## NASA DEVELOP National Program 2019 Fall Project Proposal

## California – JPL Panama Water Resources

Characterizing Vegetation Water Use in the Panama Canal Watershed to Inform Water Management in the Panama Canal

## **Project Overview**

**Project Synopsis:** This project will partner with the Smithsonian Tropical Research Institute (STRI) and the Ministerio de Ambiente de Panamá (MiAmbiente) to use NASA Earth observations, synthetic aperture radar (SAR), and *in-situ* data to characterize vegetation water use as related to vegetation structure and moisture regimes in the Panama Canal Watershed. This project will use ECOSTRESS and MODIS data to analyze evapotranspiration (ET) spatially and temporally. This project will also use SAR data from UAVSAR, ALOS PALSAR, and Sentinel-1 to characterize vegetation structure, relating it to ET to provide insight into the type of vegetation most suitable for water conservation within the watershed. These data will be used to create vegetation water use maps in order to better understand the role of land cover on vegetation water use and water flows in the Panama Canal Watershed.

**Community Concern:** Water management is critical for the continuous operation of the Panama Canal. The construction of a larger set of locks and the occurrence of stronger El Nino events have placed increasing, critical importance on the management of freshwater in the Panama Canal Watershed to support canal operation. There is concern that as water gets scarcer, the Panama Canal will only be able to operate at limited capacity and the viability of the canal as a major transportation corridor will be threatened, having a global impact on maritime shipping.

*Source of Project Idea:* Erika Podest (science advisor at JPL) and Kyle McDonald (co-advisor from CCNY) were co-leads on a Keck Institute for Space Studies (KISS) study program entitled "Unlocking a New Era in Biodiversity Science: Integrating In Situ with Space Based Observations." Helene Muller-Landau was a participant in this study program and attended both workshops. Helene, Kyle, and Erika identified DEVELOP as an opportunity to explore relationships between vegetation function and structure given the availability of UAVSAR, SAR, and ECOSTRESS data along with a wealth of in situ measurements that STRI has collected over the Panama Canal watershed that can support this assessment.

## National Application Area Addressed: Water Resources Study Location: Panama Canal Watershed, Panama

Study Period: February 2010 – September 2019

*Advisors:* Erika Podest (NASA Jet Propulsion Laboratory, California Institute of Technology), Kyle McDonald (City College of New York and JPL), Bob Stallart (Smithsonian Tropical Research Institute and University of Colorado), Helene Muller-Landau (Smithsonian Tropical Research Institute)

#### Partner Overview Partner Organizations:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
Ministerio de Ambiente de	Fransisco Abre, Department of	End User	No
Panamá (MiAmbiente)	Protected Areas		

Smithsonian Tropical Research	Jefferson Hall, Scientist	Collaborator	No
Institute (STRI)			

#### End-User Overview

#### End User's Current Decision-Making Process:

*Ministerio de Ambiente de Panamá* - MiAmbiente is in charge of managing the land and water resources of the Panama Canal Watershed. the organization has a national water safety plan, in which 20 other organizations participate, that outlines goals relating to sustainable socioeconomic development and water management in Panama. The organizations involved are completing projects of varying lengths related to water resource management.

#### End User's Capacity to Use NASA Earth Observations:

*Ministerio de Ambiente de Panamá* - MiAmbiente is familiar with NASA Earth observations, typically using data available within Google Earth Engine. They have a GIS team capable of using remote sensing data to inform the projects related to water resource management. Through the results of this project, MiAmbiente will be able to build their own capacity by replicating and applying the methods to other watersheds within Panama.

#### Collaborator & Boundary Organization Overview

#### Collaborator Support:

Smithsonian Tropical Research Institute – The STRI will provide in situ datasets for calibration and validation as well as assessing accuracy of the vegetation water use maps and vegetation structure products.

#### Project Communication & Transition Overview

**In-Term Communication Plan:** Node leadership will organize the first meeting with the team and partners within the first two weeks of the term via WebEx. The Project Lead will then be the main POC to schedule weekly or biweekly meetings with the partners to give project updates and help facilitate discussions. The team will either continue to have the meetings through WebEx video calls or with a teleconference line.

**Transition Plan:** The team will present their results to the partners over a video call during the last week of the term. Final project deliverables and end products will be emailed to the partners using NASA Large File Transfer (LFT) after export control approval. This may mean the final handoff of the end products will occur at least two weeks after the term ends. At this time software release is not anticipated, so the partners should be able to receive the products soon after the term ends.

Platform & Sensor	Parameters	Use
NASA Gulfstream III UAVSAR	L-band Polarimetric Radar Backscatter	UAVSAR L-band radar will be used to map forest structure, fragmentation, and biomass. The amount of backscatter returned will be used to assess vegetation attributes.
Sentinel-1 C-SAR	C-band dual-polarization radar backscatter	Time-series Sentinel-1 dual polarization C-band SAR will be used to map forest structure, fragmentation, and biomass. The amount of backscatter returned from the C-band will be used to assess vegetation attributes.
ALOS PALSAR	L-band dual polarization radar backscatter	PALSAR dual polarization L-band SAR will be used to map forest structure, fragmentation, and biomass. L-band backscatter will be used to assess vegetation attributes.

#### Earth Observations Overview

Terra MODIS	Evapotranspiration (ET)	MODIS evapotranspiration data will be used to assess vegetation water use.
ECOSTRESS	Evapotranspiration (ET)	ECOSTRESS evapotranspiration data will be used to assess vegetation water use.

## Ancillary Datasets:

• Smithsonian Tropical Research Institute Biodiversity *in situ* data – Field data will be used for calibrating and for assessing accuracy of the vegetation water maps and vegetation structure products.

## Software & Scripting:

- R Statistical analysis and creating graphs
- Python Data acquisition
- Esri ArcGIS Desktop Raster manipulation and analysis, image enhancement, and map creation
- Esri ArcGIS Pro Raster manipulation and analysis, image enhancement, and map creation
- Harris Geospatial ENVI and IDL Raster manipulation and analysis, image enhancement, and image classifications

# Decision Support Tool & End Product Overview

Ena	Products:	

End Product	Partner Use	Datasets & Analyses	Software Release Category
Vegetation Water Use Maps	These maps will illustrate vegetation water use for different classes of vegetation structure. The end-user will use this to better understand the role of land cover on vegetation water use and water flows in the Panama Canal watershed. In addition, this will inform on the type of vegetation most suitable for water retention within the watershed and support land use planning.	ECOSTRESS and downscaled GOES-16 data will be used for assessing evapotranspiration. Forest structure will be assessed from UAVSAR, Sentinel-1, and PALSAR. In situ data will be used to calibrate the data and validate the products.	N/A
Standard Operating Procedure	This document describing the project's methodology will allow the end user to scale this feasibility study to additional watersheds in Panama.	N/A	N/A

**End-User Benefit:** MiAmbiente is interested in better understanding how land cover impacts water resources, particularly during the dry season. The study sites, Agua Salud and Barro Colorado in the Panama Canal Watershed, represent many land cover types and have historical *in situ* datasets, making them excellent sources to address vegetation dry season water usage. MiAmbiente would like to understand how to perform similar studies in areas of Panama outside of the Panama Canal Watershed. This project will establish and document a scientifically rigorous methodology for evaluating the sponge effect of different land uses, enabling MiAmbiente to scale up the feasibility study into different watersheds. The results of this study will

suggest what types of vegetation would be most beneficial to conserving water in the Panama Canal Watershed.

## **Project Timeline & Previous Related Work**

Project Timeline: 1 Term: 2019 Fall

## **Related DEVELOP Work:**

- 2016 Fall (GSFC) Kenya Ecological Forecasting: Estimating Carbon Sequestration within Global Environment Facility Funded Protected Areas in Kenya to Aid Future Policy
- 2015 Fall (LaRC) El Salvador Ecological Forecasting: Utilizing NASA Earth Observations to Develop a Historical Baseline Trajectory of Changes in Forest Cover and Degradation Indicators in El Salvador

## Notes & References:

Notes: Anything else you deem relevant and that supports the proposal.

- This project is not a duplicate of the ROSES project "A Sustainable Forest Management and Information System (SFMIS) Tool" under Erika Podest which is focused on generating forest and non forest cover maps, as well as simple land cover change maps over time. It assesses forest management in Panama through land cover change using developed products.
- This DEVELOP project entails using ECOSTRESS, GOES-16, and SAR to look at vegetation water use and calibrating the data and validating the products with in situ measurements from STRI.
- The JPL node has worked on a variety of projects that use ECOSTRESS, GOES-16, and SAR and has expert advising from JPL scientists who specialize in these datasets. The necessary expertise is available to complete the project objectives.

#### **References:**

Condit, R., Robinson, W. D., Ibáñez, R., Aguilar, S., Sanjur, A., Martínez, R., ... & Wright, S. J. (2001). The status of the Panama canal watershed and its biodiversity at the beginning of the 21st century: long-term ecological studies reveal a diverse flora and fauna near the Panama canal, harbored within a corridor of forest stretching from the Caribbean to the Pacific, but deforestation, land degradation, erosion, and overhunting remain threats. *BioScience*, *51*(5), 389-398.

Robinson, N. P., Allred, B. W., Smith, W. K., Jones, M. O., Moreno, A., Erickson, T. A., ... & Running, S. W. (2018). Terrestrial primary production for the conterminous United States derived from Landsat 30 m and MODIS 250 m. *Remote Sensing in Ecology and Conservation*, 4(3), 264-280.