AmeriFlux

- Poster Abstracts -

For the

- 2024 AmeriFlux Annual Meeting -

Virtual Poster session: Sept 10, 2pm Eastern/11 am Pacific
Use this link: https://app.gather.town/app/agpKRKUFtw446wqN/2024Ameriflux

Topic: Artist in residence Poster 1

Sara Bouchard

Singing the Landscape

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An artist in the Fluxnet Artist-in-Residence program, I am working alongside Chris Gough and his lab at VCU to discover new ways of listening to and "singing" the landscape.

Through a multidisciplinary approach that incorporates sound, installation, performance, creative coding and video, I bring into focus local ecologies through the lens of song. My works are immersive, site-responsive and frequently take place beyond gallery walls. I use my own voice as a vessel, and I give voice to entities such as water, stone and trees. I create moments of intimacy, revealing the vulnerability and fragility of ecosystems.

I am developing a deeper understanding of my surrounding environment through myriad forms of research: observation, history, poetry, data. This interdisciplinary dialogue lays the foundation for my collaboration with the natural world and the subsequent demonstration of its agency.

Over the past few years I have begun to embrace technology more conspicuously in my work. My use of new media such as live-coding software and microcontrollers lies in tension with the organic sensibilities at the center of my work. But I am discovering in these tools a powerful and direct approach to working with nature as a collaborator and exciting possibilities for building transformative, immersive and interactive works.

Climate change and resource overconsumption are among the most critical concerns of our time. I strive to awaken environmental awareness and responsibility by offering a new connection to the landscape—one experienced through the ears.

Topic: Artist in residence Poster 2
Julia Oldham

18// Flux

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As a 2024 video artist in residence with FluxNet, paired with Dr. Christopher Still from Oregon State University, I am sharing a collection of time lapse videos titled "18// Flux" that utilize daily PhenoCam images and my own audio samples from sites in Oregon. These videos represent the color, light and texture changes that occur hourly from 4 AM to 9 PM throughout the year for as many years as the PhenoCam has been in operation at each site. Each hour of daylight, or darkness, depending on the season, appears as a vertical stripe in the video frame, 4 AM on the farthest left and 9 PM on the farthest right. As the days progress, the interplay of elements across the screen reveals the numerous variations that take place throughout the year. I am interested in using visual, lens-based data-gathering techniques to create artworks that offer a different perspective and an expansive visual examination of the FluxNet research sites. These videos share an entire day of photographic data in every frame, and each second of video contains 24 frames, the standard for traditional film. This allows a viewer to consume one year of photographic data in approximately 15 seconds and thousands of unique moments in just a few minutes.

Topic: Artist in residence Poster 3

David Glowacki

Feeling into FLUX

David Glowacki & Maoya Bassiouni
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I am a cross-disciplinary researcher, artist, and author with interests spanning computer science, nanoscience, neuroscience, aesthetics, cultural theory, & spirituality. I used a variety of interactive digital technologies to help people dissolve their sense of separated individual identity by re-imagining their interconnectedness to the complex networks of relationships in which they are embedded (https://glow-wacky.com/).

Time magazine recently suggested that ‘Apocalyptic Optimism’ might be the only viable approach to the growing sense of ‘Climate Fatalism’. The word ‘Apocalyse’ (form ancient Greek ἀποκάλυψις (apokálupsis)) tends to be misunderstood within our culture: it is generally taken to signify a sudden and painful end to all things. However, the word ἀποκάλυψις (apokálupsis) in fact translates as ‘Revelation’, and is often associated with the transmission of timeless and forgotten cosmic mysteries and which portend a new level of insight, awareness, and understanding. The moments of deepest revelation and light often co-arise alongside the deepest pain, fear, and darkness. For the Fluxnet artistic project, I will experiment with how imagery and metaphors anchored in more ancient discourses of emergence, interconnectedness and harmony can transform the pain, anxiety, and fear associated with the climate narrative into fodder that nurtures awareness, insight, and calm abiding.

Topic: Artist in residence Poster 4

Marcy Litvak

Visualizing complex ecosystem changes through the lens of an Indigenous artist

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Climatic extremes are typical in the Southwestern U.S, and the frequency of extreme temperature and precipitation events (both drought and large storms) in this region is predicted to increase in the next century. Understanding how resilient carbon pools and fluxes in these biomes are to climate extremes constitutes a large uncertainty in our ability to understand regional carbon balance. We use continuous measurements of net ecosystem exchange of carbon (NEE) and its components (gross primary productivity (GPP) and ecosystem respiration (Re) made over the New Mexico Elevation Gradient (NMEG) network of flux tower sites (desert grassland, creosote shrubland, juniper savanna, piñon-juniper woodland, ponderosa pine and subalpine mixed conifer) to test hypotheses about the biome-specific sensitivity of carbon cycling to both drought and temperature extremes. In visualizing such complex ecosystem changes through the lens of an Indigenous artist working at the intersection of western science, Native Science and art, it would be a culturally and land relevant experiment to create art using the vegetal dyes and minerals in the regions of the flux tower sites. These dyes can be used as a watercolor or acrylic paint when combined with a binder that can hold the pigment. It can also be used as a glaze for pottery. During erosion and flooding clay beds and mineral pigment outcroppings become more visible creating an opportunity for natural potters to harvest and create their wares. In this project we envision utilizing site-specific plants and minerals to portray the dance between ecosystems as they breathe to balance one another.

Topic: History and Future of AmeriFlux Poster 5
Jessica Richardson

Meet the Fluxers: Connecting Scientists and Stakeholders through Audio Media

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Meet the Fluxers is a science podcast aiming to bridge the gap between eddy covariance flux scientists and stakeholders through the audio medium. After more than one year of planning, the idea originally put forth by members of the FLUXNET Outreach Committee Working Group has materialized into a collaborative effort with specific goals regarding format, target audience, ideal outcomes, individual roles, timelines, budgets, and story-worthy topics. Prior to its launch, the podcast has already gained enthusiastic interest from researchers across disciplines, and intends on reaching many more, including 300+ members of the FLUXNET Early Career Network (ECN) and 18 active regional networks (Delwiche et al., 2024). Each episode features a discussion between a guest flux scientist and a stakeholder (e.g., farmer, community leader, restoration volunteer, etc.), with conversation moderated by the co-hosts, or "fluxers". Launching on Spotify will provide an opportunity to analyze listener data and improve the podcast accordingly. Analytics provided by the platform include information on unique listeners, followers, starts, and streams; engagement trends; demographics (i.e., age, gender, location); and episode performance. The podcast is also accompanied by a website where scripts will be published and from which more information on viewership will be available for eventual analysis. Our future aspirations for the podcast, following the release and promotion of our first season (6 episodes), include establishing an international audience and recording soundbites from conferences and workshops where people share their thoughts on flux science on-the-go. Additional opportunities exist to feature agronomists utilizing flux data in their daily work, remaining members of the Sapelo Island Saltwater Geechee whose historic community lies not far from the Georgia Coastal Ecosystems Long Term Ecological Research (GCE-LTER) site, Indigenous scientists viewing flux data through the lens of traditional ecological knowledge, and more. We encourage constructive feedback from AmeriFlux members on our published episodes.

Topic: Innovation & Imagination Poster 6

Siqin He

An Improved Analyzer for High-Precision and Low-Drift N2O/CO Ambient Monitoring

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Recognized by their critical contributions to greenhouse gas emissions, N2O and CO have recently risen to the focus for ambient monitoring, where high precision and low drift specifications are both essentially desired to ensure data integrity for long term measurements. In response to the growing needs of the monitoring community, Picarro has launched a new N2O/CO analyzer – PI5310 that integrates our renowned mid-infrared laser-based cavity ring-down spectrometry (CRDS) technology with significant software and hardware enhancements, as well as sought-after new features to better serve the remote monitoring use cases. This improved analyzer will continue to provide simultaneous real-time sub-ppb measurements of ambient N2O and CO, and with much improved precision and drift performance that exceeds the specification requirements of the Integrated Carbon Observation System (ICOS), which will be reviewed in detail in this paper. Additionally, to further explore the measurement capability and comprehensively utilize the potential of its spectroscopy in which the 13CO2 is well captured, the PI5310 analyzer was set up alongside the CO2 and CH4 measurements by a Picarro G2401 analyzer to characterize its performance in 13CO2 measurements in comparison with a Picarro iso-carbon analyzer G2201-i. The experimental set up and preliminary evaluation results are also summarized and discussed in this paper.

Topic: Innovation & Imagination Poster 7

Kate Martin

Enhancing Greenhouse Gas Analysis: Evaluating the Picarro Gas Autosampler for Discrete Gas Sample Measurements

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The greenhouse gas research community is experiencing a growing demand for automated solutions to measure greenhouse gas concentrations in small discrete gas samples. However, existing solutions often come with high initial and maintenance costs, are complex to deploy and maintain, and are impractical for fieldwork. With advancements in technology on the horizon, there is increasing anticipation for the forthcoming Picarro Gas Autosampler in combination with Picarro analyzers featuring higher flow rates (>200 scc/m), such as the G2508. This report aims to explore the compatibility, efficiency, and advantages of the Picarro Gas Autosampler with Picarro Greenhouse Gas (GHG) Concentration analyzer G2508. Our experiments demonstrate excellent precision and accuracy in discrete gas sample measurements. Additionally, we investigate linearity in dilution factors and assess memory effects and variability across different gas species (e.g., comparing CO2 vs N2O). Furthermore, this report provides recommendations on methods and best practices for discrete gas sample measurements. In summary, the Picarro G2508 (or other GHG analyzers) in conjunction with the anticipated Picarro Gas Autosampler presents an appealing, cost-effective, and simpler alternative to gas chromatographs or similar solutions currently available.

Topic: Anthro-systems Poster 8

Xiangmin Sun

Year-long eddy covariance measurements of Greenhouse Gas Fluxes (CO_2, CH_4, and N_2O) over a grazed pasture in the Midwest

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Accounting for 9.4% of total U.S. greenhouse gas (GHG) emissions in 2022, agriculture is the dominant driver for potent non-CO_2 gas emissions, such as methane (CH_4) and nitrous oxide (N_2O). Agriculture soil management practices (including fertilizer/manure application) contribute 75% of U.S. N_2O emissions, and enteric emissions from livestock production contribute 25% to total US CH_4 emissions. Under rising concerns of GHG emissions from livestock production and to more systematically quantify these gas fluxes, we set up a comprehensive eddy covariance (EC) system over a fertilized pasture with rotational cattle grazing in a USDA Long-Term Agroecosystem Research (LTAR) site in Nebraska. The comprehensive EC system consists of an open-path analyzer for CO_2 gas and a closed-path sensor for CO_2, CH_4 and N_2O gases. Collared GPS trackers recorded the movement of each animal within the pasture. The CO_2 flux measured by the open- and closed-path analyzers closely matched, which developed confidence that processing protocol for the closed-path non-CO_2 gas flux system were accurate. CO_2 fluxes peaked early May just prior to the introduction of cattle into the pasture. CH_4 fluxes were analyzed according to the spatial pattern of the cattle population within the flux footprint to estimate emissions on a per animal basis. A clear peak of N_2O flux was observed in the early growing season, while the N_2O flux was consistently low with some uncertainty during the remaining periods of the growing season. With further improvements in the uncertainty level, our EC measurements and data processing protocol over the pasture could be sufficiently accurate for long-term GHG budgets and inventories at the ecosystem level.

Topic: Nature based climate solutions Poster 9

Angela Che Ing Tang

Substantial decrease in methane emissions and carbon dioxide uptake from a Great Lakes coastal freshwater wetland due to rising water levels and vegetation shift

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Coastal freshwater wetlands sequester significant carbon but can also emit methane (CH_4) due to oxygen-deprived conditions. Rising water levels in an estuarine freshwater wetland at the Old Woman Creek National Estuarine Research Reserve in the Great Lakes region shifted the vegetation from emergent cattail dominance in 2015−2016 to floating-leaved species (lotus and water lily) since 2020. The impact of this ecological transformation on carbon fluxes remains unexplored. We analyzed flux data measured using the eddy covariance technique during the peak growing season (June−September) of 2015−2016 and 2020−2022. Seasonal CH_4 emissions decreased by 65%, from 89 ± 14 g C m^{-2} in 2015−2016 to 31 ± 13 g C m^{-2} in 2020−2022. Conversely, the wetland was a net carbon dioxide (CO_2) sink in all years except 2021, when it became a small net CO_2 source. Net CO_2 uptake decreased by 96%, from −265 ± 59 g C m^{-2} in 2015−2016 to −10 ± 57 g C m^{-2} in 2020−2022. Cumulative gross primary production (GPP) decreased by 41% in 2020−2022, while ecosystem respiration (ER) remained comparable. On a diurnal scale, the morning CH_4 peak observed in 2015−2016, driven by pressurized flow, diminished in 2020−2022, suggesting a shift to regulatory mechanisms less reliant on stomatal conductance in floating-leaved species. Path analysis between two periods revealed a significant decrease in GPP's effect on CH_4 emissions, indicating reduced substrate availability for CH_4 production. Furthermore, the aerenchyma tissues and structure of cattails promoted CH_4 transport, resulting in higher CH_4 emissions. In contrast, the higher water levels during 2020−2022 likely increased hydrostatic pressure, while the extensive floating-leaved coverage created physical barriers, both inhibiting ebullitive fluxes and contributing to decreased CH_4 emissions. These changes highlight the significant impacts of rising water levels and vegetation shifts on wetland biogeochemistry, reducing both CH_4 emissions and CO_2 uptake.

Topic: Remote Sensing Poster 10

Hamid Dashti

Convergent relationship between canopy structure and maximum light use efficiency across biomes

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Canopy maximum light use efficiency (LUEMax) is defined as the maximum capacity of plants to convert absorbed light into fixed carbon. LUEMax serves as the foundation for LUE-based models estimating gross primary production. The variability in LUEMax has been linked to various processes, from ecological evolution to factors such as water use efficiency, nitrogen availability, light quality, and atmospheric CO2 levels. One aspect that has received less attention is the relationship between LUEMax and canopy structure across biomes. In this study, we compiled data from over 300 eddy covariance sites within the AmeriFlux and Fluxnet networks, along with MODIS remote sensing data, including the fraction of absorbed radiation, leaf area index (LAI), and reflectance. Using this comprehensive dataset, we estimated LUEMax for each site. We then calculated the NIRv, defined as the product of NDVI and near-infrared reflectance, as a remote sensing proxy for canopy structure at each site and investigated the relationship between LUEMax and NIRv. Our results indicate a strong linear correlation (R^2=0.81) between LUEMax and NIRv across different biomes. An intriguing observation is the alignment of biomes along this linear relationship, with open canopies exhibiting low NIRv and LUEMax values in the lower left of the plot, gradually transitioning to denser and closed canopy biomes with higher values in the upper right. Our preliminary results also show that LUEMax has a non-linear relationship with LAI. These findings suggest potential adaptation of canopy structure to enhance LUEMax across biomes and potentially provide an approach to estimate LUEMax from remote sensing data.

Topic: General Science Session Poster 11

Bassil El Masri

Methane Dynamics in Bald Cypress and Other Bottomland Hardwood Forests in response to hydrological variability.

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Methane (CH_4) is one of the most important greenhouse gases and more than 30% of its total emissions originate from wetlands. There is high uncertainty in the contribution of mineral soil wetlands to global CH_4 budgets. To help close this gap, we are measuring the spatial and temporal dynamics of CH_4 fluxes in soils and woody structures (stems and “knees”) of temperate bald cypress (Taxodium distichum) and other bottomland hardwood stands and incorporating our measurements into an ecosystem model to improve the model representation and predictions of CH_4 fluxes. Soil collars and custom-built chambers were installed in the stems and knees of trees along four sites that span a hydrologic gradient from the terrace to the stream channel in Western Kentucky’s Clarks River National Wildlife Refuge (CRNWR) and Hancock Biological Station (HBS). We found significant differences in soil CH_4 fluxes (p-value < 0.02) between stand species composition (p-value < 0.02), but no significant differences in stem CH_4 fluxes among species (p-value $= 0.25$). Contrary to some studies, we found no significant difference among CH_4 fluxes across stem heights. Our results showed a higher average soil CH_4 uptake rate in high knee density areas compared to no knee areas ($p = 0.004$) that can offset the observed knee CH_4 emission. We found no statistically significant difference between soil fluxes during drought and after historic flooding events, but the flooding event can enhance stem and knee CH_4 emissions. We will use our ongoing monitoring, to improve our understanding of soil-vegetation interaction in hardwood bottomland wetlands and incorporate these functions into ongoing processes-based modeling efforts.

Topic: Innovation & Imagination Poster 12

Zhenhai Liu

The high-temperature shifts ecosystem respiration: underestimated temperature dependence and overestimated trending

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Ecosystem respiration (Re) is a critical process in the carbon cycle, driving the release of CO2 from plants and soils into the atmosphere. Understanding how Re responds to temperature variations is essential, particularly as global temperatures continue to rise. Recent research suggests that the effect of temperature on Re has been underestimated, especially under extreme high-temperature conditions. This study seeks to provide a more accurate understanding of temperature sensitivity of Re across diverse ecosystems.

We utilized data from the FLUXNET2015 network, encompassing a wide range of biomes and climatic conditions, to compare traditional models that do not account for high-temperature limitations with newer approaches that incorporate these effects. Our analysis revealed that conventional models significantly underestimate the activation energy (Ea) of Re at higher temperatures. This underestimation could lead to substantial overestimations of future carbon emissions, as these models fail to capture the full extent of temperature-induced changes in Re.

Our findings underscore the need for a revised approach to modeling Re, one that fully integrates the effects of high temperatures. This research provides critical insights into the temperature dependence of Re, highlighting the importance of accurate models for predicting future ecosystem responses and informing global carbon cycle projections. As climate change continues to pose significant challenges, understanding the nuances of temperature sensitivity of Re is vital for effective environmental management and policy-making.

By enhancing our models and predictions, we can better prepare for and respond to the changes in ecosystem carbon dynamics driven by rising global temperatures. This research contributes to the ongoing effort to refine our understanding of the carbon cycle and improve our capacity to mitigate climate change impacts.

Topic: General Science Session Poster 13

Maricar Aguilos

Harbingers of change: Tree mortality and net ecosystem exchange provide early warning signs of ecosystem transition in response to climate change and sea level rise

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Coastal forested wetlands are important ecosystems in global carbon (C) and hydrological services. However, these wetlands are under a myriad of threats from climate change and sea level rise, causing a decline in ecosystem functions such as C sequestration. Using the eddy covariance approach, this study assessed the changes in carbon balance and tree mortality rates in a natural hardwood forest along the lower coastal plain of North Carolina, USA. We evaluated the long-term (2009–2019) gross primary productivity (GPP), ecosystem respiration (RE), and net ecosystem C exchange (NEE) in relation to hydrology and forest cover change. We identified major tree species and quantified mortality in response to chronic changes in hydrology and episodic hurricane events. We found that our ecosystem was a net C sink (NEE = −3.68 Mg C ha−1 yr−1) in 2009 when monitoring began, but it became a net C source from 2010 to 2019 (NEE = 0.87 Mg C ha−1 yr−1 to 7.59 Mg C ha−1 yr−1). We ascribe the continuing C losses to increasing mortality rates of the dominant bottomland hardwood forest, from 1.6% in 2009 to 45.8% in 2019. We also found increased mortality of adjacent loblolly pine (Pinus taeda) stand due to hurricane occurrences and bark beetle infestation. We show that both leaf area index and air temperature were the key drivers of NEE. Our study provides a critical reference point in better understanding how C cycling responds to hydrologic change in wetland ecosystems during the early stages of transition from a healthy bottomland hardwood forested wetland to ghost forest, driven by sea level rise and its effects on inland hydrology, as related to climate change. Importantly, this study demonstrates that integrating changes in tree mortality with net ecosystem exchange provides early warning signs of coastal forest ecosystem transition.

Topic: Remote Sensing Poster 14

Monica Cervantes Jiménez

Machine learning and sun-induced fluorescence are valuable tools for predicting Gross Primary Productivity (GPP) in a semi-arid ecosystem.

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Gross primary production (GPP) represents the carbon fixed by vegetation through photosynthesis in ecosystems. Arid and semi-arid environments, where water is limited, are underrepresented in carbon dynamics models. It is essential to enhance the accuracy of GPP estimates to propose nature-based solutions to address climate change. Solar-induced fluorescence (SIF) is directly related to vegetation photosynthesis and is used as an indicator to estimate GPP. In this study, scenarios were developed to assess the accuracy of GPP models by utilizing two GPP satellite products (MOD17 and FluxSat) and one SIF product (GOSIF), meteorological variables, reflectances, and vegetation attributes obtained from remote sensors. The models were trained and evaluated using GPP estimates from an Eddy Covariance tower in a xerophytic shrubland in central Mexico with data collected during 2017 and 2018. However, all satellite products poorly explained the variation of EC measurements ($R2=0.65$ GOSIF, $R2=0.59$ MOD17, and $R2=0.57$ FluxSat). Machine learning algorithms, when combined with remote sensors, have enhanced the accuracy of GPP estimates. The ML estimates of GPP were notably improved when utilizing GOSIF and the most important variables in all the models, produced the highest R2 value (0.89). In conclusion, SIF techniques and machine learning show promise in making a practical and cost-effective contribution to the analysis of carbon dynamics in arid and semiarid ecosystems.

Topic: General Science Session Poster 15

John Lenters

Artificial CO_2 and H_2O variations in new gas analyzers: An under-compensated response to changes in cell temperature?

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Two infrared gas analyzers (IRGAs) at the University of Michigan Biological Station's AmeriFlux tower (US-UMB) were recently upgraded from LI-COR LI-7000 units to the latest LI-7200 "enclosed path" IRGA. During the spring of 2024, the new units were set up for testing in a heated shed identical to the "closed path" configuration used by our previous LI-7000s. Although the new IRGAs were initially found to perform well and were easier to operate in many ways, a curious oscillation in CO_2 concentration was observed at times, occasionally in concert with similar oscillations in H_2O. The gas concentrations were found to vary over a cycle of roughly 15-20 minutes, and with an amplitude of approximately 0.5 ppm (for CO_2). Further testing revealed that the variation was occurring in response to the on/off cycle of the electric heater in the shed, but the problem persisted even under more controlled conditions (e.g., electrical isolation and use of calibration gas instead of ambient air). Occasional CO_2 variations of up to 1-2 ppm were observed in response to only ~0.2 C variations in IRGA cell temperature. Relative to ambient CO_2 concentrations of ~420 ppm, this translates into a $d(CO_2)/dT$ sensitivity of up to 2% CO_2 per degree C (i.e., not a small sensitivity, and problematic for doing calibrations). While we continue to perform additional testing in partnership with LI-COR (who has also replicated the problem in their own labs), we present initial results here to see if others in the AmeriFlux community have observed similar issues. Since field-based variations in IRGA cell temperature can be expected to correlate with variations in vertical wind speed, w' (via sensible heat flux), it is entirely possible that the anomalous temperature sensitivity observed here is not limited to just impacts on gas concentration, but rather may also be affecting fluxes.

Topic: General Science Session Poster 16

Tiia Määttä

A comparison of eddy covariance and chamber methane fluxes across multiple sites

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Methane (CH4) is a greenhouse gas that is produced in anoxic soils. Wetlands are strong CH4 sources because their anoxic soils are suitable for CH4 production, while oxic upland soils act as net CH4 sinks due to increased CH4 consumption. Both global and regional CH4 budgets remain unconstrained due to high spatio-temporal variability in CH4 dynamics which is in part driven by spatial heterogeneity and variables related to it. However, the contribution of different abiotic and biotic factors to CH4 flux variability remains unclear, increasing uncertainties in upscaling CH4 emissions from plot to ecosystem and regional scales. As chambers and eddy covariance (EC) towers are commonly used techniques to measure CH4 fluxes at different spatio-temporal scales, understanding how they differ could help in the upscaling efforts.

We investigated the differences in CH4 emissions measured by EC and chambers at nine different sites with varying climatic conditions. Our compiled chamber datasets include both manual (n=5) and automatic (n=4) measurements. Chamber data were then combined with EC data from the same time period. We compared chamber and EC fluxes at different time scales, and investigated predictors of chamber-EC flux differences.

From over 1900 paired observations of chamber and EC CH4 fluxes, preliminary results suggest that chamber and EC observations differ significantly between temporal scales and sites, and that EC observations tend to be larger than chamber while the latter has a larger range. By using different abiotic and biotic variables as predictors for the observed EC-chamber difference, we expect to explain some of the temporal variation in EC-chamber difference. Altogether, this study will help understand the feasibility of combining CH4 data from different measurement types and allow global syntheses to use more of the available data to constrain CH4 budgets.

Topic: History and Future of AmeriFlux Poster 17

Angie Abarzua

Influences of soil properties on ecosystem fluxes across the Ameriflux network

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Soil resources mediate vegetation function. The soil environment and biological community control processes that sustain the provision of resources and nutrients to plants. Soil type and soil properties likely influence the capacity for photosynthesis and evapotranspiration.
To investigate how different soil properties and soil conditions influence ecosystem fluxes of carbon and water, we combined soil data in the Biological, Ancillary, Disturbance, and Metadata (BADM) with flux measurements made across the longest running Ameriflux sites and sites from the National Ecological Observatory Network. We reviewed the soil data available in BADM and determined which soil variables were available and here we summarize soil data availability across the network. We found that bulk density, soil pH, soil organic carbon, soil nitrogen and texture were available for up to 50 Ameriflux sites. We evaluated the relations between soil properties and net ecosystem exchange (NEE), gross primary productivity (GPP), evapotranspiration and leaf area index where available.
We found significant statistical relationships between GPP, LAI and soil pH and the proportion of clay and sand in soils. We did not find significant relationships between soil variables and NEE. We also explore relationships between fluxes and soil properties from the USDA Soil Survey Geographic Database (SSURGO). Site reported soil data availability in the BADM was biased toward evergreen needleleaf forests and several sites only reported soil taxonomic properties. It is challenging to drawn broad conclusions from the limited soils data in the BADM. However, our results suggest that soil properties likely influence the carbon uptake and hydrological function of these ecosystems. Expanding this dataset could improve our understanding of fluxes and soil interactions in contrasting vegetation and soil types.

Topic: History and Future of AmeriFlux Poster 18
J William Munger

Long-term observations at the Harvard Forest: What can we learn from 32 years of carbon flux and biomass measurements?

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Forests are an important carbon sink currently. Over time, they may approach steady state, but changing climate conditions, rising CO2, and disturbances could alter this trajectory. Carbon flux and biomass have been measured at the Harvard Forest site since 1992. Mean annual temperature has been increasing by 0.2C per decade and the frequency, duration, and intensity of winter cold snaps has decreased. Annual precipitation is variable, but more years have been above-average after 2000 than in the preceding 20 years. Above-ground woody biomass has increased from 100 Mg-C ha-1 to 130 Mg-C ha-1.

We quantify ecosystem functional response to light and temperature by fitting hourly Net Ecosystem Exchange (NEE) observations binned by 3-year blocks and separated into phenologically defined seasons to a light curve and temperature response. The model includes 4 parameters, mean ecosystem respiration (Reco.mean), temperature response, maximum GPP (GPPmax), and half saturation PAR. Fitting the model separately for three wind sectors (E, SW, NW) with subtle differences in species distribution and soils gives a significant improvement compared to an overall fit. On average Reco and GPPmax are higher in the oak-dominated SW sector than in the NW sector that has more hemlocks, and includes some wetlands. The magnitude of summertime GPPmax increases significantly to a peak in the mid 2000's and then declines. Similarly, the mean Reco parameter has a similar pattern. These results highlight that ecosystem functional responses are sensitive to subtle differences in species composition and soil characteristics at the scale of a flux tower. Because photosynthesis, carbon allocation and growth, and respiration each respond independently to the environment and on different timescales it is not surprising to observe non-linear trends in ecosystem functional response that evolve over multi-decadal periods. Long-term observations are required to detect these responses and attribute them to environmental changes.

Topic: Nature based climate solutions Poster 19

Inbar Amitay

A Process-Based Modeling Approach to Estimating Net Ecosystem Carbon Balance in Tidal Wetlands

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Blue Carbon, or carbon stored in marine environments on long timescales, is central to carbon sequestration as a climate mitigation strategy. Tidal wetland ecosystems have major potential when it comes to long-term carbon sequestration, with tidal wetlands holding an estimated soil C stock of 862 to 1350 Tg C. Previous investigations of tidal wetlands and their contributions to carbon offsets have focused primarily on the carbon captured in the sediment. There is more research needed on the lateral exchange of carbon between these ecosystems and the coastal ocean. Specifically, process-based models are needed in order to assess the true climate mitigation potential of tidal wetlands at large spatial scales. We will parameterize a process-based model (PEPRMT-Tidal-LF) using high frequency atmospheric and lateral carbon flux data to estimate net ecosystem carbon balance (NECB) at Eden Landing, a restored tidal wetland in the San Francisco Bay, CA, USA. High frequency in-situ measurements of lateral C fluxes at Eden Landing have shown net export of C during the growing season (-208 g C m-2 in the form of dissolved inorganic C (DIC)). We plan to build DIC production into the model by simulating sulfate reduction via Michaelis-Menten enzyme kinetics, where available C pools, SO4 and O2 influence rates of reaction. We will also model DIC transport as a function of inundation estimated from water level. Our model parameters, empirical functions and uncertainty will be constrained using both atmospheric and lateral flux data using a Bayesian hierarchical approach. By improving NECB modeling at Eden Landing, we can gain further insight on the climate mitigation potential of tidal wetlands more broadly.

Topic: General Science Session Poster 20

Eduardo Gamez Jr

Ecosystem Flux Partitioning in Tidal Wetlands: Analyzing Net Ecosystem Exchange and Evapotranspiration Through Artificial Neural Networks

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Tidal wetlands provide wildlife habitat, mitigate sea level rise, and sequester carbon. Despite their importance, significant knowledge gaps remain regarding water and carbon budgets in these ecosystems. Understanding transpiration and evaporation processes is crucial for effective tidal wetland management, as these processes contribute to environmental cooling and water use patterns. Additionally, studying carbon dynamics, including carbon sequestration and emissions through ecosystem respiration and gross primary productivity, is essential for assessing the role of tidal wetlands in global carbon cycles and climate change mitigation.

We have collected six years of high-frequency continuous eddy covariance data (2018-2024) at Eden Landing Ecological Reserve, a restored tidal wetland in South San Francisco Bay, CA, USA. The site showed consistently high net uptake of CO_2 (-477.9 gC-CO_2 m^{-2} yr^{-1}, Std.Dev = 58.28) and small net uptake of CH_4 (-7.2 gC-CH_4 m^{-2} yr^{-1}, Std.Dev = 1.85). Additionally, the wetland had an average total annual ET of 1722.55 mm, Std.Dev = 248.66. We plan to use artificial neural networks to partition both NEE and ET to improve our understanding of the processes regulating C and water exchange in tidal wetlands.

Topic: Anthro-systems Poster 21

Victoria Ayeh

Impact of change in forest cover on vegetation health and gross primary productivity over Bia Tano Forest Reserve in Ghana

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Carbon dioxide (CO_2) is the most responsible gas in the phenomenon of global warming on earth because of its greatest concentration and longevity in the atmosphere. Meanwhile, the forest is one of the natural sinks that can absorb CO_2 for photosynthesis and store it into biomass, so the existence of forest plays a critical role in the balance of global carbon cycle. To ensure the continuity of this service provided by the forest, it is important to understand the health and productivity levels of the forest. Gross Primary Productivity (GPP) is oneof the key variables in conducting forest productivity study because the GPP values constitute the total value of carbon fixation by terrestrial ecosystem through vegetation photosynthesis. The Normalized Difference Vegetation Index (NDVI)is another key variable for finding the health of terrestrial ecosystems. This study uses GIS and satellite images, namely LANDSAT, MODIS GPP and NDVI to assess the LULCC (Land Use Land Cover Changes), the productivity and health of the Bia-Tano Forest reserve from 2000-2020. The aim of this study is to assess the temporal trends in forest cover, vegetation health and GPP to identify any longterm impact. We argued that the LULC has a significant impact on the health and productivity of the forest. The results of this study indicated that changes in land use have contributed to a decrease in the forest health and productivity over the last two decades, when the 'closed forest' attained a peek, but the forest experienced a rise in its health and productivity when the 'closed forest' beganto fall, with the 'open forest' and 'barren/builtup' areas increasing. Expansion of 'closed forest' areas negatively impacted forest productivity due to a reduced light availability for photosynthesis. The emergence of 'barren/built up' areas altered soil properties and microclimate, affecting both forest health and forest productivity.

Topic: Nature based climate solutions Poster 22

Robert Shortt

Periodicity in a Restored Freshwater Tidal Wetland

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Methane fluxes in the Dutch Slough restored wetland in California display a periodicity which is unique compared to other impounded wetland restoration projects in the Delta. This study examines the causes of this periodicity, and propose mechanisms which are responsible for it.

Topic: Innovation & Imagination Poster 23

Adam Young

Recent eddy covariance data optimization efforts from the National Ecological Observatory Network (NEON)

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The National Ecological Observatory Network (NEON) is a large-scale, 30-year project aimed at collecting, synthesizing, and distributing high quality ecological data for major biomes within the United States. There are 20 ecoclimatic domains that define the observatory, and within each of these domains there is at least one flux tower that continuously collects standardized eddy covariance turbulent and storage exchange information. These 47 flux towers also serve as individual AmeriFlux sites as well (<https://ameriflux.lbl.gov/sites/site-search/?availability#network=NEON>). Through the AmeriFlux data portal, there are approximately 280 site years of data available for download and there have been over 61,000 data downloads since 2019.

The teams at NEON are continually exploring new ways to improve and optimize how flux measurements are collected and processed, with the goal to provide high-quality data for users. This presentation will share recent updates in flux data products, including: (1) improvements to the high-frequency correction algorithm for turbulent flux data, and (2) testing the performance of different sensors to estimate CO_2 and H_2O storage flux. As an example, the changes made to our high-frequency correction routine fixes previous issues that resulted in corrected flux values having increased attenuation (i.e., correction coefficients < 1.0). Furthermore, we are conducting an intercomparison between our wavelet-based correction approach (implemented in a single-pass workflow) against more conventional high-frequency correction methods. The evaluation of storage-flux sensors will communicate tradeoffs between sensor stability and sampling time at the scale of the whole observatory. Overall, this presentation will be beneficial to data users to communicate ongoing improvements, while also providing the opportunity to receive important feedback from the flux-data community.

Topic: General Science Session Poster 24

Mindy Priddy

Cross-scale coupling of plant traits and carbon cycling processes in a restored tidal freshwater marsh

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Tidal freshwater wetlands are understudied and biogeochemically distinct from their saline coastal and freshwater interior counterparts. These ecosystems are relatively high sources of methane and vary in their capacity to sequester carbon; however, the mechanisms that underlie carbon dioxide and methane flux exchange across spatial scales are poorly understood but crucial to improving biogeochemical models. To address this knowledge gap, we are using chambers, eddy-covariance towers, and terrestrial and airborne remote sensing to characterize the leaf-to-landscape spectral, physiological, and morphological traits tied to carbon cycling processes, with the goal of identifying the biophysical drivers of fluxes in a restored tidal freshwater wetland in the Chesapeake Bay watershed. Our study site is the US-RRC (Rice Rivers Center) AmeriFlux Core Site facility, an early successional tidal freshwater wetland restored 15 years ago following nearly a century of inundation.

Our preliminary analyses suggest that methane and carbon dioxide fluxes are coupled to plant functional traits across spatial scales, providing a mechanistic basis for inferring and interpreting tidal freshwater carbon cycling processes from remotely sensed data. At 1 to 30 meter spatial scales, we observed distinct spectral signatures among plant functional types corresponding with different profiles of stomatal conductance, net carbon assimilation, leaf mass per area (LMA), and foliar nitrogen content. At larger landscape scales, net ecosystem exchange and methane fluxes were greater where fast-growing, physiologically active annual species dominate within the flux tower footprint, highlighting a spatial connection between smaller and larger spatial scales.

Our analysis has implications for multi-scale modeling, highlighting challenges and opportunities associated with the prediction of carbon dioxide and methane fluxes in a heterogeneous, dynamic system.

Topic: General Science Session Poster 25

Lisa Haber

The carbon dynamics of a restored tidal freshwater wetland

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Coastal wetlands are highly productive and extremely biogeochemically diverse ecosystems, often encompassing saline, brackish, and freshwater salinity regimes within single estuaries. Wetland soils accumulate large amounts of carbon (C), but are also the largest natural sources of methane (CH_4), accounting for ~30% of annual global CH_4 emissions to the atmosphere. Along estuarine salinity gradients, tidal freshwater wetlands (TFWs) have been identified as especially strong sources of CH_4, yet they remain understudied relative to their more saline counterparts. In particular, there is a critical lack of high frequency data sets to assess continuous CH_4 and CO_2 fluxes from TFWs. In this study, we analyzed the first high frequency C flux data set to be collected using the eddy covariance (EC) technique in a TFW on the US East Coast. We leveraged a recently constructed EC tower (AmeriFlux network member US-RRC, located in the lower James River estuary, Virginia) to assess drivers of half-hourly to daily mean fluxes of CO_2 and CH_4. We additionally computed annual fluxes for each greenhouse gas, finding our site to be a net source of both CO_2 (682 g C m^{-2} yr^{-1}) and CH_4 (45 g C m^{-2} yr^{-1}) in our first year of data collection. Soil temperature was by far the most important biophysical driver of both CO_2 and CH_4 fluxes at the half-hourly and daily mean timescales, with water table depth also emerging as an important driver of ecosystem respiration (Reco). We conclude that US-RRC is similar in annual CH_4 efflux to other TFWs assessed with chamber flux methods, as well as to the one prior published EC study from a TFW in Louisiana. We infer from US-RRC's net CO_2 source status that site disturbance history may be contributing to net ecosystem heterotrophy, though additional years of data collection may reveal a more dynamic pattern of fluxes over time.

Topic: General Science Session Poster 26

Bethany Blakely

Scaling Fluxes for Impact: Recent Updates from the Ecometeorology Lab

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The Ecometeorology Lab at UW-Madison seeks to improve understanding of land-atmosphere interactions through advances in scaling methods and applications of flux measurements to societally relevant questions. Here, we present highlights from several projects. The ChEAS core site cluster (US-PFa, US-Syv, US-WCr, and US-Alq, US-Los) and the coincident CHEESEHEAD19 field experiment (US-PF*) allows us to develop new approaches to scaling fluxes, calculate horizontal and vertical advection budgets, and evaluate the impact of doing both on improving eddy covariance energy imbalance. Additionally, a El Ninõ driven anomalously warm winter of 2023-2024 significantly impacted winter fluxes across the domain. This and related work supports an ongoing Midwest synthesis of warm winter impacts to ecological processes. Finally, the lab has been expanding observations across a range of agricultural settings to answer questions on sustainability of water resources (US-CS*), nature-based climate solutions (US-DF*), and development of agrivoltaics (new site!). We highlight key results and welcome participants who'd like to collaborate on any of these.

Topic: Innovation & Imagination Poster 27

Madeline Scyphers

No One Is Good at Software, We Are All Just Trying To Get Better

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Software is hard, regardless of your experience level. It's easy to make mistakes, but software developers have created tools and frameworks that can make it easier for researchers. The people who make software look easy are simply those who have learned to use these tools.

The good news is that these tools are easy to use and can be employed one piece at a time. You don't have to invest a lot to learn them, and you don't have to learn them all at once.

Some of these tools include using version control systems like Git, documenting your code (manually or automatically), employing automatic testing, logging, dependency management, error handling, code, and more.

Each tool you adopt, and each technique you learn will contribute to making your development process smoother and more efficient. Remember, every small step you take adds to significant progress over time. We are all on this journey together, continually learning and improving, one step at a time.

Topic: Innovation & Imagination Poster 28
Dohee Kim

Understanding inhibition of daytime ecosystem respiration: Insights into diurnal dynamics and carbohydrate physiology

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Inhibition of daytime ecosystem respiration (Re) has been widely discussed as a potential bias in current estimates of ecosystem fluxes. Recent models and isotopic flux partitioning (IFP) approaches revealed 5 to 25% inhibition in plant daytime respiration. However, the diurnal dynamics and physiological reasoning behind inhibited Re remain unclear. Here, we present alternative estimates of CO2 fluxes using IFP along with standard nighttime flux partitioning (SFP) methods on a diurnal scale, collected in a shortleaf pine forest in East Texas. The average Re-IFP indicated about 31% lower than Re-SFP. The intensity of inhibition increased over the day, reaching 77% during the afternoon (between 1 to 8 pm). The greater inhibition of Re-IFP in the late afternoon arose from changes in soil respiration (Rs-IFP), whereas aboveground plant respiration (Ragp-IFP) was consistently about 5-fold lower than Ragp-SFP. Rs-IFP also decreased in the afternoon, but the difference compared to Rs-SFP was smaller (approximately 2-fold) than in the Ragp. This implies that our current estimate may underestimate the carbon allocated in the aboveground compartment of the plant. The relationship between Ragp and GEP exhibited some counterclockwise hysteresis (higher Ragp in the afternoon than morning at the same GEP) in the SFP data and during days with high VPD in IFP data, whereas during low VPD days, the relationship was nearly linear (no difference between morning and afternoon Ragp). The non-zero Ragp at zero GEP (the intercept of the Ragp-GEP regression) indicates the use of stored carbohydrate substrates. The decoupling of the Ragp-IFP from GEPIFP during high VPD days may indicate the activation of additional carbon dissipation pathways (lipid synthesis, secondary compounds or futile cycles) in order to protect chloroplasts against the adverse effect of soluble carbohydrate buildup.

Topic: Anthro-systems Poster 29

Katya Esquivel

Impacts of VPD on water and carbon dynamics of a pecan orchard in a semi-arid agroecosystem

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Quantifying drivers of carbon and water fluxes in agroecosystems, could be crucial to improving precision resource use and improving climate resilience. In Far West Texas, pecans are a major cash crop but not native to the region or adapted to aridity. As temperature rises and prevalence of droughts increases, VPD may play a more important role in affecting the crop productivity. Yet, a significant knowledge gap exists in the region regarding the carbon and water dynamics of pecan orchards. This study focuses on assessing the carbon and water dynamics of a pecan orchard in Tornillo, Texas, using an eddy covariance dataset from a wet, cool year (204.7 mm rain and 10 days above 37.7°C or 100°F) and a dry, hot year (26.4 mm rain and 31 days above 37.7°C or 100°F). During the irrigation season, productivity is expected to be limited primarily by VPD rather than by soil moisture, leading to lower productivity for hotter and drier conditions. Initial assessment of NEE diurnal dynamics show the presence of a midday depression even in favorable conditions of soil moisture.

To characterize the effects of VPD on productivity first the GPP and Reco for each growing season will be calculated and compared between the years. Then, the diurnal and daily dynamics of GPP will be analyzed accounting for the developmental stage of the trees. Finally, surface conductance (Gs) will be derived to evaluate the individual effects of soil moisture and VPD using empirical equations. This approach has been used previously at multiple AMERIFLUX sites, showing that VPD can account for over 70% of Gs limitation in some systems. If VPD is the dominating limiting factor, this will have significant implications for the future of pecan production in the region and the need for adaptive strategies.

Topic: Innovation & Imagination Poster 30

Justine Missik

Using a Plant Hydrodynamic Model, FETCH3.14, to Supplement Measurements and Characterize Hydraulic Traits in a Mixed Temperate Forest

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Species-specific hydraulic traits play an important role in ecosystem response 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 and improves the representation of hydraulic traits and their variation among trees and species. 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 demonstrate the model's performance in a mixed temperate forest in the footprint of the US-UMB AmeriFlux site in Michigan with species of contrasting hydraulic strategies. FETCH3.14 performed well in simulating sapflow of species with contrasting hydraulic strategies under conditions of water stress. In addition, the model was able to capture higher-level emergent traits, such as drought sensitivity. Using FETCH3.14 in combination with available observations can provide unique insights about difficult-to-measure hydraulic traits and plant hydrodynamics.

Topic: General Science Session Poster 31
Annie Carlile

Seasonal variation in the light response of NEE as an indication of photosynthetic dormancy: Exploring a GPP artifact that arises from standardized ONEFLUX processing

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Forests in middle and northern latitudes are photosynthetically dormant in the cold season. Climate warming may lead to a change in timing of the onset and end of dormancy. Wintertime photosynthesis in evergreen plants is possible under favorable conditions during winter, and such conditions may be more prevalent in the future. To learn more about such changes, we are examining the seasonality of the response of net ecosystem exchange of CO2 (NEE) to sunlight (photosynthetically active radiation, PAR) in 51 temperate and boreal forests. The slopes of simple linear regressions of daytime NEE versus PAR, at low PAR (lowest third of seasonal range in PAR), applied with a moving time window, were used to provide information about the light use efficiency of NEE (similar to a leaf-level quantum efficiency for net photosynthesis). This analysis revealed distinct air temperature (T) based thresholds for the transition between dormancy and photosynthetic activity, and the T thresholds tended to be colder for ENF forests. Our analysis has identified an artifact from standardized ONEFLUX flux partitioning, where sometimes under cold conditions NEE does not respond to light, but the standardized GPP flux partitioning products provide a modeled (and erroneous) GPP that is light dependent. Initial indications suggest this arises due to gap-filling.

Topic: Remote Sensing Poster 32

Kunxiaojia Yuan

Upscale Boreal-Arctic Wetland Methane Emissions Using Multi-Source Observations and Causality Guided Machine Learning

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Methane (CH_4) is the second most important greenhouse gas, contributing ~20-30% of global emission-related radiative forcing. Wetlands are the largest natural source of CH_4 emissions, but with the largest uncertainties. The Boreal-Arctic region contains extensive wetlands, where CH_4 emissions are closely linked to temperature. About 3-4 times faster warming than the global average was observed in this area. However, the regional response of CH_4 emissions to climate change remains unclear. In this study, we developed a causality-guided machine learning model (causal-ML) to quantify and analyze the wetland CH_4 emissions in the Boreal-Arctic area. We compiled the largest in-situ observation dataset, including eddy covariance and chamber measurements, to better constrain the model. Then, we extrapolated the well-trained causal-ML model using remote sensing and meteorological reanalysis datasets to generate an upscaled data product from 2002 to 2021. Our results indicated that the mean annual emissions were 20.3 ± 0.9 Tg CH_4 yr^{-1} during the past two decades, with ~53% of the total contributed by the two 'wetland hotspot' areas (i.e., Western Siberian Lowlands and Hudson Bay lowlands). We also found a robust increasing trend of CH_4 emissions (+8.9%), mainly contributed by emissions in early summer (June and July) and driven by warming and vegetation activities. Furthermore, we found anomalously high temperatures led to an annual peak CH_4 emission in 2016 (~15.5% higher emissions relative to 2002), driven primarily by high emissions over Western Siberian lowlands.

Topic: Anthro-systems Poster 33

Michael Benson

15 Years of Data Facilitates the Assessment of Bioenergy Feedstock Sustainability

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Bioenergy from biofuel crops will be an important tool for meeting global energy needs and evolving energy mandates. As ongoing research demonstrates the environmental costs of maize ethanol, perennial feedstocks offer a promising alternative. However, such feedstocks are poorly represented in currently available flux datasets, especially on the longer time horizons needed to evaluate their carbon mitigation potential and resilience to climate extremes. Here, we highlight key findings from 15 years of flux observations among co-located annual (e.g., maize, soy, sorghum) and perennial (e.g., switchgrass, miscanthus) bioenergy feedstocks to discuss their implications for the development of an ecologically sustainable US biofuel economy.

Topic: General Science Session Poster 34

Marguerite Mauritz

Addressing uncertainties in open-path eddy covariance CO_2 fluxes: a dryland case-study

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Addressing the uncertainties and biases in eddy covariance (EC) measurements is critical to improving our understanding of the terrestrial carbon sink. Systematic uncertainties arise from issues including instrumentation differences, calculation assumptions, and site idiosyncrasies. In dryland regions, with extremely low fluxes, these uncertainties can dominate the flux signal and have a large impact on the correct estimation of carbon exchange. Using open-path (density-based) and closed-path (mole-fraction based) infrared gas analyzer (IRGA) comparisons in two shrub sites in the US Southwest, we show large overestimates in CO_2 uptake in the open-path measurement but consistent LE estimates. Open-path measurements at an unvegetated site support the interpretation that the apparent CO_2 uptake is not driven by biological activity.

It is well-established that in hot, dry, and low-flux conditions the Webb-Pearman-Leuning (WPL) terms are similar in magnitude but opposite in sign to the measured covariance between CO_2 density and vertical wind speed. Thus, the apparent, and unlikely, CO_2 uptake in dry periods may be due to an underestimate in the WPL terms. Here, we demonstrate that an additional correction factor can be derived from a comparison between the open and closed-path flux estimates to produce more plausible CO_2 dynamics. However, this correction lacks a mechanistic basis and requires parallel instrument mounting for sufficiently long periods. Thus, we seek a more generalizable and process-based approach. We explore to what extent a combination of sensor self-heating and under-estimated sensible heat flux (i.e. energy balance non-closure) could explain the spurious CO_2 uptake. Mathematically re-distributing heat flux errors to correct for biases in CO_2 flux could provide an approach for recalculating fluxes across, and beyond, dryland sites with open-path IRGAs.

Topic: General Science Session Poster 35

John Frank

Understanding high-elevation forest recovery 4-years after Colorado's largest wildfire

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In 2020 Colorado experienced the three largest wildfires in it’s recorded history, culminating in the Cameron Peak Fire which burned in the mountains from the alpine down to communities along the Front Range. A year later the USDA Forest Service established the Cameron Peak, Sawmill Creek study site in the remains of a high-elevation subalpine forest. Four years later the area is mostly baren with minimal plant regeneration and nearly absent of tree seedlings from the former spruce-fir-pine forest. Here we present findings from the eddy-covariance site, where minimal photosynthesis, respiration, and transpiration are offset by large sensible heat fluxes, evaporation, and soil heating. Compared to other subalpine-forest disturbances, this area of the Cameron Peak Fire may never return to a forest.

Topic: Remote Sensing Poster 36

Yifan Guan

Quantifying the evapotranspiration over California almond orchards through flux tower measurements and satellite-based observations

Yifan Guan, Ian McDonald, Jarin Tasnim Anika, Rex Dave Pyles, Liam Bhajan, Kosana Suvočarev, Yufang Jin

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California's Central Valley is among the most productive regions, producing grapes, almonds, pistachios, olives, etc. Almond is the third most valuable agricultural product in the state, generating 80% of the world's production. However, climate change such as the increasing frequency and severity of droughts reduces water supply, threatening the sustainability of California's Almond industry. Monitoring and understanding the variability of crop water use is critical for optimizing water conservation and developing sustainable groundwater management strategies.

Satellite based estimation of evapotranspiration (ET), has been used for water accounting from the field to regional scale. In this study, we aim to assess the water balance in the vast area of the almond growing industry in California, through the investigation the evapotranspiration from remote sensing using ground truth observations. We first evaluate the accuracy of the satellite-based ET estimates from the OpenET products with the water fluxes measured from 2022 to 2024 by eddy covariance flux towers established over six almond orchards with various cover cropping practices in Central Valley. Preliminary results showed the robustness of OpenET products over the Almond Orchard.

We further extend our studied regions to over 100 almond orchard years over California's Central Valley, to evaluate the impact of crop properties, climate, and soil types on consumptive water use. In particular, we compare cover-cropped versus bare-soiled fields to understand differences in ET due to cover cropping practices. Our analysis potentially disentangles the net-water impacts of cover crops, such as their ability to help with water capture and storage, thus affecting different components of water budget that are relevant to sustainability of almond production.Our study results provide new insights on the variability of orchard crop water use, especially with added complexity of cover cropping practices for groundwater sustainability management under California's changing climate.

Topic: Anthro-systems Poster 37

Kosana Suvocarev

Direct and semi-drect ET measurements for Applied Research and Extension

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The State of California is moving towards sustainable groundwater management and carbon neutrality goals. This raises questions of importance to sustainable agricultural practices to: 1) decrease unnecessary water losses through over-irrigation and 2) increase carbon sequestration in the soils and 3) overall enhance water use efficiency. While implementing our cooperative extension program in Biometeorology, we took eddy covariance to numerous farms, as a tool for measuring directly water (as evapotranspiration, ET) and carbon exchange between different agricultural crops and the atmosphere. Currently we are simultaneously running 10-20 flux towers on any day of a year to address seasonality of carbon and water cycling with innovative agricultural practices. Some of the most urging questions posed by local growers, commodity boards, State agencies, NGOs and private corporations are still mainly related to water use/loss of different agricultural landscapes. Our network of towers follows the water flow from northern California rice fields (that are increasingly being fallowed for water transfers) throughout the Delta and Central Valley and toward the southern part of the State (where transferred water is being used) for perennial crops. For better spatial measurements resolution, we are often using semi-direct ET measurements, derived as a residual of energy balance closure. In addition, alternative low-cost methods (such as the surface renewal) are actively being evaluated and we are refining different approaches for their independent use. We are especially excited to increase our extension and farm education to small growers that have been historically overlooked by cooperative extension and funding agencies.

Topic: Nature based climate solutions Poster 38

Julie Shahan

Title: Tracking Mangrove Restoration through Time: Baseline Soil CO_2 and CH_4 Emissions

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Mangrove forests provide numerous ecosystem services including carbon storage, yet over the past half century global mangrove forest cover has declined significantly due to anthropogenic activity. One of the main drivers of disturbance is the conversion of mangrove forests to aquaculture ponds, which can result in a significant loss of ecosystem carbon stocks and substantial emissions of carbon dioxide (CO_2) and methane (CH_4). Water pollution from urbanization and the introduction of exotic and invasive vegetation species can also result in changes to carbon emissions and storage. There is an increasing focus on mangrove restoration as a natural climate solution, as restoring these ecosystems from other land uses may mitigate carbon emissions and encourage carbon sequestration. However, the timescale and magnitude of changes in carbon cycling due to mangrove restoration is highly uncertain. To quantify these changes, we measured soil CO_2 and CH_4 emissions using flux chambers and soil carbon stocks at two disturbed mangrove sites in Ecuador before restoration activities take place. These sites are now undergoing vegetation and/or hydrologic restoration, allowing our measurements to act as a pre-restoration baseline. At a site in the Arenillas Ecological Reserve in the El Oro Province, we recorded measurements in intact mangroves, active shrimp aquaculture ponds, and an abandoned shrimp aquaculture pond. At Isla Santay in the Guayas Province, we recorded measurements in areas dominated by mostly mangroves and areas dominated by invasive species. This research will help to inform restoration efforts and the management of mangrove ecosystems by determining how anthropogenic disturbance and restoration impact the emissions and storage of carbon.

Topic: General Science Session Poster 39

Fa Li

FLUXNET-CH4 V2.0: expected improvement in spatial representativeness and temporal coverage compared to V1.0

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The FLUXNET-CH4 V1.0, encompassing 81 sites distributed globally, has significantly advanced research on methane (CH_4) cycling, including understanding the mechanisms and spatiotemporal patterns of CH_4 sinks and sources, machine learning upscaling, and benchmarking and refinement of bottom-up biogeochemical and top-down atmosphere inversion models. Here we propose the call to develop FLUXNET-CH4 V2.0, with longer time series observations and broader spatial coverage particularly over underrepresented areas such as the tropics. As an initial step towards our expected V2.0, we synthesized the basic site information (e.g., location and site year, not the fluxes) of over 200 sites, which include sites in FLUXNET-CH4 V1.0, new sites to be built, and existing sites which were not incorporated into V1.0. We mapped the spatial distribution and environmental conditions of these sites, and compared the spatial representativeness of V2.0 with V1.0 through principal component analyses along the major environmental and biological drivers of CH_4 emissions. We found that the V2.0 exhibited expected increase in the spatial representativeness relative to V1.0. To facilitate the inclusion of new CH_4 fluxes in FLUXNET-CH4 V2.0, either through the inclusion of new sites or additional years of observations for existing sites, we are organizing the collection and aggregation of global CH_4 flux data from the flux tower community. To better synthesize and process the data and understand and model the CH_4 dynamics, we have been closely working with representatives from regional flux networks and FLUXNET, and research groups and experienced modellers from across the world. Given the challenges and invaluable efforts for field measurements, multiple opportunities for co-authorship are expected for contributors to FLUXNET-CH4 V2.0. We envision that FLUXNET-CH4 V2.0 will continue to improve our understanding of global CH_4 dynamics through the collective efforts of the entire community.

Topic: Anthro-systems Poster 40

Michael Biedebach

Measuring ET in Commercial Lettuce Fields – Salinas Valley, CA

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Irrigated agriculture in Monterey County generated approximately $4.4 billion in 2023, with leaf and head lettuce accounting for $1.3 billion. Agricultural activity accounts for the largest share of groundwater withdrawals in the region by far. All sub-basins in the area are deemed medium or high priority by the Calif. Dept. of Water Resources following the Sustainable Groundwater Management Act, which mandates groundwater sustainability by 2040. Issues include transitory or chronic overdraft, seawater intrusion, and degraded water quality. Efficient irrigation management strategies offer an important pathway to sustainability while maintaining the region's agricultural productivity. Recent advancements and availability in satellite-derived evapotranspiration (ET), such as from OpenET, provide opportunities to guide irrigation and optimize on-farm water use efficiency. Quantifying associated accuracy and limitations is key to building trust and increasing operational adoption. Here, we evaluate the accuracy of OpenET for head lettuce in the Salinas Valley during the 2023 and 2024 growing seasons. We deployed open path eddy covariance (OPEC) systems in commercial fields to measure on-ground ET rates. We summarize accuracy metrics for both years during crop phases with distinct irrigation types: crop establishment with sprinkler irrigation, post-establishment with drip irrigation, as well as full crop cycle. The findings will be compared to prior accuracy metrics of OpenET across cropland sites throughout the country. We also address some of the unique challenges posed by OPEC data collection in this environment. We conclude by summarizing ongoing OPEC data collection efforts in the Salinas Valley to further quantify the consumptive water use for management of cool-season vegetable crops.

Topic: Nature based climate solutions

Poster 41

Katrina Poppe

Identifying patterns and predictors of methane fluxes across a bicoastal network of tidal marshes

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Tidal wetlands are considered relatively effective at sequestering CO2, but CH4 fluxes are more variable in these dynamic ecosystems subject to both regular and episodic variation in flooding, salinity, and nutrient levels. This variability, and a limited understanding of its biophysical drivers, is a key uncertainty in greenhouse gas inventories and carbon finance methodologies. Both would benefit from improved models of CH4 fluxes to better estimate CH4 fluxes at a variety of tidal sites. To address this need, we are synthesizing eddy covariance data from a network of seven tidal marsh sites on the east and west coasts of the United States and Canada. These sites span a wide range of salinity regimes, flooding frequencies, and nutrient exposure and feature a standardized set of ancillary variable measurements. Mean annual CH4 fluxes appear to align well with salinity regime as expected, but water level and soil temperature a not as singularly predictive of mean annual fluxes. We used machine learning methods such as random forest along with partial dependence plots to compare dominant controls of CH4 fluxes across sites, finding that soil temperature, salinity, and soil water content have similar influence across a few sites, but in general, variable importance and even the nature of the variable influence on CH4 are quite variable across sites, thus we are further investigating possible thresholds, interactions, and lead and lag times. We have also begun a more focused examination of the influence of tidal flooding in particular on CH4 fluxes at multiple timescales, with an analytical approach that includes wavelet decomposition, wavelet coherence, wavelet cross-correlation, and mutual information. With this last analysis we aim to identify the timing and magnitude of CH4 fluxes relative to regular and episodic flooding events, with preliminary results suggesting a possible suppression of CH4 emissions during flooding.

Topic: General Science Session Poster 42

Dani Trangmoe

A full-year analysis of carbon dynamics for a subarctic fen in Churchill, Manitoba.

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The Arctic is expected to have an outsized impact on the global carbon budget due to increased rates of warming and the storage of ancient carbon stocks in permafrost. Despite its importance, large regions of the Arctic are underrepresented in carbon budgets. This underrepresentation is even more pronounced during the 9-month long Arctic winter, where harsh conditions make data collection even more of a challenge. Our eddy covariance site, in a subarctic fen near Churchill, Manitoba (Site CA-CF3), was established to address these gaps. Net ecosystem exchange for both carbon dioxide and methane fluxes has been collected continuously beginning in October 2022 using the eddy covariance method. This site has been monitored previously using the eddy covariance method both in the 1990s and the late 2000s (Sites CA-CF1 and CA-CF2), however this is the first year-round collection of CO2 and methane data, providing the first complete annual CO2 and methane flux budget for this site. Our year-round data demonstrates how respiration of both CO2 and methane throughout the winter offset the productivity traditionally measured through the growing season. Previous analysis of this site has shown a peak in methane emissions during snowmelt unaccounted for by typical controls of methane emissions, and we investigate here if the same dynamic occurs in the respiration of CO2 during that period. Analysis of the CO2 respiration for this snowmelt period provides insight into the mechanisms behind the unique springtime carbon dynamics of Arctic ecosystems. Understanding these dynamics is critical to understanding how the Arctic contributes to the global carbon cycle and responds to the changing climate.

Topic: Remote Sensing Poster 43
Yeonuk Kim

Integrating emerging equilibrium theory into satellite-based evapotranspiration estimation for enhanced temporal upscaling

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Satellite-based estimation of evapotranspiration (ET) heavily relies on temporal upscaling methods, as remote sensing snapshots provide data only at specific points in time. Typically, mean ET values are estimated at daily, multi-day, or monthly intervals using a constant assumption for variables such as the evaporative fraction. This approach is especially critical for high-resolution ET estimation, where data are sparse due to the long intervals between satellite observations, such as the 8-day and 16-day intervals used by OpenET with Landsat imagery.
In this study, we propose a novel temporal upscaling approach by assuming a constant relative humidity flux across time scales, theoretically founded on the surface flux equilibrium model. We applied this approach to AmeriFlux in-situ data, encompassing a diverse range of climates and land cover types. Our comparison with several widely used upscaling methods demonstrates the proposed approach's promising accuracy, effectively integrating the emerging ET theory. Future work beyond this application using in-situ observations will focus on applying the approach to satellite remote sensing and gridded climate data to evaluate its practical applicability at varying spatio-temporal scales.

Topic: Anthro-systems Poster 44

Cheng Meng

Exponential or unimodal relationships between nighttime ecosystem respiration and temperature at the eddy covariance flux tower sites

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Ecosystem respiration is a key flux in the terrestrial carbon cycle and is affected substantially by temperature. This work analyzed time series data of nighttime net ecosystem exchange of carbon dioxide (NEEnight) from 196 FLUXNET2015 sites to re-evaluate the relationships between NEEnight and temperature. 93 sites (48%) were identified to have a unimodal relationship between NEEnight and temperature. Site-specific apparent optimum temperature parameters were then estimated at these sites. We further assessed the impacts of using exponential or unimodal equations on NEEnight predictions. The predicted NEEnight at high temperatures were substantially higher from the exponential-type equations (mean: ~200%) than from the unimodal equation (mean: ~30%), compared to the observed NEEnight. This study calls for using a unimodal equation to predict NEEnight (often considered as nighttime ecosystem respiration, ERnight), which could substantially improve the accuracy and reduce uncertainty in ER estimates, in particular under the scenario of global warming.

Topic: General Science Session Poster 45

Cove Sturtevant

Common quality issues in NEON flux and meteorological data

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Every flux tower operator deals with a host of challenges that impact data quality. Nearly everything that can go wrong will go wrong over many years of continuous operation. Problems include instrument and infrastructure malfunctions, environmental fouling and degradation, and operator and algorithmic errors, to name just a few. A rigorous and comprehensive quality assurance and control program can greatly reduce but never eliminate bad data, making manual review a vital component of quality control. The National Ecological Observatory Network operates 47 flux tower sites across a wide range of ecosystems in the United States, including Alaska, Hawaii, and Puerto Rico. All 47 tower sites are part of the AmeriFlux network and have 5+ years of data available for download from the AmeriFlux portal, including a large suite of meteorological and soil measurements. Data undergo thorough manual review prior to submission, in addition to automated quality control procedures implemented by both NEON and AmeriFlux. Even then, the immense volume of flux tower data is a challenge in itself, and a small amount of bad data can remain in published datasets. In this presentation, we share common quality issues observed during the manual review process, along with steps being taken to reduce them. We cover issues such as leaks in closed path gas analyzer tubing, timestamp drifts, spikes in soil moisture readings, and tipping bucket blockages, among others. We share this “dirty laundry” to create user awareness of common issues, as well as facilitate discussion and feedback about quality control for new and experienced tower operators alike.

Topic: Remote Sensing Poster 46

Erika Gallo

Variability of Ecosystem Productivity Responses to the 21st Century Megadrought.

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In the last decades, large portions of the western U.S. have experienced one of the most severe drought periods observed in the last two millennia. Because this region is largely comprised of drylands (> 75%), it is critical to identify how the megadrought has altered dryland ecosystem functioning given the role of vegetation in regulating land-atmosphere exchanges of water and carbon over large spatiotemporal scales. In this study we couple gross ecosystem production (GEP) observations from 25 eddy covariance flux towers with satellite greenness and climate data to identify how the 21st century megadrought has altered ecosystem productivity across a dryland vegetation, temperature and precipitation gradient. We find that increases in mean annual temperature and VPD, and decreases in precipitation vary regionally. Ecosystem responses to the megadrought across sites are highly variable. Productivity increased in the low elevation Sonoran Desert ecosystems of southern Arizona and the sagebrush shrublands of Idaho; while productivity decreased at the high elevation, southern forests of Arizona and New Mexico. There are strong short-term (< 12 months) linkages between climate and productivity at grasslands and shrublands, and longer terms linkages in woodlands and forests regardless of their geographic location. Overall, the 20th century megadrought has had highly variable but limited impacts on Western U.S. dryland ecosystem productivity owing to the short-term linkage in productivity of many vegetation types with antecedent climate due to limited soil water storage and low precipitation amounts. Our results indicate that particular attention in management and conservation should be focused on southern latitude evergreen forests, which have been the most negatively impacted by the 21st Century megadrought.

Topic: Network optimization and holistic approach to ecosystems Poster 47
Dario Papale

Cooperation and common activities in monitoring networks: the status of the European Research Infrastructures and the Italian test case in ITINERIS

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Environmental monitoring through long term and standardized observations is becoming more and more important to evaluate the response of environment to anthropogenic pressures. In Europe there are more than 25 Research Infrastructures (RIs) in the environmental domain (ENVRI) that cover the Atmosphere, Marine, Terrestrial biosphere and Geological domains. These RIs have inevitably overlaps in the observed phenomena and variables and often common and shared observation sites and facilities. The coordination of the activities, starting from a common data discover and access system and the identification of specialized and possibly shared services (e.g. for data processing or communication) are key to ensure the best possible use of resources and maximize impacts toward the users.
The Italian Integrated Environmental Research Infrastructures System (ITINERIS) is a large national initiative where 22 RIs are developing common strategies and tools needed to move in the direction of an integrated system of RIs, able to provide in an easy and direct way critical environmental data and information. The multi-disciplinary competences available in the different RIs help to design and prototype new collaborations and services that are crucial also to ensure the RIs long term sustainability and impact. The collaboration scheme under development in ITINERIS will be evaluated for an application at European level and could be also adapted for an implementation in other continents with multiple, partially overlapping, environmental networks (e.g. AmeriFlux, NEON, LTER, LTAR, Critical Zones). In the presentation the overall idea and strategy and the critical aspects and solutions found to overcome political, technical and scientific obstacles will be discussed, highlighting the first results obtained and the possible use of results in the American context and in the collaboration between AmeriFlux and ICOS.

Topic: Nature based climate solutions Poster 48

Kyle Delwiche

High interannual variability of methane emissions following wetland restoration highlights need for long-term monitoring

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The Sacramento/San Joaquin Delta, a complex ecosystem of farmland, canals, and wetlands in California's Central Valley, has largely subsided below sea level. Due to the need to protect habitats, address climate change, and secure water resources, there has been an increase in wetland restoration projects in the Delta. The Biomet lab at UC Berkeley, led by Dennis Baldocchi, has measured ecosystem gas and energy fluxes at Delta wetlands for over a decade, collecting some of the longest methane eddy covariance records in the world.

These long data records provide unparalleled insights into the evolution of restored wetland methane flux, particularly at Mayberry wetland, which has been continuously monitored since restoration in 2011. In this study we examine variability and long-term dynamics in methane flux from Mayberry, and characterize the impact this has on the radiative forcing assessment for the wetland. We also use porewater chemistry and isotopic analysis to assess causes of interannual variability in Mayberry methane flux.

Topic: General Science Session Poster 49

Rafael Stern

Measuring ecosystem methane fluxes in different parts of the South American Amazon tropical rainforest

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Multi-annual and continuous eddy covariance measurements of CH_4 fluxes are ideal for estimating ecosystem-scale CH_4 emissions, but currently unevenly represented globally and particularly rare in tropical regions - which are responsible for about half of the global wetlands emissions, but still poorly understood. A large discrepancy between bottom-up (flux measurements and process-based models) and top-down (satellites and inversion models) approaches suggests that we still lack the right parameters or predictors to model CH_4 emissions in tropical wetlands. Many tropical ecosystems have high seasonal variability in precipitation, and therefore long-term and continuous data and synthesis work is needed to establish key controls to allow accurate upscaling of CH_4 emissions and to help reduce uncertainties in the global CH_4 budget.

We are currently establishing a tropical CH_4 flux network as part of the FLUXNET-CH4 V2.0 to collect and quantify CH_4 emissions and predictor variables (e.g., temperature and inundation) at global tropical regions. Here, we mainly focus on some South American towers: 1) upland (terrafirme) rainforest in French Guiana (“GuyaFlux”, Eastern Amazon), 2) seasonally flooded forest - varzea - (Mamiraua Reserve, Brazil, Central Amazon), 3) and various forest and wetland sites along a gradient of precipitation seasonality from no dry season to a short dry season (“AndesFlux”, Peru, Western Amazon). At each site, we are working with local scientists and universities. Initial results from the upland ecosystem in Western Amazon (Peru - Tambopata) showed that the ecosystem acted as an overall source of CH_4 to the atmosphere during the wet season, while in French Guyana the ecosystem shifts from a small sink (dry season) to a small source of CH_4 (wetter season), where the fluxes are more determined by soil water content than by temperature.Construction of the tower in the Central Amazon (Brazil) will begin in fall 2024.

Virtual-only posters

Topic: Anthro-systems Poster 50

Reem Hannun

Dry Deposition of Ozone to a Maize Crop Canopy – Implications for Crop Ozone Response and Productivity

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Tropospheric ozone (O3) is a greenhouse gas and phytotoxic air pollutant that can weaken vegetation carbon assimilation, with cascading impacts on the global carbon and water cycles. Although the dry deposition of O3 to the land surface constitutes a substantial sink of tropospheric O3, uptake into leaf stomata creates oxidative stress, reducing the yields of major agricultural crops and posing a threat to food security. A mechanistic understanding of the coupling between O3 air pollution and crop response is needed, as O3 uptake does not always coincide with exposure. However, direct measurements of O3 deposition over crop fields are extremely sparse. Here, we will present eddy covariance fluxes of O3 monitored over a maize (Zea mays) field in central Illinois during the 2023 growing season. We partition the total O3 flux into stomatal and non-stomatal components using site meteorology and fluxes of carbon dioxide and water vapor and discuss how crop physiological activity impacts stomatal O3 uptake. Our results highlight the importance of such observations for testing O3 dry deposition schemes in models and motivates the need for more sustained monitoring of O3 fluxes over agricultural sites.

Topic: General Science Session Poster 51

Ignacio Aguirre

Quantifying and disentangling the variance of different evapotranspiration modeling decisions over 140 flux towers

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To compute water fluxes (e.g., runoff and evapotranspiration) and states (e.g., soil moisture) for current and future conditions, many studies use Earth System Models driven by meteorological forcing data. Global and local policy-oriented assessments, such as the IPCC, rely significantly on results from these simulations. However, in these models, the measurements, parametric, and structural uncertainties can be substantial, hindering the predictions of the models and reducing their reliability. Structural uncertainty has received comparatively limited attention but is increasingly being recognized as the major contributor of uncertainty. For example, it explains between 50 to 70% of evapotranspiration uncertainty in the CMIP6 results. It is challenging and a community-wide goal to narrow these uncertainties.

In our study, we aim to measure how various model structure decisions (i.e., parametrizations) affect the spread and variance of evapotranspiration simulations. To achieve this, we utilized the SUMMA framework and data from 140 flux stations and the AmeriFlux Network as part of the Plumber 2 experiment. Within SUMMA, we used all permutations of three different parametrizations for stomatal resistance, three for soil stress function, and two for canopy interception. Results show that stomatal resistance decisions have the largest impact contributing to the variance, followed by soil stress function and interception decisions. We have identified that several ensemble members had transpiration ratios outside of the expected values or deviated significantly from the observed data on the Budyko curve, raising doubts about the realism of these particular simulations. In general, ensemble members with Ball-Berry or Jarvis as stomatal resistance decisions matched closely to observations.

Our results highlight the need to assess different modeling decisions while running from point-scale to large-domain assessments, especially in the current context of climate change, where accurate and faithful predictions are urgently needed to inform stakeholders, politicians, and the entire global community.

Topic: Remote Sensing Poster 52

Jack Hastings

Continuous canopy temperature monitoring to improve our understanding of forest ecosystem processes

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The past year has seen the record for the highest global average temperature ever documented be broken multiple times. Such inauspicious milestones in the Earth's climate history underscore the need to understand how terrestrial ecosystems are responding to a warming world. In forest ecosystems, temperature exerts a strong influence over the metabolic processes controlling net ecosystem exchange. Typically, to study the influence of temperature over these dynamics, flux analyses rely on air temperature (Tair) measurements, or canopy temperature (Tcan) estimates from net radiometers or satellite remote sensing. However, each of these methods is limited in its own way; for example, Tcan may either exceed Tair because of warming from incident radiation or be lower than Tair due to transpirational cooling. Furthermore, Tcan can vary significantly among cooccurring species due to differences in stomatal regulation and canopy temperature. To improve our understanding of temperature over forest canopy processes, we recently installed a thermal infrared camera (TIR) at Thompson Farm Observatory (Ameriflux site US-TFF), Durham, NH in early 2024. The camera is continuously monitoring canopy temperature of four dominant tree species within the camera's field of view. Additionally, we are conducting thermal UAV flights on multiple days across the growing season to scale tower-mounted TIR measurements across the flux tower footprint. Tower- and UAV-based measurements will be combined with existing leaf physiological, optical, and chemical trait and UAV lidar and hyperspectral data previously acquired at Thompson Farm Observatory to understand linkages between canopy architecture and leaf temperature, and their impact on stand-level carbon and water fluxes. Here, we present preliminary results of this effort and discuss future directions in the northeastern United States.

Topic: Anthro-systems Poster 53

Mohan KC

Importance of Grazing Timing on Net CO_2 uptake depends on Season in Intensively Managed Temperate Pastures

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New Zealand is a leading global milk producer, with dairy farming being crucial to its economy while also significantly contributing to the nation's greenhouse gas (GHG) emissions. Agricultural emissions account for nearly half of New Zealand's net emissions, with dairy farming responsible for almost 25% of the total. Reducing GHG emissions from managed grasslands presents a promising approach to mitigating climate change. New Zealand's rotational grazing system involves moving dairy cows between paddocks typically 10 to 12 times annually. Each grazing event is generally short, followed by a longer recovery period.

Our study aimed to determine how grazing management practices altered net CO_2 uptake, focusing on carbon capture opportunities depended on grazing timing (i.e. length of recovery period). An eddy covariance system, established to quantify the carbon balance of dairy pastures and located between the paddocks measured CO_2 exchange (net ecosystem production; NEP) data over eight years (2012-2019). Net CO_2 uptake during immediate pre- and post-grazing periods was highest from early spring to early summer (September to December) and lowest from late summer to mid-winter (February to July). The difference in NEP between pre- and post-grazing followed a similar pattern, being greatest in mid-spring to early summer and lowest from late summer to mid-winter.

Our data suggested that manipulating grazing timing by lengthening the recovery period by a few days during periods of greatest uptake (mid-spring to early summer) enhanced total net CO_2 uptake compared to other times of the year with lower uptake (late summer to mid-winter). Peak growth periods between mid-spring and early summer offer a potential opportunity to increase net CO_2 uptake and total carbon storage, if this can be managed within current farming practices without reducing profitability.

Topic: Flux science Outreach Poster 54

Carlos Román-Cascón

The FLUXNET outreach working group: communicating flux science to society

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FLUXNET is an international initiative that joins regional networks of scientists working with eddy covariance (EC) systems around the world. In this context, the FLUXNET outreach committee formed in 2022 with the goal of sharing flux science and research findings beyond the typical research community. The overall objective of this committee is to develop new ways of communicating complex science and disseminating these ideas to broad audiences outside the typical domain of research. The intent is to create new links between flux science professions to other interdisciplinary scientists, resource conservation professionals, policymakers, and society in general.

Over the last year, committee members have worked on several projects to achieve these objectives. In this work, we show some of these initiatives developed in 2023, and other initiatives being carried out in 2024. The Fluxnet Coop and the National Science Foundation are supporting an artist residency program at flux measurement sites to create new interpretations of located based science conducted at flux measurement sites. Committee members are developing plain language materials to explain technical documentation of flux measurement and contributing to the translation of existing materials in English into several other languages. The committee is also working to produce a podcast and open-access publications that serve as a bridge between peer reviewed science and accessible plain-language reporting. With this presentation, we will open discussion with the audience to help us improve our methods and suggest new projects and explore other initiatives that share similar objectives. Our activities are initial steps toward creating a more convergent global flux science community and well-informed society.

Topic: Anthro-systems Poster 55

Nahuel Bautista

Effect of precipitation on CO_2 concentrations and fluxes in Argentinean environments

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In recent years, it has been found that unfair weather events modify the exchanges of carbon dioxide (CO_2) between terrestrial ecosystems and the atmosphere. In Argentinean Pampas, around 40% of CO_2 emissions come from agricultural activities. In addition, it has a high synoptic variability with numerous frontal passages and large mesoscale systems that produce intense precipitation. For these reasons, the objective of this work is to quantify the magnitude of the changes introduced by frontal and precipitating systems in the CO_2 concentrations and fluxes of the Argentinean Pampas. CO_2 concentrations and fluxes were measured using the Eddy Covariance technique during 10 field campaigns performed on different types of ecosystems between May 2018 and May 2019. We calculated the differences in the mean values of CO_2 concentrations and fluxes between the day after and before each fair or unfair weather event. Then, we compared the distributions of both categories and we evaluated their differences using mean tests. As a result, we found that unfair weather events increased atmospheric CO_2 concentrations and sequestration in 10 sites of the Argentinean Pampas by ~15 ppm and ~1 µmol m-2 s-1, respectively, depending on the site. The values are consistent with horizontal advective processes and the CO_2 surface concentrations from other parts of the country. These results allow a better quantification of the CO_2 flux during these events, a key factor in improving the reliability of regional CO_2 balances and the possible consequences of climate change.

Topic: Anthro-systems Poster 56

Natalia Tonti

Net Ecosystem Production for an alfalfa crop under grazing in Castelli, Buenos Aires Province, Argentina

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Mitigation activities in the context of efforts to reduce the effects of climate change are altering trade conditions worldwide. Currently, for agricultural activities, demonstrating carbon neutrality is beneficial for exports, which will be achieved by modifying their production management practices. Among these activities, dairy cattle production is one of the most important agricultural activities in Argentina. Based on this fact, since August 2023 we are carrying out a micrometeorological field campaign on an intensive alfalfa production site intended for grazing by high-production dairy herds in the vicinity of Castelli, in Buenos Aires province, Argentina. The aim of this study is to present the initial results of this site analyzing the observed sequestration rate using the Eddy Covariance technique over the first year of observations. Additionally the study quantifies the potential contribution of crops intended for grazing to the carbon footprint associated with milk production. The raw data were processed using TK3 software and for the gap filling and flux partitioning ReddyProc R Package was used. It was found that the net ecosystem production from August 2023 to July 2024 was -45.85 kg ha-1 yr-1. These results aim to improve the information regarding the carbon fluxes of the main productive areas of Argentina. Previous results have shown significant differences compared to similar ecosystems in the Northern Hemisphere, so we believe that the inclusion of this new site in the AmeriFlux database will be beneficial for many researchers in the community.

Topic: Remote Sensing Poster 57

María Gassmann

Modelling 10-years of CO2 fluxes in southern South America

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The Vegetation Photosynthesis and Respiration Model (VPRM) simulates photosynthesis and ecosystem respiration processes using data from meteorological and satellite models. Since ecosystem exchanges vary by biome, calibrating the VPRM model with Eddy Covariance (EC) measurements is essential. This study aims to calibrate, implement, and run the VPRM model in conjunction with the Weather Research and Forecasting (WRF) meteorological model to estimate CO_2 fluxes across biomes in the core productive region of Argentina (between 22° and 41°S, 65° and 53°W). We analyzed EC measurement sites within the study region, which includes both natural and anthropogenically influenced environments. Net Ecosystem Exchange (NEE) half-hourly time-series were used for model calibration or evaluation. We also identified the best WRF schemes for providing optimal input variables for VPRM simulations. The combined WRF-VPRM model was run to perform independent 24-hour simulations of atmospheric CO_2 fluxes for every day from 2010 to 2019. The WRF-VPRM model successfully reproduced NEE on daily, monthly, and annual scales at the evaluation sites. However, limitations related to the representation of bi-annual crop cycles were identified. In the core productive area, dominated by crops and pastures, there is significant CO_2 uptake during the summer, followed by sustained emission throughout the rest of the year. NEE estimates are primarily influenced by soil water availability and air temperature variability, resulting in notable variations in atmospheric carbon dioxide balance across different years. The estimates indicate that the study area has acted as a net CO_2 sink, with an average value of -1.51 g CO_2 m^{-2} day^{-1} over the study period. These findings enhance our understanding of the atmospheric CO_2 balance through region's ecosystems and provide a foundation for future studies on the environmental conditions affecting CO_2 exchanges in southern South American biomes.

Topic: General Science Session Poster 58

Lucia Curto

Turbulent transport of CO_2 by coherent structures in the atmospheric surface layer

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Coherent structures are organized entities that contribute significantly to turbulent fluxes in the Atmospheric Boundary Layer. One of the fluxes involved is carbon dioxide, which is particularly important for its implication in global warming and climate change. In this work we study the turbulent transport of CO_2 by coherent structures. Micrometeorological observations were measured in a 30-ha soybean productive plot in central Argentina. Carbon fluxes, its standard deviations and stability conditions were obtained at 30-min intervals. A quality control test for turbulence was performed using the TK3 software. During daytime conditions turbulent fluxes show negative values due to the surface acting as a sink of carbon, associated with plant photosynthesis. During nighttime conditions fluxes present maximum positive values as the vegetated surface acts as a source of carbon due to plant respiration. When classified according to stability conditions, neutral situations represented the majority (34%), while unstable situations were 31%, stable situations 16%, strongly unstable were 14%, and strongly stable were only 5% of cases. The efficiency of turbulent transport, defined as the correlation of vertical velocity and carbon dioxide concentration, shows higher values for strongly unstable and unstable situations, with medians of 0.46 and 0.39 respectively. Efficiency decreases as atmospheric stability approaches neutrality, with a median of 0.27. In stable situations efficiency for CO_2 turbulent transport is lower, with medians of 0.23 for stable cases and 0.18 for strong stable cases. For unstable situations 'thermal plumes' develop, enabling substantial turbulent transport of scalars, particularly CO_2. As stability transitions to neutral, 'hairpin vortices,' which are more associated with wind shear, emerge, leading to less effective turbulent transport of CO_2. Additionally, stable cases are less common because turbulence is less developed under these stability conditions, and micrometeorological data does not reach the necessary quality control requirements.

Topic: General Science Session Poster 59

Lucia Curto

Eigenvalues analysis for detecting coherent structures in the atmospheric surface layer

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Turbulence in the Atmospheric Boundary Layer organizes in coherent structures that significantly contributes to the vertical diffusion of momentum, temperature, humidity, carbon dioxide, and other gases. The presence of these structures and their contributions to vertical turbulent transport from micrometeorological data are commonly studied through different methodologies, such as Quadrant and Wavelet Analysis. For the analysis there were used statistics from micrometeorological data were obtained at 30-min intervals for different stability regimes: near-neutral, unstable and strongly unstable conditions, based on observations from various vegetated surfaces in Central Argentina.We here implemented eigenvalue analysis to identify coherent structures that transport temperature and momentum. Vertical turbulent transport defines a two-dimension space, allowing for the calculations of two eigenvalues for each turbulent transport. As turbulence becomes more organized, a greatest portion of the variance is explained by the first eigenvalue. The ratio of eigenvalues ($\lambda1/\lambda2$) was calculated to indicate the presence of coherent structures. Ratios are higher when coherent structures are present than when they are absent. The minimum median value of the ratio was chosen as the cut-off value to distinguish the presence or absence of coherent structures. The resulting value is 1.59 for momentum, and 2.02 for temperature turbulent transport. The accuracy of the method ranges between 70 and 80%, and improves up to 85% when cases are classified according to stability. Structures that transport significant momentum are better identified in near-neutral and unstable situations, while those that transport temperature are better identified in unstable and strongly unstable situations. The eigenvalue is a fast and computationally efficient method that has proven effective in identifying the presence of coherent structures that organize turbulence. Its effectiveness improves when considering different stability regimes.

Topic: General Science Session Poster 60

Tyler Roman

Comparison of Carbon and energy fluxes from natural and degraded mountain peatlands in Colombia

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Tropical peatlands are one of the largest sources of atmospheric methane (CH4) and play an important role in both regional and global carbon budgets. Additionally, South America contains the largest area of tropical peatlands, which represent 46% of the global tropical peatland area, with peatlands present in both lowland and mountain areas. Historically, mountain peatlands in the Andes were often drained and disturbed to be used for cattle grazing or agricultural purposes. This has led to large amounts of the natural peatlands in the Andes having been altered and impacted by mankind. The effects of these disturbances are not well understood in terms of their impact on peatland hydrology, as well as C and biogeochemical cycling. Here, we present preliminary findings from a study that is comparing these aspects within a paired natural and degraded peatland in Colombia. Monitoring at the site has been ongoing since 2022 with regular measurements of fluxes with manual chambers, as well as continuous measurements of meteorological variables and fluxes with Eddy Covariance instrumentation. Results indicate that both natural and degraded sites are sources of C with respect to both Carbon dioxide and CH4 at annual scales. However, differences exist in ecosystem response to environmental variables between sites, with a noted difference in the hydrology of the sites due to the presence of ditches at the degraded site. These results will establish baseline conditions which will then be used as a reference for post restoration conditions, with the restoration planned for fall 2024.

Topic: Remote Sensing Poster 61

Li Pan

Interannual variations and trends of gross primary production and transpiration of four mature deciduous broadleaf forest sites during 2000–2020

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The interannual variations of gross primary production (GPP) and transpiration (T) in deciduous broadleaf forests reflect how the forest responds to climate change. However, our knowledge remains limited due to lack of multi-decadal data. In this study, we selected four mature deciduous broadleaf forest sites in the United States of America and Canada from 2000 to 2020 to investigate decadal trends in atmospheric CO2 concentrations, climate, vegetation indices, phenology, and carbon and water fluxes. The Vegetation Photosynthesis Model (VPM v3.0) and the Vegetation Transpiration Model (VTM, v2.0) were used to estimate GPP and T at the four sites. The GPP from the VPM simulations (GPPVPM) is highly consistent with that from the eddy flux tower sites (GPPEC) (R2 range from 0.77 to 0.89). The interannual trends of carbon and water fluxes during the period from 2000 to 2020 varied by sites, ranging from increases (CA-Cbo) to no trend (US-Ha1, US-MMs, US-WCr sites), dependent upon the temporal changes in atmospheric CO2 concentration and climate. Spring phenology at these sites had no significant trends due to the lack of an interannual trend of air temperature during 2000–2020. In those years with hotter winter and early spring season (WESS), the start of the season (SOS) advanced and the growing season length (GSL) extended, but there were little changes in the end of the season (EOS) and annual GPP. This study highlights the value of long-term measurements at forest eddy flux tower sites and the skill of VPM v3.0 and VTM v2.0 models and the ERA5 climate dataset for simulations over the past two decades, which could be used to do regional and global simulations of deciduous broadleaf forests and assess their responses to climate change.

Topic: Anthro-systems Poster 62

George Valentine

First-principles verification of CO_2 origin for flux calculations in an urban-exurban interface

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The flux tower at Manitou Experimental Forest in Teller County, CO was reinstalled under new management in early 2024 after a 16-year hiatus of data collection. The 30 m tower is located in a Ponderosa savannah at 2376 m elevation in a broad, flat valley. Flux data demonstrated a strong diel pattern in CO2 readings, with nighttime readings elevated by an average of 14 ppm over daytime readings. The spikes coincide with a diel shift in wind patterns as cool air drains out of the where the tower is located. This pattern was not present in historical data, suggesting that either new equipment on the tower or anthropogenic CO2 from new development in nearby Woodland Park, CO may be responsible. We deployed a ringdown cavity spectrometer to analyze the isotopic ratio of CO2 at the flux site to determine if the nightly spikes in CO2 were anthropogenic in origin. The Suess Effect states that emissions from fossil fuels are depleted in 13C relative to the atmosphere, so anthropogenic CO2 will have a lower proportion of 13C, or δ13C.Nighttime CO2 measured on the flux tower matched readings from the spectrometer, indicating that the diel spikes were a true pattern. Nighttime δ13C of CO2 was significantly lower than daytime δ13C of CO2, suggesting that nighttime CO2 sources were primarily human in origin and that the diel spike in CO2 was also attributable to anthropogenic emissions. By identifying diel changes in isotopic makeup, flux calculations can be made to partition natural and anthropogenic signals. These isotopic observations offer a rare chance to decouple natural and anthropogenic CO2 sources and better understand ecosystem processes in anthro-systems.

Topic: Remote Sensing Poster 63

Paul Seibert

Capturing photosynthesis with a solar-induced fluorescence imager; highlights from a 2-year campaign in Point Reyes, CA

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When plants receive sunlight, a small fraction (~0-3%) of photons are re-emitted back into the atmosphere as solar-induced chlorophyll fluorescence (SIF). SIF is a complex biophysical phenomenon that provides a snapshot of the activity of chlorophyll molecules that is often used as a proxy for gross primary productivity.

Recent advances in remote sensing technology have allowed observation of SIF at both the flux tower footprint and regional scale. Although it is relatively common to install spectrometers on towers for long-term SIF measurements, few have explored the use of hyperspectral imagers to measure SIF in the field. While tower-mounted spectrometers measure SIF over a limited area dictated by the footprint of the sensor to generate a time series, imagers are capable of capturing high spatial resolution images of SIF and more conventional vegetative indices such as the normalized difference vegetative index (NDVI) and near-infrared vegetative radiance (NIRvR). With the recent push for proximal remote sensing, imagers may be able to reveal spatial heterogeneity across landscapes that is lost within the scope of conventional field spectrometers.

The Headwall SIF imager (Headwall Photonics, Bolton, MA, USA) is an off the shelf hyperspectral imager capable of providing these images. The instrument contains 1600 spatial and 2400 spectral bands, measuring radiance between 670-780 nm and allowing SIF retrieval within highly resolved Fraunhofer lines (both O2-A and O2-B). Over the past three years, over 250 images have been taken at a coastal grassland in Point Reyes California. Here, we highlight the capabilities of the imager through a field demonstration video, images taken at a coastal grassland over the course of two growing seasons and bringing the imager itself to the AmeriFlux meeting. We observe significant seasonal and diurnal differences in SIF across two hydrologically distinct zones of our field site, that do not necessarily track with photosynthetically active radiation.

Topic: General Science Session Poster 64

Abhijith Raj

Turbulent Characteristics of Momentum Flux in the Marine Boundary Layer of North Bay of Bengal

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Wind-and-wave interactions, particularly the turbulence within the marine atmospheric boundary layer, is a key component of air-sea momentum, heat, and gas fluxes. Accurate estimation of these exchange processes is essential for numerical weather prediction models on both synoptic and climate scales (e.g., Shimura et al., 2017). Over 16 months from 2019-2020, we collected high-frequency eddy-covariance data from a moored buoy in the Bay of Bengal. This dataset allowed us to estimate heat and momentum fluxes using three methodologies: 1)Eddy Covariance: The most direct and defensible approach, 2) Bulk Methods: Utilizing the widely adopted parameterization scheme based on Monin-Obukhov similarity theory, 3)Inertial Dissipation Method: Employing spectral characteristics from the inertial subrange and Kolmogorov similarity theory. Our study focused on wind stress, or momentum exchange, at the air-sea boundary. We found that flux estimates derived from the eddy covariance method were superior due to its direct measurement approach. Existing parameterizations exhibited significant deviations, particularly under light wind conditions. This scatter and deviation is attributed to the wave effect on stress, which is unique to the marine boundary layer. Here, momentum transport from the ocean to the atmosphere cannot be accurately parameterized using current assumptions, as under such conditions, the validity of the Monin-Obukhov similarity theory is questionable. The classical turbulent kinetic energy balance of production and dissipation also tends to not work under this wave boundary layer. The inertial dissipation estimate of momentum fluxes thus requires the imbalance term arising from transport terms. Additionally, we observed that the wind stress vector over the ocean surface is frequently misaligned with the wind direction which might be another adding factor to the challenges in parameterizations.