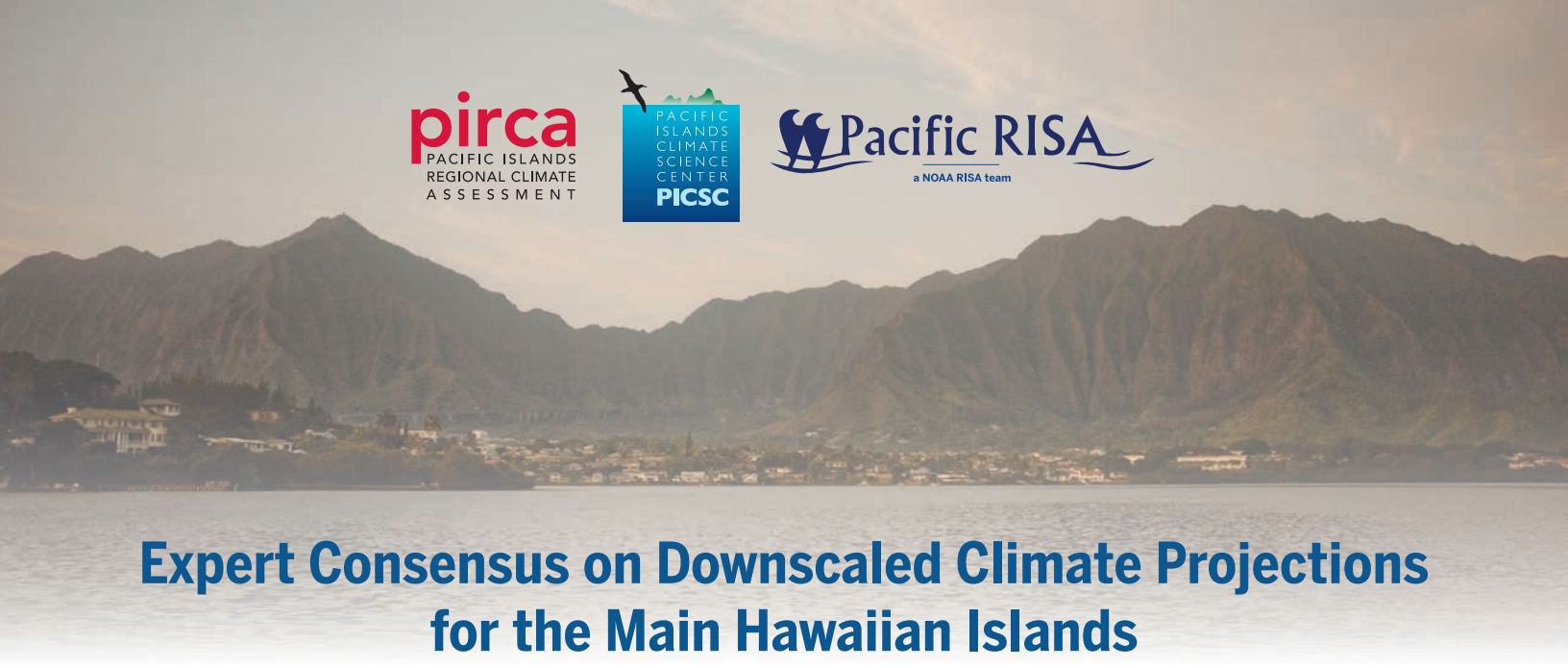


Expert Consensus on Downscaled Climate Projections for the Main Hawaiian Islands

To better understand impacts of climate change across diverse sectors in Hawai'i, resource managers and scientists collaborate with climate modelers who create projections of future climate conditions, such as changes in patterns of rainfall and temperature at the end of the 21st century. To make global climate projections applicable for Hawai'i, the models must be downscaled (see Figure 1) to provide increased spatial detail for resource managers and cultural stewards. Different methods and models are used, and because these are projections for many decades from now, the results often span a range of possibilities. A Workshop held in September 2015 brought climate modelers and resource managers together to discuss areas of agreement about different aspects of climate projection[1]. The purpose of this document is to summarize levels of expert consensus across different climate projections, and to offer guidance for resource managers, cultural stewards, and community leaders to better understand applications and limitations of available projections for the State.

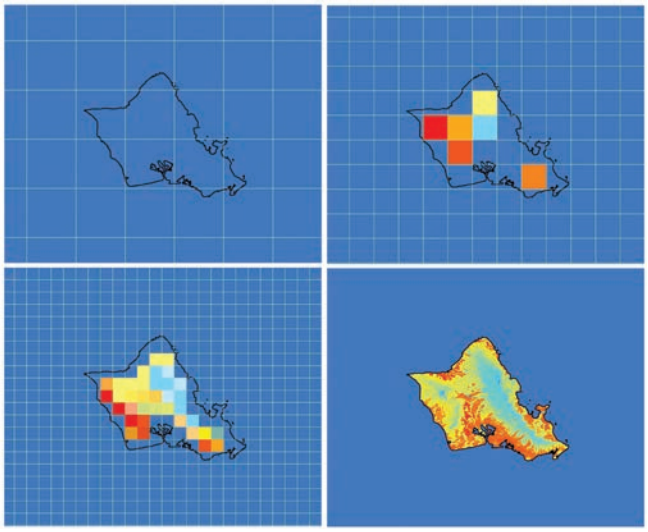


Figure 1: *Using the island of Oahu, this figure demonstrates the concept of downscaling global climate models to an island-scale. In a model with a coarse grid size in the top left corner, pixels are so large that climate projections are not useful for resource management. The process of model downscaling provides a better representation of crucial topography and microclimates that are necessary for local resource management. (Figure by Laura Brewington, East-West Center)*

Definitions

- **Projection** *{vs. prediction}*. A projection is a description of the future and the pathway leading to it. When experts give a projection a high level of confidence, it becomes a forecast or prediction.

- **Downscaling Methods** *{Statistical, Dynamical}*. Coarse global climate models are downscaled to spatial scales appropriate to represent the extreme topography and microclimates on the Hawaiian Islands.

1 Helweg et al, 2016. *https://pubs.er.usgs.gov/publication/ofr20161102*

- **RCP Scenarios** *{4.5, 8.5}*. The IPCC creates Representative Concentration Pathways (RCPs) to represent scenarios of different future socioeconomic conditions that will impact the amounts of greenhouse gases (GHG) released into the atmosphere by the end of the 21st century. RCP 8.5 assumes global society will continue to increase GHG concentrations as rapidly as it has been, i.e., a worst-case future that assumes the world will do little to combat climate change. RCP 4.5 is a more optimistic scenario and assumes slower climate change by the end of the century.

- **Ensemble/Ensemble Mean.** To better characterize the feasible ranges and uncertainty of future climate variables, multi-model "ensembles" are used, which represent a suite of different model runs or different initial conditions within a given model. The ensemble mean is a type of average of the multiple models that is often better than a single model in representing the most likely future condition.

- **Confidence.** Among scientists, confidence is described as a state of being certain that a hypothesis or prediction is correct. This is unrelated to the belief in the trustworthiness of a person or thing.

- **Sectors.** A sector is a segment of society with a particular focus, such as fresh water, energy, food, infrastructure, health, and so on.

Why are climate projections for the end of the 21st century, instead of next year?

Greenhouse gases force climate to change through atmospheric warming and other chemical processes. Even if the world stopped generating new greenhouse gases today, there already is enough there to force the atmosphere to continue to warm for hundreds of years. Changing climate has several components, including the long-term anthropogenic climate change trend that extends out over multiple decades, plus shorter-term natural variability caused by environmental modes such as

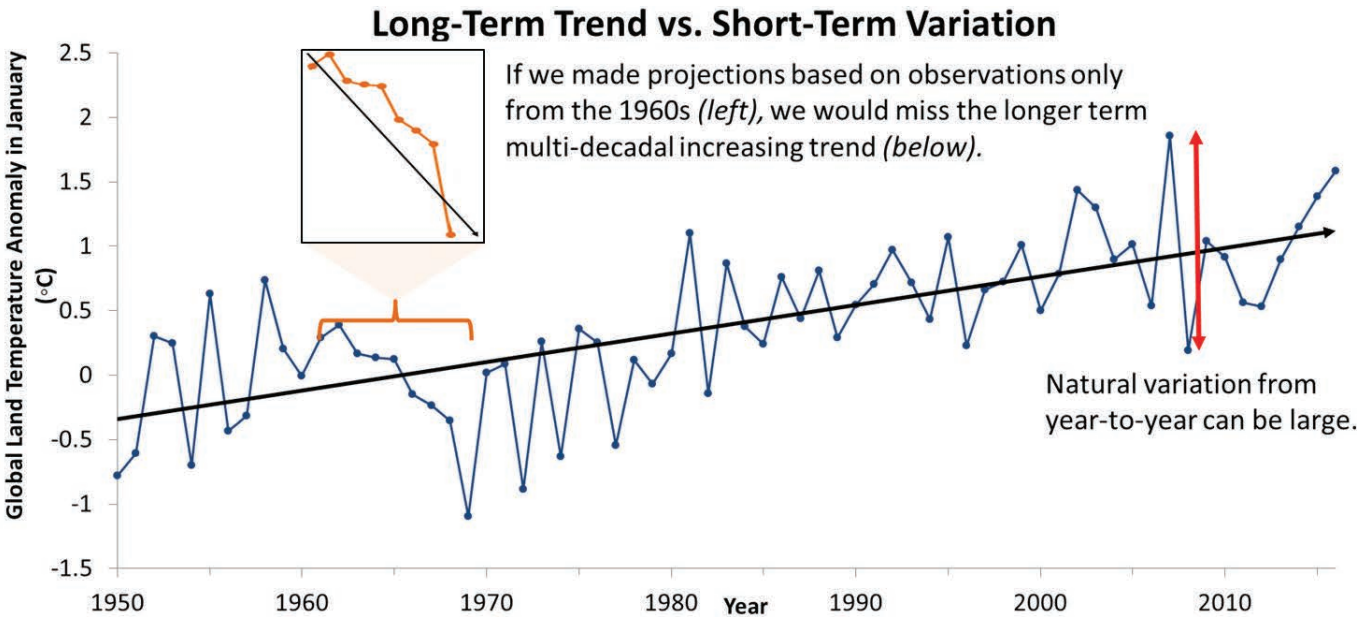


Figure 2: *This image demonstrates how by focusing on short-term trends with greater variability (in orange), we could miss the long-term trend (in blue). The data shows the average global land temperature anomaly in January from 1950 to 2016, with the increasing temperature trend as a black arrow. Climate projections tend to be for the end of the 21st century instead of the next few years so that the long-term trend becomes clear over year-to-year noise. [Global temperature anomaly data from the NOAA GHCN-M and ICOADS datasets]*

ENSO and seasonality that cycle over periods of years or months. Over shorter times such as yearly to a decade or two, variability (e.g., swings in sea surface temperatures or rainfall) tends to be larger in magnitude than the incremental change in climate. Therefore, climate modelers prefer to make projections at long time horizons (e.g., multiple decades or centuries), because the longer from the present, the greater the likelihood that the total amount of climate change will be greater than the short term variability. It is extremely challenging, if not implausible, to produce precise anthropogenic climate change projections for a period a few years to a decade from now. However, the changes in averages and extremes in the long term can help guide large policy and infrastructure decisions in the near term. Critically, while change is inescapable, we are in control of our ability to understand how changes may impact the sustainability of our communities and natural resources, and to plan accordingly.

Types of Climate Downscaling

- **Statistical Downscaling** uses observed local and large scale climate data to create relationships that make global climate model projections applicable at a regional scale. Statistical downscaling assumes that the climate will change in the future similar to how it changed in the past, however, projections may have greater skill in the next few decades.

- **Dynamical Downscaling** uses principles of atmospheric physics to make global climate model projections relevant regionally, and requires high-performance computing resources to simulate how regional climate reacts to defined boundary conditions such as increased GHG concentrations. Dynamical downscaling recognizes that climate is nonstationary, and is best used to simulate end of century changes.

Expert Consensus in late-21st Century Projected Conditions

Climate scientists and natural resource managers in Hawai'i convened for two days in September, 2015, to discuss regional climate projections and their applications. (Image courtesy of Shayne Hasegawa, East-West Center)

High confidence:

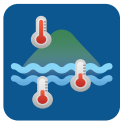
Ambient air temperatures will rise, increasing heat stress on communities

Windward sides of the islands will be increasingly wet in the winter, with the trend most pronounced on Maui and Hawai'i Islands

Sea Level Rise will continue to occur, threatening coastal infrastructure and ecosystems

Sea Surface Temperatures will rise, changing the composition and function of ocean ecosystems

Ocean pH will decrease, making waters more acid and destructive to reef ecosystems



In recent decades, higher elevation areas have warmed more rapidly compared to lower elevation areas

Medium confidence:

Extreme high temperature events will be more likely to occur

Leeward sides will be increasingly dry in the summer season

The inversion layer will decrease in height very slightly, and persistence (number of days present) will slightly increase

Where to Get Current Projected Climate Data

Observed and projected climate data and information is available for public download. While these are the most current data and projections available, continuing research means that there will be new datasets available regularly, and users are encouraged to check for new results, as well as if the most recent data is published in a peer-reviewed journal. For more information on how to utilize these data, see the contact list below.

- **Dynamically downscaled climate projections:** http://apdrc.soest.hawaii.edu/
- **Historical climate data:** The Hawai'i Rainfall Atlas http://rainfall.geography.hawaii.edu/
- **Statistically downscaled Climate Projections:** http://www.atmos.albany.edu/facstaff/timm/products_data.html
- **PICSC Geodatabase:** https://nccwsc.usgs.gov/display-csc/4f8c650ae4b0546c0c397b48
- **Sea Level Rise Projections:** http://www.soest.hawaii.edu/coasts/sealevel/
- **Downscaling in Hawai'i workshop report:** https://pubs.er.usgs.gov/publication/ofr20161102

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PACIFIC ISLANDS REGIONAL CLIMATE ASSESSMENT

For additional information, please see *www.PIRCA.org* or contact the Pacific Islands Regional Climate Assessment team:

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