We thank a reviewer for valuable comments on our manuscript. All comments are summarized with a numbering style and corresponding responses were followed by an arrow symbol (➔). The line numbers (Line) referenced will be changed for the final version of the revised manuscript.

<u>Short comment #1</u>

General comments:

The authors studied the effect of winter cover crops on nitrate loadings using SWAT. However, the authors were not able to clearly explain and visualize their findings. In addition, there are quite a few technical and organizational issues that the reviewer would like to focus on, as given below:

1.1. **(1)** First, purpose of the study design is not clear. I assume the authors were planning to isolate the individual impacts of CO2, temperature, and precipitation, and the GCM simulations were to quantify the interacting impacts of the climate factors. However, if this is the purpose, the GCM simulations were not necessary because the authors can simulate the interacting effects in the sensitivity simulations by combing climate factors. (**2)** In addition, CMIP3 data were used in the future climate scenario simulations, instead of the latest climate projections of CMIP5. Using the out-of-date climate data make the projections unnecessary.

➔ (**1)** This aim of this paper was to quantify the climate change impacts on crop growth and related nitrogen cycling/transport processes in an agricultural catchment, the typical representative of the coastal watershed in the CBW. The simulation study was designed as a two-step on purpose. The first step was to investigate the individual effects of the key climate factors on the crop biomass, water and nitrate cycling. This step was to develop in-depth knowledge and understanding on how each climate factor affects these underlying processes. The second experiment (e.g., simulation with the GCM output) was to quantify and predict these crop effects on water and nitrogen cycling at the local catchment level, with respect to the foreseeable climate changes. We used the GCM projections to describe foreseeable changes, as the combination of climate factors and their interactions could not provide complete climate change/variability information (including seasonal and inter-decadal variability, Mearns, 2001). For example, crop growth and agricultural nutrient loadings (e.g., fertilizer-driven nutrients) are highly sensitive to inter-monthly variations of the climate system. However, such variations in climate system could not be captured by a combination of three climate sensitivity scenarios as suggested by the reviewer. In our revision, we will clarify the purpose of the study design in the introduction as suggested by the reviewer.

➔ (**2)** We fully agree on your point using the latest climate projects to make prediction. As suggested, we finished the SWAT model using the state-of-the-art GCM data (CMIP5). We will present updated the method and result sections with new simulations in the revised manuscript.

1.2. Second, discussions were not sufficient. (**1)** I cannot agree with the authors that increased N export resulted from litter input. **(2)** Forest is an important land cover in both watersheds. However, the authors only focused on cropland, but paid insufficient attention to forests.

➔ (**1)** Increased litter from crop residue can contribute to increasing inorganic N in soils for crop fields, especially after harvesting crops (i.e., during winter seasons). Through harvesting practices, below-ground crop biomass and the portion of above-ground biomass remain on fields as “crop residue”. Remaining crop residue was shown to increase soil nitrate through mineralization during winter seasons for this region (Lee et al., 2016). Contribution of crop residue to soil nitrate during winter seasons has been identified by previous studies (Goss et al., 1993; Gentry et al., 2001; Randall et al., 2008). As shown in the table below, our simulation showed that the amount of mineralized nitrate during summer seasons was similar for the baseline and CO_2-elevated scenarios. However, during winter seasons (no crops on the field) a great difference in mineralized nitrate was observed between the two scenarios because elevated CO_2 concentration increases soil water contents, which promotes mineralization. If there are growing crops on the fields, nitrate from mineralization would promptly be taken up by crops. This point will be clarified by updating Fig A3, by showing mineralized nitrate during winter seasons.

Table 1. The amount of mineralized nitrate fluxes during summer and winter seasons for the baseline and elevated CO_2 concentration scenario

	Summer (Apr. – Sep.)	Winter (Oct. – Mar.)
Tuckahoe Creek Watershed		
Baseline	26 kg ha^{-1}	26 kg ha^{-1}
Elevated CO_2 concentration	27 kg ha^{-1}	33 kg ha^{-1}
Greensboro Watershed		
Baseline	16 kg ha^{-1}	18 kg ha^{-1}
Elevated CO_2 concentration	17 kg ha^{-1}	22 kg ha^{-1}

➔ (**2**) As we pointed out in the introduction, nutrients from agricultural lands are the major threat to water quality degradation in this region. Hence, we focused on understanding climate change impacts on agricultural lands (e.g., implication on crop growth, water and nitrogen cycling at the crop field, and their transport mechanisms occurring across catchment). The SWAT modeling was conducted with detailed agricultural practices and crop rotation patterns in order to provide reliable prediction and assessment. While forests ecosystem plays a key role in water and nitrogen cycling, its response to the climate change and implication to water quality was not in the scope of this paper. We will clarify this point in the revised manuscript.

As the reviewer commented, forests are another important land cover for both watersheds (>30 % of the catchment areas). While this land cover is not the focus of this study, we will include a discussion to explain how forests effect on the water and nutrient cycling is simulated. In this discussion, we will address the limitation of SWAT to represent the ecological responses of forests to the climate change (Yang et al., 2016 and Zhang et al., 2014), hence its limited capability to predict the forest impacts in water and nutrient cycling with climate change, much different from the current condition.

Specific comments:

1.3. Line 72 cycle → cycling

➔ The word will be changed in the revised manuscript.

1.4. Line 85, missing space 17and

➔ The space will be added in the revised manuscript.

1.5. Line 97, this paragraph is too long. Consider to split it to two.

➔ We will divide the paragraph into two in the revised manuscript.

1.6. Line 101 - 103, do you mean their investigation was not spatially-explicit

➔ No. We intended to point out limited understanding of climate change impacts on internal watershed processes (water and nitrate transport mechanisms) because previous studies commonly examined climate change impacts on aggregated watershed responses (e.g., stream flow and nutrient loads at the outlet of the watershed). For clarification, the sentence will be modified in the revised manuscript as a follow: *previous studies did not demonstrate climate change impacts on internal watershed processes (e.g., water and nutrient transport mechanisms)*

1.7. Line 122, are conductive

➔ For clarification, we will use "favorable" instead of "conducive" in the revised manuscript.

1.8. Line 125, remove 'areas of'

➔ It will be removed in the revised manuscript.

1.9. Line 132, would → are expected to

➔ The word will be changed in the revised manuscript.

1.10. Line 132 - 133, this paragraph repeated what you stated in the previous paragraph. Consider to reorganize it, or delete it.

➔ It will be deleted in the revised manuscript.

1.11. Line 138, effects → impacts

➔ The word will be changed in the revised manuscript.

1.12. Line 141, climate change scenario does not include changes in co2, precipitation and temperature?

➔ No. The GCM-based climate change scenario fully considers changes in CO_2, precipitation and temperature as described in the section 2.5.2. When simulating the model with the GCM-based climate change scenario, we set CO_2 concentration as 936 ppm as stated in Line 330. We will clearly state the GCM scenario considers three climate factors in the revised manuscript.

1.13. Line 161, should cite the figure after insert to the text

➔ As per the journal guideline, we placed all figures and tables right after in-text citation of figures and tables.

1.14. Line 168, results → result

➔ The word will be changed in the revised manuscript.

1.15. Line 188, this sentence is not necessary

➔ The sentence will be removed.

1.16. Line 190, does leaching occurred with the previous three water fluxes?

➔ Yes. Leaching takes place simultaneously (Neitsch et al., 2011). We will improve the description of water and nitrate transport in the revised manuscript as a follow:

Water infiltrated into soils is either delivered to streams through lateral flow or further percolated into groundwater when soil water content exceeds its field capacity. The groundwater portion is then either transported to streams, percolated into the deep groundwater aquifer, or discharged to the soil profile. The amount of nitrate in soils increases by nitrification, mineralization of soil organic and crop residue, biological N fixation, and fertilization, but decreases through denitrification and plant uptake (Neitsch et al., 2011). Nitrate fluxes move via surface runoff, lateral flow, percolated water, and groundwater flow. Nitrate concentration in the mobile water (i.e., surface runoff, lateral flow, and percolated water) is first determined and then the amount of nitrate in the mobile water is calculated based on the nitrate concentration and the amount of mobile water. Nitrate leaching indicates nitrate transport via percolation. Nitrate in groundwater is re-distributed in four ways: remain in the groundwater, recharge to deep groundwater, move to streams, or discharge to the soil profile. Nitrate removal by biological and chemical processes in groundwater is simulated by first-order kinetics. Refer to Netisch et al. (2011) for further details.

1.17. Line 193, should make clear why present equation 2 here, since it is similar to equation 1. A bit confusing here

➔ To avoid confusing, Equation 2 will remain as it represents climate change impacts on stomatal conductance and Equation 1 will be deleted. Equation 2 indicates the key physical process explaining the reduction of stomatal conductance by elevated CO_2 concentration (Field et al., 1995). Accordingly, we will revise the manuscript to reflect this revision.

1.18. Line 223, what is a grab sample?

➔ A grab sample is the discrete data collected at a specific timing over a long period. We will add brief information of our grab sample data to the revised manuscript as a follow: *nitrate grab sample data (133 samples over the simulation periods)*

1.19. Line 244, to my understanding lots of key swat processes have a daily step. How did you conduct your simulation at the monthly step

➔ Yes. The SWAT was simulated at a daily time scale, fully simulating daily hydrological and nutrient transport processes with daily climate data. The SWAT also provides the monthly or annual outputs aggregated from the daily simulation results. We used the monthly outputs provided by the model. For clarification, we will add the sentence below to the revised manuscript:

The SWAT model was simulated at a daily time step based on daily climate input, and daily outputs were aggregated for monthly outputs.

1.20. Line 290, I suggest to add more information how temperature and precipitation change scenario were prepared.

➔ As suggested, we will improv the description of temperature and precipitation sensitivity scenarios in the revised manuscript as below:

We used the maximum increase rate (and value) for 2040 – 2069 (precipitation: 11 % and temperature: 2.9 °C) and 2070 – 2099 (precipitation: 21 % and temperature: 5.0 °C) to set the precipitation and temperature sensitivity scenarios. For example, the baseline precipitation increased by 11 % and 21 % for Scenario 3 and 4, respectively, and 2.9 °C and 5.0 °C were added to the baseline temperature for Scenario 5 and 6, respectively.

1.21. Line 374, represented → presented

➔ It will be changed in the revised manuscript.

1.22. Line 380, is ET increase here comparable with other studies?

➔ Yes. The reduction rate of ET in response to elevated CO_2 concentration was within the range reported by previous studies (Ficklin et al., 2009; Pervez et al. 2015). We will briefly compare our results with previous studies in the revised manuscript as below:

The reduced rate of ET (driven by CO2 concentration of 850 ppm) demonstrated in this study is supported by previous studies using SWAT, such as Ficklin et al., 2009 (- 40 %; 970 ppm) and Pervez et al., 2015 (- 12 %; 660 ppm).

1.23. Line 392. This does not make sense. N in litter were originally from inorganic N in soil. Increased litter means more uptake of inorganic N from soil, which decrease inorganic N in soil. Attribution of the increased N export resulted from the increased litter inputs were groundless.

➔ Please see the answer in 1.2.

1.24. Line 442, I am wondering why denitrification, which is sensitive to temperature, is not considered in explaining changes in N load

➔ In the SWAT model, denitrification takes place when a soil water content exceeds the threshold value. Although warmer temperature facilitates denitrification, reduced soil water content by warmer temperature lowered denitrification. We will briefly state why temperature increase rarely influenced the denitrification in the revised manuscript as below:

Denitrification was rarely affected by temperature increase because reduced soil water content by increased ET through higher temperatures prohibited denitrification.

1.25. Line 527, how do you know fertilizer use will increase.

➔ We will improve the description of potential increase in fertilizer use for the future in the revised manuscript as below:

Fertilizer application might increase in the future because increased extreme climate conditions (e.g., high intensity rainfall and flooding) might lead to increased risk of nutrient loss to leaching and runoff, reducing the fertilizer use efficiency of field crops (Suddick et al., 2013).

<Cited references>

Ficklin, D.L., Luo, Y., Luedeling, E., and Zhang, M.: Climate change sensitivity assessment of a highly agricultural watershed using SWAT. J. Hydrol. 374 (1), 16-29, 2009.

Field, C.B., Jackson, R.B., and Mooney, H.A.: Stomatal responses to increased CO2: implications from the plant to the global scale. Plant, Cell & Environment, 18(10), 1214-1225, 1995.

Gentry, L.E., Below, F.E., David, M.B., and Bergerou, J.A.: Source of the soybean N credit in maize production. Plant Soil. 236(2),175–84, 2001.

Goss, M.J., Miller, M.H., Bailey, L.D. and Grant, C.A.: Root growth and distribution in relation to nutrient availability and uptake. Eur J Agron. 2(2), 57-67, 1993.

Neitsch, S. L., Arnold, J. G., Kiniry, J. R., and Williams, J. R.: Soil and Water Assessment Tool. Theoretical Documentation; Version 2009, Texas Water Resources Institute Technical Report No. 406, Texas A&M University System, College Station, TX, 2011.

Pervez, M.S. and Henebry, G.M.: Assessing the impacts of climate and land use and land cover change on the freshwater availability in the Brahmaputra River basin. J Hydrol: Regional Studies, 3, 285-311, 2015.

Randall, G.W.; Delgado, J.A.; Schepers, J.S.: Nitrogen Management to Protect Water Resources, in: Nitrogen in Agricultural Systems, ASA-CSSA-SSSA, Madision, WI, USA, 911–945, 2008.

Suddick, E.C., Whitney, P., Townsend, A.R. and Davidson, E.A.: The role of nitrogen in climate change and the impacts of nitrogen–climate interactions in the United States: foreword to thematic issue. Biogeochemistry. 114(1-3), 1-10, 2013.

Yang, Q. and Zhang, X.: Improving SWAT for simulating water and carbon fluxes of forest ecosystems. Sci. Total Environ. 569, 1478-1488, 2016.

Zhang, H., Yuan, W., Dong, W. and Liu, S.: Seasonal patterns of litterfall in forest ecosystem worldwide. Ecol Complex. 20, 240-247, 2014.