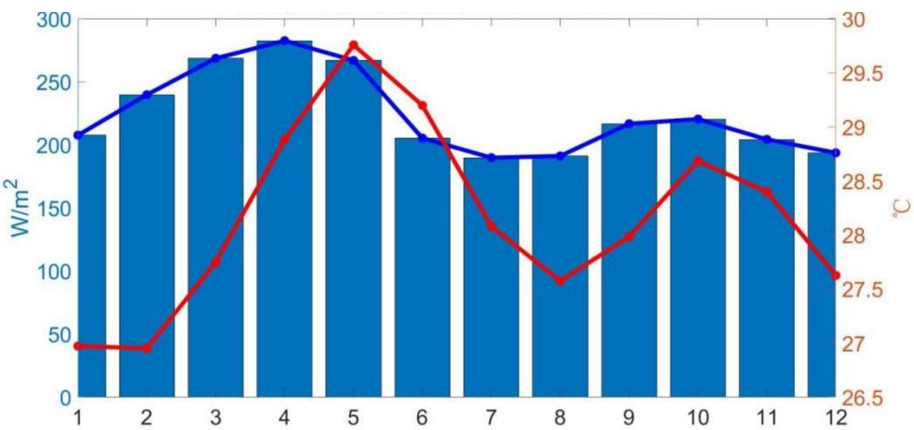

Figure 3: Monthly Variation of the net shortwave radiation at the sea surface (blue bars and lines; W/m^2) and SST (red line; ° C) of the Arabian Sea.

11. Line 211 : what is certain lag?

Thank you for your comment. We've changed " a certain lag " to " a lag of one month ".

12. Line 220 : how does MLD inhibit penetration of SWR. I am not clear with this mechanism. The authors may explain please.

According to the formula $Q_{loss} = \frac{Q_{sw}[re^{-\frac{h}{\beta_R}} + (1-r)e^{-\frac{h}{\beta_B}}]}{\rho_0 ch}$ and the spatial distribution of Q_{loss} and MLD, it can be concluded that Q_{loss} is negatively correlated with MLD. Regarding the mechanism between SWR and MLD, the statement in this paper "the mixing layer greatly inhibited the penetration of shortwave radiation flux into the mixed layer" is inappropriate. The correct statement is that MLD is forced by penetrative shortwave radiation, and the impact of penetrative shortwave radiation on the depth of the mixed layer is controlled by wind speed and net shortwave radiation at the sea surface (Liu Zhiliang, 2007). Thank you for pointing this out. The correction has been made in revised paper (line 225-229).

13. Line 228 onwards : Comment no 1,2,3. I am not clear what each of those terms mean, it is not clearly defined as well. Kindly explain. I only understand ENT1.

The entrainment process in the ocean mixed layer is the product of the entremaint velocity (W_h) and the difference of temperature between the mean temperature in the mixed layer (T) with the temperature just below the mixed layer base (T_h).The entrainment is composed of three terms(Nogueira Neto et al., 2018):

1. the entrainment due to the vertical velocity ($W_h \frac{T-T_h}{h}$).

2. the entrainment due to the local tendency of the mixed layer depth ($H\frac{\partial h}{\partial t}\frac{T-T_h}{h}$). It refers to the trend of changes in mixed layer depth over time.

3. the entrainent due to "advection of the mixed layer depth" ($(U\frac{\partial h}{\partial x}+V\frac{\partial h}{\partial y})\frac{T-T_h}{h}$). It refers to the horizontal variation of the mixed layer depth caused by the horizontal flow of seawater, with an emphasis on the distribution of the mixed layer depth in the horizontal direction.

14. Line 236 -238 : Do the authors mean that -Low wind speed made MLD more sensitive to heat flux? What is the meaning of this line? I understand MLD is always sensitive to heat flux, atmospheric conditions determine heat flux, the sensitivity is always there because MLD included the Sea surface which is always in contact with the atmosphere. I think the authors mean to write something else, but it is not clear. At the same time, how shallow MLD makes the upper sea water increase rapidly?

Thank you for pointing out this problem in our manuscript. I apologize for my ambiguous expression. Actually I mean that the low wind speeds result in shallower mixed layer, which in turn makes the seawater within the mixed layer more easily heated and sensitive to heat flux. Following your suggestion, the description has been revised as "In the development stage of the ASWP, the low wind speed made the mixed layer shallower, which made the seawater within the mixed layer more easily heated and thus more sensitive to heat flux". Therefore, during the development stage of ASWP, strong net heat flux and shallow mixed layer resulted in rapid warming of the upper sea water.

15. Line 240 onwards : Thermocline and Isothermal layer are not the same. They cannot be used interchangeably.

Thank you for pointing out this problem. We apologize for our error, and we’ ve changed “thermocline” to “isothermal”.

16. After reading through, it is not possible for me to point out each and every concern in the vertical entrainment term of heat budget. There is a diverse explanation ranging from penetration of SWR to Rossby waves. The timescales, space scales need a mention. This section needs a major overhaul and rewriting, it is very confusing currently. At the same

time, the terms and mechanisms have to be explained carefully and clearly. This section has too many issues to point out and may be worked again.

Thank you for pointing it out. According to your suggestions, we have revised the contents as follows:"The vertical entrainment is closely related to the vertical thermohaline structure of seawater and the depth of the mixed layer. When the mixing of the upper seawater in terms of temperature and salinity is inconsistent, the isothermal layer and mixed layer will differ, and a barrier layer will be formed between the bottom of the mixed layer and the top of the thermocline (Sprintall and Tomczak, 1992). The barrier layer has the characteristics of a strong salinity gradient and high gravitational stability, which makes it difficult to transport heat from top to bottom by mixing. On the one hand, a strong and stable salinity stratification can effectively inhibit the transfer of non-solar radiation flux to the interior of the ocean, which leads to the warming of the upper mixed layer. On the other hand, the existence of the barrier layer can inhibit the entry of the cold water of the thermocline into the mixed layer, which is not conducive to the exchange of heat, momentum, mass, and nutrients between the mixed layer and the thermocline (Pang Shanshan, 2021). Therefore, In the development stage of the ASWP, the low wind speed made the mixed layer shallower, which made the seawater within the mixed layer more easily heated and thus more sensitive to heat flux. Then the weak wind speed and the existence of anticyclonic circulation (Shankar et al., 2002) associated with the Lakshadweep High trapped the fresh water, contribute to the formation of the barrier layer, and maintain the ASWP by effectively inhibiting the vertical mixing of the upper ocean and causing a warming of the upper mixed layer. In the late stage of ASWP evolution, with the imminent outbreak of the summer monsoon, the stirring effect of wind started to strengthen, the mixing layer became deeper rapidly (Figure 6), and the cooling effect of entrainment was enhanced, which accelerated the decay of the ASWP (Liu Yanliang, 2013)."

17. Section 3.2.3 : The theory of EICC and NEC is explained. But how is it connected with what happens in April- June ASWP is not mentioned. Also, have the authors looked at the current systems during the months of analysis, because putting everything on NEC for the months of April-June may not be okay. The current changes its direction again in these months itself.

Thank you for pointing out this issue in our manuscript. Although the EICC and NEC input low-salinity water into the Arabian Sea from November to March, the weak wind speed and the anticyclonic circulation (Shankar et al., 2002) associated with the Lakshadweep High (Bruce et al., 1994), restrict the low-salinity water within the Arabian Sea and maintain it until May. By June, the summer monsoon is about to break out, causing changes in the surface wind field and surface flow field, gradually spreading the low-salinity water and weakening the salinity stratification.

18. The authors write at Lines 158-159 that they will explain the mechanism of slow decay, however, I failed to find a clear explanation of the same. The authors may end the section with a small paragraph explaining exactly the mechanism of slow decay.

Thank you for the above suggestion. Following your suggestion, we have added a new paragraph at the end of the section 3.2 to explain and summarize the mechanism of ASWP's decay. The new paragraph reads as follows: "In the decline stage of ASWP, the rapid decrease in shortwave radiation flux weakens the heating effect of the sea surface heat flux forcing, while the strengthening of mixing leads to an increase in vertical cooling. The combined effect of these two factors results in a sharp decrease in temperature, leading to the rapid decline of the warm pool." (line 279-282)

19. Section 4.1 : Line 282 : how do authors know that? Citations?

The years of weak warm pools correspond precisely to the years when the Indian Ocean Basin Mode (IOB) is in a negative phase (Guo et al., 2018), during which sea temperatures across the entire Indian Ocean are anomalously cold. Relevant citations have been added to the paper.

Guo, F., Liu, Q., Yang, J., and Fan, L.: Three types of Indian Ocean Basin modes, Clim. Dyn., 51, 4357-4370, 10.1007/s00382-017-3676-z, 2018.

20. Why in strong ASWP years is the average maximum temperature also high?

From Figure 4, it can be seen that the warm pool area and maximum temperature are highest during years of strong ASWP. As analyzed in Section 4.2, this is because years of strong ASWP correspond to a positive phase of IOB, during which the entire Indian Ocean is warming. As a part of the Indian Ocean, the sea temperature in the Arabian Sea also increases, resulting in a higher maximum temperature.

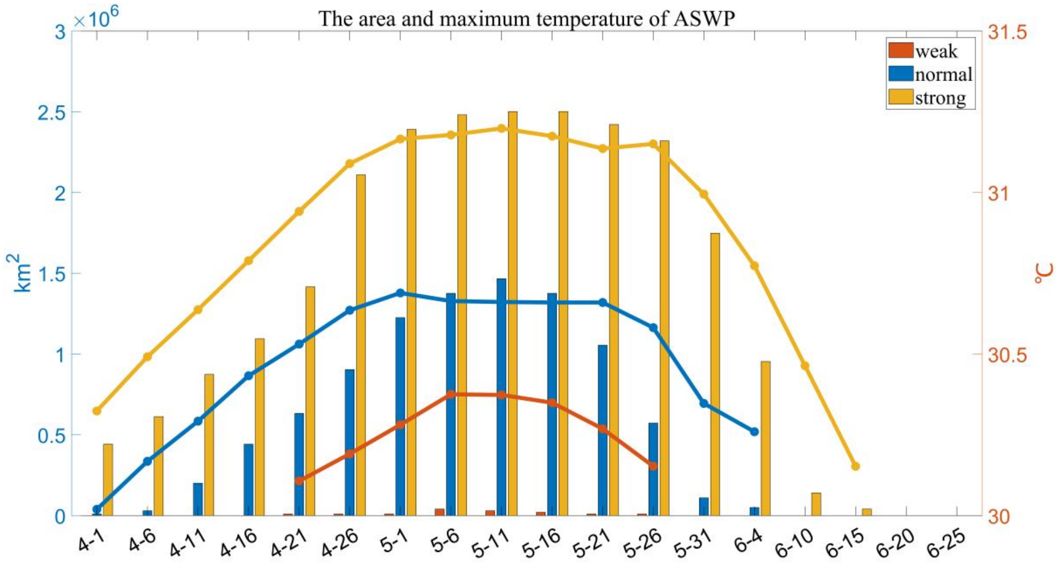

Figure 4: Variation of the area and maximum temperature of different types of ASWP, where the bars represent the area of the warm pool (km^2), the solid lines represent the maximum temperature of the warm pool (°C), red represents weak ASWP, blue represents normal ASWP, and yellow represents strong ASWP.

21. What is Climate state averaging?

This refers to the diagnostic results of the climatology from 1980 to 2016. Thank you for pointing out and we have replaced 'climate state averaging' with 'the climatology'.

22. How do you define warming phase and cooling phase? Do you do it separately for each year? Or is there any other technique being used.

The paper analyzes the warming and cooling phases of the climate state (averaging the diagnostic results for different years on the same day) based on the positive and negative values of $\frac{\partial T}{\partial t}$. When $\frac{\partial T}{\partial t}>0$, it represents a warming phase, while $\frac{\partial T}{\partial t}<0$ represents a cooling phase. Since the evolution time of ASWP for different years is different, only the climatically diagnostic results are analyzed here.

23. Line 300 : No clear meaning. I cannot understand what authors mean.

Thank you for pointing this out. The revised text reads as follows: "However, regardless of the year, the contribution of SHF to the temperature change was the largest (78.5% to 81.5%), and the contributions of ENT and ADV were relatively small. Among them, the weaker warm pool in weak ASWP years may be related to the greater cooling effect of ENT at this time (19.7%). In the cooling phase, the contribution of SHF decreased (31.9% to 38.3%), the cooling effect of ENT increased (52.2% to 54.2%), and the contribution of ADV increased slightly (9.5% to 14.6%). SHF and ENT together dominated the temperature change of the ASWP. The larger (smaller) warm pool in strong (weak) ASWP years may be related to the larger (smaller) heating effect of SHF, and the smaller (larger) cooling effect of ENT and ADV."

24. Section 4.2: Which data has been used for this? How much is the variance explained by each mode can be mentioned in the figure 12 itself. Please mention. The text seems vague for variance explained.

The temperature data used in this paper is from the SODA3.7.2 dataset, and EOF analysis was performed on the temperature in the Arabian Sea from April to June respectively. Thank you for your suggestion, the variance contribution of each mode has been added to the figure 5.

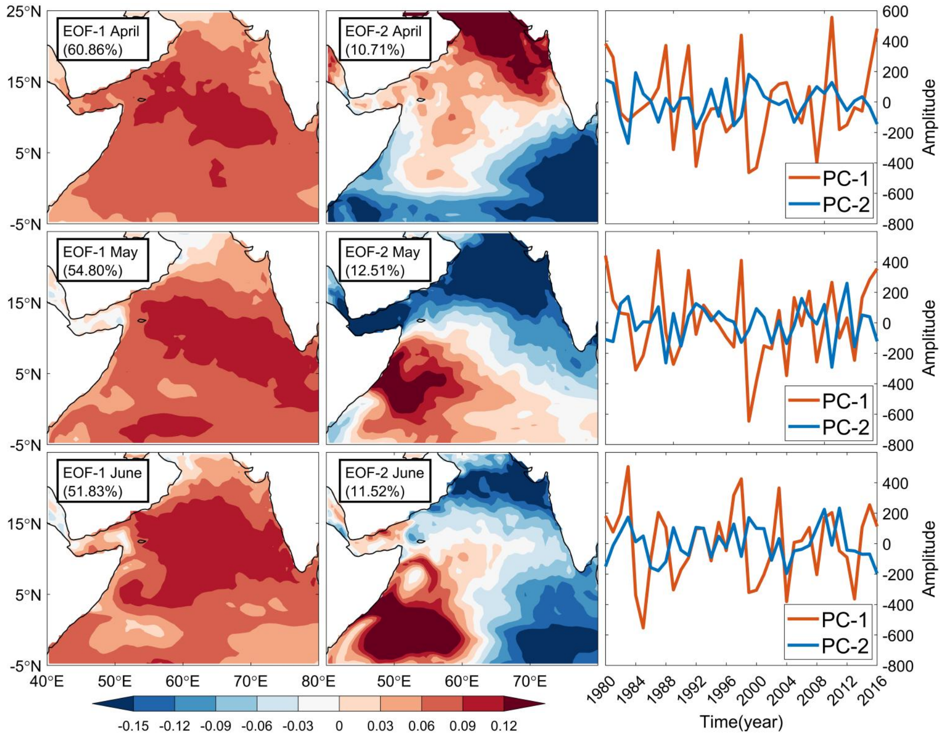

Figure 5: EOF1 (the first column), EOF2 (the second column), and PC1 and PC2 (the third column) of SST anomalies in the Arabian Sea for April–June.

25. Line 313-314 : What is IOB consistent mode? Citation please.. Line 313 is not clear, rewrite.

This refers to the Indian Ocean Basin mode (IOB) (Guo et al., 2018). We have corrected it in the paper.

26. What is B in IOB in Line 318?

Indian Ocean Basin mode (IOB).

27. Probably this is the place (after Line 316/317) where Line 282 should be mentioned rather than there.

Thanks for pointing it out, we have corrected it in the paper.

28. Why do you show PC2 if variance explained is less than 10%?

Thank you for pointing it out. The variance contribution of PC2 from April to June were 12.71%, 12.51% and 11.52%, respectively. We chose to show PC2 in this paper because the variance contribution of PC2 from April to June has passed the significance test, indicating that the spatial and temporal functions of the second mode are valuable.

29. Line 327-328 : Are these the years in which your PC also peaks (Line315) or in which ASWP is found to be stronger (Line 279).

These years are the years when the area of the ASWP was larger. We have corrected it to clearer in the paper.

30. Line 333: is the correlation significant?

Correlation coefficient (r) =0.57, $P=4.6*10^{-4}$, indicating that the correlation is significant.

31. Line 345: What is IOWP?

Indian Ocean warm pool (line 33).

32. Any citation for Line 345-346.

Thank you for the reminder, the citation has been added(Lau and Nath, 2003).

Lau, N.-C. and Nath, M. J.: Atmosphere–Ocean Variations in the Indo-Pacific Sector during ENSO Episodes, J. Clim., 16, 3-20, https://doi.org/10.1175/1520-0442(2003)016<0003:AOVITI>2.0.CO;2, 2003.

33. What is the correlation value of PC1 of ASWP with Nino? Why do you choose to analyse ENSO rather than IOD in lines 348 onwards?

The correlation value between PC1 of ASWP and ENSO ranges from 0.61 to 0.72 ($P<0.01$), when PC1 lags ENSO for 5-7 months. As a part of the Indian Ocean, the Arabian Sea is not only affected by IOB and IOD in the Indian Ocean, but also by ENSO in the Pacific Ocean. Previous studies also show that ENSO has a significant regulatory effect on SST in the tropical Indian Ocean. Therefore, the relationship between ASWP, IOB and IOD is analyzed in Section 4.2. The relationship between ASWP and ENSO is also analyzed later.

34. Line 364 :Vertical entrainment is completely different from what has been used here. Please use a different word. (Again, please note comment no 16.)

Thank you for pointing it out. We have corrected it in the paper.

Thanks again for the suggestive comments of the reviewer!

Reference：

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