Climate Change SCIENCE INSTITUTE

Newsletter

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY

JANUARY/FEBRUARY 2012 VOLUME 3, ISSUE 1

LETTER FROM CCSI LEADERSHIP

Dear CCSI,

As I will be leaving my current position with CCSI to take a position with Scripps Network Interactive on the 26th, I wanted to take a moment to tell you that I have greatly enjoyed my time at ORNL and appreciate having had the opportunity to work with you. Your support is a large part of what has helped us shape CCSI into the Institute is has become. Your dedication to advancing the science of climate change is to be commended. It's hard to remember that two years ago, words like carbon sequestration, sustainability, and dycore were not part of my vocabulary. I look forward to reading about the many great findings and discoveries that you will make in the coming months and years! Even though I will miss my colleagues in CCSI and ORNL, I am looking forward to this new challenge and starting a new phase of my career. Thanks again.

Mary Regan

2ND ANNUAL CCSI SCIENCE ADVISORY BOARD MEETING

CCSI hosted its Science Advisory Board (SAB) for the 2nd Annual Meeting January 30-February 1st. Members in attendance included Tony Janetos (Chair), Venkatramini Balaji, Virginia Burkett, Sara Graves, Rob Jackson, and Jim Randerson. Their visit was kicked off with a lively dinner discussion of the project, staff, and budget highlights from the past 16 months. Day 2 was marked with discussions on progress with integration of the four Research Themes as well as on potential new scientific focus areas. The day was capped off with a three-hour poster session during which 40 posters provided the backdrop for one-on-one interactions between the SAB and CCSI researchers, postgraduates, and technical staff. The meeting wrapped up with the SAB providing recognition, suggestions, and recommendations to further strengthen the Institute. Quarterly calls will be used over the next year to continue this dialogue. CCSI greatly appreciated the time each of the SAB Members has spent in their advisory role to the Institute.

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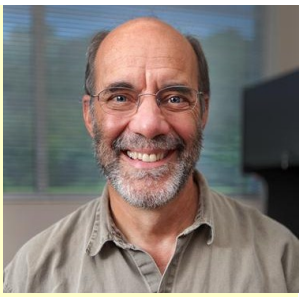
Highlighted Researcher MAC POST



Mac Post, born and raised in Pennsylvania, had an early interest in natural history even while he began his undergraduate studies in mathematics. These interests ultimately led Mac, in graduate school, to change his major to botany and ecology, ultimately earning his BS in botany from the University of Wisconsin. His Master's work was focused on algae, and later focusing more toward ecosystem ecology as he pursued his PhD in ecology.

In Mac's free time, he can typically be found outdoors— hiking, canoeing and backpacking, while leading others to enjoy these same types of experiences. In addition, he works with the Boy Scouts and Sierra Club to help them see the ecological principles and biogeochemical cycles that are underneath their feet and over their heads while walking around.

Mac Post was primarily drawn to UT—Knoxville for its involvement, with ORNL, in the International Biological Program as well as the opportunity to work with Hank Shugart who Mac credits as having had a strong influence on his educational and professional path. In addition, a postdoctoral research associate of Mac's, John Pastor, pushed Mac to think more broadly about relationships between population ecology and biogeochemical cycles.

Mac did his postdoctoral work on theoretical ecology with Don DeAngelis and soon became involved in global carbon cycling. During this time, he also had the opportunity to work with legendary soil scientist, Hans Jenny, working on developing a way of summarizing soil carbon information to be useful on a global scale.

Mac's work continued along these lines as he was attracted to taking ecological information, data, and theory, and bringing it into modeling framework so that he and other climate scientists could have a framework to explore the logical consequences of these interactions and to examine hypotheses.

Currently, Mac is working on carbon cycles in climate models, mostly focusing on climate impacts on ecological systems. Based on Mac's early soils experience, he is working to improve the representation of soil carbon dynamics in climate models. Mac stated, "We are in an exciting time – old methods and concepts are changing based on information gathered over the past 10 or 20 years which allows us to better define how soil organic matter is interacting with soil mineral components."

Mac is also the ORNL Investigator for IMPACTS (Investigation on the Magnitudes and Probabilities of Abrupt Climate TransitionS), a multi-National Laboratory project which is looking at the effects of climate induced vegetation change with strong physical feedbacks to climate—looking to see if land surface models have the possibility of representing the potential for abrupt climate change. He is also exploring application of biogeochemistry modeling to agriculture, especially in the area of sustainable development biofuels.

What role does your research play in climate change research?

Although I am involved in many aspects of climate change research, the majority of my work is on terrestrial biogeochemical cycles and the role of terrestrial ecosystems in influencing the CO_2 concentration of the atmosphere. My specialty in this general area is soil carbon - the second largest global carbon pool – 3 times larger than the amount in the atmosphere, and 4 times larger than terrestrial vegetation. I have focused on assembling datasets and building simulation models to evaluate hypotheses related to soil organic matter dynamics with respect to climate, land-use (including agriculture and forestry), vegetation disturbance/recovery, and interactions with other element cycles (N and P in particular).

Who is the customer for your research?

I view my work as incrementally increasing our understanding of global carbon cycle dynamics, so my customers are other scientists that find my work useful enough to cite. More recently, my work has involved model-data intercomparisons that are focused on evaluating and improving our representations of terrestrial carbon cycle dynamics in simulation models. Most of my support over the years has been from the DOE Office of Science, and I also receive some funding from NASA Terrestrial Ecology and NSF Ecosystems.

Why is it important to you, personally, to become involved in climate change research?

I am compelled to understand how the natural world works and knowledge about biogeochemical cycles contributes at many scales. From looking out my office window at the woods responding to the early advancing spring, to constructing models to interpret data from laboratory and field experiments, and to assembling databases for use in regional and global simulation models – they all contribute to gaining insights into this puzzle. Cli-

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POST (CONT.)

mate Change research is a context for which all these activities can usefully contribute.

In what direction do you see the future of climate change research going?

The terrestrial biogeochemical cycling component of climate change research has grown to encompass many disciplines from geology, pedology, agronomy, plant physiology, ecohydrology, vegetation dynamics, and atmospheric sciences. While fundamental contributions will continue to come from disciplinary research, climate change science is becoming much more integrative. An important component of ongoing and future research is the intimate integration of theory, with data, and simulation modeling. A short-hand way of thinking about this as numerical climate forecasting—similar to numerical weather prediction (NWP), but much more comprehensive than the focused objectives of NWP. Our science is now finding itself in a data rich environment with expanding monitoring systems, satellite data, and armies of field investigators and citizen scientists. Using this expanding array of data to build ever more complex simulation models and confront the models' explanatory power with the tidal wave of new information is our challenge for the future.

CCSI WELCOMES NEW STAFF

Danielle Touma is working in the Climate Change Science Institute in Moetasim Ashfaq's group as a Post-Master's Research Associate. She is investigating statistical bias correction methods for climate data from GCMs and RCMs to be able to improve knowledge of future climate change impacts on hydrological processes.

Danielle graduated in 2011 with an MS in Civil Engineering from North Carolina State University in Raleigh, NC. She concentrated in Water Resources and Environmental Engineering and her thesis focused on building a framework that assesses the ecological impacts of climate and land-use change in a basin. She also received her BS in Civil Engineering from North Carolina State University in 2009.

Mariya Absar is a Post-Masters Research Associate in the Computational Earth Sciences Group where she is using hydro-climatic predictions to study the impacts of climate change on water resources and the role of adaptation in reducing climate risk.

She received her BS in Computer Science from Lahore University of Management Sciences in 2004 and her MS in Environmental Management from Yale University in 2009 on a Fulbright Scholarship. After graduating, she moved to Pakistan to work as a Water Policy Research Scientist with the OIC Standing Committee on Scientific and Technological Cooperation, and later to Austria to work as a Research Assistant with the International Institute for Applied Systems Analysis (IIASA) using discounted cash flows and real options analysis to model the investment in water saving irrigation options for farmers.

Erik Green is working on the MAST-DC and DAAC projects, processing, documenting and archiving climate related data. Erik graduated from Northern Arizona University in 1997 with a BA in General Studies with an emphasis in Computer Science and a minor in History. After graduating, Erik started a career in Information Technology working for various financial companies such as American Express, Charles Schwab and Citigroup. In 2003 he moved to Tokyo, Japan where he lived for 7 years. While in Japan, Erik taught English for two years before later returning to IT work. After returning to the U.S., he decided to go back to school and received his MS in Climate Science and Solutions in December of 2011 from Northern Arizona University. In his free time, Erik enjoys travelling, skiing and rock climbing.

LAURITZEN—FEBRUARY SEMINAR SPEAKER

Peter Lauritzen visited CCSI February 28-29 as the distinguished seminar speaker for February. He spoke about the development and analysis of a new test case to evaluate transport schemes within global climate models. He also briefly described CLSAM, a transport scheme currently being implemented in the Community Atmosphere Model CAM-SE dynamical core. CSLAM demonstrates favorable advection behavior relative to other options within CAM. Peter also met with CCSI collaborators to discuss a new SciDAC project to improve the solution capabilities in the chemistry model within CAM at high resolution and also to form new collaboration areas.

Highlighted Research

MAST-DC

The Modeling and Synthesis Thematic Data Center (MAST-DC) is a component of the data system of the North American Carbon Program (NACP; www.nacarbon.org) designed to support NACP by providing data products and data management services needed for modeling and synthesis activities related to carbon fluxes for North America as well as inventories of carbon in forests, crops, the atmosphere, and soils. It is a NASA-funded project led locally by Bob Cook with Mac Post and Peter Thornton serving as co-principal investigators. Based on specific requirements established by NACP, MAST-DC provides data products for modeling and synthesis in consistent and uniform grids, projections, and formats.

MAST-DC has compiled a wide range of observations, model input, and model output at a variety of scales (from flux towers to these regions to all of North America) in close cooperation with the NACP community. These data products have been used in several NACP-wide synthesis activities to examine the spatial and temporal distribution of carbon sources and sinks as well as the processes influencing those sources and sinks.

MAST-DC provides data products and services required by NACP in a central location, with common and co-registered spatial properties in standard and easily converted formats. The MAST-DC frees modelers and those doing the synthesis and integration from having to perform data management functions. Consequently, the MAST-DC enables NACP participants to conduct their work more readily, facilitate the development of new model products needed by models, and assist in gaining new insights into the carbon cycle in North America.

Between 2007 and 2010, ORNL staff gathered gathered two groups of scientists to conduct syntheses, primarily model intercomparisons. One group looked at models implemented for flux tower sites (site synthesis) and one group looked at models implemented for North America (regional synthesis). The project hosted three workshops led by ORNL (each with approximately 40 attendees) for planning and carrying out the two syntheses.

In 2011, the Multi-Scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP) project, an outgrowth of the regional synthesis portion of MAST-DC, funded Debbie Huntzinger (University of Michigan) to conduct a formal model intercomparison. A portion of MsTMIP funds ORNL data management support for the project, including the hosting of MsTMIP workshops. MsTMIP's success is due to strong team collaboration by all members, with participation of approximately 20 different modeling teams. Yaxing Wei, Shishi Liu, and Erik Green, along with a dozen scientists, are compiling a wide variety of data (e.g., meteorological, land use, land cover, disturbance, soils, fire, crops, nitrogen deposition, phenology, atmospheric carbon dioxide) within the 1801-2010 timeframe at two scales: global at 0.5 degree and North America at 0.25 degrees.

ORNL staff are working to standardize the model output and to develop reusable cyberinfrastructure to analyze, visualize, and inter-compare the model output. In addition, they are comparing the model output to independent observations of key parameters from around the globe.

Thus far, the global driver datasets are ready and available, and the global reference simulations and global sensitivity and baseline simulations are being submitted, All North American simulations are expected to be submitted this June.

A unique feature of MsTMIP is that rather than thinking about comparison itself, the project will focus more on the

MAST-DC Interesting Findings

Analyses at individual flux towers indicated that the mean of the models out-performs the individual models, suggesting an ensemble model prediction approach may be the most effective. However, results from other teams revealed that there are specific cases where all models provide poor results, such as those results from agricultural systems, where nearly all models underestimate the intense carbon uptake rates observed in corn fields. Another example is in wetlands, where models generally fail to account for the effects of water table depth.

At a larger spatial scale, the NACP regional synthesis activity collected existing forward and inverse model simulations for North America. Observations were also compiled to validate the models, particularly forest and agricultural inventory data. Initial results from this intercomparison show that carbon cycle predictions are highly dependent on model structure, in particular the equations that govern photosynthesis.

The regional synthesis activity also confirmed the need for a standardized protocol, forcing data sets, and validation metrics for continental to global scale model simulations. This need will be fulfilled in part by MsTIMIP. This project will also be closely coordinated with the International Land Model Benchmark (ILAMB) project, a model-data intercomparison and integration project co-led by Forrest Hoffman. ILAMB is designed to improve the performance of land models and improve the design of new observational campaigns.

MAST-DC (CONT.)

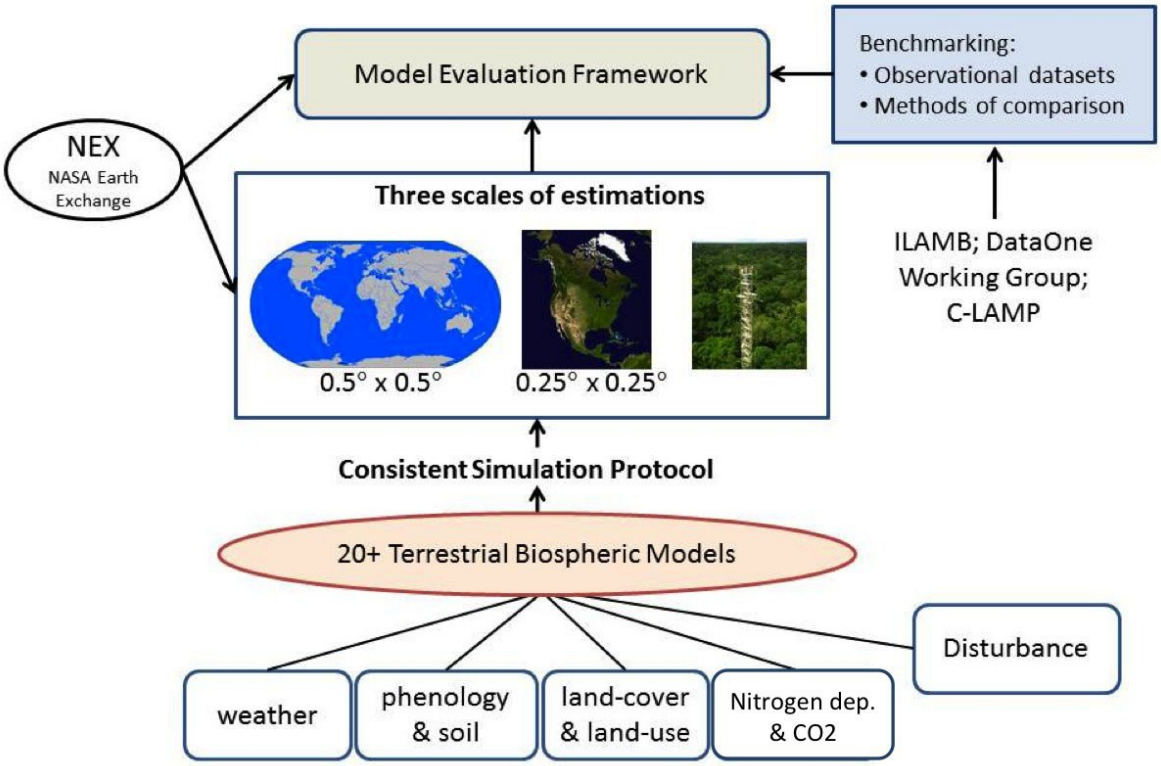
science questions. Examples of some of these questions include:

- What are the most dominant controls on land-atmosphere carbon exchange (globally, regionally)?
- How does each model estimate compare to benchmark observations in each case?
- What is the driving variability in model estimates of GPP and how do biases in GPP influence estimates of net productivity or exchange?
- Why are model estimates very similar to one another at the start of simulations, but diverge over time? What is driving this spread?
- Why are there such large differences in model estimates of permafrost in the Arctic? To what degree are these differences due to the snow model?

Project Websites

MAST-DC: http://nacp.ornl.gov

MsTMIP: http://nacp.ornl.gov/MsTMIP.shtml



MsTMIP Overview

A formal multi-scale synthesis, with prescribed environmental drivers shared among model teams, and simulations standardized to facilitate comparison with other model results and observations through an integrated evaluation framework. The overall goal of the MsTMIP is to provide feedback to the terrestrial biospheric modeling community to improve the diagnosis and attribution of carbon sources and sinks across regional and global scales.

CALENDAR

International Summer School in Glaciology (University of Alaska, Fairbanks) ……10-20 June 2012

Global Atmospheric System Studies First Pan-GASS Meeting (Boulder, CO) ……10-14 September 2012

Second International Workshop on Advances in High Performance Computational Earth Sciences (IHPCES): Applications and Frameworks (Omaha, NE)……4-6 June 2012

17th Annual CESM Workshop (Breckenridge, CO) ……18-21 June 2012

ESIP Federation Summer Meeting (Madison, WI) ……17-20 July 2012

AMS Annual Meeting (Austin, TX) ……6-10 January 2013

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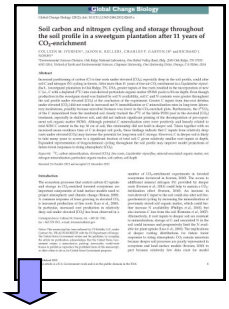
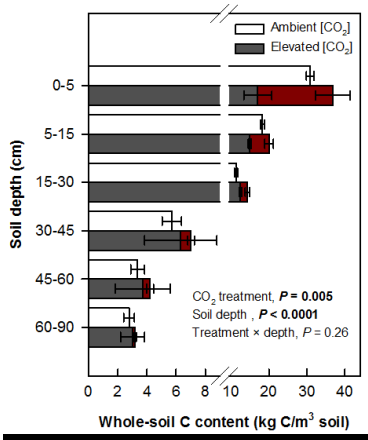
Recent Research Highlights

FINAL FACE HARVEST REVEALS INCREASED SOIL C & N STORAGE UNDER ELEVATED CO_2

- A common response of trees growing in elevated CO_2 is increased production of fine roots, especially in relatively deep soil.
- Final harvest of the Oak Ridge National Laboratory free-air CO_2-enrichment (FACE) experiment in 2009 allowed quantification of the effects of increased fine-root production and mortality on soil carbon (C) and nitrogen (N) cycling.
- Biogeochemical and isotopic analyses of soil samples to 90-cm depth revealed that elevated [CO_2] increased soil C and N contents throughout the soil profile, including in deeper soils where turnover rates of soil organic matter are reduced.
- Expanded representation of biogeochemical cycling throughout the soil profile may improve model projections of forest responses to rising atmospheric [CO_2].

Citation: Iversen CM, Keller JK, Garten CT, Norby RJ (2012) Soil carbon and nitrogen cycling and storage throughout the soil profile in a sweetgum plantation after 11 years of CO_2-enrichment. *Global Change Biology*, DOI: 10.1111/j.1365-2486.2012.02643.x.



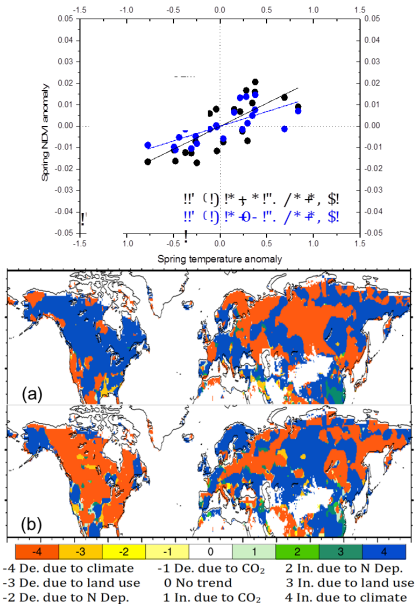


Carbon fixed during fumigation with elevated [CO2] (which was depleted in stable 13C isotope, red bars) led to increased soil C content throughout the soil profile.

CAUSES OF SPRING VEGETATION GROWTH TRENDS IN NORTHERN MID-HIGH LATITUTES 1982-2004

- A significant positive relationship between annual spring vegetation growth and temperature in most northern ecosystems is evident both in remote sensing data and in CLM4 transient simulations.
- Interannual variation in spring vegetation growth is mainly driven by climate, but other factors can have strong regional influence as well.
- Rising CO_2 and increasing nitrogen deposition are simulated to cause increased early season vegetation growth.
- The influence of land use and land cover change depends on the type of land management and on local climate.

Citation: Mao, J., Shi, X., Thornton, P.E., Piao, S. and Wang, X, 2012. Causes of spring vegetation growth trends in the northern mid-high latitudes from 1982 to 2004. *Environmental Research Letters*, 7: 014010 doi:10.1088/1748-9326/7/1/014010



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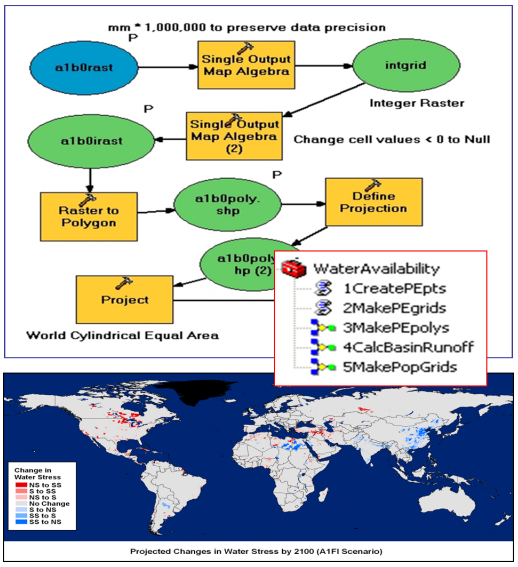
Recent Research Highlights

TOOLKIT FACILITATES INTEGRATION OF GLOBAL CLIMATE MODEL OUTPUTS AND GIS DATASETS FOR IDENTIFICATION OF POTENTIALLY WATER-STRESSED AREAS

- A fully coupled global climate model has been used to directly estimate freshwater runoff.
- Future global population distribution grids have been generated using down-scaled country-level population projections.
- Freshwater supply and demand projections have been aggregated by watershed and political unit in order to identify potential areas of water stress in 2025, 2050, and 2100.

Performed as part of ORNL's LDRD Program by Esther Parish.



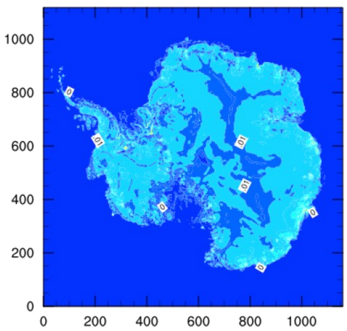
Projected Changes in Water Stress by 2100 (A1FI Scenario)

AN IMPROVED SOLUTION FRAMEWORK FOR GREENLAND AND ANTARCTICA ICE SHEET SIMULATION

- Original, serial, Picard based CISM dycore has been replaced with a more robust and efficient preconditioned Newton solver: first 100 yr Greenland simulation: 1 yr time step, avg ~42 nonlinear iterations for first 25 yrs.
- CISM has been parallelized: a 5km Antarctica 14M grid pt problem runs efficiently on 12100 processors
- This scalable version of the higher-order velocity CISM is being included in CISM2.0 to be released within CESM1.1 in May 2012
- Next generation finite element dycore also solves with preconditioned Newton for suite of test cases
- Using the Trilinos scalable solvers libraries within a CESM component has opened the door for all CESM components to take advantage of state-of-the-art solver capabilities

Citation: K. J. Evans, A. G. Salinger, P. H. Worley, S. F. Price, W. H. Lipscomb, J. A. Nichols, J. B. White III, M. Perego, M. Vertenstein, J. Edwards, and J.-F. Lemieux. A modern solver interface to manage solution algorithms in the Community Earth System Model. *International Journal of High Performance Computing Applications* February 2012 26: 54-62, doi:10.1177/1094342011435159

A modern solver interface to manage solution algorithms in the Community Earth System Model



1 year converged 5km Antarctica using the new scalable CISM, norm of surface ice velocity (lighter blue is faster ice flow)

100 yr converged 5km Greenland problem using the new scalable CISM. Blue scale represents the norm of surface velocity. Darker blue is faster ice flow.

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Coming in March's Edition

Highlighted Researcher: Colleen Iversen
Highlighted Research: UV-CDAT

Developing and executing programs for the multi-agency, multi-disciplinary climate change research partnerships at Oak Ridge National Laboratory.

RECENT PUBLICATIONS

Andres RJ, Boden TA, Bre □on F-M, Ciais P, Davis S, Erickson D, Gregg JS, Jacobson A, Marland G, Miller J, Oda T, Olivier JGJ, Raupach MR, Rayner P, Treanton K (2012) A synthesis of carbon dioxide emissions from fossil-fuel combustion. *Biogeosciences Discussions* 9:1299–1376; doi:10.5194/bgd-9-1299-2012

Ganshin A, Oda T, Saito M, Maksyutov S, Valsala V, Andres RJ, Fischer RE, Lowry D, Lukyanov A, Matsueda H, Nisbet EG, Rigby M, Sawa Y, Toumi R, Tsuboi K, Varlagin A, Zhuravlev R (2012) A global coupled Eulerian-Lagrangian model and 1 × 1 km CO2 surface flux dataset for high-resolution atmospheric CO2 transport simulations. *Geosci. Model Dev.* 5:231-243. doi:10.5194/gmd-5-231-2012.

Garten, C.T. Jr. 2012. Review and model-based analysis of factors influencing soil carbon sequestration beneath switchgrass (*Panicum virgatum*). *Bioenergy Research* 5: 124-138.

Graham D.E., M.D. Wallenstein, T.A. Vishnivetskaya, M.P. Waldrop, T.J. Phelps, S.M. Pfiffner, T.C. Onstott, L.G. Whyte, D. Gilichinsky, D.A. Elias, R. Mackelprang, N.C. VerBerkmoes, R.L. Hettich, D. Wagner, S.D. Wullschleger and J.K. Jansson (2011) Microbes in thawing permafrost: The unknown variable in the climate change equation. *The ISME Journal: Multidisciplinary Journal of Microbial Ecology* (in press).

Graham, R. L., D. A. Elias, T. J. Phelps, et al (2012) "Microbes in Thawing Permafrost: The Unknown Variable in the Climate Change Equation," *ISME Journal* 6, 709-712; doi:10.1038/ismej.2011.163.

Hayes DJ, Turner DP, Stinson G, McGuire AD, Wei Y, West TO, Heath LS, de Jong B, McConkey BG, Birdsey RA, Kurz WA, Jacobson AR, Huntzinger DN, Pan Y, Post WM, Cook RB (2012) Reconciling estimates of the contemporary North American carbon balance among terrestrial biosphere models, atmospheric inversions, and a new approach for estimating net ecosystem exchange from inventory-based data. *Global Change Biology* doi: 10.1111/j.1365-2486.2011.02627.x

Mao J, Shi X, Thornton PE, Piao S, Wang X (2012) Causes of spring vegetation growth trends in the northern mid–high latitudes from 1982 to 2004. *Environmental Research Letters* 7: 014010; doi:10.1088/1748-9326/7/1/014010

Mayes, M.A. et al. 2012. Relationship between soil order and sorption of dissolved organic carbon in temperate subsoils. Soil Science Society of America Journal (in press).

Russell LM, Rasch PJ, Mace GM, Jackson RB, Shepherd J, Liss P, Leinen M, Schimel D, Vaughan NE, Janetos AC, Boyd PW, Norby RJ, Caldeira K, Merikanto J, Artaxo P, Melillo J, Morgan MG. 2012. *Ecosystem Impacts of Geoengineering: A Review for Developing a Science Plan*. *Ambio* (in press).

Tipping E, Chamberlain PM, Fröberg M, Hanson PJ, Jardine PM (2012) Simulation of carbon cycling, including dissolved organic carbon transport, in forest soil locally enriched with ^{14}C. *Biogeochemistry* 108:91-107, doi 10.1007/s10533-011-9575-1.

Wang, G., Post, W.M., Mayes, M.A., Frerichs, J.T., Jagadamma, S., 2012. Parameter estimation for models of ligninolytic and cellulolytic enzyme kinetics. *Soil Biology & Biochemistry* 48:28-38. doi:10.1016/j.soilbio.2012.01.011.

Wicklein HF, Ollinger SV, Martin ME, Hollinger DY, Lepine LC, Day MC, Bartlett MK, Richardson AD , Norby RJ. 2012. Variation in foliar nitrogen and albedo in response to nitrogen fertilization and elevated CO_2. *Oecologia* (in press).

CURRENT CCSI JOB OPPORTUNITIES

We seek motivated individuals across a range of educational and professional experience including M.S. through Ph.D. academic qualifications at junior, as well as senior levels of experience to address some of the most pressing questions in global climate change science. You can view complete staff position descriptions and apply at http://jobs.ornl.gov. Postdoctoral and post-master's research position descriptions and online application are at http://www.orau.org/ornl/postdocs/ornl-pd-pm/default.aspx.

- Postdoctoral Research Associates