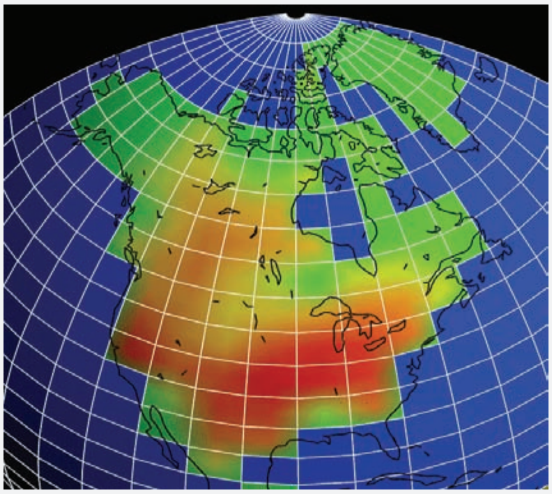
RESEARCH at the University of Maryland

Climate Modeling and Prediction



Though climate models currently predict a "warmer" world, climate modelers note that *warming* does not capture the full picture. What is really underway is rapid and sustained change in familiar weather patterns across the globe. Some places will be warmer and dryer than in the past; other places will be wetter and cooler. Moist forests can dry out; savannahs may be pelted with hail. To adapt to these inevitable climate changes, governments, businesses, and international organizations need reliable climate models that can predict where and how climate patterns will change.

Climate researchers at the University of Maryland are working on models that can provide reliable climate predictions for officials and executives. Situating their models between the familiar seven-day weather forecast and the century-long global-warming projection, Maryland researchers are developing practical short- and mid-term models that can help decision makers anticipate and address climate change.

Hugo Berbery works to improve variable rainfall predictions–vital tools for farmers and agricultural policy makers

Antonio Busalacchi studies tropical ocean circulation to refine climate models and improve hurricane prediction.

James Carton examines how the ocean traps and stores heat, which helps scientists make sense of this poorly understood driver of weather and climate.

Michael Fox-Rabinovitz's work is leading to improved predictions of extreme weather events such as monsoons, intense storms, and drought.

Eugenia Kalnay uses chaos theory to improve weather forecasting. She also documents land-use patterns and their contribution to climate change.

Ning Zeng investigates how ice sheets store carbon to predict the complex atmospheric effects of polar ice loss.

Improving Rainfall Forecasts for Farmers

Rapid changes in climate can mean unexpected changes in the frequency and quantity of rain, a vital resource for most stakeholders. For example, many farmers depend on rainwater for their crops. Hugo Berbery works to reduce uncertainty in understanding regional water cycles by focusing on complex interactions between land surfaces and the atmosphere. For example, Berbery works with soil moisture, a variable that has only recently been shown to be an important component in regional rainfall patterns and humidity levels.

Berbery also studies regional mechanisms that force monsoon precipitation over North and South America

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Modeling the Climate Effects of Tropical Oceans

Antonio Busalacchi, director of Maryland's Earth System Science Interdisciplinary Center, studies the role of tropical ocean circulation in climate. When a tropical ocean event like El Niño interacts with a land system like a specific vegetation pattern, the link is called a "coupled system." Examining coupled systems often requires data assimilation; land-based and ocean-based measurements must be reconciled to produce compatible data for coherent climate models. Busalacchi's data-assimilation work helps to predict specific kinds of events. For example, variations in El Niño events might shape irrigation needs in the critical farming valleys of Central California. Similarly, La Niña periods, due in part to jet stream path changes, boost the likelihood of hurricane events for the US.

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Understanding the Role of Oceans in Climate Change

James Carton studies the physical properties of the ocean to better understand how the seas store heat and release that energy into the atmosphere.

Over half of the solar radiation reaching the Earth is first absorbed by the ocean; thus, understanding the ocean's role in storing heat is essential for understanding climate. Carton applies data-assimilation techniques to current and historical ocean temperature data to improve modeling outcomes. Applying new models to old data helps reveal specific relationships between the oceans, the air, and global temperature change.

Carton also studies how the ocean releases stored energy, a process that drives both air and water currents. The role of "liquid wind" in generating weather is a key mystery in weather and climate studies. Understanding ocean circulation is also important for global shipping and mapping.

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Modeling the Regional Climate Change for Adaptive Planning

Climate modelers often "think big," synthesizing mountains of data into global predictions. Michael Fox-Rabinovitz also assimilates huge multivariate data sets, but he scales down his models to account for regional and sub-regional scenarios. For example, his models can anticipate extreme atypical weather events, such as monsoons and hurricanes, in specific parts of the US. Knowing where and when these events are likely to occur will help in adaptation planning.

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Accounting for Uncertainty in Weather Forecasting

Eugenia Kalnay works to improve "ensemble" weather forecasting using the tools of probability and chaos theory. Chaos theory describes the behavior of complex systems whose outcomes are highly sensitive to small variations in initial conditions. Weather is a chaos system, with thousands of inputs. Therefore, the most accurate forecasting procedures need to apply chaos theory. Kalnay uses the complex math of chaos theory in ensemble forecasting, a process that synthesizes a massive quantity of data to predict weather more accurately. To make ensemble forecasting accessible, Kalnay helped pioneer the use of "spaghetti plots," a visualization that translates chaos equations into an easy-to-read check on forecast accuracy. If the visualized data plot looks like neatly bundled spaghetti strands, the forecast is "good." If the data plot looks like a plate of tossed and tangled spaghetti, then the forecast is inaccurate.

Kalnay also works on estimating the impact of land cover and land use in climate change. By analyzing long-term temperature data recorded from satellites and weather balloons, Kalnay revealed that land-use practices alter the climate nearly as much as greenhouse gas emissions. Her work on land use and climate change was chosen by *Discovery Magazine* as one of the top 100 science news stories of 2004.

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Modeling the "Hidden Carbon" in Melting Ice

Ning Zeng studies carbon stored in ice sheets to understand how melting ice might affect the atmosphere. Zeng believes that ice sheets may be huge "sinks" of carbon dioxide. This gas moves between the biosphere, geosphere, hydrosphere, and atmosphere in the global carbon cycle. When carbon is stored in the geosphere–including stable ice formations–less carbon is loose into the atmosphere. This "carbon sinking" can help stabilize climate by keeping carbon dioxide out of the atmosphere, thus reducing global warming.

If Zeng's work is correct, as ice sheets melt, a large store of carbon may be released very quickly. Many climate models do not account for the possibility of this sudden "burp" of carbon, which means that adaptation plans could be based on inaccurate predictions.

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