What is a global climate model?

Key Points

Global climate models (GCMs) are mathematical formulations of the processes that comprise the climate system. Climate models can be used to make projections about future climate and the knowledge gained can contribute to policy decisions regarding climate change. An advantage of GCMs is their ability to perform multiple simulation experiments using different greenhouse gas emissions scenarios. A disadvantage of GCMs is their inability to resolve features smaller than about 50 miles by 50 miles. However, as computing power continues to increase, models are being constantly improved.

How Climate Models Work

Computer climate models are the key tool for simulating possible future climates. Though there are many types of models, from simple to complex, three-dimensional global atmosphere and ocean models hold the most potential for making accurate climate projections. These complex and computer-intensive global climate models have been developed to study global climate processes and to create projections of possible future climates. The knowledge gained can contribute to policy decisions regarding climate change and facilitate preparations for future climate changes.

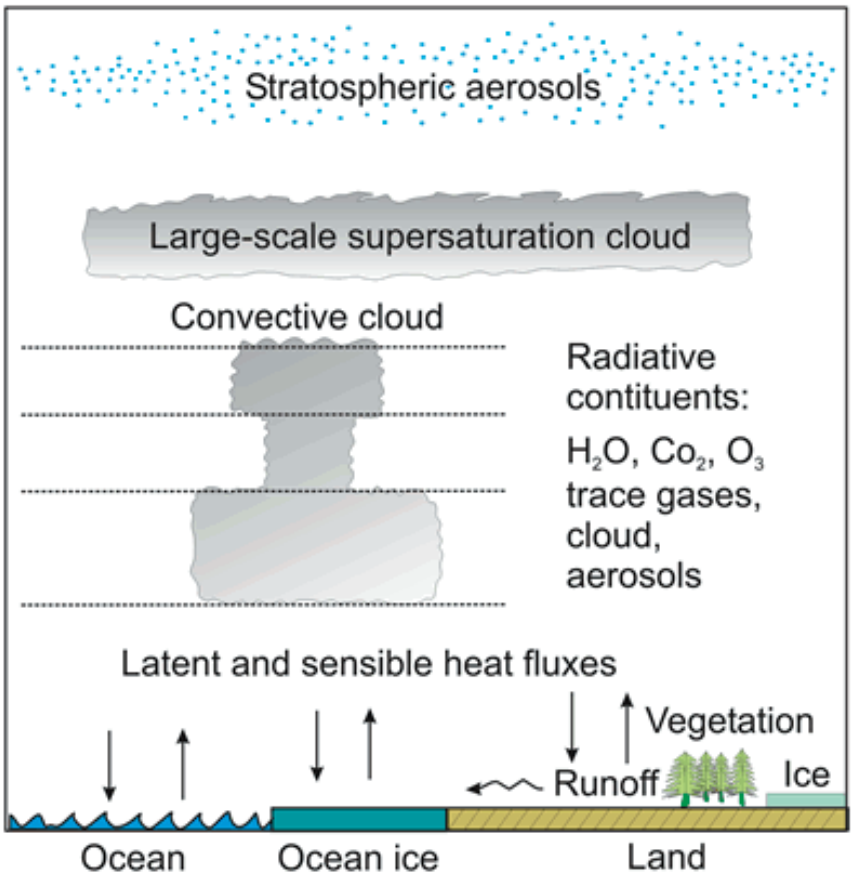

Figure 1. Schematic illustration of GCM structure at a single gridbox. Source: Hansen, J., G. Russell, D. Rind, et al. "Efficient three-dimensional models for global climate studies: Models I and II." *Monthly Weather Review* 111 (4): 609, 662, 1983

GCMs are mathematical formulations of the processes that comprise the climate system, including radiation, energy transfer by winds, cloud formation, evaporation and precipitation of water, and transport of heat by ocean currents. The model calculations are made for individual gridboxes on the order of 125 – 300 miles (200 – 500 km) in the horizontal and vertical dimensions. The equations of the model are solved for the atmosphere, land surface, and oceans in each gridbox over the entire globe using a series of timesteps (Figure 1).

Projections Made by Global Climate Models

GCMs are used to simulate the climate system's future responses to emissions of greenhouse gases and sulfate aerosols, as well as other human-induced activities that affect the climate system. Projections made by GCMs are reflections of the current state of knowledge of the processes in the climate system, but they still contain uncertainties. Figure 2 shows projected changes in temperature and precipitation in the 2050s using two global climate models, one developed by the United Kingdom Hadley Centre and the other by the Canadian Centre for Climate Modeling and Analysis.

Advantages and Disadvantages of Climate Models

An advantage of climate models is their ability to perform multiple simulation experiments using different greenhouse gas emissions scenarios. By performing multiple experiments, with multiple climate models based on multiple greenhouse gas scenarios, the

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range of possible climate outcomes, as well as the probability of specific outcomes, can be better understood.

A disadvantage of climate models is that, although computer power continues to increase rapidly, global models currently do not resolve features smaller than about 50 miles x 50 miles. This makes it impossible to resolve smaller-scale climate features. The models also simplify or parametrize complex and often non-linear processes, such as the radiation effects of high- and low-level clouds or hydrological processes on the land.

References

Flato, G.M., G.J. Boer, W.G. Lee, N.A. McFarlane, D. Ramsden, M.C. Reader, and A.J. Weaver. 1997. *The Canadian Centre for Climate Modeling and Analysis global coupled model and its climate*. The Canadian Centre for Climate Modeling and Analysis. Atmospheric Environment Service. University of Victoria, BC.

Intergovernmental Panel on Climate Change (IPCC), 2001. "Working Group I Third Assessment Report." *Cambridge University Press*.Cambridge, UK. 881 pp.

Johns, T.E., R.E. Carnell, J.F. Crossley, J.M. Gregory, J.F.B. Mitchell, C.A. Senior, S.F.B. Tett, and R.A. Wood. 1997. "The second Hadley Centre coupled ocean-atmosphere GCM: Model description, spinup, and validation." *Climate Dynamics* 13:103-134.

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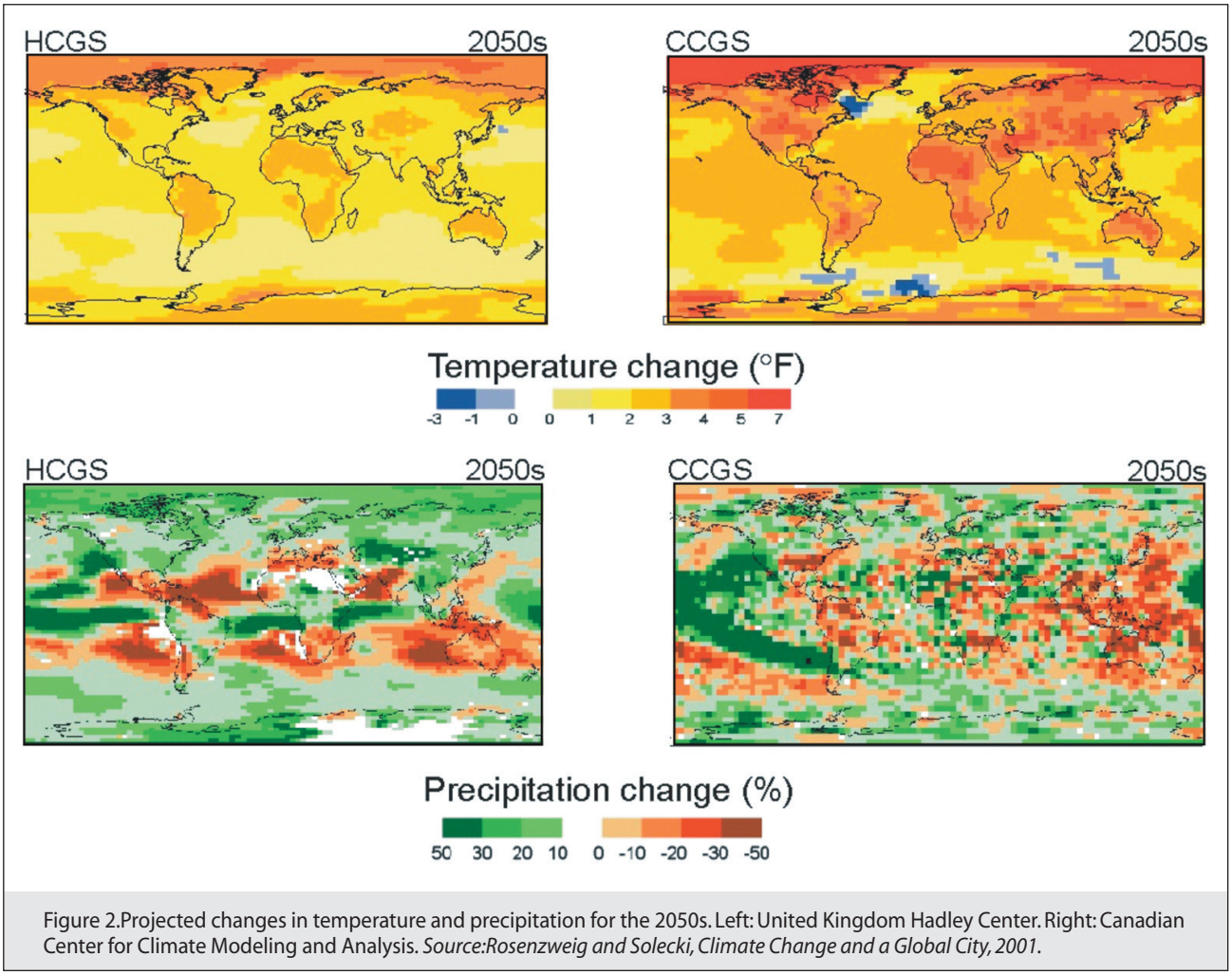

Figure 2.Projected changes in temperature and precipitation for the 2050s. Left: United Kingdom Hadley Center. Right: Canadian Center for Climate Modeling and Analysis. *Source:Rosenzweig and Solecki, Climate Change and a Global City, 2001.*

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