variability caused by forcing, the models' physics, and the models' errors due to the problems with numerical representation of model equations. It is important to overcome these problems by improving model forcing and internal model parameters based on observations. Processes of vertical and lateral mixing and the parameterization of eddies, plumes, freshwater and heat fluxes, the cold shallow halocline, and brine formation also require refinement and validation. With the increase in model horizontal resolution, sea ice dynamics and thermodynamics must be improved toward (1) a better description of small-scale processes and deformations and (2) the introduction of forcing at inertial and tidal frequencies. Frazil ice (initial stage of sea ice) formation and land-fast ice (which forms and remains fast along the coast) development and decay have to be taken into account as well.

The reduction of uncertainties in terrestrial model results can be achieved via the improvement in information about evapotranspiration, soil characteristics, precipitation and moisture fluxes, permafrost characteristics, and processes in wetlands and peatlands.

The use of a multiensemble approach based on different model realizations with standardized forcing can be valuable for the analysis of model uncertainties.

S4D Coordination

A coordinated community approach to the investigation of Arctic climate variability is the only way to assess the degree of uncertainty in the results and conclusions of different modelers, scientific groups, or institutions. Coordinated S4D activities will contribute to this assessment by establishing a set of benchmarks characterizing state-of-the-art Arctic climate modeling and the most up-to-date analysis of the Arctic climate and its variability. The benchmarks will constitute basic characteristics of polar processes that each model should reproduce with a given accuracy. These include, for example, patterns of atmosphere, ice, and ocean circulation and other parameters that characterize major climate states. A model that cannot meet these benchmarks will be recommended for improvement before its application in Arctic studies.

One of the major impacts of S4D activity will be the engagement of young scientists in Arctic studies. The program provides guidelines for a new generation of Arctic modelers on how to critically analyze and improve Arctic modeling. S4D will pay special attention to educational outreach to young scientists through publications, Web sites, and workshops, to encourage them to learn about and participate in Arctic research and modeling.

For more information about DAMOCLES and SEARCH, visit the following Web sites: http://www.damocles-eu.org/index.shtml and http://www.arcus.org/search/index.php.

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MEETINGS

The Science of Global Soil Change: Networking for Our Future

Global Soil Change Workshop; Duke University and Center for Environmental Farming Systems, Durham and Goldsboro, North Carolina, 10–13 December 2007

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Some of the most important scientific questions today concern the future of Earth's soil. Understanding the biological, ecological, chemical, and physical processes governing soil functions is directly related to most if not all of the grand challenges in environmental science outlined by the National Academies (*Grand Challenges in Environmental Sciences*, National Research Council, 2001). Because of the inherently long-term nature of soil change, addressing these questions requires research over decadal timescales. This feature of soil science presents significant challenges to those designing and implementing research programs, and yet is critical to the understanding of soil systems and the improvement of land management.

To promote and expand long-term soil research, a workshop was convened in December 2007 where participants from Africa, Asia, Australia, Europe, and the Americas formally established a global network of long-term, soil research studies. The workshop highlighted the proposition that soil studies spanning decades are critical to answering some of the most significant questions faced by humanity: (1) Can soils more than double food production in the next few decades? (2) How does soil interact with the global carbon cycle? (3) How can land management improve soil's processing of carbon, nutrients, wastes, toxins, and water?

The long-term soil research network is supported by an advanced-format Web site that showcases more than 150 long-term studies and encourages scientists from around the world to collaborate in new ways (http://ltse.env.duke.edu). At the workshop, researchers presented results from long-term studies of soil fertility and contamination, crop production, greenhouse gas emissions, and water quality. All researchers emphasized the efficacy of long-term soil experiments to quantify fundamental ecosystem changes over timescales of decades to centuries, changes that may be entirely undetectable without long-term monitoring and analysis.

Participants were challenged to engage in cross-site studies to advance the science of sustainability and to promote new, long-term studies to learn how to best meet growing demands placed on soils. Henry Janzen (Agriculture and Agri-Food Canada, Lethbridge, Alberta) made an impassioned plea for a new generation of Earth scientists to expand the vision of those who initiated long-term soil experiments, some in the nineteenth century. Participants expressed concerns about funding levels for long-term soil studies, many of which suffer from lack of stable institutional support. Many remain productive only through the dedication of individual scientists. According to workshop organizer Daniel Richter, professor of soils and ecology at Duke, "Long-term soil observatories need explicit and much greater support not only to improve our rapidly intensifying management of land and water, but also to better manage environmental change."

At the conclusion of the workshop, Ishaku Amapu (Ahmadu Bello University, Zaria, Nigeria) emphasized that "we need to make our long-term experiments work harder." Such long-term research requires long-range planning coordinated across many disciplines, and workshop organizers invite interested scientists, students, and the public to join this international effort. Organizers have funding support from the U.S. National Science Foundation's Research Coordination Network Program and Critical Zone Exploratory Network, the U.S. Department of Agriculture, and Duke University for five yearly meetings.

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