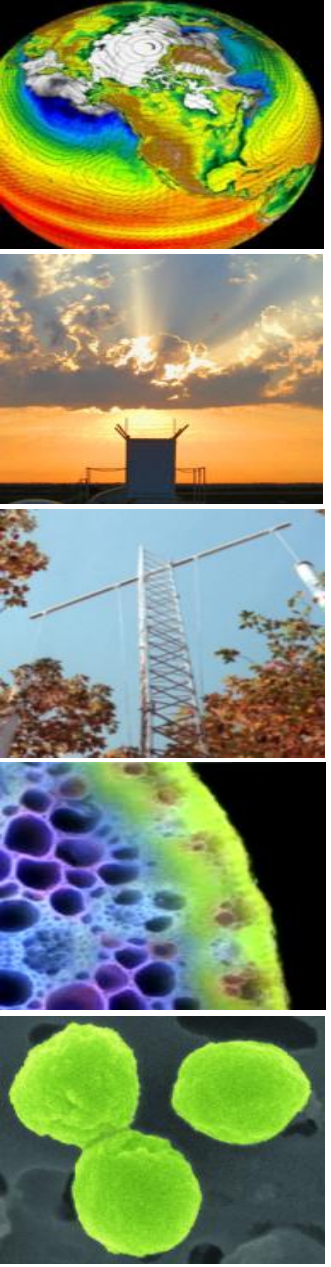


Earth and Environmental Systems Sciences Division

BERAC update

October 23, 2020

G. Geernaert

BER/EESSD

Executing our Strategic Plan 2018-2023

Vision: Improve a systems level understanding and predictability of the earth system in support of DOE's mission, through integrative theory, modeling, and experiment, over a variety of spatial and temporal scales.

High level Grand Challenges

- Integrated water cycle
- Biogeochemistry
- High latitudes
- Drivers and responses
- Data-model integration

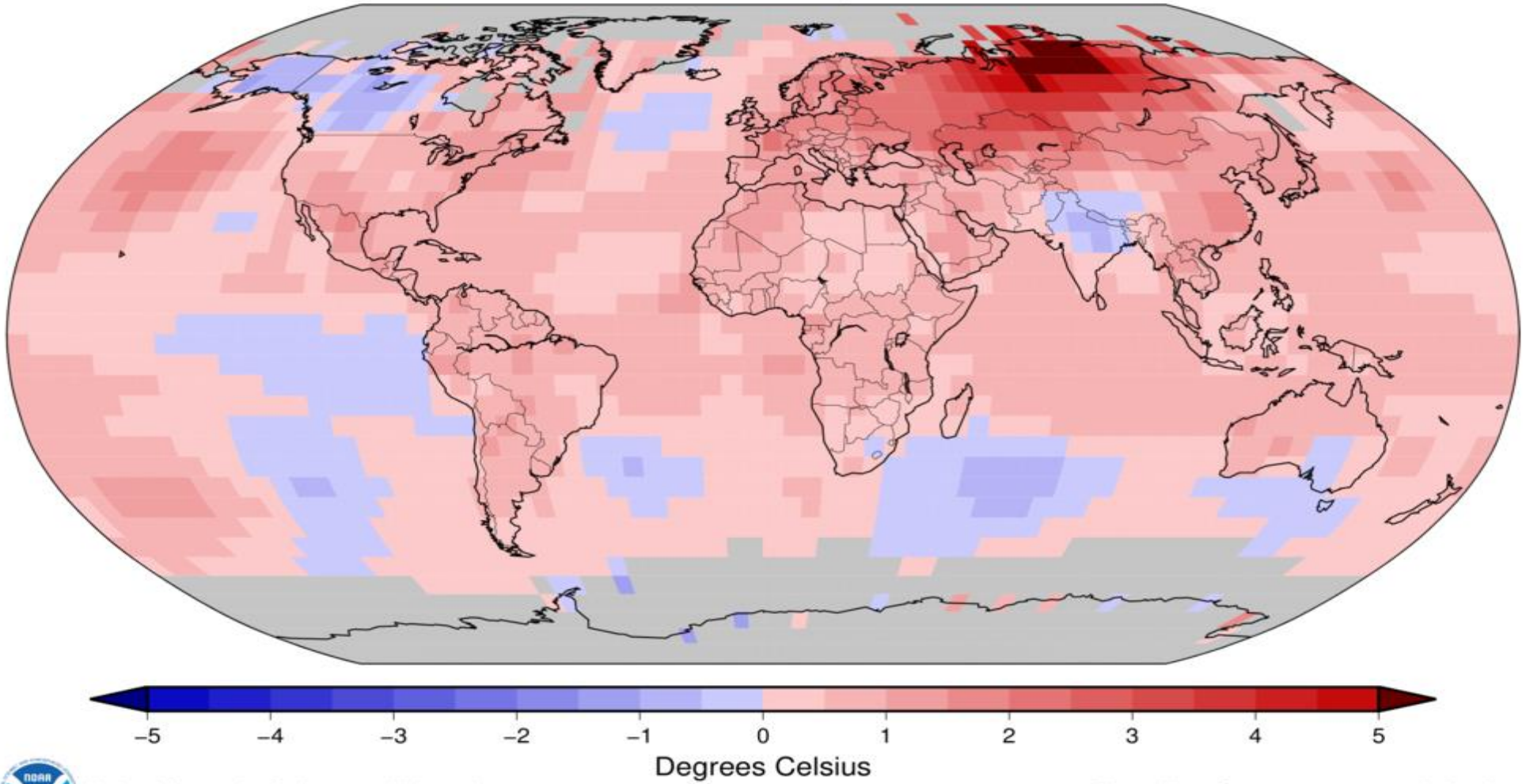
Execution

- Consolidation of programs; ESS, Modeling, ASR
- 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.

Land & Ocean Temperature Departure from Average Jan–Aug 2020

(with respect to a 1981–2010 base period)

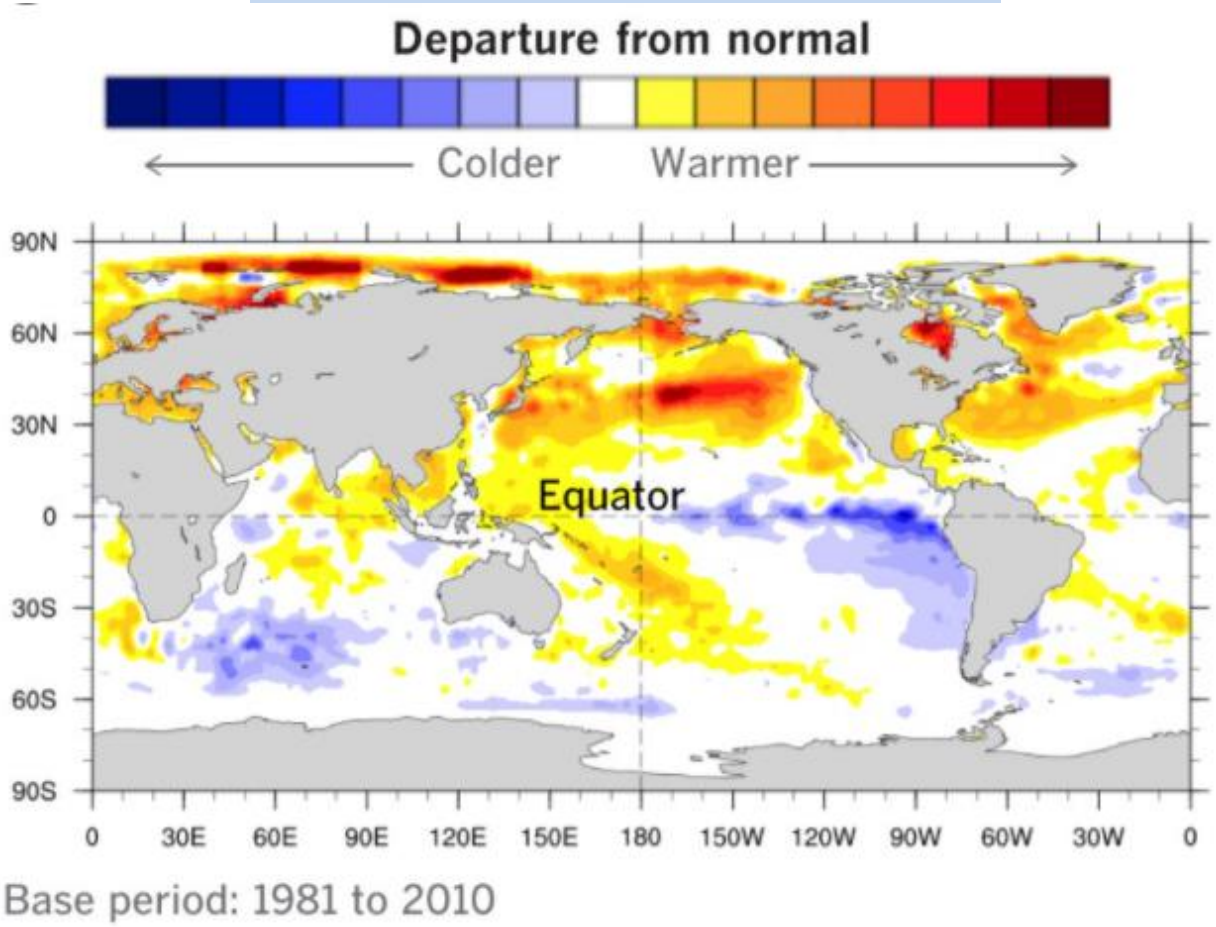
Data Source: NOAAGlobalTemp v5.0.0–20200908

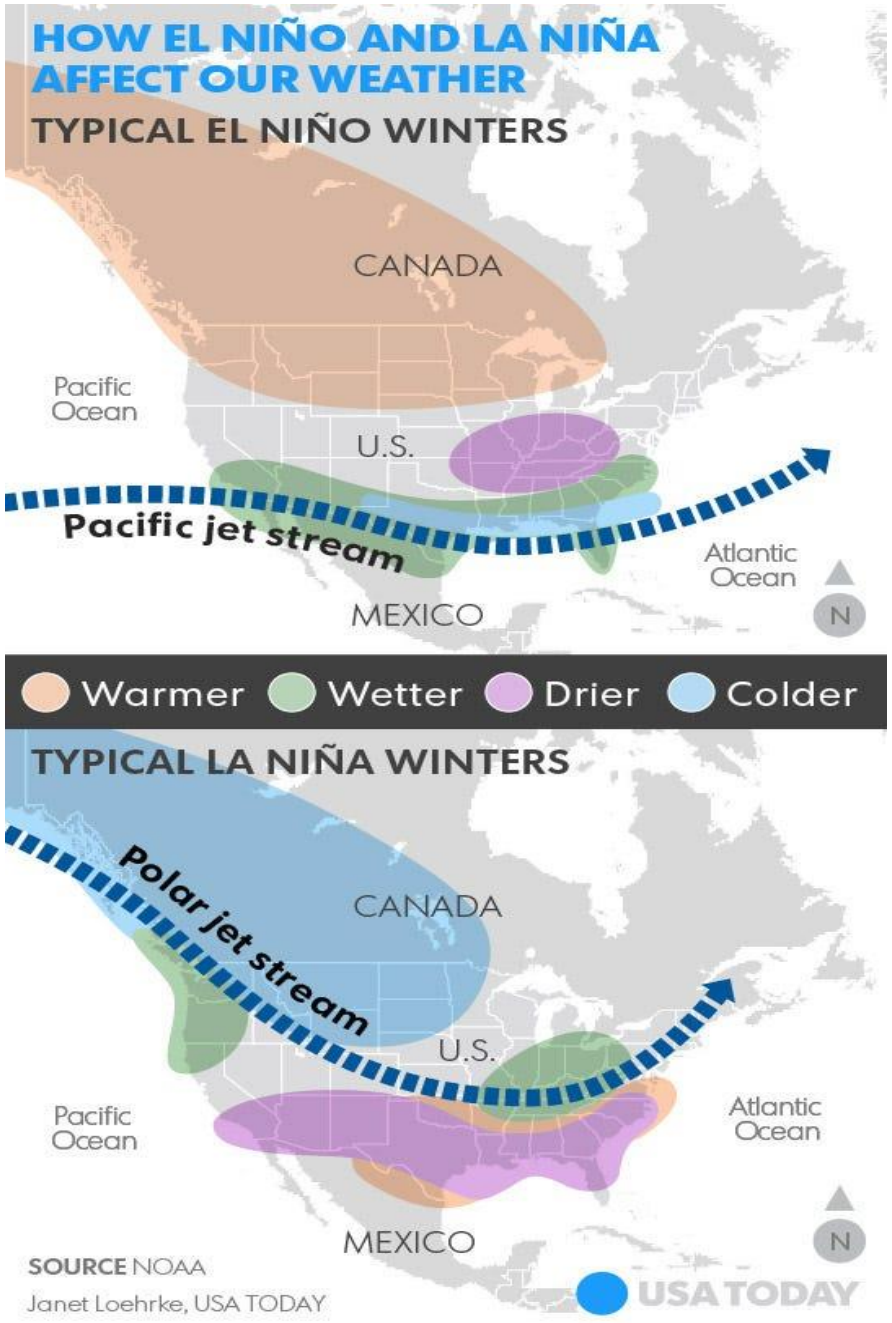


El Nino and La Nina patterns and UW West

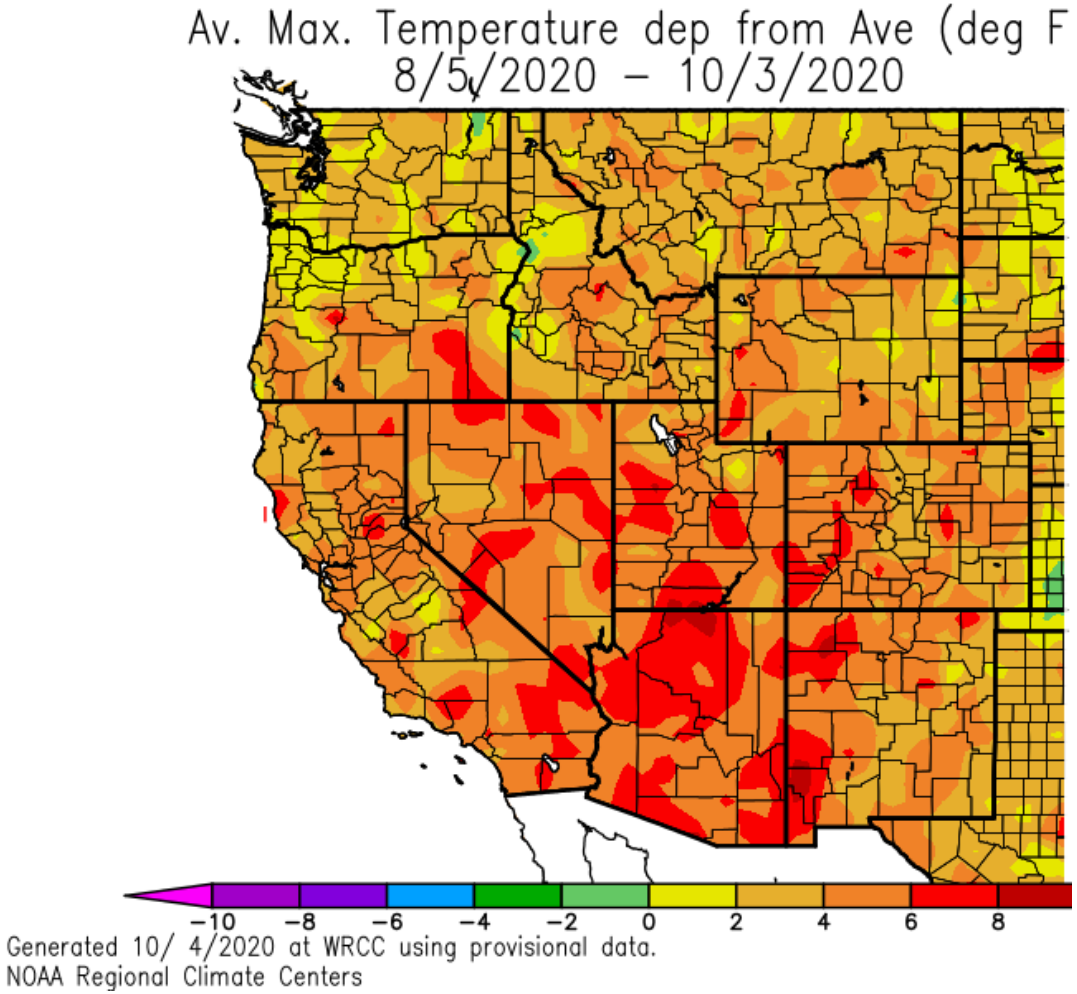
- El Nino leads to wetter than average
- La Nina leads to drier than average

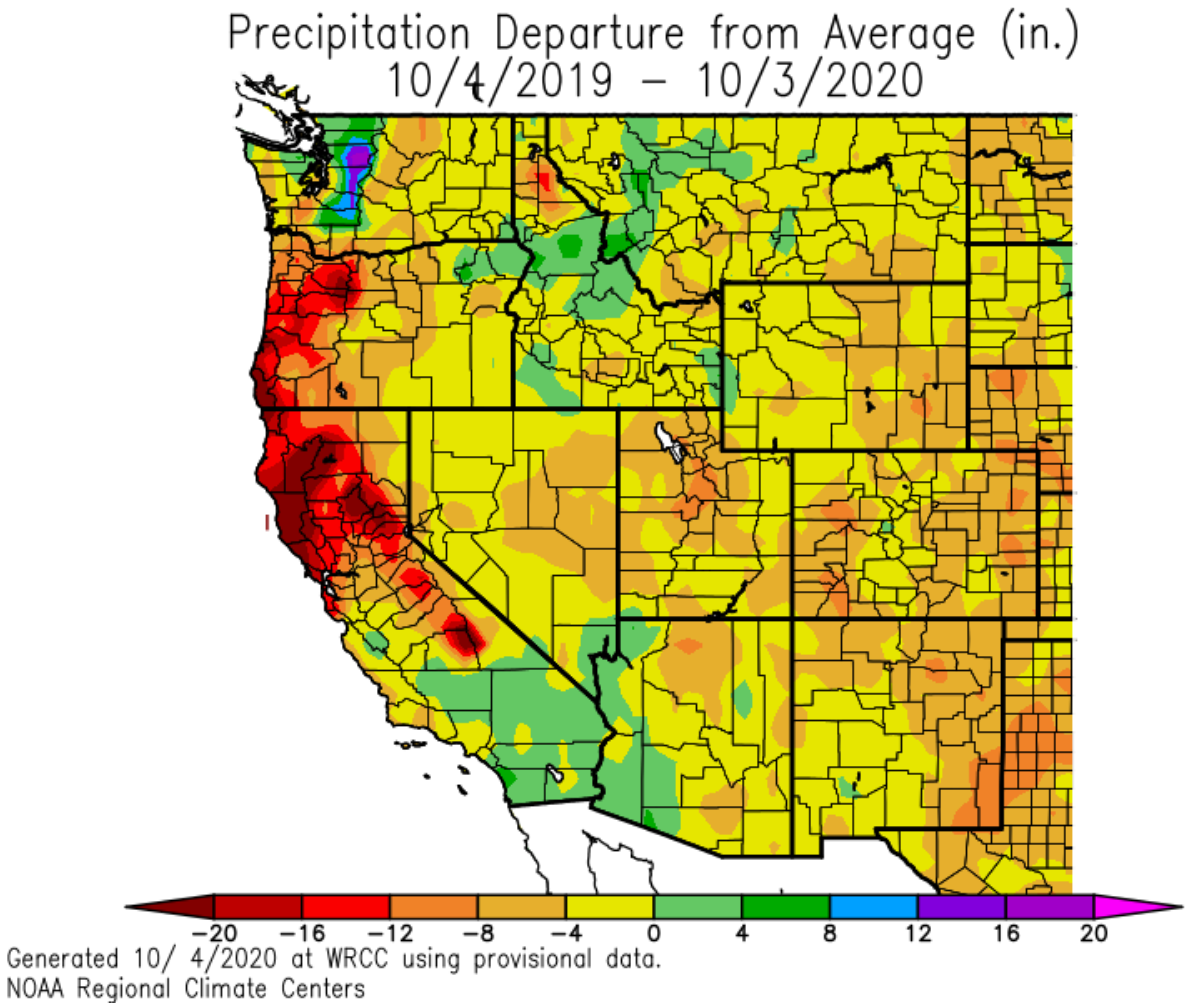
SEA SURFACE TEMPERATURE





Summer 2020 climate anomaly in US west





Fire as a fundamental ecological process: Research advances and frontiers

Scientific Challenge

The Future of Fire Consortium (FFC), composed of ecologists from around the globe with expertise ranging from paleoecology to atmospheric science, identified three emergent themes for future fire ecology research including: (1) the need to study fire across temporal and spatial scales, (2) the need to assess the mechanisms underlying a variety of feedbacks in the fire system, and (3) the need to improve representation of fire in a range of modeling contexts.

Approach & Results

In this review, critical research frontiers in six areas of fire ecology were identified: expanding concepts of fire regimes, understanding changing fire regimes, examining fire effects on aboveground and belowground ecology, increasing fuels characterization in determining fire behavior, and improving representation of fire processes in a variety of modeling contexts.

Significance & Impact

As fire regimes and our relationships with fire continue to change, prioritizing these research areas and emergent themes will facilitate understanding of the ecological causes and consequences of future fires and fire management.

McLauchlan, K. K., P. E. Higuera, J. Miesel, B. M. Rogers, J. Schweitzer, J. K. Shuman, A. Tepley, J. M. Varner, T. T. Veblen, et al. 2020. Fire as a fundamental ecological process: research advances and frontiers. Journal of Ecology. doi: 10.1111/1365-2745.13403

Workshops set the stage for future EESSD priorities

Date	Topic	Venue
Sept 4-6, 2019	Integrated hydro-terrestrial models- development of a national prediction capability. (with NOAA, NSF, USGS, and others)	NSF, Alexandria
April – June, 2020	Cloud-aerosol interactions and modeling (4 mini-workshops). w/NASA, NOAA, and NSF	Virtual as 4 webinars
May 18, 2020	Cyberinfrastructure Workshop	Virtual webinars
June 30 – July 1, 2020	Climate Modeling Summit – focus on cloud-aerosol and summary of machine learning opportunities	virtual
Nov 2, 2020	Coastal IHTM Workshop (with USGS and USACE)	virtual
Summer/Fall 2021	Lessons learned from FACE, NGEE, and MODEX	Wash DC
Spring 2021 thru 2022	MLAI framework for Earth system predictability	TBD

Management Update: solicitations

Funds	Program lead	Issued	Proposals	Panel	Selections
FY20	Early Career (model/coastal)	Nov 21, 2019	28	Apr 30 - May 1, 2020	2+2
FY20	ESS	Nov 7, 2019	116	May 4-8, 2020	20
FY20	ASR	Nov 20, 2019	87	May 11-15, 2020	31
FY20	Modeling	Dec 17, 2019	70 preapps	May 28-29, 2020	10

Management updates - PI meetings: 2019-2020

Title	Program(s)	Location	Date in 2020
ESS PI meeting	TES, SBR	virtual	May 19-20. Now virtual as 90 min webinars each day. Full PI mtg moved to 2021
PCHES PI meeting	Modeling/ MSD	virtual	June 1, 8, 15, 22
ARM/ASR PI meeting	ARM, ASR	virtual	Jun 22-26, 2020
Modeling / RGMA PI meeting	Modeling/ RGMA	virtual	Oct 13-16, 2020
Modeling / E3SM annual meeting	Modeling/ ESMD	virtual	Nov 9-10

Title		Location	Date in 2019
Committee of Visitors	CESD	Germantown	July 8-10, 2019

Management updates: Major reviews in 2019-2020

Lab	Program	Type	Review date	Decision	Date
PNNL	Model	IM3	Mar 25, 2020	Accept	May 6, 2020
PNNL	Model	GCIMS	Mar 26, 2020	Accept	May 5, 2020
PNNL	ESS	SBR	May 21, 2020	Accept	Aug 20, 2020
ANL	ESS	TES	June 2, 2020	Accept	June 23, 2020
SLAC	ESS	SBR	June 17, 2020	Accept	Aug 20, 2020
LBNL	ESS	Ameriflux mgmt	June (mail in)	Accept	Aug 31, 2020
LBNL	Data	ESS-DIVE	July 19-20, 2020	Accept	Sept 18, 2020
LBNL-ORNL	Data	Exashed	July 13, 2020	Accept	Aug 21, 2020
LLNL	Data	ESGF	Sep 22-23, 2020		
PNNL	Division	Coastal	Sep 28-30, 2020		
PNNL and other labs	ARM	Facility	Nov 4-6, 2020		
BNL/ANL	ASR	ASR	Nov 3-5, 2020		
LLNL/all	E3SM	SFA (mid course)	Nov 9-10, 2020		
BNL-ANL	ASR	SFA	Nov 17-19, 2020		

New Science Highlights

Common themes for the story-line

- **Reducing biases and uncertainties in integrative models**
- **Model-data fusion**
- **Science based on combination of field studies and lab studies**
- **Innovation - observing and data analytics**

Amplified Madden-Julian Oscillation in Pacific-North America region

Scientific Achievement

The Madden-Julian Oscillation (MJO) creates teleconnections with extratropical weather, but how MJO variability will change in the future is poorly understood.

Research Details

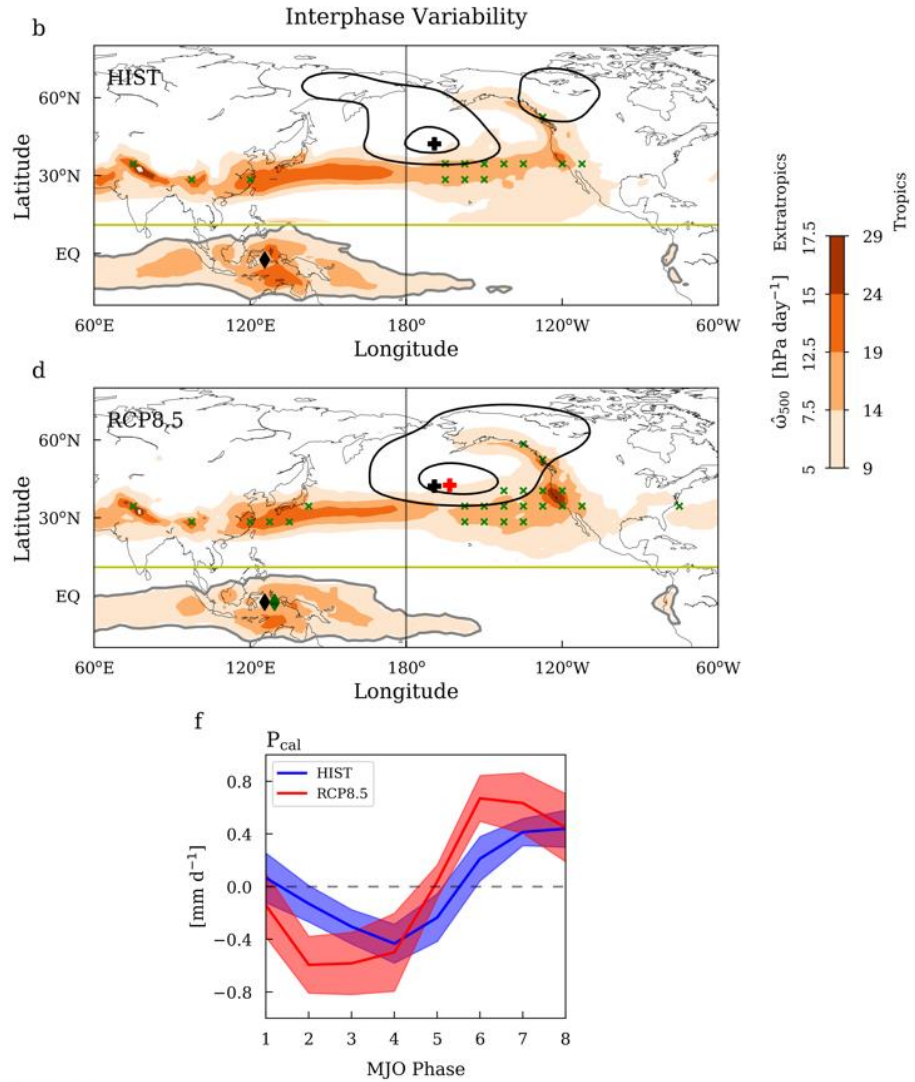
– Selected GCMs that properly simulate MJO

– MJO diagnosis based on multivariable MJO indices and phase composite

– Linear baroclinic model for understanding the mechanisms underlying the eastward-extended MJO teleconnection

Results, Significance and Impact

- The MJO teleconnection pattern will lead to amplified impacts in California and the Pacific Northwest.
- The enhanced subseasonal variability poses acute challenges on regional resource management and extreme weather preparation.



Citation: **Zhou, W., Yang, D.,** Xie, S-P & Ma J. (2020). Amplified Madden-Julian Oscillation impacts in Pacific-North America region. Nature Climate Change https://doi.org/10.1038/s41558-020-0814-0

Characterizing Tropical Cyclones in the Energy Exascale Earth System Model version 1

Scientific Challenge

- Understand how tropical cyclones (TCs) will change in the future and reduce biases in model simulations.

Approach

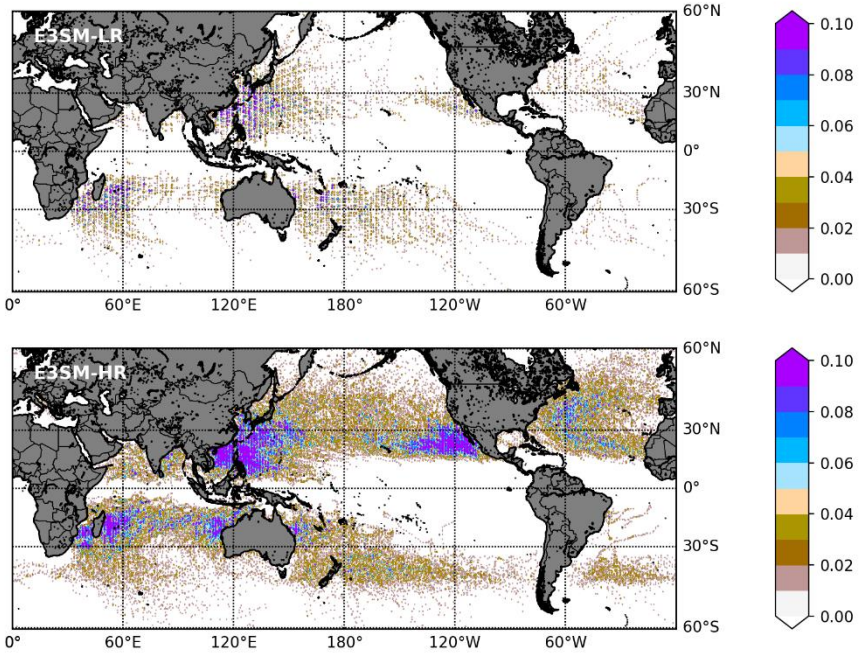
- Analyze TCs in fully coupled E3SM simulations standard (1^{o} atmosphere) and high (0.25^{o} atmosphere) resolutions.
- Understand errors in TC characteristics, e.g., spatial distribution of tracks and intensity based on those of the simulated environment.

Results using high resolution E3SM versus low resolution

- The simulated accuracy of TC characteristics, such as frequency and intensity, improve considerably.
- Sea surface cooling in response to TC-induced mixing are simulated much better with improved detail.
- For both resolutions, there remains spurious TC activity in the subtropical southeast Pacific and the south Atlantic, likely due to systematic sea surface temperature biases.

Significance and Impacts

- These results suggest that improvements in high resolution coupled model biases could alleviate errors in TC simulations.



TC track density, defined as the number of track locations determined at 6-hour intervals in a specific area per year, from the low- (E3SM-LR) and high-resolution (E3SM-HR) simulations. The distribution of TC tracks improves significantly in the high-resolution version of the model globally.

Balaguru, K., Leung, L. R., Van Roekel, L., Golaz, J.-C., Ullrich, P., Caldwell, P. M., et al. (2020). Characterizing Tropical Cyclones in the Energy Exascale Earth System Model version 1. *Journal of Advances in Modeling Earth Systems*, 12, e2019MS002024. https://doi.org/10.1029/2019MS002024

An energy consistent discretization of the nonhydrostatic equations in primitive variables

Scientific Challenge

Energy consistent discretizations are useful in guiding development of numerical methods for simulating fluid dynamics. They ensure that the discrete method does not have any spurious sources of energy, which can lead to unstable and unrealistic simulations.

Approach and Results

- We derive an energy-consistent discretization of the nonhydrostatic equations for the Earth's atmosphere, and implement in a new dynamical core for DOE's Energy Exascale Earth System Model (E3SM).
- Ensures no spurious sources of energy, with improved stability and accuracy.
- Software available: https://github.com/E3SM-Project/E3SM
- The new discretization preserves the Hamiltonian structure of the original differential equations.

Impact

This dynamical core is being used in E3SM's nonhydrostatic cloud resolving modeling project (SCREAM). This project together with DOE's upcoming Exascale resources will allow us to resolve the convective processes responsible for storm systems, removing a large source of uncertainty in climate change projections.

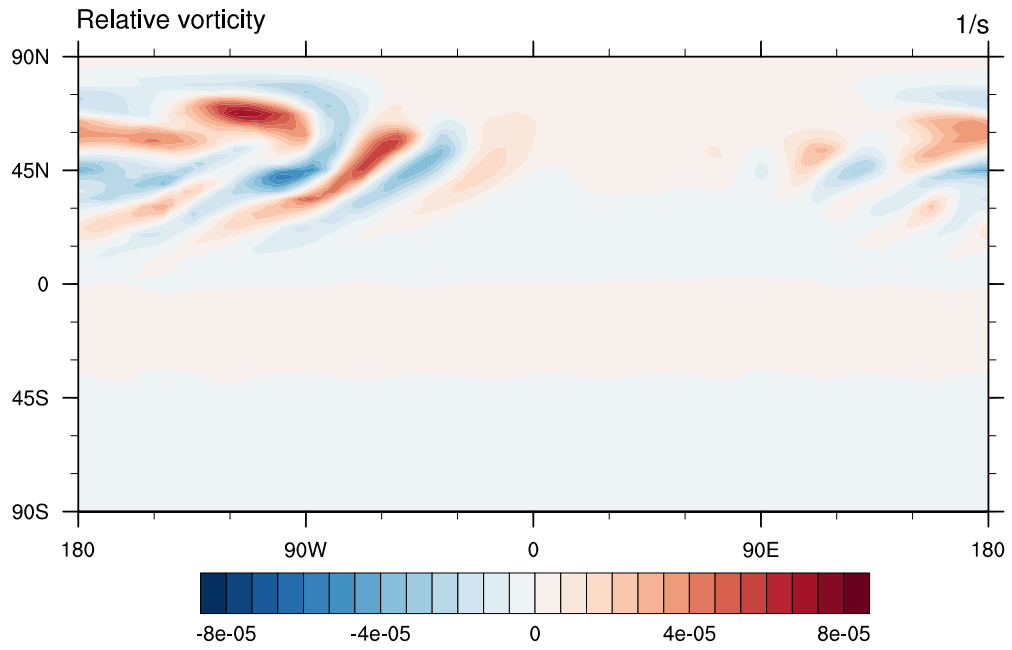


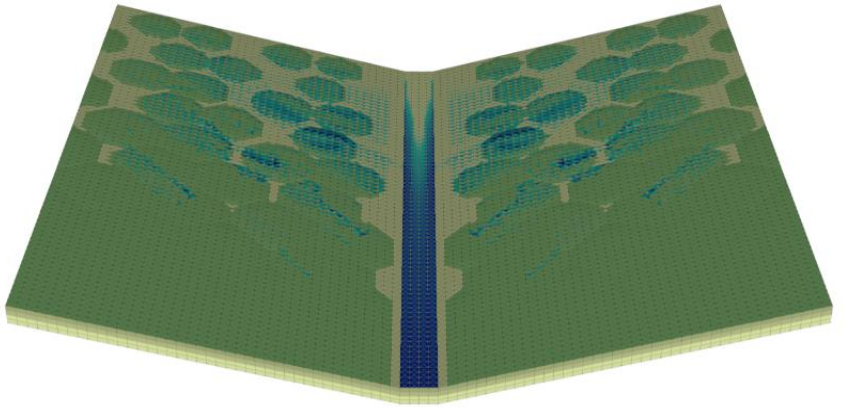
Figure: A baroclinic instability test case was used to confirm the energy conservation properties of the new discretization. Shown is the relative vorticity at 750 hPa at day 15.

Citation: Taylor, Guba, Steyer, Ullrich, Hall, Eldred, *An energy consistent discretization of the nonhydrostatic equations in primitive variables*, J. Adv. Model. Earth Syst. (2020) 10.1029/2019MS001783

Advancing the Coupling of Surface and Subsurface Water Flow in Models

Scientific Challenge

- Modeling geometrically complex landscapes where soil horizons and bedrock topography are not parallel to the surface topography presents challenges to accurately simulating water flow.



Example simulation showing a patterned ground with variable land cover and surface water during a rainstorm.

Approach and Results

- Developed a mathematical formulation of variable bedrock topography, leaf litter for use in an unstructured mesh to capture surface water runoff and magnitude as well as groundwater flow.
- Incorporated this novel mathematical formulation into the ATS code, and evaluated the approach for the ice-wedge polygonal ground and thaw areas typical of the Arctic tundra as part of the NGEE-Arctic project as well as hillslopes typical of mountainous locations.

Significance

- Implementation of this advance in the ATS code enables appropriate representation of complicated soil structure and enables model predictions of runoff and permafrost extent to remain accurate even in difficult cases such as pinched out layers and cryoturbated soils.

2020 R&D 100 WINNER

Amanzi-ATS Team
(LANL, ORNL, LBNL, PNNL

IDEAS Watersheds

Coon, Ethan T., et al. (ATS development team) "Coupling surface flow and subsurface flow in complex soil structures using mimetic finite differences." *Adv. Water Res.* 144: 103701 (2020). DOI: 10.1016/j.advwatres.2020.103701

Enhancing the Community Terrestrial System Model to Grow Perennial Bioenergy Crops

Scientific Challenge

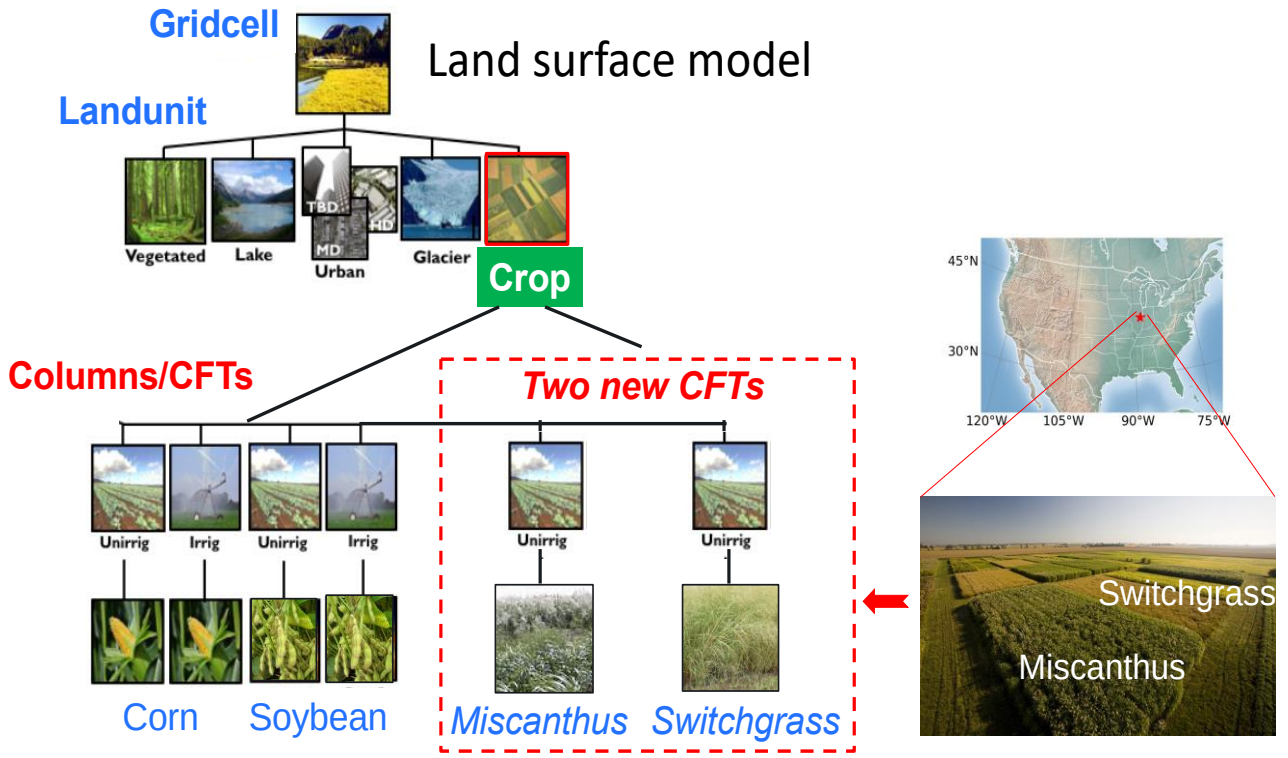
- Improve perennial bioenergy crop representation in terrestrial system models.

Approach and Results

- Implement two new perennial bioenergy crops, Miscanthus and switchgrass, into the latest version of the Community Terrestrial System Model (CTSM), previously known as the Community Land Model (CLM)
- Validate this new capability in CTSM with *in situ* observations in the Central Midwestern United States
- Demonstrate the model is capable of capturing observed patterns of energy and carbon fluxes for the two new perennial bioenergy crops.

Significance and Impacts

- Simulated perennial bioenergy crops in the CTSM land model for the first time
- Established the foundation for quantifying the effects of potential biofuel expansion on complex human-Earth system dynamics at local, regional and global scales



Effectively modeling perennial bioenergy crops is essential to understanding the effect of projected increases in biofuel production.

Cheng, Y., Huang, M., Chen, M., Guan, K., Bernacchi C., Peng, B., and Tan, Z., 2019, Parameterizing perennial bioenergy crops in Version 5 of the Community Land Model based on site-level observations in the Central Midwestern United States, *Journal of Advances for Modeling the Earth system*, 12(1), https://doi.org/10.1029/2019MS001719.

ARM Major Field Campaigns

Title	Location	Time	Principal Investigator	Major Facility
AWARE	Antarctica	Nov 2015 – Jan 2017	Dan Lubin, Scripps	AMF-2
HI-SCALE	Southern Great Plains	Apr – Sep 2016	Jerome Fast, PNNL	G-1, SGP
LASIC	Ascension Island, S. Atlantic	June 2016 – Oct 2017	Paquita Zuidema, U. Miami	AMF-1
ACE-ENA	Azores	June-July 2017; Jan-Feb 2018	Jian Wang, BNL	G-1
MARCUS	Southern Ocean	Oct 2017 – Apr 2018	Greg McFarquhar, U. Illinois	AMF-2
CACTI	Argentina	Oct 2018 – Apr 2019	Adam Varble, U. Utah/PNNL	AMF-1, G-1
MOSAIC	Arctic Ocean	Sep 2019 – Oct 2020	Matt Shupe, U. Colorado/NOAA	AMF2
COMBLE*	Norway	Jan 2020 – May 2020	Bart Geerts, U. Wyoming	AMF1
TRACER*	Houston	Apr 2021 – Mar 2022	Mike Jensen, BNL	AMF1
SAIL*	Crested Butte	Sept 2021-June 2023	Dan Feldman, LBNL	AMF2

ARM Update

Photo by Tercia Silva, Hammelmann Communications

- **MOSAIC campaign officially ended, with Polarstern return to port in Bremerhaven Oct 12, 2020**
- **ARM continuing planning for upcoming mobile facility campaigns starting in 2021 in Houston (TRACER) and Colorado (SAIL)**
- **ARM/ASR science team developing short list of potential site locations for move of AMF3 to Southeast US**
- **ARM Triennial Review – will be held virtually Nov 4-6**

- **Other ARM updates:**
  - Sites continue to implement social distancing guidelines, limiting number of operational staff on site at one time, doing as much work remotely as possible
  - Recently began allowing some travel by ARM instrument mentors and staff to sites for critical repairs/maintenance (i.e., power systems at Oliktok; C-SAPR at SGP)
  - Sites beginning to reopen to guest users – details depend on local travel restrictions (i.e., Azores still limited to EU only), number of users on site, and amount of interaction needed with ARM staff

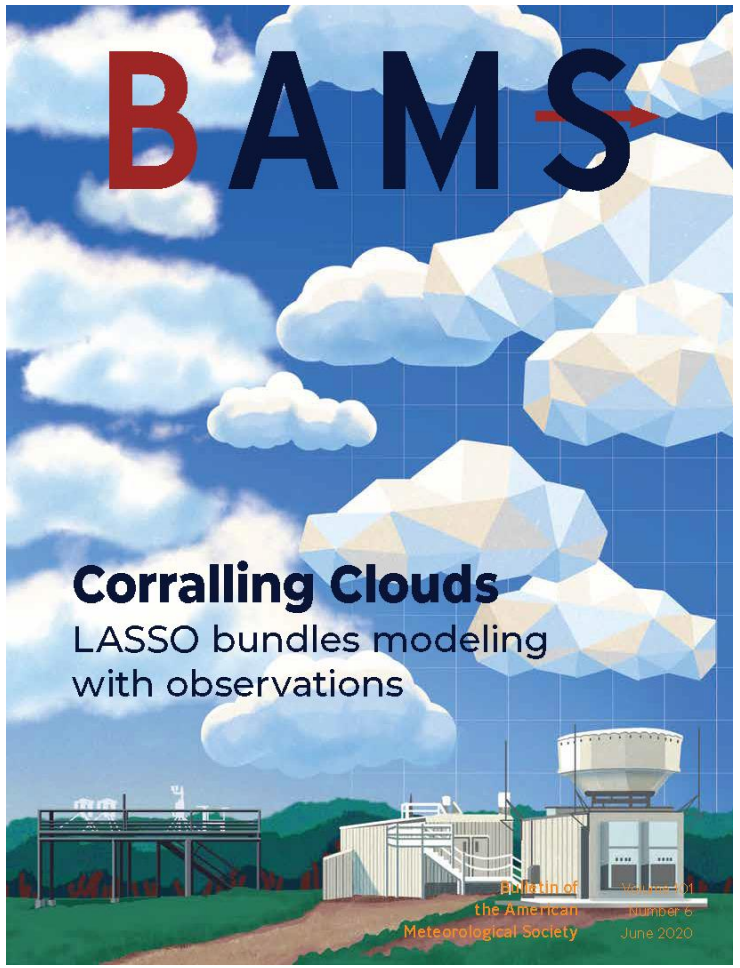
ARM's LASSO Activity: Bridging the Model-Data Divide

Scientific Challenge

- The scale gap between ARM user facility observations and large-scale earth system models can make it difficult for scientists to use ARM data for model development and evaluation

Approach and Results

- ARM developed the Large-Eddy Simulation (LES) Atmospheric Radiation Measurement (ARM) Symbiotic Simulation and Observation (LASSO) capability for users
- Combines LES ensembles of shallow convection at ARM's Southern Great Plains atmospheric observatory with a suite of ARM measurements
- Simplifies use by researchers by packaging model inputs and outputs, observations, and accompanying skill scores and diagnostics into data bundles



Significance and Impact

- Researchers have used LASSO for a variety of applications, such as improving radar methodologies, cloud parameterization, and theoretical understanding of clouds
- Takes advantage of ARM's long-term measurements and computational resources to provide large numbers of LES cases (over 78 so far) to move beyond "golden day" case study approach
- LASSO will soon be extended to deep convection cases from the CACTI campaign

Gustafson et al. 2020. "The Large-Eddy Simulation (LES) Atmospheric Radiation Measurement (ARM) Symbiotic Simulation and Observation (LASSO) Activity for Continental Shallow Convection." *Bulletin of the American Meteorological Society*, **101**, E462–E479, https://doi.org/10.1175/BAMS-D-19-0065.1.

Understanding the Source of Extremely Small Particles above the Amazon

Scientific Challenge

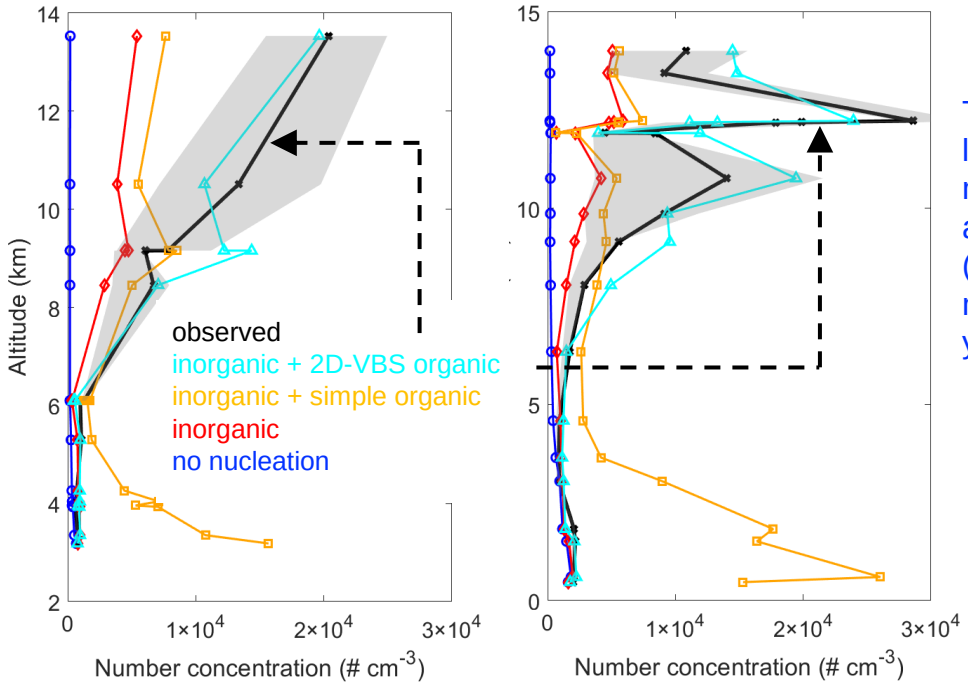
- The Amazon region is frequently used as a proxy for pre-industrial aerosol conditions.
- The high-altitude tropics constitute one of the world's largest aerosol reservoirs, which may significantly affect clouds, radiation, and hydrological cycle.
- However, the formation mechanisms of these aerosols is poorly understood due to difficulty in measuring the chemical composition of newly formed particles in the upper troposphere.

Approach and Results

- Integrate insights from laboratory measurements, chemical transport modeling, and field measurements from the GoAmazon campaign.
- Develop comprehensive model representation of the temperature-dependent formation chemistry and thermodynamics of extremely low volatility organic compounds to account for their roles in new-particle formation processes.

Significance and Impact

- Demonstrated that new particle formation is driven by extremely low volatility organics formed from natural biogenic emissions, in producing the large number of aerosols observed high above the Amazon.
- This finding is key to mitigating one of the largest sources of uncertainty in climate change studies, identifying a baseline of natural above which anthropogenic climate forcing is determined.



The new model (cyan lines) simulations are much closer to the aircraft observations (black lines) than other models (blue, red, and yellow lines).

B. Zhao et al., "High concentration of ultrafine particles in the Amazon free troposphere produced by organic new particle formation.", *Proceedings of the National Academy of Sciences,* 202006716 (2020), [DOI: 10.1073/pnas.2006716117]

Turbulence in Aerosol Activation and Cloud Formation

Scientific Challenge

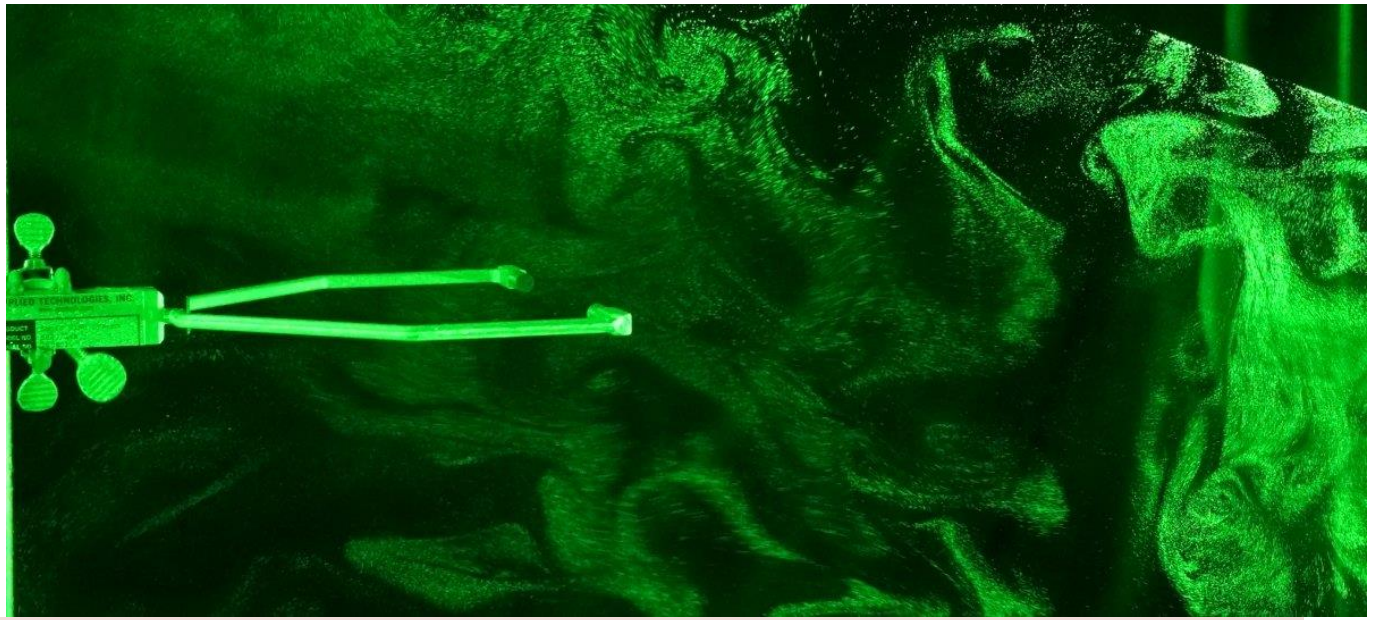
- Large scale models have generally ignored turbulence, focusing on steady state concentrations of water vapor and how they interact with aerosols in the atmosphere.

Approach and Results

- Researchers introduced aerosols into their cloud chamber—the Pi Chamber—and systematically varied water vapor concentrations above and below saturation.
- They found that the aerosols activated even at a relative humidity below saturation because turbulent fluctuations pushed the humidity in small parts of the chamber above saturation, even though the average conditions in the chamber were too dry for cloud formation with no turbulence.

Significance and Impact

- Researchers found that turbulent fluctuations about the steady state were extremely important and led to **clouds forming at much lower relative humidity levels** than previously thought to be necessary.
- Accompanying theoretical work forms a basis for future development of parameterizations for large-scale models.



Prabhakaran P, A Shawon, G Kinney, S Thomas, W Cantrell, and R Shaw. 2020. "The role of turbulent fluctuations in aerosol activation and cloud formation." *Proceedings of the National Academy of Sciences*, 117(29), 10.1073/pnas.2006426117.

Soot Particle Variations Affect Climate Modeling

EMSL

Challenge

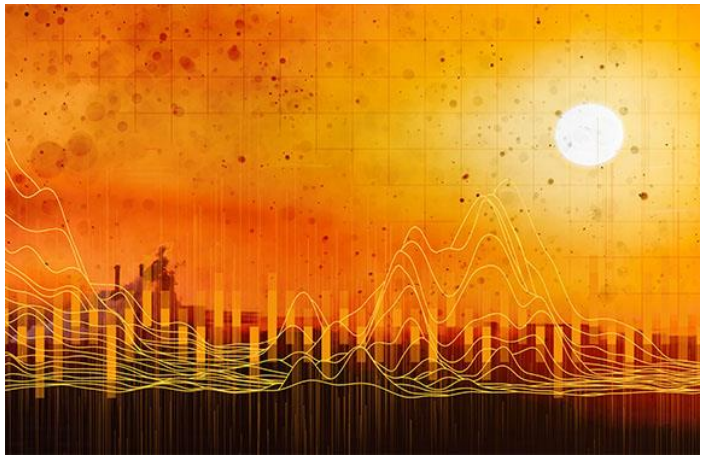
- When black carbon, or soot, enters the atmosphere, it absorbs sunlight, creating a warming effect that is not well understood.
- Current climate models tend to overestimate light absorption from soot particles, creating uncertainties about black carbon's atmospheric impact.

Approach and Results

- Researchers used laboratory and empirical data to account for differences between predicted and observed absorption enhancement for soot.
- They found two important factors are not adequately modeled: particle shape and per-particle composition, both of which tend to be more variable than assumed.

Significance and Impact

- The research provides a framework that explains globally disparate observations.
- The resulting framework can be used to improve estimates of black carbon's global radiative effect.



Airborne black carbon traps heat in the atmosphere, but the intensity of its warming effect can vary depending on the shape and composition of each particle. Illustration by Nathan Johnson, PNNL Creative Services.

Participants:
Brookhaven National Laboratory
Aerodyne Research
Boston College
University of California, Davis
Michigan Technological University
Environmental Molecular Sciences Laboratory
University of Georgia

L. Fierce, T.B. Onasch, C. Cappa, C. Mazzoleni, S. China, J. Bhandari, P. Davidovits, D.A. Fischer, T. Helgestad, A. Lambe, A.J. Sedlacek III, G.D. Smith, and L. Wolff, "Radiative absorption enhancements by black carbon controlled by particle-to-particle heterogeneity in composition," *Proceedings of the National Academy of Sciences USA (2020). DOI:*10.1073/pnas.1919723117
OSTI ID number 1607676

Water Level Influences Methane and Nitrous Oxide Fluxes from River Surfaces

Scientific Challenge

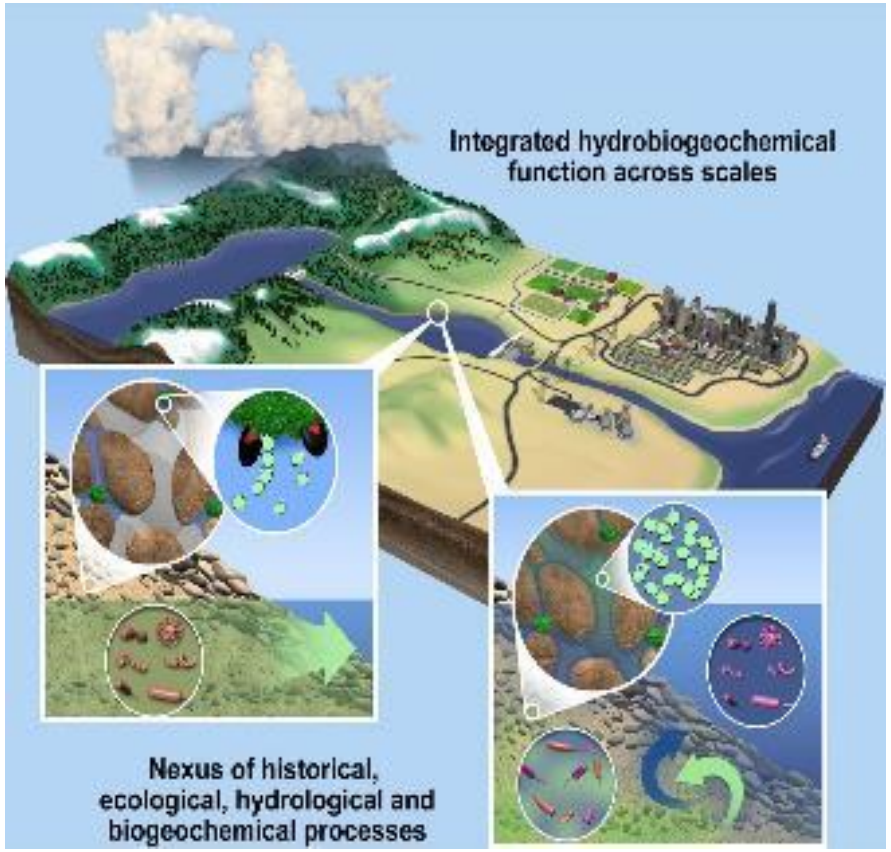
Understand the influence of hydrologic processes in aquatic sediments on the production and emission of methane and nitrous oxide.

Approach and Results

- Determined porewater concentrations of methane and nitrous oxide in hyporheic zone sediments in the Columbia River.
- Measured the surface flux of these gases.
- Found that the river acts as a source for methane emissions, especially under low water conditions.
- Nitrous oxide emissions were found to change with the rising and falling of the river stage due to upstream dam operations.

Significance and Impact

- Linked the production, oxidation and flux of methane and nitrous oxide to river hydrologic processes.
- Results can be incorporated into Earth system models.



Conceptual overview of cross-scale connections among history, ecology, and hydro-biogeochemistry.

J.A. Villa, Y. Ju, G.J. Smith, J.C. Angle, L. Renteria, E. Arntzen, S.F. Hardin, J.C. Stegen, K.C. Wrighton. "Methane and nitrous oxide porewater concentrations and surface Dfluxes of a regulated river." 2020. *Sci Tot Env* 7 15: 136920. https://doi.org/10.1016/j.scitotenv.2020. 136920.

Peatland warming strongly increases fine-root growth at SPRUCE

Scientific Challenge

The warming response of peatland plants is expected to influence future carbon uptake and storage but is poorly understood, especially belowground. Researchers from the ORNL Spruce and Peatland Responses Under Changing Environments (SPRUCE) experiment want to understand how whole-ecosystem warming and elevated CO_2 affect belowground plant growth in carbon-rich peatland ecosystems.

Approach & Results

- In the SPRUCE warming and CO_2 enrichment experiment, ORNL researchers found dramatic increases in fine-root growth, especially of shrub vegetation, in response to warming and drying of a peatland.
- The response is 20 times more pronounced than that found in warming experiments in upland ecosystems.

Significance & Impact

This work highlights belowground mechanisms that enable shrubs to rapidly adapt to warmer and drier conditions. Fine-root data and responses from this study will also enable improved representation of peatlands in Earth system models.

Shrub fine-roots, often finer than human hair, are shown tangled around a *Sphagnum* moss stem. The fate of these seemingly tiny plant components is closely tied to carbon cycling of peatlands, which are globally-relevant carbon sinks. Photo: Colleen Iversen

K. Finstad, O. van Straaten, E. Veldkamp, and K. McFarlane. "Soil carbon dynamics following land use changes and conversion to oil palm plantations in tropical lowlands inferred from radiocarbon." *Global Biogeochemical Cycles* (2020), [DOI: 10.1029/2019GB006461]

Bacterial hotspots on plant roots

Challenge

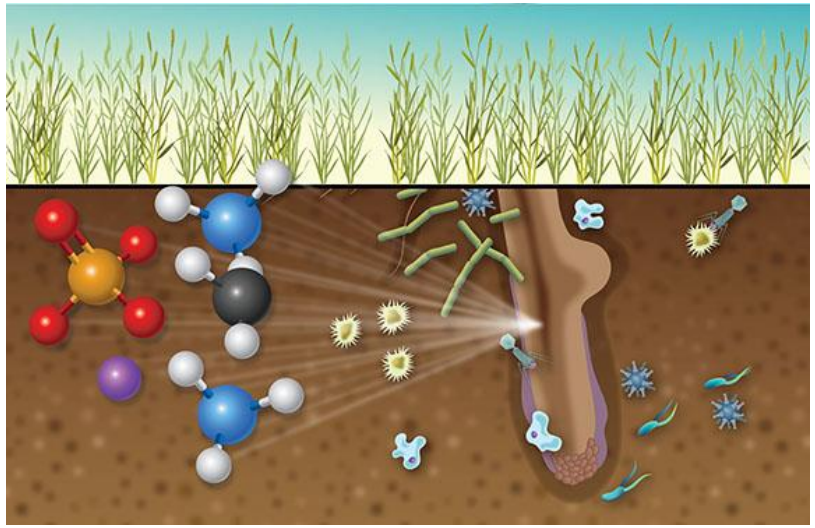
- Bacteria in the rhizosphere perform a host of beneficial functions that could be harnessed to improve agriculture, but the interactions between plants and bacteria remain a puzzle.

Approach and Results

- Scientists developed an innovative approach that allowed imaging of these interactions at the molecular level.
- Results suggest that these interactions are confined to a few specific locations along the plant root.

Significance and Impact

- If scientists could understand, predict, and control interactions between plants and bacteria in the rhizosphere, they could design ways to increase or restore plant productivity, develop natural fertilizers, and even create carbon-storage ecosystems to combat climate change.
- The results of the new study build the foundation to better understand these interactions.

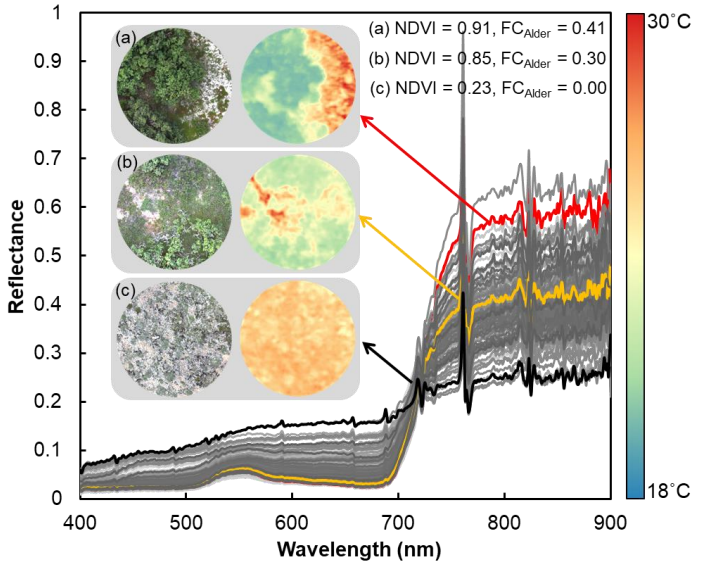


For the first time, scientists were able to view the interactions between bacteria and plants at the molecular level, offering insights for improving agriculture. Illustration by Nathan Johnson, PNNL Creative Services.

Reference: W. Liu, L. Huang, R. Komorek, P.P. Handakumbura, Y. Zhou, D. Hu, M. H. Engelhard, H. Jiang, X.-Y. Yu, C. Jansson, and Z. Zhu, "Correlative surface imaging reveals chemical signatures for bacterial hotspots on plant roots." *Analyst*, (2020). DOI: 10.1039/c9an01954e. Inner Cover.

Participants:
Environmental Molecular Sciences Laboratory
China University of Geosciences
Pacific Northwest National Laboratory

A Multi-Sensor Unoccupied Aerial System Improves Characterization of Vegetation Composition and Canopy Properties in the Arctic Tundra

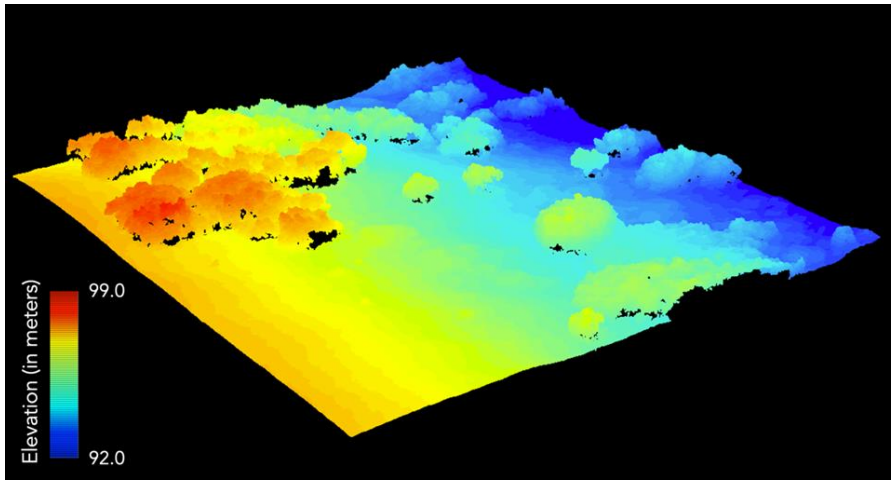


Scientific Challenge

Most current remote sensing does not provide the fine-scale understanding of Arctic plants needed by computer models to predict vegetation responses to climatic conditions. The BNL–led team designed a novel multi-sensor UAS to fill this critical gap in monitoring and scaling plant properties from leaves to ecosystems.

Approach & Results

- Traditional remote sensing platforms are impacted by resolution, cloud cover and other factors that limit the ability to characterize plants in Arctic regions.
- The team developed a UAS platform capable of collecting optical, thermal, and spectral properties of Arctic plants at centimeter-scale resolution.
- The UAS platform was used to develop detailed maps of species composition, canopy structure, albedo and functional properties across complex Arctic landscapes.



Significance & Impact

The capability provided by this novel UAS platform is critically needed for improving the representation of vegetation in complex ecosystem process models.

Yang, D., R. Meng, B. D. Morrison, A. McMahon, W. Hantson, D. J. Hayes, A. L. Breen, V. G. Salmon, and S. P. Serbin. 2020. A Multi-Sensor Unoccupied Aerial System Improves Characterization of Vegetation Composition and Canopy Properties in the Arctic Tundra. Remote Sensing 12(16), doi:10.3390/rs12162638 .

BROOKHAVEN NATIONAL LABORATORY

OAK RIDGE National Laboratory

Stony Brook University

Environmental Molecular Sciences Laboratory

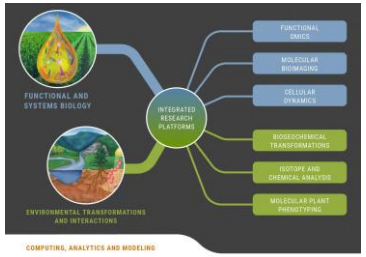
Accelerating scientific discovery and pioneering new capabilities to understand biological and environmental processes across temporal and spatial scales

COVID-19

- Limited operations – accepting samples and new proposals, adhering to social distancing in labs.
- CARES Funding - $3M CE (2 mass spec systems, cryo FIB-SEM – available) plus $1M for operations.

Strategic Planning

- Held 3 strategic planning workshops – developed Roadmap for Future Capabilities
- Relies on EMSL's Science Areas and Integrated Research Platforms (IRPs)



Outreach and User Activities

- July 6-10, Multiscale Microbial Dynamics Modeling Summer School (w/ PNNL SFA), over 500 attendees!
- October 5-8, Integration Meeting – Visualizing the Proteome
- October 1, EMSL Website Overhaul - https://www.emsl.pnnl.gov/
- December, Virtual AGU meeting – EMSL staff are convening 8 sessions

THANK YOU!