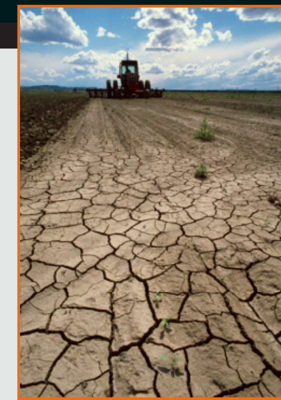
What are Some Examples of Regional Applications of Global Climate Models?



With the increased availability of climate model simulation output, impacts and applications users are rapidly applying the model results for their needs. Just as quickly, the breadth and diversity of applications will continue to grow in the future as climate is no longer considered stationary.

WATER RESOURCES IN THE WESTERN UNITED STATES

The possibility that climate change may adversely affect limited water resources in the mostly arid and semiarid western United States poses a threat to the prosperity of that region. A group of university and government scientists, under the auspices of the U.S Department of Energy–sponsored Accelerated Climate Prediction Initiative Pilot Project, conducted a coordinated set of studies that represented an end-to-end assessment of this issue. This project is noteworthy because of close coordination between production of GCM simulations and the needs of impacts modeling.

Through downscaling the global climate simulations so that higher resolution regional information could be achieved, daily time series of temperature and precipitation were used in a set of studies to assess water resource impacts. The studies, which assumed continued growth of greenhouse gas emissions, indicate that warmer temperatures will melt the snowpack about a month earlier throughout western North America by the end of the 21st Century. The shift in snowmelt will decrease flows and increase competition for water during the summer in the Columbia River Basin. In the Sacramento River and San Joaquin River basins, the average April 1 snowpack is projected to decrease by half. In the Colorado River basin, a decrease in total precipitation would mean that total system demand would exceed river inflows.

URBAN HEAT WAVES

This estimation of changes in heat-wave frequency and intensity can be accomplished using only near-surface temperature. Because heat waves are large-scale phenomena, regional downscaling is not usually required for their analysis. Global climate model output from for 2080 to 2099 was used to calculate measures of extreme heat; from this study it was found that heat waves will increase in intensity, frequency, and duration.

The information in this factsheet is drawn from CCSP's Synthesis and Assessment Product 3.1: Climate Models: An Assessment of Strengths and Limitations, led by the U.S. Department of Energy, with support from the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF).

US Climate Change Science Program
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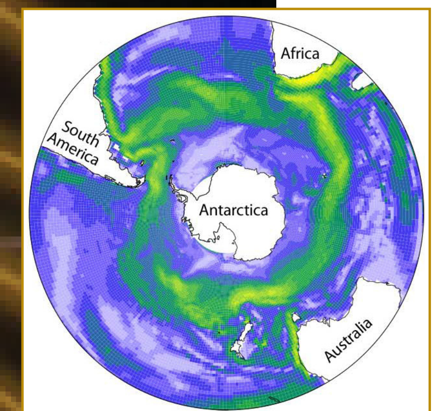
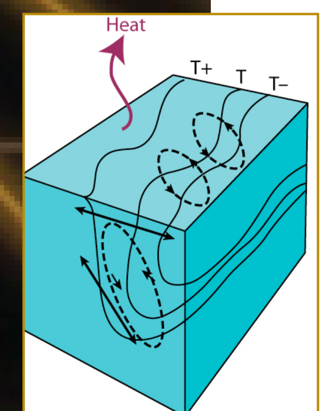
Climate Models

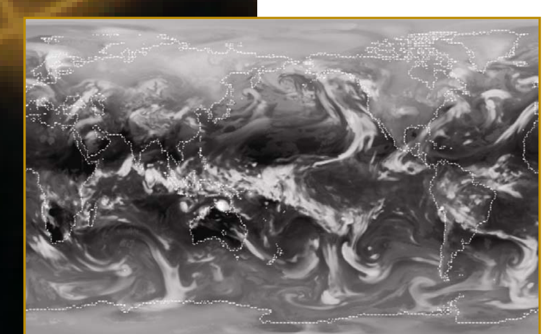
Frequently Asked Questions about computer climate models and their uses, strengths and limitations

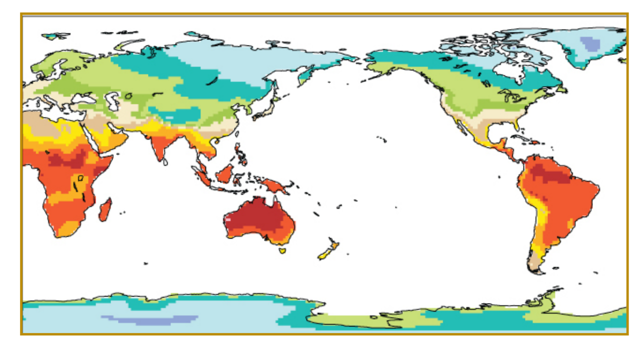


The use of computers to simulate complex systems has grown in the past few decades to play a central role in many areas of science. Climate modeling is one of the best examples of this trend and one of the great success stories of scientific simulation.



Building a laboratory analog of the Earth's climate system with all its complexity is impossible. Instead, the successes of climate modeling allow us to address many questions about climate by experimenting with simulations—that is, with mathematical models of the climate system. Despite the success of the climate modeling enterprise, the complexity of our Earth imposes important limitations on existing climate models.





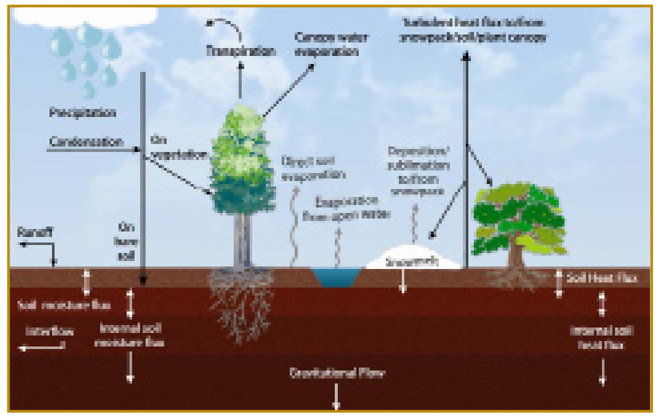
<http://www.climatescience.gov>

Climate modeling is one of the best examples of the use of computers to simulate complex systems and one of the great success stories of scientific simulation

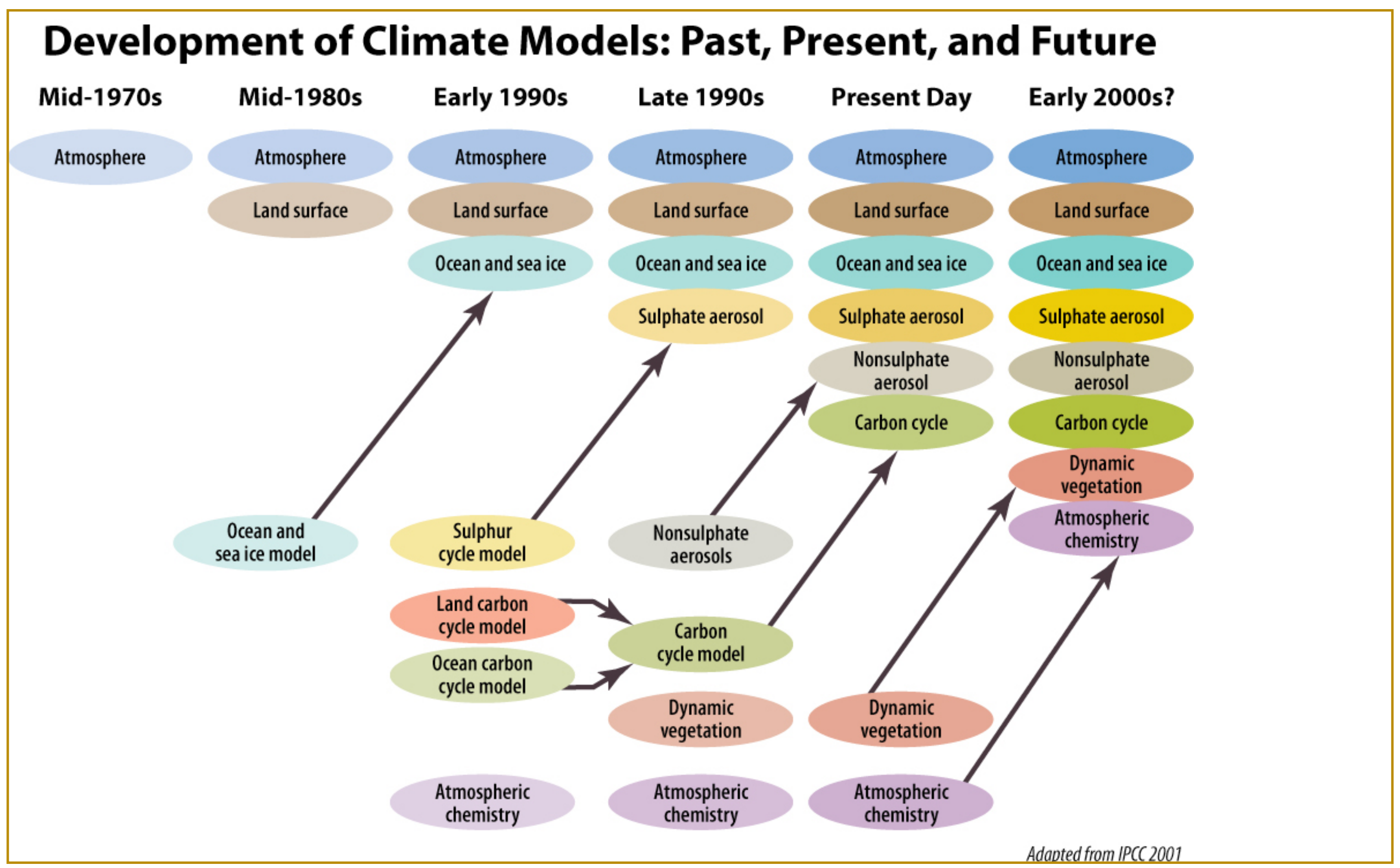
What are Global Climate Models?

Modern computer climate models are composed of a system of interacting model components, each of which simulates a different part of the climate system. The individual parts often can be run independently for certain applications. The models typically include four primary components: atmosphere, land surface, ocean, and sea ice. The atmospheric and ocean components are known as "general circulation models" or GCMs because they explicitly simulate the large-scale global circulation of the atmosphere and ocean. Distinct from weather prediction, the focus in climate modeling is not on individual weather events, which are unpredictable on long time scales, but on the statistics of these events and on the slow evolution of oceans and ice sheets.

There are several different 'classes' of climate models each of which can be used for different purposes. Coupled atmosphere-ocean models are the most complex and incorporate detailed representations of the atmosphere, land surface, oeans, and sea ice. There are also regional climate models that produce higher resolution simulations for a limited regional area. There is also a class of models known as Earth system models of intermediate complexity and although much simpler than coupled models, they are useful in exploring a wide range of mechanisms and obtaining broad estimates for future climate change projections that can then be refined with the coupled models.



Climate models have shown steady improvement over time as computer power has increased, our understanding of physical processes of climatic relevance has grown, datasets useful for model evaluation have been developed, and our computational algorithms have improved. However, the complexity of our Earth imposes important limitations on existing climate models.



How Accurate Are Global Climate Models?

Climate models allow us to experiment with global climate in a way that we cannot with 'real' data. For example, we can simulate future climate with or without human-induced greenhouse gases and see what the difference is - this helps to identify the magnitude of climate response to a given change in driving forces.

However, in order for us to have confidence in the ability of models to project future climate conditions, the models must be able to simulate present and past climate. Accurate simulation of present-day climate for near-surface temperature and precipitation is necessary for most practical applications of climate modeling. The seasonal cycle and large scale geographical variations of near-surface temperature are indeed well simulated in recent models, however, there are still elements of the climate that are not well-simulated including regional details of precipitation and clouds - in part due to cloud processes occurring at scales that are smaller than a typical grid square in most global climate models.

In an assessment of how well many different models simulated the climate of the late 20th century, results showed that all models have improved over previous versions. By taking the average of all the models, an even more accurate representation of the climate emerges. This is known as an ensemble approach and is now well-accepted as a valuable method of simulating global climate.

Climate Model Sensitivity

The sensitivity of a climate model is generally calculated as the amount of temperature change the model produces for a doubling of carbon dioxide. The equilibrium response—the response expected after waiting long enough (many hundreds of years) for the system to reequilibrate, or reach stability—is the most commonly quoted measure. Most recent models have sensitivities of greater than 2°C (3.6°F) for a doubling of carbon dioxide and the sensitivity inferred from observations is usually referenced as being between 1.5°C (2.7°F) and 4.5°C (8.1°F). Difficulties in simulating Earth's clouds and their response to climate change are believed to be the fundamental reasons preventing a reduction in this range in model-generated climate sensitivity.

Is it Possible to Simulate Climate at Regional Scales?

One of the key areas of modeling that is now receiving much attention is increasing the resolution of models so that regional features are more accurately simulated. The chief reason for performing regional simulations, is to resolve features considered important for a region's climate that a global model does not resolve. Given that many of the impacts of global climate change will be felt most especially at regional scales, increasing the resolution of models is an important focus in order to assess economic, social and environmental impacts more accurately (see back page for some applications of regional modeling).

There are different types of regional simulations and each has advantages and disadvantages. Deciding how to acheive greater regional accuracy typically involves trade-offs between improved resolution of small-scale features of the atmosphere and ocean, while avoiding placing such demand on computational power as to decrease our ability to provide results in a reasonable amount of time. As computer power increases, this trade-off will become less restrictive and smaller grid-sizes can be used for the entire globe or portions of it.