Want to know what climate change will do in your backyard? There's a dataset for that

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A small bean farm in Colombia's Darién region. Future climate scenarios can be modeled at the community scale thanks to a dataset created by the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) and the International Center for Tropical Agriculture (CIAT). Credit: Neil Palmer / International Center for Tropical Agriculture

What the global climate emergency has in store may vary from one back yard to the next, particularly in the tropics where microclimates, geography and land-use practices shift dramatically over small areas. This has major implications for adaptation strategies at local levels and requires trustworthy, high-resolution data on plausible future climate scenarios.

A dataset created by the International Center for Tropical Agriculture (CIAT) and colleagues is filling this niche. Primarily intended to help policymakers devise adaptation strategies for smallholder farmers around the world, the open-access dataset has been used in 350 research papers. Users in at least 186 countries have downloaded almost 400,000 files from the dataset since it went online in 2013.

A full description, review and validation of the dataset, including how it was built, was published January 20 in *Scientific Data*, an open-access publication by *Nature* for the description of scientifically valuable datasets.

"Climate models are complex representations of the earth system, but they aren't perfect," said Julian Ramirez-Villegas, the principal investigator of the project and a scientist with CIAT and the CGIAR Research Platform on Climate Change, Agriculture and Food Security (CCAFS). "These errors can have an impact on our agricultural models. Because these models help us make decisions, this can have dire consequences."

While the data has primarily served agricultural research, it has also been used to map the potential global spread of Zika (a mosquito-borne disease), to plan investment strategies for international development, and to predict the ongoing decline of outdoor skating days in Canada due to warmer winters.

"The use and applicability of this data have been really extensive and topically quite broad," said Ramirez-Villegas. "Of course, a large portion of the studies has been done on crops that are key to global food security and incomes such as rice, coffee, cocoa, maize, and others."

HIGH-RESOLUTION AND BIAS-CORRECTED CMIP5 PROJECTIONS FOR CLIMATE CHANGE IMPACT ASSESSMENTS

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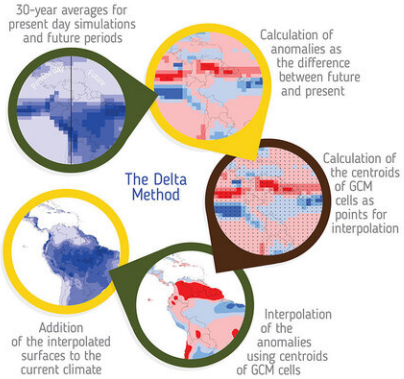
ABSTRACT

Projections of climate change are available at coarse scales (70-400 km). But agricultural and species models typically require finer scale climate data to model climate change impacts. Here, we present a global database of future climates developed by applying the delta method –a method for climate model bias correction. We performed a technical evaluation of the bias-correction method using a 'perfect sibling' framework and show that it reduces climate model bias by 50-70 %. The data include monthly maximum and minimum temperatures and monthly total precipitation, and a set of bioclimatic indices, and can be used for assessing impacts of climate change on agriculture and biodiversity. The data are publicly available in the World Data Center for Climate (WDCC; cera-www.dkrz.de), as well as in the CCAFS-Climate data portal (www.ccafs-climate.org). The database has been used up to date in more than 350 studies of ecosystem and agricultural impact assessment.

METHOD

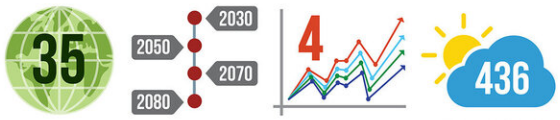
Data was produced by bias-correcting the original GCM outputs using spatial interpolation of the anomalies or deltas (differences between future and current climates). We then applied the interpolated anomalies to the baseline climate of the WorldClim high resolution (30 arc-s) surfaces. This method is called delta change or change factor (DC).



DATA RECORDS

Our datasets comprise the most up-to-date (i.e. IPCC AR5) and comprehensive downscaled set of climate change scenarios.

Scenarios



General Circulation Models (GCM) | 4 different 30-year running mean periods | Representative Concentration Patways (RCP) | Different global scenarios produced. (Not all GCM are available for each RCP).

Variables

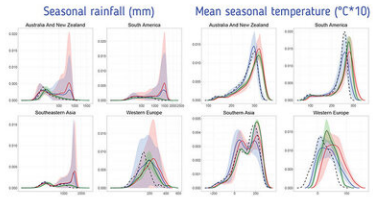
Temperature | Rainfall | Bioclimatic

Resolutions

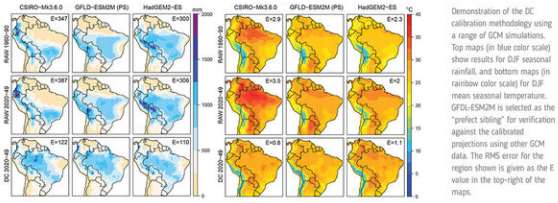
~1KM Primary resolution 30 arc-s | ~5KM Aggregation 2.5 arc-m | ~10KM Aggregation 5 arc-m | ~20KM Aggregation 10 arc-m

VALIDATION

The method changes much of the distribution of the mean seasonal temperature and seasonal rainfall in the majority of the world zones studied. In some regions the method appears to correct the systematic underestimation of seasonal rainfall under 500 mm. These high-frequency and low-intensity events are frequently referred to as the 'drizzle problem' in GCMs. The DC approach brings the shape of the PDF of the future projections closer to that of the observed PDF, therefore likely reducing model error.



Probability density functions (PDF) of seasonal mean temperature for DJF season in comparison with observations. The continuous lines belongs to PDF average and the shading shows the average ± one standard deviation, for all GCM-future (red), GCM-historical (blue) and DC (DC GCM (green). Dotted line is average PDF for the observations (i.e. WorldClim).



Demonstration of the DC calibration methodology using a range of GCM simulations. Top maps (in blue color scale) show results for DJF seasonal rainfall, and bottom maps (in rainbow color scale) for DJF mean seasonal temperature. GFDL-ESM2M is selected as the "prefect sibling" for verification against the calibrated projections using other GCM data. The RMS error for the region shown is given as the E value in the top-right of the maps.

The RMSE decreases significantly applying DC compared with the uncalibrated case. For the South America region the error fluctuates between E=246-387 mm season-1 in the raw case and E=122-159 mm season-1 (i.e. roughly 50 % lower) in the DC case for DJF seasonal precipitation, and between E=2-3.5 °C season-1 in the raw case and E=0.4-1.4 °C season-1 in the DC case for DJF seasonal mean temperature.

DIFFUSION AND IMPACT

The data are publicly available in the World Data Center for Climate (WDCC; cera-www.dkrz.de), as well as in the CCAFS-Climate data portal (www.ccafs-climate.org). . Users can dynamically choose different combinations of parameters (RCP-GCM-period-variable-resolution) and download data.

The complete dataset set is ~7 TB in size. Data is stored in the AWS cloud & in the The World Data Center for Climate (WDCC) portal

https://aws.amazon.com/datasets/ccafs-climate-data
https://doi.org/10.26050/WDCC/CCAFS-CMIP5_downscaling

Users

From 2014 to date, downscaled data portal has nearly 2700 users in more than 186 countries. Users of the data include representatives from national government research institutions and the NGO sector as well as the research community.

We have significant impact by putting climate change information into the hands of non-climate scientists and next users which represent up to 19% of all CCAFS-Climate users.

Key stats

Purposes of use of data

PARTNERS

Alliance

Go to CC Portal

A poster with infographics describes the review of a dataset for climate modeling at high resolution. DOI: 10.1038/s41597-019-0343-8 Credit: Carlos Eduardo Navarro / International Center for Tropical Agriculture

Pinpointing climate impacts

Climate-change projections are typically available at coarse scales, ranging 70-400km. But models for the impact of climate change for many agricultural plant varieties require data at finer scales. The researchers used techniques to increase the spatial resolution (a process known as downscaling) and to correct errors (a process known as bias correction) to create high-resolution future climate data for 436 scenarios.

"This is a critical resource for modeling more realistically the future of crops and ecosystems," said Carlos Navarro, the lead author of the study who is affiliated with CIAT and CCAFS.

For a given emissions pathway and future period, each scenario includes monthly information for average and extreme temperatures, rainfall, and 19 other related variables. The data are publicly available in the World Data Center for Climate and the CCAFS-Climate data portal.

"Through these scenarios, we can understand, for instance, how agricultural productivity might evolve if the world continues on the current greenhouse emissions trajectory," said Navarro. "They also provide the data to model what types of adaptations would best counter any negative climate change effects."

Global and regional models analyze climate conditions at a rougher scales and simplify natural processes, producing results that may deviate

from realistic scenarios.

The dataset is CGIAR's biggest Findable Accessible Interoperable Reusable (FAIR) database. It also underscores CGIAR's role in big data for development, through its Platform for Big Data in Agriculture. The dataset is currently included in its Global Agriculture Research Data Innovation and Acceleration Network (GARDIAN).

The high-resolution scale of this data is useful for scientists, policymakers, NGOs and investors, as it can help them understand local climate change impacts and therefore make better bets on adaptation measures, which plans can specifically target watersheds, regions municipalities or countries.

More information: Carlos Navarro-Racines et al. High-resolution and bias-corrected CMIP5 projections for climate change impact assessments, *Scientific Data* (2020). DOI: 10.1038/s41597-019-0343-8

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