Author's response letter for "Sensitivity of future Continental United States water deficit projections to General Circulation Model, evapotranspiration estimation method, and greenhouse gas emission scenario" by S. Chang et al.

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We appreciate the thoughtful comments from the reviewers, which have helped us to improve the original manuscript. We explain in detail how we responded to each of the reviewer's comments, with line numbers referring to the revised manuscript unless otherwise noted. We changed our title to "**Sensitivity of future Continental United States water deficit projections to General Circulation Model, evapotranspiration estimation method, and greenhouse gas emission scenario**" in response to reviewers comment. In addition, we upload revised manuscript and responses to reviewers as our supplemental material.

Referee # 2

Index		Comments
1	Referee review	Before using the GCMs output to force hydrological model (even estimate RET), the some forms of prior bias correction are always conducted due that GCM often show strong bias over historic period (Wood et al., 2002; 2004). I can only believe the authors use the raw data causing I did not find any information associated with the bias correction description in the paper. So how about the matching degree between the GCM-simulated variables and historical observation? And whether some bias correction jobs should be done before employing these GCMs output.
	Author's response	We added an explanation in the methods section regarding why we focused on the sensitivity of changes in raw GCM predictions rather than changes in bias-corrected GCM predictions. "*Because GCM predictions are known to contain systematic biases (Hwang and Graham, 2013; Wood et al., 2002, 2004) we evaluated the sensitivity of the mean monthly <u>change</u> in raw climate predictions between retrospective and future periods to the choice of GCM, ET_0 estimation method and RCP trajectories. This is analogous to using the delta change GCM bias correction method that involves shifting the mean of a series of observed climate data by the mean difference in raw GCM output between the corresponding observed time period and the desired future period. Teutschbein and Seibert (2012) pointed out that all bias correction methods are based on the stationarity principle that assumes that similar biases occur in the retrospective and future predictions and thus the same bias-correction algorithm may be applied to both. Muerth et al. (2013) found that the impact of bias correction on the relative change of flow indicators between retrospective and future*

		periods was weak for most indicators, however Pierce et al. (2015) found that some bias correction methods altered model-projected changes in mean precipitation and temperature. LaFond et al. (2014) found that the delta change GCM bias correction method was more useful for simulating hydrologic extreme events than the quantile mapping bias correction method as it preserved daily climate variability better. In this study, we differenced raw rather than bias corrected GCM outputs in order to prevent spurious alteration of the climate change signal between retrospective and future GCMs that might be induced by the bias correction method"
2, 3	Referee review	GCM simulated temperature is commonly considered to have high confidence than other climatic variables such as vapor pressure and radiation (Randall et al., 2007). The differences of estimated ET between temperature-based ET equations and radiation based equations maybe due to the uncertain input data quality rather than the method selection as the authors declared. In fact, temperature-based equations have been considered not competent in RET change (e.g., Roderick et al., 2009) due that a steady increase in temperature over time will translate into a calculated steady increase in evapotranspiration. Generally, using combination equations maybe more suitable for projection future RET. However, as the above comment pointed out, the GCM-simulated temperature was also widely considered to have relatively high confidence in comparison with other meteorological variables. The different combinations between methods and data should be discussed (see some literatures, Kingston et al., 2009; Wang et al., 2015).
	Author's response	The main finding of our paper is that the choice of ET estimation method is as important as GCM selection and the effects of ET estimation method vary depending on region and season. We agree that the effects of the ET estimation method depend both on the physics represented in the method and the reliability of the parameters needed for the method. We revised the manuscript to make this point more clearly and included discussion of the references suggested above on P12: *"Kingston et al. (2009) recommended the use of different ET_0 equations to evaluate global ET_0, and Wang et al. (2015) found that although different methods predict similar future ET_0, there are important differences in uncertainties due to ET_0 estimation methods and input data reliability. Currently many hydrological models use a single evapotranspiration method for simulation, which may substantially increase the uncertainty and reduce the reliability of future projections. Our results strongly indicate that an ensemble of ET_0 estimation methods should be used to understand potential future water availability and water deficit due to climate change.*" Furthermore we added a paragraph in the discussion section and a new plot in the supplemental material (Fig. S-3). "*GCMs estimate some climate variables, such as temperature, with higher confidence than other variables (Randall et al., 2007). However, for some evapotranspiration estimation methods the effect*

		of temperature on evaporation is smaller than other climate variables (Linacre, 1994; Thom et al., 1981, Roderick et al., 2009a, 2009b). We found that temperature and net radiation from the CMIP5 GCMs show increasing trends over the 2005-2100 time period, while wind speed and surface pressure are relatively constant (Fig. S-3). Because we considered various ET_0 estimation methods our results include the impacts of the different physics represented in the ET_0 methods, the projected changes each of the climate variables contributing to the different ET_0 methods, and the reliability of the predictions of each variable.
4	Referee review	ET always mean actual evapotranspiration, it may be better use RET/ET0 to represent reference evapotranspiration.
	Author's response	We changed this for clarity and refer to reference evapotranspiration as ET_0 throughout the manuscript.
5,6	Referee review	It is better to divide the results into several sub-sections. Results should be presented as such and not mingled with explanations (analysis section), so please separate the results section and discussion section.
	Author's response	We divided the previous combined section into separate results and discussion sections.

Plot added to Supplementary Materials

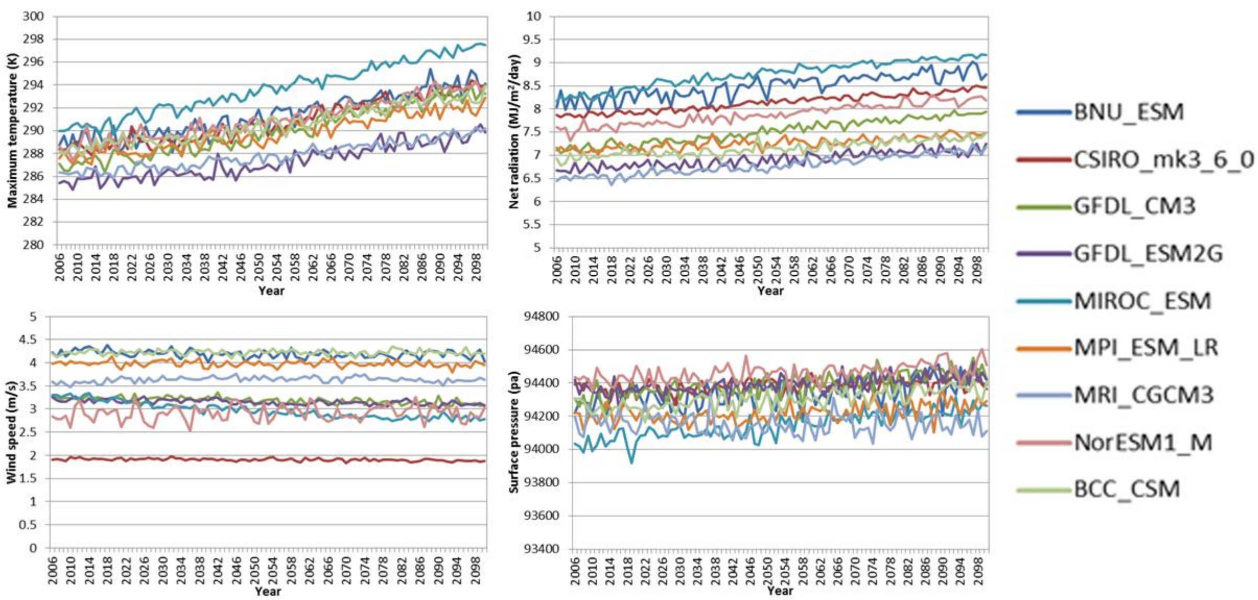

Fig. S-3 Projections of mean maximum temperature, net radiation, wind speed at 2 m surface, and surface pressure of CMIP5 from 2005 to 2010 for RCP 8.5.

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