Climate Change SCIENCE INSTITUTE

Newsletter

JUNE 2010 VOLUME 1, ISSUE 2

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

LETTER FROM CCSI LEADERSHIP

The CCSI has had a great year and many accomplishments since our inception last fall. We thank all of you for your efforts leading to this successful start, and the future looks to be just as exciting. We have two major proposals for climate change modeling, simulation, and computational science due this summer. The prototype equipment for the SPRUCE experiment is ready to be turned on for testing, while we make plans for a next-generation ecosystem experiment in Alaska. Our science is seeing opportunities for applications as well as through connections with the private sector (Parsons-Brinkerhoff and Northrop Grumman). As you will read, our proposal success has set us up to make some tremendous accomplishments to climate change science with our valued partners. Kate Evans and Jim Hack showcased their high-resolution global climate modeling results, and Peter Thornton discussed the latest terrestrial biogeochemistry additions at the Community Climate System Modeling (CCSM) workshop in June. Our first annual Science Advisory Board meeting is set for September 28-30, and we should all be moved into our new location so that a portion of the meeting will be held in Building 2040 (National Energy Security Center). We realize the pace of all these opportunities is stretching many of you (and us) thin. Hang in there, because our staffing plans are also gaining momentum with both new staff and post-graduates arriving. It is an exciting time to be a climate change researcher at ORNL and to continue our important contributions to understand and help address this global issue.

CCSI ESTABLISHES SCIENCE ADVISORY BOARD

We have established a Science Advisory Board (SAB) for the CCSI. The SAB is chartered to provide advice, guidance, and counsel on the strategic science objectives of CCSI. The SAB serves as the CCSI's key external advisor and advocate of strategy, scientific relevance, and quality. The members are appointed by the CCSI director through consultation with the deputy director, business manager, and thrust leaders. The membership consists of at least eight external (non-ORNL, non-UT-Battelle) advisors with knowledge of and influence in the major research areas of the CCSI. SAB members will serve a three-year term for up to two consecutive terms. Terms will be sufficiently staggered to permit continuity of operation and institutional knowledge. The SAB will meet annually at ORNL to gain in-depth knowledge of relevant activities. Up to three conference calls may be held to provide updates to the SAB in between the site visits. We are planning for the first SAB meeting to be at ORNL September 28-30. More details as they develop.

The SAB members are:

Dr. Venkatramini Balaji, Princeton, Geophysical Fluid Dynamics Laboratory
Dr. Virginia Burkett, U.S. Geological Survey
Dr. Sara Graves, University of Alabama in Huntsville
Dr. Kevin Gurney, Purdue University
Dr. Rob Jackson, Duke University
Dr. Anthony Janetos, Joint Global Change Research Institute, Pacific Northwest National Laboratory and the University of Maryland
Dr. Jeffrey Kiehl, National Center for Atmospheric Research
Dr. James Randerson, University of California – Irvine

ORNL AND UTK TO HOST ESIP SUMMER MEETING

Federation of Earth Science Information Partners
MAKING DATA MATTER

The Federation of Earth Science Information Partners (ESIP Federation) will hold its summer meeting in Knoxville at the University of Tennessee Conference Center, July 20-23. Links to meeting registration and the agenda can be found at http://tinyurl.com/esip0710. Registration is $475 for members and $575 for non-members. At ORNL, the Earth Systems Grid and the ORNL DAAC (Distributed Active Archive Center) are members of ESIP. Chris Lenhardt (Environmental Sciences Division) currently serves as vice-president for ESIP.

The ESIP Federation is a collaboration involving approximately 120 organizations that collect, interpret, and develop applications for Earth observation information. The Federation includes data centers from multiple US Federal agencies, as well as groups from research universities, education resource providers, information technology innovators, nonprofit organizations, and commercial enterprises.

The focus area for the summer meeting is "Energy and Climate." Activities will include parallel tracks relating to information needs in energy (particularly renewable energy), air quality, water quality, ecological forecasting, and education. There will also be technology tracks relating to use of content management systems in environmental data, web services, semantic web, and other information systems applications. Wednesday's activities include two plenary presentations, presentation of the Falkenberg award (joint with the American Geophysical Union for young investigators in earth science informatics), and a late afternoon poster session.

More information at http://www.esipfed.org.

Inside this issue:

Highlighted Researcher KATE EVANS

Kate's interest in science can be traced back to her great grandmother, Lillian Gilbreth, who is sometimes called "The First Lady of Engineering." Gilbreth (along with her husband, Frank) was a pioneer in industrial engineering at a time when women were still far from being accepted in science and engineering fields. "She received her PhD in engineering in 1914, but occasionally had to convince conference organizers to admit her to speak since some conference venues didn't allow women! Gilbreth was best known as the mother of the12 children chronicled in the 2003 film Cheaper by the Dozen.

Kate has two children and is married to ORNL scientist Tom Evans of the Nuclear Science and Technology Division. In her free time, Kate likes to run and play a little electric bass.

For Dr. Kate Evans, the allure of climate change research lies in the ability to provide demonstrably accurate climate simulation. She performs research investigations of improved numerical algorithms and model frameworks, specifically higher-order spatial resolution dynamical cores and new consistent temporal integration schemes. As an example of the importance of time accuracy for fluid models such as weather and climate, Evans uses the 2008 World Series Game 5 rainout as an example. Her beloved Phillies were scheduled to play at home to win the title when an approaching heavy precipitation event threatened play. There had never been a game called due to rain during the World Series, such that a partially finished game would be considered complete and decide the winner. So the event organizers looked to the weather experts who consulted the weather models. Weather models are not unlike the global climate models we work with here at ORNL in terms of the equations that are solved and the physical parameterizations used to generate fields such as precipitation. Unfortunately, the weather models didn't come through, and the game was suspended in the middle of the sixth inning with no precedence on how to proceed. The following day, Major League Baseball Commissioner Bud Selig told the Washington Post, "We were told about 7:45 PM that it would only be a tenth of an inch of rain between then and midnight or thereafter . . . I had a nagging fear because these forecasts had changed so much." Turned out the rain arrived ahead of schedule, causing the remainder of the game to be postponed to another evening. The forecast for rain was accurate, but the timing of the event was off. For climate, temporal accuracy has a more subtle role—very long-time runs cannot provide useful information if time error accumulates.

Evans is a research staff member in the Computational Earth Sciences Group. She earned her PhD in Atmospheric Science with a minor in math from Georgia Tech in 2000, and joined ORNL in 2007 after four years at home with her children and a stint as a postdoc at Los Alamos National Laboratory (LANL) in the Decision Applications and Theoretical Division. Her research interests include atmospheric dynamics and numerical methods. Evans was awarded a travel grant from the COST (European Co-operation in the field of Scientific and Technical Research) Action Program for a special course on the upper troposphere and lower stratosphere at the Cargese International School in Corsica. This grant helped her stay current in atmospheric dynamics and chemistry while working on numerical schemes. She is a member of the American Meteorological Society, American Geophysical Union, and the Society of Industrial and Applied Mathematicians. She received the William Rhodes Graduate Fellowship while at Georgia Tech, and in her last year received the Senior Dean's award for most outstanding PhD student. While a postdoc at LANL, she was awarded an outstanding poster presentation award at a symposium for students and postdocs.

Evans's current work is spread across several climate projects, two of which she is the principal investigator (PI). All are intertwined in varying degrees.

PI for A Scalable Solution Framework for the Community Ice Sheet Model (FY10-12) SEACISM is an Office of Advanced Scientific Computing Research (ASCR) -funded project within the newly formed Ice Sheet Initiative for Climate Extremes (ISICLES). The overall goal of this project is to develop a scalable, accurate, and efficient DOE Community Ice Sheet Model (CISM) by providing a state-of-the-art algorithms and tools framework which climate model developers can use to create a predictive ice sheet modeling capability. "As a project, we are tasked with meeting many of these goals in time for the next IPCC* report. This couldn't happen without the hard work of fellow ORNL team member Pat Worley, former ORNL team member Trey White, and team members at Sandia National Laboratory (SNLA), LANL, and New York University," said Evans. Her team has implemented the Trilinos solver package into the model which is currently running on Jaguar. "We can now take advantage of a number of scalable, robust solution methods," said Evans. "In addition, postdoc Jeff Nichols in the Environmental Science Division has joined the project to help make the code scalable to 10K processors utilizing these new solvers."

Next steps include adding more robust and efficient preconditioners for the ice sheet solvers and scaling developments. This model will also be linked into the main Community Climate System Model (CCSM) to provide a coupled ice sheet modeling option with the land model. Developments in the ice sheet model also provide research that can enhance methods development work in other components of the CCSM.

PI for Tests of Decadal Predictive Skill Using the Community Climate System Model (FY09-10) Having found follow-on project funding through DOE's Office of Biological and Environmental Research (BER) (see Ultra-High Res project below), this Laboratory Directed Research and Development (LDRD) project is ending early to allow funds to go toward other climate project development. Nonetheless, the main goal of the project—to develop the CCSM for higher resolution atmospheric and coupled high resolution modeling—is well un-

**IPCC (International Governmental Panel on Climate Change) is an international body of scientists who evaluate data to inform policymakers as to the state of climate science.*

derway. This project has provided two main capabilities: a spectral dynamical core option in the CCSM for regular and high resolution runs, and a new set of aerosol data for use in the model. This aerosol dataset contains aerosol concentrations from a wider set of emissions data such as wildfires, and also contains a temporal component so the increase in aerosols from anthropogenic sources is now incorporated.

Based on the success of this LDRD, ORNL was funded as the lead lab for the **Ultra-High Resolution Climate Simulation Project (FY10-14).** As part of this project, under PI and CCSI Director, Jim Hack, Evans has been working to configure the spectral and spectral element dynamical-core version of the atmospheric component of the CCSM. This model analysis work is somewhat of a return to the type of work she did in graduate school, and there is a lot of development that allows the model to run and produce accurate climate simulations in a reasonable timeframe. With each new resolution, the model's dynamical behavior and subgrid scale effects such as cloud condensation and chemical reactions must be evaluated, and Evans is involved in this effort. She and her colleagues have developed a high-resolution coupled model capability with the spectral model dycore, allowing them to run 1/3 and 1/4 degree atmosphere resolution with 1/10 degree ocean resolution.

A Scalable and Extensible Earth System Model; a DOE SciDAC Project to Develop the CCSM This is a multi-laboratory collaboration led by ORNL and includes LANL, Lawrence Berkeley National Laboratory, Argonne National Laboratory, and Lawrence Livermore National Laboratory. This project has many facets, and Evans' role on this project is working with Mark Taylor at SNLA to help develop the HOMME spectral element atmospheric component. Taylor wrote the precursor to HOMME before the SciDAC project, and Evans is working to help him establish HOMME as a viable dycore alternative in the CCSM. This project involves both methods development and performance analysis; HOMME has shown favorable scaling using 100K plus processors on Jaguar PF with an 1/8 degree resolution. This work interfaces well with a previous LDRD (PI Trey White) and the IAA project (algorithms PI George Fann) to develop advanced numerical schemes in HOMME. With collaborators, Evans has implemented an implicit solver option in HOMME for its shallow water option.

What role does your research play in climate change research? "My research focuses mostly on the investigation of new algorithms for the improved efficiency and accuracy of high-resolution climate models. This involves a lot of model development to run the climate models at finer resolutions and then evaluating the effects of resolving these scales. Figure 4 is a recent high-resolution climate run, and it is able to resolve smaller scale features such as hurricanes. My interests lie in the accuracy at finer spatial scales. It isn't enough to predict that climate change is occurring, but also on what time and spatial scales, and how unknowns propagate forward or change over time. From research done last year, my colleagues and I showed that a test bed version of the CCSM atmosphere component also produces more accurate solutions with the same method." (Figure 5)

Who is the customer for your research? "Those who use long-term climate simulations, steady state spin ups for slowly varying components such as the ocean and ice sheets, and where very high-solution accuracy is desired would be most interested in the sort of algorithms and higher spatial resolution being developed. Time slice runs to assess regional impacts are also an application of the development work being done."

Why is it important to you, personally, to become involved in climate change research? "I have always liked all kinds of Earth science (AKA 'weather weenie' in some circles), and the climate change problem is very challenging. For example, the new ice sheet model development project, SEACISM, combines my interests in numerical methods and climate modeling and is charged with providing a predictive capability for ice sheet simulation in a very short time frame. The last IPCC report was not able to comment on predicted sea level rise because there were not enough observations or model results available. Figure 6, provided by Jesse Johnson of U Montana of a very recently compiled set of observed ice sheet velocities over Greenland, is our simulation goal at 1 km, with many hundreds of years to reach steady state. This capability will then allow modeling of the ice sheet under a climate change scenario."

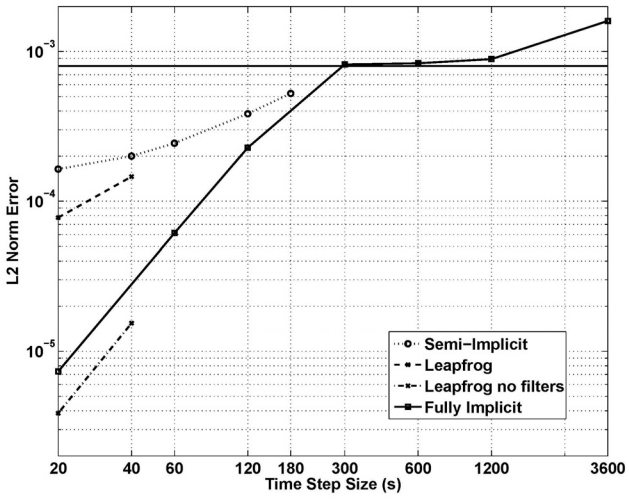

Figure 5 *Accuracy Analysis of Shallow Water HOMME*

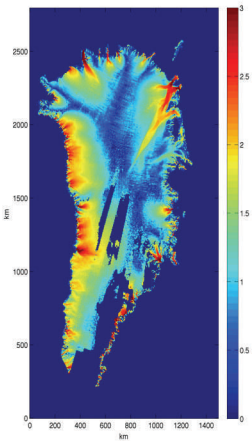

Figure 6 *Ice Sheet Velocities over Greenland*

In what direction do you see the future of climate change research going? "Luckily it isn't my place to speculate the future of climate change research from a political or funding perspective. I do think climate scientists need to work hard to explain what we know, what we don't know, and the steps we plan to take to gain a better understanding. I hope the future for climate science involves continually going back to the basics of a physical understanding of the Earth system, and from that place of confidence, explore various aspects of climate. There is so much we still need to learn, and I'm glad to be a part of the process."

OAK RIDGE CLIMATE CHANGE SCIENCE INSTITUTE NEWSLETTER

Recently Awarded

ULTRA HIGH RESOLUTION GLOBAL CLIMATE SIMULATION

PI: Jim Hack

Funding:
$9.095M

Duration:
5 years

Sponsor:
DOE/SC/BER

Partners:
LANL
LBNL
LLNL

Participating Staff:
Kate Evans
Peter Thornton
Forrest Hoffman
Pat Worley
Rich Archibald
Moet Ashfaq
Michael Ham

This project will develop the scientific framework to ascertain the benefit of employing very-high-resolution global models to investigate regional-scale phenomena. The goal is to test the hypothesis that higher resolution models are necessary to accomplish the related objectives of 1) the explicit simulation of nonlinear phenomena and interactions on the small scale that have feedbacks on large-scale climate features, and 2) the accurate and explicit simulation of local- to regional-scale phenomena, including low-probability, high-impact hydrological events. A rigorous evaluation of the hypothesis with high-resolution simulations of observed climate and variability will be the focus.

DEVELOPING A REGIONAL INTEGRATED ASSESSMENT MODEL FRAMEWORK

PI: Ben Preston

Funding:
$1.35M

Duration:
3 years

Sponsor:
DOE/SC/BER

Partners:
PNNL (Lead)
US Geological Survey
NOAA

Participating Staff:
Tom Wilbanks
Tony King
Mac Post
Auroop Ganguly
Dave Bader
Peter Thornton

This project will develop and apply a regional integrated assessment modeling framework (R-GCAM) to the Gulf Coast region of the United States. One of the main objectives of the proposed work is to understand the implications of integrated modeling at regional scales and how the insights that such models might provide differ from insights derived from models at coarser scales, particularly with respect to mitigation and adaptation decision-making. To this end, ORNL is undertaking a suite of research tasks in support of the development of R-GCAM including supporting modifications to CLM-CN and the Erosion Productivity Impact Calculator (EPIC) model to support their deployment in the regional context. ORNL will also develop quantitative models of the vulnerability of Gulf Coast/Southeast energy production due to climate change, and develop and apply methods for the characterization of nonlinear dynamics and tipping points in the context of regional climate variability and change and their impacts on ecological and socio-economic systems.

ULTRA-SCALE VISUALIZATION CLIMATE DATA ANALYSIS TOOLS (UV-DAT)

PI: Dave Bader

Funding:
$1.35M

Duration:
3 years

Sponsor:
DOE/SC/BER

Partners:
LANL
LBNL
LLNL (Lead)
University of UT

Participating Staff:
Galen Shipman
Ranga Raju Vatsavai
Feiyi Wang
Zhe Zhang

Working directly with climate science analysis projects, this project team will develop and deploy data and computational resources useful to a wide variety of stakeholders, including scientists, policymakers, and the general public. In particular, the team will work closely with BER-funded scientific programs to advance the development of state-of-the-art tools to support BER's science requirements, which includes making publicized data archives (such as model intercomparison projects data, observational data, and very high-resolution climate model simulations) more useful to stakeholders-climate researchers, policymakers, and the general public. In addition, this project will meet specific needs of national and international climate projects by integrating and developing tools and techniques suitable for large data sets in a familiar, distributed, federated infrastructure. The project will also provide international climate centers and U.S. government agencies with a wide-range of climate data analysis tools and diagnostic methods for ultra-large climate datasets-to include supporting working groups focused on mitigation and adaptation.

VISUAL DATA EXPLORATION AND ANALYSIS OF ULTRA-LARGE CLIMATE DATA

PI: Sean Ahern

Funding:
$1.539M

Duration:
3 Years

Sponsor:
DOE/SC/BER

Partners:
LANL
LBNL (Lead)
LLNL
UC Berkeley

Participating Staff:
Dave Pugmire
George Ostrouchov
Alex Sorokine

An insightful analysis in climate science depends critically on the choices of software tools to discover, access, manipulate, and visualize the often large and unwieldy datasets of interest. These data-exploration tasks can be complex and time consuming, and frequently involve use of many resources spread throughout the modeling and observational climate communities. The inability to find data, large data set sizes, lack of adequate metadata, poor documentation, and lack of sufficient computational and diagnostic/visualization resources impede climate researchers from using currently available climate data. This project seeks to help advance climate science by addressing all of these issues for the US DOE climate modeling and measurements data resources through the development of advanced software applications for data discovery, management, visualization, and analysis.

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CCSI Projects

DEVELOPMENT OF FRAMEWORKS FOR ROBUST REGIONAL CLIMATE MODELING

PI: Dave Bader

Funding:
$1.522M

Duration:
3 years

Sponsor:
DOE/SC/BER

Partners:
LANL
LBNL
PNNL (Lead)

Participating Staff:
Kate Evans
Moet Ashfaq

Predicting the regional hydrologic cycle at time scales from seasons to centuries is one of the most challenging goals of climate modeling. Because hydrologic cycle processes are inherently multiscale, increasing model resolution to more explicitly represent finer-scale processes may be a key to improving simulations of the hydrologic cycle. The team will propose a hierarchical approach with four increasingly complex stages to test the veracity of global high resolution, global variable resolution, and nested regional climate model for regional climate modeling. They hypothesize that systematic analysis of the fidelity of different modeling approaches in each stage will lead to better understanding of their relative merits and improve the frameworks for robust regional climate simulation. They will determine (1) whether modeling frameworks that allow scale interactions through global high resolution or variable resolution may be more skillful in simulating the regional hydrologic cycle in climate regimes dominated by convection, (2) whether regional coupled models are more skillful in simulating regional climate variability, and (3) whether differences in simulating feedbacks by different modeling approaches may be modulated by surface heterogeneities to amplify differences in simulating regional hydrologic cycle changes in the future climate.

CARBON DATA ASSIMILIATION TO IMPROVE ESTIMATES OF CURRENT AND FUTURE IMPACTS OF CHANGING CLIMATE ON TERRESTRIAL CARBON CYCLING AND FEEDBACKS ON CLIMATE

PI: Peter Thornton

Funding:
$1,535,603

Duration:
4 years

Sponsor:
DOE/SC/BER

Partners:
LANL
LBNL

Participating Staff:
Forrest Hoffman

Carbon-cycle climate feedback uncertainties play a large role in defining the overall uncertainty envelope for predictions of future greenhouse gas concentrations, terrestrial ecosystem structure and function, and associated climate changes. The processes thought to dominate the sign and magnitude of carbon-climate feedbacks vary across latitudinal zones, and integrated prediction of the global-scale feedbacks depend on detailed understanding of regional and zonal mechanisms connecting the terrestrial cycles of carbon and nutrients with the climate system. The approach is 1) to quantify critical uncertainties in global-scale climate predictions associated with carbon-climate feedbacks, 2) to improve our understanding and model representation of processes controlling these feedbacks through zonally-specific model-data evaluation exercises, and 3) to extend our data-based evaluation to quantification of carbon-climate feedback responses and uncertainties in a large population of global-scale carbon-climate models. Use of observations and experimental results to evaluate model performance is an integrating theme across these three regional focus areas. This effort will result in an improved model evaluation framework, building on the success of the existing Carbon-Land Model Intercomparison Project (C-LAMP). The team will add new observations and metrics to C-LAMP and use this system to test hypotheses related to the causes of variations among carbon–climate models.

Coming in July

Integrated Assessment
Highlighted Researcher: Peter Thornton
New NOAA Collaboration
Mike Kuperberg Visit & SPRUCE Tour

OAK RIDGE CLIMATE CHANGE SCIENCE INSTITUTE

One Bethel Valley Road
P.O. Box 2008, MS-6008
Oak Ridge, TN 37831-6008

Phone: 865-574-5435
Fax: 865-574-6476
E-mail: climatenews@ornl.gov

We're on the Web!
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RECENT DATA PRODUCTS

TJ Blasing and CDIAC published an important and unique atmospheric database during April. The "Atmospheric concentrations of methane, non-methane hydrocarbons, alkyl nitrates, and chlorinated carbon compounds including 3 chlorofluorocarbons (CFC-11, CFC-12, and CFC-113) in whole-air samples" database submitted by Dr. Donald Blake (University of California, Irvine) contains measured concentrations of several greenhouse gases and ozone-depleting gases, and covers time periods sufficient to reveal trends. Several ozone-depleting substances have been essentially discontinued, so tracking their concentrations reveals information about their atmospheric lifetimes. This database is also important from a climate viewpoint, as several of these gases have high global warming potentials. For example, this data shows a recent decline in atmospheric concentration of CFC-12, which has a global warming potential of 10,900 times an equivalent mass of carbon dioxide integrated over a century.

RECENT PUBLICATIONS

Gu, L., Pallardy, S.G., Tu, K., Law, B.E., Wullschleger, S.D., (2010) Reliable estimation of biochemical parameters from C3 leaf photosynthesis-intercellular carbon dioxide response curves. Plant, Cell and Environment (in press).

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Kramer C, Trumbore S, Froberg M, Cisneros-Dozal LM, Zhang D, Xu X, Santos G, Hanson P.J. (2010) Recent (<4 years old) leaf litter is not a major source of microbial carbon in a temperate forest mineral soil. Soil Biology and Biochemistry 42:1028-1037.

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Rosenzweig, C., and Wilbanks, T. (2010). "The State of Climate Change Vulnerability, Impacts, and Adaptation Research: Strengthening Knowledge Base and Community," Climatic Change, 100 (2010): 103-106.

CALENDAR

SciDAC 2010 (Chattanooga, TN) ……...11-15 July 2010
Summer School on Atmospheric Modeling (Boulder, CO) ……..…19-21 July 2010
Federation of Earth Science Information Partners, Summer 2010 Meeting* (Knoxville, TN) ……..…..…..…. 20-23 July 2010
2010 TeraGrid Conference (Pittsburgh, PA)…..……..…..…..…..2-5 August 2010
95th Ecological Society of America Annual Mtg (Pittsburgh, PA) ….……....1-6 August 2010
PROMITHEAS, The Energy and Climate Change Policy Network (Athens) ..……..7-8 October 2010
17th AMS Conference on Air-Sea Interaction (Annapolis, MD) …….. 27 Sept-1 Oct 2010
American Geophysical Union Fall Meeting (San Francisco, CA) ……....13-17 December 2010

*Denotes full or partial ORNL sponsorship.

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

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 global climate change science questions. You can view complete position descriptions and apply at www.jobs.ornl.gov.

- Deputy Division Director— Environmental Sciences
- Climate Computational Scientists
- Postdoctoral Research Associates