1. **Award Title**: The Pacific RISA: Supporting Integrated Decision Making Under Climatic Variability and Change in Hawai‘i and the US-Affiliated Pacific Islands

2. **Performance Period:** June 1, 2015 to May 31, 2016

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4. Do you have any **NEW areas of focus or partnership** that have begun this past year? Please provide some context for why you are expanding into this area or partnership. Include any NEW cross-RISA partnerships.

Regional Pacific-Basin Migration: Climate Migration from US Affiliated Pacific Islands to Hawai'i
Though much research and debate has focused on the relationship between climate and migration, it is widely recognized that a lack of rigor and clarity characterize research on the climate/migration nexus. Climatic changes often act in concert with other socioeconomic factors to drive displacement. Moreover, factors triggering mobility are often intertwined – environmental changes can generate health problems or food insecurity, and may play an even greater role if they emerge in a community characterized by political, social, or economic tension. The number of variables translates to high uncertainty and local variability, and results in different, and often conflicting, policy positions from a range of actors. Policymakers require better information, empirical data, and analysis of the challenges involved to plan for the future. With financial support from the DOI Pacific Islands Climate Science Center (PI-CSC) and assistance from Project Specialist Grecni and a Master's student intern, this new initiative led by Pacific RISA PI Burkett has begun to produce a comprehensive map and accompanying white paper that describes the drivers of migration, both current and forecast, as well as the stock and flow of migration over a given time period. Climate data including downscaled climate projections, historic and future ENSO conditions and sectorally specific thresholds will be used to help clarify the drivers of potential past and future migration, helping policymakers to prepare adequately for the changes to come. The second part of the project will explore the legal issues associated with such migration. Numerous legal issues plague the current migration debate, including the status of migrants in transit and in host

communities, domestic immigration policy, relocation assistance and resettlement rights, and ownership of natural resources. Subsequent work will produce two policy white papers intended for diverse policy and academic audiences: the first will detail the legal and policy implications of migration for the US-Affiliated Pacific Islands (USAPI), while the second will analyze the legal and policy implications for Hawai‘i as a host state.

Evaluating Similarities and Differences between Statistical and Dynamical Downscaling Projections
Future rainfall patterns have been projected for the Hawaiian Islands using statistical and dynamical downscaling methods. However, more work needs to be done to test and refine methods in order to produce reliable results. Both statistical and dynamical downscaling methods have inherent uncertainties, which regional stakeholders are grappling with in their efforts to make climate-adaptive decisions. The first objective for this project, led by Pacific RISA PIs Giambelluca and Annamalai, is to test the validity of the projected rainfall anomalies derived from statistical downscaling methods. The general pattern of the projected rainfall changes appears consistent with recent dynamical downscaling results. However, the drying trend is less severe in the dynamical results, and a larger increase in the wet region rainfall is projected in the dynamical downscaling scenario. The team will examine in more detail how robust the statistical model results are with respect to the applied method and the large-scale climate information that are used as predictors. The second objective is to test the sensitivity to changes in large-scale climate information. The ultimate goal is to obtain a better understanding for the differences between the existing statistical and dynamical downscaling results, which show substantial disagreement in the magnitude of the projected rainfall changes as well as locally opposing signs in the future rainfall anomalies. Detailed analysis of the statistical downscaling results will determine what large-scale climate signal controls the regional spatial pattern seen in the projected rainfall anomalies, and how sensitive the magnitude and the pattern itself are to variations in the chosen large-scale climate predictor information.

Assessing Economic Impacts of Climate Change and Variability Planning and Adaptation
As island-scale projections of future climate variability and change are released and integrated into planning documents, managers still lack detailed information on the value and tradeoffs associated with future climate impacts and the implementation of different adaptation strategies. Limited efforts have attached metrics of value to an island’s natural resources. Policymakers and managers need to have measures of valuation to decide between alternative adaptation options and to weigh the potential costs of inaction. This project builds on the participatory scenario process developed by the Pacific RISA in Phase II to generate a set of rules concerning climate variables, management options, and policy alternatives that will be used to inform ecosystem services valuation and adaptation strategies for Maui. Led by Pacific RISA PI Oleson and Postdoctoral Fellow Fezzi, watershed-scale modeling will be embedded in a decision support tool that quantifies, maps, and values ecosystem services from land to sea. The project, parts of which have been funded by USDA, NOAA, and the PI-CSC, leverages existing models such as InVEST42 and ARIES43, with an aim to guide management by predicting how key ecosystem services will change under alternative management policies and climate change scenarios. The ecosystem services that are currently captured include sediment retention, water yield, fisheries, and coastal protection. We will continue to build on this work by expanding the services captured and attaching more explicit valuations to the different adaptation options of interest in the three future climate scenarios on Maui.

Evaluating Impacts of Climate Variability and Change on Public Health in Hawai‘i
As their focus for 2015-2016, the Hawai‘i Public Health Association (HPHA) chose to concentrate on exploring the potential impacts of climate change on human health in the state of Hawai‘i. Pacific RISA PIs Keener and Lewis were invited to sit on the Hawai‘i Climate Change and Health Working Group (HCCHWG), which was convened as a result of the Climate Change and Health Policy Action bill (HCR 108, SD1) passed in May of 2015 by the Hawai‘i State Legislature. The HCCWG met 10 times during the reporting period, producing a white paper outlining research priorities and gaps on climate and health that was submitted to the Hawai‘i Department of Health (HCCHWG, 2016). HCCHWG will continue to move

forward with the Department of Health to incorporate climate questions into the Hawai‘i Health Survey so that key variables can be tracked longitudinally. Key findings from the HCCHWG report include:

- The range of health issues that may increase or be intensified by climate change include airborne allergens, wildfires, temperature extremes, and precipitation extremes, as well as diseases carried by vectors, food and waterborne disease, and water and food security issues.
- Climate change is projected to increase and exacerbate already-existing public health problems, such as acute and chronic diseases, stress and mental health issues, dengue, and other vector and waterborne diseases. Major challenges will be to identify, measure and analyze/interpret key health indicators to determine changing health trends that are attributable to climate change conditions.
- Disparities in health impacts are projected for already vulnerable populations, such as elderly, poor, young, ill, and marginalized populations, as well as specific at-risk groups such as workers exposed to increased heat and sun outdoor risks.
- Increased heat is projected to increase problems with air and respiratory and cardiac-affected populations, as well as increase risks for more heat-related illness and death: vector-borne (mosquitos), water-borne, and food-borne (food poisoning).
- Mental health disorders and stress impacts are projected to increase, due to changing conditions and increasing long-term future adaptation required and potential mental distress associated with anxiety about impacts and fear of losing one’s home.

Key recommendations include:

- A major focus for health should be on comprehensive and coordinated adaptation strategies by Hawai‘i’s public health system and related services, engaging scientists/researchers, planners, and policymakers to support adaptation to changing environmental challenges and conditions.
- The Department of Health should have increased dedicated fiscal and personnel resources to lead efforts addressing development of climate change and health public health issues, including:
    - Adequate resources to include several questions on climate change and health on the state health survey
    - Stronger protections against both infectious and chronic climate-associated disease threats by including further identifying factors that affect the risks of vector-borne, foodborne, and waterborne diseases
    - Increasing disease surveillance to provide a baseline measure of disease activity and enable the detection of new diseases and tracking the geographic spread of diseases and vectors.
    - Focusing surveillance on major projected climate change threats to link climate indicators with health impacts (heat, chronic diseases, mental health, communicable diseases, food-related illness, water-related illness) and to help provide early warning of potential health threats.

5. Please tell us which States or territories in your region are using new or tailored climate services (tools, information, technical assistance, or products) as a result of your interaction with decision makers over the past year. Please describe at least one new/tailored climate service per State/territory that you include.

El Niño and Pacific Island Fact Sheets

The strong El Niño event that is occurring between 2015-2017 is having significant impacts in Hawai‘i and the Pacific Islands region, including extended drought conditions, enhanced risk of damaging tropical cyclones, increased risk of coral bleaching, and possible spread of vector borne disease and illness. Impacts vary by island, however, and in fall of 2015 the NOAA Hawai‘i and Pacific Islands ENSO Tiger Team created seven fact sheets outlining different physical impacts on different sectors and projected

trends in relevant climate variables for Hawai‘i, American Sāmoa, Guam and the Commonwealth of the Northern Marianas Islands, the eastern and western Federated States of Micronesia, the Republic of Palau, and the Republic of the Marshall Islands. The NOAA Pacific Regional Climate Services Director (RCSD, Marra) and Pacific RISA PI Keener worked closely with the Pacific ENSO Applications Climate Center (PEAC) and the University of Hawai‘i to help raise awareness of the impacts of El Niño by answering common questions including: What is El Niño? What might the impacts be in your region? What about impacts such as sea level rise, tropical cyclones, and rainfall? Fact sheets can be found on the Pacific RISA website at http://www.pacificrisa.org/2015/11/12/pacific-island-fact-sheets-released-on-el-Niño-and-sectoral-impacts/.

Water and Policy Analysis for American Sāmoa

Pacific RISA Project Specialists Wallsgrove and Grecni completed a water and policy analysis for American Sāmoa, which used stakeholder input to identify climate adaptation planning opportunities in the territory (Wallsgrove and Grecni, 2016). Specifically, the report highlighted ENSO as a crucial predictor of impacts for decision makers, including the American Sāmoa Power Authority (ASPA), the American Sāmoa Environmental Protection Agency (ASEPA), and the American Sāmoa Department of Commerce. The report also identified water quality research as a critical need for planning for future water resources. ASEPA and ASPA are currently incorporating recommendations that resulted from this research in their water monitoring and management protocols.

Future Land Cover Maps for Maui

The future land cover maps for Maui island developed by Pacific PIs Brewington and Keener have been distributed widely throughout county and state levels of governance and are published on the Pacific RISA webpage. They are being used in an increasing number of policy-relevant and research applications, including ecosystem services valuation for west Maui, the West Maui Ridge to Reef initiative, and an upcoming project on Maui sustainability led by the Pacific Islands Climate Change Cooperative (PICCC). Their utility and broad usage has increased Pacific RISA visibility in Hawai‘i and a new project investigating water resources on Oahu under climate change will employ a similar explicit land cover-based approach.

6. A. How are you measuring the overall program-level impact of your RISA team? Please provide information on your evaluation model, including metrics or indicators that you use to evaluate your program.

Supporting Hawai‘i’s Climate Adaptation Efforts: The Role of the Pacific RISA

Independent Pacific RISA evaluator Dr. Susi Moser continued her efforts to track the impact that Pacific RISA research has had in the region while PI Finucane updated the action-logic model and understanding of theory of the Pacific RISA impact. A final report is currently in the draft phase that will report on advancements in the action-logic model and ongoing evaluation efforts for Phase II. During the reporting period Dr. Moser created and analyzed spreadsheet data that assembled all tracking sheets during the five years of Phase II into one document, describing each project team's reported progress for each year of the previous RISA award. Finucane created a draft of the revised action-logic model, which organizes activities around four main functions that better reflect the iterative stages of our projects from inputs, to outputs, to outcomes (Figure 1).

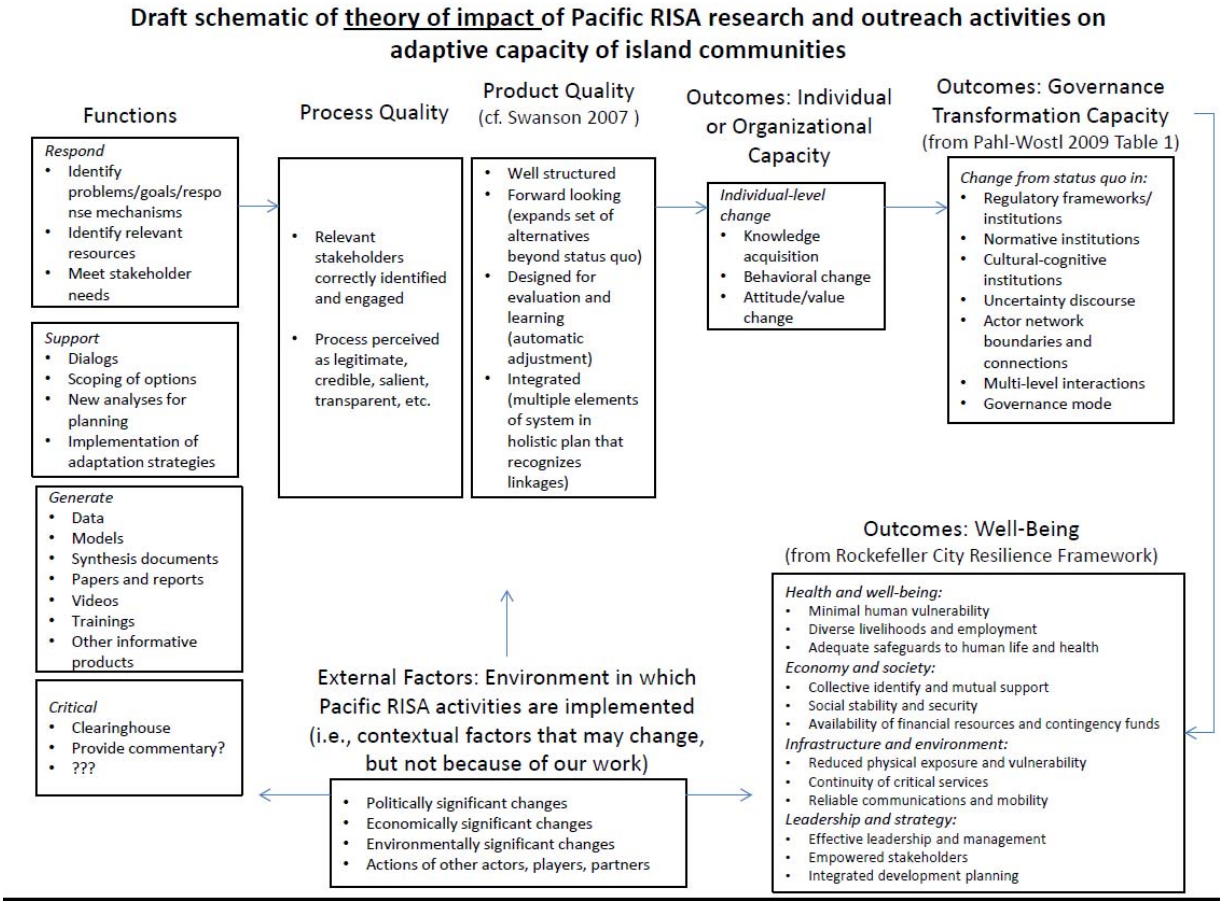

Figure 1: Revised action-logic model for the Pacific RISA program (still in draft form).

B. Please describe your overall program-level impact including (if applicable) a summary of the results from your evaluation efforts.

Dr. Moser conducted a comprehensive assessment of multiple metrics at multiple points in time of the Pacific RISA activities during Phase II. Findings indicate that in spite of progressive cuts in funding, the Pacific RISA captured adequate progress in assessing and addressing the climate adaptation needs in the region. Her findings also deepened knowledge about the strengths and weaknesses of the current evaluation methods (both external and internal). The final report for the RISA Phase II evaluation is forthcoming. In the last two annual independent evaluations Dr. Moser's research was able to trace the Pacific RISA products to specific policy outcomes, mainly concerning the intersection of freshwater sustainability and climate change adaptation at the county and state level. Relying predominantly on stakeholder interviews and supplementary document review, the evaluation found the following (See Question 12 for more information):

- Demonstrable impact on state-level adaptation policy-making
- Strong impact on state-level water management
- Beginning impact on local-level water management
- Continued impact of the PIRCA in all policy realms

7. How have you helped to build the expertise and ability of local/regional decision-makers to prepare and adapt to climate variability and change?

- The Hawai‘i Commission on Water Resource Management has continued the process of updating Hawai‘i’s primary and comprehensive water planning policy tool – the Water Resource Protection Plan and its components – including efforts to address Pacific RISA recommendations regarding climate change adaptation.
- Building off of climate adaptation legislation passed in 2014 and the resulting ongoing efforts related to adaptation, the Hawai‘i legislature passed at least two bills in 2016 to increase adaptive capacity for water resources. Climate adaptation and appropriate planning horizons were issues raised in the deliberation of both bills. Work is progressing on the Interagency Climate Adaptation Committee Act 83, implemented in 2014, with public engagement to commence shortly and the committee's report anticipated in 2017. Hawai‘i legislators and regulators have looked to the Pacific RISA for assistance in understanding and developing climate adaptation laws and policies.
- The Honolulu Board of Water Supply has budgeted for new capital improvement projects that are consistent with adaptation recommendations, including recycled water mains and water storage facilities.
- The American Sāmoa Power Authority has moved forward with plans to increase stream and rainfall monitoring capacity, consistent with opportunities identified by the Pacific RISA.
- The American Sāmoa EPA has begun to include groundwater monitoring in their standard monitoring protocols, consistent with recommendations from the Pacific RISA.
- The Maui Scenario Planning process was effective in creating plausible scenarios of future land use on Maui island, Hawai‘i. In January 2016, Hawai‘i Commercial & Sugar Company announced that they would be suspending all sugarcane operations in the central isthmus (30,000 cultivated acres) and transition to a diversified agriculture model (http://www.staradvertiser.com/business/business-breaking/last-sugar-plantation-in-Hawai‘i-to-close-this-year/). One of the stakeholder defined land use scenarios represented exactly this scenario, giving us the ability to utilize that model in planning sooner rather than later.

8. What is the accomplishment from this past year of which your team is most proud? Why?

A survey designed by the Pacific RISA and an associated workshop in fall 2015 were extremely informative in identifying the respective information needs that climate scientists and natural resource managers have when it comes to the generation and interpretation of available climate information in Hawai‘i (see ***Perceptions of Climate Needs and Downscaling Data by Modelers and Resource Managers in Hawai‘i***, below). Results from the survey were tallied by sector, and thanks to the significant role that the Pacific RISA has played in the state water resources management sector, respondents from water management reported much higher use of climate information, while areas that have been underrepresented by the Pacific RISA (wildfire management and ecosystems management, for example). This pointed to clear opportunities for influence and new research directions in the future. In addition to that, when groups were asked to quantify their confidence in different climate variable projections, while climate scientists had fairly similar evaluations of statistical and dynamical downscaling data, the major finding was that virtually all natural resource managers had no opinion or didn't know how well any downscaling method reproduced historical variables or projected future variables. Therefore much more effort is needed to assist in translation and use of climate projections in resource management. Workshop discussions following presentation of the survey results pointed to a strong need for the Pacific RISA and other boundary organizations to continue to translate regional climate science into useable products and easily accessible formats for end users, particularly among ecosystems and wildfire manager groups. They also confirmed long-standing concerns about uncertainty inherent in model downscaling and disagreement between modeling products, both of which are main

components of the Pacific RISA Phase III efforts. The final report for the workshop is currently in review by the USGS (see ***Publications***).

9. Please provide a list of up to 5 **research findings**.

Dynamical Seasonal Prediction of Precipitation for the Hawaiian Islands

Because of the small relative size and topographical diversity of Pacific Islands, significant downscaling of global model predictions is needed to make them applicable to island-scale decision making. In Phase II, the Pacific RISA supported the development of the Hawai‘i Regional Climate Model (HRCM) by the University of Hawai‘i International Pacific Research Center (IPRC). The HRCM is a dynamically downscaled regional model for the Hawaiian Islands at 15 km, 3 km, and 1 km horizontal grid scales, which has been used to perform a 20-year (1990-2009) present-day climate and projected 20-year (2080-2099) simulations for late 21st century conditions (Zhang et al., 2016). One salient result is that both the improved model physics and high model resolutions are needed for realistic simulation of current climate and future projections. Dynamical seasonal prediction of precipitation over the islands is still in its infancy. The skill of both versions of the NOAA operational model (CFSv1 and CFSv2) hindcast experiments were assessed from deterministic (anomaly correlation), probabilistic (rank probability skill score) and categorical (Heidke score) perspectives. Based on these NOAA-recommended metrics, the consensus is that both models are able to capture modest skill when assessed over the Hawaiian archipelago. However, during strong El Niño events (i.e., 1997-1998) the large swings in rainfall and persistence of dryness (from fall through winter and the following spring) are skillfully forecast at longer leads by all ensemble members, primarily attributed to realistic representation of physical processes. This project, led by Pacific RISA PI Annamalai and Postdoctoral Fellow Widlansky, pursued three main objectives over the reporting period: 1) Seasonal prediction of precipitation over the Pacific Islands during the El Niño winter/spring of 2015-2016; 2) Evaluation of the NOAA prediction model capacity to forecast regional rainfall during El Niño (2015-2016) and La Niña (2016-2017); and 3) Configuring the Hawai‘i regional model to assess its ability to capture regional distribution of rainfall during an ongoing ENSO event (2015-2017).

The ENSO evolution of warm conditions (El Niño in 2015) followed by cold conditions (La Niña in 2016) provides a classic test-bed for validating seasonal predictions of precipitation over the Pacific Islands made by the NOAA prediction model. The project team has been monitoring the ongoing La Niña and will bring out an experimental forecast of precipitation for the ensuing seasons. Additionally, they are collecting station-level rainfall observations for 2015-2016 and are in the process of model validation. Daily forecast data was downloaded from NOAA and archived locally to diagnose the solutions and update the forecast every 10 days. The model shows a high level skill in forecasting winter/spring rainfall anomalies over the Pacific Islands, with a drought moving through the region brought by one of the strongest El Niño events since record keeping began 60 years ago (Figure 2). It started in the southwest Pacific, where it brought famine to Papua New Guinea and Vanuatu, reaching the South Pacific, tropical West Pacific, and Hawaiian Islands between December 2015 and May 2016. While the effect of El Niño in the Pacific Islands receives little global attention, it has proved severe, particularly among vulnerable island populations. Prolonged drought can compromise not only freshwater supplies and food security, but can also have cascading impacts on public health, economies, food distribution, and even trigger civil unrest. Past experiences with regional drought, current actions being taken, and the most current predictions for El Niño’s effects on the Pacific Islands, suggest strategies that governments and aid groups can take to prepare for this powerful climate event (Annamalai et al., 2016).

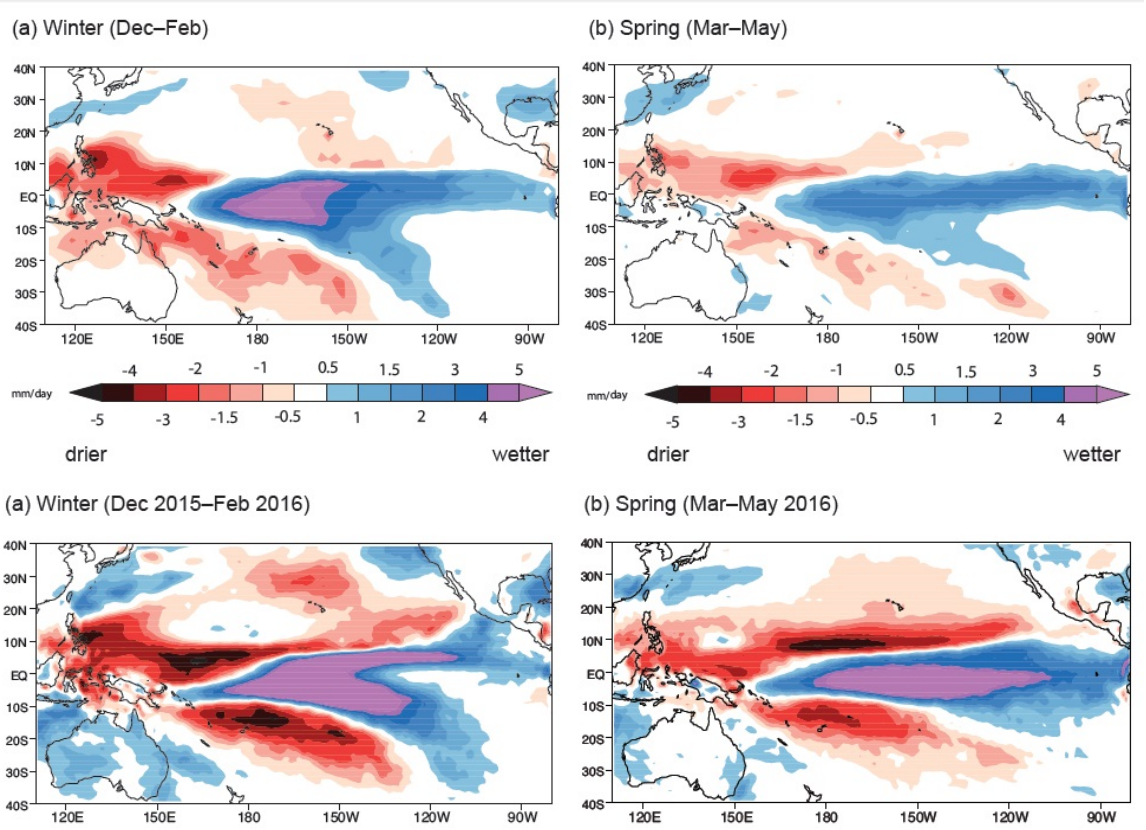

Figure 2: Historical rainfall and drought conditions during past El Niño events (top); Predicted rainfall and drought conditions for El Niño 2015-2016 (bottom).

The Hawai‘i regional model will continue to be tested and fine-tuned for the regional spatial distribution of rainfall over the Hawaiian Islands with a focus on ENSO 2015-2017, during both the El Niño and La Niña phases. Ensemble simulations will be performed and the results will be compared with island-level rainfall observations.

Impact of Future Climate Variability on Freshwater Resources in American Sāmoa

This project, led by Pacific RISA PI El-Kadi and Graduate Research Assistant Schuler, evaluates how groundwater quality and quantity on the island of Tutuila, American Sāmoa, are influenced by climate variability and change, as well as land use decisions to address sustainable management of future water resources. In Faga’alu Valley, a federal priority watershed management area, anthropogenic contaminant sources have been implicated in degraded reef health and have resulted in the consistent failure of stream and coastal waters to meet the American Sāmoa EPA's 303(d) water quality standards. Although investigations of surface water-derived pollutants have been undertaken, as of yet there have been no studies conducted to quantify groundwater quality, movement, or flux rates in Faga’alu bay. This project seeks to develop a more complete understanding of groundwater-derived nutrient fluxes, which are needed to begin assessing the degree of anthropogenic impact and nutrient loading from groundwater sources to the coastal ecosystem.

Development of a conceptual model of surface water/groundwater interactions within Faga’alu Vtream and quantification of groundwater-stream water exchange and associated nutrient flux was accomplished with a sampling and discharge survey throughout the lower reach of Faga’alu stream. The survey included sampling for nutrients and geochemical tracers, as well as measuring discharge from multiple locations

throughout the reach. To assess the spatial variability of Submarine Groundwater Discharge (SGD) in coastal waters, a nearshore groundwater tracer survey was conducted. Additionally, temporal variability in SGD was assessed by scaling the spatial information measured in the survey by a time-series groundwater tracer measurement at a single location over a 48-hour period. These measurements allowed quantification of the rate of groundwater discharge and associated nutrient flux from the coastal aquifer to the reef environment (Figure 3). Measurements were also validated with modeled estimates of groundwater flux and nutrient loading based on land-use and watershed modeling results developed with the Soil and Water Assessment Tool (SWAT). This modeling tool was used to estimate the proportion of potential SGD as well as to develop estimates of nitrogen and phosphorous loading to the nearshore aquifer.

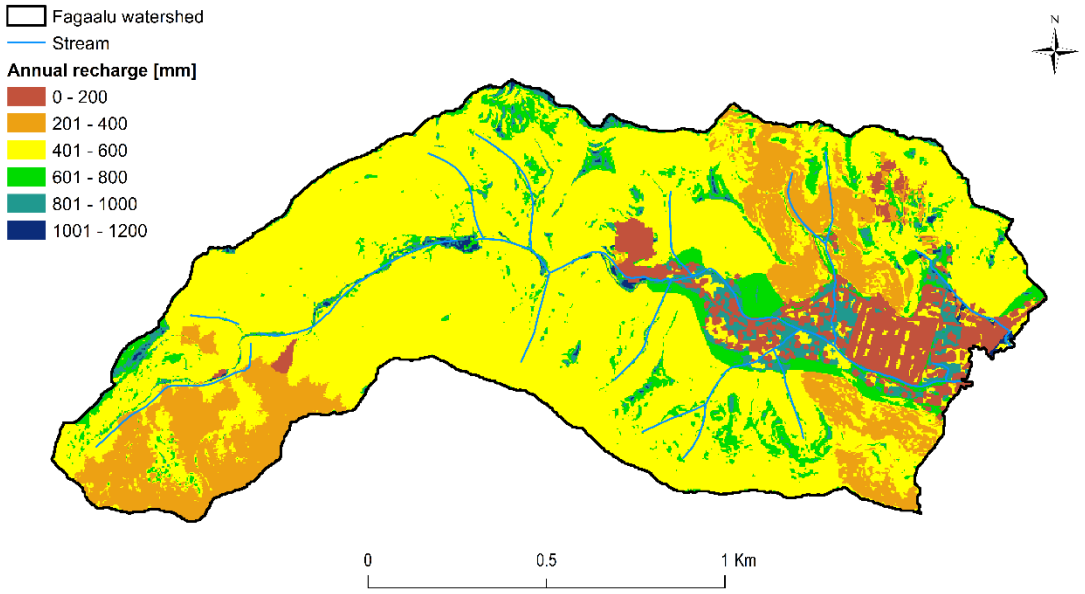

Figure 3: Modeled groundwater recharge for Faga'alu Valley from the SWAT model.

The results indicate that nutrient delivery via groundwater is an important process in Faga'alu Valley. In Faga'alu's coastal waters, levels of inorganic nitrogen are higher than those found in offshore waters, indicating that local terrestrial nutrient sources are clearly affecting the geochemistry of the bay. Within the bay itself, nutrient levels are elevated in the northern part relative to the southern part. Calculations of groundwater derived nutrient flux and surface water derived flux indicate that SGD may contribute about twice the nutrient load to the bay that stream water does at base flow conditions. The watershed modeling results agree with the geochemical tracer results, and lend an additional degree of confidence to these estimates. While the stream is the primary source of sediment to the bay, the effects of groundwater on coastal water geochemistry cannot be ignored, and thus coastal health management should consider groundwater as an additional source of potential contamination.

Watershed Hydrological Modeling and Climate Change Impact Assessment in He'eia and Nu'uanu Areas, Oahu

Following the suitability and applicability testing of the Soil and Water Assessment Tool (SWAT) for the Faga'alu watershed (American Sāmoa, see above), the model was used to estimate the groundwater coverage and amount of water that can be potentially harvested from the He'eia and Nu'uanu area watersheds on Oahu. The SWAT estimated groundwater recharge and reservoir stored water will be used as input for the groundwater modeling analyses. The watershed modeling process by SWAT utilizes climate, hydrological, and geospatial data. The team, led by Pacific RISA PI El-Kadi and Postdoctoral Fellow Leta, collected climate (rainfall, temperature, relative humidity, wind speed, and solar radiation)

and geospatial data (DEM, land use, soil type) for the watersheds from various US agencies. While several rain gauging stations are available from the NOAA National Climate Data Center, daily maximum and minimum temperature, relative humidity, solar radiation, and wind speed data are only available outside of the watershed boundary from the Western Regional Climate Center. In order to fill in the missing rainfall data, the team considered the significant rainfall spatial variability of the case study based on the rainfall contour maps that we derived from the Rainfall Atlas of Hawai‘i. Then, the missing rainfall values were entered based on the nearest station within the contour lines and interpolation techniques. Similarly, the maximum and minimum temperature, solar radiation, and relative humidity maps of Oahu were used to fill the corresponding data gaps. After data analysis and quality check, the SWAT model was developed based on the available climate and geospatial data. Finally, the model was calibrated and validated using the daily streamflow data monitored at various stations by the US Geological Survey (USGS) Pacific Islands Water Science Center (PIWSC). For model parameter optimization, the SWAT Calibration and Uncertainty Program was used.

The calibrated and validated SWAT model was then used to assess the impact of climate change on water budget components and streamflows for the study areas. The team used the recently statistical downscaled rainfall anomalies reports for the Hawaiian Islands for both Representative Concentration Pathways (RCP) of 4.5 and 8.5. SWAT model performance comparison for daily streamflow simulation was done for both the He‘eia and Nu‘uanu area watersheds. While the He‘eia watershed experiences scarcity of hydrological and climate data, the Nu‘uanu area watersheds have relatively good quality data. Performance evaluation showed a range of “satisfactory” under scarcity of data (He‘eia watershed) to “very good” for relatively good quality data (Nu‘uanu area watersheds). The findings highlight the importance of using multiple gauging stations within a watershed in order to capture the high climate variability and improve model performance, which is particularly important for the He‘eia watershed. For the Nu‘uanu area, the SWAT simulated average annual subsurface flow components is 580 mm, which accounts for 75% of the annual streamflow (770 mm). While the annual average evapotranspiration (ET) is 940 mm that accounts for 51% of the annual rainfall (1844 mm), the annual average rainfall contributes 20% (365 mm) to the groundwater system as recharge. This recharge value is within the range of 18 to 43%, which were previously reported for the Hawaiian islands but the percent of SWAT simulated recharge to rainfall is 13% lower than the reported value (603 mm) by earlier studies for the same case study. Because the USGS-PIWSC water budget model does not consider the lateral flow component separately, it is likely that the lateral flow that directly discharges to stream before it joins groundwater system might be accounted as groundwater recharge in the water budget model. This could be a possible explanation for the discrepancy between the two results.

Regarding climate change impacts on water resources, extreme low and peak flows analysis indicate that an increase in peak flows of up to 22% is expected for higher return period under RCP 8.5 scenario, indicating that those events can potentially cause flooding and adverse consequences, such as damages to infrastructure. In contrast, the future extreme low flows are expected to decrease by 56% compared to baseline due to less rainfall availability and high ET during the dry season. Consequently, by the end of 21st century, more frequent drought periods are expected, which negatively affect agricultural crop productivity, freshwater availability, and ecological functioning of river riparian ecosystem. Startlingly, although the temperature is projected to increase, the monthly actual ET is expected to decrease up to 8% in the future. This is most likely due to less rainfall availability (moisture limitation), indicating that rainfall change is the main factor for the general decrease in ET as compared to temperature change. Overall, the water budget components such as surface runoff, baseflow, streamflow, ET, soil moisture, and recharge are projected to decrease by the end of 21st century. Compared to the other water budget components, the monthly baseflow values will be consistently decreased in the future. Additionally, the amount of water potentially harvested by Nu‘uanu reservoir is expected to decrease up to 36%, indicating less freshwater availability in the future with serious implications for sustainability.

Estimating Changes in Groundwater Recharge under Future Climate Conditions on Maui
In Phase II, the Pacific RISA used a participatory scenario process to identify key stakeholders making short and long-range decisions about freshwater resource management, and defined climate, land use, and development futures for Maui. The Pacific RISA also has existing relationships with a rich set of regional freshwater decision makers identified through the PIRCA process. During the reporting period, the USGS-PIWSC led by Pacific RISA researchers Steven Anthony and Alan Mair 1) Assessed the impact of future climate projections on groundwater recharge under a set of land-cover and climate scenarios; and 2) Began the process of publishing the results of the water-budget modeling in a USGS Scientific Investigations Report. The Maui water-budget model was used to estimate groundwater recharge using two sets of late 21st century downscaled climate projections: 1) Updated set of dynamically-downscaled projections for a CMIP3 A1B climate scenario, and 2) A set of statistically-downscaled projections for a CMIP5 RCP8.5 climate scenario. The project progress was delayed because an updated set of dynamically-downscaled climate projections from the IPRC was made available to the USGS-PIWSC in October 2015, requiring new model runs for each of the four land cover scenarios and future climate scenarios to account for new input data on rainfall and reference evapotranspiration projections.

Comparison between water-budget output using two sets of climate projections that represent "wet" and "dry" future scenarios for a 2010 land cover condition project the following for the island of Maui:

- Two climate scenarios indicate contrasting effects on estimated recharge across most of Maui
- The greatest changes to recharge occur in west Maui mountains and wet windward areas of Haleakalā

Island-wide impacts to water budget:

- Mean annual rainfall changes by plus or minus 20%
- Mean annual ET changes by plus 5% to minus 12%
- Mean annual direct runoff changes by plus 34% to minus 18%
- Mean annual recharge changes by plus or minus 21%

The apparent inconsistencies between climate projections derived from statistical downscaling and those derived from dynamically downscaling have resulted in feedback from numerous stakeholders that highlights the need for developing a credible explanation for those differences. Such feedback forms part of the rationale for reconciling the differences between the two sets of predictions (see ***Evaluating Similarities and Differences between Statistical and Dynamical Downscaling Projections***, above). Additional next steps include finalizing the simulations of future recharge for the future land cover and climate scenarios, completing development of manuscript for peer-review and publication in a scientific journal, completing development of GIS coverages and associated metadata for peer-review and release via the USGS water resources node, and a final presentation to the State of Hawai'i Commission on Water Resource Management in July 2016.

Perceptions of Climate Needs and Downscaling Data by Modelers and Resource Managers in Hawai'i
This research effort and associated workshop, sponsored by the PI-CSC, the PICCC, and the Pacific RISA, evaluated existing and ongoing efforts to generate downscaled climate projections for Hawai'i and how they are being used by researchers, agencies, and decision makers. The objectives were to 1) Gain insight into the perceptions that climate scientists and end users have about climate information at the regional level; 2) Generate background information on the kind of climate information that different resource managers use and need; and 3) Recognize the differences in views and/or opinions about climate science production, availability, and utility. A brief survey was distributed to four targeted groups in the state of Hawai'i: climate scientists and modelers (n=19); wildfire managers (n=12); ecosystems managers (n=19); and freshwater managers (n=15). Of the 65 total respondents, most were extremely experienced in their field or sector with at least 20-30 years of experience. Climate scientists were largely from the academic sector, while managers were typically associated with county, state, or federal agencies. Each

group reported a limited understanding of the others' level of expertise: over half of the climate scientists reported "some" to "little or none" familiarity with natural resource policies and planning processes in Hawai'i, for example. Over 75% responded that more policy/management relevant knowledge would help them perform their job better (Figure 4).

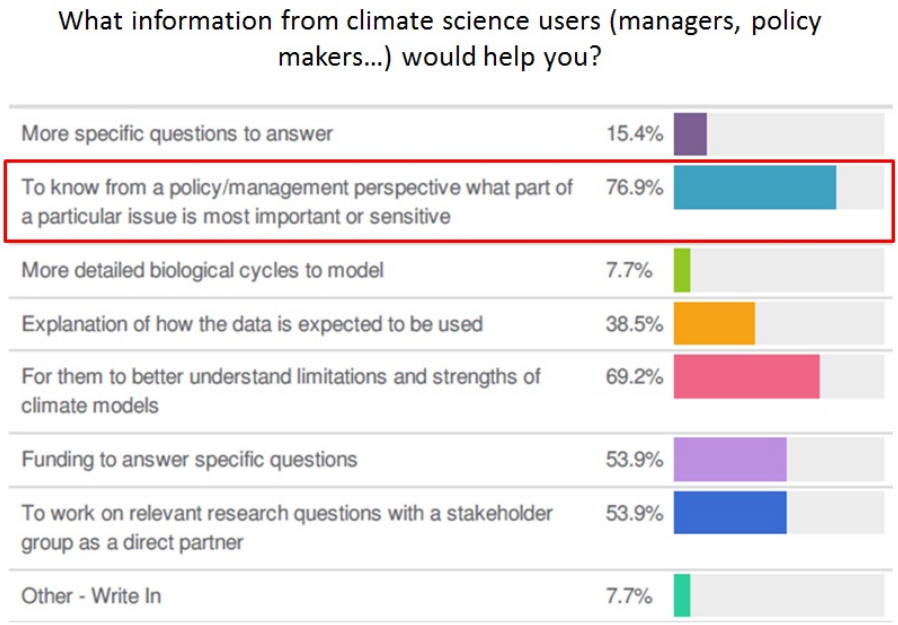

Figure 4: Climate scientist responses to questions about needs from end-users.

The vast majority of freshwater, ecosystems, and wildfire managers, on the other hand, reported low to moderate levels of understanding of climate systems modeling in Hawai'i. In fact, only freshwater managers responded that they used downscaled climate information on a regular basis, potentially due to the Pacific RISA focus on freshwater research and extensive outreach to that sector (Figure 5). Importantly, most managers don't want better technical understandings of the model aspects (only 11%), but rather better understanding about uncertainty in the models and variables (55%).

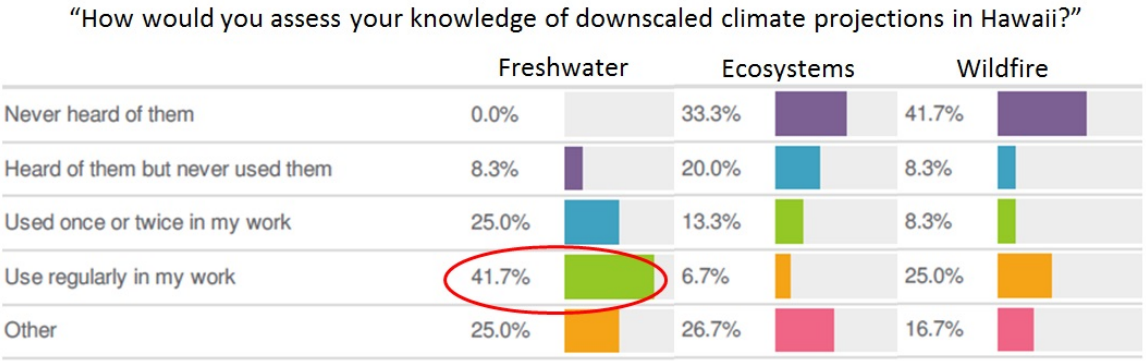

Figure 5: End-user responses to questions about familiarity with regional climate models.

Overall, the survey revealed a high interest in improving collaboration within the climate science community, as well as better involvement of climate scientists in the collaborative design and delivery of products and data for end-user managers. A subsequent workshop, titled "Climate Downscaling and its Application in High Hawaiian Islands" was held from September 16-17, 2015 in Honolulu, Hawai'i. The purpose of the workshop was to bring together different schools of regional climate modelers, intermediate modelers, and resource managers to evaluate available the downscaled climate model

products for Hawai'i and to initiate a climate downscaling application strategy for the Hawaiian islands. There were approximately 30 participants from academia in climate modeling at the University of Hawai'i IPRC and Geography department, the USGS-PIWSC, the National Center for Atmospheric Research, the PI-CSC, NOAA, USDA, the Institute of Pacific Islands Forestry, US Army Corps of Engineers, Hawai'i -Volcanos National Park, the PICCC, Hawai'i Commission on Water Resource Management, and Honolulu Board of Water Supply. The first day of the workshop was organized around a focus on technical climate modeling issues and the second day focused on resource manager applications and needs. Workshop objectives consisted of 1) Reviewing the Pacific RISA survey results on perceptions of downscaled climate products from modeler and end-user perspectives; 2) Identifying agreements among current projections in the main Hawaiian islands; 3) Developing best applications of current products (from a management perspective) in terms of locations, spatial scales, and temporal frames; 4) Developing best practices for climate downscaling (from a science-researcher perspective), envisioned as a framework for modeling conditions that will facilitate comparison of results and outputs; and 5) Providing opportunities to bring other approaches into the discussion. Outputs included 1) "Consensus statements" about downscaled climate variable projections in Hawai'i upon which "high" or "medium" confidence was placed; and 2) The creation of a working group for modelers from different methodologies to get together and regularly share findings and updates in a constructive manner.

10. Please provide a list of up to 5 **outreach or communication activities** that you have undertaken in the past year.

The PIRCA Sustained Assessment Process

In collaboration with the PI-CSC, the NOAA RCSD (Marra), the East-West Center, and the PICCC, the Pacific RISA hired a dedicated Sustained Assessment Specialist (SAS, Grecni) to coordinate activities related to the Pacific Islands Regional Climate Assessment (PIRCA). The SAS will also provide timely and ongoing support for the National Climate Assessment and the Development Advisory Committee. Objectives during the reporting period were to 1) Begin developing a dedicated, independent website for PIRCA; 2) Assemble a bibliography of peer-reviewed literature on climate change indicators, impacts, and adaptive capacity in the Pacific Islands; and 3) Generate a set of socioeconomic impact climate indicators to correspond to physical climate indicators.

A dedicated PIRCA website is under development (PIRCA.org), which will house and showcase the 2012 PIRCA outputs, coordinate future PIRCA products, and serve as a valuable resource for stakeholders on the current status of regional climate and observed and anticipated trends. Resources include a "living bibliography" of published literature specifically relating to the indicators and impacts of climate change in the Pacific Islands, and assessing adaptive capacity. The bibliography is intended for use by National Climate Assessment authors and other researchers. By the end of May 2016, the bibliography contained 180 items. The SAS, along with NOAA Climate Program Office staff and PIRCA partners, is coordinating the development of Pacific Island narratives for the Climate Resilience Toolkit (toolkit.climate.gov), an initiative under the President's Climate Action Plan. The Pacific Islands will be one of the first US regions to be featured in the Toolkit. Publication of regional content is anticipated for August 2016. The SAS also began to build a set of technical indicators as part of a project with the NOAA RCSD (Marra). The Republic of the Marshall Islands was selected as an initial location, and public health as a priority sector, for determining key indicators. Preliminary contacts and interviews with public health managers have been conducted and workshops or focus groups will be held with the same health stakeholders later in the project cycle to confirm findings.

Other activities include:

On May 23-25, 2016, Pacific RISA PI Keener and Project Specialist Grecni visited NOAA CPO and the US Global Change Research Program (USGCRP) in Washington, DC to present on the sustained

assessment research plan, early findings, and the PIRCA website development. While in Washington, they held meetings with key federal collaborators:

- USGCRP assessment staff and interagency partners (e.g., DOI, USDA, EPA; 12 interagency staff members in total)
- USGCRP leadership (Executive Director and Deputy Executive Director)
- NOAA CPO staff (approx. 10 staff members)
- NOAA climate and health specialists (2 staff members)
- NOAA international program staff (2 staff members)
- NOAA CPO Director of Communication and Education

They also found that stakeholders continue to report using the 2012 PIRCA outputs (full report, executive summary, and case studies) in recent presentations (Pacific RISA Advisory Committee members), political speeches (staff in Senator Brian Schatz's Washington, DC office), and as a reference document (Pacific RISA Advisory Committee members, Association of Small Island States negotiators, Senator Brian Schatz's staff).

Pacific RISA Collaborations and Communication

El Niño Outreach

A strong El Niño developed in the Pacific, leading to severe drought in the western Pacific and increased stakeholder interest in ENSO forecasting and impacts. During the reporting period the Pacific RISA and regional partners including the PEAC Center and the NOAA RCSD spent significant outreach resources to spread the impending drought warning to Hawai‘i and especially the west Pacific Islands. As the PEAC Center coordinated much of the outreach in the islands, PIs Annamalai and Keener published a paper (Annamalai et al., 2016) intended to target high-level policymakers in Asia and the Pacific that might experience repercussions of the West Pacific drought through their populations (agricultural exports, economies, movement of people, public health, civil conflict…). The paper outlined general impacts of El Niño and specific rainfall and sea-level conditions for the Pacific region, and discussed high level strategies for addressing the complex socioeconomic and political impacts of El Niño, while recognizing that the Pacific Islands have a long history of coordinating regional responses to El Niño and drought events.

Pacific RISA Advisory Committee Meeting

On April 5-6, 2016 the Pacific RISA Advisory Committee met with PIs to discuss successes and gaps in the Pacific RISA Phase II five-year award and showcase new research and plans for the Phase III award (2015-2020). About 20 participants from different sectors across the Pacific Islands region were brought together to discuss research and collaboration opportunities going forward for the RISA. Key themes that emerged included how to improve regional communication, finding new opportunities for collaboration and improving existing partnerships, identifying effective strategies for synthesizing and disseminating information, and ways of improving and leveraging existing Pacific RISA projects with regional efforts.

Cross RISA Collaborations

Pacific RISA PI Keener participated in the California Nevada Applications Program sponsored workshop titled “Evaluating Co-Produced Climate Science: developing metrics and measures” workshop on February 2-3, 2016, at the Desert Research Institute in Reno, NV. The purpose of the two-day workshop was to increase and aggregate understanding between different integrated climate science initiatives about how to best evaluate co-produced climate science at the programmatic, project, and process levels. Participants included RISA PIs, Climate Science Center, and Landscape Conservation Cooperative representatives, as well as professionals in evaluation science.

Developing Future Climate Scenarios (Maui and Oahu)
In Phase II, Pacific RISA PIs Keener, Finucane, and Brewington used a participatory scenario process to identify key stakeholders making short and long-range decisions about freshwater resource management, and defined climate, land use, and development futures for Maui. Four future land cover scenarios were defined based on extensive stakeholder interviews to represent desirable and undesirable management decisions that could impact future water resources under a changing climate. These were translated into spatially explicit GIS layers for input into a USGS-PIWSC water-budget model (see ***Estimating Changes in Groundwater Recharge under Future Climate Conditions***, above). The research team had four main objectives for this reporting period: 1) Publish a peer-reviewed paper on scenario process and GIS methodology for Maui project; 2) Make the GIS scenarios and metadata available online at PacificRISA.org; 3) Continue to promote use of scenarios and maps across different projects on Maui; and 4) Begin identifying new stakeholders and available land cover data for an Oahu scenarios project (with assistance and funding from the Water Resources Foundation).

Four stakeholder-driven future land cover scenarios were derived for the island of Maui using a participatory integrated assessment method across a variety of planning and management options. The use of remote sensing and GIS enabled the research team to quantify and spatially represent a variety of different "futures." Key contrasting variables related to forest cover, development, agriculture, ranching, and surface water management reflected the complex socioeconomic and biophysical parameters that the scenarios represent. Through the scenario process, stakeholders became more comfortable with the idea and magnitude of the uncertainties inherent in all climate projections and the variable timelines in which those futures could occur. They were also reminded that the land cover scenarios were not predicting the future, but were meant as a visual tool informed by the best possible science and local knowledge, so that managers and decision makers could start to implement climate adaptive water management strategies that were resilient to a range of potential futures. As climate models and projections are generally unfamiliar to most decision makers, the scenario process was a useful education tool for climate modeling in addition to creating a useful future planning tool (Brewington et al. 2016).

Setbacks due to the late release of updated climate projections for input into the USGS-PIWSC water-budget model translated in a pushback of the deadline for final presentations and discussions with stakeholders on Maui. The Pacific RISA has been unable to proceed with the groundwater work until USGS publishes and releases their final reports. As the USGS-PIWSC water-budget model and reporting continues, PIs Brewington and Keener are incorporating the future land cover scenario maps into other projects in west Maui, including the West Maui Ridge 2 Reef Initiative, which includes collaborators from the watershed partnerships, the US Army Corps of Engineers, NOAA Sea Grant, the Hawai‘i Division of Aquatic Resources, among others. This fall the Pacific RISA will begin working with EcoAdapt on Maui to use the scenario maps to identify adaptation priorities under different available climate projections and land uses. In general, the future scenario process pioneered by the Pacific RISA in Maui has been popular with state agencies and planners, who are interested in recreating similar processes for all the Hawaiian Islands. This led to the development of a scenarios-based collaboration on Oahu with the Honolulu Board of Water Supply and consulting team Brown and Caldwell, with funding from the Water Research Foundation. The Oahu project, which will focus on water resources management and modeling under projected climate change and was anticipated to kick-off in early 2016, encountered legal delays, and the first workshop is now scheduled for mid-September, 2016. The project team has begun to assimilate relevant land cover data for the island of Oahu and will work with stakeholders to identify future scenarios of interest.

WRRC Water Resources Stakeholders Meeting, Utulei, American Sāmoa
The Water Resources Research Center (WRRC) at the University of Hawai‘i started to administer the State Water Resources Research Institute Program (WRRIP) for American Sāmoa in 2013. Several remote calls with some key players in American Sāmoa were made early on, yet an integrative

consultation with the stakeholders of the water sector needed to be carried out. This project proposed to carry out an integrative consultation with the stakeholders of the water sector in American Sāmoa through a full-day workshop and related field visits. This aim was to strengthen the WRRIP and its implementation in American Sāmoa by increasing awareness of the program among local stakeholders, as well as provide an opportunity for the WRRC to better understand the requirements and priorities of local research partners and opportunities. For this purpose WRRC personnel held a workshop meeting in American Sāmoa with stakeholders from the American Sāmoa Community College (ASCC), the ASEPA, ASPA (the agency in charge of the public water system), the American Sāmoa Coral Reef Advisory Group, American Sāmoa Department of Commerce, and the National Parks Service. Cooperative activities will continue into the future and will include continuous consultations, securing help in data collection, and training ASCC students. The meeting was held in Pago Pago on Tutuila on January 5, 2016 and included three presenters and around 20 participants. Participants all shared ideas and concerns for future water resources research in the territory.

11. Please provide a list of **key publications** from the past year.

Annamalai, H., V. Keener, M.J. Widlansky, and J. Hafner, 2015: El Niño Strengthens in the Pacific: Preparing for the Impacts of Drought. AsiaPacific Issues, (122), 1-10. IPRC-1162. http://www.eastwestcenter.org/system/tdf/private/api122.pdf?file=1&type=node&id=35429

Brewington, L., V. Keener, M. Finucane, and P. Eaton, in press: Participatory Scenario Planning for Climate Change Adaptation Using Remote Sensing and GIS. In S.J. Walsh (ed). Remote Sensing for Societal Benefits. Amsterdam: Elsevier.

Ferguson, D.B., Finucane, M.L., Keener, V.W., Owen, G. (2016). Evaluation to Advance Science Policy: Lessons from Pacific RISA and CLIMAS. In Parris, A., Garfin, G. et al (eds). Climate in Context: Science and Society Partnering for Adaptation. West Sussex, England: Wiley. ISBN: 978-1-118-47479-2

Wallsgrove, R. and Z. Grecni, 2016: Water Resources in American Sāmoa: Law and Policy Opportunities for Climate Change Adaptation. Honolulu: Pacific Regional Integrated Sciences and Assessments. http://www.eastwestcenter.org/system/tdf/private/wateramericanSāmoa-2016.pdf?file=1&type=node&id=35601

Zhang, C., Y. Wang, K. Hamilton, and A. Lauer, 2016: Dynamical downscaling of the climate for the Hawaiian Islands. Part I: Present-day. Journal of Climate, 29, 3027-3048, doi:10.1175/JCLI-D-15-0432.1. IPRC-1175.

12. Please provide up to 3 narrative **examples** from the past year of plans, policies, strategies, tools, agreements, etc. that were proposed, adopted, and/or implemented as a result of RISA work. Please describe the role of RISA in achieving the accomplishments described.

Evaluating Existing Climate Adaptation Policies and Laws

The Pacific RISA aims to assist in information exchange and collaboration between scientists and governments in preparing and adopting laws and policies that facilitate cost-effective, efficient, and equitable adaptation strategies. Pacific RISA has pioneered this process for assessing and enhancing adaptive capacity in Hawai‘i and American Sāmoa. In many ways, these two examples illustrate endpoints on a spectrum of adaptive strategies, between top-down approaches like those employed in Hawai‘i working with state agencies and administrators, to bottom-up approaches working with utilities services in American Sāmoa. Moreover, the Hawai‘i experience has demonstrated that the process can identify and accelerate mechanisms for integrating scientific climate findings with regulatory and policy processes. In American Sāmoa, opportunities to enhance adaptive capacity are similarly growing (for example, the 2015 Pacific Islands Environmental Conference, convened by the ASEPA, June 15-18, 2015).

Project Specialist Wallsgrove has continued to refine the Pacific RISA water adaptation evaluation rubric, and in particular its application to other island settings and legal frameworks. We are exploring the utility of that rubric to identify adaptation opportunities in new and varied settings, although some elements of that applicability have been confirmed (e.g. applicability to water quantity in Hawai‘i vs. water quality in American Sāmoa). Applicability in other policy settings (e.g. within the broader frameworks for adaptation as defined by international development organizations and applied to locations such as Republic of Marshall Islands) requires further investigation and possible revision.

Continued stakeholder engagement focused on research and information-gathering during the report period has included the following:

- Hawai‘i Commission on Water Resource Management
- US National Park Service
- State of Hawai‘i legislators
- American Sāmoa Power Authority
- Honolulu Board of Water Supply

Representatives from these groups have been reached via stakeholder engagement in prior reporting periods, but in some instances recent engagement has included new individuals. Work during the study period has not targeted growth in stakeholder engagement or new partnerships. Rather, the purpose of this engagement has been to 1) Monitor ongoing developments related to prior research; 2) Gather ongoing guidance and information on law and policy options to assist research; and/or 3) Evaluate or assist stakeholder climate adaptation policy decisions based on research. There is continued evidence of climate change adaptation measures being incorporated into water law and policy, and evidence of interest in new island settings. Examples that demonstrate not only an enhanced awareness of climate change impacts, but also concrete steps to address those impacts and actions that are consistent with prior Pacific RISA recommendations include:

- The Hawai‘i Commission on Water Resource Management has continued the process of updating Hawai‘i's primary and comprehensive water planning policy tool – the Water Resource Protection Plan and its components – including efforts to address Pacific RISA recommendations regarding climate change adaptation. Climate change adaptation is one of five key new elements of this update, and Pacific RISA's climate research and law and policy research is incorporated, and components (e.g. Maui County Water Use and Development Plan) are directly addressing climate adaptation using RISA scientific research. As that planning update proceeds, the Commission is continuing to implement adaptation recommendations in other ways. For example, Commission staff recently recommended for approval a proposal to jointly fund an evaluation of water monitoring needs the with USGS-PIWSC.
- Building off of climate adaptation legislation passed in 2014 and the resulting ongoing efforts related to adaptation, the Hawai‘i legislature passed at least two bills in 2016 to increase adaptive capacity for water resources. House Bill 2040 implemented a funded two-year pilot program for a water security advisory group to enable public-private partnerships that would utilize state matching funds for projects that increase groundwater recharge, encourage water reuse for landscape irrigation, and improve the efficiency of agricultural and potable water use. House Bill 2626 limits the issuance of permits for underground fuel tanks in the shoreline areas that may be susceptible to climate change, and which may subsequently impact groundwater and coastal water quality. Climate adaptation and appropriate planning horizons were issues raised in the deliberation of both bills. Work is progressing on the Interagency Climate Adaptation Committee Act 83, implemented in 2014, with public engagement to commence shortly and the committee's report anticipated in 2017. Hawai‘i legislators and regulators have looked to the Pacific RISA for assistance in understanding and developing climate adaptation laws and policies.

- The Honolulu Board of Water Supply has budgeted for new capital improvement projects that are consistent with adaptation recommendations, including recycled water mains and water storage facilities.
- The American Sāmoa Power Authority has moved forward with plans to increase stream and rainfall monitoring capacity, consistent with opportunities identified by the Pacific RISA.
- The American Sāmoa EPA has begun to include groundwater monitoring in their standard monitoring protocols, consistent with recommendations from the Pacific RISA.

Appendix 1: Select Presentations and Webinars Relevant to Pacific RISA Research ***June 1, 2015 to May 31, 2016.***

Date	Presenter name	Title	Location
Aug 1, 2015	Chris Schuler	University of Hawai‘i Water Science Activity Briefing Seminar	Pago Pago, American Sāmoa
Aug 26, 2015	Victoria Keener	Climate Trends, Future Projections, and Impacts on Planning in Hawai‘i: For the Hawai‘i Land Use Commission	Honolulu, Hawai‘i
Sept 29, 2015	Victoria Keener	Climate Trends, Future Projections, and Impacts on Planning in Hawai‘i: For the Hawai‘i Office of Planning	Honolulu, Hawai‘i
Sept 29, 2015	Zena Grecni	Testing Regional Pacific-Basin Migration: Climate Migration from the USAPI to Hawai‘i: Presentation for the European Cooperation in Science and Technology Workshop on Combining Quantitative and Qualitative Methods for a Better Understanding of the Climate Change-Migration Nexus	Seville, Spain
Oct 14, 2015	Laura Brewington	Pacific RISA Water Research Updates for the Pacific Islands Regional Climate Outlook Forum	Suva, Fiji
Oct 27, 2015	Victoria Keener, Laura Brewington	Perceptions of Downscaled Climate Data, and Future Land Use & Climate Scenarios for Maui Island	Kihei, Hawai‘i
Oct 20, 2015	Victoria Keener	Climate Impacts and Adaptation: Invited Department of Energy webinar with Dr. Jo-Ann Leong for the Pacific Islands Chapter of the National Climate Assessment	Honolulu, Hawai‘i
Nov 11, 2015	Victoria Keener	Climate Trends, Projections, Impacts & Adaptation in Hawai‘i: Presentation for the Rising Tides Seminar	Honolulu, Hawai‘i
Dec 2, 2015	Olkeba Leta, Aly El-Kadi	Evaluating the performance of SWAT model for simulating daily streamflow in selected watersheds of Oahu island (Hawai‘i): 2016 Water Resources Conference	Honolulu, Hawai‘i
Dec 3, 2015	Aly El-Kadi, Chris Schuler	Water Resource Challenges and the Updated Conceptual Hydrological Model of Tutuila Island, American Sāmoa: 2016 Water Resources Conference	Honolulu, Hawai‘i
Dec 4, 2015	H. Annamalai	El Niño Strengthens in the Pacific: Preparing for the Impacts of Drought: 2016 Water Resources	Honolulu, Hawai‘i

		Conference	
Dec 7, 2015	Victoria Keener	The Pacific RISA: Co-Production of Climate Research in Hawai‘i and The Pacific Islands	Honolulu, Hawai‘i
Jan 14, 2016	Victoria Keener	PBS Insights: Climate Change and Pacific Islands: Dr. Keener, Jim Lyon of Lyon Inc., Dr. Chip Fletcher (UH SOEST) and Bob Stanton (Hawai‘i Office of Planning)	Honolulu, Hawai‘i
Jan 15, 2016	Laura Brewington	Adapting to Climate Change in Pacific Islands: Global Politics, Local Practices	Manila, Philippines
Jan 19, 2016	Victoria Keener	ThinkTech Hawai‘i: Climate Change: Beyond Outrage	Honolulu, Hawai‘i
Feb 4, 2016	Alan Mair	Estimating Climate Change Impacts on Groundwater Recharge for the Island of Maui, Hawai‘i: 2016 Pacific Water Conference	Honolulu, Hawai‘i
Feb 4, 2016	Laura Brewington	Participatory Scenario Planning for Climate Change Adaptation: The Maui Groundwater Project: 2016 Pacific Water Conference	Honolulu, Hawai‘i
Mar 23, 2016	Laura Brewington	The East-West Center and the Pacific RISA Program: Overview for the World Meteorological Organization and the Pacific International Training Desk	Honolulu, Hawai‘i
Apr 11, 2016	Chris Schuler	Sustainability Studies of Groundwater Resources in American Sāmoa	Pago Pago, American Sāmoa
May 24, 2016	Zena Grecni, Victoria Keener	Pacific Islands Regional Climate Assessment (PIRCA): Sustaining the Assessment Process: For the USGCRP	Washington, DC
May 25, 2015	Zena Grecni, Victoria Keener	Pacific Islands Regional Climate Assessment (PIRCA): A Framework for Tracking Physical and Social Indicators of Climate Change Across Pacific Islands: For NOAA CPO	Silver Spring, Maryland

Appendix 2: Additional Publications.

Dulaiova, H., 2016: Quantifying Groundwater Discharge from the Faga'alu Aquifer, American Sāmoa. Report prepared for Water Resources Research Institute Program 104B. Honolulu.

El-Kadi, A.I., 2016: Assessing Ground Water Sustainability of the Island of Tutuila, American Sāmoa. Report prepared for Water Resources Research Institute Program 104B. Honolulu.

Hawai‘i Climate Change & Health Working Group, 2015: Preliminary Report and Recommendations, Submitted via the Hawai‘i State Department of Health to the 2016 Legislature (12/30/15).

Helweg, D.A., V. Keener, and J. Burgett, 2016: Report from the Workshop on Climate Downscaling and its Application in High Hawaiian Islands: U.S. Geological Survey report: Retton.

Appendix 3: Other Products.

- Development of a dedicated PIRCA website: http://pirca.org/
- Downloadable land cover scenario GIS coverages and metadata added to PacificRISA.org: http://www.pacificrisa.org/projects/maui-groundwater-project/building-the-scenarios/ and http://pacificrisa.org/wp-content/uploads/2015/10/Maui_future_land_cover_scenarios.shp.xml