B02: That biogeochemistry has a short attention span! Insights for scaling

Conveners: Colin Whitfield[1], and Nora Casson[2]

Co-chairs: Colin Whitfield[1], and Nora Casson[2]

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Session Description

Many hydrochemical and biogeochemical processes are extremely variable in both space and time. Despite technological advances, there are often significant barriers to characterizing the full complexity of these processes. A fundamental challenge of this work is scaling from short-term dynamics to longer time scales and understanding the importance of transient biogeochemical processes in larger scale patterns. This is particularly important for understanding how biogeochemical cycles respond to environmental drivers, including precipitation events, temperature fluctuations and redox conditions, among others. This session will feature contributions from researchers investigating transient biogeochemical processes. We encourage submissions with a focus on short-term biogeochemical patterns and those that address the challenges of scaling local or transient dynamics to larger scales, through novel technologies or new quantitative approaches.

Primary Affiliation: Biogeosciences / Hydrology

NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION B02a

Chairs: Colin Whitfield and Nora Casson **Room: AERL 120**

Wednesday, May 31st

TIME	AUTHORS	TITLE
9:00	M.Q. Morison*, R.M. Petrone, M.L. Macrae & L. Fishback [Invited]	Capturing temporal and spatial variability in the chemistry of shallow permafrost ponds
9:15	Cavaliere, E.*, Baulch, H., & Koehler, G.	The rise and fall of nutrients in ice-covered wetlands
9:30	O. Ahmed, J. Leathers, K. Nugent, T. Prentice, M. Sauer, H. Baulch, N. Casson, R. North, J. Venkiteswaran, & C. Whitfield	The effect of freeze-thaw cycles on nutrient release from wetland macrophytes in North America
9:45	A. Ducharme*, N. Casson, S. Higgins, M. Paterson & C. Emmerton	The Effect of Topography and Hydrology on DOC Export to Streams at the Experimental Lakes Area in Northwestern Ontario
10:00	N.J. Casson & A. Ducharme	The relative importance of internal vs. external controls on DOC concentrations in streams and lakes: insights for scaling
10:15	M.S. Johnson, A.J. Jollymore, R.S. Jassal, I. Hawthorne & T.A. Black	Carbon connectivity at the terrestrial-aquatic interface as a function of ecohydrology and forest management in a Douglas-fir watershed

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SUBMITTED ABSTRACTS

B02-01: Capturing temporal and spatial variability in the chemistry of shallow permafrost ponds

Matthew Q Morison[1*], Richard M Petrone[1], Merrin L Macrae[1] and LeeAnn Fishback[2]

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Abstract
Across the circumpolar north, the fate of small freshwater ponds and lakes (< 1 km^2) has been the subject of scientific interest due to their ubiquity in the landscape, their potential to inform researchers about past climates, and shed insight into future climates. A changing climate has implications for the capacity of ponds and lakes to support organisms and store carbon, which in turn has important feedbacks to climate change. Thus, an improved understanding of pond biogeochemistry is needed. To characterize spatial and temporal patterns, a suite of tundra ponds were examined to determine (1) Does temporal variability exceed spatial variability? (2) If temporal variability exists, do all ponds (or groups of ponds) behave in a similar temporal pattern, linked to season or hydrology? Six shallow ponds located in the Hudson Bay Lowlands region were monitored between May-October 2015 (inclusive, spanning the entire open-water period). The ponds span a range of biophysical conditions including pond area, perimeter, depth, and presence/absence of macrophytes. Water samples were collected regularly, both bimonthly over the snow free season, and intensively during and following a large summer storm event. Samples were analyzed for nitrogen speciation (nitrate, ammonium, dissolved organic nitrogen) and major ions (Cl^-, SO_4^{2-}, K^+, Ca^{2+}, Mg^{2+}, Na^+). Across all ponds, temporal variability (across the season and within a single rain event) exceeded spatial variability (variation among ponds) in concentrations of several major ion species (chloride, sulphate, sodium, potassium, and calcium). Evapoconcentration and dilution of pond water with precipitation and runoff inputs were the dominant processes influencing a set of major ions which are hydrologically driven (DON, chloride, sodium, potassium, and magnesium), whereas the dissolved inorganic nitrogen species were likely mediated by processes within ponds. This work demonstrates the importance of understanding hydrologically-driven chemodynamics in permafrost ponds on multiple scales (seasonal and event scale). [300 words]

Presentation type: Oral Presentation

B02-02: The rise and fall of nutrients in ice-covered wetlands

Cavaliere, E.[1*], Baulch, H.[1], and Koehler, G.[2]

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Abstract:
Wetlands throughout Canada experience ice-cover. Many experience winter anoxia for several months each year, likely leading to important biogeochemical changes. With little work done in winter months, our understanding of the biogeochemistry wetlands has critical gaps. In the prairie pothole region, wetlands are most likely to 'fill and spill' in spring – meaning that winter and spring conditions may be important determinants of downstream solute export. Here, we explored changes in biogeochemistry of three prairie potholes across three winter periods with detailed sampling during the spring melt period. We demonstrate that winter, and ice out in prairie wetlands have several distinct phases. Stable isotopes of water indicate that these ponds are isolated from the surrounding landscape in winter. Dissolved oxygen concentrations begin to drop with the onset of ice cover, and near complete anoxia is observed within one to two months. Around that same time, there is a peak in nitrous oxide concentrations. By the end of winter, ammonium concentrations are quite high. During the melt period, the ponds undergo dramatic physical, chemical and biological changes due to increases in light, loss of ice cover, introduction of oxygen, and the input of melt water. Nutrient concentrations decrease rapidly as ice melt begins. During this period nitrification is low, instead, loss of ammonium is associated with high uptake of algae and bacteria. In the next phase, spring snowmelt brings nitrate to the ponds, but ammonium and phosphorus concentrations stay low. Climate change will alter pond nutrient dynamics by decreasing ice-cover duration and increasing nutrient demand through algal and bacterial uptake. To more fully understand what this means to wetland nutrient cycling, we need to better understand impacts across seasons, recognizing changes in winter and spring phases may have important impacts on wetland productivity and downstream nutrient export.

Presentation type: oral presentation

B02-03: The effect of freeze-thaw cycles on nutrient release from wetland macrophytes in North America

Osama Ahmed[1], Jeremy Leathers[2], Katy Nugent[1], Tyler Prentice[3], Matthew Sauer[4], Helen Baulch[1], Nora Casson[2], Rebecca North[4], Jason Venkiteswaran[3], and Colin Whitfield[1]

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Abstract
Wetlands are an important feature of many ecosystems and are well known to provide numerous ecological services, including nutrient retention. The emergent wetland macrophyte *Typha* (cattail) is a dominant species in many wetlands, and an ideal candidate in artificial wetlands used for wastewater treatment owing to its nutrient retention capacity. While P, N and C can be elevated during snowmelt runoff, the question of how winter conditions may impact nutrient release from *Typha* has not been addressed. Here we will present the results of experimental investigations of the importance of freeze-thaw cycles for nutrient release from *Typha*. We collected *Typha* from a range of wetlands in 3 provinces (MB, SK, ON) and 1 state (MO) during autumn and exposed the plants to freeze-thaw cycles in the laboratory. Our results suggest that freeze-thaw cycles can induce transient leaching of nutrients from these plants. The effects may be enhanced where freeze-thaw conditions take place shortly after the growing season. [155 words]

Presentation type: Oral Presentation

B02-04: The Effect of Topography and Hydrology on DOC Export to Streams at the Experimental Lakes Area in Northwestern Ontario

Adrienne Ducharme[1*], Nora Casson[2], Scott Higgins[3], Michael Paterson[3] and Craig Emmerton[3]

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Abstract
Dissolved organic carbon (DOC) is an important control on the functioning of aquatic ecosystems as it influences many parameters, including light penetration, temperature, microbial respiration, pH and mobility of metals. DOC concentration increases have been widely observed in lakes in recent years in the Northern Hemisphere but there is no consensus around the mechanisms for this increase. One hypothesis is that climate-driven changes in hydrology result in changes in terrestrial DOC export to lakes. More recent work suggests that watershed-specific hydrologic and topographic characteristics play an important role in controlling DOC export from forested catchments. During high-flow hydrologic events, the mechanisms of DOC transport can change compared to baseflow conditions and therefore routine monitoring programs might misrepresent both patterns and mechanisms of DOC export. This study examined how variability in catchment wetland coverage and hydrological conditions (e.g., storm events, spring melt) influenced catchment DOC export to boreal headwater streams using two approaches. First, long-term stream chemistry and discharge records were used to evaluate trends and variability in DOC export from three subcatchments. Secondly, we used an end-member mixing analysis (EMMA) to estimate the number of potential end-members and their proportions that might be mixing to form stream water for each of the three subcatchments. Average annual DOC concentrations in these streams are not increasing significantly, and in fact the one stream draining a wetland-dominated subcatchment shows a significant decrease over the 26 year record (Sen Slope = -42.3 $\mu mol\ L^{-1}\ y^{-1}$; p=0.01). Notably, in this stream DOC concentrations are not significantly correlated with precipitation (p=0.06), whereas in the other two streams, this relationship is significant (p<0.05 in both cases). These results suggest that considering watershed-specific characteristics are important when scaling observed changes in DOC at intensively monitored catchments across regions. [290 words]

Presentation type: Oral Presentation

B02-05: The relative importance of internal vs. external controls on DOC concentrations in streams and lakes: insights for scaling

Nora J. Casson[1] and Adrienne Ducharme[2]

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Abstract
While long-term increases in aquatic DOC concentrations have been widely reported across the northern hemisphere, detailed investigations of seasonal and storm-based patterns have suggested that mechanisms controlling DOC transport may be highly site-specific. Furthermore, at sites where long-term records of both streams and lake chemistry exist, changes in DOC are not always coherent. Aquatic DOC concentrations will be influenced by both changes to external (e.g. decomposition, runoff dynamics) and internal processes (e.g. photo-oxidation, sediment storage). The relative importance of internal vs. external controls will vary depending on the hydrological connectivity of systems, both to the terrestrial catchment and also to other streams or lakes. In order to effectively scale from intensively monitored sites across a region, understanding the balance of these controls is critical. To illustrate this point, we use long-term records (1985 – 2010) from three headwater streams and the lake into which they drain to investigate controls on annual and seasonal DOC dynamics. The study site is located in the Canadian boreal forest, at the Experimental Lakes Area (IISD-ELA) in northwestern Ontario, and is underlain by Precambrian shield geology. Seasonal stream DOC concentrations are highly variable (ranging from 76 – 4424 $\mu g\ L^{-1}$) and show contrasting patterns with climatic factors (temperature and precipitation). Coherence between stream and lake DOC dynamics varies throughout the record and also depends on climatic factors. These results highlight some of the challenges when trying to reconcile local controls on stream and lake chemistry with regional drivers.

Presentation type: Oral

B02-06: Carbon connectivity at the terrestrial-aquatic interface as a function of ecohydrology and forest management in a Douglas-fir watershed

Mark S. Johnson[1,2], Ashlee J. Jollymore[1], Rachhpal S. Jassal[3], I. Hawthorne[2] and T. Andrew Black[3]

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Abstract
Hydrologic flowpaths between terrestrial and aquatic ecosystems also represent carbon conduits, resulting in connectivity of a range of carbon compounds across the terrestrial-aquatic interface. These carbon drainage fluxes vary episodically, seasonally, and in response to management factors, and are co-dependent on interacting landscape and climatic factors that affect watershed connectivity. Here, we present a study on connectivity-conditioned fluxes of dissolved organic carbon (DOC) and dissolved CO_2 from a 90-hectare catchment to a first-order stream in a Douglas-fir forest in the Pacific Northwest near Campbell River, British Columbia. Data include high-frequency in-situ measurements of DOC fluxes, DOC optical characteristics, and CO_2 fluxes in groundwater and surface water. Temporal lags between terrestrial carbon production and transport are assessed by comparing eddy covariance measurements of biospheric CO_2 dynamics with DOC and CO_2 dynamics at the terrestrial-aquatic interface. We then discuss controls on hydrological connectivity that mediate these carbon transfers using remote sensing of spatial patterns in forest canopy phenology in concert with ground water level and soil moisture data. Periods of low connectivity were characterized by carbon fluxes dominated by dissolved CO_2 produced in soils and ultimately transported to streams by groundwater. Periods of higher connectivity resulted in carbon fluxes with a larger DOC fraction, with DOC characteristics varying on event and seasonal bases. We also discuss the impact of forest harvest on carbon connectivity at the terrestrial-aquatic interface.

Presentation type: Oral Presentation