**NASA DEVELOP National Program**

**North Carolina-NCEI**

*Project Summary – Spring 2018*

**Carolina Disasters**

*Utilizing Precipitation Estimates from NASA Earth Observations and NOAA Climate Data Records to Enhance Understanding of Extreme Events in the Carolinas*

**VPS Title:** Extreme Precipitation: Evaluating Satellite Estimates in the Carolinas

**Project Team**

***Project Team*:**

Andrew Shannon (Project Lead), ashannon@sas.upenn.edu

Shelby Ingram

Michael VonHegel

***Advisors & Mentors*:**

Olivier Prat (Cooperative Institute for Climate and Satellites, NOAA National Centers for Environmental Information)

Brian Nelson (NOAA National Centers for Environmental Information)

**Project Overview**

***Project Synopsis*:** This project partnered with NOAA’s Office for Coastal Management (OCM) and University of North Carolina Asheville, National Environmental Modeling and Analysis Center (NEMAC) to test the feasibility of using satellite-derived Quantitative Precipitation Estimates to monitor extreme precipitation and provide a historical analysis of extreme precipitation patterns. This project expanded upon past research involving NASA’s Tropical Rainfall Measuring Mission and NOAA’s Climate Data Records program. The final product improved NOAA’s Climate Resilience Toolkit with the assistance of NEMAC. The results highlighted the benefits of NASA’s Earth Observation satellites by providing readily available, actionable data to regional governments, organizations, and individuals. This information can be used to address the risks and threats of extreme precipitation in the Carolinas.

***Abstract:***

In October 2015, the state of South Carolina experienced a recording-breaking precipitation event leading to detrimental flooding that caused 19 fatalities and over one billion dollars of damages, which has prompted researchers and resource managers to enhance their understanding of extreme precipitation. This project explored multiple satellite-derived Quantitative Precipitation Estimates (QPE) in an effort to capture historical extreme precipitation patterns and risk-prone areas in both South Carolina and the greater southeastern United States. Using NASA Earth Observations and NOAA Climate Data Records, we analyzed the benefits of using short-term, high-resolution datasets to measure extreme precipitation patterns compared to surface observations. Satellite observations included NASA’s Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement (GPM) mission, as well as NOAA’s Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks Climate Data Record (PERSIANN-CDR). Surface observation records were retrieved from the Global Historical Climatology Network-Daily (GHCN-D) estimates, a network of global rain gauge stations. We highlighted areas prone to extreme precipitation with bias adjusted precipitation estimates. Results also assessed variability in precipitation measurements for recent years in an effort to integrate high-resolution QPE in NOAA’s Climate Resilience Toolkit and to address spatial gaps in surface observation datasets. This project served to provide a better understanding of climate stressors for the Carolinas and to pose a discussion on effective methods of using climate resilience toolkits integrated with satellite-derived datasets.

**Keywords:**

NASA Earth observations, Global Precipitation Measurement, NOAA, NEMAC, climate resilience, extreme precipitation, remote sensing

***National Application Area(s) Addressed:*** Disasters, Transportation and Infrastructure, Urban

Development, Water Resources

***Study Location:*** NC and SC

***Study Period:*** January 1983 – September 2017

***Community Concern:***

* Surface observation records from rain gauge stations are not spatially comprehensive throughout the study domain and leave gaps of reliable precipitation data in areas lacking nearby stations.
* The state of South Carolina recently experienced in 2015 a period of 1000-year return level precipitation leading to detrimental flooding that caused 19 fatalities and over one billion dollars of damages.
* Areas with increasing population and development are expected to be more greatly impacted by flooding, landslides, and other infrastructure damage associated with extreme precipitation in the future, especially for coastal communities who have seen increases in annual flooding events up to 200% in frequency.

***Project Objectives:***

* Demonstrate the benefits of high-resolution NASA Earth Observations for the Office of Coastal Management
* Evaluate uncertainty of quantitative precipitation estimates in the NC and SC region of the southeastern United States
* Assess historical variability and patterns of precipitation to better understand extreme events and their state-wide impact

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **NOAA, Office for Coastal**  **Management** | Adam Stein, Coastal Hazards  Specialist | End User | Yes |
| **University of North Carolina**  **Asheville, National**  **Environmental Modeling and**  **Analysis Center** | Matt Hutchins, Research Scientist and  Environmental Change Project Lead | Collaborator | Yes |

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

The OCM recognizes flooding as their foremost natural disaster concern as well as the most probable. Operating under the direction of the Coastal Zone Management Act (1972), the OCM seeks to keep the natural environment, developed areas, quality of life, and economic growth of coastal areas in balance utilizing technology, data, and management techniques with local state and national organizations. The OCM addresses these concerns through the National Coastal Zone Management Program, the Natural Estuarine Research Reserves, the NOAA Coral Reef Conservation Program and the Digital Coast website.

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

The OCM will utilize these end products to inform future disaster management planning against flooding events and other disasters associated with extreme precipitation. Maps and figures of the variability and uncertainty of satellite-derived precipitation estimates will give the OCM a better understanding of future vulnerabilities to extreme precipitation.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **GPM GMI & DPR -IMERG** | Precipitation estimates | Precipitation estimates will be used to determine how high-resolution datasets measure (extreme) precipitation compared to other satellite-derived and rain-gauge datasets. |
| **TRMM TMPA** | Precipitation estimates | Precipitation estimates will be used to determine how high-resolution datasets measure (extreme) precipitation compared to other satellite-derived and rain-gauge datasets. |
| **PERSIANN-CDR** | Precipitation estimates | Precipitation estimates will be used to determine how high-resolution datasets measure (extreme) precipitation compared to other satellite-derived and rain-gauge datasets. |

***Ancillary Datasets:***

NOAA Global Historical Climatology Network-Daily (GHCN-D) *In Situ* Precipitation

Measurements – QPE validation

World Meteorological Organization Global Precipitation Climatology Centre (GPCC) Gridded

Precipitation Data - QPE validation

NOAA Storm Event Database – Identify extreme events and provide monetary costs estimates and

human casualty counts for each event (extreme precipitation, tropical storms, flash floods, storm surges, etc.)

***Software & Scripting:***

Esri ArcGIS – Geospatial analyses; map creation

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

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

Python – Data acquisition, processing, and validation

FORTRAN - Data acquisition, processing, and validation

Unix - Data acquisition, processing, and validation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Uncertainty Plots/Charts for**  **Satellite Derived Quantitative**  **Precipitation**  **Estimates’ Ability**  **to Monitor**  **Extreme**  **Precipitation** | TRMM TMPA, GPM GMI & DPR IMERG, PERSIANN-CDR | These charts and graphs will inform end users and collaborators of  uncertainty and biases in using the satellite-derived datasets to measure (extreme) precipitation in comparison to ground-based rain gauges. | N/A |
| **Variability Maps for**  **Satellite Derived Quantitative**  **Precipitation**  **Estimates’ Ability**  **to Monitor**  **Extreme**  **Precipitation** | TRMM TMPA, GPM GMI & DPR IMERG, PERSIANN-CDR | These maps and figures will inform end users as to  how the satellite-derived datasets perform and capture extreme events. Additionally, set the stage for a focus on climate resilience planning and community-level impacts in the second term. | N/A |
| **Decision Support Framework** | TRMM TMPA, GPM GMI & DPR IMERG, PERSIANN-CDR | A user’s guide to QPE and a framework demonstrating the value of satellite QPE’s. This end product will also feature an outline for the tool that is to come in the second term. | N/A |

**Project Handoff Package**

**Transition Plan:**

The project team will hand off all completed results to the NOAA Office for Coastal Management and the National Environmental Modeling and Analysis Center via a video conference or in-person meeting. The team will also present the results of their extreme precipitation analysis and comparison of satellite-derived QPE measurements during the aforementioned hand off meeting. The team will also provide a thorough documentation of their results and methods to NC node leadership to maintain for the second project term.

**Project Continuation Plan**: Upon handing off the atlas, precipitation datasets, and maps and figures, the second term team will be set up to develop a tool that performs the analysis per user input. This tool will be used by end users such as Adam Stein, among other state and local planners. With the depth of this analysis provided on an easy to use, and interfaced location environment, much more information can be provided to end users that is superior to just using on the ground measures of precipitation. Therefore, demonstrating to all users the benefits of satellite derived datasets. Additionally, the second term team will be able to focus on flooding and tropical cyclones in specific areas like Charleston and foster additional partners and users in the area.

**Team POC:** Andrew Shannon, ashannon@sas.upenn.edu

**Partners POC**: Adam Stein, adam.stein@noaa.gov, Matthew Hutchins, mwhutchi@unca.edu

**Handoff Package:**

* An atlas compiling project methods, results, and conclusions that displays all static graphs and figures, including uncertainty charts, among other statistical graphs.
* Processed datasets of QPE to incorporate into NEMAC Climate Resilience Toolkit
* Maps and figures including long-term and short-term statistical analyses of extreme precipitation, rainfall climatologies throughout the study area, threshold value and percentile maps of extreme precipitation.
* Decision support framework website detailing information about QPE for any data user and how to go about using the information provided in the atlas and coming tool in the second term

**References:**

Coastal Zone Management Act of 1972 (16 USC 1451-1464, Chapter 33; P.L. 92-583, October 27,

1972; 86 Stat. 1280)

Spanger-Siegfried, E., Fitzpatrick, M., & Dahl, K. (2014). Encroaching Tides: How sea level rise and tidal flooding threaten U.S. East and Gulf Coast communities over the next 30 years, *Cambridge, MA: Union of Concerned Scientists,* pp. 8-11.