How do scientists make projections about future climate change and climate impacts?

Key Points

Scientists generally use several models in combination with different emissions and development scenarios to make a range of projections for each climate variable and to construct multiple global change scenarios. These scenarios can be used to get a sense of the direction and relative magnitude of changes in temperature, precipitation, and other climate variables and can help define potentially critical thresholds of climate-sensitive processes. Understanding the range of possible futures helps policymakers and the general public evaluate responses.

Climate Change Projections: A Flow Chart of Processes

Climate change projections are made based on a flow chart of processes (Figure 1). The flow chart begins with socioeconomic assumptions that affect projections of greenhouse gas emissions and ends with climate system feedbacks and policy. There are different types of uncertainties associated with each level of the flow chart, but the interaction of these uncertainties does not necessarily make the overall outcome more uncertain.

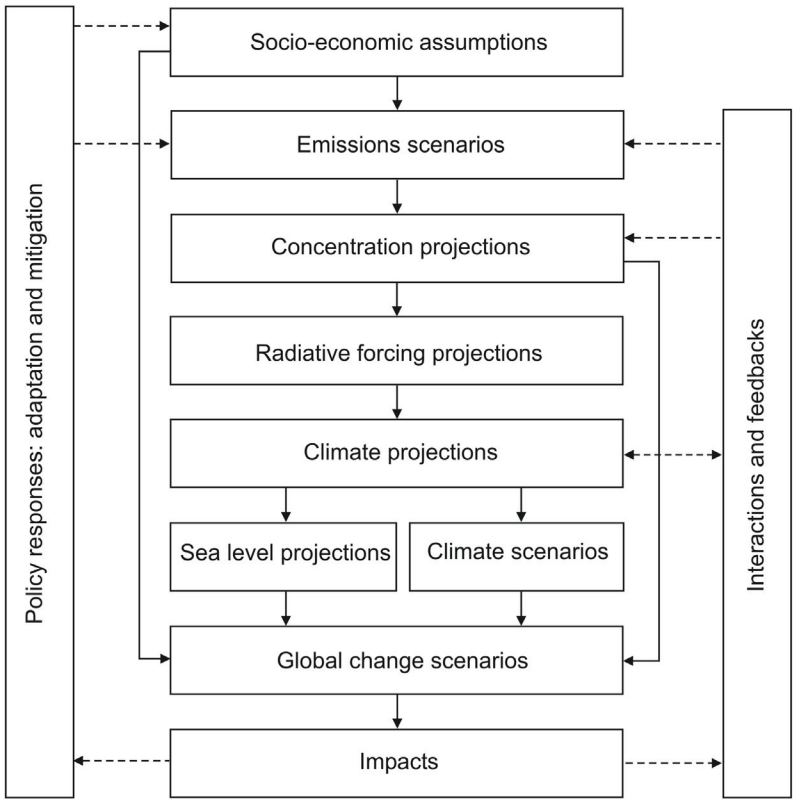

Figure 1. Cascade of Uncertainties. With each additional box the uncertainty increases. Source: Intergovernmental Panel on Climate Change (IPCC), Working Group I Third Assessment Report. 2001.

Socio-economic Assumptions

Assumptions about population growth, economic growth and development, and land-use change affect how quickly scientists think greenhouse gases will be added to the atmosphere. Future emissions of greenhouse gases may occur along a range of pathways related to population and economic growth and technology and land-use change. Relatively fast economic growth and continued use of fossil fuels would lead to an increase in greenhouse gas emissions, while relatively slow economic growth and an increase in the use of alternative energies would lead to a decrease in greenhouse gas emissions.

Emissions Scenarios and Concentration Projections

Figure 2 shows temperatures associated with seven different carbon dioxide (CO_2) emissions scenarios. The low end of the IPCC range suggests that in the year 2100 the concentration of CO_2 in the atmosphere would be approximately 550 parts per million (ppm), or approximately double the pre-industrial value, while an alternate scenario suggests that the concentration could be close to 1,000 ppm. The other five scenarios fall somewhere in between.

Radiative Forcing Projections

While anthropogenic sources of greenhouse gas emissions are increasing atmospheric concentrations, how the climate system responds to the higher concentrations, as well as to other radiative forcings such as sulfate aerosols and black carbon, is likely to be complex. For example, an increase in temperatures may cause an increase in cloud cover. However, the effect of the additional clouds is uncertain because some types of clouds are associated with a cooling effect and other types of clouds are associated with a warming effect.

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Climate Projections

Climate projections depend on emissions scenarios and on how climate processes and radiative forcing are modeled. Climate projections include predicted changes in atmospheric variables such as temperature and precipitation as well as associated changes in other components of the climate system - for example sea-level rise. Temperature projections for the twenty-first century vary depending on the emissions scenario and the model used (Figure 2).

Global Change Scenarios

Climate scenarios and sea-level rise projections can aid scientists as they create global change scenarios and ask questions such as 'How will the future climate change?' 'By how much will global temperature rise?' and 'What will be the consequences?'

Impacts

Impacts are projected based on global change scenarios often downscaled to regional levels. Impacts are projected for water, ecosystems, coastal zones, human settlements and industry, and human health. Projected impacts vary depending on scenario, sector, and region. Changes in mean temperature and precipitation as well as changes in the extremes are important for the projected impacts.

Interactions and Feedbacks

Feedbacks and interactions among impacts, projections, and emissions may amplify or dampen climate change.

Policy Responses: Adaptation and Mitigation

Response to climate change will occur at individual, regional, and global levels. Adaptation responses involve adjusting to climate change whereas mitigation responses involve an intervention to reduce the concentration of greenhouse gases in the atmosphere.

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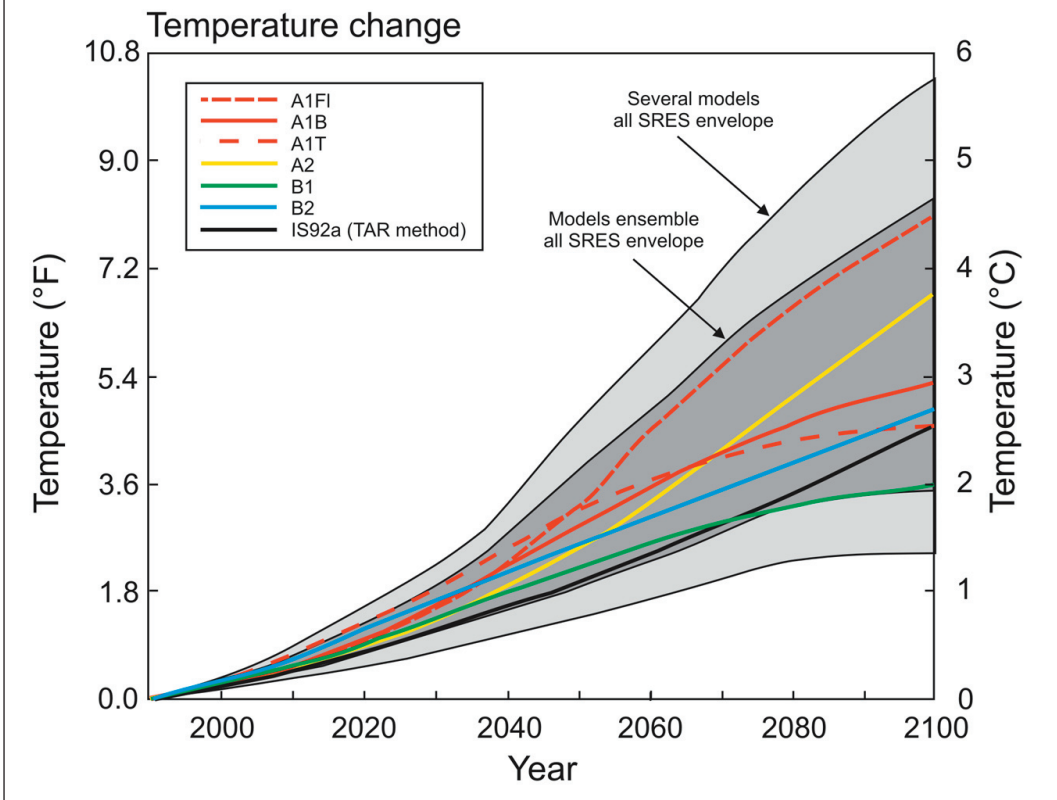

Figure 2. Temperature change projections for the twenty-first century. Source: Intergovernmental Panel on Climate Change (IPCC), Working Group I Third Assessment Report. 2001.

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