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Biogeosciences
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Interactive comment on "Capturing interactions between nitrogen and hydrological cycles under historical climate and land use: Susquehanna watershed analysis with the GFDL Land Model LM3-TAN" *by* M. Lee et al.

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<Anonymous Referee #1>

Dear Reviewer, We deeply appreciate the time and effort you spent on reviewing our manuscript. We trust that all of your comments are addressed in the following point-by-point reply to your comments, and which greatly helped to improve our manuscript.

Reviewer's Comment 1:

Model description in section 2.4 and Tables 1 and 2. It is not clear which parameters

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are fixed (from literature and/or measurements) and which are calibrated: in table 1 all listed (new) parameters are fixed?

Response 1:

This is a valid comment and we plan to modify Table 1 to clarify this point.

In the column "Reference or Rationale", we will specify if the parameters were calibrated or taken/adapted from published values.

Reviewer's Comment 2:

Also in Table 2 the word "variable" I think is not properly used: it seems a mix between state variables, inputs (or forcings) and parameters.

Response 2:

Agreed, we will modify Table 2 specifying if the variables are prognostic or diagnostic or inputs/forcings.

Reviewer's Comment 3:

The implementation should be better explained here: in the abstract is written the model calibration was done at Marietta and it was done a spatial validation using the rest of stations. Why it was not done a temporal validation? In my opinion, it can affect the temporal extrapolability/predictability of the model. Or not?

Response 3:

Agreed, we will modify page 5686, lines 3-7 to read:

We simulated with LM3-TAN stream dissolved organic-N, ammonium-N, and nitrate-N loads throughout the river network. The model was calibrated by comparing the modeled stream N loads with the corresponding reported N loads at the last downstream SRBC station Marietta, in which contributions of the entire watershed to the stream flows and N loads can be assessed. Thus, temporal evaluation of the stream discharges and N loads for the period 1987-2005 was focused on at the Marietta station. River data from the 15 monitoring stations (1986-2005) were also used to evaluate spatial stream discharges and N loads.

The temporal evaluation was done at Marietta. This is explained in the above response; page 5687, lines 3-5; Fig. 5.

Reviewer's Comment 4:

Section 7 is relatively short. I miss results concerning the implementation and exploitation of hydrological state variables. Probably there are interactions with N state variables.

Response 4:

Interactions between hydrological and N state variables are explained in section 2.4.1, pages 5676-5678.

Our initial paper was much longer, and we shortened it to about 10,000 words, which is still much longer than most manuscripts in Biogeosciences. Because this paper focuses on model development, we could not further shorten the model description sections, which led to a relatively the short result section. At this point we prefer not to increase the length of the manuscript.

Reviewer's Comment 5:

P5671 L25. "Global", in which sense: planet scale or simulating all processes or both? I think authors are thinking for the spatial scale, but the multi-process aspect can be also important due to potential interactions between different state variables. See my comment concerning section 7.

Response 5:

To clarify the scale issue, will modify page 5671, lines 23-27 to read:

To characterize implications of human and climate driven perturbation in the earth N cycling and its implication for water and air quality, the next-generation of N cycling models need to (1) account for regional and local changes in terrestrial and aquatic ecosystem structure and functioning, (2) represent in a consistent manner emissions and transformation of N to air, rivers and coasts, and (3) be global in extent and integrated with climate and earth system models.

Reviewer's Comment 6:

P5675 L1-3. Can you explain better? In particular, how to link "historical reconstruction" with "land use change scenarios"? The same for "unique disturbance histories" in L7.

Response 6:

We propose to modify page 5675, lines 1-3 to read:

The model tracks hundreds of years of land use change using global land use transition scenarios that were historically reconstructed by combining satellite-based contemporary patterns of agriculture with historical data on agriculture and population (Hurtt et al., 2006).

Furthermore, we will modify page 5675, lines 5-7:

The model is spatially distributed, and each grid cell consists of up to 15 tiles: 1 natural vegetation, 1 cropland, 1 pasture, and 1 to 12 secondary vegetation tiles representing unique disturbance histories (i.e. de/reforestation, agricultural practice change).

Reviewer's Comment 7:

P5672 and P5674: "vetetation"

Response 7:

Agreed, "vetetation" will be changed to "vegetation".

Reviewer's Comment 8:

P5677 and others. Add a sentence to introduce the equations.

Response 8:

We will add sentences introducing each of the equations:

page 5677, line 19:

Dissolved organic, ammonium, and nitrate N leaching from the soil are described as:

page 5678, lines 19-22:

Because soil nitrate contents are relatively low and limiting under natural conditions, we used a first-order loss function with respect to soil nitrate N content, with adjustments for the influence of soil water content and temperature to simulate soil denitrification rate:

page 5681, lines 7-8:

The N loads in a reach are routed downstream with the water as following.

Reviewer's Comment 9:

If authors like structured conclusions, they can be grouped into model characteristics, implementation results and exploitation.

Response 9:

Agreed, we will change the order of the conclusions by moving a sentence in page 5690, lines 11-14 to between line 19 and 20.

Interactive comment on Biogeosciences Discuss., 11, 5669, 2014.

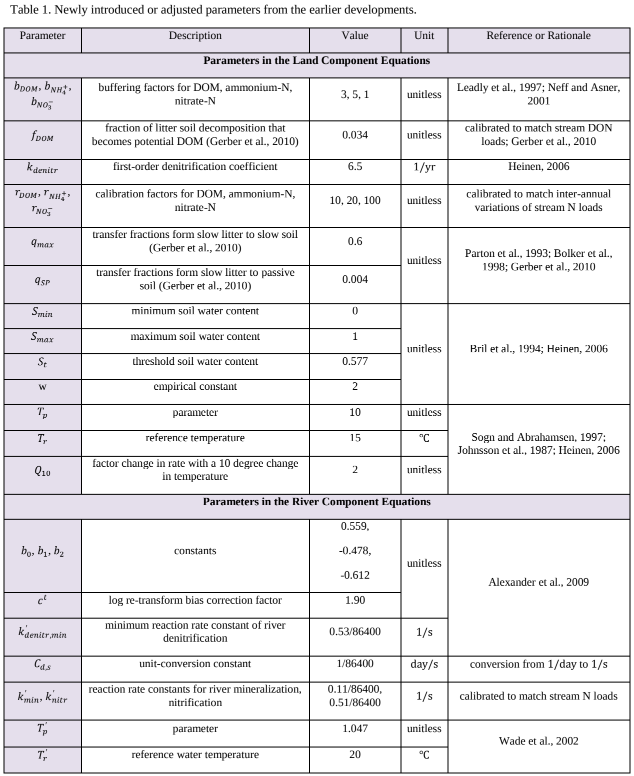

Table 1. Newly introduced or adjusted parameters from the earlier developments.

Parameter	Description	Value	Unit	Reference or Rationale
Parameters in the Land Component Equations				
$b_{DOM}, b_{NH_4^+}, b_{NO_3^-}$	buffering factors for DOM, ammonium-N, nitrate-N	3, 5, 1	unitless	Leadly et al., 1997; Neff and Asner, 2001
f_{DOM}	fraction of litter soil decomposition that becomes potential DOM (Gerber et al., 2010)	0.034	unitless	calibrated to match stream DON loads; Gerber et al., 2010
k_{denitr}	first-order denitrification coefficient	6.5	1/yr	Heinen, 2006
$r_{DOM}, r_{NH_4^+}, r_{NO_3^-}$	calibration factors for DOM, ammonium-N, nitrate-N	10, 20, 100	unitless	calibrated to match inter-annual variations of stream N loads
q_{max}	transfer fractions form slow litter to slow soil (Gerber et al., 2010)	0.6	unitless	Parton et al., 1993; Bolker et al., 1998; Gerber et al., 2010
q_{SP}	transfer fractions form slow litter to passive soil (Gerber et al., 2010)	0.004		
S_{min}	minimum soil water content	0	unitless	Bril et al., 1994; Heinen, 2006
S_{max}	maximum soil water content	1		
S_t	threshold soil water content	0.577		
w	empirical constant	2		
T_p	parameter	10	unitless	Sogn and Abrahamsen, 1997; Johnsson et al., 1987; Heinen, 2006
T_r	reference temperature	15	℃	
Q_{10}	factor change in rate with a 10 degree change in temperature	2	unitless	
Parameters in the River Component Equations				
b_0, b_1, b_2	constants	0.559, -0.478, -0.612	unitless	Alexander et al., 2009
c^t	log re-transform bias correction factor	1.90		
$k'_{denitr,min}$	minimum reaction rate constant of river denitrification	0.53/86400	1/s	
$C_{d,s}$	unit-conversion constant	1/86400	day/s	conversion from 1/day to 1/s
k'_{min}, k'_{nitr}	reaction rate constants for river mineralization, nitrification	0.11/86400, 0.51/86400	1/s	calibrated to match stream N loads
T'_p	parameter	1.047	unitless	Wade et al., 2002
T'_r	reference water temperature	20	℃	

Fig. 1. Table 1

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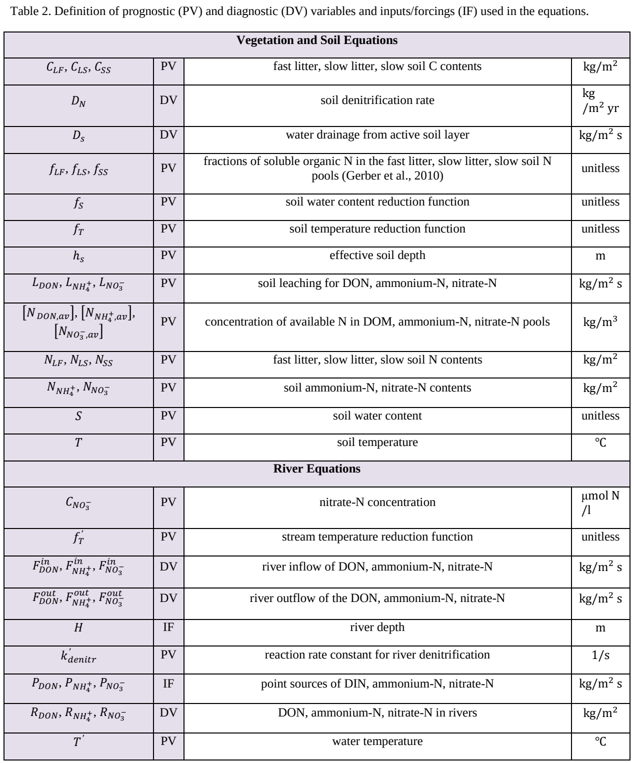

Table 2. Definition of prognostic (PV) and diagnostic (DV) variables and inputs/forcings (IF) used in the equations.

Vegetation and Soil Equations			
C_{LF}, C_{LS}, C_{SS}	PV	fast litter, slow litter, slow soil C contents	kg/m^2
D_N	DV	soil denitrification rate	$kg /m^2 yr$
D_s	DV	water drainage from active soil layer	$kg/m^2 s$
f_{LF}, f_{LS}, f_{SS}	PV	fractions of soluble organic N in the fast litter, slow litter, slow soil N pools (Gerber et al., 2010)	unitless
f_S	PV	soil water content reduction function	unitless
f_T	PV	soil temperature reduction function	unitless
h_s	PV	effective soil depth	m
$L_{DON}, L_{NH_4^+}, L_{NO_3^-}$	PV	soil leaching for DON, ammonium-N, nitrate-N	$kg/m^2 s$
$[N_{DON,av}], [N_{NH_4^+,av}], [N_{NO_3^-,av}]$	PV	concentration of available N in DOM, ammonium-N, nitrate-N pools	kg/m^3
N_{LF}, N_{LS}, N_{SS}	PV	fast litter, slow litter, slow soil N contents	kg/m^2
$N_{NH_4^+}, N_{NO_3^-}$	PV	soil ammonium-N, nitrate-N contents	kg/m^2
S	PV	soil water content	unitless
T	PV	soil temperature	℃
River Equations			
$C_{NO_3^-}$	PV	nitrate-N concentration	μmol N /l
$f_T^{'}$	PV	stream temperature reduction function	unitless
$F_{DON}^{in}, F_{NH_4^+}^{in}, F_{NO_3^-}^{in}$	DV	river inflow of DON, ammonium-N, nitrate-N	$kg/m^2 s$
$F_{DON}^{out}, F_{NH_4^+}^{out}, F_{NO_3^-}^{out}$	DV	river outflow of the DON, ammonium-N, nitrate-N	$kg/m^2 s$
H	IF	river depth	m
$k_{denitr}^{'}$	PV	reaction rate constant for river denitrification	$1/s$
$P_{DON}, P_{NH_4^+}, P_{NO_3^-}$	IF	point sources of DIN, ammonium-N, nitrate-N	$kg/m^2 s$
$R_{DON}, R_{NH_4^+}, R_{NO_3^-}$	DV	DON, ammonium-N, nitrate-N in rivers	kg/m^2
$T^{'}$	PV	water temperature	℃

Fig. 2. Table 2

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