

Interactive comment on “Climatic controls on watershed reference evapotranspiration vary dramatically during the past 50 years in southern China” by Mengsheng Qin et al.

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Response to Reviewer 1 by Qin et al.

Dear Reviewer,

First of all, we appreciate your interest in this study and your insightful suggestion to make our conclusions more convincing. Accordingly, we provide following response point to point:

General comments: Section 2.2 is well-known material, and except for equation (1), the remaining material should be included as Supplementary Material.

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Response: Yes, we have retained the FAO-56 Penman-Monteith and added the other equations into the Supplement Material.

I'm happy for Sections 2.3, 2.4 and 2.5 to be retained.

Response: We have deleted the original 2.3, 2.4 and 2.5 sections and briefly introduce the data analysis methods in new 2.3 section: Statistical analysis, and add the detailed steps of the methods to the Supplementary Material.

The results discussed in Section 3 need to be reduced to a small number of key observations. The current detail in Section 3 is unnecessary and very difficult to follow. All the information is shown clearly in the tables and figures which should be retained.

Response: Thank you for this valuable suggestion. To address the reviewer's concerns we have made two major efforts in this revision: We have deleted the complex expressions, revised the confusing and unclear technical details. We hope these changes can make the paper easier to understand. Some subtitles were added in this paper (3.1.1 Climatic characteristics over QRB, 3.1.2 Trends of climatic variables in 1961-1987 and 1988-2012, 3.3.3 Contributions of climatic variables to trends of ETo at both seasonal and annual scale).

Specific comments:

Ls48-50: Because the authors have adopted FAO56 reference crop equation (Allen et al. 1998) as the basis of their analysis, they need to be specific about the definition of a reference crop. A reference crop is defined as “A hypothetical reference crop with assumed crop height of 0.12 m, a fixed surface resistance of 70 s m⁻¹ and an albedo of 0.23” (Allen et al., 1998, page 23). Quoting a secondary reference like Liu et al. (2017) is inappropriate especially as the definition is not specifically correct.

Response: Thank for the advice. We have quoted the definition of reference crop “A hypothetical reference crop with assumed crop height of 0.12 m, a fixed surface resistance of 70 s m⁻¹ and an albedo of 0.23” (Allen et al., 1998)

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L49: It is not necessary to have estimates of ETo to determine actual ET. Actual ET is measured directly or through a water balance procedure where in some applications ETo is an input.

Response: we agree. The sentence was revised “essential” to “important” in line 49.

Ls94-96: I think this statement is optimistic. Understanding climate controls on actual ET is much more important.

Response: Thanks for your excellent suggestions. We revised the sentence to better describe this point (line 94). The revised sentence is “A further understanding of the climatic control on ETo could help us better understand the climatic control on actual ET, thus contribute to comprehend watershed hydrological processes and project the impacts of climatic change and land use change on water resources in this basin.”

Ls100-104: I suggest you mention Theil-Sen estimator and the De-trending method here.

Response: we have mentioned these two methods here.

L108: It would be helpful to report all the percentage areas for paddy rice fields, dryland cropping, woodland and urban areas.

Response: We have added percentage areas of each land cover in Section 2.1 as “The land use is dominated by paddy rice field and dry cropland which occupied for nearly 33.4% and 26.1% of the whole basin respectively. Woodland and urban areas occupied for 11.9 and 24.1% of this basin (Fig.1).”(line106)

L112: Please indicate whether there were missing data and, if so, how were the time series infilled.

Response: The missing data were limited in our study. Except for data in Jiangning station which were unavailable after 2007, the data in other five stations provided by China Meteorological Data Sharing Service System and Jiangsu Weather Bureau

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was almost complete (missing daily data < 1%). These data were processed and the missing data were interpolated according to chapter 23 in this book “The Criterion of Surface Meteorological Observation, 2004, China Meteorological Administration”.

L115: I assume daily temperature was not measured but the result of averaging maximum and minimum temperatures. Please clarify in the paper.

Response: Also according to section 20.4 in the book “The Criterion of Surface Meteorological Observation, 2004, China Meteorological Administration”. The mean daily climatic variables such as relative humidity, temperature, wind speed were computed by averaging the observations at 02am, 08am, 02pm, 08pm.

L116: What is the relevance of the statement “Data from Jiangning station was available before 2007” when the authors say nothing about the data from the other five stations?

Response: The revised sentence is “Data from Jiangning station was only available prior to 2007, while the other five stations have almost complete data from 1961 to 2012. Therefore, ETo at Jiangning station during 2007-2012 was null.” (line 116)

L150: This section requires a concluding observation stating which variables will be discussed in the following analysis especially as the authors do not consider sunshine hours yet include solar radiation which is not a variable measured at the meteorological stations.

Response: Thank you for this valuable suggestion. We have added the reasons for selecting these variables which are discussed in the last paragraph in section 2.3. The evapotranspiration process is determined by the amount of energy available to vaporize water and Rs is the largest energy source (Allen et al., 1998).

Besides sunshine hours, we must consider the locations of evaporating surface when evaluating impacts of radiometric term on ETo trends. Rs not only consider the sunshine hours and the location of weather station, but also consider the position of the

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sun for 365 days throughout the year.

L184: Before you begin discussing the results there needs to be a short explanation of the choice of climate variables you plan to discuss, noting that observed data are available for only four variables – wind speed, sunshine hours, relative humidity and temperature, yet you are including in your discussion solar radiation which is unknown but, I assume, is estimated by Equation (4). You do not tell the reader how R_a is estimated which is required to estimate R_s .

Response: Yes, we have added the reasons for selecting these variables which are discussed in the last paragraph in section 2.3. We also have added the equation (5) which indicates that how the extraterrestrial radiation (R_a) was obtained into the supplementary material. $R_a = 1440/\pi G_{sc} d_r \omega_s \sin(\varphi) \sin(\delta) + \cos(\varphi) \cos(\delta) \sin(\omega_s)$ (5) R_a extraterrestrial radiation (MJ m⁻² d⁻¹), G_{sc} the solar constant (0.08232 MJ m⁻² min⁻¹), d_r inverse relative distance from earth-to-sun, ω_s the sunset hour angle (rad), φ latitude (rad), δ solar declination(rad),

L191: The authors have not said why they are discussing R_s when it is not a measured variable. Why not discuss n (sunshine hours) for which data are available?

Response: Good suggestion on discussing Rs. We have answered this question in comment 9.

L195: I don't think the authors tell the reader that the ETo values used in the analysis are calculated values based on Equation (1).

Response: We have revised the sentence as "The MK test and linear regression both showed that the annual ETo estimated by FAO 56 P-M model over QRB has significantly decreased ($p < 0.01$) during 1961–1987, then significantly increased ($p < 0.01$) during 1988–2012 (Table 3 and Fig. 3f)." line195

L195: This section (3.1) would have been clearer to me if the mutation point (I think I'd rather use the terms 'change point' or 'turning point') was discussed initially and then

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follow with a discussion of trends.

Response: I am sorry for the incorrect expression of “mutation point” and negligence of the change points. We have listed Table 1 reporting change points (tested by Cramer’s test) for each variable. We added this table in the Supplementary material.

Table 1. Change points of climatic variables in Qinhuai River Basin during 1961-2012

Spring Summer Autumn Winter Growing season Annual Rs (MJ m⁻² d⁻¹) 1994 1984
 1985 1993 1985 1987 WS (m s⁻¹) 1993 1993* 1993* 1993* 1993* 1993* RH (%) 1986
 1984* 1985* - 1987* 1987* AH (g m3) 1983 1984 - 1983 - 1983 VPD (kpa) 1984 1987*
 1986* 1986 1987* 1987* Tmean (°C) 1986* 1986* 1986* 1986 1986* 1986* Tmax (°C)
 1986* 1986* 1979* 1986 1986* 1986* Tmin (°C) 1986* 1986* 1986* 1980* 1986* 1986*

Ls 364,365: Delete the sentence beginning "However". Because of the different periods examined, this sentence has little merit.

Response: Done.

L418-421: This has not been discussed before. Delete. It is not a conclusion.

Response: Done

Table 1: Please replace all “-“ with the values of the trend. Although not statistically significant together they will provide a more complete picture of the trends.

Response: We have added the values of insignificant trends in Table 2.

Table 2. Trends of key meteorological variables in Qinhuai River Basin during 1961–1987 and 1988–2012 Periods Variables Spring Summer Autumn Winter Growing season Annual 1961–1987 Rs (MJ Å um–2 Å ud–1) 0.013 –0.061* 0.007 -0.021 -0.031 -0.027* WS (m Å us–1) -0.031*** –0.014* -0.032*** -0.034*** –0.025*** -0.027*** RH (%) -0.103 0.104* 0.035 -0.03 0.071 0.033 AH (g m3) -0.012 -0.029 -0.012 -0.008 -0.013 -0.013 VPD (kpa) 0.001

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-0.005^{**} -0.001 0.001 -0.003 -0.002 Tmean ($^{\circ}\text{C}$) -0.009 -0.043^{*} -0.01 -0.003 -0.015
 -0.013 Tmax ($^{\circ}\text{C}$) -0.02 -0.054^{**} -0.017 -0.018 -0.026^{+} -0.029^{+} Tmin ($^{\circ}\text{C}$) -0.007
 -0.029^{*} -0.005 -0.007 -0.018 -0.011 1988– 2012 Rs (MJ m $^{-2}$ d $^{-1}$) 0.048^{+} -0.073^{+}
 -0.051^{*} -0.02 -0.049^{+} -0.018 WS (m s $^{-1}$) 0.002 0.001 0.002 0.004 -0.001 0.002 RH
 $(\%)$ -0.52^{***} -0.31^{***} -0.20^{*} -0.28^{***} -0.33^{***} -0.38^{***} AH (g m $^{-3}$) -0.026 -0.046^{*}
 -0.006 -0.024^{+} -0.030^{+} -0.025 VPD (kpa) 0.014^{***} 0.014^{***} 0.007^{***} 0.003^{*} 0.013^{***}
 0.010^{***} Tmean ($^{\circ}\text{C}$) 0.079^{**} 0.038^{+} 0.058^{**} -0.014 0.045^{**} 0.039^{*} Tmax ($^{\circ}\text{C}$) 0.114^{**}
 0.037^{+} 0.03 -0.028 0.048^{**} 0.038^{+} Tmin ($^{\circ}\text{C}$) 0.056^{+} 0.045^{*} 0.084^{**} 0.001 0.055^{***}
 0.041^{*}

Figure 2d: Please plot with same scale on both axes.

Response: Done.

Fig. 2. Basic meteorological information in Qinhuai River basin during 1961–2012. Bars in the figures represent the average based on the six sites and the 52 years of data. (a) Reference evapotranspiration (ETo) and Precipitation (P); (b) Relative humidity (RH) and Absolute humidity (AH); (c) Vapor pressure deficit (VPD) and Mean temperature (Tmean); and (d) Maximum temperature (Tmax) and Minimum temperature (Tmin).

Add to Figure 2 caption before (a): ‘Bars in the figures represent the average based on the six sites and the 52 years of data.’

Response: We have revised.

Caption to Figure 5: Replace “1987” with ‘2012’. And delete from “and 1988-2012 . . . (Tmin)”

Response: We have revised

Technical correctionsiijŽ L25: simply → simplifies

Response: Modified

C7

L44: I suggest the authors do not use emotive terms like “dramatic”. They are unnecessary

Response: We deleted the word “dramatic”, as well as the words like “extremely, obvious . . .”

L52: Add ‘a’ between “provided” and “summary”

Response: Modified

L57: Suggest rephrase to ‘. . . and effective use of water resources in irrigation. . .’

Response: Modified

L65: has increased → increasing

Response: Modified

L79: Suggest rephrase to ‘Our literature review suggests . . .’

Response: Modified

L81: Suggest rephrase to ‘and (iii) changes to ETo were affected not only by air temperature but . . .’

Response: Modified

L97: Suggest rephrase to ‘Based on previous studies of ETo in humid regions, . . .’

Response: Modified

Ls118-119: Suggest rephrase to ‘Accordingly, data for six periods were analysed: the four seasons, the annual period and the rice growing period.’

Response: Modified

L127: “Vapor pressure deficit” → ‘vapor pressure deficit (VPD)’

Response: Modified

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Ls173-174: Suggest rephrase to 'This method comprises three steps: (i) removing for each variable the trend to render the variable stationary, . . .'

Response: Modified.

L176: Suggest rephrase to ' . . . in ETo can be quantified by evaluating. . .'

Response: Modified.

L179: Characterize → is

Response: Modified

L179: "n" Would it not be better to use another letter here as 'n' is defined earlier as the number of sunshine hours?

Response: Modified

L181: More appropriately "R = 0" should be replaced by 'R \approx 0'

Response: Done

L182: lead → leads 210

Response: Done

L188: "Table 2" should be 'Table 1'

Response: Modified

L191: Suggest replace "which was similar to" with 'noted also by'

Response: Modified

L202: Slops → Slopes

Response: Modified

L214: Suggest rephrase to 'Variations in RH . . .'

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Response: Modified

L215: State which decades

Response: we have stated in paper "in the past three decades"

L223,224: I don't understand the sentence beginning "ETo of..". Please rephrase.

Response: The sentence has been revised as "The multi-year average ETo in 1961–1987 and 1988–2012 were both close to 1000mm, 70% of which occurred in the growing season."

L226: Would it be correct to say 'In each of the four seasons, the mean values . . .'

Response: Modified

Ls234-235: This maybe better expressed as 'The daily detrended values were aggregated to yield detrended seasonal and annual detrended values.'

Response: Modified

L235: Delete full stop after "Figure" and delete "obvious". This adjective is not necessary.

Response: Modified

L236: Suggest rephrase to ". . .detrended variables at the annual time step"

Response: Modified

L238: drtended → detrended

Response: Modified

L243: Suggest rephrase to 'It is noted that . . .'

Response: Modified

L251: Replace "between annual original ETo and recalculated" with 'between the orig-

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inal annual ETo and the recalculated annual ETo. . .

Response: Modified

L254: Delete “phenomenon”.

Response: Modified

L257: Delete “Obviously,”.

Response: Modified

L260: Replace “on the” with ‘at the’.

Response: Modified

L265: Delete “only” and replace “and then” with ‘which were’

Response: Modified

L272: On → At

Response: Modified

L277: Replace “In” with ‘ During the’

Response: Modified

L287: Add ‘in the growing’. Response: Modified

L294: phenomenon → feature

Response: Modified

L295: Delete “the”

Response: Modified

L301: Rephrase ‘We found significant decreases in RH...’.

Response: Modified

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L304: evapotranspiration → evaporation (One cannot have ET from an ocean as there is no vegetation.)

Response: I am sorry for the negligence. We have modified.

L304: Rephrase “limited the evapotranspiration” with ‘reduce relatively the evaporation’.

Response: Modified

L304,305: Rephrase “from oceans eventually” with ‘from the oceans’.

Response: Modified

L306: was corresponding → corresponded

Response: Modified

L308: increase → increases

Response: Modified

L309: replace ” cement surface” with ‘hard surfaces’

Response: Modified

L310: city → cities.

Response: Modified

L314: Delete “tendency”.

Response: Modified

L315: Replace “It is unclear about the causes of AH variation” with ‘The causes of the AH variation are unclear’.

Response: Modified

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L318: Replace “globally (Matsoukas et al., 2011). Matsoukas et al. (2011) suggested that the global” with ‘globally by Matsoukas et al. (2011). They suggest that global . . .’

Response: Modified

L320: Replace “of” with ‘in’.

Response: Modified

L321: I assume Platte River Basin is in USA. Please say so.

Response: Modified

L322: Add ‘strongly’ after “correlated” and delete “to a great extent”. Also add a reference supporting the Platte River increased VPD.

Response: We have revised the sentence below this suggestion. We also added a reference (Irmak, S., Kabenge, I., Skaggs, K. E., and Mutiibwa, D.: Trend and magnitude of changes in climate variables and reference evapotranspiration over 116-yr period in the Platte River Basin, central Nebraska–USA, *J. Hydrol.*, 420–421, 228–244, doi:10.1016/j.jhydrol.2011.12.006, 2012.) To support the increased VPD in Platte River Basin, central Nebraska – USA.

L323: Add after “was” ‘found to be ‘

Response: Modified

L323: on → in

Response: Modified

L323,324: Replace “1988-2012 and attributed to these reasons” with ‘1988- 2012. The is attributed to two reasons:’

Response: Modified

L325: Delete “in QRB”.

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Response: Modified

L326: Add after “that” ‘there was an’ and replace “were found in vast majority” with ‘during most’.

Response: Modified

L333: Add ‘and to’ before “vast”

Response: Modified

L338: Add ‘the’ before “annual”

Response: Modified

L339: Replace “at” with ‘for the’

Response: Modified

L353: Replace “Different from these literatures” with ‘In contrast’

Response: Modified

L354: Rephrase as follows ‘driven not only by air’

Response: Modified

L354: Add ‘by “ before “other” Response: Modified

L355: Replace “periods. During 1961–1987,” with ‘periods, 1961-1987 and 1988-2012. During the first period, decreased. . .’

Response: Modified

L359: After “same” add ‘result’

Response: Modified

L363: Replace “with the” with ‘for a’

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Response: Modified

L367: Replace “another word” with ‘other words’

Response: Modified

L368: was → is

Response: Modified

L371: Replace “S” with ‘s’

Response: Modified

L375: Delete “water shed”

Response: Modified

L377: Delete “during the recent 30 years”

Response: Modified

L381: Delete “new”

Response: Modified

L391,392: Replace “to water vapor and” with ‘and hence’

Response: Modified

L392: Delete “has”

Response: Modified

L394: increase → rise

Response: Modified

L395: delete “then”

Response: Modified

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L396: influence → influences

Response: Modified

Please also note the supplement to this comment:

<https://www.hydrol-earth-syst-sci-discuss.net/hess-2017-241/hess-2017-241-AC1-supplement.pdf>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2017-241>, 2017.

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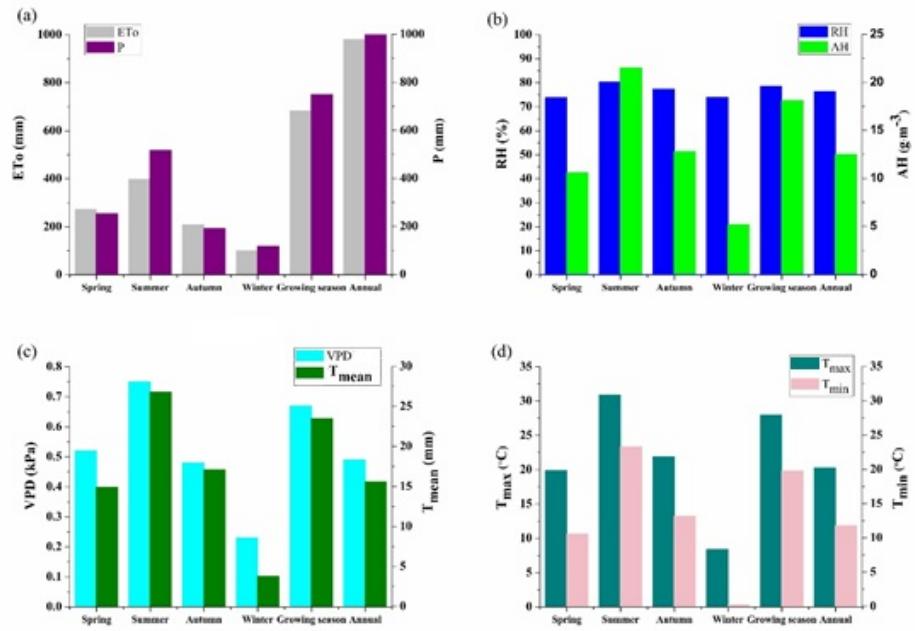


Fig. 1. Fig. 2. Basic meteorological information in Qinhuai River basin during 1961–2012.