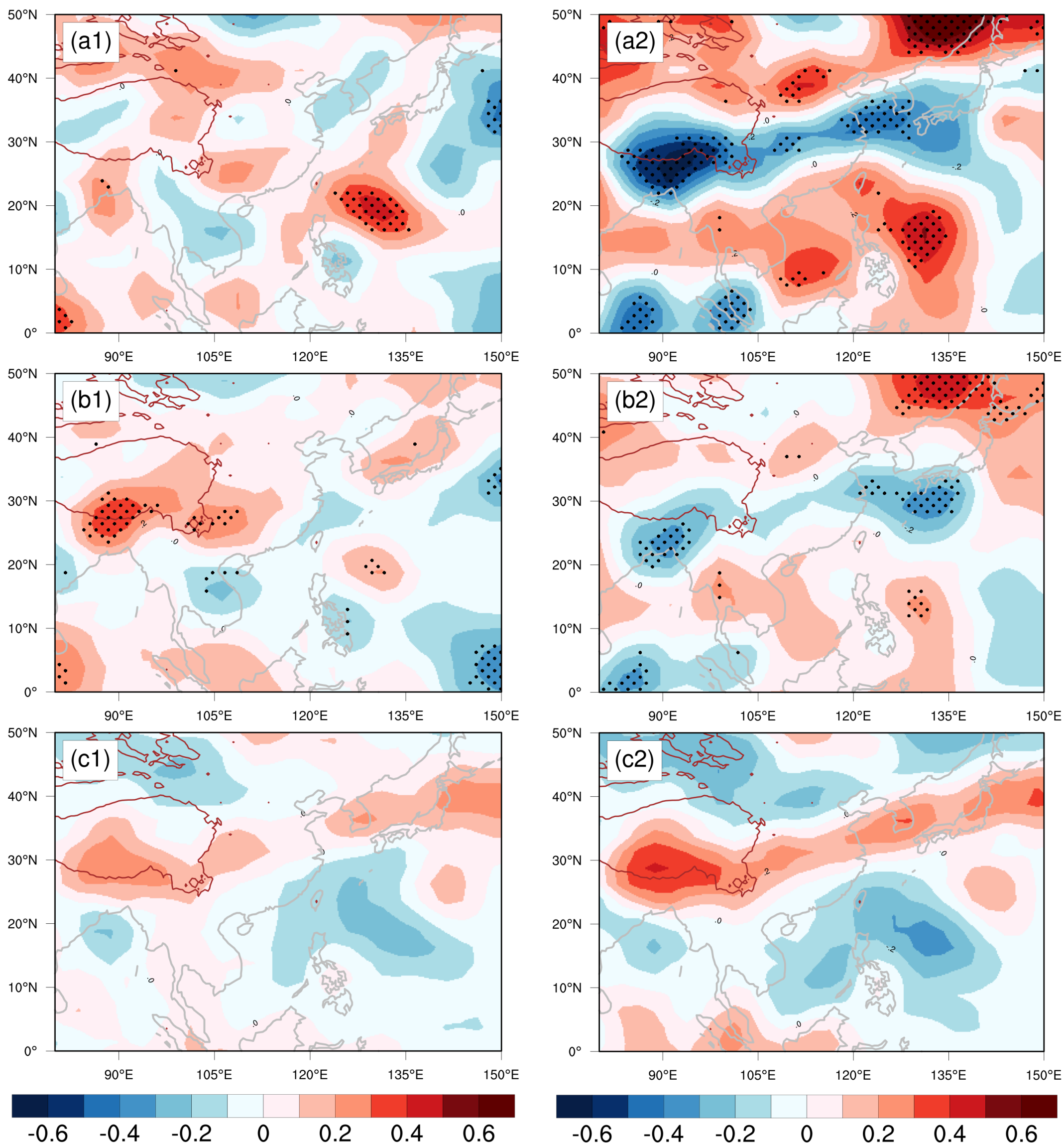
Responses to Reviewer #2:

We wish to thank the reviewer for the detailed comments and suggestions that helped us substantially improve the formula, phrasing, logic, and quality of our manuscript. We have revised the manuscript accordingly. Please see below our point-by-point response. The original comments are formatted in *Italics*.

Major comments: *Both the warming amplification over the Tibetan Plateau (TP) and the decadal change in eastern China feature by the so-called southern flood-norther drought have been well documented. In this work, the authors argue that the relationship between the TP temperature and summer precipitation in East Asia seems to be weakened after the enhanced warming amplitude over the TP. The data employed in this work, including station observed temperature and precipitation, GPCP precipitation field, together with MERRA2, are basically reliable. However, the method (liner regression) and overall procedure are questionable. Statistical relationship between the TP warming and summer precipitation in East Asia dese not necessary mean intrinsic connection between them. The explanation for the influence of TP warming upon the summer rainfall change presented here cannot provide solid evidence. In fact, at least the following issues need be answered before one can accept the main conclusion drawn here.*

Comment 1: *First, warming in which season is responsible for the circulation and rainfall pattern change in downstream regions?*

Response: Thank you for your valuable comment. Note that, in the revised manuscript, MERRA2 reanalysis data is used to analyze the TP temperature and atmospheric circulation, so the study period was changed to 1980-2016. Figure S4 shows the standard partial regression coefficient of TP-EASM in 1980–2016 at spring (MAM), summer (JJA), fall (SON), winter (DJF) respectively. In Summer (Figure S4-a2), the spatial distribution of the partial regression coefficient like a “sandwich”. Positive relationship is found in South China, Indochina Peninsula, South China Sea, and the Northwest Pacific Ocean. It’s also obviously positively correlated North China and Northeast China too. Negative relationship is found along a southwest-northeast oriented rain belt extending from southern TP across the mid-lower reach of the Yangtze River Valley to the Korean peninsula and Japan, which is primarily along the East Asia subtropical front (called Meiyu in Chinese). Comparing these four seasons (Figure S4), such a complete spatial distribution of the partial regression coefficient in East Asia, we found that only summer season. At the same time, the central value of the partial regression coefficient in summer can reach 0.5 and -0.6, and it is larger than that in other seasons. Consequently, we initially think that mainly summer season is responsible for the circulation and rainfall pattern change in downstream regions. The results and analysis above have been supplemented in the paper. (Figure S4; P3, L316-323)



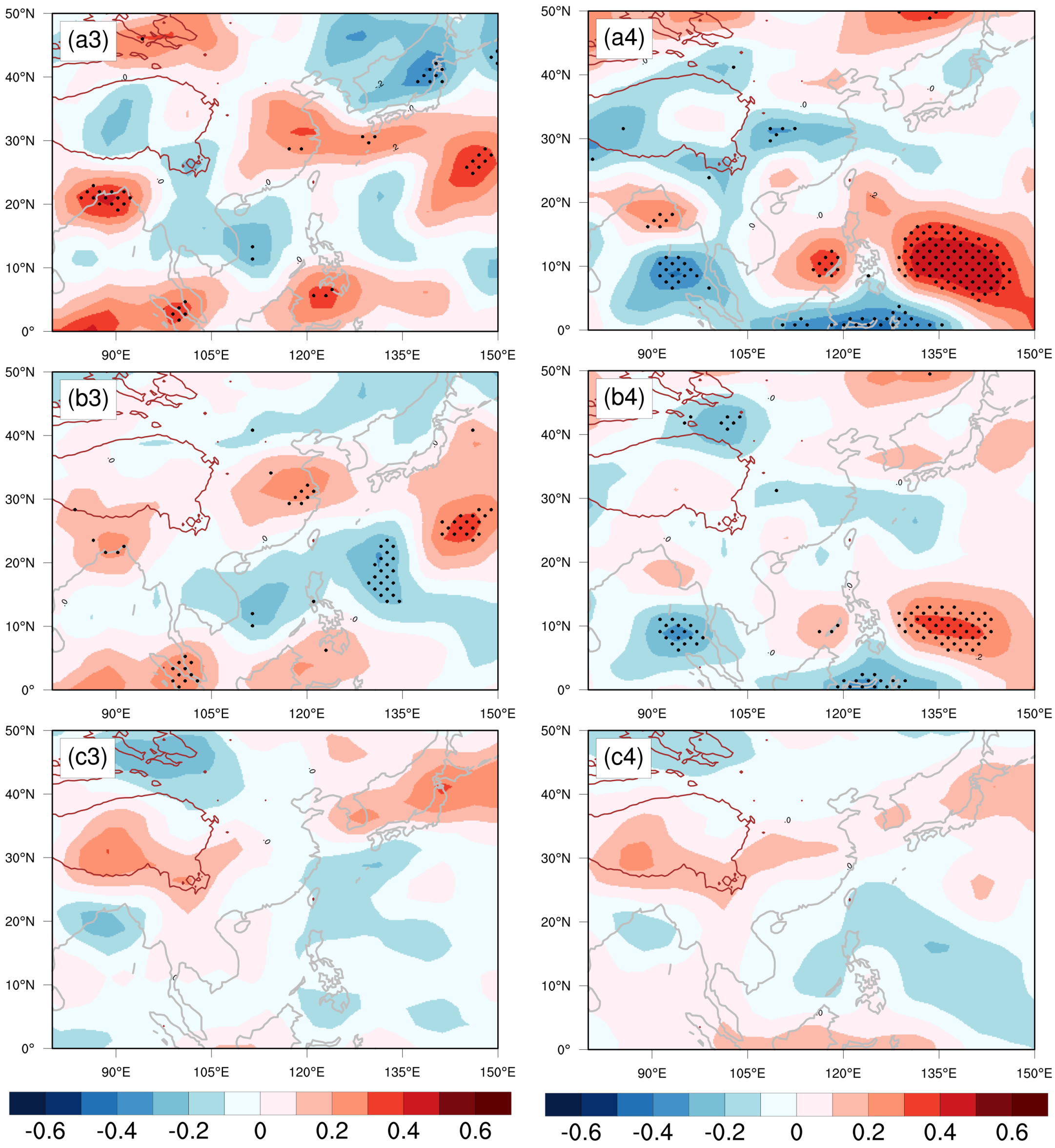


Figure S4. The standard partial regression coefficient of precipitation and TP temperature in East Asia in 1980–2016 (precipitation based on GPCP data; brown contour delineates the altitude of 2000m). (a) represents all variables are not detrended; (b), precipitation and TP temperature have been detrended; (c) is the difference between (a) and (b); 1, 2, 3, 4 represent spring (MAM), summer (JJA), fall (SON), winter (DJF) respectively; black spots indicate statistical significance above the 90% confidence level.

Comment 2: *Second, during 1979-2016, for which period this connection is obvious?*

Response: Thanks for your valuable suggestion. Note that, in the revised manuscript, MERRA2 reanalysis data is used to analyze the TP temperature and atmospheric circulation, so the study period was changed to 1980-2016. In order to check, during 1980-2016, which period this connection is obvious. At first, Mann-Kendal method is used to test whether there is a regime shift in TP temperature, and the result is showed in Figure 2. A regime shift is found in 1997, and it is statistically significant at the 95% confidence level. Then the entire research time is broken into two period, 1980-1996 and 1997-2016. The partial regression coefficient of precipitation and TP temperature in 1980-1996, 1997-2016 and 1980-2016 respectively (Figure 6). It shows that over the past 20 years (1997–2016) the relationship pattern of precipitation and TP temperature is change comparing with the period 1980-1996. In 1997–2016, negative relationship is found along a southwest-northeast oriented rain belt extending from the mid-lower reach of the Yangtze River Valley across South Korea to eastern Japan, which is primarily along the EA subtropical front (called Meiyu in Chinese, Changma in Korean, and Baiu in Japanese). Positive relationship is found in South China, Indochina Peninsula, South China Sea, and the Northwest Pacific Ocean. During 1980-2016, for the second period 1997-2016 this connection between TP warming and rainfall pattern change in downstream regions is obvious. The above results and analysis have been supplemented in the revised manuscript. (Figure 2 and Figure 6; P2, L293-310)

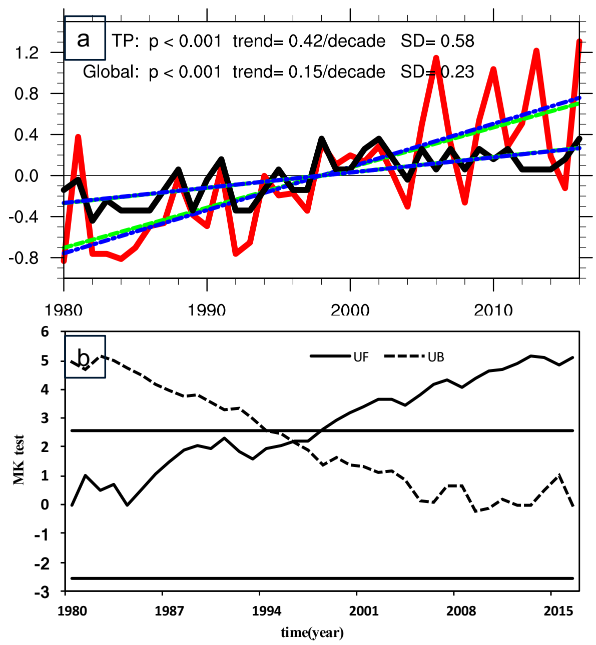


Figure 2. (a) Interannual change of summer temperature averaged by the TP (red) and global (blue). Trend significant test are from Mann-Kendall test (blue line) and the Theil-Sen estimator (green line). (Units: °C). (b) Mann-Kendall regime shift test of the temperature of the eastern part of the TP. Both trends are statistically significant at the 99% confidence level.

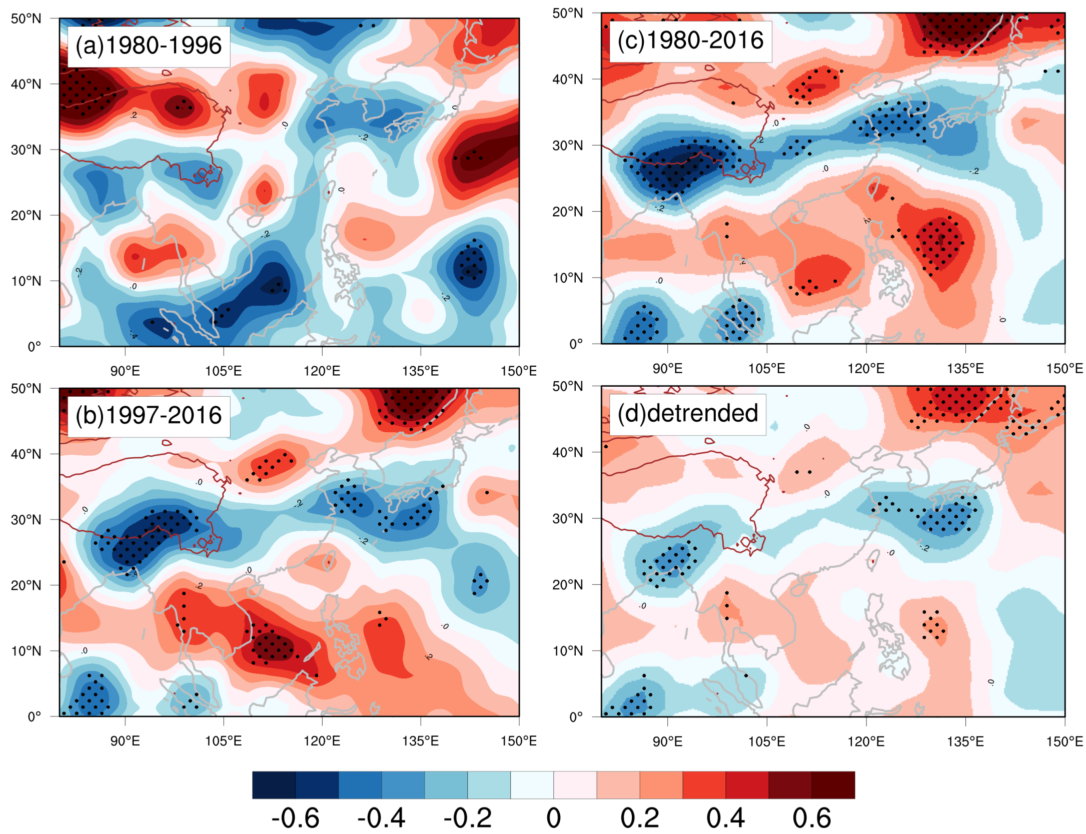


Figure 6. The standard partial regression coefficient of precipitation and TP temperature in East Asia. (a) represents the first period 1980-2016; (b) represents the second period 1997-2016; (c) is the whole period 1980-1996; (d) the same as Figure 6c but after detrending all data. black spots indicate statistical significance above the 90% confidence level.

Comment 3*: Third, if this connection is real, it appears in decadal time-scale or just linear trend?*

Response: Thanks for your suggestion. To obtain further insight into the connection of the temperature-monsoon relationship, we perform the partial regression coefficient of precipitation and TP temperature in different condition, as shown in Figure 6. It's believed that after TP warming amplification, the magnitude of the TP-EASM correlation enhance (strengthened positive correlations and strengthened negative correlations; Figure 6c). So, TP-EASM relationship is negative during the period of 1980–1996 but becomes obvious positive for the period of 1997–2016 in the South China Sea and the Northwest Pacific Ocean (Figure 6a and Figure 6b). At the same time, negative correlation along the East Asia subtropical front (Meiyu) become stronger in period of 1997–2016. In summary, during 1980-2016, this connection between TP-EASM is obvious after late 20 years, and the connection of it underwent obvious interdecadal variability and linear trend. The above results and analysis have been supplemented in the revised manuscript. (P3, L306-314)

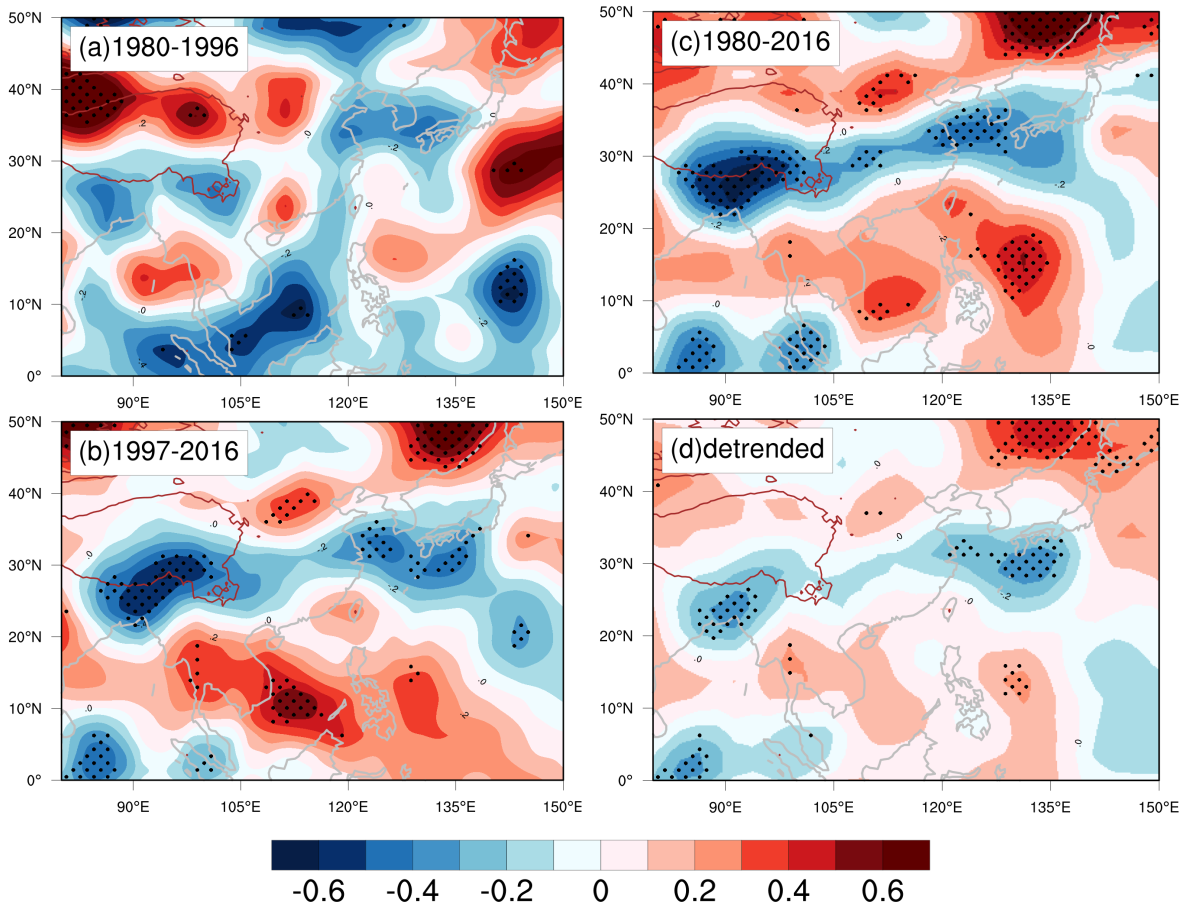


Figure 6. The standard partial regression coefficient of precipitation and TP temperature in East Asia. (a) represents the first period 1980-2016; (b) represents the second period 1997-2016; (c) is the whole period 1980-1996; (d) the same as Figure 6c but after detrending all data. black spots indicate statistical significance above the 90% confidence level.

***Comment 4**, what is the involved mechanism? In this work the authors claimed that the two Rossby wave trains related to the TP warming are responsible for the rainfall change in north part of East Asia and south part of East Asia, respectively. However, atmospheric wave pattern is stimulated by topography or diabatic heating, sometimes also generated from internal dynamics in atmosphere. Since the topography remains unchanged, TP warming induced heating anomaly or internal dynamics induces these two anomalous wave trains?*

Response: Thank you for your suggestions. In our study, we just performed the statistical method (multiple regression method) to analysis the phenomenon instead of numerical model. But in previous research, some works have done, and we have quoted the results of them. Wang et al. (2008) performed numerical experiments with a comprehensive AGCM (ECHAM4) to see the mechanisms by which the atmosphere responds to the Tibetan Plateau warming. The mechanism through which the atmosphere responds to the warming TP is illustrated by the schematic diagram shown in Figure S5. Two Rossby wave trains are excited due to the TP warming. One has a barotropic structure and propagates downstream along the upper-level westerly jet stream to enhance the anticyclonic circulation to east of Japan. Another wave train developing along the low-level southwesterly monsoon propagates into the South China Sea and enhances the low-level anticyclonic ridge there.

Uncertainties remain in understanding the linkage between TP temperature and EASM precipitation based on statistical analysis. To achieve a deeper understanding of the physical mechanisms, it remains necessary to use numerical model results for further verification. We will check it by using CMIP6 model data and different numerical model in later work. Thanks for your valuable comment again.

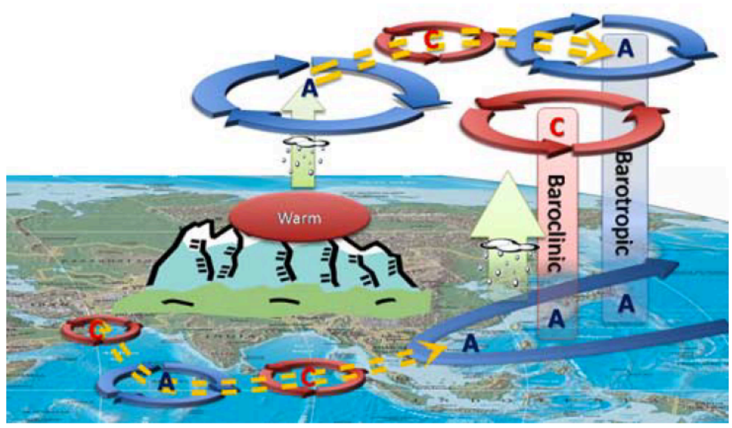


Figure S5. Schematic diagram showing the mechanisms by which the atmosphere responds to the Tibetan Plateau warming, in particular the remote impact of TP warming on East Asian summer monsoon rainfall through two Rossby wavetrains. The letters A and C denote anticyclonic and cyclonic circulation centers, respectively (Wang et al., 2008).

Reference:

Wang B., Qing B., Brian Hoskins et al.: Tibetan Plateau warming and precipitation changes in East Asia, Geo. Res. Let. 35L14702, https://doi:10.1029/2008GL034330, 2008.

Comment 5*, global warming and/or interdecadal natural variability such as AO, PDO, and AMO are often used to explain the summer rainfall change in this area. How to exclude these factors and identified the regional contribution of the TP warming?*

Response: Thank you for your suggestions. In addition to TP temperature, one of the key factor affect East Asian summer monsoon (EASM) is the El Niño-Southern Oscillation (ENSO; Wu et al. 2003); on decadal scales, ENSO's influence on the monsoon can also be heavily modulated by the Pacific Decadal Oscillation (PDO; Feng et al. 2014; Song and Zhou 2015). Yet, the variability of the tropical Pacific can explain only part of the rich structure of the monsoon. Recently, remote teleconnections on East Asia from the North Atlantic region have garnered considerable attention. For example, the Atlantic Multidecadal Oscillation (AMO) has been linked to multidecadal changes in atmospheric circulation and precipitation over China (Lu et al. 2006; Lin et al. 2016; Wu et al. 2016a, b). The western North Pacific subtropical high (WNPSH) is an also crucial component of the East Asian summer monsoon (EASM) system and significantly influences the precipitation in East Asia (Lu, 2001; Lee et al., 2013). On the whole, global warming and interdecadal natural variability such as ENSO, NPSH, PDO, and AMO also influence the summer rainfall change in this area. Here multiple regression method is applied to exclude these factors. As a predictive analysis, the multiple linear regression model is used to explain the relationship between one continuous dependent variable and two or more independent variables. We just analysis the standardized partial regression coefficients between TP temperature and EASM precipitation, and evaluating the relative contribution to the EASM precipitation.

Comparing with single linear regression, it is some difference after considering other factors. In Figure 6, the results indicate that the strength (correlation) of the linkage between TP-EASM (strengthened positive correlations in the south of East Asia and strengthened negative correlations in East Asia subtropical front) has increased with the TP warming amplification. Consequently, in the later period of 1997-2016, the spatial distribution of the correlation of TP-EASM relationship is change. It is from negative to obvious positive during the period of 1980–1996 to 1997–2016 in the South China Sea and the Northwest Pacific Ocean. At the same time, negative correlation along the East Asia subtropical front (Meiyu) enhance in the period of 1997–2016. The above results and analysis have been supplemented in the revised manuscript. Thanks again for your valuable comments that helped us substantially improve the logic and quality of our manuscript.

Reference:

Wu R, Hu ZZ, Kirtman BP (2003) Evolution of ENSO-related rainfall anomalies in East Asia. J Clim 16:3742–3758.

Feng J, Wang L, Chen W (2014) How does the East Asian summer monsoon behave in the decaying phase of El Niño during different PDO phases? J Clim 27:2682–2698

Song F, Zhou T (2015) The Crucial role of internal variability in modulating the decadal variation of the East Asian Summer Monsoon–ENSO Relationship during the twentieth century. J Clim 28:7093–7107

Lu R, Dong B, Ding H (2006) Impact of the Atlantic Multidecadal Oscillation on the Asian summer monsoon. Geophys Res Lett 33: L24701. https://doi.org/10.1029/2006GL027655

Lin J S, Wu B, Zhou TJ (2016) Is the interdecadal circumglobal teleconnection
pattern excited by the Atlantic multidecadal Oscillation? Atmos Ocean Sci Lett 9:451–457.

Wu B, Lin J, Zhou T (2016a) Interdecadal circumglobal teleconnection pattern during boreal summer. Atmos Sci Lett 17:446–452

Wu Q, Yan Y, Chen D (2016b) Seasonal prediction of East Asian monsoon precipitation: skill sensitivity to various climate variabilities. Int J Climatol 36:324–333

Lu, R., 2001: Interannual variability of the summertime North Pacific subtropical high and its relation to atmospheric convection over the Warm Pool. J. Meteor. Soc. Japan, 79, 771-783.

Sun-Seon Lee, Ye-Won Seo, Kyung-Ja Ha, and Jong-Ghap Jhun. Impact of the Western North Pacific Subtropical High on the East Asian Monsoon Precipitation and the Indian Ocean Precipitation in the Boreal Summertime. Asia-Pacific J. Atmos. Sci., 49(2), 171-182, 2013. DOI:10.1007/s13143-013-0018-x

Specific comments:

Point 1*. The results shown in Fig.1 and 2 are annual mean or winter season?*

Response: Here the season we analyzed is summer. The relationship between TP summer temperature and EASM precipitation are mainly performed, and we have specified it in the legend and the text.

Point 2. *Figure 4b. The two rectangular represent north and south parts of East Asia, respectively. However, salient regional difference in summer precipitation can be easily seen in these two domains. This basic feature has also been reported by many literatures. Therefore, it is not reasonable to divide the entire East Asia into only two regions.*

Response: Thank you for your comment. We have reviewed the relevant literatures and did find that there is a little different with the basic feature has also been reported by previous literatures (Yu and Zhou 2007; Zhou et al. 2009a; Nigam et al., 2015). The anomalous rainfall pattern is often referred as the South-Flood North-Drought (SFND) pattern, which is performed as a coherent meridional dipole over eastern China, with significant drying in the middle and lower reaches of the Yellow River (where climatological rainfall is less than 4 mm/day) and increasing rainfall across and to the south of the Yangtze River is also evident. Therefore, we have reorganized the sentences and do not quote the SFND pattern. Note that it is slightly difference with the spatial distribution of the multiple regression method of TP-EASM precipitation analyzed latterly. Therefore, combining the spatial distribution of the trend and the multiple regression, we mainly divide it into three parts to analysis, namely the southern part of East Asia, East Asia subtropical front zone, and the Inner Mongolia and Northeast China.

Reference:

Yu, R. C., and T. J. Zhou, 2007: Seasonality and three-dimensional structure of the interdecadal change in East Asian monsoon, J. Climate, 20, 5344-5355.

Zhou, T., D. Gong, J. Li, and B. Li, 2009a: Detecting and understanding the multidecadal variability of the East Asian summer monsoon -Recent progress and state of affairs. Meteor. Zeitschrift, 18, 4, 455-467.

Nigam Sumant, Yongjian Zhao, Alfredo Ruiz-Barradas, Tianjun Zhou, 2015: The South-Flood North-Drought Pattern over Eastern China and the Drying of the Gangetic Plain, 437-359pp (Chapter 22) in: Climate Change: Multidecadal and Beyond, edited by Chih-Pei Chang, Michael Ghil, Mojib Latif, John M. Wallace, 2015 World Scientific Publishing Co.

Point 3*. Figure 5. What season for temperature in eastern TP? And it is also strange that the summer precipitation during 1979-2016 regressed on the temperature in eastern TP is almost same with that with liner trend removed. Did the author removes the trend in TP temperature and precipitation simultaneously?*

Response: The *temperature* in eastern TP is summer (JJA). Only the trend in TP temperature are removed in previous manuscript. In the revised manuscript, we remove the trend in TP temperature and precipitation simultaneously (Figure 6c, 6d), and the pattern is still same with liner trend unremoved.

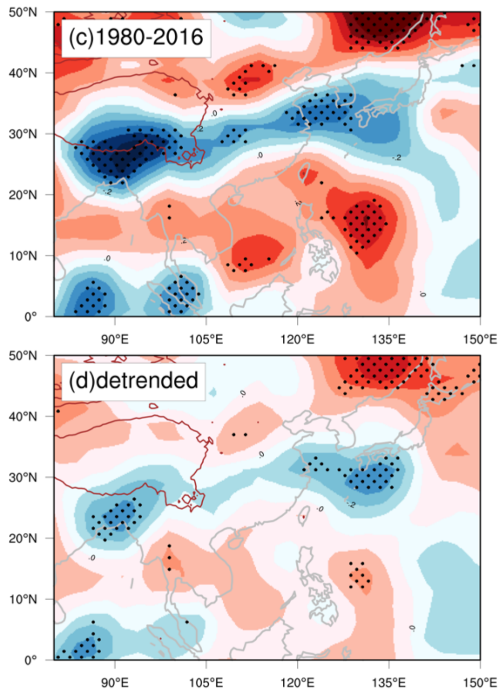


Figure 6. Standardized partial regression coefficients between TP temperature and EASM precipitation (GPCP) for (c) 1980-2016, (d) the same as Figure 6c but TP temperature and EASM precipitation are detrended. Black spots indicate statistical significance above the 90% confidence level.

Point 4. *Two Rossby wave trains shown in Fig.8a and b are used to explain the possible mechanism of TP warming effect. At least in the lower panel. i.e., the south branch in the lower troposphere, the wave pattern is hard to identify especially for the anticyclone just to the south of TP.*

Response: In the revised manuscript, multiple regression method is applied to exclude these factors (ENSO, NPSH, PDO, and AMO), and results are showed in Figure 7. It can be seen from Figure 7b and Figure 7c that, in 1997-2016 and 1980-2016, one wave-like structure in the tropics moves along the low-level monsoon westerly (the red dotted line in Figure 7). A cyclonic circulation is apparent in the Indochina Peninsula and South China Sea. In the south of TP there is characterized by anticyclonic circulation.

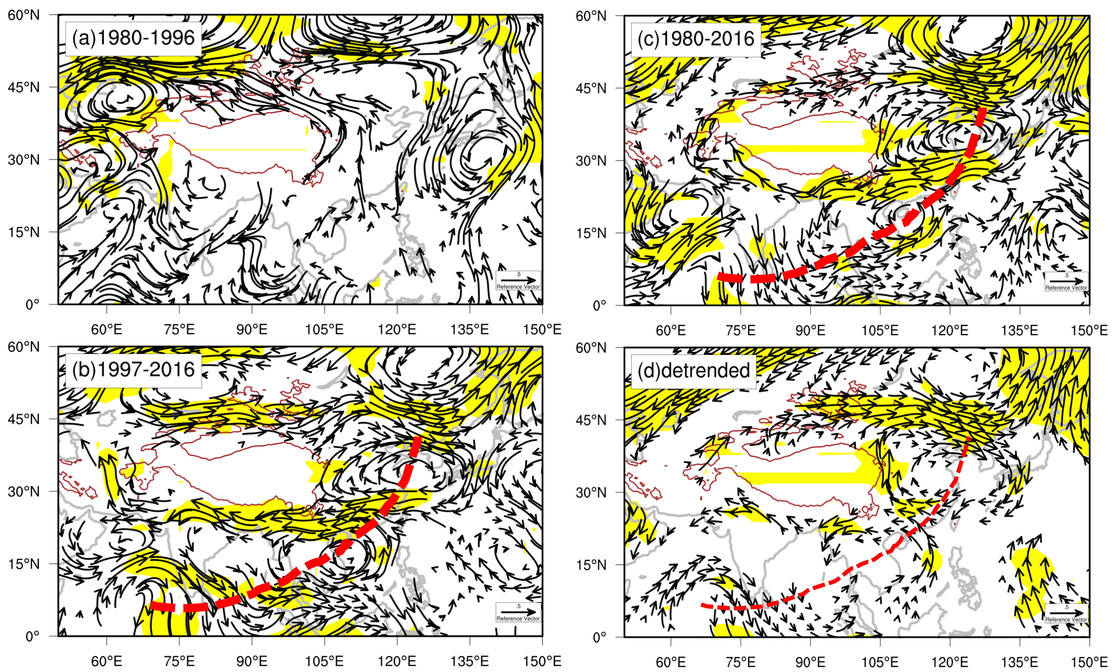


Figure 7. Standardized partial regression coefficients between TP temperature and wind field for (a)1980-1996, (b) 1997-2016, (c) 1980-2016 respectively. (d) the same as Figure 5c but after detrending all data. Vectors are ignored when values less than 0.15, and shading indicate statistical significance above the 90% confidence level.
