C01: What the flux?! Surface-atmosphere exchange of energy and mass

Conveners: Andrew VanderZaag[1], and Aaron Glenn[2]

Co-chairs: Andrew VanderZaag[1], and Aaron Glenn[2]

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Session Description

Over the past two decades, micrometeorological techniques have been increasingly used to by meteorologists, ecologists and agricultural scientists to measure the surface-atmosphere exchange of energy and mass. Advances in fast-response sonic anemometry-thermometry, infra-red gas analyzers, data acquisition, processing and storage systems have allowed for near continuous, multiyear measurements of sensible heat and water vapor fluxes that can be used to directly assess components of the surface energy and water balance. With further recent developments of field-robust instrumentation to measure mass concentrations at sufficient frequencies, researchers now routinely employ micrometeorological methods such as eddy covariance, flux gradient, mass balance techniques, and inverse-dispersion analysis to measure fluxes of trace gases such as CO_2, CH_4, N_2O, NH_3, and various isotopologues, as well as, particulate matter between the atmosphere and a plethora of land surfaces including natural ecosystems, urban landscapes and agricultural sites. The purpose of this session is to bring together scientists from the various backgrounds and disciplines utilizing micrometeorological methods to share their surface-atmosphere flux-related discoveries and challenges.

Primary Affiliation: CSAFM

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 C01a

Chairs: Andrew VanderZaag & Aaron Glenn **Room: AERL 120**

Tuesday, May 30th

TIME	AUTHORS	TITLE
9:00 (30min)	Chuixiang Yi, George Hendrey, Shan Gao, Guangwei Mu, and Wei Fang	Potential links between tree-ring data and eddy-fluxes measurements
9:30	Bharat Rastogi* , Yueyang Jiang, Maxwell Berkelhammer, Sonia Wharton , David Noone, Christopher Still	Seasonal carbon fluxes for an old-growth temperate forest inferred from carbonyl sulfide
9:45	Gesa Meyer1* , T. Andrew Black , Rachhpal S. Jassal , Zoran Nesic , Nicholas J. Grant , David L. Spittlehouse , Arthur L. Fredeen , Andreas Christen, Vanessa N. Foord and Rebecca Bowler	Carbon and water balances of three lodgepole pine stands following mountain pine beetle attack in northern interior British Columbia
10:00	Jilmarie Stephens*, Andy Black, Rachhpal Jassal, Zoran Nesic, Nick Grant, Alan Barr, Andrew Richardson, Mark Johnson and Andreas Christen	Effects of forest tent caterpillar defoliation on carbon and water fluxes in a boreal aspen stand
10:15	Pierre-Erik Isabelle*, Daniel F. Nadeau, Marie-Hélène Asselin, Annie-Claude Parent, Sylvain Jutras and François Anctil	Spatiotemporal variability and modeling of solar irradiance transmissivity through a juvenile balsam fir humid boreal forest

ORAL SESSION C01b

Chairs: Andrew VanderZaag & Aaron Glenn **Room: AERL 120**

Tuesday, May 30th

TIME	AUTHORS	TITLE
14:00 (30 min)	John D. Wilson	Micrometeorology of non-ideal sites: computing the wind field
14:30	Amanda M. Taylor*, Brian D. Amiro, Mario Tenuta, and Matt Gervais	The spatial variability of turbulent energy fluxes over agricultural fields
14:45	Kelsey A. Everard*, Andreas Christen[1], Marco Giometto[2], Holly J. Oldroyd[3], Paul Skaloud[1]	Coherent structures controlling heat and momentum exchange in a nighttime drainage flow through a vineyard canopy

15:00	H. Jones*, T.A. Black, R. S. Jassal, Z. Nesic	Radiative properties of plastic films and their use as soil mulches and in low tunnels to modify crop microclimate
15:15	Shannon E. Brown, Claudia Wagner-Riddle, and Aaron Berg	The characterization of a new lysimeter facility measuring N transport via drainage and soil gas emissions

ORAL SESSION C01c

Chairs: Andrew VanderZaag & Aaron Glenn **Room: AERL 120**

Tuesday, May 30th

TIME	AUTHORS	TITLE
16:00 (30 min)	François Anctil, Islem Hajji, Audrey Maheu, Charles Malenfant, Biljana Music, Daniel Nadeau, Vincent Fortin, Étienne Gaborit, Jingfeng Wang, and René Therrien	Construction of a hydrological surface model around Maximum entropy production
16:30	Sung-Ching Lee*, Andreas Christen, T. Andy Black, Mark S. Johnson, Rachhpal S.Jassal, Rick Ketler, Zoran Nesic, Markus Merkens	Greenhouse gas balance of a restored and rewetted bog in Metro Vancouver
16:45	Brenda D'Acunha*, Mark S. Johnson	Carbon drainage from a restored peatland in British Columbia, Canada: dissolved organic carbon (DOC) fluxes and characteristics
17:00	Caitlin Semmens*, Andreas Christen	Exchange efficiency of carbon dioxide fluxes over a heterogeneous urban landscape
17:15	Manuel F. Schmid*, Marco G. Giometto , Andreas Christen , Scott Krayenhoff, and Marc B. Parlange	Closure Models for Reynolds-Averaged Navier-Stokes Simulations of Flow Within and Above Urban Canopies

POSTER SESSION C01

Chairs: Andrew VanderZaag & Aaron Glenn **Room: ESB Atrium**

Wednesday, May 31st

Poster No.	AUTHORS	TITLE
P01-C01	Megan Cowan*, Jon Warland, Claudia Wagner-Riddle, Shannon Brown, Aaron Berg	Comprehensive measurement of all energy budget components to improve closure
P02-C01	Tobias KD Weber, Lars Gerling, Sascha Iden, Wolfgang Durner, and Stephan Weber	Inverse modelling of net ecosystem exchange in a mountainous peatland: influence of

		distributional assumptions on parameter estimates and total carbon fluxes
P03-C01	Amal Roy, Aaron J. Glenn, Sanjayan Satchithanantham, and Henry F. Wilson	Soil nitrous oxide and methane fluxes in contrasting riparian plant communities on a stream reach floodplain in southwestern Manitoba
P04-C01	Andrew VanderZaag, Hambaliou Baldé, Sean McGinn, Aaron Glenn, and Ray Desjardins	Inverse dispersion measurements of methane emissions from manure storages in regions across Canada

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SUBMITTED ABSTRACTS

C01-01: Potential links between tree-ring data and eddy-fluxes measurements

Chuixiang Yi[1,2], George Hendrey[1,2], Shan Gao[1], Guangwei Mu[1], and Wei Fang[1]

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Abstract
Tree-ring data can reveal long-term trends and historical patterns of the co-variance of forest growth with climate drivers, while eddy-flux-tower measurements have extensive data on the dynamics of forest exchanges of carbon, water and energy with the atmosphere but fail to capture long-term trends. There is a knowledge gap between these two sets to better understand how climate change modifies forest resilience and tipping point. Here, we attempt to build the linkage of these two datasets in order to model and understand forest resilience mechanisms and dynamics. Thus, eddy-flux data will be useful to understand the mechanisms regulating fluctuations of tree-ring data, while tree-ring data will provide historical trends of forest-climate interactions for linking the eddy-flux data into mechanistic models of forest resilience dynamics. We propose to formulate a stochastic tree-ring model to link the two types of datasets together to understand forest resilience potential and transition mechanisms.

Presentation type: Oral Presentation

C01-02: Seasonal carbon fluxes for an old-growth temperate forest inferred from carbonyl sulphide

Bharat Rastogi[1]* , Yueyang Jiang[1] , Maxwell Berkelhammer[2] , Sonia Wharton[3], David Noone[4], Christopher Still[1]

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[4] College of Earth Oceanic and Atmospheric Sciences, Oregon State University, Corvallis

Abstract
Characterizing and quantifying the processes that control terrestrial ecosystem exchanges of carbon and water are critical for understanding how forested ecosystems respond to a changing climate. A small but increasing number of studies has identified carbonyl sulfide (OCS) as a potential tracer of canopy photosynthesis and stomatal function. Here we present seasonal fluxes of OCS from a 60m tall old-growth temperate forest. An offaxis integrated cavity output spectroscopy analyzer (Los Gatos Research Inc.) was deployed at the Wind River Experimental Forest in Washington (45.8205◦N, 121.9519◦W) in 2014 and 2015. GPP (Gross Primary Production) is inferred from OCS fluxes and compared with estimates derived from measurements of NEE (Net Ecosystem Exchange) from eddy flux data as well as GPP predictions using a process-based model. Our findings seek to resolve scientific questions regarding ecosystem carbon exchange from tall old growth forests, which have a complicated vertical leaf area structure, high above ground biomass and amount and aerial cover of epiphytic vegetation. Estimates of canopy conductance calculated using tower flux data are also combined with measurements of stable isotopologues of CO2 to infer emergent ecosystem properties such as canopy ci/ca and water use efficiency.

Presentation type: Oral Presentation

C01-03: Carbon and water balances of three lodgepole pine stands following mountain pine beetle attack in northern interior British Columbia

Gesa Meyer[1]* , T. Andrew Black[2] , Rachhpal S. Jassal[2] , Zoran Nesic[2], Nicholas J. Grant[2], David L. Spittlehouse[3], Arthur L. Fredeen[4], Andreas Christen[5], Vanessa N. Foord[6] and Rebecca Bowler[4,6]

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Abstract
Tree mortality due to the recent mountain pine beetle (MPB) outbreak in British Columbia (BC) is expected to impact gross ecosystem photosynthesis (GEP), ecosystem respiration (R), evapotranspiration (E), and snow accumulation and melt, thereby influencing net ecosystem productivity (NEP) and hydrology. To quantify these effects, we used eddy-covariance (EC) measurements of CO2 and water vapour fluxes over ten and six years, respectively, in two MPB-attacked lodgepole pine (LP) stands in northern interior BC that were not salvage harvested and over three years in a partially salvage harvested (i.e., only dead LP trees were removed) stand, complemented with short-term EC measurements in nearby clearcuts. One of the not-salvage-harvested stands was an almost pure LP stand with little understory (MPB-06), while the other stand had considerable understory consisting of LP, subalpine fir and white spruce. The partiallysalvage-harvested stand (MPB-09) originally consisted of 50% LP and 50% spruce and was winter logged. Our hypotheses were that the not-salvage-harvested stands would initially have significantly reduced E and be strong annual carbon (C) sources. Instead, our measurements have shown little change in E following attack in all three stands. The relatively constant E was likely due to the compensating effects of understory transpiration and soil evaporation as the stands recovered. GEP derived from the EC measurements slowly recovered over the six to ten years with the not-salvage-harvested stands becoming C neutral within three to five years following MPB attack and remaining weak C sinks thereafter (NEP up to 73 g C m-2 year-1 at MPB-06). NEP at MPB-09 increased from -108 to -53 g C m-2 year-1 during the three measurement years. To fully investigate the effects of such management strategies on water and C balances following MPB attack, the EC measurements were also used to parameterize a modified version of the process-based model, 3-PG.

Presentation type: Oral Presentation

C01-04: Effects of forest tent caterpillar defoliation on carbon and water fluxes in a boreal aspen stand

Jilmarie Stephens[a*], Andy Black[a], Rachhpal Jassal[a], Zoran Nesic[a], Nick Grant[a], Alan Barr[b], Andrew Richardson[c], Mark Johnson[d] and Andreas Christen[e].

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Abstract
Insect outbreaks can have large effects upon the carbon and water balances of forests. Forest tent caterpillars (FTC) are the one of the most significant pests of aspen forests in Canada. Thus the caterpillars could have a large impact on regional carbon and water fluxes. In the summer of 2016, a FTC infestation occurred at our long-term trembling aspen (*Populus tremuloides*) research site (Old Aspen) in the southern boreal forest. The stand is over 90 years old and the trees are about 21 m tall. The caterpillar infestation led to a defoliation of the canopy in the middle of May, the typical full leafing period when photosynthesis and thus carbon uptake reach near maximum levels. We used the 20 years of pre-infestation measurements to quantify the impact of the defoliation event on the carbon and water fluxes. The fraction of change in flux due to the climate of 2016 was analyzed by modelling the fluxes assuming there was no attack, using 2016 climate data. The defoliation insignificantly affected the evapotranspiration, while having a large effect on the carbon fluxes. Net ecosystem productivity (NEP) and gross ecosystem productivity (GEP) were greatly reduced during the defoliation which led to annual values, respectively, 110% and 24% lower than expected. This led the NEP to be the most negative in 20 years (-130 g C m^{-2} y^{-1}), less than even the three years of drought, turning the site from being its usual C sink to a C source.

Presentation type: Oral Presentation

C01-05: Spatiotemporal variability and modeling of solar irradiance transmissivity through a juvenile balsam fir humid boreal forest

Pierre-Erik Isabelle[1*], Daniel F. Nadeau[1], Marie-Hélène Asselin[2], Annie-Claude Parent[1], Sylvain Jutras[3] and François Anctil[1]

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Abstract
Solar irradiance is the largest driver of land-surface exchanges of energy, water and trace gases. Its absorption by a forest canopy generates considerable sensible and latent heat fluxes as well as tree temperature changes. A fraction of the irradiance gets transmitted through the canopy and powers another layer of energy fluxes which can reach substantial values. Transmitted radiation is also of particular relevance to understory vegetation photosynthesis, snowpack energetics and soil temperature dynamics. Boreal forest canopy transmissivity needs to be quantified to properly reproduce land-atmosphere interactions in the circumpolar boreal biome, but its high spatiotemporal variability makes it a challenging task. This study was located in the Montmorency forest, 80 km north of Quebec City. The vegetation includes mostly juvenile balsam firs, 6 to 8 m tall. Since January 2016, a 15-m flux tower measures 4-components radiation, sensible and latent heat fluxes, and several other meteorological variables. In summer 2016, 20 portable weather stations were mounted in a 150 by 200 m grid around the flux tower. These stations were equipped with silicon-cell pyranometer and provided measurements of downwelling irradiance at a height of 2 m. This setup allows us to compute irradiance transmissivity and assess its spatiotemporal variability at the site. Measurements of leaf area index at each 20 site were done using hemispherical photography, as this index is commonly used to model transmissivity. Models coming from various land surface schemes are compared to observations, but fail to reproduce the complete range of observed transmissivity. A new probabilistic approach is proposed to model boreal forest transmissivity using only the Sun's position. The advantage of this approach is that it does not depend on leaf area index, and hence should not be site-specific, while still being vegetation-specific. The method, while promising, still needs to be applied on other vegetation stands.

Presentation type: Oral Presentation

C01-06: Micrometeorology of non-ideal sites: computing the wind field

John D. Wilson[1]

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Abstract
Not uncommonly in agrometeorology, compromises are necessary in the choice of a field site such that one is reluctant to adopt Monin-Obukhov similarity theory as a framework for the surface layer state. In principle one can rationally accommodate horizontal gradients, though this in practice is likely to entail blending limited measurements with a wind model. Decades of research have addressed the calculation of boundary layer wind over hills of significant amplitude, sometimes in the context of wind power. Here however the interest is to explore the feasibility and utility of computing wind variation over the minor undulations that sometimes mar a field site (amplitude of the topography say 1-10 m). Computations have been undertaken to iteratively solve the steady-state, Reynolds-averaged momentum equations over a laterally-periodic domain, using a simple eddy viscosity closure and neglecting thermal stratification. Comparison with measured mean winds along a 140 m transect over gently rolling terrain permits to investigate factors such as the minimum acceptable span and depth of the flow domain, computational resolution (gridlength), the necessity to taper topography towards boundaries, etc. Grid-independent solutions have not as yet been procured, and the available Digital Elevation Map (i.e. model terrain) perhaps imposes its own limit (post spacing 15 m, vertical resolution 30 cm) on what can be achieved. Be that as it may, though far from perfect the computed wind transects accord surprisingly well with (some of) the measured irregularities of the mean wind field that one might (otherwise) have been tempted to attribute to nothing more than anemometer bias.

Presentation type: Oral Presentation

C01-07: The spatial variability of turbulent energy fluxes over agricultural fields

Amanda M. Taylor*, Brian D. Amiro, Mario Tenuta, and Matt Gervais

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Abstract
Turbulent flux measurements help us understand how different surface processes affect the movement of water and energy between the surface and atmosphere. This is of particular importance in agricultural systems, where fluxes are controlled by water availability and its influence on crop growth. Despite visual homogeneity, crop fields may be quite variable given topography, soil moisture, and crop coverage, which in turn influence sensible (H) and latent (LE) heat. Using short- and long-term data, we evaluated whether one eddy covariance tower was enough to accurately represent H and LE fluxes, and potential causes of variability. Three identical towers measured both H and LE over a perennial forage and a spring wheat crop in 2014 in southern Manitoba. Regression comparisons showed r^2 values generally declined as the towers were further apart, and were lower for LE (~0.79 to 0.94) than H (~0.9 to 0.97). When the Bowen ratio was compared to the temperature difference between the surface and the air, the forage and wheat each had distinct, separate asymptotes, partially relating to the wheat's senescence during measurements. Heat flux comparisons over four years had consistently high r^2 values (0.96-0.98) among four towers. Years with taller crops (corn) had slightly lower r^2 values than shorter crops (soybean, spring wheat) in summer. When flux footprints were calculated with tall and short crop heights, the corn had 4-14% less area coverage at the 95th flux footprint isoline, and 33% less at the 50th, measuring an area closer to the tower with potentially more heterogeneity.

Presentation type: Oral Presentation

C01-08: Coherent structures controlling heat and momentum exchange in a nighttime drainage flow through a vineyard canopy

Kelsey A. Everard*[1], Andreas Christen[1], Marco Giometto[2], Holly J. Oldroyd[3], Paul Skaloud[1]

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Abstract
Knowledge of the thermal environment in nocturnal drainage flows is relevant, especially for flows affecting crops and vegetated canopies, such as grapevines, that are sensitive to temperature changes. Under drainage flow conditions in a vineyard, the interaction of two dynamical regimes, the drainage flow regime and the canopy layer regime, results in a complex flow situation that controls the thermal environment (*i.e.*, stratification). To investigate the fundamental character and the evolution of drainage flows interacting with a vineyard canopy, simultaneous high frequency wind measurements and spatially distributed temperature observations were obtained during one night over a 6° vineyard slope near Oliver, BC, Canada in July 2016. Wind and turbulence were measured on a mast with sonic anemometers at 5 heights (10 Hz) and temperatures were measured with 50 high-frequency spatially distributed thermocouples (2 Hz). The vertical domain of observation extended from the surface to 2*h*, where *h* = canopy height of 2 m, and the horizontal domain extended upslope along the incline (parallel to the vineyard rows) up to 32 m from the sonic mast. Integral length scales based on the spatially distributed thermocouple measurements are calculated to characterize the dominant scale driving exchange, and a quadrant analysis is employed to characterize heat and momentum exchange. Time traces of temperature are used to identify ramp structures and the movement of such structures in the vertical and down-slope directions to complete the description of coherent motion in the canopy environment under drainage wind conditions. Such an understanding allows for better parameterization in model approaches to assist in forecasting the effect of drainage winds on the thermal environment and the transport of potentially damaging scalars, and hence, assists agricultural planning and management.

Presentation type: Oral Presentation

C01-09: Radiative properties of plastic films and their use as soil mulches and in low tunnels to modify crop microclimate.

H. Jones[1*], T.A. Black[1], R. S. Jassal[1], Z. Nesic[1]

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Abstract

Plastic films used for soil mulches and in low tunnels have the potential to supress weeds, prevent erosion, alter the surface energy balance, conserve soil moisture (θ_s), and modulate soil (T_s) and air (T_a) temperature. Since becoming available in the early 1950s, global annual consumption of plastic films in agriculture has reached 6.5 Mt yr^{-1}. Our goal is to characterize the spectral radiative properties (reflectivity (ρ), transmissivity (τ) and absorptivity (α)) of various modern plastic films and determine their ability to alter net radiation, soil heat flux density (G), T_s and θ_s when used as soil mulches and in low tunnels to protect crops. We measured the spectral radiative properties in the laboratory using a shortwave (350 – 2500 nm) spectroradiometer (model Field Spec 3, ASD Inc., Boulder, CO, USA). Field trials were conducted at 3 organic farms: UBC Farm, Mackin Creek Farm (near Soda Creek, BC) and Cropthorne Farm (in Delta, BC). A soil mulch experiment at UBC Farm showed that plastic films with high τ (i.e., transparent) achieved the highest daytime G and T_s compared to the control (bare soil), whereas films with high ρ (e.g., white), particularly in the visible portion of the spectrum (400–700 nm), resulted in lower G and T_s than the control. A vegetation free low-tunnel experiment at the UBC Farm showed that August daily maximum T_a inside low tunnels with plastic films of high and low longwave radiation τ was 16 and 20°C greater, respectively, than ambient T_a. Nighttime T_a inside the low tunnel covered with low longwave radiation τ plastic film was 1-4°C greater than ambient T_a. Heat transfer coefficients for low-tunnel floor and walls, obtained using energy balance analysis, will be reported. The results will assist BC farmers to adapt to climate change using readily available materials, techniques and models.

Presentation type: Oral Presentation

C01-10: The characterization of a new lysimeter facility measuring N transport via drainage and soil gas emissions

Shannon E. Brown[1], Claudia Wagner-Riddle[1], and Aaron Berg[2]

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Abstract
Diversifying annual crop rotations is a strategy that mimics natural ecosystems and is postulated to increase agricultural resilience to climate change, soil quality and provision of soil ecosystem services. However, diverse cropping systems could increase soil mineral N levels and lead to greater leaching and/or N_2O emissions; which raises the questions: (i) are diverse cropping systems actually beneficial for air and water quality? (ii) what are the trade-offs between soil, water, and air quality upon implementing a diverse cropping rotation? It can be difficult to fully evaluate the interactions between the two N-pollution pathways simultaneously in traditional field studies as drainage is largely unconstrained. Weighing lysimeters solve this issue by providing a closed system to measure N outputs via drainage and soil gas fluxes. A set of 18 weighting lysimeters were installed in Elora, Ontario, Canada in May 2016, to establish a long-term study of N-leaching and greenhouse gas emission from traditional and diverse cropping rotations for two different soil types. Each lysimeter is equipped with an automated chamber for continuous measurement of soil N_2O and CO_2 fluxes. A full characterization of variations of physical properties that may affect GHG emissions (e.g., soil temperature, moisture, drainage and evapotranspiration rates) amongst the lysimeters is required prior to application and assessment of the management treatments. This full description of the lysimeters will be presented along with preliminary results of the N_2O and CO_2 soil flux measurements.

Presentation type: Oral Presentation

C01-11: Construction of a hydrological surface model around Maximum entropy production

François Anctil[1], Islem Hajji[1], Audrey Maheu[2], Charles Malenfant[1], Biljana Music[3], Daniel Nadeau[1], Vincent Fortin[4], Étienne Gaborit[4], Jingfeng Wang[5], and René Therrien[6]

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Abstract

The Maximization of the Entropy Production (MEP) method was recently adapted to model land surface fluxes, namely evaporation from soil and transpiration from vegetation. The MEP model of land-surface fluxes requires limited input data and operates under the constraint of energy conservation at the surface. The first portion of the presentation introduces an evaluation of the capability of the MEP model to realistically simulate evapotranspiration (ET) over a wide range of climates and vegetation covers, comparing the model outputs with in situ observations of ET collected at eight FLUXNET sites across the continental US. A weighting coefficient is proposed to partition ET into evaporation and transpiration and a function is introduced, based on soil moisture condition, to account for a variable stomatal aperture. Results confirm the remarkable agreement between simulated ET with the MEP model and observations. The second portion of the presentation highlights efforts towards the coupling of the MEP model with a soil moisture model taken either as the physically-based HydroGeoSphere (HGS) hydrological model or as the soil component of the Soil, Vegetation, and Snow (SVS) land-surface model, under development at the Meteorological Research Division of Environment and Climate Change Canada. Using data from four FLUXNET sites, tests reveal that both HGS and SVS provide realistic soil moisture time series when observed precipitation and ET are used as inputs, opening up the potential of constructing a hydrological surface model around a MEP model of land-surface fluxes.

Presentation type: Oral Presentation

C01-12: Carbon drainage from a restored peatland in British Columbia, Canada: dissolved organic carbon (DOC) fluxes and characteristics

Brenda D'Acunha[1*], Mark S. Johnson[1,2]

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Abstract
Dissolved organic carbon (DOC) is one of the main components of the carbon budget in aquatic ecosystems, where it plays a major role in a wide range of ecological processes and reactions in water, soil and sediments. In peatlands, DOC is of particular importance since it can influence the size of the carbon sink or source, which depends in part on the environmental conditions and the state of the ecosystem. We conducted research in Burns Bog, Delta, BC, Canada, a highly disturbed peat bog located in the Fraser River Delta, and one of the largest raised peat bogs on the west coast of the Americas. Currently, ecological restoration efforts are underway by a large-scale ditch blocking program with the aim to re-establish a high water table. Here we present data on the flux and composition of DOC in water draining Burns Bog. Water samples were collected from five locations inside the footprint of an eddy covariance system that was mounted on a floating tower platform. The water samples were analyzed for DOC concentrations and DOC characteristics using fluorescence and absorbance spectroscopy. Results showed that drainage waters were typically high in DOC (> 30 mg L^{-1}), with an estimated annual DOC drainage flux of 22.5 g C m^{-2} y^{-1}. Further, the DOC in the water surface of Burns Bog had optical characteristics that were indicative of a predominantly terrestrial origin. In this presentation, we will summarize the temporal dynamics of the DOC fluxes, and compare the magnitude and dynamics of the DOC fluxes with dissolved gas measurements (CO_2, CH_4 and N_2O) and ecosystem-scale trace gas fluxes (CO_2 and CH_4) measured via eddy covariance.

Presentation type: Oral Presentation

C01-13: Greenhouse gas balance of a restored and rewetted bog in Metro Vancouver

Sung-Ching Lee[1]*, Andreas Christen[1], T. Andy Black[2] , Mark S. Johnson[3,4], Rachhpal S. Jassal[2], Rick Ketler[1], Zoran Nesic[1,2], Markus Merkens[5]

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Abstract
Many peatlands have been drained and harvested for peat. Rewetting these, as one of the most common restoration strategies, facilitates their ecological recovery, and may help them revert from sources to sinks of carbon dioxide (CO2). However, rewetting of disturbed peatlands may also cause substantial emissions of the potent greenhouse gas (GHG), methane (CH4). We measured year-round fluxes of CO2 and CH4 from a disturbed and recently rewetted raised bog ecosystem located in the Burns Bog Ecological Conservancy Area (BBECA), a 20 km2 bog in Delta, BC, Canada. BBECA is recognized as the largest raised bog ecosystem on North America's west coast and has been declared a conservancy area since 2005 to promote natural Sphagnum (peat moss) regeneration. The investigated part of the BBECA has been rewetted since 2008 and consisted of Sphagnum and Rhynchospora alba (white beak-sedge). The annual CO2 budget of the ecosystem studied was -179 g CO2-C m^{-2} $year^{-1}$ (CO2 sink) and the annual CH4 budget was 16 g CH4-C m^{-2} $year^{-1}$ (CH4 source) indicating that the study area was a C sink during the study year (7th year following rewetting). The key environmental factors controlling the seasonality of both fluxes were photosynthetically active radiation and soil temperature at the 5-cm depth. High water table caused by ditch blocking limited ecosystem respiration. With low temperatures in winter, CH4 emission was more suppressed than ecosystem respiration. Annual net GHG fluxes calculated, by using 100- year and 20-year time horizon global warming potentials of CO2 and CH4, in terms of CO2 equivalents (CO2e) was -55 g CO2e m^{-2} $year^{-1}$ (net CO2e sink) and 1147 g CO2e m^{-2} $year^{-1}$ (net CO2e source), respectively. Consequently, the ecosystem was a weak CO2e sink on a 100-year time horizon but was a significant CO2e source on a 20-year time horizon during the study period.

Presentation type: Oral Presentation

C01-14: Exchange efficiency of carbon dioxide fluxes over a heterogeneous urban landscape

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Abstract

The eddy covariance (EC) method of analyzing data from urban flux towers is an established tool in monitoring and verifying municipal emission inventories and identifying the role of the urban biosphere. However, the EC method was developed for homogenous ecosystems like croplands and forests, where the source area has a roughly uniform spatial distribution of carbon dioxide (CO_2) sources and sinks. In cities, emission sources and sinks of CO_2 vary greatly, both spatially and temporally. To date, few studies have addressed the challenges presented by urban source/sink heterogeneity on the measurement of CO_2 exchange. This study uses an eight-year EC dataset from an urban tower in Vancouver, BC, Canada, to characterize the exchange efficiencies of CO_2 over a heterogeneous urban landscape. This long-term dataset allows for the separation of seasonal and diurnal variability, and links this variability to modelled emission patchiness. Attribution of measured CO_2 fluxes to the urban surface was achieved using source area models in combination with traffic counts and building energy information. As the footprint-averaged traffic count increased, flux densities of CO_2 increased as well as the exchange efficiency of CO_2. Exchange of CO_2 exhibited higher correlation from wind directions where major traffic corridors exist, and CO_2 fluxes from residential source areas became increasingly correlated as a function of heating degree days (HDD). Diurnal trends in CO_2 exchange efficiency showed highest correlation at times of peak vehicle traffic amounts (7:00 and 19:00 PST), with substantial decreases in exchange efficiency around noon and during summer, corresponding to the times when CO_2 uptake by photosynthesizing plants caused counter-directed fluxes. We conclude that the exchange efficiency of CO_2 over a city is related to source/sink availability and distribution, and the relative strength of opposing fluxes (photosynthesis, fuel emissions, and respiration).

Presentation type: Oral

C01-15: Closure Models for Reynolds-Averaged Navier-Stokes Simulations of Flow Within and Above Urban Canopies

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Abstract
Turbulence plays a key role in the exchange of energy, water, pollutants, and momentum between cities and the atmosphere. Yet, the complexity of urban canopies presents a challenge to numerical prediction of weather, hydrology, and air quality in the urban canopy layer, where people live. Increasingly, weather-forecasting and urban-dispersion models employ urban canopy parameterizations (UCPs) as wall closures. UCPs must be reasonably simple and fast, so most UCPs rely on one-dimensional lower order closure schemes based on canonical inertial sublayer flow. Recent large-eddy simulations of flow over realistic urban geometries have highlighted similarities between plant canopy flows and urban canopy flows, which suggests that existing, more accurate, higher order closure schemes for plant canopies based on the Reynolds-averaged Navier-Stokes (RANS) equations could be transferred to cities. However, there are significant additional contributions to both diffusion of momentum and production of turbulent kinetic energy originating from non-negligible dispersive terms in bluff-body canopies, not present in vegetation canopy flows. Such processes are not included in standard (e.g., k-l and k-ε) nor higher order RANS closures. As a result, current UCPs suffer from lower than observed scalar-diffusion rates within the urban canopy layer, which results in higher than expected scalar concentrations in the lower canopy where predictions are most relevant. To characterize the extent of these problems and to explore possible improvements, we evaluate the application of various first and second order closure models for predicting flow and turbulence profiles in urban environments. Different models are implemented and adapted to account for the effects of the urban surface and the role of dispersive fluxes. The results are tested against large-eddy simulations from flow over realistic urban surfaces in Vancouver, BC.

Presentation type Oral Presentation

P01-C01: Comprehensive measurement of all energy budget components to improve closure

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Abstract
Energy budget closure has long been an issue in microclimatology. An energy budget at the surface remains unclosed when the sum of sensible and latent heat fluxes do not equal the available energy, where the available energy is the net radiation minus the soil heat flux and the heat storage terms. In this study, comprehensive measurements for all components of the energy budget were measured in order to achieve closure. This included the use of soil heat pulse probes for measuring soil heat flux and soil heat storage. The use of the probes increased the footprint of these measurements capturing greater soil heterogeneity and allowing for greater accuracy in these measurements. Data collection was carried out in July and August of 2016 over a flat, homogeneous cornfield at the University of Guelph, Elora Research Station, Elora, Ontario, Canada. When simple linear regression was applied to the energy budget data, the slope was found to be 0.99 with an intercept of 2.85 ($R^2 = 0.93$). These results suggest that over agricultural fields, energy budget closure can be obtained when all components of the energy budget equation are carefully measured. It was also found that the total daily latent heat flux had an influence on the closure accounting for ~40% (P-value < 0.05) of the variability. The total sensible heat flux did not have a similar relationship ($R^2 < 0.1$, P-value > 0.05). These results may indicate that latent heat flux measurements are more prone to error than the sensible heat flux measurements.

Presentation Type: Poster

P02-C01: Inverse modelling of net ecosystem exchange in a mountainous peatland: influence of distributional assumptions on parameter estimates and total carbon fluxes

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Abstract
The soil-plant-atmosphere exchange of energy, water, and carbon in peatlands is key in controlling the long-term development of boreal and temperate peat bogs. Frequently, the eddy covariance technique is used to quantify these fluxes. For example data of CO2 flux measurements can be used to calibrate net ecosystem exchange models (NEE). This permits testing our systems understanding and to use the models for prediction purposes. However, one crucial aspect is the question of how to treat stochastic measurement errors in these models. To address this topic, we measured the energy and CO2 exchange of a temperate ombrotrophic peat bog in the Harz Mountains, Germany, during the growing season in 2013. CO2 flux data were used to calibrate an established bio-physical NEE model which was then used for gap filling and the calculation of cumulative C exchange between the bog and the atmosphere over the entire time period of the measurement campaign. Model parameters and uncertainties were estimated in a Bayesian framework using an adaptive Markov Chain Monte Carlo sampler. Three statistical distributions of model residuals (errors) were tested: the Gaussian distribution, the Laplace distribution, and Student's t-distribution. In all cases, the model error heteroscedastic. We show that the statistical model based on the t-distribution lead to the highest posterior likelihood and the smallest value of the deviance information criterion and was thus identified as best model. Additionally, without changing the biophysical model, it lead to significantly different estimates of the NEE model parameters and reduction in parameter uncertainty by about 40%. For the C accumulation, it lead to an almost 10% increase in predicted C accumulation during the measurement period compared to the standard approach assuming Gaussian error distribution. This finding demonstrates how important it is to critically assess the influence of distributional assumptions during inverse modeling of NEE.

Presentation type: Poster

P03-C01: Soil nitrous oxide and methane fluxes in contrasting riparian plant communities on a stream reach floodplain in southwestern Manitoba

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Abstract
Due to the potential for riparian soils to act as hot spots for carbon and nitrogen cycling in agricultural catchments, it is important to quantify their role in the atmospheric greenhouse gas (GHG) balance. During the 2014 and 2015 growing seasons, soil nitrous oxide (N_2O) and methane (CH_4) emissions were quantified for two riparian plant communities on a stream reach floodplain in southwestern Manitoba using the static chamber method. The paired vegetation compared at the site consisted of a grass (*Bromus inermis*, smooth brome) dominated segment adjacent to a riparian forest dominated by *Acer negundo* (boxelder or Manitoba maple). In the relatively wet year of 2014 (70% greater than normal rainfall), the cumulative N_2O emissions were higher from the grass and forest segments than in 2015, a growing season with closer to normal rainfall. Soil N_2O emissions tended to be higher from the forest than the grass, however, this difference was only significantly different for one of the two growing seasons. In 2014, the grass segment soil was a small source of CH_4 while the forest soil was a sink. In 2015, both the riparian grass and forest soils were sinks for CH_4, however, the forest soil had significantly more uptake than the grass segment. Despite inter-annual differences in N_2O and CH_4 emissions when each trace gas was considered individually, when expressed as CO_2 equivalents, the net soil GHG (N_2O + CH_4) fluxes were not significantly different between the grass and forest segments of the stream reach in either growing season. The dynamics of soil GHG emissions in the contrasting plant communities along this stream reach have implications for riparian land management decisions in the context of possible trade-offs with the provision of ecosystem services and other potential environmental impacts (eg. livestock production, wildlife habitat, flood protection, and water quality).

Presentation type: Poster

P04-C01: Inverse dispersion measurements of methane emissions from manure storages in regions across Canada

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Abstract
The Government of Canada has made international commitments to reduce greenhouse gas emissions 17% by 2020. To reach this goal, reductions are necessary from every sector, including agriculture. While lab-studies have a role in methane emissions research, it is essential to use farm-scale studies that include actual management and production of the farm. The complex and interconnected processes of manure production and removal, carbon transformations, and emission of methane from farm-scale manure storages cannot be recreated in a lab. In our study we have established a network of flux sites at six commercial livestock operations across Alberta, Manitoba, and Ontario. Methane emissions are measured with the backward Lagrangian stochastic (bLS) technique using open-path laser spectrometers and 3D sonic anemometers. Results of the measurements to-date will be presented and discussed, highlighting the effect of regional climate and management on methane emissions.

Presentation type: Poster