Climate Change SCIENCE INSTITUTE

Newsletter

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

LETTER FROM CCSI LEADERSHIP

Well, we are wrapping up our first year of co-location in 2040! It has been a year of surprises, changes, and major accomplishments. We thank all of you for doing a marvelous job with your science in the ever-increasingly important subject of climate change. The past several weeks have been busy and productive for all of us, but especially for the CSSEF and NGEE teams. An NGEE team from ORNL, LBNL, LANL, and BNL traveled to Alaska to look at field sites and meet with local scientists and community groups. You can see pictures and read about the trip at their blog: http://ngee-arctic.blogspot.com/. The CSSEF teams have been producing results for our important first-year deliverables. The entire CSSEF group met with DOE last week to provide an update, and DOE seems pleased with the results that are being produced on an accelerated schedule.

Some quick CCSI statistics for FY2011 (through Aug 17, 2011):
102 Scientific publications published or in press
170 Scientific presentations/posters
83 Conference or workshops organized or attended
27 Interactions with stakeholders or the public (television, print, and radio)
43 Leadership activities in national and international planning activities

Some of our outreach activities include the following:

Ester Parish and Dan Hayes. Presented a climate tutorial to the Great Smokey Mountains Institute student workshop on the environment
Stan Wullschleger (with Larry Hinzman and Cathy Wilson). Published EOS article on arctic ecology workshop.
Ben Preston. Participated in the Climate Change Science Day on the Hill
Paul Hanson and Stan Wullschleger. Contributed to article "Step into My Time Machine" featured in the Natural Resources Defense Council monthly OnEarth publication (2011)
Jim Hack, Paul Hanson, Colleen Iversen, and Jeff Warren. Participated in a Nat Geo JASONS curriculum on climate change that is soon to be released (www.jason.org)
Tom Boden. Conducted a telephone interview with the BBC for a documentary on how climate change research has helped shape modern science
Colleen Iversen and Jeff Warren. Two local TV interviews on SPRUCE and student interns at PiTS
Kate Evans. Featured interview with Physorg.com on modeling ice sheets.

Again, we thank you for your efforts and success. Please let us know if there are specific topics you would like to see us cover in future letters.

HERE STUDENTS & CCSI RESEARCHERS IN THE NEWS

ORNL interns taking advantage of a chance of a lifetime—(WBIR news story) Colleen Iversen, Jeff Warren, and three students were featured in a Knoxville television report at the FACE site, making use of the residual ^{13}C signature for a study on carbon partitioning. The students in this segment are: Lauren Breza (a UTK graduate), Claire Cambell (a Furman University student), and Jonathan Brooks (a Hope College student). Click to see the news story.

ECOLOGICAL SOCIETY OF AMERICA 96TH ANNUAL MEETING

CCSI had a strong showing at the 96th Annual Meeting of the Ecological Society of America (ESA) held August 7-12th in Austin, TX. CCSI researchers led or were participants in several workshops, posters, and sessions during which they highlighted their work associated with projects such as SPRUCE, Terrestrial Ecosystem Science Focus Area (TES SFA), DataONE, FACE, IMPACTS, MODIS, and NGEE-Arctic (please see the CCSI website for a complete description of these projects). A specific highlight was when Paul Hanson and Rich Norby provided brief overviews of TES SFA activities during the DOE Office of Biological and Environmental Science Town Hall meeting organized by Dan Stover. A full listing of these sessions can be found on the ESA website.

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Highlighted Researcher BOB COOK

Bob Cook is a native New Yorker. He was born and raised in Niagara Falls which, one might argue, was the perfect place for someone to become interested in the greenhouse gas aspects of climate change research. Cook—who is a licensed professional geologist in the state of Tennessee—received both his MS (geology) and his PhD (geochemistry) from Columbia University. He obtained his BA in chemistry from Eisenhower College in Seneca Falls, New York in 1974.

His research interests include biogeochemistry, global change, integrated assessments, aqueous geochemistry, transport and fate of contaminants in aquatic ecosystems, and water resources management. Bob spent one year as a postdoctoral research associate in Sweden studying the interactions of sulphur, nitrogen, and carbon cycles as part of a larger United Nations Environment Programme project on biochemical processes. This project culminated in *The Major Biogeochemical Cycles And Their Interactions* (for which he was an editor).

After receiving his doctorate degree, Bob Cook worked in Minnesota performing luminologic studies, looking at the history of lake acidification until he was recruited by Jerry Ellwood to come to ORNL in 1986. Currently, Bob is chief scientist in the Distributed Active Archive (DAAC) group.

While at ORNL, Bob continued his work on lake acidification and acid deposition including participation on the national acid precipitation assessment program. This was a 10-year study to inform Congress of the impacts of acid deposition with the intent of leading to changes to the Clean Air Act. Bob's primary project is the NASA-funded ORNL DAAC, an archive for biogeochemical dynamics data. He serves as the interface with investigators who are generating data for deposit at the DAAC. In addition, he works with the research community to identify tools and services for easy access and extraction of data from the ORNL DAAC.

More recently, Bob's focus has been on DataONE (Observation Network for Earth) (for which he is co-principal investigator [PI]) and DAAC. DataONE is a cyber repository (funded by the National Science Foundation) that provides universal access to data about life on Earth and the environment that sustains it. DataONE supports environmental science by: (1) engaging the relevant science, data, and policy communities; (2) providing easy, secure, and persistent storage of data; and (3) disseminating integrated and user-friendly tools for data discovery, analysis, visualization, and decision-making. Previous to this, Bob has served as the PI for several NASA projects (Modeling and Synthesis Thematic Data Center [MAST-DC], Large-Scale Biosphere Atmosphere [LBA]-Ecology Data Support, and FLUXNET) as well as a US Geological Survey project (Metadata Clearinghouse for the National Biological Information Infrastructure).

Bob has seen how this area of research has benefited from the technology changes over the past couple of decades, most notably in being able to provide users with data via the Internet versus via disc, allowing them the ability to provide users with services for access to data.

Bob is an active member of the North American Carbon Program (NACP) on which he has served on the science steering committee. Currently, he is coordinator of NACP interim synthesis activities.

What role does your research play in climate change research?

Climate and carbon cycle research requires large volumes of multi-disciplinary observational and experimental data -- this is an approach now called Data Intensive Science. I work on a couple of projects that provide data as well as tools to discover, access, and visualize the enormous amount of data needed for climate change research. For the North American Carbon Program, I am coordinating several large interdisciplinary synthesis activities that evaluate the fluxes and inventories of carbon in North America. Part of this coordination role is to ensure that the data and model results required for the synthesis are readily available to the researchers.

Who is the customer for your research?

We have a couple of different customers, depending on the research project. For most of my projects, the customers are our NASA funders and the research community. For the North American Carbon Program, an international and interagency program, we are advancing our understanding of the carbon cycle by compiling information and comparing fluxes and stocks of carbon in for-

In Bob's spare time, he is an avid basketball and tennis player and can be seen out on the courts many times each week.

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COOK (CONT.)

ests, grasslands, agricultural lands, and populated areas using a number of different estimates -- agricultural census information, forest inventories, and different kinds of models (terrestrial biosphere models, and atmospheric transport models). At the NASA-funded ORNL DAAC, our customers are NASA and researchers whose data we curate and archive. In addition, the ORNL DAAC provides data, tools and services for the global research community to use to study climate change. In the past year, we worked as part of an interdisciplinary team led by the Cornell Lab of Ornithology and NSF-funded DataONE to prepare a report on the state of the birds in the US that was released by Secretary of Interior Ken Salazar and Agriculture Under Secretary Harris Sherman.

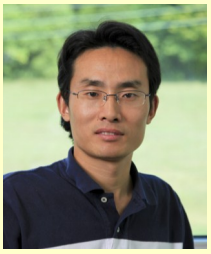
Why is it important to you, personally, to become involved in climate change research?

This involvement started early for me and has continued throughout my career. I was a chemistry major in college, but really couldn't see myself working in the chemical industry. I was fortunate to land a couple of summer environmental internships that combined chemistry, with working in the outdoors on environmental problems. That led to grad school in the 70s in the Geology Department at Columbia University, a place that worked on Earth system questions, including work to understand the perils of burning the world's supply of fossil fuels and increasing concentrations of the greenhouse gas CO2.

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

Climate research is increasingly becoming interdisciplinary and data intensive. I think we'd all like to see a more technically advanced research system with ready access to highly diverse and well-integrated observational, experimental, and model output data with tools to analyze and visualize the information. Of critical importance, in both today's and this future world, is easy access to high performance supercomputers. Having access to information, tools, and analysis capability will advance climate change research. In addition, we need new and innovative collaboration tools to share ideas, analyses, and

CCSI WELCOMES NEW STAFF



Xiaofeng Xu is a postdoctoral research associate in the Ecosystem Simulation Science group at ORNL. His research focuses on the global change and its impacts on terrestrial ecosystems. The current efforts include combining the results from the Next Generation Ecosystem Experiment (NGEE) with the Community Land Model (CLM) to evaluate the permafrost feedbacks on global climate system in the framework of earth system model. Xu received his PhD in Forestry in December 2010 from Auburn University where he also worked as a postdoctoral fellow.

Shishi Liu is a postdoctoral research associate in the Distributed Active Archive group. She recently received her PhD in Geography from the University of California, Santa Barbara. While at ORNL, Shishi will be working on the North American Carbon Program using output from a number of advanced models to understand the fluxes and stocks of carbon in the biosphere. Shishi will be working with a multi-institutional team that is evaluating a dozen terrestrial biosphere models and how well they estimate observed fluxes and carbon inventories.

CALENDAR

Computing in Atmospheric Sciences 2011 (Annecy, France) ……11-14 September 2011
27th New Phytologist Symposium: Stoichiometric flexibility in terrestrial ecosystems under global change (Oracle, AZ)……25-28 Sept 2011
Fifth Intl. Conference on Flood Management (Tsukuba, Japan)……27-29 September 2011
ASA, CSSA, and SSSA International Annual Meetings (San Antonio, TX)……16-19 October, 2011
ICCCGW 2011: International Conference on Climate Change and Global Warming (Venice, Italy)……23-25 November 2011
Partners in Environmental Technology Technical Symposium and Workshop (Washington, DC)……29 Nov–1 Dec 2011
AGU Fall Meeting (San Francisco, CA) ……5-9 December 2011
92nd Amer. Meteorological Society Meeting (New Orleans, LA)……22-26 January 2012
AAAS Annual Meeting (Vancouver, Canada)……16-20 Feb 2012
2012 Ocean Sciences Meeting (Salt Lake City, UT)……20–24 February 2012

Highlighted Research

HIGH-RES GLOBAL SIMULATION

Climate change modeling and simulation is arguably one of the most challenging fields in computational sciences, in large part due to the need to accurately describe a very complex nonlinear system of systems. Climate scientists are striving to produce comprehensive models that encapsulate the physics and dynamics of the Earth's climate system to produce climate projections which can be used by policy and decision makers. Although the large -scale impacts of increasing greenhouse gas concentrations have been clearly demonstrated, the more detailed impacts on time and space scales required for managing natural and man-built systems require substantially more fidelity than has typically been possible until now. Higher spatial resolution, allowing regional scale analysis, using the most complete formulations for climate processes is a direction in which the science community is beginning to move and is to a large extent limited by available computational power. One such effort is a multi-laboratory project, led by ORNL, called the Ultra-High Resolution Global Simulation to Explore and Quantify Predictive Skill for Climate Means, Variability and Extremes (hereafter referred to as Hi-Res). Other partners in this activity are Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Lawrence Livermore National Lab (LLNL).

The objective of the Hi-Res project is to rigorously test hypotheses about the value of higher resolution global simulation models. By configuring global models at the highest resolutions possible, scientists explicitly include the simulation of new non-linear phenomena and interactions on the small scale that have feedbacks on large scale climate features. This project hopes to demonstrate that higher resolution will help to create more accurate and explicit simulations of local to regional scale phenomena, including low-probability, high-impact hydrological events. Currently, there are key uncertainties of regional projections. For some regions, there have been only very limited studies of key aspects of regional climate change, particularly with regard to extreme events. Previous generations of global Earth System Models show little consistency in projecting regional precipitation change.

In regions where the local climate is affected by topography, there is insufficient information about topographic forcing contributions to climate change. Better representations of mesoscale storm structure and intensity are needed, as are higher resolution atmospheric models, to correctly simulate the climatology of monsoon season rainfall events over Asia. The project's initial experimental approach was to leverage investments in the Community Earth System Model (CESM), including preliminary work with atmospheric components using discrete grid increments between 25 and 50 km coupled to a high-resolution global ocean. Simulation biases in earlier investigations pointed to the need to address important details about the high-resolution configuration such as the initial ocean state, proper representation of the climate system's energy balance, and the potential role for the discrete formulation of the atmospheric dynamical core to introduce systematic biases. The experimental protocol addressed these needs through 1) exploration of a realistic initial ocean state free of excessive drift; 2) spin-up experiments of the coupled system to provide the best representation of the global energy budget; 3) design of an experimental suite to address specific resolution hypotheses; 4) exploration of multiple atmospheric dynamical cores (Finite Volume, spectral and spectral ele-

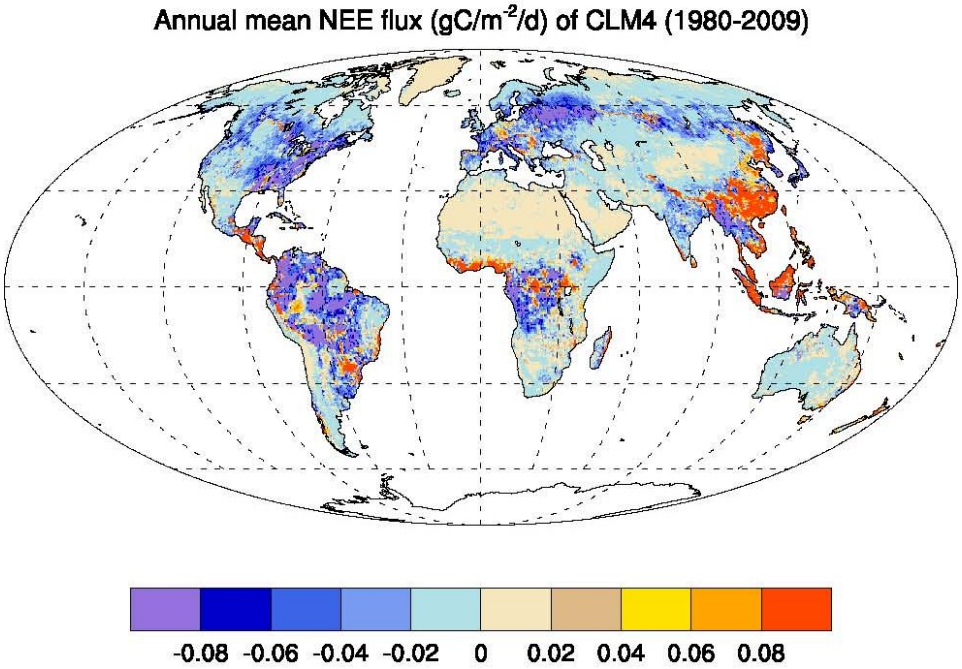


Figure 1. Model estimated net flux of carbon between land ecosystems and the atmosphere, shown as an average value over the period 1980-2009. Negative values (blues) show regions of carbon accumulation on land, resulting from the combined influences of CO_2 fertilization, increased nutrient availability, and recovery from past disturbances (e.g. fire and forest clearance for agriculture). Positive values (orange) show regions of carbon loss on land, resulting mainly from recent disturbances, such as fire and land use change. This simulation, performed with the Community Land Model, version 4 (CLM4), used historically accurate representations of surface weather patterns, changing atmospheric CO_2 concentrations, changing atmospheric nitrogen deposition, and patterns of land use and land cover change.

HI-RES (CONT.)

ment); and 5) development of a comprehensive and systematic plan for simulation evaluation. Features of the simulations to be evaluated include systematic bias, low and high frequency modes of climate variability, regional climate simulation quality and extremes analysis. Over the first year, the initial work was to stand up a multiple-resolution CESM coupled modeling capability on Jaguar. The ORNL team has spent several months fine-tuning the various model components and has launched the first high-resolution simulation using a spectral dynamical core with numerical accuracy comparable to a 25 km finite difference technique. Because of CESM's interest in higher-resolution configurations of the finite-volume dynamical core, two atmospheric dynamical cores will eventually be evaluated at high resolution through these experiments: the understood spectral dynamical core and a more scalable spectral element dynamical core, CAM-SE (Community Atmosphere Model-Spectral Element, formerly known as HOMME). The high-resolution coupled system has been relatively well optimized, and the scaling issues continue to be analyzed and optimized in the context of solution sampling. In addition, the project is leveraging ASCR (Advanced Scientific Computing Research) investments in migrating CAM-SE to next generation architectures. The ORNL team has needed to address several challenges in the first phase of the project, which have led to interesting scientific, workflow and infrastructure investments. Since the modeling framework does not include an interactive aerosol capability, ORNL staff member Salil Mahajan has generated a high-resolution monthly time-series of tropospheric aerosol for the latter half of the twentieth century from the latest emissions data of aerosol precursors and oxidants. Experiments with the spectral configuration of CAM4 forced with the new aerosol dataset reveal significant interannual variability induced by the aerosol forcing on regional climate, particularly over the tropical Atlantic and South East Asia. Mahajan also found that radiative forcing induced by the present day distribution of tropospheric aerosols leads to meridional shifts of the Intertropical Convergence Zone over the tropical Atlantic and a weakening of the Indian monsoons. From a computational point of view, throughout this project, ORNL staff member Pat Worley in collaboration with the other team members was able to find ways to reduce the required computing resources for a CESM production run by over a factor of six. His work has led to a new methodology in the spirit of defining best practices, for improving the default optimization settings. An important element of Worley's work is to archive and post-process performance data for production runs in order to automatically suggest opportunities for optimizations in subsequent runs. Similarly, team members have spent considerable time with ORNL collaborators on the Earth System Grid to create workflows that allow the export of simulation datasets on the size of 100s of terabytes.

An important component of this simulation project was to develop a low-resolution spectral dycore version of the CCSM4, in this case a T85 truncation. Results of this exercise, completed by ORNL staff member Kate Evans, with support from Ray Flannery, have demonstrated that the T85 configuration produces a moderately superior global climate relative to its CAM4 FV configuration and its CAM3 predecessor. The T85 configuration provides the low-resolution benchmark for a direct comparison to its higher-resolution T341 configuration and includes the 1) creation of new, higher quality datasets to interpolate data exchanged with the other CESM components, 2) utilization of recently created sea-surface temperature datasets from the Hadley Centre with monthly varying values from the preindustrial period forward, and 3) subcycling of the dynamics to enhance computational efficiency and provide more flexibility for evaluating the physics components during the model integration.

So far, the team's analysis of the T341 configuration indicates it does a credible job of reproducing the observed dynamical circulation at higher latitudes although many low latitude systematic biases remain, suggesting the source of these errors are largely introduced by the parameterized physics. This is a surprising result given that the high-resolution model includes a wide range of new transient phenomenology (e.g., hurricanes). This is leading investigators to examine in more detail how the simulated large-scale mean features are maintained at two widely different horizontal resolutions. The team is also working on understanding the systematic drying of the simulated atmosphere and an associated reduction of clouds which introduces challenges in accurately simulating the global energy budget. Part of this work includes exploring extensions to the scheme used to parameterize clouds.

At the same time as the ORNL-LANL-LBNL-LLNL partnership is working toward the development and evaluation of a high-resolution Earth System Modeling framework, we are witnessing a fundamental change in high-performance computing platforms. As the computational science community moves toward exascale architectures, it is clear they will need to deal with the imminent introduction of hybrid multi-core systems, which comprise both multi-core general-purpose CPUs and Graphics Processing Units (GPUs). Any scientific application wanting to realize the full potential of next-generation and exascale machines will require significant changes to the formulation and implementation of their models. Rick Archibald (in collaboration with a team at the Oak Ridge Leadership Computing Facility Center for Accelerated Application Readiness) is already working on adapting CAM for the next generation of hybrid systems using the spectral element dycore, CAM-SE.

Upcoming CCSI Seminars

Christa Peters Lidard
-Postponed-

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Coming in September's Edition

Highlighted Researcher: Dan Hayes
Highlighted Research: CSiTE

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

RECENT PUBLICATIONS

Andres R.J., J.S. Gregg, L. Losey, G. Marland, and T.A. Boden. 2011. Monthly, global emissions of carbon dioxide from fossil fuel consumption. *Tellus B* 63:309-327. doi: 10.1111/j.1600-0889.2011.00530.x.

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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.

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