Department of the Interior Climate Science Centers and the US Insular Areas

The Department of the Interior operates eight Climate Science Centers (CSCs) in the lower 48 states, Alaska and the Pacific Islands. CSCs are government-university cooperatives whose scientific directions and focus are driven by the information needs of regional decision makers and resource managers. Their goal is to provide science that can directly be used by these management partners in decision making about adaptation to a changing climate.

The **Pacific Islands CSC** is located in Hawaii, and its area of responsibility includes Hawaii and all U.S. insular areas in the Pacific. The **Southeast CSC** is located in Raleigh, North Carolina, and its area includes Puerto Rico and the U.S Virgin Islands.

Each CSC is advised by a Stakeholder Advisory Committee comprised of Federal, state, tribal, and other governmental partners (e.g. insular governments).

Following are summaries of projects that either are underway (PI CSC and SE CSC) or could be applied to additional insular areas (PI CSC).

Department of the Interior Pacific Islands Climate Science Center
Strategic Climate Science Support for the U.S. Affiliated-Pacific Islands

The Pacific Islands Climate Science Center (PI-CSC) has established two Cooperative Agreements (CA) with regional universities to provide strategic science support. One CA is made with the Hawaii Cooperative Studies Unit (HCSU) at the University of Hawaii at Hilo. The CA started in 2013 and extends for several years, and provides for a project specialist who supports PI-CSC coordination with other climate programs and resource management stakeholders operating out of Hawaii The second CA is new in 2015 and is being made with the **Center for Island Sustainability at the University of Guam**. This CA provides for two part-time positions, one for a Climate Coordinator and one for a Geospatial Information Systems (GIS) Coordinator.

These Agreements establish a capacity for strategic science support at two universities in the region in which Pacific Island students seek education and technical training. The PI-CSC has created both CAs to exist as a service to regional resource managers seeking to increase their understanding of climate change and means by which communities can prepare and adapt, and are a resource for the Office of Insular Affairs.

Department of the Interior Pacific Islands Climate Science Center

Projects in the U.S. Affiliated-Pacific Islands Currently Under way

Vegetative Guide and Dashboard: relating atoll agroforestry recommendations to predicted climate and sea level conditions in the Marshall Islands

Lead Scientists: Maria Haws, Ph.D., University of Hawai`i at Hilo; Kathleen Friday, Ph.D., Forest Service (USDA), Pacific Southwest Region

The low-lying islands and atolls of the Republic of the Marshall Islands are vulnerable to storm surges and the effects of drought. Winter storm waves crash over sea walls and flood roads, farms, homes, and businesses, and the dry season brings drought and water shortages. These influxes of seawater and an inconsistent freshwater supply create a harsh environment for sustaining food or commercial crops.

Food security is a key part of adapting to accelerating climate change impacts. Maria Haws and Kathleen Friday are working with local farmers and agricultural agents to develop a website (dashboard) and associated products that will help guide and support sustainable food production. Collaborating alongside a weather prediction dashboard provided by the NOAA National Climatic Data Center alongside the USAID program, this dashboard will help home gardeners, farmers, and agriculture extension agents anticipate how upcoming weather will affect their yields, water supply, and economic decision-making.

The dashboard will provide climate and agroforestry information through quick, easy-to-understand displays and case studies that are tailored for the Marshall Islands. In addition, traditional agriculture practices and uses of traditional crops will be supported following the revival of these crops in recent years, as well as nutritional and cultural resources to further assist users of the dashboard. Protection of natural resources and food crops is an important aspect of life on small islands, so information on shoreline protection efforts are also included.

The researchers are further establishing relationships and pathways for Marshallese users to collaborate with project partners and give input for dashboard improvement. The dashboard will include a user interface and community products that suit the needs of Marshallese community members in a culturally appropriate and adaptive way. By making this information accessible to community members the dashboard can offer good agricultural practices in the context of climate change thereby increasing community resilience and adaptive ability in the people of the Marshall Islands.

Coral Reef Resilience to Climate Change in the Commonwealth of the Northern Mariana Islands: Field-based Implications for Vulnerability and Future Management

Project Leaders: Laurie Raymundo, Ph.D., University of Guam; and Jeffrey Maynard, Ph.D., Cornell University

Scientists agree that climate change poses the single greatest long-term threat to coral reefs. Among other impacts, climate change is expected to result in more frequent and severe tropical storms and coral bleaching events. Coral reefs are also under great pressure from human activities, like overfishing and coastal development, that increase the sensitivity of organisms on reefs to climate change threats. There is now unprecedented pressure on the natural resilience of coral reef systems; their ability to endure and recover from stress events. Managers thus have to provide for sustainable use and maintain cultural values associated with coasts while supporting reef resilience by limiting human impacts.

This study is a collaboration between the PI-CSC, NOAA, and others and focuses on the resilience potential of fringing reefs on the islands of Rota, Tinian, and Saipan in the Commonwealth of the Northern Mariana Islands (CNMI) in the western Pacific Ocean. About 60 reef sites are being evaluated through resilience indicators including coral disease, coral diversity, bleaching resistance, coral juvenile populations, macroalgae cover, herbivorous fish and invertebrates, and human impacts. To further support marine management efforts, researchers are concurrently surveying reef sites for threatened and endangered species.

Through extensive and direct communications, the research team hopes to inform marine managers with their limited resources to target actions in CNMI that support and build reef resilience. In addition to workshops and trainings for local managers on potential management actions in the short- and long-term, researchers will also share their advances in methodology, processes, and the results of the study to cultural practitioners and resource managers in the broader Pacific region and the Caribbean.

21st Century High-Resolution Climate Projections for Guam and American Samoa

Lead Scientist: Yuqing Wang, Ph.D., University of Hawai`i at Mānoa, International Pacific Research Center

The small islands of the tropical and subtropical Pacific include 15 sovereign nations and several territories and are home to over 9 million people. There is a great concern about the impacts of anticipated anthropogenic climate change over the coming decades over these islands in terms of vulnerability of their small, geographically isolated ecosystems and economies as well as their extreme susceptibility to extensive inundation from rising sea levels. Despite this awareness at an international level, there have been almost no useable climate projections for these societies because the large-scale climate models used in IPCC are not sufficiently detailed for these tiny landmasses.

Dr. Wang and his team are creating climate models to produce projections of mean changes and changes in extreme events at very high resolution for the islands of Guam and American Samoa. The

research team is building and improving on a previous model—the Hawaiian Regional Climate Model, or HRCM—to simulate systems that cause extreme rainfall events and windstorms using the global warming increments from the ensemble of CMIP5 (Coupled Model Intercomparison Project, phase 5 of the World Climate Research Programme) model projections. This downscaled model will aid other research in hydrological and ecosystem models on Pacific islands.

To date, the research team has achieved the highest resolution (0.8 km), long-term climate simulations in the world. Simulations from the largest scale dataset have depicted a reduction of tropical cyclone frequency with an increase in tropical cyclone intensity, consistent with most model simulations, giving credibility to the current model configuration and model tuning. In coming months, the team plans to create downscaling projections for 20-years and 5-year increments, which will then be made available to resource managers and decision makers.

Department of the Interior Pacific Islands Climate Science Center

Projects with Methods or Purposes that COULD BE IMPLEMENTED in the U.S. Affiliated-Pacific Islands

Hawaiian Seascapes and Their Management Implications

Lead Scientist: Noelani Puniwai, Ph.D. candidate, University of Hawai'i at Mānoa

Unlike landscapes, seascapes provide very little long-term proof of their physical changes. The relationships between human activity and the environment create ecological, socioeconomic, and cultural patterns, and the mental maps created through these interactions can provide highly accurate insights.

Hawai'i's climate is changing, and the need to observe and document past and current states of the ocean becomes more relevant in order to predict and prepare for those changes. The spatial scale at which people interact with their environment is difficult to explain yet extremely pertinent when comparing observations with others, interacting with datasets, and visualizing in GIS. This research is focused on discovering those interactions between people and their ocean environment by combining sensor data and human experience to infer future characteristics of the changing marine environment.

Hawaiians and other recent immigrants play and work on the coast and in the near-shore waters of the islands, observing and experiencing those changes over time. By interviewing respected ocean observers the team is learning more about the changes they have witnessed and the spatial scale and ocean conditions that are important to them. Comparison of these scales with the surface current information and models made available to the public identifies overlaps in ocean information and fills in gaps in scientific knowledge for conditions such as past rainfall, stream flow, wave direction, wind speeds, and sea level rise. This project combines anthropological qualitative methods and participatory mapping to further the discipline of natural resource management and to

understand the most relevant scales of oceanic and meteorological information to local ocean users. With this research, the team can help support coastal managers who make important decisions about these vital ocean resources and provide the results of the study to the local ocean users who added knowledge to the research.

Valuing Climate Change Impacts on Coral Reef Ecosystem Services

Lead Scientist: Kirsten L. L. Oleson, Ph.D., University of Hawai'i at Mānoa

With every year that passes, more impacts due to climate change are observed in the islands of Hawai'i. Often, these changes are documented in ocean processes such as sea surface temperature, sea level rise, wind patterns, and storm intensity. Coral reefs provide vital services and resources to coastal communities in the form of coastal protection, commercial extraction, cultural sites, tourism, food resources, and more. Some of these services and resources are easily quantified through economic valuation processes, while others, such as recreation or cultural and traditional uses, are more difficult to compare. Marine managers must weigh the economic value and quality of life benefits of coral reefs as this resource changes over time and make decisions to protect and sustain it into the future.

By adapting a coral reef model for Hawai'i, Dr. Oleson's team and partner organizations are developing a watershed-scale management tool that will assist marine managers to make decisions in the face of climate change impacts. To do this, the team is identifying areas critical for coral reef ecosystem services—the most important human benefits from coral reefs—and the stressors that affect coral reefs. Stressors can come from either the terrestrial or marine side of the waterline and include human-induced (fishing, pollution from runoff) or climate-change-induced (sea-level rise, rising ocean temperature, increased storm intensity).

Various climate scenarios and potential management decisions will be assessed based on these critical services to find cost-effective adaptive management actions that will ensure optimal and equitable benefits for all. The end result will be a decision-support tool for managers to better promote resilient reefs and communities.

Future Coral Reef Community Projections of DOI-Managed Coastal Assets in the Hawaiian Islands

Lead Scientist: Erik Franklin, Ph.D., University of Hawai'i at Mānoa

The islands of the Hawaiian Archipelago share a long geological history, but they also share a biological history. This history is evident in the species that are common throughout the chain of islands, on the land and in the water. Similar to organisms in terrestrial habitats, marine organisms are also subject to changes that occur in their marine ecosystems. Changes in weather, wind and wave patterns, temperatures, and ocean chemistry can have profound and far-reaching effects on

marine food chains. As climate change impacts ocean systems, scientists are investigating how those physical systems are affecting biological communities in the Hawaiian Islands. This study is evaluating the response of coral reef ecosystems to anticipated climate scenarios.

Dr. Franklin's research team is determining the relative amount of change to coral, fish, and urchin populations under different climate scenarios using a combination of three models. Larval connectivity models establish the connection and pathways of larval distribution among Hawaiian reefs. Physical disturbances from waves differentially affect islands in the archipelago; therefore, wave models and ocean circulation models are added to simulate wave and ocean current climatology under future scenarios. With these models, climate change impacts to coral communities can be determined.

As natural resource managers determine the most effective management strategies to protect and support marine organisms and ecosystems, they will require tools to aid in their decisions regarding future climate outcomes. The models and workshops produced by this study will train and inform managers in the anticipated shifts in reef species for future climate scenarios relevant for fisheries, tourism, and coastal protection.

Expanding a Dynamic Model of Species Vulnerability to Climate Change for Hawai‘i

Project Leader: Lucas Fortini, Ph.D., USGS Pacific Island Ecosystems Research Center and Pacific Islands Climate Change Cooperative

While research on climate change impacts has typically focused on uncertainties of climate projections, the uncertainties in the underlying ecological responses to climate shifts are perhaps an even greater challenge to address in Hawai‘i and other Pacific islands. The proposed dynamic research prioritization tool starts a concerted effort to address the biological impacts of climate change on Pacific island ecosystems. This species vulnerability assessment is possibly the largest in scope for the entire country, with over 1000 species considered and comprising a substantial proportion (319 species) of all threatened and endangered species listed under the Endangered Species Act.

This project uses a variety of geographic and life-history information about native Hawaiian plant species—many of which are threatened or endangered—to model their ability to cope with climate change. There are four broad methods for a species to survive in a changing climate: it might tolerate the new conditions, it could evolve to adapt to the new environment, it may persist in micro-refugia (small pockets of acceptable habitat in an otherwise hostile landscape), or it can migrate to new habitat that becomes available as old habitat deteriorates. Different species have different physical and genetic traits and so will respond differently. An expert panel of botanists assisted the project team to refine the vulnerability factors and detail the life-histories of the study species.

This research and resultant model will rank which species are most vulnerable to the effects of climate change and identify how those species are likely to cope based on the most sensitive factors

in each species' life-history. The vulnerability estimates produced by this study will support resource managers prioritize conservation efforts for the species they manage. The model software is designed to be applied in other locations with other suites of species of concern.

Proposed Workshop on:

Exploration of Innovative and Practical Methods to Acquire High – Accuracy Elevation Geodata Across US Pacific Islands for Increased Coastal Resilience

Contacts: Jeff Danielson, USGS EROS Science Center, Sioux Falls, SD, John Brock, USGS Coastal and Marine Geology Program, Reston, VA, and David Helweg, USGS PI-CSC

There are over 2000 islands in the Pacific that are extremely vulnerable to sea-level rise, storm surge, coastal flooding, and climate change that could impact sustainability of infrastructure, groundwater, and ecosystems. Among the climate change impacts that small islands face are increased frequency and intensity of extreme storms, sea-level rise, coastal erosion, coral reef bleaching, ocean acidification, and contamination of freshwater resources by salt water. Comprehensive integrated onshore – offshore baseline elevation data are vital for emergency planning, disaster response, and hazard mitigation policy development for these areas.

High accuracy landform models that run seamlessly from underwater up across the waterline and over the landmass are essential for coastal vulnerability assessments that involve inundation prediction and tsunami impact forecasting, and also to analyze the impact of various climate change scenarios on coast regions. The Coastal National Elevation Database (CoNED) project is actively working along US Atlantic, Pacific, Gulf of Mexico and Alaskan coasts, collecting and integrating disparate lidar and bathymetric data sources to construct Coastal Zone models that fulfill this need.

Given the pressing need for high accuracy elevation data along the shorelines of Pacific Islands, CoNED is planning a Workshop on the *Exploration of Innovative and Practical Methods to Acquire High – Accuracy Elevation Geodata Across US Pacific Islands for Increased Coastal Resilience*. This Workshop is to be aimed at defining practical methods for wide-ranging but highly targeted acquisition of high accuracy – high resolution topographic and bathymetric data on and around low-lying US Pacific Islands. Because atolls and islets are very close to sea level, an attempt to analyze vulnerability demands unprecedented precision, and that in itself is a scientific challenge. Recognizing that remote and vegetated islands present unique technical and logistical challenges, through this Workshop we seek to bring together a community of stakeholders, surveyors, mapping specialists and GIS experts to discuss needs within the USAPI, explore innovative surveying methods, and examine options for data access through a web-based portal. An outcome of the Workshop will be formation of a tiger team of experts who will write a work plan for data collection and analysis that will result in the high precision maps needed by resource managers and community planners in USAPI.

Department of the Interior Southeast Climate Science Center

Strategic Climate Science Support for the U.S. Affiliated-Pacific Islands

Developing multi-model ensemble projections of ecologically relevant climate variables for Puerto Rico and the US Caribbean: The development of adaptation strategies that respond to ACC for the CLCC, and particularly for Puerto Rico, is currently hindered by the lack of local-scale climate scenarios that resolve the complex topographical and meso-scale climate features that will mediate the island-wide response to the global anthropogenic climate forcing. Project scientists are developing a suite of climate model projections for Puerto Rico and the U.S. Caribbean region, with model outputs defined in collaboration with users of the data.

Developing long-term urbanization scenarios for the Caribbean LCC as part of the Southeast Regional Assessment Project: This project extends the long-term urbanization modeling already undertaken for the South Atlantic, Gulf Coastal Plains and Ozarks, and Appalachian into the Caribbean LCC.

Impact of Ocean Warming and Acidification on Growth of Reef-building Corals: Coral reef ecosystems are degrading quickly due to a variety of factors at local, regional, and global scales due to factors that include increasing ocean surface temperatures, and decreasing ocean pH (ocean acidification). This study identifies differences in climate vulnerability among three important reef-building coral species in the Territory of the U.S. Virgin Islands, producing information needed for resource management decisions regarding reef restoration and species protection policies.

Global Change Monitoring Portal: This project provides scientists and the general public with access to information about programs that monitor the effects of global change processes, such as climate and land use change, on important air, land, and water resources. This is a public service project intended to support both education and decision making by providing comprehensive “one stop” access to information about hundreds of monitoring programs throughout the Southeast, including the Caribbean.