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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Teleconnection analysis of runoff and soil moisture over the Pearl River basin in South China" *by* J. Niu et al.

J. Niu et al.

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We thank the reviewer for his/her constructive comments and useful suggestions. Our detailed responses to the review comments are as follows.

General Comments: The manuscript tried to establish the teleconnection between ENSO and IOD for the Pearl River Basic. The authors utilized modeled runoff and soil moisture (with VIC model) and a variety of statistical methods. They found that the dominant variability of the time series of the runoff and soil moisture is correlated with IOD. Specific Comments:

Review Comment 1: VIC model has no consideration of connectivity, which is important for runoff generation (quantity and timing). Discussion on how this might affect your

interpretation and validity of this research should be discussed.

Author Response: Yes. We agree with the reviewer that routing processes are important for the streamflow simulation on quantity and timing at basin outlet or a control point in the downstream reach which involves many grid cells. Niu and Chen (2010) have examined the routing effects in the Pearl River basin, as shown in the Figure R-1 (below). From the figure, it is observed that the effect of the routing scheme is very significant at small time scales (less than 1 week). The Nash-Sutcliffe efficiency coefficient (NSE) value reaches to a certain flat level after 2 weeks for the North River and East River and after 3 weeks for the West River, which indicates the routing scheme would not be effective for a temporal scale beyond. For compatibility with the large-scale climate indices, monthly scale is chosen as the basis of the teleconnection analysis in this study. As the monthly time interval is longer than 4 weeks, the routing effects (i.e. the consideration of connectivity) for the current study will not be negligible. This can be easily clarified, by adding the following sentence in the revision.

"It is also noted that the routing effects is effective within 2-3 weeks for the Pearl River basin (Niu and Chen, 2010); this study adopted the monthly scale for analyzing teleconnection, and the monthly scale is longer than the timescales of the routing effects."

Review Comment 2: There are lots of places that put too much emphasis on statistical significance, but do not mention the physical (hydrological) meaning. For example, three modes were separated out though Principle Component analysis, but the physical meanings of these three modes are not discussed. In addition, a correlation coefficient 0.3, albeit statistical significant, can only explain less than 10% of the variance of the dependent variable, which do not have much meaning of predicting the dependent variable from the independent. Therefore, I would not say too much if the correlation coefficient is less than 0.4 (depends on the authors).

Author Response: The physical meaning of the separated three modes can be easily explained, as presented below.

The relevant physical meanings for the runoff modes : “One rainstorm center in the Pearl River is located in the lower reach of Hongshui River basin (Pearl River Water Resources Commission, 2005), which results in the highest power at 0.5–1 year period for the third mode of precipitation and runoff in the central part. The Nanpan River basin is in the northwest region of the Pearl River. This region has the highest altitudes, and is influenced by the topographic rain shadow with respect to the prevailing storm tracks. The east region of the Pearl River is close to the South China Sea, which is subjected to convective movement of water by semitropical hurricanes and typhoons (Niu, 2013). The higher variability in the 1–4 year band is more obvious, compared to the third mode of runoff in the central part of the Pearl River.”

The relevant physical meanings for the modes of soil moisture : “The Beipan, Nanpan, and Youjiang river basins, located at the northwestern region with the highest altitudes, belong to the first mode of soil moisture that displays a single peak of high variability at longer timescales. In these basins, the high-frequency precipitation variability is less kept by runoff, and therefore more reflected by soil moisture at low-frequencies. The second mode of soil moisture, including the North, Guihe, Zuoyu River basins and the West River Lower Reach, shows relatively flat variability power distribution (see Fig. 3b), which either has lower altitudes or is located at the downstream of the Pearl River. Meanwhile, the third mode of soil moisture, which the Liujiang, Hongshui and East River basins belong to, sits between the above two distinctive modes, which is partly consistent with elevation variations between two other modes.”

The coherent modes of runoff are basically dominated by that of precipitation, and coherent modes of soil moisture are geographically apart due to more between modes shift. Details of the physical meaning of three precipitation modes in the Pearl River basin are already reported in Niu (2013) (i.e., Niu, J. (2013) Precipitation in the Pearl River basin, South China: Scaling, regional patterns, and influence of large-scale climate anomalies. Stochastic Environmental Research and Risk Assessment, 27(5), 1253-1268. doi: 10.1007/s00477-012-0661-2). It would indeed be interesting to study

how and why the coherent mode shifts from precipitation to runoff and soil moisture, but such is beyond the scope of the current study. We will report the analysis and outcomes of such a study elsewhere.

About correlation coefficients in Table 2, there are 55 values statistically significant for corresponding time periods and 8 of them (about 15%) less than 0.4. In addition, we did not develop any equation for prediction based on these correlation analyses in this study, but to examine the scale-dependent teleconnection between a regional hydrological variable and a climate pattern.

Review Comment 3: Interpretation of the wavelet spectra needs improvements. I think wavelet coherency figures should be divided into global and local. In most cases, we are interested in global features, rather than the local features. If your purpose is to establish teleconnection, you need to look at global wavelet coherency, not the local coherency. In your analysis (Figs. 8 and 9), there are only local features. Local coherency could be coincidence. In my opinion, only when there five or more statistical significant local features at the same scale can be considered as global.

Author Response: We agree with the reviewer. The wavelet coherency can be divided into local and global (see Fig.8 and Fig.9 below). We find that the global wavelet coherency results are basically consistent with the conclusion that the variabilities of runoff and soil moisture in the Pearl River basin are more correlated with IOD, especially for the eastern and central region (i.e. the second and third modes of runoff and soil moisture).

This can be easily explained as follows: “The global wavelet coherence spectrum can be obtained by averaging the local wavelet coherence spectrum in time, which is helpful to examine the characteristic scales (Torrence and Compo, 1998; Labat, 2010a).” “The global wavelet coherence results in Fig. 8 also show the oscillation correlation around the 1–6 year band, especially between the second and third modes of runoff and IOD (the right panel of Fig. 8b and 8c).” “The global wavelet coherence in Fig. 9b and 9c shows the teleconnection peaks between regional (the eastern and central parts) soil moisture and climatic patterns at long-term timescales."

Review Comment 4: Correlation coefficients and coherency should be large to be considered as useful for data interpretation. In your wavelet coherency figures, there are no legends on wavelet coherency grey scales. Please add them, because we are not only interested in statistical interpretation, but also values of the coherency and Spearman rank correlation coefficients.

Author Response: The legends on wavelet coherency grey scales have been shown in Fig. 8 and Fig.9. The values of Spearman rank correlation are listed in Table 2. In addition, the wavelet power spectrum in Fig. 2 is categorized into three levels, which are at normalized variances of 1, 2, and 4 for runoff and soil moisture respectively.

Review Comment 5: I am not sure if "inferences on drought and floods" section is needed. Little new information is added to the paper by the two sections.

Author Response: We appreciate the reviewer's comment. However, we believe that the "Inferences on drought and floods" section is necessary, as it discusses: (1) the previous study results for South China; and (2) the information derived from the bandpass-filtered time series of runoff/soil moisture, proposed in Fig. 5. This is eventually to infer that the impactful appearance of small-scale activity (variability) is supported by larger-scale activity (Kumar, 1996).

Review Comment 6: You need to add more details on the PCA. Explain how you did it, and what the physical meaning of the three modes is.

Author Response: We agree with the reviewer. The details of the PCA application can be explained, in the revised version, as follows.

"The main procedures for the PCA application in this study include: (1) a covariance matrix is obtained by using the wavelet power spectra for s (equal to 49) timescales of one of runoff/soil moisture in 10 sub-basins; (2) decomposing the covariance matrix

to get eigenvectors of the Matrix, which accounts for the maximum amount of the joint variability of anomalies of initial wavelet power spectrum at each sub-basin; (3) the new variables are produced after projecting the data on the obtained eigenvectors; (4) the first three principal components are selected for runoff and soil moisture respectively; (5) each sub-basin was then classified as belonging to the mode where its coefficient of the eigenvectors (i.e., the length of the vector projected on corresponding direction) was largest absolute value."

As for the physical meaning of the three modes, please refer to the Author Response to Review Comment 2 above.

Minor Comments:

Comment 1: Line 12, Page 11955, please add description and provide basic statistical parameters of your raw data of precipitation, runoff and soil water contents, so the readers could. Otherwise, I cannot judge much variance in the raw data can be explained by the independent variables.

Author Response: We agree with the reviewer comments. The basic statistical properties will be included in the revised version.

Comment 2: Line 15, Page 11956. You can count the number of large spikes from Figure 2 and 3 to verify the scales or frequency of runoff and soil water.

Author Response: We agree with the reviewer comments. The statement can be further illustrated by the spike features as follows. "..., with the large spikes (about 6 in amount) in Fig. 2a-ii appeared around 2-year scale, and the spikes with the largest area (in time-frequency domain) existed around 2-year scale in Fig. 2b-ii."

Comment 3: Line 1, Page 11957, how did you select BLVB? What is the criterion?

Author Response: Figure R-2 (below) illustrates the local dominant variability band for individual GWS, which is defined as the longest projecting portion with its peak spectrum at least above the mean red-noise spectrum and most likely to reach a higher confidence level (e.g., 95% level). Then, the dominant low-frequency variability band (DLVB) for each hydrological variable is the period that covers most of the identified dominant variability bands of the 10 sub-basins, as shown in Fig. R-2. The obtained dominant variability bands for the Pearl River basin are 0.83-5.21 yr (approximately 10-63 months) for runoff and 1.92-5.21yr (approximately 23-63 months) for soil moisture (see the shaded areas in Figure R-2). The determination of DLVB can be easily clarified in the revised version, as follows:

“Apart from the high variability for less than 1-year period, the variability in the dominant low-frequency variability band (DLVB), 0.83–5.21 years, demonstrates the distinct features of the three multi-scale variability modes in the Pearl River basin (see Fig. 3a). The DLVB is determined by two-steps: (1) the local dominant variability band is defined as longest projecting portion with its peak spectrum at least above the mean red-noise spectrum and most likely to reach a higher confidence level (e.g., 95% level); and (2) the DLVB is the band that covers most of the identified dominant variability bands of the 10 sub-basins.”

Comment 4: Line 5, Page 11957. Can you also test the statistical significance of the “Striking Features”?

Author Response: The striking features are visually observed based on the quantification of DLVB. About the statistical significance, it should be sought in the way of Figure R-2 in Minor Comments 3 above.

Comment 5: Line 10, Page 11961. Pay attention to the values of your correlation coefficients. Some of them are too small to be meaningful.

Author Response: We agree with the reviewer comments. Please refer to the second part of Author Response to Review Comments 2 on the correlation coefficients.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 11943, 2013.

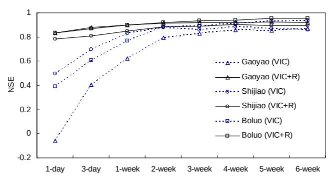

Fig. R-1. The statistical results of *NSE* for the VIC daily streamflow simulations (with (VIC+R) and without (VIC) the routing scheme) aggregated to different temporal scales for three gauge stations in the Pearl River (Niu and Chen, 2010).

1

Fig. 1. Fig. R-1

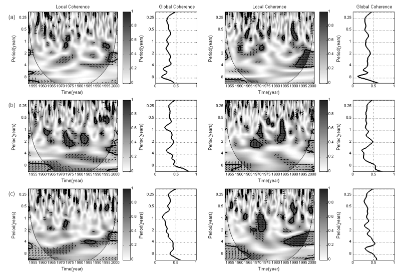

Fig. 8. (a) Squared wavelet coherence (local and global) between the first mode runoff and ENSO time series (left panel), and between the first mode runoff and IOD time series (right panel). The 5% significance level against red noise is shown as a thick contour and the cone of influence (COI) where edge effects might become important is shown as a thin black line. The relative phase relationship is shown as arrows (with in-phase pointing right, anti-phase pointing left, runoff leading ENSO by 90° pointing straight down, and ENSO leading runoff pointing straight up). (b) Same as (a) but for the second model of runoff. (c) Same as (a) but for the third model of runoff.

2

Fig. 2. Fig. 8

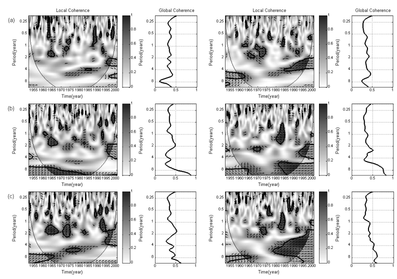

Fig. 9. Same as Fig. 8 but for soil moisture.

3

Fig. 3. Fig. 9

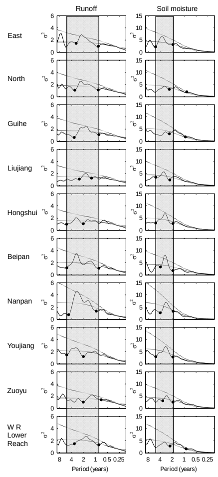

Fig. R-2. Global wavelet power spectra of runoff and soil moisture in 10 sub-basins. The corresponding variance value for each figure is listed in Table 2. The dashed lines are mean red-noise spectrum (lower dashed line), and 95% confidence spectrum (upper dashed line); the bold dots on the solid lines indicate the location and span of the identified local dominant variability band. Shaded area covers most identified dominant variability bands.

5

Fig. 4. Fig. R-2