Abstract Book

Land-Atmosphere Interactions 2021 Workshop

June 10-21, 2021

Organizing committee: Andrew Richardson, Eric Beamesderfer, Celia Faiola, Manuel Helbig, Zulia Mayari Sanchez Mejia, Ana Maria Yañez Serrano, and Yunyan Zhang

This workshop is organized in connection with the AmeriFlux "Year of Water Fluxes," and with support from the AmeriFlux Management Project and the Department of Energy's Office of Science and in collaboration with community representation from the U.S. Department of Energy's ARM User Facility, and ASR and ESS programs.

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Abstract number: P1

Viscosity and liquid–liquid phase separation in healthy and stressed plant SOA

Natalie R. Smith, Giuseppe V. Crescenzo, Yuanzhou Huang, Anusha P.S. Hettiyadura, Kyla Siemens, Ying Li, Celia L. Faiola, Alexander Laskin, Manabu Shiraiwa, Allan K. Bertram, Sergey A. Nizkorodov

Abstract:
Molecular composition, viscosity, and liquid-liquid phase separation (LLPS) were investigated for secondary organic aerosol (SOA) derived from synthetic mixtures of volatile organic compounds (VOC) representing emission profiles for Scots pine trees under healthy and aphid-herbivory stress conditions. Model "healthy plant SOA" and "stressed plant SOA" were generated in a 5 m3 environmental chamber by photooxidation of the mixtures at 50% relative humidity (RH). The stressed plant SOA had increased abundance of higher molecular weight species, reflecting greater fraction of sesquiterpenes relative to monoterpenes in the stressed VOC mixture. LLPS occurred in both the healthy and stressed plant SOA; however, stressed plant SOA exhibited phase separation over a broader humidity range than healthy plant SOA, with LLPS persisting down to 23 ± 11 % RH. At RH ≤ 25 %, both stressed and healthy plant SOA viscosity exceeded 10^8 Pa s, value similar to tar pitch. At 35% and 50% RH, stressed plant SOA had the highest viscosity, followed by healthy plant SOA and then α-pinene SOA in descending order. The observed peak abundances in the mass spectra were also used to estimate the SOA viscosity as a function of RH and volatility. The predicted viscosity of the healthy plant SOA was lower than that of the stressed plant SOA driven by both the higher glass transition temperatures and lower hygroscopicity of the organic molecules making up stressed plant SOA. These findings suggest that plant stress influences the physicochemical properties of biogenic SOA. Furthermore, a complex mixture of VOCs resulted in a higher SOA viscosity compared to SOA generated from α-pinene alone at ≥ 25 % RH, highlighting the importance of studying properties of SOA generated from more realistic multi-component VOC mixtures.

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Theme area:
Aerosols

Abstract number: P2

Dynamics of volatile organic compounds in a western Mediterranean oak forest

Ana Maria Yáñez-Serrano, Albert Bach, David Bartolomé-Català, Vasileios Matthaios, Roger Seco, Joan Llusia, Iolanda Filella and Josep Peñuelas

Abstract:
Volatile organic compounds (VOCs) are emitted from many sources and have important implications for plant fitness, ecological interactions, and atmospheric processes, including photochemistry and ozone formation. Forest ecosystems are strong sources of biogenic VOCs. We aimed to characterize forest below-canopy VOC mixing ratios, monitored by Proton Transfer Reaction Mass Spectrometry (PTR-MS), at Montseny Natural Park, 50 km from the Barcelona urban area every two minutes during six months around the maximum emission period of summer. All VOCs had diel cycles with higher mixing ratios during the day, but different patterns over time. Monitored VOCs were grouped as biogenic, oxygenated, or aromatic compounds. Additionally, a positive matrix factorisation analysis identified four emission profiles that were attributed to photochemical VOC production, biogenic emissions, mixed VOC emission sources, and traffic emissions. Even though the biogenic source was the strongest source profile at the site, we found a strong influence of anthropogenic air masses infiltrating the forest canopy and altering the biogenic air masses at the site.

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Theme area:
Atmospheric chemistry

Abstract number: P3

Forest-Atmosphere Exchange of Ozone and Reactive Carbon Over a Mixed Temperate Forest in Northern Wisconsin

Michael Vermeuel, Jonathan Thom, Patricia Cleary, Ankur Desai, Timothy Bertram

Abstract:
The exchange of trace gases between the biosphere and the atmosphere is an important process that controls both chemical and physical properties of the atmosphere with implications for air quality and climate change. The terrestrial biosphere is a major sink of ozone (O3) through dry deposition by stomatal uptake and nonstomatal processes and is a source of reactive carbon in the form of biogenic volatile organic compounds (BVOC) that can govern atmospheric concentrations of oxidants. Over forests, the net surface-atmosphere exchange of O3 and BVOC depends on the unique physical properties of individual compounds as well as the mean physical conditions of the forest canopy (e.g. temperature, sunlight, leaf area) that control surface emissions and loss processes (e.g. uptake to stomata, surface adhesion). To date, there are few eddy covariance studies of O3 and BVOC in mixed temperate forests, limiting the ability to predict net sources and sinks of trace gases over heterogeneous terrain. Here, we present two eddy covariance studies at a mixed temperate forest in Park Falls, WI over two consecutive summers. One study focused on O3 and HCOOH flux (July 2019) and the other on BVOC flux (September 2020) during the summer to autumn transition. The July 2019 study revealed a missing nonstomatal fraction of O3 deposition ranging between 10-90% of the total deposition for a given hour. HCOOH fluxes were correlated with nonstomatal O3 deposition, suggesting fast in-canopy ozonolysis of terpenes. The September 2020 study provided a thorough description of BVOC species at the site and revealed that emissions and concentration of monoterpenes (MT; C10H16) and a monoterpene oxide (C10H16O) were enhanced during leaf senescence. The magnitude of sesquiterpene flux/concentrations suggest in-canopy oxidative loss prior to detection. Both studies report the flux of reactive species in a mixed temperate forest as well as evidence for in-canopy oxidation modulating observed fluxes.

Presented by:
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Theme area:
Atmospheric chemistry

Abstract number: P4

Large Eddy Simulation Coupled to a Multilayer Forest Canopy Model and Ambient Chemistry

Olivia E. Clifton, Edward G. Patton, Siyuan Wang, Mary Barth, John Orlando

Abstract:
Exchanges of reactive gases between forests and the atmosphere influence tropospheric chemistry, climate, and ecosystem health. Ambient chemistry in forests can alter these exchanges yet our understanding of the chemistry and the processes influencing the chemistry is incomplete. Organization in turbulence can lead to the physical separation of reactants ('segregation'), which may cause reactions to speed up or slow down compared to the rates that assume well-mixed conditions. Previous work prioritizes complex chemistry over micrometeorology in the multilayer models of forests used to probe in-canopy chemistry. Here we trade complex chemistry for condensed chemistry but resolved atmospheric turbulence interacting with vegetation and chemistry in order to quantify segregation inside and above a forest canopy. Specifically, we use the NCAR large eddy simulation coupled to a multilayer canopy model and a simplified chemical mechanism. Simulations mimic summer daytime conditions at a temperate deciduous forest. We find that in-canopy segregation can bias reaction rates that assume well-mixed conditions by up to -42 to +19% and is particularly high for reactions involving NOx. Segregation is stronger for reactions involving NOx with higher soil NO emissions. Segregation mostly limits reaction rates, but in some cases expedites rates, compared to the rates that assume well-mixed conditions. Except for segregation in the reaction between OH and isoprene, which maximizes at canopy top, segregation is highest in the lower canopy. Capturing in-canopy segregation accurately requires a full understanding of reactant variability on fast timescales at different heights in the canopy. Our findings emphasize the need for simultaneous observations of in-canopy vertical flux and concentration profiles for a slew of reactive gases, as well as constraints on micrometeorology and leaf-level processes.

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Theme area:
Atmospheric chemistry

Abstract number: P5

On the use of eddy-covariance and ECOSTRESS data to model the height of the atmospheric boundary layer

Camilo Rey-Sanchez, Sonia Wharton, Jordi Vilà-Guerau de Arellano, Kyaw Tha Paw U, Kyle S. Hemes, Jose D. Fuentes, Jessica Osuna, Daphne Szutu, J. Vinicius Ribeiro, Joseph Verfaillie, Dennis Baldocchi.

Abstract:
In this study we run a comparison of atmospheric boundary layer height (ABL) height estimates from radar wind profilers and slab models. The study is done in the Sacramento-San Joaquin River Delta, in California, a site of Mediterranean climate, flat terrain, and clear summers with high rates of atmospheric subsidence and cold-air advection from the adjacent ocean. After testing a new algorithm to calculate ABL heights from 915 MHz radar wind profilers, we evaluated a hierarchy of three slab models to recreate the diurnal and annual patterns of ABL growth. The three models were successful in replicating the diurnal growth in ABL height, and to a lesser extent the daily maximum value of ABL height. We found that the lower ABL heights in the Delta, particularly during late summer, are driven by the combined effects of increased atmospheric subsidence and marine air advection. A land composite of latent and sensible heat fluxes obtained through a meso-network of eddy-covariance measurements and the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission resulted in higher model skill, thus showing that land cover heterogeneity is an important driver of ABL growth. These results can help to understand the effects of changes in land cover on the boundary layer height and the air quality within it.

Presented by:
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Theme area:
Boundary layer meteorology

Abstract number: P6

Using atmospheric modelling tools to analyze wildfire effects on Atmospheric Boundary Layer dynamics

Marc Castellnou, Brian Verhoeven, Mercedes Bachfischer, Catelijne Stoof, Jordi Vila-Guerau de Arellano

Abstract:
Northern Europe. Recent fire behavior above the expected by state-of-the-art models has highlighted the need to consider boundary layer-wildfire interactions to understand and predict extreme fire periods for responding agencies. We aim to test the feasibility of atmospheric modeling to understand these interactions' physics and help predict faster than expected fire spread. We use ERA5 (ECMWF) hourly vertical profile to analyze divergences between predicted and observed ABL compared with real radio-sounding, radar, and on-site observations. Results show good concordance between ERA5 modeled profile and the observed boundary layer on the fire day. On the other side, the plume top observed suggests that surface flux is enhanced by fire, forcing deeper entrainment. Observed shallow momentaneous Pyrocu, indicated also modified LCL height as a consequence. We conclude that Surface flux enhanced by fire and adding to ABL top shear turbulence created significant changes on CBL profile and LCL elevation. Those changes, therefore, affected fire on the surface, allowing for an increase in fire spread.

Presented by:
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Theme area:
Boundary layer meteorology

Abstract number: P7

River Winds and Pollutant Recirculation in the Amazon

Tianning Zhao, Jianhuai Ye, Igor O. Ribeiro, Yongjing Ma, Hui-Ming Hung, Carla E. Batista, Matthew P. Stewart, Patricia C. Guimarães, Jordi Vilà-Guerau de Arellano, Rodrigo A.F. de Souza, Alex B. Guenther, and Scot T. Martin

Abstract:
Local atmospheric recirculation flows (i.e., river winds) induced by thermal contrast between wide Amazon rivers and adjacent forests could affect pollutant dispersion, but observational platforms for investigating this possibility have been lacking. The transport of urban, fire, and forest pollutant emissions by river winds has implications for the health of the millions of river-side inhabitants. Herein, a copter-type unmanned aerial vehicle (UAV) operated from a boat collected daytime vertical profiles of meteorological variables and chemical concentrations up to 500 m during the 2019 dry season. Cluster analysis showed that a river-forest recirculation flow occurred from surface to 300 m for 23% (13 of 56) of the profiles whereas it was completely absent for 21% of them. In fair weather, the thermally driven river winds fully developed for synoptic wind speeds below 4 m s-1, and during these periods the vertical profiles of carbon monoxide (CO) and total oxidants (Ox, defined as O3 + NO2) were significantly altered. Under some conditions, the river winds recirculated pollution back toward the riverbank and its point of origin. There are significant implications for air quality in the many human settlements along the rivers throughout northern Brazil.

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Theme area:
Boundary layer meteorology

Abstract number: P8

Persistence analysis of velocity and scalar fluctuations in canopy turbulence

Tirtha Banerjee , Subharthi Chowdhuri, Khaled Ghannam

Abstract:
Turbulent transport of momentum and scalars in the vicinity of vegetation canopies remains a vexing problem to model due to complex relations between mean flow and turbulence, often requiring higher-order closure theories than the simple gradient diffusion. This complexity is now known to be associated with the unique eddy structure in the roughness and canopy sublayers. The current work aims at characterizing this dynamics using the concept of persistence timescales often employed in applications of non-equilibrium statistical mechanics and stochastic process analysis. Persistence is defined as the probability that the local value of a fluctuating field remains at a particular state for a certain amount of time, before being switched to another state. Specifically, we carry out a detailed analysis of the statistical characteristics of the persistence probability distribution functions (PDFs) of velocity, temperature and greenhouse gas fluctuations within and above canopies, using a field-experimental dataset (GOAMAZON) and large eddy simulation experiments. Our results demonstrate that when the persistence time scales (tp) are scaled with a combination of the friction velocity at canopy top (u*) and the canopy height (h), the persistence PDFs of the vertical velocity fluctuations reveal a peak at normalized time scales tpu*/h>0.1, for the heights within the canopy (z<h). However, for the persistence PDFs of the streamwise velocity fluctuations, such a bulge is not as clearly visible as in the vertical velocity fluctuations. To explain this behaviour, we establish a possible linkage with the spectral short-circuiting of the energy cascade, a phenomenon commonly observed within the canopy sub-layer.

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Theme area:
Boundary layer meteorology

Abstract number: P9

The convective boundary layer over thermally and aerodynamically heterogeneous surfaces: LES and model development

Khaled Ghannam

Abstract:
Characterizing the effects of spatial heterogeneity at the land surface on the convective boundary layer (CBL) persists as an outstanding issue in climate models. As Ameriflux towers provide single-point measurements, large eddy simulation (LES) resolves heterogeneity scales at the land surface as boundary conditions and the turbulent flow aloft. The work here therefore uses LES to characterize the implications of land heterogeneity on the CBL. Results show significant effects of land heterogeneity on turbulent fluxes for a variety of geostrophic wind speed conditions, and indicate that existing ABL physics in climate models, which relies on aggregating/averaging heterogeneous land properties, underestimates turbulent fluxes and entrainment rates (ABL growth), leading to delayed crossing time between the ABL height (H) and lifting condensation level. This effect is a strong function of the amplitude of heterogeneity (standard deviation of land fluxes) and background wind, and is a weaker function of the heterogeneity lengthscale (patch size relative to H), at least for scales relevant to climate models. The enhanced mixing over heterogeneous surfaces is attributed to dispersive fluxes --subgrid horizontal advection in the ABL -- which scale with land surface properties and is modeled as such in the ABL scheme.

Presented by:
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Theme area:
Boundary layer meteorology

Abstract number: P10

The Amazonian Low-Level Jet at the ATTO site and its effect on Ozone concentrations above the rain forest

Stefan Wolff, David Walter, Anywhere Tsokankunku, Daiane Brondani, Fernando Rossato, Sam Jones, Sebastian Brill, Eva Pfannerstill, Achim Edtbauer, Rodrigo Souza, Marta de Oliveira Sá, Alessandro C. de Araújo, Cléo Q. Dias-Júnior, Christopher Pöhlker, Matthias Sörgel

Abstract:
The pristine Amazon rainforest is a unique place to study ozone (O3) deposition rates and tropospheric transport, due to the absence of nearby sources of anthropogenic pollution. Parts of the low background O3 are considered to be transported from the stratosphere into the troposphere. This occurs due to general entrainment of stratospheric air at the tropopause. Within the troposphere, downdrafts provide effective vertical mixing and are known to increase surface O3 values. Low-level jets can also enhance O3 concentrations due to long range transport and locally induced mixing in the nocturnal boundary layer. Therefore, we study these phenomena based on long term datasets from 2012 to present from tall measurements towers (80 m and 325 m).

Ozone mixing ratios were measured at the ATTO site (Amazon Tall Tower Observatory) in the Central Amazon (02°08’38.8’’S, 58°59’59.5’’W) since 2012 at 8 different heights between 5 cm and 80 meters and additional measurements from 80 m up to 325 meters are running since 2017. From 2015 to 2017, 3-dimensional wind measurements have been performed in 150 meters height in 10 Hz sampling rate, showing evidences for the formation of a nocturnal low-level jet (LLJ), which leads to higher turbulent mixing inside the residual layer/ stable nocturnal layer. We were comparing the nocturnal LLJ with downdrafts of air due to strong thunderstorms which led to increases of O3 as well. We are analyzing these events regarding their in-canopy air exchange, their frequency and seasonality and comparing them with the effects of the nocturnal LLJ. As the data series comprises more than eight years of data we are also analyzing the interannual variability.

Presented by:
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Theme area:
Boundary layer meteorology

Abstract number: P11

Derivation of Integral Length Scales from Mini Micro Pulse Lidar Backscattering Profiles

Darrel Baumgardner, Justin Fisher, Adam Slagel

Abstract:
Measurements of the vertical aerosol particle mass are usually made from instrumented towers where fast response particle counters are collocated with vertical motion sensors at several heights above the surface. Spectral analysis of the covariance of particle number or mass and vertical velocity provides information on the length scale of turbulent eddies from which mixing rates are derived. A similar approach is possible using vertical profiles of backscattered light from aerosol particles measured with a Mini Micro Pulse Lidar (miniMPL). Whereas the tower measurements are limited in the number of sensors, as well as the maximum altitude for the highest sensor, lidar can typically measure aerosol backscattering at resolutions as small as 5 m and > 2000 data points up to altitudes of 10 km. This density and resolution of vertical profile measurements provides information highly complementary to tower flux measurements. The miniMPL is also valuable as a standalone system capable of producing near-real time measurements of the length scale of aerosol mixing.

As defined by the American Meteorological Society's Glossary of Meteorology, the integral length scale is a measure of the largest separation distance over which components of the eddy velocities at two distinct points are correlated. In the most general form, the integral scales are functions of position and are defined in terms of normalized two-point velocity correlations. The miniMPL is not a doppler lidar, i.e., particle velocity is not measured; however, by measuring correlations between the light scattering at two points in space and time, a comparable length scale can be derived that is related to the mixing length. These mixing lengths as a function of altitude and time are related to vertical particle fluxes and can be used to study how the atmospheric boundary layer evolves.

Presented by:
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Theme area:
Boundary layer meteorology

Abstract number: P12

Transition of shallow to deep convection in the Amazon: a cloud resolving modeling study

Leandro Alex Moreira Viscardi, Henrique de Melo Jorge Barbosa

Abstract:
Convection in the Amazon region is important for several reasons: its water budget contributes significantly to the global hydrological cycle on both seasonal and annual time scales, its copious rainfall drives global tropical circulations, and the expansive deep cloud cover impacts global radiation budgets. In this poster we present preliminary results about the role of surface energy flux during shallow-to-deep convection transition in the Amazon rainforest by using observational datasets of GoAmazon 2014/5 campaign. We discuss how surface energy flux and the atmospheric boundary layer height differ from shallow and deep regime days, and how numerical model experiments could help understand such biosphere-atmosphere interaction

Presented by:
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Theme area:
Clouds/convection

Abstract number: P13

Approaching coastal Stratocumulus through variations of surface heat fluxes

Mónica Zamora

Abstract:
Coastal Stratocumulus clouds (Sc) develop over land, where surface fluxes have a strong diurnal cycle, unlike the more studied marine Sc. The strong fluxes over coastal land can influence the quick dissipation of the cloud layer during morning hours, but details of the dissipation process are still a matter of research. For modeling coastal Sc, realistic changes of surface fluxes can be obtained using sophisticated land surface models. However, these models need to be calibrated with observations, and observations are not available everywhere. In this work, we model the development of Sc clouds using Large Eddy Simulations and vary the surface sensible heat flux (SHF) during the day in order to resemble the diurnal variations that occur over land. Our variations have different rates of change of SHF after sunrise. Preliminary results show that stronger SHF rates lead to warmer, drier, and well-mixed boundary layers but that cloud cover does not clearly correlate to the changes on SHF.

Presented by:
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Theme area:
Clouds/convection

Abstract number: P14

The LES ARM Symbiotic Simulation and Observation (LASSO) Activity: LES Library for Central U.S.

William I. Gustafson Jr., Andrew M. Vogelmann, Zhijin Li, Xiaoping Cheng, Kyle K. Dumas, Satoshi Endo, Michael Giansiracusa, Karen L. Johnson, Tami Fairless, and Heng Xiao

Abstract:
The U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) facility has generated a library of large-eddy simulations (LESs) of shallow convection over a five-year period at its Southern Great Plains (SGP) atmospheric observatory in Oklahoma. This library product is called the LES ARM Symbiotic Simulation and Observation (LASSO) activity. The SGP is ARM's flagship long-term observation site, which is also an AmeriFlux site, with extensive meteorological, soil, radiation, and aerosol observations. The LASSO activity provides a means of bridging the scale gap between observations and larger-scale models through the use of LES. This is a powerful tool for understanding shallow convective clouds and related boundary layer processes. Both model input for reproducing the LES and the LES output are packaged alongside a suite of observations to ease use by researchers. With the 95 available case dates and an ensemble of LES for each date, researchers have a statistically robust sample of LES at their fingertips. More information is available at https://www.arm.gov/capabilities/modeling/lasso.

Presented by:
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Theme area:
Clouds/convection

Abstract number: P15

Sparv Embedded Offerings

Anders Petersson

Abstract:
Seeing the gaps in environmental measurements around the world, Sparv Embedded set out to enable dense measurements of the boundary layer where this was previously too expensive or troublesome. We produce small and lightweight equipment to make in-situ data collection of the boundary layer easier. Here we present our existing solutions and some ideas for extensions.

Windsond radiosondes are the lightest radiosonde on the market. The standard system can track 8 sondes on a single radio frequency. This can be extended up to 120 sondes. Sondes can also be reused. The upcoming version “S2” will be even smaller and lighter with improvements such as better battery time and quicker GPS fix. The new version will also support new use cases such as dropsondes and novel sensors to measure air pollution etc.

The sensor system “Sparvio” is a plug and play solution for UAVs to measure various quantities. We already offer sensors for T/RH, winds, CO_2, O_3, CH_4 and particles and are happy to support more sensors on customer request. The generic platform for sensor connectivity is also useful in research projects, in prototypes and in commercial products.

Presented by:
Anders Petersson (anders@sparvembedded.com), Sparv Embedded

Theme area:
Instrumentation

Abstract number: P16

Atmospheric data Community Toolkit (ACT): A Python Library for Atmospheric Data Exploration and Analysis

Adam Theisen, Ken Kehoe, Bobby Jackson, Zach Sherman, Alyssa Sockol, Corey Godine, Jenni Kyrouac, Jason Hemedinger, Scott Collis, Michael Giansiracusa

Abstract:
The Atmospheric data Community Toolkit (ACT) is an open-source Python library for working with n-dimensional atmospheric time-series datasets that helps users process, analyze and interpret atmospheric measurements. ACT contains functions for every aspect of the research lifecycle, from retrieving data from specific data web services, such as the Atmospheric Radiation Measurement (ARM) user facility, to calculating cloud base heights from lidar data. Once in an xarray object, using the including scripts for reading data or the standalone xarray ones, the rest of the toolkit can easily be utilized in addition to the existing capabilities already included in xarray. There are modules for corrections, quality control, visualizations, general utilities, and retrievals/calculations. ACT is currently supported by the Department of Energy ARM user facility and has helped to streamline some of ARM's internal processes, such as quicklook visualization for the hundreds of instruments that are operating in the field on a daily basis. However, it is not just designed for ARM, datasets from other programs (Ameriflux, NOAA, NEON) can be read into the same xarray object and utilize the entirety of the toolkit. The repository is on Github (https://github.com/ARM-DOE/ACT) and installable through pip and anaconda under the package name act-atmos.

Presented by:
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Theme area:
Instrumentation

Abstract number: P17

Compact Ceilometers for Network Deployment

David Sonnenfroh, Scott Bender, Joseph Goodwin

Abstract:
Increased knowledge of the boundary layer structure and its diurnal evolution is the goal of recent activity in Europe to establish networks of lidars and ceilometers to monitor boundary layer height, in addition to other parameters. The value of these networks underlies the desire to add aerosol profiling ceilometers to the AmeriFlux network, especially to aid in regional flux monitoring efforts. Given that AmeriFlux sites utilize instrumented towers, whose automated sensors are exposed to the full range of weather and operate with limited electrical power, a new class of laser ceilometer is needed to add boundary layer height measurement capability to the AmeriFlux network.

We are developing a compact laser ceilometer for retrievals of both boundary layer height and cloud ceiling that is compatible with the demands imposed by the wide environmental conditions experienced by, and automated operation required of, site instrumentation throughout the AmeriFlux network. For deployment at an AmeriFlux tower site, substantial reductions in size, weight, and power, compared to existing ceilometer designs, are needed. Compact size, ruggedization, and thermal management with a very small available power budget are similar to design restrictions placed on aircraft and spacecraft payloads. Our design for a compact ceilometer considers thermo-mechanical stability and thermal management in the entire environmental envelope as the foundation for the sensor design.

We review the system design, including the thermal, mechanical and optical modeling. Ongoing characterization of an engineering prototype is presented, including intercomparison with a commercial grade ceilometer. Example retrievals of boundary layer height and cloud ceilings are presented. Lastly, we report on the status of a smaller ceilometer that will provide cloud ceiling and sky coverage in both network settings and to support operations at untowered airports.

Presented by:
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Theme area:
Instrumentation

Abstract number: P18

The Surface Atmosphere Integrated Field Laboratory (SAIL) Field Campaign

Allison Aiken, William Boos, Rosemary Carroll, Venkatachalam Chandrasekar, William Collins, Scott Collis, Jeff Deems, Paul DeMott, Jiwen Fan, Alejandro Flores, David Gochis, Jerry Harrington, Matt Kumjian, L. Ruby Leung, Travis O'Brien, Mark Raleigh, Alan Rhoades, S. McKenzie Skiles, Jim Smith, Ryan Sullivan, Paul Ullrich, Adam Varble, Ken Williams

Abstract:
As water resources in the Western United States dwindle, the ability of models to predict the timing and availability of such resources derived from mountainous systems become ever-more critical. Process, regional, and Earth System Models face persistent challenges in predicting snowpack and snowmelt dynamics in the cold season and monsoonal dynamics during the warm season across the Colorado Rocky Mountains because it is difficult to isolate the source(s) of model error in complex terrain with limited atmospheric or land-surface observations across the scales of their variability. Therefore, the mountain hydrometeorology community has repeatedly called for integrated atmospheric and land observations of water and energy budgets in complex terrain that span these scales to establish benchmarks against which scale-dependent models are developed.

In response to these calls, the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program will deploy an atmospheric observatory (an ARM Mobile Facility) to the East River Watershed near Crested Butte, Colorado from September, 2021 to June, 2023 to measure precipitation, clouds, aerosols, radiation, atmospheric thermodynamics, trace gases, radiation and surface turbulent fluxes of latent, and sensible heat. In conjunction with the spatially-distributed surface and sub-surface observational network supported by the DOE's Watershed Function SFA and NOAA's Study of Precipitation and Lower-Atmospheric impacts on Streamflow and Hydrology (SPLASH) network of radiation and surface flux measurements, the East River Watershed will be a focal point for intensive measurements of evapotranspiration, snow sublimation, and three-dimensional radiation across seasons. As these data are collected, the SAIL Team looks forward to working with researchers to explore model representations of these processes, especially to formulate hypotheses of source(s) of model error that can be tested prospectively.

Presented by:
Daniel Feldman (drfeldman@lbl.gov), Climate Sciences Department, Lawrence Berkeley National Laboratory, USA

Theme area:
Instrumentation

Abstract number: P19

Advancing boundary-layer research with CHEESEHEAD19

Ankur Desai, Brian Butterworth, Sreenath Paleri, Luise Wanner, Stefan Metzger, Matthias Mauder, CHEESEHEAD team

Abstract:
Intensive field campaigns of surface-atmosphere interactions allow for a deep dive into boundary-layer processes. The Chequamegon Heterogenous Energy-balance Study Enabled by a High-density Extensive Array of Detectors (Butterworth et al., 2021, BAMS) was one such study conducted in the summer of 2019. During a four-month period, 19 above-canopy eddy-covariance flux towers were deployed in the mixed forest and wetland landscape across a 10x10 km area surrounding the US-PFa 400 m Ameriflux supersite. A suite of atmospheric boundary-layer profiling by radar, LiDAR, SODAR, microwave radiometer, ceilometer and radiosonde were deployed near the tall tower to characterize temporal evolution of the PBL. Over three intensive observing periods, eddy-covariance equipped aircraft sampled carbon and energy fluxes across the landscape twice a day while also flying additional instrumentation to characterize the boundary-layer. Finally, a suite of ground, airborne, and drone ecological sampling for vegetation hyperspectral reflectance, surface temperature, canopy structure, autumn phenology, soil properties, and net primary productivity were deployed in a number of sites. Currently, we are using these data to parameterize a 30x30 km large-eddy simulation to test hypotheses on mesoscale contributions to surface energy balance. The open-source data are available at https://www.eol.ucar.edu/field_projects/cheesehead and can be collaboratively analyzed through National Science Foundation cloud computing at https://cyverse.org.

Here, we present the available observations, analysis tools, and initial results.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P20

Evaluating the response of diurnal surface and air temperature to evaporative conditions across vegetation types in FLUXNET and ERA5

Annu Panwar and Axel Kleidon

Abstract:
Often surface and air temperature are assumed related, but we show that during the day the response of surface temperature (Ts) to evaporative conditions depends on vegetation types but for air temperature (Ta) it does not. These responses are quantified in terms of diurnal temperature range (DTR) for multiple (163) FLUXNET sites and global ERA5 data. On days with high evaporative fraction, DTsR reduces by 20 K in short vegetation, whereas by 10 K in the forest. Surprisingly, DTaR reduces only by 5 K in response to evaporative fraction across all vegetation types. These findings are in agreement with our previous studies Panwar et al. (2019) and Panwar et al. (2020). The weaker responses of air temperature are explained using a simple atmospheric boundary layer (SABL) model. To account for the role of boundary layer dynamics we use ERA5's boundary layer height. Based on the model we show that overall, the response of the DTaR to evaporative fraction is constrained by the total solar energy input and boundary layer dynamics but is independent of aerodynamic conductance of vegetation. Similarly, for DTsR we present a simplified surface energy balance (SSEB) model that shows, DTsR is mainly driven by solar radiation, evaporative fraction and aerodynamic conductance of vegetation. The SABL and SSEB models reproduces DTR sensitivities to evaporative fraction and solar radiation similar to what is obtained in ERA5 and FLUXNET. Additionally, we also discuss the differences in FLUXNET and ERA5 sensitivities that reveal systematic DTR biases in ERA5. To conclude, our findings show that diurnal surface and air temperature respond differently to changes in evaporative conditions and these responses can be modeled using fundamental physical concepts. It is important to identify the differences between surface and air temperature while using and interpreting them for meteorological phenomenon associated to the variability of moisture, energy and vegetation.

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Theme area:
LandAtm: Atm

Abstract number: P21

Land-atmosphere coupling at the U.S. Southern Great Plains: A comparison on local convective regimes between ARM observations, reanalysis, and climate model simulations

Cheng Tao, Yunyan Zhang, Qi Tang, Hsi-Yen Ma, Virendra P. Ghate, Shuaiqi Tang, Shaocheng Xie, and Joseph A. Santanello

Abstract:
Synoptic weather variability and long-term regional climate are impacted by the interactive processes between land surface and the overlying atmospheric boundary layer and clouds. While models showed a strong land-atmosphere (L-A) coupling at the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site, a relatively weak signal is found in observational studies. Using the 9-yr warm-season observations at SGP, the L-A coupling in North American Regional Reanalysis (NARR) and two climate models (hindcasts with the Community Atmosphere Model v5.1 by Cloud-Associated Parameterizations Testbed [CAM5-CAPT] and nudged runs with the Energy Exascale Earth System Model Atmosphere Model v1 Regionally Refined Model [EAMv1-RRM]) are evaluated with a focus on three local convective regimes. Particularly, we diagnose model behaviors using the Local Coupling metrics. With these metrics, we aim to advance process-oriented understanding of L-A coupling on diurnal timescale and diagnose model deficiencies. Overall, NARR agrees well with observations on the atmospheric moisture budget and surface energy budget, except a slightly warmer and drier surface with higher downwelling shortwave radiation and lower evaporative fraction (EF). Both models simulate warmer and drier early-morning conditions on clear-sky days, with EF significantly underestimated by EAMv1-RRM. The majority of the observed shallow cumulus (ShCu) days are simulated as days with no or little low-level clouds in either model simulation. When captured in models, the simulated ShCu shows much less cloud fraction and lower cloud bases than that observed. Late-afternoon deep convection days in models tend to exhibit a stable early-morning lower atmosphere more often than the observations. This implies that deep convection is triggered more frequently by elevated instabilities in models. (This work was performed under the auspices of the U.S. DOE by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-822739)

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P22

Linking Latent Heat Fluxes to Column Water Vapor in the North American Monsoon Region: Collocated GPS Meteorological Stations at Eddy flux Sites

David Adams, Benjamin Lintner, Russell Scott

Abstract:
Investigating land-atmospheric coupling in deep convective regimes, such as the North American Monsoon (NAM), is a daunting task. Surface coupling is complex, with both positive and negative feedbacks between precipitation and local surface fluxes. Quantifying the terrestrial water vapor flux contribution to the atmospheric column is critical for estimating convective instability and moisture recycling. Here, we present results from the North American Monsoon GPS Hydrometeorological Network 2017. Our approach to linking land/atmosphere consists of collocated GPS meteorological stations at three flux tower sites, two in Sonora, Mexico and an AmeriFlux site in Arizona. GPS provides frequent precipitable water vapor (PWV). Collocating GPS receivers/flux sites provides an approach, albeit with inherent spatial scale disparities, for linking soil moisture, LE, PWV, and convective activity, avoiding the necessity of estimating boundary layer growth.

Our results demonstrate only small local surface water vapor flux contribution to PWV. Comparing surface LE integrated from 7am to 3pm to the change in PWV suggests that locally-derived surface moisture do not determine column moisture changes. Hence, larger-scale water vapor advection/convergence dominates PWV. Furthermore, considering the relationship between LE and diurnal convective triggering, as assessed with Vaisala GLD360 lightning data, observations indicate little connection between days with large LE and deep convection. In fact, very moist surface conditions are detrimental to NAM convection. This weak LE forcing on sub-daily time scales has implications for local-scale moisture recycling, as well as terrestrial versus oceanic water vapor sources for the NAM region. In this poster, we will provide a brief overview of our planned (2021) GPS Meteorological Network at three AmeriFlux tower sites in southern Arizona which will provide a mesoscale view over different ecosystem types and complex topography.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P23

Carbon fluxes from a grassy manicured tropical lawn

Erik Velasco, Elvagris Segovia, Amy M.F. Chong, Benjamin K.Y. Lim, Rodrigo Vargas

Abstract:
Turfgrass is an important component of the urban landscape frequently considered as an alternative land cover to offset anthropogenic CO2 emissions. However, quantitative information of the potential to directly remove CO2 from the atmosphere by turfgrass systems is lacking, especially in the tropics. Most assessments have considered the carbon accumulated by grass shoots and soil, but not the release of CO2 to the atmosphere by soil respiration (i.e., soil CO2 efflux). Here, we measured at high-temporal resolution (30-min) soil CO2 efflux, production, and storage rate for nearly three years in a residential lawn of Singapore. Furthermore, we quantified the carbon capture related to biomass production and CO2 emissions from fossil fuel consumption associated with maintenance activities (e.g., mowing equipment). Warm and humid conditions resulted in relatively constant rates of soil CO2 efflux, CO2 storage in soil, and aboveground biomass production (3370, 652, 1671 Mg CO2 km-2 yr-1; respectively), while the systematic use of mowing machinery emitted 27 Mg CO2 km-2 yr-1. Soil CO2 efflux and CO2 mowing emissions represent carbon losses to the atmosphere, while CO2 storage in soil and biomass productivity represent gains of carbon into the ecosystem. Under a steady state in which soil CO2 losses are only compensated by atmospheric CO2 uptake by photosynthesis, an ideal clipping waste disposal management, in which no CO2 molecule returns to the atmosphere (i.e., clippings are not burnt), and a 3-week mowing regime, this site can act as a sink of 2296 Mg CO2 km-2 yr-1. In the scenario of incinerating all clippings, the lawn acts as an emission source of 1046 Mg CO2 km-2 yr-1. Thus, management practices that reduce mowing frequency together with clipping disposal practices that minimize greenhouse gas emissions are needed to make urban lawns a potential natural solution to mitigate global environmental change.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P24

The Land-Atmosphere Feedback Observatory (LAFO)

Florian Späth, Shehan Morandage, Andreas Behrendt, Thilo Streck, Volker Wulfmeyer

Abstract:
A new Land-Atmosphere Feedback Observatory (LAFO) was established at the University of Hohenheim, Stuttgart, Germany. It is considered as a role model for a network of GEWEX LAFOs (GLAFOs) that is a central project and proposed by the GEWEX Global Land/Atmosphere System Study (GLASS) panel. Its main objective is to observe directly land-atmosphere (LA) feedback for process understanding and improving its representation in weather and climate models. The set up phase of this research facility was funded by the Carl Zeiss Foundation. LAFO targets four research objectives:

1) Characterization of LA feedback by suitable metrics.

2) Advance process understanding and parameterizations with respect of vegetation dynamics, surface and planetary boundary layer (PBL) fluxes.

3) Investigation of the diurnal cycle of the PBL including its turbulent properties.

4) Verification of mesoscale and turbulence permitting weather forecast and regional climate models.

LAFO's sensor synergy bases on a combination of instruments with unequaled spatial and temporal resolution to measure an extended set of soil physical, plant dynamic as well as meteorological variables throughout the PBL focusing on evapotranspiration and turbulent exchange processes over an agricultural landscape. Observations are recorded with state-of-the-art instruments on a long-term basis as well as with a more sophisticated sensor setup campaign-based.

Unique is the set of scanning lidar systems to capture atmospheric humidity, temperature, and wind fields. At the land-surface is a soil water and temperature sensor network distributed over the agricultural study area combined with two eddy-covariance stations to observe fluxes at the land surface. The vegetation can be characterized with, e.g., a phenotyping platform or unman aerial vehicles (UAVs).

For specific campaigns, research partners are highly welcome to join our research team. Following the FAIR data principle, our data will be made available on a website.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P25

Soil moisture signature in global weather balloon soundings

Jasper M. C. Denissen, Renè Orth, Hendrik Wouters, Diego G. Miralles, Chiel C. van Heerwaarden, Jordi Vilà-Guerau de Arellano and Adriaan J. Teuling

Abstract:
The land surface influences the atmospheric boundary layer (ABL) through its impacts on the partitioning of available energy into evaporation and warming. Previous research on understanding this complex link focused mainly on site-scale flux observations, gridded satellite observations, climate modeling, and machine-learning experiments. Observational evidence of land surface conditions, among which soil moisture, impacting ABL properties at intermediate landscape scales is lacking. Here, we use a combination of global weather balloon soundings, satellite-observed soil moisture, and a coupled land-atmosphere model to infer the soil moisture impact on the ABL. The inferred relationship between soil moisture and surface flux partitioning reflects distinctive energy- and water-limited regimes, even at the landscape scale. We find significantly different behavior between those two regimes, associating dry conditions with on average warmer (≈3 K), higher (≈400 m) and drier (≈1 kPa) afternoon ABLs than wet conditions. This evidence of land–atmosphere coupling from globally distributed atmospheric measurements highlights the need for an accurate representation of land–atmosphere coupling into climate models and their climate change projections.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P26

Observational evidence of the land cover effect on shallow cumulus clouds over the U.S. Southern Great Plains

Jingjing Tian, Yunyan Zhang, Stephen A. Klein, David M. Romps, Rusen Öktem, LikunWang

Abstract:
The continental shallow cumulus clouds (ShCu) are tightly coupled with the land surface. The land covers (e.g forest, grassland, crops) with different albedo, surface roughness, soil moisture content and leaf area index, can impact the surface energy balance and the turbulent transfer of momentum, heat and water vapor, therefore the formation of clouds. However, the observational evidence of such impact is limited. In this study, we use the cloud observations from stereo cameras at the U.S. Southern Great Plains (SGP), the reflectance data from Geostationary Operational Environmental Satellite (GOES-R), and high-res land cover data to study the coupling between land surface and shallow cumulus. This study will answer two questions (1) what is the preference of the ShCu occurrence over different land covers at SGP? (2) what is the impact of land cover heterogeneity length scale on cloud occurrence? We find that during the summertime, (1) ShCu prefer to occur more over forest than over grassland; (2) A land cover heterogeneity length scale (< 9km) preference is more significant at the onset stage of the cloud population than at the mature stage. This work is performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL ABS-821790.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P27

Multivariate analysis of CO_2 turbulent fluxes and environmental variables in a forest site near Santarém, in Amazônia.

Luciana Rizzo, Pedro Corrêa

Abstract:
The Amazon forest plays an important role in the terrestrial carbon balance, acting both as a carbon sink, through the process of photosynthesis, and as a carbon source to the atmosphere, through autotrophic and heterotrophic respiration, biomass burning and wetland emissions. Previous studies have shown that CO_2 exchanges in Amazonia are spatially heterogeneous, and depend on environmental conditions in a complex and non-linear fashion. Surface CO_2 fluxes have been monitored in the Amazon since the 1990's within the LBA project (Large-Scale Biosphere-Atmosphere Experiment in Amazonia), and in collaboration with Brazilian and international research institutions. Here we present preliminary results of a master degree research project which aims to investigate the main environmental factors that determine the temporal and spatial variability of carbon exchange in Amazonia, applying data mining tools to unveil data patterns and promote the discover of knowledge. Multivariate analysis and interactive visualization tools were applied to a time series dataset of 16 variables in the period 1999-2006, using software R. The dataset included daily-basis data of CO_2 and heat fluxes measured at the K67 LBA Tower Flux in the Amazon forest, and remote sensing environmental variables like ozone concentrations from the AIRS sensor, cloud cover and Aerosol Optical Depth from the MODIS sensor aboard NASA's Acqua satellite. Principal components analysis was applied to this dataset, resulting in a solution with 4 components, explaining 74% of the common variance, whereas the first explained most variance of variables related with radiation, and the second variables related to CO_2 exchange. However, the elimination procedure missing data resulted in 90% loss of information. For mitigation this issue will be tested input methods. This analysis is a preparing step to development of machine learning model to promote better understanding of the CO_2 exchange in Amazon forest.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P28

Land-atmosphere biogeochemistry developments in the E3SMv1.1-BGC model

Sha Feng, Susannah Burrows, Bryce Harrop, Daniel Kaufman, Philip Cameron-smith, Sam Silva, Katherine Calvin

Abstract:
The biogeochemistry (BGC) configuration of the Department of Energy's Energy Exascale Earth System Model (E3SM)—i.e., model version E3SMv1.1-BGC and related configurations—were released as part of the E3SM contributions to the Coupled Climate-Carbon Cycle Model Intercomparison Project and other projects. E3SMv1.1-BGC simulates historical carbon cycle dynamics, including the loss in carbon associated with land use and land cover change as well as responses of the carbon cycle to changes in climate and prescribed atmospheric CO_2 scenarios. The land biogeochemistry representations in E3SMv1.1-BGC demonstrated great success when evaluated against observational benchmarks.

To extend the application of E3SMv1.1-BGC, a land-atmosphere-interaction focused configuration (E3SMv1.1-BGC%LNDATM) is under development within the original release. This configuration includes radiatively-active prognostic CO_2 in the atmosphere, active land BGC, and simulation of land-atmosphere CO_2 fluxes. Computational costs are reduced by using prescribed oceanic CO_2 fluxes and dynamics, enabling the configuration to serve as a testbed for interactions of land BGC and atmospheric processes. The first production run will focus on evaluating the configuration in historical simulations. To facilitate the evaluations, a companion software tool is being developed to generate diagnostics that compare simulated atmospheric CO_2 concentrations and fluxes with surface, aircraft, and satellite CO_2 observations in terms of trends, inter-annual variability, and seasonality. Eventually, a suite of E3SMv1.1-BGC%LNDATM simulations will be conducted to study the atmospheric CO_2 transport and responses to emissions scenarios. We anticipate that this model configuration will also serve to inform the development of a fully coupled prognostic CO_2 capability in E3SMv2and will be adaptable as an E3SM testbed for future studies examining the interactions of non-CO_2 atmospheric tracers with land BGC processes.

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Theme area:
LandAtm: Atm

Abstract number: P29

The GEWEX Land-Atmosphere Feedback Observatory (GLAFO)

Volker Wulfmeyer, Michael Ek, Craig R. Ferguson, Kirsten Findell, David D. Turner, Peter van Oevelen, Anne Verhoef

Abstract:
The understanding of L-A feedbacks is severly limited by the lack of corresponding observations in all climate regions. These observations must cover all compartments of the land system from bedrock to the lower atmosphere. Particularly, the 3D dynamics and the thermodynamics from the land surface to the lower troposphere must be considered as Terra Incognita in Earth system science.

We propose a new design or enhancement of current measurement capabilities by combining observations of the terrestrial and the atmospheric legs of L-A feedbacks. We define this sensor synergy as GEWEX Land Atmosphere Feedback Observatory (GLAFO). At the University of Hohenheim in Stuttgart, Germany, a first Land-Atmosphere Feedback Observatory (LAFO) of this kind is under development (see https://lafo.uni-hohenheim.de/en). We envision a network of GLAFOs in all climate zones and call for a interdisciplinary collaboration of scientists that are interested to advance our understanding of L-A feedbacks as well as the performance of the next generation of weather forecast, climate, and earth system models.

GLAFOs will observe the relevant processes and variables with respect to water, mass, energy, and momentum transport with unprecedented spatial and temporal resolutions, from bedrock to the lower troposphere. The measurements will be realized through the synergistic combination of in-situ instruments as well as and passive and active remote sensing systems, partly with 3D scanning capability. As these measurements will be operational and available 24/7 at the sites, an unprecedented data set will be provided for the study of L-A feedbacks from the diurnal cycle, via seasonal/annual to ideally climatological time scales.

A new set up of a GLAFO or the upgrade of present sites will be realized by a hierarchy of well-defined levels of instrumentation and complexity so that a smooth and reproducible development will be possible also considering funding constraints.

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Theme area:
LandAtm: Atm

Abstract number: P30

Using Mixing Diagrams to Study Land-Atmosphere Interactions

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Abstract:
Land-atmosphere interactions play a critical role in both the atmospheric water and energy cycles. Changes in soil moisture, vegetation health, and seasonal vegetation dynamics alter the partitioning of surface water (soil evaporation and transpiration) and energy fluxes, influencing diurnal evolution of the planetary boundary layer (PBL), and even subsequent cloud and precipitation development. Greater understanding of how the atmosphere and land surface covary, also referred to as land-atmosphere coupling, is essential to improving predictability of extreme events (e.g., drought, heat waves, heavy rainfall events) and is critical for short- and medium-range weather forecasts and climate predictions.

We have adopted the use of mixing diagrams, which were first pioneered by Alan Betts in the mid-1990s, to understand the evolution of the heat and moisture budget within the convective boundary layer (CBL). We demonstrate that observations from the Department of Energy Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site provide all of the needed inputs needed for the mixing diagram framework, allowing us to quantify the impact from the surface fluxes, advection, radiative heating, encroachment, and entrainment on the evolution of the CBL. Profiles of temperature and humidity retrieved from the ground-based infrared spectrometer (called the Atmospheric Emitted Radiance Interferometer, or AERI) are a critical component in this analysis. We compare the observation-derived mixing diagrams with those from a large eddy simulation model and different versions of the High-Resolution Rapid Refresh (HRRR) cloud-resolving model to illustrate the strength of the approach to evaluate CBL evolution.

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Theme area:
LandAtm: Atm

Abstract number: P31

Correlation Between Air Pollution, sociodemographic, and Health in Colombia

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Abstract:
Air pollution is an environmental factor that has a great influence on human health [1]. Epidemiological studies show that about 60 million deaths a year are caused by respiratory diseases, mainly in sensitive groups such as children under 5 years of age and elderly adults [2]. In the principal cities of Colombia, atmospheric pollutants are commonly above the permissible limits, according to data provided by IDEAM [3]. We analyzes the correlation of air quality with respiratory diseases in Colombian territory, as well as its influence on morbidity and mortality due to COVID 19. The analysis was carried out taking data from 2010 to 2019 and from January 1, 2020 to June 30, 2020, for 11 localities in the city of Bogotá and 15 cities nationwide, using the dose-response methodology, taking into account previous models used by researchers worldwide and applying them to the Colombian case. The influence of short- and long-term exposure and affectation to pollutants on morbidity and mortality due to COVID 19 was analyzed, showing that O3 and PM10 are the pollutants with the greatest influence, in addition to variables related to pre-existing diseases, socioeconomic status, meteorological parameters and health habits.

Presented by:
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Theme area:
LandAtm: Atm

Abstract number: P32

Disentangling the relative drivers of seasonal evapotranspiration across a continental-scale aridity gradient

Adam M. Young, Mark Friedl, Eric Beamesderfer, Steve Frolking, Minkyu Moon, Toby Ault, Carlos Carrillo, Xiaolu Li, Jim Le Moine, Andrew D. Richardson, and AmeriFlux Collaborators

Abstract:
Vegetation phenology is tightly linked to seasonal shifts in evapotranspiration (ET). However, the relative importance of phenology as a control of ET compared to other important environmental and climatic factors remains unclear. Here, we investigated how phenology acts as a control of ET at seasonal time scales using daily data from AmeriFlux. Phenology was quantified using canopy greenness from PhenoCam imagery. We focused on characterizing if and how evaporative fraction [EF = LE/(LE + H)] and bulk surface conductance (Gs) responded to phenology. We used structural equation modeling (SEM) to quantify the relative strength of the potential drivers of EF and Gs. Our study sites spanned a continental-scale aridity gradient (Φ = PET/P) across the contiguous U.S., including five different plant-functional type (PFTs) and > 100 site years of data. Phenology emerged as a key control over seasonal changes in EF and Gs. From our path analysis, the path coefficients linking canopy greenness → Gs → EF had the strongest influence over EF at our least-arid sites (i.e., $\Phi < 1$). In comparison, the total effect of either precipitation or VPD was highest in more arid ecosystems. These relationships indicate phenology can act as a dominant control over seasonal evapotranspiration and ecosystem water balance across a broad range of ecosystems. Understanding the strength of these linkages will become increasingly important for anticipating climate change impacts on the seasonality of the land-surface energy balance.

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Theme area:
LandAtm: Land

Abstract number: P33

Coupling stomatal resistance/photosynthesis algorithms of CLM model with COSMO model

Evgenii Churiulin, Merja Tölle, Vladimir Kopeikin, Markus Übel, Jürgen Helmert, Jean M. Bettems

Abstract:
Due to climate changes and warmer temperatures in mid-latitudes in spring there is a necessity in modernization of vegetation atmosphere interactions in the regional climate model COSMO-CLM. The phenological cycle in COSMO-CLM is based on a 6-year climatology, which follows the same sinusoidal fitted curve between its maximum and minimum value each year neglecting any influence or feedback on the environmental conditions. Moreover, COSMO-CLM applies highly simplified dependencies, and the canopy layer is represented as a "big-leaf". Although complex phenology and photosynthesis schemes exists in dynamic vegetation models (CARAIB, JSBACH, CLM, LPJ-GUESS, ORCHIDEE), these schemes have not been implemented for exploitation in COSMO-CLM. Here we show the results of updating the phenological cycle algorithms of COSMO-CLM based on algorithms which were implemented in CLM model. We have implemented the Ball and Berry approach for stomatal conductance, instead of Jarvis approach. As well, the photosynthesis algorithms were implemented in COSMO-CLM (Farquhar (for C3 grass) and Collatz (for C4 grass) models). We have tested COSMO-CLM with updates over 3 small domains with similar types of plants (C3 grass) located on the territory of Germany (near Linden, near Lindenberg, near Cologne) from 1999 to 2015. The data from the FLUXNET project were used as in-situ data for verification of our upgrades together with data from the meteorological observatory Lindenberg and the Climate Impact Research Station Linden. We also used the gridded datasets (E-OBS, HYRAS and GLEAM) to compare temperatures, precipitation, potential evaporation and transpiration values. The results are demonstrating significant improvements for calculating potential evaporation and transpiration. Because of that we are going to continue our work and implement the carbon allocation and plant growth for the next step.

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Theme area:
LandAtm: Land

Abstract number: P34

Leveraging land-atmosphere coupling to estimate evapotranspiration from weather data

Kaighin McColl, Shiliu Chen, Angela Rigden

Abstract:
Evapotranspiration (ET) is extraordinarily difficult to model because it depends, in part, on heterogeneous land surface features -- such as soil moisture, land cover type and plant physiology -- resulting in substantial disagreement between models. By leveraging the fact that the land and atmosphere are tightly coupled in many continental environments, we show that the evaporative fraction (ET as a proportion of available energy at the surface) can be estimated across a broad range of water- and energy-limited conditions using a simple, closed-form equation with no free parameters and no land surface inputs; only air temperature and specific humidity observations are required. The method is based on a recent theory of land-atmosphere coupling ('surface flux equilibrium' or SFE), which we here evaluate using multi-scale observations and climate models. The equation performs well when compared to daily eddy covariance measurements at 76 inland continental sites, with overall prediction errors indistinguishable from errors in the measurements themselves, despite substantial variability in surface conditions across sites. When evaluated against multiyear mean annual ET obtained from catchment water balance estimates from 221 catchments across the United States, the resulting error statistics are comparable to those in the catchment water balance estimates themselves. The theory is also reproduced well within a broad selection of CMIP6 climate models. In total, these results reveal an emergent simplicity to continental ET, in which land-atmosphere coupling efficiently embeds land surface information in the near-surface atmospheric state on daily to monthly time scales. This result allows ET to be studied globally using weather data, which have much greater spatial and temporal coverage compared to current ET observation networks.

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Theme area:
LandAtm: Land

Abstract number: P35

A tool for evaluation of target area homogeneity at ecosystem stations employing eddy covariance method

Ladislav Sigut, Thomas Wutzler, Tarek El-Madany, Milan Fischer, Mirco Migliavacca

Abstract:
Eddy covariance method relies on a number of assumptions that can be affected by a selection of station location. Most importantly, terrain of the target area should be flat, target area should be homogeneous and adequate air mixing should be achieved. Although possible shortcomings can be reduced by careful site inspection before tower installation (flat terrain) or can be corrected for during data post-processing (filtering of periods with low mixing), preliminary assessment of target area homogeneity is difficult as well as correction of its impacts afterwards. The influence of such inhomogeneities can lead to a bias in the flux annual sums but also a bias in their relationships with environmental variables. Certain solutions were already proposed, but target area homogeneity was so far assessed only at a few selected sites. Here we aim to provide a suit of software tools that build on the existing software and allow easy diagnosis of the situation at the given ecosystem station. We plan to provide directional analyses of variables of interest. This will allow to identify the wind sectors that show large deviations from the mean value of the whole target area. In a further step, we plan to combine footprint modeling with CO2 and energy flux measurements and thus provide attribution of mean (weighted) fluxes to their source area. Based on the differences with the directional analyses we will assess whether the higher computational expenses of footprint modeling are justified and bring additional information.

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Theme area:
LandAtm: Land

Abstract number: P36

Land/Sea breeze influence on atmospheric stability and turbulent fluxes over a subtropical semiarid coastal lagoon in the Gulf of California

Lidia I. Benítez-Valenzuela, Bernardo Figueroa-Espinoza, Manuel Helbig, Camilo Rey-Sanchez, Nidia E. Rojas-Robles, Crhistian A. Silva-Ontiveros, Jorge M. Uuh-Sonda, Enrico A. Yépez-González, Zulia M. Sanchez-Mejia.

Abstract:
The difference in surface temperature between the land and the sea creates a gradient that results in a breeze. Through this mechanism advection transports heat, that can enhance the turbulent kinetic energy (TKE) and the growth of the planetary boundary layer (PBL), and moisture that can deplete the height of the lifting condensation level (LCL). The North American Monsoon System drives the climate in the Sonoran coast of the Gulf of California, providing a unique opportunity to study the effect of land and sea breezes on local heat and moisture transport processes and land-surface atmosphere interactions overall. The objectives of this study are to characterize sea and land breeze over a coastal lagoon during the Pre- Monsoon, Monsoon, and Post-Monsoon season and analyze variation of atmospheric stability, turbulent fluxes, and LCL height under different seasonal and breeze conditions. The study site is a subtropical semiarid coastal lagoon, Estero El Soldado (MexFlux-EES), located in the Northwestern México (27°57.248’N, 110°58.350’W). Measurements were performed from January to December 2019 with an Eddy Covariance system (EC) and micrometeorological instruments over the water surface. Results show that sea and land breeze present a diurnal cycle, where sea breeze is more frequent during the day and land breeze at night. Sea breeze is more frequent and intense during the Pre-Monsoon and Monsoon seasons, while land breeze is more frequent during Post-Monsoon season. Atmospheric stability exhibited a diurnal cycle independently of seasons and breezes. During the Monsoon, sea breeze provides cooler humid air toward the land; in addition, with available energy for LE + H, and TKE, it leads to lower LCL (~ 800m) due to the amount of water vapor (q=23 g kg-1).

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Theme area:
LandAtm: Land

Abstract number: P37

Surface energy budget and the interaction with the evapotranspiration in an urbanized valley, Medellín (Colombia)

Paola Andrea Montoya Lopera, Laura Herrera-Mejía, Janet Barco

Abstract:
Urban surfaces can represent a significant challenge for understanding the structure, variability and dynamics of the Atmospheric Boundary Layer. The variety of building materials and human activities can impact in many ways the exchange of mass and energy between the soil and the atmosphere and therefore the local meteorology, impacting variables such as evapotranspiration. This variable plays an important role in hydrological and meteorological modeling at both regional and global levels, consequently, the correct estimation of the evapotranspiration is necessary for an adequate management of water resources. Different efforts have been made to develop ETP estimation methodologies, being the energy balance based the most accurate; nevertheless, due to the difficulty of obtaining heat flux data to the ground, this is usually neglected.

In this research data from an Eddy Covariance Flux tower located in the Aburrá Valley Colombia, a densely urbanized complex terrain, was used to estimate potential evapotranspiration (ETP), then the energy balance was used to estimate the amount of net radiation converted into storage heat flux on soil/urban-structures (SSHF). Furthermore, the potential evapotranspiration was estimated using Penman's methodology, with and without considering the SSHF. The results show that between 30% and 60% of the net radiation is converted into SSHF, accumulating a large amount of energy on the city surfaces and subsequently released during the night, causing latent and sensible heat fluxes to remain positive even at night. Neglecting this flux produce overestimates in ETP during the day and underestimates during the night, generating zero or negative nighttime evapotranspiration values. These results highlight the importance of the stored heat flux in soils and urban structures in the water and energy balance in urban areas.

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Theme area:
LandAtm: Land

Abstract number: P38

Understanding the Impacts of Land Surface and PBL Observations on the Terrestrial and Atmospheric Legs of Land-Atmosphere Coupling

Patricia Lawston-Parker, Joseph Santanello, Sujay Kumar

Abstract:
Accurately representing land-atmosphere (L-A) interactions and coupling in NWP systems remains a challenge. New observations, incorporated into models via assimilation or calibration, hold the promise of improved forecast skill, but erroneous model coupling can hinder the benefits of such activities. To better understand model representation of coupled interactions and feedbacks, this study demonstrates a novel framework for coupled calibration of the Single Column Model (SCM) capability of the NASA Unified Weather Research and Forecasting (NU-WRF) system coupled to NASA's Land Information System (LIS). The local land-atmosphere coupling (LoCo) process chain paradigm (Santanello et al. 2018) is used to assess the processes and connections revealed by calibration experiments. Two summer case studies in the U. S. Southern Great Plains are simulated in which LSM parameters are calibrated to diurnal observations of LoCo process chain components including 2-meter temperature, 2-meter humidity, surface fluxes (Bowen ratio), and PBL height. Results show a wide range of soil moisture and hydraulic parameter solutions depending on which L-A variable (i.e. observation) is used for calibration, highlighting that improvement in either SHP or ISM when not in tandem with the other can provide undesirable results. Overall, this work demonstrates that a process chain calibration approach can be used to assess L-A connections, feedbacks, strengths, and deficiencies in coupled models, as well as quantify the potential impact of new sources of observations of land-PBL variables on coupled prediction.

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Theme area:
LandAtm: Land

Abstract number: P39

Improving the global modeling of soils in JULES and the Unified Model: Updating from UM/HWSD to SoilGrids soil properties and from the Brooks & Corey to the van Genuchten soil-hydraulics model

Patrick C. McGuire, Pier Luigi Vidale, Martin J. Best, David H. Case, Imtiaz Dharssi, Maria Carolina Duran Rojas, Rosalyn S. Hatcher, Grenville M.S. Lister, Alberto Martinez de la Torre, Carsten Montzka, Omar V. Müller, Valeriu Predoi, Eddy Robertson, Markus Todt, Anne Verhoef, Simon S. Wilson

Abstract:
We have updated the soil properties used in JULES (Joint UK Land Environment Simulator), which is the land-surface component of the UM (Unified Model, the UK Met Office's climate model). JULES models the interaction of the land surface with the atmosphere, and simulates the energy, water, and carbon fluxes. JULES allows either: (i) the Brooks & Corey (BC) model for estimating soil hydraulic properties, or (ii) the van Genuchten (VG) model but using hydraulic parameters translated from the BC model. One advantage of the VG model over the BC model is the smoother dependence of water retention upon matric potential for nearly saturated soils. Herein, we report on our work towards fully implementing the VG model in JULES and in the UM, through the implementation and evaluation of several VG pedotransfer functions (PTFs) for estimating the soil hydraulic parameters used in the hydraulic functions.

We have tested three VG PTFs in global offline JULES runs (driven with WFDEI data over 1979-2012): the combination of Tóth et al. PTFs 17 & 20, the Weynants et al. PTF, and the Zhang & Schaap ROSETTA3 H1 PTF (modified for sandy soils). We also modernized the soil basic properties that are conventionally used for JULES and the UM, from the UM version of the Harmonized World Soil Database (HWSD) to the SoilGrids database.

Evaluation of JULES simulations shows (i) that the modified version of the Zhang & Schaap ROSETTA3 H1 PTF is the best VG option, and (ii) that it compares favorably with the BC control model (which uses the Cosby et al. PTF and the UM/HWSD soils), in terms of the surface energy balance and the mitigation of near-surface temperature biases over mid-latitude continental regions. This modified version of the Zhang & Schaap ROSETTA3 H1 PTF with SoilGrids soils is also currently being used in coupled land-atmosphere UM runs.

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Theme area:
LandAtm: Land

Abstract number: P40

Site characteristics mediate the relationship between forest productivity and satellite measured solar induced fluorescence

Theresia Yazbeck, Gil Bohrer, Pierre Gentine, Luping Ye, Nicola Arriga, Christian Bernhofer, Peter D. Blanken, Ankur R. Desai, David Durden, Alexander Knohl, Natalia Kowalska, Stefan Metzger, Meelis Mölder, Asko Noormets, Kim Novick, Russell L. Scott, Ladislav Šigut, Kamel Soudani, Masahito Ueyama, Andrej Varlagin

Abstract:
Solar-Induced Chlorophyll Fluorescence (SIF) can provide key information about the state of photosynthesis and offers the prospect of defining remote sensing-based estimation of Gross Primary Production (GPP). There is strong theoretical support for the link between SIF and GPP and this relationship has been empirically demonstrated using ground-based, airborne, and satellite-based SIF observations, as well as modeling. However, most evaluations have been based on monthly and annual scales, yet the SIF:GPP relationship can be strongly influenced by both vegetation structure and physiology. Here, we test how well SIF can predict the inter-daily variation of GPP during the growing season and under stress conditions, while taking into account the local effect of sites and abiotic conditions. We compare the accuracy of GPP predictions from SIF at different timescales, while evaluating effect of adding environmental variables to the relationship. We utilize observations for years 2018-2019 at 31 mid-latitudes, forested, eddy covariance (EC) flux sites in North America and Europe and use TROPOMI satellite data for SIF. Our results show that SIF is a good predictor of GPP, when accounting for inter-site variation, probably due to differences in species composition and canopy structure. Seasonally-averaged leaf area index and canopy conductance provide a predictor to the site-level effect. We show that light saturation is the main factor driving errors in the linear model at high temporal resolution. Adding water stress indicators, namely VPD, LE, and canopy conductance, to a multi-linear SIF-based GPP model provides the best improvement in the model precision, showing the importance of accounting for water stress in GPP predictions, independent of the SIF signal. SIF is a promising predictor for GPP among other remote sensing variables, but more focus should be placed on including canopy structure, water stress, and light saturation effects in the relationship.

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Theme area:
LandAtm: Land

Abstract number: P41

Assessment of arctic treeline migration impacts on regional climate in Northwest Territories near Inuvik

Vincent Graveline

Abstract:
The boreal forest ecosystem is currently migrating into the arctic tundra ecosystem. This migration will lead to structural and functional changes since these two ecosystems have very different land surface characteristics. The land surface directly affects the atmosphere at the local and regional scale trough the exchange of energy and water vapor. Therefore, these exchanges influence the local air temperature and moisture content in the lower atmosphere. My project aims to explain differences in air temperature and humidity between boreal forest and tundra ecosystems near Inuvik, NWT. To explain theses differences, I am investigating the controls of biophysical characteristics and depth of the atmospheric boundary layer on air temperature and humidity. This is accomplished by a characterisation of seasonal variations in energy partitioning and the modelling of boundary layer properties. I am using long term eddy covariance measurements from Travail Valley Creek research station in arctic tundra (68°45' N 133°30'W) and Havikpak Creek research station in the boreal forest (68°20'N 133°30' W). These two sites characterize the arctic treeline Ecotone near Inuvik. These measurements allow the characterisation of seasonal variations in turbulent fluxes, in biophysical characteristics like surface resistance and will serve as input for the atmospheric boundary layer model. The atmospheric boundary layer model is driven by turbulent fluxes. It will be validated by using radiosonde data from balloons sounding that are deployed at Inuvik Airport, 2km from the boreal forest site. By validating the model for the boreal forest ecosystem, it will then be possible to apply the model to the tundra ecosystem and then explain the differences in air temperature and humidity between the two ecosystems.

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Theme area:
LandAtm: Land

Abstract number: P42

Soil moisture drydown curves after flooding events across an irrigated farmland

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Abstract:
Soil moisture (□) is a key variable for agriculture, however a gap remains in observations at intermediate scales, the cosmic-ray neutron sensor (CRNS) is a novel tool for such applications. We designed an experiment using a CRNS and time domain reflectometry (TDR at vegetated and bare soil sites) to measure □ in the Yaqui Valley, where wheat (Triticum spp) is the main crop and water is managed by flooded irrigation. We used a drydown analysis of the daily rate at which □ is lost (□decay) after every irrigation, and the amount of □ that represents 1/3 of the remaining □ as soil dries (□threshold). Statistical analysis included multivariate correlations (Spearman) and a principal components analysis (PCA) using □ , meteorological variables, and vegetation greenness. With TDR's we observed differences in □decay, it was higher at the vegetation site □decay= 0.53 cm3/cm3 /day, while □threshold was higher at bare soil site 0.33 cm3/cm3. The □decay observed with the CRNS was higher for the 2nd and 3rd irrigation (0.7 cm3/cm3 /day and 0.16 cm3/cm3 /day, respectively). After each irrigation, the meteorological variables correlated with □ varied, highlighting air temperature (Tair, r=-0.7) in the 1st irrigation, evapotranspiration (ET, r>0.5) and vapor pressure deficit (VPD, r=0.6, r=-0.8) for the 2nd and 3rd irrigation, and normalized difference vegetation index (NDVI, r=0.8) for the 3rd irrigation. The variation explained by PC1 and PC2 increases with each irrigation event, relevant variables in PCA where □, Tair, VPD, NDVI, and precipitation. The results of this study suggest that CRNS is a suitable technique at field scale and that drydown curves are useful to quantify soil dryness and the influence of meteorological variables and crop development, thus providing an opportunity for water management in agriculture.

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Theme area:
LandAtm: Land

Abstract number: P43

An emergent spatial Water/Energy/Carbon relationship explained by local coupling

Daniel Short Gianotti, Dara Entekhabi

Abstract:
The terrestrial water, energy, and carbon cycles co-vary in space and time, both due to instantaneous fluxes between the cycles (e.g., root water uptake, turbulent heat fluxes) and spatial co-ordination over biogeographical timescales. We present observations of an emergent spatial relationship between a location's mean turbulent flux partitioning (evaporative fraction) and landscape photosynthesis (gross primary productivity)over the Contiguous United States, a convex curve suggesting a dominant role of vegetation cover vs. water use efficiency—each of which pull on available water in different directions. We show that this relationship can be explained by observable coupling between daily-scale water, energy, and carbon fluxes. We present evidence of a sub-seasonal negative relationship between water-use efficiency and vegetation cover fraction. We propose the use of this spatial W/E/C coupling relationship as a benchmark in Earth System Models and suggest ramifications for landscape stability, ecosystem "optimality" theories, and bridging bio-meteorology and bio-climatology.

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Theme area:
LandAtm: Land

Abstract number: P44

Direct Partitioning of Eddy-Covariance Water and Carbon Dioxide Fluxes into Ground and Plant Components

Einara Zahn, Elie Bou-Zeid, Stephen Good, Gabriel Katul, Khaled Ghannam, James Smith, Marcelo Chamecki, Nelson Dias, Jose Fuentes, Joseph Alfieri, Kelly Caylor, Zhiqiu Gao, Keir Soderberg, Nicolas Bambach, Lawrence Hipps, John Prueger,William Kustas

Abstract:
The partitioning of evapotranspiration into evaporation (E) and plant transpiration (T) is essential for better quantification of water and energy budgets. Similarly, the associated partitioning of total CO2 flux into soil respiration (R) and photosynthesis (P) is required to advance the understanding of the role of various biomes as carbon sinks or sources. Promising partitioning approaches are methods based on the analysis of conventional high-frequency eddy-covariance (EC) data, which require a smaller number of input parameters and are simple to implement. In this work, we propose a new partitioning approach — the Conditional Eddy Covariance (CEC) — solely based on the similarity of scalars transport and conditional sampling. Its performance across different sites (forests and crops) was compared to two previously proposed techniques, the Flux-Variance Similarity method (FVS) and the Modified Relaxed Eddy Accumulation (MREA) method. We then evaluate the results for transpiration obtained by the three methods over a grass site in Kenya, which has independent T estimates from leaf-level measurements and the stable isotope technique. For this site, CEC results in the best agreement with both leaf-level and isotopic estimates, with the smallest root-mean square error (5−6.3 Wm-2) and correlation coefficient larger than 0.83. Considering the results from the Kenya and other sites, our results indicate that CEC, FVS, and MREA tend to agree more (and to perform better) in sparse canopies with negative net CO2 flux, and when the measurements are collected close to the canopy. In order to conduct further validations of the three partitioning methods, we recommend more experiments that satisfy the conditions for their implementation; in addition, we recommend below and above canopy EC measurements, which would provide an estimate of soil fluxes and also allow the investigation of canopy mixing and its impact on the assumptions embedded in each of the three methods.

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Theme area:
Micrometeorology

Abstract number: P45

Non-Closure of Surface Energy Balance Linked to Asymmetric Turbulent Transport of Scalars by Large Eddies

Heping Liu, Zhongming Gao, Gabriel Katul

Abstract:
How large turbulent eddies influence non-closure of the surface energy balance is an active research topic that cannot be uncovered by the mean continuity equation in isolation. It is demonstrated here that asymmetric turbulent flux transport of heat and water vapor by sweeps and ejections of large eddies under unstable atmospheric stability conditions reduce fluxes. Such asymmetry causes positive gradients in the third-order moments in the turbulent flux budget equations, primarily attributed to substantially reduced flux contributions by sweeps and sustained large flux contributions by ejections. Small-scale surface heterogeneity in heating generates ejecting eddies with larger air temperature variance than sweeping eddies, causing asymmetric flux transport in the atmospheric surface layer. Changes in asymmetry with increasing instability are congruent with observed increases in the surface energy balance non-closure. To assess the contributions of asymmetric flux transport by large eddies to the non-closure requires two eddy covariance systems on the tower to measure the gradients of the turbulent heat flux and other third-order moments.

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Theme area:
Micrometeorology

Abstract number: P46

Short-term ecosystem responses to microclimate drives decadal water use efficiency trends

William Riley, Trevor Keenan

Abstract:
The terrestrial carbon and water cycles are primarily driven by photosynthesis and transpiration that are both regulated by plant stomatal conductance. This physiological link affects ecosystem responses to microclimate and modulates carbon, energy, and water exchanges between the biosphere and the atmosphere. The relationship between water losses via transpiration relative to carbon gains via photosynthesis can be quantified by plant water-use efficiency (WUE). Recent increase in WUE is qualitatively consistent across leaf to ecosystem scales; however, the unexpectedly large multi-year WUE trends inferred from the ecosystem scale have challenged the ecophysiology represented in Earth System Models. Here, we analyze the ecosystem-scale WUE inferred from 40 FLUXNET sites with at least 10 years of measurements. Our results demonstrate that observed ecosystem-scale WUE trends are caused by short-term microclimatic conditions instead of decadal climate trends. In particular, short-term variations in solar radiation and turbulence strength are the most important factors contributing to higher ecosystem-scale WUE and WUE trends. Earth System Models participating in CMIP6 did not capture the large ecosystem-scale WUE sensitivity to microclimate inferred from measurements. Collectively, our findings suggest that ecosystem-scale WUE trends reflect water-carbon interactions across multiple temporal scales, and disentangling factors contributing to emergent ecosystem responses is needed to infer ecophysiological relationships and model structures from observations.

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Theme area:
Micrometeorology

Abstract number: P47

Soil moisture assimilation in Regional NCUM

Abhishek Lodh, Ashish Routray, Devajyoti Dutta and John P. George

Abstract:
The land surface processes are represented through land surface models (viz. JULES) in the global and regional NWP systems. Hence it is important to initialize the land surface variables with reliable observations in the NWP system. Soil moisture is an important variable controlling the partitioning of moisture and energy fluxes at the surface, which play a major role in the energy and water budget during the Indian monsoon season. An Extended Kalman Filter (EKF) based global and regional soil moisture data assimilation system (SMDAS) has been implemented to improve the soil moisture initial conditions in the high resolution (4km) regional NWP system NCUM-R (NCMRWF Unified Model-Regional) coupled with JULES land surface model. The soil moisture assimilation system uses screen-level temperature and humidity information as well as satellite measured soil moisture estimates from ASCAT instrument on board MetOp-A and B satellites. The soil moisture analysis from both global and regional SMDAS is compared against ERA5 analysis during January 2021 period, with shows reduced RMSE from regional NCUM-R simulations using improved soil moisture initial conditions prepared by SMDAS over Indian region.

An Observing System Experiment has been carried out to assess the impact of ASCAT soil moisture observations used in SMDAS on the NCUM-R forecast. A depression case over coastal Odisha during 19thJuly to 23rd July 2018 has been studied in detail. Soil moisture analysis and forecasts are modified wherever satellite soil moisture observations (ASCAT) are available. Forecasts of near surface and lower tropospheric variables show good agreement with ERA5 reanalysis. Track errors of the monsoon depression during 21st – 23rd July 2018 reduced in the forecast due to soil moisture assimilation. Good positive impact of assimilation of ASCAT soil moisture on the analysis and forecasts is noticed in this study.

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Theme area:
Modeling

Abstract number: P48

Exploring the respirations of active biomass, structural biomass, and soil in biosphere interactions modeling

André Santos and Maurício Gobbi

Abstract:
The impacts of climate change on the biological world vary spatially. Species can adapt, migrate, or die in response to the greenhouse effect and its consequences. An issue is the productivity loss in plantations or the need to exchange traditional crops for others with climate resilience. In this context, photosynthesis and respiration processes are essential for studies on vegetation development, nowadays with attentiveness to autotrophic and heterotrophic respiration due to their relationship with temperature increases.

The use of respiration products by plants varies during its phenological stages. We sought to understand the CO2 flux of the vegetation in more detail, testing different respiration calculations, dependent or not on photosynthesis, for the various compartments of a plant. We tested combinations between three modules for active biomass respiration, two modules for structural biomass respiration, and one module for soil respiration. Surface fluxes were measured at a soybean plantation in Argentina using the eddy covariance method (Posse et al., 2014).

Models with different respiration implementations had similar responses to latent and sensible heat predictions during the crop's full development. However, slight variations were observed for CO2 flux during daylight and significant variations for the night period. Soil temperatures and humidities predictions were also influenced, especially in the root layer. Modules for the active biomass respirations had differents sensitivities to leaf temperature and root zone moisture, and as expected, affected the biomass growth. Structural and soil respiration were sensitive to temperature and do not directly influence biomass growth.

In SVAT modeling, photosynthesis/respiration, biomass growth, and soil properties interact dynamically. Thus, biosphere models with the partitioning of the CO2 flux can better detail biological processes with interactions between the surface-vegetation-atmosphere feedback.

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Theme area:
Modeling

Abstract number: P49

The Atmospheric Raman Temperature and Humidity Sounder

Diego Lange, Andreas Behrendt, Volker Wulfmeyer

Abstract:
Due to a lack of suitable measurements, the thermodynamic field of the lower troposphere must still be considered as Terra Incognita in our Earth system. Recently, a thermodynamic profiler was developed based on the Raman lidar technique, which has the potential to close these measurement gaps.

We call this instrument the Atmospheric Raman Temperature and Humidity Sounder (ARTHUS). ARTHUS can be operated on ground-based, ship-borne and airborne platforms. Due to an advanced design of the transmitter and the receiver, simultaneous profiling of temperature and water-vapor mixing ratio is possible with unprecedented accuracies and resolutions. Typical resolutions are a few seconds and 7.5 m in the lower atmospheric boundary layer and 10 s and 100 m from the surface to the lower troposphere during day and night resulting in statistical errors of approx. 1 K and 10 % for mixing ratio. The bias is < 0.5 K and approx. 5 % for mixing ratio. The special design of the receiver permits measurements in clouds and rain up to an optical thickness of approx. 2.

Very stable 24/7 operations on ground-based and shipborne platforms were achieved during several field campaigns and at the Land Atmosphere Feedback Observatory (LAFO, see https://lafo.uni-hohenheim.de/en) accumulating to almost a year of data and covering a huge variety of weather conditions.

We demonstrate that ARTHUS is capable of resolving (1) the strength of the inversion layer at the atmospheric boundary layer (ABL) top and thus the ABL depth zi, (2) elevated lids in the free troposphere, and (3) turbulent fluctuations in mixing ratio and temperature. In combination with Doppler lidar, the latter permits measurements of sensible and latent heat flux profiles in the convective ABL and thus flux-gradient relationships. Consequently, ARTHUS can be applied for process studies such as land-atmosphere feedback, weather and climate monitoring, model verification, and data assimilation in weather forecast models.

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Theme area:
Remote sensing

Abstract number: 50

Investigating the impact of temperature dependence of photosynthesis on CO2 and CH4 fluxes in an Amazonian peatland with the E3SM Land Model

Fenghui Yuan, Daniel M. Ricciuto, Daniel T. Roman, Jeffrey D. Wood, Erik Lilleskov, Hinsby Cadillo-Quiroz, Xiaofeng Xu, Randall Kolka, Lizardo Fachin, Timothy J. Griffis

Abstract:
Plant photosynthesis is temperature dependent mainly due to the sensitivities of photosynthetic enzymes of and the electron transport chain to temperature, and the stomatal responses to leaf-to-air vapor pressure (VPD). For tropical species, their carbon sequestrations are thought to be more susceptible to climate warming due to a narrower range of temperatures than other regions. However, it is still not clear which process dominates the response of photosynthesis to temperature in tropical peatland, and how this process impacts the CO2 and CH4 fluxes at ecosystem level.

Here, we studied the impact of temperature dependence of photosynthesis on CO2 fluxes and CH4 fluxes in an Amazonian palm swamp peatland using the E3SM land model (ELM). A combination of the Farquhar–von Caemmerer–Berry photosynthesis (FvCB) model and the Ball–Berry stomatal conductance model was used for photosynthesis simulation. Temperature dependent parameters were estimated from observational CO2 and CH4 fluxes (2018-2019) and other field data. A parameter sensitivity analysis using a Latin hypercube sampling approach was performed to determine the key process controlling the temperature response of photosynthesis.

Preliminary results showed that after temperature dependence function improvement, the parameterized model can capture the responses of the photosynthetic processes to temperature changes better. Stomatal control is more important for the plant carbon sequestration in Amazonian palm swamp peatland, although the photosynthetic enzymes process is also sensitive to temperature. The temperature dependence of photosynthesis significantly affected the ecosystem CO2 and CH4 fluxes in the tropical peatland, mainly on the processes of autotrophic respiration and methane transport through aerenchyma. This study will offer an opportunity to explore future CO2 and CH4 fluxes in tropical peatlands under climate warming with the earth system model.

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Theme area:
Modeling

Abstract number: 51

Exploring land-atmosphere interactions in alpine regions: machine learning vs. mathematical modeling

Thomas Y. Chen

Abstract:
With the rise in the availability and importance of big data, machine learning approaches in the field of land-atmosphere interactions, including specifically in the alpine regions, have rapidly become more prevalent in the scientific literature. Artificial intelligence is a fast-changing field, with deep learning techniques (with important applications in computer vision) popularized in the last decade. Weather and climate forecasting using machine learning approaches has been shown to enhance conventional statistical techniques. Methods break down into a few major categories, including now-casting, short-range weather prediction, medium-range prediction, sub-seasonal forecasting, seasonal forecasting, and climate-change prediction. In this session, we raise the questions, will artificial intelligence totally replace numerical models? If not, how can they supplement or enhance the performance and results of traditional mathematical models? How can we continue to prioritize domain-specific knowledge in interdisciplinary collaborations? In this scope, the answer to these questions can be different for the various subareas of study within meteorological modelling. For instance, “Hard AI” refers to applications in which predictions on the corresponding timescales can be largely or completely replaced by artificial intelligence; in this case, physical constraints, like conservation laws, are able to be ignored as marginal errors that do not accumulate to a significant level over time. Mobile phone data is an excellent source of data for this purpose, as it provides a large database of information to work with, which is necessary for machine learning. In general, a wide range of machine learning algorithms and models have use cases in alpine meteorology, from linear regression, to random forest ensembles (RFs), to convolutional neural networks (CNNs), to generative adversarial networks (GANs).

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Theme area:
Modeling

Abstract number: 52

Methodology to determine the coupling of continental clouds with surface from lidar and meteorological data

Zhanqing Li, Youtong Zheng

Abstract:
The states of coupling between clouds and surface or boundary-layer have been investigated much more extensively for marine stratocumulus clouds than for continental low clouds, partly due to more complex thermodynamic structures over land. A manifestation is a lack of robust remote sensing methods to identify coupled and decoupled clouds over land. Here, we have generalized the concept of coupling and decoupling to low clouds over land, based on potential temperature profiles. Furthermore, by using ample measurements from a lidar and a suite of surface meteorological instruments at the U.S. Department of Energy's Atmospheric Radiation Measurement Program's Southern Great Plains site from 1998 to 2019, we have developed a method to simultaneously retrieve the planetary boundary layer (PBL) height (PBLH) and coupled states under cloudy conditions during the daytime. The coupled states derived from lidar show strong consistency with those derived from radiosondes. Retrieving the PBLH under cloudy conditions that has been a persistent problem in lidar remote sensing, is resolved in this study. Our method can lead to high-quality retrievals of the PBLH under cloudy conditions and the determination of cloud coupling states. With the new method, we find that coupled clouds are sensitive to changes in the PBL with a strong diurnal cycle, whereas decoupled clouds and the PBL are weakly related. Since coupled and decoupled clouds have distinct features, our new method offers an advanced tool to separately investigate them in climate systems.

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Theme area:
LandAtm: Atm

Abstract number: 53

Temporal relationships of PERSIANN and MODIS-NDWI satellite images in Tamil Nadu, India

Venkadesh Samykannu

Abstract:
Remote sensing images provide key information to monitor environmental problems in near-real time over large areas. This study investigated the temporal relationships of PERSIANN-rainfall and MODIS-NDWI condition for seven zones of Tamil Nadu, India between 2015 and 2017 to measurements of seasonal variations during majorly received rainfall period of north east monsoon from October to December. Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks- Cloud Classification System- (PERSIANN-CCS) and Moderate Resolution Imaging Spectro-radiometer (MODIS) combined 16-Day normalized difference water index (NDWI) were used in this study. From this study evaluated, PERSIANN recorded a minimum precipitation of 219.87, 59.83 and 171.65 mm and a maximum precipitation of 1,411, 244 and 723 mm, respectively. NDWI during NEM grouped 11.07, 35.19 and 17.79 percent of croplands of Tamil Nadu as stressed due to drought during 2015, 2016 and 2017, respectively. Among different zones, North Western Zone (2,10,375 ha), Southern Zone (9,78,275 and 6,95,050 ha) registered maximum area under stress in the corresponding years. Among the three years of study in Tamil Nadu, 2016 was classified under severe risk category of agricultural drought based drought severity index. While Western, North Western and Southern Zone were classified under severe agricultural risk during the NEM of 2016. This study require to extend for long term period for better investigation with Further study is require to investigate the NDWI value for long term period

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Theme area:
Remote sensing