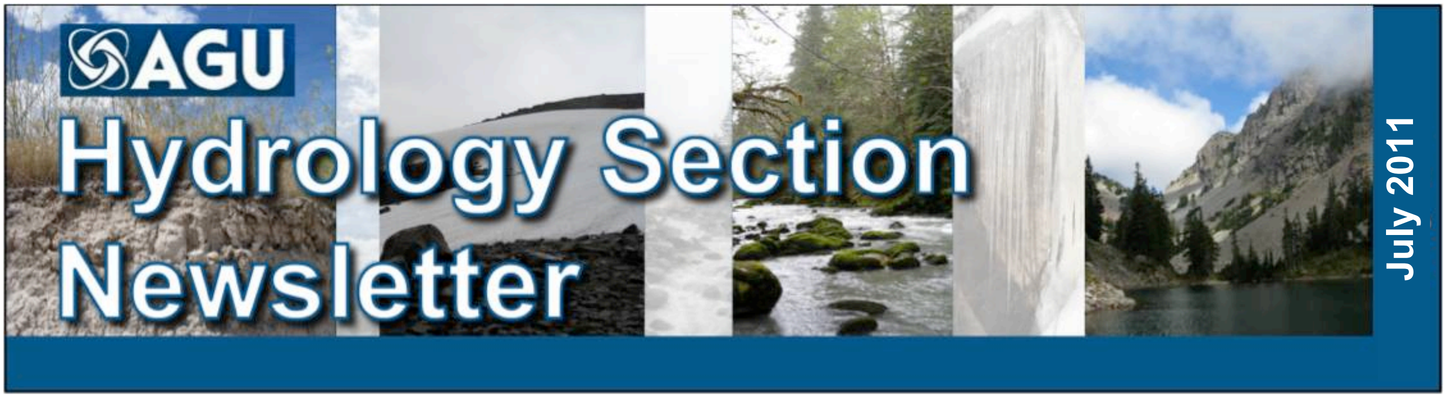
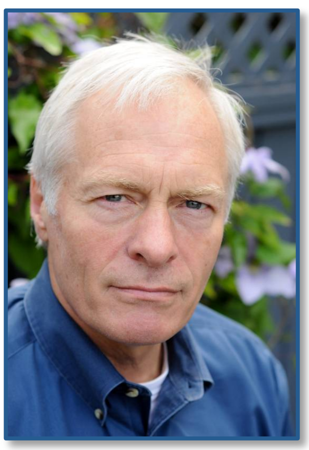


From the Section President

Dennis P. Lettenmaier (University of Washington)

I'd like to open by congratulating the Fellows Class of 2011 who are affiliated with the Section. These include Mary Jo Baedecker (U.S. Geological Survey), Mark Brusseau (University of Arizona), Ed Cook (Lamont-Doherty Earth Observatory), Giuseppe Gambolati (University of Padova), John Melack (University of California, Santa Barbara), and Jeff Richey (University of Washington). You'll find articles in *The Fellows Speak* section of this issue by Cook, Melack, and Richey, and I'm sure you'll find their perspectives intriguing. Articles by Baedecker, Brusseau, and Gambolati will appear in the December issue. Thanks are due to all of those who wrote nominating or supporting letters last year, and I encourage you to participate in this year's process. The deadline for nominations for the Class of 2012 will rapidly be upon us (July 15). If you are thinking of making a Fellows nomination, I'm sure that you'll find the article in this issue by Andrew Barry and Eric Wood insightful and useful.



I also want to congratulate the recipients of Outstanding Student Paper Awards (OSPA) from the Fall 2010 Annual Meeting (FM10). The 30 award recipients were selected from well over 500 student oral and poster presentations at FM10. A great deal of credit goes to our Section Secretary,

Martha Conklin, who has helped to reform the Union's judging process for these presentations. Martha and AGU staff have designed and implemented a process that is now standard across the Union, initial aspects of which were in place for FM10. These new procedures have helped to increase greatly the number of student presentations that are judged. Those of you who have submitted proposals for sessions at this year's Fall Meeting (FM11) may have noticed one aspect of the new procedures that Martha has helped to set in motion – convenors are now required to designate a judges' liaison, who will have overall responsibility for assuring that student presentations in their session are judged. We expect that this will help to increase further the number of judged student presentations.

Speaking of FM11 -- Most of you are probably aware that the deadline for abstract submissions has been moved forward to August 4 (2400 GMT, to be specific; see the AGU web site for details). This change has had a number of ripple effects. Among these are that there is a tight window, immediately following the abstract submission deadline, during which the Section's Fall Meeting Committee (chaired by Matt Rodell, assisted by Mike Cosh and Stefan Kollet) has to organize the program. The problem they face is that the number of hydrology session proposals has exploded over the last few years – from 94 in 2009 to 111 last year to 137 this year! Matt and his committee have already reduced the number from 137 to 115 by "encouraging" aggregation of similar sessions. However, during the period August 6-10, they'll be required to further reduce the number from 115 to (probably) around 80. The exact number is dictated by the number of poster-only sessions and the availability of rooms for oral sessions, and is complicated by joint sessions, but it's been capped at about the same number for at least the last three years. For comparison purposes, at FM10 there were 62 sessions that used the 86 quarter-day oral time slots (some had two or three). What this means is that Matt and his team will be faced with consolidating sessions, probably reducing the number by at least 30-40 (depending on the number of poster-only sessions) over the period August 6-10 (note that this includes a weekend). Those of you who are convening sessions should have already been notified that either you, or a designee, will need to be available by phone during the period August 6-10. Please keep in mind that it is a huge job that Matt, Mike, and Stefan face, and there simply won't be time for negotiation with all 115 convenors. Please recognize the constraints, and do your best to work within them. For instance, it may be possible to sequence talks in combined sessions with similar, but not identical topics, in such a way that there's a progression of subtopics throughout the session. In your discussions, please try to extrapolate whatever complications you face with your session by a factor of 100+, and ask yourself whether "special handling" is really feasible. I'm sure that the FM11 program will be the best ever, but we do need to work together to make it happen.

Finally, I want to note the formation of two new technical committees. The Soil Systems and Critical Zone Processes Committee is joint between the Biogeosciences and Hydrology Sections, and is co-chaired by Dani Or (ETH Zurich) and Yakov Pachepsky (USDA/ARS). They will hold their first meeting at FM11, and like all Hydrology technical committee meetings, theirs will be open to all. The Water and Society technical committee is joint with the Societal Impacts and Policy Sciences Focus Group. The chair is Casey Brown (University of Massachusetts), with a co-chair to be named. Casey's article in this issue describes some of the underlying issues that motivate formation of this committee, which will also meet for the first time at FM11.

In concluding, I want to thank all of you who participated in the guided group discussions at FM10 and who participated in the member survey. Those activities have provided critical input to AGU's ongoing Mission Alignment Project (see my article in the December 2010 issue), results of which will be known later this year. The guided group discussion and survey results (to be released soon) clearly show that hydrologists were well represented, which is certainly in our best interests.

I wish all of you the best for the summer. I hope that you will be able to clear away the administrative clutter that seems to engulf us during the rest of the year, and think science!

The Fellows Speak: The River-to-Ocean Continuum

Jeffrey E. Richey (University of Washington)

Near and dear to the heart of hydrologists is understanding how water moves across the landscape. And, for some hydrologists, who incorporate biogeochemistry into their work, understanding how that water mobilizes and transports dissolved and particulate materials from the landscape to the sea is an additional – if complex – motivation. While water availability is clearly a crucial determinant of terrestrial primary production, the immediate role of freshwaters in broader biogeochemical cycles has been considered to be relatively minor. The classic perspective is that the role of freshwaters is defined as the global export of riverine organic matter to the world's oceans, where long-term preservation of this terrestrially derived organic matter occurs largely from sediments that accumulate along continental margins. But, as summarized by Melack (2011), lakes and rivers appear to play a much broader role than historically thought. Through outgassing to the atmosphere (freshwaters are frequently supersaturated in CO_2 and CH_4) and burial of carbon in lake and reservoir sediments, freshwater systems are not passive conduits but rather dynamic process-rich systems that themselves influence global geochemical balances in both ocean and atmospheric environments.

In the spirit of following water downstream, I will extend the Melack thesis from lakes and rivers to the lower reaches of large rivers, and to their potential direct influences in the ocean. I will emphasize tropical systems, given their high discharge and sediment loads. As with many of the simplifying calculations made in global budgets, broad-brush portrayals of the export of organic carbon from rivers to the sea as "0.5 to 1.0 Gt/y" (Degens et al., 1991, as an early example) do not accurately represent the dynamics of the underlying processes, especially with respect to the coupling of hydrologic and biogeochemical cycles.

Most, if not all, characterizations of the mass flux of material from rivers have been performed at the downstream-most gauging station on that river. Such stations are typically located a considerable distance from the actual confluence of the river with the sea, at a convenient site for gauging, usually above tidal influences. Just outside the mouth, in the "river impacted ocean margin" (McKee et al., 2004), the river continuum transforms. Typically the river slows, deposits a great deal of sediment, and then the water is clear enough for primary production to dominate over respiration in the surface layer. Scientists (and their funding agencies) have mostly ignored this critical transition region, creating a severe gap in our knowledge of material transfer on Earth.

In the case of the Amazon River, for example, the defining gauge is located at Óbidos, some 900 km from the sea. In the reach below Óbidos, three major tributaries (Tapajós, Xingú, and Tocantins/Araguaia), plus many smaller tributaries and local flood plain drainages, add ~40,000 m^3/s, or an additional 20% to the river's total annual discharge (about two Mississippi Rivers' worth). It takes ~7 transit days from Óbidos before the Amazon meets the sea. These tributaries all have large, estuarine-like "mouthbays," which modify upstream chemical signals and yield water with high primary production. It is a region of extensive varzéas (floodplain lakes), with high production, and high rates of outgassing of CO_2 and CH_4. Hence these additional waters have very different chemical and biological signatures from the sediment-rich main stem, likely with the potential to alter the metabolism of the waters flowing to the sea. To make life even more complicated, the primary discharge of the Amazon is to the north of Marajó Island, but the water discharged to the south of it is likely constituted primarily of water from the Tocantins and the Xingú, such that the actual marine delivery from the southern arm of the Amazon will be quite different from the northern branch, with unknown consequences for the sea.

Further, the physical dynamics of the lower river are extremely complex. A comparison of fluxes between Óbidos and offshore sediment accumulation by Nittrouer et al. (1995) suggested that roughly a third of the sediment from upstream is captured somewhere in the tidal river. The recent development of acoustic measurement techniques (ADCP) that permit rapid discharge measurements provides insights into the dynamics of these lower reaches (by making continuous cross-channel transects for 13 hours covering the tidal cycle). Tides induce significant, local semi-diurnal discharge fluctuations. Kosuth et al. (2009) reported differences of 30,000 m^3/s to 130,000 m^3/s at Almeirim (nearly 500 km upstream) and tidal wave propagation as far as Óbidos, during a low water period. Large flow reversals are observed closer to the sea (M.S. da Silva, pers. comm). Such extreme fluctuations will clearly have a large impact on any attempts to measure material flux.

The next part of the River-Ocean Continuum occurs in the river plume itself. The Amazon River generates an offshore plume (Fig. 1) that covers ~2 million km^2 (about a third the area of the entire Amazon basin) of the western tropical North Atlantic Ocean (WTNA) each summer with a thin (5–10 m) layer of low-inorganic-carbon, and low-salinity (mesohaline) water (Cooley et al., 2007). The tropical North Atlantic Ocean is generally considered a net source of ~30 Tg Cy^{-1} to the atmosphere (Takahashi et al., 2002). But the results from more recent direct measurements (Subramaniam et al., 2008) indicated a biologically mediated C sink of about 15 Tg/y in the mesohaline region. They believe this resulted from excess riverine phosphorus (P), silica (Si), and iron (Fe) input and N_2-fixation within the Amazon plume (by diatom-diazotroph symbiotic associations, DDAs). Combined with a sink of about 8 Tg/y in the inner plume, from direct river N, new production in the plume driven by river nutrients, appears to reverse the normal tropical surface ocean condition and leads to CO_2 uptake and sequestration in areas that would otherwise be outgassing. But the calculation of the plume drawdown is dependent on an accurate knowledge of the river end member's total alkalinity and dissolved inorganic carbon (DIC), but these are currently poorly quantified (Cooley et al., 2007).

To put these values into perspective, Richey et al. (1990) reported that the annual flux of total organic carbon at Óbidos was 36 Tg/y (*cf.* to direct outgassing to the atmosphere from the river system of about 500 Tg/y; Richey et al., 2002). That is, the river export of organic carbon to the sea is roughly equivalent to the river-supported new production in the plume. Therefore, inclusion of the terrestrial-driven marine fixation would essentially double the "effective" impact of the river on the plume. It could be argued that the carbon budget of the Amazon should be extended to include the oceanic component.

How relevant are these results to other large tropical rivers? Sediment trapping has been observed in, for example, the Ganges-Brahmaputra, by Goodbred and Kuehl (1999). Although the Amazon represents the largest riverine input to the tropical ocean, there are numerous other tropical rivers that deliver large volumes of water with ''excess'' P and Si, with the presence of DDAs and other N_2-fixing symbionts, (Subramanian et al., 2008). Hence carbon sequestration by DDAs associated with excess nutrients supplied by tropical river plumes may be a globally significant phenomenon, and tropical mesohaline waters are a potentially important interface between terrestrial and oceanic realms.

Figure 1: True-color image of the Amazon River sediment outflow (light brown), and the formation of the Amazon plume (dark green) into the Atlantic Ocean (modified from Subramaniam et al., 2008).

A discussion of this type would not be complete without consideration of how the tropical river-ocean continuum will fare in the Anthropocene (*sensu* Syvitski and Kettner, 2011). The impact of dams is well-documented in global riverine literature, but many of the high-sediment rivers of the tropics have escaped damming in the past. But there is currently a "hydropower renaissance" in the world. Emerging global dynamics (developing regions, re-visiting carbon- and nuclear based energy) are contributing to an expansion, or desire for expansion of hydropower. This is especially true in the tropics. New dams are under development in the Amazon (on the Madeira and Xingú Rivers, with others planned). A series of dams is being planned for the lower Mekong, including in Cambodia, as well as multiple dams on tributaries in Laos (Grumbine and Xu, 2011). The obvious question is: what will the effect of these new dams be on the river-ocean continuum in these regions? Not to mention on riverine ecosystems and the human ecosystems that depend on the rivers for food, potable water, waste disposal and transportation? Adding to the dam considerations are changes in flow regimes from land use and climate change.

In summary, a more thorough consideration of the river-ocean continuum poses a series of interesting, and important, questions.

- What is the interplay of hydrodynamics and biogeochemistry in lower river basins (below the "last" gauge), and how does that interplay impact the actual delivery of dissolved and particulate materials to the sea and to the atmosphere?
- How much does river-supplied P, Fe, and Si (either dissolved or particulate) fuel a significant plume CO_2 drawdown by diazotrophs offshore, and how universal is this phenomenon?
- How will new dams and shifts in temperature, precipitation, and land use alter biogeochemical cycling across the river-ocean continuum?
- And what are the economic, ecological and climatic impacts of these phenomenon?

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