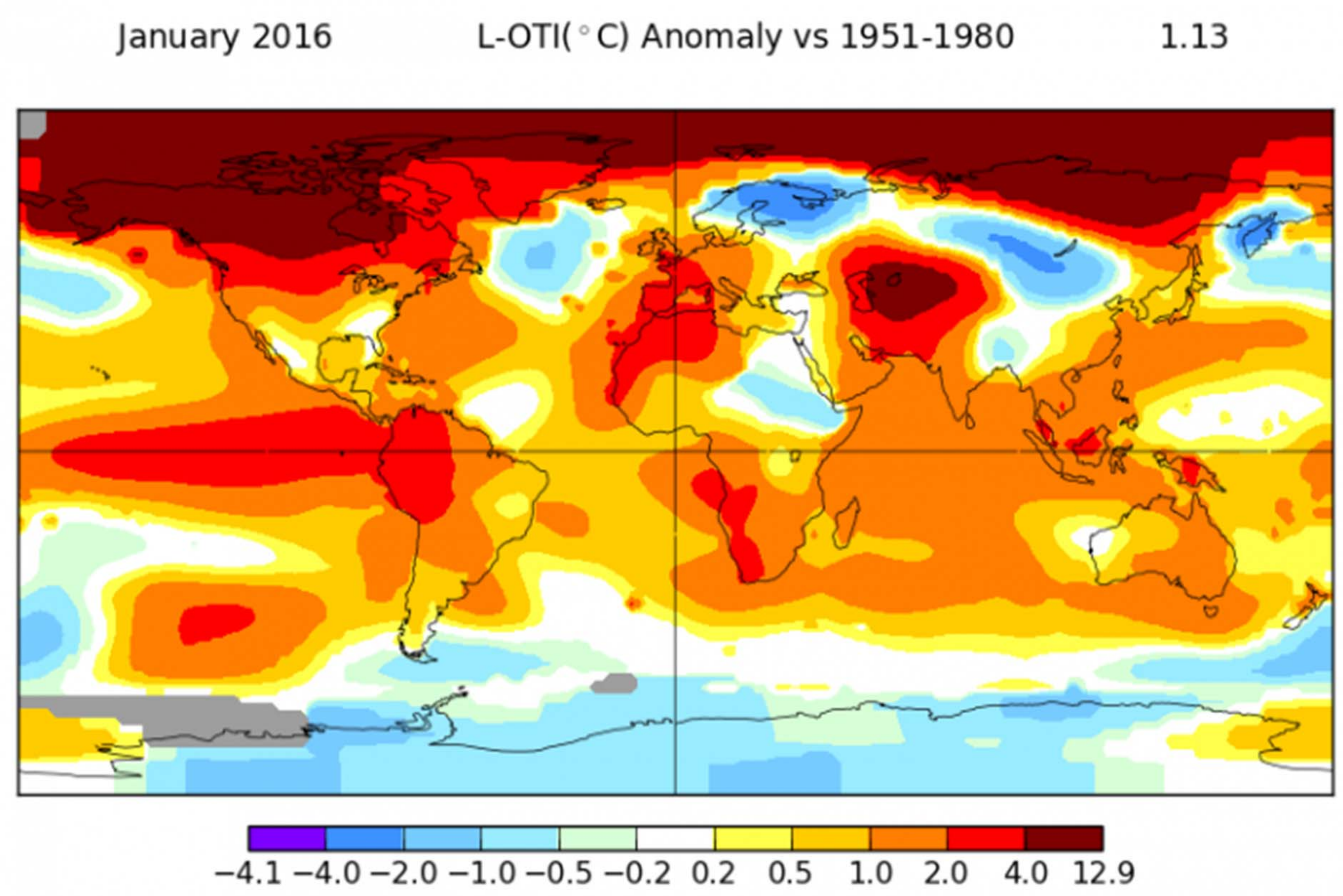
Climate and Environmental Sciences Division

BERAC update

March 23, 2016

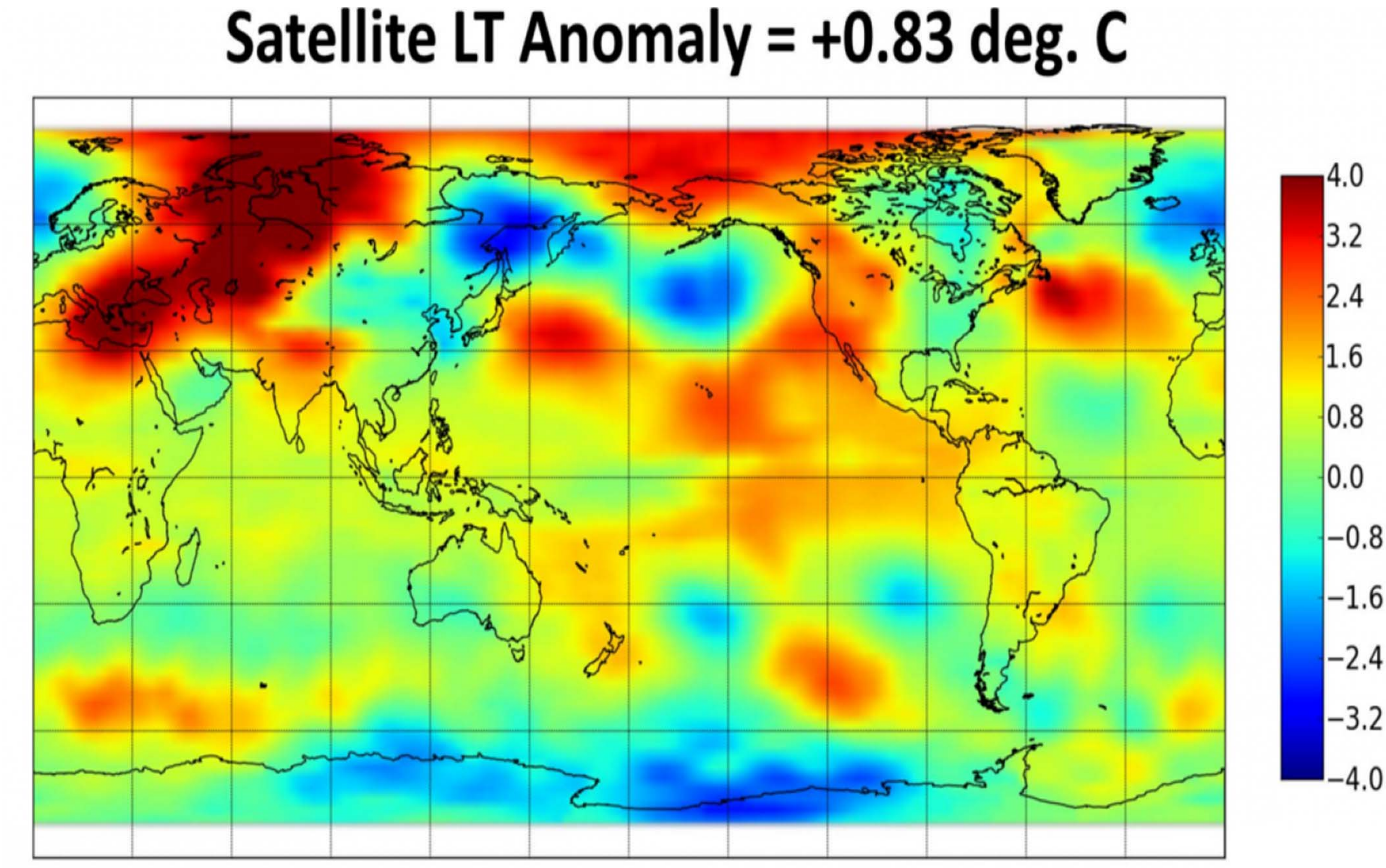
G. Geernaert
BER/CESD

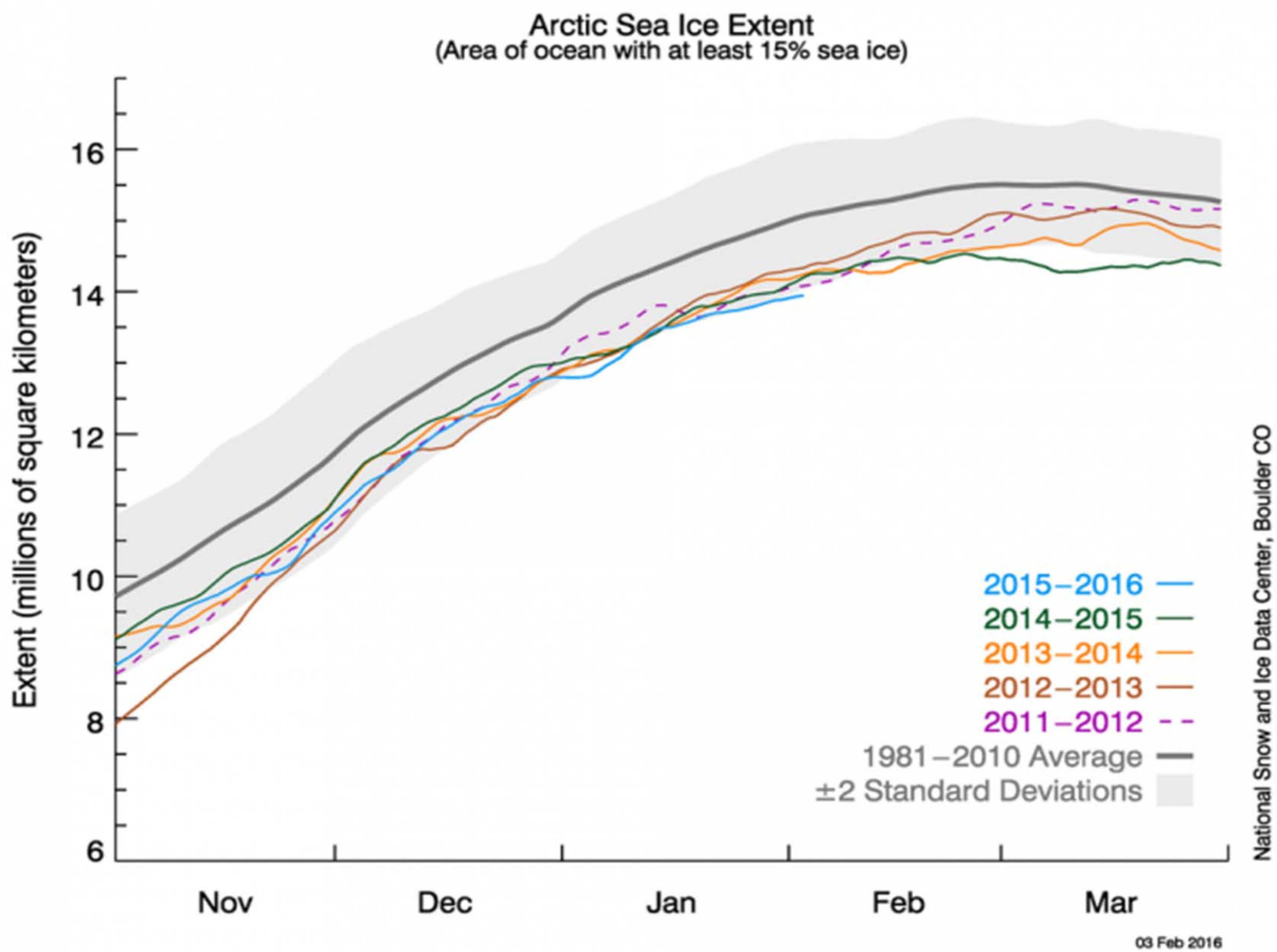
Warmest January on record – by far!



Credit: NASA GISS

FEBRUARY 2016 – WARMEST ON RECORD (NOAA SATELLITE DATA)





Credit: NSIDC

Outline

- Where are we heading - strategic update
- New activities and efforts: CMDV; EWN
- Administrative
- Highlights – facilities and new science

Preview of updated strategic plan

<u>Guiding Principles for Grand Challenge science</u>

- Maps to "earth system" predictability, not just climate system predictability
- Difficult to solve on 5-10 year time horizon
- Involves multiple programs and user facilities
- Exploit DOE's unique computational assets
- Exploit workshop outputs from BERAC and scientific community
- DOE can exert significant leadership, yet include multiple collaborating agencies

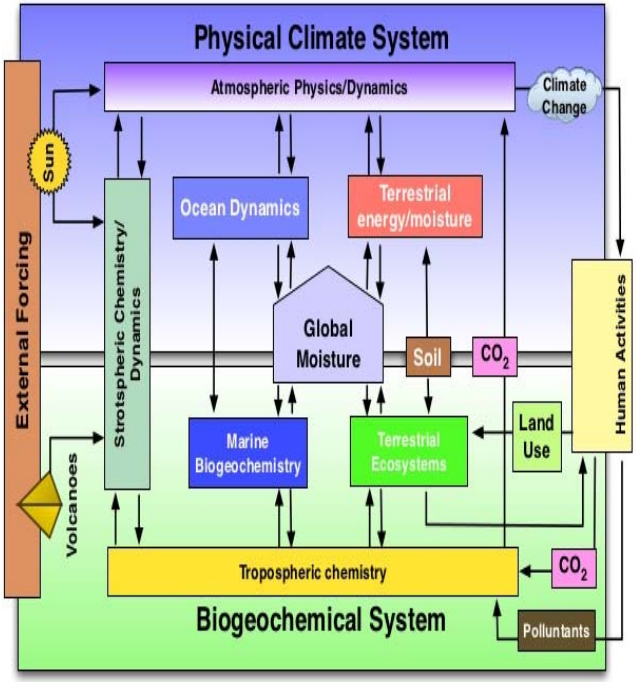
<u>CESD culture – all challenges owned by Division</u>

- Challenges big enough to demand multiple program engagement, shared investment and management

<u>Next steps</u>

- Draft plan available by autumn 2016

Dynamic earth system

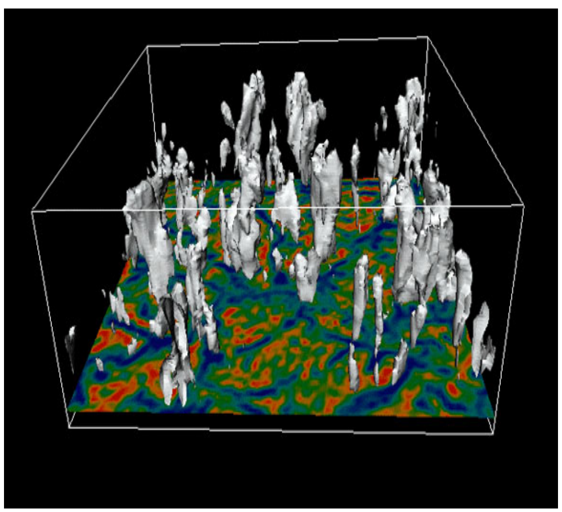


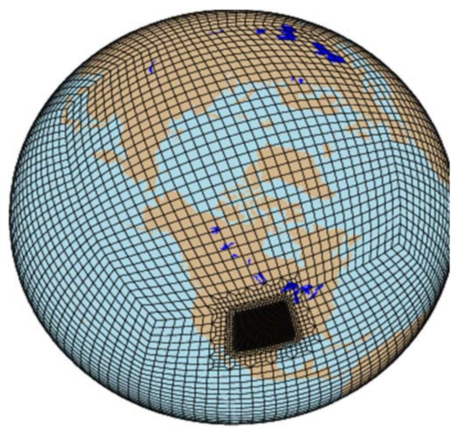
Climate Model Diagnostics and Validation (CMDV)

Climate Model Development: combines major upgrades in advanced software code development, downscaling methodologies, and validation against ARM testbeds

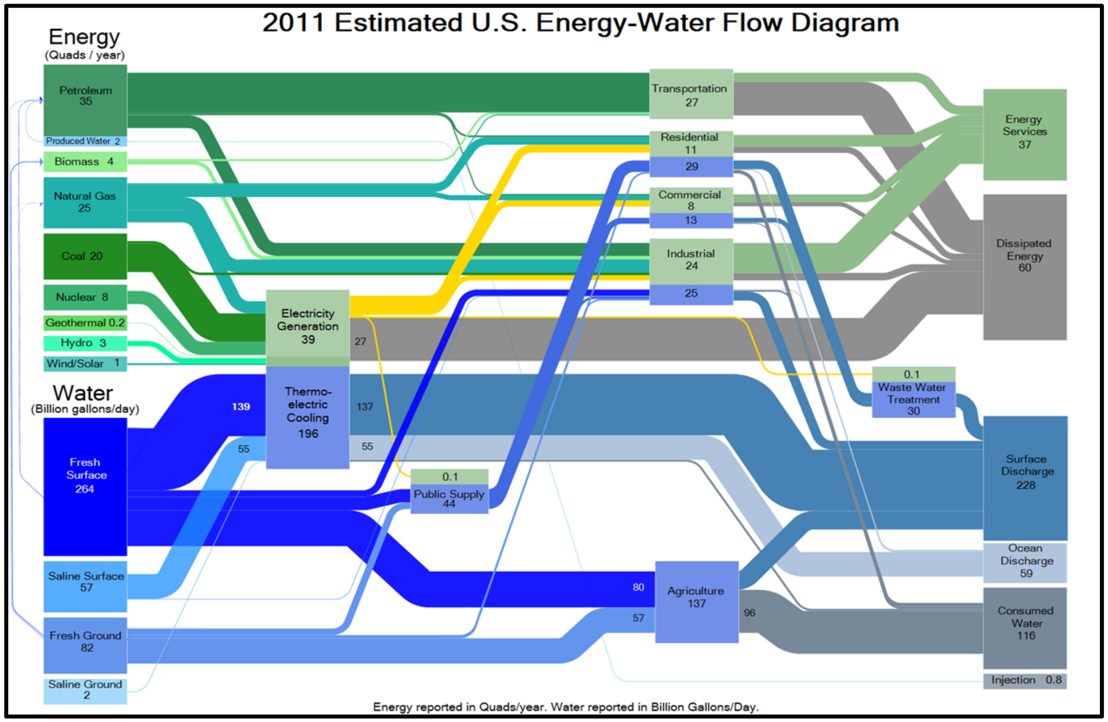
Timing, opportunity and priorities

- Goal to enhance predictability of extreme atmospheric phenomena spanning seasonal to multi-decadal is USGCRP and DOE priority, requiring major science, modeling, and software improvements using LCFs to achieve this goal.
- Link to 'Exascale strategy' is critical to achieve success.
- Requires investments in: **software**; **multi-scale physics**; **LES**; and **use cases involving major field activities**.



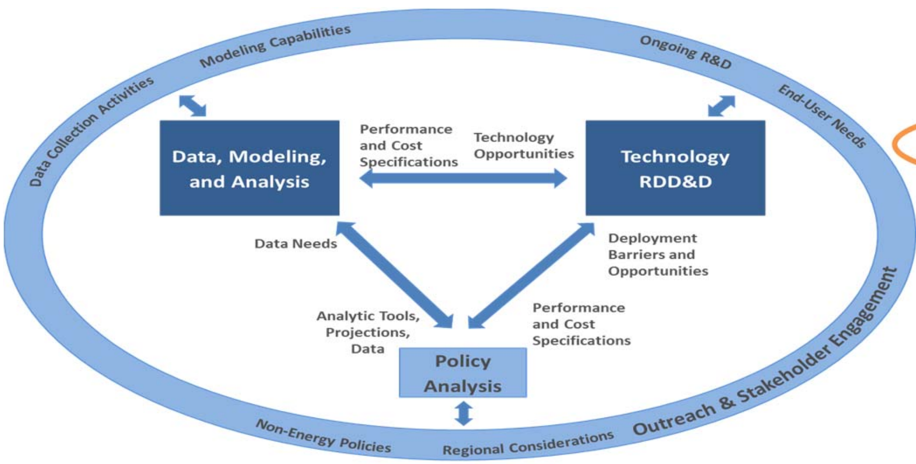


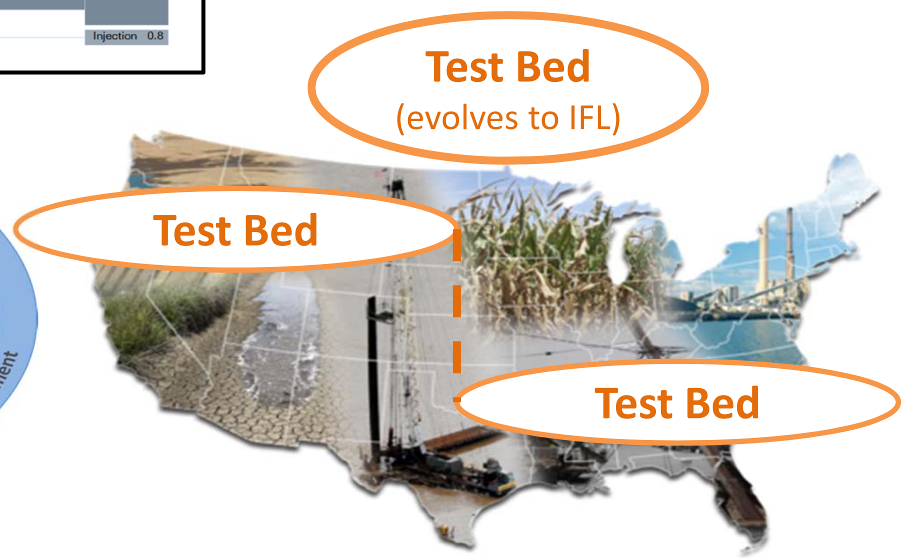
ENERGY-WATER NEXUS



Data, Modeling and Analysis

- Test Beds with teleconnections
- Priorities: drought stress; infrastructure vulnerability
- More details evolving to Integrated Field Laboratory (IFL)
- Regional locations and scales TBD





Workshops – these matter “a lot” to our planning!

Date: 2015-16	Date	Venue
Aug 13-14	Workshop on Virtual Data Integration	GTN
Sept 30 – Oct2	Workshop on High Res Modeling (joint with NOAA)	NCEP
Oct 6-8	RGCM Team Leads strategic planning meeting	Bethesda
Oct 21-22	ARM-ASR-ACME Coordination workshop	GTN
Nov 17-18	Trait methods for land models	Rockville
Nov 19	ACME-NGEE coordination workshop	Rockville
Dec 7-11	ESGF annual meeting	Monterey
Jan 20-21	ASR topical workshop on absorbing aerosols	GTN
Jan 27-29	ASR topical workshop on marine low clouds	ANL
Feb 3-5	ASR topical workshop on convection	PNNL
March 9-10	Climate Modeling Summit (USGCRP)	USGCRP
March 29-31	BER exascale modeling workshop	GTN
April 20-21	IA – Economics workshop	JGCRI
May 16-18	Workshop on ILAMB	Wash DC
May 22-24	Workshop on IA and IAV science challenges	USGCRP
June 20-23	CESM Annual Workshop	Breckenridge
July/August	Terrestrial-Aquatic Interface Workshop	DC area

Management Update: solicitations

Funds	Program lead	Issued	Proposals	Panel	Selected
FY16	Environmental System Science – annual FOA	Oct 7, 2015	146	April 4-6	
FY16	ASR – annual	Oct 2, 2015	102	March 21-22	
FY16	ASR - data products	Oct 2, 2015	26	March 29-31	
FY16	ASR/ESM - CMDV	Feb 5, 2015		April 29	
FY16	RGCM/IAM - EWN	Feb 5, 2015		June 1-2	

Management updates: Major reviews in 2016

Lab	Program	Type	Review date	Outcome
SFA - LBNL	SBR	Triennial	Apr 28-29, 2016	
Ameriflux	TES	Renewal	April/May TBD	
SFA – ANL	TES	Triennial	May 23, 2016	
ACME (LLNL, etc)	ESM	Mid-term	June 10	
CDIAC / TDIS (ORNL)	Data, ESS	Project renewal	Summer	
LBNL Cascade SFA	RGCM	Triennial	Aug/Sept	
LLNL – ESGF	Data	Renewal	Fall 2016	
BNL ASR SFA	ASR	Triennial	Winter	
PNNL ASR SFA	ASR	Triennial	Winter	

Management updates: 2015-2016. PI meetings

Title	Program(s)	Location	Date in 2015/2016
RGCM SFA/CA PI meeting	RGCM	Gaithersburg	Oct 6-8, 2015
ESS PI meeting	TES, SBR, EMSL	Bolger	April 26-27, 2016
ARM/ASR Facility PI meeting	ARM, ASR	Tysons	May 2-5, 2016
ACME PI meeting	ESM	Bolger	June 7-10, 2016

EMSL Updates

Leadership Change and Scientific Awards

- Allison Campbell, President Elect for the American Chemical Society.
- Lee Ann McCue, new Molecular Science Computing (MSC) Lead
- Chongmin Wang, recipient of the 2016 Innovation in Materials Characterization Award from the Materials Research Society
- Christer Janssen, climate-friendly rice name a 2015 top science development by *Popular Science*.

Proposal Opportunities

- 2016 Science Theme call – Proposals received February 29th.
- 2016 EMSL-JGI call (renamed FICUS, for Facilities Integrating Collaborations for User Science – LOIs due April 4th.
- Pilot EMSL-ARM Call – Issued Dec 9th. - 5 proposals received.

FICUS Facilities Integrating Collaborations for User Science

EMSL

ARM CLIMATE RESEARCH FACILITY

Capabilities

- *NWChem* 6.6 Released – new algorithms for hybrid architectures.

Outreach and User Activities

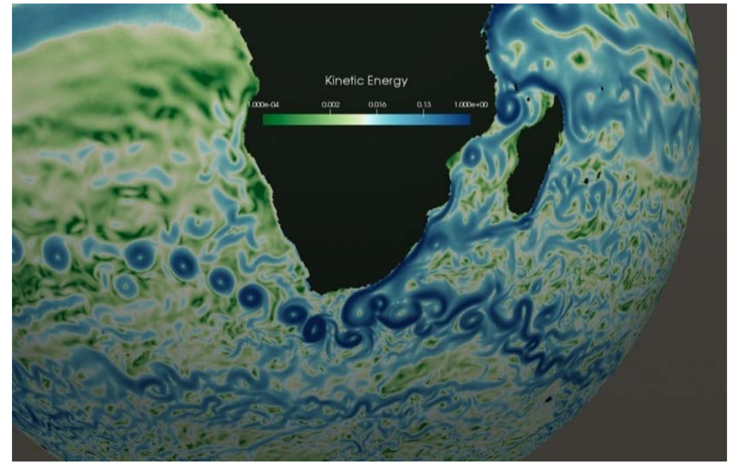
- *Molecular Bond*: Sea Spray Aerosols and Interfacial Surfaces
- 2016 User Meeting – Focused on Nutrient Cycling and Rhizosphere Dynamics – Sept 2016

Accelerated Modeling For Energy News

ACME Accelerated Climate Modeling for Energy

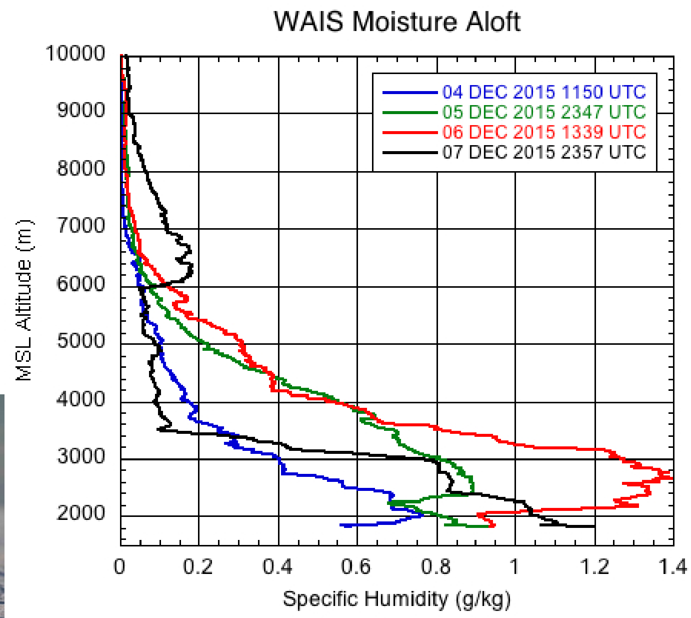
- Version 1 (v1) is frozen, now in debugging, coupling and testing phase.
- v1 features MPAS ocean at 10km resolution, coupled to MPAS sea-ice and land-ice.
- Atmosphere will be 25km, with CLUBB convection and full set of aerosols
- Land will include PFLOTRAN, and C-N-P biogeochemistry
- v1 release on track for summer 2017
- ACME has secured ALCC, INCITE awards, as well as early access for SUMMIT and CORI

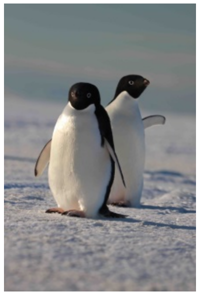
- Project 2nd mid-term review: June-2016
- Next major review: CY2017
- Leadership change: Ruby Leung (chief scientist)
- ESM FOA 2016 will bring in University partner-projects



ARM West Antarctic Radiation Experiment (AWARE)

- West Antarctica is one of the most rapidly warming regions on Earth, with significant impacts on ice sheet melting and sea level rise
- What is the role of clouds, atmospheric moisture, and radiation feedbacks in this melting?
- ARM Mobile Facility deployed to McMurdo, Antarctica Jan 2016 – Dec 2017
- Additional ARM instruments deployed to West Antarctic Ice Sheet (WAIS) for one season
- Collaboration with NSF/US Antarctic Program





ARM Mobile Facility at McMurdo

AWARE PI: Dan Lubin, Scripps

Impact

- First radiosondes launched in West Antarctica since 1967; show deep layer of moisture that accompanies storms arriving on WAIS from the Southern Ocean
- Ongoing analysis of ARM observations of recent significant warming event at WAIS that was accompanied by widespread surface melting in West Antarctica – paper in prep for *Nature Geosci.*
- Comprehensive ARM measurements at McMurdo station, including cloud radar & lidar, will provide insights into Antarctic cloud properties

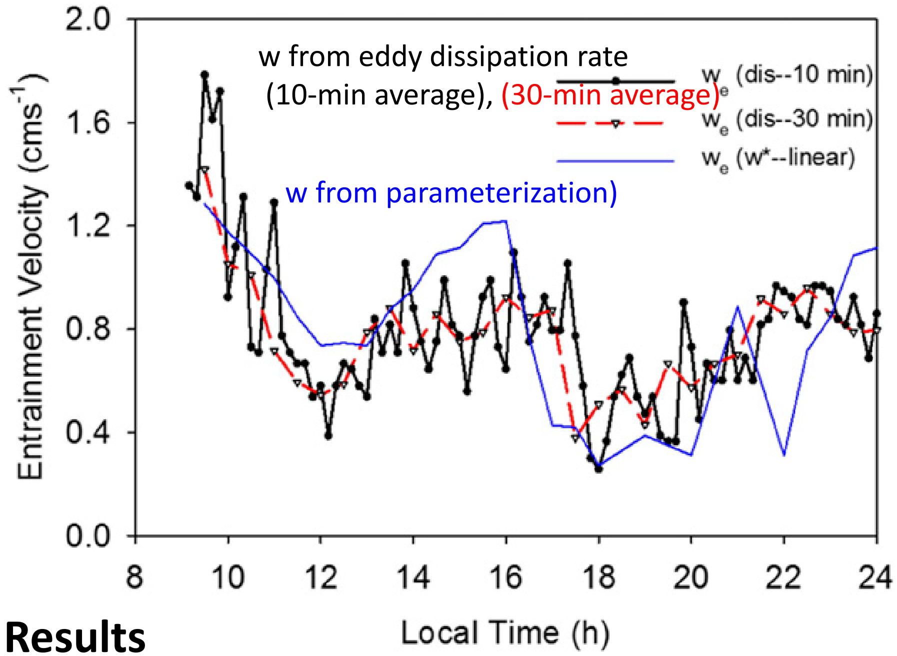
Testing stratocumulus cloud-top entrainment parameterizations using ARM Doppler cloud radar

Entrainment (mixing of cloudy air with clear air) at cloud top makes stratocumulus clouds especially difficult to model

Objective: Use radar observations to test different methods of parameterizing entrainment rate in numerical models

Approach

- Use data from a 14-hour stratocumulus case over SGP to calculate entrainment rate (w) based on:
  - Radar-derived vertical velocity variance
  - Radar-derived energy dissipation rate
  - Inversion height budget derived from cloud top height and large scale field from ECMWF reanalysis
  - Average entrainment rate (using a standard convective velocity-scale parameterization)



Results

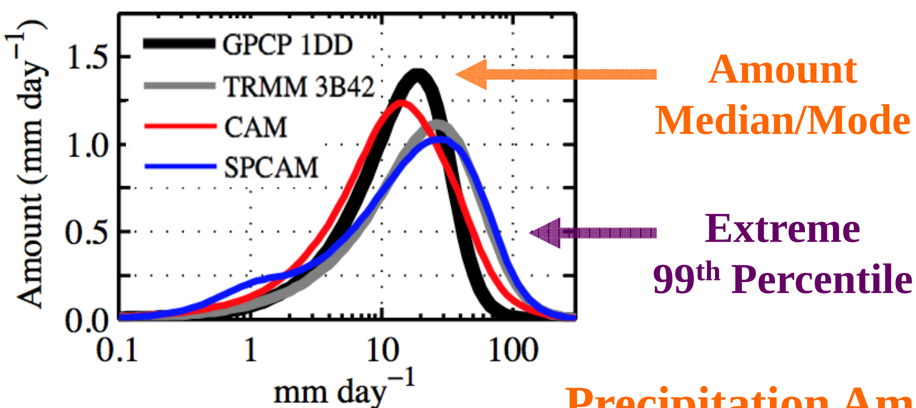
- Radar data can provide entrainment rate at higher temporal resolution than other methods and is suitable for testing existing parameterizations
- Calculating entrainment rate using radar-derived energy dissipation rate has the advantage of not requiring observations of height or mixing length scales

Albrecht B, M Fang, and V Ghate. 2016. "Exploring Stratocumulus Cloud-Top Entrainment Processes and Parameterizations by Using Doppler Cloud Radar Observations." *Journal of the Atmospheric Sciences*, 73(2), 10.1175/JAS-D-15-0147.1.

Superparameterization (SP) improves the representation of moderate and extreme rainfall intensity in regions of organized convection

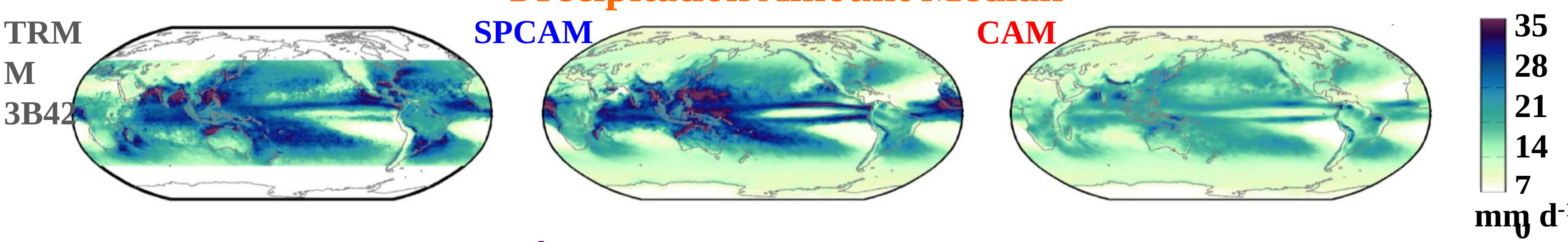
A detailed global analysis in 3 (SP)CESM version pairs of the entire rainfall amount PDF

Precipitation Amount Distribution

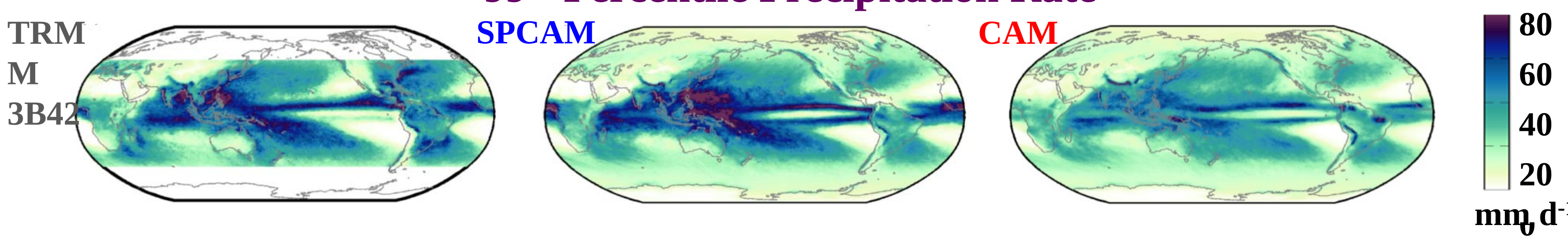


- SP captures the intensity of rain observed by TRMM 3B42, for both the peak (median) and extreme tail (99th %) of the distribution. The most significant improvements are in the tropics (e.g. MJO, ITCZ, and monsoon regions).
- Resilience of SP benefits to exterior horizontal resolution: SP is a strategy for scale awareness.
- Effects especially striking from vantage point of the mode – rain rate that delivers most accumulation.

Precipitation Amount Median



99th Percentile Precipitation Rate



Kooperman, GJ, MS Pritchard, MA Burt, MD Branson, DA Randall, 2016: J. Adv. Model. Earth System (JAMES), in press.

Relative contributions of mean-state shifts and ENSO-driven variability to precipitation changes in a warming climate

Objective

Investigate how regional precipitation (P) in the 21st century may be affected by changes in both ENSO-driven P variability and slowly-evolving mean P.

Research

- Identify a time-invariant canonical ENSO (cENSO) pattern in observed SST data (Fig. 1).
- Evaluate how well/when 33 coupled models replicate *this* pattern in simulations of the historical and future climate.
- Compute the associated winter P responses to ENSO variability for the 20th century.
- Assess whether these P responses change with global warming.

Impact

- Models with better representation of the cENSO pattern produce more realistic winter P teleconnection patterns.
- Teleconnections are more stationary during the 21st century in simulations with large amplitude of cENSO variability (Fig. 2).
- In most regions, ENSO-driven P response will intensify in the future (Fig. 3), even if ENSO remains unchanged.
- The model-predicted 21st century rainfall response to cENSO are decomposed into a 3-term sum. By examining the 3 terms jointly allows the identification of regions likely to experience future rainfall anomalies that are without precedent in the current climate (Fig. 4).

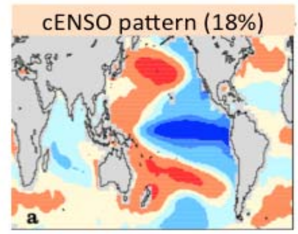


Fig. 1

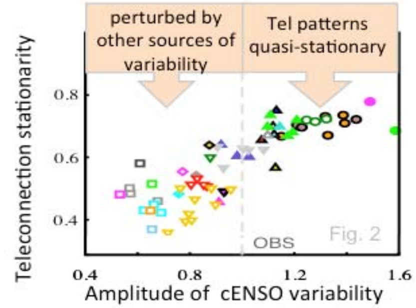


Fig. 2

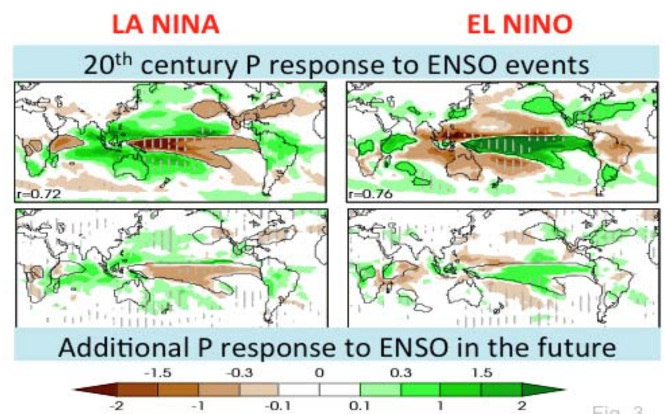


Fig. 3

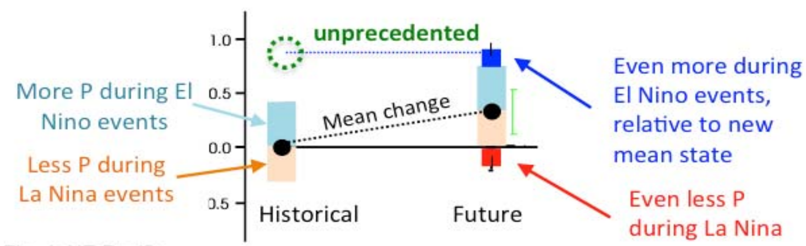


Fig. 4: NE Pacific

Bonfils C, B Santer, T Phillips, K Marvel, R Leung, C Doutriaux, A Capotondi, 2015, Relative contributions of mean-state shifts and ENSO-driven variability to precipitation changes in a warming climate. *Journal of Climate*, 28, 9997-10013. doi: http://dx.doi.org/10.1175/JCLI-D-15-0341.1

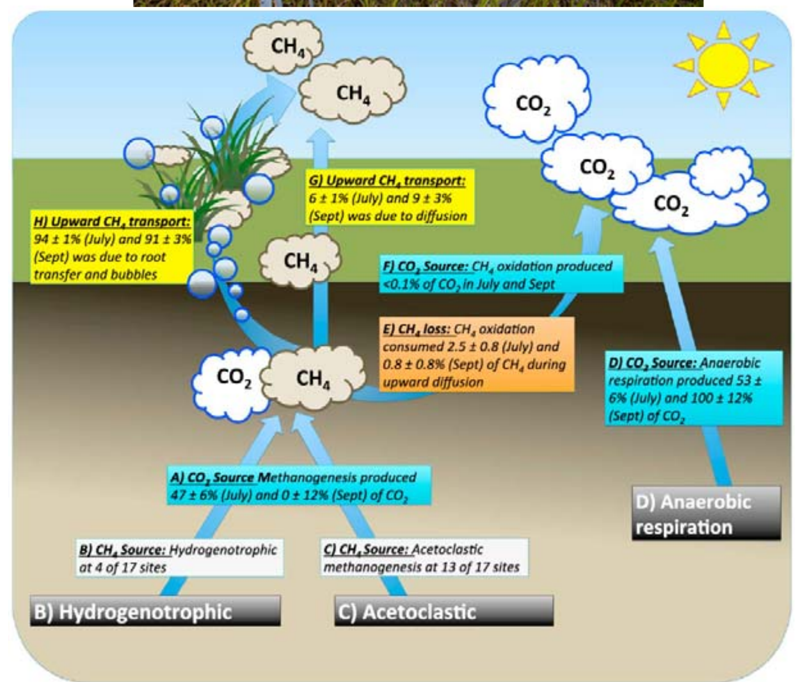
Pathways and transformations of dissolved methane and dissolved inorganic carbon in Arctic tundra watersheds: Evidence from analysis of stable isotopes

- **Background:** Permafrost soils have the potential to release vast amounts of CO_2 & CH_4 into the atmosphere. However, predicting this release is challenging due to substantial landscape heterogeneity.

- **Approach:** This study quantified stable isotopes of dissolved carbon and CH_4 in Barrow, AK to estimate CH4 pathways and transformations.

- **Results:** The majority of subsurface CH4 was transported upward by plants and ebullition (bubbling), thus bypassing the potential for CH4 oxidation.

- **Impact:** Results highlight the importance of micro topography and temporal variability when trying to predict CH_4 efflux from Arctic systems and will lead to improved model accuracy..



Throckmorton, H.M., Heikoop, J.M., Newman, B.D., Altmann, G.L., Conrad, M.S., Muss, J.D., Perkins, G.B., Smith, L.J., Torn, M.S., Wullschleger, S.D. and Wilson, C.J., 2015. Pathways and transformations of dissolved methane and dissolved inorganic carbon in Arctic tundra watersheds: Evidence from analysis of stable isotopes. *Global Biogeochemical Cycles*, *29*(11), pp.1893-1910.

FOREST ECOLOGY

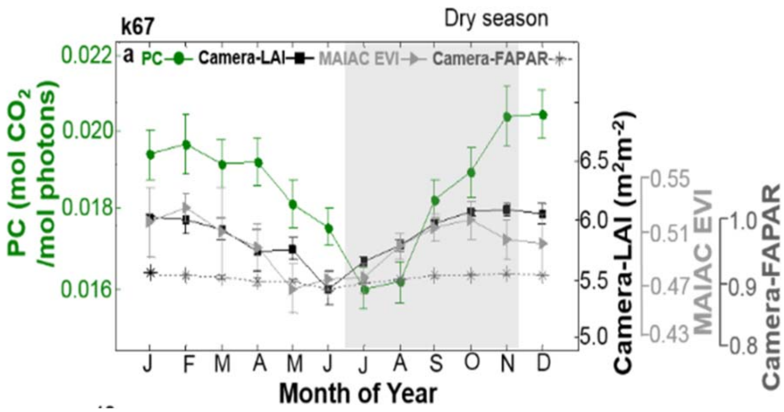
Leaf development and demography explain photosynthetic seasonality in Amazon evergreen forests

- **Background:** While most tropical forests are evergreen, their ability to photosynthesize is seasonal, which rises in the dry season and the cause was under debate.

- **Approach:** Cameras were used to monitor leaf changes throughout the canopy and CO2 was measured to quantify changes in photosynthesis.

- **Results:** During the dry season, old leaves senesce and replaces by more photosynthetically-efficient new growth.

- **Impact:** Results elucidate how tropical forests regulate their seasonal efflux of CO_2 and helps reconcile the discrepancy between direct observations of photosynthesis with changes in canopy "greenness" observed from remote sensing. By not assuming constant canopy greenness, models can be transformed to improve our ability to predict how tropical forest function in a changing climate.



Wu, J., L.P. Albert, A.P. Lopes, N. Restrepo-Coupe, M. Hayek, K.T. Wiedemann, K. Guan, S.C. Stark, B. Christoffersen, N. Prohaska, J.V. Tavares, S. Marostica, H. Kobayashi, M.L. Ferreira, K. Silva Campos, R.da Silva, P.M. Brando, D.G. Dye, T.E. Huxman, A.R. Huete, B.W. Nelson, S.R. *Saleska*. 2016. Leaf development and demography explain photosynthetic seasonality in Amazon evergreen forests. *Science*. Vol 351, Issue 6276, pp. 972-976.

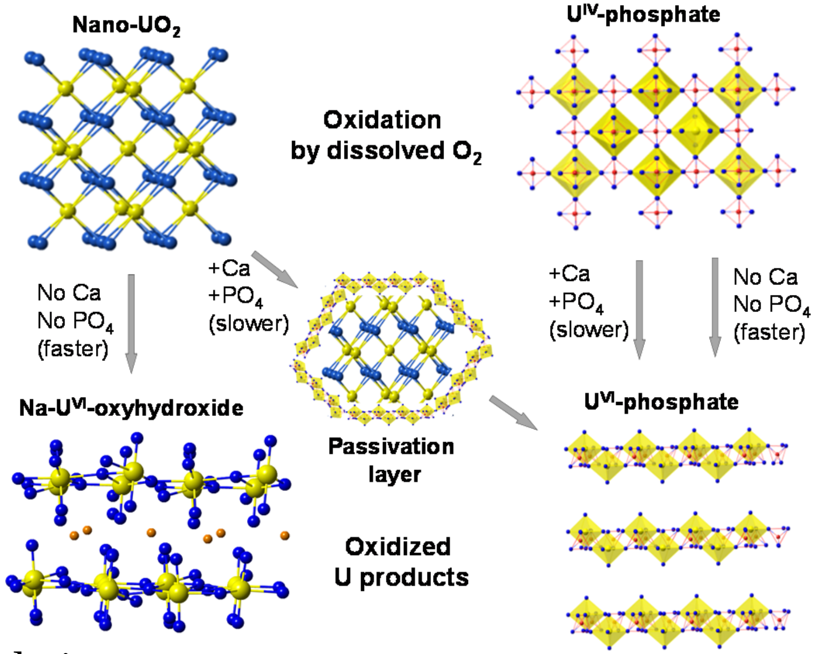
Calcium and Phosphate Affect Uranium Transport

Challenge

- The effect of environmental variables on the transformations of newly-discovered subsurface uranium forms is currently unknown, limiting our ability to include these predominant U species in reactive transport models

Approach and Results

- The oxidation of field-relevant U(IV) species was studied in the presence of two groundwater ions
- Synchrotron x-ray spectroscopy revealed the molecular structure and the oxidation mechanisms
- Ca and PO_4 slow down the oxidation of U(IV) by forming a passivation layer, also change the products of oxidation

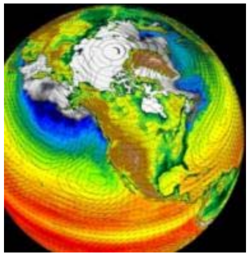


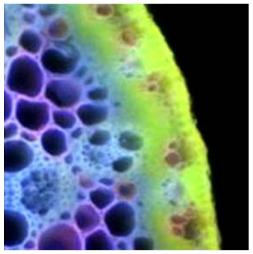
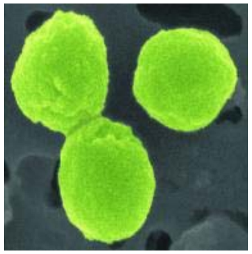
Significance and Impact

- Provided a mechanistic understanding of U(IV) oxidation, including reactants, products, and kinetic parameters
- This information enables inclusion of reactions for relevant U species, which will improve contaminant transport predictions

Participants:
Argonne National Laboratory
Bulgarian Academy of Sciences
The University of Iowa
Illinois Institute of Technology

Reference: D. E. Latta, K. M. Kemner, B. Mishra, M. I. Boyanov, "Effects of calcium and phosphate on uranium(IV) oxidation: Comparison between nanoparticulate uraninite and amorphous U^{IV}–phosphate". *Geochim. Cosmochim. Acta* **174**, 122 (2016).



Thank you!

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