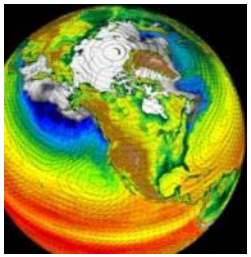
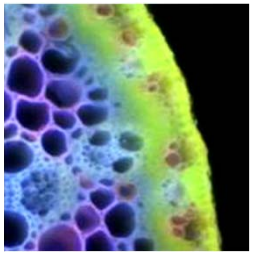
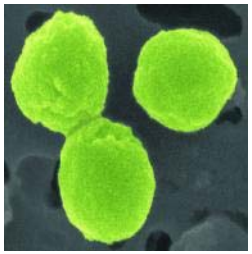


Climate and Environmental Sciences Division

BERAC update

November 2, 2017

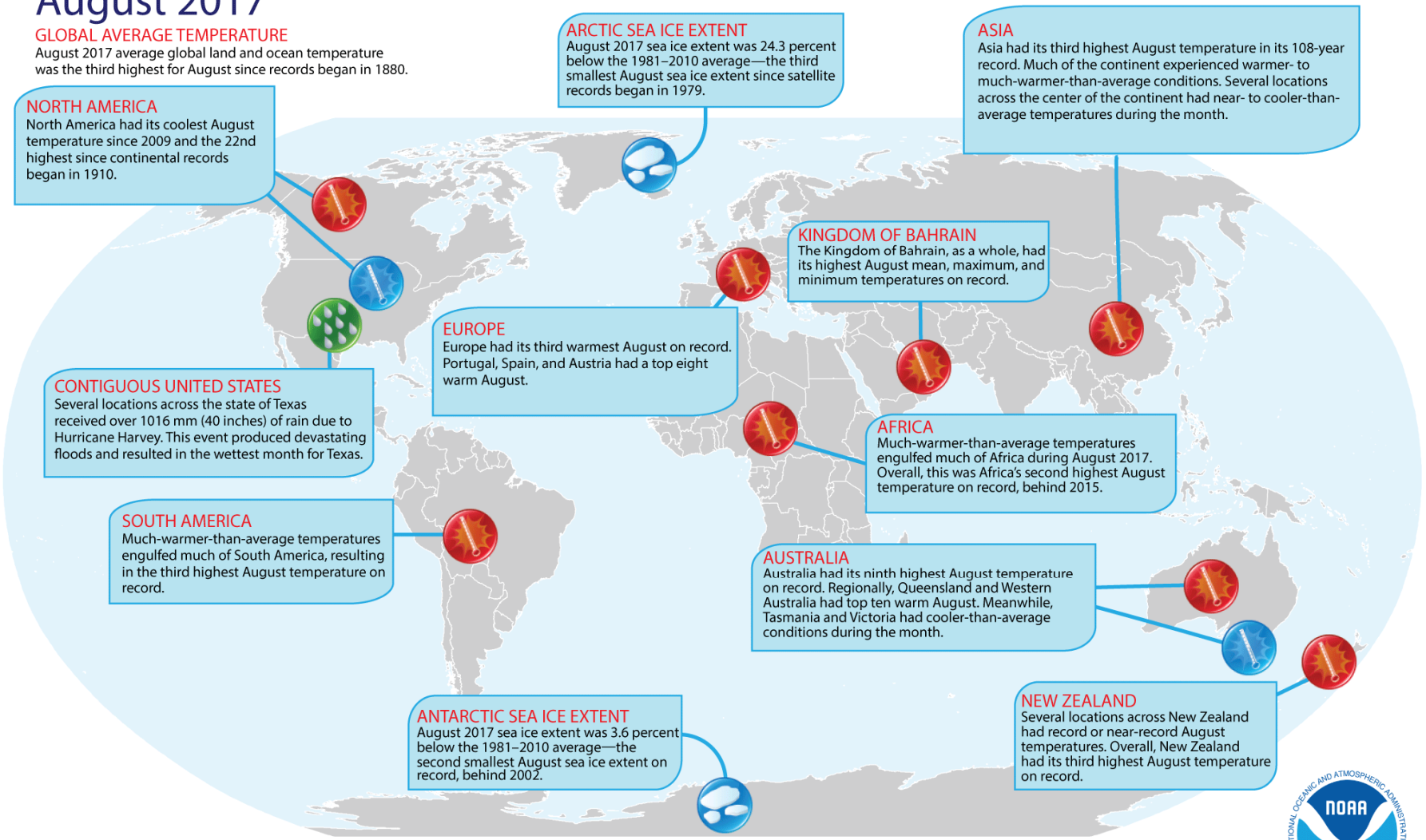
G. Geernaert

BER/CESD

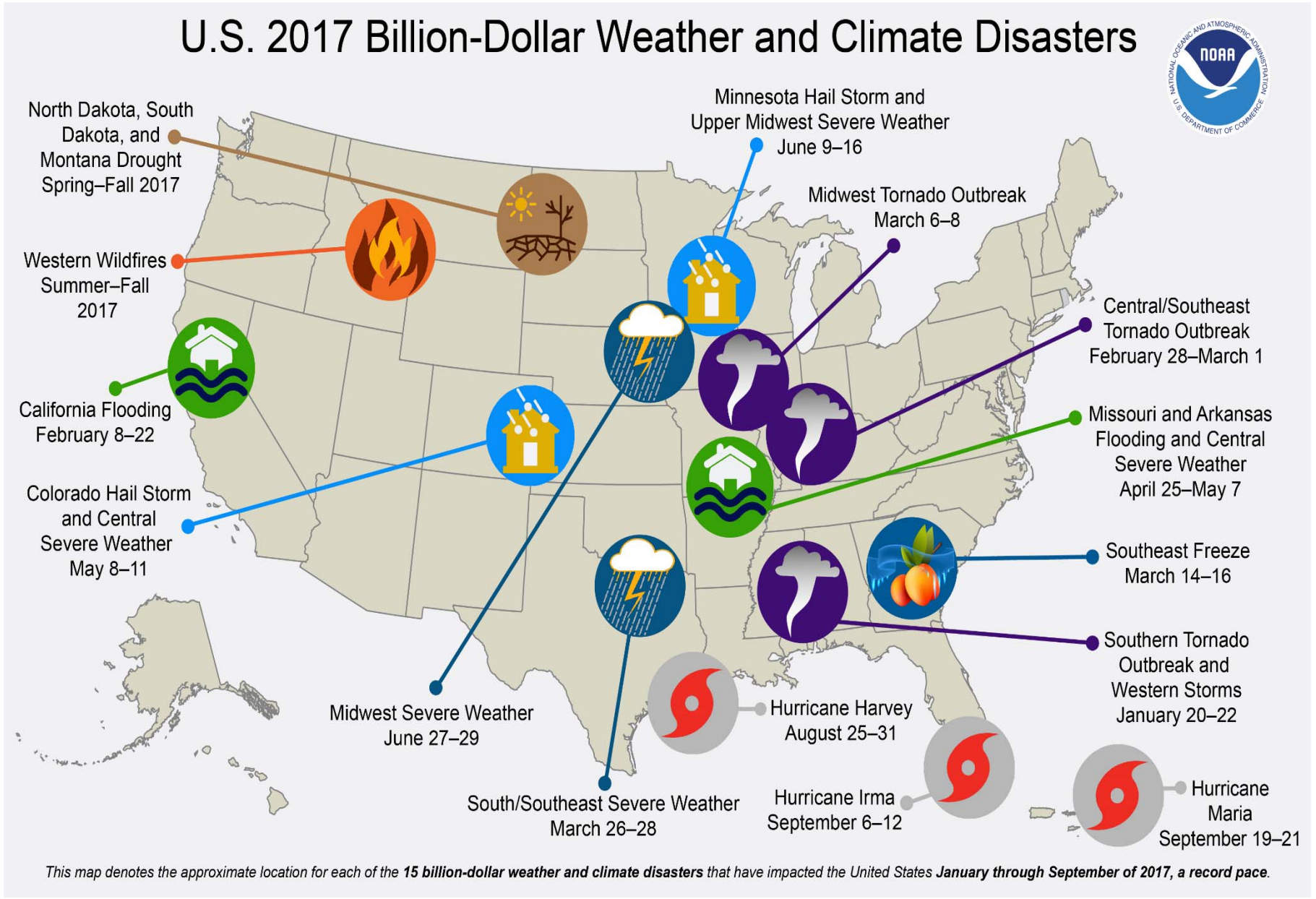
Outline

- Recent extreme events
- Strategic science challenges
- Administrative
- Scientific highlights

Selected Significant Climate Anomalies and Events
August 2017



Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc


U.S. 2017 Billion-Dollar Weather and Climate Disasters
North Dakota, South Dakota, and Montana Drought Spring–Fall 2017
Western Wildfires Summer–Fall 2017
California Flooding February 8–22
Colorado Hail Storm and Central Severe Weather May 8–11
Minnesota Hail Storm and Upper Midwest Severe Weather June 9–16
Midwest Tornado Outbreak March 6–8
Central/Southeast Tornado Outbreak February 28–March 1
Missouri and Arkansas Flooding and Central Severe Weather April 25–May 7
Southeast Freeze March 14–16
Southern Tornado Outbreak and Western Storms January 20–22
Midwest Severe Weather June 27–29
Hurricane Harvey August 25–31
South/Southeast Severe Weather March 26–28
Hurricane Irma September 6–12
Hurricane Maria September 19–21
This map denotes the approximate location for each of the 15 billion-dollar weather and climate disasters that have impacted the United States January through September of 2017, a record pace.

Updated Strategic Plan – will be released in FY 2018

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.

Scope: Integration of atmospheric, oceanic, terrestrial, ecological, hydrological, and human components, and inclusion of system level uncertainty quantification

High level Grand Challenges

- System forcers – drivers of the coupled Earth-energy-human system
- High latitude – process feedbacks and interdependencies with the global system
- Biogeochemistry – biogeochemical processes and cycles across multiple scales
- Integrated water cycle – scale aware and response to short and long-term perturbations
- Data-model integration: interconnected capabilities and facilities that support the integration and management of models, experiments, and data across a hierarchy of scales and complexity

Workshops set the stage for future CESD priorities

Date: 2017	Topic	Venue
April 24, 2017	Cyberinfrastructure workshop	Bolger
June 13, 2017	Energy-water Nexus KDF experts working	Bolger
June, 2017	Arctic Workshop (USGCRP)	NASA HQ
June 27, 2017	Climate Modeling Summit (USGCRP)	NASA HQ
June 19-22, 2017	CESM Annual Workshop (UCAR)	Boulder
July 25-Aug 4, 2017	Energy Modeling Forum (Stanford)	Snowmass
Aug 24, 2017	Predicting Infectious Diseases (USGCRP)	virtual

Workshops in the pipeline include, e.g.,

- Coupled model initialization
- Data analytics and management strategy
- Dynamic vegetation and disturbance
- ARM strategy involving sites and deployments

Management Update: solicitations

Funds	Program lead	Issued	Proposals	Panel	Selected
FY17	SCIDAC (ESM, ASCR)	Nov 9, 2016	91	May 3-4, 2017	10
FY17	ASR	Aug 19, 2016	74	Feb 7-9, 2017	17
FY17	DATA	White papers Dec 21, 2016	4	March 20-21, 2017	1
FY17	SBR	Dec 23, 2016	60+22	April 15-17, 2017	2 Full 5 exploratory
FY17	IA	White papers Dec 17, 2016	6	June 14-16, 2017	----
FY18	RGCM + ESM	pending			
FY18	ASR	pending			

Management updates: Major reviews in 2017-2018

Lab	Program	Type	Review date	Decision	Decision-date
PNNL	ASR	SFA	Feb 27-28, 2017	Approved	Apr 4, 2017
BNL	ASR	SFA	April 4-5, 2017	Approved	Apr 19, 2017
PNNL	ARM	Facility	April 10-12	Approved	May 3, 2017; June 30
PNNL	SBR	SFA	April 27-28, 2017	Approved	Jun 22, 2017
SLAC	SBR	SFA	May 18, 2017	Approved	Jul 24, 2017
LLNL	ESGF	Project	June 8-9, 2017	Approved	Jul 25, 2017
ORNL	NGEE-Arct	Project	Sep 18, 2017	Approved	Oct 3, 2017
UCAR	RGCM	CA	Sep 19-20, 2017	Approved	Oct 24, 2017
ORNL	RGCM	SFA	Sep 25-26, 2017	Pending	

Management updates: Major reviews in 2017-2018

Lab	Program	Type	Review date	Decision	Decision-date
PNNL	EMSL	Facility	Nov 29-30, 2017		
LBNL	TES	SFA	May 3, 2018		
E3SM	ESM	SFA	May 15-17, 2018		
ORNL	SBR	SFA	early May 2018		
ANL	SBR	SFA	late May 2018		
LLNL	SBR	SFA	late May 2018		
LANL	RGCM	SFA	June-July 2018		
PNNL	RGCM	SFA	June-Aug 2018		

Management updates - PI meetings: 2017-2018

Title	Program(s)	Location	Date in 2017-2018
ESS PI meeting	TES, SBR, EMSL	Bolger	April 25-26, 2017
NACP PI meeting (w/other agencies)	TES	Bethesda	March 27-30, 2017
ARM/ASR Facility PI meeting	ARM, ASR	Tysons	March 13-17, 2017
ACME PI meeting	ESM	Bolger	June 5-7, 2017
CMDV PI meeting	ESM, ASR, ARM	Bolger	June 8-9, 2017
ARM/ASR PI meeting	ARM, ASR	Tysons	March 19-23, 2018
ESS PI meeting	TES, SBR	Bolger	April 30 – May 4, 2018

Science Highlights

Storyline is that revolutionary science requires one to challenge paradigms and utilize novel technologies

Environmental Molecular Sciences Lab

Advancing discovery and mechanistic understanding of molecular- to meso-scale biological, chemical and physical processes and interfaces to enable predictive understanding.

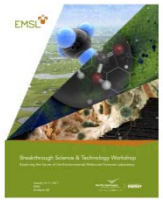
EMSL provides access to premier instruments for experimental research, high performance computing (HPC) capabilities and a variety of software codes for a range of modeling studies.

Proposal Opportunities

- Science Theme call for FY2018 Projects – XX projects/181 proposals.
- FICUS (Facilities Integrating Collaborations for User Science Call for FY2018 Projects – 14 projects/49 proposals

Scientific Leadership

- Ljiljana Pasa-Tolic – Editorial Boards of JASMS and J Proteome Res.
- Workshop Reports:
  - Breakthrough Science & Technology - June 2017



Outreach and User Activities

- 20 Year Anniversary Celebration: https://www.emsl.pnl.gov/emslweb/about/emsls-20th-anniversary
- 2017 User Meeting + Multi-omics Conference – Aug 1-3, 2017.
- *Molecular Bond* online: https://www.emsl.pnl.gov/emslweb/molecular-bond

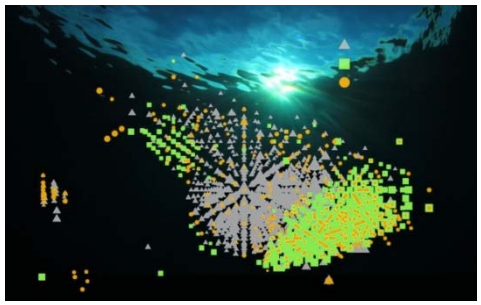
Sunlight Stimulates Microbial Respiration of Organic Carbon

Challenge

Sunlight and microbes interact to degrade dissolved organic carbon (DOC) in surface waters, but scientists cannot currently predict the rate and extent of this degradation in dark and light conditions

Approach and Results

- A collaborative research team characterized microbial and DOC composition.
- The rates microbes can process DOC is likely governed by 1) a combination of the abundance and instability of DOC exported from land to water and produced by photochemical processes, and 2) the capacity and timescale microbial communities have to adapt to metabolize DOC exposed to sunlight.



Study helps explain how sunlight alters microbial pathways and stimulates respiration in waters in the Arctic. (**WHOI, EMSL, UM, OSU**)

Significance and Impact

- These results suggest rates of microbial processing of DOC in pan-arctic inland waters are controlled by 1) the abundance of smaller, more adaptable and aliphatic, and less oxidized DOC exported from land to water, and/or 2) produced photo-chemically, and the capacity and timescale that microbial communities have to adapt to and then degrade this photo-altered DOC.
- The coupled photochemical and biological degradation of permafrost DOC may be an increasingly important component of the arctic C budget as the climate warms.

C.P. Ward, S.G. Nalven, B.C. Crump, G.W. Kling, and R.M. Cory. "Photochemical alteration of organic carbon draining permafrost soils shifts microbial metabolic pathways and stimulates respiration." Nature Communications (2017). DOI: 10.1038/s41467-017-00759-2

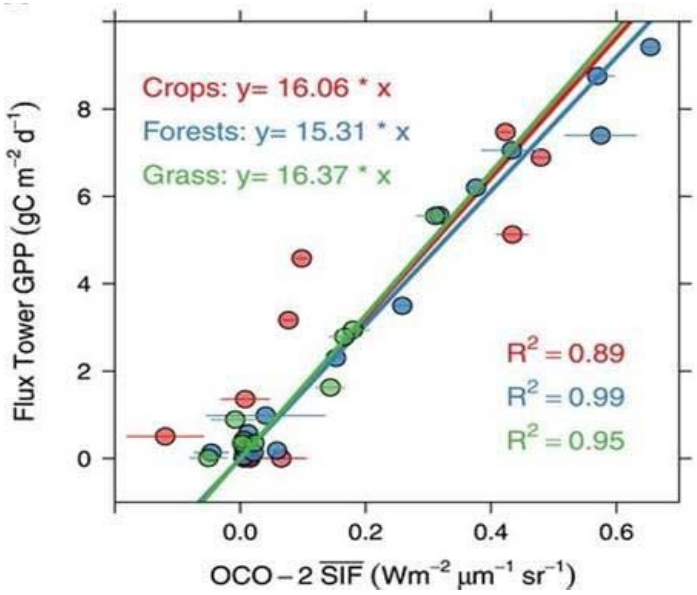
Measuring photosynthesis from Space via Solar-Induced Florescence (SIF)

Objective

- Combine flux tower and satellite observations to 'measure' gross primary production from space via solar- induced chlorophyll fluorescence using NASA OCO-2 and

New Science

- Energized by sunlight, chlorophyll molecules in plant leaves emit a faint red light, i.e., SIF
- SIF measured by Orbiting Carbon Observatory-2 (OCO-2) is compared to gross primary production (GPP) estimated from eddy covariance flux sites under OCO-2 orbital tracks.
- SIF and GPP relationships obtained



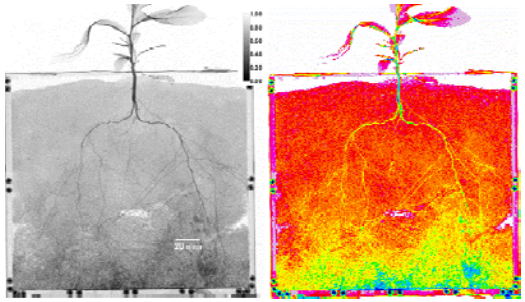
Impact

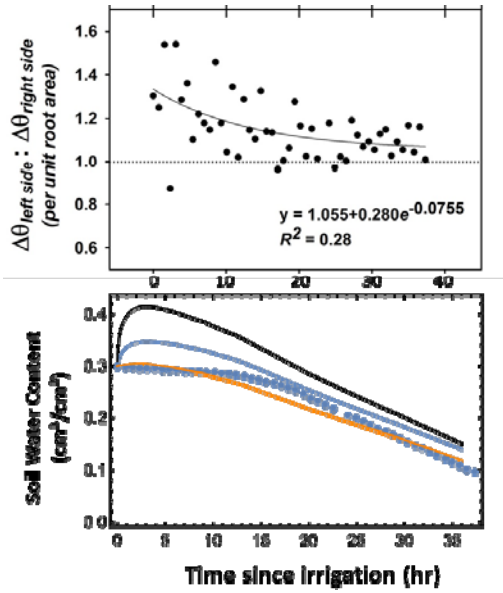
- Our ability to measure gross photosynthetic processes at large scales has been extremely limited
- Demonstrating SIF as a direct proxy of photosynthesis, this allows new research at multiple scales and shows how ground-based observations and satellite remote sensing can be integrated to advance local to global coverage/

Science AAAS

*Sun Y, Frankenberg C, **Wood JD**, Schimel DS, Jung M, Guanter L, Drewry DT, Verma M, Porcar-Castell A, Griffis TJ, **Gu LH**, Magney TS, Köhler P, Evans B, Yuen K. 2017. OCO-2 advances photosynthesis observation from space via solar-induced chlorophyll fluorescence. Science 358, eaam5747 (2017). DOI: 10.1126/science.aam5747*

Measuring and Modeling Root Water Extraction After Drought using Neutron Imaging





Dhiman, I, H Bilheux, K DeCarlo, SL Painter, L Santodonato, **JM Warren**. 2017. *Plant and Soil* [doi.org/10.1007/s11104-017-3408-5].

Scientific Achievement

Neutron radiography was used in situ to measure soil water movement and water uptake by individual roots. This method links root water uptake to characteristic root traits, and allows researchers to assess performance of water uptake models

Significance and Impact

- Root water uptake is linked to root traits, such as diameter or age.
- Model analysis based on root-free soil hydraulic properties indicated unreasonably large water fluxes between vertical soil layers after wetting
- Problems exist with common soil hydraulic or root surface area methods

Research Details

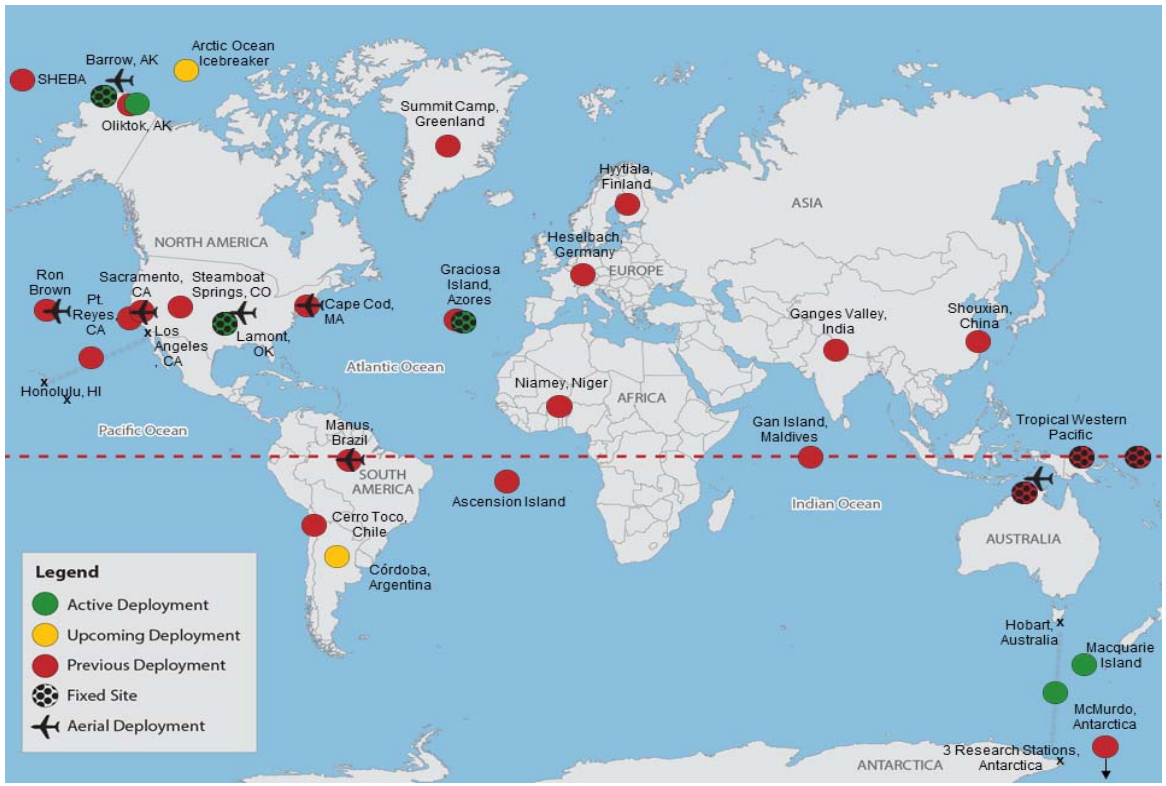
- Neutron radiography (NR) was used to assess *in situ* water uptake from newer, finer roots and older, thicker roots of a poplar seedling growing in sand.
- Smaller diameter roots had greater water uptake per unit surface area than the larger diameter roots, ranging from 0.0027–0.0116 g/cm2 root area/h.
- NR provided dynamic water content observations through time in each of 18 selected soil compartments, then root distribution and traits were measured.

Conclusion

- Results highlight the need for continued exploration of root-trait specific water uptake rates in situ and impacts of roots on soil hydraulic properties - both critical components for mechanistic modeling of root function

Supported by Biological and Environmental Research Program in the Office of Science, U.S. Department of Energy, the LDRD Program at Oak Ridge National Laboratory, the Office of Workforce Development for Teachers and Scientists, Office of Science Graduate Student Research (SCGSR) program, and the ORNL High Flux Isotope Reactor CG-1D imaging beamline.

ARM Update



<u>Need for new aircraft</u>
<u>G1 service life ends in FY20</u>

- CD-0 Mission needs statement approved 2/2017
- AOA completed, under review by OAM
- CD-1 review (4/2018)
- CD-2/3 approval plan (12/2018)
- First missions: FY21

- LASIC (Ascension Island) ended 10/31/17
- MARCUS (Southern Ocean campaign): first voyage started 10/29/17

Using ARM measurements to identify cause of central U.S. dry and warm biases in global models

Objective

Understand and determine cause for the long-standing bias in Earth system models: warm and dry conditions in the central U.S.

Approach and Result

Using long-term measurements from the DOE ARM SGP Facility, the team linked the bias to deficient strong precipitation events that are then followed by shallow convective clouds and less solar radiation to the surface. The team also found that models with larger biases tend to project larger future warming in this region.

Significance and Impact

The source of a common model bias over the SGP is identified. Correction to this bias in the models reduces the model temperature spread by 40% and reduces projected temperature increase by around 20%.

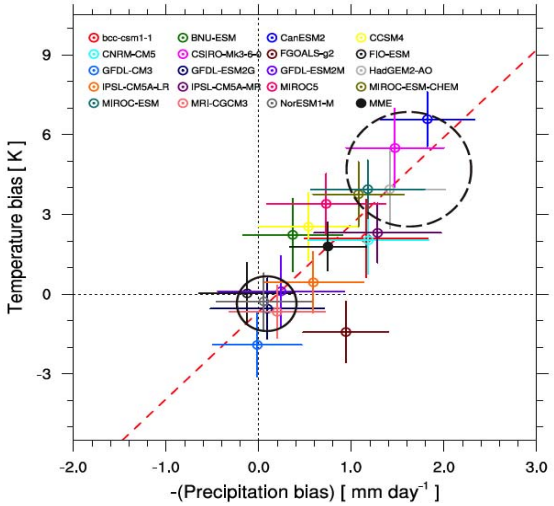


Figure 1. Relationship between warm bias and dry bias in CMIP5 models

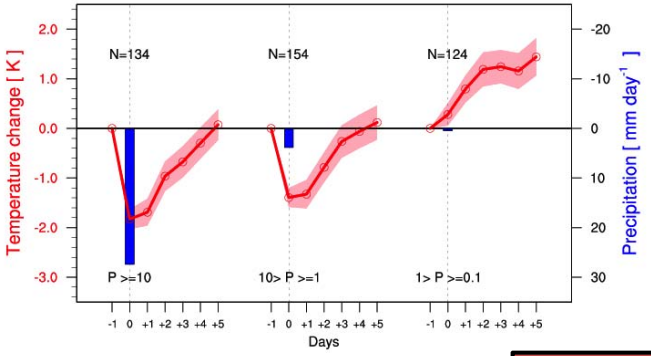


Figure 2. Cooling of surface temperature after rain events.

CMDV

Lin, Yanluan and Dong, Wenhao and Zhang, Minghua and Xie, Yuanyu and Xue, Wei and Huang, Jianbin and Luo, Yong, *Nature Communications* 8, Article number: 881(2017) doi:10.1038/s41467-017-01040-2

Stony Brook University

That's intense: ice microphysics has macro impact on simulations of thick storm clouds

Objective

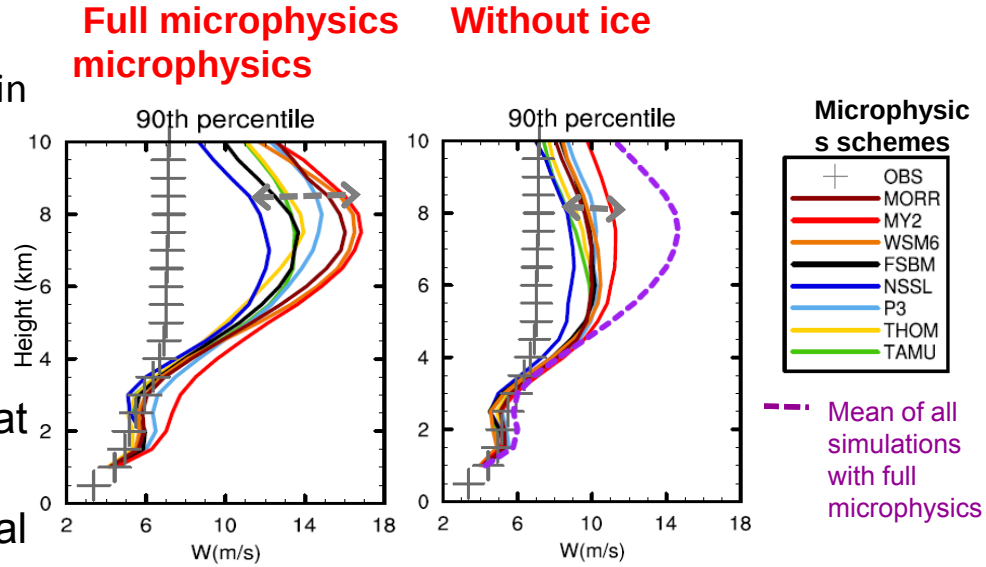
- Identify which factors cause the large spread in model simulations of deep convection and squall lines

Approach

- Test eight cloud microphysics schemes with varying complexities in the Weather Research and Forecasting (WRF) model at 1-kilometer horizontal grid spacing
- Compare with ARM Midlatitude Continental Convective Clouds Experiment (MC3E) measurements of precipitation and convective updrafts

Impact

- Majority of microphysics schemes overestimate convective updraft speed and radar reflectivity in upper parts of clouds.
- Model spread in updraft velocity likely due to differences in cold pool intensity and latent heating resulting from ice parameterizations



The left graph illustrates a large spread across schemes in **simulated updraft intensity** when full microphysics is applied. The right graph shows that ice microphysics is the major factor leading to the large spread. This is because of increasing differences in both latent heating and cold pool intensity.

Fan J, B Han, A Varble, H Morrison, K North, P Kollias, B Chen, X Dong, SE Giangrande, A Khain, Y Lin, E Mansell, JA Milbrandt, R Stenz, G Thompson, and Y Wang. 2017. "Cloud-Resolving Model Intercomparison of an MC3E Squall Line Case: Part I – Convective Updrafts." *Journal of Geophysical Research: Atmospheres*, in press. DOI: 10.1002/2017JD026622

Early Career Awardee Overturns Turbulence Assumptions

Motivation

- Turbulent eddies are important to transportation of heat, moisture, gases, & momentum
- Eddy covariance flux measurement technique is based on Taylor's "frozen turbulence" hypothesis that time averages can replace spatial averages

Approach

- Developed field experiment using new distributed temperature sensing (DTS) optical fiber measurements to test the frozen turbulence assumption
- DTS fibers set up at 4 heights within atmospheric surface layer along a 230-m transect
- Very high resolution temperature measurements along the fiber allow scientists to examine detailed characteristics of turbulent eddies

Distributed temperature sensing system at the Oklahoma State University Range Research Station site. Credit: Yu Cheng

Impact

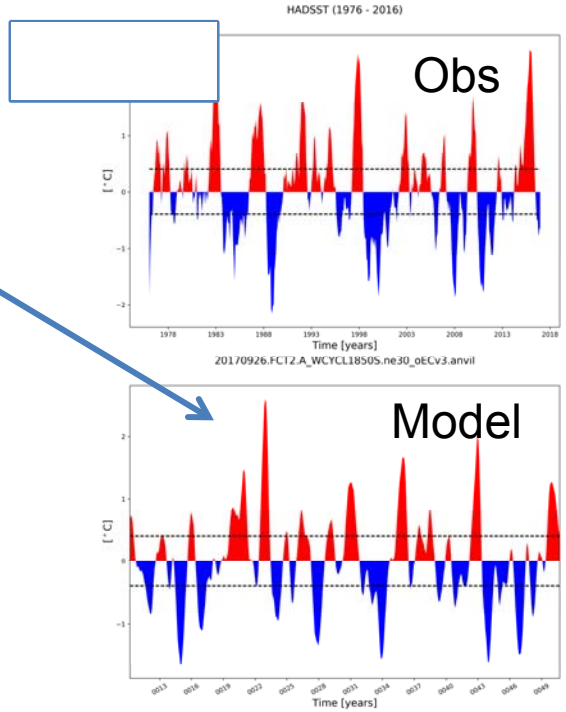
- Frozen turbulence assumption holds for larger eddies, but fails for smaller eddies because they lose their coherence due to turbulent diffusion
- Applying frozen turbulence assumption systematically underestimates turbulent energy by 10-30%
- The authors propose a correction that can be applied to existing flux tower eddy-covariance data
- Results may resolve a long-standing issue in closing the energy budget at flux tower sites

Reference: Cheng, Y., C. Sayde, Q. Li, J. Basara, J. Selker, E. Tanner, and **P. Gentine** (2017), Failure of Taylor's hypothesis in the atmospheric surface layer and its correction for eddy-covariance measurements, Geophys. Res. Lett., 44, doi:10.1002/2017GL073499.

E3SM - updates

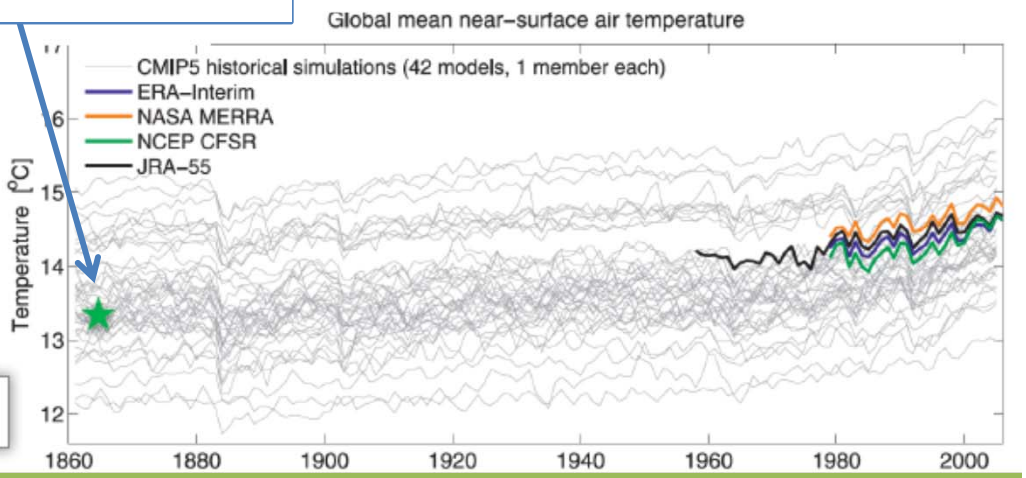
Version 1 (v1)

- Low resolution (100 km) coupled “water-cycle” version is performing well in pre-industrial control. Initial difficulties with cold ocean and weak ENSO have been resolved!
- Low-resolution coupled transient, CMIP-DECK and coupled BGC experiments are starting
- High-resolution (25km) 1950 control simulations are starting
- V1 release (of both low and high resolution version) planned for April, 2018
- FATES model has been assimilated into code



Project phase 2

- Updated E3SM Strategic Plan is drafted
- V2 focus on regionally-refined Arctic model
- Increased focus on high-resolution model version
- Proposal phase 2 review planned for May 2018



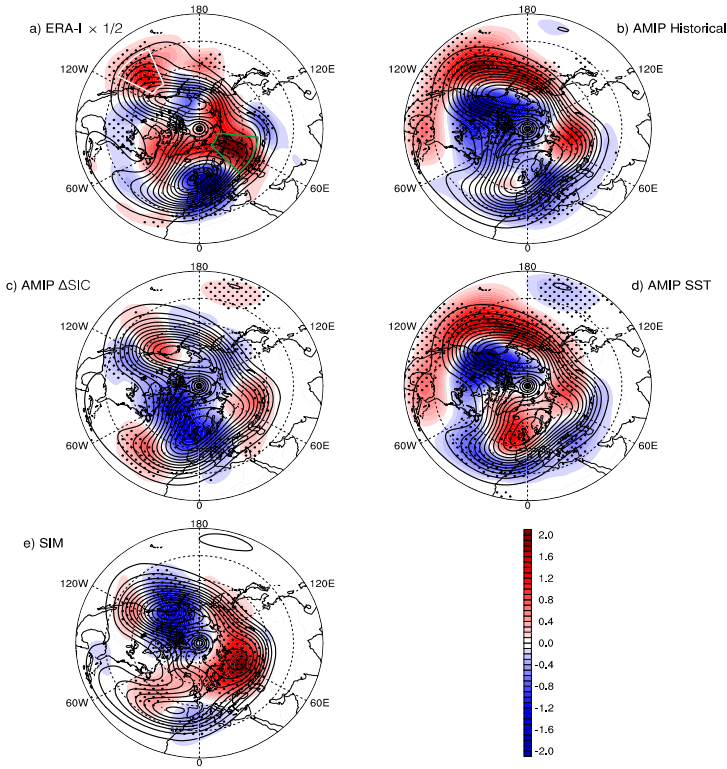
Local Increase of Anticyclonic Wave Activity over Eurasia under Arctic Sea Ice Melting: More Frequent Extremes?

Objective

- To understand the 1990–2014 trend of midlatitude wave activity and related temperature extremes during the decline of Arctic sea ice

Approach

- Analyze ensembles of AMIP-style simulations with observed SST and sea ice forcing using European Centre Hamburg version 5 atmospheric general circulation model
- Examine time-slice experiments using CAM4 under both present and future Arctic sea ice conditions
- Use local anticyclonic wave activity to quantify the wave component of the circulation trend



Through ensembles of AMIP-type simulations, the observed trend (panel a) of the wave activity of north-central Eurasia, in the green box, can be attributed to both the Arctic sea ice loss (c) and the trend of the SST (d). This trend will be amplified under the future sea ice loss (e).

Impact

- Arctic sea ice loss led to increase of wave activity over north-central Eurasia, bringing local cooling
- However, numerical experiments cannot replicate the observed midlatitude-wide increase of the wave activity, leaving its explanation to internal variability

Xue D, J Lu, L Sun, G Chen, and Y Zhang. 2017. "Local Increase of Anticyclonic Wave Activity over Northern Eurasia under Amplified Arctic Warming." *Geophysical Research Letters* 44:3299-3308. DOI: 10.1002/2017GL072649

Accounting for Groundwater Use and Return Flow Improves Modeling of Water Management

Objective

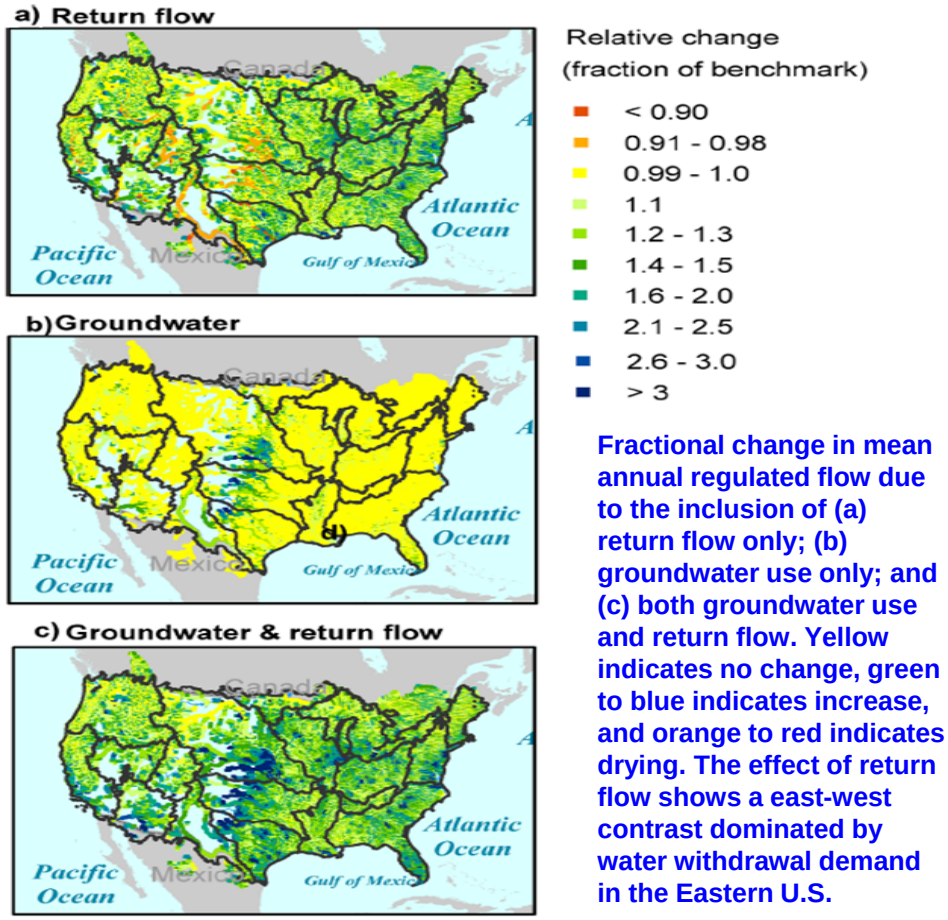
- Refine Earth system modeling of water management by considering groundwater use and return flow, and differentiating sectoral (irrigation/non-irrigation) water demands

Approach

- Extend an integrated water model based on a river transport model coupled to a water management model and a regional integrated assessment model to represent groundwater use and return flow, and explicitly addressing sectoral water demand input
- Perform numerical experiments over the United States at 1/8-degree resolution
- Evaluate the simulations using water supply deficit as a metric

Impact

- Advanced capability to model water management in Earth system models
- Groundwater use and return flow shown to have large influences on redistribution of water resources and deficits in the United States



Fractional change in mean annual regulated flow due to the inclusion of (a) return flow only; (b) groundwater use only; and (c) both groundwater use and return flow. Yellow indicates no change, green to blue indicates increase, and orange to red indicates drying. The effect of return flow shows a east-west contrast dominated by water withdrawal demand in the Eastern U.S.

Voisin N, MI Hejazi, LR Leung, L Liu, M Huang, H-Y Li, and T Tesfa. 2017. "Effects of Spatially Distributed Sectoral Water Management on the Redistribution of Water Resources in an Integrated Water Model." *Water Resources Research* 53:4253-4270. DOI: 10.1002/2016WR019767 (Supported by PRIMA, ESM/ACME, & IARP/IM3)

THANK YOU!