Climate Models

A Southern Sierra Adaptation Workshop Information Brief

GENERAL CIRCULATION MODELS (GCMs)

General Circulation Models (GCMs) are computer models used for weather forecasting and climate predictions. They describe climate behavior by inputting basic laws of physics with empirical observations of physical, chemical, and biological components that affect climate. There are two types of models – Atmospheric General Circulation Models (AGCMs) and Oceanic General Circulation Models (OGCMs). In these models, the globe is partitioned into grids, and different variables are calculated within each grid while also calculating interactions with neighboring grids. When AGCMs and OGCMs are coupled together and other parameters like sea ice and land surface components are included, an Atmosphere-Ocean General Circulation Model (AOGCM) is formed, giving a more complete picture as to how the actual global climate system behaves[1,2].

Twenty-three GCMs have been developed by climate modelers. Two GCMs are used by the State of California for climate change impact analyses – GFDL 2.1 and PCM. GFDL 2.1 projects much warmer and drier conditions and PCM projects moderately warmer temperatures but similar precipitation to recent conditions (see Figure 1).

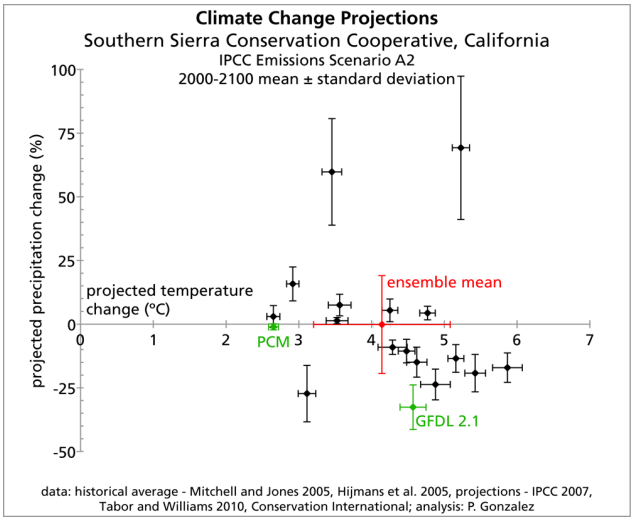

Figure 1: The 18 GCMs and the ensemble average and their predictions of precipitation and temperature (3 GCMs encompass the entire range of variability and are not included in the ensemble). Adapted from Gonzalez 2012.

CARBON EMISSION SCENARIOS

Since future levels of carbon emissions are uncertain, several emissions scenarios have been developed (SRES 2000, IPPC 2007) (See Figure 2). Three commonly used emissions scenarios (B1, A1B, A2) are described in Table 1. Current global emissions are following a trajectory that exceeds the A2 scenario[3]. In the future, a different set of emission scenarios will be used than in past IPCC analyses.

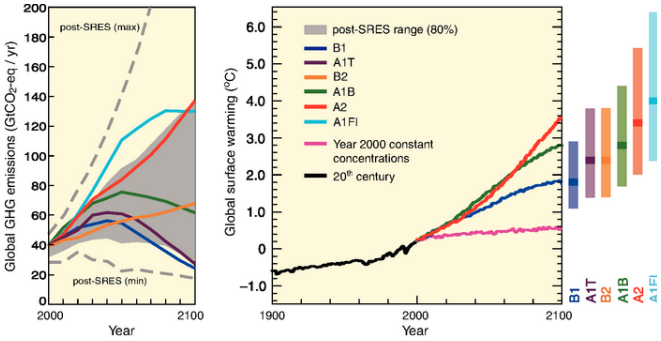

Figure 1: Left: Emissions scenarios through 2100. B1 is the dark blue line, A1B the green, and A2 the red. Middle: Surface warming predictions in degrees Celsius for different emissions scenarios. Right: Best estimate (solid line within bar) and likely range of warming for each scenario. Figure Adapted from IPCC 2007 Synthesis Report.

CLIMATE PROJECTIONS

An emission scenario is applied to a GCM to produce a global climate projection. Global projections can be "downscaled" to finer spatial resolution using statistical methods or dynamic regional climate models[4]. When a climate projection is linked to a hydrologic, biologic, and or socio-economic model it can be used to predict changes in species distributions, ecological processes, and more.

UNCERTAINTY & CONFIDENCE IN CLIMATE PROJECTIONS

Uncertainty is the degree to which a value is unknown due to lack of information, disagreement about what is known, or because the value is unknowable[5].Climate projections incorporate uncertainty from our inability to perfectly model the earth system and predict future carbon emission scenarios, as well as errors in the observed climate data used to downscale GCM output. When a climate projection is linked to a biological or other type of model, additional sources of uncertainty are introduced based on our inability to perfectly model physical, biological, and social systems.

The confidence in climate projections can be quantified using the level of agreement among different projections. For example, confidence in projected warming is high because all models predict some degree of warming in the S. Sierra (Figure 1)[3,5]. Models do not agree on precipitation predictions, however, as about half predict more and half predict less for the S. Sierra (Figure 1). The degree to which models are able to reproduce observed climates of the past also is a method to quantify confidence in a climate projection.

Models may share biases because of the way they were developed, however. An "outlier" among a number of projections may be just as likely to foretell the future as it may include key processes not modeled in the other GCMs[4]. Considering a range of possible futures can help managers plan in the face of uncertainty.

Table 1: Description of emissions scenarios used in some of the models described in the Resource Information Briefs predicting climate change in the southern Sierra. Predicted changes here are global. Current concentration of atmospheric CO2 is 379 ppm. Adapted from IPCC 2007.

Emission Scenario	Temp. Increase (°C) (2090-2099)	Emissions	[CO2] (ppm) (2100)
B1	1.1-2.9; best estimate of 1.8	Lower	600
A1B	1.7-4.4; best estimate of 2.8	Medium	850
A2	2.0-5.4; best estimate of 3.4	Higher	1,250

Authorship Note

This information brief was created by Katy Cummings (NPS) and Koren Nydick (NPS). Additional thanks to Erika Williams (NPS) for graphic design assistance.

References

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