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Biogeosciences Discussions

Interactive comment on "Use of geomorphic, hydrologic, and nitrogen mass balance data to model ecosystem nitrate retention in tidal freshwater wetlands" *by* E. D. Seldomridge and K. L. Prestegaard

Anonymous Referee #1

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General Comments

Seldomridge and Prestegaard present an interesting and timely analysis of the relationships between nitrate retention and geomorphic variables in tidal freshwater marshes of the Patuxent River. Scaling of ecosystem functions with geomorphology has produced valuable models in similar estuarine ecosystems (Hood 2002), but has not yet been attempted in tidal freshwater marshes. The current study is therefore a novel exercise that may advance development of generalized models of tidal freshwater marsh nitrogen retention. I also believe this effort comes at an opportune time. While detailed investigations of nitrogen cycling have greatly advanced our understanding of nitrogen cycling within tidal freshwater marshes (e.g. Bowden et al 1991; Gribsholt et al 2007; Neubauer et al 2005), there has been increasing emphasis on synthesizing this knowledge into predictive models that couple nitrogen cycling in tidal freshwater wetlands with adjoining river and estuarine ecosystems (Davidson and Seitzinger 2006; Ensign et al 2012). The current study is a positive step in this direction.

The study measured nitrogen retention by mass balance at the mouth of three tidal freshwater marsh creeks, and measured geomorphic variables at these three creeks and 264 neighboring creeks within the tidal freshwater Patuxent River. Two empirical relationships were developed, the first between tidal prism and measured nitrate retention, and the second between three geomorphic variables and tidal prism. These relationships were combined to extrapolate nitrate retention to the population (n=264) of marshes to calculate nitrate retention during a spring tidal cycle within the Patuxent River tidal freshwater marsh complex. This method relied on a fairly strong relationship between tidal prism (water volume exchanged over a spring tide) and nitrate retention (presented as moles N per L in table 1, and as a scatter plot in figure 7). I have two overall criticisms of the methodology, and one criticism of the conclusions drawn from the data that are addressed below.

Specific Comments

The study focused on nitrate alone, but nitrite also appeared to be a major component of the inorganic nitrogen budget (figure 2). Since both ions (as well as ammonium) undergo rapid uptake and release within the marsh, a mass balance that includes all inorganic nitrogen forms seems more appropriate for examining ecosystem-scale fluxes between river and marsh. Why not examine the total inorganic nitrogen retention? While the data show that nitrate undergoes the largest decrease in concentration during the ebb tide, it would be more ecologically-meaningful to examine total inorganic nitrogen retention.

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My second criticism is of the method used to calculate the overall nitrate retention presented in figure 8. Data presented in figure 8 were calculated using equations in table 2 where n=6, but only 3 field measurements of nitrate retention are shown in figure 7. Why not include the other 13 observations (shown in open white circles in figure 7) in the equations in table 2? Wouldn't you have greater confidence in the predictions presented in figure 8 given a larger sample size? There is significant deviation between the field observations and corresponding predictions in figure 6 (as is acknowledged in the Results); how does this deviation translate into uncertainty in the calculations in figure 8? I wonder if the uncertainty in these predictions of total nitrate retention is smaller or larger than the differences between bars in figure 8a.

One prominent conclusion of the study is that water volume (tidal prism) is an underlying control of nitrogen retention. While the study demonstrated that the volume of water exchanged through the mouth of a tidal freshwater creek is proportional to the nitrate retained, it is unclear how water volume itself could affect nitrate retention. I would agree that water volume is a predictor of nitrate retention, but I am not convinced that water volume itself limits nitrate retention (as stated in the last sentence of section 4.3). Water volume must be related to some other hydrologic variable (e.g., contact time with marsh sediments as governed by marsh topography and creek morphology) or mechanism (e.g., greater hydraulic gradients along creek banks to drive greater interstitial flow). I would recommend rewriting this conclusion in a way that does not attribute nitrate retention to tidal prism directly. The authors may wish to elaborate on potential mechanisms by which tidal prism affects nitrogen retention.

Additional Comments

1. Tidal prism was estimated based on channel area and tidal range (equation 2). How was depth estimated along the channel length? Presumably there was a decrease in channel depth upstream from the inlet that would affect channel volume and it is not clear how this was accounted for. Equation 2 only estimates the water volume in the channel and does not account for overbank flow onto the marsh. Wouldn't equation

2 under-estimate tidal prism, and therefore affect any comparison between measured and predicted tidal prism? Could this resolve the discrepancy discussed in the last paragraph of section 3.3?

2. Section 2.6 of the Methods presents results of the nutrient measurements. I think these could be moved to the Results section.

3. Equation 3 would be better written as: Sum(Qt(flood)xCt(flood))-Sum(Qt(ebb)xCt(ebb)) since the duration of flood and ebb tides may differ. Different durations of flood and ebb tide would affect the total flux of nitrogen, and the equation as written assumes flood and ebb tide durations are equal.

4. Equation 11 shows n=6, but figure 7 only shows 3 measurements. Presumably the open circles in figure 7 are based on a predicted volume and measured retention. A figure legend is necessary.

5. Equation 12 includes the "integrated average nitrate concentration". It is not clear if this value is equivalent to the flux of nitrate, but it is the total mass of nitrate during flood and ebb tides that would be relevant in equation 12. It is also not clear where these equations were used in the study, since equation 3 was used to calculate the values in table 1. I'm not sure if equations 12 and 13 are particularly important to the study since they are merely a derivation of equation 3.

6. I assume that all calculations described in section 3.5 are for a single spring tide, correct? How was error in nitrate mass calculated?

7. Table 1. Are water volume and tidal prism equivalent? Using both of these terms interchangeably throughout the manuscript is confusing, and it would be better if one was used consistently.

8. Table 1 shows site 1 as having a retention rate of 8.5, but I calculate 9.6. Also, shouldn't the units of nitrate retention rate per volume be micromoles per liter?

9. Table 2. Is "V" volume? Is this equivalent to tidal prism?

10. Figure 5. Panel b x axis could be labeled "distance across channel" so as to not be confused with channel width at the inlet.

11. Figure 6. The caption refers to gray triangles when diamonds are used in the figure.

12. Figure 7. Again, the x axis is equivalent to tidal prism, correct?

Technical Corrections

p 1514 line12: change "shows" to past tense p 1422 line 22: change "marshes" to marsh

References

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