Assessing changes in Cloud Dynamics in the Luquillo Tropical Montane Forest Using NASA Earth Observations and Following Defoliation from Hurricane Maria

Abstract

The Luquillo Mountains in the El Yunque National Forest contain the most biologically diverse forest in the United States. It is a cloud forest rich in endemic species and its streams bring clean water to the people of Puerto Rico. This unique environment was exposed in the aftermath of Hurricane Maria, which devastated Puerto Rico during its landfall on September 20th, 2017. One of the numerous effects hurricane Maria had on the landscape was substantial defoliation of the forest within the Luquillo Mountains. Large scale defoliation events have been linked to changes in the physical environment as well as cloud formations potentially related to a decrease in evapotranspiration (ET) rates from vegetation. This project investigated how hurricane Maria impacted cloud dynamics in the Luquillo Mountains. It is known that relatively small changes in cloud base height (CBH) can have a drastic impact on the flora and fauna of the area that have evolved to live in near constant cloud immersion. The team utilized Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data to determine CBH over the study area and calibrated it against the theoretical CBH from radiosonde data. We also used Landsat cloud mask data to analyze changes in cloud coverage pre- and post- Maria. This work provides the US Forest Service International Institute for Tropical Forestry (IITF) with an estimated change in CBH and cloud distribution before and after Maria that can be incorporated to IITF's management plans.

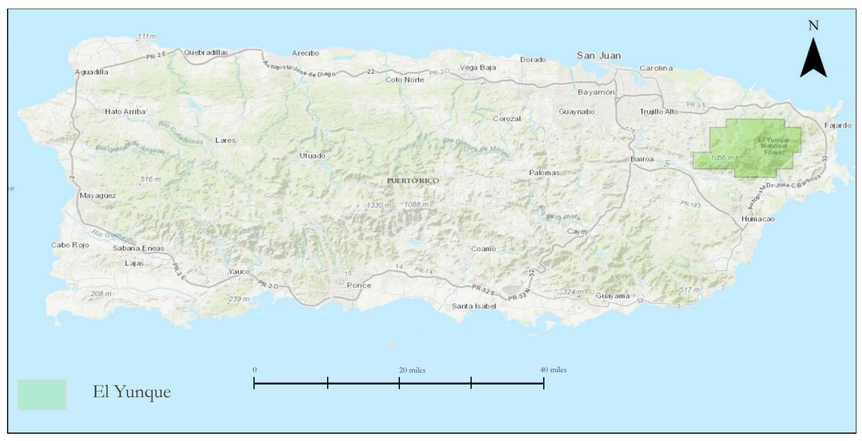
Objectives

- **Determine** changes in cloud base height (CBH) pre- and post-Hurricane Maria
- **Analyze** cloud spatial distribution change pre- and post-Hurricane Maria
- **Provide** the partners with products to better estimate changes in CBH and cloud coverage pre- and post-Hurricane Maria

Project Partners

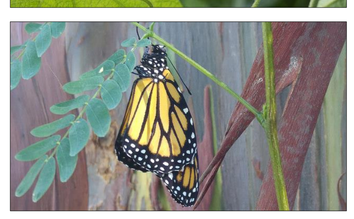
USDA, US Forest Service, **International Institute of Tropical Forestry**

Study Area



Study Area: El Yunque National Forest in Puerto Rico

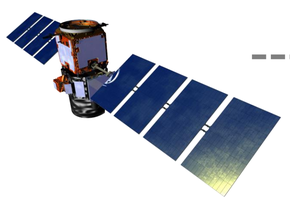
Credit Gary Potts_USFS IITF



Credit Maribelís Santiago_USFS IITF

Study Period: December 2006 – March 2018 (CALIPSO)
December 2013 – March 2018 (Landsat 8)

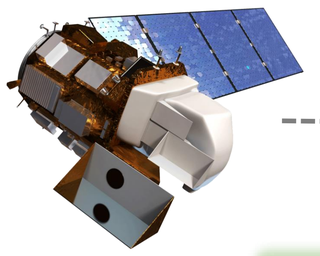
Earth Observations & Methodology



CALIPSO

- Import Level 2 CALIPSO Data via PyHDF
- Subset collection to area of interest using python commands
- Create table containing location and CBH
- Convert to point shapefile

Python Script



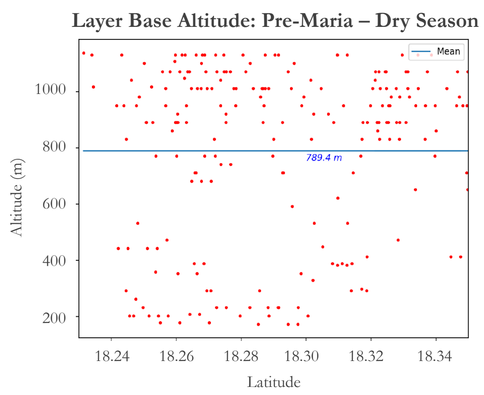
Landsat 8

- Create image collection for study period
- Create cloud mask image for each image in collection
- Create a mean image for the entire collection
- Subtract the post- hurricane mean image from the pre- hurricane image to highlight areas of average cloud cover change

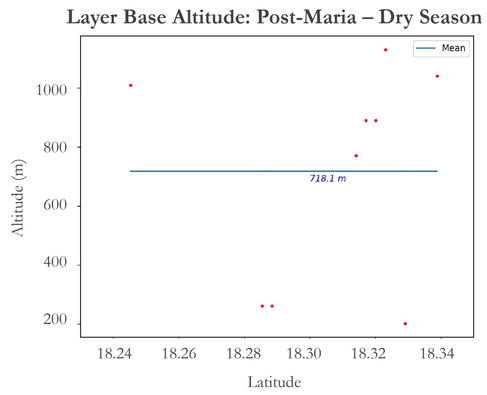
Google Earth Engine

Results

Vertical Cloud Profile



2006 –2017 (Dec.– Mar.)

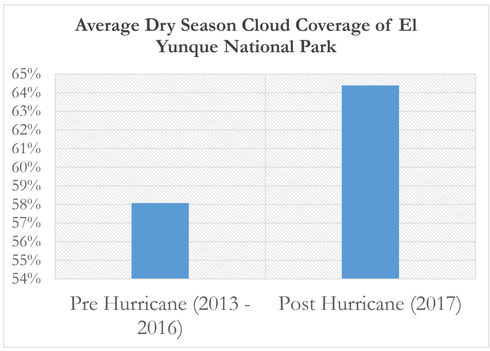


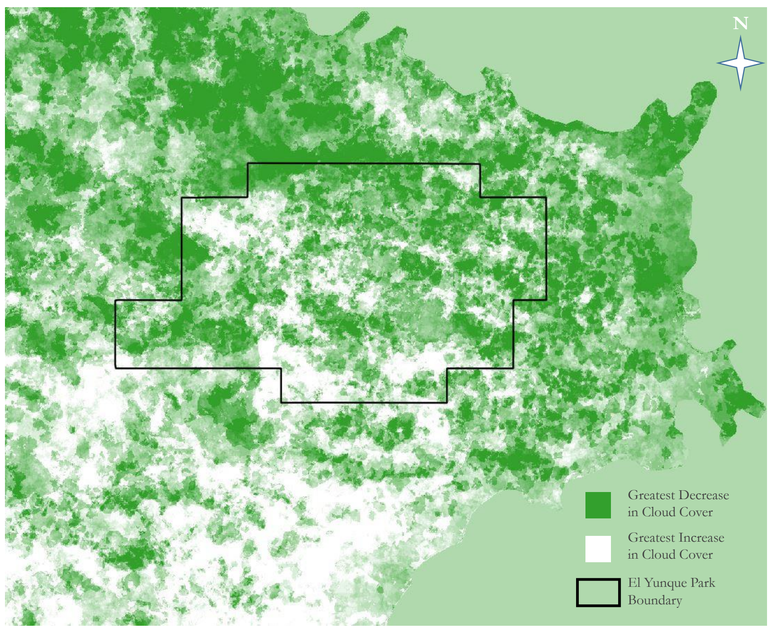
Dec. 2017 – Mar. 2018

- Pre-Maria average cloud base height: 789.4 meters above sea level
- Post- Maria average cloud base height: 718.1 meters above sea level
- -78.1 m difference between pre- and post-Maria Dry Season average for cloud base height

Horizontal Cloud Profile

Puerto Rico has three primary seasons.. Of the three seasons, the weather in the dry season is the most likely to be influenced by orographic factors and other small scale variables such as cloud cover. Our analysis indicates that there was a ~11% increase in cloud cover after Hurricane Maria made landfall September 20, 2017. The map on the right shows the spatial distribution of these changes.





- Average cloud coverage during the dry season, as determined by the cloud mask data available from Landsat 8, increased ~11% across the El Yunque Park post Hurricane Maria. The pixel level changes in cloud cover, as displayed in the above map, highlight areas where further studies can determine how these changes affect other environmental factors such as NDVI or evapotranspiration.

Conclusions

- With only a small amount of post-Hurricane data, it is difficult to ascertain whether or not the changes in vertical and horizontal cloud dynamics were definitively a product of Hurricane Maria or a product of larger synoptic weather patterns.

Acknowledgements

Project Partners: **Dr. Grizelle Gonzalez**, Research Scientist, USDA, US Forest Service, International Institute of Tropical Forestry, and **Dr. Martha Scholl**, Research Hydrologist, USGS National Research Program

Science Advisors: **Dr. Thomas Mote**, University of Georgia, and **Dr. Paul Miller**, University of Georgia

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This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A. Any mention of a commercial product, service or activity in this material does not constitute NASA endorsement. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.