Number 1 — Spring 2010

Welcome!

Welcome to the first edition of OCCRI's quarterly newsletter. We showcase the Northwest's first climate science conference, which OCCRI is organizing; introduce our first staff hire, Kathie Dello; and highlight recent research results on global change, especially in the Northwest. With your input, we can expand the research highlights to keep you abreast of developments in climate science. Tell us what you think.

—**Philip Mote,** Director
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In This Issue . .

OCCRI will lead new NOAA RISA for the Northwest

The Oregon Climate Change Research Institute (OCCRI) led a consortium that proposed a new approach to regional climate services. Under the National Oceanic and Atmospheric Administration (NOAA) **Regional Integrated Science and Assessments (RISA)** program, the Northwest RISA project was open for competition, and OCCRI has learned that our proposal was successful.

The grant establishes the Pacific Northwest Climate Decision Support Consortium – one of what will soon be eleven RISA projects in the USA.

Faculty from Oregon State University will work with faculty from the Universities of Washington, Oregon, and Idaho and Boise State University, as well as Oregon Sea Grant and the extension programs of all three states, to address needs of businesses, state and federal agencies, municipalities, tribal leaders and non-governmental organizations for climate assessment and services in the Pacific Northwest.

Philip Mote and Denise Lach, also from OSU, are the principal investigators. Other faculty

(*Continued on page 2*)

OCCRI News

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Pacific Northwest Climate Science Conference

June 15 - 16, Portland, OR

The Pacific Northwest and British Columbia are home to some of the world's leading climate research institutions. Five of the Northwest's research universities have joined with 12 federal and 4 state agencies to organize the most comprehensive conference to date on the science of climate change and climate variability in the Pacific Northwest. Conference topics span a broad range of research and policy concerns in this region:

Climate in the Pacific NorthWest
Greenhouse gas fluxes
Ocean climate
Ecosystems
Hydrology
Human Systems and Management

In addition, a panel of state and federal officials will describe climate change activities. Tom Armstrong, senior advisor for Global Change Programs in the US Geological Survey, will kick off the panel discussion.

Over one hundred abstracts were submitted for poster or oral presentations at the conference. The program is available on the conference website. Prof. Andrew Fountain of Portland State University is the program chair.

With the support of its university and governmental co-sponsors, the Oregon Climate Change Research Institute is organizing this two-day conference and Portland State University is hosting it in Hoffman Hall on its campus. Abstracts are no longer being accepted, but registration is available on this Oregon State University website.

The university-based sponsors are Portland State University, the Climate Impacts Group at the University of Washington, Idaho's EPSCoR program, the Pacific Climate Impacts Consortium of British Columbia, and OCCRI. For further details, consult the conference website.

(***RISA program at Oregon CCRI*** *—Continues from page 1)*

involved are John Bolte, Barbara Bond, Chris Daly, and Peter Ruggiero from OSU; David Hulse from the University of Oregon; Venkataraman Sridhar from Boise State; John Abatzoglou and Von Walden from the University of Idaho; and Dennis Lettenmaier from the University of Washington. Mote participated in the previous Pacific Northwest RISA project at the University of Washington in Seattle, which had been the first NOAA-funded regional climate project in 1995.

Research by Bolte and Hulse demonstrates how the new RISA can help Northwest decision-makers. Their *Envision* project uses geographic information system (GIS) software to develop community environmental assessments and planning. They have worked with community leaders to assess alternative futures for the Willamette Valley and the Puget Sound region, and the RISA funding will permit incorporation of future climate impacts into *Envision*.

Funding for the consortium will begin in September 2010 and will open again for competition after five years. The project will hire a program manager and a climate extension specialist who will work in Oregon, Washington and Idaho. The project will also fund two post-doctoral researchers and two graduate students to work with faculty at the five participating universities.

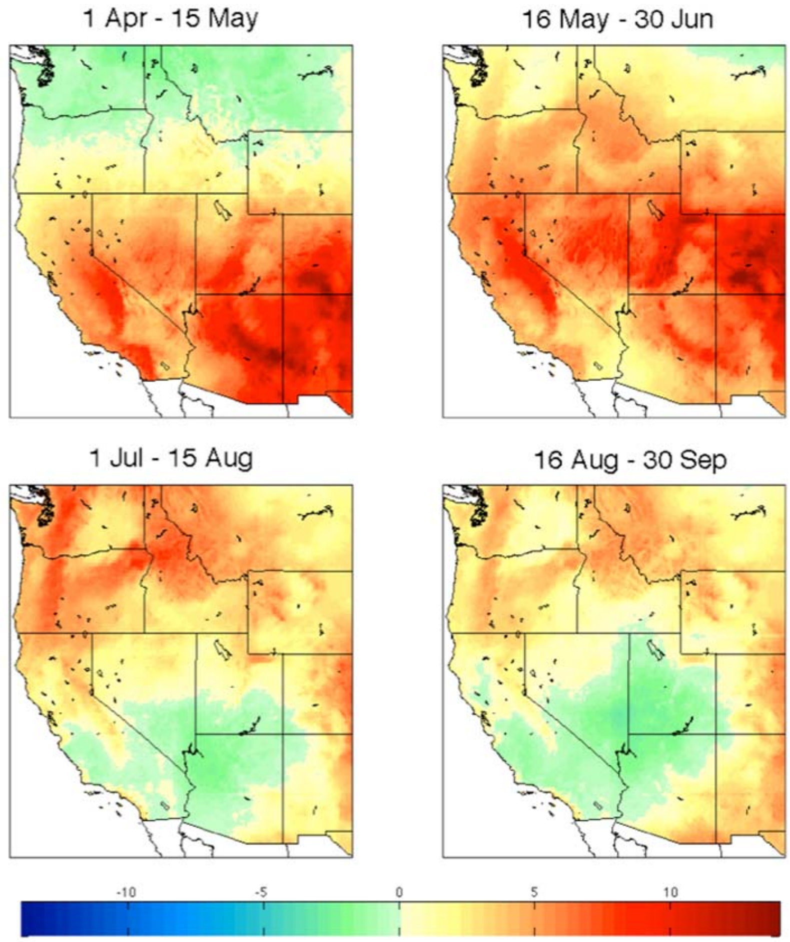
Highlights - European Geosciences Union Meeting

OCCRI Director Philip Mote returned from the annual meeting of the European Geosciences Union (EGU) with highlights about climate changes and their impacts:

Increased risk of fire in western states

T. Brown and J. Abatzoglou of the Desert Research Institute in Reno, Nevada calculated the changes expected in the *energy release component* index (ERC). The ERC index is used by fire managers to make day-to-day decisions in evaluating fire risk across the landscape. Using observed climate data for the 20th century, and climate model projections for the end of the 21st century, these authors mapped expected changes in the ERC index for the western states over the next 100 years (see figure at right). Springtime fire risk will remain low in our region, but summertime risk will increase in all of Oregon and Idaho and most of Washington—with a substantially higher fire risk in the Cascade Mountains and other highlands in mid-summer.

Brown also emphasized that the fire season is likely to begin some 2 to 5 weeks earlier. Furthermore, the risk of “synchronous fires” in much of the West has risen since 2000 and is projected to be the norm by 2100, with multiple large wildfires likely to occur at the same time in much of the region.



Change in Fire Risk over 21st century, using ERC index
(from presentation of Brown and Abatzoglou, 2010, at EGU)

Pacific Northwest streamflow declines

Luce and Holden (2009), of the US Forest Service in Boise, report that low streamflows have become much more prevalent in the Pacific Northwest over a period of 58 years, although mean streamflows have not changed much. In short, the statistical distribution of annual flows has broadened. They investigated whether precipitation and land cover were driving these trends, and suggested that east of the Cascade Mountains the main driver in changing the statistics of annual flow has been precipitation, whereas west of the Cascades the main driver was the re-growth of forests as logging rates diminished.

How will sea level change by 2100?

A. Grinsted of Copenhagen's Niels Bohr Institute estimated potential sea level rise by the year 2100 using a statistical model that considers many types of natural and human influences on sea level. The team projected sea level **to rise from 60 to 160 cm** in ninety years, with a most likely value of around 1 m. Their analysis has been published in *Geophysical Research Letters* (Jevrejeva et al., 2010), and is one of several recent statistically based estimates of future sea level rise. Other recent research into observed and modeled ice flow, especially in Greenland, has also advanced the understanding of future sea level rise.

Citations:

Jevrejeva, S., J. C. Moore, and A. Grinsted (2010), How will sea level respond to changes in natural and anthropogenic forcings by 2100?, *Geophys. Res. Letters.*, ***37***, L07703, doi:10.1029/2010GL042947.

Luce , C. H. and Z. A. Holden (2009), Declining annual streamflow distributions in the Pacific Northwest United States, 1948–2006, *Geophys. Res. Lett.*, **36,** L16401, doi:10.1029/2009GL039407.

OCCRI's new website

The image above depicts several new features at the site **http://www.occri.net**.

An "upcoming events" feature alerts you to meetings such as the Pacific Northwest Climate Science Conference (page 2).

An interactive page allows you to see how the Northwest environment may be affected when you change the CO_2 content of the air. In Oregon, these effects include changes in the water flow of the Columbia River, the times of high and low flow, and the amount of snowpack in the Cascade Mountains.

The Climate Science page offers a capsule summary of the greenhouse effect and the most important findings of the Intergovernmental Panel on Climate Change (IPCC). On other pages, the climate of Oregon and its variability is highlighted. Potential impacts of climate change on the region's agriculture, forests, water resources, and fish and wildlife are also summarized.

Comments are much appreciated and will enable us to better inform you. Write to *Darrin Sharp* at dsharp@coas.oregonstate.edu. Thank you!

Who we are . . .

Kathie Dello

Each newsletter we will publish a mini-bio of an OCCRI staff member. Here, our spotlight shines on Kathie Dello.

Kathie coordinates and edits the first-ever Oregon Climate Assessment Report, mandated by the legislation that created the Institute three years ago. In addition, she works with state agencies to bridge the gap between science and policy by building a Climate Adaptation Framework for Oregon.

Kathie supports the needs of our stakeholders for climate science information, and creates visualizations of such data for federal and state agencies and projects.

She is the public face of the Oregon Climate Service, which is the state climate office for Oregon and provides data and interpretations of past climate. Numerous inquiries about Oregon climate come to her.

Kathie comes to us from the New York State Department of Environmental Conservation. Prior to her many years there, she received a Master's degree in physical geography and a Bachelor's degree in atmospheric science from the State University of New York in Albany. Contact her at kdello @coas.oregonstate.edu.

New Fungal Infection Emerges in Pacific Northwest

Oregon State University biomedical scientist Robert J. Bildfell and ten colleagues reported an emerging disease causing lung infections and spread by spores in forested areas. Found only in tropical regions until recently, the fungus has been spreading from Vancouver Island since 1999, and now a unique strain has been found in Oregon by Edward Byrnes of Duke University. Among the 270 cases in British Columbia, Washington and Oregon, 40 people have died from fungal infections of the lungs and brain. Oregon has reported thirty-nine infections.

Byrnes says that many experts think the spread of *Cryptococcus gattii* is an effect of climate change. The Duke University-led team published their report in the medical journal PLOS Pathogens. They reported that the "studies extend our understanding of how diseases emerge in new climates and how they adapt to these regions to cause disease. Our findings suggest further expansion into neighboring regions is likely to occur."

Bildfell commented that, like most fungi, this species probably thrives in a damp environment rich in organic matter. New sub-strains are most often discovered in a region as organisms adapt to a new environment, he added.

Citation:

Byrnes, EJ, W Li, Y Lewit, H Ma, K Voelz, P Ren, DA Carter, V Chaturvedi, RJ Bildfell, RC May, J Heitman(2010): Emergence and Pathogenicity of Highly Virulent *Cryptococcus gattii* Genotypes in the Northwest United States. *PLoS Pathogens* **6** (4): e1000850. doi:10.1371/journal.ppat.1000850.

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Diminishing Snow Cover and Northern Hemisphere Circulation

The IPCC report (Lemke et al., 2007) and others have related the extent of snow-covered land in North America with temperature, and with changes in Northern Hemisphere circulation. Globally, the extent of snow cover has decreased in spring and summer, and is most variable in autumn. Over an 83-year period, snow cover in spring has diminished by 7.5%, and snowmelt now occurs nearly two weeks earlier. Yet snow cover has not decreased much in winter, and in North America, winter snow cover has actually increased due to increasing precipitation. Of all snow-related indicators, Brown and Mote (2009) found the duration of seasonal snow cover to be the strongest indicator of warming temperatures in most climates. Maritime climates having winter temperatures within ±5°C of the freezing point were the most sensitive.

McCabe and Wolock (2010) add to the understanding of these links by applying a snowmelt and accumulation model to a century-long dataset for the Northern Hemisphere. Their findings are:

- Snow cover in March has decreased since 1970, while winter temperatures (in the five months of November-to-March) have consistently increased. Decreasing snow cover area was strongly correlated with increasing temperature.
- The ratio of snow to total winter precipitation has decreased in all latitudes where snow occurs.
- Increasing temperatures throughout the hemisphere were accompanied by decreasing sea level pressure in the polar region, but by increasing pressure in low- to mid-latitudes. This implies that storm tracks and the preferred position of the polar front have shifted northward. It is consistent with observed precipitation decreases in mid-latitudes and increases in higher latitudes.

Warmer winter temperatures have resulted in a smaller fraction of winter precipitation that occurs as snow, in all locations, and in earlier snowmelt for most of the Northern Hemisphere. The changes in snow statistics are associated with atmospheric circulation changes consistent with the circulation changes projected by models for the 21st century.

Citations:

Brown, R.D., and P.W. Mote, 2009: The response of Northern Hemisphere snow cover to a changing climate. *J. Climate*, **22**: 2124-2145.

Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas and T. Zhang, 2007: Observations: Changes in Snow, Ice and Frozen Ground. Chapter 4 in: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK and New York, USA.

McCabe, G.J., D.M. Wolock, 2010: Long-term variability in Northern Hemisphere snow cover and associations with warmer winters. *Climatic Change* (March 2010) **99**: 141–153, DOI 10.1007/s10584-009-9675-2.

Climate Reanalysis Data may Never Attain Gold Standard of Climate Quality

Users of Earth observation data have long had different expectations about the quality of observations over the long term. Many people use observations to monitor the Earth "right now," while a few use the same data to diagnose changes over long periods of time. In atmospheric science, weather forecasters want the most complete analysis possible for one hour of observation; long-term trends do not matter for them. Climate scientists want to faithfully detect a slow trend over the long term and are willing to discard a lot of data that may not be reproducible from one decade to another.

Reanalyses are by far the most widely utilized climate data product. Some scientists, though, have called for a "climate quality" reanalysis that retains long-term fidelity (Karl, 2006). In the *Bulletin of the American Meteorological Society*, Thorne and Vose (2010) argue that reanalysis strategy would have to change before the products are recognized as faithful to long-term trends.

The current observing system was never designed for monitoring long-term changes in climate. Observations are neither spatially complete nor uniform. Changes in instruments, location, and even time of day of observations all introduce non-climatic biases that affect long-term data sets. Furthermore, these data sets are weighted toward the most recent data, and consist of huge volumes of remote sensing data mixed with a few in-situ observations. It is not realistic to expect any dataset to be perfect. How, then, can scientists agree that a dataset is climate quality? Thorne and Vose posit that a dataset could be considered climate qualify if its uncertainty lies within ±10% of the expected signal due to climate change, for important indicators.

Attaining climate quality data reanalyses requires minimizing the following errors:

Observational errors: Do not ingest all available data; rather, choose the data having longer and more stable periods of record.

Model errors: Current models are optimized for today's data-rich observation system. They are not optimized for fidelity to long-term trends.

Errors in methodology: When questions arise about including data, or correcting them, use Observing System Experiments (OSE) to answer questions about how to proceed. These experiments specifically test the impact of including or not including data.

Use ensembles to bracket the remaining uncertainty. Each member of the ensemble begins with a different choice (of physics, external forcing, etc.) from a set of equally sensible decisions.

The authors conclude that two sets of reanalysis may be needed: one as a snapshot for weather analysis, the other as a record of long-term climate trends.

Citations:

Karl, T. R., S. J. Hassol, C. D. Miller, and W. L. Murray, eds., 2006: Temperature trends in the lower atmosphere: Steps for understanding and reconciling differences. U.S. Climate Change Science Program Synthesis and Assessment Product 1.1, 180 pp.

Thorne, P.W., and R.S. Vose, 2010: Reanalyses Suitable for Characterizing Long-Term Trends: Are They Really Achievable? *Bulletin of the American Meteorol. Society*, 91: 353-361.

Gaps in Measuring Earth's Energy Budget

The net difference between energy coming into the planet from space and energy leaving the planet leads to global warming or cooling. This difference is too small to be measured directly, although satellites have measured the inbound and outbound fluxes separately since 2000. It has long been a challenge to close the energy budget of Earth. Trenberth and Fasullo (2010) plotted the excess energy that has returned from Earth to space and claim that, since 2005, a large and increasing portion of the excess cannot be accounted for (see their Fig. 1, next page). Most of the excess energy retained by the Earth has gone into warming the oceans, where it can be measured (blue area on the figure). Temperature measurements since 2004 suggest that the rate of ocean warming has slowed, but the slowdown cannot yet be explained. Melting

(Continued on page 7)

*(**Missing Energy . . . . Continued from page 6**)*

of ice on land and sea accounts for the small difference between the blue area and the area under the red curve. Note the increasing area of "missing energy" (light orange) which represents a difference between satellite measurements of excess energy leaving the Earth, and changes in the heat content of the planet—essentially in the oceans and the ice.

The authors conclude that closure of the energy budget is elusive.

Citation:

Trenberth, K.E. and J.T. Fasullo, 2010: Tracking Earth's Energy. *Science*, **328,** 316-317, 16 Apr 2010.

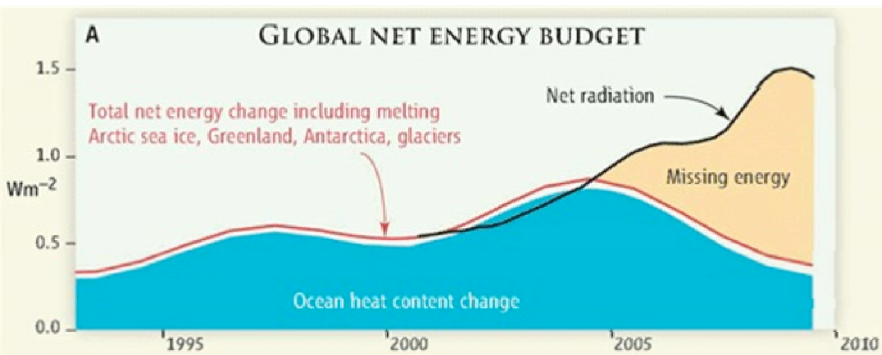

Fig. 1 from Trenberth and Fasullo (2010) (article above)

High CO_2 may alter Biochemistry of Food Webs

Even without the complication of global warming, the relatively rapid rise in the CO_2 concentration in the atmosphere (now 38% above the original, pre-industrial levels 150 years ago) has resulted in decreasing pH of the ocean, or in other words, ocean acidification (though more accurately, the ocean is becoming less basic). The abundance of CO_2 may also have a more subtle but equally large effect on the food web.

Van de Wal et al. (2010) comment on the rapidly expanding field of *ecological stoichiometry*, the investigation of the elemental composition of organisms and their environment, in *Frontiers in Ecology and the Environment*.

Land-based plants and oceanic phytoplankton (known as the *producers*) absorb carbon (C) from CO_2 in the air or water, as well as nutrients such as nitrogen (N) and phosphorus (P). They are quite flexible in living within a wide range of the carbon-to-nutrients ratio in the environment, and in fact, the ratio within their cells tends to mirror the ratio in the environment. When CO_2 is elevated in the environment, the C:nutrient ratio tends to be high in their cells.

That is not the case with all other organisms, known as the *consumers*, which as a rule are animals, fungi, and many bacteria. Many of these creatures tend to keep the C:nutrient ratio within narrow limits – a tendency termed *homeostasis*. Their intake of carbon and nutrients reflects the ratio found in their food. However, the nutrient content of animals is higher than the nutrient content of plants.

As a result, grazing organisms – animals that consume plants – can become nutrient-limited. Lab and field experiments have confirmed that greater availability of light led to greater abundance of phytoplankton, but also to a larger C:nutrient ratio in their cells. This decreased the quality of food for zooplankton, which consume the phytoplankton. In other studies, that suppressed growth of nutrient-demanding species.

In a nutshell:

- Rising levels of CO_2 lead to higher levels of carbon in ecosystems.
- Warming of the air leads to warming of surface waters, but little warming of deeper waters. That stratifies the water column, which suppresses the mixing of nutrients from deep water into the surface layer.
- Greater C content but lower N and P (nutrient) content in surface waters leads to higher carbon-to-nutrient ratios in phytoplankton.
- Such phytoplankton have less nutritional value.
- Changes in the elemental composition of organisms may cascade through the entire food web.

Citation:

van de Waal, Dedmer B., Antonie M Verschoor, Jolanda MH Verspagen, Ellen van Donk, Jef Huisman, (2010): Climate-driven changes in the ecological stoichiometry of aquatic ecosystems. *Frontiers in Ecology and the Environment:* **8,** #3, pp. 145-152. Doi: 10.1890/080178 .

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