Responses to the comments from Reviewer #3

We are very grateful to the Reviewer for the positive and careful review. The thoughtful comments have helped improve the manuscript. The reviewer's comments are italicized and our responses immediately follow.

The article entitled, "Extending seasonal predictability of Yangtze River summer floods"by Wang and Yuan explores the seasonal predictability of both moisture flux and precipitation in the CFSv2 forecast system. The study aims to determine whether moisture flux forecasts can be used to better predict for summer flood prediction (compared to precipitation). I found the study interesting and potentially useful to decision-makers and end-users in the region. However, I have several major concerns that I hope the authors will address, as well as a number of minor comments.

Response: We would like to thank the reviewer for the positive comments. Please see our responses below.

Major comments:

1. While much of the study is well written, there are numerous places in the text where there are grammatical issues. These range from simple subject-verb agreement (as in the first sentence, "was" should be replaced with "were"), to passages where the language is misleading and it is not clear what the authors mean to say. The paper (and its corresponding conclusions) would benefit greatly from a thorough proofread by a colleague who can help address and correct the language issues.

Response: Thanks for the comments. We have improved the clarification and carefully proofread the manuscript, including the first sentence.

2. A major conclusion of the study is that the moisture flux can be better predicted than precipitation in summers directly following ENSO events, and particularly El Niño. However, there is very limited discussion of how and why El Niño impacts this area and therefore lends itself as a potential predictor of moisture flux and hence, flooding in the region. Without providing some further discussion to the paragraph that begins on line 220 that speaks directly to how ENSO is understood to impact the area and how the plots shown in Figure 6 are consistent with this, I find that the major conclusions are not fully supported by the study at present. For example, are the moisture flux vectors shown in Figure 6 related to the anomalous high, and is that known to be forced by El Niño? Some more explanation and discussion is needed.

Response: Thanks for the comments. We have clarified as follows:

Section 3.3: "As mentioned above, the Yangtze region in eastern China is one of the most strongly ENSO-affected regions in the world, and the precipitation variability in this region is generally influenced by the anomalous ENSO forcing (e.g., Wang, 2000; Wu et al., 2003; Ding and Chan, 2005).....It is found that the second mode (MCA2) explains 23% of the variance, and

its corresponding SST anomaly pattern is very similar to the traditional ENSO-like pattern with a warm anomaly over the equatorial eastern Pacific and a horse-shoes cold anomalies over the western tropical and central Northern Pacific (Fig. 5a). Meanwhile, its temporal evolution is strongly correlated with the NINO3.4 SST anomaly (r = 0.92, black line in Fig. 5c). Correspondingly, the summer precipitation in the Yangtze region is above normal significantly (Fig. 5b)." Above all, there is no doubt that the El Niño signals have an crucial role on the climate variability over the Yangtze region, especially on the precipitation anomalies by impacting the large-scale circulation variation over the Northwestern Pacific Ocean and the associated water vapor transport to the Yangtze region. When El Niño occurs in preceding winter, there is always an enhanced western Pacific subtropical high (WPSH) accompanied with a weakened East Asia summer monsoon (EASM) in the following summer, thereby resulting in an anomalously anticyclonic circulation pattern over the northwestern Pacific that brings large amounts of atmospheric moisture from the oceans to the Yangtze River (Wang et al., 2000; Yuan et al. 2017).

In the revise version, we add some detailed discussion about the mechanism for the lag-impact of El Niño on East Asia summer climate including how the El Niño forcings impact the atmospheric moisture transport to the Yangtze region as follows:

"As shown in Figure 6c, there is an anomalously high pressure center over western subtropical Pacific, which is a recurrent pattern in post-El Niño summers (Xie et al., 2016) and implies that the western Pacific subtropical high (WPSH) is enhanced. Such circulation pattern would bring large amounts of atmospheric moisture from southern oceans to Yangtze River basin, which corresponds well with extreme hydrologic events. The mechanism for this lag-impact of El Niño on East Asia summer climate is the Indo-western Pacific ocean capacitor (IPOC), where the coupled wind–evaporation–SST feedback over Northwest Pacific in spring persists to trigger East Asia–Pacific/Pacific–Japan (EAP/PJ) pattern that arises from the interaction of the anomalous anti-cyclone and North Indian Ocean warming in post-El Niño summers (Xie et al., 2016)." (L241-250 in the tracked version of the revised manuscript)

Minor comments:

1. Line 39-40, the sentence that mentions model precipitation being influenced by"meso-scale convections" is unclear. Here, are the authors referring to mesoscale(local) circulation patterns that impact precipitation? Also, it might be worth noting that convection schemes themselves (used to parameterize finer scale processes) would also impact forecasted precipitation.

Response: Thanks for the comments. We have revised the manuscript as follows:

"The atmospheric moisture flux is supposed to be better predicted by large-scale climate models than precipitation that is not only connected to mesoscale (or more local scale) circulation but also influenced by the vertical convection and localized orography (Lavers et al., 2014, 2016b)." (L39-42)

2. Line 75: The pressure levels of the variables studied should be identified.

Response: Thanks for the comments. We have specified as "Monthly mean atmospheric fields including geopotential height, u-wind, v-wind, and specific humidity at 300, 400, 500, 700, 850, 925 and 1000 hPa were derived from the ERA-Interim reanalysis". (L77-79)

3. In Figure 1, is there a reason why the AC is higher for the moisture flux at 1.5months lead-time compared to 0.5 months? It would be good if the authors could provide some understanding of why this is the case or if they believe it to be spurious because it is surprising.

Response: Thanks for the comments. In general, the predictability drops over lead times, but not necessarily for any cases.

We plotted the results for all 24 ensemble members in Figure R1, and found that the AC for 0.5-month lead is not necessarily higher than 1.5-month lead. However, the average results for the 24 AC (Fig. R1c) shows that AC decreases over leads on average.

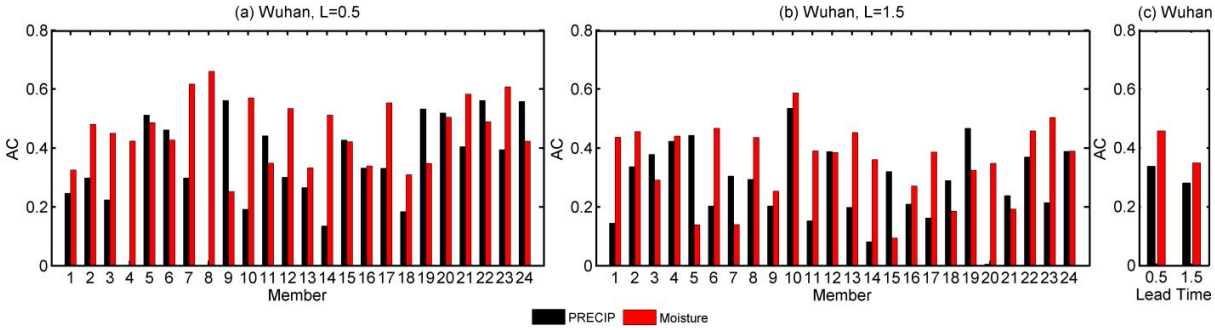

Figure R1. Potential predictability (AC value) when different ensemble member was taken as the truth and the mean of the members was the prediction at Wuhan city for the (a) 0.5-and (b) 1.5-month leads. (c) the final estimate of the potential predictability in Wuhan city.

4. Line 124: There is no "b" in the equation on line 123.

Response: We have removed it**.**

5. Lines 132-134: This sentence is awkward, particularly the use of the word "pummeled," please rewrite.

Response: Thanks for the comments. We have changed it as "In particular, continuous heavy rainfall hit the Yangtze River basin, with rainfall anomalies locally exceeding 300 mm within 10 days (June 26-July 5; Yuan et al., 2018)". (L145-147)

6. The sentence on Lines 174-177 is also awkward and does not clearly explain the results from Figure 4.

Response: Thanks for the comments. We have revised as "The AC values for precipitation drop quickly with forecast leads, and Fig. 4c shows that more than half of the AC values are less than 0.2 over the Yangtze region at 1.5-month lead. However, the moisture flux performs well with

many AC values higher than 0.3 at 1.5-month lead, especially over the south eastern mountain region (Fig. 4d)." (L187-191)

7. Line 206: This sentence is a bit contradictory as it says "To explore the impacts of preceding El Nino signals…" and then tells us that "hit rates conditional on different ENSO phases…" are shown in Figure 6. Figure 6 shows both El Niño and La Niña hit rates, so really the authors are showing the impacts of preceding ENSO events (not just El Niño as is written). Please switch "El Niño" in the beginning of the sentence with "ENSO" and in the second mention of "ENSO" phases, could add "(i.e. El Niño and La Niña)".

Response: Thanks for the comments. We have revised as suggested.

"To explore the impacts of preceding ENSO signals on Yangtze precipitation and moisture flux predictability, correlations and hit rates conditional on different ENSO phases (i.e., El Niño and La Niña) at different leads are shown in Figure 6." (L222-224)

8. Lines 228-230 conclude that the different circulation patterns predicted for the two ENSO phases determine a higher predictability for extreme hydrologic events in post-El Niño summers. However, why is it necessarily higher predictability and not just a different signal that is predicted because of the different ENSO events? This conclusion seems like a bit of a stretch to me without understanding of why the El Niño signal would translate to higher predictability than La Niña based solely on the evidence presented in the manuscript.

Response: Thanks for the comments. We have added more explanations in the revised manuscript as follows:

"The asymmetric performance during El Niño and La Niña has drawn many attentions. One of the reasons is that the atmospheric response to tropical Pacific SST anomaly is inherently nonlinear (Hoerling et al., 1997), where both the amplitude of SST anomaly in the eastern equatorial Pacific and the associated atmospheric response are significantly larger during El Niño than during La Niña episodes (Burgers and Stephenson 1999)." (L228-232)

"It implies that the precipitation deficits or droughts are more likely to occur in this region in post-LaNiña summers. The contrast is obvious even for forecasts at 6.5-month lead (Figs. 6e-6f).The differences in predicted circulation and associated moisture transport largely result in higher predictability for extreme hydrologic events over middle and lower reaches of the Yangtze River basin in post-El Niño summers (Hu et al., 2014)." (253-258)

9. Line 373 references the "middle and lower reaches of Yangtze River basin."However, these areas are not previously defined in the text. I assume they may be the boxes outlined in Figure 2a, but this needs to be clarified.

Response: We have now defined it in the Introduction section as follows:

"In present study, we aim to address the above questions by evaluating the seasonal predictability of precipitation and moisture flux for the middle and lower reaches of Yangtze River (110-123°E, 27-34°N) based on multisource observational data, and ensemble hindcasts

and real-time forecasts from a dynamical seasonal forecast model Climate Forecast System version 2 (CFSv2; Saha et al., 2014) for the period of 1982-2016." (L68-72)

*10. The legend for Figure 2c defines the 850 hPa moisture flux vectors in g/cm*hPa*s. I have never seen this unit used before for moisture flux and would recommend it be converted to m/s kg*kg.*

Response: Thanks for the comments. According to the suggestion from reviewer#1, we have used the total column-integrated moisture flux instead of that at the 850 hPa level in revised manuscript. The corresponding unit has also been converted to kg•m^{-1}s^{-1}. (L418-426)

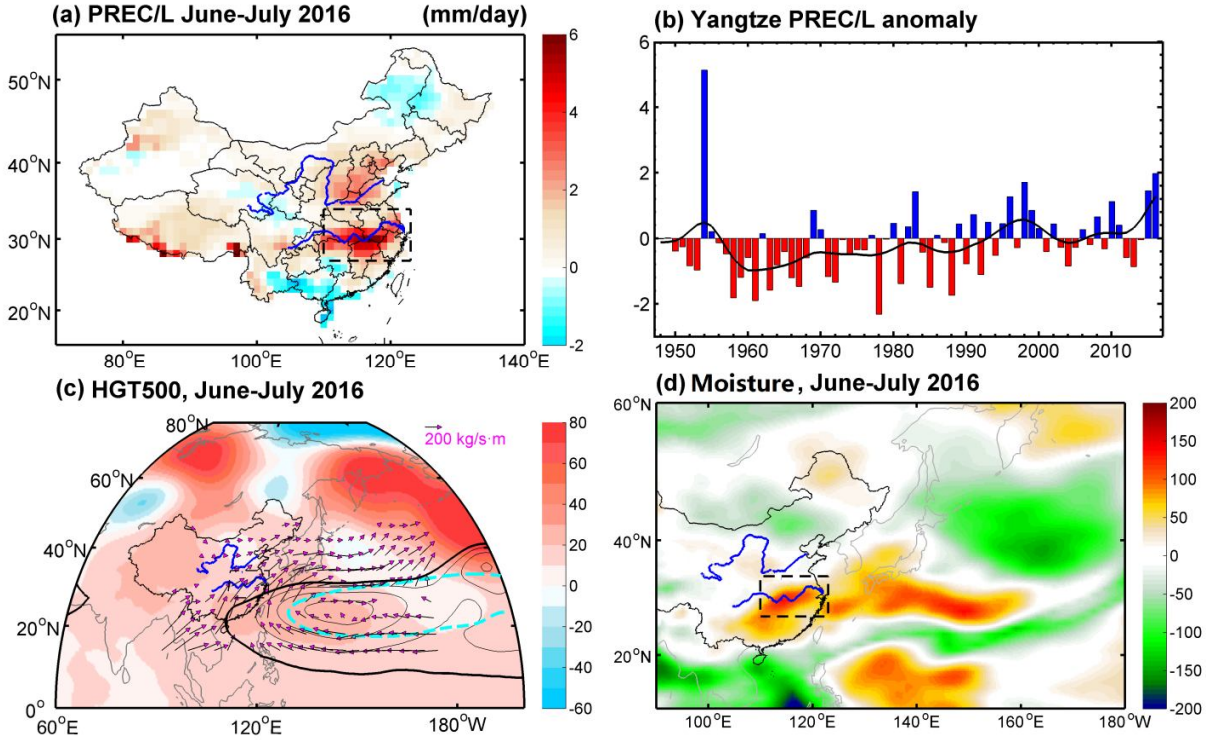

Figure 2. The 2016 extreme summer flood. (a) Mean precipitation anomaly (shading, mm/day) during the June-July of 2016. (b) Time series of the June-July mean precipitation anomaly averaged over the middle and lower reaches of Yangtze River basin (110-123°E, 27-34°N) in (a). (c) Anomaly of 500 hPa geopotential height (shading, gpm) superimposed by absolute integrated horizontal moisture transport between 1000 to 300 hPa layers(vectors, kg•m^{-1}s^{-1}). The thick contour lines are 5880 gpm, implying the location of the West Pacific Subtropical High, where the black denotes the June-July 2016 and the cyan is the climatology during 1982-2010. (d) Anomaly of integrated horizontal moisture transport amount (shading, kg•m^{-1}s^{-1}).

11. Figure 3: the different columns are plotted with a different longitudinal domain. It would be helpful in comparing the precipitation to the moisture flux if all panels were plotted using the same longitude bounds.

Response: Revised as suggested.

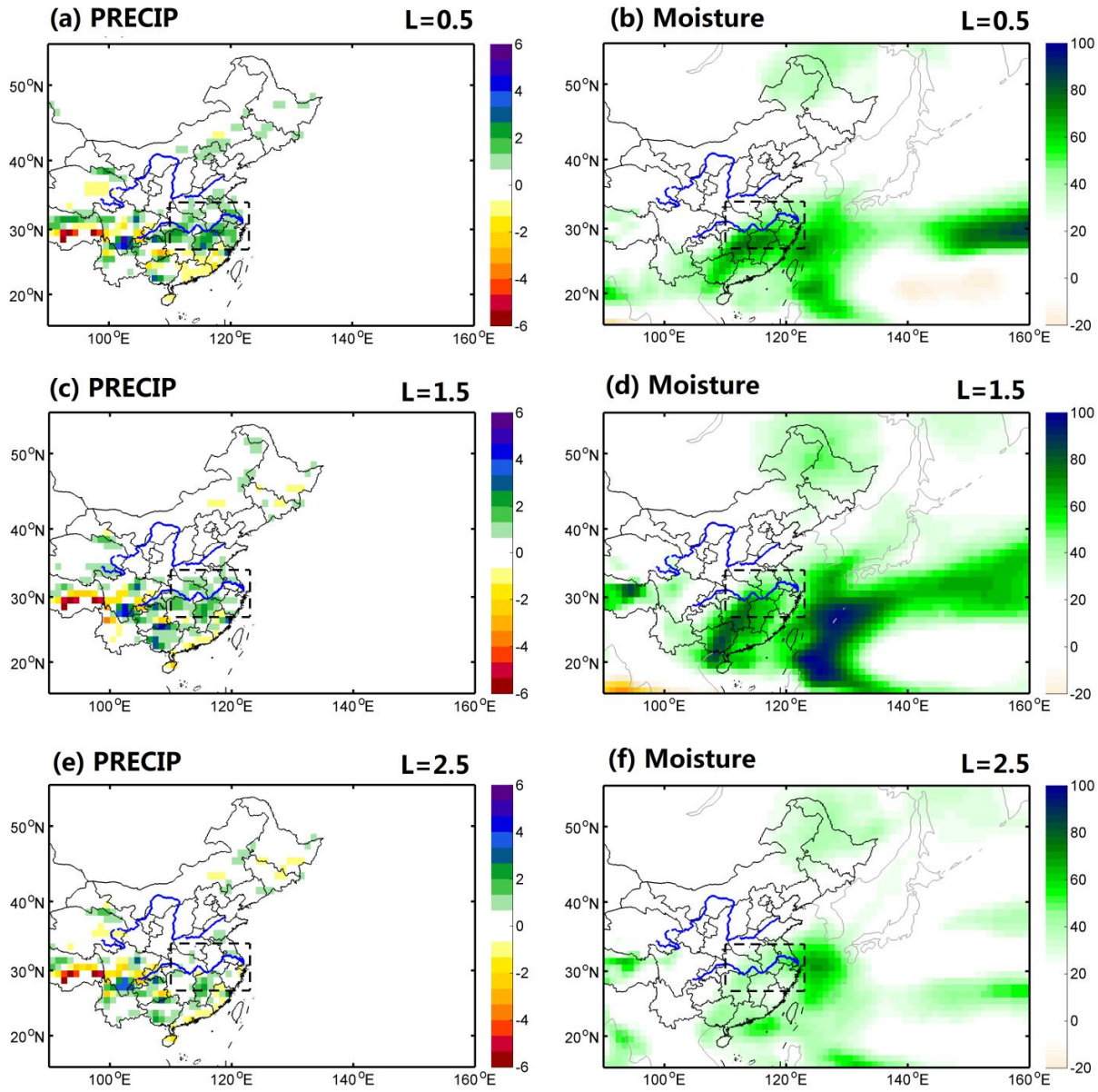

Figure 3. Spatial distributions of CFSv2 predicted anomalies of precipitation (shading, mm/day) and atmospheric moisture flux (shading, $Kg \bullet m^{-1}s^{-1}$) in the June-July of 2016 at the 0.5-, 1.5- and 2.5-month leads, where the 0.5-month lead was initialized from mid-May to early June, 1.5-month lead was initialized from mid-Apr to early May, and so on.

12. Figure 4 seems to contradict what is shown in Figure 1 (see Minor Comment #3).The correlation maps shown in Figure 4 indicate that Wuhan City has a lower AC value for lead-time 1.5 than lead time 0.5, but Figure 1d indicates that the AC is 0.44 for 1.5 month lead but only 0.33 for 0.5 month lead. Why is there a discrepancy?

Response: Please see the response to minor Comment #3 above.

13. While the methods employed are interesting and the figures generally informative, I would encourage some reorganization of Figures 2-6. Figures 2-3examine the anomalous 2016 event that the text implies is related to the El Niño that occurs that year so when it is followed up by Figure 4 which shows the potential predictability based on all years (1982-2016), it is a bit misleading. I would recommend putting Figure 4 directly after Figure 1 and then continuing on to the Figures detailing the 2015-2016 event.

Response: Our motivation of this study started from the prediction of the pluvial flood event over the Yangtze region in the summer of 2016, as mentioned in the first paragraph of the Introduction section. Therefore, we first showed the observation and prediction for the 2016 summer in Figs. 2-3, and found better prediction of moisture flux than the precipitation. Then, we analyzed the potential predictability based on all hindcast and real-time forecasts during1982-2016, and found that moisture flux has a higher predictability than precipitation. Finally, we explored the varying predictability conditioned on different ENSO phases based on all observations, hindcast and real-time forecasts. We believe the logic is straightforward, so we would like to keep the original organization.

References

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