

Response to Comments from Reviewer #1

We thank Dr. Wang for his extremely thorough and insightful comments, which have been very helpful in the further revision of our manuscript. We have made every effort to address all the concerns raised by this review. Our point-by-point response is given below.

Major comments:

1. P.13776: *In this paper, diagrams of normalized hourly rainfall are shown to demonstrate the eastward propagation of organized convection within the diurnal cycle (such as Fig. 2). It would be nice if the averaged rainfall (without normalization) in the Hovmoller plots can also be shown to accompany Fig. 2 before going into more details and the spectral analysis. Sometimes, maximum and minimum in the original and normalized plots do not exhibit the same degree of significance, and the readers should be aware of this.*

Reply: Thanks for Dr. Wang's comment. We have added the Hovmoller plots of averaged rainfall in the revised Figure 2.

2. P.13778, L9-24 (and possibly other places, including p.13788, L8-9): *The averaged westerly wind speed (u-component) is shown to be higher in the North America (midlatitudes, 30-48N) than East Asia (mostly subtropics, 27-35N) over the focus domains in Fig. 5 here, and consistent with the difference in propagation speed of rainfall signals. However, the authors also say that the signals propagate faster than the mean steering level wind speed (400-500 hPa) in both continents, and I am not very comfortable with this statement. In the Hovmoller plots, the propagating signals are dominated by organized convection and the phase speed can be estimated without much problem. On the contrary, the MCSs in individual cases may correspond to the steering flow in particular region and height, which are different among the cases, and thus the steering speed would be smoothed out (and under-estimated) significantly by averaging. At least, caveats are needed here for clarification. The sentence in p.13788 (8-9) for a cause-and-effect relationship may be too strong.*

Reply: Thanks for the comment. Possibly some wording is misunderstood. We meant to point out that the propagation phase speed is partially influenced by the steering wind. Carbone et al. (2002) found that the phase speed of episodes (rain streaks) commonly exceeds the phase speed of upper troposphere anomalies and often exceeds zonal steering winds in the low to mid-troposphere and suggested a convectively generated propagation mechanism. We have changed the related statements, such as the sentence in p.13788 has been changed into "The phase speed of the propagating precipitation in North America is faster than that of East Asia partially influenced by the higher ambient wind speed of the westerlies."

Minor comments:

1. P.13774, L6-15: It should be pointed out that the latitudinal range used for North America (30-48N) to the lee of the Rockies is considerably wider than that used for East Asia (27-35N) to the lee of the TP. Also, in p.13794, the two study domains (fixed latitude/longitude boxes) should be fan-shaped in Figs. 1a and 1c, instead of rectangular, to avoid possible confusion.

Reply: The text (L11) has been changed to “The North American domain (110–78°W, 30–48°N, the latitudinal range is wider than that of East Asian domain) covers most of the continent including the Rocky Mountains, the Great Plains and part of the Appalachian Mountains.” The domain shape in the revised Figure 1 has been changed to fan-shaped as suggested.

2. P.13775, L5: While the study domain for North America is 30-48N, 78-110W, the authors state that the (power spectral) analysis of CMORPH data is from 35N to 48N here. Is the statement correct? Please check and clarify.

Reply: It is a typo, which should be 30-48N. Text changed.

3. P.13780, L1-9 and Figs. 7b and 7d: To me, there also appears to be a second solenoid between about 84W and 88W at 0600 and 1800 UTC (between the Great Plains and the Appalachians) in the North America, with a direction opposite to S0. A similar pattern is also noted in Carbone and Tuttle (2008, their Fig. 9). Perhaps, the mean circulation at low levels in NCEP FNL is not strong enough, and the authors can decide whether they want to mention it or not.

Reply: We agree with the reviewer that there might be another solenoid to the extreme eastern edge of the study domain related to the Appalachians which was not well represented well by FNL. Our focus is on the MPS circulation between the Rocky Mountains and the central plains but we add the following description in the revision “There also appears to be another weak solenoid between the Great Plains and the Appalachians (about 84-88°W) at 0600 and 1800 UTC with a direction opposite to S0 as pointed out in Carbone and Tuttle (2008).”

4. P.13803-804, P.13815-816 (Figs. 10 and 18): In these two figures, rainfall distributions are plotted in color (same in each continent) and their perturbations in contours, which are not very easily seen partly because the font size of contour labels is too small. Maybe the authors can consider switch them (using color for perturbation and contours for rainfall), or at least use more appropriate contour intervals and specify them (the intervals) explicitly in the figure captions.

Reply: Both Figures 10 and 18 have been redrawn as recommended.

Other comments:

1. P.13773, L21-22: *I suggest to use “: : : was used recently by: : : to study the diurnal evolution: : :”.*

Reply Per reviewer's suggestion, this sentence is now changed to “The CMORPH dataset was used recently by He and Zhang (2010), BZS11 and Sun and Zhang (2011) to study the diurnal evolution of the summertime precipitation over East Asia lee of the TB but has not been systematically applied over North American downstream of the Rockies.”

2. P.13777, L9: *I am not sure if the word “inversion” is a good choice here. Please consider other wording possibilities.*

Reply: We consider “reversal” for exchange. The sentence is changed into “Compared with the main low-lying plain (Figs. 2a and 3), the precipitation over the adjacent oceanic area exhibits land–sea *reversal* of diurnal rain fall phase, with a nighttime precipitation maximum (18:00–03:00UTC) and a daytime minimum (09:00–15:00 UTC).”

3. P.13780, L23-25: *It should be noted that the positive (negative) wave-number correspond to eastward (westward) propagating signals in Fig. 8 (and other similar figures), either in the text or in figure caption.*

Reply: We add the interpolation in the text.

Figure 8 shows the power spectra of the hourly precipitation throughout the warm season east of the TP over East Asia and east of the Rocky Mountains over North America. The positive (negative) wavenumber corresponds to eastward (westward) propagating signals of precipitation. Our focus is on the eastward precipitation propagation. There are two striking, common features of the power spectra over the two continents.

4. P.13782, L24: *It should be “: : : over both continents: : :”. Also, this sentence is a bit too long and can be broken into two sentences for better readability.*

Reply: This sentence is changed into “The filtered precipitation perturbation between phase speed lines is the primary eastward propagation signal compared with the raw hourly precipitation over both continents. The spatial distribution of the filtered precipitation perturbation (Figs. 11 and 12) shows the similar diurnal phase of propagation to normalized hourly precipitation (Figs. 3 and 4, described in Sect. 3.1).”

5. P.13797, Fig. 4: *The plots (and the labels) are too small to read clearly, and perhaps the readability can be improved by adjusting the layout (for example, put just 4 panels in one page).*

Reply: We adjusted the layout of the panels as suggested.

6. P.13801, Fig. 8: *It would be helpful if the axes of power maxima can be marked in the panels.*

Reply: The slant lines along the ridges of power spectra added in the panels of revised Figure 8 which indicate the phase speeds of 15ms^{-1} over East Asia and 20ms^{-1} over North America.

Technical points:

All technical and editorial minor points are well taken off in the revised manuscript according to the suggestions of the reviewer.

1. P.13774, L6: The two analysis domains: : :

Reply: The text has been changed.

2. P.13783, L20: Figures 10b-c and e-f show the time-longitude diagrams: : :

Reply: The sentence has been changed.

3. P.13793, Table 1 (and Figs. 8, 9, and 14): The acronym “CPD” (cycles per day) is not defined anywhere in the text before its use.

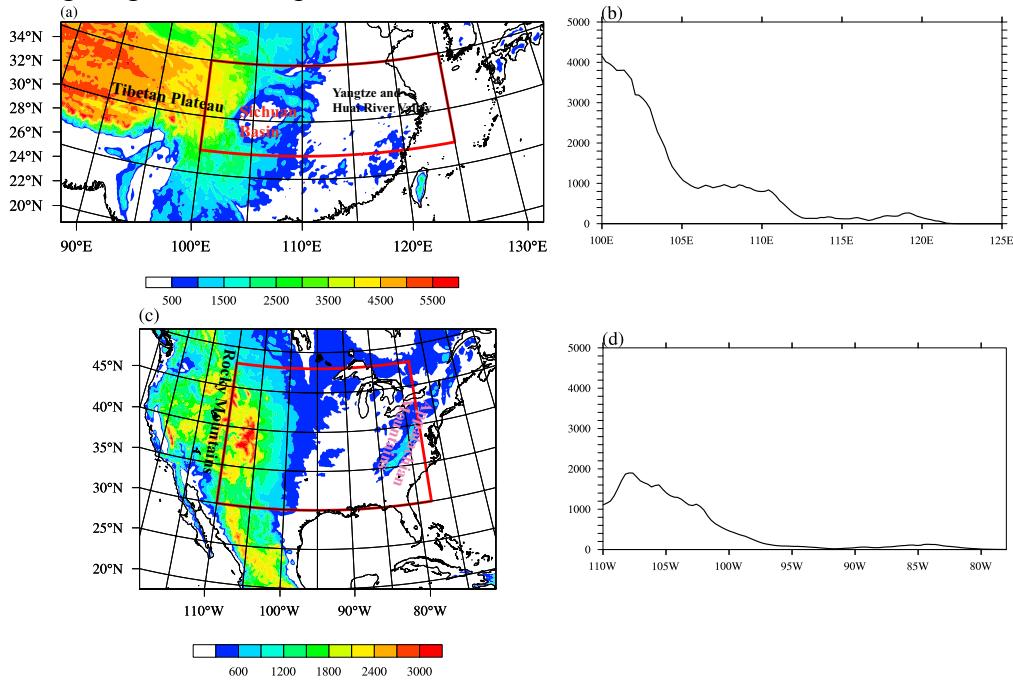
Reply: The definition has been added in caption of Figure 8 (the first time it appears).

We again thank Dr. Wang for his thorough and insightful comments that help greatly in our revision of the manuscript.

Summary of Revisions in Response to Both Reviewers' Comments

1. P.13770, L19: change “due to more the complex” into “due to the more complex”.
2. P. 13771, L3: add “hereafter HZ10” after “He and Zhang, 2010,”
3. P.13773, L21-22: change “The CMORPH dataset was used in recent studies of He and Zhang (2010), BZS11 and Sun and Zhang (2011) for studying the diurnal evolution of the summertime precipitation over East Asia lee of the TB but has not been systematically applied over North American downstream of the Rockies.” to “The CMORPH dataset was used recently by He and Zhang (2010), BZS11 and Sun and Zhang (2011) to study the diurnal evolution of the summertime precipitation over East Asia lee of the TB but has not been systematically applied over North American downstream of the Rockies.”
4. P.13774, L6: change “The two analysi domains” into “The two analysis domains”.
5. P.13774, L11: add “the latitudinal range is wider than that of East Asian domain” after “110–78°W, 30–48°N”.
6. P.13775, L5: change “35 to 48°N” to “30 to 48°N”.
7. P.13776, L3: change “Figure 2 shows time-longitude diagrams of normalized hourly precipitation ”to “Figure 2 shows time-longitude diagrams of hourly precipitation and normalized hourly precipitation”.
8. P.13776, L6: change “BZS11,” to “BZS11;”.
9. P.13777, L9: change the word “inversion” to “reversal”.
10. P.13788, L8-9: the sentence changes to “The phase speed of the propagating precipitation in North America is faster than that of East Asia partially influenced by the higher ambient wind speed of the westerlies.”
11. P. 13780, L9: add “There also appears to be a second solenoid between the Great Plains and the Appalachians (about 84-88°W) at 0600 and 1800 UTC with a direction opposite to S0 (Carbone and Tuttle, 2008).” at the end of the paragraph.”
12. P.13780, L23-25: add “The positive (negative) wavenumber corresponds to eastward (westward) propagating signals of precipitation and this work studies the eastward precipitation propagation.” Before “There are two striking, common features”.
13. P.13781, L17: change “less then” to “less than”.
14. P. 13782, L17-18: change “CAR02,” to “CAR02;”.
- Change “Zhou et al;” to “Zhou et al.,”.
15. P.13782, L24: the sentence changes to “The filtered precipitation perturbation between phase speed lines is the primary eastward propagation signal compared with the raw hourly precipitation over both continents. The spatial distribution of the filtered precipitation perturbation (Figs. 11 and 12) shows the similar diurnal phase of propagation to normalized hourly precipitation (Figs. 3 and 4, described in Sect. 3.1).”
16. P.13783, L20: change “Figures 10b-c and e-f shows the time-longitude diagrams” to “Figures 10b-c and e-f show the time-longitude diagrams”.

17. Change caption of Figure 8 to “**Figure 8.** Top: Zonal wavenumber-frequency power spectra (with base-10 logarithmic transform) of the hourly precipitation throughout the warm season summed over the focus domains in (a) East Asia and (c) North America. Bottom: the same as in the left panels except for smoothed power spectra for (b) East Asia and (d) North America. The y-axis on the left is the frequency in units of CPD (cycle per day), and on the right the time period in hours. The black solid lines points out the ridges of power spectra.
18. Change Figure 1 to the panels below:



19. Change Figure 4 to Figure 4a and Figure 4b

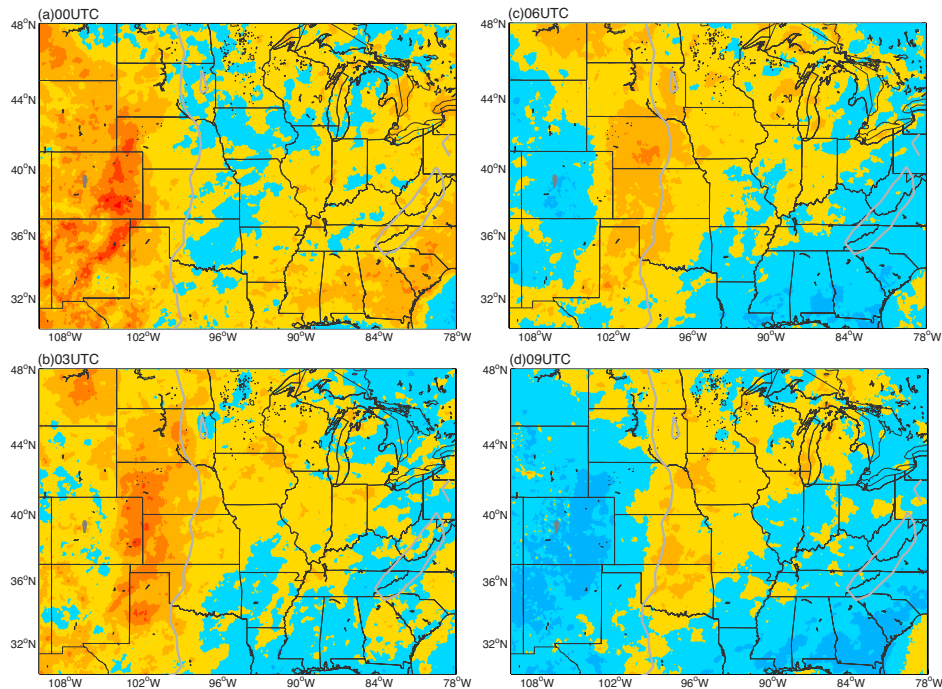


Figure 4a. Similar to Fig. 3 but normalized hourly mean precipitation over North America from 00UTC to 09UTC (a~d). The darker gray line represents terrain elevation of 3000m and the lighter one is 500 m.

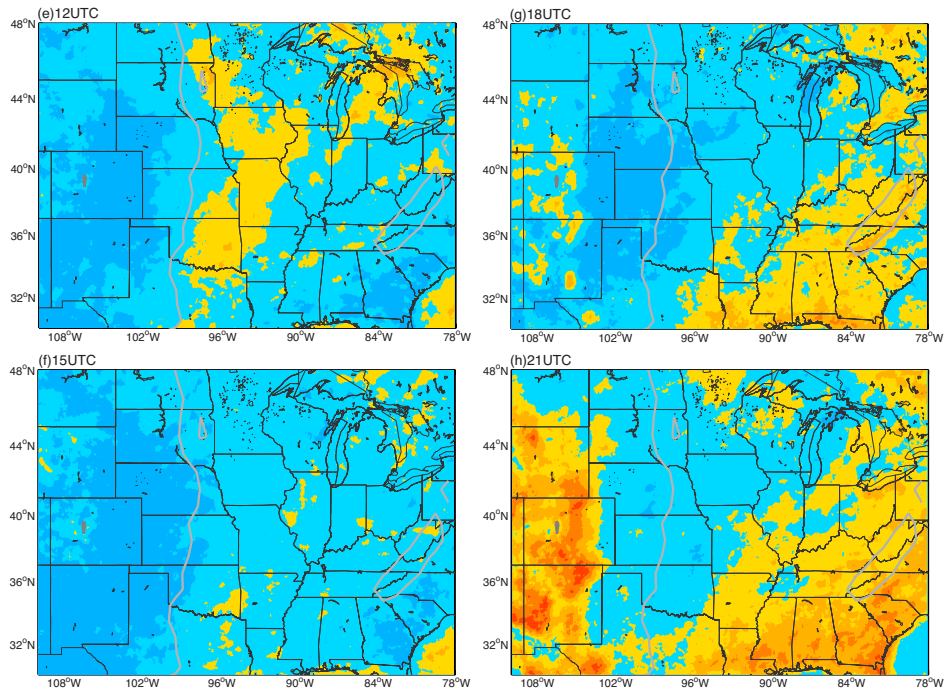


Figure 4b. Similar to Fig. 4a but from 12UTC to 21UTC (e~h).

20. Change Figure 10 to Figure10a and Figure 10b

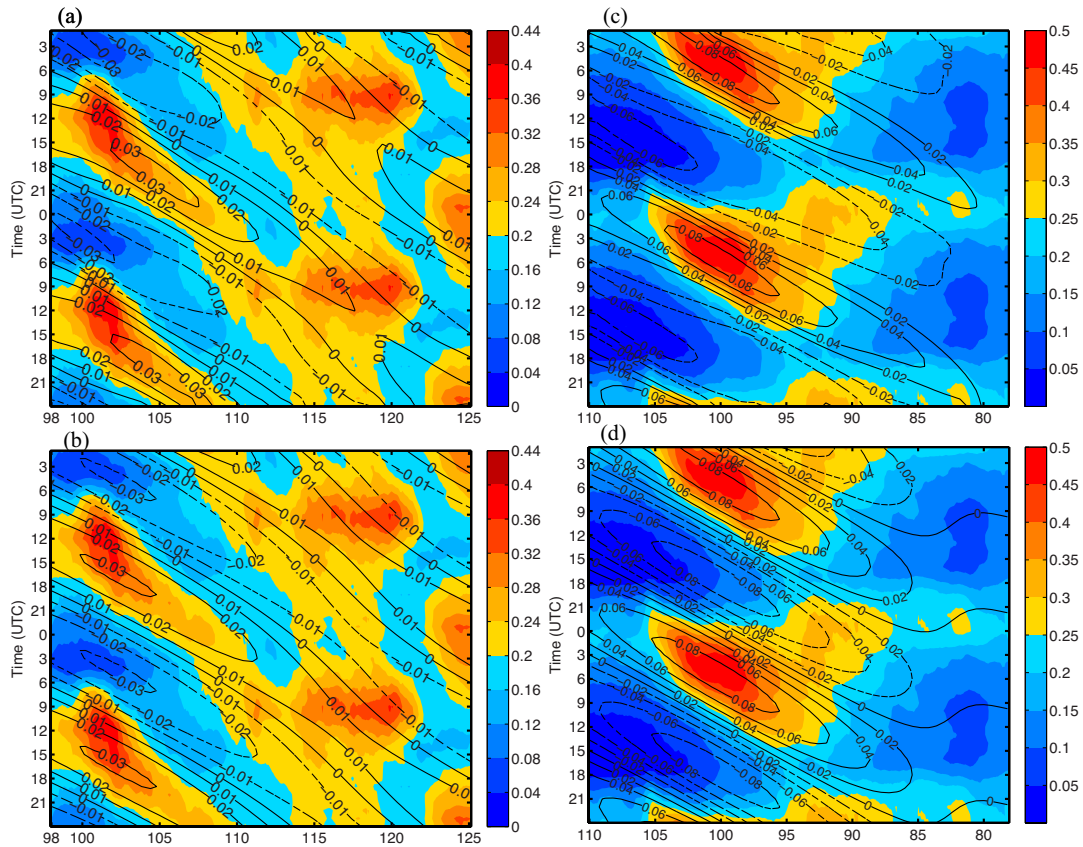


Figure 10a. Left: the time-longitude diagram of the diurnal variation in the hourly precipitation (shadings) and the filtered precipitation perturbation (contours) for **(a)** spectrally filtered for phase speeds between 10 and 25ms^{-1} **(b)** SR1 derived over the focus domain in East Asia, values of contours are from -0.03 to 0.03 with interval of 0.01. Right: as in the left panels but for the filtered perturbations for **(c)** for phase speeds between 13 and 30ms^{-1} , **(d)** SR1 over the focus domain in North America, values of contours are from -0.08 to 0.08 with interval of 0.02.

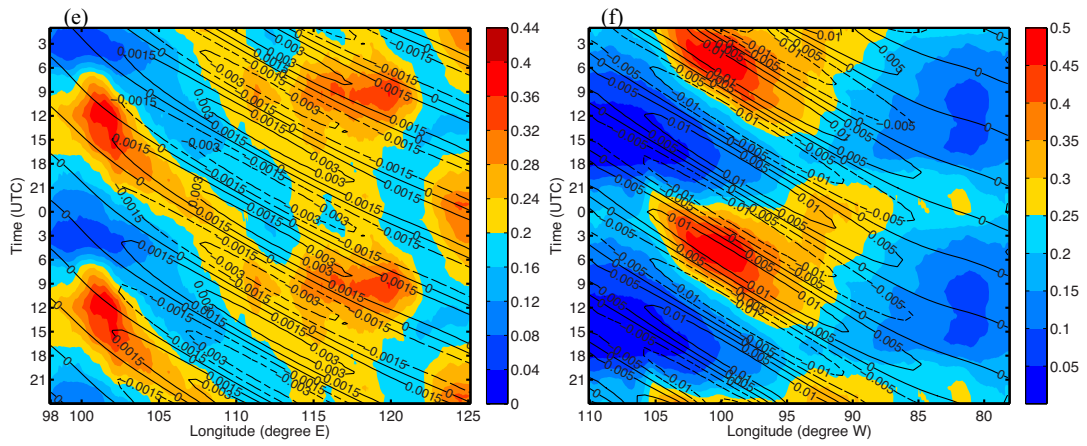


Figure 10b. similar to Figure 10a , but left panel is SR2 derived over the focus domain in East Asia, values of contours are from -0.003 to 0.003 with interval of 0.001, right one is SR2 over the focus domain in North America, values of contours are from -0.01 to 0.01 with interval of 0.005.

21. Change Figure 8 to the following panels

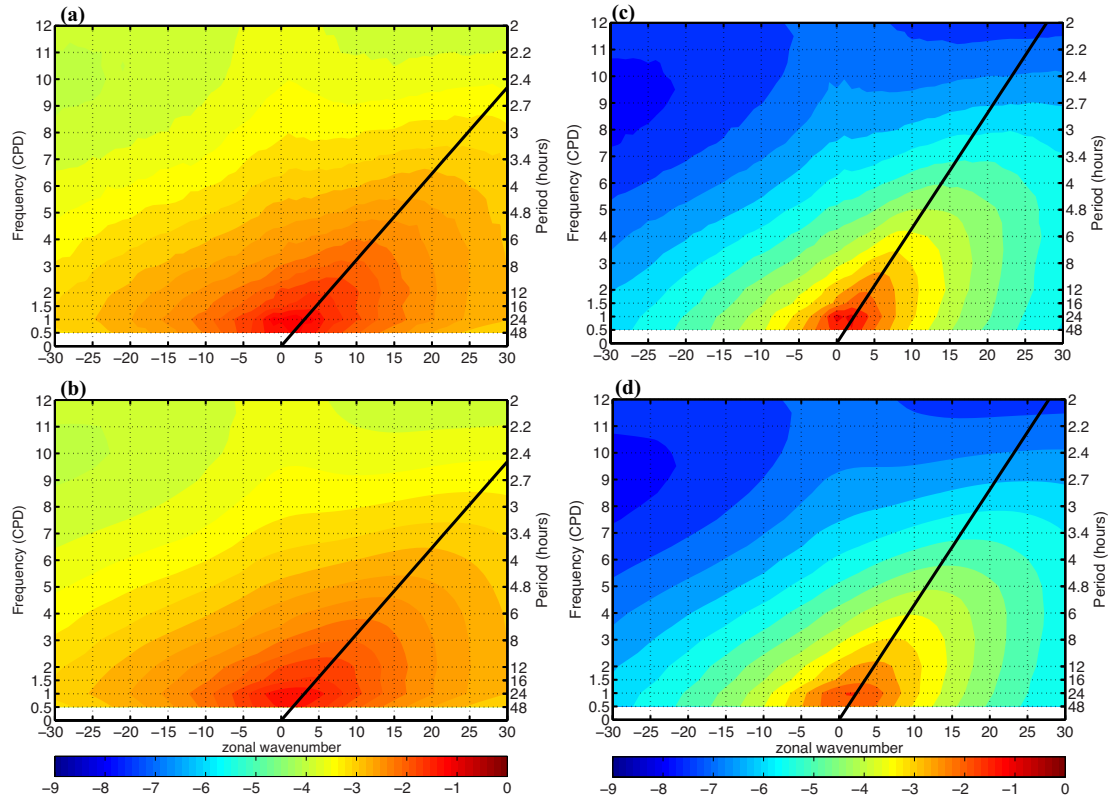


Figure 8. Top: Zonal wavenumber-frequency power spectra (with base-10 logarithmic transform) of the hourly precipitation throughout the warm season summed over the focus domains in **(a)** East Asia and **(c)** North America. Bottom: the same as in the left panels except for smoothed power spectra for **(b)** East Asia and **(d)** North America. The y-axis on the left is the frequency in units of CPD (cycle per day), and on the right the time period in hours. The black solid lines point out the ridges of power spectra.

22. Change Figure 18 to the following panels.

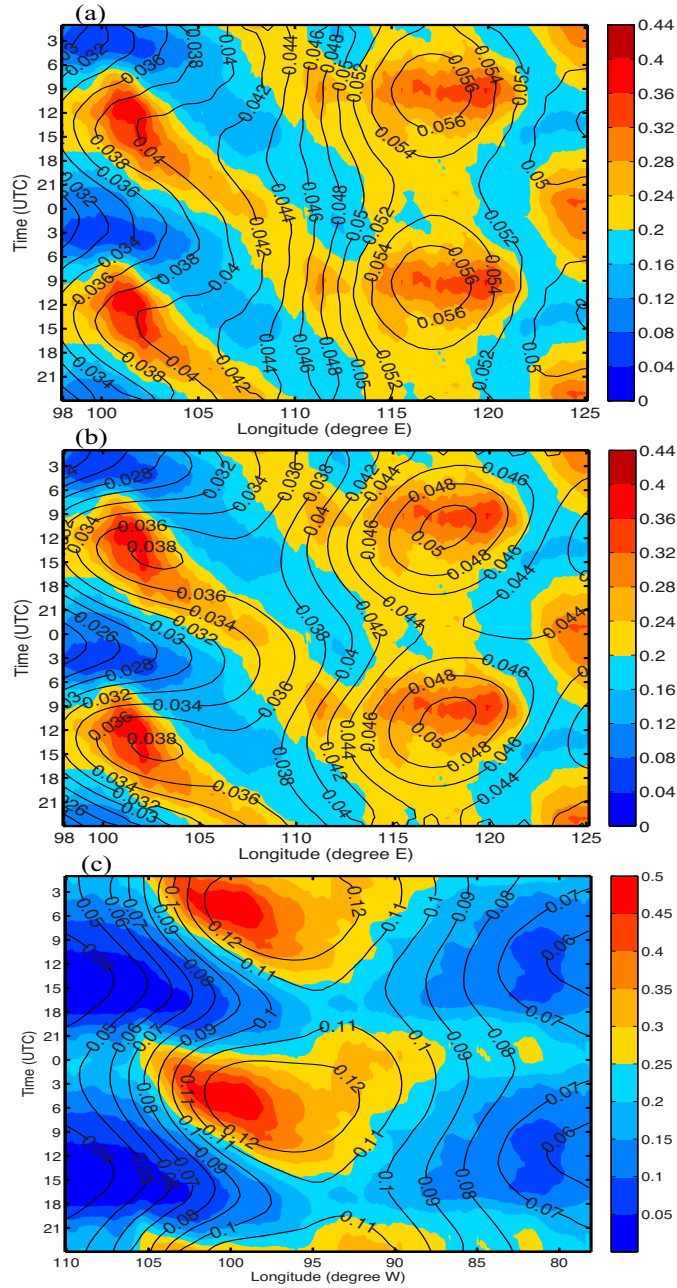


Figure 18. Time-longitude diagram of the diurnal variation in the hourly precipitation (shadings) and the filtered precipitation perturbation variances (contours) for **(a)** SR3 and **(b)** SR4 over East Asia, contours interval is 0.02 and **(c)** for with SR3 for North America, contours interval is 0.01.

Response to Comments from Reviewer #2

We thank Dr Bao's insightful comments, which have been very helpful in the further revision of our manuscript. We have made every effort to address all the concerns raised by this review. Our point-by-point response is given below.

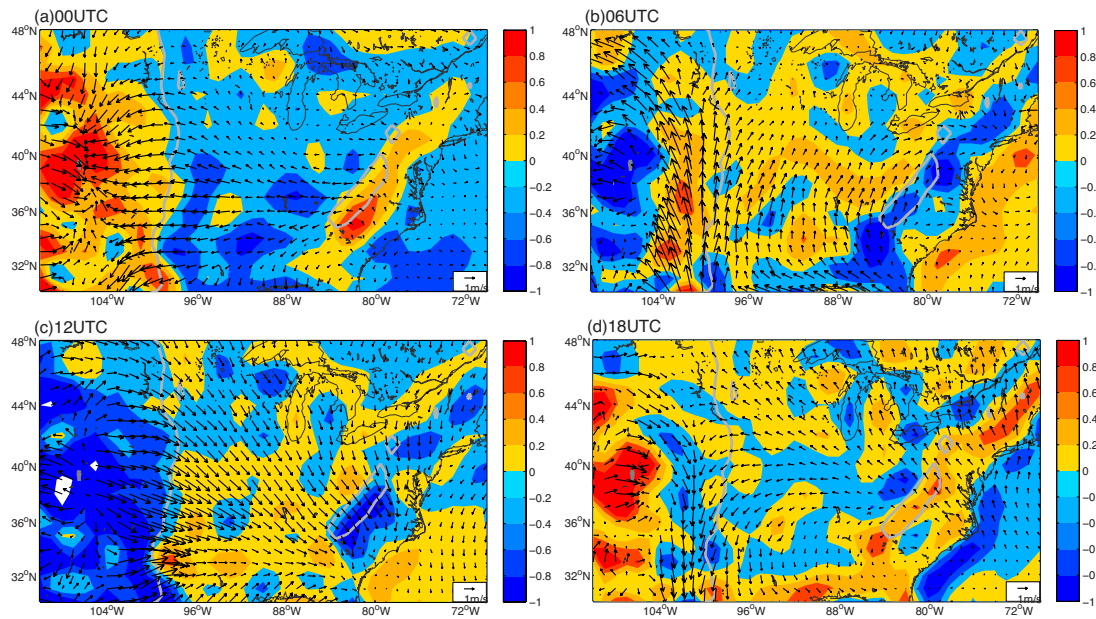
General comments:

This paper explores the differences and similarities of the diurnal variation of warmseason precipitation in the East Asia and North America downstream of the big topography. The multi-scale, multi-modal features of precipitation over both continents are also examined and discussed. This manuscript is generally well written, and is recommended to be accepted after very minor revisions.

Minor comment:

- 1. There is a little difference between these two focus domains. In East Asia, the focus domain includes a small part of ocean, so the impact of the land-sea circulation is discussed and seems important to the diurnal precipitation over the coastal area and the ocean. While the focus domain in the North America is in the continent completely, doesn't include the ocean in the east, and just the mountain-plains circulation is analyzed. On the other hand, there is another downdraft (updraft) between 86-81W in Fig.7b (7d) except for the one of S0. This downdraft/updraft seems to belong to another circulation which is not obvious in Fig. 7. If the domain in Fig.7 could extend to the east ocean, or the horizontal distribution of the low-level vertical motion derivations over the larger domain as Fig. 9 in BZS11 can be showed, the other circulations beside S0 in connection with the diurnal precipitation should be clear and entire.*

Reply: We did not include ocean for NA domain for three reasons. (1) the longitudinal range of this domain is the lengthscale of wavenumber 1 of 4000km; (2) our focus is on the impact of Rocky Mountains and the east coast of NA has another mountain ranges which is different from China; and (3) the current selection of the domain is to make the size more comparable for both regions. The figure below shows that beside the circulation of S0 over the eastern edge of the Rocky Mountains and the central plains, there is another circulation of smaller scale between the Appalachian Mountains and the oceanic area, however, considering the reasons described above the oceanic areas is not in our focus domain.



Supplementary Figure: Spatial distribution of the 850-hPa vertical motion derivations (cm s^{-1} , colors) and perturbation wind vectors diagnosed with the GFS analyses at (a) 00, (b) 06, (c) 12, and (d) 18 UTC averaged over the warm-season over the domain of 30-48°N, 110-70°W.

2. *According to Fig. 7, The period that MPS circulation in North America converts from daytime pattern (00 UTC, Fig. 7a) to nighttime pattern (06 UTC, Fig. 7b) seems to be around 6h, is shorter than that in East Asia (around 12h, Fig. 6). Does the faster transition influence the propagation of diurnal precipitation signal? Or is this just because the low temporal resolution of FNL analysis can't give the correct peak time of daytime and nighttime MPS pattern? Because this question needs the higher temporal resolution data to resolve, so the authors can glance at it merely.*

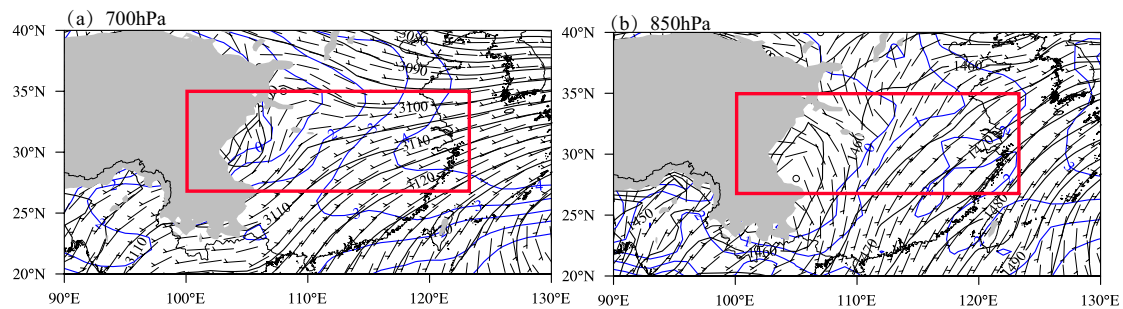
Reply: It is possible that the faster transition of MPS circulation influence the diurnal precipitation signal, but we need further research to verify the hypothesis with higher temporal resolution data (such as simulation results). This has been noted in the revision.

3. *P. 13771, L5-13 and P. 13774, L6-15: In these two paragraphs, a lot of toponyms are used to describe the topography features of East Asia and North America in detail, but aren't showed in the corresponding topographic map Fig. 1a and 1c. While some key places, such as Tibetan Plateau, Yangtze and Huai River Valley, Rocky Mountains, Appalachian Mountains, are mentioned frequently. So it will be very helpful to readers unfamiliar with these regions to mark these key placenames or their abbreviations in Fig. 1a and 1c.*

Reply: The key place names have been added in Fig.1a and 1c as recommended.

4. P. 13784, L18-20: The southwestern low level jet (LLJ) is introduced to be the possible reason that the wind speed at levels lower than 500 hPa over the southern area is slightly larger than the northern wind speed, but it is not explored further. Please cite some relational references to support this statement.

Reply: The figures below show the wind field at 850 hPa and 700 hPa (symbolizing the low levels)over East Asia. Wind speed of LLJ over south of 30N (southern area) is larger than the northern wind speed. We add the some description in text.



Supplemental Figure: Mean geopotential height (black line: gpm), wind barb (full barb: 5 m s⁻¹) and zonal wind speed (blue line: m s⁻¹) at 700 hPa and 850 hPa over East Asia. The red boxes show our focus domain.

5. P. 13801, Fig. 8: please use the same color bars of the power spectra in both domains.

Reply: This figure is changed as suggested by both reviewers.

Technical points:

All technical and editorial minor points are well taken off in the revised manuscript according to the suggestions of the reviewer.

1. P. 13774, L5: lost a full stop "." at the end of the paragraph.

Reply: The full stop has been added at the end of the paragraph.

2. P. 13776, L6: please change "BZS11," to "BZS11;".

Reply: "BSZ11," has been changed into "BZS11;".

3. P. 13779, L1: please change "He and Zhang, 2010," to "He and Zhang, 2010;".

Reply: "He and Zhang, 2010" has been changed into "He and Zhang, 2010;".

4. P. 13782, L17-18: "CAR02," should be "CAR02;". "Zhou et al;" should be "Zhou et al.,".

Reply: "CAR02" and "Zhou et al;" are changed into "CAR02;" and "Zhou et al.,".

5. P. 13784, L12: "HZ10" is not defined before its use.

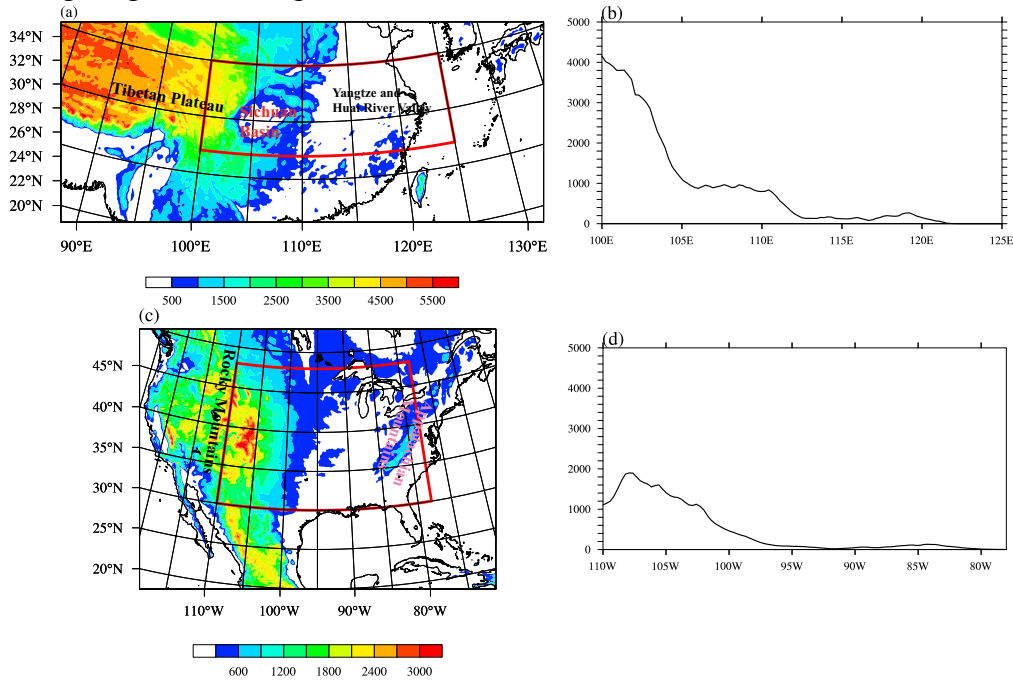
Reply: We add "hereafter HZ10" after "He and Zhang, 2010," in P. 13771, L3.

Summary of Revisions in Response to Both Reviewers' Comments

1. P.13770, L19: change “due to more the complex” into “due to the more complex”.
2. P. 13771, L3: add “hereafter HZ10” after “He and Zhang, 2010,”
3. P.13773, L21-22: change “The CMORPH dataset was used in recent studies of He and Zhang (2010), BZS11 and Sun and Zhang (2011) for studying the diurnal evolution of the summertime precipitation over East Asia lee of the TB but has not been systematically applied over North American downstream of the Rockies.” to “The CMORPH dataset was used recently by He and Zhang (2010), BZS11 and Sun and Zhang (2011) to study the diurnal evolution of the summertime precipitation over East Asia lee of the TB but has not been systematically applied over North American downstream of the Rockies.”
4. P.13774, L6: change “The two analysi domains” into “The two analysis domains”.
5. P.13774, L11: add “the latitudinal range is wider than that of East Asian domain” after “110–78°W, 30–48°N”.
6. P.13775, L5: change “35 to 48°N” to “30 to 48°N”.
7. P.13776, L3: change “Figure 2 shows time-longitude diagrams of normalized hourly precipitation ”to “Figure 2 shows time-longitude diagrams of hourly precipitation and normalized hourly precipitation”.
8. P.13776, L6: change “BZS11,” to “BZS11;”.
9. P.13777, L9: change the word “inversion” to “reversal”.
10. P.13788, L8-9: the sentence changes to “The phase speed of the propagating precipitation in North America is faster than that of East Asia partially influenced by the higher ambient wind speed of the westerlies.”
11. P. 13780, L9: add “There also appears to be a second solenoid between the Great Plains and the Appalachians (about 84-88°W) at 0600 and 1800 UTC with a direction opposite to S0 (Carbone and Tuttle, 2008).” at the end of the paragraph.”
12. P.13780, L23-25: add “The positive (negative) wavenumber corresponds to eastward (westward) propagating signals of precipitation and this work studies the eastward precipitation propagation.” Before “There are two striking, common features”.
13. P.13781, L17: change “less then” to “less than”.
14. P. 13782, L17-18: change “CAR02,” to “CAR02;”.
Change “Zhou et al;” to “Zhou et al.,”.
15. P.13782, L24: the sentence changes to “The filtered precipitation perturbation between phase speed lines is the primary eastward propagation signal compared with the raw hourly precipitation over both continents. The spatial distribution of the filtered precipitation perturbation (Figs. 11 and 12) shows the similar diurnal phase of propagation to normalized hourly precipitation (Figs. 3 and 4, described in Sect. 3.1).”
16. P.13783, L20: change “Figures 10b-c and e-f shows the time-longitude diagrams” to “Figures 10b-c and e-f show the time-longitude diagrams”.

17. Change caption of Figure 8 to “**Figure 8.** Top: Zonal wavenumber-frequency power spectra (with base-10 logarithmic transform) of the hourly precipitation throughout the warm season summed over the focus domains in (a) East Asia and (c) North America. Bottom: the same as in the left panels except for smoothed power spectra for (b) East Asia and (d) North America. The y-axis on the left is the frequency in units of CPD (cycle per day), and on the right the time period in hours. The black solid lines points out the ridges of power spectra.

18. Change Figure 1 to the panels below:



19. Change Figure 4 to Figure 4a and Figure 4b

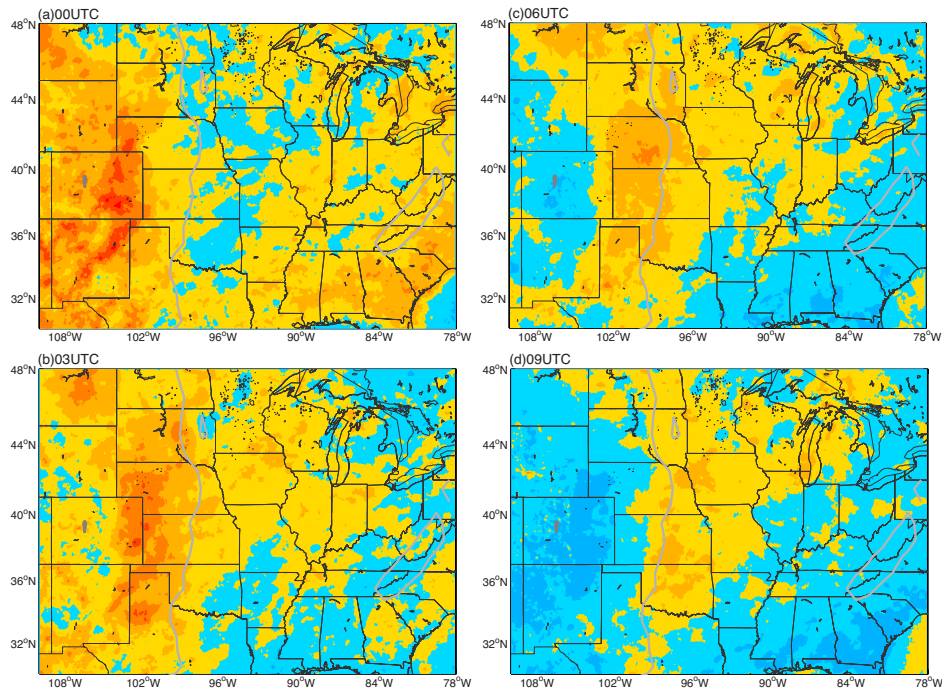


Figure 4a. Similar to Fig. 3 but normalized hourly mean precipitation over North America from 00UTC to 09UTC (a~d). The darker gray line represents terrain elevation of 3000m and the lighter one is 500 m.

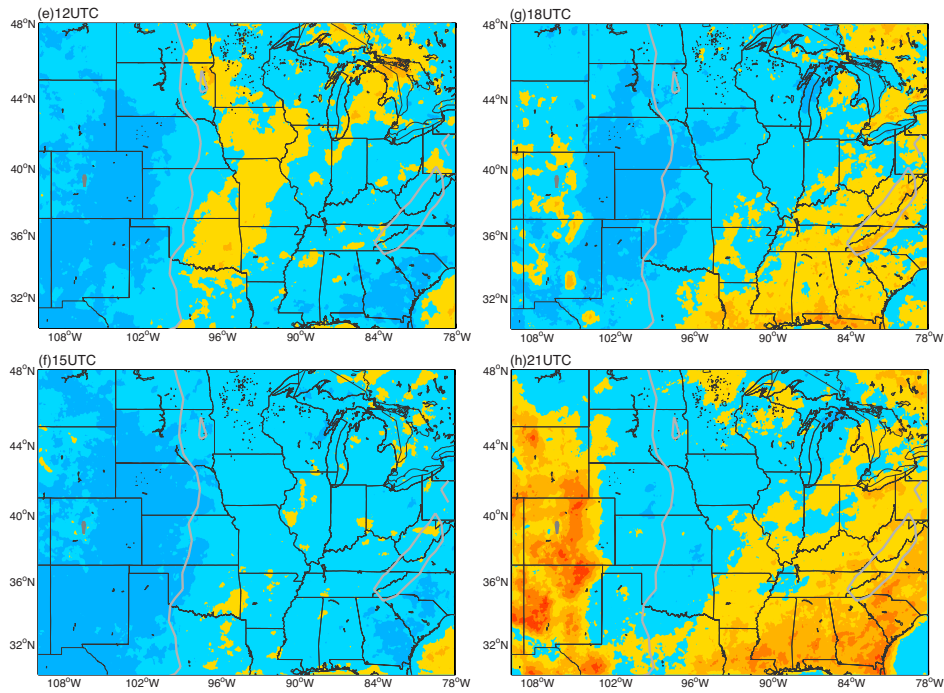


Figure 4b. Similar to Fig. 4a but from 12UTC to 21UTC (e~h).

20. Change Figure 10 to Figure10a and Figure 10b

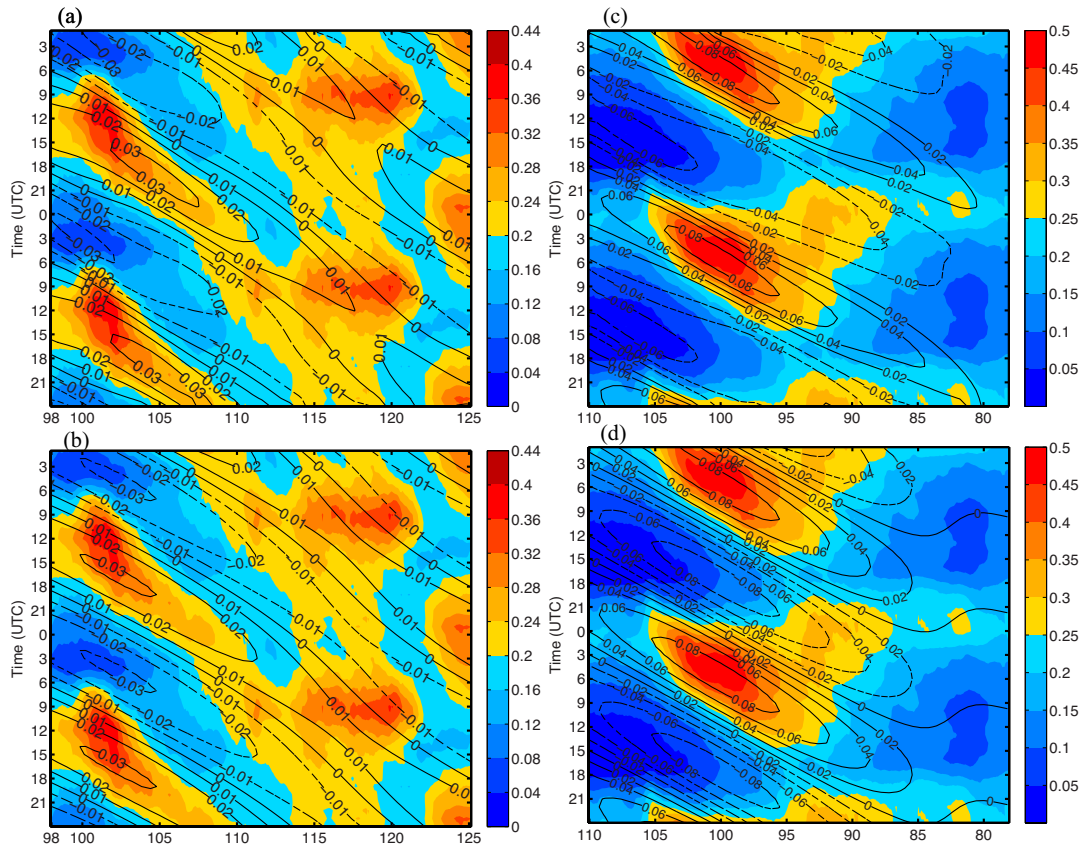


Figure 10a. Left: the time-longitude diagram of the diurnal variation in the hourly precipitation (shadings) and the filtered precipitation perturbation (contours) for **(a)** spectrally filtered for phase speeds between 10 and 25ms^{-1} **(b)** SR1 derived over the focus domain in East Asia, values of contours are from -0.03 to 0.03 with interval of 0.01. Right: as in the left panels but for the filtered perturbations for **(c)** for phase speeds between 13 and 30ms^{-1} , **(d)** SR1 over the focus domain in North America, values of contours are from -0.08 to 0.08 with interval of 0.02.

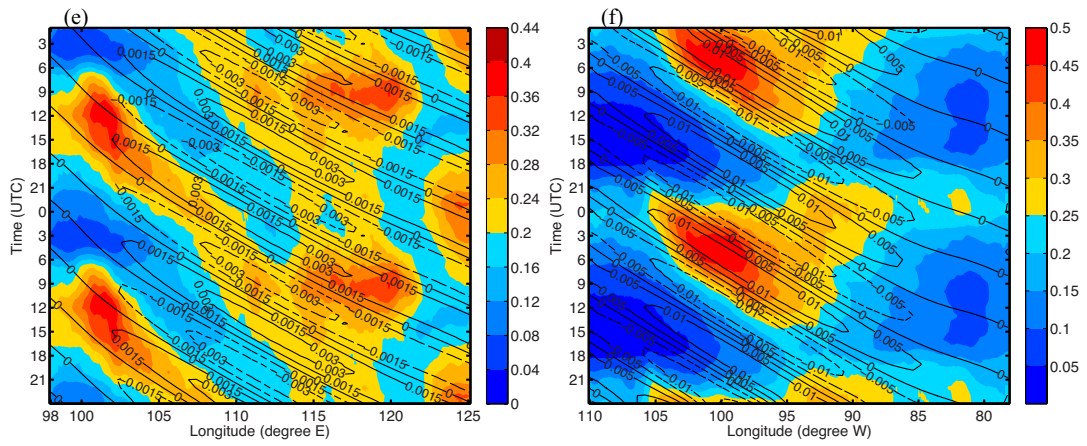


Figure 10b. similar to Figure 10a , but left panel is SR2 derived over the focus domain in East Asia, values of contours are from -0.003 to 0.003 with interval of 0.001, right one is SR2 over the focus domain in North America, values of contours are from -0.01 to 0.01 with interval of 0.005.

21. Change Figure 8 to the following panels

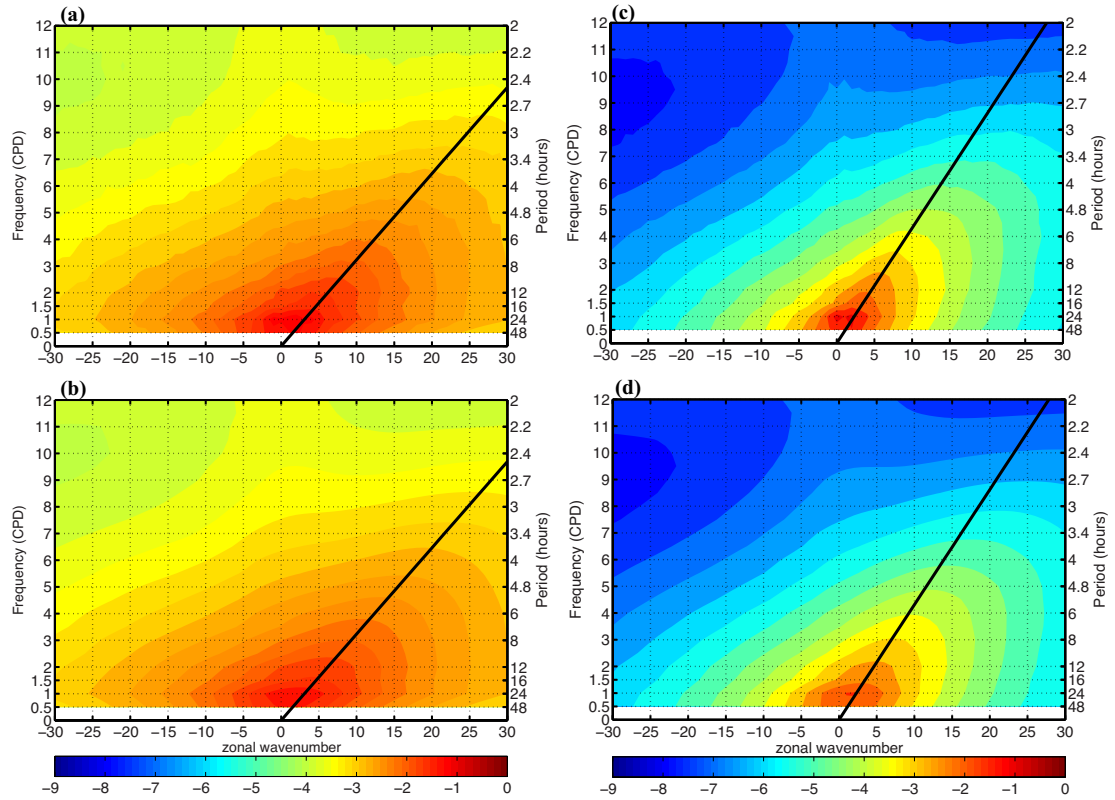


Figure 8. Top: Zonal wavenumber-frequency power spectra (with base-10 logarithmic transform) of the hourly precipitation throughout the warm season summed over the focus domains in **(a)** East Asia and **(c)** North America. Bottom: the same as in the left panels except for smoothed power spectra for **(b)** East Asia and **(d)** North America. The y-axis on the left is the frequency in units of CPD (cycle per day), and on the right the time period in hours. The black solid lines points out the ridges of power spectra.

22. Change Figure 18 to the following panels.

