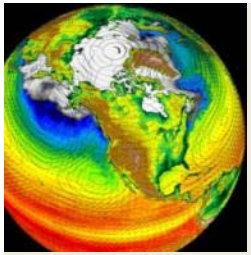
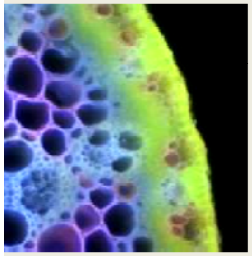
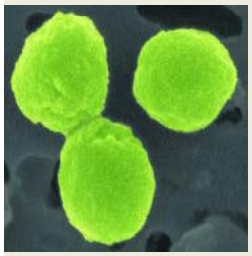


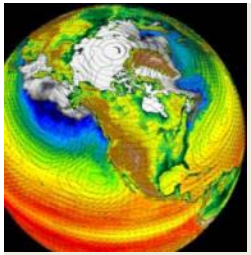




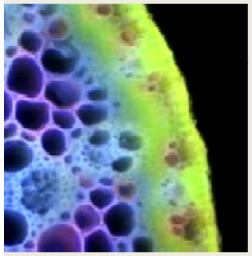
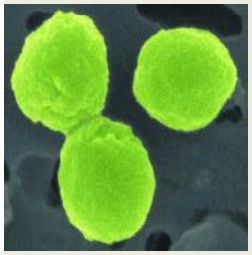
Climate and Environmental Sciences Division

BERAC update

March 3-4, 2014

G. Geernaert
BER/CESD

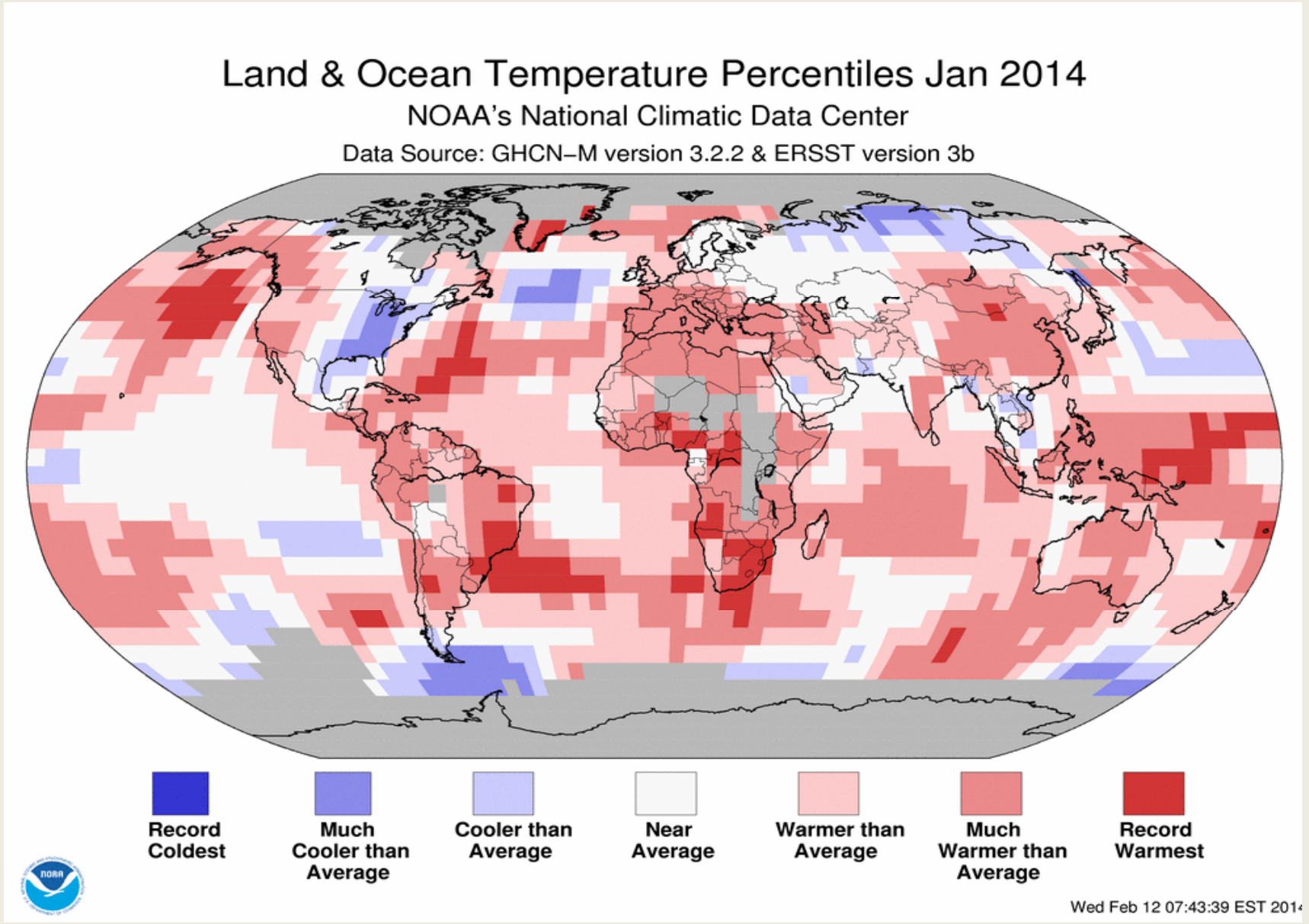


Outline

- Administrative
- Science and Facility Highlight
  - Climate model spin-up (1)
  - Modeling the hiatus (2)
  - Clouds dynamics, fluxes, aerosols (3)
  - ARM update

- Vision for data and informatics – initial thinking



- Warmest southern hemisphere on record
- 4th warmest January northern hemisphere

Management Update: Recent and projected FOA's

Funds	Program lead	Participating programs	Issued	Preapps	Proposals	Selected
FY14	ASR	ASR	Mar 13, 2013	123/146	111	Panel July 15 wk
FY14	TES (via NASA ROSES)	NASA, NOAA, USDA, NSF	Feb 13, 2013	391	235	7-9 (est)
FY14	ASR	BER (RGCM, TES); FAPEAM, FAPESP	May 13, 2013	--	30	6
FY14	ESM	ESM, RGCM	Nov 20, 2013	193	168	Panel Apr 21-23: 10-15 (est)
FY15	TES	TES	*May 2014*	yes		
FY15	ASR	ASR	*May 2013*	yes		
FY15	SBR	SBR	*May 2013*	yes		

Management updates: recent reviews (SFA decisions conveyed)

Lab	Program	Type	Date	Outcome
LBNL	SBR SFA	Renewal	April 2013	Approved
ANL	TES SFA	New	April 2013	Approved
BNL	ASR SFA	Renewal	Sept 9-10	Approved
LBNL	RGCM SFA	Renewal	Sept 11-12	Approved

Management updates: upcoming FY14 reviews

Lab	Program	Type	Date in FY14	Notification
LLNL, multi-lab	ESM SFA	New	March 4-6	Aug 1, 2013
LBNL	ASR SFA	Renewal	April 8-9	Oct 2, 2013
LBNL	TES SFA	Renewal	April 8-9	Jan 18, 2013
PNNL, multi-lab	ARM facility	Review	April 14-17	Oct 30, 2013
SLAC	SBR SFA	Renewal	May 5	Oct 3, 2013
PNNL	SBR SFA	Renewal	May 8	Oct 3, 2013
ORNL, multi-lab	RGCM SFA	New	May 16	Oct 11, 2013

Management updates: FY14 - PI meetings, workshops

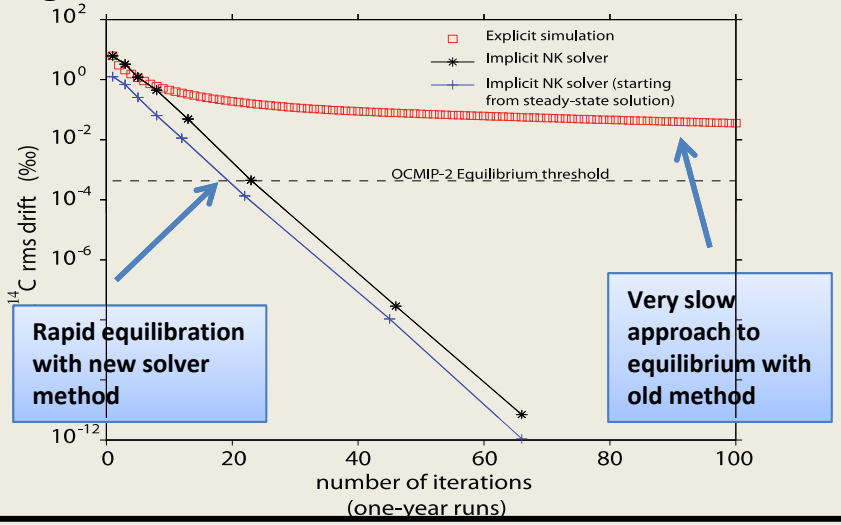
Title	Program(s)	Location	Date in FY14
ASR PI meeting	ASR	Bolger	March 10-12
Mechanistic modeling of Terrestrial environments	SBR, TES, ESM	DOE/GTN	March 26-27
Obs4MIP CMIP6 workshop	RGCM, IA	NASA HQ	Apr 29 – May 1
Ameriflux PI meeting	TES	Bolger	May 4-5
ESS PI meeting	TES, SBR	Bolger	May 6-7
TES Data Needs Workshop	TES	Bolger	May 8
Modeling PI meeting	ESM, RGCM, IA	Bolger	May 12-15
ARM LES workshop	ARM, ASR	Rockville	May 19-20
Molecular Sciences Workshop	BER-wide	DOE/GTN	May 27-29
Population dynamics workshop	IA / USGCRP	Rockville	June 23-24
Land Use Land Cover Workshop	IA / USGCRP	Rockville	June 25-27

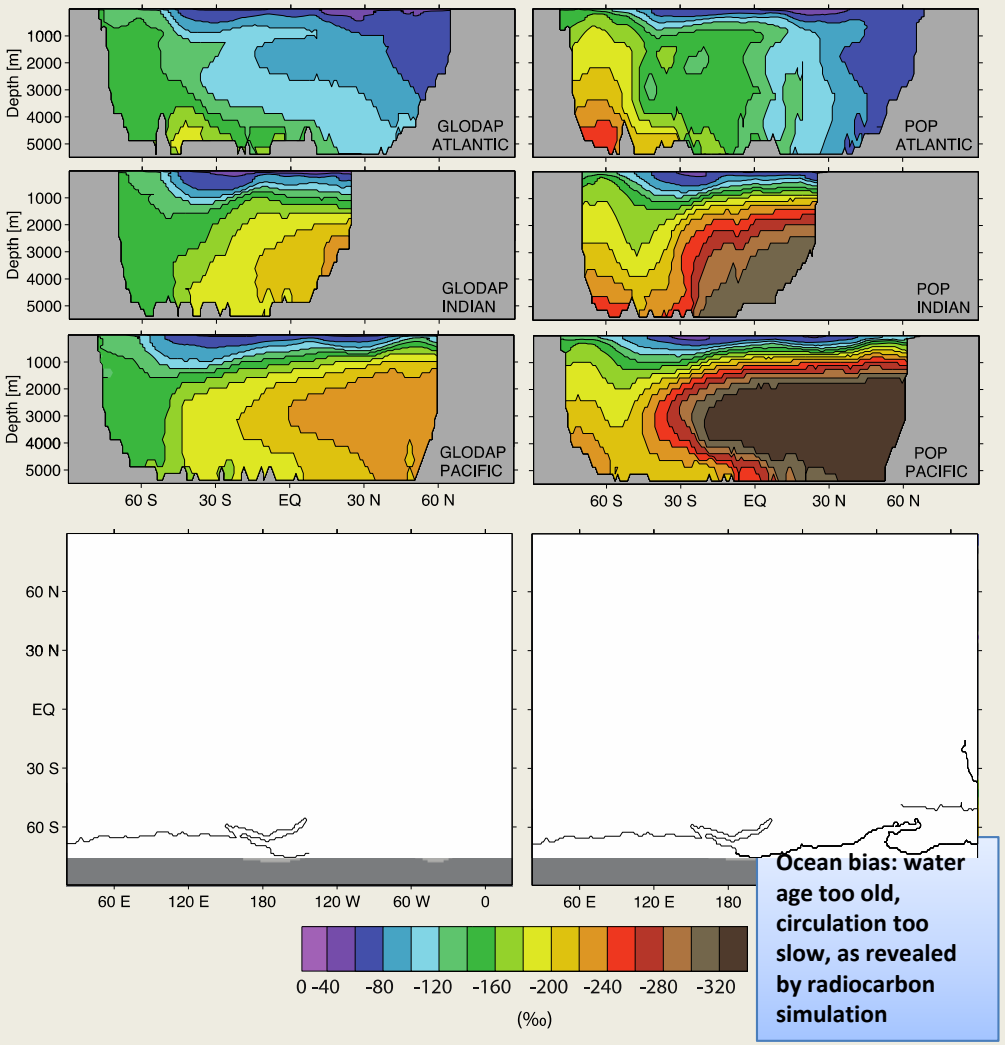
New method to speed ocean model spin-up and enable deep-ocean age testing

Challenge: For high-resolution ocean modeling experiments, equilibration takes too long to achieve.

Approach: Based on a DOE-University-SciDAC project, developed an advanced Newton-Krylov solver method that allows rapid equilibration.

Impact: Simulation test for natural radiocarbon in the Community Earth System Model. Equlibrated two orders of magnitude faster.





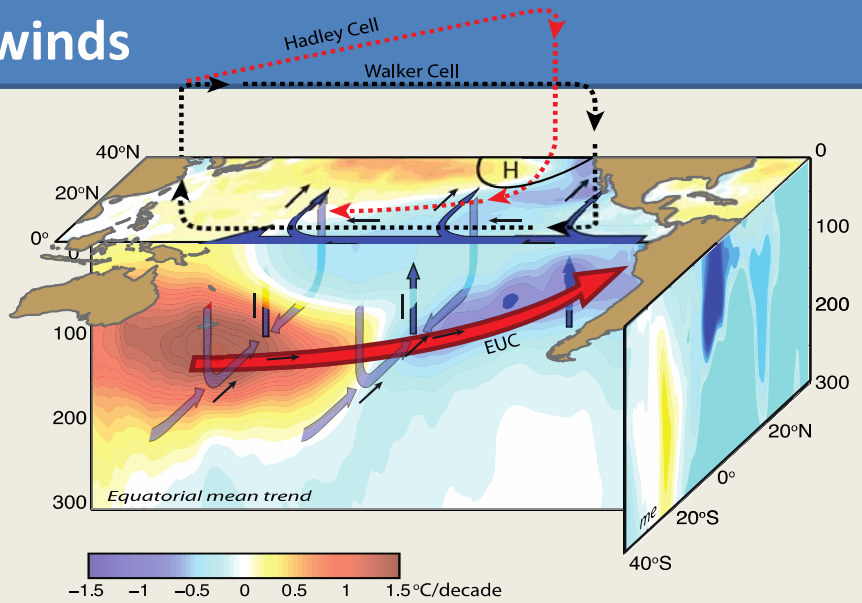
Comparison of the simulated (POP) and observationally based (GLODAP) estimate of the prebomb radiocarbon component in the ocean reveals clear biases in the deep North Pacific Ocean.

Bardin, Ann; Primeau, François; Lindsay, Keith, An offline implicit solver for simulating prebomb radiocarbon, *Ocean Modelling* vol. 73 January, 2014. p. 45-58

Slowdown of global warming in the early-2000s due to stronger Pacific trade winds

Objective

The cause of the slow-down of global warming in the early-2000s has been attributed mainly to the negative phase of the Interdecadal Pacific Oscillation (IPO), but the details of the mechanisms that mix heat into the subsurface ocean need to be explored further.



Approach

- Run an ocean model with observed Pacific trade winds that have strengthened about 30% over the past two decades in the negative phase of the IPO.
- Analyze the processes that produce cooler tropical Pacific sea surface temperatures and mix heat into the subsurface ocean.

The negative phase of the IPO (cooler tropical Pacific ocean temperatures) has stronger trade winds that drive upwelling of cool water in the equatorial Pacific, and mix heat deeper in the Pacific subtropics and western Pacific to produce the hiatus

Impact

The wind-induced cooling in the ocean model can account for approximately 50% of the observed early-2000s hiatus of global warming when comparing the observed and model temperature projections out to 2012. When the trade winds relax with a transition of the IPO from negative to positive, a rapid global warming could occur such as was observed in the mid-1970s climate shift.

England, M.H., S. McGregor, P. Spence, **G.A. Meehl**, A. Timmermann, W. Cai, A. Sen Gupta, and M.J. McPhaden, 2014: Slowdown of surface greenhouse warming due to recent Pacific trade wind acceleration, *Nature Climate Change*, DOI: 10.1038/NCLIMATE2106.

Volcanic contribution to decadal changes in tropospheric temperature

Objective

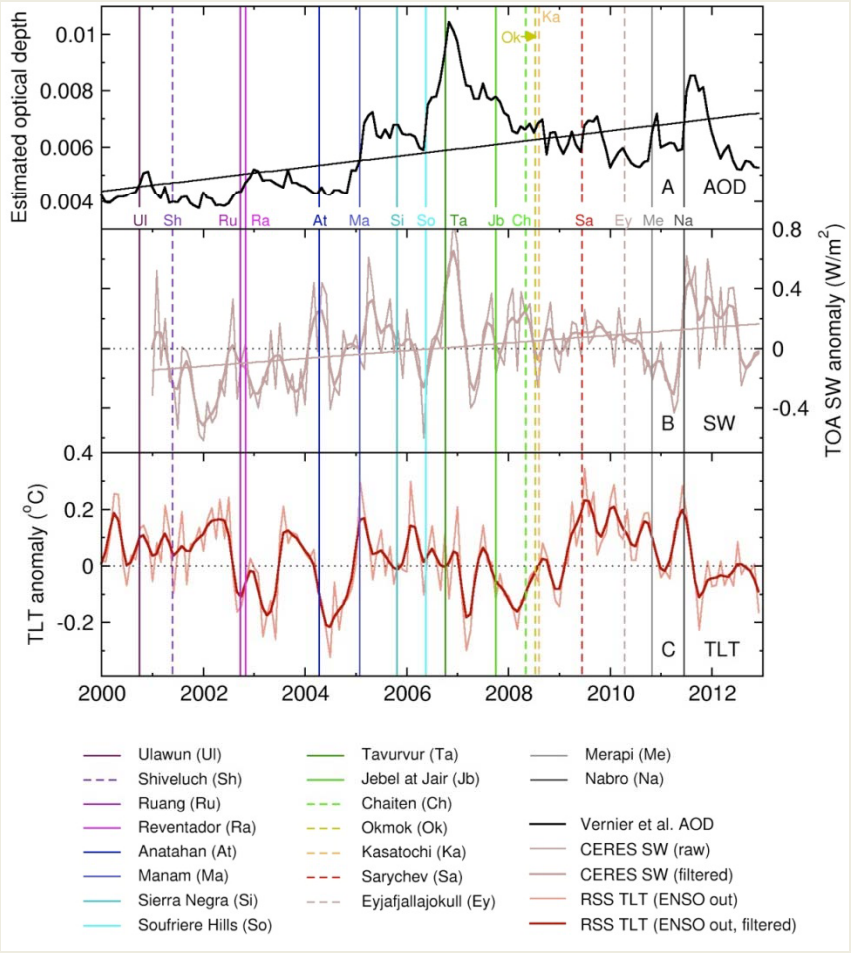
- Improve scientific understanding of the volcanic contribution to the post-1998 "warming hiatus"

Research

- To determine whether signals of early 21st century volcanic activity are identifiable in satellite observations
- To understand the causes of differences between modeled and observed tropospheric warming trends

Impact

- Early 21st century volcanic activity had a cooling influence on surface and tropospheric temperature
- This cooling influence is statistically identifiable in satellite observations of correlations between stratospheric aerosol optical depth (SAOD) and tropospheric temperature (and between SAOD and SW fluxes at the top of atmosphere)
- Omitting the cooling effect of early 21st century volcanic activity from CMIP-5 simulations of historical climate change contributes to a model-average warm bias in tropospheric temperature trends
- Results do not support claims of a factor of three error in model climate sensitivity estimates



Changes in observed stratospheric aerosol optical depth (SAOD; panel A), net-clear sky short-wave fluxes at the top of the atmosphere (panel B), and lower tropospheric temperature (after statistical removal of ENSO effects; panel C). Vertical lines denote the start dates of early 21st century volcanic eruptions. For further details, refer to Fig. 2 in Santer *et al.* (2014)

Reference: B. D. Santer , **C. Bonfils**, **J.F. Painter**, **C. Bonfils**, **M.D. Zelinka**, C.A. Mears, S. Solomon, G.A. Schmidt, J.C. Fyfe, J.N.S. Cole, L. Nazarenko, **K.E. Taylor**, and F.J. Wentz (2014): Volcanic contribution to decadal changes in tropospheric temperature. *Nature Geoscience*, doi: 10.1038/ngeo2098.

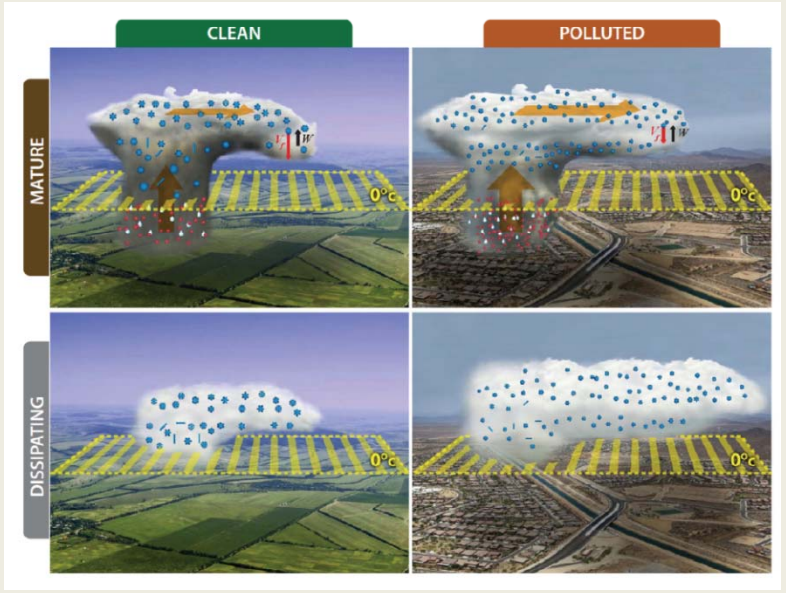
A New Mechanism Explaining Aerosol-Deep Convective Cloud Interactions

Objective

Examine mechanisms for explaining observed ubiquitous invigoration of convection by aerosols in deep convective clouds

Approach

- Conduct cloud resolving model simulations with spectral-bin cloud microphysics at a long-time period over a large domain
- Examine typical summer convection over tropics and mid-latitudes at multiple locations
- Analyze observations from Atmospheric Radiation Measurement (ARM) Climate Research Facility long-term surface measurements



Schematic illustration of the differences in cloud top height, cloud fractions and thickness for the storms in clean and polluted environments.

Impact

- The microphysical effect induced by aerosols is a fundamental reason for the observed increases in cloud fraction, cloud top height, and cloud thickness in the polluted environment, even when thermodynamical invigoration is absent.
- Improve understanding of important mechanisms for aerosol impacts on storms and help parameterize aerosol impacts on convection clouds in climate models to reduce uncertainties in weather and climate predictions.

Fan J, LR Leung, D Rosenfeld, Q Chen, Z Li, J Zhang, and H Yan. 2013. "Microphysical Effects Determine Macrophysical Response for Aerosol Impacts on Deep Convective Clouds." *Proceedings of the National Academy of Sciences*, *early online ahead of print, Nov 11, 2013.* DOI:10.1073/pnas.1316830110

Understanding Water Vapor Transport in Stratocumulus Clouds

Motivation and Objective

- Highly reflective low-level stratocumulus clouds cover vast areas of the Earth
- Small changes in cloud cover or thickness have large impacts on radiation budget
- To predict stratocumulus cloud cover in models, must understand factors controlling turbulent transport of water vapor from ocean surface

Approach

- ASR scientists performed unique analysis combining coincident remote sensing measurements from a multi-agency field campaign to examine turbulence structure of boundary layer
- Identified primary processes controlling water vapor transport on scales smaller than climate model grid cells

Impact

- Transport of water vapor primarily controlled by radiative cooling near tops of the clouds and difference between sea surface and air temperature
- Developed new formulation of convective velocity scale that accounts for both these factors and is able to predict most of the upward transport of water vapor from the ocean surface to the clouds
- Unlike previous methods, new convective velocity scale is applicable to both coupled and decoupled boundary layers and thus could be used to improve climate model parameterizations of stratocumulus cloud formation and evolution

Reference: Ghate, Virendra P., Bruce A. Albrecht, Mark A. Miller, Alan Brewer, Christopher W. Fairall, 2014: Turbulence and Radiation in Stratocumulus-Topped Marine Boundary Layers: A Case Study from VOCALS-REx. J. Appl. Meteor. Climatol., 53, 117–135. doi: http://dx.doi.org/10.1175/JAMC-D-12-0225.1.

Measuring Properties of Biomass Burning Aerosol

Motivation

- Biomass burning (e.g., wildfires or agricultural fires) is a large source of carbonaceous aerosols.
- Impact of biomass burning on Earth's radiative balance is uncertain as aerosol particles formed in different fire conditions have different optical properties.

Approach

- ASR scientists performed laboratory combustion studies with different fuel sources & conditions to examine aerosol optical properties.
- Developed parameterization from lab studies to predict aerosol scattering
- Evaluated parameterization with field data from two wildfires.

Impact

- Single scattering of biomass burning aerosol spans a large range and shows strong spectral dependence.
- 60 percent of scattering variation can be explained and captured by the fire-integrated modified combustion efficiency (MCEFI).
- Since MCEFI has been measured extensively for most vegetation classes and types of biomass burning, new parameterization could be used to predict the optical properties of fresh smoke for most fire types.

Reference: Liu S, AC Aiken, C Arata, M Dubey, CE Stockwell, RJ Yokelson, EA Stone, T Jayarathne, AL Robinson, and PJ DeMott. 2014. "Aerosol single scattering albedo dependence on biomass combustion efficiency: Laboratory and field studies." *Geophysical Research Letters*, , 10.1002/2013GL058392, Accepted.

ARM Creates Two Supersites

- ***Southern Great Plains****—measurements at the SGP site in Oklahoma will be augmented to include additional scanning and profiling remote sensors and more detailed measurements of the land-atmosphere interface.*
  - TWP instruments will be moved to SGP to create supersite.
  - Configuration of instruments will support LES modeling.
- ***North Slope of Alaska****—aerial operations will link measurements from Barrow and Oliktok, and unmanned aerial systems will provide additional spatial information around Oliktok.*
  - Piloted flights between Barrow and Oliktok will begin summer of 2015
  - UAS flights are being conducted at Oliktok to complement ground-based measurements

GOAMAZON 2014 - 2015 Begins

- GOAmazon is designed to enable the study of how aerosols, along with changes to heat and energy at the surface, influence cloud cycles under clean conditions, as well as how aerosol and cloud life cycles are influenced by pollutant outflow from a tropical megacity.
- Modeling and observations are coupled to advance scientific understanding of how land-atmosphere processes affect tropical hydrology and climate, and improve the representation of these coupled processes in climate models.
- Began January 1; opening ceremony Feb. 18.

Hyytiälä, Finland Experiment Begins

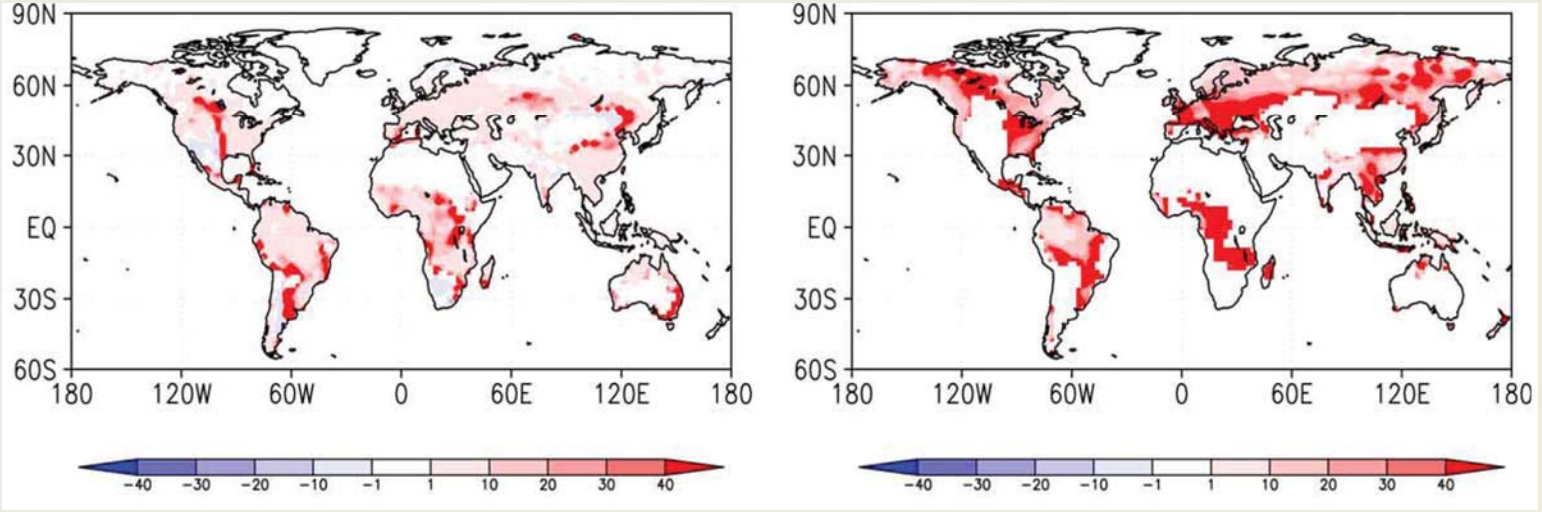
- Second ARM Mobile Facility (AMF2) deployed in a Scots pine forest in southern Finland from February through September 2014 to obtain surface-based measurements of biogenic aerosols and gases.
- Experiment will measure biogenic aerosols emitted from forests in order to determine their effects on clouds, precipitation, and climate
- These measurements will be augmented by Finnish aircraft observations of aerosol microphysics, as well as measurements from the University of Helsinki's Station for Measuring Ecosystem-Atmosphere Relations (SMEAR-II).

Nitrogen Limitation and Hydrological Processes in CLM4-CN

Objective: Improve the terrestrial component of IGSM by bringing estimations of gross primary productivity, a measure of plant growth in CLM4-CN, closer to historical observations and simulating impacts on hydrology. Model estimates for GPP were previously higher than historical observations.

Approach: Add the capacity to consider how nitrogen limitation affects plant growth within CLM4-CN. This allows researchers to examine the relationship between increased atmospheric CO_2 (which speeds growth), nitrogen in the ecosystem (which can limit growth), and how these factors impact the water supply through runoff and evapotranspiration.

Impact: When nitrogen limitation is considered, simulations show growth still increases as CO_2 increases, but the global mean increase in growth is 18.3% less than when nitrogen limitation is not considered. This means that more water enters ecosystems as runoff than previously thought.



Comparisons of surface runoff (left) and subsurface runoff (right) between unaltered CLM-CN and CLM-CN updated to include effects of nitrogen limitation. Maps show percent change.

Lee, Eungul, Benjamin S. Felzer , and Zavareh Kothavala, Effects of nitrogen limitation on hydrological processes in CLM CN, Journal of Advances in Modeling Earth Ecosystems, IN PRESS , online first, doi: 10.1002/jame.20046

Mycorrhizal-Mediated Competition Between Plants and Decomposers Drives Soil Carbon Storage

Background and Objective

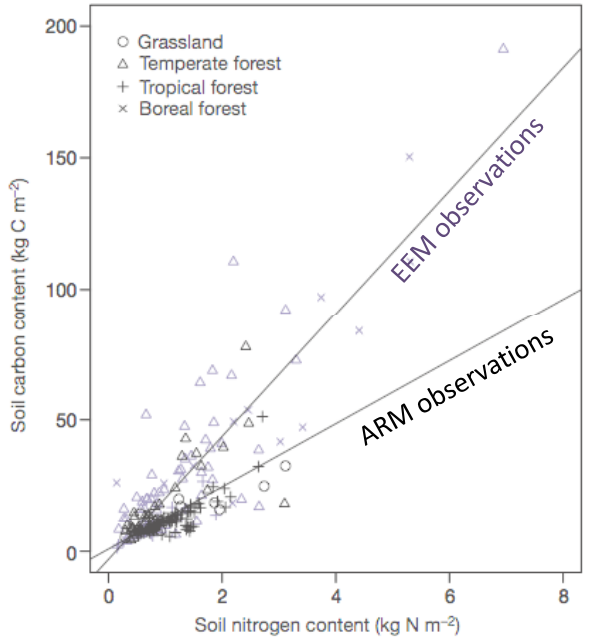
- Soil contains more C than biomass and atmosphere combined
- Nearly all plant species associate with symbiotic mycorrhizal fungi to acquire nutrients from soil
- Ecto- & ericoid mycorrhizal [EEM] fungi produce N-degrading enzymes. Arbuscular mycorrhizal [ARM] fungi do not

Results

- Ecosystems dominated by EEM fungi store >70% more C in soil than ARM dominated ecosystems; successful competition for N by EEM explains pattern
- The effect holds across latitudes, from tropics to the boreal zones
- Traditional controls – temperature and precipitation– of secondary import

Conclusions

- Biotic factors more than climate variables correlate with spatial variations in soil C content across the globe
- Global models do not include microbes or microbial functional groups in analysis of terrestrial feedbacks to climate
- Substantial model revision is required for accurate projections of terrestrial feedbacks to future atmospheric [CO_2] with climate change.



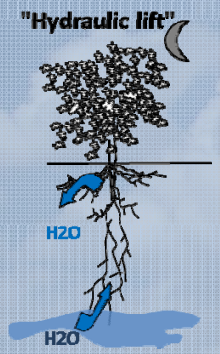
Averill, C., B.L. Turner and A.C. Finzi. 2014. Mycorrhiza-mediated competition between plants and decomposers drives soil

"Hydraulic lift" of water by deep-rooted plants enhances surface soil nutrient availability

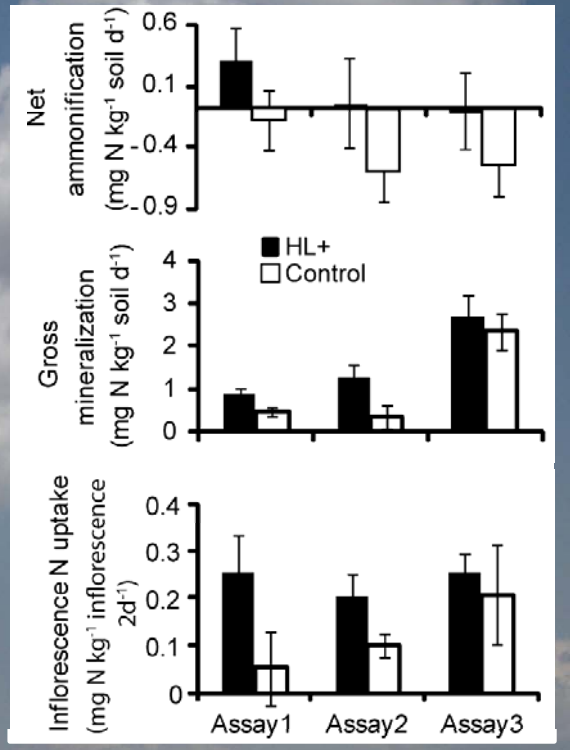
During drought, in seasonally dry ecosystems world-wide, water flows through plant root systems from deep, moist to dry surface soil.

<u>Hypothesis:</u> This "hydraulic lift" enhances nutrient availability to plants by hydrating soils and the soil microbes responsible for nutrient cycling.

<u>Results:</u> In northern Utah's sagebrush-steppe, a new, gas-based, stable isotopic labeling technique revealed:



- sagebrush carrying out hydraulic lift spurred enhanced microbial activity and nutrient cycling in surrounding surface soil (compared to control plants lifting less water)
- sagebrush carrying out hydraulic lift ~doubled their uptake of nitrogen from surface soil (compared to control plants), exactly when they were flowering and setting seed.



<u>Implications:</u> Models from ecosystem to global scales have only begun to include effects of hydraulic lift on water and surface energy fluxes. These field results indicate that plants carrying out HL can also substantially enhance decomposition and nitrogen cycling.

Cardon ZG, Stark JM, Herron PM, Rasmussen JA. (2013) Sagebrush carrying out hydraulic lift enhances surface soil nitrogen cycling and nitrogen uptake into inflorescences. *PNAS* 110(47):18988-18993. DOI: 10.1073/pnas.1311314110

Subsurface Sediment at RIFLE Site Yields Novel Organism

The Science:

Through metagenomics, researchers reconstructed a dominant organism and member of a new phylum-level lineage from an aquifer sediment in Colorado.

Approach:

A LBNL/UCB team led by DOE JGI collaborator Jillian Banfield sequenced samples from 2 microbial communities in a contaminated aquifer at the Rifle IFRC site in Colorado.

Key Results:

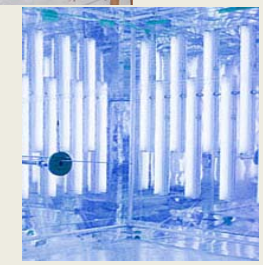
- Discovered that the subsurface microbial communities consisted of many bacteria and archaea from classes and orders that had not been previously recognized or sampled.
- Researchers were able to completely reconstruct the genome of a dominant organism called RBG-1 in a microbial community, one previously unknown and which turned out to be a member of a new phylum.
- Analysis of the complete microbial genome led to a detailed metabolic model with evidence for multiple new enzymes and pathways.

Castelle CJ et al. Extraordinary phylogenetic diversity and metabolic versatility in aquifer sediment. Nat Commun. 2013 Aug 27. doi: doi:10.1038/ncomms3120

On-going and Upcoming Activities at EMSL

Science

- Aerosol Mass Spec (AMS) deployed on GOAmazon campaign.
- Scientists from PNNL and University of Nevada – Reno found brown carbon SOA forms when alpha-pinene is oxidized by nitrate radicals but does not form brown SOA under more typical atmospheric conditions.
- "Cascade" supercomputer available; ranked #13 among world's fastest.



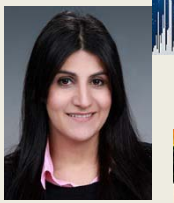
PNNL Aerosol Test Chamber

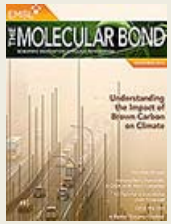
Proposal Opportunities

- 2014 Science Theme call – due March 3, 2014.
- 2014 EMSL-JGI collaboration due April 7, 2014.

Outreach and User Activities

- EMSL to host annual NUFO Meeting – April 30 – May 2, 2014.
- User Meeting on Atmospheric Organics – May 6-7, 2014.
- New User Executive Committee (UEC) members align with BER interests.
- TES-funded postdoc selected – Malak Tfaily from FSU.
- December issue of *Molecular Bond* focuses on impact of brown carbon on climate.
- Virtual Tour: http://www.emsl.pnl.gov/capabilities/virtual_tour.jsp
  You Tube Videos: http://www.youtube.com/user/EMSLatPNNL



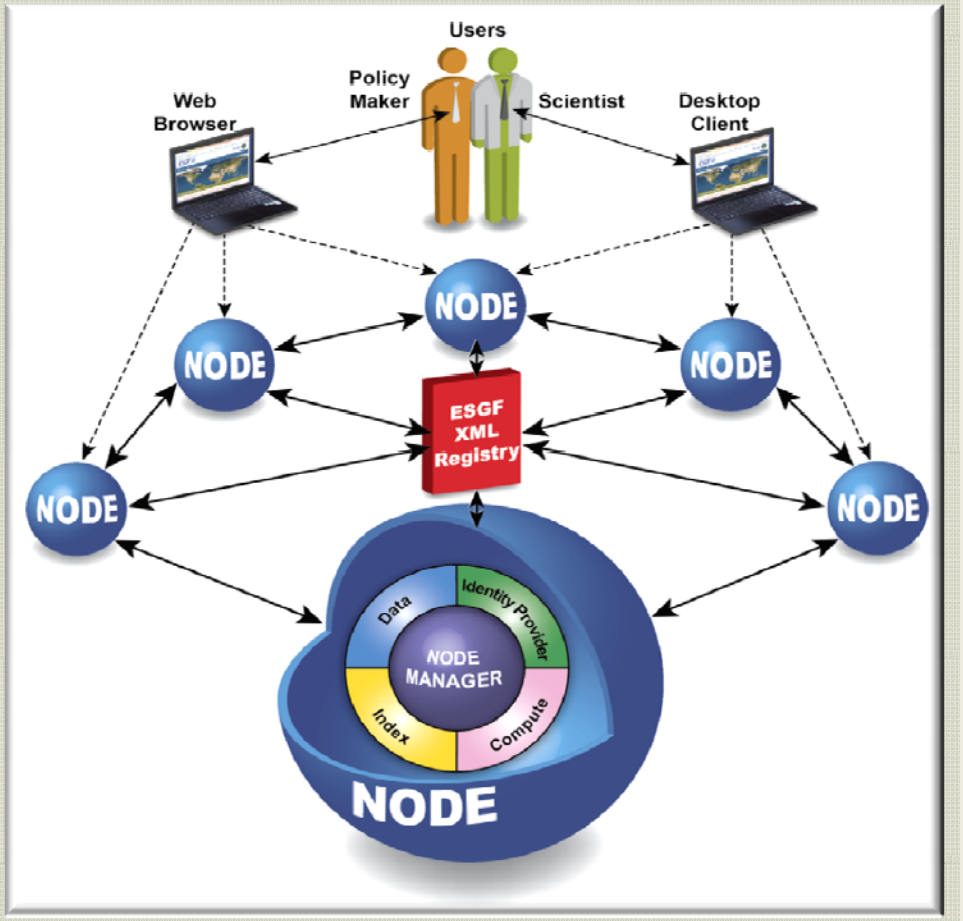


Song *et a*l., 2013. "Light Absorption by Secondary Organic Aerosol from alpha-Pinene: Effects of Oxidants, Seed Aerosol Acidity, and Relative Humidity." *J Geophys Res* 118: 1-9. DOI: 10.1002/jgrd.50767.

Preview - Data and Informatics

An initial co-located and distributed data grid archival and retrieval system

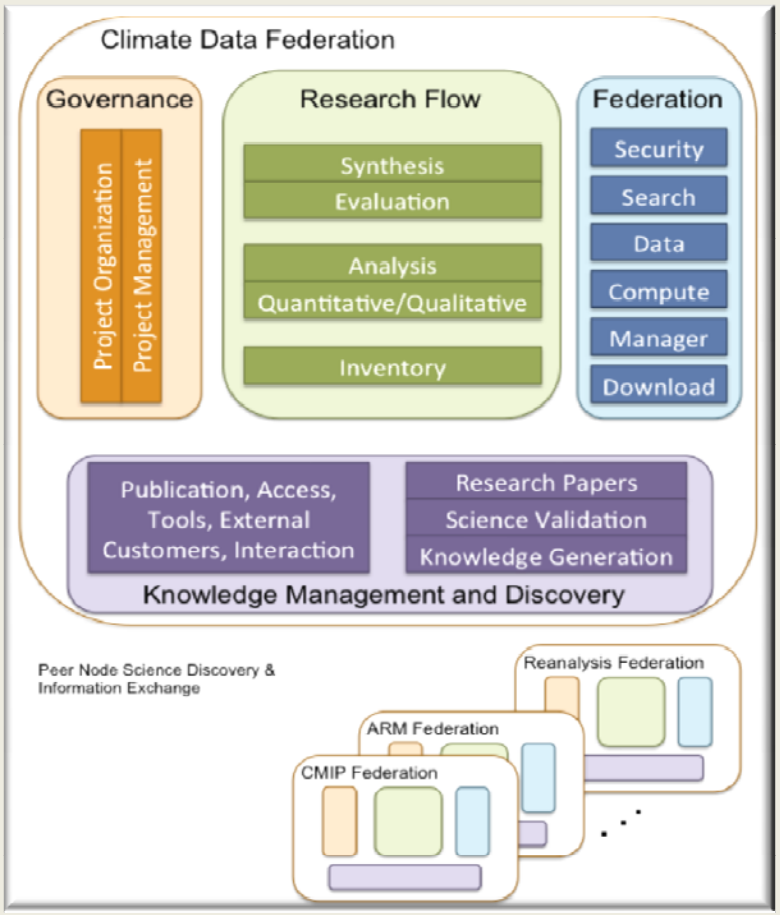
- Distributed and federated architecture
- Support discipline specific sites
- Support browser-based and direct client access
- Single Sign-on
- Automated publication tools as well as
  - ontologies that allow multi-discipline cross talk
- Full support for data aggregations
  - A collection of files, usually ordered by simulation time, that can be treated as a single file for purposes of data access, computation, and visualization
- User notification service
  - Users can choose to be notified when a data set has been modified

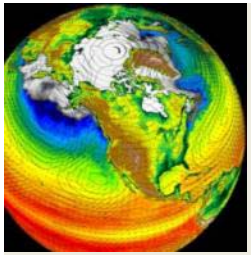


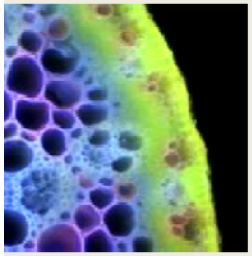
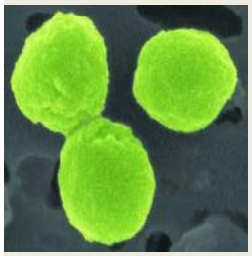
A BER Virtual Laboratory

The data grid will become part of large robust work environment

- An environment where data access and computations are coupled.
- It represent the merging of observational, modeled and experimental data
- Offers a spectrum of compute platforms that can be tailored to specific needs
- Data fusion, discovery and intelligent search capabilities
- Data mining and knowledge generation
- Comprehensive visualization and analytic engines
- Modular and scalable in design





Thank you!

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