RESPONSES TO REVIEWERS' COMMENTS

We are grateful to the reviewers and associate editor for their detailed and insightful comments. In light of the suggestions, we have made efforts to significantly revise the manuscript. The suggestions and comments have substantially contributed towards improving the paper. More details are as follows:

Interactive comment on "Modeling the Potential Impacts of Climate Change on the Hydrology of Selected Forested Wetlands in the Southeastern United States" by Jie Zhu et al.

Anonymous Referee #1

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GENERAL COMMENTS: This study uses a linear regression model to estimate future water table changes in five forest sites in Southeastern US. The topic is interesting. However, this study lacks of innovation in climate change impact assessment. Besides the simple regression model, there are critical issues/errors in the methodology (see major comments). Please find my detailed comments below.

RESPONSE: This study develops site-specific empirical hydrologic models for five representative forested wetlands with different characteristics by synthesizing long-term observed meteorological and hydrological data and coupling climate changes from 20 CGMs. These wetlands represent typical Cypress Ponds/Swamps, Carolina Bays, Pine Flatwoods, and Wet Pine, and natural Bottomland Hardwoods ecosystems, and cover a range of climatic/topographic gradients and different management conditions located in the SE US. This study provides quantitative information on the different potential magnitudes of wetland hydrological responses to future climate changes for adaptive management of typical forested wetlands in the southern U.S. Based on the Reviewer's suggestions, we have added clarifications in the methodology in the revised manuscript in line 131-134, line 141-144, line 148-156, line 161-175, line 195-198, line 223-232, etc., made relevant corrections in line 81, line 250-252, line 207-208, etc., and improvements in the title, tables in line 700 and line 710, figures in line 725, line 730, line 740, line 745, line 755, and line 760, and also added new references in line 467-689.

MAJOR COMMENTS:

Point #1

COMMENT: In fitting the regression model, water table at the current time step is the dependent variable while water table at the previous time step is included as one of the independent variables. This is not reasonable given the potential autocorrelations between current water table and antecedent water table especially at the daily scale. In fact, the unbelievably high R2 value of 0.97 in predicting water table at the LP site could be due to the inclusion of antecedent water table in the statistical model. What's more, how can future water table be predicted by the statistical model which requires inputs of antecedent water table conditions?

RESPONSE: We address reviewer's three major questions below.

(1) Reasonability of model structure using the antecedent water table as an explanatory variable,

(i) This study adopted the well-established methodology of dynamic panel model widely used in statistics and econometrics. The dynamic panel modeling includes the first lag dependent variable coupled with the explanatory variables (e.g. P, PET, in this study). The model structure with a given lag effect were successfully used in the previous studies for hydroregime prediction (Greenberg et al., 2015, Webb et al., 2003), urban water demand prediction (Almendarez-Hernández et al., 2016; Arbués et al., 2004; Arbues et al., 2010, Lyman, 1992), and energy-food-water interaction modelling (Liu et al., 2017; Ozturk, 2015). Lyman's (1992) and Ozturk (2015) confirmed the adjustments significance of minimizing heterogeneity in the traditional Ordinary Least Squares assumptions by including the first lagged dependent variable. Webb et al. (2003) improved the sensitivity and explanatory power of the hourly based water-air temperature regression models by incorporating a lagged response of water temperature. In a wetland hydrology and climate change study, Greenberg et al. (2015) successfully forecasting the hydroregimes of multiple wetlands by modeling the water table depth using water level of the prior week and precipitation as predictors of current water table.

(ii) The statistical model structure has physical meaning and can be viewed from the perspective of water balance. A lagged effect of water table was supported by the water balances and the water table dynamics of wetlands. It is due to the fact that wetland groundwater has memories which can be carried beyond the next season as to influence the water balance in the coming years (Miguez-Macho and Fan 2012). Firstly, the water balance of the five selected wetlands can be written as $\mathrm{WT_t} - \mathrm{WT_{t-1}} = \alpha + \beta(\mathrm{P_t} - \mathrm{ET_t}) + \varepsilon_\mathrm{t}$. It indicates the causality balances between water tables changes (left side terms of the above equation i.e., $\mathrm{WT_t} - \mathrm{WT_{t-1}}$) and its water availability changes (right side terms of the above equation). The item of WT_{t-1} depending on the time scale can be considered as the memory effect of water tables. By moving the memory item (WT_{t-1}) to the right side, the different statistical coefficient of WT_{t-1} can reflect the different memory characters/effects in the five selected wetlands. Based on these reasons, we believe the model structure that includes a lagged water table in this study can offer more information concerning not only water tables changes due to changes in climate variables, but also the different memory effects of different wetlands in this region.

(iii) All the information is not contained in the antecedent water table conditions of wetlands. The lagged water table only offers the basis for the current condition, however, the forcings (e.g. climate and water availability in this study) alters the water table depth. In another word, the water table depth would always decrease/increase along with a given initial discharge/recharge condition for the wetland. But, a wetland actually alternatively discharges or recharges for the flatness, thus water tables fluctuated with the forcings. Therefore, both the forcings and the lagged water table would determine the water tables for a wetland. What's more, when using the water table at LP site with forcings from FL-WET site, the statistics show that in spite of the same antecedent condition, the R^2 becomes poorer to 0.54 from 0.83.

(iv) From the perspective of the proved wide-sense stationary first-order autoregressive process of water tables in the five selected wetlands, the variance will not change with the autoregressive process introduced into the statistic model. For an autoregressive process given by: $Y_t = \alpha + \beta Y_{t-1} + \varepsilon_t$, where ε_t is a white noise process with zero mean and constant variance σ_ε^2. The first-order autoregressive process is wide-sense stationary when and only when $|\beta|<1$, because it is the output of a stable filter with a white noise input (Mills, 1990). In the wetlands analyzed in the study, the coefficient of WT_{t-1} are<1 (Table 4), indicating a wide-sense stationary autoregressive process of water table. Thus the variance of the process does not change with simulation over time, and the intertemporal effect ($\beta^n \varepsilon_1$) of shocks diminishes toward zero in the limit.

(v) From the perspective of the independence of the explanatory variables, introduce of antecedent water table does not violate the independence requirements among the explanatory variables. Independence between the explanatory variables was satisfied since correlation coefficient between P-PET and WT_{t-1} was very poor (<2.7) for the five selected wetlands in the study.

According to the comment, we added the justification in the revised manuscript (Line 161-175, similarly hereinafter) to make it clearer for readers.

(2) For the question of "unbelievably high R2 value of 0.97 at LP site", it was actually the correlation coefficient (R) for model verification, which was corrected in line 250-252. The model was developed with a determination coefficient (R^2, proportion of the variance in predicted water table) of 0.83, which was also the highest among the five wetlands. It appears during the verification, the model was able to well capture the variations for the entire verification period for the LP site. The good capability of LP site may be explained by the contribution of the high interception value of the statistical model, which may include the contribution of artificial drainage system of this pine plantation. As mentioned in (1)-iii, all the information is not contained in the antecedent water table conditions of LP site. The R^2 becomes poorer to 0.54 from 0.83 when using the forcings from FL-WET site, in spite of the same antecedent condition.

(3) For the question of 'daily scale', this regression model is developed at the 15-day time step, not on a daily scale (Line 207-208).

(4) The related new references were added to the revised manuscript as follows:

"Almendarez-Hernández, M., Avilés Polanco, G., Hernández Trejo, V., Ortega-Rubio, A., and Beltrán Morales, L.: Residential Water Demand in a Mexican Biosphere Reserve: Evidence of the Effects of Perceived Price, Water, 8, 428, 2016. (Line 467-469)

Arbués, F., Barberán, R., and Villanúa, I.: Price impact on urban residential water demand: A dynamic panel data approach, Water Resour Res, 40, 2004. (Line 475-476)

Arbues, F., Garcia-Valinas, M. A., and Villanua, I.: Urban Water Demand for Service and Industrial Use: The Case of Zaragoza, Water Resour Manag, 24, 4033-4048, 2010. (Line 477-478)

Liu, G., Yang, Z., Tang, Y., and Ulgiati, S.: Spatial correlation model of economy-energy-pollution interactions: The role of river water as a link between production sites and urban areas, Renewable and Sustainable Energy Reviews, 69, 1018-1028, 2017. (Line 574-576)

Lyman, R. A.: Peak and off-peak residential water demand, Water Resour Res, 28, 2159-2167, 1992. (Line 586)

Miguez-Macho, G., and Y. Fan, The role of groundwater in the Amazon water cycle: 1. Influence on seasonal streamflow, flooding and wetlands, J. Geophys. Res., 117, D15113, 2012. (Line 600-601)

Mills, Terence C. Time Series Techniques for Economists. Cambridge University Press, 1990. (Line 602)

Ozturk, I.: Sustainability in the food-energy-water nexus: Evidence from BRICS (Brazil, the Russian Federation, India, China, and South Africa) countries, Energy, 93, 999-1010, 2015. (Line 627-628)

Webb, B., Clack, P., and Walling, D.: Water–air temperature relationships in a Devon river system and the role of flow, Hydrological processes, 17, 3069-3084, 2003. ” (Line 688-689)

Point #2

COMMENT: There are major issues related to the short calibration and validation periods for the statistical model. For example, two years of data is used for fitting regression model for the AR site while one year is used for validation. I am wondering whether climatic conditions in the validation year is significant different from the calibration year? Future climate especially for the later periods of 21st century would be quite different from the calibration periods based on which the regression model is constructed. Therefore, the historical relations trained from such a short time period may not hold in the future with significant changes in climate.

RESPONSE: We agree that regression models are limited data availability and can contribute to model deficiency (Line 223-232). However, long-term, high resolution observed wetland water table data for multiple sites in the southeast U.S. are extremely rare. For example, the Alligator River Wildlife Refuge bottom hardwood wetland (AR site), is located in a remote location and water table data are in the only data sets extremely valuable to characterize the local hydrological conditions. Fortunately, the dataset covered both dry and wet years at the selected sites and was ideal for model development and validation purposes. For example, at wetlands FL–UP and FL-WET, the time series including wet and dry years (1993–1994) was used to develop the model, and the remaining data (1992, 1995, and 1996) were used for model validation (Fig. 3). Additionally, the model was then applied to predict water table based on the GCMs dataset in a full time scale (1950-2099) including both the baseline period (1980-1999) and the future period (2040-2059, 2080-2099) (Line 147-156). Thus, during model applied to predict water table based on the GCMs dataset, future and historical climate will share the same bias. The changes from the historical to the future are comparable.

Point #3

COMMENT: The downscaled GCM climate should be validated for the baseline period in the study sites before it can be used for future predictions.

RESPONSE: The climate data that we used in baseline period (1980-1999) and future period (2040-2059, 2080-2099) are both the downscaled GCM climate dataset (Line 148-156). These downscaled climate datasets are found to be as a good match (90% of Perkins PDF skill score between 0.8-0.95) regionally over the southeastern United States by means observations, and the entire distribution of observations (Keellings, 2016). Besides, both the baseline period and future period would share the same bias. Thus, the hydrologic and climate changes from the baseline period to the end of this century are comparable. According to the comment, we added a few sentences (Line 141-144 and Line 148-156) in the revised manuscript.

The related new reference was added in the revised manuscript as follows:
"Keellings, D.: Evaluation of downscaled CMIP5 model skill in simulating daily maximum temperature over the southeastern United States, Int J Climatol, 36, 4172-4180, 2016." (Line 559-560)

MINOR COMMENT:

Point #1

COMMENT: In Section 80, RCP stands for "Representative Concentration Pathway" rather than "Regional Concentration Pathways".

RESPONSE: Corrected in line 81. Thanks.

Point #2

COMMENT: Hamon's equation is selected for estimating PET. Justifications on this should be added.

RESPONSE: The justifications were added in line 195-198 as follows:
"PET is mainly controlled by net radiation, air temperature, wind speed, air humidity (Hargreaves and Samani, 1982). Due to data availability, here we used the air temperature-based Hamon equation to calculate PET (Hamon, 1963) using widely available temperature data. This Hamon's PET method has been widely used worldwide to estimate potential water uses, especially in this region (Sun et al., 2002)."

The new reference was added to the revised manuscript as follows:

“Hargreaves, G. H. and Samani, Z. A.: Estimating potential evapotranspiration, Journal of the Irrigation and Drainage Division, 108, 225-230, 1982.” (Line545-546)

Point #3

COMMENT: In section 130, the estimated PET is adjusted to match “realistic” PET values for forests. What are the realistic PET values for forests?

RESPONSE: The ‘realistic PET’ was a typo; it should be the actual ET for the forests in this region. The sentence was re-written as “A correction coefficient (Sun et al., 2002) was used to adjust PET calculated by Hamon’s equation to better represent the forest PET for the study region. The correction coefficients were reported to range from 1.0 to 1.2 (North Carolina, Federer and Lash, 1978b), and was 1.3 for the Florida site (Sun et al., 1998). To be consistent and reduce uncertainty of PET estimates, 1.2 was used for all study wetlands in this study.” in line 131-134.

Point #4

COMMENT: The climate for the baseline period is based on observations or GCM simulations?

RESPONSE: We appreciate the reviewer’s careful review. The climate for the baseline period 1980–1999 (historical run) was based on of the downscaled GCM datasets (1950-2099) (Line 148, line 152).

Point #5

COMMENT: A table with a brief description of the GCMs should be added.

RESPONSE: A new table (Table 3, as follows) with summary of the GCMs was added in the revised version (line 710).

Table 3 Summary of the 20 CMIP5 GCMs used in this study from the downscaled MACA dataset.

No.	Model Name	Country	Model Institution	Atmosphere Resolution (Lon x Lat)
1	bcc-csm1-1	China	Beijing Climate Center, China Meteorological Administration	2.8 deg x 2.8 deg
2	bcc-csm1-1-m	China	Beijing Climate Center, China Meteorological Administration	1.12 deg x 1.12 deg
3	BNU-ESM	China	College of Global Change and Earth System Science, Beijing Normal University, China	2.8 deg x 2.8 deg
4	CanESM2	Canada	Canadian Centre for Climate Modeling and Analysis	2.8 deg x 2.8 deg
5	CCSM4	USA	National Center of Atmospheric Research, USA	1.25 deg x 0.94 deg
6	CNRM-CM5	France	National Centre of Meteorological Research, France	1.4 deg x 1.4 deg
7	CSIRO-Mk3-6-0	Australia	Commonwealth Scientific and Industrial Research Organization/Queensland Climate Change Centre of Excellence, Australia	1.8 deg x 1.8 deg
8	GFDL-ESM2M	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg
9	GFDL-ESM2G	USA	NOAA Geophysical Fluid Dynamics Laboratory, USA	2.5 deg x 2.0 deg
10	HadGEM2-ES	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg
11	HadGEM2-CC	United Kingdom	Met Office Hadley Center, UK	1.88 deg x 1.25 deg
12	inmcm4	Russia	Institute for Numerical Mathematics, Russia	2.0 deg x 1.5 deg
13	IPSL-CM5A-LR	France	Institut Pierre Simon Laplace, France	3.75 deg x 1.8 deg
14	IPSL-CM5A-MR	France	Institut Pierre Simon Laplace, France	2.5 deg x 1.25 deg
15	IPSL-CM5B-LR	France	Institut Pierre Simon Laplace, France	2.75 deg x 1.8 deg
16	MIROC5	Japan	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies,and Japan Agency for Marine-Earth Science and Technology	1.4 deg x 1.4 deg
17	MIROC-ESM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg
18	MIROC-ESM-CHEM	Japan	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	2.8 deg x 2.8 deg
19	MRI-CGCM3	Japan	Meteorological Research Institute, Japan	1.1 deg x 1.1 deg
20	NorESM1-M	Norway	Norwegian Climate Center, Norway	2.5 deg x 1.9 deg

Point #6

COMMENT: This study focus on the projection of water table depth at five forest sites. The title should mention “water table depth” rather than “hydrology” which is a broad concept.

RESPONSE: The word “hydrology” was changed to “water table depth” in the title.