AMERIFLUX

- Poster Abstracts -

For the

- 2022 AmeriFlux Annual Meeting -

Guler Aslan Sungur

Eddy covariance measurements over the bioenergy crops (miscanthus and sorghum) and standard row crops (corn and soybean)

Guler Aslan-Sungur*[1], Nic Boersma*[1], Emily Heaton*[1,2] and Andy Vanloocke*[1]
[1] Department of Agronomy, Iowa State University, Ames, Iowa
[2] Department of Plant Biology, University of Illinois Urbana-Champaign, Illinois

gulera@iastate.edu

Bioenergy crops research efforts have focused on how bioenergy crops alter carbon, water, and energy cycles. Energy sorghum (Sorghum bicolor) is a promising annual bioenergy crop because of its drought tolerance and high biomass productivity. Miscanthus (Miscanthus × giganteus), a perennial grass, is a leading bioenergy crop because of its productivity and broad adaptation range. However, little research focused on the variation of carbon fluxes in these two bioenergy crops (sorghum and miscanthus) compared to the standard row crops (corn and soybean). Long-term monitoring of carbon water and energy fluxes is critical to understanding the bioenergy crop component fluxes and how biogeochemical cycles and climate interact to change these fluxes over time. Here we present data from Iowa State University Sustainability Advanced Bioeconoy Research Farm (SABR) to compare biogeochemical cycles variation in standard row crops (corn and soybean) and bioenergy crops (miscanthus and sorghum) over time. Carbon fluxes of the crops were monitored using eddy covariance techniques (EC) in SABR for three growing seasons (2019-2020-2021). The preliminary results showed that cumulative net ecosystem carbon dioxide exchange (cumNEE) was higher at -705 and 744 g C m-2 in sorghum than miscanthus (-588 and 692 g C m-2), corn (681 and 514 g C m-2) and soybean (-321 and -202 g C m-2) for the first two years (2019 and 2020). However, because of the high ecosystem respiration in sorghum and miscanthus in 2021 compared to corn and soybean, cumNEE decreased dramatically to -4 g C m-2 for sorghum and -454 g C m-2 for miscanthus. Future work will include to figure out the variation of the driving force on carbon fluxes of the crops in time during the growing season.

Mallory Barnes

Harnessing the potential of thermal remote sensing for forest ecology

Mallory L. Barnes, Indiana University Bloomington

malbarn@iu.edu

Assessment and prediction of the impacts of climate change on the environment and human societies requires multi-scale understanding of interactions between biogeochemical, hydrologic, and atmospheric cycles. For many years, measures of greenness from spaceborne satellites were the only way to consistently observe the terrestrial biosphere. Recent and emerging advances in thermal remote sensing data resolution, availability, and analytics present a timely opportunity to explore new aspects of vegetation-climate interactions. Surface temperatures are mechanistically linked to vegetation biophysical and physiological processes, providing valuable insight into plant patterns and underlying plant controls in ecosystems. Although remote sensing in the thermal infrared (TIR) domain can offer novel insights into the impacts of changing surface temperatures on vegetation, the transformative potential of remote sensing for plant ecology has not yet been realized.

First, I will introduce a unifying framework to link leaf to globe through thermal remote sensing. Then, I will present results from Uncrewed Aerial Vehicle (UAV) measurements of canopy temperatures in the Morgan Monroe State Forest, including the US-Mms flux tower near Bloomington Indiana. We conducted UAV flights in Summer 2021 and Summer 2022 across transects that extend from forest interior across forest edges at multiple timepoints to help characterize differences in the thermal environment between edges and forest interior. We found that horizontal thermal profiles could be used to evaluate seasonal and weather-driven shifts in the temperature differential between forest edges and interiors. We also found that canopy-scale UAV measurements could resolve temperatures of individual tree crowns that were linked to biophysical processes including transpiration. TIR remote sensing data could allow for early detection of stressed trees, enable in situ monitoring of trees experiencing stressful conditions, increase our understanding of tree mortality and ecological responses to climate extremes, and enable better monitoring and effective management interventions.
"

Maoya Bassiouni

Knowledge-guided machine learning and information flows disentangle drivers of ecosystem function

Maoya Bassiouni 1 , Yanghui Kang 1 , Andrew Bennett 2 , Trevor Keenan 1,3

1 Department of Environmental Science, Policy and Management, UC Berkeley, Berkeley, CA, USA.
2 Department of Hydrology and Atmospheric Sciences, University of Arizona, Tucson, AZ, USA.
3 Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.

maoya@berkeley.edu

Eddy covariance towers capture complex eco-physiological processes that ultimately inform water and carbon fluxes. Disentangling this complex process network is challenging yet critical to gain deeper understanding of the interactions between ecosystem fluxes, function, and climate. Here we integrate a big-leaf model structure and formulations of optimal stomatal conductance into a neural network to infer eco-physiological quantities that are not directly observed at the ecosystem level. We train the hybrid model at selected AmeriFlux sites and evaluate the joint causal interactions in the model by comparing modeled and observed information flows and their partitioning. We use this framework to diagnose the sensitivities of eco-physiological state variables to water availability and climate. Specifically, we test hypotheses on eco-evolutionary patterns of water use efficiency necessary to constrain CO_2 fertilization effects.

Sebastien Biraud

A New Framework for Testing and Statistical Analysis to Calibrate PAR Sensors

Sébastien C. Biraud [1], Stephen W. Chan [1], Housen Chu [1], Sigrid Dengel [1], Boris Faybishenko [1], Andrew B. Moyes [1], Chad Hanson [2], Victor Cassela [3], Dave Johnson [4]
[1] Lawrence Berkeley National Laboratory
[2] Oregon State University
[3] Kipp & Zonen
[4] LI-COR

scbiraud@lbl.gov

Photosynthetically Active Radiation (PAR) sensors are commonly used to measure the Photosynthetic Photon Flux Density (PPFD). PPFD is quantified as the sum of photons between 400 and 700 nm in units of µmol m^{-2} s^{-1} that reaches a surface (e.g. a leaf for ecologists). PAR data is of high value to numerous remote sensing, model validation and other methods to determine and estimate GPP. PAR sensors are calibrated by manufacturers against a known, traceable standard and given a coefficient to convert their specific output signal into usable scientific units (i.e., µmol m-2 s-1). PAR sensors sensitivity changes with age and regular recalibration is necessary to keep measurement uncertainty within acceptable limits. Due to different approaches to correct for deviations from ideal spectral sensitivity, sensors from different manufacturers yield different absolute values of PAR, up to 8.9% for the two most common sensors in our study, under the same conditions.

Here we present a discussion of PAR sensor sources and magnitude of uncertainty and error, in addition to the development of a new framework to calculate calibration coefficients of PAR for new or previously deployed sensors against a common standard spectra, using reference sensors to transfer spectrally corrected calibrations to field sensors under natural sunlight. This framework was developed by field testing PAR sensors manufactured by Kipp & Zonen (https://www.kippzonen.com/) and LI-COR (https://www.licor.com) during eleven one-day tests over the course of multiple years. A statistical analysis of the test results was conducted to assess the accuracy of field PAR sensors and the repeatability of their calculated calibration coefficients using a set of reference PAR sensors. Statistical fusion using a maximum likelihood Bayesian averaging of the time series of reference sensors based on measurements, and the calculation of calibration coefficients for Field PAR sensors using a linear regression statistical analysis were used in the analysis.

Bethany Blakely

Over a decade of flux data facilitates the assessment of bioenergy feedstock sustainability

Bethany Blakely *[1,2], Christy Gibson [1,2], Taylor Pederson [1], Carl Bernacchi* [1,2,3]
[1] Department of Plant Biology, University of Illinois at Urbana-Champaign, Urbana, IL, USA
[2] Center for Advanced Bioenergy and Bioproducts Innovation, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States of America
[3] USDA-ARS, Global Change and Photosynthesis Research Unit, Urbana, IL, USA

blakely6@illinois.edu

Bioenergy from biofuel crops will be essential for meeting global energy needs in a future lower-carbon economy. As ongoing research demonstrates potential environmental costs of maize ethanol, perennial feedstocks such as miscanthus and switchgrass offer a promising alternative. However, such feedstocks are poorly represented in currently available flux datasets, especially on the longer time horizons needed to constrain their impact on the carbon cycle and to capture rare climatic events. To fill this gap, we present insights from a new dataset of collocated maize and perennial feedstocks spanning over 10 years.

Five feedstocks are included in the new dataset: maize (Zea mays), giant miscanthus (Miscanthus × giganteus), switchgrass (Panicum virgatum), native prairie (27 Illinois-native species), and energy sorghum (Sorghum bicolor). We find that maize is a consistent carbon source (+2.3tC ha-1 y-1) to the atmosphere, switchgrass and miscanthus are consistent atmospheric carbon sinks (-2.1 and -1.2 tC ha-1 y-1, respectively), and sorghum is a small sink or source depending on the year (0.16 +/- 1.61 tC ha-1 y-1). The new dataset also captures several rare climatic events, including drought, flooding, and wind damage. We find that drought and flooding increase carbon flux to the atmosphere by increasing ecosystem respiration and altering microbial community dynamics, highlighting the potential importance of these and other extreme events for the carbon cycle. By capturing a relatively long, and ongoing, record of both maize and alternative bioenergy feedstocks, we hope to contribute to a greater understanding of long-term carbon cycle dynamics in bioenergy feedstocks under increasingly challenging climatic conditions.

GIL   BOHRER

Lake-level changes, ecological dynamic and carbon budgets at a Lake Erie coastal wetland

Gil Bohrer [1], Justine Missik [1], Theresia Yazbeck [1], Noah Charlton [1], Yvette Onyango [1], Haley Kujawa [1], Jorge Villa [2], William Riley [3], Kelly Wrighton [4]

[1] Ohio State University
[2] University of Louisiana at Lafayette
[3] Lawrence Berkeley national Laboratory
[4] Colorado State University

bohrer.17@osu.edu

Carbon sequestration is one of the key ecological co-benefits of wetlands. Methane emissions reduce the overall benefit of greenhouse-gas regulation by wetlands. To maximize the overall climate-regulation co-benefits, a wetland design should strive for reducing methane emissions, while maximizing carbon uptake. Methane emissions and carbon sequestration rates have very high spatial variability within the wetland, and vary strongly between ecological patches and hydrological conditions. This high variability makes the carbon fluxes of wetlands hard to predict, and therefore hard to account for a-priori when designing a wetland.

We used an eddy covariance system to conduct long term observations of methane and CO_2 fluxes over a large footprint at Old Woman Creek, a Lake Erie estuarine coastal marsh. We made point-scale flux measurements at different vegetation and hydrological patches within the wetland. Our observations show that long-term (inter-annual) changes of wetland water depth, which are driven by increasing Lake Erie water elevation, are affecting both CO_2 and methane flux at the whole-wetland scale. At the patch scale, both hydrology and vegetation type control carbon fluxes. Our results are used to develop a patch-level model for predicting methane and CO_2 fluxes. Such a model can be used to optimize the design of wetlands with regards to climate regulation services.

Category: General Science Session
Poster 7   Poster Session: Wed

Sean   Burns

Quality Control of Eddy-Covariance Fluxes Just-Above and Within the Subalpine Forest at the US-NR1 Site

Sean P. Burns *[1,2], David R. Bowling [3], Russell K. Monson [4], Peter D. Blanken [1]
[1] Department of Geography, University of Colorado, Boulder, USA
[2] National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA
[3] Department of Biology, University of Utah, Salt Lake City, USA
[4] Retired

sean.burns@colorado.edu

Ecosystem-scale fluxes of heat, water vapor, and carbon dioxide have been measured with eddy-covariance at the Niwot Ridge Subalpine Forest AmeriFlux site (US-NR1) since 1 November 1998. In preparation of the public release of the subcanopy (at 2.5 m height) fluxes, we present a comparison of the quality-control statistics from eddy-covariance instruments between: (1) sonic anemometers (CSAT3s) and infrared-gas analyzers (IRGAs) located just-above and within the subcanopy, (2) open-path IRGAs versus closed-path IRGAs, and (3) winter statistics versus warm season statistics. We also present comparisons of the eddy-covariance CO_2 fluxes with soil chambers and introduce other novel quality-control checks to estimate the quality/reasonableness of the ecosystem-scale fluxes.

Kyle Delwiche

Pairing eddy-covariance derived NPP with tree-ring data to understand forest growth dynamics

Kyle Delwiche*[1], Trevor Keenan[1]
[1] University of California, Berkeley

kdelwiche@berkeley.edu

Tree ring observations provide a unique historical record of tree growth rates and responses to environmental drivers. When paired with co-located eddy flux towers, tree ring data can be combined with estimates of forest net primary production to elucidate the relationship between photosynthesis and tree growth. Forest growth can be source limited (constrained by the rate of carbon assimilation) or sink limited (constrained by limits on converting carbon to plant matter). Where a forest sits on the spectrum between source and sink limitation has important implications for how forests will respond to climate change, particularly CO_2 fertilization. In this work we combine eddy flux tower data, modeled estimates of autotrophic respiration, and tree ring growth observations to better understand the drivers and constraints on forest growth dynamics, and predict future changes.

Category: 25 Years of AmeriFlux
Poster 9   Poster Session: Wed

Ankur Desai

Global change in the upper Midwest: Drivers of decadal carbon fluxes across temperate ecosystems

Ankur R. Desai [1], Susanne Wiesner [1], Nikaan Koupaei-Abyazani [1], Bailey Murphy [1], Andi Muttaqin [1], Sreenath Paleri [1], Paul Stoy [1]
[1] University of Wisconsin-Madison

desai@aos.wisc.edu

The terrestrial biosphere features the largest global sources and sinks of atmospheric carbon. Changes in growing season length, disturbance frequency, human management, increasing atmospheric CO2 concentrations, amount and timing of precipitation, and warmer air temperatures all influence the carbon cycle. Observations from the global eddy covariance flux tower network have been key for diagnosing these changes. However, data from most sites are limited in length. Here, we explore how multi-decadal carbon flux measurements from the Chequamegon Ecosystem-Atmosphere Study (ChEAS) cluster of flux towers in forests and wetlands in northern Wisconsin and Michigan (US-PFa, US-WCr, US-Syv, US-Los, US-ALQ) respond to environmental change. Despite the proximity of the sites, year-to-year variation in carbon fluxes was rarely similar between sites. Surprisingly, warmer fall temperatures and reduced thermal insulation of the underlying soil due to decreased snowpack led to later spring green-up, likely due to a muted spring phenological signal and delayed triggering of dormancy release. Higher CO2 and warmer temperatures impacts to carbon fluxes were not evident in flux trends but did influence parameters that relate carbon flux sensitivity to climate. With additional observations for the CHEESEHEAD19 experiment, we also show a mismatch in flux measurements from a very tall tower flux to the network suggesting that the whole does not seem to be simply a sum of its measured parts. More elaborate approaches may be needed to understand the processes that control carbon fluxes across large landscapes.

Category: Emerging Topics: Coastal and Urban
Poster 10   Poster Session: Thu

Inke Forbrich

From tides to seasons: How cyclic tidal drivers and plant physiology interact to affect carbon cycling at the terrestrial-estuarine boundary

Inke Forbrich* [1], Zoe Cardon [1], Anne Giblin [1], Mikaela Martiros [1], Teri O'Meara [2], Benjamin Sulman [2], Yongli Zhou [1], Cove Sturtevant [3]
[1] Marine Biological Laboratory
[2] Oak Ridge National Laboratory
[3] National Ecological Observatory Network

iforbrich@mbl.edu

Our overarching goal is to improve mechanistic process understanding and modeling of tidal wetland hydro-biogeochemistry in coastal Terrestrial-Aquatic Interfaces. Key characteristics that distinguish coastal wetlands, such as tidal oscillation, sulfur biogeochemistry, and plant structural adaptations to anaerobic soil, are beginning to be incorporated in land surface models such as the E3SM Land Model (ELM) through coupling with reactive transport code (ELM-PFLOTRAN). There remains large uncertainty in their parameterization. Particularly challenging are: 1) the small-scale, dynamic, heterogeneous redox conditions in wetland soils; 2) the aerenchyma tissue in wetland plants that greatly facilitate gas fluxes into and out of sediment; and 3) the temporal and spatial variability in salinity, which is a key determinant for plant species distribution and productivity, as well as organic matter decomposition. Working in a brackish marsh since May 2022, we combine intensive and new spatially-explicit sediment redox measurements with continuous sediment redox, salinity, and water table data, and then test relationships between these sediment variables and atmospheric fluxes of carbon and energy.
Three questions, spanning small to ecosystem scales, and short to long-term drivers, guide our approach:
1. Subsurface processes: How do tidal water level oscillations, evapotranspiration-driven water level changes, and oxygen (O2) transport from roots into the rhizosphere control tidal marsh redox and sediment oxygen distribution?
2. Sediment-plant-atmosphere exchange over time: How do hydrology, biogeochemistry and plant biology interact on different timescales (tidal, diel, neap-spring, seasonal, interannual) to influence energy and greenhouse gas fluxes?
3. Climate change scenarios: How will carbon sequestration and greenhouse gas fluxes respond to changes in climate and sea level?

Alex Fox

Understanding ecosystem processes in the subalpine forests of Wyoming and Colorado under synergistic disturbances from bark beetles, wildfire, and climate change

Alex Fox *[1], John Frank *[2], Peter Blanken [3], Mario Bretfeld [4], Sean Burns [5], Brent Ewers [1], Rob Hubbard [2], Bill Massman [2], Stefan Metzger [6], Andy Parsekian [7], David Reed [8], Xiaonan Tai [9], Ye Zhang [7]

[1] University of Wyoming, Dept. of Botany, Laramie, WY
[2] USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO
[3] University of Colorado, Dept. of Geography, Boulder, CO
[4] Kennesaw State University, Dept. of Biology, Kennesaw, GA
[5] University of Colorado, Dept. Geography, Boulder, CO
[6] National Ecological Observatory Network Program, Battelle, Boulder, CO
[7] University of Wyoming, Dept. of Geology and Geophysics, Laramie, WY
[8] University of Science and Arts of Oklahoma, Dept. of Environmental Science, Chickasha, OK
[9] New Jersey Institute of Technology, Dept. of Biology, Newark, NJ

afox18@uwyo.edu

In subalpine forest ecosystems of the Rocky Mountains, increasing disturbance under climate change affects landscape-scale water and carbon cycles. These ecosystems house the headwaters of many of the United States' most significant watersheds, highlighting a need to anticipate these changes. To address this, flux towers were built across this region to capture a variety of disturbances: the Niwot Ridge (US-NR1, 3060m elevation, South Platte River watershed), Fraser Experimental Forest (2860m, Colorado River watershed), and Rocky Mountain National Park (US-xRM, 2740m, South Platte River watershed) sites provide a baseline context for low and medium-disturbance engelmann spruce/subalpine fir/lodgepole pine ecosystems. The GLEES site (US-GLE, 3190m, North Platte River watershed) provides data on a high-mortality spruce beetle outbreak. The Chimney Park site (US-CPk, 2760m, North Platte River watershed) provides data on a mid-severity mountain pine beetle outbreak followed by wildfire. The recently established flux tower at Sawmill Creek (3100m, South Platte River watershed) will provide data on recovery in a high-altitude severely burned region of the 2020 Cameron Peak fire. Additionally, a recent project will establish three new monitoring stations along a 35km transect between US-CPk and US-GLE to investigate whether regional groundwater supports fire and beetle-resistant forest refugia. These stations provide the depth of data necessary to study the main forest and watershed responses to climate change in this region. However, major challenges still exist: growing season length and ecosystem function in this region are linked to snowmelt behavior in a way that varies by disturbance and ecosystem type, but energy budget closure becomes less reliable during this time. Melting snowpack makes site access difficult, and the energy absorbed by melting snow is difficult to measure. Improving data collection and analysis during this period will help to predict the

consequences of disturbance and climate change year-round and make better informed management decisions.

Chris Gough

A quarter century of UMBS~flux: what have learned from 25 years of data?

Jeff Atkins [1], Gil Bohrer* [2], Cameron Clay [3], Peter S. Curtis [2], Chris Gough* [3], Lisa Haber* [3], Ellen Stuart-Haëntjens* [3], Ashley Matheny*[4], Kayla Mathes* [3], Luke Nave [5], HaPe Schmidt [6], Christoph Vogel [5]

1USDA Forest Service, Southern Research Station, South Carolina, USA
2The Ohio State University; Columbus, OH, USA
3Virginia Commonwealth University; Richmond, VA USA
4University of Texas at Austin; Austin, TX, USA
5University of Michigan Biological Station; Pellston, MI, USA
6KIT/IMK-IFU, Garmisch-Partenkirchen, Germany

cmgough@vcu.edu

The University of Michigan Biological Station (UMBS) established eddy-covariance flux towers in 1997 and 2007, with the goal of quantifying baseline net ecosystem CO_2 exchange in control and successionally transitioning northern temperate forests, respectively. While analysis during the first decade of observations emphasized climatic controls over annual carbon (C) fluxes, an accumulation of multi-decadal data facilitated the interpretation of disturbance, community compositional, and physiological changes over decade-plus timescales and in real-time. Primary findings benefiting from long-term, continuous data are threefold. First, we found that UMBS forests sustain high rates of C uptake and storage when subjected to moderate severity disturbances that cause partial tree mortality, but more extreme temperatures may be eroding this C sink by increasing respiratory CO_2 losses. Secondly, while aspen was the primary tree species at UMBS a quarter-century ago, age-related senescence of this early successional species is prompting the ascension of red maple and red oak; against expectations, this compositional change is increasing C uptake and storage, demonstrating that mid-late successional forests can sequester C at rates equal to or greater than their younger successional predecessors. Lastly, leaf to canopy physiological changes over time are interacting with a progressively dryer climate to alter water fluxes, with potential feedbacks on vegetation and C cycling processes. Our work highlights the value of long-term, interdisciplinary data collection and the pairing of flux with ecological data.

Category: Emerging Topics: Coastal and Urban
Poster 13   Poster Session: Wed

Jason Horne

What is the impact of turf grass on urban carbon dioxide fluxes?

Jason P. Horne *[1], Kenneth J. Davis* [1,2], Claire Jin* [3], Samantha Murphy* [1], Natasha L. Miles* [1], Scott J. Richardson* [1], Kai Wu* [4]
[1] Department of Meteorology and Atmospheric Science, The Pennsylvania State University, University Park, PA, United States of America
[2] Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, United States of America
[3] School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, United States of America
[4] School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom

jph6488@psu.edu

Climate mitigation requires the quantification of urban greenhouse gas (GHG) emissions. Urban systems mix anthropogenic and biogenic GHG fluxes. Disaggregation of these fluxes is necessary to understand urban systems. We explore the impact of turf grass on biogenic CO_2 fluxes in the urban environment. Three-meter-tall flux towers were placed in Indianapolis in a golf course and a cemetery between August 2017 and April 2019. We use these data to parameterize the Vegetation Photosynthesis and Respiration Model (VPRM), a simple flux-interpolation model commonly used to estimate urban biosphere fluxes. We test the sensitivity of urban biosphere flux estimates to the creation of a unique turf grass plant functional type (PFT). Our parameterization enables urban turf grasses to continue photosynthesizing at air temperatures below 0˚C, as observed at both sites during winter. Turf grass fractional coverage is calculated using a linear relationship with impervious surface cover. We run VPRM at resolutions of 250 meters and 1-hour using WRF model outputs and MODIS data. The model domains are 87x87km² encompassing the city of Indianapolis and one year. We will explore daily and seasonal variability in turf grass fluxes and their impact, integrated across the city, on total urban CO_2 fluxes. This study will illustrate the importance of creating a turf grass PFT in quantifying urban GHG fluxes.

Yanghui Kang

Machine Learning Upscaling of Gross Primary Productivity Incorporating CO2 Fertilization

Yanghui Kang * [1,2], Max Gaber [1,3], Maoya Bassiouni [1,2], Xinchen Lu [1,2], Trevor Keenan [1,2]
[1] Department of Environmental Science, Policy and Management, UC Berkeley, Berkeley, CA, USA.
[2] Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA.
[3] University of Copenhagen, Copenhagen, Denmark

yanghuikang@berkeley.edu

Photosynthesis is the largest flux in the terrestrial carbon cycle. For decades, eddy covariance networks have served as the primary tool to measure ecosystem-level photosynthesis (or gross primary production, GPP). Eddy covariance measurements of GPP from various sites have been upscaled using satellite data and machine learning to understand the spatiotemporal dynamics of global photosynthesis. However, existing upscaled GPP products often overlook the response of photosynthesis to a rising atmospheric CO_2, known as CO_2 fertilization, which is responsible for a large proportion of the historic increase in the terrestrial carbon sink.
In this work, we developed a global GPP product considering the CO_2 fertilization effect by upscaling eddy covariance measurements with satellite data, machine learning, and theoretical constraints. Our product provides global monthly GPP maps at 0.05-degree resolution from 1982 – 2020. The CO_2 fertilization effect was implemented in two ways: a hybrid approach combining machine learning with biophysical theory, and a data-driven approach relying on machine learning alone. This presentation will provide technical details of our product and evaluation results against other GPP estimates from remote sensing, upscaling, and dynamic global vegetation models.

Helen Kenion

Estimation of greenhouse gas fluxes from mole fraction measurements using Monin-Obukhov Similarity Theory

Helen C. Kenion *[1], Kenneth J. Davis* [1,2], Natasha L. Miles* [1], Vanessa C. Monteiro *[3], Scott J. Richardson *[1], Jason P. Horne *[1]
[1] Department of Meteorology and Atmospheric Science, The Pennsylvania State University, University Park, PA, United States of America
[2] Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA, United States of America
[3] National Isotope Centre, GNS Science, Lower Hutt, New Zealand

hck5061@psu.edu

Tower-based greenhouse gas (GHG) mole fraction measurements are used in many cities to quantify whole-city GHG emissions. The purpose of this study is to determine whether GHG fluxes can be quantified from tower-based mole fraction networks using Monin-Obukhov Similarity Theory (MOST). Local-scale, micrometeorological flux estimates would complement whole-city estimates from atmospheric inversions. CO_2 mole fraction data and eddy-covariance CO_2 flux data are available at an urban site in Indianapolis, IN, from October 2020 through April 2022. Using MOST flux-variance and flux-gradient relationships, CO_2 fluxes were calculated using these mole fraction data and compared to the eddy-covariance fluxes. MOST-based fluxes were calculated using varying measurement heights and methods of estimating stability. The MOST flux-variance relationship method showed good temporal correlation with eddy-covariance fluxes at this urban site, and agreed in magnitude with the eddy-covariance fluxes after a site-specific correction was applied. Correlation between eddy-covariance flux and fluxes calculated from variances is highest at an instrument height of 20m. Fluxes calculated using flux-gradient relationships showed lower temporal correlation with eddy-covariance fluxes, but were closer in magnitude to eddy-covariance fluxes without a site-specific correction, compared to flux-variance estimates. Mole fraction gradients using the highest and lowest available measurement heights showed better agreement than those from measurements closer in height. When stability estimates based on eddy-covariance flux measurements were replaced with stability classes based on wind speed, time of day and cloud cover, the MOST-based fluxes still captured the temporal patterns measured via eddy-covariance, except during the night-to-morning transition. Based on these results, MOST can be used to estimate temporal patterns in local GHG fluxes at mole fraction tower sites, complementing the small number of eddy-covariance flux measurements available in urban settings. These results are being used to construct a multi-city, multi-year evaluation of the impact of the COVID-19 pandemic on urban GHG emissions.

Yeonjoo Kim

DISPROPORTIONATELY ADVANCING GREENUP AND SNOWMELT: THE IMPLICATIONS ON THE TUNDRA ECOSYSTEM IN ALASKA

Yeonjoo Kim*[1], JiHyun Kim[1], Donatella Zona[2,3], Walter Oechel[2,4], Sang-Jong Park[5], Bang-Yong Lee[5], Yonghong Yi[6], Angela Erb[7], and Crystal L. Schaaf[7]
[1] Department of Civil and Environmental Engineering, Yonsei University, Seoul, Republic of Korea
[2] Department of Biology, San Diego State University, San Diego, CA, USA
[3] Department of Animal and Plant Science, University of Sheffield, Sheffield, UK
[4] Department of Geography, University of Exeter, Exeter, UK
[5] Division of Atmospheric Sciences, KOPRI, Incheon, Republic of Korea
[6] Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, CA, USA
[7] School for the Environment, University of Massachusetts Boston, Boston, MA, USA

yeonjoo.kim@yonsei.ac.kr

The latitudinal gradients in the greenup and snowmelt may be altered by the ongoing disproportionate changes in temperature and precipitation at high latitude regions, which would affect tundra growth and its carbon flux dynamics. To investigate the net effect of the snowmelt timing variation, we (1) analyzed remote-sensing datasets (MODerate resolution Imaging Spectroradiometer phenology data, MCD12Q2.V006, and snow cover data, MOD10A1.V006) and ground measurements (eddy-covariance flux tower data) and (2) implemented a process-based model (the Ecosystem Demography model version 2, ED2) at seven tundra flux tower sites in Alaska for 18 years (2001–2018). Our results showed that the increasing rates of spring temperature (significant latitudinal gradient) has largely driven the rates of advance of greenup timing (8.4 ± 1.5 days per decade, $p < 0.05$ at one site), while the advance of snowmelt timing (5.0 ± 3.7 days per decade, $p > 0.05$ at all sites) were more driven by the decreasing trends in winter precipitation (no latitudinal gradient), which may imply high likelihood of more frequent delayed snowmelt at higher latitudes. We also found that that ecosystem response to early greenup or delayed snowmelt is largely varied depending on the local climatic constraints. Specifically, the increases in the net ecosystem productivity (NEP) due to warming-driven early greenup were amplified at the higher latitude sites (strongly colimited by temperature and water). On the other hand, the NEP decreases caused by delayed snowmelt were alleviated at the lower latitude site (weakly limited by water) due to a relief of water stress. Our results highlighted that it is critical to consider the role of snowmelt timing on the phenology of the Arctic tundra ecosystem, and its impact on vegetation growth and carbon dynamics under different climatic limits, under ongoing climate change.

Category: General Science Session
Poster 17   Poster Session: Wed

Nikaan Koupaei-Abyazani

The Influence of Interannual Carbon Variability on Long-Term Sequestration in Proximate Northern Forests and Wetlands

Nikaan Koupaei-Abyazani *[1], Ankur R. Desai [1], Paul C. Stoy [2], Min Chen [3]

[1] Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison
[2] Biological Systems Engineering, University of Wisconsin-Madison
[3] Forest and Wildlife Ecology, University of Wisconsin-Madison

nikaan.koupaei@gmail.com

Carbon dioxide (CO2) levels are rising dramatically as a result of increased anthropogenic activity. One way of countering excessive CO2 emissions is by restoring natural ecosystems that have historically been found to be efficient carbon (C) sinks. To be economically viable, these efforts must consider biomes with long-term sustained C sequestration capacities. Low interannual variation in this sink capacity minimizes risk of sequestration reversal. The goal of this study was to compare the interannual variability (IAV) of C at eight proximate Ameriflux eddy covariance sites across northern Wisconsin, Michigan's Upper Peninsula, Saskatchewan, Alberta, and the Northwest Territories with up to two decades of observations per site. Two wetlands (Allequash Creek (US-ALQ) and Lost Creek (US-Los)) and an unmanaged and managed forest (Sylvania Wilderness Area (US-Syv) and Willow Creek (US-WCr), respectively) were considered in the temperate region while boreal sites consisted of a bog (CA-SCB), peatland (CA-WP1), evergreen needleleaf forest (CA-SCC), and deciduous broadleaf forest (CA-Oas). To consider the fuller C budget, stream discharge data from the United States Geological Survey was also incorporated for some sites. In most of the measured years, on average, net ecosystem CO2 exchange (NEE) in all ecosystems was negative, indicating C uptake by the ecosystem. The standard deviation of the yearly NEE cumulative sums for US-Los was 63 gC m-2 yr-1 while for US-Syv and US-WCr it was 111 gC m-2 yr-1 and 154 gC m-2 yr-1 respectively, implying greater variability for the deciduous forests than the wetlands. A similar result was found for the boreal sites. Mutual information analysis was used to determine influences of carbon components (gross primary productivity and ecosystem respiration) and drivers on NEE. Our results demonstrate that for these regions, wetlands are a more reliable biome for C storage on decadal scales than forests.

Nikaan Koupaei-Abyazani

The Legend of Eddy - Demystifying Eddy Covariance Through Science Outreach

Nikaan Koupaei-Abyazani* [1], Sreenath Paleri* [1], Susanne Wiesner* [2]

[1] Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, Madison, Wisconsin, USA
[2] Department of Biological Systems Engineering, University of Wisconsin-Madison, Madison, Wisconsin, USA

nikaan.koupaei@gmail.com

Climate change poses one of the largest existential threats to humanity in the twenty-first century. This phenomenon is mainly caused by an increase in atmospheric greenhouse gas concentrations such as methane and carbon-dioxide. To understand how the carbon cycle responds to global change at the ecosystem scale, scientists have deployed a global network of eddy covariance towers to measure carbon fluxes and meteorological variables. The process of eddy covariance, however, is not well-known to general, non-scientific audiences, which causes a large knowledge gap between science and society. This is especially the case for students in K-12 science classes. Here, we have created a science outreach comic book focused on eddy covariance flux towers to bridge this gap. This comic is based on lab members within Dr. Ankur Desai's Eco-Meteorology Lab at the University of Wisconsin-Madison. The story involves a personified eddy covariance tower named "Eddy" who travels across different ecosystem types to converse with experts and figure out its role in addressing how the carbon cycle responds to perturbations and management changes. We hope this story will convey, in simple terms, the importance of the eddy covariance method, while also providing insight into how carbon fluxes and meteorological variables differ between ecosystems (i.e. forests, wetlands, agriculture, and urban). With the vibrant colors and cartoon-esque artstyle, we believe this form of science outreach will appeal to adults and kids alike. The purpose of this project is not only to inspire the scientists of tomorrow, but to also increase science literacy and particularly demystify the role of ecosystems in mitigating/contributing to climate change.

John Lenters

14 Years and Counting for the Great Lakes Evaporation Network: Time to Join Ameriflux?

John Lenters*[1], Peter Blanken*[2], Newell Hedstrom*[3], Chris Spence*[3], Kyle Beadle*[4], Lauren Fry*[4], and Philip Chu*[4]
[1] Michigan Technological University
[2] University of Colorado-Boulder
[3] Environment and Climate Change Canada
[4] NOAA Great Lakes Environmental Research Laboratory

jdlenter@mtu.edu

Lake evaporation is arguably one of the most important physical processes occurring in lake ecosystems, affecting everything from water levels and stratification to ice cover and aquatic chemistry. Yet prior to 2008 there were no continuous, direct measurements of open-water evaporation anywhere on the Laurentian Great Lakes, the largest lake system in the world by surface area. This represented a significant gap in knowledge for Great Lakes science, management, and policy, and it was the hydrologic community within the International Joint Commission that first recognized the need for at least one "evaporation gauge" on the Great Lakes. This led to the installation of an eddy covariance station atop Stannard Rock lighthouse in Lake Superior during the summer of 2008. In subsequent years, and through the collaborative effort of three institutions, two countries, and multiple funding sources, the measurement sites eventually grew to five stations across four of the Great Lakes by 2012, thereby establishing the "Great Lakes Evaporation Network (GLEN)." In later years, two additional sites were added in Lakes Erie and Ontario, effectively making GLEN a "basin-wide" observational flux network. In this presentation, we discuss some of the successes and challenges that have accompanied the formation, growth, and maintenance of the GLEN network over the 14+ years, including aspects related to data use and management, field site visits, research funding, and "doing science, not just monitoring." We also discuss how the network has evolved from a grassroots collaboration among a few scientists in 2008 to a more expansive partnership in 2022 that now includes multiple universities, federal agencies, and research scientists. Recent discussions with AmeriFlux members suggest that the time may be right for GLEN flux sites to become part of AmeriFlux, and this presentation is intended to further that discussion.

Category: Remote Sensing

Poster 20   Poster Session: Thu

Troy Magney

Linking optical fluxes to carbon fluxes in evergreen needleleaf forests

Troy Magney*[1], Zoe Pierrat*[2], Logan Brissette*[1], Dave Bowling[3], Barry Logan[4], Jaret Reblin[4], Christian Frankenberg [5], Jochen Stutz[2]
[1] UC Davis
[2] UCLA
[3] University of Utah
[4] Bowdoin College
[5] Caltech

tmagney@ucdavis.edu

Detecting the seasonality of photosynthesis in evergreen needleleaf forests (ENFs) using remote sensing techniques has been challenging due to their pervasive 'greenness,' understory phenology, snow and cloud cover. To improve our understanding of how biological function (i.e. photosynthesis) can be detected using optical techniques, multi-disciplinary research can serve as a model for coordination and integration of observations made at multiple scales by scientists from different fields. Here, we focus on reconciling the gap between the needle, tower and satellite with an emphasis on how fundamental plant biological and biophysical processes control the fate of photons from leaf to globe. Specifically, we focus on data from four ENF sites across a latitudinal gradient (from Florida to Alaska) with co-located CO_2 fluxes, tower-based remote sensing data, and needle-scale pigment data. Our results suggest that photoprotective pigments (i.e. carotenoids, xanthophylls) exert a stronger control on the seasonality of photosynthesis at higher latitudes, and can be optically detected using spectral decomposition methods in the VIS-NIR range. Additionally, despite little variation in chlorophyll concentration across our sites throughout the season, the semi- or complete downregulation of photosynthesis can be tracked using solar-induced fluorescence (SIF). The potential and caveats of pigment sensitive reflectance indices and SIF for detecting the seasonality of photosynthesis in ENFs across a range of environments will be discussed.

Jackie Matthes

Wintry Mix: The impacts of non-summer rain events on forest-atmosphere carbon, water, and energy flux over 30 years at Harvard Forest

Jaclyn Hatala Matthes* [1], J. William Munger [2], Emery Boose [1], Mark VanScoy [1]

[1] Harvard Forest, Harvard University, Petersham, MA, USA
[2] School of Engineering & Applied Sciences, Harvard University, Cambridge, MA, USA

jaclyn_matthes@fas.harvard.edu

Rates of total annual precipitation within the northeastern U.S. are increasing with a higher frequency of extreme rainfall events in fall, winter, and spring due to climate change. Rainfall outside of the deciduous growing season can potentially increase soil CO_2 flux with mild rain or suppress soil respiration with more severe soil inundation. Extreme rainfall can also enhance evapotranspiration rates and potentially shift the surface energy balance between sensible and latent heat flux, altering surface microclimate. This project uses the 30-year record from the EMS tower at Harvard Forest in Petersham, MA to assess the impacts of non-summer rainfall events on forest-atmosphere carbon, water, and energy flux from seasonal to interannual timescales. Leveraging this long-term record that captures many non-summer rain events, we tested for a relationship between the magnitude of precipitation and carbon flux and evapotranspiration. We also assessed long-term temporal trends in the non-summer surface energy balance that are potentially related to changing total precipitation and extreme precipitation events. Long-term records like those from the Harvard Forest EMS tower can provide important context for quantifying the ecosystem impacts of precipitation changes in temperate forests and yield insight into future change.

Category: Remote Sensing
Poster 22   Poster Session: Thu

Karem Meza Capcha

Estimation of Evapotranspiration over Urban Turfgrass Using Eddy Covariance Flux Measurements and Remote Sensing-Based Models

Karem Meza*[1], Alfonso Torres-Rua[1], Lawrence Hipps[2], Kelly Kopp[2], Rui Gao[1], Laura Christiansen[1], Oliver Hargreaves[1], Katherine Osorio[1], Jobie Carlisle[2], Ian Gowing[1], Cal Coopmans[1]
[1] Civil and Environmental Engineering Department, Utah State University
[2] Plant, Soil, Climate Department, Utah State University

karem.mezacapcha@usu.edu

Green urban areas are increasingly affected by water scarcity and climate change. The combination of warmer temperatures and increasing drought poses substantial challenges for the management of urban landscapes in the western U.S. Quantification of urban evapotranspiration is difficult because of the large spatial variability of urban landscapes. To address the water irrigation needs from these landscapes, a better understanding and modeling of consumptive water use (Evapotranspiration, ET) using ground instrumentation and well as spatial information is necessary. Regarding instrumentation, Eddy covariance (EC) measurements can allow precise quantitative estimates of actual ET in turfgrass. Historical models based on the Penman-Monteith equations fail to consider soil-plant-atmosphere interactions, and physiological responses to environmental conditions above the canopy, as well as coupling surface and atmospheric conditions. The two-source energy balance (TSEB) remote sensing-based model and the Ensemble estimates from the OpenET API, offer the capability of delivering spatial maps of actual ET. Therefore, the objective of this research is to quantify actual ET using EC over urban turfgrass located at a golf course in Roy, Utah, and use it to validate the estimates from the TSEB and OpenET. Hourly and daily ET were estimated using EC flux measurements over the study site for the 2021 summer. High-resolution multispectral and thermal imagery data were acquired from Unmanned Aircraft Systems (UAS) to run the TSEB model. Ensemble actual ET data was requested from the OpenET API. While more complete and thorough comparisons are being conducted, current validations indicate that TSEB model estimated actual ET with an RMSE value of 0.2 mm/day, and the OpenET validated with an RMSE of ET 0.7mm/day. The findings from this study demonstrated the capability of remote sensing products such as the TSEB model and OpenET to estimate accurately actual ET over Urban Turfgrass. Additionally, it showcases the benefit of UAS data in complex urban green areas to separate non-turfgrass features such as trees, sand traps, shadows, and impervious areas.

Justine Missik

Examining species-specific stomatal regulation using flux measurements and a hydrodynamic canopy transpiration model (FETCH3)

Justine Missik *[1], Gil Bohrer [1], Madeline Scyphers [1], Joel Paulson [2], Marcela Silva [3], Ashley Matheny [4], Ana Maria Restrepo [4]

[1] Department of Civil, Environmental and Geodetic Engineering, The Ohio State University, OH, USA
[2] Department of Chemical and Biomolecular Engineering, The Ohio State University, OH, USA
[3] Department of Civil Engineering, Monash University, Clayton, VIC, Australia
[4] Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, TX, USA

missik.2@osu.edu

Improving the representation of plant hydraulic behavior in vegetation and land-surface models is critical for improving our predictions of the impacts of drought stress on ecosystem carbon and water fluxes. Species-specific hydraulic traits play an important role in determining the response of ecosystem carbon and water fluxes to water stress. Here, we use a newly developed tree hydrodynamic model (FETCH3) to investigate the influence of species-specific hydraulic traits on stomatal response to water stress. FETCH3 simulates water transport through the soil, roots, and xylem as flow through porous media. The model resolves water potentials along the vertical dimension, and stomatal response is linked to xylem water potential. The tree-level model is scaled to the plot scale based on the species composition and canopy structure of the plot, allowing the model to be parameterized using observations at both the tree level (sap flux) and plot level (eddy covariance).

We demonstrate how ET observations at both the tree and plot scale can be used in conjunction with this new modeling framework and a multi-objective Bayesian optimization approach to provide insights about species-specific hydraulic traits. Here, we parameterized the model using both sap flow and eddy covariance measurements from a mixed forest at the University of Michigan Biological Station (UMBS). This approach allows us to resolve information about species-specific hydraulic parameters, and provides insights about the interactions among water stress, species-specific hydraulic strategies, and stomatal regulation.

Ngoc Nguyen

Using Water Availability to Improve Ecosystem Respiration Partitioning Algorithm from Eddy Covariance Flux Networks

Ngoc Nguyen*[1], Trevor Keenan*[1] [2]
[1] University of California, Berkeley
[2] Lawrence Berkeley National Laboratory

ngoc.nguyen@berkeley.edu

Water availability has long been a crucial determining factor of ecosystem dynamics, specifically vegetation photosynthesis (GPP) and ecosystem respiration activities (RECO) of above and below-ground components. Nevertheless, during the last 20 years, water availability has not been included in the FLUXNET GPP-RECO nighttime partitioning method, resulting in its inability to effectively estimate GPP and RECO from water-limited sites such as US-Tonzi (R-squared for half-hourly RECO estimation is 0.210) and US-AR1 (0.267). The nighttime partitioning method only uses temperature as the predictor for RECO, therefore, there is an urgent need to examine whether adding other climatic factors besides temperature could improve the model performance. In this study, besides temperature, Evaporative Fraction (EF) and Soil Water Content (SWC) were tested as the second predictor for RECO under various forms of possible equations that mimic the RECO-water availability relationship (reciprocal, quadratic, cubic functions). We used non-linear regression with gradient descent algorithm to estimate parameters for each running window, then depending on the type of parameter (whether it is time-dependent or not), we decided to linear-interpolate or take the value with the lowest RSE. The results show that over 53 studied sites, EF better represents the relationship between RECO and water availability than SWC. In addition, not all flux towers have SWC measurement while in all towers, EF can be calculated as the ratio between latent heat and total land surface energy. Compared to the FLUXNET nighttime method, the model with the reciprocal function form of EF yields a higher R-squared and lower RMSE in grassland, woody savanna, and shrubland areas, as well as in growing seasons of most sites. This indicates that EF could capture the variability of RECO caused by water limitation, and improve the model performance. Nevertheless, the reciprocal function of EF still has not been able to capture most abrupt changes in RECO values due to rain patterns; hence, there is a lot of room for improvement of the current partitioning algorithm.

Category: General Science Session
Poster 25   Poster Session: Wed

Yvette   Onyango

Modeling Interactions of Nutrient Loadings, Greenhouse Gases, Dissolved Organic Carbon & Hydrological Regime of the Old Woman Creek Wetland

Yvette Onyango*[1]

onyango.6@osu.edu

The delivery of nutrients such as phosphorus and nitrogen to wetlands emanates from continuous land use for agricultural activities. However, the impact of farming on dissolved organic carbon (DOC) is still largely unknown. Different research has proven that wetlands play a big role in modifying global carbon cycle, thus, it is important to analyze pollutant fate of different nutrients in wetlands as the character of dissolved organic carbon is related to nutrient loading and agricultural land use. Amounts of organic carbon varies through a wetland's hydrological regime. This project therefore seeks to analyze the effect of nutrient loadings on DOC amounts, and how the hydrology of Old Woman Creek (shallow, intermediate and deep points in its backflow, mid flow and outflow channels), influences the amount of organic carbon in the wetland and how these amounts of DOC influences methane and carbon dioxide fluxes in the wetland.

Raia   Ottenheimer

Using the PT-JPL algorithm to estimate evapotranspiration and its components from space and eddy covariance towers at half-hourly intervals

Raia Ottenheimer *[1,2], Victoria Shveytser [2,3], Paul Stoy [2], Ankur Desai [2],
[1] University of Toronto
[2] University of Wisconsin – Madison
[3] United States Forest Service

raia@ottenheimer.com

Perhaps surprisingly, it is not entirely clear if global evapotranspiration (ET) is increasing, decreasing, or unchanging over time. Part of the challenge in understanding this fundamental part of the water cycle is that, although ET can be readily measured by eddy covariance, the processes that control it – evaporation (E) and transpiration (T) – is relatively difficult to quantify. E and T can be estimated from space using common algorithms like PT-JPL, but these have never been validated against ecosystem-scale observations of these terms. Algorithms like flux variance similarity that separate eddy covariance-measured ET into E and T can resolve this issue, but have only been used at select sites to date. Further, daily estimates of water cycling from common satellite platforms miss the detailed sub-daily information about water cycle processes measured with towers. New advancements to geostationary satellites, like the Advanced Baseline Imager (ABI) on the Geostationary Operational Environmental Satellites – R Series (GOES-R), make it possible to apply algorithms like PT-JPL on time scales of minutes, aligning earth observation with ecosystem observations.

To quantify the reliability of satellite-based ET estimates for water resource management purposes, data from Ameriflux towers located in Northern Wisconsin forests were used in combination with GOES-ABI band 2 & 3 readings to produce an estimate for ET via the PT-JPL algorithm. With an r squared value of 0.89, preliminary results indicated a striking degree of similarity between algorithm-predicted ET and that of the tower for the Willow Creek eddy covariance tower (US-WCr). Initial investigations into using the PT-JPL algorithm to estimate E and T independently from the CHEESEHEAD19 study ecosystems reveals promising results but also opportunities for improvement. Our real-time estimates of water flux and its components, made by combining tower and geostationary satellite data, provide a framework for improving our process-level knowledge of water cycling.

Colby Reavis

Understanding the impacts of alternative management on methane emissions in US rice

Colby W. Reavis *[1], Michele L. Reba [1], Daniel Shults [2], Benjamin R.K. Runkle [3]

[1] USDA Delta Water Management Research Unit
[2] Arkansas State University
[3] University of Arkansas-Fayetteville

colbyreavis0@gmail.com

Rice is a food staple that accounts for 20% of global caloric intake. Key challenges to the future of rice production include a limited irrigation water supply and increasing methane emissions associated with expanded production area. In response, sustainable growing practices are being implemented to reduce the amount of methane being produced while providing other tangible benefits to producers, including reducing water use. Still, comparative studies have indicated a large amount of uncertainty in global rice methane emissions when compared to other anthropogenic methane sources. Thus, concerted efforts are needed to both quantify methane emissions across different regions and identify the impacts of different management practices on rice methane emissions.

In our work, we assess the mitigation potential of different management practices on methane emissions in US rice. Most US rice is grown in the California and the Mid-South, which includes Eastern Arkansas, coastal Texas, Louisiana, western Mississippi and southeastern Missouri. Using an IPCC Tier 2 approach, we estimate methane emissions across the California and the Mid-South from 2008-2020. In our analysis, we examine the impacts of both floodwater management and year-to-year crop rotations on cumulative methane emissions in rice producing regions, including the maximum mitigation potential based on different management scenarios. When determining the impacts of management, we identify areas with the most potential for reducing methane emissions in each scenario. In the Mid-South, we also compare the modeled Tier 2 estimates to cumulative methane emissions measured using eddy covariance (EC). In the comparison of Tier 2 estimates to EC observations, we include an assessment of how well the Tier 2 regional scaling factors compare to factors derived from EC observations made in production fields with known management.

Ana Maria Restrepo Acevedo

Data within the data: extracting soil water stress responses from raw sap flux data

Ana Maria Restrepo Acevedo *[1], Elizabeth Agee [2], Ashley Matheny [1].
[1] Department of Geological Sciences, University of Texas at Austin, Austin, Texas, USA
[2] Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA

anarestrepo@utexas.edu

Increasing evidence has shown diurnal variations in the hydraulic capacitance of stems as a result of changes in water stress under laboratory conditions. These variations may induce inaccuracy in the nocturnal maximum temperature baseline of thermal dissipation probes causing underestimations in the sap flux measurements. Sap flux measurements are the most common individual-scale measurements and are used as a proxy for transpiration through the conservation of mass. Therefore, it is critical to study the dynamics between wood water content and sap flux measurements under natural conditions to establish the likely impact of these variations and their influence on estimations of transpiration.

In this study we pair continuous measurements of wood water content from frequency domain probes with maximum temperature difference observations retrieved from Granier-style sap flow sensors in mature trees in a mixed forest in northern lower Michigan. We studied three common temperate tree species: red maple (Acer rubrum L.), red oak (Quercus rubra L.), and white pine (Pinus strobus L.) and we also explored whether or not changes in atmospheric and soil moisture conditions were reflected in the strength of the relationship between these parameters. We demonstrated that wood water content and maximum temperature difference are inversely correlated under natural conditions in all three species, particularly during inter-storm (drier) periods. The strength of the relationship between the maximum temperature difference and wood water content increased as soil became drier. Based on this finding, we believe that it is likely that the widely used Granier-style sap flow sensors record information regarding the overall behavior of wood water content and root-zone soil water availability for all species. Using a low-frequency filter in the post processing procedure, may allow the extraction of wood water content data from raw sap flux observations collected under natural conditions.

Category: General Science Session
Poster 29   Poster Session: Wed

Sophie Ruehr

Isolating ecosystem dependence on deep water sources using machine learning

Sophie Ruehr*[1,2], Manuela Girotto[1], Joseph Verfaillie[1], Trevor Keenan[1,2]

[1] University of California Berkeley Department of Environmental Science, Policy & Management, Berkeley CA
[2] Lawrence Berkeley National Lab Earth & Environmental Sciences, Berkeley CA

sophie_ruehr@berkeley.edu

Deep subsurface water stored in unconfined aquifers or fractured bedrock (groundwater, GW) is a critical ecosystem resource in semi-arid and arid environments. Many deep-rooted plants rely on GW when surface conditions are dry to minimize water stress. However, the effect of GW availability on ecosystem carbon cycling is challenging to isolate from other drivers of carbon fixation. Here we employ four machine learning models to quantify the effect of GW anomalies on daily gross primary productivity (GPP) anomalies from 2006-2022 at Tonzi Ranch, an AmeriFlux eddy covariance tower site. Model performance is significantly improved when GW measurements are incorporated, and model residuals show slight but significant correlations with GW anomalies, suggesting that ecosystem carbon fixation is diminished during dry GW conditions. Secondary data sets, including continuous water table depth and tree diameter measurements, also show diminished GPP and tree growth under negative GW anomalies. Our findings highlight the need for increased attention to GW hydrology in predicting ecosystem resilience to drought and the importance of combining multiple long-term data streams at flux sites.

Gabriela Shirkey

Fine resolution remote sensing spectra improves estimates of gross primary production of agricultural lands

Michigan State University, Department of Geography, Environment and Spatial Science

shirkeyg@msu.edu

Gross primary production (GPP) is a fundamental measure of the terrestrial carbon cycle critical to our understanding of ecosystem function under the changing climate and land use. Remote sensing enables access to continuous spatial coverage, but remains challenged in heterogeneous agricultural lands. Coarse resolution products, like MOD17A (500 m), may aggregate fragmented land cover types commonly found in heavily managed landscapes and misrepresent their respective contribution to carbon production.

Conversely, the advancement of high-resolution and narrow spectral bands show promise to increase precision and capture seasonal variability. This study demonstrates the capability of fine-resolution imagery (20-30 m) and red-edge vegetation indices to characterize GPP across seven Midwest cropping systems. Four sites were established on a 22-year-old USDA Conservation Reserve Program (CRP); and the other three on land conventionally farmed with corn-soybean-wheat rotation (AGR). Each three of the CRP fields and three of the AGR fields transitioned to no-till continuous corn, restored prairie and switchgrass; and one CRP field was maintained without any change. We compare in situ GPP estimates from eddy-covariance towers with ten satellite models: three vegetation photosynthesis models (VPMs) with EVI2, five VPMs with Sentinel-2 red-edge vegetation indices, as well as conventional products Landsat CONUS (30 m) and MOD17A (500 m). As expected, daily and cumulative fine-resolution imagery integrated within VPM agreed with tower-based GPP MODIS-VPM or conventional GPP products. Red-edge index NDRE2 advanced the explanatory power of Sentinel-2 VPMs between 3-16% in eight out of fourteen site-years. While MODIS-derived GPP is an important baseline for regional and global studies, future endeavors in estimating GPP in managed landscapes with greater frequency and improved accuracy are accessible and affordable at 30 m and 20 m resolutions.

Category: General Science Session
Poster 31   Poster Session: Wed

Cove   Sturtevant

NEON in AmeriFlux: Continued Harmonization and Advancement of Network Science

Cove Sturtevant* [1], Christopher Florian [1], David Durden [1], and Stefan Metzger [1]
[1] National Ecological Observatory Network, Battelle

csturtevant@battelleecology.org

Since 2016, the integration of NEON in the AmeriFlux network and accompanying collaborative efforts have yielded substantial harmonization between the networks and continue to create new avenues for advancing network science. Flux and meteorological data from all 47 NEON tower sites are available in the AmeriFlux BASE product, with data records ranging from 3 to 5 years. Expanded datasets with additional measured quantities and quality information are downloadable from the NEON data portal, and tools to convert between NEON and AmeriFlux formats are available. Gap-filled and partitioned fluxes will soon be available in the AmeriFlux ONEFlux data product. From late 2021, methane concentration vertical profiles at each site are already available from the NEON data portal and will soon be available from AmeriFlux. Collaboration between NEON, AmeriFlux, and the flux community at large is ongoing to derive methane gradient fluxes for potential inclusion in AmeriFlux datasets, along with intercomparisons to understand broad-scale alignment of these methods across the network. Additional AmeriFlux-FLUXNET-NEON collaborations that this presentation will touch on include i) continued standardization of data and metadata, ii) promoting flux towers for anchoring robust carbon accounting, and iii) alignment of gap-filling and flux partitioning algorithms between the NCAR-NEON project and ONEFlux processing.

Xiangmin sun

Eddy covariance measurements of Greenhouse Gas Fluxes (CO2, CH4, and N2O) in commercial Corn-soybean agroecosystems

Xiangmin Sun [1], Carl J. Bernacchi [1, 2, 3, 4], Taylor L. Pederson [1], Evan DeLucia [1, 3, 4], Kaiyu Guan [1, 3, 5]

[1]   Institute for Sustainability, Energy, and Environment, University of Illinois at Urbana Champaign, Urbana, IL 61801, USA
[2]   USDA-ARS, Global Change and Photosynthesis Research Unit, Urbana, IL 61801, USA
[3]   Department of Plant Biology, University of Illinois, Urbana, IL 61801, USA
[4]   Carl R. Woese Institute for Genomic Biology, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA
[5]   Department of Natural Resources and Environmental Sciences, College of Agricultural, Consumer and Environmental Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, USA

sunxm03@illinois.edu

Agriculture accounts for 11.2% of U.S. greenhouse gases (GHGs) emission in 2020. The consistent increase in GHG emissions from agricultural sector is largely driven by non-CO2 emissions, especially methane (CH4) and nitrous oxide (N2O). Though CO2 fluxes at ecosystem scale has been extensively investigated using eddy covariance (EC), flux measurements in commercial agronomic settings are relatively less common, as are flux measurements of CH4 and N2O. Three EC flux and micro-meteorology monitoring sites were established in extensive commercial cropland ecosystems in Illinois, USA with varied management practices that include conventional tillage and two conservation tillage approaches. Each EC system consists of a sonic anemometer, an open-path analyzer for water vapor and CO2 concentration, and a closed-path infrared laser absorption spectroscopy for CH4 and N2O observations. Besides standard data processing and flux calculation for CO2 and H2O, a methodological protocol for EC measurements of CH4 and N2O fluxes was developed which includes: 1) data acquisition and synchronization with anemometer observation, 2) overflow setup for inlet flow and calibration correction, 3) despiking algorithms for raw data, 4) time lag detection and compensation, and 5) spectral correction for high frequency loss. Based on the data processing protocol, we present a comprehensive dataset of the major GHGs (CO2, water vapor, CH4, and N2O) flux inventory for these corn-soybean rotation agroecosystems. The minimized soil disturbance was evaluated for mitigation potential of GHGs emission and agricultural adaptation under climate change.

Brian Widmer

Long-term litter and environmental dynamics of a temperate deciduous forest

Brian W. Widmer, Jeffrey D. Wood, Benjamin O. Knapp

University of Missouri
brianwidmer@missouri.edu

The return of plant material to the forest floor as litter drives carbon, nutrient, and energy cycling in forest ecosystems. Understanding forest litterfall dynamics and relationships with environmental conditions is needed to predict forest-level responses to severe disturbances such as drought and climate change. There is a knowledge gap regarding litterfall dynamics of broadleaf, deciduous forests in the Central U.S. We therefore measured leaf, reproductive, and twig litterfall (monthly intervals at most) over 11 years at the Missouri Ozark AmeriFlux (MOFLUX) site, in conjunction with ecosystem gas exchange and predawn leaf water potential. From 2005-2015, total annual litterfall ranged from 395–578 g m-2 and mean annual leaf, reproductive, and woody litter production was 383 g m-2 ± 42, 42 g m-2 ± 14, and 37 g m-2 ± 22, respectively. Leaf litter made up 83% of total litter on average and showed a decreasing trend over 11 years (-7.9 g m-2 yr-1), which is consistent with independent observations of leaf area index. Leaf litterfall was significantly correlated with the prior year community predawn leaf water potential integral (an integrated measure of plant water stress, r = 0.72), net ecosystem exchange of water vapor (r = 0.74) and carbon (r = -0.73), and soil respiration (r = 0.64), indicating the important legacy effects of climate and, more specifically, drought on leaf production. Reproductive litter production exhibited sensitivity to extreme climate events, as we observed decreased flowering when there was a hard freeze after early green-up and decreased fruiting following periods of drought stress. Findings from this study can be used to inform forest management practices in temperature deciduous forests.

Theresia Yazbeck

Functional-type modeling approach and data-driven parameterization of methane emissions in coastal wetlands

Theresia Yazbeck*[1], Gil Bohrer[1], Qing Zhu[2], William J. Riley [2]
[1] The Ohio State University, Civil, Environmental, and Geodetic Engineering
[2] Lawrence Berkeley National Laboratory"

yazbeck.3@osu.edu

Accurately predicting terrestrial net methane (CH4) fluxes from wetlands depends on multiple physical, biological, and chemical mechanisms that are poorly understood, oversimplified, or missing in regional and global biogeochemical models. The large uncertainty of CH4 fluxes and the challenging aspects of modeling them are driven, to a large degree, by the small-scale spatial and temporal heterogeneity of CH4 fluxes, the complex coupling between aboveground and belowground processes, and the complexity of meteorological, hydrological, ecological, and microbial processes that affect these fluxes. We aim to improve the quantitative understanding of the key processes that affect methane emissions at a high (patch level, vertically detailed) spatial resolution, and translate this understanding to improve the modeling of wetland CH4 fluxes in E3SM Land Model (ELM v1).
Eddy Covariance, chambers, and peepers' measurements are taking place in three coastal wetlands: a freshwater estuarine in Ohio, a saltmarsh, and a swamp site in Louisiana. ELM advancements included developing and incorporating an aerenchyma model based on chamber and pore water field data, activating the wetland landunit at the grid level, and parametrizing the corresponding plant functional types based the different observed flux data. This project will improve the simulation of wetland plant biogeochemical and physical dynamics (such as seasonal leaf area, photosynthetic capacity, CH4 transport through aerenchyma, etc.) at the level of the eco-hydrological patch type in land surface models, potentially resulting in a more accurate prediction for methane flux in wetlands.

Kuang-Yu Chang

Hourly water-carbon interactions modulate decadal water-use efficiency trends inferred from ecosystem-scale measurements

Kuang-Yu Chang*[1], William J. Riley[1], Trevor F. Keenan[1, 2]
[1] Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory,
Berkeley, CA 94720, USA
[2] Department of Environmental Science, Policy & Management, UC Berkeley, Berkeley, CA 94720, USA

ckychang@lbl.gov

Plant stomatal conductance regulates photosynthesis and transpiration. This physiological link affects ecosystem responses to microclimate and harmonizes carbon, energy, and water exchanges between the biosphere and atmosphere. The relationship between water losses via transpiration and carbon gains via photosynthesis can be quantified by plant water-use efficiency (WUE). While leaf- and ecosystem-scale observations both suggest rising WUE in recent decades, WUE trends inferred from the ecosystem scale are much larger than those inferred from the leaf scale or implied by theory. The unexpectedly large ecosystem-scale WUE trends complicate interpretation of ecophysiological responses to changing environmental conditions. Here, we analyze ecosystem-scale WUE inferred from 40 FLUXNET sites, each with at least 10 years of measurements. Our results demonstrate that observed ecosystem-scale WUE trends are more sensitive to hourly weather conditions than longer-term changes in atmospheric carbon dioxide or vapor pressure deficit. Our analysis shows that Earth System Models participating in CMIP6 did not capture the observed WUE sensitivity to spatial heterogeneity and microclimatic conditions. Collectively, our findings suggest that ecosystem-scale WUE trends reflect water-carbon interactions across multiple temporal scales, and disentangling factors contributing to emergent ecosystem responses is needed to infer ecophysiological relationships and model structures from observations.

Chi Chen

CO2 fertilization of terrestrial photosynthesis inferred from site to global scales

Chi Chen*[1], William J. Riley [2], I. Colin Prentice[3], Trevor F. Keenan [1,2]
[1] University of California, Berkeley
[2] Lawrence Berkeley National Laboratory
[3] Imperial College London, United Kingdom

chenchi@lbl.gov

Global photosynthesis is increasing with elevated atmospheric CO2 concentrations, a response known as the CO2 fertilization effect (CFE), but the key processes of CFE are not constrained and therefore remain uncertain. Here, we quantify CFE by combining observations from a globally distributed network of eddy covariance measurements with an analytical framework based on three well-established photosynthetic optimization theories. We report a strong enhancement of photosynthesis across the observational network (9.1 gC m-2 year-2) and show that the CFE is responsible for 44% of the gross primary production (GPP) enhancement since the 2000s, with additional contributions primarily from warming (28%). Soil moisture and specific humidity are the two largest contributors to GPP interannual variation through their influences on plant hydraulics. Applying our framework to satellite observations and meteorological reanalysis data, we diagnose a global CO2-induced GPP trend of 4.4 gC m-2 year-2, which is at least one-third stronger than the median trends of 13 dynamic global vegetation models and eight satellite-derived GPP products, mainly because of their differences in the magnitude of CFE in evergreen broadleaf forests. These results highlight the critical role that CFE has played in the global carbon cycle in recent decades.

Tommaso Julitta

Hyperspectral JB Devices integration in flux network

Tommaso Julitta*[1], Andreas Burkart*[1], Campbell, Petya K.*[2], Roberto Colombo*[3], Edorardo Cremonese* [4], Alexander Damm*[5], Tarek El-Madany*[6], John Gamon*[7], Radosław Juszczak*[8], Marika Honkanen*[9], Fred Huemmrich*[2], Mirco Migliavacca*[5], Mika Aurela*[9], Uwe Rascher*[11], Marilyn Roland*[12], Micol Rossini*[3], Dirk Schuettemeyer*[13], Jan Segers*[12], Pellikka, Petri*[14], Hans Tømmervik*[15], Janne Heiskanen*[14], Dario Papale*[16]

[1] JB Hyperspectral Devices GmbH, Düsseldorf, Germany
[2] NASA Goddard Space Flight Center. Green Belt, USA
[3] University of Milano Bicocca, Milano, Italy
[4] Environmental Protection agency Aosta Valley, Aosta, Italy
[5] University of Zurich. Zurich, Switzerland
[6] Max Plank Institute for Biogeochemistry. Jena, Germany
[7] University of Lincoln Nebraska, Lincoln, USA
[8] Poznan University of Life Sciences, Poznan, Poland
[9] Finnish Meteorological Institute, Sodankylä Finland
[10] European Commission, Joint Research Centre. Ispra, Italy
[11] Forschungszentrum Jülich. Jülich, Germany
[12] University of Antwerp. Antwerpen, Belgium
[13] European Space Agency, ESTEC. Noordwijk, the Netherlands
[14] University of Helsinki. Helsinki, Finland
[15] Norwegian Institute for Nature Research. Trondheim, Norway
[16] University of Tuscia, DIBAF. Viterbo, Italy

tommaso@jb-hyperspectral.com

Well-established carbon flux monitoring networks are recognized worldwide for providing high quality and standardized fluxes and meteorological data. Field spectroscopy, provide a link between fluxes and satellite remote sensing, enabling local information to be scaled up to global information. There is a general interest in optical sensors to obtain information that allows additional interpretation of fluxes, both in terms of structure and function of the underlying ecosystem. Many approaches to do this have been initiated but standardization on instrumentation, analysis has been challenging. So far Ameriflux data system accommodates multispectral sensors, leaving the issue of how to integrate hyperspectral sensor data into the flux data system largely unresolved
JB devices (FloX and RoX) are hyperspectral instruments acquiring field data with standardized routines. They have been collecting data for half a decade and together with the already implemented open source data processing chain, the instruments provide a valuable opportunity to fill this gap and provide a foundation for improved integration of proximal optical remote sensing with the flux network.
About 15 eddy covariance sites in Europe and US have the device installed and through a collaboration with the flux networks we are working to integrate a first set of spectral related variables (mainly

Vegetation Indices and hyperspectral radiance and reflectance) with the flux and meteo data and made them available to the scientific community under the CC-BY license. This will help to evaluate the interest and possible use of these data by a large community (including the CalVal activities) and optimize data acquisition and processing.

A full integration of the spectral related measurements in the FLUXNET context requires also the development and publication of the processing chain (already existing for the JB devices) and the definition of all the metadata needed to correctly interpret the measurements, including devices specification and setup."

Sara Knox

Quantifying carbon and greenhouse gas fluxes in wetlands in the Prairie Pothole Region Canada

Sara Knox* [1], Pascal Badiou [2], Nick Lee [3], Darian Ng [1], Zoran Nesic [4]
[1] The University of British Columbia, Department of Geography, Vancouver, Canada
[2] Ducks Unlimited Canada, Winnipeg, Canada
[3] Max Planck Institute for Biogeochemistry, Department of Biogeochemical Integration, Jena, Germany
[4] The University of British Columbia, Faculty of Land and Food Systems, Vancouver, Canada

sara.knox@ubc.ca

With growing interest in wetland management and restoration as a Natural Climate Solution (NCS) improved estimates of wetland carbon (C) sequestration and greenhouse gas (GHG) exchange across wetland types are strongly needed. In this study, we focus on small isolated wetlands in the Prairie Pothole Region (PPR) of Canada since these ecosystems are understudied relative to other wetland types in Canada, yet they play important roles in C cycling and climate regulation, water quality and quantity regulation, and are hotspots for biodiversity. Eddy covariance flux towers were installed at two small isolated wetlands embedded in grasslands and cropland ecosystems in the PPR of southwestern Manitoba. While both sites are freshwater marshes dominated by Typha, one site (Young) is spatially heterogenous, consisting of a mix of open water and vegetation patches, while the other (Hogg) is more homogenous and dominated entirely by emergent vegetation. While the more homogenous wetland (Hogg) was a net CO_2 sink on an annual scale, sequestering ~150 gC m-2 y-1 in 2021, the more heterogeneous site (Young) was a net CO_2 source, emitting ~64 gC m-2 y-1. While the Young wetland was a moderate CH_4 source, emitting ~9 gC-CH_4 m-2 yr-1, surprisingly the Hogg wetland had virtually no CH_4 emissions (emitting less than 1 gC-CH_4 m-2 yr-1). Differences in CH_4 emissions between these sites are likely driven by higher sulfate (SO_4^{2-}) and lower phosphorus (P) concentrations observed at Hogg and lower SO_4^{2-} and higher P observed at Young. Given the low CH_4 emissions at Hogg, this site was a net GHG sink in 2021, while Young was a net GHG source.

Ning Liu

Multiple methods for partitioning evapotranspiration in a coastal loblolly pine (Pinus taeda L.) plantation in the southeastern United States

Ning Liu*[1], Ge Sun[1], Maricar Aguilos[2], Jean-Christophe Domec[3], Asko Noormets[4], John S King[2], Michael Gavazzi[1], Steven G. McNulty[1]
[1]Eastern Forest Environmental Threat Assessment Center, Southern Research Station, U.S. Department of Agriculture Forest Service, Research Triangle Park, NC 27709, USA
[2]Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27695, USA
[3]Bordeaux Sciences Agro, UMR 1391 INRA ISPA, 33175 Gradignan Cedex, France
[4]Department of Ecosystem Science and Management, Texas A&M University, College Station, TX 77843-2138, USA

ln1267@gmail.com

Transpiration (T) is the dominant component of evapotranspiration (ET) in forests and the critical process connecting carbon assimilation to water cycling through stomatal behavior. Reliable T estimates are vital for climate change mitigation and water resources management. Separation methods have been proposed to derive T from ET measurements due to the challenges of measuring T directly. However, the accuracy of those methods has not been well tested. In this study, we evaluated five T estimation methods, including a multiple linear regression model (MLR), trained Random Forest (RF) model, underlying water use efficiency (uWUE) method, Priestley-Taylor Jet Propulsion Laboratory (PT-JPL) model, and a daily Water Supply Stress Index (WaSSI) model. We evaluated these methods against ET measurements from an eddy flux tower and sap flow measurements of T at a loblolly pine plantation site on the North Carolina lower coastal plain in the southeastern United States. Throughout the study period (2007-2010), observed annual ET ranged from 852 to 949 mm yr−1, with the T to ET ratio ranging from 0.64 to 0.93. Transpiration averaged 2.5 mm day−1 during the peak growing season (June - September) and 1.7 mm day−1 during non-growing season (October - May). We found that the trained RF model using potential ET and leaf area index as dependent variables had the best performance for estimating T, with the root mean square error (RMSE) of 0.5 mm day−1, followed by the MLR model (RMSE = 0.6 mm day−1). The uWUE method was slightly better than the daily WaSSI model and the PT-JPL model. The daily WaSSI model performed better than the PT-JPL model in simulating ET. All models overestimated transpiration in the peak growing season, but underestimated it in other seasons. Our study demonstrates that there is large uncertainty in existing ET models and T separation methods for coastal plain loblolly pine plantations. The trained RF model gives the best results while the remote sensing-based PT-JPL model requires further improvement for regional applications under forest conditions.

Riasad Bin Mahbub

Evaluating the potential of in-situ phenology data on improving the estimation of satellite driven gross primary productivity of rice in Arkansas

Riasad Bin Mahbub *[1][2], Michele L. Reba [3] Benjamin R.K. Runkle [2]
[1] Environmental Dynamics Program, University of Arkansas, Fayetteville, AR 72701, USA
[2] Department of Biological & Agricultural Engineering, University of Arkansas, Fayetteville, AR 72701, USA
[3] USDA-ARS Delta Water Management Research Unit, Jonesboro, AR 72401, USA

riasadbmahbub@gmail.com

One of the prominent satellite-based models to estimate gross primary productivity (GPP) is the vegetation photosynthesis model (VPM). Previous studies have found that VPM is sensitive to the parameterization technique of the parameters maximum light use efficiency (LUEmax) and optimum air temperature (Topt). The values differ not only across geolocations but also within the growing season, especially for an annual crop like rice which quickly transitions through different maturation phases. Therefore an improved version of the model is needed, and recent studies have found better results using site information and modifying the model to phenological VPM (PVPM) by bringing phenological LUEmax and Topt values into the model structure. However, most of the studies have been constrained to site-scale implementation. In this study, we leverage the potential of 16 site-years in-situ data (via eddy covariance (EC)) to estimate the LUEmax at 8 days interval and characterize the phenological nature LUEmax and Topt of rice fields based on the days after planting variable in Arkansas. We use phenological information to modify the VPM model and employ this relationship across the state's rice production region to have an improved estimate of GPP of Arkansas rice. Preliminary results validated against 16 site years have shown that at site scale, PVPM performs better than VPM by having higher R2, better slope and lesser root mean square error and mean absolute error. The spatial pattern of GPP at the state scale has shown that rice fields located in the north and mid latitude are more productive than rice fields located in other regions of Arkansas. The improved estimate of GPP will help to identify its underlying meteorological and soil factors, derive relationship with crop yield, investigate crop response to changing climate, and render a benchmark for validating prediction output from environmental models.

Asko Noormets

Beyond flux partitioning: Carbon allocation and nonstructural carbon dynamics inferred from continuous fluxes

Asko Noormets *[1], Guofang Miao [2], Michael Gavazzi [3], Bhaskar Mitra [4], Jean-Christophe Domec [5], Ge Sun [3], Steve McNulty [3], John S. King [6]
[1] Texas A&M University
[2] Fujian Normal University
[3] USDA Forest Service
[4] University of Northern Arizona
[5] Bordeaux Sciences AGRO
[6] North Carolina State University

noormets@tamu.edu

Carbon (C) allocation and nonstructural carbon (NSC) dynamics play essential roles in plant growth and survival under stress and disturbance. However, quantitative understanding of these processes remains limited. Here we propose a framework where we connect commonly measured carbon cycle components (eddy covariance fluxes of canopy CO_2 exchange, soil CO_2 efflux, and allometry-based biomass and net primary production) by a simple mass balance model to derive ecosystem-level NSC dynamics (NSC_i), C translocation (dC_i), and the biomass production efficiency (BPE_i) in above- and belowground plant (i = agp and bgp) compartments. We applied this framework to two long-term monitored loblolly pine (Pinus taeda) plantations of different ages in North Carolina and characterized the variations of NSC and allocation in years under normal and drought conditions. The results indicated that the young stand did not have net NSC flux at the annual scale, whereas the mature stand stored a near-constant proportion of new assimilates as NSC every year under normal conditions, which was comparable in magnitude to new structural growth. Roots consumed NSC in drought and stored a significant amount of NSC post drought. The above- and belowground dC_i and BPE_i varied more from year to year in the young stand and approached a relatively stable pattern in the mature stand. The belowground BPE_{bgp} differed the most between the young and mature stands and was most responsive to drought. With the internal C dynamics quantified, this framework may also improve biomass production estimation, which reveals the variations resulting from droughts. Overall, these quantified ecosystem-scale dynamics were consistent with existing evidence from tree-based manipulative experiments and measurements and demonstrated that combining the continuous fluxes as proposed here can provide additional information about plant internal C dynamics. Given that it is based on broadly available flux data, the proposed framework is promising to improve the allocation algorithms in ecosystem C cycle models and offers new insights into observed variability in soil–plant–climate interactions.

Category: 25 Years of AmeriFlux

Poster 42

Poster Session: ~~Virtual Thu~~ **in-person Thu**

David Reed

Letting data self-cluster: Harmonic analysis of the AmeriFlux network

David Reed*[1]
Housen Chu*[2]
Brad G Peter[3]
AmeriFlux Collaborators

[1] The University of Science and Arts of Oklahoma
[2] Lawrence Berkeley National Laboratory
[3] The University of Alabama

david.edwin.reed@gmail.com

There has been an increasing focus on long-term land-atmosphere flux observation networks in order to monitor Earth's ecosystems response to climate change. However, it is difficult to quantify representativeness of sites across a network in order to guide new site selection, put limited resources towards unique sites, or guide multi-site synthesis projects. To this end, we use information from the time-series data itself to cluster sites and determine how unique each site's data is relative to the network. Using the AmeriFlux BASE data products of net carbon flux, sensible heat flux, latent heat flux, net radiation, air temperature, soil water content, vapor pressure deficit, and friction velocity, data was aggregated into composite diurnal-seasonal time series that consisted of median 24 hours values for each of 24 time periods equally spaced throughout a year. This aggregated time series data was used to cluster AmeriFlux sites into clusters based on time series characteristic. Using these novel methods, we find clear spatial patterns within the data with a high degree of influence from latitude for air temperature and net radiation, larger spatial clusters for latent heat and friction velocity, and smaller spatial clusters for soil water and vapor pressure deficit. A site-specific uniqueness parameter was derived showing induvial sites or clusters that are, based only on their time series data, more distinctive than other sites within the network. Ultimately, this analysis allows quantification of which regions of the network are over- or under-sampled and would justify multi-site comparison studies from spatially distance sites.

Elahe Tajfar

Effects of irrigation management practices on net ecosystem exchange of CO 2 in the U.S. mid-South rice fields

Elahe Tajfar [1] , Michele L. Reba [2] , Bryant Fong [2] , Kosana Suvočarev [1,3] , Colby W. Reavis [1,2] , Beatriz Moreno-García [1] , Yin-Lin Chiu [2] , Benjamin R. K. Runkle [1]
[1] Department of Biological & Agricultural Engineering, University of Arkansas, Fayetteville, Arkansas 72701, United States
[2] USDA-ARS Delta Water Management Research Unit, Jonesboro, Arkansas 72401, United States
[3] Department of Land, Air and Water Resources, University of California, Davis, CA 95616, USA

tajfar@uark.edu

Water saving methods, such as alternate wetting and drying (AWD), furrow irrigated rice (FIR), multiple-inlet rice irrigation (MIRI), and zero-grade irrigation (ZRG) are emerging in rice agriculture to compensate for water scarcity. These irrigation management practices have been wildly used in Arkansas, the top producer of rice in the United States. However, a complete understanding of the carbon dynamics associated with rice production under these irrigation management strategies compared to conventional delayed flooding (DF) is lacking in this region. This study reports the CO 2 fluxes from ten production-sized fields in Arkansas across 16 field-seasons to enhance understanding of these flux dynamics in rice cropping systems. Measurements were collected from a selection of eight sites in northeast Arkansas and two sites in east central Arkansas during the growing seasons (April–September) of 2015 to. The CO2 fluxes were measured as net ecosystem exchange (NEE) and were gap-filled and partitioned to create estimates of gross primary productivity (GPP), and ecosystem respiration (R eco). The average cumulative NEE was 8043 kg C ha -1 season -1 under the DF+MIRI treatment compared to slightly lower magnitude values of 7467, 6515, 6433, and 5310 kg C ha -1 season -1 (p>0.05) under FIR, AWD+MIRI, DF+ZRG, and AWD+ZRG practices, respectively. Sites under FIR displayed the highest ecosystem respiration (R eco) (8694 kg C ha -1 season -1), likely due to more suitable soil environments for CO2 production. However, none of the aerobic production systems have significantly different R eco compared to DF. The fields were not subject to drought stress and showed no obvious agronomic impact of the occasionally drier growth conditions. However, the net uptake (i.e., cumulative NEE) tended to be correlated to field water use conditions (either measured or estimated) and was greater at fields associated with lower water use (r 2 = 0.45). The R eco rates were more similar than GPP across sites, so GPP appeared to drive the variability in NEE. Conservation irrigation methods had relatively weak influence on the site's seasonal CO2 budget; thus, they can generally be encouraged for their potential water savings benefits.

Alex Valach

Revisiting ammonia fluxes using eddy covariance: quantifying dry deposition in sensitive ecosystems

Alex Valach*[1], Christoph Häni[1], Albrecht Neftel[2], and Thomas Kupper[1]
[1] Bern University of Applied Sciences, Switzerland
[2] Neftel Research Expertise, Bern, Switzerland

a.c.valach@gmail.com

Ammonia (NH3) emissions produce negative effects on human health through the formation of fine particulate matter reducing air quality, as well as in the environment via eutrophication and acidification impacting soil and water quality. Globally, contributions from the livestock sector are responsible for 90% of NH3 emissions with minor sources from other industrial, waste management and energy production processes. Sensitive ecosystems such as forests and wetlands have experienced high nitrogen deposition from nearby sources causing biodiversity loss especially in countries with high livestock densities. As part of the Gothenburg Protocol, atmospheric concentrations are monitored and emission inventories must be reported, however fluxes are highly localised.
There are numerous methods to quantify NH3 emissions. State-of-the-art methods can measure emissions, such as by using line-integrated concentration measurements up- and downwind of sources, but many are then coupled with high frequency wind data to model the inverse dispersion of the plume from the source area. Such methods have multiple advantages including covering different source configurations and activities over longer periods. However, the deposition component of the net flux relies on modelled estimates containing rather loose assumptions. Dry deposition estimates can be as high as 50% of the measured emissions and hence are non-negligible components of the net flux carrying high uncertainties.
Fluxes have been measured using eddy covariance methods but were generally coupled with closed-path analyzers frequently suffering from artefacts related to the inlet line, which can become increasingly severe over longer measurement durations. New open-path instrumentation with fast response measurements and low power requirements present new opportunities to directly quantify deposition fluxes of NH3 especially in sensitive ecosystems without access to mains power. Here we present a review of the current state of available data on dry deposition measurements of NH3 and investigate the potential of new technologies to improve flux estimates.

Jeffrey Wood

Illuminating forest drought responses from roots-to-shoots, and leaf-to-landscape

Jeffrey D. Wood [1], Lianhong Gu [2], Rose Abramoff [2], Marvin Browne [3], Grace Cochran [1], Christian Frankenberg [4], Natan Holtzmann [5], Vincent Humphrey [6], Bella Kamplain [1], Alexandra Konings [5], Melanie Mayes [2], Camila Medeiros [3], Anna Ongjoco [3], Lawren Sack [3], Hunter Seubert [1], David Thompson [7], Nidhi Vinod [3], Yujie Wang [4], Brian Widmer [1]

[1] University of Missouri
[2] Oak Ridge National Laboratory
[3] University of California Los Angeles
[4] CalTech
[5] Stanford University
[6] ETH Zürich
[7] Jet Propulsion Laboratory

woodjd@missouri.edu

Drought is a major constraint on ecosystem productivity that threatens forests across the globe. Developing integrated understanding of how forests respond to drought is urgently needed to improve projections of ecosystem function, climate, and the carbon cycle. Here, we describe ongoing collaborative efforts at the Missouri Ozark AmeriFlux (MOFLUX) site directed towards unravelling how forests respond to drought using multi-scale observations and modeling approaches aimed at understanding how the tissue- and organ-level give rise to ecosystem behavior. The MOFLUX site, established in 2004, is strategically located in the ecotone between the Eastern Deciduous Forest and Great Plains. It is an ideal site for studying plant water relations and ecosystem scale drought responses because of high precipitation variablity and relatively thin soils that exacerbate physiological water stress during periods with abnormally low precipitation. Indeed, our 18-year record of weekly-to-biweekly measurements of predawn leaf water potential for 6 species illustrates shows strong variation in drought stress both within and across years. This presentation will highlight ongoing collaborative research projects that include: i) long-term perspectives on ecosystem drought responses, ii) bridging models and remote sensing for understanding drought responses, and iii) characterization of plant hydraulic and economic traits as part of continental monitoring. These efforts have been enabled through long-term and ongoing support of MOFLUX from the DOE's Oak Ridge National Laboratory Terrestrial Ecosystem Science Scientific Focus Area, and current projects funded by NASA and NSF. This body of work represents collaborations among faculty, staff and students at 5 universities, and scientists at DOE and NASA, and will be a team presentation emphasizing contributions from students.

Lianhong Gu

Coupling Photophysics, Photochemistry, and Biochemistry for a Complete Modeling and Remote Sensing of Photosynthesis

Lianhong GU, Oak Ridge National Laboratory

lianhong-gu@ornl.gov

Photosynthesis consists of photophysical, photochemical, and biochemical reactions. These three stages of reactions are spatially separated, follow different laws, and operate at vastly contrasting time scales. The photosynthetic machinery uses the feedforward and feedback interactions among these reactions to conduct a series of complex tasks to convert light energy from the sun to chemical bond energy in sugar for long-term storage and support of life on earth. Yet we still lack a broadly-applicable model that couples all three stage of reactions to predict photosynthesis. Recently, we have developed steady-state, mechanistic models for the photophysical and photochemical reactions. The photophysical model predicts the partitioning of absorbed photon energy among different dissipation pathways. The photochemical model describes the photosynthetic electron transport controlled by the redox reactions between enzyme complexes and electron carriers along the electron transport chain between PSII and PSI. The developed photophysical and photochemical models can be directly coupled with the conventional Farquhar-von Caemmerer-Berry biochemical (carbon reaction) model. This coupling forms a complete model of photosynthesis to predict essentially all light and carbon reaction variables of interest at leaf and canopy scales, such as net and gross photosynthetic rates, actual electron transport rates, state transitions, ratio of cyclic electron transport in PSI, fluorescence emission, redox states of PSII, plastoquinone, and cytochrome b6f complex, non-photochemical quenching, and constitutive heat dissipation. We have tested the coupled model with pulse amplitude modulated (PAM) fluorometry and gas exchange measurements made on leaves of numerous species across climates.

Lejla Latifovic

THE IMPACT OF A GYPSY MOTH DEFOLIATION EVENT ON NET ECOSYSTEM PRODUCTIVITY IN A MATURE DECIDUOUS FOREST IN SOUTHERN ONTARIO

Lejla Latifovic, Dr. Altaf Arain

School of Earth, Environment & Society, McMaster University, Hamilton, ON Canada

latifol@mcmaster.ca

Temperate forests are an important global carbon sink. However, various environmental disturbances can impact carbon sequestration. An invasive defoliation attack by the gypsy moth (Lymantria dispar L.) during the growing season of 2021 decimated a mature oak-dominated forest stand situated north of Lake Erie in Southern Ontario, Canada. This forest is >90 years old and is know as CA-TPD site in the Global Water Futures and global FLUXNET networks. In this study, we quantify the extent and severity of the forest disturbance (defoliation) using eddy covariance measurements of net ecosystem productivity (NEP), gross primary productivity (GPP), and ecosystem respiration (RE) in the forest.

Previous research at our site indicated a strong carbon sink suggesting that sequestration capabilities of the forest were resilient to environmental stresses. On average, between 2012 and 2020, the forest was an annual carbon sink of 197 g C m-2 yr-1. Following the defoliation event in 2021 NEP dropped to -455 g C m-2. Current research examines how continued climate variability and the sever attack by Lymantria dispar impacted carbon dynamics and the potential of the stand to remain a strong carbon sink.

The extent to which North American temperate forests remain an important carbon sink will depend on the severity and rate of recovery from forest disturbance and extreme weather events under a changing climate.

Category: Remote Sensing
Poster 48   Poster Session: Virtual

Max Gaber

Estimating Gross Primary Productivity with Auto Machine Learning

Max Gaber *[1], Yanghui Kang [1]
[1] University of California, Berkeley

qdv806@alumni.ku.dk

Estimating gross primary production (GPP) in space and time is fundamental for understanding the behavior of the terrestrial biosphere under anthropogenic forcings such as climate change. Recent advances in machine learning (ML) techniques have opened new opportunities to model upscaled land-atmosphere fluxes based on local eddy-covariance measurements and improving remote-sensed data.

However, despite various ML models being investigated, considerable temporal and spatial uncertainties remain in estimating GPP. The lack of a balanced global representation of flux measurements, short observation times, insufficient remote-sensed products, and model biases pose a considerable challenge to model selection and design.

With the recent development of Automated ML (Auto-ML) and its first successful application in environmental sciences, a new way to combine the strengths of different ML models in a computerized selection process could outperform classical ML approaches. In my research, I trained different Auto-ML models on GPP data from 243 flux towers from 2001 to 2019, using several combinations of gridded remote-sensed and climate variables as predictors. In a repeated cross-validation approach with random stratified splits, I determined their applicability in predicting GPP as well as its spatial and temporal variability and created a global GPP dataset.

The overall predictions were similar to classical ML methods but showed slight improvements in estimating trends and interannual variabilities. However, not all AutoML models performed consistently, and the performance varied with the selected predictors. H2O AutoML models slightly outperformed other models, with an overall median R2 of 0.74 and R2-values of 0.40, 0.66, 0.80, and 0.12 for trend, across-site variability, mean seasonal cycle, and interannual variability, respectively. Globally upscaled data agreed well with other ML-based products but consistently showed higher trends in most world regions. This research benchmarks the application of Auto-ML in GPP estimation and touches upon their potential and limitations for future upscaling experiments.