Downscaling

What is Downscaling?

Global climate models (GCMs) output gridded data, meaning that Earth's surface is divided into square cells, much like pixels in a digital photo, and each cell is assigned a value for the model's output. In raw GCM output, each grid cell might cover an area of 100 km², about the size of the Bronx in New York City. Such large grid cell size, also known as "resolution," makes GCM output data too coarse for capturing local details. To make results more useful for understanding local projections, data need to be **downscaled**. Downscaling is a process that makes the cells of the grid smaller, covering areas as small as 1 km², thereby providing a much clearer picture of local conditions. In a simple sense, looking at GCM data is like looking at a low-resolution photo while looking at downscaled data is like looking at a high-resolution photo.

Downscaling can be done using two methods: dynamical or statistical. Both downscaling methods have pros and cons, but neither is necessarily better than the other.
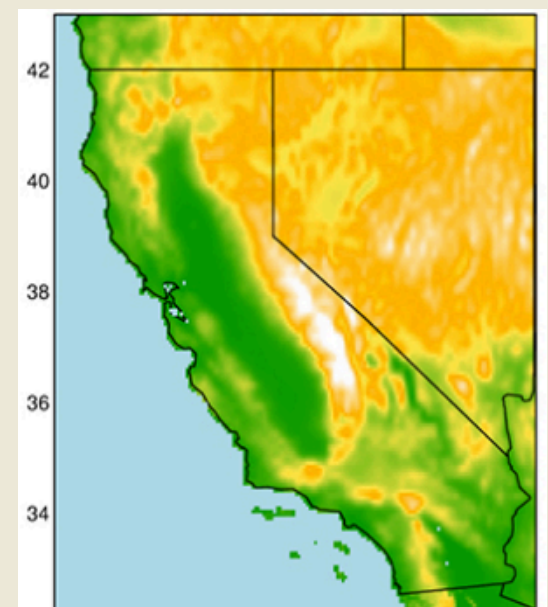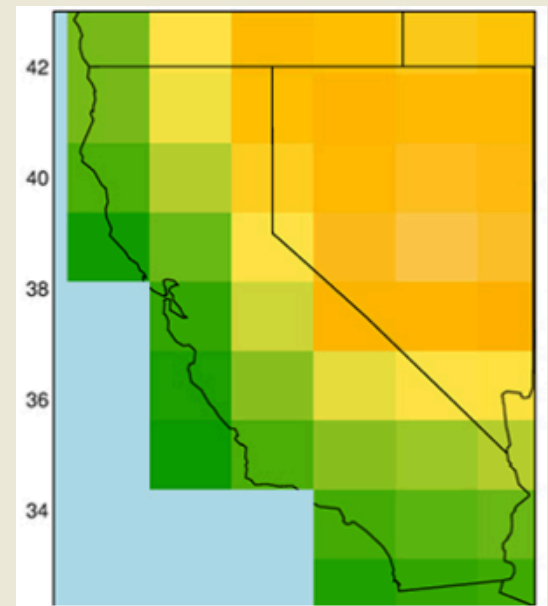
Dynamical Downscaling

In dynamical downscaling, a GCM is used alongside a regional climate model (RCM) which captures the interaction between the weather patterns of the GCM and the regional terrain, filling in the complexities of local and regional climate processes that are not captured by GCMs. This method of downscaling is highly dependent on the availability of a local RCM.[1]

Statistical Downscaling

Statistical downscaling uses the statistical relationships between coarse resolution weather and climate patterns and local resolution climate conditions to derive regional projections. This method requires local weather

Climate Model Outputs

The figures below present a visual example comparing the raw output of a GCM (top) and its downscaled counterpart (bottom). This data represents California's elevations, and was downscaled using LOCA.

(USGS)

data and will yield better results where the weather data are high quality and have been taken over a longer time period.[1]

Hybrid Methods

Sometimes dynamical and statistical downscaling are used alongside each other. If dynamically downscaled results are still too coarse for a user's purposes, statistical downscaling can be used to further refine the results.

Open-Access Downscaled Data

There are many online datasets that provide open-access downscaled GCM data. Below are three examples of datasets that provide downscaled GCM data for California. Your choice of data will depend on your needs and desired applications.

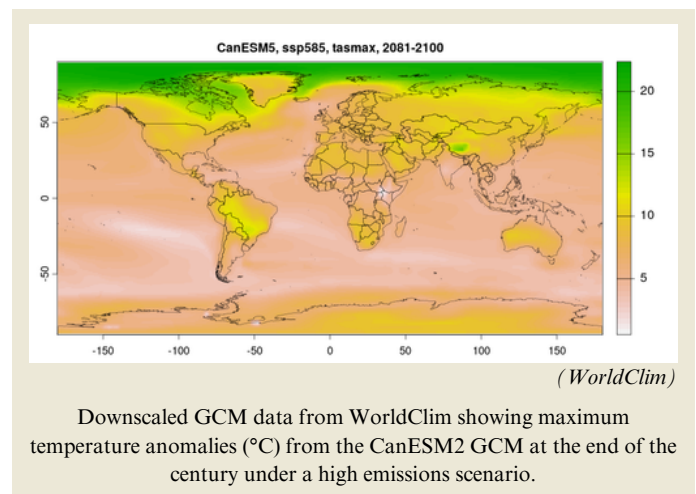## LOCA: A Statistically-Downscaled Climate Dataset

Localized Constructed Analogs (LOCA) is a technique for statistical downscaling created at the University of California, San Diego. In 2023, LOCA version 2 was used to downscale CMIP6 data for both California and North America. The publicly available datasets provide downscaled data for California at a scale of 3 km² and for all of North America at a scale of 6 km². Both datasets include daily projections of minimum temperature, maximum temperature, and precipitation.

MACA

Multivariate Adaptive Constructed Analogs (MACA) is a technique for statistical downscaling created at the University of California, Merced. Two MACA datasets are available for download, one at a 6km² resolution and the other at a 4 km² resolution. Both datasets use 20 CMIP5 GCMs and include daily projections of maximum and minimum temperature, maximum and minimum relative humidity, precipitation accumulation, downward surface shortwave radiation, wind-velocity, and specific humidity. A new 11 km² resolution MACA dataset for CMIP6 models is expected in mid 2024.

WorldClim

WorldClim is a global collection of downscaled CMIP6 GCM data that includes monthly projections of precipitation and mean, minimum, and maximum temperature at a scale of 1 km². WorldClim data also includes 19 pre-calculated bioclimatic variables commonly used in ecological applications like species distribution modeling.

(WorldClim)

Downscaled GCM data from WorldClim showing maximum temperature anomalies (°C) from the CanESM2 GCM at the end of the century under a high emissions scenario.

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1. Copernicus Climate Change Service. What is statistical and dynamical downscaling? *European Centre for Medium-Range Weather Forecasts.* https://climate.copernicus.eu/sites/default/files/2021-01/infosheet8.pdf.