**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**NASA Jet Propulsion Laboratory**

**Arizona Agriculture**

*Utilizing Simulated ECOSTRESS Data Products to Speed and Scale the Selection of Drought and Heat Tolerant Varieties of Crops*

**Project Overview**

***Project Synopsis*:** Working with the US Department of Agriculture (USDA) in Maricopa, AZ, this project will utilize simulated ECOSTRESS data products for remotely sensed phenotyping and identification of superior heat and drought tolerant varieties of crops. ECOSTRESS data products will be used along with in situ data provided by the USDA to differentiate varieties of crops which will increase both the speed and scale of selecting superior crop varieties. This will be done on a farm scale and the potential to repeat this process on a global scale using global ECOSTRESS data products along with global reanalysis datasets will also be explored.

***Community Concern:*** Non-destructive, image-analysis-based phenotyping via remote sensing is an emerging and developing field of research with potential for agricultural and ecosystems applications. Phenotyping is used in agricultural contexts to describe the performance of plants in a given environment which allows plant breeders to identify heat-tolerant individuals and target their management practices. Currently, this is done on an individual plant scale which can take many years and have high costs. Simulated ECOSTRESS data will be used along with *in situ* biological, geographical, and meteorological data provided by the USDA to find predictive relationships that will aid in differentiating varieties of crops on a farm field scale.

***Source of Project Idea:*** Andrew French is a science team member on the ECOSTRESS mission and works for the USDA. The project arose from discussions with Andrew French who is currently part of a major USDA effort in Maricopa, AZ to utilize remote sensing for plant phenotyping.

***National Application Areas Addressed:*** Agriculture, Water Resources

***Study Location:*** Maricopa, AZ

***Study Period:*** January 2013 – December 2016

***Advisors:*** Josh Fisher (NASA Jet Propulsion Laboratory, California Technical Institute), Christine Lee (NASA Jet Propulsion Laboratory, California Technical Institute), Dr. Glynn Hulley (NASA Jet Propulsion Laboratory, California Technical Institute)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| US Department of Agriculture (USDA), ARS U.S. Arid-Land Agricultural Research Center | Andrew French, Research Physical Scientist and Martha Anderson, Research Physical Scientist | End-User | Yes |

***End-User Overview***

***End-User’s Current Decision-Making Process:*** Plant phenotyping is widely done on the individual plant scale, which makes the selection of superior, heat-tolerant, individuals a long and costly process. Utilizing remote sensing as a tool for phenotyping is relatively new but rapidly developing and has the potential to dramatically speed and scale plant phenotyping. Evapotranspiration, a critical variable in agricultural water management and for monitoring the health of ecosystems, is a key plant phenotype as it indicates vegetation water status and possible water stress.

***End-User’s Capacity to Use NASA Earth Observations:***

*US Department of Agriculture (USDA)* – Andrew French has utilized NASA Earth Observations data, such as Landsat, MODIS, and ASTER in a variety of his projects including evapotranspiration estimation over irrigation districts in Central Arizona; San Joaquin Valley, CA; and Jornada, NM . This project will build the USDA’s capacity to both work with and apply ECOSTRESS data.

***Dissemination by Boundary Organizations*:** *USDA –* There will be three potential avenues for disseminating ET/ECOSTRESS related research: 1) incorporation of ET estimates into an existing public/private partnership research program now underway within the Yuma Irrigation District and supported by USBR;, 2) dissemination of results for cotton belt research conducted under sponsorship of Cotton, Inc., and 3) incorporation of results into phenotyping research being conducted at Maricopa by Cotton, Inc, USDA, and a project conducted by the Danforth Center and sponsored by the U.S. DOE.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** We will set up, at a minimum, biweekly or weekly teleconferences to share updates, in addition to a webinar presentation once per month (synchronized with the DEVELOP deliverables schedule). We will also look for opportunities to create joint deliverables, such as reports, presentations, and visualizations.

***Transition Plan*:** We will deliver all products available to the partner in a format compatible with ArcGIS and possibly Google Earth Engine. All products will be shared via e-mail throughout the 10 week term as results and analysis are completed.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Suomi NPP VIIRS** | Land Surface Temperature (LST) | We will use these data to generate the simulated ECOSTRESS L2 LST as the primary input into determining evapotranspiration (L3 product). |
| **Terra ASTER GED** | Emissivity, NDVI | We will use these data to generate the simulated ECOSTRESS L2 Wide-band Emissivity data as required by the L3 product, and to downscale the VIIRS LST from 375 m to ECOSTRESS 70 m resolution. |
| **Aqua and Terra MODIS** | Cloud Mask | We will use these data to generate the simulated ECOSTRESS L2 products as well as an input into the model used to assess trends in vegetation water stress. |

***Ancillary Datasets:***

US Department of Agriculture (USDA) – *In situ* data – Use *in situ* data in combination with simulated ECOSTRESS data to find predictive relationships that will aid in plant differentiation. Andrew French will provide support temperature, soil moisture, multiband plant spectral reflectance, and crop height data acquired over two seasons, 2013-2014, of cotton phenotyping at Maricopa, AZ.

National Center of Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) – Reanalysis data – Using this data as a substitution for *in situ* data will allow the project to explore a potential to scale to global.

***Modeling:***

Priestly-Taylor Jet Propulsion Laboratory (PT-JPL) (POC: Joshua Fisher, NASA Jet Propulsion Laboratory)

***Software & Scripting:***

MATLAB – Producing net radiation data using FLiES and BESS, analysis

Python – Preprocessing MODIS data for net radiation, producing PT-JPL data, analysis

R - Data analysis and visualization

ESRI ArcGIS – Data analysis and visualization

QGIS – Data analysis and visualization

Google Earth Engine API – Data analysis and visualization

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Simulated ECOSTRESS Data Product – Evapotranspiration (ET) | ET Maps have been identified by the partner as a useful resource for informing irrigation practices in regions such as Yuma, AZ; The maps will be useful for regional assessments of crop water stress in rainfed areas. ET methodology used to create the maps will be useful for detailed scale assessment of plant phenotypes. | This product will utilize the simulated Level 2 products, MODIS PT-JPL, and meteorology from NCEP and will be determined at multiple time points to establish understanding of a ET variability over a daily cycle. | I |
|  |  |  |  |
| Crop Variety Classification Map | Crop variety maps will allow the partner to differentiate crop varieties and select superior heat-tolerant ones | The crop varieties will be identified and differentiated through simulated Level 2 and 3 products and in situ data provided by the USDA | N/A |
|  |  |  |  |

***End-User Benefit*:** The end-user will utilize the end products of this project to increase speed and scale of the process used to identify superior heat-tolerant crop varieties. Research and decisions on which crop varieties are appropriate in drought prone areas can be made faster. Scaling the process from individual plants to remotely sensed farm fields will save the end-user both time and money.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2017 Spring

***Related DEVELOP Work:***

2015 Summer (JPL) - New Mexico Water Resources I: Investigating Rangeland Conditions in New Mexico Using MODIS-Derived Evapotranspiration Products

2015 Fall (JPL) - New Mexico Water Resources II: Investigating Rangeland Conditions in New Mexico Using MODIS-Derived Evapotranspiration Products

2016 Summer (JPL) - Costa Rica Water Resources I: Applying ECOSTRESS Diurnal Cycle Land Surface Temperature and Evapotranspiration to Agricultural Soil and Water Management

2016 Fall (JPL) - Costa Rica Water Resources II: Analyzing Advantages of ECOSTRESS Data as a Tool for Drought Detection and Water Management Practices

**Notes & References:**

***References:***

(n.d.). Retrieved from ecostress.jpl.nasa.gov