Key new ingredient in climate model refines global predictions

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For the first time, climate scientists from across the country have successfully incorporated the nitrogen cycle into global simulations for climate change, questioning previous assumptions regarding carbon feedback and potentially helping to refine model forecasts about global warming.

The results of the experiment at the Department of Energy's Oak Ridge National Laboratory and at the National Center for Atmospheric Research are published in the current issue of Biogeosciences. They illustrate the complexity of climate modeling by demonstrating how natural processes still have a strong effect on the carbon cycle and climate simulations. In this case, scientists found that the rate of climate change over the next century could be higher than previously anticipated when the requirement of plant nutrients are included in the climate model.

ORNL's Peter Thornton, lead author of the paper, describes the inclusion of these processes as a necessary step to improve the accuracy of climate change assessments.

"We've shown that if all of the global modeling groups were to include some kind of nutrient dynamics, the range of model predictions would shrink because of the constraining effects of the carbon nutrient limitations, even though it's a more complex model."

To date, climate models ignored the nutrient requirements for new vegetation growth, assuming that all plants on earth had access to as much "plant food" as they needed. But by taking the natural demand for nutrients into account, the authors have shown that the stimulation of plant growth over the coming century may be two to three times smaller than previously predicted. Since less growth implies less CO_2 absorbed by vegetation, the CO_2 concentrations in the atmosphere are expected to increase.

However, this reduction in growth is partially offset by another effect on the nitrogen cycle: an increase in the availability of nutrients resulting from an accelerated rate of decomposition - the rotting of dead plants and other organic matter - that occurs with a rise in temperature.

Combining these two effects, the authors discovered that the increased availability of nutrients from more rapid decomposition did not counterbalance the reduced level of plant growth calculated by natural nutrient limitations; therefore less new growth and higher atmospheric CO_2 concentrations are expected.

The study's author list, which consists of scientists from eight different institutions around the U.S. including ORNL, the National Center for Atmospheric Research, the National Oceanic and Atmospheric Administration Earth System Research Laboratory, and several research universities, exemplifies the broad expertise required to engage in the multidisciplinary field that is global climate modeling.

"In order to do these experiments in the climate system model, expertise is needed in the nitrogen cycle, but there is also a need for climate modeling expertise, the ocean has to be involved properly, the atmospheric chemistry . . . and then there are a lot of observations that have been used to parameterize the model," said Thornton, who works in ORNL's Environmental Sciences Division.

"The biggest challenge has been bridging this multidisciplinary gap and demonstrating to the very broad range of climate scientists who range everywhere from cloud dynamicists to deep ocean circulation specialists that [incorporating the nitrogen cycle] is a worthwhile and useful approach."

The ability to handle the increase in complexities of these models was facilitated by the capabilities of ORNL's Leadership Computing Facility, which currently houses the world's fastest supercomputer for civilian research. Jim Hack, director of the National Center for Computational Sciences, emphasizes that Thornton and his team were not limited by computational resources in the construction of his model. "It's one of the laboratory competencies, so we want to make sure we enable leadership science," he said.

This breakthrough is one more step toward a more realistic prediction for the future of the earth's climate. Nevertheless, potentially significant processes and dynamics are still missing from the simulations. Thornton also stresses the importance of long-term observation so scientists can better understand and model these processes.

A 15-year study of the role nitrogen plays in plant nutrition at Harvard Forest was an important observational source used to test their mathematical representation of the nitrogen cycle--a long experiment by any standards, but still an experiment that, according to Thornton, could improve the accuracy of the simulation if conducted even longer.

Other shortcomings of climate simulations include the disregard of changing vegetation patterns due to human land use and potential shifts in types of vegetation that might occur under a changing climate, although both topics are the focus of ongoing studies.

Source: Oak Ridge National Laboratory (news : web)