Explore the Effects of Climate Change on Puerto Rico and Other Caribbean Islands: New Statistically Downscaled Climate Projections for the period 1960-2099 available through the Caribbean Landscape Conservation Cooperative Data Center

New Datasets Available in the CLCC Data Center[1]!

- Projections of daily maximum and minimum temperature and twenty-four hour cumulative precipitation for over 200 long-term weather stations throughout the region for the period 1960-2099 based on Global Climate Models (GCMs) from the Third Coupled Model Intercomparison Project (CMIP3) used for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4 IPCC).
- Projection datasets are available for three greenhouse gas emission scenarios: high (A2), medium (A1B), and low (B1). The global model output for precipitation and temperature were downscaled to local station locations by Hayhoe (2013)[2]: 71 stations for precipitation, 29 stations for maximum temperatures (Tmax) and 27 stations for minimum temperatures (Tmin).
- Included in the Hayoe (2013) Report Only[2]: Projected changes in 85 secondary climate indicators, including seasonal averages, thresholds and through 2099.

Data Analysis Results

The Hayhoe (2013) analysis of 85 secondary climate indicators, including seasonal averages, thresholds and extremes shows that "Puerto Rico is expected to warm faster than the global average, with increases in both mean and extreme temperatures, including days per year over 95°F and nights warmer than 85°F. Rainfall is projected to decrease, particularly in the wet season, with more frequent dry days. The frequency of 'moderate extreme' precipitation (e.g., more than 1 inch of rain) is projected to decrease, while more extreme precipitation (e.g., more than 3 inches of rain in a day) is expected to become more common. Projected temperature changes are large enough to affect temperature-sensitive crops, species, and ecosystems, while the combined effects of changes in temperature and precipitation are likely to increase the demand for energy, the risk of water stress and drought, and the risk of impacts from heavy rainfall events" (Hayhoe 2013: 2).

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[1] Visit the CLCC Data Center at http://caribbeanlcc.org/data-center/

[2] Hayhoe, K (Department of Political Science, Texas Tech University, TX) Quantifying Key Drivers of Climate Variability and Change for Puerto Rico and the Caribbean. Final Report 1 Oct 2011-30 Sep 2012. 2013. 241 p. Agreement No.: G10AC00582. Data and relevant publications can be found at www.caribbeanlcc.org/interactivemap/

Potential Uses for Natural & Social Science Researchers and other Science Providers

The availability of these new datasets lays the foundation to explore the potential effects of climate change on Puerto Rico and other Caribbean islands. The information was generated and distributed so that natural and social science researchers and other science providers can collectively work towards expanding and enhancing the climate change knowledge base for the region. Project Principal Investigator Dr. Katharine Hayhoe writes in the project report, "One of the most important reasons we study climate change is to understand how it may exacerbate existing vulnerabilities in both human systems and the natural environment. We know that coastal flooding and storm damage will occur as a result of sea level rise and increasingly more powerful tropical cyclones and hurricanes. In the case of Puerto Rico and other Caribbean islands, however, other key vulnerabilities to climate change relate to the issue of how to sustain growing populations and unique ecosystems with limited land area and scarce water resources. This project laid the foundation to explore the potential impacts of climate change on Puerto Rico and other Caribbean islands."[3]

A primary objective of the CLCC is to facilitate communication and information transfer among climate modelers, impacts modelers, and resource managers. One-way knowledge flow has been the norm for decades and the CLCC is committed to facilitate two-way communication between the modeling communities and decision makers. If you use this new statistically downscaled climate dataset for research or impacts assessments please let us know by notifying CLCC Science Coordinator, Dr. Brent Murry (brentmurry@caribbeanlcc.org).

These data are one of two efforts to develop downscaled climate data for the Caribbean. A second project will produce dynamically downscaled information for Puerto Rico and the US Virgin Islands. More work and investment will be needed to produce this information for the Caribbean Basin and incorporate the most recent global projections and scenarios. These kinds of data provide the basis for addressing a wide range of important issues for resource managers and decision makers involved in conservation of natural and cultural resources, forestry and agriculture. The CLCC has several projects underway making use of these data, and we hope the CLCC scientific community will see additional opportunities to use the data. The following are some potential research uses for these new datasets.

Regional Ecosystem Impact Assessments of Plausible Future Changes

Projected climate changes will affect certain species and ecosystems more than others, depending on where they are located, their requirements for thriving, suitable ranges and their ability to cope with change. Regional Impact Assessments (RIAs) are needed to better understand the vulnerabilities of Puerto Rico and the Caribbean's ecosystems[4]. These downscaled climate data can be useful to use as future climate scenarios for RIAs for the following (as examples):

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3 Hayhoe, page 2

4 Puerto Rico Climate Change Council (PRCCC). 2012. Puerto Rico's State of the Climate 2010-2013: Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate. Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR.

4 Current CLCC projects are addressing these. See our projects page for more information.

- Forest cover [4]
- Soil moisture deficits and drought [4]
- Groundwater recharge
- Vegetation dynamics [4]
- Stream flow [4]
- Future species distributions and dynamics
- Wildfires [4]
- Carbon sequestration
- Ecosystem Services

For more information on how to use downscaled climate projections for ecological applications see new report by our partners at the USGS Southeast Climate Science Center: Downscaled Climate Projections for the Southeast United States: Evaluation and Use for Ecological Applications.

Regional Social Impact Assessments of Plausible Future Changes

Projected climate changes will affect certain groups of people more than others, depending on where they live and their ability to cope with different climate hazards.

- Agriculture and food security [4]
- Drinking water resources (aquifers and reservoirs) [4]
- Urban flooding
- Vector-borne diseases like Dengue and Chikungunya
- Non-infectious human health conditions
- Land Use Change [4]
- Economic activities and services
- Local tourism and recreational activities
- Energy consumption and costs
- Cultural and historic resources

Analysis of Policy and Action Scenarios

Cities, states, territories and countries around the world are evaluating the feasibility and effectiveness of different policy scenarios for mitigation and adaptation of climate change. Very few studies exist in Puerto Rico and the Caribbean. Evaluations of potential policy options to help avoid the negative effects of climate change could include:

- Green roof and green spaces
- Cooling centers for vulnerable populations to escape the heat
- Expansion, relocation or corridor creation for protected areas
- Species or nest relocations
- Investment in improved infrastructure to deal with changes in rainfall
- Shifts in agricultural practices

Key uncertainties and data use limitations

It is important to note that uncertainties in the data do affect what sort of efforts these data can support and how they are conducted. Projections of the future climate of the Caribbean region are possible, but uncertainties exist from five main sources (adapted from Tabor and Williams 2010):

- Scenario uncertainty – future greenhouse gas emissions and atmospheric conditions are driven by human behavior and socio-economic activities that are largely determined by trends in population, land use, technology, and policy, and therefore emissions scenarios are difficult to predict.
- Modeling uncertainty – the internal or natural variability of the climate system combined with our incomplete understanding of *all* climate processes.
- Observational uncertainty – the observed data used in the base map from which all predictions are based contain a variety of biases, such as data errors from relocation of weather stations.
- Change-factor uncertainty – relationships exist between macro- (i.e. global) and micro-climates and models run with the assumption that these relationships stay constant over time. As a result assumed model bias remains constant over time.
- Statistically downscaled data offers limited ways to validate future predictions (Charles et al 2004, Gonzalez-Rouco et al. 2000) and predictions (based on statistical regressions) will frequently lie outside the range of the observed data used to develop the models.

These data are *not* day-, week-, month, or even year-specific predictions and should not be treated as such (Hayhoe 2013). These data *are* suitable to represent long-term (e.g., decadal scale) trends in climate conditions.

There is much to learn regarding the key drivers in the Caribbean and Puerto Rico climate systems. Input from both the scientific and management communities can help inform and prioritize future climate modeling and climate science work. The CLCC is working to facilitate discussions between the data user communities and the data provider communities and we encourage atmospheric and climate scientists to focus on unresolved Caribbean climate questions, needs, and areas for improvement, such as:

- Improved understanding of the various processes that govern the climate system, such as local and regional processes that drive precipitation events.
- Techniques to reduce the uncertainties associated with certain parameters, especially rainfall.
- Climate predictions and projections on time scales ranging from seasons to decades to match with decision makers' planning horizons.
- Improved understanding of climate change effects on El Niño/Southern Oscillation, cloud formation, and hurricanes

Literature Cited

Charles, S.P.,B.C. Bates, and J.P. Hughes. 2004. Statistical downscaling of daily precipitation from observed and modelled atmospheric fields. Hydrological Processes

Gonzalez-Rouco, J.F., H. Heyen, E. Zorita, and F. Valero. 2000. Agreement between observed rainfall trends and climate change simulations in the southwest of Europe. Journal of Climate 13: 3057-3065.

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Tabor, K. and J.W. Williams. 2010. Globally downscaled climate projections for assessing the conservation impacts of climate change. Ecological Applications 20: 554-565.