Response to Referee #3

By Sun S. et al.

Major Comments:

This work done by Sun et al. is trying to assess the potential impact of future climate change on water and carbon balance over the entire continental US by using dynamic downscaled climate data and process-based watershed scale ecohydrological model. The writing and data analysis are sound while it's hard to find novelties from this study. The authors talked about the impacts of future climate change on both ET and GPP but didn't discuss the linkage and interactions between these two fluxes.

Response: The linkage between water and carbon is through the Water Use Efficiency term. For the WaSSI model, GPP is expressed as ET multiplied by the water use efficiency parameters that vary by land cover type, i.e., GPP=a×ET.

Here, a represents the water use efficiency parameters (Table 1), which were derived from measured site-level water and carbon fluxes for a variety of land cover types monitored by the FLUXNET system of eddy-covariance flux towers (Sun et al., 2011). The related description can also be found in the manuscript, i.e., "The ecosystem productivity module computes carbon dynamics (GPP and respiration) using linear relationships between ET and GPP derived from global eddy covariance flux measurements (Sun et al., 2011a, 2011b).".

Table 1. Model parameters for estimating GPP as a function of ET (Sun et al., 2011)

Land cover	*a*	Land cover	*a*
Crop	3.13	Shrubland	1.35
Deciduous forest	3.20	Wetland	2.74
Evergreen forest	2.46	Open water (US only)	/
Mixed forest	2.74	Urban (US only)	1.35
Grassland	2.12	Barren (US only)	1.35

Thus, a linear relationship between GPP and ET is used in the WaSSI model for estimating ecosystem productivity. As discussed in our manuscript, the assumption of a constant WUE would introduce some uncertainties into our results, because of climate-induced changes in the water use efficiency parameters (Miller-Rushing et al., 2009; de Kauwe et al., 2013; Zhang et al., 2014; Liu et al., 2015). With regard to these uncertainties, we have showed the related discussions in the section of "4.1 Uncertainties". Please see the revision version.

Reference:

Sun, G., Caldwell, P., Noormets, A., Cohen, E., McNulty, S., Treasure, E., Domec, J. C., Mu, Q., Xiao, J., John, R., Chen, J., 2011. Upscaling key ecosystem functions across the conterminous United States by a water-centric ecosystem model. *Journal of Geophysical Research*, 116(G00J05), doi:10.1029/2010JG001573.

Liu, Y., Xiao, J., Ju, W., Zhou, Y., Wang, S., Wu, X., 2015. Water use efficiency of China's terrestrial ecosystems and responses to drought. *Scientific Report*, doi:10.1038/srep13799. (online)

Zhang, F., Ju, W., Shen, S., Wang, S., Yu, G., Han S., 2014. How recent climate change influences water use efficiency in East Asia. *Theoretical and Applied Climatology*, 116(1-

2):359-370

Miller-Rushing, A. J., Primack, R. B., Templer, P. H., Rathbone, S., Mukunda, S., 2009. Long-term relationships among atmospheric CO_2, stomata, and intrinsic water use efficiency in individual trees. *American Journal of Botany*, 96(10):1779-1786.

de Kauwe, M. G., Medlyn, B. E., Zaehle, S., A. P.. Walker, M. C., Dietze, T., Hickler, JAIN, A. K., Luo, Y., Parton, W. J, Prentice, I. C., Smith, B., Thornton, P. E., Wang, S., Wang, Y. –P., Warlind D., Weng, E., Crous, K. Y., Ellsworth, D. S., Hanson, P. J., Kim, H. –S., Warren, J. M., Oren, R., Norby, R. J., 2013. Forest water use and water use efficiency at elevated CO_2: a model-data intercomparison at two contrasting temperate forest FACE sites. *Global Change Biology*, 19:1759-1779.

This study seems not filling gaps the authors mentioned in the instruction. For example, the author listed two major research gaps. As to the first gap (i.e. few studies assess impacts of future climate change on water and carbon balances at watershed scale), the authors mentioned that "key hydrological processes (e.g., lateral surface and subsurface flows among grid boxes) embedded in LSMs have not been considered", did this study considers these processes?

Response: Here, we would like to emphasize that the water budget for each LSMs grid box is unbalanced, because of the grid box mismatching with the natural watershed. Therefore, the key hydrological processes (e.g., lateral surface and subsurface flows) should be considered among the grid boxes of the LSMs. However, in practice, these processes are scarcely coupled by most of the LSMs, consequently introducing some uncertainties for estimating the hydrological variables (e.g., ET and water yield). For the WaSSI model, ET and water yield are calculated at natural watershed scale (i.e., 12-digit HUC watershed), and the flow is routed from one watershed to the adjacent one, and a full water budget is counted. At the HUC12 watershed scale, WaSSI considers overland flow, subsurface flow, and baseflow. All the flow components are modeled based on soil water balances. We will clarify these points in the revision.

As to the second gap (i.e. "future climate projections have high uncertainty"), the authors argued that "the statistical downscaling methods ... could introduce uncertainties into the crucial land surface variables", while they didn't discuss the advantage or new message come from this study by using WRF dynamically downscaled climate data, which I thought could be the uniqueness of this activity.

Response: We would like to clarify that a downscaling method with considerations of atmospheric dynamical processes is used in this study. We intend to remove this sentence and reformatted the description of the second gap in the revision.

Through reviewing the previous studies, we have identified two major gaps that can introduce some uncertainties for assessing the future climate change impacts. For reducing these uncertainties, we have linked the process-based watershed scale ecohydrological model (i.e., the WaSSI model) with the dynamically downscaled climate data by the WRF model to assess the potential impact of future climate change. The overall goal of this study was to resolve these two gaps. We appreciate the referee's suggestion that is a very good research topic. Future studies should examine the effects of downscaling methods on quantifying changes in future hydrological and ecosystem fluxes.