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Interactive comment on "Nutrient dynamics, transfer and retention along the aquatic continuum from land to ocean: towards integration of ecological and biogeochemical models" *by* A. F. Bouwman et al.

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The paper by Bouwman et al addresses an important, broad area of research: integrated modeling of the transfer and processing of nutrients and carbon from land through aquatic systems, ultimately at a global scale.

The authors, particularly the first author (to my knowledge), bring an impressive and very significant background of successful, multi-disciplinary integrated modeling at regional to global scales, such as represented by the IMAGE modeling system (Bouwman et al, 2006) and various aspects of global nutrient budgets and exports by river systems (eg, Bouwman et al, 2011; Seitzinger et al, 2010).

However, I'm afraid the scope of this manuscript is ultimately too ambitious for a single article. The overall modeling scope it covers is quite large as it is. But the paper also tries to do distinct two things: 1. Provide a substantial background (if not comprehensive review, as appropriately pointed out in the manuscript) of relevant ecological concepts and existing biogeochemical modeling approaches. 2. Provide some details and elements of the approach they're likely or planning to pursue for each modeling component. The abstract states that the paper "compares existing river ecology concepts with current approaches to describe river biogeochemistry, and assesses the value of these concepts and approaches for understanding the impacts of interacting global change disturbances on river biogeochemistry. Through merging perspectives, concepts, modeling techniques, we propose integrated model approaches that encompass both aquatic and terrestrial components in heterogeneous landscapes."

Accomplishing these goals successfully in a single article would be difficult. Perhaps inevitably, the results in this manuscript are mixed and uneven. The review of river ecological concepts is up-to-date, representative and well written. But an issue that should be raised is whether "ecological" concepts are really the only relevant, important conceptual frameworks needed (or currently lacking) in addressing the stated modeling goals. Additional important concepts that seem equally relevant involve hydrogeomorphic frameworks, such as presented and reviewed in the special issue of Freshwater Biology introduced by Tockner et al (2002); Church (2002) and Poole (2002) are particularly good examples.

Coverage of different components is uneven. Here I'll focus on the following observations: 1. coverage of carbon is quite weak compared to nutrients 2. coverage of particulates is weak compared to solutes 3. recognition and coverage of large-scale and significant landscapes or environments is weak or inconsistent, particularly regarding large floodplains, mountain watersheds, or high-latitude (permafrost/freeze-thaw) processes

The treatment of carbon compared to "nutrients" (which I define here as N, P and Si) and of particulates compared to solutes provide good illustrations. Carbon dynamics can be quite different from that of nutrients. Unlike N and P, globally important anthropogenic increases in C inputs to rivers are not apparent; unlike Si, C undergoes diverse processes and conversions between particulate, dissolved and gaseous phases. The presentation on DOC (section 4.2.2) is largely restricted to a restatement of the Neff and Asner (2001) review and model – a model that has never been implemented at a large scale due to its complexity; the proposed addition of considerations of DOC quality is very limited and illustrated only by narrow and fairly old approaches (Servais et al, 1987, 1989). Identifying widespread properties of DOM that determine mineralization rates remains a challenging, active area of research. Moreover, the potential role of direct litterfall on streams (eg, Webster et al, 1999) is not mentioned.

A similar critique may be made for particulates, specially POC. The section focused on "delivery of sediment and particulate carbon and nutrients to streams" (4.2.1) focuses entirely on sediments proper, without any mention of carbon (or nutrients). While some of the riverine ecological concepts such as the RCC address POM, their focus is typically on labile POM that's not bound to mineral particles and therefore does not encompass the primary mechanisms for large-scale transport of POC. The manuscript does not discuss relevant conceptual models for mineral-associated POC, such as that of Blair et al (2004). Table 2 does not list particulate nutrient forms under "retention" processes (though the role of reservoir retention is discussed elsewhere). The introduction to section 4 states: "We concentrate on the material flows from below the soil surface to the river mouth". The authors do discuss particulates in several sections, but the focus on "flows from below the soil surface" is representative of a general emphasis or strength on solutes.

Floodplain dynamics and interactions are fundamental hydrological, geomorphological, ecological and biogeochemical features of large rivers not highly constrained by human engineering (eg, Blair et al, 2004; McClain & Naiman, 2008; Melack et al, 2011); such rivers include globally important rivers such as the Amazon and the Ganges. The bio-

geochemical role of floodplains remains difficult to quantify. Floodplains are indeed mentioned in the paper (eg, section 4.3.2, Bank erosion and sediment transport), but it's clear that they represent a blind spot in the overall thrust of the paper. For example, the authors "define rivers as the continuum of the hydrological system from soil, groundwater and riparian zones to the main channel with its hyporheic zone, lakes, reservoirs and wetlands"; the "soils, groundwater, riparian zones, streams, rivers, lakes and reservoirs" sequence of landscape elements is one that is often repeated in the manuscript (eg, p. 8738, 8742, Fig. 1, Table 2) and clearly reflects the dominant paradigm running through this manuscript. This implicit paradigm omits floodplains as river landscapes with two-way interactions with river water, unlike the conventional, unidirectional presentation of "riparian zones" as depicted in Fig. 1. A similar observation could be made about the absence of specific consideration of mountain processes or their linkages to downstream systems (eg, Blair et al, 2004; Church, 2002; McClain & Naiman, 2008; Viviroli & Weingartner, 2004).

Similar instances of uneven coverage could be pointed out. But ultimately, that would not be a constructive exercise. The main problem with this manuscript is that it's too ambitious for a single manuscript. I think it would best be split into two. One would focus on the conceptual review and synthesis, with expanded coverage of other relevant conceptual frameworks beyond purely ecological ones, such as hydrogeomorphic frameworks. The second would then be able to provide a clearer, more balanced, and indeed more detailed presentation of the foundational components of the integrated model that is being designed. Another consideration for the authors is to assess the extent to which they wish to address carbon in their integrated model. Currently it is lumped under the "nutrient" label, but it's apparent that carbon sources and dynamics that may be distinctive relative to those for N and P are not as well conceptualized by the authors as nutrients per se.

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