- Poster Abstracts -

For the

- 2023 AmeriFlux Annual Meeting -

Virtual Poster session: Oct 10, 2pm Eastern/11 am Pacific
Use this link: https://app.gather.town/app/oCK7k7OUQ0wcArAv/2023Ameriflux

Topic: Methane Poster 1

Darian Ng

Characterization and Prediction of Methane Spatial Heterogeneity within and beyond a Flux Tower Footprint

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This study explores a novel approach to characterizing the spatial distribution of CH4 fluxes (FCH4) within a single flux tower footprint, and then predicting beyond it, using a combination of remote-sensing via the Landsat 8 satellite and eddy covariance (EC) Footprint-weighted Flux Maps.
There were two research objectives: 1) to determine whether there exist significant relationships correlating remote-sensing with within-footprint FCH4, and 2) to investigate the potential of extrapolating and upscaling these relationships to predict FCH4 beyond the flux tower. The Normalized Difference Vegetation Index (NDVI), Water Index (NDWI), Moisture Index (NDMI), and Land Surface Temperature (LST) remote-sensing products were collected from Landsat 8, and EC data from four wetland sites, MBPPW1, MBPPW2, US-Myb, and US-WPT were used for the Flux Maps. Hierarchical clustering was used on the Flux Maps to identify distinct FCH4 features, and then applied to Landsat 8 to process the data for use in two stages of regression analysis. The first stage used simple linear regression to assess the relationships between FCH4 and each of the four remote-sensing indices. The second stage used multiple linear regression (MLR) to model the spatial distribution of FCH4.
The simple linear regression analysis demonstrated strong relationships between remotely-sensed surface conditions and FCH4, and found stronger FCH4 from open water at MBPPW2 and US-WPT, and stronger FCH4 from the emergent vegetation at US-Myb. MBPPW1 demonstrated a limitation of this approach requiring sites to have strong FCH4 signals. The MLR models supported the feasibility of upscaling using remote-sensing by capturing much of the FCH4 variance, but had reduced accuracy resulting from strong error biases and low regression slopes. This study demonstrates the applicability of a novel methodology to upscale FCH4 using remotely-sensed data and paves the way for future studies aiming to improve estimates of FCH4 from wetlands at a regional level.

Topic: Methane Poster 2

Patty Oikawa

Constraining CO2 and CH4 fluxes from Diverse Tidal Wetlands: Standardizing measurements and analysis across a network of eddy covariance sites in North America and Canada

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Tidal wetlands and other blue carbon systems are the strongest long-term carbon (C) sinks per unit area, yet these ecosystems, and the biogeochemical processes regulating C exchange, are not well represented in Earth System Models. In 2021, NATURA (A Network of north American Tidal wetlands: Understanding through coordinated Research Activities) was established, funded by the Department of Energy. This project unites 7 eddy covariance flux sites along the East and West coasts of the United States and Canada and aims to improve empirical understanding and assist process-based biogeochemical modeling of these critical ecosystems. We are coupling field measurements, statistical analyses, and experimental mesocosms in a ModEx approach to 1) improve net ecosystem exchange (NEE) partitioning into gross primary production (GPP) and ecosystem respiration (Reco), 2) quantify the influence of elevation, nitrate, and salinity on GPP and methane fluxes, 3) derive thresholds and responses of C fluxes to non-periodic pulses of salinity and nitrogen, and 4) inform and improve biogeochemical models, MEM-PEPRMT and PFLOTRAN-E3SM. Our analysis of 3 NEE partitioning approaches revealed high variability in performance both within and across tidal wetlands (n = 6 EC sites). This variability likely results from pulses of NO3 and salinity as well as tidal pumping of dissolved CO2 and other forms of respired C. Stable isotope partitioning and lateral C flux measurements are being used to evaluate and improve partitioning algorithms. We have improved MEM-PEPRMT model performance across sites by incorporating NO3 and salinity data from the tidal channel to help predict GPP, Reco, and methane exchange. We are now in the process of standardizing nitrogen, salinity, water level, and additional measurements in all 7 NATURA sites and, in Spring 2023, began running mesocosm experiments using a ModEx approach to isolate the effects of nitrogen and salinity on GPP and methane fluxes.

David Moore

Testing the State-Factors-Interactive-Controls hypothesis using eddy covariance

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The state factor-interactive-controls hypothesis is a pervasive concept in ecosystem ecology. The concept is adopted by ecologists whenever a gradient analysis is used (a chrono-sequence or a climate gradient). In this framework ecosystem processes are controlled by state factors that are not themselves influenced by ecosystem processes at local scales. The state factors in this framework are climate, potential biota, topography, geological parent material, and time. Because whole ecosystem process measurements are labor intensive and seldom measured in a consistent way, it has been challenging to test this framework in terrestrial ecosystems. The last two decades have seen the growth of the Ameriflux network in North America; similar measurements of ecosystem carbon, water and energy exchange made across a wide range of ecosystem types. We tested whether gross primary productivity, estimated using the eddy covariance method across 40 ecosystems in North America conformed to the State-Factor-Interactive-Controls hypothesis. To estimate state factors we combined satellite observations, digital elevation models, geological and soil maps and climate re-analysis. By limiting our analysis to sites with more than 8 years of data we were able to remove the effect of short term direct controls (light, temperature, moisture etc) on gross primary productivity. We found significant interactive effects of climate and geological substrate ($p < 0.05$) and a strong direct effect of climate on average gross primary productivity ($p < 0.05$). We also found a strong effect of biota on the variation that was not explained by state factors. Together these findings provide support for the state factors-interactive-controls hypothesis and suggest new opportunities for ecological synthesis using networks of ecological data. We also demonstrate how this approach can be used to more robustly benchmark and improve terrestrial biosphere models.

Topic Data processing and visualizing Poster 4

Jiangong Liu
Spatiotemporal Dependence of Photosynthesis on Environmental Drivers in Energy-Limited Ecosystems

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Ecosystem gross primary productivity (GPP) represents an intricate consequence of environmental driver influences on photosynthetic processes. These drivers typically display distinct temporal and spatial variations, resulting in instantaneous responses and long-term acclimation and adaptation of photosynthesis. Moreover, considering the causal hierarchy of these drivers is crucial for accurately ranking their importance to GPP. In this study, we analyzed the spatiotemporal dependence of ground-based eddy covariance GPP observations and satellite-derived GPP proxies (TROPOMI SIF) on environmental drivers in energy-limited periods and regions. Water-limited ecosystems were excluded due to their tight atmosphere-biosphere coupling, which forms cyclical loops. Employing explainable machine learning techniques, integrated with causal chain graphs and Pearl's do-calculus, our study indicated that energy-related drivers are the dominant factors affecting GPP both temporally and spatially, while water vapor pressure governs the spatial distribution of annual GPP in drylands. Notably, the functional dependence of ecosystem photosynthesis on environmental drivers can differ across temporal scales and biome types. Despite soil moisture's limited predictive capacity for GPP, its contributions to GPP showed an increasing trend in 55% of flux sites. In contrast, contributions from atmospheric CO_2 concentrations decreased in 52% of these sites. Our findings highlight the need to account for temporal and spatial scales when quantifying GPP dependance on its drivers and developing land surface models.

Topic: General Science Session Poster 5

Jagriti Suneja
On the linkage between surface heat fluxes and planetary boundary layer height

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In this study, we establish the relationships between the surface heat fluxes – sensible heat and the latent heat flux with the changes in the planetary boundary layer height. The study is done for a site around Lake Wheeler in Raleigh, North Carolina, which is a flat terrain having a mix of both agricultural as well as urban landscapes . The PBL heights estimated using a ceilometer for a year were studied based on changes in the intensity of the backscatter profiles obtained each day. The surface heat fluxes obtained using the eddy- covariance method, were studied for the same duration. Data were filtered to include only clear days with convective conditions and the sensible and latent heat fluxes were averaged daily for those times between sunrise and sunset. We found that the latent heat flux has stronger relationship with the maximum PBL height as compared to the sensible heat flux. Surface fluxes from a larger area of influence on the site are analyzed using satellite imagery from the ECOsystem Spaceborne Thermal Radiometer Experiment (ECOSTRESS) to understand the evapotranspiration rates and the influence of surface fluxes on PBL height. This analysis provides better insights into the land – atmospheric interactions in convective systems, with applications to the improvement of evaporation and air quality models.

Topic: General Science Session Poster 6

Tirtha Banerjee
Persistence behavior of heat and momentum fluxes in land-atmosphere exchange

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Characterizing heat and momentum fluxes is of paramount importance for several applications in Earth sciences. In the geophysical context, these fluxes quantify the surface-atmosphere momentum and heat exchanges, which eventually drive the Earth's climate. Therefore, it is necessary to develop a comprehensive understanding of the turbulent generation mechanisms of the heat and momentum fluxes. A fundamental challenge associated with modeling turbulent fluxes is associated with their intermittent behavior, which is caused by the aperiodic occurrences of ejection and sweep motions. In this work, we show how we can tackle this issue by studying the switching patterns of intermittently occurring turbulent fluctuations from one state to another, a phenomenon called persistence. Our results show that the length scales of turbulent motions that contribute to this flux intermittency display a clear power-law signature up to the integral scales with an exponential drop thereafter. This property allows one to separate the patterns created by coherent structures in the atmospheric flows. Furthermore, the length scales associated with flux intermittency also depend on the underlying surface features, such as the presence of a forest canopy. For instance, in a dense canopy flow, the persistence patterns of the momentum flux signals, when appropriately scaled, remain largely independent of whether the observation heights are within or above the forest canopy. This result points to a persistent memory imposed by canopy-induced coherent structures and their role as an efficient momentum-transporting mechanism between the canopy airspace and the region immediately above. Overall, this methodology provides a new understanding of the causal linkages connection between flow organization and flux generation mechanisms crucial for land-atmosphere interaction.

Topic: Remote Sensing Poster 7

Lianhong Gu
SIF as a Window into Photosynthesis

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Sun-induced Chl a fluorescence (SIF) is the only optical signal emitted from the core of the photosynthetic machinery that is detectable via non-intrusive remote sensing. SIF is functionally related to photosynthesis, therefore its detection and quantification offers the promise of remotely monitoring photosynthesis and plant stress in real time. However, how SIF is related to photosynthesis and plant stress is a complex issue. This complexity arises because photosynthesis consists of three stages of reactions (i.e., photophysical, photochemical, and biochemical). Furthermore, SIF is emitted from the first stage of a long chain of events — the photophysical reactions whereas ecologically important targets that are intended for inference with observed SIF take place in subsequent stages. In particular, CO2 assimilation, a primary interest for applying SIF, occurs in the last stage — the biochemical reactions. In between are the photochemical reactions which are sensitive and serve as detectors of plant stress. The photophysical, photochemical, and biochemical reactions are spatially separated, follow different laws, and operate at vastly contrasting time scales, which creates challenges for relating SIF to downstream processes such as CO2 assimilation and plant stress. In the last few years, we have developed necessary mechanistic models of photophysical and photochemical reactions. These models can now be coupled with the traditional biochemical model of photosynthesis to form a complete mechanistic framework to infer ecologically important information from SIF observations. This framework shows that SIF is a window into photosynthesis through which different insights can be gained, depending on the level of additional independent information that is available. For example, when only a limited amount of additional information is available (e.g., when the fraction of open reaction centers can be modeled independently), SIF can be used to infer energy use in different dissipation pathways. At the next level of independent information availability, SIF can be used to infer the redox state of the electron transport chain (ETC) and therefore plant stress if certain characteristics of the ETC, which may vary with species, are known. Finally, if information about the characteristics of the Calvin-Benson cycle is available, SIF can be used to infer CO2 assimilation. In this presentation, we will briefly introduce these advances.

Topic: General Science Session Poster 8

Tyson McKinney

Using eddy covariance to investigate ecosystem and climate controls on evapotranspiration (ET) across the Edwards Aquifer recharge region of central Texas

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The Edwards Aquifer of central Texas is a prolific artesian aquifer that serves almost two million people. It is karst-dominated, with recharge occurring through both focused and diffuse mechanisms. Understanding the water budget of this system is vital, especially the diffuse mechanisms that are poorly characterized and parameterized in hydrologic models. In this study, the eddy covariance (EC) technique has been used to directly measure fluxes of water vapor (i.e., evapotranspiration; ET) at five locations across the Edwards Aquifer recharge region since 2016, representing different climates and ecosystems across the recharge area.
From 2016-2018, three stations were maintained at Camp Bullis, north of San Antonio, one each in oak savanna, oak-ashe juniper woodland, and grassland ecosystems. Similar average ET rates were observed at each site during the study period (~2.0 ± ~1.1 mm/d), with seasonal differences based on vegetation. To understand the control of climate variability on ET across the recharge region, two stations were moved to the more humid eastern (Cibolo) and more arid western (Uvalde) portions of the recharge area. The Uvalde station collected data in a mesquite woody savanna from 2021-2023, while the Cibolo station has collected data in an oak-ashe juniper woodland from 2021-present. From March 2021 through February 2023, the average daily ET was greater at Cibolo (1.63 ± 1.1 mm/d) than Uvalde (1.38 ± 1.15 mm/d), with both sites experiencing seasonal differences in ET rates. Precipitation in excess of ET on a seasonal basis (a first-order estimate of the potential for recharge) ranged from +186.76 mm during spring 2021 at Cibolo to -100 mm during summer 2021 at Uvalde (positive numbers indicate potential for diffuse recharge). Future work will correlate ET data with satellite-derived vegetation indices and ET estimates to upscale point measurements and apply the results across the Edwards Aquifer recharge region.

Topic: Methane Poster 9

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

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Our overarching goal is to improve mechanistic process understanding and modeling of 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 and methane fluxes.

Working in a brackish marsh (US-Plo) since May 2022, we observed a high salinity event (>20psu) in summer 2023 during an extreme drought in Massachusetts. This impacted energy and carbon fluxes differently, but the most immediate and long-lasting impact was a reduction in methane emissions. We will use continuous sediment redox, salinity, and water table data to test relationships between these sediment variables and atmospheric fluxes of carbon and energy.

These 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?

Topic: Diverse Ecosystems Poster 10

Bella Kamplain

Species-specific Dehydration and Rehydration Dynamics in Oak-Hickory Forests

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As drought conditions increase and intensify due to climate change pressures there is a need to better understand how tree water status changes over time in response to increased environmental stress. Tree water status is intimately linked with forest gas and heat exchange. Predawn leaf water potential (ψpd) measurements provide key information on the physiological water status of trees by quantifying the stem water potential of the plant. By analyzing changes of ψpd over time, we can better understand the dynamics of tree water stress at the species and ecosystem level. We will leverage ψpd observations of six prominent tree species at the Missouri Ozark AmeriFlux (MOFLUX) site collected at weekly to biweekly intervals over 19 years to characterize dehydration/rehydration dynamics of co-occurring tree species in a Quercus-Carya (oak-hickory) forest. Leaf samples are collected at predawn, and the data is collected using a pressure chamber from the following species: Quercus alba (white oak), Quercus velutina (black oak), Acer saccharum (sugar maple), Carya ovata (shagbark hickory), Juniperus virginiana (eastern redcedar), and Fraxinus americana (white ash). Here, we will examine species-specific dehydration and rehydration rates and investigate correlations with environmental factors such as temperature and vapor pressure deficits. Overall, our results will help us to better understand the hydrologic processes occurring within each individual tree species and at an ecosystem level as environmental factors led to increased plant water stress.

Topic: General Science Session Poster 11

Audrey Maheu

Evapotranspiration in temperate forests undergoing changes in structure and composition

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In temperate forests of southern Quebec (Canada) as well as elsewhere in eastern North America, a marked increase in the dominance of American beech (Fagus grandifolia Ehrh.) has been observed in stands typically dominated by sugar maple (Acer saccharum Marsh.). Various studies have reported the development of a dense (>1500 saplings per hectare) and almost monospecific layer of American beech in maple-dominated stands which will likely have implications for the forest water balance. The objectives of this study are i) to assess how beech expansion will influence interception (i.e. evaporation of canopy-intercepted precipitation) and ii) to assess how beech expansion will influence transpiration, including under drought conditions. We monitored water fluxes at 6 sites, 3 sugar maple stands with beech proliferation (basal area of beech saplings > 2 m^2/ha) and 3 control sites. Each site was subdivided into two plots of 20 m x 20 m, that is one plot with a rainfall exclusion and one control pot. In control plots without rainfall exclusion, we assessed interception by measuring gross rainfall in clearings < 1 km from plots and by measuring throughfall with 81 containers (total surface area = 0,9 m^2). Across all plots, we measured sap flux density at a total of 66 trees (~3 mature sugar maples and ~2 beech/maple saplings per plot) with sensors using the heat pulse method. We also measured soil moisture (volumetric water content and water potential) at each plot at a depth of 10 cm. To assess the influence of litter on water fluxes, we also measured soil moisture in a 1m^2 quadrat where litter was removed. Overall, this poster will present the experimental set up installed in forest stands to assess how changes in structure and composition (i.e. American beech expansion in sugar maple stands) may interact with global change (i.e. increased frequency of droughts) and influence the forest water balance.

Topic: Methane Poster 12

Yvette Onyango

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

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Estuarine marshes are at the interface between terrestrial riverine flows and oceans or lakes. Thus, they play a crucial role in the movement, storage, and atmospheric fluxes of carbon. We monitored carbon fluxes, in the form of CH_4, and CO_2, and the concentration and loading of dissolved organic carbon (DOC) in Old Woman Creek (OWC), one of Lake Erie's estuarine wetlands in northern Ohio. Sampling of surface water for DOC and gas exchange chamber measurements were conducted simultaneously at three distinct hydrological positions in the wetland: the outflow, mid-flow, and backflow areas and at three different relative depths (deep, intermediate, and shallow) within each position, monthly, over summer and autumn periods of 2022 and 2023. The temporal and spatial correlation between DOC, CH_4 and CO_2 fluxes in OWC wetland were investigated, with a focus on the inflow dynamics from nearby rivers and the wetland's hydrological regime. We hypothesized that the very high CH_4 flux levels observed in OWC are driven by the wetland's intake of DOC. We found that DOC in the wetland's inflow positively correlates with the river stage, and with CH_4, and CO_2 gas fluxes in the wetland. Additionally, average DOC loading over a two-week period was significantly related to CH_4 flux. We observed that varying depths within the wetland influenced the wetland's DOC concentration thus playing a significant role in regulating methane emissions. However, we did not find a direct spatial correlation between DOC and CH_4 when considering the timing of sampling. The mid-flow area had the highest DOC concentration and exhibited the highest total methane flux. Temporal variations in DOC concentration at different locations throughout the wetland did not significantly affect CH_4 fluxes from these locations, when other factors (temperature, depth, river stage) were considered. Based on our findings, the input of water and organic matter in the wetland's inflow from the nearby river system emerged as a crucial environmental driver that likely contributes to the variations in DOC concentrations and consequential emissions of greenhouse gases within the wetland. Understanding these relationships is significant in understanding the importance of wetlands as greenhouse gas sources and sinks in relation to climate change, and in the development of targeted mitigation strategies. We recommend that future models should include DOC transportation as a parameter for wetland greenhouse gas emissions.

Topic: Data processing and visualizing Poster 13

Housen Chu

AmeriFlux BASE data pipeline to support network growth and data sharing

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AmeriFlux is a network of independent research sites that measure carbon, water, and energy fluxes between ecosystems and the atmosphere using the eddy covariance technique to study a variety of Earth science questions. AmeriFlux's diversity of ecosystems, instruments, and data processing routines all create challenges for data standardization, quality assurance, and sharing across the network. To address these challenges, the AmeriFlux Management Project (AMP) designed and implemented the BASE data-processing pipeline. The pipeline begins with data uploaded by the site teams, followed by the AMP team's quality assurance and quality control (QA/QC), ingestion of site metadata, and publication of the BASE data product. The pipeline automated and facilitated communication, tracking, QA/QC, and publication functions, enabling us to keep pace with the rapid growth of the network. As of 2022, the AmeriFlux BASE data product contained 3,130 site years of data from 444 sites, with standardized units and variable names of more than 60 common variables, representing the largest long-term data repository for flux-met data in the world.

Topic: Diverse Ecosystems Poster 14

Patrick Murphy
Renewable energy considerations for new Arctic sites

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Permafrost thaw is accelerating with global climate change, further amplifying the release of greenhouse gasses into the atmosphere. Despite an expansive network of eddy covariance sites in the Arctic and sub-Arctic, some regions in this Arctic-Boreal zone remain understudied. To more accurately model and quantify the flux of carbon across the Arctic as the climate continues to change, it is imperative that these regions be included in long- term monitoring. However, adding and maintaining flux towers in the Arctic comes with logistical and technical challenges due to lack of infrastructure. Here, we present an overview of power and communications designs at new and existing AmeriFlux sites. A combination of solar and wind generation was capable of powering a site in northern Manitoba (CA-CF3) year-round. In December 2022 and January 2023, the site collected approximately four hours of CO_2 and CH_4 flux data per day leading to 16% monthly data coverage. However, meteorological data from the site remained free of gaps throughout the winter. This was possible because of effective monitoring of battery voltage and automated control of load. By prioritizing the low-power meteorological sensors, we are in a better position to gap-fill the flux data outside of the growing season at this site. While we continue to add new sites above the Arctic circle, we solicit feedback and suggestions from the community to better use renewable energy to capture year-round fluxes.

Marco Montemayor
Decadal differences in seasonal carbon fluxes from a subarctic fen

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Temperatures have risen more rapidly in Arctic-boreal regions than anywhere else on the planet, leading to soil warming, accelerated permafrost thaw and the amplification of the permafrost carbon feedback loop. Approximately 1700 Pg of soil carbon (C) are stored in the top three meters of permafrost, with some of the highest concentrations of C in permafrost peatland. Additionally, there are varying projections as to how much C will be released into the atmosphere due to increased warming in these environments. Here we investigate the change over time in C fluxes from a subarctic fen in Churchill, Manitoba Canada by comparing eddy covariance (EC) flux data from 2007-2011 (Ameriflux sites CA-CF1 and CA-CF2), to our new site CA-CF3 placed in the same subarctic fen 10 years later. By analyzing CH_4 and CO_2 flux (FCH_4, FCO_2) measurements in response to changing meteorological conditions, specifically air temperature, soil temperature, precipitation and radiation, we are seeking to quantify the differences over this time period in C flux dynamics and magnitude. Additionally, we examine C flux effects from a lengthening growing season and extended zero-curtain effect in the fall. Lastly, we integrate winter flux data, which has not before been measured at this site, to get a more accurate representation of annual FCH_4 and FCO_2. Although winter flux magnitude is smaller than the summer season, due to the long duration of winter it must be incorporated in order to have an accurate annual budget of C flux.

Topic: Diverse Ecosystems Poster 16

Justine Missik

Examining species-specific hydraulic traits using ET measurements and the hydrodynamic canopy transpiration model FETCH3.14

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Species-specific hydraulic traits play an important role in the response of ecosystem carbon and surface fluxes to water stress; however, representation of biodiverse forest canopies remains a challenge in land-surface models. We introduce FETCH3.14, a multispecies, canopy-level, hydrodynamic model which builds upon previous versions of the Finite-difference Ecosystem-scale Tree Crown Hydrodynamics model (FETCH). FETCH3.14 simulates water transport through the soil, roots, and stem as porous media flow. Stomatal conductance is controlled by xylem water potential, which is resolved along the vertical dimension. A key feature of FETCH3.14 is a multi-species canopy formulation, which uses crown and stem dimensional characteristics to allow the model to produce both tree-level and plot-level outputs. Fluxes from representative model trees with distinct hydraulic traits are scaled to the plot level 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, stem water storage) and plot level (eddy covariance evapotranspiration).

Parameter optimization is performed using the newly developed Bayesian Optimization for Anything (BOA) package, which facilitates parameter optimization using multi-scale and multi-variate observations. This framework allows us to incorporate multiple sources of information, including multi-scale ET observations, soil and stem water potential observations, and carbon flux observations 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, flux site US-UMB). We examine the differences in hydraulic stress responses between an anisohydric, deep-rooted species (oak) and a strongly isohydric, shallow-rooted species (maple). The two species demonstrate marked differences in their response to drought periods, with stomatal conductance and transpiration being strongly reduced in maples but not in oaks. FETCH3.14 was able to capture the species-specific hydraulic traits that lead to these observed differences in drought responses. Our results provide insights about the interactions among species-specific traits and water stress, hydraulic strategies, and stomatal regulation.

Topic: Data processing and visualizing Poster 17

Madeline Scyphers

Showcasing Bayesian Optimization for Anything (BOA), a Multi-Scale, Language-Agnostic Hyperparameter Tuning Package, applied to a Hydrodynamic Canopy Transpiration Model

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Mathematical optimization is the process of optimize a performance metric by identifying the best possible value among the set of all feasible options, which naturally arises in many modeling situations, including land-surface modeling. Such optimization problems are very challenging to solve whenever evaluating performance for feasibility requires an expensive/black-box simulation whose results may be corrupted by random errors (variance in instrument measurements, gap filling, human error, etc.). Bayesian optimization (BO) is a class of machine learning-based optimization algorithms, shown to achieve state-of-the-art performance on several important applications from this problem class, which has spurred significant interest from practitioners in recent years.

We utilize our own highly flexible, language-agnostic, BO and model wrapping framework package, Bayesian Optimization for Anything (BOA), which reduces optimization setup time, simplifies data assimilation, and eases advanced use cases such as High-Performance Computing (HPC) parallelization and optimization restarting through automatic serialization. We showcase two examples, one, we optimize a synthetic function where everything is written entirely in another language than BOA to showcase its language-agnostic potential, and two, we parameterize FETCH3.14, a multispecies, hydrodynamic canopy transpiration model which builds upon the previous versions of the Finite-difference Ecosystem-scale Tree Crown Hydrodynamics model (FETCH) to showcase BOA's real world potential. We use flux data from representative trees that get scaled to the plot level based on the composition of species and structure of the canopy, which allows parameterization using tree-level observations (sap flux, stem water storage) and plot-level observations (eddy covariance evapotranspiration). Using BOA we set up a multi-objective optimization inverse problem with little overhead or boilerplate code, allowing us to utilize multi-scale observations to resolve species-specific hydraulic parameters, including parameters that are difficult or impossible to measure in the field.

Typically, BO packages require the users to have a level of BO domain knowledge, write a substantial amount of boilerplate code, and lock themselves into a particular language. BOA is written to address these hurdles while maintaining a robust BO package, allowing users to easily set up their optimization with sensible defaults or configure it extensively.

Topic: General Science Session Poster 18

Holly Roth

The Impacts of Chinook Windstorms on Turbulent Energy Exchange in Colorado Reservoirs

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In the Colorado Front Range, Chinook windstorms are common phenomenon, occurring on average, 40 times each year, and most often in the fall and winter months. Chinooks are caused by the interaction between synoptic scale flow and mountainous terrain and are characterized by strong westerly winds that bring relatively warm and dry air to the lee of the North American Rocky Mountains. Even though Chinooks are a well-known occurrence in the Colorado Front Range, their impact on latent and sensible heat fluxes, as well as other reservoir processes is not as well understood. This knowledge gap creates the potential for large implications for water resource decisions as Chinooks occur when reservoir evaporation is often assumed to be minimal. Eddy covariance measurements are coupled with in-situ lake measurements and are used to explore atmospheric boundary-layer and limnological conditions at Standley Lake, a relatively large water supply reservoir in Westminster, CO. A specific Chinook windstorm is explored to better understand how Chinooks influence water and energy exchange processes. During these events, reservoirs can warm and mix, and turbulent energy exchange between the reservoir and atmosphere can be enhanced up to 3-5 times the average of the respective month the event occurred in. Because of the potentially large impacts on a water supply reservoir, there is a need to fully understand and adequately account for the influence of Chinook windstorms and similar events on reservoir dynamics and in water supply planning, especially in light of a changing climate system.

Topic: Remote Sensing Poster 19

Kathryn Wheeler
Predicting carbon fluxes at NEON sites using remotely-sensed structural characteristics

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Terrestrial ecosystems hold an important and uncertain role in global and local carbon cycles through photosynthesis and respiration. Previous research has shown that structurally more complex canopies have higher rates of increases in plant stem biomasses, it is still unclear how structural complexity impacts ecosystem carbon fluxes. Many earth system models neglect structural characteristics such as complexity and height. For example, all plant functional types are assigned the same canopy height in the default version of Community Land Model (CLM). The importance of structural complexity in improving carbon flux predictions likely differ throughout the year and might be strongest in the shoulder seasons when different layers of plant canopies often greenout and senesce at different timings. Thus, structurally more complex canopies likely have greater variation in the timing of phenological events, which could lead to worse predictions and longer periods of greendown and greenup. Here we investigated how structural characteristics (e.g., complexity and height) impact carbon fluxes at sites within the National Ecological Observatory Network (NEON). Specific questions included do growing season total carbon fluxes correlate with structural complexity across sites of the same dominant plant functional type; are CLM predictions of carbon fluxes in the shoulder seasons worse for more structurally complex sites; and do structurally more complex canopies have longer greenup and greendown periods. To estimate structural characteristics, we used the NEON Airborne Observation Platform discrete return LiDAR point clouds. To estimate carbon fluxes, we used NEON’s prototype gap-filled gross primary productivity (GPP) product. Preliminary results indicate that structurally more complex plant canopies have greater total growing season GPP.

Topic: General Science Session Poster 20

Benju Baniya

US-CRK: new carbon allocation observatory in shortleaf pine forest

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Shortleaf pine had the widest historical natural range of the southern pines, but harvesting, fire exclusion, and conversion to loblolly pine in the past 40 years have led to the decline of shortleaf pine-dominated stands to less than 10% of its historic range. In 2013, USDA Forest Service and several state agencies put together the Shortleaf Pine Restoration Plan, with the goal of restoring the plant communities and habitat associated with the species. In 2021, we established a new eddy covariance site and ecosystem-wide carbon observatory in a shortleaf pine-post oak forest in Davy Crockett National Forest in east Texas. The forest is managed by USDA Forest Service for red-cockaded woodpecker, a federally endangered species that prefers open mature pine canopy with open understory. To achieve these conditions, the forest is burned every two years, resulting in the dominance of American beautyberry in the understory (>90% of ground cover).
Flux measurements are conducted both above and below pine canopy (30m, basal area=31.0 m2 ha-1) on a 45m tower (LI-7200 and Gill WindMaster at 43m and 11m). Both heights are also sampled for fluxes of CO2 isotopologues using Aerodyne Tunable Infrared Laser Direct Absorption Spectroscope (TILDAS). The instruments also include a multi-chamber soil CO2 efflux system (LI-8100) and standard micrometeorological systems (air temperature and humidity, precipitation, photosynthetically active and net radiation (4 components), soil temperature and moisture profile, and soil heat flux). In addition, soil CO2 efflux, litterfall, tree increment, and fine root growth are monitored monthly in five central vegetation survey plots. During the first year of measurements, annual net ecosystem exchange was -270 g C m-2 yr-1, evapotranspiration was 1050 mm, and soil respiration was 1248 g C m-2 yr-1.

Topic: General Science Session Poster 21

Matthew Friedkin
Weather Forecast Model Evaluation Using the New York State Mesonet Flux Network

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Established in 2017, the New York State Mesonet (NYSM) is a comprehensive network of 126 standard meteorological sites, 17 profiler sites (3D scanning lidar and microwave radiometer), 17 snow sites, and 18 flux sites (momentum, heat, moisture, and CO2) that spans the complex terrain of New York State. The NYSM was conceived as a monitoring/early warning detection network; however, it also provides a unique observational data set for evaluating forecast models. Verification and evaluation are important to quantify the accuracy of weather models and can suggest processes within the models that need improvement. A collaborative project between University at Albany's Atmospheric Sciences Research Center (ASRC) and the National Center for Atmospheric Research (NCAR) aims to combine high-resolution forecast model output (an experimental version of the high-resolution Unified Forecast System) with NYSM observations using Model Evaluation Tools (METPlus), a versatile verification and visualization system developed by NCAR, the National Oceanic and Atmospheric Administration (NOAA), and the community. METPlus includes a suite of tools for calculation of statistics between model outputs and in situ observations at various temporal and spatial scales. While initial METPlus workflows have focused on basic meteorological variables (e.g., 2-m temperature) measured at standard sites, our goal is to use fluxes and flux-derived measures of surface-atmosphere coupling (e.g., Bowen Ratio) to test physically-based parameterization schemes and provide insight into model biases.

Topic: Techniques Poster 22

Dohee Kim

High-Frequency Carbon Isotope Measurements for Investigating Forest Carbon Allocation Dynamics

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The eddy covariance (EC) of CO_2 isotopologues offers the promise of partitioning bulk CO_2 fluxes to different components at high temporal resolution and provides novel ways of validating ecosystem carbon cycle models. Here we present the first few months of measurements of CO_2 isotopologues with tunable infrared laser direct absorption spectrometer (TILDAS; Aerodyne Research, Billerica, MA), collected in a shortleaf pine forest (US-CRK) in East Texas. The mixing ratio of CO_2 isotopologues and the $\delta^{13}C$ was calculated for the Keeling plot approach. We analyzed the Keeling plots of 10Hz measurements over 30 minutes, looking at the contrast between spring (March) and summer (June) in both day- and nighttime fluxes. The negative correlation of the daytime $\delta^{13}C$ with VPD indicates the stomatal limitation of photosynthesis. The intercepts of the Keeling plots of nighttime $\delta^{13}C$ against $1/[CO_2]$ show the variability of the respiration sources. We observed the average nighttime intercept was slightly (3‰) more depleted in summer, suggesting a greater contribution of plant-derived carbon. The R^2 of the Keeling plots was significantly higher in June than in March. The response time of daytime $\delta^{13}C$ to VPD was on the order of 1 to 6 hours, which is distinctly faster than commonly reported, suggesting a faster coupling of canopy gas exchange with water status.

Topic: General Science Session Poster 23

Emily Mather

Quantifying advective flux contributions to energy budget closure at CHEESEHEAD19 study sites

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An imbalance between measured incoming and outgoing energy is observed at most eddy covariance flux sites. Advective energy fluxes are typically not measured and are assumed to be negligible relative to the turbulent fluxes. However, some studies have suggested that these neglected fluxes may contribute significantly to the energy budget closure gap. Here ,we investigate horizontal and vertical advection of sensible and latent heat and their relative contribution compared to turbulent and dispersive fluxes to the energy budget imbalance at 19 sites within the CHEESEHEAD19 study. We used profiles of temperature, humidity, and wind measurements made within the dense 10x10 km array of CHEESEHEAD19 tower sites to estimate temperature and humidity gradients across individual sites. These gradients were then used to calculate advective fluxes of sensible and latent heat. The dense network provides a pathway to reducing uncertainty and biases in energy balance measured by eddy covariance.

Topic: Urban fluxes Poster 24

Benjamin Ahlswede
Flux Towers in Baltimore, an Introduction to the Baltimore Social Environmental Collaborative

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The Baltimore Social Environmental Collaborative (BSEC) seeks to improve urban climate research in Baltimore in partnership with the communities that are impacted by urban climate. The BSEC project will address several urban climate science questions across natural and social sciences. Here we present plans to deploy two eddy covariance towers in the Baltimore area, other instruments that will measure atmospheric properties, and findings from urban flux towers in Indianapolis illustrating hypothetical future findings. We plan to deploy two eddy covariance systems for a minimum of two years in Baltimore. The first is in the Broadway East neighborhood, a high density, low vegetation cover, low income, majority African American neighborhood. The second tower is in the Howard Park neighborhood, a medium density, medium vegetation cover, higher income, lower minority population area. Both towers are in developed urban areas but represent a range of urban land-cover types. In addition to the flux instruments at these locations, we will also be deploying a 4 sonic anemometers tree at each tower, and a lidar instrument measuring the boundary layer. These observations will help inform and constrain climate and earth system model simulations of the Baltimore area, enhancing urban climate science leading to equitable solutions for climate change in urban areas.

Topic: Remote Sensing Poster 25

Paul Stoy

Fluxes everywhere and all the time: Weather satellites can accurately estimate ecosystem carbon uptake and respiration at half hourly time steps

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The eddy covariance technique that we all know and love makes flux measurements every half hour (or every hour, or sometimes every few minutes). The satellite observations used to upscale flux observations usually provide data every day, or every few days, or longer. What if there was a way to connect flux and satellite observations on time scales of minutes – and in real-time – to learn even more about the dynamic response of carbon dioxide fluxes to dynamic pressures from climate and land management?

Here, we demonstrate how geostationary ("weather") satellites around the world can be linked with eddy covariance fluxes to provide real time carbon cycle knowledge. We compiled products like top-of-atmosphere reflectances, inferred surface reflectances, downward shortwave radiation, and land surface temperature from the Geostationary Environmental Operational Satellite - R Series (GOES-R) at 413 Ameriflux ecosystems across the Western Hemisphere and made the data available in .csv files for use by the community. We show how the GOES-R downwelling shortwave radiation algorithm has remarkable agreement with incident shortwave radiation observations (SW_IN) from hundreds of towers, especially if the GOES-R data – which arrive every 10 minutes across the full disk and 5 minutes across CONUS – are interpolated to better align with the midpoint of the half hourly SW_IN observations from Ameriflux. We also demonstrate how machine learning models using GOES-R observations trained on carbon flux observations from Ameriflux sites can be used to effectively gapfill missing flux measurements on half-hourly time scales with R2 values upward of 0.94. We are using these models to estimate GPP and RECO in real time across CONUS in a project we are calling ALIVE (Advanced Baseline Imager Live Imaging of Vegetated Ecosystems) and will present loops and other visual demonstrations to help the Ameriflux community visualize what a real-time carbon flux estimation network can look like.

Topic: Techniques Poster 26

Israel Begashaw

Direct Evapotranspiration Measurement with the LI-710 Evapotranspiration Sensor

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Water is a crucial resource for both irrigated and dryland agricultural systems. With a projected 3 billion people facing water shortages by 2050 and an estimated 2 billion already affected, water management optimization is essential for sustainable agriculture.
Evapotranspiration (ET) is a crucial process in the global water cycle, moving 500,000 km3 of water annually. Of this, 70,000 km3 is lost over land, which completely surpasses the global water demand of about 4,600 km3 per year. Conserving just 5-10% of ET by retaining it in soil, groundwater, or freshwater bodies can significantly contribute to solving the global water scarcity problem.
Accurate measurement of evapotranspiration is essential for effective water management. Eddy covariance provides accurate timely information that can be used to make better water management decisions. In the past, this approach's high cost and complexity have severely limited its use outside academic research.
A new cost-effective solution for direct, automated, and real-time ET measurements has been developed by LI-COR. This technology extends the application of eddy covariance ET measurements beyond academia to various research, regulatory, and commercial domains. The LI-710 sensor is an easy-to-use device that measures ET, sensible heat, temperature, humidity, and air pressure every 30 minutes. It is significantly more affordable than typical flux stations, costing 5-10 times less, and consumes only 1.5 W of power.
Preliminary field test results will be compared with traditional eddy covariance systems in multiple locations.
By providing more accurate and affordable ET measurements, this new technology can help optimize water management in both irrigated and dryland agricultural systems, ultimately contributing to addressing the global water scarcity problem through sustainable water use.

Topic: Remote Sensing Poster 27

Robert Shortt

Pixel-Wise Footprint Analysis of GPP Using High-Resolution NDVI/NIRv Data

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Associating fluxes with footprint estimates has been shown to improve the predictive capability of spectral indices compared to estimates using satellite data centered on flux towers. Most, if not all, of these spatially explicit footprint analyses have been done by aggregating footprints into polygons based on the 50%-90% estimated flux contributions, and then associating those polygons with fluxes and spectral signals within them. NIRv, expressed as NDVI * total NIR, has been shown to be a powerful predictor of GPP using in-situ spectral measurements. In this poster I will showcase some work I have done combining various resolutions (3cm-3m) of drone-captured NDVI and NIRv with pixel-wise footprint mapping of GPP. My goal is to test whether NIRv out-performs NDVI in predicting GPP in this context, and to show the strengths and weaknesses of high vs. low resolution when relating flux data with drone imagery.

Topic: Nature based climate solutions Poster 28

Matthew Roby
Cover crop impacts on ecosystem carbon and water exchange in an irrigated pistachio orchard

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There is growing interest in applying nature-based climate solutions, including cover crops, to increase carbon sequestration in agroecosystems. However, information is lacking on how cover crops influence ecosystem-scale fluxes of carbon and water in irrigated perennial cropland, which is a major land use type in California. To address this gap, we deployed two pairs of flux towers and soil chamber systems in a young pistachio (Pistacia vera) orchard near Davis, California to compare net ecosystem exchange of CO_2 (NEE), evapotranspiration (ET), and soil CO_2 efflux (Fs) in adjacent blocks with and without cover crops. Results from the first year of data collection indicate that cover crops increased net carbon uptake (-NEE), ET, and Fs during the spring, compared to the block without cover crops. During the summer growing season, rates of NEE, ET, and Fs were similar in the cover and non-cover blocks. Notably, rates of NEE were similar during the spring (cover crop growing season) and summer (pistachio growing season), whereas ET was greater during the summer. These results indicate that cover crops can have a considerable impact on ecosystem-scale carbon exchange and water-use-efficiency in young orchards with developing canopies. These measurements will be continued to examine how cover crops alter annual carbon and water dynamics. Results from this research may help identify strategies to increase the carbon uptake capacity of irrigated agroecosystems and evaluate potential carbon-water tradeoffs associated with cover crop adoption.

Topic: General Science Session Poster 29

Jackie Matthes

Long-term impacts of hemlock woolly adelgid progression on ecosystem processes at Harvard Forest

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Disturbances caused by forest insect pests are widespread and potentially interact with climate change to shift ecosystem processes. However, studies that have characterized long-term ecosystem-scale responses with multiple years of pre-disturbance data are rare. Within a tract of forest dominated by eastern hemlock (Tsuga canadensis) at the Harvard Forest in Petersham, MA, long-term measurements since 2004 have captured shifts in ecosystem processes before, during, and after invasion by the hemlock woolly adelgid (HWA; Adelges tsugae). Hemlock woolly adelgid arrived in 2009 and began to create persistent stress in 2013, permitting comparison across time periods of pre-disturbance (2004-2009), initial invasion (2010-2015), and long-term changes and recovery in ecosystem processes with ongoing HWA presence (2016-2022). One of the most important functional shifts within the decline of hemlock due to HWA is the conversion from an evergreen-dominated forest to an increasingly deciduous forest. This shift in forest composition impacts ecosystem dynamics during the growing season due to the slower physiological rates of hemlock in comparison with deciduous trees. It also has a strong potential to shift the seasonality of ecosystem carbon, water, and energy flux with the replacement of "low and slow" hemlock ecosystem rates with faster and more seasonally punctuated early successional deciduous dynamics.

Since 2004, measurements have captured ecosystem-scale carbon dioxide and water flux with eddy covariance towers along with measurements of leaf area index and litterfall, subcanopy microclimate, soil respiration, tree growth rates and mortality in hemlock and a nearby red oak (Quercus rubra) site. At the hemlock site there has been a long-term decline in spring hemlock leaf area index (-0.178 m2/m2 per year, 2012-2021) and an increase in the fraction of incoming photosynthetically active radiation (fPAR) reaching the understory (0.00831 per year, 2009-2021). Before HWA, the subcanopy at the hemlock site was cooler (in reference to the above-canopy temperature) in both spring and summer than the red oak site. But since 2012 the hemlock subcanopy has become consistently warmer in spring, and the hemlock subcanopy summer temperature has become warmer than that of the red oak site. Documented shifts in ecosystem structure and composition due to long-term HWA stress suggest a concurrent shift in energy, carbon and water fluxes at the ecosystem scale.

Topic: Remote Sensing Poster 30

Angela Erb
Satellite albedo products across resolutions

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Multiple biophysical feedback relationships are associated with rapid climate warming, with the potential to contribute both positively and negatively to overall surface warming and cooling. A key factor in these relationships is land albedo which represents the proportion of incoming solar radiation reflected directly back to space, and consequently, that energy which is available to drive photosynthesis and surface heating.

The NASA MODIS MCD43 daily product suite is an established standard for daily global albedo products at a gridded 500m resolution since 2000 and this suite has now achieved stage 4 validation through participation in the CEOS SALVAL effort. The VIIRS Suomi-NPP launched in 2011, JPSS-1 in 2017 and JPSS-2 in 2022 and are used to provide continuity and continuation of the MODIS satellite record and provide global daily albedo products at 500 and 1000m resolutions (VNP43/VJ143/VJ243). They rely on the semi-empirical linear RossThick-LiSparse Reciprocal (RTLSR) BRDF model to characterize surface anisotropy, using a 16-day moving window to accumulate multi-angle observations for each pixel. Daily black sky and white sky albedos are calculated observations associated with each day.

At finer resolutions, Landsat (30m) and Sentinel-2 (20m) sensors provide a higher spatial resolution record of changes on the Earth's surface. The Harmonized Landsat Sentinel surface reflectance product combines data from these platforms to provide continuity across sensors. As near-nadir instruments, these instruments do not provide the multi-directional observations necessary to reconstruct truly hemispherical surface albedo quantities. To generate higher resolution albedo, simultaneous surface anisotropy information from MODIS/VIIRS BRDF products is used in conjunction with Landsat and Sentinel-2 surface reflectances to produce diffuse white-sky albedo and direct black-sky albedo.

Here we present a comprehensive evaluation of this broad suite of satellite albedo products across a broad spatial and temporal range following the CEOS surface albedo validation best practices protocol. Data from MODIS (MCD43), VIIRS (VNP43/VJ143), Landsat and HLS albedo products are compared to tower data from spatially representative Ameriflux, NEON and international tower sites in accordance with the calibration standards. We highlight the advantages of each sensor and the continued need for both high spatial and temporal satellite albedo products globally.

Topic: General Science Session Poster 31

Cove Sturtevant

NEON in AmeriFlux: What's new and what's on the horizon?

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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. Fluxes of CO2, latent heat, and sensible heat, with a full suite of meteorological and soil data extend as far back as 2016, and methane concentrations have been collected since 2021. Gap-filled and partitioned fluxes are now available for at least 27 sites in the AmeriFlux FLUXNET product. Additional measured quantities, including remote sensing and field samples, along with in-depth quality information are downloadable from the NEON data portal. Collaboration between NEON, AmeriFlux, and the flux community at large is ongoing to derive methane gradient fluxes and other non-eddy-covariance methane flux products for potential inclusion 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 NCAR-NEON projects and FLUXNET processing.

Topic: General Science Session Poster 32

Savannah Rivera
Comparing AmeriFlux wetland sites using a distance matrix

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Wetlands are not only important in carbon sequestration, but are also the largest natural source of methane into the atmosphere. This, along with their role in our day-to-day life with their ability to store and provide water, make them a critical ecosystem to research. Using the AmeriFlux network, wetland sites can be compared to better understand the relationships between gas fluxes, precipitation, and air temperature. It is currently understood that gasses, such as methane, will increase with air temperature, giving them a direct relationship. For this research, 32 wetland sites were compared by examining the time series characteristics and determining how similar the site data looks to another. Our methodology uses site-pairs, evaluating the uniqueness of methane, precipitation, net ecosystem exchange, and air temperature based on the distance matrix scores. For precipitation, and air temperature, and net ecosystem exchange, the site-pairs are more unique as distances between site-pairs increases. Air temperature was also compared directly to methane as well as net ecosystem exchange. When compared to methane, the sites were similar with both variables, while net ecosystem exchange shows more uniqueness. Precipitation was compared to methane as well, which has less data but a clear trend of more uniqueness in precipitation and less with methane. Precipitation compared to net ecosystem exchange shows more similar air temperature sites with more similar net ecosystem exchange sites as well. These results show unique relationships between the site pairs that can allow for a better understanding of how wetlands can vary depending on location, precipitation, and air temperature. Our understanding of similarities between wetlands will help inform the AmeriFlux network on placement of future sites as well as help scale wetlands data between sites.

Topic: Diverse Ecosystems Poster 33

David Miller
Water use efficiency and drought sensitivity across the eddy covariance network

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Vegetation uses loses water through stomata in exchange for gaining carbon, and the rate at which this exchange is made is known as water use efficiency (WUE). WUE is an important parameter for monitoring the connection between the carbon and water cycles, and it can vary across vegetation types and water availability. However, the range of WUE variability with drought conditions has remained understudied, in comparing how different ecosystems will respond to drying conditions. Future changes in climate are likely to lead to more extreme wet and dry conditions, with potential implications for vegetation's ability to utilize water effectively. Here, we use a cross-network collection of eddy covariance sites (e.g., from FLUXNET2015, ONEFlux, ICOS, AmeriFlux FLUXNET) to evaluate WUE sensitivity to drought. We use the Palmer Drought Severity Index (PDSI) from TerraClimate to quantify drought conditions. Initial results at the monthly scale suggest that both humid and arid climates downregulate maximum WUE by a similar relative amount during drought conditions (PDSI < 0) compared to non-drought conditions (PDSI > 0). For example, the 95th percentile at US-MMS, in a humid climate, during drought is 87.5% (0.0041 g C / ml) of the 95th percentile during non-drought (0.0046 g C / ml); at US-Wkg, in an arid climate, 0.0014 g C / ml during drought is 87% of 0.0016 g C / ml during non-drought. Further analysis will investigate how consistently this holds across the network and across gradients of aridity.

Topic: Methane Poster 34

Samuel Jurado

Analysis of Temperate Forest Methane Dynamics under Soil Moisture Limited Evapotranspiration Regimes

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Methane is an important greenhouse gas that accounts for 42% of atmospheric warming since the pre-industrial period. While biogenic methane (CH4) emissions are thought to be of a similar magnitude to anthropogenic emissions, they remain the largest source of uncertainty in the global CH4 budget which impedes our ability to predict climate change. The methane dynamics of some environments, such as the temperate forests of the Northeastern United States (NEUS), are highly dependent on soil moisture availability. We predict that as a result of more extreme precipitation patterns, NEUS land-atmosphere interactions will increasingly fall within a soil moisture limited transitional evapotranspiration regime (SL-T) and promote positive soil moisture-precipitation feedbacks. These positive feedback loops may make NEUS soils more dependent on synoptic scale storms to provide moisture to the system. Since dry soils do not sequester methane as efficiently as moist soils, we anticipate that longer dry periods and more intense bursts of rain will limit the diffusion of methane into the soil. We employed the mixed Bowen ratio method - in which vertical concentration gradients of a target gas are multiplied by the known eddy diffusivity of a tracer gas - to calculate methane gradient fluxes for the growing season (JJAS) of the years 2022 - 2023. Evolving correlations between evaporative fraction (EF) and soil moisture were sorted into three evapotranspiration regimes: a sensible heat dominated dry regime, a transpiration dominated buffer regime, and a transitional regime leading to energy limited surface interactions. Results indicate that forest transpiration may have a major impact on land-atmosphere coupling strength that undermines the development of increasingly arid positive soil moisture-precipitation feedback loops and promotes the sequestration of methane within the buffer regime.

Topic: Diverse Ecosystems Poster 35

Erika Gallo

Two decades of riparian woodland water and carbon flux responses to environmental variability.

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Riparian woodlands comprise a small proportion of global drylands yet hold disproportionate regional importance because they provide a wide range of ecosystem services and are hotpots for carbon and water cycling. Projected shifts in hydroclimate bring new urgency to understanding how and why ecosystem responses in these unique woodlands vary temporally. Here we use 20 years of eddy covariance measurements to understand the controls on land-atmosphere carbon and water fluxes of a semi-arid riparian mesquite (Prosopis velutina) woodland with year-round access to deep groundwater supplemented by highly variable summer and winter rainfall. Contrary to general expectations of climatic drying, there was a shift to more favorable soil moisture conditions. Access to groundwater resulted in evapotranspiration (ET, 662 ± 62 mm) that far exceeded annual P (262 ± 50 mm) making this riparian woodland a substantial carbon sink (366.6 ± 83.3 g C m-2 yr-1). Annual gross ecosystem production (GEP) and respiration (Reco) increased over time (9.4 ± 4.3 g C m-2 year-1 and 8.6 ± 3.8 g C m-2 year-1, respectively), and were largely buffered from climate variability. Phenophase regression models show that water and energy vary in how they control ecosystem responses throughout the growth cycle. Groundwater subsidies supported the ET demand during the dry phenophases, while soil moisture contributed significantly to ET, GEP and Reco during the wet phenophases. Favorable GEP conditions established during dormancy lead to higher productivity during subsequent phenophases, pointing to the importance of seasonal antecedent conditions. In addition, GEP emerged as a major Reco control variable, indicating that Reco is largely driven by autotrophic respiration. These results highlight the dynamic nature of water and carbon cycling in semiarid riparian woodland and show the importance of access to two water sources in driving seasonal ecosystem responses.

Topic: Remote Sensing Poster 36

Bassil El Masri

Remote Sensing-based Temperature and Greenness Model to Estimate Mangrove Forest Gross Primary Production

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Mangrove forests ecosystem plays an important role in the global carbon cycle by storing blue carbon in the above and below-ground biomass at a rate ten times greater than mature tropical forests annually. Because of their important function in sequestering carbon and their role as intertidal vegetation systems, assessing and predicting mangrove forest carbon fluxes is essential to better understand the effects of climate change on this ecosystem. In this study, we are modifying the Temperature-Greenness (TG) model to improve the accuracy and prediction of remote sensing-based gross primary production (GPP) for Mangrove forests. The modification includes adding salinity and sea surface temperature scalars to the TG model, as it has been found that mangrove forest carbon fluxes are impacted by water salinity and sea surface temperature. We validate the model GPP against an eddy covariance flux tower site data at the Everglades National Park. MODIS, Landsat 7, 8, and 9 as well as Sentinel 2 and 3 data are used to run the TG and the modified TG models. In addition, salinity and sea surface temperature are obtained from the European Space Agency and MODIS, respectively. Statistical methods will be used to assess the performance of the model. This study will also help in assessing natural disturbance impacts on the mangrove forest GPP. Accurate estimation of mangrove forest carbon fluxes is timely and critical for accurate predictions of how terrestrial ecosystems will respond to climate change.

Zoe Dietrich

Autonomous floating chamber with low-cost sensors to measure methane and carbon dioxide fluxes from small water bodies

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Greenhouse gas (GHG) fluxes from fresh and shallow water bodies such as wetlands, ponds, and reservoirs are poorly constrained yet may account for significant global carbon emissions. A common method of measuring fluxes requires manual sampling of the changes in gas concentrations over time in a floating chamber (i.e., upside-down bucket), either by collecting gas samples for later laboratory analysis (gas chromatography) or attaching expensive analyzers (LI-COR or Picarro) to run in-line with the chamber. These sampling methods are costly in salary time and equipment and can introduce bias for daytime and fair-weather fluxes in accessible areas. In lieu of manual sampling, we present a solar powered, autonomous floating chamber that utilizes low-cost carbon dioxide (~$120, Senseair), methane (~$15, Figaro), and temperature and humidity (~$30, Sensirion) sensors to capture GHG fluxes at high temporal resolution. Our prototype builds on previous designs published by David Bastviken's group at Linköping University, Sweden. The system floats on small water bodies, continuously measuring gas concentrations every 30 seconds. The chamber is raised and lowered using a linear actuator, capturing fluxes from water surfaces when lowered and flushing chamber headspace with ambient air when raised. The chamber is controlled by an Arduino Uno, which is programmed to set the time intervals at which the chamber measures fluxes and flushes. The Arduino Uno stores time-stamped data to a local SD card and transmits data wirelessly through XBee radio modules, which also allow for remote control of the chamber activities. We present methane and carbon dioxide fluxes measured with the chamber on small agricultural reservoirs in Mato Grosso, Brazil. Diffusive fluxes as well as ebullition events were captured in intervals ranging from 5-30 minutes and validated with a LI-COR 7810 GHG analyzer in the field. We also address a calibration strategy for the methane sensor, which co-reacts with humidity and temperature changes. Our low-cost (~$450 materials cost) chamber has the potential to autonomously measure GHG fluxes for weeks to months in remote water bodies where manual sampling is not feasible and flux estimates are rare or nonexistent.

Topic: Nature based climate solutions Poster 38

Xiaoyong Li

Improving Model Representation of Forest Management in the Dynamic Land Ecosystem Model Using AmeriFlux and FIA Data: Toward a Decision Support Tool for Climate-Smart Forestry

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Forests play an essential role in the global carbon cycle, and improved forest management has the largest mitigation potential in natural climate solutions. Climate-smart forestry (CSF) has become a hot and widespread topic in multiple realms for its potential to increase ecosystem carbon storage, enhance the resilience of forests, and secure forest production. However, a big challenge is accurately to monitor, report and verify (MRV) the roles of different forest management practices on ecosystem carbon storage (i.e., vegetation carbon (VegC) and soil organic carbon (SOC)) under climate change. To address MRV challenges in forestry sector, in this study we improved model representation of forest management practices in the Dynamic Land Ecosystem Model for supporting Climate-Smart Forestry (DLEM-CSF). The DLEM-CSF has been evaluated against field data from forest sites in the AmeriFlux/NEON networks and FIA (Forest Inventory and Analysis) for improving model performance. In conjunction with satellite-based observation on forest harvest and forest structure, the DLEM-CSF is used to quantify the effects of the multiple forest management practices (e.g., thinning, harvest, residue management and fertilizer application) on carbon storage in Southern forests. Simulated results show that the forest ecosystem carbon storage exhibited significant variations among different forest management practices combinations. Harvest age and thinning intensity play a primary role in altering forest VegC, residue management significantly affects SOC, and fertilizer application can accelerate the growth of new planting forests. Thus, optimizing management practices could contribute substantially to the carbon sequestration capacity and carbon storage of U.S. forests. Our modeling framework provides a decision support tool for implementing and optimizing forest management practices to promote Climate-Smart Forestry to achieve climate change mitigation/adaptation goals.

Topic: Data processing and visualizing Poster 39

Michael Dietze
The NEON Ecological Forecasting Challenge

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Addressing today's environmental challenges requires an ability to understand and predict ecosystems processes at a heretofore unprecedented scale and speed. Near-term iterative forecasting aims to respond to this challenge by creating a rapid, iterative cycle of prediction, and adaptive learning, and management. To accelerate improvements in ecological forecasting, we designed and launched the NEON Ecological Forecasting Challenge, an open platform for the ecological and data science communities to forecast data from the National Ecological Observatory Network (NEON) before they are collected. Designed with input from academic, government, and private sectors, the Challenge ask participants to submit repeated prediction in one or more of the five forecasting themes: (1) terrestrial carbon fluxes and evapotranspiration; (2) freshwater temperature, dissolved oxygen, and chlorophyll-a; (3) plant canopy phenology; (4) tick populations; and (5) beetle communities. The forecast challenge is open to any type of model (process-based, statistical, machine learning) and to date over 200 teams from around the world have participated, including 11 courses. Participants are provided with near-real time "target" data, which are available for model testing and scoring, and daily 35-day weather forecasts downscaled to each NEON site. Forecasts are submitted through a cloud-based portal that validates, scores, and visualizes forecasts, while simple null models provide benchmarks of forecast performance. To reduce barriers to entry we have curated a wide range of resources, including example forecasts, documentation, and videos. This poster will particularly highlight the terrestrial flux challenge and ways in which the Ameriflux community can participate.

Topic: General Science Session Poster 40

Waheed Ullah
Energy Fluxes application for land-atmosphere interaction over Himalayan Tibetan Plateau

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My work is about the role of land-atmosphere interaction over the Himalayan Tibetan Plateau and its impact on the Asian monsoon onset and precipitation variations in time and space. For the most important part of the work we used different soil moisture and energy fluxes products and discovered substantial differences among them round the warm and cold season. I will present this work and see how we are moving forward with this.

Topic: Methane Poster 41

Withdrawn

Ruth Varner
Recommendations for Observation Infrastructure for Natural Methane Fluxes

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Biogenic methane accounts for about 50% of emissions globally. While wetlands are considered the largest natural source of methane to the atmosphere, the magnitude and seasonal variability of natural sources are not well constrained. In addition, large areas with relatively small uptake or low emission rates have been largely understudied but could significantly impact regional and global budgets. We convened a workshop to discuss the potential for a national infrastructure project for observing natural methane fluxes. The workshop was held at Yale University September 5-7th with the goals of: 1) Assessing researcher needs to better understand natural biogenic CH4 fluxes at various scales, 2) Determining the data products and use cases that would reduce our uncertainty in biogenic CH4 processes and budget, 3) Identifying physical infrastructure needs that would advance CH4 research, 4) Exploring the data discovery tools that would enhance and ease the exploration of the data, and enhance accessibility of the data to underserved communities; 5)Identifying innovative training opportunities that a new CH4 infrastructure could offer; and 6) Devising pathways for continued engagement with the research community in the establishment of such infrastructure. We will present recommendations from this workshop that will inform the development of an infrastructure proposal to build a continental methane observatory.

Topic: Remote Sensing Poster 42

Ruohan Li

Comparison between deep learning architectures for the 1 km, 10/15-min estimation of downward shortwave radiation from AHI and ABI

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The retrieval of downward shortwave radiation (DSR) with high spatiotemporal resolution and short latency is critical. It is the fundamental driving force of surface energy, carbon and hydrological circulations, and a key energy source for photovoltaic electricity. However, existing methods face significant challenges owing to cloud heterogeneity and their reliance on other satellite-derived products, which hinder the retrieval of accurate and timely DSR with high spatiotemporal resolution. In addition to the spectral features used in traditional approaches, deep learning (DL) can incorporate the spatial and temporal features of satellite data. This study developed and compared three DL methods, the DenseNet, bidirectional gated recurrent unit without surface albedo as inputs (BiGRU_nor), and convolutional neural network with gated recurrent unit without surface albedo as inputs (CNNGRU_nor), to estimate DSR at 1 km and 10/15 min resolutions directly from top-of-atmosphere reflectance over Advanced Himawari Imager (AHI) onboard Himawari-8 and Advanced Baseline Imager (ABI) onboard GOES-16 coverage with high accuracies. The instantaneous root mean square error (RMSE) and relative RMSE for the three models were 68.4 (16.1%), 69.4 (16.3%), and 67.1 (15.7%) W/m^2, respectively, which are lower than the baseline machine learning method, the multilayer perceptron model (MLP), with RMSE at 76.8 W/m^2 (18.0%). Hourly accuracies for the three DL methods were 58.6 (14.1%), 57.8 (14.0%), and 57.3 (13.8%) W/m^2, which are within the DSR RMSEs that we estimated for existing datasets of the Earth's Radiant Energy System (CERES) (88.8 W/m^2, 21.4%) and GeoNEX (77.8 W/m^2, 18.8%). The study illustrates that DL models that incorporate temporal information can eliminate the need for surface albedo as an input, which is crucial for timely monitoring and nowcasting of DSR. Incorporating spatial information can enhance the retrieval accuracy in overcast conditions, and incorporating infrared bands can further improve the accuracy of DSR estimation.

Topic: General Science Session Poster 43

Chris Still

Seeing the forest and the trees: stem dendrometry and sapflow dynamics at the US-Me6 AmeriFlux core site

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Given the notable impacts of heat and drought on forest growth and mortality, better understanding how trees respond to seasonal and interannual temperature and moisture variations, as well as climate extremes, can lead to improved management strategies to enhance landscape carbon storage and resilience to climate extremes. Here we present initial results from a small-scale network of automated point dendrometers and thermal dissipation sapflow probes within the flux footprint of AmeriFlux site US-Me6. The goal of this network is to improve understanding of how individual forest trees respond to short-term seasonal weather events and to longer-term changes in climate. The dendrometers provide information on tree water relations by measuring diurnal stem girth fluctuations to deduce seasonal water use and water stress. These data are compared directly to sapflow velocity data to quantify tree water use on the same trees. The dendrometers also directly measure radial growth and thus provide unique information about timing and controls of tree growth dynamics.

A total of 13 point dendrometers were installed in June and July 2022 at breast height on 9 trees with existing sapflow sensors; accessible branches on a subset of trees were also instrumented with dendrometers. Dendrometer data were used to calculate tree physiological proxies derived from stem radial displacement changes. The proxies include accumulated growth (irreversible radial displacement) and tree water deficit (any reduction in daily maximum radial displacement from the previous maximum). We examined meteorological measurements and tree sapflow velocity and stem displacement data for two representative trees during early July (moderate water stress) and early August (high water stress). Interestingly, the tree with higher sapflow in both periods, as well as larger displacement variations, also experienced higher tree water deficit (stress) and also stopped growing much earlier than the other tree. This suggests a more “conservative” water use strategy leads to higher stem growth and C accumulation in this semi-arid system. Landscape position of the two trees also played a role in their responses. The tree with more growth and less water stress is located in a cluster of other trees and is more shaded than the tree with less growth and more water stress which also received more sun exposure.

Topic: Nature based climate solutions Poster 44

Altaf Arain

Evaluating variable retention harvesting for forest carbon uptake monitoring using remote sensing for nature-based climate solutions

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Variable retention harvesting (VRH) is an ecologically based silvicultural practice that emulates the natural dynamics of forest growth following disturbances. The spatial arrangement and density of the retained trees significantly influences the growth, productivity, resistance to environmental stress, mortality and carbon sequestration capacity of the remaining trees. This study examined the effectiveness of four VRH treatments, each characterized by specific harvesting intensity and tree distribution, including 33% aggregate retention (33A), 55% aggregate retention (55A), 33% dispersed retention (33D), 55% dispersed retention (55D) and additionally unharvested control (CN) within 1-hectare plots and replicated four times in a 90-year-old red pine (Pinus resinosa Ait.) forest located in southern Ontario, Canada. High-resolution satellite and drone remote sensing data were used to evaluate VRH treatments impact on forest carbon uptake. Satellite- and drone-derived normal difference vegetation index (NDVI) and gross primary productivity (GPP) were estimated for each treatment during the growing seasons from 2010 to 2020. Over this period, observed mean daily NDVI values ranged from 0.25 to 0.86 among treatments, where the 55D treatment consistently showed the highest NDVI values. Remote sensing-derived mean annual GPP for the entire 20 ha study site was 1651 ± 89 gC/m2/year, with a range of 1407 to 1864 gC/m2/year from 2010 to 2020. These satellite-derived annual GPP values were similar and linearly related with observed annual GPP (R2 = 0.88, p = 0.032) measured using the eddy covariance technique in an adjacent white pine plantation of similar age and height over the study period. Overall, the highest mean daily GPP values were observed in the CN treatment, followed by the 55D, 55A, 33D, and 33A treatments. The study findings indicate that VRH treatments with a uniformly dispersed residual canopy, retaining more than half of the initial basal area (such as 55D), are effective forest management strategies to optimize forest growth and increase carbon uptake. This research will help in developing forest management strategies that contribute to nature-based climate solutions.

Topic: Techniques Poster 45

Maryam Saffariha

Comparing Machine Learning Techniques for Assessing Failure Hazard in Platanus orientalis Trees: Introducing the Tree Failure Prediction Model (TFPM) in Urban Forestry

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Urban trees are subjected to a range of factors, including both ecological conditions and anthropogenic pressures, which can cause harm. This study aims to compare the effectiveness of three models, namely the multilayer perceptron (MLP) neural network, radial basis function neural network (RBFNN), and support vector machine (SVM), in predicting failures of Platanus orientalis trees in urban forest ecosystems. To conduct this research, a detailed field survey was conducted to identify issues faced by P. orientalis trees. A total of 500 target trees were examined, and data on 12 variables were recorded, categorized into two groups: (1) tree variables and (2) tree defects and disorders.

By employing artificial intelligence techniques, we developed a tree failure prediction model (TFPM) to forecast the year of tree failures. The SVM model demonstrated the highest R2 values across all data sets, with 0.99 in training, 0.986 in the test, and 0.989 overall, surpassing the MLP and RBFNN models. Sensitivity analysis revealed that the classes of tree hazard were influenced by three variables: soil depth, cracks and cavities, and wind protection. The SVM modeling results exhibited a classification accuracy of 97.5% in the test samples, outperforming the MLP (94%) and RBFNN (87.9%) models. Consequently, the TFPMSVM model emerged as an ecological failure hazard assessment model for P. orientalis.

Similar to other prediction models in urban tree management, TFPMSVM was specifically developed to assist urban forest and green space managers in assessing the hazard of failure in old P. orientalis trees, facilitating timely precautionary planning. TFPMSVM serves as an environmental decision support system, enabling the identification of old and hazardous trees that may require rehabilitation or removal before unexpected failures occur.

Topic: Urban fluxes Poster 46

Erik Velasco
Mapping of CO_2 emissions at the scale of buildings and roads

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Accurate emission inventories of CO2 at fine spatial and temporal scales that are directly related to urban spaces and human activities are needed to develop effective strategies to mitigate climate change. On this account, we propose that the aerodynamic resistance approach, based on the Monin-Obukhov similarity theory and challenging the Reynolds analogy to estimate the transfer of sensible heat (QH), can be used as a proxy to investigate the exchange of CO2 at such scales. We instrumented a bicycle to measure georeferenced mixing ratios of CO2 every second along a defined route across a residential neighborhood of Singapore during 1.5 hour periods. These measurements were used in conjunction with readings of incoming and outgoing longwave radiation, and fluxes of QH collected from an eddy covariance flux tower located within the study area, to derive CO2 fluxes along the transect route considering the bulk aerodynamic resistance to QH as equivalent to the bulk aerodynamic resistance for CO2. An interpolation subroutine based on the original Delaunay triangulation was then applied to interpolate the observed fluxes across the neighborhood for 20×20 m grid cells. This approach was able to identify hotspots of CO2 emissions at the local scale and micro scale (i.e., from neighborhoods to buildings and roads). For the neighborhood assessed in this study, larger emission rates of CO2 were observed at traffic intersections, as well as at a block with multiple eateries and coffee shops. The sum of the interpolated fluxes from all grid cells agreed within one standard deviation with the long-term fluxes measured by eddy covariance over the entire neighborhood.

Topic: Techniques Poster 47

Brian Wang

Lost In Transition – aquatic carbon evolution along a headwater stream network

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Out of the 5 gigaton (Gt) of carbon (C) transported through Earth's aquatic conduit every year, up to 80% are degassed back to the atmosphere which is the same magnitude as the 3.9 GtC sequestered by land surfaces globally. Growing efforts have been put on quantifying the degassing of CO2 from inland water into the atmosphere especially aimed at providing a process-based understanding at capturing different fluvial–atmospheric carbon exchanges and response under variable hydrological conditions.

Headwater monitoring stations were installed in University of British Columbia's Malcolm Knapp Research Forest (MKRF) in the North American Pacific Coastal temperate rainforest (PCTR) region - an aquatic carbon hotspot due to its high productivity rainforest ecosystems and steep elevation gradient. This research reports trends of aquatic DOC dynamics and CO2 evasion fluxes where continuous DOC measurements where continuous DOC measurements [s::can UV-Vis Spectrolyzer] are validated monthly with the Shimadzu Total Organic Carbon analyzer and time series data obtained from dissolved CO2 probes [Vaisala GMP221] are corrected using gas chromatography [Agilent 7890A]. Monitoring stations (DOC and pCO2) installed over three kilometers in the same stream permitted an investigation into how aquatic carbon evolves between organic and inorganic phases, as well as CO2 transfer between the dissolved phase and the atmosphere.

Preliminary data indicates that over the 3.3 km reach, pCO2 decreased by an average of 22.8%, while DOC declined by 2.35 mg/L between upstream and downstream sites - a 74.9% reduction in DOC concentration over this distance. Preliminary data from September to December 2022 suggests that over the 2km reach, pCO2 decreased by an average of 22.8%, while DOC declined by 2.35 mg/L between upstream and downstream sites - indicating a 74.9% reduction in DOC concentration over this distance.

Topic: Nature based climate solutions Poster 48

Jessica Silberman

A comparative analysis of atmospheric carbon and lateral DIC fluxes and in tidal marshes with differing environmental conditions and management practices

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Tidal ecosystems play an important role in the removal of atmospheric carbon (C), and storing C in sediments at millennial time scales. There is a need for more continuous co-located atmospheric and lateral C flux data in order to further understand the climate mitigation potential of these ecosystems. We will compare atmospheric and lateral flux data (with a focus on dissolved inorganic C; DIC) at two separate tidal marshes in the San Francisco Bay-Delta, California: Suisun Bay and Eden Landing Ecological Reserve. Our objective is to compare multiple years of data between the two sites with different elevation, sulfate availability, and historical management practices. We hypothesize that the higher elevation marsh with less frequent tidal inundation and lower sulfate levels (Suisun Bay) will be less of a C sink and have overall lower export of lateral C compared to the lower elevation wetland with more frequent inundation and higher sulfate levels. A previous study revealed that at Suisun Bay, NEE was -185 g C m-2 yr-1 and lateral flux of DIC was -97 g C m-2 yr-1 suggesting that DIC fluxes are at a scale of 52% of NEE. However recent data from Eden Landing suggest much higher DIC export during the growing season (-226 g C m-2) compared to Suisun Bay. Further, the NEE during the growing season at Eden was also higher relative to Suisun Bay (-557 g C m-2 yr-1), however the relative proportion of C exported as DIC relative to NEE was similar (40%). It is important to understand how DIC lateral export in tidal marshes contributes to acidification and alkalinization of coastal waters. Investigating multiple years of NEE and lateral DIC flux data will help improve understanding of how net ecosystem C balance of these ecosystems change as a function of environmental and management conditions.

Topic: Diverse Ecosystems Poster 49

Tyler Roman
Progress and challenges in moving towards the development of a national flux network in Colombia

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Eddy covariance towers (ECT) are sophisticated and complex systems that allow us to better understand many different ecological, hydrological and energetic processes. ECT data support national and subnational greenhouse gas (GHG) inventories providing precise estimates on net exchange of several relevant gasses, including CO2, CH4, N2O. Historically, many of the ECT have been located in the northern hemisphere with emphasis on either agricultural or conserved natural ecosystems. The development and growth of both the Fluxnet and Ameriflux networks have led to many of these sites being centered in Europe and the United States respectively. In recent years these networks have encouraged their expansion and growth into other regions of the globe, resulting in the establishment of several other networks (i.e. Mexflux, Ozflux, Asiaflux, etc.) This timeline of expansion has coincided with technological developments that have allowed for ECT technology to be generally more accessible and feasible for use in projects worldwide. Here we highlight the status of several projects measuring GHG fluxes in varying ecosystem types (lowland and montane forests, lakes, peatlands and alpine ecosystems) within the country of Colombia and look at the potential for development of GHG flux networks at both national and regional scales. Several of these projects in Colombia are aimed at quantifying GHG emissions of natural, disturbed or restored ecosystems. These aspects are of particular interest for countries that are interested in development of emissions factors for these ecosystem types, with the aim of including them in their Nationally Determined Contributions (NDC's) to the Paris Agreement.

Topic: General Science Session Poster 50

Elizabeth Arango Ruda

DROUGHT IMPACT ON WATER FLUXES AND WATER-USE EFFICIENCY OF A AGE-SEQUENCE OF EVERGREEN CONIFER FOREST IN SOUTHERN ONTARIO, CANADA

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Forest evapotranspiration (ET) plays a crucial role in terrestrial ecosystems. However, droughts can disrupt ET and forest water use efficiency (WUE). Assitionally, mono-specific forest management practices significantly influence ET and WUE responses to extreme weather conditions. Therefore, quantifying ET and WUE is essential to clarify the drought effect on the water balance of managed conifer stands. This study presents 14 years of water fluxes collected using the eddy covariance technic (2008-2021) in an age sequence (84, 49, and 21 years as of 2023) of eastern white pine (Pinus strobus L.) forests in southern Ontario, Canada. The mean annual ET values were 465 ± 41, 466 ± 32, and 403 ± 21 mm in the 84-, 49-, and 21-year-old stands, respectively, with the highest annual water flux observed in the 48-year-old stand from 2013. Mean annual WUE was 3.4 ± 0.4, 3.6 ± 0.4, and 4.0 ± 0.7 g C m–2 yr–1 in the 84-, 49-, and 21-year-old stands, respectively. The highest WUE observed in the younger forest was due to lower ET relative to gross ecosystem productivity (GEP). The 48-Year Conifer had the highest annual mean GEP of 1660 ± 115 (g C m–2 yr–1). Air temperature (Ta) was identified as the dominant control on ET annually in all three different-aged stands, while drought had a more minor yet significant impact on ET. The relative importance of environmental controls varied according to the season and forest age. In the mature forest, PAR) had better relative importance (19.5%) in summer and spring (21.3%). For the 48-Year Conifer, ET was better explained by vapour pressure deficit (VPD) in spring (15%) and fall (18%) but by PAR in summer (15%). The 20-Year Conifer's ET showed the higher relative importance of VPD in summer (2.4%). Additionally, the older forest exhibited lower sensitivity to drought (0.29), indicating lower variations (higher resilience) in ET, explained by variations in VPD and soil moisture likely due to different species establishment and understory contributions. However, in 2017, the older stand exhibited a higher WUE (4.1 g C kg-1 yr-1) than the 48-Year Conifer (3.7 g C kg-1 yr-1), equaling the younger forest (4.1 g C kg-1 yr-1). The study highlights the importance of drought and forest age on water fluxes and the coupling of forest carbon and water, with significant implications for ecosystem functioning and sustainable management.

Topic: Diverse Ecosystems Poster 51

Akash Verma
Revealing the Influence of Ecosystem Memory on Carbon Fluxes

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Ecosystem memory is the ability of ecosystems to integrate and retain past weather conditions. It plays a critical role in shaping ecological dynamics and responses to changing climate/weather patterns. In this study, we investigate the role of ecosystem memory on net ecosystem exchange (NEE) from FLUXNET datasets. FLUXNET provides an extensive dataset of carbon fluxes between ecosystems and the atmosphere, enabling us to assess the role of past weather conditions in determining present-day carbon uptake and respiration. We employed information theory-based methods on eddy covariance flux data to capture the influence of climate variables on gross primary productivity and ecosystem respiration, which governs the NEE variability. The study aims, (1) to identify sub-daily scale (hourly data) variations by generating networks over monthly time windows, (2) to analyse the change in the ecosystem memory under NEE extremes. To examine the spatial variation of ecosystem memory among various climatic zones and plant functional types, we selected flux tower sites for forests across the globe. The study explores ecosystem memory and its implications on carbon uptake, contributing to the enhancement of carbon and water flux representations in land surface models.

Keywords: Ecosystem memory, Carbon uptake, FLUXNET, Information theory

Topic: Nature based climate solutions Poster 52

George Burba

Utilizing Flux Measurements for Immediate Social Benefits: Clear Explanations, Data Sharing, and Weather Station-inspired Approach

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Continental-scale research infrastructures and flux networks, along with smaller GHG flux networks and individual sites, are instrumental in measuring the exchange of greenhouse gases (GHGs) and water vapor fluxes between ecosystems and the atmosphere. These measurements, conducted using cutting-edge technology and high-resolution methodology, have been primarily used for academic research in ecological and hydrological studies, climate modeling, and ecosystem analysis.

However, despite their potential to provide valuable insights into GHG emissions and evapotranspiration (ET), these measurements are rarely utilized outside of academia. There are several key reasons for this underutilization. Firstly, the perceived complexity of the methodology can be addressed by providing simple explanations and a detailed guide to facilitate understanding. Secondly, the lack of data in specific ecosystems or regions and the associated costs of establishing new measurement stations can be significantly reduced through peer-to-peer cross-sharing of data and resources.

Furthermore, the absence of a robust approach for utilizing flux measurements for immediate societal benefits can be resolved by adopting a similar approach employed by automated weather stations (AWS) that utilize remote sensing products for weather modeling and forecasting. By integrating flux measurements into such systems, their applicability for real-world decision-making applications can be enhanced.

The ultimate aim of this presentation is to spark a discussion on the latest needs, ideas, and practical examples of utilizing flux measurements for everyday decision-making processes that benefit society as a whole.

Eli Perez-Ruiz

Seasonal variability of carbon dioxide, water vapor and energy fluxes in a university campus in Ciudad Juárez, Chihuahua

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Changes in surface conditions due to urbanization processes cause considerable alterations in surface-atmosphere interactions, mainly due to the substitution of natural material elements with greater impermeability and thermal capacity, and to the imbalance of sources and sinks of matter and energy. To understand the dynamics of fluxes in urban ecosystems, we analyze the seasonal variability of carbon, water, and energy fluxes on a university campus in Ciudad Juarez, Mexico. Fluxes were measured from January 2020 to August 2022 using an Eddy Covariance system installed at a total height of [illegible] m. Daily fluxes values were obtained, as well as diurnal cycles for the entire study period and the different seasons. The behavior of fluxes during cold seasons (autumn and winter) was dominated by the high consumption of natural gas, with positive values (emission) of carbon fluxes and low values of heat fluxes. On the contrary, during warm seasons (spring and summer), high values of energy fluxes were found, not only due to the increase in temperature but also due to the increase in water fluxes due to the greening of the vegetation and the constant irrigation of green areas. The latter also led to prolonged periods where vegetation activity was able to offset carbon emissions, particularly during holiday periods of low anthropogenic activity. During the lockdown due to the COVID-19 pandemic in 2020-21 there was a decrease in emissions at the site. The results obtained in this urban ecosystem show a combined effect of anthropogenic and natural factors on the dynamics of fluxes, as well as a considerable influence of the COVID-19 pandemic; however, longer-term data are necessary to identify clear patterns of behavior and elucidate the factors that primarily influence fluxes.

Manuel Helbig
Satellite and flux tower observations of post-fire successional microclimatic changes across the North American boreal forest

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Wildfire is the most important disturbance agent in boreal forests and plays a major role in the boreal forest carbon cycle. Wildfires lead to long-lasting post-fire impacts on microclimatic conditions. For example, a forest's ability to minimise differences between land surface and air temperature can preserve permafrost and can lower soil temperatures and thus soil respiration. Fire and post-fire succession is linked to changes in ecosystem function and structure shaping land-atmosphere interactions and thus forest microclimate for decades after the disturbance event. Here, we analyse surface energy balance observations from 17 eddy covariance flux tower sites across disturbance chronosequences in the North American boreal forest to identify drivers of post-fire changes in land surface-air temperature gradients. Additionally, we extract MODIS time series of land surface temperature, albedo, and leaf area index from 150 sites covering a wide range of wildfire histories. The combined analysis of flux tower and satellite observations allows us to improve process understanding of changing land-atmosphere interactions during post-fire succession and to extend the limited spatial and temporal coverage of flux towers in the boreal biome.
We find that the summer daytime surface-air temperature gradient and land surface temperatures increase after the fire disturbance indicating reduced ability to cool the land surface during the summer months. Decreased leaf area index and consequently aerodynamic conductance contributes mainly to the post-fire surface heating. Evaporative fraction increases initially in the first few decades after the post-fire disturbance. However, during drought years the evaporative fraction declines rapidly. Our results provide important insights into fire impacts on microclimatic conditions and ground thermal regimes in boreal forests and highlight the reduced capacity of post-fire forests to reduce land surface temperatures during heatwave events. The findings have the potential to contribute to a better mechanistic understanding of post-fire permafrost thaw and soil respiration changes.

Topic: Methane Poster 55

Lisa Haber

Ecosystem functional recovery following disturbance: drivers of carbon flux in a restored tidal freshwater wetland

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Tidal freshwater wetlands (TFWs) contribute substantial uncertainty to estimates of wetland carbon (C) cycling, even as they are among the largest methane sources globally. Among the factors limiting mechanistic understanding of TFW C cycling is their susceptibility to disturbance and underrepresentation in flux data sets. In particular, we have few observations of both CH_4 and CO_2 from TFWs undergoing recovery following disturbance. We leverage a recently added AmeriFlux eddy covariance tower site (US-RRC) to characterize and interpret hourly to seasonal ecosystem-scale CH_4 and CO_2 fluxes in a recovering TFW after deforestation and decades of impoundment in the upper James River estuary, Virginia, USA. Our measurements include CH_4 and CO_2 fluxes along with a suite of biometeorological variables, water table height, and plant phenology to assess the principal biophysical drivers of C fluxes in this globally underrepresented ecosystem type. Our initial findings indicate that hourly to seasonal CH_4 emissions correspond with daytime irradiance and secondarily water table height, while seasonal CO_2 fluxes are primarily driven by water table height and soil temperature. Overall, our TFW may contribute net positive radiative forcing due to high methane emissions, consistent with observations from other recently disturbed TFWs. Continued measurements at our site and recent addition to a bicoastal network of eddy covariance towers will enable further exploration of C cycling drivers, including pulse salinity and nitrate loading, in these critically important yet understudied systems.

Topic: Nature based climate solutions Poster 56

Yongfa You

How can soils be a part of the climate solution? Net GHG balance in U.S. croplands

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Agricultural soils play a dual role in regulating the Earth's climate by releasing or sequestering carbon dioxide (CO2) in soil organic carbon (SOC) and emitting non-CO2 greenhouse gases (GHGs) such as nitrous oxide (N2O) and methane (CH4). To understand how agricultural soils can play a role in climate solutions requires a comprehensive assessment of net soil GHG balance (i.e., sum of SOC-sequestered CO2 and non-CO2 GHG emissions) and the underlying controls. Herein, we used a model-data integration approach to understand and quantify how natural and anthropogenic factors have affected the magnitude and spatiotemporal variations of the net soil GHG balance in U.S. croplands during 1960-2018. Specifically, we used field observations of SOC sequestration rates and N2O and CH4 emissions from the Ameriflux network and other sources to calibrate, validate, and corroborate model simulations. Results show that U.S. agricultural soils sequestered 13.2±1.16 Tg CO2-C yr-1 in SOC (at a depth of 3.5 m) during 1960-2018 and emitted 0.39±0.02 Tg N2O-N yr-1 and 0.21±0.01 Tg CH4-C yr-1, respectively. Based on the GWP100 metric (global warming potential on a 100-year time horizon), the estimated national net GHG emission rate from agricultural soils was 121.9±11.46 Tg CO2-eq yr-1, thus contributing to climate warming. The sequestered SOC offset ~28% of the climate-warming effects resulting from non-CO2 GHG emissions, and this offsetting effect increased over time. Increased nitrogen fertilizer use was the dominant factor contributing to the increase in net GHG emissions during 1960-2018, explaining ~47% of total changes. In contrast, the adoption of agricultural conservation practices (e.g., reduced tillage) and rising atmospheric CO2 attenuated net GHG emissions from U.S. croplands. Our study highlights the importance of concurrently quantifying SOC-sequestered CO2 and non-CO2 GHG emissions for developing effective agricultural climate change mitigation measures.

Jon Gewirtzman

Upland trees modulate soil fluxes and offset ecosystem uptake of methane

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