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Advancing Ideas, Methods in Interdisciplinary Climate Change Research for New Ph.D.s

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The global environmental changes that the Earth is experiencing today impact the smallest of organisms to global biogeochemical cycles. Climate change, one of the most noticeable alterations, is at least partly caused by our influence on worldwide physical, chemical, and biological systems. Climate change also has strong implications for political, economic, and social policy. Because climate change affects such a wide variety of disciplines and people, pursuing research in this field requires an interdisciplinary approach. This need to simultaneously understand climate change and forecast and effectively deal with its impacts on present and future generations presents a great challenge to the global research community.

With this perspective in mind, the Dissertations Initiative for the Advancement of Climate Change Research (DISCCRS) was formed in 2002 to bring together recent Ph.D. recipients across the range of disciplines whose work involves climate change and its impacts.

DISCCRS is a multi-agency and multi-organization initiative sponsored by the American Geophysical Union, the American Meteorological Society, the American Society of Limnology and Oceanography, the Ecological Society of America, and Whitman College; and funded by NASA's Office of Earth Science and the U.S. National Science Foundation's Geosciences Directorate (Climate Dynamics and Education and Human Resources). The goal of DISCCRS is "to catalyze interdisciplinary understanding and peer networking among recent grads" by bringing them together via several different avenues. These various avenues are a Ph.D. Dissertation Registry that is accessible online (over 200 dissertation abstracts were registered during the program's first year; see http://aslo.org/phd.html), an electronic message board that fosters communication among the DISCCRS registrants, and a capstone symposium that brings the registrants together to introduce the concept of interdisciplinary research and its many possibilities.

The first of these symposia was held 10–15 March 2003, in Guanica, Puerto Rico. The week-long event brought together 40 recent graduates from 36 institutions and 11 countries. The participants were selected by a committee from among 72 applicants. Excellence and diversity of research background were the primary selection criteria to ensure that the participants represented a range of expertise.

First Symposium Held

The first part of the symposium was dedicated to sharing each participant's doctoral work. Due to the variety of scientific disciplines represented, many key elements of current climate change research were presented. Topics included:

- **Climate modeling and atmospheric science.** The impact of aerosols, ozone, dust, pollution, and clouds on climate; El Niño-Southern Oscillation (ENSO);
- **Paleoclimate.** Evidence for climate variability from cave stalagmites, Scottish pine, and marine and lake sediments; glacial-interglacial variability of sea ice and the carbon cycle;
- **Modern climate.** Links to biogeochemical cycling, lake ecosystems, carbon sequestration in forests, the hydrological cycle, terrestrial habitat loss, and biodiversity;
- **Tropical climate change.** Relation to variation in coral growth, tropical trees, and ecosystems;
- **High-latitude climate change.** Relation to Arctic sea ice, the carbon cycle in the Arctic tundra and the upper ocean, and glacier dynamics;
- **Social science.** Policy development and conflict resolution in environmental and developmental negotiations.

As can be seen by the list above, correlations were demonstrated between climate and many different natural systems. Implications for the future were woven into both formal presentations and informal discussions. In addition, many of the social and political difficulties of mitigating for and adapting to climate change were highlighted. By showing just how pervasive the impacts of climate change are on our world and how tricky it is to deal with them, these presentations laid the foundation for the rest of the week: the truly interdisciplinary part of the symposium.

For the next 4 days, the participants worked together to develop interdisciplinary strategies for defining the complex processes and interactions of climate change and its impacts. Formal discussions were formed around topics that were chosen by the group. These included the implications of climate change for species interactions, forests, and biogeochemical cycles, as well as ways in which temporal (fast versus slow), spatial (large versus small), and ecological (species versus ecosystem) scales affect our ability to do research and properly understand our results. A large group discussed the politics of climate change and the difficulties inherent in getting people and political entities to acknowledge climate change and pursue its mitigation. Another lengthy discussion focused on mentoring. From these sessions, participants began to learn how to assemble an interdisciplinary team to cover the range of expertise necessary to address the issues of climate change.

To help the group more successfully work in teams, communication consultant Chris Olex led sessions on communication skills and working group dynamics. Another important aspect of being a scientist is sharing your work with the wider public. Ashley Simons of SeaWeb focused on communicating beyond academia, both with the public and the press. The suggestions presented by these two experts apply both to speaking and to writing effectively, skills that new scientists often have not extensively practiced.

"Ideal" Climate Change Program

One of the most important parts of the symposium was a session during which participants were asked to design the "ideal" climate change Ph.D. program. We discussed the positive and negative aspects of our respective Ph.D. programs and tried to identify program components that would be more conducive to creating an environment of "interdisciplinarity" and bestowing general knowledge in climate change. It was commonly agreed that any climate change researcher needs a disciplinary anchor for credibility and for finding job opportunities.

However, many had difficulty finding supervisors and program components that went beyond this disciplinary structure and fostered the pursuit of interdisciplinary research. It was suggested that, rather than creating a specific department or degree in climate change, the ideal program would give students access to a climate change institute on campus from which he or she could take courses and pursue a minor, in addition to the disciplinary major. The institute faculty could serve as co-advisors. In addition to interdisciplinary scientific training, the ideal programs would train students to work effectively as part of an interdisciplinary team.

To pursue professional research, knowledge of funding opportunities and training in proposal development is essential. Representing the U.S. National Science Foundation, Fae Korsmo gave an overview of programs relevant to interdisciplinary research in climate change. Korsmo, symposium organizer Susan Weiler, and two established DISCCRS interdisciplinary mentors, Jerry Mahlman and Ronald Mitchell, provided practical guidelines for writing quality proposals. Jerry, an atmospheric scientist, and Ron, a political scientist, also spent innumerable hours presenting their perspectives on building interdisciplinary careers and interacting with colleagues from different disciplines and beyond the scientific community. During both formal and informal meetings, they shared their day-to-day experiences as professional scientists and their perspectives on the future of climate change research. Jerry and Ron also led sessions on job-hunting and mentoring of undergraduate and graduate students. By being official mentors at the DISCCRS symposium, they have both agreed to be available to the participants to address questions and concerns that may arise throughout the early stages of their careers.

In addition to providing an overview of climate-related research, the symposium enabled the participants to establish a diverse peer network that has already been put to use. This network should encourage interdisciplinary thinking, result in new pathways for addressing climate change research, and enrich the participants throughout their professional lives. Most of the participants have encountered obstacles and challenges to building interdisciplinary scientific careers. The main problem is continued disciplinary segregation in both the education and publication processes. While these challenges can be daunting, the symposium showed how interdisciplinary science can work and what can be accomplished by transcending the traditional disciplinary boundaries.

Acknowledgments and Final Notes

We extend special thanks to C. Susan Weiler for her excellent organization of the DISCCRS program and symposium; to Ashley Simons for reviewing this manuscript; and to Ron Kiene and David Kieber, who have made their collaborative proposal available electronically for use as a model to new scientists (http://aslo.org/phd/modelproposal.pdf). Pending success of a new proposal, a second DISCCRS symposium will be held in 2005. In the interim, the DISCCRS Ph.D. Dissertation Registry and news list sign-up will continue at http://also.org/phd.html.

—JULIE FRIDDELL, Cold Regions Research and Engineering Laboratory, Hanover, N.H.; and THORSTEN BLENCKNER, Uppsala University, Sweden

MEETINGS

Great Plains Workshop Held to Prepare for USArray Deployment

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Relative to most parts of North America, the Great Plains region, which is bordered by the Rocky Mountain Front on the west and the Mississippi River on the east, has been understudied in terms of the structure, formation, and evolution of the underlying crust, mantle, and core. The anticipated arrival of the USArray portable seismic stations, which will cover the entire United States regardless of surface geology and tectonic activities, and the deployment of the accompanying flexible array stations and the permanent seismic stations in this area, will fill this gap and address numerous problems related to the structure and dynamics of the Earth. Detailed information about USArray can be found at http://www.earthscope.org/usarray/.

To maximize the effectiveness of the upcoming USArray, formulate cooperative studies, and identify geologic targets for detailed studies using the flexible array stations of USArray, a pre-EarthScope Great Plains workshop was recently hosted by Kansas State University's Department of Geology. The workshop brought together about 40 geoscientists with interests ranging from surface processes to mantle dynamics, from about 25 institutions. Participants discussed scientific objectives related to USArray's Great Plains coverage, with an emphasis on future collaborations to maximize our understanding of the geology of the Great Plains region, from the Earth's surface to the core-mantle boundary. This will lead to a better understanding of the geologic development of cratonic regions, and provide valuable data for integrated studies of continental lithosphere and deep Earth structure over a wide range of scales.

Presentations and posters of related geological and geophysical research provided useful background information for the discussions. The workshop concentrated on the topical problems highlighted below.

Formation of the Great Plains

The Great Plains region, currently part of the "stable" North American Platform, had an active tectonic history in the Precambrian period. Most of the Precambrian metamorphic and igneous rocks are covered by Phanerozoic sedimentary strata of marine and non-marine origin. The basement of the Great Plains consists of a series of island arcs accreted to the craton by Proterozoic collisions in the area between the current Rocky Mountains and the Nemaha Uplift to the Canadian Shield. All of these accretionary features persisted as zones of weakness in the crystalline basement, and were the trends of rejuvenation during periods of regional stress. This is an ideal locale for studying accretionary features such as the composition, thickness, and fabrics of the crust and mantle at different stages of the Earth's history, and for gaining a better understanding of plate tectonic processes using data from USArray.

In the Great Plains region, surface and subsurface structure displays a series of anticlinal arches that are attributed to horizontal contraction. The gentle folds may be associated with the final phases of the late Paleozoic Appalachian orogeny, and the Mesozoic and Cenozoic Laramide orogeny. These structures indicate that the lithosphere is capable of transmitting stresses into the continental interior. Detailed mapping and analysis of those intra-continental structures, using data from USArray, will provide critical information on intra-cratonic deformation and the strength of the lithosphere.

Crustal and Mantle Structure Beneath the Mid-continental Rift

Geophysical study of major continental rifts has been largely focused on modern rifts. It is now clear that beneath most modern rifts, there is a thinned crust and up-warped asthenosphere which replaced a significant part of the continental lithosphere. It is unclear, however, whether the modified lithosphere will become normal or remain chemically distinct after the rifting process ceases, and whether the "lost" crust will be reclaimed. The 1.1-billion-year-old Mid-continental Rift (MCR) is an ideal location to answer those questions.

MCR is a 2000-km-long and 100-km-wide feature. It extends from Kansas, or possibly farther south to New Mexico and Texas, through Iowa, Minnesota, and Wisconsin, before turning southeastward into Michigan. During the 20–40 million years of rifting, which is a relatively short period compared to the rifting duration of other ancient and modern rifts, it was a zone of considerable seismicity and volcanism, which erupted a layer of basaltic lava up to about 20 km thick along the rift valley. These rocks yield large gravity and magnetic anomalies. Results from previous seismic experiments suggest normal mantle velocities and thickened crust beneath the MCR. In addition, it seems that the original mantle fabrics associated with the rifting process have been eliminated or significantly weakened. Those results, if confirmed by USArray, will enable us to better understand the post-rifting evolution of the hot and possibly depleted mantle beneath continental rifts.

Transition from the Rocky Mountains to Great Plains

The nature of the transition from the western U.S. orogenic zones and the stable Great Plains