

Reply to Referee 3#

We sincerely appreciate your efforts to review our manuscript and give us the constructive suggestions. The following is the answer one by one:

General comments:

This study presents BEPS model simulations of evapotranspiration (ET) and water yield over terrestrial ecosystems of China between 2000 and 2010. The BEPS model is a remote sensing based model or approach for quantifying the terrestrial water and carbon cycles. This study is significant since ET is important for understanding water and carbon cycles of terrestrial ecosystems. The authors used eddy covariance ET estimates from 5 China Flux towers to validate the BEPS model simulations and compared the BEPS model simulations with ET inferred using statistical hydrological data in 10 basins across China. In addition the authors attempted to address the spatial and temporal variations of ET and water yield in China's terrestrial ecosystems and evaluated the roles of temperature, precipitation, and LAI in regulating ET. Overall I found the study was important and I commend the effort shown by the authors' in analyzing huge data sets in this study.

However, the study does not provide new information on the spatial and temporal variations of ET and water yield except for the finer spatial resolution (500 m). The authors reported that the results from this study are comparable to other studies but they did not show what is new and what improvements were made to the previous studies to increase our understanding of ET and water yield in China.

Answer: Thanks for the efforts to review our manuscript and provide constructive comments. We will seriously revise the manuscript with the consideration of the comments.

I have the following suggestions for the authors:

1. The paper needs editing, proof reading, and check all typographical errors. The grammar needs to be improved, some sections are not easy to read and follow. Specific comments are listed in the supplement file attached.

Answer: We will carefully edit the manuscript to remove typographical and grammar errors and rewrite some sections following the comments.

2. Include other international and local references related to this study. For example (Li, X., Liang, S., Yuan, W., Yu, G., Cheng, X., Chen, Y., Zhao, T., Feng, J., Ma, Z., Ma, M., Liu, S., Chen, J., Shao, C., Li, S., Zhang, X., Zhang, Z., Sun, G., Chen, S., Ohta, T. Varlagin, A., Miyata, A., Takagi, K., Saiqusa, N. and Kato, T. (2012), Estimation of evapotranspiration over the terrestrial ecosystems in China. *Ecohydrol.* doi: 10.1002/eco.1341)

Answer: This is a good suggestion. Recently, many papers related to regional and global ET have been published, such as [Li et al. \(2012\)](#) and [Yao et al. \(2013\)](#). We cite these papers as references and compare the similarity and difference between this study and their study in the current version of the manuscript in [Lines 18-25, P13, Lines 24-26, P14](#) and [Lines 30-31, P14](#).

3. The ET inferred from statistical hydrological data in 10 basins (section 3.1.2) cannot be used for BEPS model validation. This is model inter-comparison not validation. For some regions precipitation is interpolated and irrigation is not included in the BEPS model. This section brings a lot of uncertainties and is one of the drawbacks in this study.

Answer: The validation of simulated regional ET is a challenge. Many previous studies, such as [Zhang et al. \(2009\)](#), [Vinukollu et al. \(2011\)](#), and [Liu et al. \(2008;2012a\)](#), used the ET estimated

using the water balance method to validate simulated ET at the watershed scale. In the previous version of this manuscript, we used the ET estimated using the water balance method to validate modelled ET in 10 major basins in China. As pointed by the reviewer, ET estimated using this method contains some uncertainties related to the sizes of basins and the assumption that the annual change of soil water storage is zero. Following the suggestions from the first and third reviewers, we removed this content in the current version of the manuscript.

4. The spatial patterns of simulated annual ET (page 5415), the authors stated that “the mean of ET in the terrestrial ecosystems of China simulated in this study is somewhat lower than the global value due to the vast semiarid and arid regions in northwestern and northern China and the vast frigid Tibetan Plateau, in which ET is very low”. It is not clear whether these areas were included in the previous studies or not? This needs to be clarified.

Answer: This is a good suggestion. We clarified the confusion in [Lines 27-28, P 12](#), in the current version of the manuscript.

All these areas were included in previous studies. We only to express the ET level of China during the 2000-2010 were lower than global averages. In the revision we delete “due to the vast semiarid and arid regions in northwestern and northern China and the 20 vast frigid Tibetan Plateau, in which ET is very low” to avoid ambiguity .

5. On the influence of land cover change on ET (page 5423), it is not clear whether the national total ET of cropland increased or decreased. The authors have to rewrite the section and clearly state a decrease or increase in the national cropland ET in China.

Answer: It was mentioned that “The national total ET of cropland increased at the rate of $2.83 \text{ km}^3 \text{ yr}^{-2}$ ” in the discussion version in [Lines 25-26, P 5423](#). This confusion was clarified in [Lines 40, Page 17](#) in the current version of the manuscript.

Specific comments are listed in the supplement file attached.

Answer: Honestly thanks again for revising our manuscript. All specific comments listed the supplement file will be carefully revised.

The response to the specific comments is in the supplement.

(1) P5397 change the title “from 2000 to 2010” to “during the period 2000-2010”

Answer: This change was made in the current version of the manuscript in [Lines 1-2, P 1](#).

(2) P5399, Line 9, what other spatial dataset?

Answer: “MODIS landcover data, meteorological data and soil data” was added in the current version of the manuscript in [Lines 8-9, P 2](#).

(3) P5399, Line 13, “measured at 5 ChinaFLUX sites”

Answer: “typical” was deleted in the current version of the manuscript in [Line 13, P 2](#).

(4) P5399, Line 24, it is better to us r2

Answer: R2 was used in the current version of the manuscript in [Line 22, P 2](#).

(5) P5399, Line 26-28, “The temporal patterns of ET varied spatially during the 11 years study period, increasing in 62.2% of China’s landmass, especially in the cropland areas of southern Haihe river basin, most of the Huaihe river basin, and southeastern Yangtze river basin.” very long sentence...not easy to follow.

Answer: Thanks for the comments. We rewrote the abstract to highlight the new findings in this study in the current version of the manuscript.

(6) P5400, Line 5, change “of” to “in”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 29, P 2](#).

(9) P5400, Line 8, change “vegetations” to “vegetation”.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 32, P 2](#).

(10) P5400, Line 8, affected or influenced?? not clear?

Answer: It was changed to “This study shows that the terrestrial water cycles in China’s terrestrial ecosystems appeared to have been intensified by recent climatic variability and human activity induced vegetation changes” in [Lines 30-32, P 2](#).

(11) P5400, Line 23, change “further warming will further” to “Global warming will further”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 12, P 3](#).

(12) P5400, Line 24, change “Accurately estimating the spatial and temporal variations of ET is critical” to “Accurate estimation of the spatial and temporal variations in ET is critical”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 12, P 3](#).

(13) P5401, Line 2, change “the heterogeneity of the landscape and ” to “land surface heterogeneity”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 17-18, P 3](#).

(14) P5401, Line 6, change “eddy covariance technique” to “eddy covariance, and scintillometers”.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 20-21, P 3](#).

(15) P5401, Line 9, delete “fortunately”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 24, P 3](#).

(16) P5401, Line 23, there are other better references on the estimation of ET using remote sensing. e.g. Courault et al. 2005; Verstaeten et al., 2007; Gowda et al., 2007, e.t.c....

Answer: We thank the referee for this valuable comment. We add these **references** in [Line 31, P 3](#).

(17) P5402, Line 10, change “global” to “earth”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 9, P 4](#).

(18) P5402, Line 18, change “have” to “has”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 16, P 4](#).

(19) P5402, Line 24, change “during the period from 2000 to 2010” to “during the period 2000-2010”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 21, P 4](#).

(20) P5402, Line 24, change “(FAO, 2010) (Piao et al., 2012)” to “(FAO, 2010; Piao et al., 2012).”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 21, P 4](#).

(21) P5402, Line 25, change “dramatically” to “intensively”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 22, P 4](#).

(22) P5402, Line 26, change “changes” to “change”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 23, P 4](#).

(23) P5402, Line 28, change “spatial-temporal” to “spatio-temporal”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 25, P 4](#).

(24) P5403, Line 3, change “most of national ET” to “most of the national ET”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 28-29, P 4](#).

(25) P5403, Line 4-5, change “data. In addition, the changes of 5 water yield in the terrestrial ecosystems of China have been less studied.” to “In addition, there are very few studies on the changes of water yield in the terrestrial ecosystems of China.”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 30-31, P 4](#).

(26) P5403, Lines 10-15, change “employed” to “used”, change “during the period from 2000 to 2010” to “during the period 2000 - 2010”

Answer: Following reviewer’s comments, unique contribution of this study should be added into the manuscript, therefore, this part was changed to “In this study, to constrain the uncertainties, daily ET and water yield were simulated at a spatial resolution of 500 m with improved leaf area index (LAI) and the well calibrated and validated process-based BEPS (Boreal Ecosystem Productivity Simulator) model. Then, the spatial and temporal variations of ET and water yield in different regions of China during the period 2000-2010 were analyzed.” in [Lines 35-39, P 4](#).

(27) P5404, Line 13, change “global” to “globe”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 26, P 5](#).

(28) P5405, Line 5, in equation, there is gamma not r.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 8, P 6](#).

(29) P5405, Line 21, change “photosynthetically active radiation” to “Photosynthetic photon flux density”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 24, P 6](#).

(30) P5408, Line 7, change “type” to “map”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 8, P 8](#).

(31) P5409, Line 20, change “minimum temperatures” to “minimum air temperatures”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 7, P 9](#).

(32) P5410, Lines 18-19, “basin-level ET inferred from statistical precipitation and run off data in 10 basins across China” can not be used as model validation.

Answer: Following this comment and other reviewer’s suggestions, “2.3.2 ET inferred from statistical hydrological data in 10 basins” was deleted and “basin-level annual ET was calculated as the residual of precipitation minus runoff (named as inferred basin-level ET hereafter)” was also deleted.

(33) P5410, Line 20, What type of EC technique? direct with open path or closed path analysers? what was the frequency of measurements? This section needs details of the EC flux measurements....

Answer: According to this comment, the following was added to the manuscript in this current version in [Line 36, P9 and Lines 1-4, P 10](#): “The EC systems consisted of open-path infrared gas analyzers (Model LI-7500, LICOR Inc., Lincoln, NE, USA) and 3-D sonic anemometers (Model CSAT3, Campbell Scientific Inc., Logan, UT, USA). The signals of the instruments were recorded at 10 Hz by CR5000 datalogger (Model CR5000, Campbell Scientific Inc.) and then block-averaged over 30-min intervals for analyses and archiving.”

(34) P5410, Line 21, delete “typical”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 27, P 10](#).

(35) P5411, Line 4, this is not validation, this is model comparison.

Answer: Following this comment and other reviewer’s suggestions, this part was deleted in the current version of the manuscript.

(36) P5411, Lines 15-16, why is the annual change in storage within a basin negligible?

Answer: [Liu et al. \(2008\)](#) pointed out that water yield is the total water budget of an ecosystem and river basin, and it can be used as an index representing the over-all water availability for use by human and others. In this study, the annual water yield refers to the remaining precipitated water after loss through ET, so we use “PPT minus ET” to represent water yield.

(37) P5411, Lines 17-18, This needs validation because ET is estimated as the difference between precipitation and runoff, ignoring the storage term..

Answer: Following this comment and other reviewer’s suggestions, this part was deleted in the current version of the manuscript.

(38) P5412, Line 19, change “at 5 sites” to “at the 5 sites”

Answer: Following this comment, corresponding changes were made in the current version of the

manuscript in [Line 27, P 10](#).

(39) P5412, Line 20, “about 66%” means $R^2=0.66$

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 15, P 11](#).

(40) P5413, Line 3, “3.1.2 Validation of simulated basin-level annual ET” Model inter-comparison.

Answer: Following this comment and other reviewer’s suggestions, “3.1.2 Validation of simulated basin-level annual ET” was deleted.

(41) P5415, Lines 17-20, used. “Therefore, it can be concluded that the mean of ET in the terrestrial ecosystems of China simulated in this study is somewhat lower than the global value due to the vast semiarid and arid regions in northwestern and northern China and the 20 vast frigid Tibetan Plateau, in which ET is very low (Fig. 6a)” were these areas included in the previous studies?? if yes then there should other reasons for the differences....

Answer: This is a good suggestion. All these areas were included in previous studies. We only to express the ET level of China during the 2000-2010 were lower than global averages. In the revision we delete “due to the vast semiarid and arid regions in northwestern and northern China and the vast frigid Tibetan Plateau, in which ET is very low” to avoid ambiguity. We clarified the confusion in [Lines 27-28, P 12](#), in the current version of the manuscript.

(42) P5415, Lines 21, “The total of ET” should change to “The total ET”.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 29, P 12](#).

(43) P 5416, Lines 2-3, “Water yield is calculated as the difference between annual precipitation and ET (M. L. Liu et al., 2012)” should move to the methodology section and put some details on how it was estimated....

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 11-12, P 10](#).

(44) P5416, Line 14, delete “of”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 8, P 13](#).

(45) P5416, Lines 26-27, what is new in this study?

Answer: In this study it was pointed out that “The change of simulated ET with land cover types in China identified here is generally consistent with previous studies” in [Lines 26-27, P 5416](#) in the discussion version. However, the higher spatial resolution of ET was simulated to decrease the uncertainty at regional scale in this study.

(46) P5417, Lines 12-19, “ mmyr^{-2} ” should change to “ mmyr^{-1} ”

Answer: In this study “ mm yr^{-2} ” means the increasing rates, so it was not changed in the current version of the manuscript.

(47) P5418, Line 19, “ mmyr^{-2} ” should change to “ mmyr^{-1} ”

Answer: In this study “ mm yr^{-2} ” means the increasing rates, so it was not changed in the current version of the manuscript.

(48) P5418, Line 22, “obvious” should be deleted.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 29, P 14](#).

(49) P5419, Lines 1-7, “mm yr⁻²” should change to “mmyr⁻¹”.

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript

(50) P5419, Lines 15-23, Include also other international references...

Answer: The reference of [Seneviratne et al. \(2010\)](#) was added in the current version of the manuscript in [Line 16, P 15](#).

(51) P5419, Line 25, “yr” should be changed to “years”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 21, P 15](#).

(52) P5420, Line 5, “shows” should be changed to “show”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 9, P 16](#).

(53) P5420, Lines 10 and 23, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(54) P5421, Lines 9-25, what is new in this study? Spatial resolution of 500 m?

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 30-33, P16](#).

(55) P5422, Lines 3-9, this section (3.5.1 Changes of ET with LAI) needs more discussion. not explained well....

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 36-37, P 16 and Lines 1-4, P 17](#).

(56) P5422, Lines 14, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(57) P5422, Lines 20, what caused the decrease in LAI? is it land use change?

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 37, P 16 and Lines 1-2, P 17](#).

(58) P5423, Lines 15, 19, 22, 25 and 26, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(59) P5423, Lines 28, Not clear whether the national total ET of cropland increased or decreased?

Answer: It was mentioned that “The national total ET of cropland increased at the rate of 2.83 km³ yr⁻²” in [Lines 25-26, P 5423](#), which was in [Line 40, P 18](#) in the current version of the manuscript.

(60) P5424, Lines 2 and 9, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(61) P5424, Line 11, delete obviously

Answer: Following this comment, corresponding changes were made in the current version of the manuscript.

(62) P5424, Line 21, don't put initials in text....delete Q.

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Line 20, P 18](#).

(63) P5424, Line 27, see previous comments...

Answer: Following this comment, “and basin-level ET inferred using statistical hydrological data in 10 major river basins” was deleted.

(64) P5425, Line 3, “Following conclusions could be drawn:” should be changed to “the following conclusions can be drawn:”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [Lines 28-29, P 18](#).

(65) P5425, Line 3, change “The BEPS model could explain the 92% variations of inferred basin-level ET in 10 river basins (p < 0.0001).” to “The BEPS model could explain the 92% variations of inferred basin-level ET in 10 river basins (p < 0.0001).”

Answer: Following this comment, “The BEPS model could explain the 92% variations of inferred basin-level ET in 10 river basins (p < 0.0001).” was deleted.

(66) P5425, Line 22, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(67) P5426, Lines 2 and 7, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(68) P5426, Lines 11, change “or/and” to “and/or”

Answer: Following this comment, corresponding changes were made in the current version in [Line 32, P 19](#).

(69) P5439, in Table 1, “the information” changes to “information”, include the type of Ec sensors e.g. type of sonic, IRGA, e.t.c...

Answer: Following this comment, corresponding changes were made in the current version in [Table 2 P 31](#), which was added to the manuscript in this current version in [Lines 1-4, P 10](#): “The EC systems consisted of open-path infrared gas analyzers (Model LI-7500, LICOR Inc., Lincoln, NE, USA) and 3-D sonic anemometers (Model CSAT3, Campbell Scientific Inc., Logan, UT, USA). The signals of the instruments were recorded at 10 Hz by CR5000 datalogger (Model CR5000, Campbell Scientific Inc.) and then block-averaged over 30-min intervals for analyses and archiving.”

(70) P5440, in Table 2, change “at 5 tower sites” to “at the 5 tower sites”

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [P 31](#).

(71) P5441, in Table 3, “mmyr⁻²” should change to “mmyr⁻¹”

Answer: In this study “mm yr⁻²” means the increasing rates, so it was not changed in the current version of the manuscript.

(72) P5442, The land cover map of China in 2001 could be changed to any recent map?

Answer: Following this comment, the land cover map of China in 2001 had been changed to map of 2010 in P 34.

(73) P5443, in Figure 2, No flux towers for North west China and sparse Meteorological stations. This is the source of uncertainties in NWRB..

Answer: We have tried to get flux observations in NWRB, but it was too difficult for us to obtain the flux data due to the limited flux observation sites. Therefore, there was no model validation conducted in NWRB. We have mentioned the disadvantage in [Lines 25-32, P 19](#).

(74) P5444, in Figure 3, there is big difference between the observed and simulated

Answer: There was big difference between the observed and simulated ET in YC cropland site. The underestimation of simulated ET mainly occurred in the period from the jointing stage to blossoming stage of winter wheat. It was mainly caused by the inversed LAI used to drive the BEPS model. For example, the inversed LAI ranges from 2 to 4 while the LAI measured at flux tower ranged from 4.2 to 7.5 in the period from the jointing stage to blossoming stage of winter wheat in 2004. When the measured LAI was used to drive the BEPS model, the underestimation of simulated ET will be removed. The disagreement between inversed and measured LAI was possibly caused by the scale effect and heterogeneity of land cover in the growing season of winter wheat. The spatial resolution of LAI data used was at a spatial resolution of 500 m while the footprint of the flux tower at this site is normally just 190 m ([Mi et al., 2006](#)). The 500 m pixel is a mixture of winter wheat, roads, bare soil. Consequently, inversed LAI will be lower than the value measured close to the tower, which will definitely cause simulated ET to be lower than measured values. Corresponding changes were made in the current version of the manuscript in [Lines 8-14, P 11](#).

(75) P5444, in Figure 3, delete (.)

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [P 35](#).

(76) P5445, in Figure 4, p<0.01 significant...

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [P 35](#).

(77) P5446, in Fig.5, it is a comparison, this is right...change previous sections to comparison like this...

Answer: Following the suggestions of reviewers, the Figure was deleted.

(78) P5452, in Fig.11, use r² not r and p> 0.01. is this statistical significant? what is the use of presenting r an p values in this graph?

Answer: Following this comment, corresponding changes were made in the current version of the manuscript in [P 39](#).

Reference:

Li, X., Liang, S., Yuan, W., Yu, G., Cheng, X., Chen, Y., Zhao, T., Feng, J., Ma, Z., Ma, M., Liu, S., Chen, J., Shao, C., Li, S., Zhang, X., Zhang, Z., Sun, G., Chen, S., Ohta, T., Varlagin, A., Miyata, A., Takagi, K., Saiqusa, N., and Kato, T.: Estimation of evapotranspiration over the terrestrial ecosystems in China,

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Chen, J. M., Liu, J., Cihlar, J., and Goulden, M. L.: Daily canopy photosynthesis model through temporal and spatial scaling for remote sensing applications, *Ecol. Model.*, 124, 99-119, 1999.

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