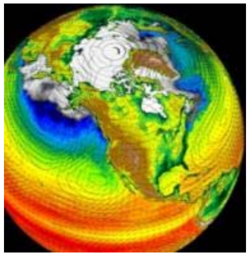
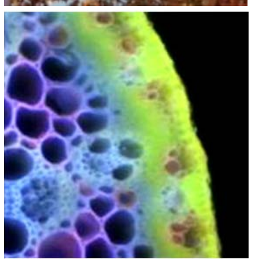


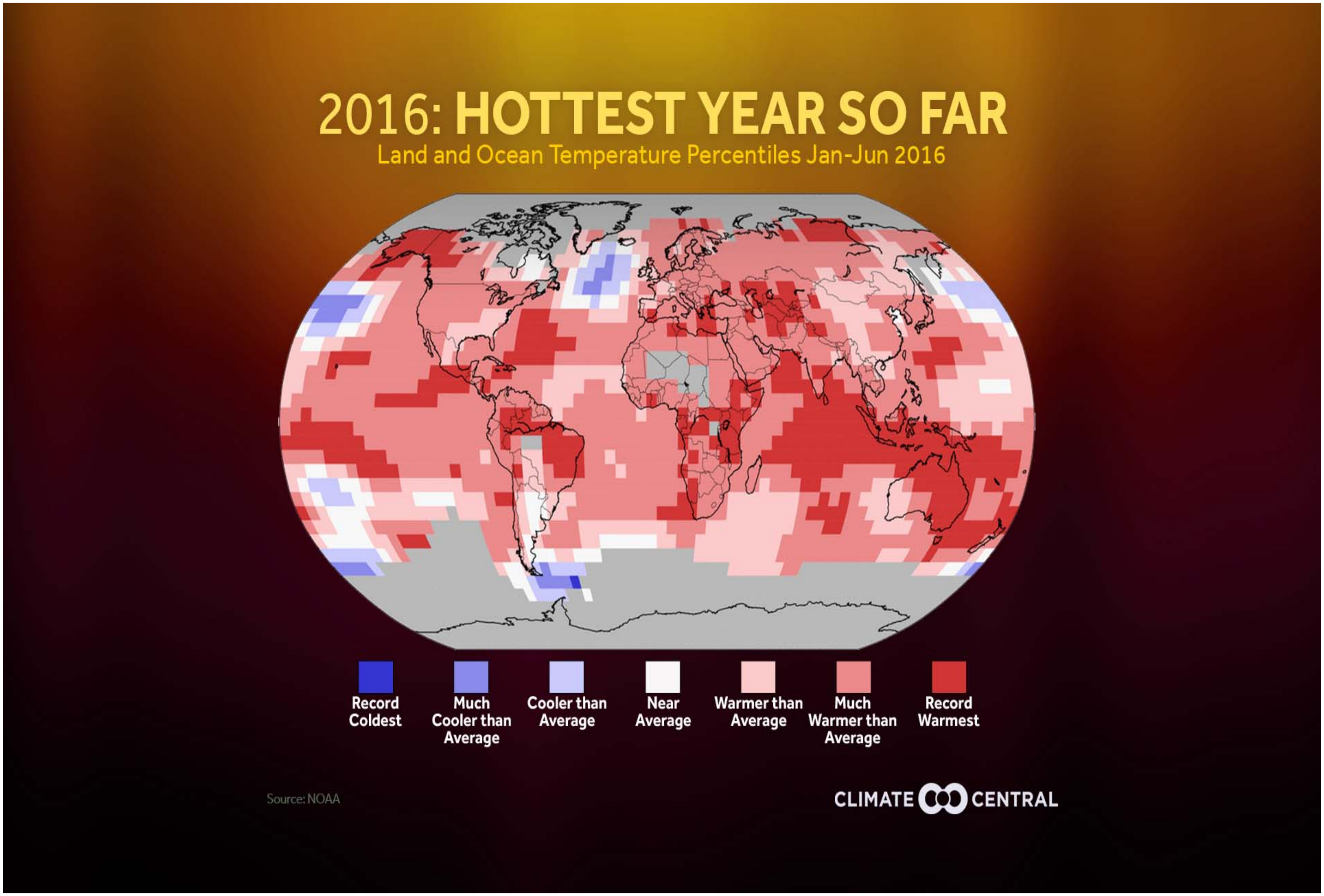



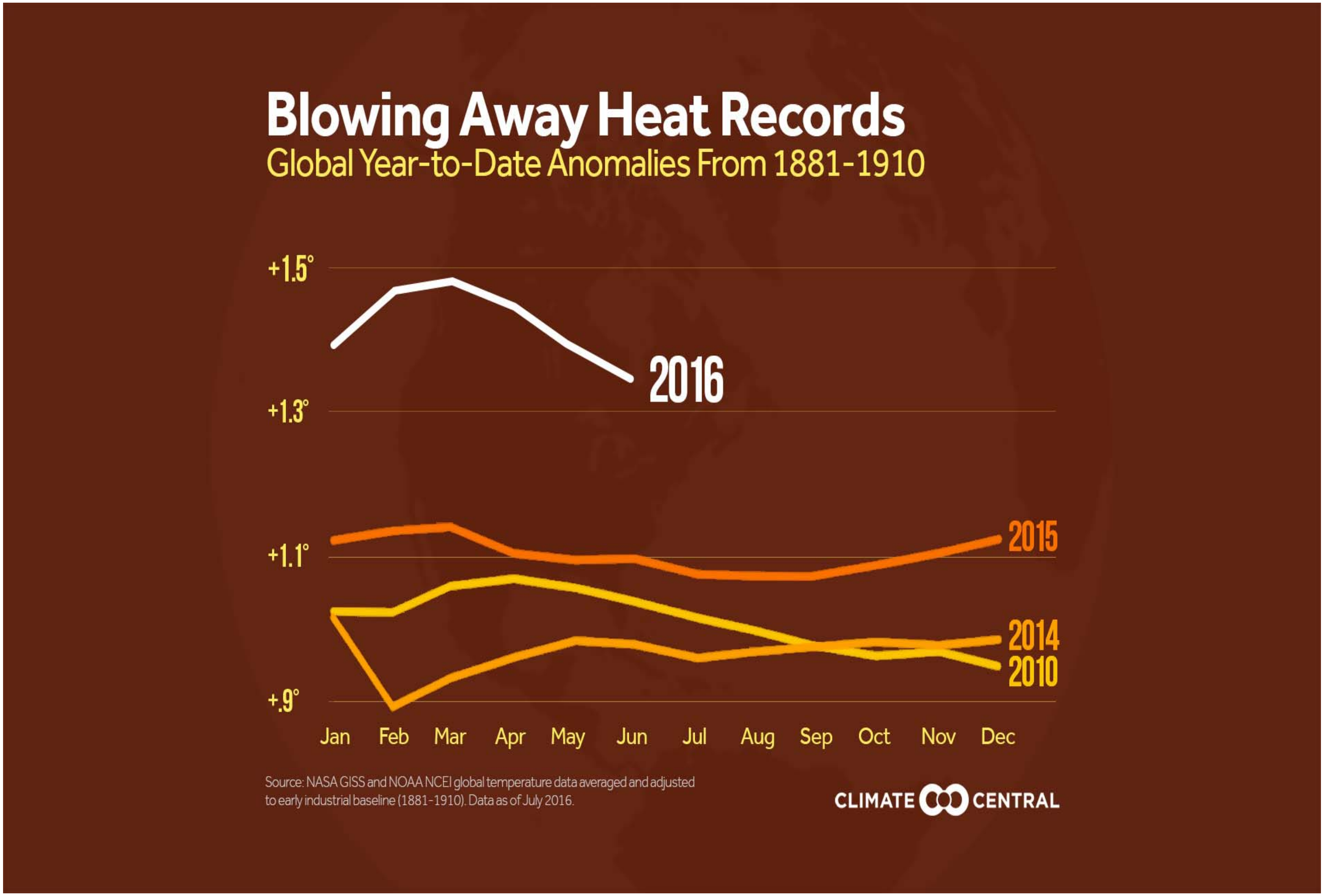

Climate and Environmental Sciences Division

BERAC update

October 27, 2016

G. Geernaert
BER/CESD


2016: HOTTEST YEAR SO FAR
Land and Ocean Temperature Percentiles Jan-Jun 2016
Record Coldest
Much Cooler than Average
Cooler than Average
Near Average
Warmer than Average
Much Warmer than Average
Record Warmest
Source: NOAA
CLIMATE CENTRAL



Blowing Away Heat Records
Global Year-to-Date Anomalies From 1881-1910
+1.5°
+1.3°
+1.1°
+.9°
2016
2015
2014
2010
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Source: NASA GISS and NOAA NCEI global temperature data averaged and adjusted to early industrial baseline (1881-1910). Data as of July 2016.
CLIMATE CENTRAL

Outline

- Where are we heading - strategic update
- Administrative
- Highlights – facilities and new science

Planning process

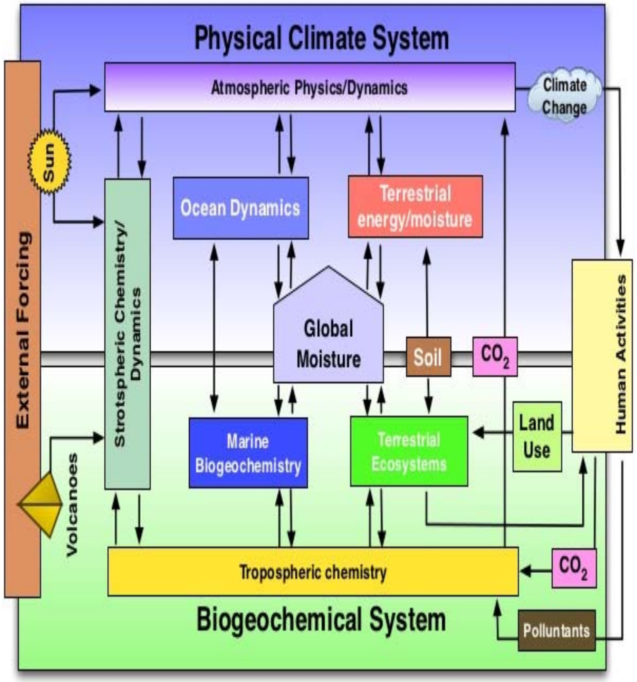
Guiding Principles for Grand Challenge science

- 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 BERAC and community workshop conclusions
- Allow DOE to exert significant leadership, yet include multiple collaborating agencies

CESD culture – all challenges owned by Division

- Challenges big enough to demand multiple program engagement, shared investment and management
- Strengthened relationship with ASCR, other offices

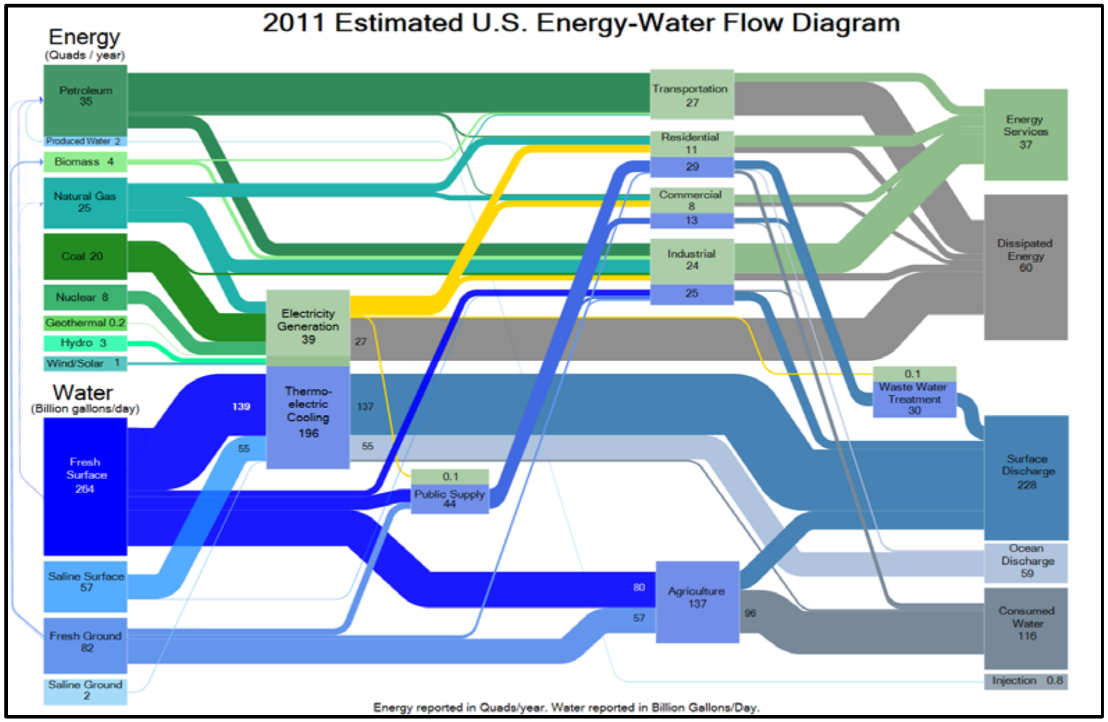
Dynamic earth system



Strategic Planning updates – Workshops set the stage

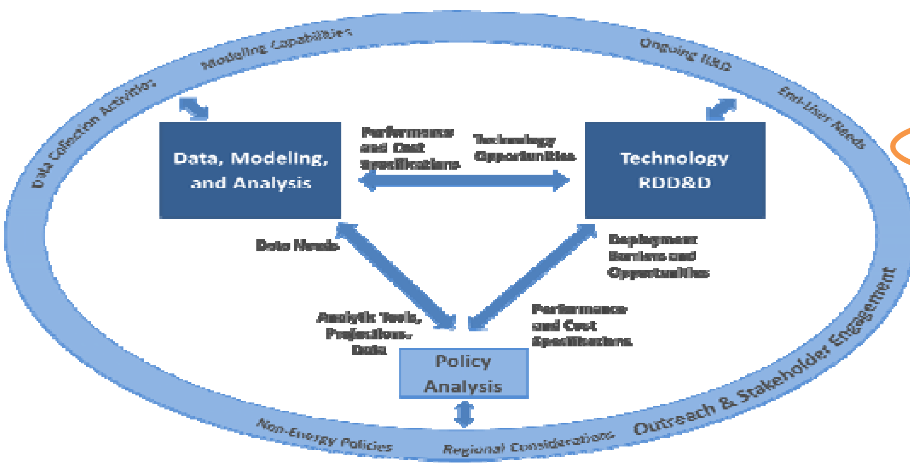
Date: 2016	Date	Venue
March 9-10	Climate Modeling Summit (USGCRP)	USGCRP
March 29-31	BER exascale modeling workshop	GTN
April 20-21	IA – Economics workshop	JGCRI
May 16-18	Workshop on ILAMB	Wash DC
May 24-26	DOE/USGCRP Workshop on IA and IAV science challenges	JGCRI
June 20-23	CESM Annual Workshop	Breckenridge
July 25-29	Energy Modeling Forum (IA/IAV week)	Snowmass
Aug 29-30	ESS Cyberinfrastructure working group	GTN
Sept 7-9	Terrestrial Aquatic Interface workshop	Rockville
Sept 12-14	AXCICCS (computational requirements for climate modeling) workshop	Rockville

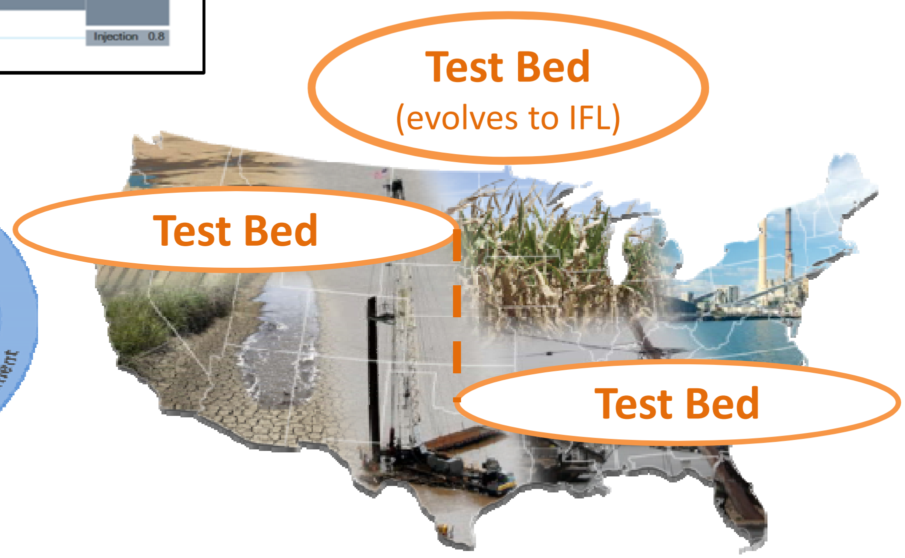
Strategic Planning – incorporating DOE-wide "nexus" issues



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





Strategic Planning Update – preview of the next five years

Vision: Develop a strong and vibrant use-inspired, basic research portfolio to enable transformational advances in the understanding and projected changes of Earth's complex climate and environmental systems, in support of national energy strategies.

Scope: merging of climate, environmental, and human components

High level Grand Challenges

- Climate forcers – co-evolution of climate-human system, scales
- High latitude – process feedbacks, global interdependence
- Biogeochemistry – hydrobiogeochemistry, scale interactions, environ genomics
- Hydrology – scale aware processes, water cycle perturbations, geomorphology,
- Supporting infrastructure: DOE User Facilities, integrative model systems, Leadership Class Computers, and Data Management/Informatics

Cross-cutting: compartment and scale interactions; natural-human interdependencies, disturbance, thresholds, tipping points; predictability using MODEX; and exascale model systems

Management Update: solicitations

Funds	Program lead	Issued	Proposals	Panel	Selected
FY16	Environmental System Science – annual FOA	Oct 7, 2015	151	April 4-6	11
FY16	ASR – annual	Oct 2, 2015	102	March 21-22	19
FY16	ASR - data products	Oct 2, 2015	26	March 29-31	4
FY16	Earth System Modeling	Feb 15, 2015	83	April 19-20	14
FY16	ASR/ESM - CMDV	Feb 5, 2016	4	May 9	2
FY16	RGCM/IAM - EWN	Feb 5, 2015	9	June 1-2	2

Management updates: Major reviews in 2016

Lab	Program	Type	Review date	Outcome
SFA - LBNL	SBR	Triennial	Apr 28-29, 2016	Approved
Ameriflux	TES	Renewal	April/May TBD	Approved
Stanford CA	IA	Renewal	May 2	Approved
SFA – ANL	TES	Triennial	May 23, 2016	Approved
ACME (LLNL, etc)	ESM	Mid-term	June 10	Approved
CDIAC / TDIS (ORNL)	Data, ESS	Project renewal	June 2-3	Declined
IAV SFA (PNNL)	IA	SFA initiate	June 16-17	Approved
LBNL Cascade SFA	RGCM	Triennial	Aug 25-26	Approved

Management updates: 2015-2016. PI meetings

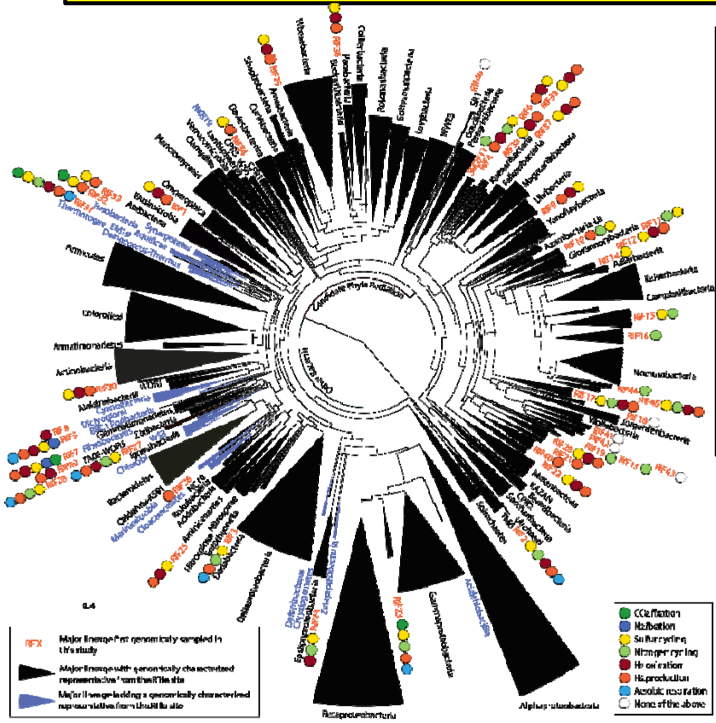
Title	Program(s)	Location	Date in 2015/2016
ESS PI meeting	TES, SBR, EMSL	Bolger	April 26-29, 2016
ARM/ASR Facility PI meeting	ARM, ASR	Tysons	May 2-5, 2016
ACME PI meeting	ESM	Bolger	June 7-9, 2016
NGEE Tropics annual PI	TES	Wash DC	Sept 21-22
RGCM PI	RGCM	Wash DC	Nov 29 – Dec 1

Science Highlights

Story line focus on interdisciplinary science from smallest scales to regional and global impacts!

- Science based on biogeochemistry and environmental genomics
- Carbon uptake from soils more problematic into the future
- Aerosol chemistry and coupling to storm dynamics
- Storm surge and future hurricanes risks greater in future
- ACME updates
- Nonlinear vulnerability of energy sector to climate change

Thousands of microbial genomes shed light on interconnected biogeochemical processes in an aquifer system



New Science from SBR SFA Rifle site

- 2,540 genomes that represent the majority of known bacterial phyla and 47 new phylum-level lineages were reconstructed from sediment and groundwater collected from a semi-arid floodplain near Rifle, CO.
- Analyses showed that inter-organism interactions are required to turn the carbon, sulfur and nitrogen biogeochemical cycles and revealed that complex patterns of community assembly are likely key to ecosystem functioning and resilience.

Colors of the wedges indicate the following:
Black: Phylum-level lineage identified at Rifle;
Blue: Phylum-level lineage not identified at Rifle.
Colored circles describe important biogeochemical roles inferred for newly described phylum-level lineages (RIF1-46, SM2F11).

RESULTS/IMPACT:

- Identified ecological roles for 36% of all organisms identified in this ecosystem to date.
- Analyses showed that microbial metabolic exchange cross-links the biogeochemical cycles of carbon, nitrogen, and sulfur in the subsurface.
- The research almost doubled the number of major bacterial groups and provided detailed information about the ecosystem roles of organisms from these groups.

K. Anantharaman, C. T. Brown, L. A. Hug, I.Sharon, C. J. Castelle, A. J. Probst, B. C. Thomas, A. Singh, M. J. Wilkins, U. Karaoz, E. L. Brodie, K. H. Williams, S. S. Hubbard, and J. F. Banfield. "Thousands of microbial genomes shed light on interconnected biogeochemical processes in an aquifer system". Nature Communications 7, ncomms13219 (2016).

Potential Carbon Emissions Dominated by Carbon Dioxide from Thawed Permafrost Soils

Objective:

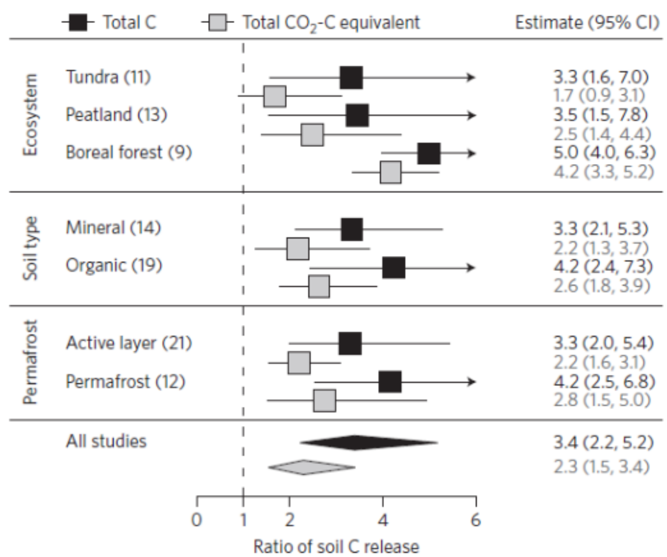
To determine if the release of carbon from thawed permafrost is carbon dioxide or the more potent greenhouse gas methane

Approach:

- Two meta-analyses were used to investigate the greenhouse gas release from soils sampled from across the permafrost zone and warmed in laboratory incubations

Results/Impacts:

- Potential warming of 10°C increased total carbon release by a factor of two, and even when taking into account the stronger warming potential of methane, total carbon release was greatest under aerobic soil conditions
- The implications of these results are that drier soils may provide a larger, positive feedback to global warming than wetter soils



Ratio of C released from permafrost-affected soils comparing aerobic to anaerobic incubation conditions

Schädel C, Bader MKF, Schuur EAG, Biasi C, Bracho R, Capek P, De Baets S, Diakova K, Ernakovich J, Estop-Aragones C, Graham DE, Hartley IP, Iversen CM, Kane E, Knoblauch C, Lupascu M, Martikainen PJ, Natali SM, Norby RJ, O'Donnell JA, Chowdhury TR, Santruckova H, Shaver G, Sloan VL, Treat CC, Turetsky MR, Waldrop MP, Wickland KP. 2016. Potential carbon emissions dominated by carbon dioxide from thawed permafrost soils. Nature Clim. Change, DOI:10.1038/nclimate3054.

Radiocarbon constraints imply reduced carbon uptake by soils during the 21st century

Objective:

To use radiocarbon data to constrain the mean age of soil carbon in earth system models (ESMs)

Approach:

- Compile 157 vertical profiles of the radiocarbon content of soils from around the world
- Create reduced complexity models that mimic the behavior of the original ESMs using carbon cycle simulations from the 5th Coupled Model Intercomparison Project
- Adjust the reduced complexity models so they match the radiocarbon from the observed profiles and then use these models to estimate future carbon uptake

Results/Impacts:

- Earth systems models underestimate the mean age of soil carbon by about a factor of 6
- Soil carbon uptake of atmospheric CO_2 decreases by 40 ± 27%
- More carbon from fossil fuel emissions may accumulate in the atmosphere than expected, contributing to climate warming

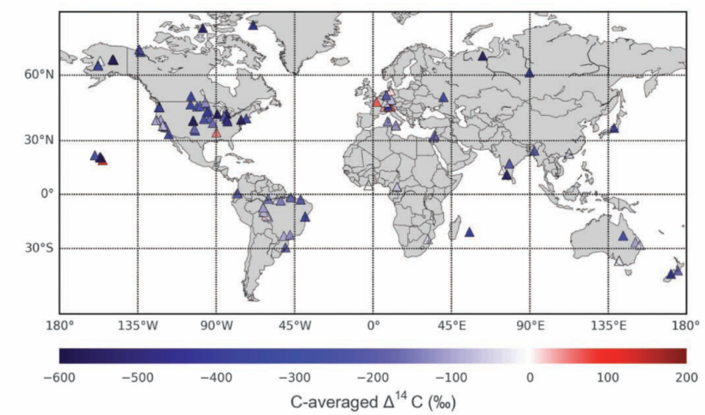


Fig. 1. Location of soil profiles

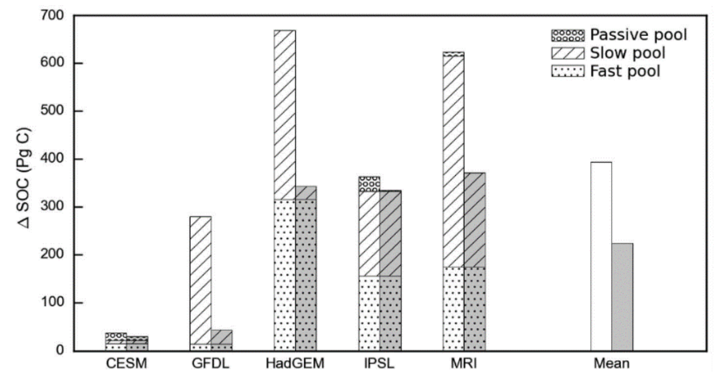


Fig. 2. Soil carbon accumulation before (white) and after (grey) application of the radiocarbon constraint

He, Y., S.E. Trumbore, M.S. Torn, J.W. Harden, L.J.S. Vaughn, S.D. Allison, and J.T. Randerson. 2016. Radiocarbon constraints imply reduced carbon uptake by soils during the 21st century. *Science*. 353: 1419-1424.

Biogenic Particles Contribute to Formation of Aerosols

Challenge

- Provide molecular-level insights into how a volatile organic compound called α-pinene—the most abundant emission from natural plants—interacts with solvents to form new atmospheric organic aerosols.

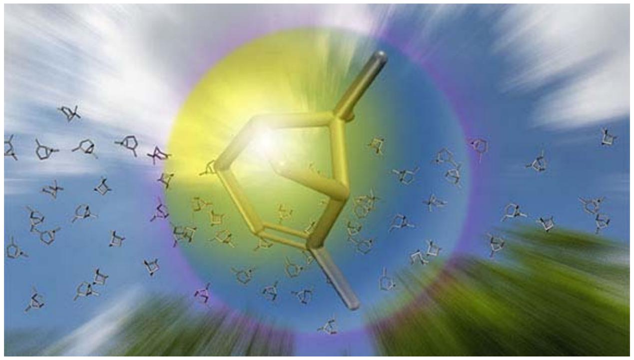
Approach and Results

- EMSL users combined negative ion photoelectron spectroscopy (NIPES) and theoretical calculations to examine the early stage formation of clusters consisting of *cis*-pinic acid—a major oxidation product of α-pinene—and three common atmospheric solvents: water, methanol, and acetonitrile.

- The findings revealed *cis*-pinic acid takes on different functions and structures in different solvent environments.

Significance and Impact

- These findings could be incorporated into models to enable more accurate representations of abundant atmospheric particles and to simulate their effect on climate and air quality.



This combined experimental and computational study can help improve the accuracy of numerical models that simulate the effect of organic aerosols on climate and air quality.

Participants: **EMSL, PNNL and the Chinese Academy of Sciences**

Reference: G.-L. Hou, X.-T. Kong, M. Valiev, L. Jiang, and X.-B. Wang. 2016. "Probing the early stages of solvation of *cis*-pinate dianions by water, acetonitrile, and methanol: A photoelectron spectroscopy and theoretical study," *Phys. Chem. Chem. Phys.* 18:3628. [DOI: 10.1039/c5cp05974g]

Growth of Atmospheric Particles to Climate-relevant Sizes

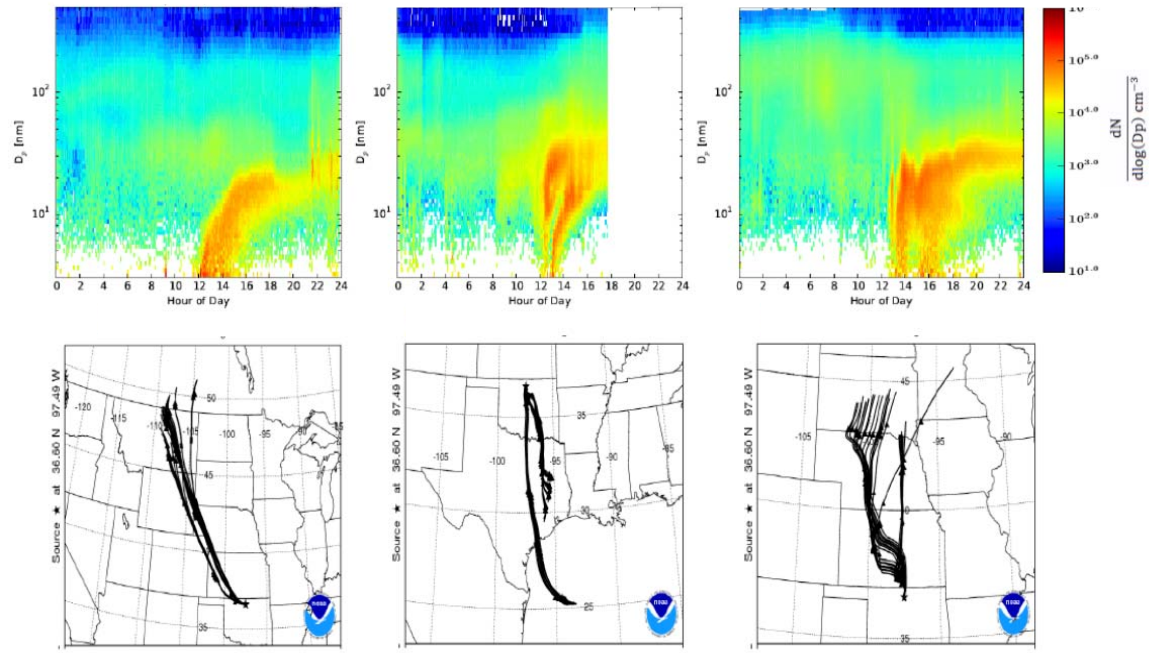
ARM SGP campaign finds examples of three different particle growth mechanisms

Objective: Observe and model atmospheric nanoparticles from birth to sizes relevant to cloud droplet formation.

Approach:

- Measurements of important trace gases and aerosol properties were made during the 2013 New Particle Formation Study at the ARM Southern Great Plains site.
- A mechanistic particle growth model was developed and used to interpret observations.

Hodshire AL, et al.. 2016. "Multiple new-particle growth pathways observed at the US DOE Southern Great Plains field site." *Atmospheric Chemistry and Physics*, 16(14), doi:10.5194/acp-16-9321-2016.



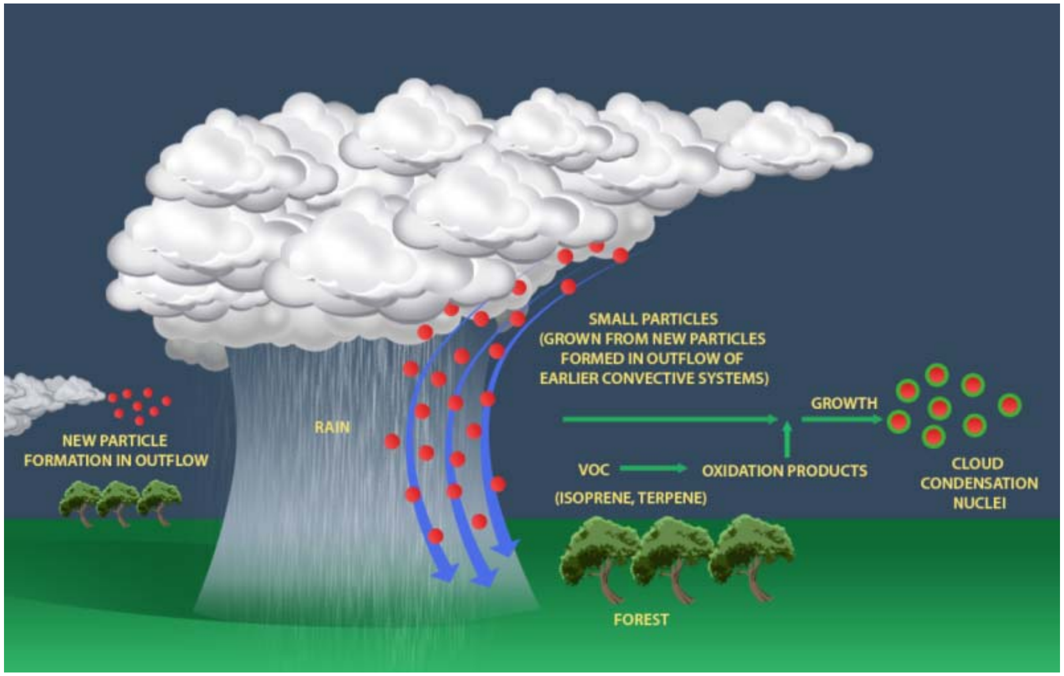
Results and Future Work:

- Campaign data shows that there are multiple observed particle growth pathways at the SGP site
- Currently models only include the sulfuric acid growth mechanism - this study demonstrates the importance of considering the chemical complexity of a site.
- A follow-up study was recently conducted during HI-SCALE using an even larger suite of instruments.

Amazon boundary layer aerosol concentration sustained by vertical transport during rainfall

Objective: How do aerosol particles and cloud condensation nuclei form in the natural conditions of the Amazon basin, where there are few sources of pollutants?

Approach: Use observations from the GOAmazon field campaign to track the temporal variation of aerosol size spectrum before, during, and after precipitation events, in combination with the vertical profile of aerosol size spectrum and vertical air motion.



Results and Impact:

- Growth of new particles formed in the outflow region of earlier convective clouds leads to high concentrations of small particles in free troposphere.
- These particles descend from free troposphere into boundary layer during rainfall, then grow into CCN.
- The vertical transport helps maintain boundary layer CCN population, thereby influencing cloud properties and climate under natural conditions.
- Results have important implications for understanding aerosol formation in pre-industrial conditions.

Wang J, et al., 2016. "Amazon boundary layer aerosol concentration sustained by vertical transport during rainfall", *Nature*, In press.

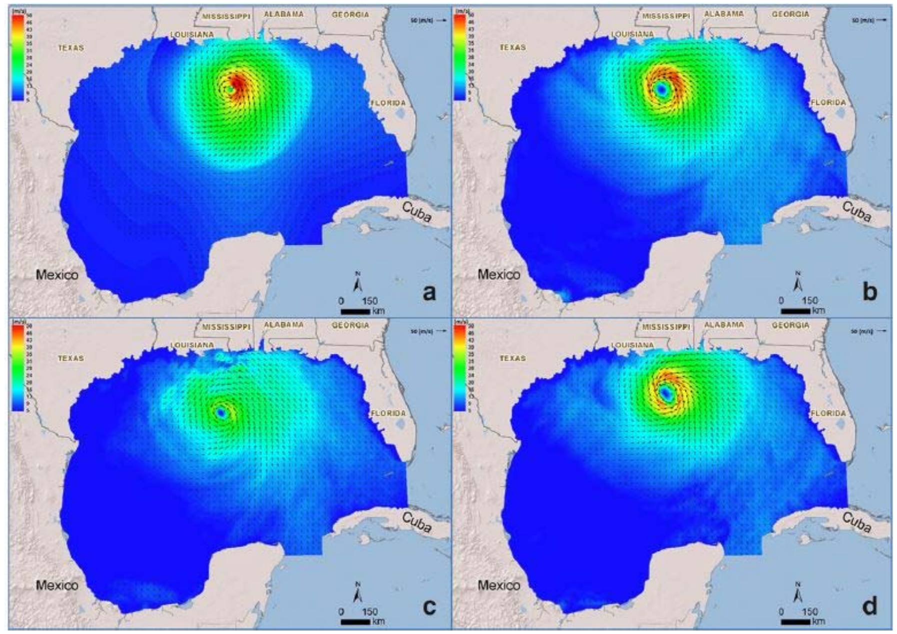
Storm Surge Modeling Tested with an Ensemble of Tropical Cyclone Simulations

Objective

- Determine the feasibility of modeling storm surge using regional simulations of hurricane winds and pressure

Approach

- Perform an ensemble of regional simulations of Hurricane Katrina using different combinations of parameterizations of convection and cloud microphysics
- Simulate storm surge using a storm surge model driven by observed and simulated hurricane winds and pressure
- Evaluate the simulated the storm surge using high-water marks from FEMA for the northern Gulf coast



Large differences in hurricane Katrina wind fields simulated by a regional model with different physical parameteri-zations

Impact

- Demonstrated that skillful simulations of Hurricane Katrina can be achieved to provide forcing to a storm surge model for realistic simulations of high-water marks in northern Gulf of Mexico after Hurricane Katrina
- Reducing uncertainty in modeling tropical cyclones may advance more skillful prediction of storm surge, with important implications to our ability to evaluate the risk of coastal inundation in a warming climate

Yang Z, S Taraphdar, T Wang, LR Leung, and M Grear. 2016. "Uncertainty and Feasibility of Dynamical Downscaling for Modeling Tropical Cyclones for Storm Surge Simulation." *Natural Hazards*. DOI: 10.1007/s11069-016-2482-y

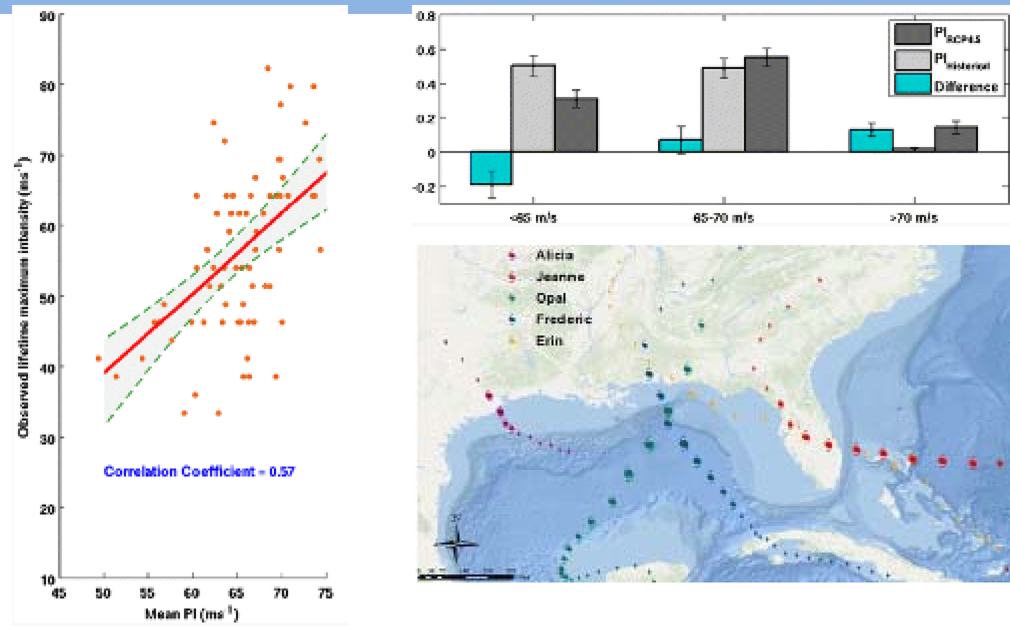
Thermodynamic Potential Intensity Projections of Future Hurricane Storm Surge Risk for U.S. Gulf coasts

Objective

- Estimate changes in future hurricane intensity based on the observed relationship between the mean Potential Intensity (PI) conditions experienced by hurricanes and their observed lifetime maximum intensity, and changes in mean PI conditions projected by climate models
- Examine the impact of these hurricane intensity changes on future storm surge

Approach

- Correlated mean PI conditions for Atlantic hurricanes, based on NCEP-DOE 2 reanalysis and NOAA SST data, with corresponding lifetime maximum intensities
- Estimated projected changes in Atlantic hurricane intensity using historical hurricane tracks and 10 different CMIP5 climate models under the RCP4.5 scenario
- Evaluated impact of hurricane intensity changes using the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model and the tracks of 5 historical hurricanes that made landfall in the Gulf of Mexico and Florida



Left: Scatter between mean PI conditions experienced by Atlantic hurricanes (X-axis) with the observed lifetime maximum intensities (Y-axis). Top right: Probability distribution functions of PI conditions experienced by Atlantic hurricanes based on CMIP5 models. Bottom right: Tracks of 5 historical hurricanes used with the SLOSH model.

Impact

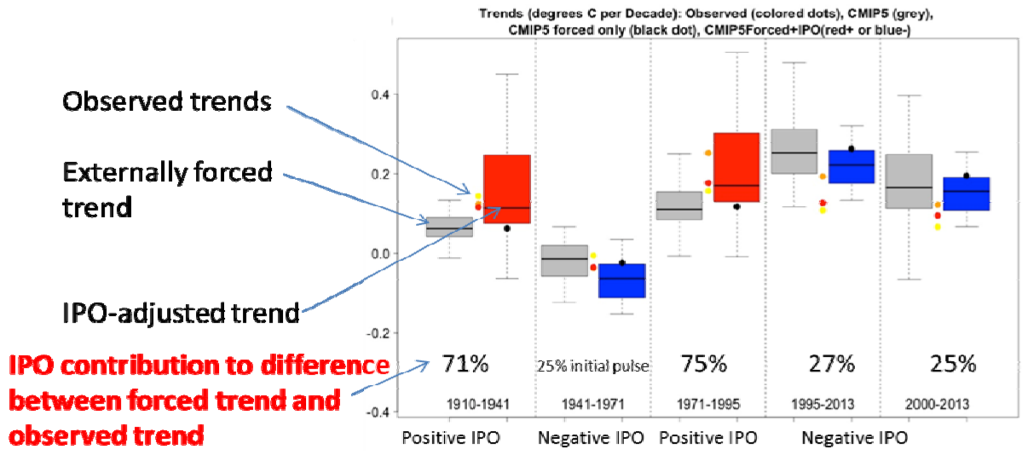
- Lifetime maximum intensities of Atlantic hurricanes may increase by 4±1.3%, consistent with projections from dynamical downscaling studies
- Increased storm surge due to increased hurricane intensities is about 10% of surge due to sea level rise.

Balaguru K, DR Judi and LR Leung. 2016. “Future Hurricane Storm Surge Risk for the U.S. Gulf and Florida Coasts Based on Projections of Thermodynamic Potential Intensity.” *Climatic Change*, DOI:10.1007/s10584-016-1728-8.

Contribution of the Interdecadal Pacific Oscillation (IPO) to 20th-century global surface temperature trends

Objective

To quantify the contributions of specific internally generated decadal processes, in this case the Interdecadal Pacific Oscillation (IPO), to global climate.



IPO contributions to observed epoch trends (defined by phase of the IPO) of global surface temperature

Approach

- Use the CMIP5 multi-model ensemble to define the human-caused part of observed global surface temperature trends
- Use an 1100 year control run from CCSM4 to quantify the IPO contribution in its positive and negative phases to global surface temperature trends
- Then adjust the externally-forced trends with results from the model control run to quantify the IPO contribution

Impact

The IPO contributes 25% to 75% of the difference between the human caused surface temperature trends and the observed trends, thus providing a foundation for improving decadal climate predictions

Meehl, G.A., A. Hu, B.D. Santer, and S.-P. Xie, 2016: Contribution of the Interdecadal Pacific Oscillation to twentieth-century global surface temperature trends. *Nature Climate Change*, **6**, DOI:10.1038/nclimate3107.

ACME Developments

UV-CDAT version 2.6 release

Objective

- Improved version of visualization and analysis platform for ACME, with open-source release

Accomplishments

- Anaconda port: Easier installation on multiple platforms, including laptops
- Improved plotting, new projects, new colormaps, vector improvements, pattern-fill option, new graphics (polar plots and histograms)

Impact

- Extensible and customizable for high-performance interactive and batch visualization and analysis for climate science and other disciplines of geosciences.

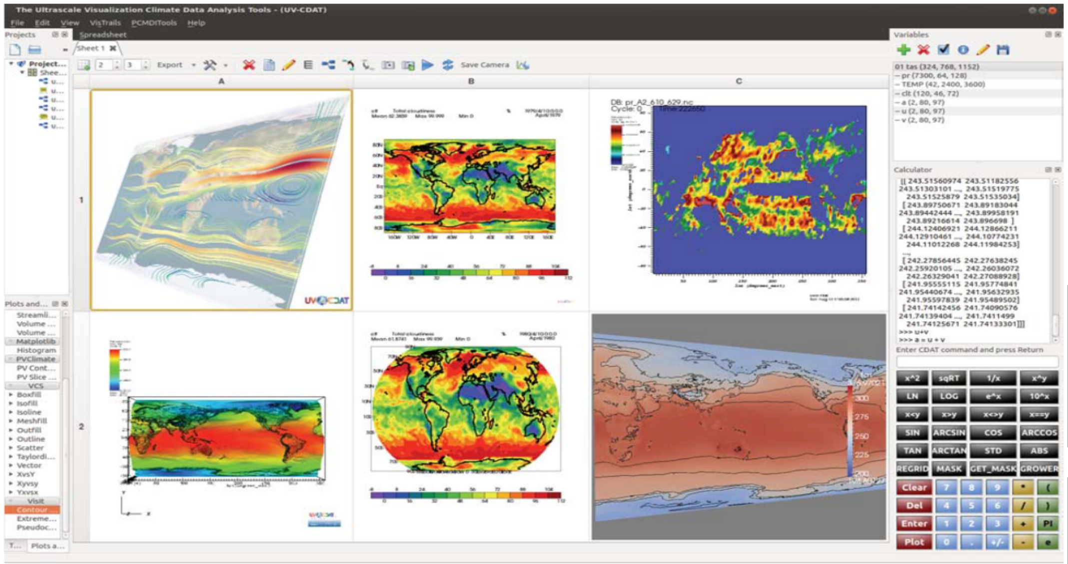
Development of UVCMetrics

Objective

UVCMetrics designed for diagnostic testing of ACME

Accomplishments

- Starting point is the NCAR-AMWG diagnostics
- Customizable inputs: levels, colormaps (more choices, user-settable, better defaults), choice of variables to run, choice of observation, and user-defined variables
- FAST! Parallelized climatology and diagnostic calculations
- Publication quality output
- An online viewer for diagnostics was created for sharing and viewing output with others
- Provenance capture described in output, even inside PNG graphics files



McEnerney, J. , Ames, S. , Christensen, C. , **Doutriaux, C. , Hoang, T. , Painter, J. , Smith, B. , Shaheen, Z. and Williams, D.** (2016) "Parallelization of Diagnostics for Climate Model Development". Journal of Software Engineering and Applications, 9, 199-207. doi: 10.4236/jsea.2016.95016.. May 2016.

Zender, C. S. (2016), Bit Grooming: Statistically accurate precision-preserving quantization with compression, evaluated in the NetCDF Operators (NCO, v4.4.8+), Geosci. Model Dev., 9, 3199-3211, doi:10.5194/gmd-9-3199-2016.

Williams, D. N. (2016), Better tools to build better climate models, *Eos, 97,* doi:10.1029/2016EO045055. Published on 9 February 2016

U.S. Western Electric Grid Vulnerability to Hydro-Climatological Conditions: How Bad Can It Get?

Objective

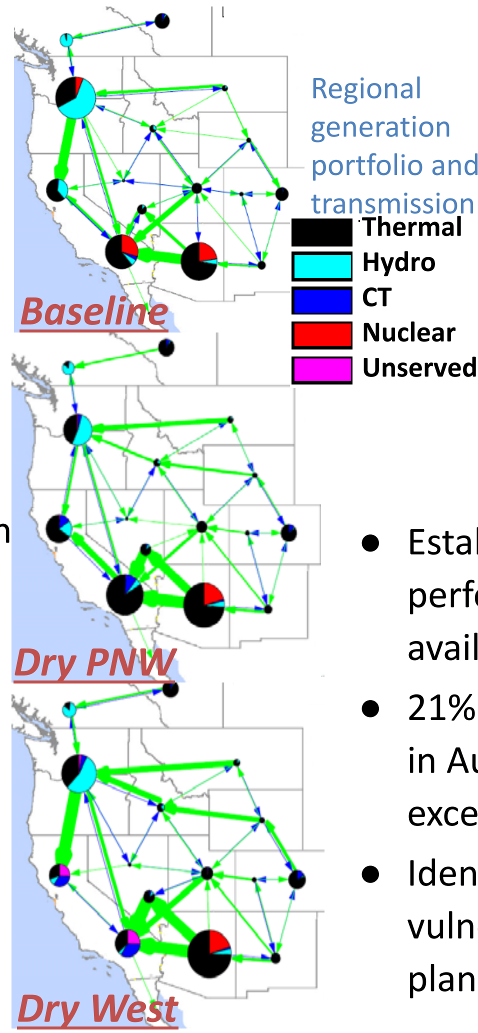
- Understand the vulnerability of Western U.S. grid operations to drought conditions

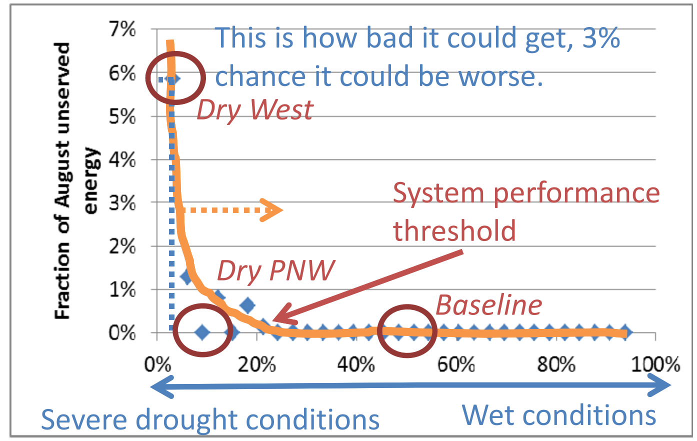
Approach

- Developed a grid-centric drought severity index
- Used integrated water supply and demand modeling to simulate 30 years of historical water availability
- Quantified the impacts of droughts on summer grid operations using a production cost model that accounts for drought-related de-rating of hydropower generation and thermoelectric plant capacity

Voisin N, M Kintner-Meyer, J Dirks, R Skaggs, D Wu, T Nguyen, Y Xie, M Hejazi. 2016. “Vulnerability of the US Western Electric Grid to Hydro-Climatological Conditions: How Bad Can It Get?” *Energy* **115**: 1-12. DOI: 10.1016/j.energy.2016.08.059

Specific drought patterns drive to higher vulnerability

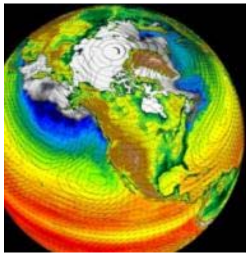


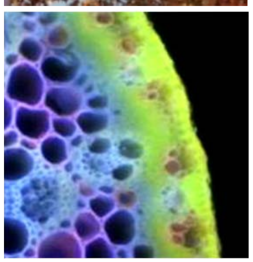


Risk distribution as a function of drought conditions

Impact

- Established a risk distribution for grid performance as a function of inter-annual water availability
- 21% chance that some demand could not be met in August, 3% chance that unserved energy could exceed 6%.
- Identified drought patterns driving to higher vulnerability, which is useful for informing grid planning and adaptation and mitigation scenarios




Thank you!

Gary Geernaert
Gerald.Geernaert@science.doe.gov
http://science.energy.gov/ber/research/cesd/