U.S. DEPARTMENT OF ENERGY | Office of Science

Earth and Environmental Systems Sciences Division

BERAC Update

April 20, 2023

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FY2023 –Updates on Initiatives

Urban Integrated Field Laboratories (Urban IFLs)

- In FY23, added a 4th IFL focusing on Southwest US
- IFL Kickoff meeting Nov 2022 with all 4 centers; AGU 2022 town hall; PI meeting planned Sept 2023

National Virtual Climate Laboratory

- Advance access to DOE climate science through partnerships with National Laboratories, HBCUs, MSIs, and regional stakeholders
- Public launch – May 15, 2023 - portal that provides information on climate research activities across the DOE National Laboratories.

Climate Resilience Centers (CRCs)

- A set of climate centers affiliated with HBCUs, MSIs, Emerging Research Institutions (ERIs) to accelerate basic climate system science towards equitable solutions and community engagement
- FY23 FOA for 5 centers - proposals under review; FY24 request would add 5 -10 new centers

EESSD Participation in Cross-SC Initiatives

Reaching a New Energy Workforce (RENEW)

- Aims to build foundations for Office of Science (SC) research and training at institutions historically underrepresented in the SC research portfolio.
- 4 FY22 awards made in EESSD; FY23 proposals due Apr 25

Funding to Accelerated, Inclusive Research (FAIR)

- New cross-SC initiative to encourage applications from institutions historically underrepresented in the SC portfolio to perform basic research in fields supported by SC

Energy EarthShots

- Solicitations for Laboratory Research Centers and academic proposals for cross-cutting research
- Address basic research challenges motivated by Energy EarthShot goals
- EESSD focus - floating offshore wind and hydrogen

Program Management - PI Meetings & Workshops

PI Meeting	Dates	Location
ESS PI Meeting	May 16-17, 2023	Bethesda, MD/hybrid
ARM-ASR Joint Meeting	Aug 7-10, 2023	Rockville, MD/hybrid
Urban IFL PI Meeting	September 27-28, 2023	DC area/hybrid
Modeling PI Meeting	November 2023	TBD

Workshop	Dates	Location
AI4CH4	March 2023; 4 sessions	Virtual
ESS Cyberinfrastructure Working Group	May 15, 2023	Bethesda, MD
ASR Ice Processes	Fall 2023	Richland, WA/hybrid

Program Management Update – FOA Reviews

Program	Issued	Proposals	Review Panel
RENEW (FY22)	May 2022	16	Oct 19, 2022
ASR	Oct 27, 2022	76	Apr 10-18, 2023
ESS	Nov 1, 2022	71	May 1-4, 2023
Early Career (modeling)	Nov 16, 2022	32	May 9-10, 2023
ARM Mobile Facility	Oct 17, 2022	4	May 22-23, 2023
Climate Resilience Centers	Dec 2, 2022	28	May 24-25, 2023
FAIR	Dec 15, 2022	TBD	Mail-in reviews; May
BER-RENEW (FY23)	Jan 9, 2023	TBD	June 5-8, 2023
EarthShot Research Centers	Jan 18, 2023	TBD	TBD
EarthShot FOA	Mar 21, 2023	TBD	TBD

Program Management Update – Major Reviews

Lab	Program	Type	Review Date	Decision	Date
LANL	Modeling	HILAT SFA (Triennial)	Oct 20-21, 2022	Accept	Feb 2023
LLNL-led	Modeling	E3SM (Triennial)	Oct 31-Nov 2, 2022	Accept	Dec 2022
ORNL	ESS	WADES (post Hg/Critical Interfaces)	Nov 3-4, 2022	Accept	Mar 2023
PNNL	ESS	COMPASS - FME	June 2023		
ORNL	ESS	SPRUCE	July 10-12, 2023		
PNNL	Modeling	WACCEM SFA (Triennial)	Fall 2023		
LBNL	Modeling	CASCADE SFA (Triennial)	Fall 2023		
LBNL/SLAC	ESS	Watershed Function SFA (Triennial)	Fall 2023		

Program Management – Sampling of Recent Activities in Interagency/International Coordination

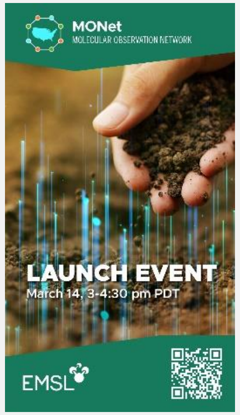
- Satellite Needs Working Group – co-chair with USDA; conducted 4th biennial survey of agency needs (including those of DOE researchers)
- Interagency Arctic Research Policy Committee (IARPC) – Biennial Implementation plan released Nov 2022
- National Climate Assessment – PMs are Coordinating Leads for several chapters; Several DOE researchers are lead & contributing authors
- DoD Strategic Environmental Research and Development Program (SERDP)
- Earth Observation Assessment – identifying key Objectives, Products, and Outcomes for Climate and Forestry/Agriculture Societal Benefit Areas
- US Global Change Research Program & Interagency Council for Advancing Meteorological Services– co-chair & participate in multiple working groups
- Newly developed US-EU Modeling of Transition Pathways Working Group

EESSD Science Highlights

Environmental Molecular Sciences Laboratory

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

EMSL Strategic Planning



- MONet – Molecular Observation Network
  - Official launch Feb. 13 with solicitation for soil cores
  - MONet launch event live stream March 14 featuring Dr. Berhe
- Microbial Molecular Phenotyping Capability (M2PC) Project ($80-$120M)
  - IPR June 6-8, ICER June 20-23
  - CD-1 review in Q4 FY23, construction start in FY25, start-up in FY29

User Proposals for FY24 – 176 LOIs total

Large-Scale Research | 99 LOIs

Functional And Systems Biology	**30**	Environmental Transformations and Interactions	**51**	Computation, Analytics, and Modeling	**18**

EMSL-JGI FICUS | 38 LOIs, 13 new to EMSL

EMSL-ARM FICUS | 6 LOIs, 2 new to EMSL

EMSL-APS FICUS (PILOT) | 4 Projects; 2 BSSD, 2 EESSD

FY23 Exploratory | 33 LOIs, 20 new to EMSL

Upcoming Outreach and User Activities

- EMSL Summer School "Demystifying Multi-omics with Data Science" | July 24-28, 2023
  - On site! 25 students with focus on HBCU enrollment
- EMSL LEARN Tutorial Series | emsl.pnnl.gov/learn
- EMSL User Meeting | Visualizing Chemical Processes Across the Environment | Oct. 3-5, 2023
- MONet User Community Fall Meeting | Oct. 6, 2023
- EMSL Podcast: Bonding over Science

Discovering How Transport and Source Affect Properties of Aerosol Particles

Objective

- Determine how aerosol particles change phases (liquid, semisolid, or solid) as the wind transports them thousands of miles from their origin.

Approach

- Sampled particles transported across the North Atlantic Ocean at height.
- Used a new analytical approach to discover chemical composition and phases, estimating changes from the shape of the particle as it hit the sampler.
- Traced path and origin using sophisticated computer simulation.

Impact

- Aerosol particles play a vital role in regional and global climates, and that role is heavily influenced by their phase.
- Understanding how aerosol particles change phases in transport becomes an important factor in predicting both weather and climate at local and regional scales.

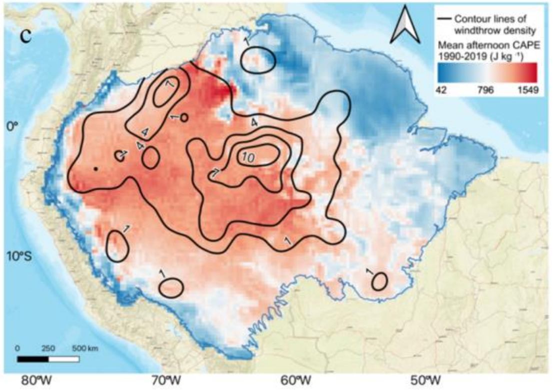
Scientists climbed above the clouds to sample aerosol particles so they could determine how the particles change as they were transported across the North Atlantic Ocean.

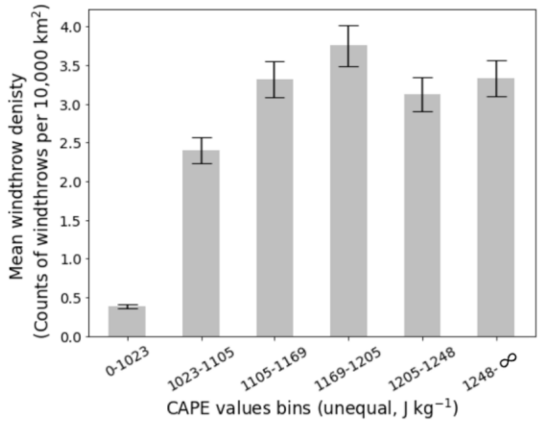
EMSL

Z. Cheng, *et al.*, "Particle phase-state variability in the North Atlantic free troposphere during summertime is determined by atmospheric transport patterns and sources." *Atmospheric Chemistry and Physics* **22**, 9033 (2022). [DOI: 10.5194/acp-22-9033-2022]

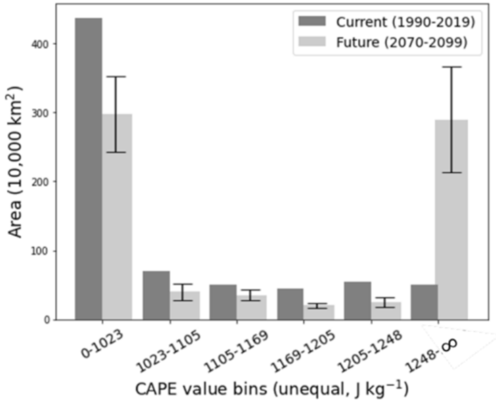
Amazon Windthrow Disturbances are Likely to Increase with Storm Frequency Under Global Warming

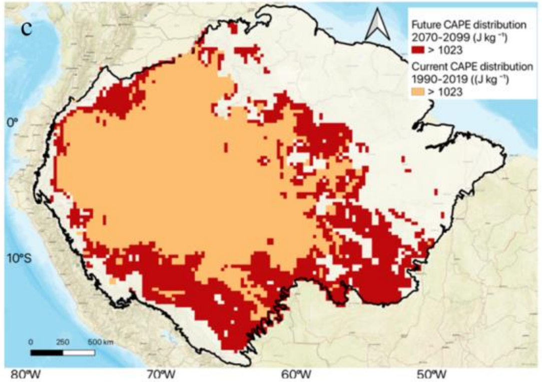
Association between current windthrows and CAPE





Future windthrows and CAPE





Feng, Y., Negrón-Juárez, R.I., Romps, D.M. and Chambers, J.Q., 2023. Amazon windthrow disturbances are likely to increase with storm frequency under global warming. *Nature Communications*, *14*(1), pp.1-8. [https://doi.org/10.1038/s41467-022-35570-1]

Objectives

- Windstorm-driven tree mortality is a key driver of forest dynamics, yet is not currently included in ESMs.

Approach

- Map 1012 large windthrow events encompassing 30 years.
- Generate hourly convective available potential energy (CAPE), which represents the environmental conditions of potential storms from ERA5 reanalysis data.

Significance and Impact

- Results show a relationship between CAPE and windthrows in the Amazon - windthrows occur nearly 8 times more frequently in the favorable environments with high CAPE.
- The model projects a 51% ± 20% increase of extreme storms, and a 43% ± 17% increase in windthrow within the Amazon by the end of this century
- This paper provides a framework for representing the coupling between forest dynamics and heavy rainfall.

Vertical Canopy Structure: A key Mechanism Facilitating Grassland Woody Encroachment

Objective - Fire and herbivory restrict most woody plant species in grasslands. However, a few woody species have strategies to overcome these disturbances, enabling their encroachment of grasslands

Approach - To better understand the mechanisms that enable woody species to encroach grasslands, Kansas State University researchers evaluated the vertical canopy structure and leaf-level physiology of rough-leaf dogwood, the predominant encroaching shrub in the Kansas tallgrass prairie.

Findings

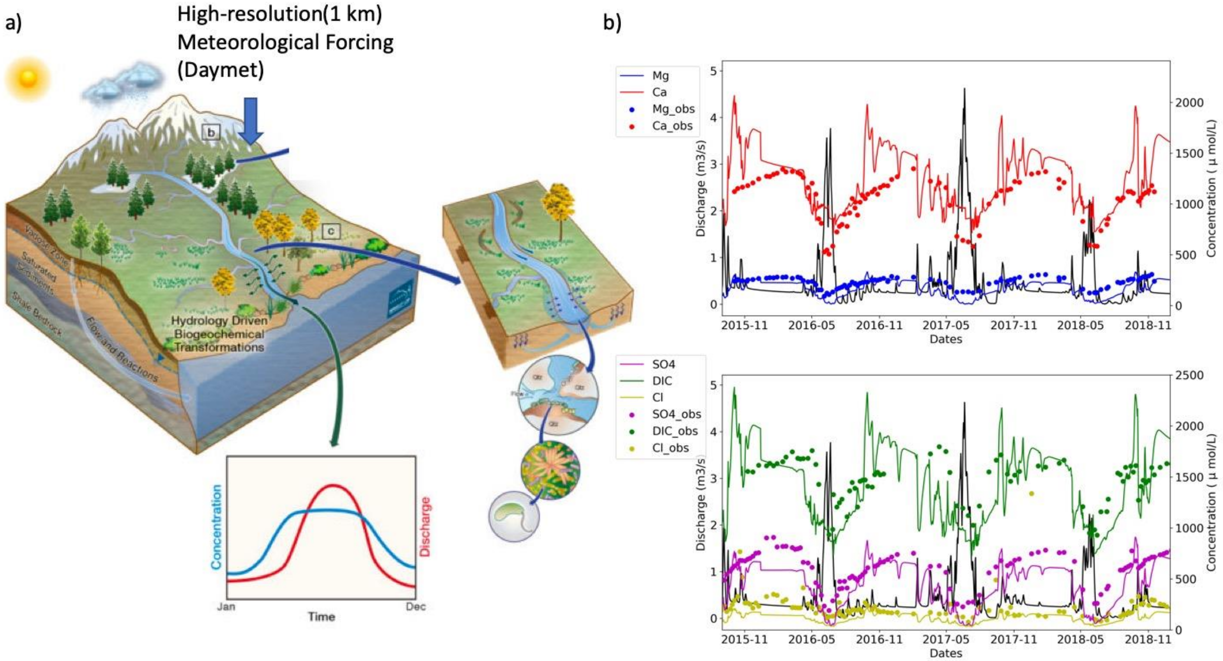
- Large vertical variation in leaf morphology and physiology enable rough-leaf dogwood to overcome the limitations of self-shading to form dense canopies—a key factor leading to their encroachment.
- These clonal shrubs have high leaf trait plasticity within a canopy, leading to greater resource-use-efficiency and photosynthetic capacity in browsed canopies compared to control canopies.

Impact

- This study reveals the growth investment strategy of rough-leaf dogwood, which enables it to achieve dense canopies, have compensatory growth in response to browsing, respond positively to periodic grassland disturbance, and alter the grassland C and water cycle following successful encroachment into former grassland ecosystems.

Tooley, E. G., et al., "Intra-canopy leaf trait variation facilitates high leaf area index and compensatory growth in a clonal woody encroaching shrub." *Tree Physiology* 42(11), 2186-2202. (2022).

Understanding the Hydrogeochemical Response of a Mountainous Watershed to Disturbances



a) The variety of processes important to the concentration-discharge (C-Q) response of mountainous watersheds (from Hubbard et al., 2018).
b) Simulated C-Q responses from the ATS numerical model compared to measurements taken at the watershed outlet.

Xu et al., Understanding the hydrogeochemical response of a mountainous watershed using integrated surface-subsurface flow and reactive transport modeling, Water Resources Research, 10.1029/2022WR032075

Scientific Challenges

- Climate change significantly impacts water resources in mountainous headwater catchments such as the Upper Colorado River Basin that are key for water supply in downstream regions of the western U.S.
- A mathematical model is needed to quantify the movement of water and chemical species under changing weather and climate conditions

Approach and Results

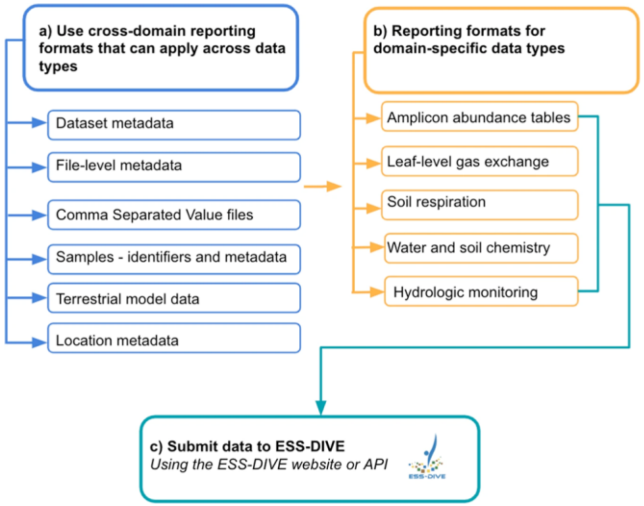
- The ATS+PFLOTRAN integrated hydrology and reactive transport model is used to simulate the Concentration-Discharge (C-Q) relationship & demonstrate the annual variability of C-Q between wet and dry years.
- The simulations are performed for 10 years and calibrated against measurements.

Significance

- The model is able to resolve the spatial variability of snowmelt and infiltration due to topographic effects driven by meteorological forcing.
- The 3D model makes it possible to understand how the watershed’s topography and the flow of water in the streams and the groundwater interact in time and in space.
- North- and south-facing slopes of the river valley contribute differently to these concentrations. These effects are relatively small but larger climate variability could enhance them.

Enabling FAIR data in Earth and environmental science with community-centric (meta)data reporting formats

Community approach to develop reporting formats



Workflow for using cross-domain and specific reporting formats before submission to ESS-DIVE for publication.

Objectives

- Reuse and integration of Earth and Environmental data is difficult due to its diversity and lack of standard reporting practices, creating barriers to scientific advancement.

Approach

- ESS-DIVE community projects reviewed existing (meta)data reporting practices and standards in multiple Earth and Environmental science disciplines.
- After thorough community review, developed 11 reporting formats ready for use with accompanying documentation – publication in **Nature Scientific Data** presenting the formats to the community.

Impacts

- Reporting formats can be integrated into the data publication workflows of projects in the ESS community and beyond to facilitate data sharing, provide guidelines for consistent data collection, and streamline scientific workflows.
- Use of standard reporting formats preserves scientific knowledge that may not be typically stored or reported with the data.

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

Future Sharpening of Winter Storms in the Western United States

Objective

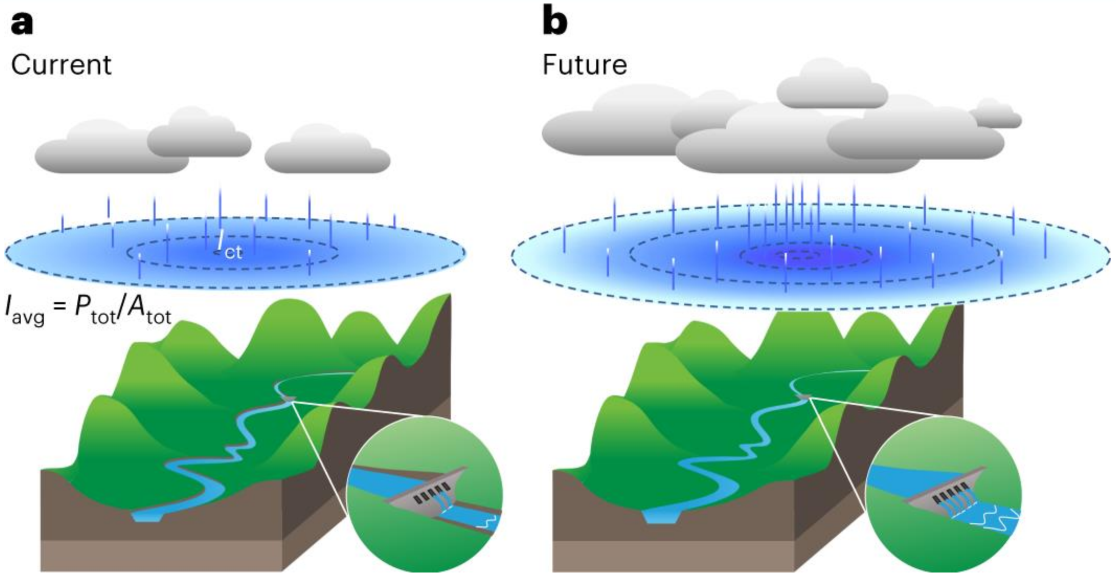
- Understand future changes in Western U.S. storm characteristics and their implications for flood risk and water resources management.

Approach

- Conduct regional storm-resolving simulations for two periods, historical and future mid-century, under a high emissions scenario.
- Track simulated storm events and evaluate storm spatial structure metrics (precipitation volume, area, and peak intensity).
- Analyze how future warming affects the storm structure.

Impact

- Identified a robust, ~31% increase in future storm precipitation by mid-century.
- Decomposed the precipitation volume increase into contributions from increase in storm size (~22%) and mean intensity (~9%).
- Revealed a storm-sharpening effect, with a larger increase in storm center intensity (~19%) compared to the mean intensity increase.
- Future changes in storm spatial structure will challenge water infrastructure design and resource management.



Current and future winter storm characteristics in the Western United States. Compared to storms in the current climate (a), future storms (b) exhibit a 22% increase in spatial extent and a 9% increase in average intensity. This results in a 31% increase in total precipitation volume. The intensity near the storm center (+19%) increases faster than the overall average intensity (+9%), causing a spatial concentration of precipitation toward the storm center known as storm sharpening.

Chen, X., Leung, L. R., Gao, Y., Liu, Y. & Wigmosta, M. “Sharpening of cold-season storms over the western United States,” *Nature Climate Change* **13**, 167–173 (2023). [DOI: 10.1038/s41558-022-01578-0]

Faster Storm Surge Modeling with Local Time-Stepping

Science

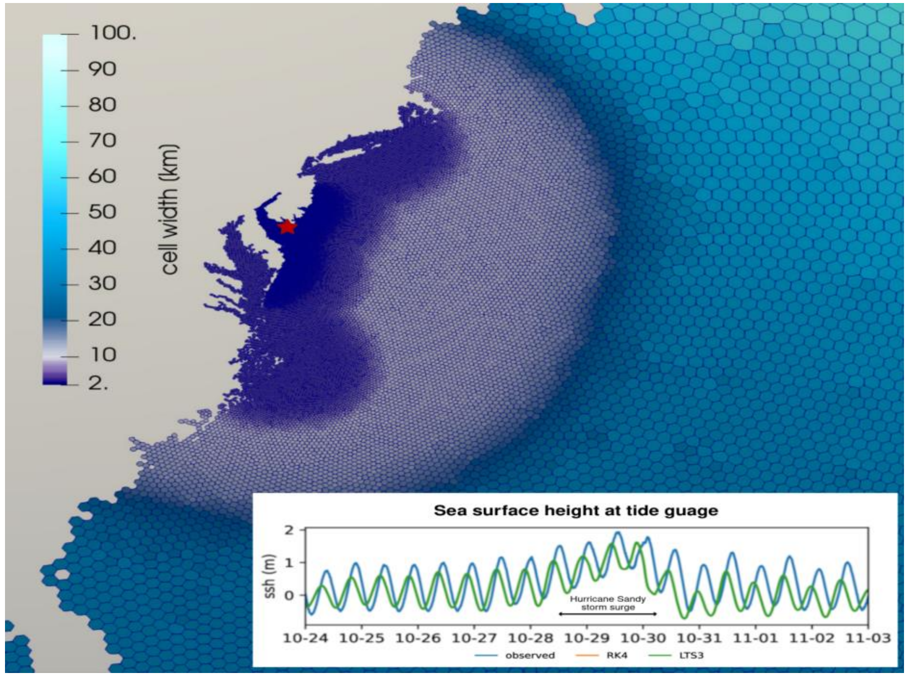
- In variable-resolution meshes in numerical models, the globe is partitioned into cells of different sizes, depending on the level of accuracy desired in a specific region. Regions where more accuracy is needed use smaller cells, with larger cells elsewhere to save on computational costs.
- A well-known limitation of explicit time-stepping method is that the largest time step the model can take is limited by the size of the smallest cell in the mesh.

Approach

- Explore the use of local time-stepping (LTS) methods, which allow researchers to select multiple time-steps based on the size of cells in a localized region.
- Evaluate the LTS methods in the ocean model used in E3SM (Model for Prediction Across Scales-Ocean; MPAS-Ocean) in a simulation of the storm surge around Delaware Bay caused by Hurricane Sandy in 2012.

Impact

- The LTS method produces results that are similar in accuracy to a more computationally expensive, state-of-the-art global method, but up to 35% faster.
- These results provide guidance on efficient mesh design requirements - the ratio of cells using the coarse time-step compared to the number of cells using the fine time-step is important and should be at least 1:5.



The image shows the different sized grid cells, which are substantially smaller near the coastline. The inset shows the model results compared to observations.

Lilly, J. R., et al. "Storm surge modeling as an application of local time-stepping in MPAS-Ocean," *Journal of Advances in Modeling Earth Systems*, **15,** e2022MS003327 (2023). [DOI: 10.1029/2022MS003327]

Atmospheric Radiation Measurement (ARM) User Facility

Campaign & Site Updates

- EPCAPE – Eastern Pacific Cloud Aerosol Precipitation Experiment
  - BER site visit and media day mid-Feb
- CAPE-K- Cloud & Precipitation Experiment at Kennaook
  - Upcoming AMF deployment to Tasmania
- UAS flights at SGP
  - 3 flight campaigns planned this spring/summer
- AMF3 at Bankhead National Forest
  - USFS approved special use permit
  - Site prep/installation beginning for main site & tower – operational by end of FY23

Outreach and User Activities

- ARM Booth at AGU (~300 visitors) and AMS (~500 visitors)
- AMS short course on "Open Science in the Rockies: Working With ARM Data from SAIL"
- April 26 webinar on Jupyter Notebook analysis tools

ARM User Proposals

- Four full proposals for urban AMF deployment
- TBS LOIs – 6 ARM-EMSL FICUS; 2 ARM only
- 8 small campaigns approved 1st quarter FY23; 15 small campaigns submitted 2nd quarter FY23

New Technique for Analyzing Aerosol Samples from UAS

Objectives

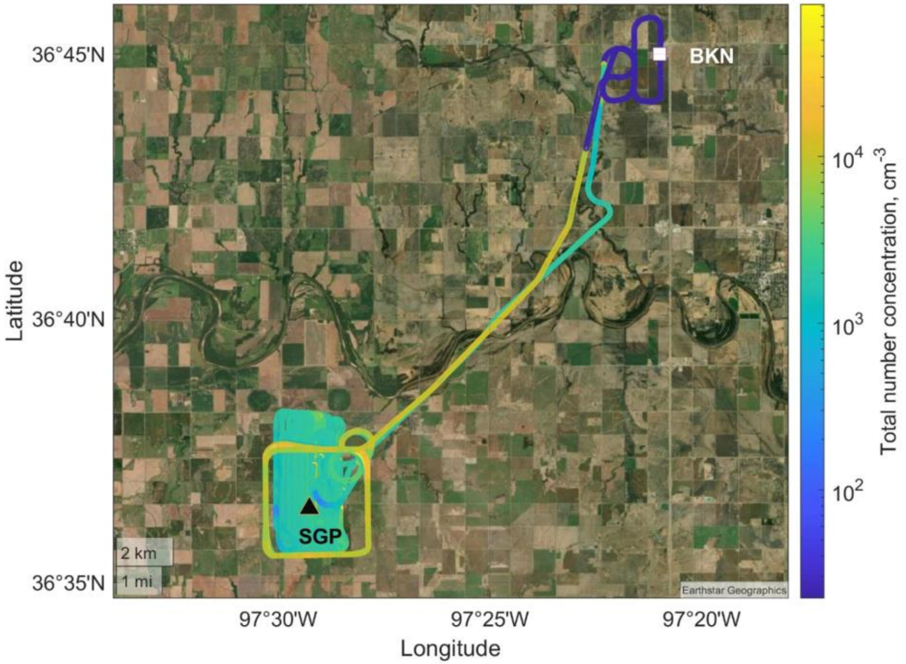
Detailed information on aerosol chemistry and composition is needed to understand sources of aerosol particles and their potential impacts on radiation, cloud formation, and health. Uncrewed aerial systems (UAS) offer a unique platform for measuring aerosol particles aloft, but due to weight/power limitations have lower volume flow rates that limit collected aerosol mass.

Approach

- Researchers at UC Davis developed a micronebulization aerosol mass spectrometry technique for offline chemical composition analysis of small volume aerosol samples taken during UAS flights.
- Samples taken from ARM's Arctic Shark UAS and analyzed with new technique compared to ground-based measurements at the SGP site and detailed analysis at EMSL.

Impacts

- New technique broadens the applicability of offline aerosol mass spectrometry analysis by requiring significantly lower particulate mass and sample volumes for analysis (nanograms instead of milligrams).
- Isotopically-labeled internal standard allows for quantitative analysis without external validation.



UAS flight track over SGP site on Nov 13, 2021. Flight track is colored with total particle number concentration.

Understanding How Clouds Evolve During Arctic Cold Air Outbreaks

Objectives

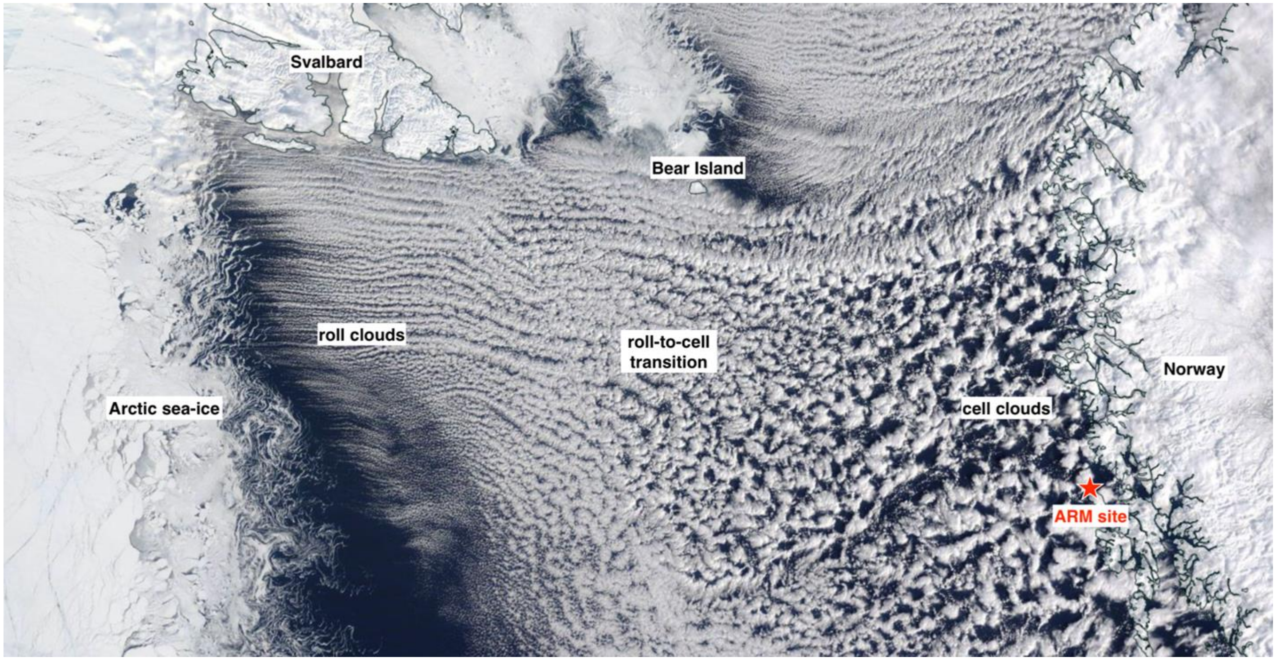
Observations show that cloud patterns transform from elongated rolls to broken cells along the pathway of a cold-air outbreak (CAO). However, the internal cloud processes that cause these changes are poorly understood. ASR-funded researchers selected two cases observed during the COMBLE campaign to quantify the evolution of cloud size distributions as an air mass moves from the Arctic over a comparatively warmer ocean.

Approach

- Used an object segmentation method to identify individual clouds from satellite images. Roll-to-cell transition was identified from the homogeneity of the cloud field.
- Assessed relationships between cloud morphology during the roll-to-cell transition and environmental parameters.

Impacts

- Generated a quantitative description of the fetch dependency of cloud morphology, which can enhance scientific understanding of poorly understood CAO cloud processes.
- These findings provide critical data for evaluating and improving weather and climate models.



Thank you!