Cornellians build computer climate-change model

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(PhysOrg.com) -- Researchers are contributing to a new model of climate change that may give more accurate predictions of the amount of carbon dioxide and other greenhouse gases in Earth's future.

As Yogi Berra said, prediction is hard -- especially about the future. The computer models scientists use to predict climate change are always works in progress.

In a sort of cosmic reality competition, 20 groups around the world are developing new models they plan to submit for review under the auspices of the Intergovernmental Panel on Climate Change (IPCC), the international body whose recommendations are being considered at the U.N. Climate Change Conference in Copenhagen, which ends Dec. 17. Three modeling groups are based in the United States, and Cornell researchers are involved in one of them.

Natalie Mahowald, associate professor of earth and atmospheric sciences, and Peter Hess, associate professor of biological and environmental engineering, are members of a large group of scientists nationwide working on the Community Climate System Model (CCSM), managed by the National Center for Atmospheric Research, with funding from the National Science Foundation and the U.S. Department of Energy. Mahowald is co-chair of the CCSM Biogeochemistry working group; Hess is co-chair of the climate/chemistry working group.

Eventually, all the models and their output will be submitted to a vast online archive hosted by the U.S. Department of Energy for all scientists to review and use, and the results of that work will become part of the next IPCC report, due around 2013.

Models of the physical climate that attempt to predict how the interaction of land, atmosphere and oceans will determine future temperature and weather have not traditionally included the carbon cycle -- how carbon moves between land, air, water and living things -- Mahowald notes. Meanwhile, other models have considered the carbon cycle separately in land, atmosphere and oceans. Many models also have simplified computation by treating the atmosphere as two-dimensional.

The new round of "fully coupled 3-D" climate models for the next IPCC report will include modeling of the entire carbon cycle, including predictions of the amount of the greenhouse gas carbon dioxide (CO2) that will be present in the atmosphere. This requires understanding how vegetation and ocean productivity respond to climate change, Mahowald points out.

The CCSM climate/chemistry working group also is working to add to the model other constituents of the atmosphere that affect Earth's temperature, such as methane, nitrous oxide and ozone and aerosols. The concern is not only with climate change, Hess points out, but also with the health effects of pollutants.

The number of interacting elements in a climate model is large and growing. Burning fossil fuels release CO2, and humans and animals exhale it, while plants absorb it and some dissolves into the ocean. Some scientists have assumed that the capacity of plants and oceans to absorb the gas is unlimited, but humans are cutting down forests and changing the chemistry of the oceans; a warming climate speeds the decay of dead vegetation to release its stored CO2 and reduces the amount of gas the water can dissolve.

Some models assume that more CO2 will encourage more plant growth to absorb more of the gas. CCSM is one of the first fully coupled 3-D models to take into account the limitations placed on plant growth by the availability of nitrogen. Most plants can't take the nitrogen they need out of the air. It must be "fixed" in a water-soluble form by such plants as legumes working with symbiotic bacteria, or by industrial processes that make synthetic fertilizer. Since the amount of fixed nitrogen is finite, the ability of plant growth to expand to absorb additional CO2 could eventually reach a limit, according to this model. In models that include nitrogen limitation, predicted future levels of CO2 are higher than in "carbon only" models. That conclusion is still controversial, Mahowald notes.

The new models are tested by comparing their output with climate data from 1850 to 2000; then the model is run on into the future, as far distant as 2200. The modelers try three scenarios: With ideal reductions in emissions; with "politically feasible" changes; and with "business as usual." Preliminary runs suggest that in the first case "we will be pretty well off," Mahowald says, "but it will be very hard to get to." The second case is "not so good," and the last is "pretty dire."

But the models still need refinement and must be compared with improved measurements in the field, Mahowald points out. "You put in your best guess of how something works, and then you have to revise," Hess explains.

The CCSM group has advocated for creating an organized system to compare computer models with observations in the field. "We need to involve global modelers and observationalists to design and perform numerical and field experiments to understand what is going on in the real world," Mahowald says. "There are many studies that have not yet been used to compare to the model."

The basic predictions of climate change are based on very simple models, but we need to develop and refine these more elaborate models to make the predictions more precise, Hess says.

"This is the first or second generation for these models. In five or 10 years we'll have models we can trust much more," Mahowald concludes. "That will show us how much we have to cut emissions, but in the meantime, we have to be coming up with new energy technologies and cutting as much as possible."

Provided by Cornell University

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