U.S. DEPARTMENT OF ENERGY | Office of Science

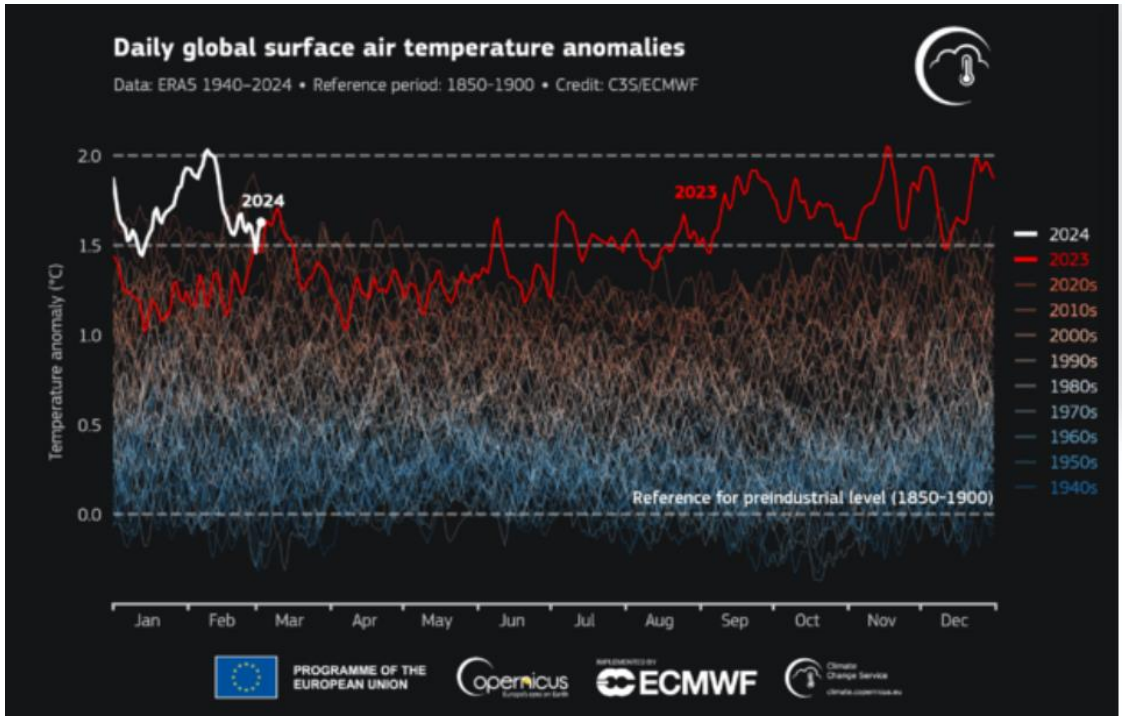
Earth and Environmental Systems Sciences Division

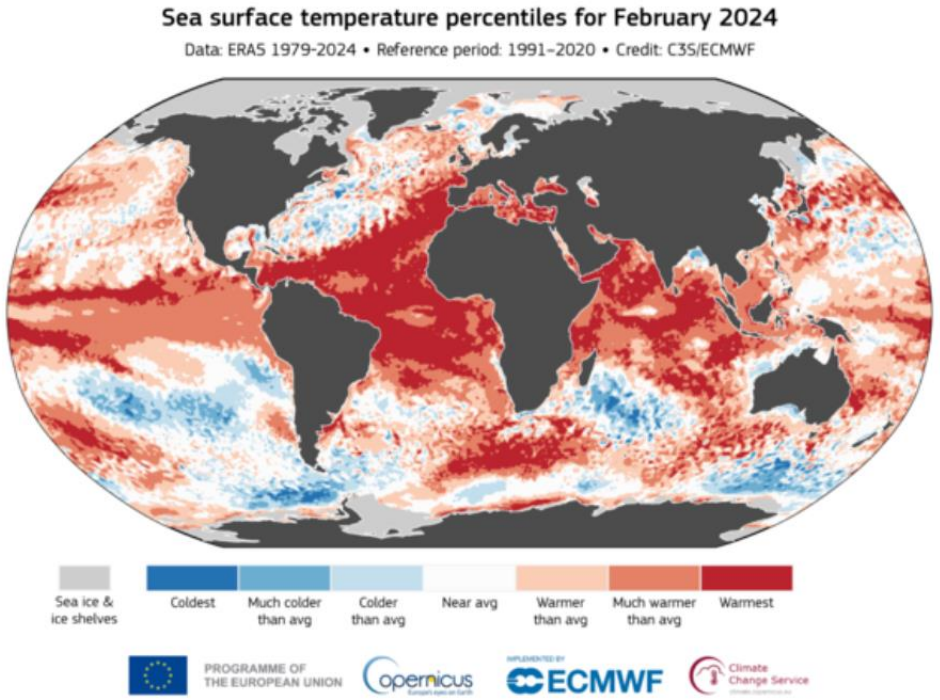
BERAC Update

Gary Geernaert

April 11, 2024

What's Happened Since October 2023





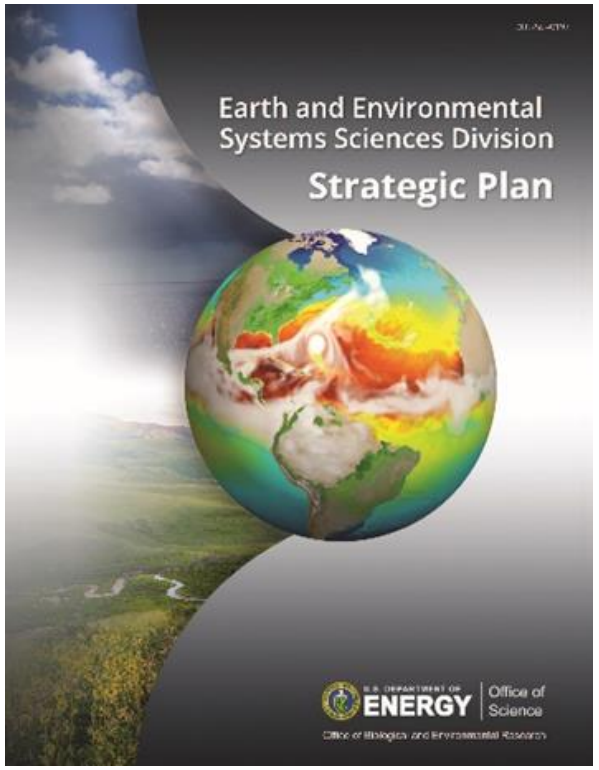
Texas wildfire
CA snowfall
MI tornado

Preview of our next Strategic Plan 2024-2029

EESSD's Vision: To enhance the seasonal to multi-decadal scale predictability of the Earth system using long term field experiments, DOE user facilities, modeling and simulation, uncertainty characterization, best-in-class computing, process research, and data analytics and management in order to inform the development of advanced solutions to the Nation's energy challenges.

What's going to be new

- Culture will have greater emphasis on DEI
- Disturbance and extremes will have greater emphasis across portfolios
- Predictability extends to shorter time scales, e.g., sub-seasonal to multi-decadal
- Applied offices and stakeholders connected to basic research investments
- Strengthened coordination/collaboration across facilities
- Collaborative investments with BSSD
- Mapping to a new higher level strategy for BER



Management Updates – PI Meetings

PI Meeting	Dates	Location
E3SM PI Meeting	Nov 7-8, 2023	Bethesda, MD
ESS PI Meeting	April 15-17, 2024	Reston, VA
Modeling PI Meeting	August 5-8, 2024	Rockville, MD
Urban IFLs PI Meeting	Oct 28-29, 2024	Rockville, MD
ARM/ASR PI Meeting	Fall 2024	Rockville, MD

Management Updates – Major Reviews in FY2023-2024

Lab	Program	Type	Review date	Decision	Date
PNNL	ESS	COMPASS-FME	June 13-15, 2023	Accept	Nov 21, 2023
ANL/LLNL	ESS	Terrestrial wetland function SFA	Nov 2-3, 2023	Accept w/R	Feb 6, 2024
LBNL/SLAC	ESS	Watershed Function SFA	Nov 7-8, 2023	Accept w/R	Mar 1, 2024
LBNL	Modeling	CASCADE	Nov 30-Dec 1, 2023	Accept	Mar 12, 2024
PNNL	Modeling	WACCEM	Dec 4-5, 2023	Accept	Mar 12, 2024
ORNL	ESS	NGEE Arctic	Feb 26-27, 2024	Accept	April 3, 2024
PNNL	ESS	River Corridor Hydrobiogeochem SFA	July 9-10, 2024		
LBNL	ESS	NGEE Tropics	July 16-17, 2024		
ORNL/ANL	Data	ESGF review	Aug 13-14, 2024		
LBNL	Data	ESS-DIVE	Aug 27-28, 2024		
Penn State	Modeling	PCHES Cooperative Agreement	Sept 9-10		
PNNL et al	ARM	ARM facility triennial review	Sept 16-18, 2024		
PNNL	Modeling	COMPASS-GLM; ICOM	Nov 2024		
LANL	Modeling	Interface	Nov 2024		
PNNL	ASR	PASCALLS SFA	Nov 2024		

Management Updates – Solicitations in 2024

Funds	Program lead	Issued	Proposals	Panel (2022)	Selections tbd
FY24	ARM Mobile Facility AMF1 FOA	Jan 2024	7		1
FY24	Climate Resilience Centers FOA	Oct 18, 2023	43	April 23-24	8-12
FY24	ASR FOA	Oct 19, 2023	101	Mar 28-29, Apr 5-6, 9-10	15-20
FY24	ESS FOA	Oct 30, 2023	70	May 5-9	5-10
FY24	Modeling FOA	Nov 29, 2023		May 23-24, 30-31	10-12
FY24	Early Career (ASR) FOA	Dec 20, 2023		May 21-23	3-5
FY24	Funding for Accelerated Inclusive Res.	Mar 12, 2024			
FY24	Reaching a New Energy Workforce	Mar 12, 2024			
FY25	EESSD Southeastern US Research	June 2024		Fall 2024	16-20
FY24	Marine clouds and ships lab call	June 2024			1

Management Updates – Workshops FY23-24

Workshop	Program	Dates	Location
Southeast Land-Atmosphere Research Opportunities (SELARO)	ESS	Aug 23-24, 2023	Virtual
MSD Community of Practice Workshop	Modeling	October 3-5, 2023	UC Davis, hybrid
Decision Relevant Regional Climate Projections	Interagency	Oct 24-26, 2023	LBNL, hybrid
New Directions in Atmospheric Ice Processes Workshop	ASR	Oct 25-27, 2023	Richland, WA
IHTM Interagency Workshop	Interagency	Oct 31-Nov 1	Washington, DC
CAMAS – Community Arctic Science		Feb 13-16, 2024	Santa Fe, NM
Future of LASSO Workshop	ARM	Nov 2-3, 2023	Boulder, CO
Observing marine aerosols-clouds from ships	ASR	March 18-19, 2024	Virtual
Southeast Coastal Research workshop	All programs	March 26-28, 2024	Virtual
Cyberinfrastructure workshop	ESS	April 15, 2024	Reston, VA
Climate Modeling Summit; coupled data assimilation worksho	Modeling	May 1-3, 2024	GFDL, Princeton
Energy Modeling Forum – urban	Modeling	June 24-28, 2024	Snowmass
Lessons learned and best practices from past ecological	ESS, etc.	Fall 2024	
Modeling and Metrics associated with CMIP	Modeling	Fall-Winter 2025	

SCREAM: E3SM's Global Cloud Resolving Model

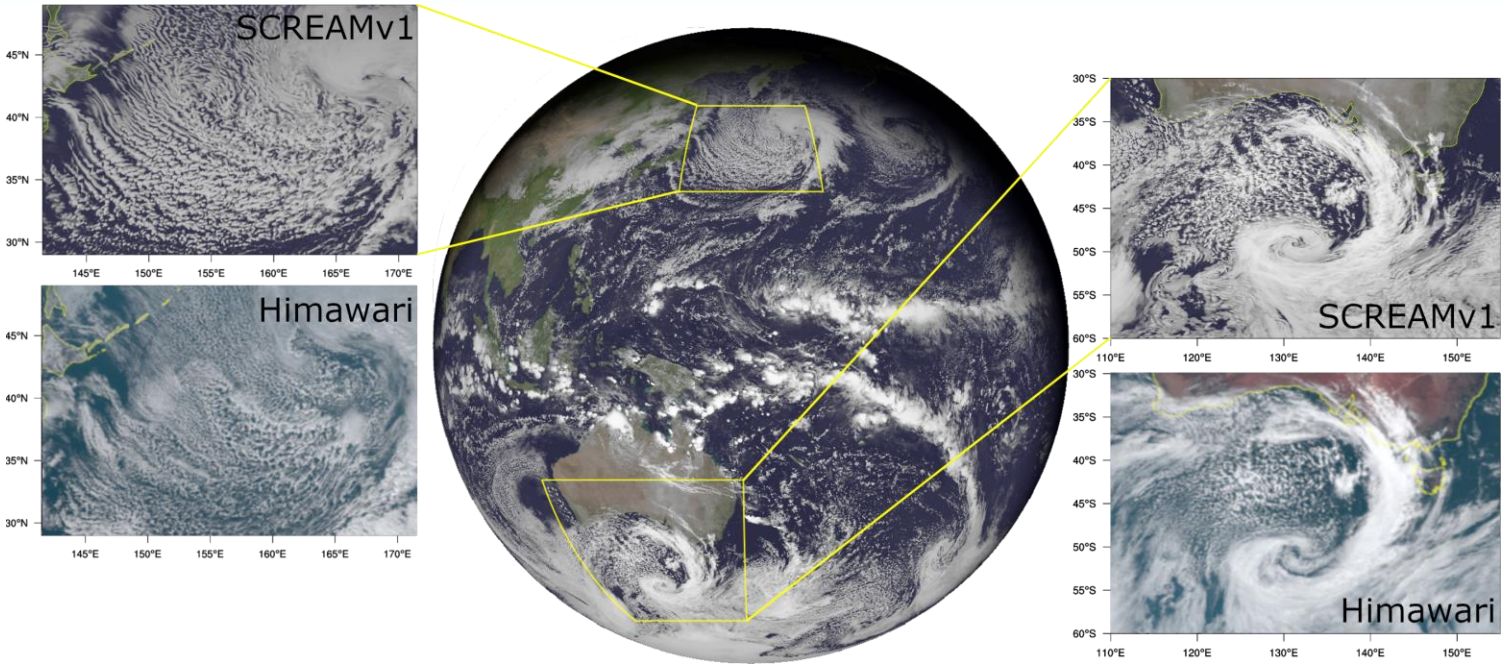
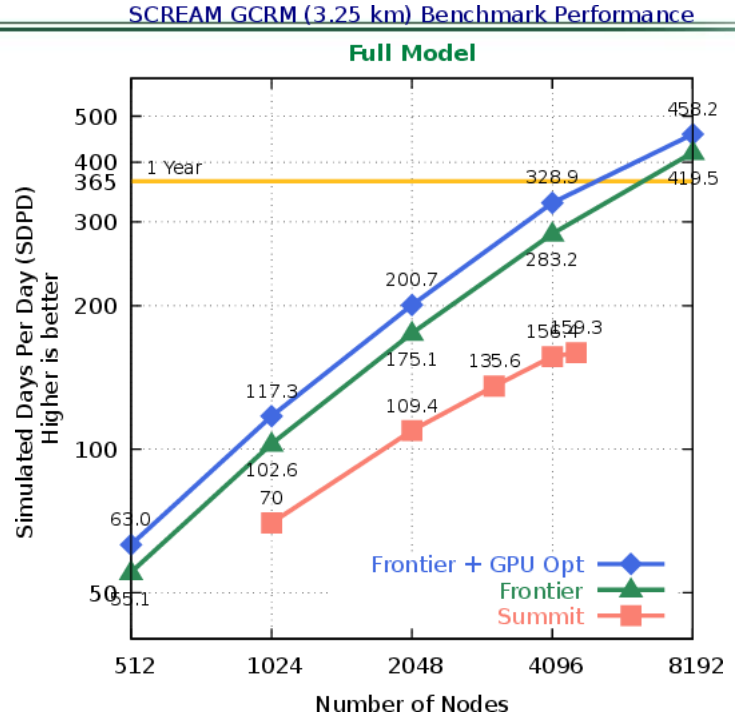


Image from a 40 day SCREAM DYAMOND simulation. Shortwave cloud radiative flux compared to Himawari visible satellite image two days into the simulation (January 22, 2020 at 2:00:00 UTC).



SCREAM 3.25 km AMIP configuration
Performance on Fronter and Summit
Best performance: 458 SDPD

- **First GCRM to run on an Exascale computer, break the 1 SYPD barrier at cloud resolving resolutions, and run on both AMD and NVIDIA GPUs**
- **Winner for the 2023 ACM Gordon Bell Prize in Climate Modeling**

Taylor et al, The Simple Cloud-Resolving E3SM Atmosphere Model Running on the Frontier Exascale System, to appear, SC '23: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, November 2023, 7, Pages 1–11, https://doi.org/10.1145/3581784.3627044.

Environmental Molecular Sciences Laboratory

EMSL

Accelerating scientific discovery and pioneering new capabilities to understand biological and environmental processes across temporal and spatial scales

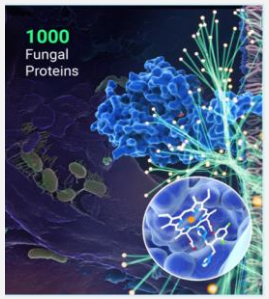
EMSL Strategic Science

MONet – Mol. Observ. Network

- 714 cores received.
- April 30 - Data portal launches.

DigiPhen – Digital Phenome

- Nov 23 - 1000 Fungal Proteins wkshp.
- On-going - 1000 Fungal Proteins pilot.



Letters of Intent submitted for FY25

Large-Scale Research: 98 total

Funct & Systems Biol	31	Env Transf & Interactions	52	Comp, Anal & Modeling	15

FICUS Research: 79 total

EMSL and JGI	61	EMSL and ARM	11	EMSL and APS	6

CY24 Outreach Activities

- **MONet workshop at Association of 1890's Research Directors Roundtable** | April 2024
- **FY25 Exploratory Proposal call opens** | June 2024
- **EMSL Summer School: 1000 Fungal Proteins** | July 2024
- **EMSL/SLAC Integrated Chemical Imaging workshop** | August 2024
- **MONet symposium at SSSA** | Nov 2024

Drought Shifts the Type of Carbon Emitted by Soil Microbes

Objective

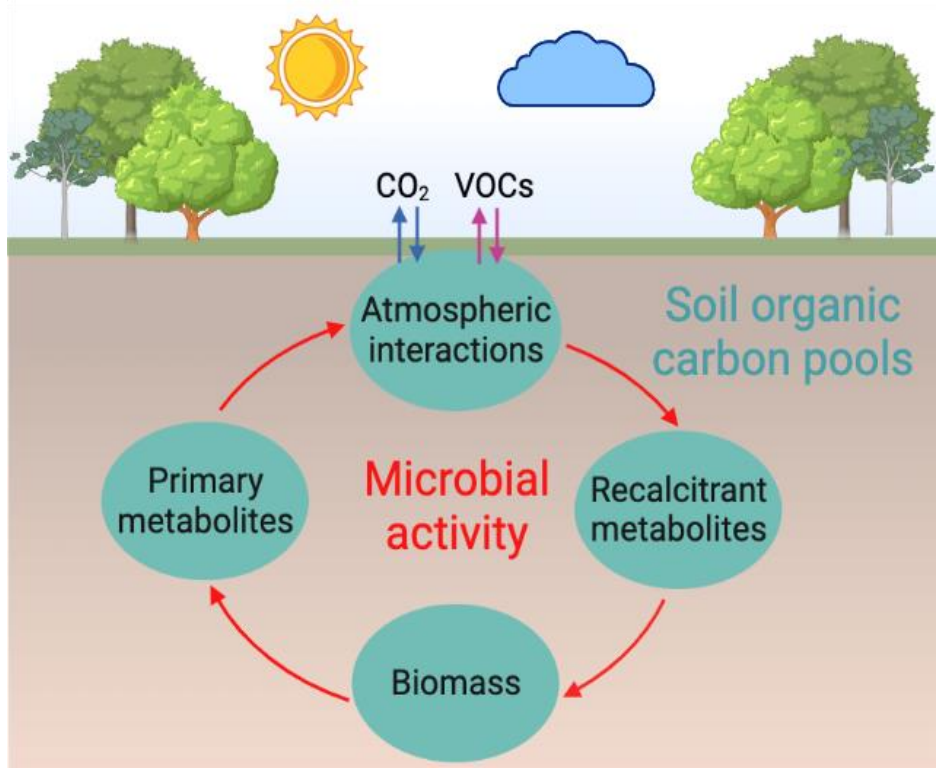
- Demonstrate the impact of drought on microbial activity.
- Understand carbon cycling and storage pools during drought.

Approach

- Tracked ^{13}C from position-specific ^{13}C-labelled pyruvate into CO_2 and VOCs in an artificial tropical rainforest.
- Used EMSL's Nuclear Magnetic Resonance and Fourier-Transform Ion Cyclotron Resonance capabilities.

Findings and Impact

- Drought impacts on microbial activity can alter soil carbon fate, leading to a loss of soil carbon to the atmosphere as emissions of microbially produced volatile organic compounds (VOCs).
- Some VOCs could indicate soil microbial stress and signal for specific microbial metabolic processes occurring belowground.



Microbes produce VOCs that are cycled and used as soil carbon or are released into the atmosphere.

Honeker, L.K et al. (2023) "Drought re-routes soil microbial carbon metabolism towards emission of volatile metabolites in an artificial tropical rainforest." *Nature Microbiology* **8**, 1480–1494. [DOI: 10.1038/s41564-023-01432-9]

How Tropical Plants Beat Drought with Special Root Tricks

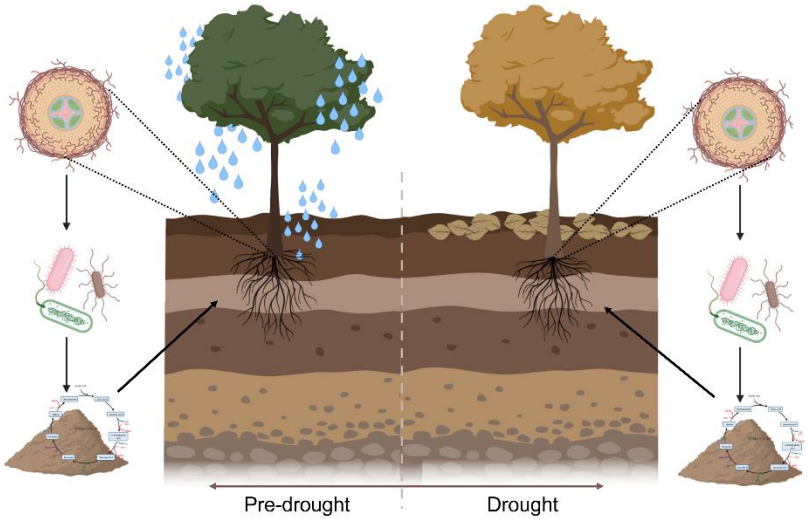
EMSL

Objective

- Examine how different tropical plant species and their associated microbial communities influence soil organic carbon turnover in the rhizosphere, specifically under drought conditions.

Approach

- Used multi-omics approaches to characterize changes in root exudation, rhizosphere bacterial communities, and metabolomes across three plant species under drought stress.
- Position-specific ^{13}C-pyruvate labeling was further used to track plant-derived carbon flow through rhizosphere microbes.



During drought conditions, changes in the root metabolic profile shaped the rhizosphere metabolome either alone or by driving changes in the bacterial community composition.

Impact

- Revealed that drought-induced changes in root exudation shaped the rhizosphere metabolome in a plant species-specific manner, influencing reliance on microbial communities.
- During climate extremes, the rhizosphere microbiome is dynamic and linked to changes in root exudation patterns.

G.A. Hildebrand, et al. "Uncovering the dominant role of root metabolism in shaping rhizosphere metabolome under drought in tropical rainforest plants." *Science of the Total Environment,* 899, 165689 (2023). [DOI: 10.1016/j.scitotenv.2023.165689]

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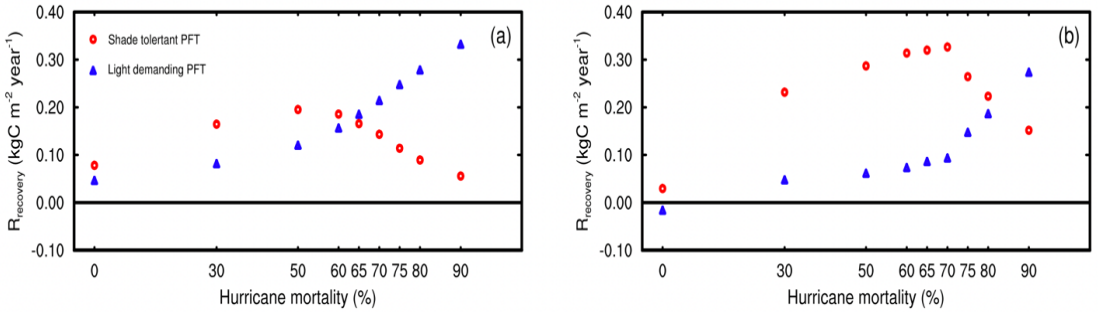
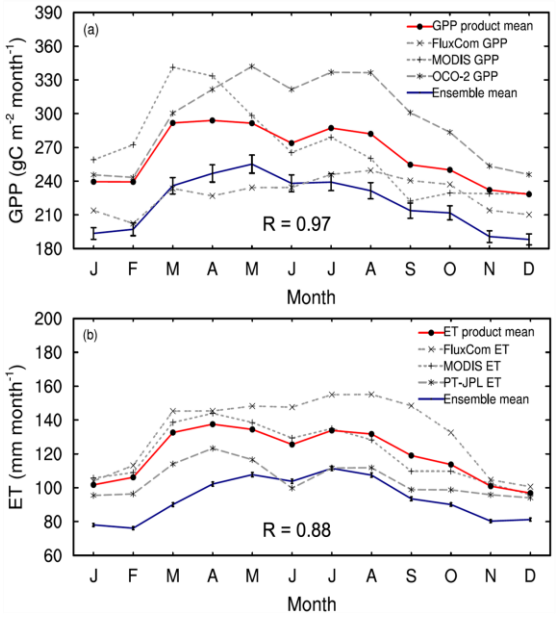
Functionally Assembled Terrestrial Ecosystem Simulator (FATES) for Hurricane Disturbance and Recovery



The linear regression coefficient of biomass recovery ($R_{recovery}$) over time (1951–1960) for experiments with defoliation, structural damage, and varied hurricane mortality rates. (a) and (b) show the $R_{recovery}$ values obtained with a relatively equal and a realistic pre-hurricane biomass partition between plant functional types (PFTs), respectively.



(a) Gross primary production (GPP) and (b) evapotranspiration (ET) comparison between model ensemble simulations that use the initial condition with a realistic pre-hurricane biomass partition between PFTs and the observed hurricane mortality rates. R is the correlation coefficient between the ensemble mean and the mean of different data products.

Scientific Achievement

This research uses ELM-FATES ensemble simulations and at the Luquillo Experimental Forest of Puerto Rico and random forest feature importance to identify key factors controlling the post-hurricane forest recovery.

Significance and Impact

This study enhances our understanding of the ELM-FATES model behavior associated with hurricane disturbance and broadens the application of random forest feature importance in quantifying the parameter sensitivity of a dynamic global vegetation model (DGVM). This research addresses the essential role of representing hurricane induced forest damage with varied intensity in DGVMs.

Research Details

- Post-hurricane forest recovery favors the light demanding type when hurricane mortality rates are equal to or higher than 60% at Bisley.
- Hurricane mortality and background mortality are the key factors regulating the post-hurricane forest recovery and biomass composition.
- ELM-FATES simulations at a Puerto Rico forest site can represent reasonable GPP and ET seasonality but the flux magnitudes are biased low.

Citation: Shi, M., Keller, M., Bomfim, B., Li, L., Koven, C., Kueppers, L., et al. (2024). Functionally assembled terrestrial ecosystem simulator (FATES) for hurricane disturbance and recovery. Journal of Advances in Modeling Earth Systems, 16, e2023MS003679. https://doi. org/10.1029/2023MS003679.

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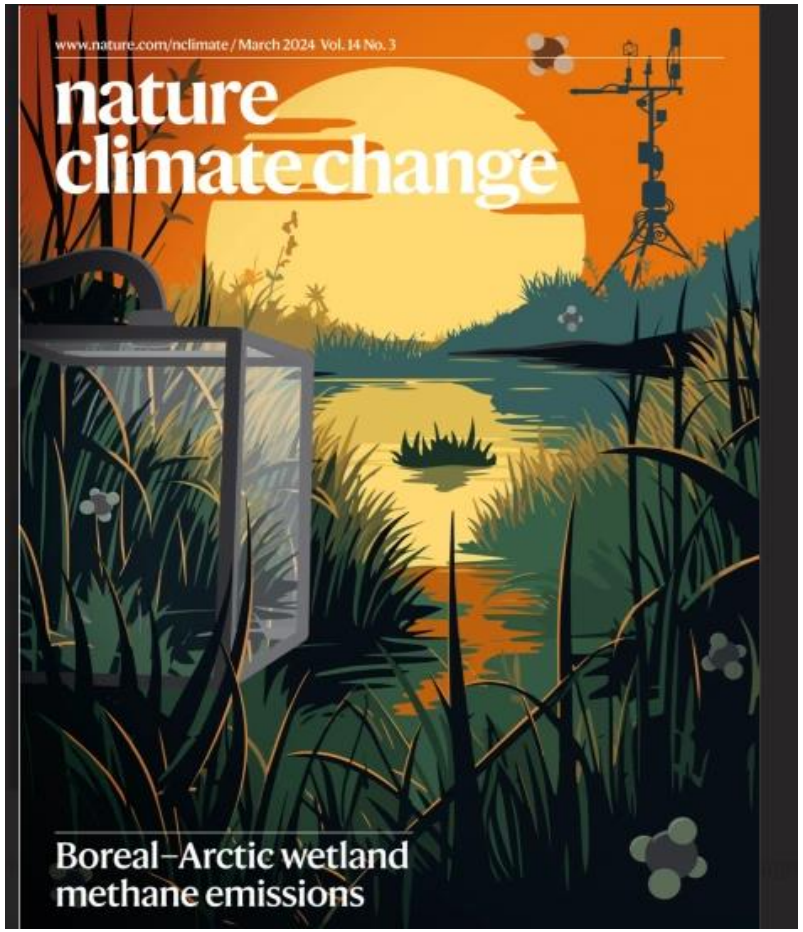
NGEE-Tropics Next-Generation Ecosystem Experiments

High latitudes wetland methane emission is growing



Scientific Achievement

- We find the strong signal of wetland CH_4 emission increases occurred in early summer (June and July) and were mainly driven by warming (52.3%) and ecosystem productivity (40.7%).
- 2 °C temperature anomaly in 2016 led to the highest recorded annual CH_4 emissions (22.3 Tg CH_4 yr−1) over this region, driven primarily by Western Siberian lowlands.

Significance and Impact

- Boreal-Arctic wetlands are vulnerable to climate change. This study analyzed two decades (2002–2021) of methane emissions over this region revealed a 9% increase.
- Strong inter-annual variation was observed and peak emission was due to overlapping of arctic warming with wetland hotspots.

Research Details

- This analysis used eddy covariance and chamber observations and highlighted the big impacts of warming and vegetation activity.
- A causality-guided machine learning approach (developed at LBNL) was used to upscale and analyze Boreal-Arctic wetland CH_4 dynamics

Yuan, K.. et al. Boreal-Arctic wetland methane emissions modulated by warming and vegetation activity. *Nat. Clim. Chang*. (2024).https://doi.org/10.1038/s41558-024-01933-3

Work is performed at LBNL, supported by Reducing Uncertainties in Biogeochemical Interactions through Synthesis and Computation (RUBISCO) Scientific Focus Area Project.

Atmospheric Radiation Measurement (ARM) User Facility

ARM Mobile Facility Updates

- CAPE-K- Cloud & Precipitation Experiment at Kennaook
  - Starts April 15, 2024; opening ceremony April 30
- CoURAGE – Coast Urban Rural Atmospheric Gradient Experiment – Dec 2024 – Nov 2025
  - Site/planning tour in Feb after AMS
- AMF3 at Bankhead National Forest
  - Delays in site installation; now expect summer operation date for main & supplemental sites

CAPE-k photos courtesy of Los Alamos National Laboratory

Other ARM Activities & User Support

- ARM open science summer school May 19-24, 2024
- 10 new/updated data products released since January
  - https://arm.gov/news-events/data-announcements
- Continued development of ARM data workbench
- Future of LASSO workshop – report expected in May
- ARM released new Aerosol Operations Plan

ARM Proposal Call/Review Updates

- ArcticShark science proposal selected for May flights
  - "Turbulent layers promoting new particle formation", PI – Gannett Hallar (U. Utah)
- ARM Mobile Facility Call
  - 7 pre-applications encouraged; June review panel
- Tethered Balloon System (TBS) proposal calls
  - ARM-only call
  - Joint call with EMSL for analysis of aerosol samples
- ARM Triennial Review scheduled Sept 2024

Ice-Nucleating Particles Vary Seasonally and with Altitude

EMSL

Objective

- Collect and analyze ice-nucleating particles (INPs) from a remote low latitude marine region to determine particle characteristics.

Approach

- As part of the Aerosol and Cloud Experiments in the Eastern North Atlantic campaign, collected particle samples in the marine boundary layer and free troposphere over the Portuguese Azores islands.
- Examined particle samples using a variety of analytical capabilities at EMSL to assess mixing state and organic matter as well as particle morphology and composition.

Impact

- INPs varied seasonally and with altitude in a remote marine region.
- Results add new information to cloud and atmospheric models.

ARM's Gulfstream-159 (G-1) research aircraft sits on the tarmac on Terceira Island during the winter 2018 intensive operational period in the Azores.

D. A. Knopf, et al. 2023. "Physicochemical characterization of free troposphere and marine boundary layer ice-nucleating particles collected by aircraft in the eastern North Atlantic." Atmospheric Chemistry and Physics 23, 8659–8681. [DOI: 10.5194/acp-23-8659-2023]

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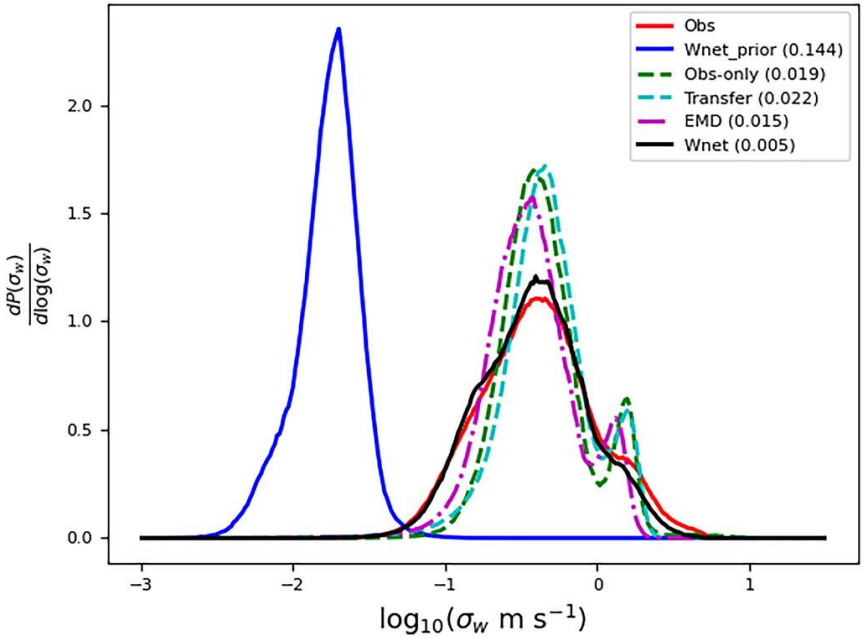
ARM Observations Constrain Deep Learning Parameterization of Vertical Wind Velocity

Scientific Challenge

- Vertical air motion plays a crucial role in atmospheric processes, such as cloud droplet and ice crystal formation.
- However, it often occurs at scales smaller than those resolved by standard atmospheric models, leading to uncertainties in climate predictions

Approach

- NASA-funded scientists developed a novel deep learning approach that provides a representation of small-scale vertical wind velocity suitable for integration into atmospheric models.
- ARM high-frequency radar and lidar measurements from 9 sites provided observational constraints to the deep learning algorithm.



Probably distribution functions of vertical velocity variance predicted by the model prior (blue), different versions of the algorithm (dashed lines), and the final parameterization (black), compared to the observational data (red).

Significance and Impact

- Key aspect is integration of observational constraints directly within the parameterization.
- The parameterization reproduces the observed statistics of vertical velocity and leverages learned physical relations from the model simulations to guide extrapolation beyond the observed domain.
- The parameterization can be applied online within large-scale atmospheric models, or offline using output from weather forecasting and reanalysis products.

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Barahona D, K Breen, H Kalesse-Los, and J Röttenbacher. 2024. "Deep Learning Parameterization of Vertical Wind Velocity Variability via Constrained Adversarial Training." *Artificial Intelligence for the Earth Systems*, 3(1), 10.1175/AIES-D-23-0025.1.

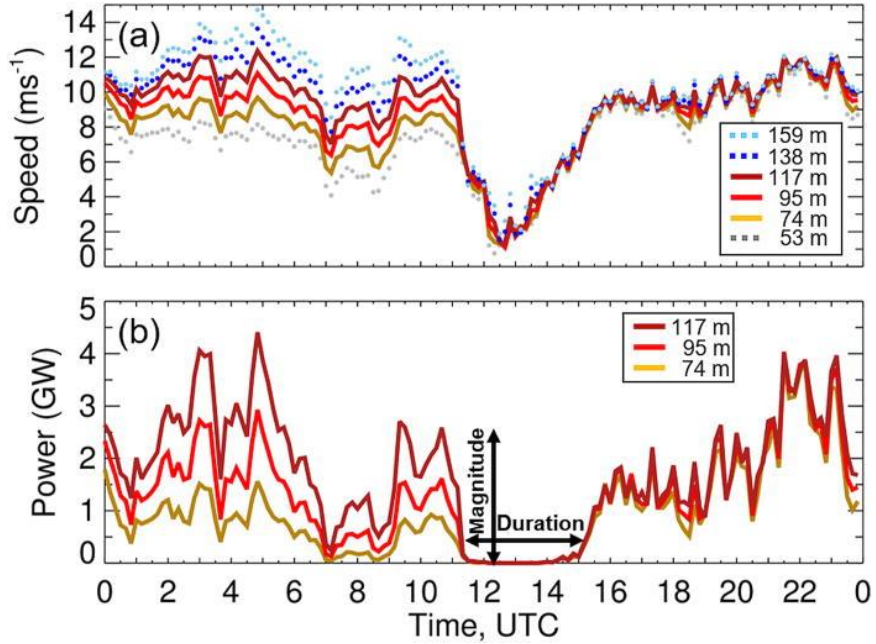
ARM Lidar Observations Provide Critical Information to Study Wind Ramp Events

Scientific Challenge

- Rapid changes in wind speed over a short period of time are defined as“ramp events.” These may lead to significant fluctuations in the power generated by wind turbines and bring large uncertainties to power scheduling and trading.
- It is important to understand the atmospheric conditions that drive such wind ramp events to improve wind forecasting.

Approach

- A wind ramp event in north-central Oklahoma was studied using Doppler lidar data from five ARM sites around the Southern Great Plains (SGP) facility.
- The lidar network provided an exceptional opportunity to estimate the spatial variability of this significant ramp event, identify weather-related causes of the sudden change of wind speed, and to quantify the ability of simulations to capture the ramp event.



(top) Time-series of wind speed from lidar measurements at SGP site. (bottom) Wind power calculated for the “virtual” turbine. Black arrows indicate the magnitude and duration of the power ramp event for the wind turbine.

Significance and Impact

- The ramp event was attributed to an atmospheric bore, most likely produced by a gust front from thunderstorm activity to the northwest.
- Current generation NWP models have difficulty predicting correct timing and location of detailed atmospheric structures associated with thunderstorm activity; supplementary observations upstream of wind turbines would be useful for predicting such events and their impact on wind energy production.

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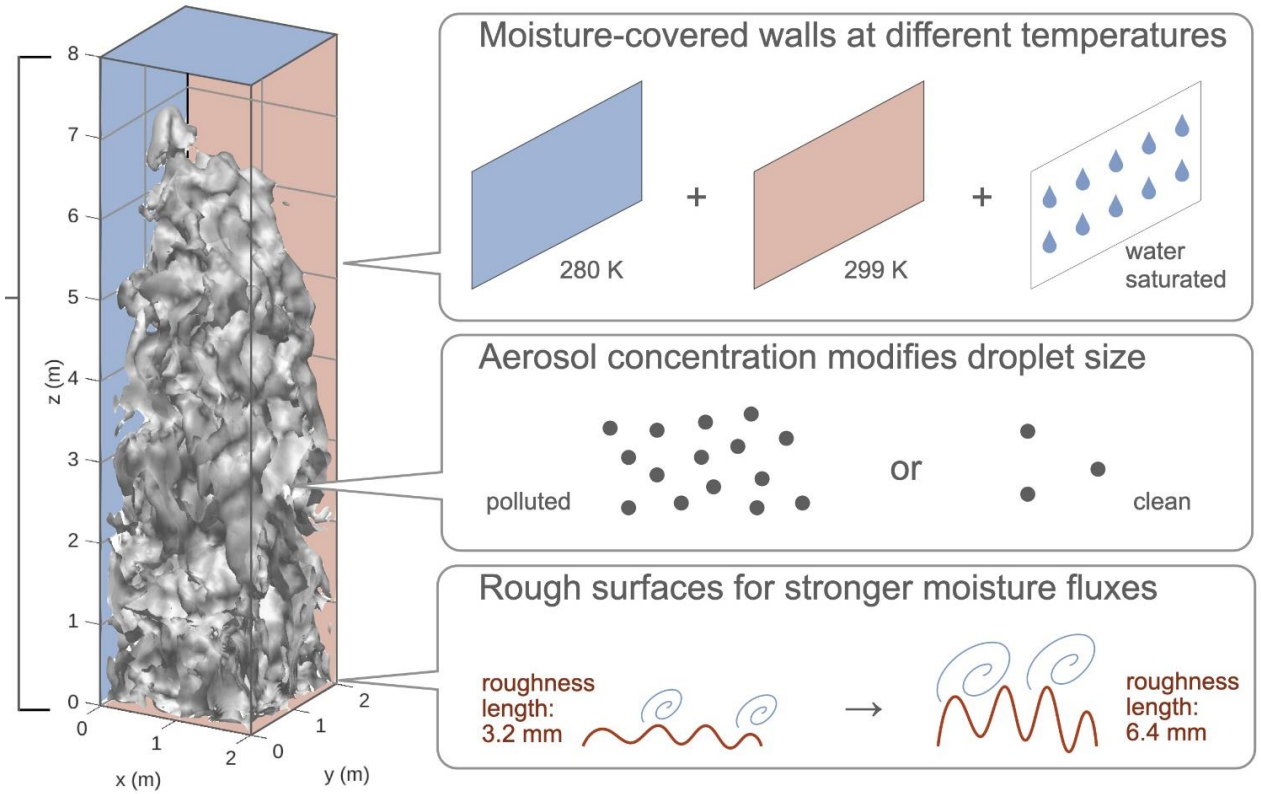
Pichugina Y et al. 2024. "Case study of a bore wind-ramp event from lidar measurements and HRRR simulations over ARM Southern Great Plains." Journal of Renewable and Sustainable Energy, 16(1), 013303, 10.1063/5.0161905.

Tailoring a Convection-Cloud Chamber for Optimizing Droplet Collisions



Schematic illustrating the factors contributing to increased cloud water content and enhanced droplet collisions. The three-dimensional surfaces within the chamber represent the spatial distribution of liquid water content from one of the simulations.

Scientific Challenge

- ASR-supported researchers used large-eddy simulations (LES) to guide design of a convection-cloud chamber with enhanced probability of droplet collision, a prerequisite for drizzle formation.

Approach

- Perform LES to resolve turbulent motions in a chamber and their effects on aerosol–cloud–drizzle interactions.
- Resolve droplet size distributions in LES to model nucleation and growth by condensation and collision-coalescence.
- Examine collision-coalescence effects for various combinations of chamber shapes and sizes, side-wall temperature variations, side-wall wetness, surface roughness, and aerosol injection rates.

Significance and Impact

- The current convection-cloud chamber (the Pi Chamber) is likely too small to explore how turbulence affects the collision-coalescence among cloud droplets
- The likelihood of detectable collisional growth increases significantly in a tall chamber with two warm and two cold-saturated side walls and rough wall surfaces

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Wang, A., M. Ovchinnikov, F. Yang, S. Schmalfuss, and R. A. Shaw, 2024: Designing a Convection-Cloud Chamber for Collision-Coalescence Using Large-Eddy Simulation with Bin Microphysics. *Journal of Advances in Modeling Earth Systems*, 16, e2023M003734, https://doi.org/10.1029/2023MS003734.

Different Aerosol Emission Sources Work Together to Drive the Slowdown of Atlantic Overturning Circulation

Objective

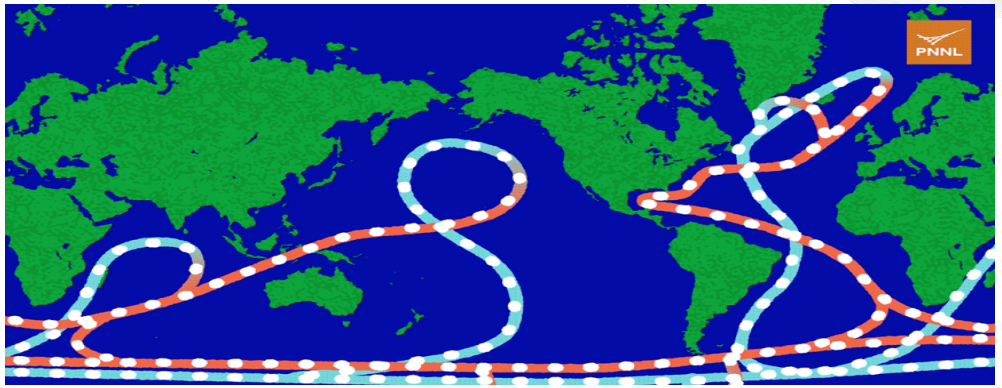
- Investigate the trends in anthropogenic aerosol emissions for the eastern versus western hemispheres to determine the driving force of the sharp weakening of the Atlantic Meridional Overturning Circulation (AMOC).

Approach

- Manipulate the solar insolation to mimic the cooling/warming effect of increased/decreased aerosol emissions.
- Run 10-member ensemble simulations using the Community Earth System Model version 1.
- Perform water mass transformation analysis to diagnose the mechanism for the reduction in deep water formation.

Impact

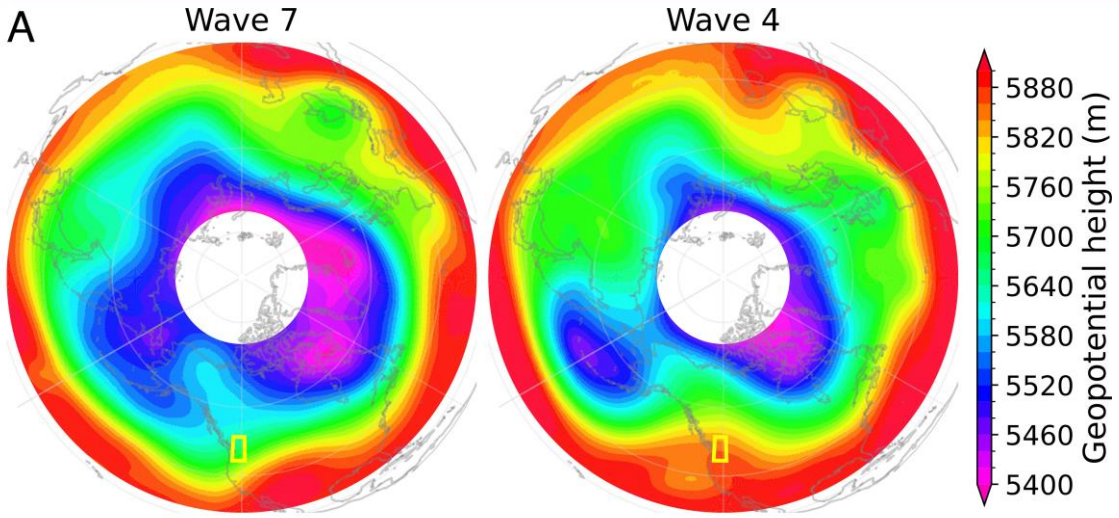
- Both the increase in emissions from Asia and the decrease in emissions from the US and Europe since the mid 1980s contribute to the AMOC slowdown.
- The weakening of the AMOC due to aerosol emissions from Asia is through an atmospheric pathway that shifts and weakens the westerlies over the deepwater formation region in the North Atlantic.



Trends in aerosol emissions from both the eastern and western hemispheres contribute to the weakening of the AMOC, as seen in the (a) aerosol optical depth trend between 1986 – 2020; (b, d) ensemble-mean evolutions of the AMOC index forced by the aerosol cooling from the eastern and western hemispheres, respectively;

Liu F., X. Li, Y. Luo, W. Cai, J. Lu, X. -T. Zheng, S. M. Kang, H. Wang, and L. Zhou. 2024. "Increased Asian aerosols drive a slowdown of Atlantic Meridional Overturning Circulation," *Nature Communications*, 15:18. DOI: 10.1038/s41467-023-44597-x

Role of atmospheric resonance and land–atmosphere feedbacks as a precursor to the June 2021 Pacific Northwest Heat Dome event



Wave patterns during the record-shattering heat wave at different stages. Polar stereographic projection of 500 hPa geopotential height fields (m) averaged over the wave 7 and wave 4 regimes characterized in this study, respectively. The yellow box indicates the PNW region.

- We demonstrate a combination of factors contributed to the singularly anomalous Pacific Northwest Heat Dome event of summer 2021, involving the phenomenon of resonant planetary wave amplification—not well represented in state-of-the-art climate models—which interacted with land surface feedbacks to catalyze the extreme heat event.

- Neglecting preconditioning feedback mechanisms in climate model analyses could potentially cause underestimates in the future likelihood or severity of extreme continental heat waves. Our findings hold the potential for more skillful predictions of low-probability yet impactful weather extremes that can have devastating consequences.

We find that there was an interplay between a persistent, amplified large-scale atmospheric circulation state and soil moisture feedbacks as a precursor for the June 2021 Pacific Northwest “Heat Dome” event. An extended resonant planetary wave configuration prior to the event created an antecedent soil moisture deficit that amplified lower atmospheric warming through strong nonlinear soil moisture feedbacks, favoring this unprecedented heat event.

Xueke Li, Michael E. Mann, Michael F. Wehner, Stefan Rahmstorf, Stefan Petri, Shannon Christiansen, Judit Carrillo (2024) Role of atmospheric resonance and land-atmosphere feedbacks as a precursor to the June 2021 Pacific Northwest “Heat Dome” event. *Proceedings of the National Academy of Science.* 121 (4) e2315330121

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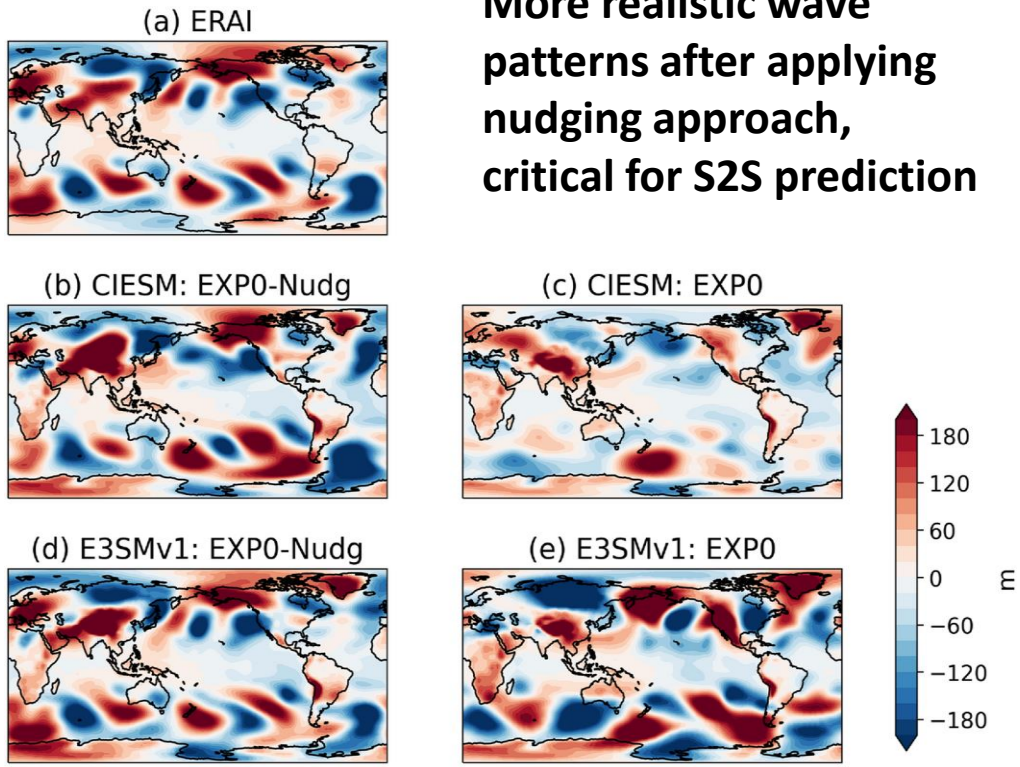
CASCADE
CALIBRATED & SYSTEMATIC CHARACTERIZATION, ATTRIBUTION, & DETECTION OF EXTREMES
BERKELEY LAB

Initialization for Subseasonal-to-Seasonal Precipitation Prediction

Science question: How does nudging contribute to climate models' ability to generate initial conditions closely aligned with observations, and why is this alignment crucial for meaningful subseasonal-to-seasonal (S2S) applications?

More realistic wave patterns after applying nudging approach, critical for S2S prediction



Non-zonal geopotential height (m) at 200 hPa from (a) ERAI reanalysis, (b) CIESM with nudging, (c) CIESM without nudging, (d) E3SMv1 with nudging and (e) E3SMv1 without nudging on April 30th, 2003

Accomplishments

- Nudging towards reanalysis winds emerges as a pivotal factor enabling climate models to generate realistic initial conditions.
- Simulations with nudged initial conditions significantly improve climate models' capability to capture global summertime precipitation responses to springtime Tibetan Plateau land surface temperature/subsurface temperature anomalies.
- The enhanced S2S prediction skill is largely attributable to the substantially improved initialization of the Tibetan Plateau-Rocky Mountain Circumglobal (TRC) wave train pattern in the atmosphere.
- Highlight the importance of initial conditions on S2S prediction

Qin, Y., Tang, Q., Xue, Y. et al. Improved subseasonal-to-seasonal precipitation prediction of climate models with nudging approach for better initialization of Tibetan Plateau-Rocky Mountain Circumglobal wave train and land surface conditions. Clim Dyn (2024). https://doi.org/10.1007/s00382-023-07082-1

Urban Expansion - a Dual Threat to Food Security and Climate Stability

IM3 INTEGRATED MULTISECTOR MULTISCALE MODELING

Objective: Investigate the consequences of dynamic urban land expansion on the land system, crop production, and net primary production (NPP) to understand potential negative impacts on food security and carbon sequestration.

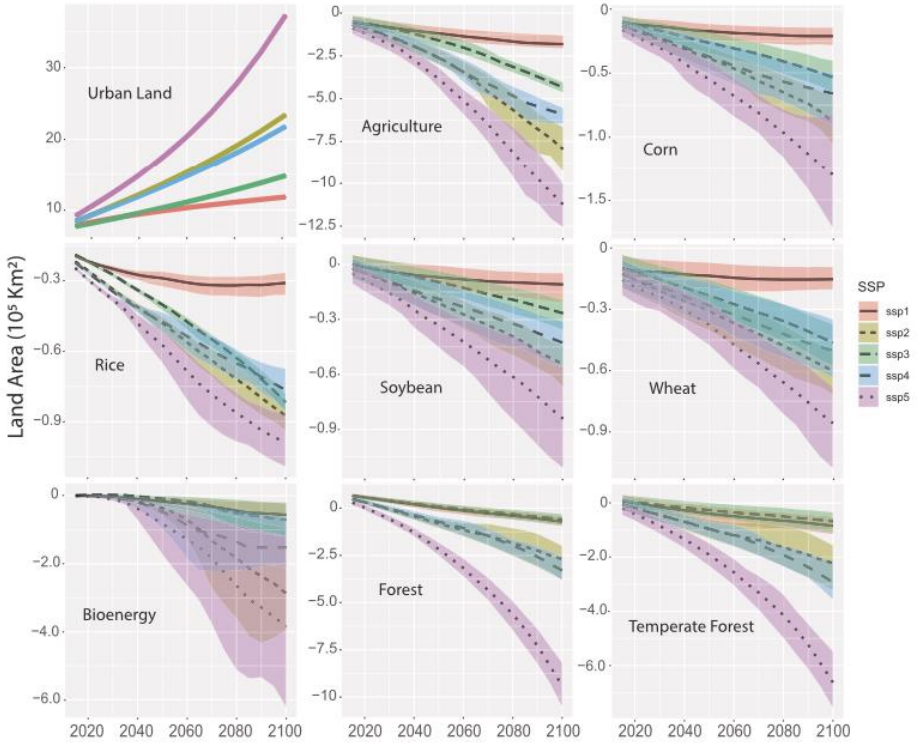
Approach:

- Integrate high-resolution urban land projections from the SELECT model with dynamic non-urban land projections from the GCAM-Demeter model to quantify the displacement of agricultural and forest lands due to urban expansion.
- Calculate the changes in crop yields and net primary production (NPP) by applying region- and basin-specific average crop yield rates and a range of NPP estimates to the areas of land lost to urbanization, providing a conservative estimate of the impact on land-carbon equilibrium.

Impacts

- Urban land expansion by 2100 could displace up to 1.4 million km² of agricultural lands, compromising significant quantities of staple crop production.
- Projected urbanization may reduce global net primary production by 0.24 to 2.24 Gt C yr^{-1}, potentially increasing land CO_2 emissions by 1.19 to 6.59 Gt CO_2 yr^{-1}.
- The study highlights that not accounting for dynamic urban land changes in models can lead to underestimations of urbanization's impact on land-carbon equilibria.

Global land area adjustments from dynamic urbanization



This figure highlights the significant impact of urban growth on key land types, such as agricultural and forested areas, vital for food production and carbon sequestration. The results are shown for the five Shared Socioeconomic Pathways (SSP1-5) and the ranges in values for each SSP represent different scenarios based on a range of Global Circulation Models, Representative Concentration Pathways, and the land harmonization procedure.

McManamay, R.A., C.R. Vernon, M. Chen, I. Thompson, Z. Khan, & K.B. Narayan. 2024. "Dynamic urban land extensification is projected to lead to imbalances in the global land-carbon equilibrium." Communications Earth & Environment 5.1 (2024): 70. DOI: 10.1038/s43247-024-01231-y

U.S. DEPARTMENT OF ENERGY | Office of Science

Outreach Activities

- **Organize Webinars, Tutorials, and Bootcamps**
  - Data management lessons learned, ingest best practices
  - Data discovery and access, analysis frameworks and tools

➜ **ESGF Webinar series playlist at https://www.youtube.com/@esgf2432**

- **Hackathons and Workshops**
  - Data standards, data node deployment and user compute resources
  - Hold at large relevant conferences, e.g., AGU, EGU, AMS

➜ **Open ESGF Workshop at AGU 2022 (Chicago)**

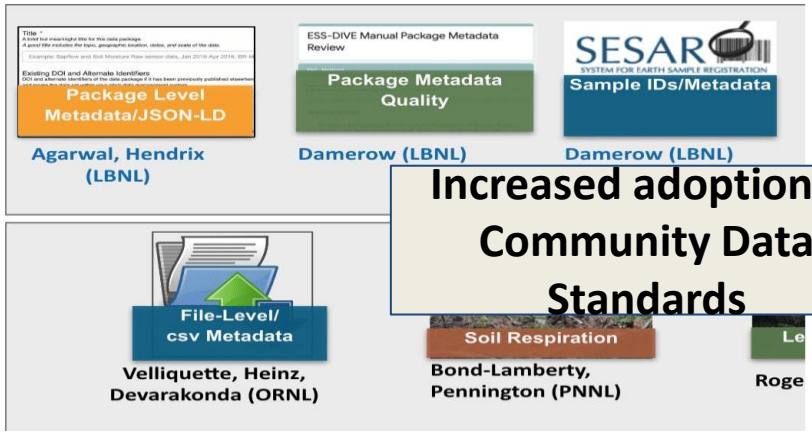
➜ **Open ESGF Workshop & Tutorial at AGU 2023 (San Francisco)**

- **Organize / host annual ESGF Developer and User Conferences**

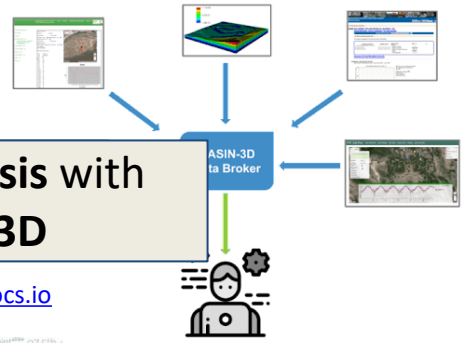
➜ **Ninth ESGF Developer and User Dual-Hybrid Conference was held January 18–20, 2023 at ORNL and Toulouse**

➜ **Tenth ESGF Developer and User Conference scheduled for Rockville, MD, on April 23–26, 2024**

ESS-DIVE: Enabling Integration Across Diverse Environmental Systems Data



Increased adoption of **Community Data Standards**



Data Synthesis with **BASIN-3D**

https://basin3d.readthedocs.io

Deep Search with the **Deep Dive API**

https://fusion.ess-dive.lbl.gov/

Technical Advancement

ESS-DIVE is addressing challenges of ***integrating interdisciplinary BER data*** with:

- Development and adoption of community data standards (Crystal-Ornelas et al., 2023)
- Links to data published in other data repositories.
- Linking related data from multiple analyses of samples.
- Standardized data within files validated and searchable through a new **FusionDB feature**
- BASIN-3D software to integrate data from multiple databases into a harmonized format

Significance and Impact

ESS-DIVE has improved the quality and accessibility of data in ESS-DIVE datasets.

- ***Looking inside files:*** Indexing and validating 100+ datasets that have file-level metadata
- ***37% of newly published datasets*** (since July 23) are searchable in the FusionDB Deep Dive API with ***11,563 unique data fields***. We are seeing growing adoption of File-Level Metadata format that is indexed by FusionDB.
- ***Data Synthesis:*** BASIN-3D enables synthesis through a common data interface across remote data sources. We enabled support for the ESS-DIVE Hydrological Monitoring Reporting Format in BASIN-3D.

Technical Details

- ***Deployed Fusion DB automated validation pipeline*** for internal dataset publication reviews.
- ***Released publicly accessible FusionDB "Deep Dive API"*** which enables standardized data to be searched.
- ***BASIN-3D 1.0 was released*** and can be now used synthesize datasets using the hydrologic reporting format.
- Identified needed improvements for ESS-DIVE community standards.

Thank you!!