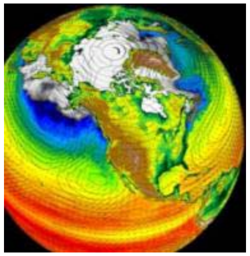
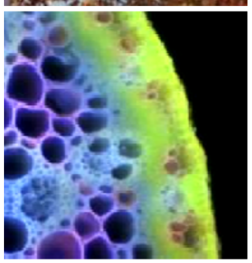




Climate and Environmental Sciences Division

G. L. Geernaert

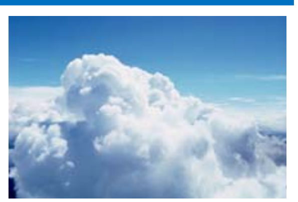
Outline

- From the last BERAC
- Strategic planning
- Outreach activities
- Management updates
- Science highlights
- The next 6-12 months

Climate and Environmental Sciences Division
(Gary Geernaert)
(Karen Carlson-Brown; Leslie Runion, Patrick Horan; Nver Mekerdijian)

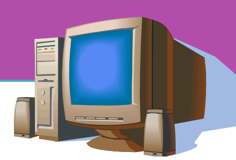
Atmospheric Science

- Atmospheric System Research (Ashley Williamson)
- Atmospheric Radiation Measurement (ARM) Climate Research Facility (Wanda Ferrell; Rick Petty)



Climate and Earth System Modeling

- Regional & Global Climate Modeling (Renu Joseph)
- Earth System Modeling (Dorothy Koch)
- Integrated Assessment (Bob Vallario)



Environmental System Science

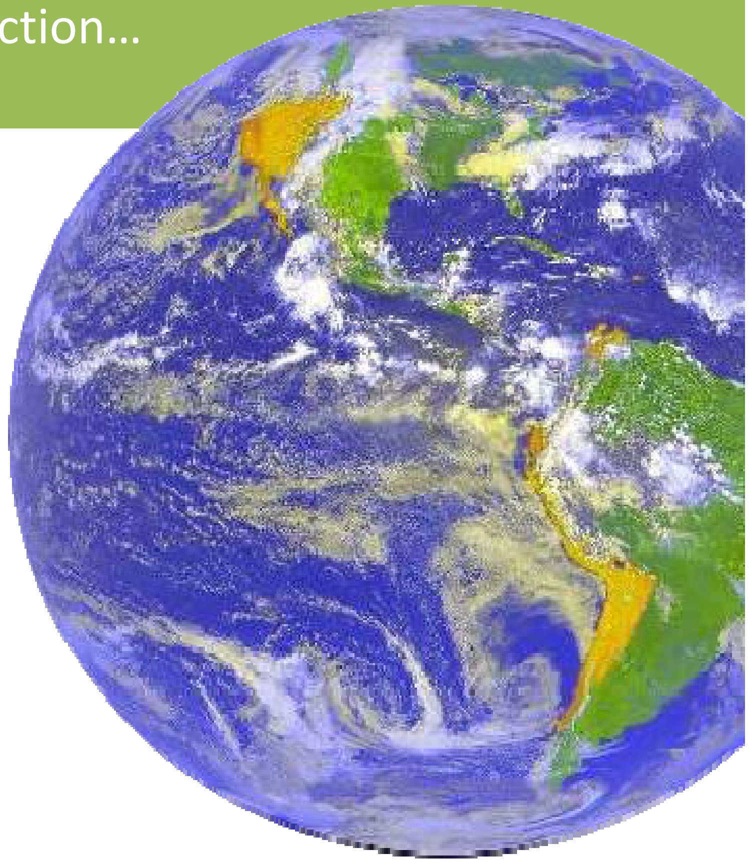
- Terrestrial Ecosystem Science (Mike Kuperburg, Dan Stover)
- Subsurface Biogeochemical Research (Todd Anderson, David Lesmes)
- Environmental Molecular Sciences Laboratory (Paul Bayer)

From last BERAC
October 2011

- Focus mission on “system predictability”
- Further strategic planning with goals, objectives
- Serious player in USGCRP
- Linkages to DOE applied offices
- Visibility in scientific conferences
- Visionary science, uniqueness, value

Strategic Planning
The Energy-Environment-Climate Nexus

Greenhouse gases are emitted during energy production…
and climate change will impact energy production



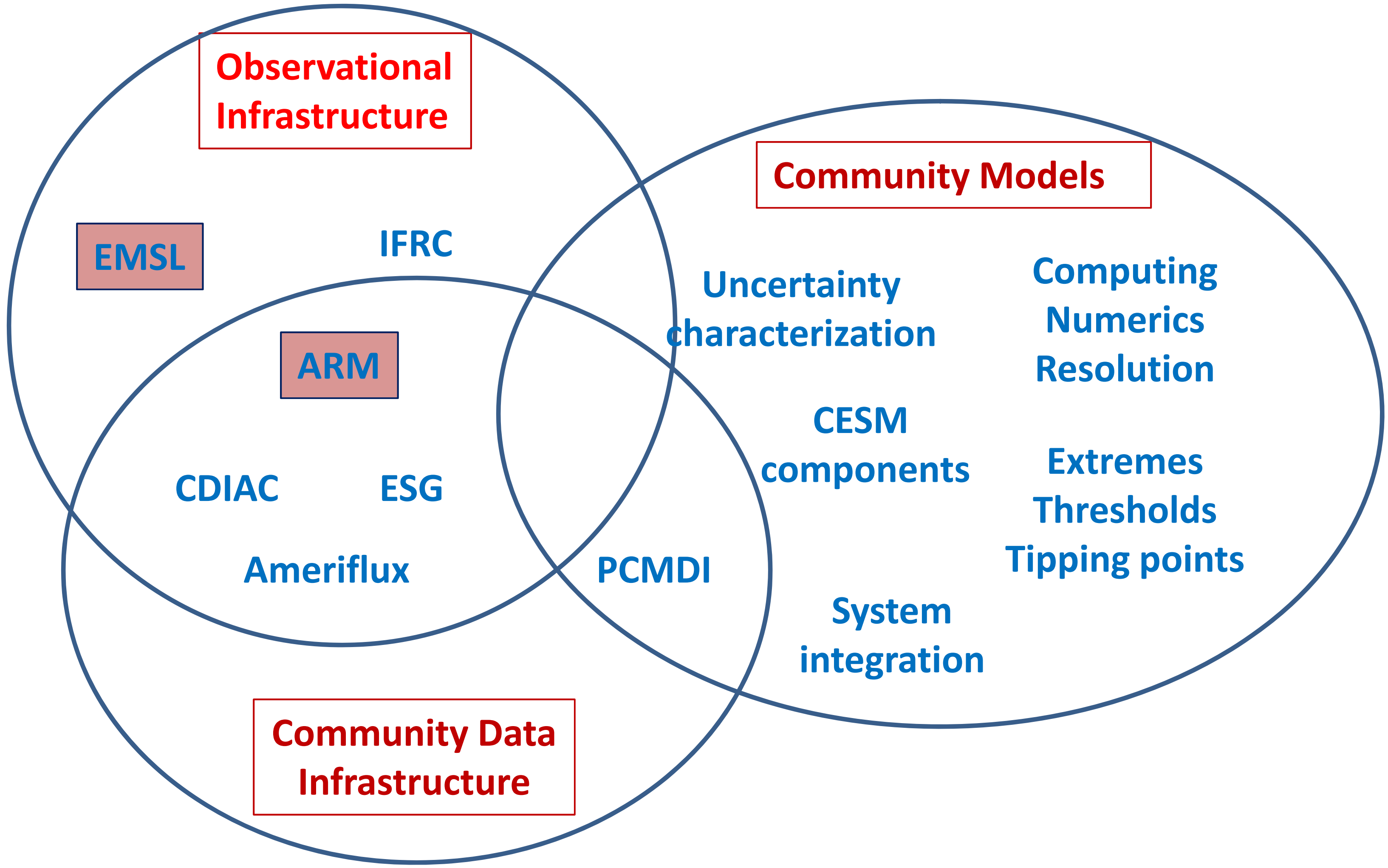
Building on our CESD mission:

To advance a robust predictive understanding of Earth's climate and environmental systems and to inform the development of sustainable solution to the Nation's energy and environmental challenges.

Climate & Environmental Sciences Division Strategic Goals

1. Synthesize new process knowledge and innovative computational methods advancing next generation, integrated models of the human-earth system.
2. Develop, test and simulate process-level understanding of atmospheric systems and of terrestrial ecosystems extending from bedrock to the top of the vegetative canopy.
3. Advance fundamental understanding of coupled biogeochemical processes in complex subsurface environments to enable systems-level prediction and control.
4. Enhance the unique capabilities and impacts of the ARM and EMSL scientific user facilities and other BER community resources to advance the frontiers of climate and environmental science.
5. Identify and address science gaps that limit translation of CESD fundamental science into solutions for DOE's most pressing energy and environmental challenges.

Platforms for science integration



NGEE Concept
(Next Generation Ecosystem "Experiment")

- Target systems that are:
  - Globally important
  - Climatically sensitive
  - Relatively unstudied

- Carefully couple modeling and field/laboratory research / planning

- Representation of scale/resolution of a high resolution Earth System Model (ESM) grid cell (i.e., a maximum 30x30 km grid size)

- NGEE Arctic Phase I proposal accepted with revisions for FY 12
- NGEE Tropics starts in FY13, workshop planning under development

Management updates

- Federal collaborations: participant, discussions
  - DOE: EERE, FE, PI
  - USGCRP; NEO; IARPC
  - CCIWG
  - NSF, NOAA, Navy, DHS, USGS, USDA, USACE
- Town Halls at scientific societies
  - Completed
    - Ecological Society of America (ESA): 1 TH: TES programs
    - American Geophysical Union (AGU): 2 TH's: climate diagnostics, GOAMAZON
    - American Meteorological Society (AMS): 1 TH: climate modeling
  - Planned
    - Ecological Society of America: TES programs
    - AMS and AGU: ARM/modeling; NGEE; CLM; IA
    - In the pipeline: Strategy for seamless community earth system prediction

Programmatic Activities

***Reviews completed*:**

- EMSL Review of User Program: last stages
- LANL SFA (July 2011): last stages

***Upcoming reviews this FY*:**

• ANL SFA SBR	May 3, 2012
• ORNL SFA SBR	May 29-31, 2012
• ORNL SFA TES	April 25, 2012
• NCAR cooperative agreement	June 22, 2012
• PNNL SFA ASR/model	August 2012
• LLNL SFA modeling	Aug/Sept 2012
• LLNL subsurface	Aug/Sept 2012

Programmatic activities

Upcoming PI meetings

- ASR: March 12-16, 2012
- TES: April 23-25, 2012
- Subsurface: April 30- May 3, 2012
- Modeling: Winter/spring 2013

Upcoming workshops

- Root modeling workshop: March 7-9
- TES Experiment-model fusion workshop: March 19-21
- Water cycle (in the pipeline)
- NGEE tropics (in the pipeline)

Programmatic activities

Research Opportunities

- ARM: 16 preproposals
- TES: panels met Jan 16-20. 141 proposals reviewed
- Early Career:
  - PROPOSALS: Modeling UQ; TES; SBR
- SCIDAC: 6 proposals reviewed
- Ameriflux: 6 white papers received

FOA's to be released

- ASR: aerosol-cloud-ppt
- ASR/RGCM: tropical clouds

Budget: FY11 → FY12 and FY13

Growth

- ARM: establish two new facilities
- Modeling: UQ, diagnostics
- Climate sensitive geographies: Arctic; Amazon

Declines

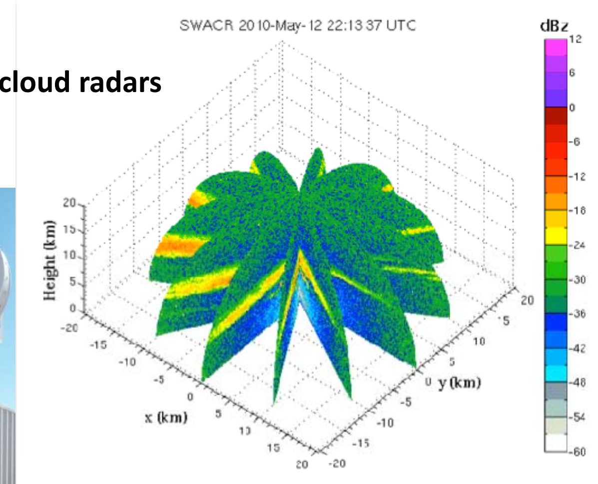
- Subsurface program

ARM Climate Research Facility – Next Generation

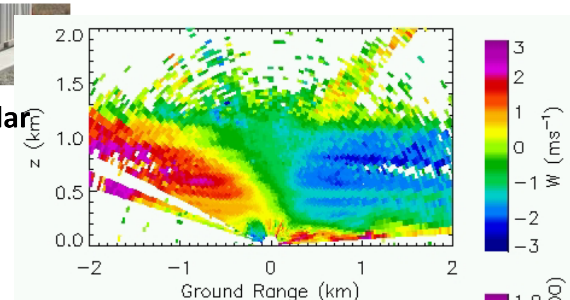
- ARM provides unique, continuous, long-term measurements : the role of clouds and aerosols in climate change
- New instruments: 3-dimensional measurements of cloud, aerosol and precipitation to improve climate models.

- **In FY 2013, ARM opens new sites:**
  - **Azores (marine clouds)**
  - **Alaska Arctic coast**

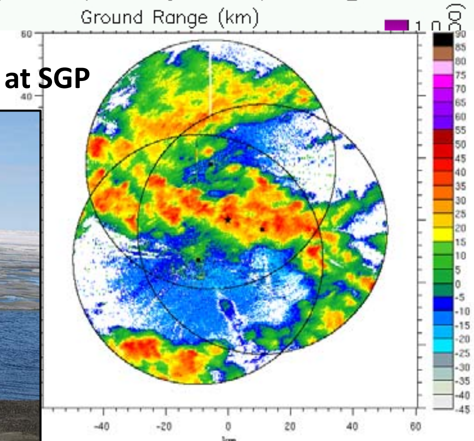
Scanning cloud radars



Doppler Lidar



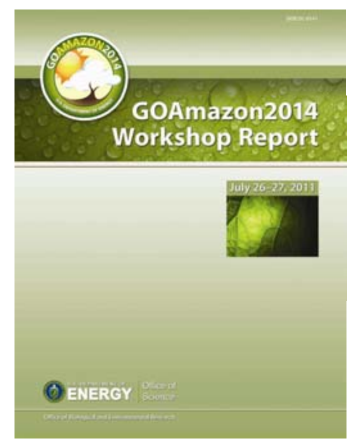
Precipitation Radars at SGP



Oliktok, AK

Tropical Studies

- NGEE Tropics: ecological response to climate stress: 2013 –
- GOAMAZON ARM experiment: 2014
  - impact of biogenic aerosol, rain forest, pollution on clouds
  - Mobile Facility and G1 aircraft to Manaus, Brazil
  - International coordination
- Most CESD programs are collaborating



Science Highlights

- **Sea level rise**
- **Arctic issues**
- **Cloud research**
- **Climate and ecology**
- **Subsurface sciences**

Committed sea-level rise for the next century from Greenland ice sheet dynamics during the past decade

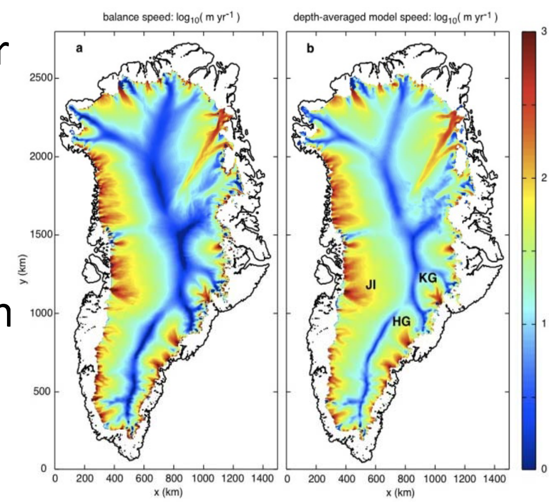
Objective

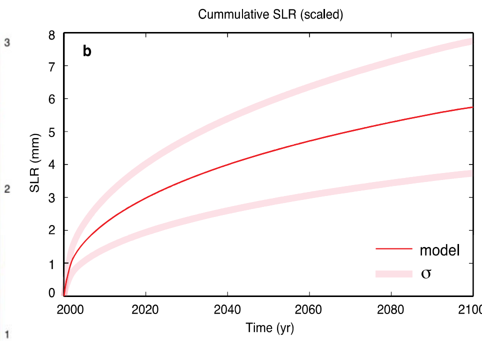
Estimate future mass loss from Greenland ice sheet to the ocean as a result of dynamic perturbations to outlet glacier during the late 1990's and early 2000's

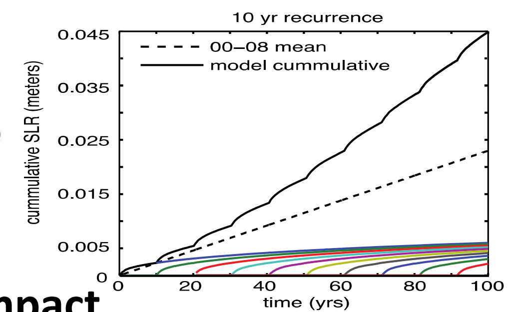
Approach

- Tune ice sheet model (CISM) to present day Greenland assuming approx. steady-state prior to perturbations
- Perturb outlet glacier dynamics based on observations
- Step model forward in time to 2100 and integrate spatial and temporal mass loss to estimate contribution to sea level

Present-day Greenland ice velocity based on obs. and model (left); Estimates of min. and max. sea-level rise by 2100 from Greenland ice dynamics (right).







Impact

One of the first estimates of future sea-level rise from ice dynamics using a large-scale ice sheet model with realistic dynamics and physics (min of ~6 mm and max of ~45mm by 2100)

Price, S.F., A.J. Payne, I.M. Howat, and B.E. Smith. 2011. Committed sea-level rise for the next century from Greenland ice sheet dynamics during the past decade. *PNAS*, doi:10.1073/pnas.1017313108.

Near-surface permafrost and seasonally frozen ground in CCSM4

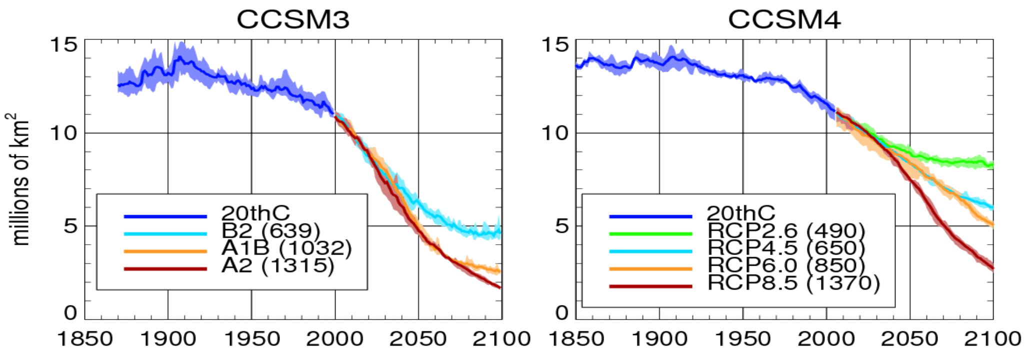
Objective

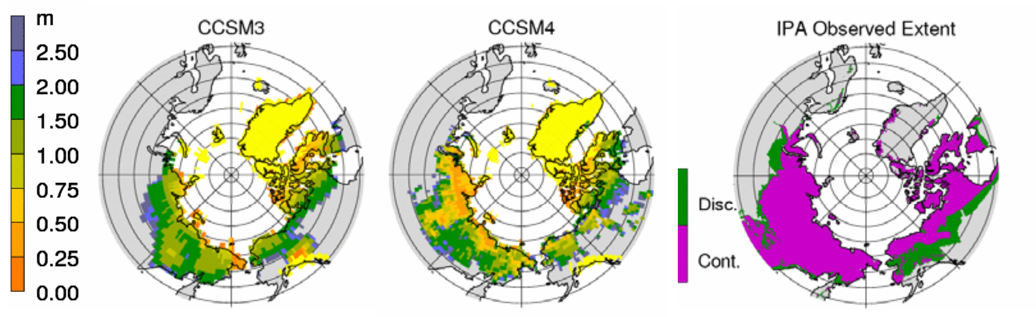
Evaluate the ability of CCSM4 to represent permafrost and seasonally frozen ground and examine projections of change for these cryospheric quantities.

Approach

- Assess CCSM4 permafrost simulation against CCSM3 and offline CLM simulations and compare to available observations of extent, active layer thickness and borehole measurements
- Update projections of near-surface permafrost degradation in CCSM4 and provide first projections of changes in seasonally frozen ground
- Assess impact of climate biases on permafrost and permafrost projections

Projections of near-surface permafrost extent and present-day maps of ALT and extent





Impact

Permafrost is much better simulated in CCSM4, though climate biases, particularly excessive snowfall, degrade the simulation. Sets the stage for studies of permafrost-carbon feedback

Work funded by the Regional and Global Climate Modeling Program:
Lawrence, D.M., A.G. Slater, and S.C. Swenson, 2012: Simulation of Present-day and Future Permafrost and Seasonally Frozen Ground Conditions in CCSM4. ***Accepted to J. Climate CCSM4 Special Collection.***

Global models overestimate tropical convective cloud depth and strength

Motivation

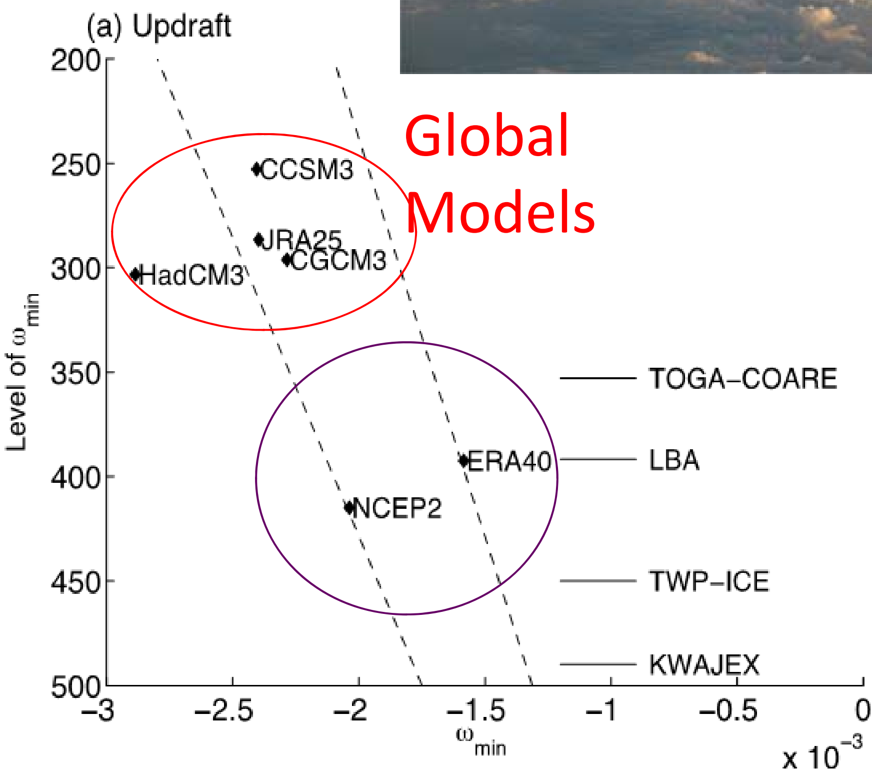
- Tropical convective behavior has profound influence on the general circulation and on global precipitation distribution

Approach

- Tropical clouds from 3 GCMs, 3 global reanalyses and 4 in-situ field measurements were studied.

Result

- Global models have deeper and stronger tropical divergent circulation than soundings and reanalyses. These errors will lead to errors in future projections of water cycle.



Tropical divergence simulated by GCMs (CCSM3, JRA25, CGCM3, HadCM3) is outside the range of uncertainty of the soundings (TOGA-COARE, LBA, TWP-ICE, KWAJEX).

Hagos, S., and L.R. Leung. 2011. "On the Relationship Between Uncertainties in Tropical Divergence and the Hydrological Cycle in Global Models." *Journal of Climate*, DOI:10.1175/JCLI-D-11-00058.1

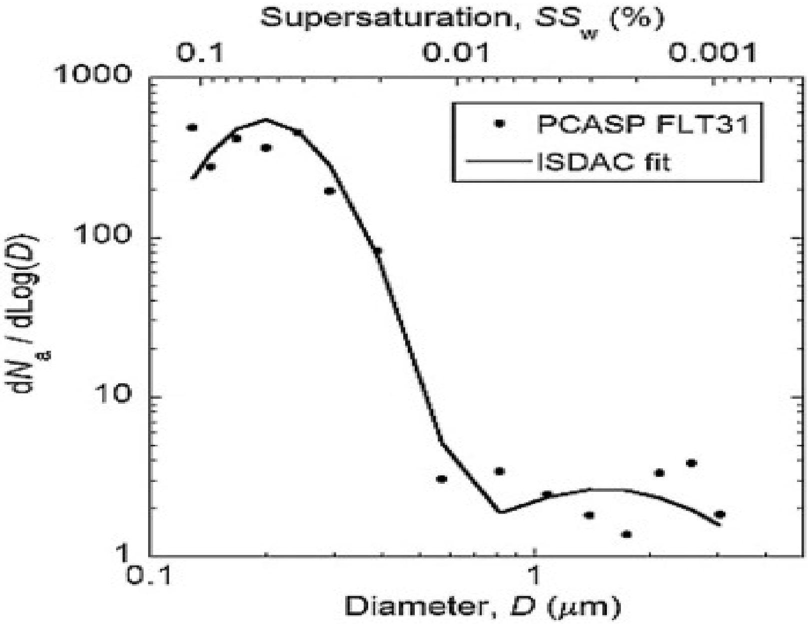
Demise of Arctic Clouds due to Ice Crystals

Goal: Understanding the formation and dissipation of Arctic clouds is needed for global climate models.

Approach: Environment Canada and PNNL analyze G-1 aircraft data to simulate microphysical processes in Arctic clouds.

Results: If the number of ice crystals in Arctic clouds is increased, then water vapor would condensate on the ice crystals instead of liquid water droplets and the clouds would collapse.

Impact: Arctic clouds will experience highly heterogeneous and significant characteristics, with more arctic leads in future climates.



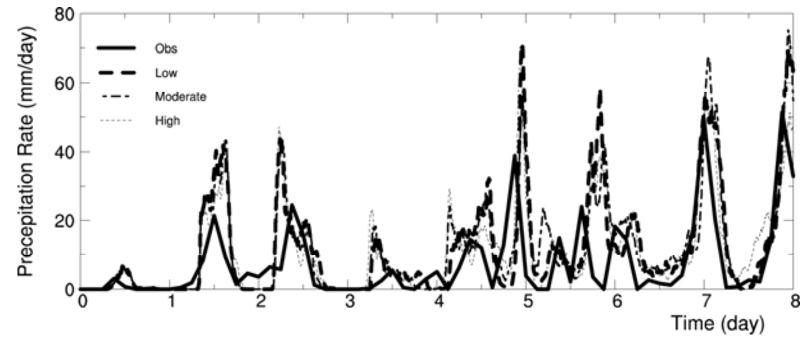
Ovchinnikov M , et. al. (2011) *Effects of Ice Number Concentration on Dynamics of Shallow Mixed-Phase Stratiform Cloud*. **J. Geophys. Res.** DOI: 10.1029/2011JD015888.

ARM Data Improves Climate Models

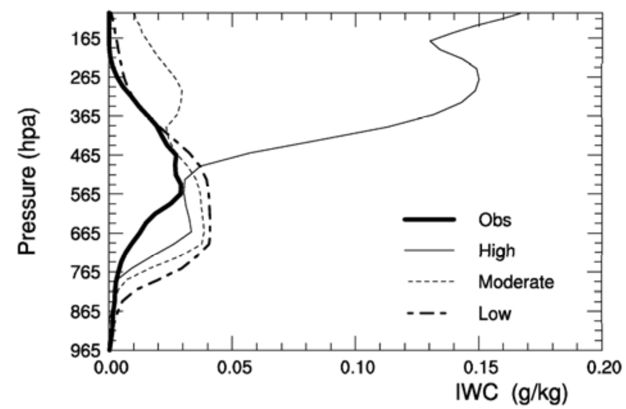
- Ice nuclei, a class of aerosol particles, can significantly affect cloud ensembles via ice crystal concentration, which in turn impacts radiation in atmosphere.

- Long-term model simulations were compared with ARM cloud observations showing that the impact of ice crystals in clouds is approximately 1000 times larger in the tropics than that in middle latitudes.

- Findings used to update model that can now be used to simulate clouds not only in middle latitudes but also in the tropics.



Tropics: Precipitation rate vs model simulations for different ice crystal concentrations



Mid-latitude: Ice water content vs model simulations for different ice crystal concentrations

Zeng X, W Tao, T Matsui, S Xie, S Lang, M Zhang, DO Starr, and X Li. 2011. "Estimating the ice crystal enhancement factor in the tropics." *Journal of the Atmospheric Sciences*, 68(7), doi:10.1175/2011JAS3550.1

Growth and expansion of boreal shrubs enhances warming

Objective: How does shrub height & expansion affect boreal climate and permafrost?

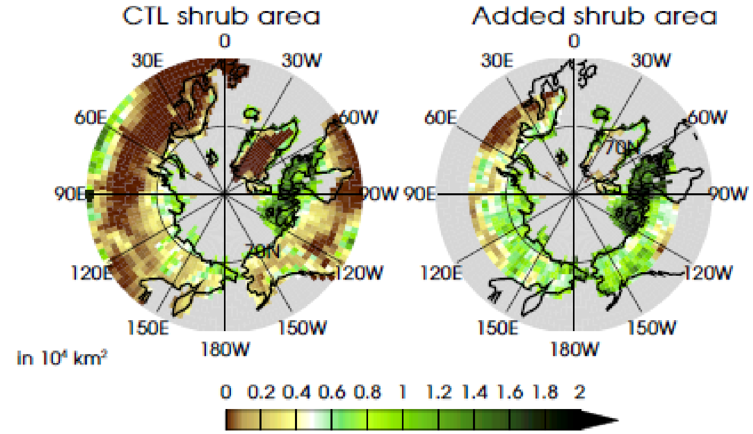
Approach: 9 experiments performed with CCSM4:

- Expanding shrubs, taller shrubs
- Coupling to climate
- Increasing CO_2

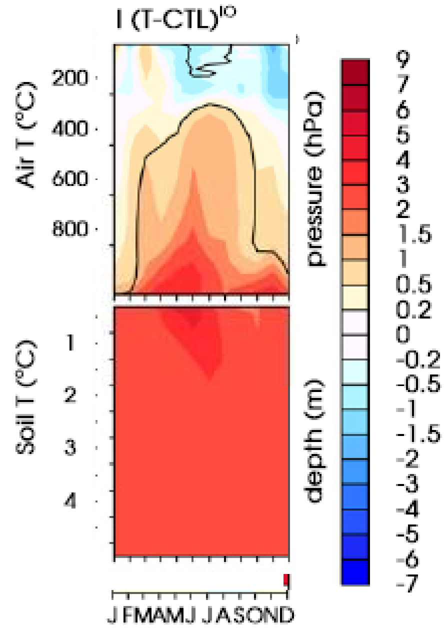
Results

- Shrub expansion leads to atmospheric heating through two feedbacks (albedo and evapo-transpiration)
- The strength and timing of these feedbacks are sensitive to shrub height
- Tall shrubs destabilize the permafrost more substantially than short shrubs

Bare ground north of 60°N converted into shrubs



Seasonal air and soil warmer from expanded and taller shrubs



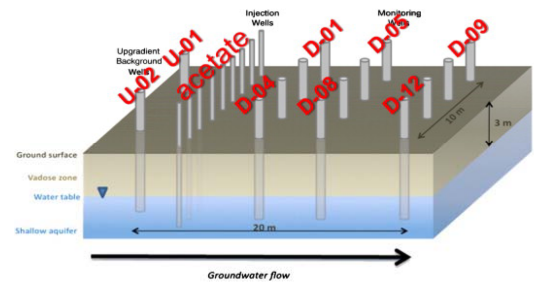
Bonfils, C., TJ Phillips, DM Lawrence, P Cameron-Smith, WJ Riley, ZM Subin, 2011: On the influence of shrub height and expansion on northern high latitude climate. *Environmental Research Letters*, **7**, 015503, 2012.

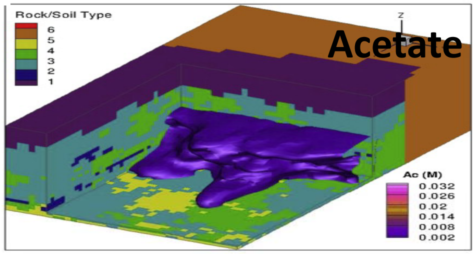
High Performance Computing Simulation of Complex Subsurface Processes

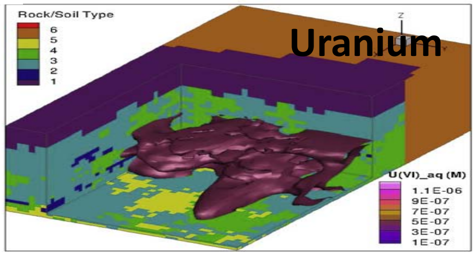
Objective: Simulate the coupled physical, geochemical and microbiological processes controlling uranium mobility during an in situ bioremediation test.

New Science: 3D simulations track changes in microbial community composition, microbial geochemistry and dynamic hydrologic characteristics during an in situ test of uranium bioremediation.

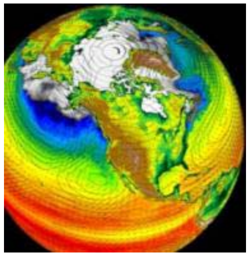
Significance: High performance computing at EMSL enabled researchers to computational test hypotheses on complex subsurface biogeochemical processes controlling contaminant transport <u>before</u>, <u>during</u> and <u>after</u> an actual in situ field test.

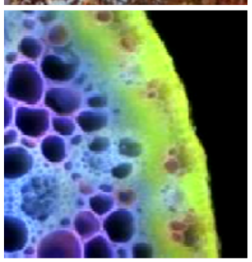






Yabusaki SB, et. al. (2011) *Variably saturated flow and multicomponent biogeochemical reactive transport modeling of a uranium bioremediation field experiment*. **J. Contam. Hydrol.** 126:271-290.




Thank you!

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