**NASA DEVELOP National Program**

****NASA Jet Propulsion Laboratory

Spring 2017

**Short Title: Arizona Agriculture**

**Subtitle:** Demonstrating the Potential Applications of ECOSTRESS Evapotranspiration Products in Plant Phenotyping and Predicting Patterns in Global Species Richness

**VPS Title:** Oh the Places Evapotranspiration Can Go!

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

Dr. Joshua Fisher (NASA Jet Propulsion Laboratory)

Dr. Christine Lee (NASA Jet Propulsion Laboratory)

Dr. Ryan Pavlick (NASA Jet Propulsion Laboratory)

Dr. Andrew French (United States Department of Agriculture)

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| United States Department of Agriculture (USDA) | Dr. Andrew French, Research Physical Scientist | End-User | Yes |

**Project Details**

**Applied Sciences National Applications Addressed:** Agriculture

**Study Area:** Maricopa, AZ and Global

**Study Period:** Local: 2013 – 2014 (August – September); Global: 1986 – 2007

**Earth Observations & Parameters:**

* Advanced Very High Resolution Radiometer (AVHRR) – Pathfinder – visible and near-infrared reflectance, SAVI, NDVI
* International Satellite Land Surface Climatology Project, Initiative II (ISLSCP II) – net radiation, air temperature, water vapor pressure

**Ancillary Datasets Utilized:**

* USDA *in situ* data from Maricopa, AZ – temperature, plant height, evapotranspiration, irrigation, multiband plant spectral reflectance, and soil moisture
* Published data from Kreft & Jetz (2007) – Vascular Plant Species per 10,000 km2
* Published data from Kier et al. (2005) – Number of Plant Species by Terrestrial Ecoregion

**Models Utilized:**

* Priestly-Taylor Jet Propulsion Laboratory (PT-JPL) model

**Software Utilized:**

* ESRI ArcGIS – raster manipulation/analysis, image enhancement
* R – statistical analysis and graphics
* MATLAB – statistical analysis and graphics
* Python – data processing and analysis
* Adobe Photoshop & Illustrator – graphics

**Project Overview**

**80-100 Word Objectives Overview:**

To protect agricultural systems and global species richness, understanding changes in both water and energy availability is crucial. Working with the US Department of Agriculture (USDA) in Maricopa, AZ, this project aims to explore how evapotranspiration can be used for phenotyping at the farm-scale and for biodiversity studies at the global-scale. Phenotyping via remote sensing will allow plant breeders to increase both the speed and scale of selecting superior crop varieties and plan irrigation regimes to protect valuable water resources. Expanding to the global level, evapotranspiration can give conservationists a tool to remotely sense shifts in biodiversity which can in turn, inform conservation management strategies.

**Abstract:**

A changing climate has the potential to affect both agricultural productivity and global levels of biodiversity. In the agricultural context, the ability to rapidly identify more water-efficient and drought tolerant crop varieties will be vital for international food security. Current methods of phenotyping superior crop types are often destructive, time-intensive, and costly. Remote sensing affords the opportunity to expedite the phenotyping process by expanding both the spatial and temporal scale of analyses – bypassing the limitations of current genetic testing and plant breeding trials. As biodiversity research presents analogous constraints to *in situ* phenotyping, similar resolution benefits are attributed to monitoring shifts in species richness at the global scale using remote sensing technologies. With the anticipated launch of the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) in 2018, we investigated the potential applications of its evapotranspiration (ET) products to inform agricultural management practices and global conservation efforts. Evapotranspiration, or water vapor entering the atmosphere from the combination of transpiration and evaporation, differs by plant type and has been used in previous work to model species richness. On the farm-scale, we investigated the utility of ET to phenotype and identify the best performing varieties of cotton in water-stressed conditions. We then examined how well evapotranspiration can predict global vascular plant species richness.

**Keywords:**

Remote sensing, evapotranspiration, biodiversity, phenotyping, cotton, species richness

**Community Concerns:**

* A changing climate impacts water and energy availability, both of which are crucial to plant health. Changes to these environmental variables therefore threaten both agricultural systems and global biodiversity as a whole
* Selecting superior crop varieties is currently very costly and labor intensive
* Demonstrated need for non-destructive, large-scale phenotyping via remote sensing to catch up to progress made in plant genotyping
* Need for global, remotely-sensed tool to study biodiversity

**Current Management Practices & Policies**:

Selecting superior crop varieties is accomplished primarily through genomic studies. The field experiment conducted in Maricopa used tractor-mounted sensors such as an infrared thermospectrometer and an acoustic system. Global studies to predict patterns in species richness involve different types of statistical models to extrapolate field survey data in combination with environmental variables.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software** **Release** |
| Crop Variety Performance Rankings | N/A | Inform producers of cotton of superior heat and drought-tolerant varieties, and demonstrate the future applications of ECOSTRESS evapotranspiration data | N/A |
| Global Biodiversity Biome Correlation Maps | Advanced Very High Resolution Radiometer (AVHRR), International Satellite Land Surface Climatology Project, Initiative II (ISLSCP II) | Simulate the possibilities of ECOSTRESS evapotranspiration data to predict global patterns in species richness | N/A |