Choosing Specific Climate Change Projections for Climate Change Planning

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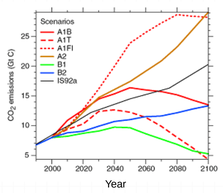
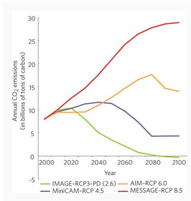
Understand how climate projections are developed

Resource managers, conservation organizations, and others wanting to incorporate climate change into their planning need local and specific information about plausible, potential future climate trends and patterns. How do you get from the general, broad-scale information provided in reports and agency planning handbooks to the real numbers you need to assess your species' or system's vulnerability to climate change?

1. Emissions scenarios (AR4, right) or representative concentration pathways (AR5, far right) provide input for global-scale models.

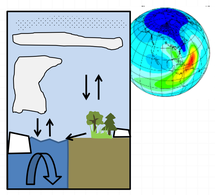


from Nakićenović and Swart 2000

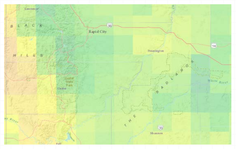


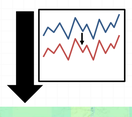
from Inman 2011

2. Global climate models (including Atmosphere-Ocean General Circulation Models, Earth System Models, and more) simulate contemporary and future climate using the above input and algorithms representing the physical and biological processes governing materials and energy exchange and cycling on a coarse spatial scale.

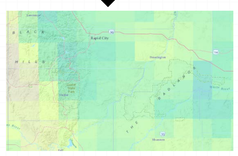


3. Data output from a global model are downscaled using either a dynamic or statistical approach, providing climate projections at a finer spatial resolution that incorporates topographical features like the Black Hills. Dynamic downscaling nests a regional climate model within a global model. Statistical downscaling derives a statistical relationship between weather station observations and global-model output, then applies the same relationship to the model's output for the future.





4. In most cases, some form of bias correction of the downscaled data is necessary to ensure consistency between historical, observed climate and future projections. Often the bias-correction is done as part of the statistical downscaling process.



Understand the options

The 2007 Intergovernmental Panel on Climate Change assessment report (IPCC 2007) included 6 emissions scenarios and 21 global climate models, each of which was run 1-5 times for each scenario. These results have been used in multiple statistical and dynamic downscaling projects, providing a large number of high-resolution (800 m – 50 km grid cell size) datasets available for use. Updated climate models using more recent representative concentration pathways continue to be downscaled using various methods. There is no shortage of options for quantitative climate projection data that can be used in quantitative ecological assessments needed for climate change planning*. Instead, the practitioner is faced with the question,

➢ **Which of these projections should I use?**

* Some sources for these data include (not an exhaustive list):

- The USGS Geo Data Portal (http://cida.usgs.gov/gdp/) is a repository of both historical climate and downscaled projections and provides some processing options for the data.
- The North American Regional Climate Change Assessment Program (NARCCAP; http://www.narccap.ucar.edu/data/index.html) provides dynamically downscaled projections.
- Statistically downscaled data (Maurer et al. 2007) for a large number of global models are available at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html#Welcome

Determine which climate features are important

The first step towards choosing projections is to determine the climate features that drive the system of interest. For example, temperature extremes, rather than means, may govern the distribution of a bird species, or the timing of precipitation may be just as important as the amount of precipitation for the germination and survival of a plant species of interest. Quantitative sensitivity analysis via system models or qualitative sensitivity assessments based on expert opinion provides these insights (Snover et al. 2013).

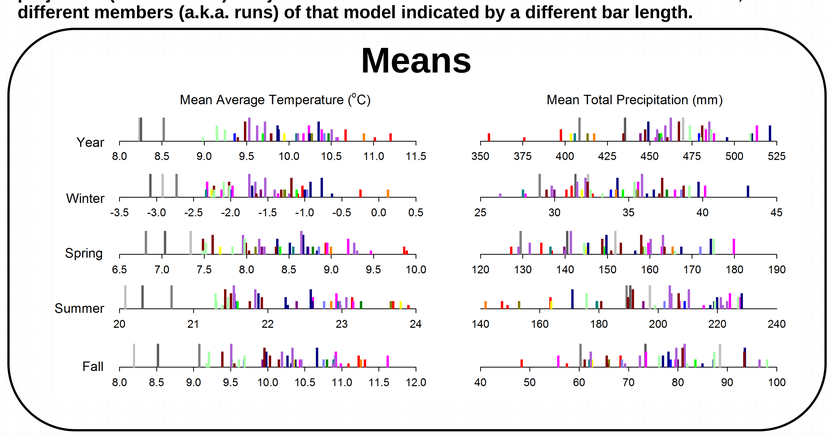
Eliminate projections based on assessment goals and necessary features

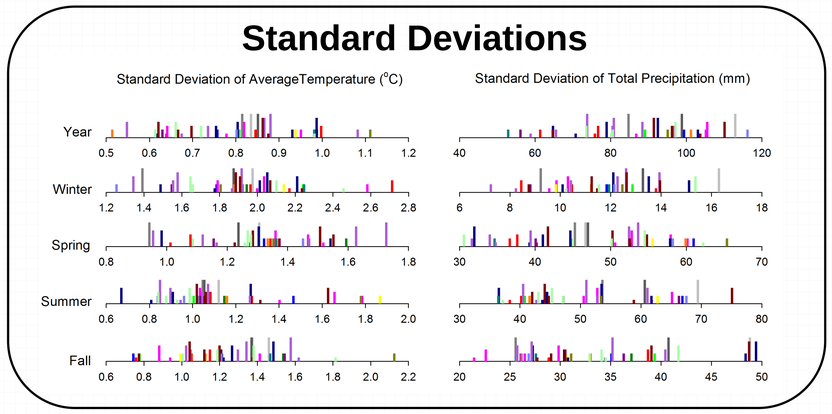
- In the near term (through 2050), emissions scenarios or concentration pathways differ primarily in the **rate** at which a certain level of CO_2 is reached, not **how high** [CO_2] will get. Also, measured emissions are currently higher than many scenarios. Projections based on lower emissions could be ruled out on this basis.
- Available projection datasets may lack one or more features you require, such as a specific type of data (e.g., relative humidity) or a complete time series from the present time to your end date.
- The credibility of different climate models for specific regions, climate processes, climate variables, and spatial and temporal scales varies. Some projections could be ruled out on this basis, but climatologists are just now beginning to develop an evaluation framework to provide the necessary information to do so (Barsugli et al. 2013, https://earthsystemcog.org/projects/ncpp/EvalTransMain).
- When multiple climatic factors strongly influence the system of interest, a dynamical downscaling approach, which ensures physical consistency among climate output variables, may be more appropriate than a statistical approach (Snover et al. 2013).

Compare and select from the remaining projections

Even after eliminating projections using the above criteria, many options may still remain. The recommended practice for climate input into ecological assessments seems to be shifting from using an average of multiple climate projections to using multiple projections that represent the full range of existing datasets. For the latter, a graphical representation of this range, for a variety of climate variables of interest, may be helpful. One such representation is presented below for the grid cell (dimensions = 1/8° lat/lon) in which the Wind Cave National Park visitor center is located.†

In the figures below, each bar represents the statistic's value for observed data for a historical time period (1980-1999; 1951-1970, 1950-1999) or for 2031-2050 for a single climate projection (colored bars). Projection bars of the same color are from the same model, with different members (a.k.a. runs) of that model indicated by a different bar length.





- ➢ Projections from members of the same climate model vary as much as projections from different climate models.
- ➢ Projections with similar annual values may differ substantially in their seasonal characteristics. For example, the projection represented by the longest dark blue bars has low-moderate precipitation for the year (relative to other projections), but high fall precipitation and low summer precipitation. The projection represented by the medium-length, dark red bars has similarly low-moderate mean annual precipitation but one of the highest mean winter precipitation values.
- ➢ Projections with similar mean values may differ substantially in their variation. Compare the annual precipitation means and standard deviations for the bright green bar and the shortest light purple bar.
- ➢ Including climate statistics calculated for historic periods of known characteristics (i.e., the relatively dry 1950-1971 period and the relatively wet 1980-1999 period in the figures at left) in the same figure as the projections illustrates how the range of projections compares to climate variability within institutional memory. It is critical to use historical and projection data that have been downscaled in the same way when making these comparisons, since different downscaling methods produce different values even when based on the same historical data.

Projections can be compared on the basis of many other statistics than those shown here. Selection should be driven by the climate features determined to be most important to the species or system being assessed.

† METHODS: I downloaded mean monthly temperature and total monthly precipitation, statistically downscaled from global climate model output by Maurer et al. (2007), for the area bounded by 43.500 – 43.625° N, 103.500 – 103.375° W for 1950-2050 from "Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections" (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/) on 15-16 July 2013. I obtained data for all climate models and members using the A2 emissions scenario available from this source 36 total). I calculated statistics presented above in Excel; climate projection calculations are for 2031-2050.

Literature Cited

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This poster was inspired by conversations that were part of a project funded by the North Central Climate Center, in which my collaborators (Dominique Bachelet, David King, Andrea Ray, and Joseph Barsugli) provided insights into means for crossing the climatology-ecology void. The diagrams comparing projections on this poster were inspired by the National Climate Predictions and Projections Platform's August 2013 "Quantitative Evaluation of Downscaling" workshop.