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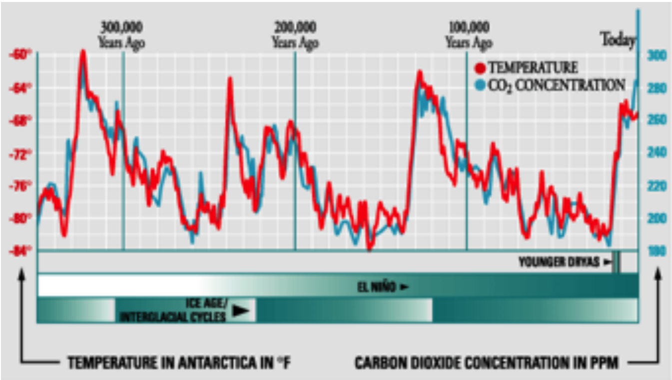
PURDUE EXTENSION

Climate Tools

Past Climate "Proxy" Data

"It has been at least 800,000 years—probably more—since Earth saw carbon dioxide levels over 400 ppm."

— Jim Butler, global monitoring director at the National Oceanic and Atmospheric Administration's Earth System Research Lab



Source: Koshland Science Museum of the National Academy of Sciences

How do scientists like Jim Butler know what carbon dioxide levels were in our atmosphere hundreds or thousands of years before human observation?

Climate data derived from geologically ancient natural sources extend the archive of weather and climate hundreds of millions of years. These data—often called "proxy" data—include geophysical and biological measurements to help reconstruct climate variables such as temperature and precipitation.

Natural sources of climate proxy data include:

Ice cores. A core sample is typically removed from an ice sheet (most commonly from Antarctica or Greenland) and used to reconstruct a climatic record based on the annual layers of snow. This gives clues to local temperature and atmospheric composition.

Tree rings. Growth rings on trees generally are wider during warm periods and narrower during cold ones, so their rate of growth provides a picture of Earth's temperature over past centuries.

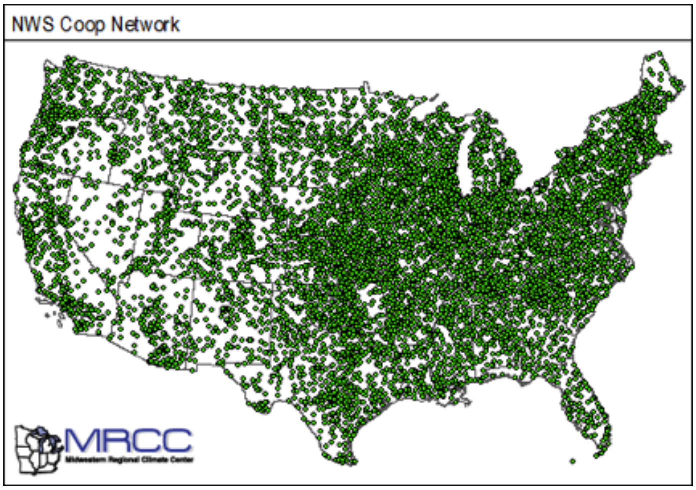
Corals. Using stable isotope and trace metal analyses, corals can serve as proxies of upper ocean environment (e.g., sea surface temperature and salinity) over the past several centuries.

Pollen. Pollen grains that are washed or blown into lakes can accumulate in sediments and provide a record of past vegetation.

Source: NOAA

Present Climate Observations

Historical weather observations go back to the early 1800s in the United States. US Army Surgeons at forts across the United States recorded the first organized observations in 1820. By the mid-1800s, these observations were recorded by volunteers for the Smithsonian Institution and later by members of the US Army Signal Corps. In the early 1890s, the station networks evolved into the Cooperative Observer Program. This network continues today with some 11,000 volunteer observers taking measurements across the country for the National Weather Service.

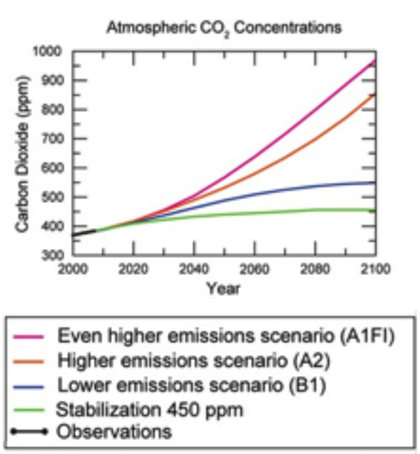


In addition to cooperative weather stations, modern weather observations are also routinely taken hourly at airports, at mesonets throughout the country, and through other volunteer networks across the United States, like CoCoRaHS (Community Collaborative Rain, Hail, and Snow Network).

Satellite and radar data is also used to obtain indirect measurements of variables like precipitation, cloud data, solar radiation, snow cover, and sea ice extent.

Future Climate Predictions

Climate models are mathematical representations of Earth's climate system (atmosphere, ocean, land surface, and ice) used to predict how the atmosphere and climate of the future will respond to natural and human-caused processes. Climate models projecting future climate change are typically quite complex. They are coupled atmosphere-ocean-sea-ice global climate models (GCM) that solve the full equations for mass and energy transfer and radiant exchange.



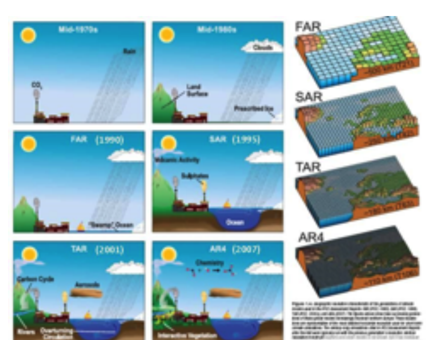
Source: US Global Change Research Program, 2009

Scientists are confident that climate models provide reasonable estimates of future climate conditions, particularly at the level of continents or the world, as a whole. This confidence comes from their ability to reproduce observed features of current and past climate changes. While it is not possible to precisely project all aspects of future climate, many scientists agree that there is enough information about future climate trends and patterns to be begin implementing robust adaptation strategies.

The range in climate model projections for variables like precipitation and temperature are partially a result of the different carbon dioxide emission scenarios underlying each climate model simulation. Low, intermediate, and high emission scenarios are often used, each scenario representing a different level of carbon dioxide by the end of the century. Predicting the level of carbon dioxide throughout the next century is difficult because of the uncertainties inherent in predicting how many humans may change or may not change their actions in the future. In addition, differences in model structure and function affect the projection.

Uncertainty in climate models generally comes from the fact that many processes at work in the earth-atmosphere system and feedback systems are not, yet, fully understood. Therefore, it is very difficult for models to accurately represent these complicated climate processes. The representation of cloud and hydrological processes still remains the single largest source of uncertainty in climate model simulations. That is why precipitation projections often have a much wider range and higher uncertainty than temperature projections. Finally, regional topography and regional circulation patterns are crudely represented in GCMs and even downscaled regional climate models may not fully capture these smaller-scale processes.

Regional climate models use smaller grid spacing than do global models. It is done by "downscaling" global models. The incorporation of an additional downscaling "layer" to generate high-resolution scenarios both creates and contributes to uncertainty within the modeling framework, resulting in significant regional variation between downscaled projections. In spite of these shortcomings, regional downscaling is still considered valuable.



Resources

Climate Change and Chicago—Projections and Potential Impacts: Chapter Two – Climate. Chicago *Climate Action Plan:* November 7, 2007.

Fealy, R., 2012. Deriving probabilistic based climate scenarios using pattern scaling and statistically downscaled data: a case study application from Ireland. *Progress in Physical Geography*, Vol. 37, 178-205.

Hayhoe, K., J. VanDorn, T. Croley II, N. Schlegal, and D. Wuebbles, 2010. Regional climate change projections for Chicago and the US Great Lakes. *Journal of Great Lakes Research*, Supplement 2, Vol. 36, 7-21.

Midwestern Regional Climate Center, 2017. cli-MATE. http://mrcc.isws.illinois.edu/CLIMATE/

National Oceanic and Atmospheric Administration, 2016. Satellite Data. https://www.ncdc.noaa.gov/data-access/satellite-data

National Oceanic and Atmospheric Administration, 2016. Radar Data. https://www.ncdc.noaa.gov/data-access/radar-data

National Oceanic and Atmospheric Administration, 2016. Paleoclimatology Data. https://www.ncdc.noaa.gov/data-access/paleoclimatology-data

US Global Change Research Program, 2009. National Climate Assessment.

Winkler, J.A., R.W. Arritt, S.C. Pryor, 2012: Climate Projections for the Midwest: Availability, Interpretation and Synthesis. In: *U.S. National Climate Assessment Midwest Technical Input Report.*

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