U.S. DEPARTMENT OF ENERGY | Office of Science

Earth and Environmental Systems Sciences Division

BERAC Update

Gary Geernaert

October 19, 2023

Welcome New EESSD Staff

Gil Bohrer

- Ohio State University
- Professor of Civil, Environmental, and Geodetic Engineering
- Expertise in Ecohydrology, GHG, wetlands, and AmeriFlux

- IPA for 1 year with the ESS team

Community Awards and Honors

American Geophysical Union

Fellows

Suzana Camargo (Columbia Univ.)
Atul Jain (Univ. of Illinois)
Xiaohong Liu (Texas A&M Univ.)-*BERAC*
Adam Sobel (Columbia Univ.)
Claudia Tebaldi (PNNL)

Early Career Awards

Daniella Rempe (Univ. of Texas) – Hydrologic Sciences
McKenzie Skiles (Univ. of Utah) – Cryosphere

Other Awards

William S. And Carelyn Y. Reeburgh Lecture Award

- Whendee Silver (Univ. of California, Berkeley)

Yoram Kaufman Outstanding & Unselfish Coop. in Research Award

- Sonia Kreidenweis (Colorado State Univ.) - *BERAC*

Atmospheric Sciences Ascent Award

- Timothy Bertram (Univ. of Wisconsin-Madison)

American Meteorological Society

Fellows

William Collins (LBNL)
Gabriel Katul (Duke Univ.)
Branko Kosovic, NCAR
Xiaohong Liu, Texas A&M Univ.) – *BERAC*
Yun Qian (PNNL)
Paquita Zuidema (Univ. of Miami)

Other Awards

David and Lucille Atlas Remote Sensing Prize

- Christine Chiu (Colorado State Univ.)

Helmut E. Landsberg Award

- David Sailor (Arizona State Univ.)

2023 Chairman of ACS Geochemistry Division

- Eric Pierce (ORNL)

Washington State Academy of Sciences

- Vanessa Bailey (PNNL)

Executing Our Strategic Plan 2018-2023

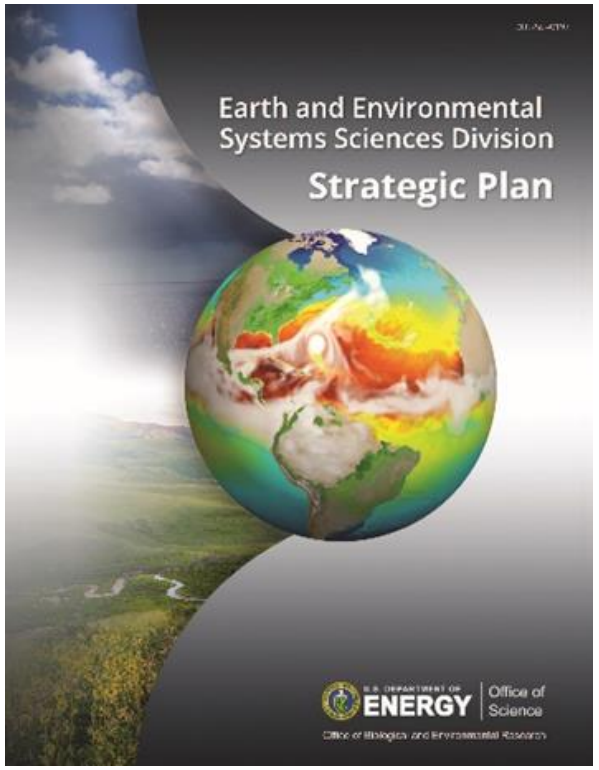
EESSD's Vision: To enhance the seasonal to multi-decadal scale predictability of the Earth system using long term field experiments, DOE user facilities, modeling and simulation, uncertainty characterization, best-in-class computing, process research, and data analytics and management in order to inform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

High-Level Scientific Grand Challenges

- Integrated water cycle
- Biogeochemistry
- High Latitudes
- Drivers/Responses in the Earth System
- Data-Model Integration

<u>Execution involving emphasis on boundaries, interfaces, extremes</u>

- Collaborative opportunities: NOAA; USGS; NGA; NSF; NASA; others
- Topics: disturbance, initialization, data analytics (e.g., machine learning), software, advanced technologies, Terrestrial-Aquatic Interfaces, Coastal, etc.



https://science.osti.gov/-/media/ber/pdf/workshop-reports/2018_CESD_Strategic_Plan.pdf

What's Happened Since the Last BERAC in April 2023

More extreme weather

- Hottest summer on record
- Record rain in NYC
- Canadian wildfires
- Sustained heat domes
- Florida ocean temp above 100F
- Atmos rivers / hurricane in CA
- Drought in east Africa / Chile
- Hurricane in eastern Canada
- Coral bleaching in Florida

OSTP

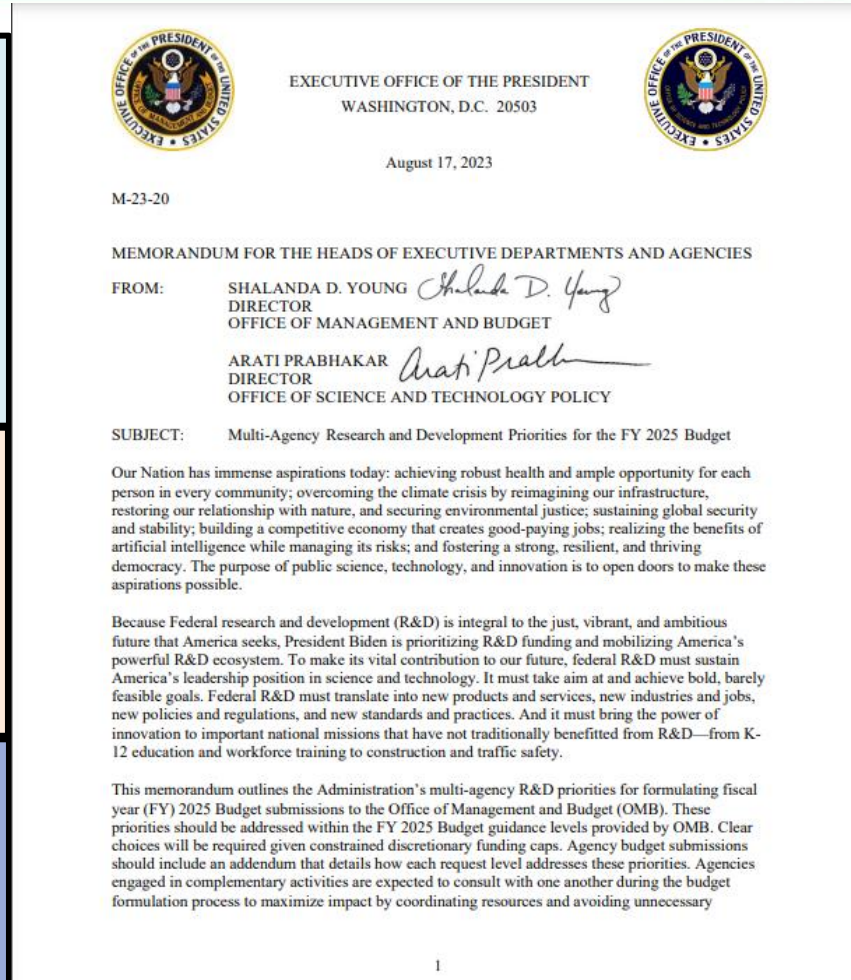
- USGCRP NCA6 underway
- National nature assessment
- New Urban IWG in motion
- Bilateral collaborations AI / climate

A new era of prediction science

- AI4ESP – hybrid science
- Water cycle – mtn hydrology
- EJ40 initiatives: IFL; NVCL, RDPP, RENEW, Centers

Administration Executive Orders on Climate

EO13985: Racial equity, underserved communities
EO13990: Health, environment, climate – reversing last 4 yrs
EO14008: climate crisis – home and abroad, security
EO14017: America's supply chains
EO14027: Climate change support office established
EO14030: Climate related financial risk



EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20503

August 17, 2023

M-23-20

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: SHALANDA D. YOUNG
DIRECTOR
OFFICE OF MANAGEMENT AND BUDGET

ARATI PRABHAKAR
DIRECTOR
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: Multi-Agency Research and Development Priorities for the FY 2025 Budget

Our Nation has immense aspirations today: achieving robust health and ample opportunity for each person in every community; overcoming the climate crisis by reimagining our infrastructure, restoring our relationship with nature, and securing environmental justice; sustaining global security and stability; building a competitive economy that creates good-paying jobs; realizing the benefits of artificial intelligence while managing its risks; and fostering a strong, resilient, and thriving democracy. The purpose of public science, technology, and innovation is to open doors to make these aspirations possible.

Because Federal research and development (R&D) is integral to the just, vibrant, and ambitious future that America seeks, President Biden is prioritizing R&D funding and mobilizing America's powerful R&D ecosystem. To make its vital contribution to our future, federal R&D must sustain America's leadership position in science and technology. It must take aim at and achieve bold, barely feasible goals. Federal R&D must translate into new products and services, new industries and jobs, new policies and regulations, and new standards and practices. And it must bring the power of innovation to important national missions that have not traditionally benefitted from R&D—from K-12 education and workforce training to construction and traffic safety.

This memorandum outlines the Administration's multi-agency R&D priorities for formulating fiscal year (FY) 2025 Budget submissions to the Office of Management and Budget (OMB). These priorities should be addressed within the FY 2025 Budget guidance levels provided by OMB. Clear choices will be required given constrained discretionary funding caps. Agency budget submissions should include an addendum that details how each request level addresses these priorities. Agencies engaged in complementary activities are expected to consult with one another during the budget formulation process to maximize impact by coordinating resources and avoiding unnecessary

1

Trustworthy AI, computing, Climate, Health, global security, economic competitiveness

Management Updates – PI Meetings

PI Meeting	Dates	Location
ESS PI Meeting	May 15-18, 2023	Bethesda, MD / hybrid
E3SM PI Meeting	Jun 26-28, 2023	Denver, CO
ARM-ASR PI Meeting	Aug 8-10, 2023	Bethesda, MD / hybrid
Interface PI meeting	Aug 15, 21, 2023	Virtual
SciDAC PI Meeting	Sep 12-14, 2023	Rockville, MD
COMPASS-GLM PI Meeting	Sept 20-21, 2023	Ann Arbor, MI / hybrid
HiLat+RASM PI Meeting	Sept 21-23, 2023	San Diego, CA / hybrid
Urban IFLs PI Meeting	Sept 27-28, 2023	Rockville Hilton / hybrid
ARM/ASR PI Meeting	Spring 2024	TBD
ESS PI Meeting	Spring 2024	TBD
Modeling PI Meeting	Summer 2024	TBD

Management Updates – Major Reviews in FY2023

Lab	Program	Type	Review date	Decision	Date
LANL	Modeling	High-Latitude Application and Testing of Earth System Models (HILAT) SFA (triennial)	Oct 20-21, 2022	Accept	Feb 28, 2023
LLNL-led	Modeling	E3SM (triennial)	Oct 31–Nov 2, 2022	Accept	Dec 16, 2022
ORNL	ESS	Watershed Dynamics and Evolution (WaDE) SFA	Nov 3-4, 2022	Accept	
PNNL	ESS	Coastal Observations, Mechanisms, and Predictions Across Systems and Scales (COMPASS)-FME	Jun 13-15, 2023	Accept	Aug 8, 2023
ORNL	ESS	Terrestrial Ecosystem Science SFA (SPRUCE)	Jul 10-12, 2023	Accept	Sept 1, 2023

Management Updates – Upcoming Major Reviews in FY2024

Lab	Program	Type	Review date	Decision	Date
ANL/LLNL	ESS	Terrestrial Wetland Function and Resilience SFA (new)	Nov 2-3, 2023		
LBNL/SLAC	ESS	Watershed Function SFA (combined)	Nov 7-8, 2023		
LBNL	EESM	Calibrated & Systematic Characterization, Attribution, & Detection of Extremes (CASCADE) SFA	Nov 30-Dec 1, 2023		
PNNL	EESM	Water Cycle & Climate Extremes Modeling (WACCEM) SFA	Dec 4-5, 2023		
ORNL	ESS	NGEE Arctic Phase IV (final)	Feb 27-28, 2024		
PNNL	ESS	River Corridor Hydrobiogeochemistry SFA	Spring 2024		
LBNL	ESS	NGEE Tropics Phase III (final)	Summer 2024		
PNNL	EESM	Coastal Observations, Mechanisms, and Predictions Across Systems and Scales (COMPASS)-GLM	Summer 2024		
LBNL	DM	ESS-DIVE			

Management Updates – Solicitations in FY2023 and 2024

Funds	Program lead	Issued	Proposals	Panel (2022)	Selections
FY23	ARM Mobile Facility Deployment	10/17/2023	4	May 22, 2023	1
FY23	ASR FOA	10/27/2022	74	April 10-18, 2023	24
FY23	ESS FOA	11/1/2022	65	May 1-4, 2023	17
FY23	Early Career (Modeling) FOA	11/16/2022	32	May 9-10, 2023	4
FY23	ESS: Climate Resilience Centers FOA	12/2/2022	29	May 24-25, 2023	6
FY23	Funding for Accelerated Inclusive Res.	12/15/2022	35	Mail-in reviews	3
FY23	Reaching a New Energy Workforce	1/9/2023	17	June 5-8, 2023	8
FY23	Energy Earthshot Research Centers	1/18/2023	35		3/1
FY23	Establishing Science Foundations for Energy Earthshots	3/21/2023	21		18 (5)
FY24	FOAs: ARM-AMF, ASR, ESS, CRC, Modeling, ECRP, DRACO, SEUS, RENEW, FAIR	TBD			

Management Updates – Workshops FY-2023

Workshop	Program	Dates	Location	Status
Artificial Intelligence for Methane (AI4CH4)	EESSD	Weekly, Mar 2023	Virtual	Report in final review
Climate Modeling Summit	EESM	Apr 24-26, 2023	GFDL, hybrid	
Future of Atmospheric Large Eddy Simulations	ASR	Apr 25-26, 2023		Report published
Cyberinfrastructure Working Group Workshop	ESS	May 15, 2023	Hybrid	Report shared with ESS
Energy Modeling Forum	EESM	Jun 26-30, 2023	Snowmass	
Southeast Land-Atmosphere Research Opportunities (SELARO)	ESS	Aug 23-24, 2023	Virtual	Report being drafted

Management Updates – Workshops FY2024

Workshop	Program	Dates	Location	Status
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, 2023	Washington, DC	
Future of LASSO Workshop	ARM	Nov 2-3, 2023	Boulder, CO	
Ship Observations Workshop	ARM/ASR	Jan/Feb 2024	Washington DC	
CAMAS – Community Arctic Science		Feb 13-16, 2024	Santa Fe, NM	Planning
Lessons Learned and Best Practices from Past Ecological Studies Workshop	ESS	Winter 2024	Virtual	Planning
Southern Coastal Workshop	ESS	Winter 2024	Gaithersburg, MD	Planning
Climate Modeling Summit	Modeling	Spring 2024	TBD	

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 – Molecular Observation Network**
  - First solicitation - 200 cores within 4 months
  - MONet Symposium for PI's - Nov. 7-8, 2023
- **DigiPhen – Digital Phenome**
  - 1000 Fungal Proteins initiative
  - Advances fungal genome annotation
  - Connects validated function to proteins
  - Workshop/Training - Nov. 13-17, 2023

User Proposals Awarded for FY24

Large-Scale Research

Functional And Systems Biology	11
Environmental Transformations and Interactions	12
Computation, Analytics, and Modeling	9

EMSL-JGI FICUS | 11 projects

EMSL-ARM FICUS | 2 projects

EMSL-APS FICUS | 4 projects (2 BSSD, 2 EESSD)

FY24 Exploratory | 40 submitted proposals

Upcoming Outreach and User Activities

- FY25 Large Scale Research and FICUS Solicitations open in December 2023.
- APS included as full FICUS member in FY25 call topics.
- EMSL Booth at Fall 2023 AGU meeting.
- EMSL TerraForms (soils/rhizosphere) available for user research: | https://www.emsl.pnnl.gov/science/instruments-resources/terraforms
- EMSL Podcast Series (Bonding over Science): https://bondingoverscience.podbean.com/

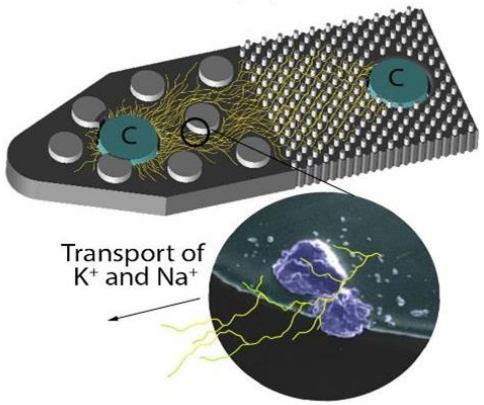
Discovering How Fungi Increase Soil Potassium through Mineral Weathering

Objective

- Determine the biogeochemical processes by which fungi free potassium bound in minerals in soils.

Approach

- Used a mineral-doped micromodel, developed at EMSL, to study chemical changes in a synthetic soil habitat. The platform is one type of a group of EMSL-developed technologies called TerraForms.
- Partnered with the Stanford Synchrotron Radiation Lightsource to visualize mineral weathering in action.



Impact

- Potassium is an essential element for plant growth that can only be obtained through plant roots. However, this element is scarce, even in fertilizer form and largely confined in minerals in the soil.
- Research into alternative, sustainable practices to increase the local nutrient supply through natural processes could improve the health of agriculture and bioenergy crops.

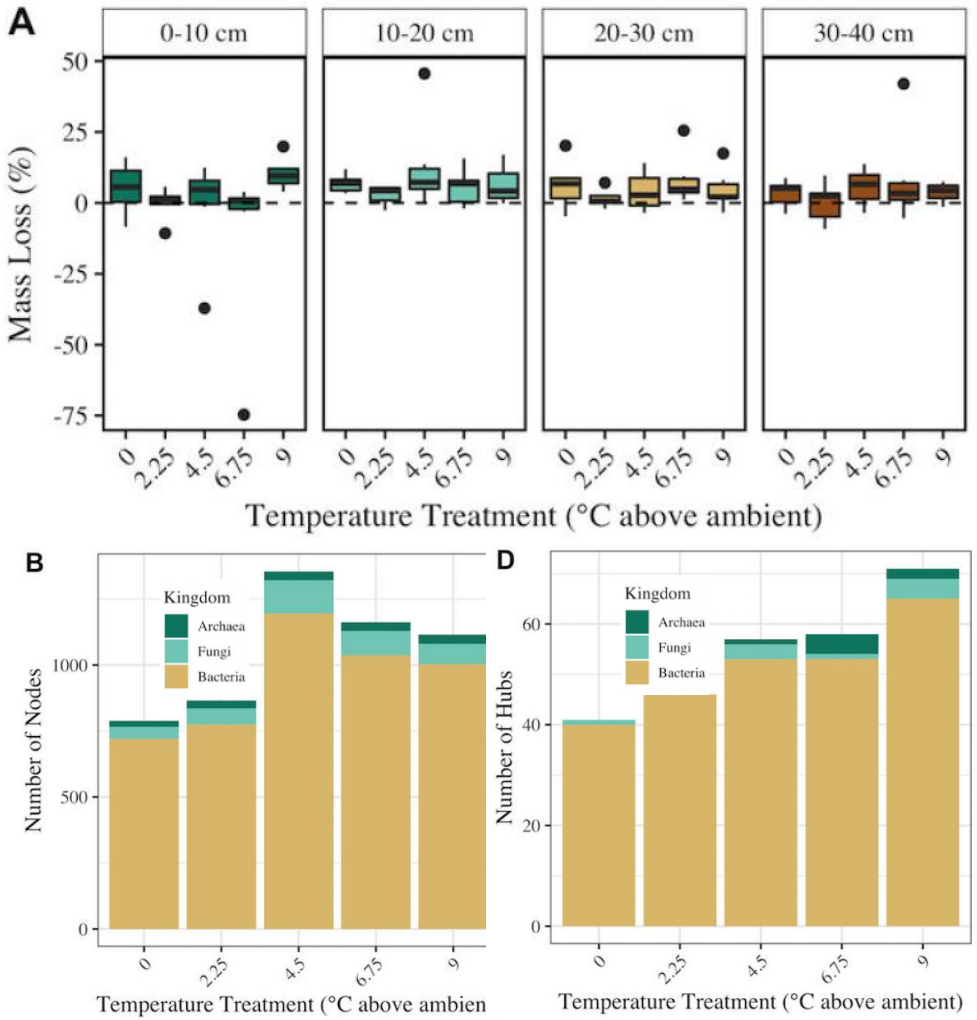
Because of the difficulty in observing soil chemical processes, scientists used a type of synthetic soil habitat, which is a member of a group of technology called TerraForms, to determine how mineral-bound elements like potassium (K) can be released into the soil as an important nutrient for agricultural and bioenergy crops.

J.A. Richardson, *et al.*, "Saprotrophic Fungus Induces Microscale Mineral Weathering to Source Potassium in a Carbon-Limited Environment." *Minerals* **13**, 641 (2023). [DOI: 10.3390/min13050641]

Elevated Temperatures Alter Microbial Communities During *in situ* Peat Decomposition

Scientific Achievement: A new approach to examine temperature-driven peat decomposition patterns at the SPRUCE experiment showed changes in microbial communities with warming, but no evidence for increased decomposition rates.

Research	• Depth specific rates and mechanisms of peat decomposition across elevated temperatures were assessed using ”peat decomposition ladders”
New science	• A method was adapted to assess, depth-specific, *in situ*, peat soil decomposition. • Low rates of mass loss (~4.5%) were observed across all treatments. • Microbial communities however, showed increases in diversity as well as alteration of patterns within their interaction networks with warming treatments.
Impact	• This research showed decomposition rates were unaltered by elevated temperature over the 1st three study years



Peat decomposition rates and changes in microbial communities with elevated temperature

Roth et al. 2023. Elevated temperature alters microbial communities, but not decomposition rates, during 3 years of in situ peat decomposition. mSystems, in press

U.S. DEPARTMENT OF ENERGY | Office of Science

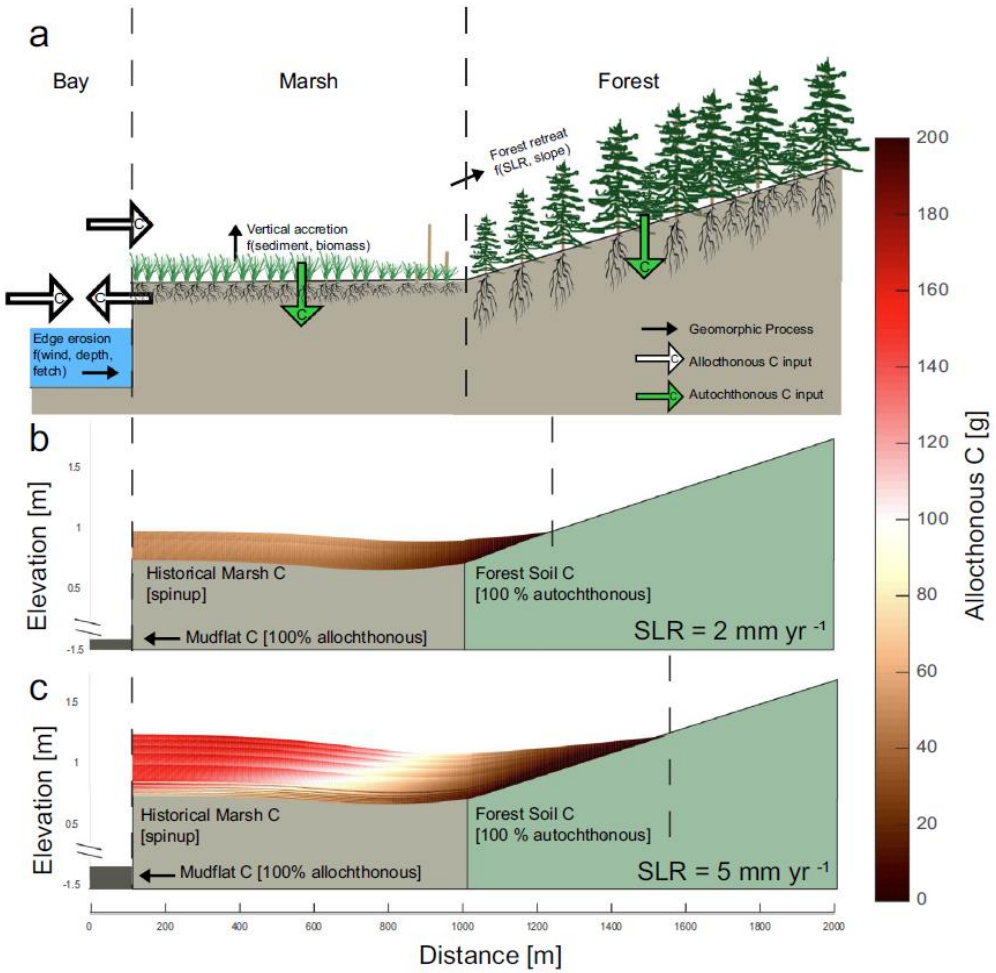
How Does Ecosystem Connectivity Influence Coastal Carbon Cycling?

Objective

- Develop a numerical model that simulates carbon cycling in forests, marshes, and bays to understand how ecosystem connectivity influences carbon accumulation across the coastal landscape.

Results and Significance

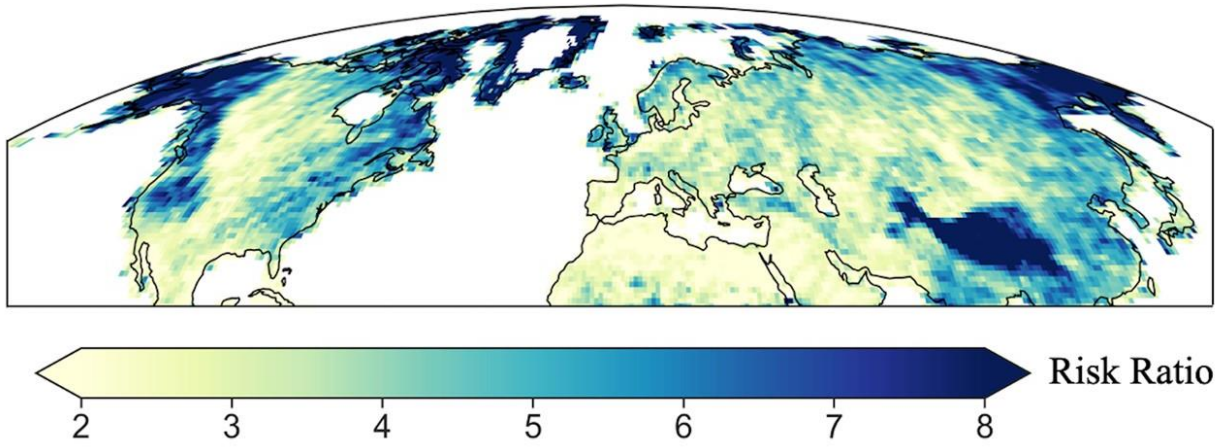
- Landscape-scale C stocks and accumulation rates peak at intermediate sea level rise rates.
- Sea level rise leads to a shift from coastal carbon dominated by forest biomass towards marsh soils.
- Climate change strengthens connectivity between ecosystems, but with tradeoffs that include carbon accumulation in more vulnerable portions of the coastal landscape.



Schematic and numerical model output illustrating the processes influencing coastal carbon cycling (a) under a slow (b) and moderate (c) rate of sea level rise. In this simulation, an increase in sea level rise rate leads to wider marshes, smaller forests, deeper carbon stocks, and enhanced allochthonous carbon deposition.

Valentine, K. Herbert, E.R., Walters, D.C., Chen, Y., Smith, A.J., and Kirwan, M.L., 2023. Climate-driven tradeoffs between landscape connectivity and the maintenance of the coastal carbon sink. *Nature Communications* 14:1137 **[DOI:**10.1038/s41467-023-36803-7**].**

A Warming-Induced Reduction in Snow Fraction Amplifies Rainfall Extremes



The Risk Ratio (RR) of extreme rainfall. An RR value of 2 means that an event is 2 times more likely to occur in a future climate. Regions in dark blue color (e.g., Pacific Mountain ranges, Rockies, Himalayas) have high risk of rainfall extremes in a future climate.

Ombadi M., Risser M., Rhoades A., & Varadharajan C., A warming-induced reduction in snow fraction amplifies rainfall extremes. Nature (2023). https://doi.org/10.1038/s41586-023-06092-7

Scientific Challenges

Global warming is widely recognized to intensify precipitation extremes. Of particular importance are rainfall (liquid phase) extremes due to their devastating impacts of flooding, landslides and soil erosion. However, to this date, it remains largely unknown how the intensity of rainfall extremes will change. Additionally, it is not known whether high elevation regions would be at more risk due to the shift of snow to rain.

Approach and Results

Our results indicate that high elevation regions exhibit a 15% increase in the intensity of rainfall per 1 degree C of warming, which pinpoint those regions as hotspots vulnerable to risk of rainfall extremes.

Significance

- Identifying mountainous regions and their foothills as hotspots of rainfall extremes. This underlines the importance of developing sound adaptation and mitigation strategies to protect the built environment and the communities residing in those regions.
- Our results single out certain components of climate models requiring improvement to reduce uncertainty in projections of rainfall extremes.

Atmospheric Radiation Measurement (ARM) User Facility

ARM Mobile Facility Updates

- CAPE-K- Cloud & Precipitation Experiment at Kennaook
  - Campaign starts April 2024
- CoURAGE – Coast Urban Rural Atmospheric Gradient Experiment – Dec 2024 – Nov 2025
  - Newly selected AMF campaign in Baltimore, MD
  - Collaborative with BSEC Urban IFL
- AMF3 at Bankhead National Forest
  - Site prep/installation beginning for main site & tower – expected operational by end of CY23
- EPCAPE continuing at Scripps Pier through Feb 2024

Outreach and User Activities

- Outreach booths at AAAR, AGU and AMS meetings
- Webinars/short courses for ARM users:
  - Aug - short course at AMS radar meeting
  - Sep 6 - ARM uncrewed aerial system capabilities
  - Sep 20 - ARM high performance computing
  - Jan – short course at AMS annual meeting

ARM Capability Updates

- ARM aircraft – revised schedule based on FAA requirements; expect available for user-proposed science missions in 2026
- New lidar and aerosol capabilities planned for AK site
- RFI released for new C-band precipitation radar for mobile facilities
- Call released for user proposals for ArcticShark flights

Arctic Warming by Abundant Fine Sea Salt Aerosols from Blowing Snow

Scientific Challenge

- In the Arctic, sea salt is a significant portion of aerosol mass during winter and spring.
- However, the mechanisms behind sea salt aerosol production during these seasons remain unclear.

Approach

- Using comprehensive measurements taken during the MOSAiC expedition, an ASR-funded team led by Washington University-St. Louis shows that the sublimation of blowing snow produces high concentrations of fine-mode sea salt particles with diameters below 300 nm during the winter and spring in the Arctic.

Significance and Impact

- Blowing snow produces a substantial amount of sea salt particles, thereby increasing the concentration of cloud condensation nuclei (CCN) and the longwave emissivity of clouds. This results in substantial surface warming during the winter and spring in the Arctic.

Gong, X. et al.: Arctic warming by abundant fine sea salt aerosols from blowing snow, *Nature Geoscience*, 10.1038/s41561-023-01254-8, 2023.

Edge Computing-Capable Machine Learning Algorithms for ARM Lidars

Science

- Doppler lidar systems at the ARM measurement sites provide important information on boundary layer winds, turbulence, and cloud properties. Standard instrument processing saves only the moments of the Doppler velocity spectra.
- The full Doppler spectrum from the lidar can provide additional information, especially in situations with multi-modal distributions (such as clouds and precipitation in the same volume), but the data is too large to store for all conditions.

Approach

- ANL scientists developed a machine-learning-based pipeline optimized to run on the edge computing node installed at the ARM Southern Great Plains atmospheric observatory.
- The best machine learning model developed was able to classify whether a scene is clear or cloudy with about 96% accuracy.

Impacts

- The new algorithms and pipeline allow identification processing, and storage of cloudy sky Doppler spectra from Doppler lidars.
- Applying the pipeline to ARM Doppler lidars will provide additional scientific data to ARM users in cloudy/precipitating conditions without significantly increasing the amount of data storage space required.

Jackson R. et al., 2023. "ARMing the Edge: Designing Edge Computing-capable Machine Learning Algorithms to Target ARM Doppler Lidar Processing." *Artificial Intelligence for the Earth Systems*, 10.1175/AIES-D-22-0062.1.

Adding Ice Shelves Improves the Accuracy of Global Tidal Models

Objective

- Include Antarctic ice shelf cavities in global ocean simulations to improve tidal amplitude and phase results over the whole Earth

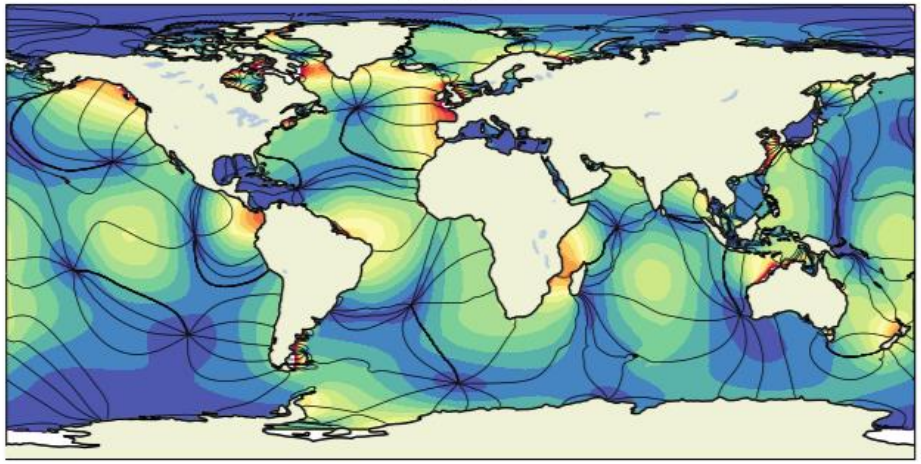
Approach

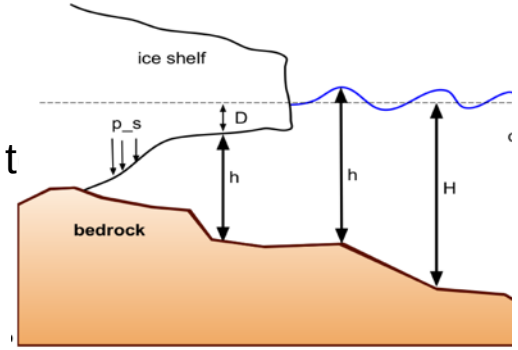
- Extend the ocean model domain into ice shelf cavities, including the pressure induced by overlying ice and the bedrock topography.
- Compare global simulations with and without ice shelves, using resolutions from 64 to 5 km grid cells. Analyze results for the amplitude and phase of the five largest tidal constituents.

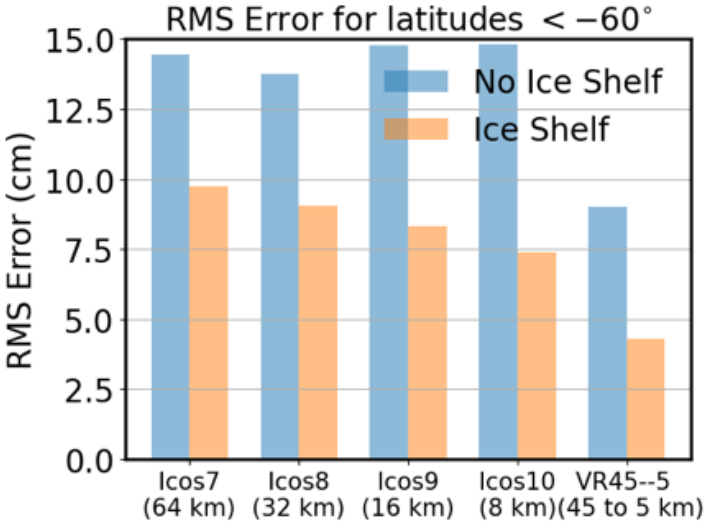
Impact

- Errors compared to satellite observations were reduced by up t 50% near Antarctica and by 5 – 10% globally.
- Tidal modeling is important for coastal inundation studies of future climates. Validation against observations and improved accuracy is a critical first step.

Tidal amplitude and phase







Pal, N., et al. “Barotropic tides in MPAS-Ocean (E3SM V2): impact of ice shelf cavities.” *Geoscientific Model Development,* **16,** 1297–1314 (2023). [DOI: 10.5194/gmd-16-1297-2023]

Heightened U.S. Coastal Hurricane Risk Under Global Warming

Objective

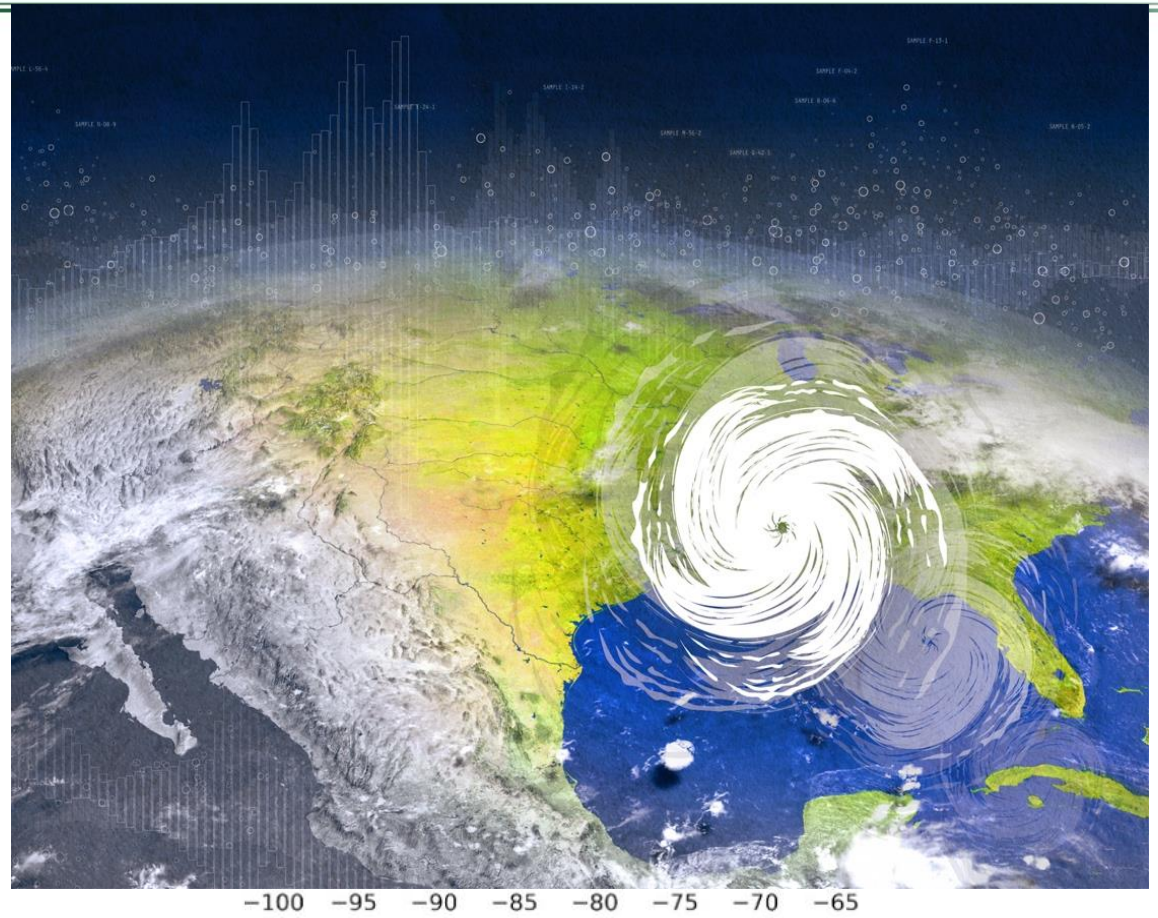
- Use a hierarchical modeling framework to project U.S. coastal hurricane risk into the future and understand the physical mechanisms responsible for any changes.

Approach

- Combine the Risk Analysis Framework for Tropical Cyclones (RAFT) with Coupled Model Intercomparison Project Phase 6 (CMIP6) climate models to project changes in U.S. coastal hurricane frequency (CHF).
- Analyze the ambient storm environment projected by the CMIP6 climate models to understand its role in the evolving CHF.
- Use a non-linear stationary wave model to delve into the detailed dynamical processes.

Impact

- An increase in CHF is projected for the Gulf and lower East coasts, but CHF changes for the upper East Coast are mostly insignificant.
- Examining various factors suggests that changes in steering flow play the dominant role in future CHF changes.
- Experiments with the stationary wave model suggest that enhanced warming in the eastern tropical Pacific, which triggers a baroclinic stationary Rossby wave in the atmosphere, leads to circulation and steering flow changes.
- Besides altering steering flow, wind changes also reduce wind shear near the coast and further enhance hurricane risk.



CHF is projected to increase along the Gulf and lower eastern U.S. coasts under global warming, primarily due to steering wind changes. A) Projected changes in CHF based on RAFT combined with 8 CMIP6 models. B) The contribution of changes in steering flow to the total change in CHF shown in (A). Change is defined as the mean over 2066-2100 minus the mean over 1980-2014. The future climate corresponds to a high-end (SSP585) emissions scenario.

Balaguru, K., Xu, W., Chang, C.-C., Leung, L. R., Judi, D. R., Hagos, S. M., Wehner, M. F., Kossin, J. P., Ting, M. "Increased US coastal hurricane risk under climate change," *Science Advances*, 9 (14) (2023). DOI: 10.1126/sciadv.adf0259.

SCREAM: E3SM's Global Cloud Resolving Model

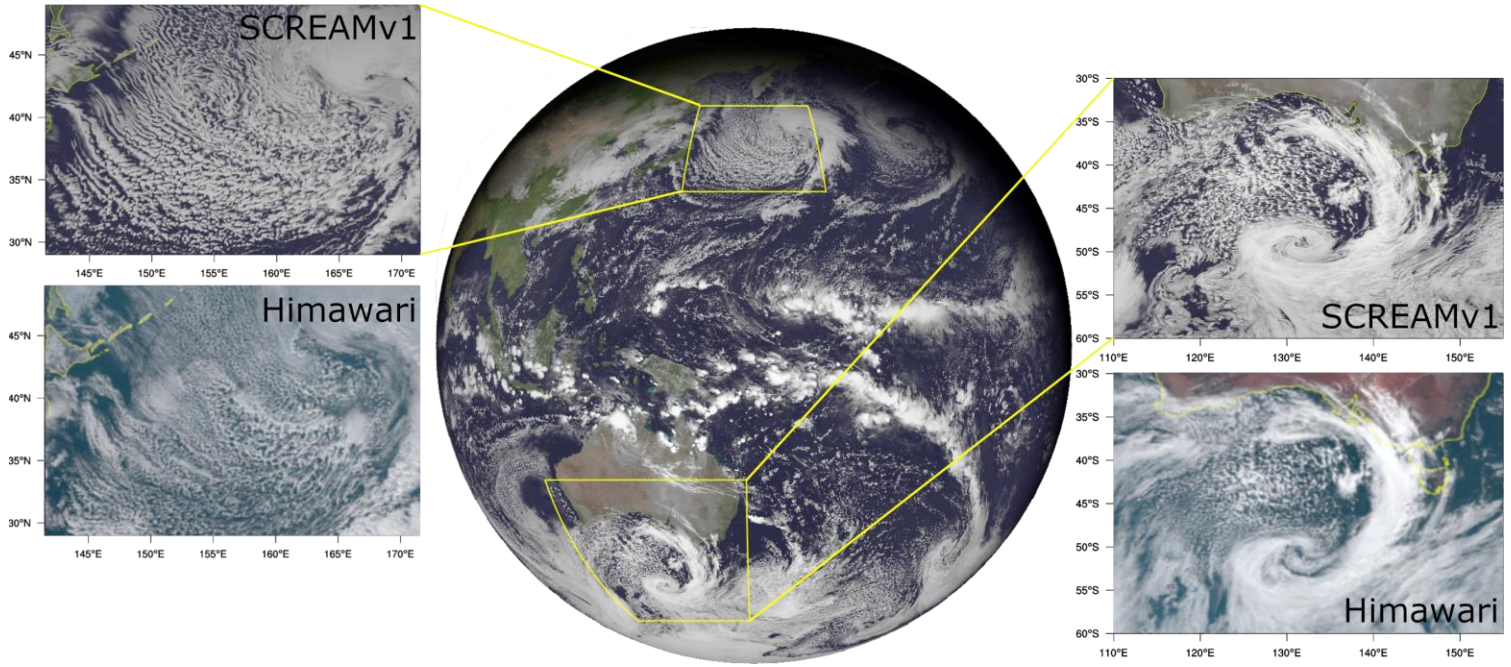
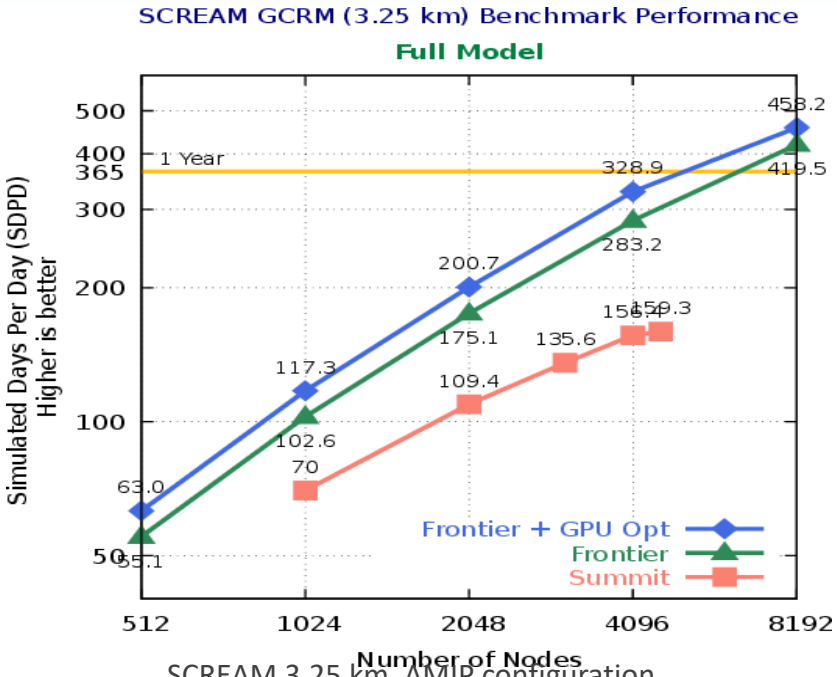


Image from a 40 day SCREAM DYAMOND simulation. Shortwave cloud radiative flux compared to Himawari visible satellite image two days into the simulation (January 22, 2020 at 2:00:00 UTC).



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**
- **Finalist (1 of 3) 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.**

New Deep Neural Network Could Speed Calculations in Climate Models

EMSL

Objective

- Increase the speed of climate model calculations through the use of a physics-informed deep neural network.

Approach

- Used knowledge of physics and chemistry to develop a sophisticated mathematical model known as a deep neural network (DNN).
- Trained the DNN on seven hours of data from measurements of a key secondary organic aerosol found over the Amazon.
- Embedded the DNN into a regional climate model to generalize results over a six-day period.

Impact

- DNN use cut computational processing time in half without accumulating the errors that had plagued previous types of DNNs.
- The proof of concept shows substantial promise for improving processing times of climate models.

Researchers trained a deep neural network using measured data from the Amazon for a key parameter, secondary organic aerosols. The trained network generalizes results faster without accumulating errors and does not require as much compute time.

H. Sharma, M. Shrivastava, and B. Singh, "Physics informed deep neural network as aerosol emulator embedded in a regional chemical transport model." *npj Climate and Atmospheric Sciences* **6**, 28 (2023). [DOI: 10.1038/s41612-023-00353-y]

Navigating the Future of Global Water Use: A High-Resolution Analysis

Objective

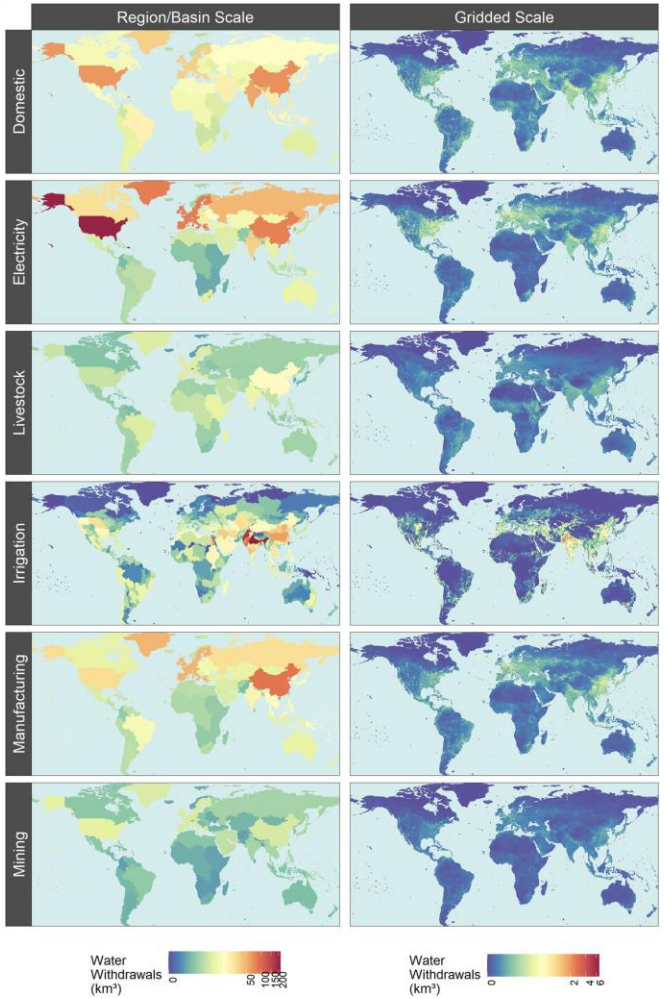
- Generate a global, gridded, monthly sectoral water withdrawal and consumption dataset for 2010–2100 for a range of scenarios to support studies evaluating the implications of human and Earth system change on future global and regional water dynamics.

Approach

- Couple the Global Change Analysis Model (GCAM) with a land use spatial downscaling model (Demeter), a global hydrologic framework (Xanthos), and a water withdrawal downscaling model (Tethys) to generate a global gridded monthly sectoral water use dataset.
- Use 75 scenarios harmonized with Shared Socioeconomic Pathways and Representative Concentration Pathways to capture a range of futures reflecting diverse global change across the human and Earth systems.

Impact

- The dataset quantifies global demand-side pressures on scarce water resources under various future scenarios, highlighting that future water scarcity is primarily driven by human demands rather than climate effects.
- The research provides a transparent and open-source dataset with a fine spatiotemporal scale, capturing key drivers of future water scarcity and offering a more detailed understanding of irrigation water use by crop type.



The spatial downscaling of 2010 water withdrawals by sector from GCAM regions and basins to 0.5° × 0.5° grid cells. This helps researchers understand future water usage and scarcity at a finer spatiotemporal scale across diverse socioeconomic and climate scenarios.

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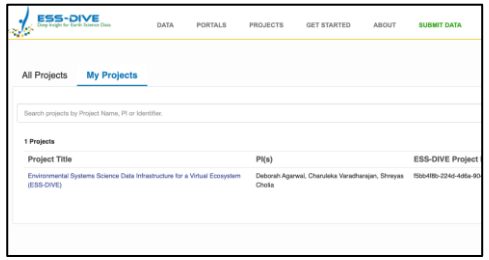
Khan, Z., I. Thompson, C.R. Vernon, N.T. Graham, T.B. Wild, and M. Chen. "Global monthly sectoral water use for 2010–2100 at 0.5° resolution across alternative futures." *Sci. Data.*, **10(201),** (2023). DOI: 10.1038/s41597-023-02086-2

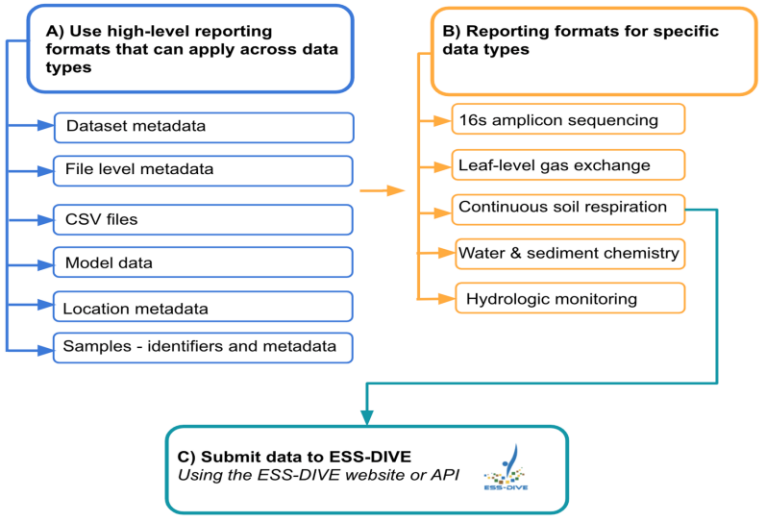
New Features & Services Enable Growth in Diversity & Size of ESS Data & User Community

I. New Features:
Project data management & large data



- **Project team** administration
- **Team data sharing** & collaborative curation
- **Data search** within a project
- **Tier 2 storage**: large & hierarchical data; >100GB/file

II. FAIR Data:
Standardized reporting formats



Crystal-Ornelas, R. et al. 2022. scientific data

III. Community Building: *Engagement and training*

- **Tutorials**: 2nd Annual Workshop & ESS PI mtg
- **Engagement & discussions:** ESS Cyberinfrastructure groups & BER Unified Data framework
- **Quarterly community meetings & webinars**
- **Presentations**: 15 conferences/meetings
- **Community working groups:** Complex data citations (Research Data Alliance) & sample data (Earth System Information Partners)

ESS-DIVE At-A-Glance

Authorized users	Public datasets	Private datasets	Total file size	Data views	File downloads	Contributing projects
273 (+32%)	795 (+27%)	181 (+14%)	2 TB (+34%)	530K+ (+42%)	243K (+40%)	79 (+24%)

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Figure source: Crystal-Ornelas, R. et al. 2022. Enabling FAIR data in Earth and environmental science with community-centric (meta)data reporting formats. Nature Scientific Data. https://doi.org/10.1038/s41597-022-01606-w

Thank you!!