Terrestrial Ecosystem Science

Environmental System Science Principal Investigator Meeting
Potomac, MD

April 25-26, 2017

Daniel B. Stover, Ph.D.

Climate and Environmental Science Division

(FY 2017 Funding Levels – Based on Current Continuing Resolution at FY 2016 level)

- Research Programs
  - Climate and Earth System Modeling ($98.6M)
  - Atmospheric Systems Research ($26.4M)
  - Environmental Systems Science
    - Terrestrial Ecosystem Science ($40.0M)
    - Subsurface Biogeochemical Research ($23.2M)
  - Climate Data Informatics/Management ($7.1M)
- Facilities
  - Atmospheric Radiation Measurement (ARM) Climate Research Facility ($65.4M)
  - Environmental Molecular Sciences Laboratory ($43.2M)

Terrestrial Ecosystem Science (TES) Program

Goal: The TES program seeks to improve the representation of terrestrial ecosystem processes in Earth system models, thereby improving the quality of Earth system and environmental model projections and providing the scientific foundation of solutions for DOE's most pressing energy and environmental challenges.

Approach: A model-inspired fundamental research approach focusing on processes and ecosystems that are:

- Globally/regionally significant;
- Climatic or environmentally sensitive;
- Insufficiently understood or inadequately represented in predictive models

Terrestrial Ecosystem SCIENCE

Collaborative interactions as an Environmental Systems Science group with the Subsurface Biogeochemistry Research (SBR) Program.

Staff Changes

- Jared DeForest returned to Ohio University in December.
- Instrumental in developing FOA's, SBIR topics, SFA's and day to day management of the TES community.
- Led the development of the terrestrial-aquatic interfaces workshop and report.
- CESD appreciates Jared's help and commitment to the TES community!

TES Program Update

- FY-14 NASA ROSES Joint Solicitation - $8.2M over 3 year
  - 10 awards, Jointly supported with NASA, USDA, and NOAA
- FY-15 ESS Annual University Solicitation - $9.7M over 3 years
  - 185 Pre-apps, 117 full applications, 11 awards
- FY-16 ESS Annual University Solicitation - $6.0M over 3 years
  - 16 awards, 184 full application
- FY-17 NASA ROSES Joint Solicitation
  - Jointly supported with NASA, USDA, and NOAA
  - TES: 3.1.2 Carbon Dynamics in Arctic/Boreal Terrestrial Ecosystems
- Office of Science Graduate Student Research (deadline May 11)
  - Provides support for Ph.D. student to pursue parts of graduate research at DOE labs
- FY-17 Small Business Innovative Research (SBIR)
  - Compact, low power celiometers
  - 3 phase I awards

New Awards/Honors/Recognitions in the TES Portfolio

- **2016 AGU Fellows**
  - Michael Goulden, University of California, Irvine
  - Yiqi Luo, University of Oklahoma
- **2017 ESA Fellows**
  - David Eissenstat (Pennsylvania State University
  - Peter Reich (University of Minnesota
  - Russ Monson (University of Arizona)
- **2017 ESA Early Career Fellow**
  - Colleen Iversen (ORNL)
- **National Academy of Engineering**
  - Ruby Leung (PNNL)
- **National Academy of Science**
  - Jim Ehlringer (University of Utah)
- **2016 AAAS Fellow**
  - Baohua Gu (ORNL)
- **Corresponding Member of the Brazilian Academy of Science**
  - Michael Keller (US Forest Service)
- **Society of Exploration Geophysics, 2016 Harold B. Mooney Award**
  - Susan Hubbard (LBNL)

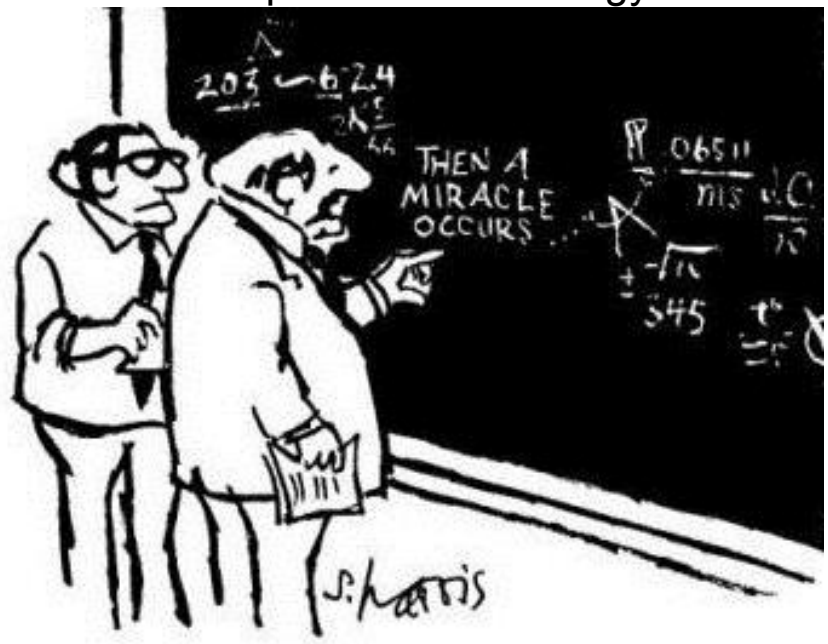
Early Career Awards

Daniel Hayes
ORNL/University of Maine
Arctic Ecology

Daniela Cusack
UCLA
Tropical Forest Ecology

Melanie Mayes
ORNL
Tropical Forest Ecology

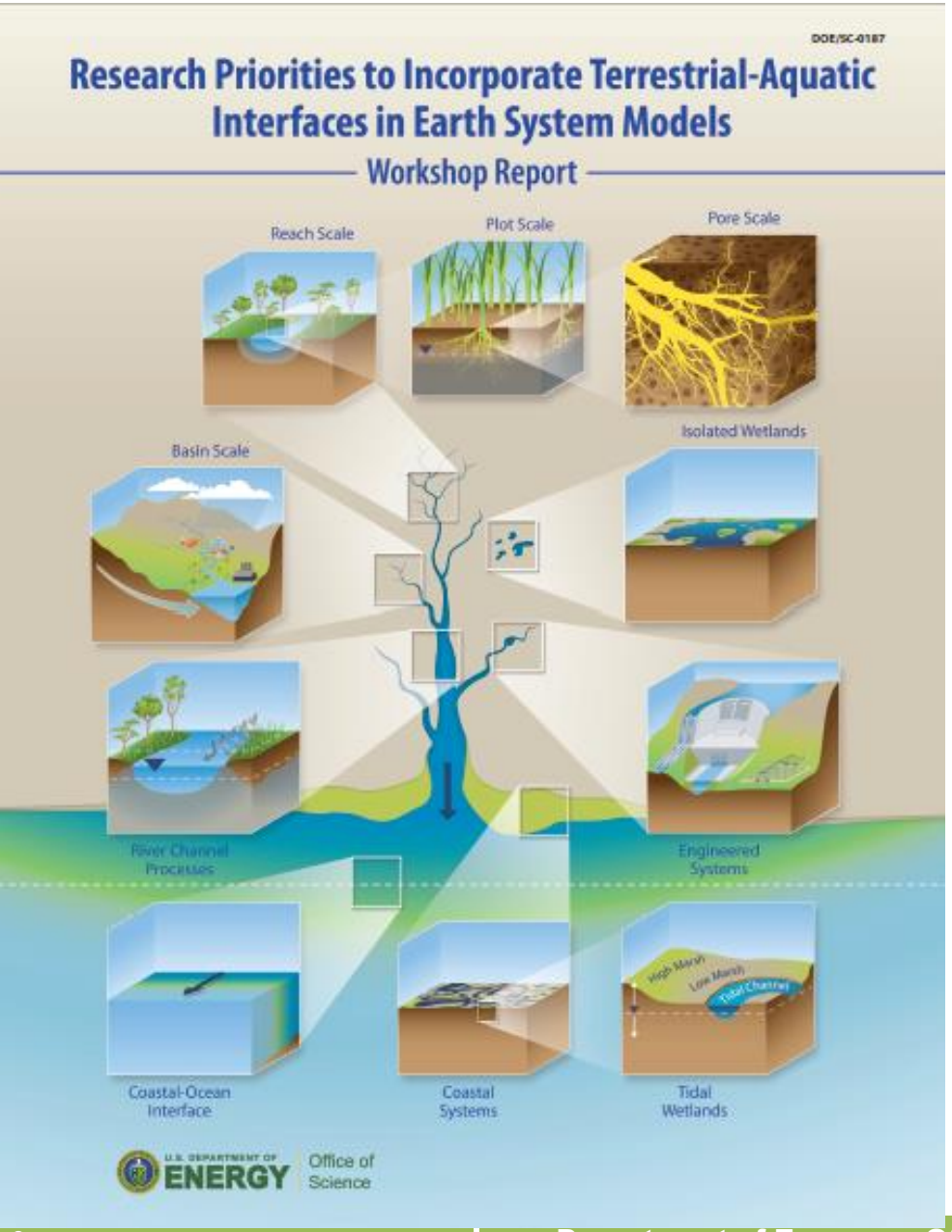
Rebecca Neumann
University of Washington
Belowground Ecology



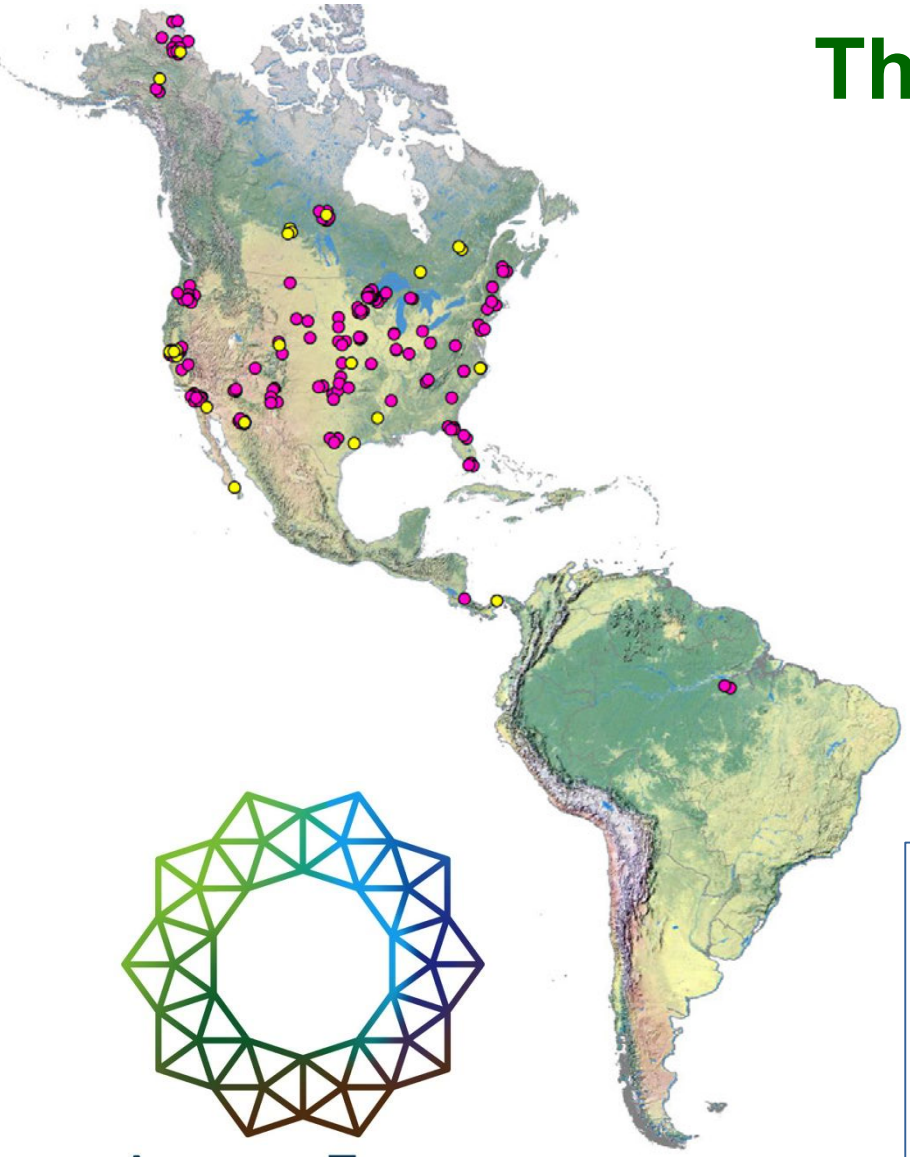
"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Karis McFarlane
LLNL
Tropical Forest Ecology

Terrestrial-Aquatic Interface Workshop



- Workshop organizers
  - Vanessa Bailey (PNNL)
  - Pat Megonigal (SI)
  - Joel Rowland (LANL)
  - Tiffany Troxler (FIU)
- Draft report released Feb 2017, formal release in early May
- Out Briefing tomorrow morning



AMERIFLUX

The AmeriFlux Network

Celebrated its 20th Anniversary!!!

265 registered Sites in the Network

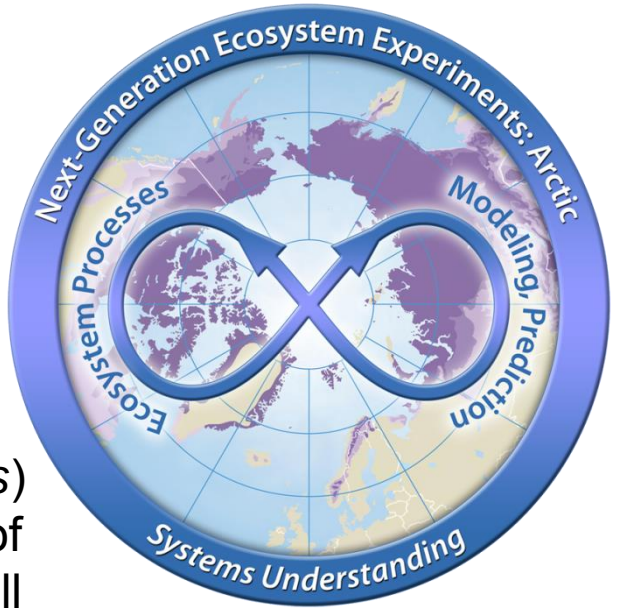
- 160 actively submitting sites
- 108 new or rejoined sites
- 8 QA/QC site visits
- 3 Rapid Response Systems deployed
- 2015 Fluxnet release (1500 site years and 28,000 unique downloads)
- Joint meeting with NACP

AmeriFlux Management Program Support:

- Contracts for operations
- Data managers' trainings*
- QA/QC intercomparisons, calibrations, loaners*
- Safety Training*
- Assistance w/ data & metadata processing

** Offered to whole network!*

NGEE – Arctic



Goal: Advance the predictive understanding of the structure and function of Arctic terrestrial ecosystems in response to climate change.

Objectives:

- Development of a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy, in which the evolution of (*Arctic ecosystems*) in a changing climate can be modeled at the scale of a high resolution Earth system model (ESM) grid cell (i.e., approximately 30x30 km grid size).

Approach:

- Collaborative effort among DOE National Laboratories and universities, led by Oak Ridge National Laboratory.
- Interdisciplinary, multi-scale approach to advance predictive understanding through iterative experimentation and modeling.

- **Recent Progress:**
  - Expanding efforts from Barrow to Seward and developed strong partnership with NASA ABoVE

NGEE – Tropics

Goal: Improve our understanding of ecosystem-climate feedbacks due to changes in precipitation, temperature, nutrient cycling and disturbance in tropical forests.

Objectives:

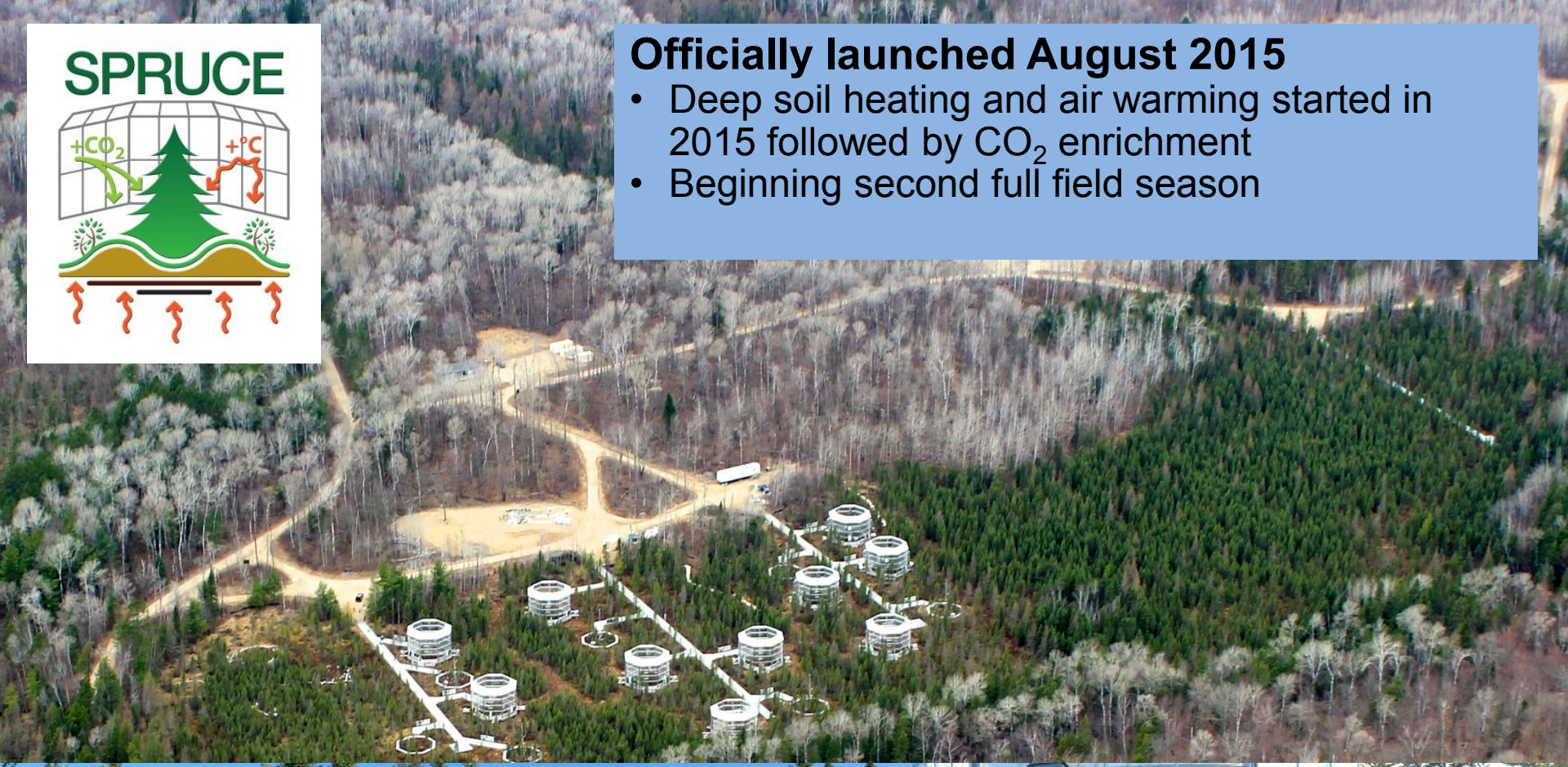
- Development of a representative, process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy-atmospheric interface, in which the evolution and feedbacks of tropical ecosystems in a changing climate can be modeled at the scale/resolution of a high resolution next generation Earth system model (ESM) grid cell.

Approach:

- Collaborative effort among DOE National Laboratories and universities, led by Lawrence Berkeley National Laboratory.

Update:

- Deployed efforts in Puerto Rico, Panama and Brazil to study recent ENSO event
- FATES model development
- Phase I midterm review



Officially launched August 2015

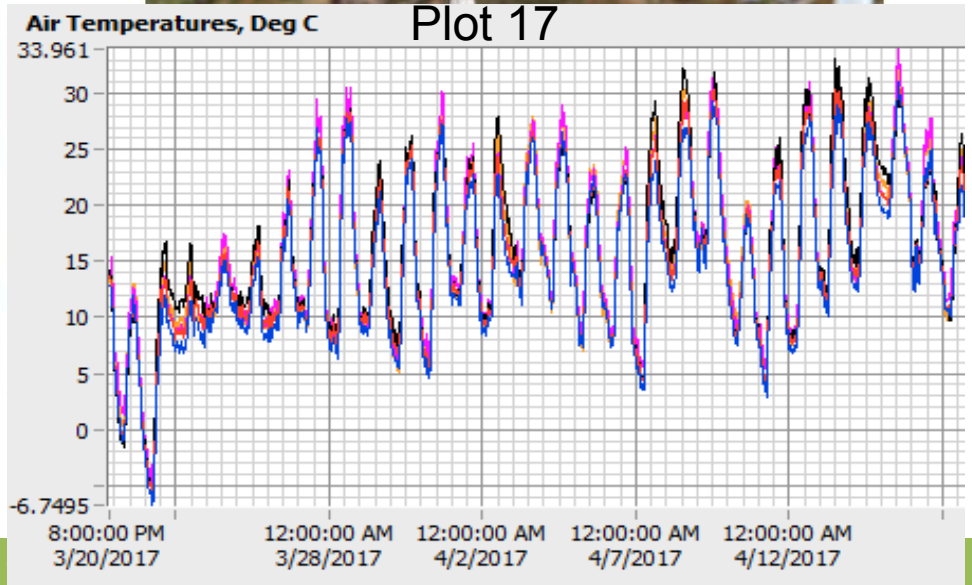
- Deep soil heating and air warming started in 2015 followed by CO_2 enrichment
- Beginning second full field season

2017 Phenology Begins

Plot08 - 29 March 2017

Plot 17 - 29 March 2017

Plot 17



Looking Ahead and Strategic Plans

- CESD Strategic Plan to be released later this Spring
- Two sessions at the Ecological Society of America Annual Meeting (Portland, OR)
  - Ignite Session on Trait-Based Approach to Study Belowground Systems
  - Early Career Networking Sessions
- Anticipating FOA release in Fall 2017
- Connect projects closely to other research activities within CESD, within BER, and among the other Federal agencies.
  - E.g., ILAMB, ACME, Genomic Sciences Program
- Forge strong programmatic coordination with the BER Scientific User Facilities (ARM, EMSL, JGI and Synchrotrons) Tues Lunch session; Wed. Breakfast session

Science Highlights

An important way to communicate scientific accomplishments to program managers, BER, the Office of Science and the public.

- BER has a new publication highlight policy and procedure
  - Will greatly streamline the process of posting highlights online
- A template that the author fills out when the publication has a DOI number
  - Should clearly articulate and distill the major points of the publication for a several audiences (scientists to the **general public**)
- Requested for all BER-funded projects
  - National Labs & University
- A one-slide PowerPoint slide

[Day] [Month] [Year]

[Title in Capitalized Format]

[Subtitle not capitalized, ending with a period.]

The Science

[A sentence or two, accessible to the non-specialist.]

The Impact

[A sentence or two, accessible to the non-specialist. The "impact" of a use-inspired science highlight is typically a potential technological advance while the "impact" of a discovery science highlight might be to open up new frontiers of science or resolve a longstanding question.]

Summary

[A paragraph, hopefully still accessible to the non-specialist, but may be more technical if necessary.]

Contacts (BER PM)

[Name]
[Institution with optional title, optional address]
[Email and/or telephone]

(PI Contact)

[Name]
[Institution with optional title, optional address]
[Email and/or telephone]

Funding

[Explanation of funding ***including citation of all significant sources, including non-DOE sources if applicable***; formatting is flexible: can be a bulleted list, a sentence, or a short paragraph.]

Publications

[List publications one per line in the format used by Nature:
M. Butterworth, "Optimal sugar content of artificial maple syrup." *Science* **35**, 221 (2012). [DOI].]

Related Links

[include optional related links, one per line]

So Easy….

Terrestrial Ecosystem Science Program

About the Program | Research | Highlights | PI Meeting | Site Map | Contact Us

U.S. Department of Energy Office of Biological and Environmental Research

PI-Submitted Research Highlights for Terrestrial Ecosystem Science Program

DOE TES Researchers: Submit Your Research Highlight!

Tell us about your research! This system is designed to collect brief science highlights describing published research supported t program within DOE's Office of Biological and Environmental Research (BER). For each highlight, you will be asked to submit a r a PDF of the BER highlight slide (*slide examples*).

Once submitted, these science highlights are (1) used by the TES program management team as part of regular efforts to inform s management of the importance and impact of TES-supported research; (2) posted on the TES website to inform other TES-suppo work; (3) submitted to BER's science highlights archive; (4) considered for use in TES, Climate and Environmental Sciences Divis materials; and (5) used for other scientific outreach and communication purposes [e.g., posted on the Office of Science highlights

Edits

To edit or delete a previous submission, please contact the administrators.

Checklist and Instructions

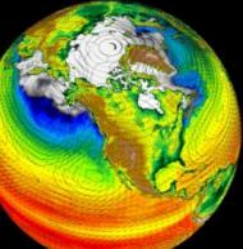
Please have the following information ready.

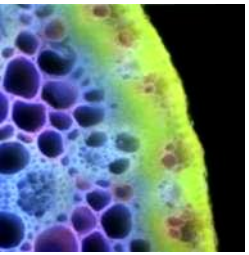
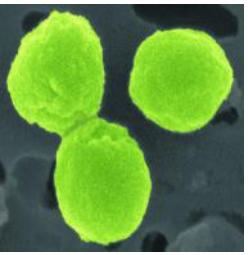
1. Highlight as a Word document. *(required)* Create highlight using **this new template** before beginning form.

"We'd like to publish it, do nothing to promote it, and watch it disappear from the shelves in less than a month."

And Don’t Forget Data!!!

- Data management plans are required
- Research data obtained through public funding are a public trust and must be publicly accessible.



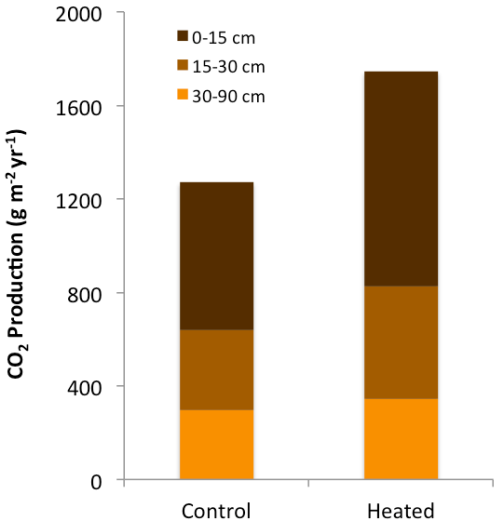
Terrestrial Ecosystem SCIENCE

Questions?

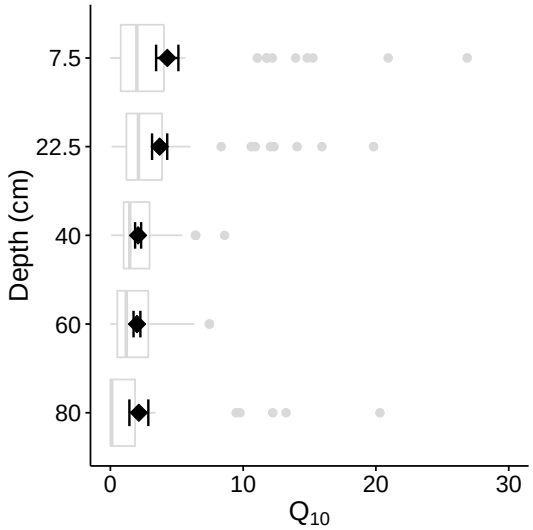
Backup slides

Whole-Soil Carbon Flux in Response to Warming

(A) Soil CO_2 production increased by about 35% in the heated plots with 40% of the response coming from >15 cm and 10% from >30 cm.



(B) Mean apparent Q_{10} over 20 months is similar at all depths (±SE, black diamonds).



- Berkeley Lab scientists created the first replicated field experiment to warm the whole profile of a mineral soil, in a conifer forest in California. Warming the whole profile by 4°C increased annual soil respiration by 34-37%. More than 40% of this increase in respiration came from below 15 cm depth, which is below the depth considered by most studies.
- The impact of warming on soil CO_2 flux is a major uncertainty in climate feedbacks. This whole-soil warming experiment found a larger respiration response than (1) many other controlled experiments, which may have missed the response of deeper soils, and (2) most models. Thus, currently the strength of the soil carbon-climate feedback may be underestimated.

In this year-round experiment, plots were warmed by a ring of 22 vertical heating cables installed to 2.4m depth. Three plots (3 m diameter each) were warmed by 4°C and three served as controls. Soil respiration was measured three ways: continuous autochamber (1 per plot), monthly survey chambers (7 locations per plot), and gas tubes at 5 depths (1 set per plot). Radiocarbon content of CO_2 and soil fractions suggests that respiration—and its warming response—was dominated by decadal cycling carbon.

Hicks Pries, C.E., C. Castanha, R.C. Porras, and M. S. Torn. The whole-soil carbon flux in response to warming. Science. Science 2017; eaal1319 DOI: 10.1126/science.aal1319

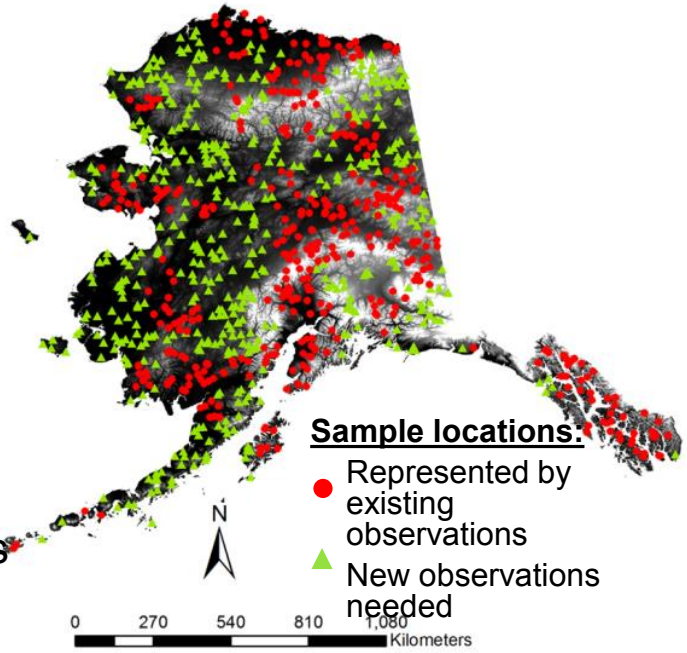
Observational Needs For Estimating Alaskan Soil Carbon Stocks Under Current and Future Climate

Challenge

- Existing estimates of Alaskan soil C stocks are based on an unbalanced spatial distribution of observations with vast areas of the region completely unrepresented

Approach and Results

- Geospatial relationships among climate data, land surface properties, and existing soil C observations were used to identify where new observations (green triangles) are needed to characterize soil C stocks across all of Alaska with a confidence interval of 5 kg m^{-2}
- Greatest needs for new samples are from scrub (mostly tundra) land cover types and from the Aleutian Meadows and Bering Taiga ecoregions (in southwestern Alaska)
- Future climate projections (to 2100) will not greatly alter number and locations of required observations



Significance and Impact

- Identified observation sites can inform studies seeking to reduce uncertainties in soil C estimates and create robust spatial benchmarks for Earth system model results

Reference: Vitharana U.W.A., U. Mishra, J.D. Jastrow, R. Matamala, and Z. Fan. 2017. "Observational needs for estimating Alaskan soil carbon stocks under current and future climate". *Journal of Geophysical Research-Biogeosciences,* doi:10.1002/2016JG003421.

In Deep Active-Layer Boreal Soils, How Temperature and Moisture Affect Greenhouse Gas Emissions

Objective

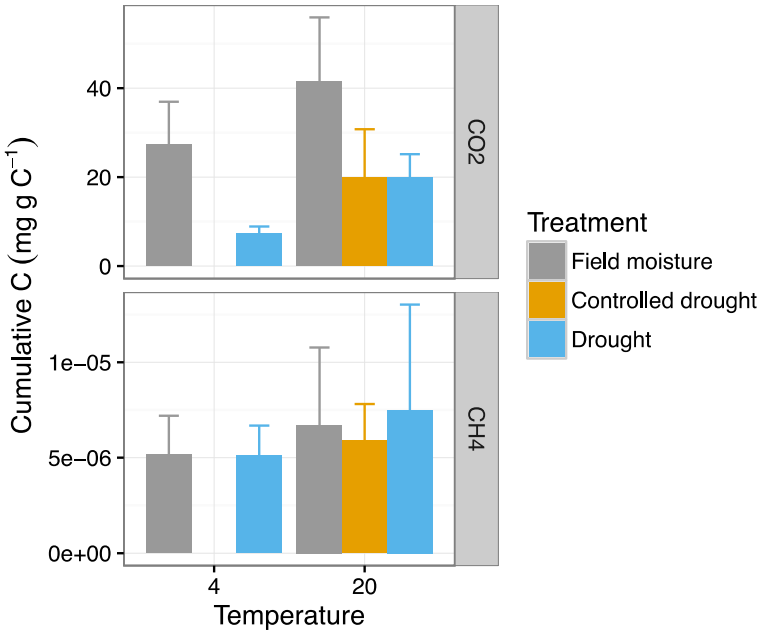
- Study deep active-layer soils to better understand how soils in high-latitude ecosystems—regions that hold large stocks of soil carbon—respond to changes in temperature and moisture and to changes in their overlying vegetation.

New Science

- Examined how temperature and moisture control CO_2 and CH_4 emissions in soils sampled from directly above permafrost in an Alaskan boreal region.
- After subjecting six groups of six samples each to a 100-day incubation at different temperatures (with some samples subjected to drying treatments to simulate drought), the researchers also characterized the soils according to chemical and structural properties.
- Three hypotheses were true: CO_2 would be the dominant pathway for carbon loss; soils kept moist and warm would lose more CO_2 than cold soils; and CH_4 fluxes would be small and sensitive to only temperature.

Significance

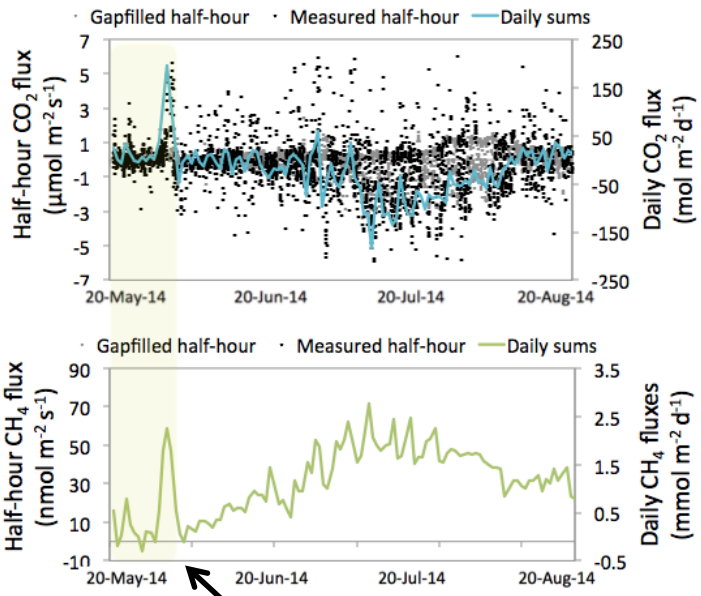
- The results underscore the particular importance of understanding the effects of moisture (more than temperature) on fluxes of carbon dioxide. It also identifies important areas for future research on northern soils, which sequester enormous and climate-critical quantities of soil organic carbon.



Cumulative carbon emissions from experimental soil cores, by gas: carbon dioxide (CO2) top, methane (CH4) bottom. Bars are colored by experimental treatment. Note difference in y-axis scale between panels

B. Bond-Lamberty, et al., "Temperature and moisture effects on greenhouse gas emissions from deep active-layer boreal soils." Biogeosciences, 13, 6669-6681, 2016. http://www.biogeosciences.net/13/6669/2016/. DOI: 10.5191/bg-13-6669-2016.

Large CO_2 and CH_4 Emissions from Polygonal Tundra During Spring Thaw in Northern Alaska



Pulse

- Berkeley Lab scientists measured a large pulse of carbon greenhouse gases released from the frozen Arctic tundra when soils started to thaw in early June 2014. Little has been known about such releases; the researchers show that the pulse was the result of a delayed mechanism, in which gases produced in fall were trapped in the frozen soils and released in spring.
- The research identified a large, underrepresented source of carbon
- emissions in the Arctic. The findings suggest that the Arctic may be even less of a carbon sink than previously thought. A multi-institution team linked hydrology, biogeochemistry, and geophysics to uncover the pivotal roles of warmer fall weather and of spring rain-on-snow events, implying these pulses may be more frequent in the future.

– Pre-thaw carbon flux pulse, measured by eddy covariance, offset 46% of CO_2 summer uptake and added 6% to CH_4 summer fluxes

– A similar pulse was measured 5 km away, indicating that this was a widespread phenomenon in 2014.

– Laboratory experiment linked pulse emissions to a delayed microbial production mechanism

– The type of rain-on-snow event that triggered the pulse is gradually becoming more frequent over the past 30 years

- Raz Yaseef, N., M. Torn, Y. Wu, D. Billesbach, A. Liljedahl, T. Kneafsey, V. Romanovsky, D. Cook, and S. Wullschleger (2016), Large CO_2 and CH_4 emissions from polygonal tundra during spring thaw in northern Alaska, Geophys. Res. Lett. , 43, doi:10.1002/2016GL071220.

Stability of the Temperate Peatland Carbon Bank to Rising Temperatures

Objective

- Peatlands contain ~1/3 of Earth's soil carbon and are climatically sensitive. Our objective was to quantify the response of large belowground carbon stores, greenhouse gas emissions, and heterotrophic microbial communities in peatlands to warming.

New Science

- As part of the SPRUCE (http://mnspruce.ornl.gov) experiment led by ORNL, peat up to 2 m deep was experimentally warmed over 13 months in an ecosystem-scale climate manipulation that incorporates deep peat heating (DPH) up to 9°C above ambient. Although CH_4 emissions were found to increase exponentially with deep heating, the response was due solely to the warming effect on surface peat. No changes with warming were seen in microbial communities nor did geochemical analyses provide evidence of enhanced peat carbon degradation suggesting that deep peat is stable under increasing temperatures.

Photos by Paul Hanson and SPRUCE team

Significance

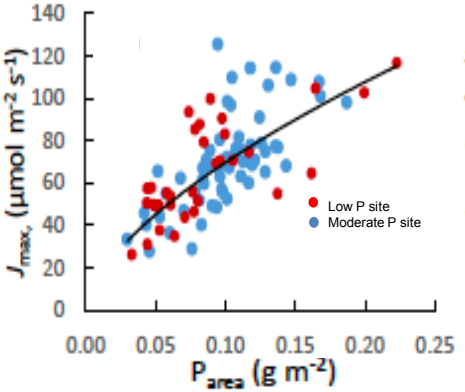
- This study demonstrates that most of the carbon residing under water-saturated anoxic conditions in the deep peat reservoir (catotelm) is stable under warmer temperatures providing important insights into the potential response of peatlands under future climate warming.

Citation - Wilson, R.M. and A.M. Hopple, M.M. Tfaily, S.D. Sebestyen, C.W. Schadt, L. Pfeifer-Meister, C. Medvedeff, K.J. McFarlane, J.E. Kostka, M. Kolton, R. Kolka, L.A. Kluber, J.K. Keller, T.P. Guilderson, N.A. Griffiths, J.P. Chanton, S.D. Bridgham, and P.J. Hanson. 2016. Stability of peatland carbon to rising temperatures. Nature Communications 7: 13723. http://doi.org/10.1038/ncomms13723 (Impact factor = 11.329).

Informing Models Through Empirical Relationships Between Foliar Phosphorus, Nitrogen and Photosynthesis Across Diverse Woody Species in Panama

- Scientific Achievement

- Relationships between photosynthetic parameters of tropical trees and foliar nitrogen and phosphorus content were studied. These relationships important to predictive modeling were improved by including wood density, suggesting that a mechanistic approach incorporating trait covariation could be useful.



Research

- Objective: assess relationships between photosynthetic parameters and foliar nutrient concentrations from tropical forests to inform model improvements.

- Gas exchange and nutrient content data were collected from upper canopy leaves of 144 trees at two forest sites in Panama, differing in species composition, rainfall, and soil fertility.

- Relationships between photosynthesis, foliar N and P, and wood density were evaluated against mechanistic and empirical models.

- Impact

- Our study provides a basis for improving models of photosynthesis based on phosphorus nutrition and increases the capability of models to predict the future C uptake capacity of P-limited tropical forests.

- Research support by ORNL Laboratory Directed Research and Development Program and Next Generation Ecosystem Experiments-Tropics (NGEE-Tropics), funded by U. S. Department of Energy, Office of Science.

Richard J. Norby, Lianhong Gu, Ivan C. Haworth, Anna M. Jensen, Benjamin L. Turner**, Anthony P. Walker, Jeffrey M. Warren, David J. Weston, Chonggang Xu,** and Klaus Winter. (2016), Informing models through empirical relationships between foliar phosphorus, nitrogen and photosynthesis across diverse woody species in Panama. *New Phytologist* doi: 10.1111/nph.14319

Global Analysis Reveals Accelerating Plant Growth

Objective

- Terrestrial photosynthesis is the fundamental coupling between global cycles of energy, carbon, and water. Yet, we lack a clear picture of global trends in photosynthesis over the last few centuries. Our objective was to infer a global history of photosynthesis from records.

New Science

- Gases trapped in different layers of Antarctic snow allow scientists to study global atmospheres of the past. The key to this study was finding a gas stored in the ice that provides a record of the Earth's plant growth. Previous studies have found that carbonyl sulfide (COS) has this property. It's a cousin of CO_2. Plants remove COS from the air through a process that is related to the plant uptake of CO_2. The researchers analyzed the Antarctic COS record and estimated that the sum of all plant photosynthesis on Earth grew by 30 percent during the industrial era.

Significance

- The rise in global photosynthesis has far reaching effects as virtually all life on our planet depends on photosynthesis. This important process creates food, shapes the water cycle, and influences climate.

nature

Citation - Campbell, J. E., Berry, J. A., Seibt, U., Smith, S. J., Montzka, S. A., Launois, T., Belviso, S., Bopp, L., and Laine, M. (2017). "Large historical growth in global terrestrial gross primary production." **Nature**, 544(7648), 84-87.

The New York Times

Outreach – New York Times, April 5, 2017, "Antarctic Ice Reveals Earth's Accelerating Plant Growth"