GLEON 13 Cool Things Abstracts

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Since 2010 our group at the UQÀM has been developing a large-scale research project focusing on C biogeochemistry and greenhouse gas in aquatic systems in Northern Québec. This project aims at quantifying and integrating lake, stream, river and wetland C cycling processes in the major types of boreal landscapes in Québec. The project has two main components: The first is comparative in its conception, and focuses on determining cross-system patterns along broad environmental and geographic gradients. The second component explores temporal variability in these processes, and their mechanistic underpinnings, in a small set of sentinel watersheds distributed across the boreal landscape. This component involves the continuous, long-term monitoring of C processes and a suite of complementary variables in a target lake and its inlet rivers in each of these sentinel watersheds. The lakes will be instrumented with autonomous buoys, which will allow us to monitor O_2 and CO_2 dynamics and link these to the lake physical structure, biological parameters and climate. Here we present the first of the four planned sentinel sites: Lake Croche, which is located one hour North of Montreal and represents our southernmost sentinel system. Lake Croche is within the Université de Montreal field station and does not have public access, so it is logistically convenient. In addition, it has been studied for over 30 years, and there are currently several major ongoing research projects, including a large-scale manipulation of temperature in one of its basins to explore impacts of climate change. Our aim is for Lake Croche to soon be part of the GLEON network.

Paul C. Hanson[1]

Control of dissolved oxygen from days to months: complex data and models lead to dodgy interpretation

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High-frequency data from 15 GLEON lakes were used to assess scales of variability ranging from days to months. Relationships between dissolved oxygen and predictor variables -- temperature, PAR, water column stability -- were scale dependent, lake dependent, and complex. To explain most of the observed variability in dissolved oxygen required that model complexity scale inversely with time. Further Interpretation of results will require a large gradient in limnological experience, coupled with diverse skill sets and tea leaves.

Bruce R. HARGREAVES[1]

Sentinel Responses to Extreme Weather in a Small Seepage Lake: Changes in hydrologic flux.

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With the increasing probability of extreme weather as a response to global warming it is important to understand how aquatic ecosystems in different geographic regions may respond. The lake-catchment ecosystem is well suited to evaluate hydrologic response to the environmental forcing of droughts and major storms. Small seepage lakes (lacking inputs from groundwater or streams) represent an interesting case because of their near-constant concentration of dissolved organic carbon but large variations in UV transparency. Lake Lacawac is a seepage lake in NE Pennsylvania with extensive data since 1993 on UV transparency and weather and since 1997 on hydrology. Conventional lake buoy weather data and water temperatures have been supplemented with high-resolution water level (0.1mm hourly resolution), stream outflow modeling from lake level (with help from beavers), and evaporation calculated from weather and lake data. Combining these measurements and calculations provides estimates of cumulative storm and snowmelt runoff, and hourly net seepage. Net seepage is correlated with average Precipitation minus Evaporation (a proxy for groundwater recharge), while runoff as a fraction of watershed precipitation varies with nominal wetness of the catchment. One of the outcomes of collecting this large data set is the ability to calculate changes in net seepage during dry and wet periods, changes in the catchment yield of runoff from rain events and snowmelt, and changes in the hydraulic residence time. Typical seasonal patterns will be contrasted with extreme weather events to show the utility of this approach, and to suggest its applicability to other instrumented lakes.

Scott Higgins, Ray Hesslein, Mike Stainton, Morris Holoka, Stephen Page

Novel approaches for assessing ecosystem metabolism and greenhouse gas fluxes at the Experimental Lakes Area

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The Experimental Lakes Area (ELA), jointly operated by Fisheries and Oceans Canada and Environment Canada, is a remote field station situated in the boreal shield of Northwestern Ontario, Canada. Researchers at the ELA have access to >80 lakes in near pristine watersheds set aside for research purposes. Research at the ELA has two primary foci: A long-term monitoring program (LTER) for air quality and water quality (from water chemistry to fish populations), and whole-ecosystem/watershed manipulations. Interest on the impacts of hydroelectric reservoir creation on greenhouse gas fluxes led our team to develop a deployable automated 'gas box' system to assess concentrations of CO_2, DIC and CH_4 from one to six depths in the water column. Optical sensors for O_2, chlorophyll (Chl), phycocyanin, and DOC were later added to expand the utility of this system to assess ecosystem metabolism and address other research questions. More recently, our team has developed a 'smart' vertical profiling system to deploy an instrument package (optical sensors for, O_2, and Chl and phycocyanin are currently being used) throughout the water column at small depth increments (5-10 cm). The 'dynamic profiler' system is being used to help assess ecosystem experiments on the impacts of aquaculture and climate change. This year our team is developing an *in situ* 'water-column incubator' to remove the effects of air-water and sediment-water gas exchange, and isolate water-column metabolism from whole-lake metabolism. An overview of these novel systems, the data they generate, and their utility for answering a variety of research questions will be presented.

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Three Gorges Reservoir

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Three Gorges Reservoir will be introduced as a prospective GLEON lake and what we've learned about the reservoir from 4 years of water quality monitoring will be summarized. The presentation will include a brief description of the reservoir and its hydrologic characteristics, the study area and monitoring program. Thermal stratification in tributary bays results in density currents that supply nutrients to the bays. Water-level fluctuations produce short term changes in Z_{eu}/Z_{mix} in addition to the longer term seasonal variation and can strongly affect algal blooms. An eutrophication model is being developed based on current data and it will be refined as new data becomes available. Deploying a buoy equipped to collect high frequency data is important for refining and improving the model and understanding the system's hydrodynamics, particularly the effect of altering Z_{eu}/Z_{mix} on phytoplankton dynamics.

Medina O. KADIRI

Seasonal trend in the primary productivity of a tropical African reservoir

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The primary productivity of Ikpoba Reservoir, a small tropical reservoir in West African sub-region was estimated *in situ* at monthly interval for two years. The values of gross primary productivity (GPP) and net primary productivity (NPP) though highly variable, discernible peaks were obtained in the dry season whereas lowest values were recorded in the rainy season especially in the second annual seasonal cycle. Decreased primary production during the rainy season was due to decline in water column stability, high turbidity and concomitant low light intensity. On the contrary, stability of water column, favourable climatic conditions and optical properties were responsible for high productivity during the dry season. In the first annual cycle, primary productivity was chiefly due to desmids in the rainy season, blue greens and diatoms in the dry season while in the second annual cycle, primary productivity was mainly due to blue greens in the rainy season and desmids and diatoms in the dry season.. Comparatively, the primary productivity of the Ikpoba Reservoir is low relative to those reported for Eastern African lakes and this is ascribed to low nutrient levels (mean conductivity =16.32 ± 0.37µS/cm).

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Variations of DO as a stress factor in various freshwater ecosystems of Korea and weather conditions as their driving factor

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Abnormal concentration of dissolved oxygen, depletion and supersaturation, can be stressful to aquatic animals. Diel variations of DO were measured at high frequency by automatic logging sensors in various freshwater bodies of South Korea and their responses to weather conditions were analyzed. In many rural streams supersaturation of oxygen seems to be a major stress factor, while urban streams showed larger diel variations and occasional depletion, especially after rain events. A eutrophic levee lake (Wupo) covered with macrophytes showed anoxic pelagic zone basically, but oxygen was supplied episodically after rain events. A eutrophic lagoon (Youngrang) with consistent supersaturation in the epilimnion and hypoxia in the hypolimnion showed intermittent drop of epilimnetic DO after a spate of strong wind due to the entrainment of anoxic hypolimnion, resulting in occasional fish kill events. In the bioassay of toxicity using fish supersaturation caused the increase of stress biomarker hormone, cortisol.

Kyle S. Kwaiser[1], Susan P. Hendricks[2], Kevin C. Rose[3], Heidi Purcell[4]

What transpired at the Freshwater Advanced Aquatic Sensor Workshop

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The first known collaboration between members of the Global Lake Ecological Observatory Network (GLEON) and the Alliance for Coastal Technologies (ACT) brought together 44 scientists, engineers, and industrial representatives for a two-day training workshop. Experience levels varied from novice to expert as presentations and demonstrations from 18 participants covered a broad spectrum of topics related to advanced aquatic sensors. Topics covered included sensor selection and evaluation, case studies of deployed buoys, data management, data quality control, platform demonstrations and software demonstrations. The workshop took place from September 12-13th, 2011 at the University of Michigan Biological Station. Other represented organizations included Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Consortium of Universities for the Advancement of Hyrdologic Science (CUAHSI), the University of Waikato's Lake Ecosystem Restoration New Zealand (LERNZ) program, and the University of Michigan's Ocean Engineering Laboratory. Informal conversations with workshop participants showed that this workshop format was highly productive, well received, and there exists a need for further similar/complementary training opportunities.

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Deep Chlorophyll Maxima: Where do they form and what implications do they have for ecosystem structure and metabolism estimates?

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Research has demonstrated that deep chlorophyll maxima (DCMs) can represent well over 50% of total productivity in freshwaters. Despite the potential importance of this hypolimnetic production, the physical controls on DCMs remain poorly constrained and ecosystem metabolism measurements are often estimated from a single epilimnetic sensor. We used a Biospherical Instruments profiling radiometer combined with simultaneous casts of a Turner Designs C6 (with a C7 chlorophyll fluorometer) to measure transparency to both UV (320, 380nm UV) and PAR (400-700nm) and identify the presence/absence of deep chlorophyll maxima in over 75 lakes throughout North America and New Zealand. We found that DCMs were never observed when 1% of PAR exceeded the maximum depth of the site or when 1% PAR did not exceed the depth of the mixed layer. In the 50 lakes where we identified a DCM, we found a very strong ($R^2>0.9$) significant ($p<0.001$) linear relationship between PAR transparency and DCM depth. These findings highlight the importance of physical controls (mixing depth and transparency) on DCM formation, although these results do not dismiss the importance of other factors, such as nutrients, in also playing a role in DCM formation. As the presence of DCMs has important implications for ecosystem metabolism estimates, these results imply that the physical characteristics (transparency and mixed layer depth) of lakes can control the relative vertical distribution of GPP (gross primary productivity) and R (respiration) within the water column of lakes. These results also provide an explanation for how sharp transitions may occur in observed lake trophic status and epilimnetic productivity concurrent with degradation in transparency.

Nihar R. Samal[1], Don Pierson[2], and Aavudai Anandhi[3]

Analysis of future scenarios of simulated water temperature data using Lake Analyzer

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Future climate scenarios were derived by examining the differences between simulations of baseline (1980-2000) and future (2045-2065 and 2080-2100) time periods associated with three GCM models available from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (CMIP3) dataset. Based on these differences, change factors were developed and applied to local records of meterorlogical data to produce future scenarios of air temperature, precipitation, humidity, solar radiation and wind speed. These data are used to drive the Generalised Watershed Loading Functions-Variable Source Area (GWLF-VSA) watershed model to simulate the future inflows. A one dimensional hydrothermal model is applied to simulate the vertical water temperature over historical data sets and future scenarios for a reservoir. Stratification and mixing indices are derived from the simulated water temperature and the wind speed under the different climate scenarios using the lake analyzer program developed by GLEON network. Our results suggest that under future conditions water temperature will be warmer, stratification will be of longer duration and that the resulting vertical temperartutre gradients will be stronger. On average we predict that the length of stratification will increase by 10 and 21 days in the case of the A1B and A2 emmission scenarios. Water temperature under these different climate scenarios will increase, with the mean surface water temperature is increasing by 4.5% and 9.8% while the mean bottom water temperature is increased by 3.1% and 6.5%. The schmidt stability calculated over the multiple years of baseline and future scenarisos was found to increase by 15.27 % (A1B Scenario) and 29.4% (A2 Scenario) and buoyancy frequency showed a similar increase of 14.54% (A1B Scenario) and 25.83% (A2 Scenario) in the future scenarios. The wedderburn number and Lake number both displays a high amount of variability and both of these dimensionless indices explains the potential for diapycnal mixing events. Dispite the high levels of variability both indexs increase in value under the future climate scenarios suggesting that the reservoir will experience stronger and longer period of stratification with weak likelihood of substantial diapycnal mixing during the stable stratification period.

Kew words: climate change, stratification and mixing indices, one dimensional model, watershed model, timing of stratification, lake analyzer.

Ashley SHADE[1], Jack Gilbert[2,3], and the Earth Microbiome Project[3]

Introducing the Earth Microbiome Project: systematically characterizing microbial life from a microbial perspective

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The Earth Microbiome Project is a multidisciplinary initiative to systematically characterize global taxonomic and functional microbial diversity on this planet, from a microbe's perspective. The EMP will explore different biomes using microbial communities from samples currently available from researchers across the globe, and then compliment this with new samples to fill in the gaps in biome representation. The EMP will analyze at least 200,000 samples from these communities using metagenomics, metatranscriptomics and amplicon 16S rRNA sequencing to produce a global Gene Atlas describing protein space, environmental metabolic models for each biome, approximately 500,000 reconstructed microbial genomes, a global metabolic model, and a data-analysis portal for visualization of all information. For the EMP to be successful, well-curated metadata are imperative for interpreting patterns of microbial diversity across biomes. GLEON, with its rich sensor metadata, strong representation of aquatic microbial ecologists, and collaborative spirit, may be helpful to the EMP's global mission. In return, GLEON researchers would receive a plethora of sequencing data from their study sites.

Robyn SMYTH[1], Kevin ROSE[1], Paul Hanson[2], Emily Kara[2], Gordon Holtgrieve[3], Denise Bruesewitz[4], and Kathleen Weathers[5]

Novel Applications of High-frequency Sensor Data in Aquatic Ecosystems: summary of the GLEON session at the Ecological Society of America meeting, Austin, TX.

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In August 2011, Paul Hanson and Cayelan Carey brought together several GLEON scientists to present research findings in a special organized session at the annual meeting of Ecological Society of America. Several presenters drew upon high frequency dissolved oxygen (DO) measurements that are made at many GLEON sites. Paul Hanson discussed variability in DO and potential drivers across timescales ranging from days to years. Denise Bruesewitz showed relationships between productivity, respiration, land use and nutrient concentrations across 25 GLEON lakes. Gordon Holtgrieve showed several patterns in nocturnal respiration rates (constant, linear, exponential, and sigmoidal) and discussed implications for estimating ecosystem metabolism. Robyn Smyth showed that the mixed layer depth is often more shallow than what is commonly used in lake metabolism studies by comparing direct measurements of turbulent mixing to high frequency temperature measurements more commonly used to define mixing depth. Kevin Rose presented a comparison of traditional and novel allochthony indicators across a range of freshwater lakes and discussed their relevance to GLEON data. Emily Kara compared time series observations from the buoy on Lake Mendota to output from the DYRESM-CAEDYM lake model. Finally, Kathleen Weathers presented an overview of GLEON and described collaborative outreach efforts and citizen science at Lake Sunapee.

Peter Staehr[1], Biel Obrador[2] and Jesper Christensen[3]

Application of profiling buoys to determine whole lake metabolism in stratified lakes: Relevance of the metalimnetic zone

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Although the diel DO technique has been refined and improved substantially since its initial applications, there remain numerous uncertainties regarding the proportion of whole-lake metabolism being measured. An important uncertainty arises from the fact that most lake metabolism studies only deploy DO sondes at one central station at shallow depth. Such an approach essentially assumes that the sensor integrating local processes of oxygen production and consumption is representative of these processes on a whole-lake scale. While this is likely in small, shallow, well-mixed lakes, recent research has shown that there is a zone of influence on the sensor, and those sensors at different locations and different depths within the same lake can yield different estimates of GPP, R, and NEP. Here we present results from a newly developed method to determine depth specific rates of GPP, NEP and R using frequent automated profiles of dissolved oxygen (DO) and temperature. Metabolic rate calculations were made for three lakes using a diel DO methodology that integrates rates across the entire depth profile and includes DO exchange between depth-layers driven by mixed layer deepening and eddy diffusivity. We show that not taking account of vertical differences in metabolism will generally underestimate GPP and R, and may lead the erroneously conclusion of areal NEP > 0 during summer. Metabolic processes occurring in the metalimnion are shown to be very important for overall carbon processing in lakes of different trophic status, during summer stratification. Estimating metabolism from vertically distributed DO measurements is recommended in stratified lakes because it permits assessment of vertical exchange between epilimnetic and hypolimnetic waters and provides insight into metalimnetic and benthic metabolism.

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Renconciling differences in the temperature-dependence of ecosystem respiration across time scales and ecosystem types

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Ecosystem respiration is the biotic conversion of organic carbon to CO_2 by all the organisms in an ecosystem, including both consumers and primary producers. Respiration exhibits an exponential temperature dependence at the subcellular and individual levels, but at the ecosystem level, this temperature dependence can be modified by many variables, including community structure, which varies substantially among ecosystems. Despite its importance to predicting the responses of the biosphere to climate change, it is as yet unknown whether the temperature dependence of ecosystem respiration varies systematically between terrestrial and aquatic environments. Here we use the largest database of respiratory measurements yet compiled to show that, over a time span of days, the temperature sensitivity of ecosystem respiration is remarkably similar for estuaries, lakes, oceans, rivers, forests, and non-forested terrestrial systems that span the globe, and converges on an activation energy identical to that of the respiratory complex

(~0.65 eV). By contrast, annual ecosystem respiration exhibits a substantially greater temperature-dependence in aquatic (~0.65 eV) relative to terrestrial ecosystems (~0.32 eV). Using a model[3] derived from metabolic theory, we demonstrate that these findings can be reconciled based on similarities in the biochemical kinetics of metabolism at the subcellular level and differences in the factors structuring aquatic and terrestrial biota at the community level. Our findings suggest that the effects of warming on carbon cycling may be more pronounced in aquatic than in terrestrial ecosystems.