**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Alabama – Marshall**

**Iowa Agriculture & Food Security**

*Utilizing ECOSTRESS to Assess Drought-induced Stress and Evaluate its Impact on Crop Production across Iowa*

**Project Overview**

***Project Synopsis*:** Iowa is predominantly rural as 92% of state lands are used for agricultural production. Prone to high water stress conditions, Iowa often experiences drought, which is a major concern because the state’s economy is dependent on the health of its lands. This project seeks to provide the Iowa Department of Agriculture and Land Stewardship, Climatology Bureau with an additional resource to monitor drought throughout the state. The team will use the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) Evaporative Stress Index (ESI) to assess vegetation health and determine the feasibility of using ECOSTRESS to detect drought sooner. Along with ECOSTRESS, the team will use SMAP, GPM IMERG, and Landsat 8 OLI products to produce a drought assessment and compare these results with the current assessment strategy. Using these products, the team will also evaluate crop vulnerability during times of drought. The results of this project can improve the drought early warning system for the project partner and provide new methodologies of drought assessment.

***Community Concern:*** The state of Iowa leads the nation with the greatest percentage of land used for agriculture, dedicating 92% of state lands to the production of important crops, such as corn and soybeans. With increasing temperatures and decreasing precipitation trends increasing across the United States, drought and water stress have become limiting factors of productivity and crop yield. Between 2010 and 2014, Iowa experienced the longest drought in the state since 2000, portions of which were considered to be exceptionally dry. Lasting for 151 weeks, this drought caused shortages of water across the state, leading to widespread crop loss and water emergencies. More recently, Iowa experienced a severe drought in the fall and winter of 2018.

***Source of Project Idea:*** This project was inspired by discussions with Alabama – Marshall science advisors and mentors, including Dr. Jeffrey Luvall, one of the applied science co-leads for the ECOSTRESS mission. Level 4 ECOSTRESS data products, such as the L4\_ESI\_ALEXI product, are specifically designed for evaluating crop plant moisture stress and can be extremely valuable for mapping and evaluating drought conditions across Iowa. In addition, discussions with Iowa State Climatologist Justin Glisan determined the usefulness of this project in increasing his drought monitoring methods.

***National Application Area Addressed:*** Agriculture and Food Security

***Study Location:*** IA

***Study Period:*** July 2018 – September 2018

***Advisors:*** Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), Dr. Robert Griffin (University of Alabama in Huntsville)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Iowa Department of Agriculture and Land Stewardship, Climatology Bureau** | Dr. Justin Glisan, State Climatologist | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Currently, the Climatology Bureau uses a variety of satellite-derived drought indicators, such as VegDRI and the standardized precipitation index, to determine drought conditions in the state. Looking for a convergence of drought evidence, the state climatologist is responsible for classifying drought and relaying this information to the US Drought Monitor (USDM) office every week. The weekly USDM drought map can instigate disaster declarations and ascertain the state’s eligibility for low interest loans to deal with such disasters. As a result, classifications of drought assigned by the Climatology Bureau are incredibly important to the livelihoods of many Iowans.

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

*Iowa Department of Agriculture and Land Stewardship, Climatology Bureau* – Currently, the department does not create any drought indices in house, rather they rely on publicly available drought resources. These drought indicators utilize NASA Earth observations but are not formally processed by the Climatology Bureau. The department is eager to expand its capacity to use remotely-sensed products to fill data gaps in the state.

***Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Iowa Department of Agriculture and Land Stewardship, Climatology Bureau* – The Climatology Bureau works closely with officials at the USDM and will share the results of this project with them. The USDM is responsible for declaring drought classifications across the United States, and access to the methodologies and products from this project will assist personnel with their weekly drought classifications. The Climatology Bureau will also share the Story Map product with the local communities it serves, while the University of Alabama in Huntsville will host the product.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Center Lead will schedule a conference call for the first week of the term for participants and partners to introduce themselves and determine if there are any adjustments that need to be made to the end products. The Project Lead will be the main POC for the partners throughout the term and will update partners weekly via email as well as organize meetings once every one or two weeks.

***Transition Plan*:** At the end of the term, the end products and results will be disseminated to the project partner through a web conference. During this meeting, the team will give a presentation of the results and field any questions that the partners may have. This will be followed by a tutorial explaining how to use the end products.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **ISS ECOSTRESS** | Evapotranspiration | The ECOSTRESS ESI data will be used to assess heat-induced crop stress. |
| **SMAP** | Soil moisture | The team will use soil moisture data to analyze what factors lead to heat-induced crop stress. |
| **Landsat 8 OLI** | Land surface temperature (LST), Normalized Difference Vegetation Index (NDVI), and land cover classification | The team will use LST and NDVI to analyze drought. Landsat will also be used by the team to determine the type of crop most affected by drought. |
| **GPM IMERG** | Precipitation totals | The team will use precipitation data to determine if an area is experiencing drought conditions. |

***Ancillary Datasets:***

USDA CropScape – identify crop type

USDA Crop Explorer – validation for drought parameters

US Drought Mitigation Center Vegetation Drought Response Index (VegDRI) – the current satellite-derived product the state uses that will be compared with the final ECOSTRESS-derived results

***Software & Scripting:***

Esri ArcGIS – raster manipulation and analysis, imagery processing, and map production

Python – process ECOSTRESS data

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **ECOSTRESS Drought Assessment** | This product will provide an additional tool for the Climatology Bureau to assess drought. The Climatology Bureau can apply these methodologies when identifying converging evidence of drought. | ECOSTRESS, SMAP, Landsat 8 OLI, GPM IMERG, and ancillary datasets will be combined to identify areas in drought. | I |
| **Comparative Drought Time Series** | This product will allow the partner to see any differences between two drought detection methodologies by comparing ECOSTRESS drought classifications of the summer of 2018 with the weekly state drought maps that were created by the state climatologist and derived from VegDRI and the standardized precipitation index. | ECOSTRESS and weekly state drought maps produced by the state climatologist will be compared to VegDRI to determine the earliest prediction method. The team will investigate false positives of ECOSTRESS. | N/A |
| **Crop Vulnerability Assessment** | The partner will use this product to identify when certain crops begin to show the onset of drought and which crops are most sensitive to drought within the study period. These methodologies can be applied in future drought scenarios. | Areas of drought identified by ECOSTRESS, SMAP, Landsat 8 OLI, and GPM IMERG will be used to identify which crops, using ancillary datasets, showed indications of drought and when these indications occurred. | N/A |
| **ArcGIS Online Story Map** | This product will communicate the potential benefit of using NASA Earth observations for enhancing drought monitoring in Iowa. The Climatology Bureau will use this Story Map as an outreach tool. | ECOSTRESS, SMAP, Landsat 8 OLI, GPM IMERG, and ancillary datasets will be integrated into an online story map to display results to the public. | N/A |
| **ECOSTRESS Tutorial** | This product will be an educational tool for the Climatology Bureau to evaluate the feasibility of incorporating ECOSTRESS into its current assessment of drought. | This product will provide step-by-step instructions on acquiring and processing ECOSTRESS data for drought monitoring. | N/A |

***End-User Benefit*:** This project will provide additional resources to the Climatology Bureau’s current assessments of drought. In particular, this project will utilize the recently launched ECOSTRESS mission to assess vegetative stress, which is a unique indicator not included in any of the partner’s other resources. Additionally, the team will produce end products that the state climatologist can use to compare drought parameters and indices for the past year, which will help him prepare for the upcoming summer.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Spring

***Related DEVELOP Work:***

2017 Spring (JPL) – Arizona Agriculture: Demonstrating the Potential Applications of ECOSTRESS Evapotranspiration Products in Plant Phenotyping and Predicting Patterns in Global Species Richness

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

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

2014 Spring (MSFC) – Southeast US Water Resources: Development of an Alternative Drought Monitoring System using NASA Earth Observation-Derived Drought Indices and Groundwater Storage Estimates for Improved Water Resource Monitoring in the Southeastern United States

**Notes & References:**

***Notes*:** N/A

***References:***

Brown, J. F., Wardlow, B. D., Tadesse, T., Hayes, M. J., & Reed, B. C. (2008). The Vegetation Drought Response Index (VegDRI): A new integrated approach for monitoring drought stress in vegetation. *GIScience & Remote Sensing*, *45*(1), 16-46. https://doi.org/10.2747/1548-1603.45.1.16

Hulley, G., Hook, S., Fisher, J., & Lee, C. (2017). ECOSTRESS, A NASA Earth-Ventures Instrument for studying links between the water cycle and plant health over the diurnal cycle, In *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)* (pp. 5494-5496). Fort Worth, TX: IEEE. https://doi.org/10.1109/IGARSS.2017.8128248

National Drought Mitigation Center. (2018). Frequently Asked Questions. Retrieved from https://vegdri.unl.edu/FAQ.aspx

Otkin, J. A., Anderson, M. C., Hain, C., Mladenova, I. E., Basara, J. B., & Svoboda, M. (2013). Examining rapid onset drought development using the thermal infrared–based evaporative stress index. *Journal of Hydrometeorology*, *14*(4), 1057-1074. https://doi.org/10.1175/JHM-D-12-0144.1