[Paper # gmd-2015-68]

Response to Anonymous Referee #1's comments on "Integration of nitrogen dynamics into the Noah-MP land model v1.1 for climate and environmental predictions"

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Thank you to the reviewer for his/her insightful comments. We have incorporated revisions to address the suggestions as best as possible and hope that our changes will address all concerns.

The comments from the reviewer are pasted below (in **black font**) with our responses inline (in **blue font**).

This manuscript presents the incorporation of nitrogen processes into Noah-MP by leveraging the process descriptions from the FUN and SWAT models respectively. The topic is important given the role of Noah-MP as the next generation land component of WRF. The strategy, i.e., learning/adopting from FUN for the plant nitrogen dynamics and from SWAT for soil nitrogen dynamics, is overall appropriate. However, I have a few concerns specified as below, and hence recommend a moderate revision before possible acceptance for publication.

1. Lack of a clear parameterization strategy. The authors should provide a concentrated description of how they determine the hydrologyical, and plant and soil nitrogen parameters for this study site. Moreover, a land model such as Noah-MP is usually expected to be applied over large scales, say regional for example. How would the authors envision the parameters used, hence the understanding gained at this specific site, to be generalized to other places? Some discussion in the end along this line would be useful since this study is motivated to provide simultaneous predictions of weather and environment, both of which are generally large-scale in nature.

Re: We appreciate the insightful comment. Regarding the parameters, our strategy is to minimize changing them from the default values that were documented in Fisher et al. (2010) regarding FUN and Neitsch et al. (2011) regarding SWAT. As both of these models have been applied to several large scale studies, we assumed that these default values are applicable for general conditions. Indeed, for those parameters from FUN, we used all default vales. At the same time, we attempted to use some parameters that were measured at the site to best represent the location. During the modeling process, we also found some very sensitive parameters that have large impacts on the model results, such as $\gamma_{sw,thr}$ (threshold value of soil water factor for denitrification to occur), β_{min} (rate coefficient for mineralization of the humic organic nitrogen), and β_{rsd} (rate coefficient for mineralization of the fresh organic nitrogen in residue). We adjusted these parameters to match observations. We have modified the text in the manuscript accordingly to clarify the parameterization strategy (section 2.2).

We developed the model for eventual extrapolation to large regions. For instance, we realized that the observed nitrogen fertilizer application data used in this study, which is important to the nitrogen dynamics, may not be available when we apply the model to large regions, especially the fertilizer application dates. Therefore, we investigated this issue (Figure 8 in the manuscript) and recommended that when we apply the model to a region, a simple survey of the approximate fertilizer application dates is needed (see section 3.7).

2. Systematic bias in the model simulated soil moisture, as clearly shown in Figure 2. Given that nitrate is highly soluble and highly affected by soil water dynamics, one would infer that this systematic bias of soil moisture simulation may propagate to the nitrogen simulation. It appears to me that Noah-MP in this study is systematically underestimating the variation range of the soil moisture. This is very likely due to some deficiencies in the hydrology component, being the runoff scheme or parameters. Which TOPMODEL scheme is used in this study, the one with groundwater or with an equilibrium water table? Is the groundwater level at this site shallow enough so that all TOPMODEL assumptions hold? Have you tried to calibrate/adjust the hydrology parameters for this site? If currently Noah-MP is not hooked up with an automatic calibration package, some manual calibration will be feasible at least and just enough.

Re: As suggested by the reviewer, we have tried to manually calibrate many soil hydrology related parameters including eight out of ten soil parameters. We were able to reduce or increase the mean of the simulated soil moisture, which is unnecessary because it is already very close to observation. As an example shown in Figure 1, a higher Clapp-Hornberger *b* parameter for soil produced higher soil moisture and thus lower soil nitrate concentration and nitrate leaching. However we could not make much improvement in terms of increasing the variation range. But the observed large variation range may also include systematic errors, as we can see from the large spread of the observed range defined by the six replicates. Due to this large uncertainty, we cannot totally trust the observation. Anyway, we thank the reviewer for pointing out this issue that we did not pay enough attention to. We will check if this issue persists in our upcoming regional or global model evaluation.

This study uses the TOPMODEL with groundwater scheme. The simulated water table depth ranges from 2.24 m to 2.68 m, which can meet the TOPMODEL assumptions.

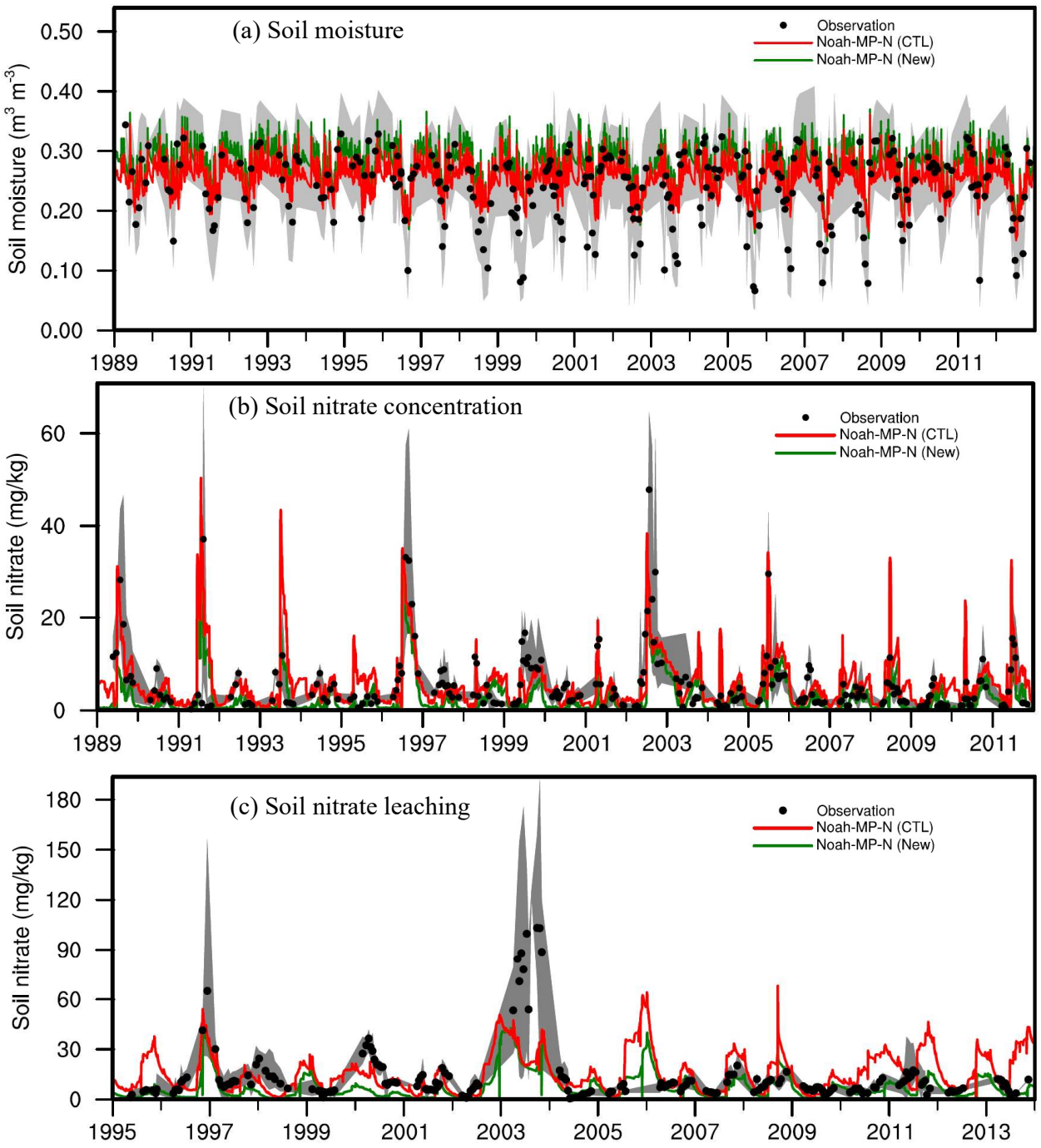

Figure 1 Observed and model simulated (a) volumetric soil moisture, (b) soil nitrate concentration, and (c) soil nitrate leaching. CTL: the default model (with N dynamics) setup in the original manuscript; New: an experiment that changes the soil parameter B from the default value (4.74) to 6.74 and everything else is the same as CTL.

3. Inconsistent treatment of tillage between the water and nitrogen, as indicated at Line8-10, Page 4127. The authors need to carefully evaluate the possible bias in soil moisture simulation and the subsequent

nitrate simulation, then decide whether it is appropriate to consider the tillage effects in nitrogen redistribution only but not in water redistribution.

Re: From Figure 1, we can see that soil moisture has influence on nitrogen simulation. For nitrogen model implementation, we separate a 10 mm surface layer from the first soil layer (surface to 100 mm deep) in Noah-MP to better represent the soil properties on soil surface (high organic content). We currently assumed that tillage can only reach 100 mm which is just the depth of the first soil layer in Noah-MP. Within this surface layer, there is no redistribution of N, as the soil moisture content at different depth is considered the same within a soil layer in the model. In other words, one purpose of tillage is to bring the surface residue down into lower soil layers; while this is not necessary for water.

Actually, to our best knowledge, the SWAT model does not consider the redistribution of soil water due to tillage either, probably because of the same reason. While it is possible that we can add a surface layer for the hydrology part as well, our intention is not to change the original Noah-MP structure. We thank the reviewer for the good comment. We will have a more comprehensive investigation on this issue and make necessary changes in our future model development.

References

Fisher, J. B., Sitch, S., Malhi, Y., Fisher, R. A., Huntingford, C., and Tan, S. Y.: Carbon cost of plant nitrogen acquisition: A mechanistic, globally applicable model of plant nitrogen uptake, retranslocation, and fixation, Global Biogeochem. Cy., 24, 2010.

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, Texas A&M University, College Station, TXTechnical Report No. 406, 2011.