**NASA DEVELOP National Program**

**North Carolina – NCEI**

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*Project Summary – Fall 2017*

**Hawai’i & U.S. Affiliated Pacific Islands Disasters**

*Using Global Climate Models to Project Monsoon and Future Extreme Weather Trends in the Pacific*

**VPS Title:** The Future of Extreme Pacific Weather: Projecting Monsoon & Storm Trends into the 21st Century

**Project Team**

***Project Team*:**

Andrew Shannon (Project Lead), andrew.clark.shannon@gmail.com

Aaron Mackey

Rachel Wegener

***Advisors & Mentors*:**

Michael Kruk (Earth Resources Technology Inc., NOAA NCEI)

**Project Overview**

***Project Synopsis*:** This project partnered with the National Oceanic and Atmospheric Administration (NOAA) Regional Climate Services Director (RCSD) for the Pacific Region, Dr. John J. Marra, to analyze future changes in and impacts from extreme weather events based on global climate model outputs. The project team utilized high resolution wind speed and rainfall data from NOAA’s Ocean Near-Surface Atmospheric Properties – Climate Data Record (ONSAP – CDR) derived from the Special Sensor Microwave Imager (SSM/I) and Precipitation Estimates from Remotely Sensed Information Using Artificial Neutral Networks – Climate Data Record (PERSIANN – CDR), respectively, to verify and select global climate model outputs. The project team created decadal maps and figures to the year 2100 that highlight the changes in magnitude, frequency, and distribution of extreme weather events in the region.

***Abstract*:**

Hawai’i and the U.S. Affiliated Pacific Islands (USAPI) comprise more than 2,000 islands that span thousands of miles of ocean and are home to nearly 1.9 million people. This region is particularly vulnerable to economic, social, and environmental impacts resulting from changes in sea level rise and storm patterns over the next century. Climatologists and regional decision makers are interested in understanding projected long-term changes in extreme weather events for adaptation and mitigation planning. This study provided an initial outlook at regional trends in the location of the monsoon and distribution of the extremes in wind speed and rainfall over the course of the 21st century. Select Global Climate Models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) were verified against historic NOAA satellite data. This project used the future simulations to calculate the projected changes in magnitude for extreme values of wind speed and rainfall rate, return interval frequency for rainfall and wind speed, and distribution of monsoon events. The results include gridded maps of monsoon distribution and extreme wind and rain values, as well as return interval plots for virtual stations within the USAPI and Hawai’i Exclusive Economic Zones on a decadal basis for the years 2030-2100.

**Keywords:**

Storminess, monsoon, CMIP5, remote sensing, USAPI, Hawai’i, Global Climate Model

***National Application Area Addressed:*** Disasters

***Study Location:*** Hawai’i and U.S. Affiliated Pacific Islands (Federated States of Micronesia, American Samoa, Guam, the Republic of Palau, the Republic of the Marshall Islands, and the Commonwealth of the Northern Mariana Islands)

***Study Period:*** January1988 – December 2005; Projections to 2030, 2040, 2050, 2060, 2070, 2080, 2090, and 2100

***Community Concern:***

* Changes in regional climate patterns are expected to increase sea surface temperature and height, impact freshwater availability, and alter storm patterns, including wave run-up, storm surges, and flooding events.
* Hawai’i and the USAPI are at increased risk from coastal hazards, including coastal erosion, inundation events, and infrastructure damage due to geographic location and geological makeup where populations are clustered on coasts and low-lying islands rise only feet in elevation above present mean sea level.
* Island communities have low adaptive capacity with high adaptation and mitigation costs in relation to GDP.
* Regional decision makers are expressing a strong desire to quantify future risk of extreme weather events and monsoons for coastal communities.

***Project Objectives:***

* Verify historic Global Climate Model datasets with NOAA CDR platforms
* Extract surface wind and rainfall data from Global Climate Model future simulations for the period 2030-2100
* Determine projected trends in magnitude of extreme wind speed and rain rate (95th and 5th percentile threshold value) for study area
* Compute 50-year return intervals of wind speed and rainfall totals at virtual stations for study area
* Create projected trend in Western North Pacific Monsoon Index

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **NOAA, Regional Climate Services, Pacific Region** | Dr. John J. Marra, Director | End User | Yes |
| **University of Guam** | Dr. Mark Lander, Professor | Collaborator | No |

***Decision Making Practices & Policies***:

Dr. Marra currently distributes reports describing climate impacts and outlooks on a quarterly basis to decision makers in the region. These reports include precipitation and storm outlooks for the upcoming quarter or season with a maximum 3-month forecast. National Weather Service (NWS) officers in the USAPI and other decision makers use these outlook reports and NWS forecasts to prepare for potential extreme weather events in near-real time and up to three months in the future. These reports pull together outlooks from a variety of sources and utilize a menagerie of satellite and *in situ* datasets. However, many of these datasets have large data gaps and lack long-term future timescales.

***Project Benefit to End User***:

The end products of this project will help regional decision makers make long-term climate adaptation and mitigation plans. The maps indicate expected outlooks in extreme wind and rainfall events and monsoon indices up to the year 2100, providing small island communities with insight into what extreme weather will look like in the future. Smaller island communities such as the Republic of the Marshall Islands have little to no resources that could be used to analyze expected changes in climate. These results highlight the expected return interval of extreme wind and rain events in future decades to give these end users an "advanced warning," so that decisions can be made sooner, rather than later. The end-products will facilitate an open dialogue between the regional decision makers and the NWS (and other partner offices) on future resilience and adaptation options and planning.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **ONSAP-CDR SSM/I** | Wind speed | Wind speed observations will be used to validate and verify Global Climate Model historical simulations of wind speed.  |
| **PERSIANN-CDR** | Precipitation estimates | Precipitation estimate observations will be used to validate and verify Global Climate Model historical simulations of precipitation estimates. |

***Ancillary Datasets:***

World Climate Research Programme Coupled Model Intercomparison Project Phase 5 (CMIP5) – historic and future simulations of precipitation flux and components of wind speed and direction

***Software & Scripting:***

Esri ArcGIS – Geospatial analysis; map creation

R – Data acquisition, processing, validation, and various statistical analyses

Python – Data acquisition, processing, and validation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Future Western North Pacific Monsoon Distribution Maps** | ONSAP-CDR SSM/I, PERSIANN-CDR | These maps will be distributed by the end user and utilized by regional decision makers specifically for monsoon-related management and adaptation planning.  | N/A |
| **Return Interval Maps and Time Series**  | ONSAP-CDR SSM/I, PERSIANN-CDR | These maps utilized by regional decision makers and end users to enhance understanding of changes in frequency of wind and rain events for climate adaptation and management planning.  | N/A |
| **Maps of Projected 95th and 5th Percentile Value Wind Speed and Rain Rate and Expected Exceedance Days** | ONSAP-CDR SSM/I, PERSIANN-CDR | These maps will inform end users and regional decision makers about potential future weather risks as extreme patterns change.  | N/A |

**Project Handoff Package**

**Transition Plan:**

The project team will hand off all completed results, including maps and figures identifying changes in magnitude, frequency, and distribution of monsoon and extreme wind and speed events in the region for the years 2030 to 2100 to the end user at the end of the term via video conference. No software release will be required for the results of this project.

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**Partner POC**: John Marra, john.marra@noaa.gov

**Handoff Package:**

* Maps of changes between projected and historical data for magnitude and frequency of extreme wind speed and rain rate (95th and 5th percentile threshold value) on a decadal basis from 2030 to 2100
* Time series plots for 1000, 500, 100, 50 and 10 year return interval values for monthly total rainfall and monthly wind speed at virtual stations from 2030 to 2100
* Maps of average decadal Western North Pacific Monsoon index values from 2030 to 2100 for the geographic Western North Pacific Monsoon domain

**References:**

Kruk, M.C., Hilburn, K., & Marra, J.J. (2015) Using microwave satellite data to assess changes in storminess over the Pacific Ocean. Monthly Weather Review, *143*, 3214-3229.

Marra, J.J., Kari, U., & Sabbatelli, T.A. (2008) Anatomies of historical storm events in the Pacific. Proceedings of the Solutions to Coastal Disasters Congress, 222-228. Oahu, HI: American Society of Civil Engineers doi: 10.1061/40968(312)20

Nurse, L. A., Mclean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Peleskoti, N., . . . & Webb, A. (2014). Small Islands. Retrieved May 4, 2017, from <https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap29_FINAL.pdf>

Ramsay, D. (2011). Coastal erosion and inundation due to climate change in the Pacific and East Timor. Department of Climate Change and Energy Efficiency, Government of Australia.