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NCAR Scientists Study Effects of Rising CO_2 Levels on El Niño

NCAR scientists Gerald Meehl and Grant Branstator, Climate and Global Dynamics Division (CGD), and CGD director Warren Washington have recently simulated changes in the El Niño/Southern Oscillation (ENSO) that may result from increased levels of greenhouse gases.

Meehl, Branstator and Washington are the first scientists to document the possible changes of ENSO events in a global climate model with doubled levels of greenhouse gases. Several other modeling centers in the United States, England, Germany, and Australia are working on similar problems. The use of a dynamical ocean model was critical to the experiment, because the ocean-atmosphere interaction plays a tremendous role in the development of ENSO. In the observed system, easterly trade winds normally tend to push warm surface water toward the western Pacific, with cold waters rising to the surface in the eastern Pacific. In turn, the ocean temperatures affect atmospheric convection and a lack or abundance of precipitation. However, about every three to five years, the coupled ocean-atmosphere system produces a dramatic alteration of these conditions. Warmer waters then appear in the eastern Pacific, and weather patterns change as a result. The exact timing and strength of ENSO events are still impossible to predict.

As depicted in a global circulation model, ENSOs continue to occur, but their effects on weather in the midlatitudes may be quite different from those today. These variations occur, in part, because of ENSO's interaction with a weaker midlatitude jet stream caused by reduced temperature gradients between the poles and equator. This change in the strength of the westerlies will change how large-scale atmospheric waves propagate from the tropical Pacific, where ENSO is centered. In one simulation using a version of NCAR's community climate model coupled to a dynamical ocean model, the western United States experiences colder winters during composite El Niño events in an increased carbon dioxide (CO_2) environment, as opposed to the warmer winters that now occur in the West during most El Niños in the model. In the eastern United States, the opposite is found.

The tropics also experience change in this experiment, in which an atmosphere with double the present-day levels of CO_2 is modeled for 40 to 60 years. Increases in average water temperature of the tropical Pacific, due to warming associated with the increased CO_2, magnify evaporation during ENSO events. In turn, the areas of heavy rain in an ENSO event become more intense. The compensating atmospheric circulations could intensify drought in such areas as Australia, where crop yields have been directly correlated with ENSO. Other social implications of ENSO may also be heightened as the extreme conditions that already occur are superimposed on other changes produced by enhanced greenhouse warming.

Because of the uncertainties around ENSO, there is intense global interest in the work of Meehl, Branstator, Washington, and their colleagues at other institutions. Concerns range from sea-level changes to the length of growing seasons to the economic future of countries bordering the Pacific. According to Meehl, nations may have no choice but to manage their resources more wisely, given that the climate effects associated with the already unpredictable El Niño may change in years to come.

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