**Iowa Agriculture & Food Security**

*Assessing Drought-Induced Vegetation Stress and its Impact on Crop Production Across Iowa*

**VPS Title:** Take a Rain Check: Monitoring Drought Conditions in Iowa

**Project Team**

***Project Team:***

Brittany Greene (Project Lead)

Audrieauna Beatty

Abigail Whiteside

***Advisors & Mentors:***

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (University of Alabama in Huntsville)

Helen Baldwin (University of Alabama in Huntsville)

Maggi Klug (University of Alabama in Huntsville)

Leigh Sinclair (University of Alabama in Huntsville, Information Technology & Systems Center)

**Project Overview**

***Project Synopsis:*** This project assessed the impact of changing weather patterns on agriculture in Iowa, which has become increasingly prone to drought conditions. The team used data from the International Space Station (ISS) ECOSystem Spaceborne Thermal Radiometer Experiment on the Space Station (ECOSTRESS) Evaporative Stress Index (ESI), Suomi National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite (NPP VIIRS), Landsat 8 Thermal Infrared Sensor (TIRS), and Atmosphere-Land Exchange Inverse (ALEXI) ESI to assess drought conditions in 2018. The final products will assist the Iowa State Climatologist in assessing the comprehensiveness of the current drought monitoring methods and may help identify droughts earlier, thus improving drought mitigation efforts.

***Abstract:***

Iowa dedicates 92% of its land to agriculture, leaving the state economically and culturally vulnerable to drought. Current climate trends show increasing temperatures and decreasing precipitation levels, which are environmental factors that put stress on vegetation and force farmers to rely on dwindling aquifers for crop irrigation. It is difficult to identify droughts until plants show signs of stress, by which time the chance of recovery drops drastically. The Iowa Climatology Bureau (ICB) in the Iowa Department of Agriculture and Land Stewardship (IDALS) is responsible for identifying areas experiencing drought and alerting decision makers of emergency situations. The team used remote sensing data from the International Space Station (ISS) ECOsystem Spaceborne Thermal Radiometer Experiment on the Space Station (ECOSTRESS) Evaporative Stress Index (ESI), Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS), and Landsat 8 Thermal Infrared Sensor (TIRS) to determine the feasibility of detecting droughts sooner. A statewide drought analysis was conducted using the Atmosphere-Land Exchange Inverse (ALEXI) Evaporative Stress Index (ESI). The team compared their new techniques with existing methodologies to determine if NASA Earth observations can enhance the partner’s current drought analysis procedures. The team determined that the higher temporal and spatial resolution of ESI products provide finer details of drought conditions. The ICB will be able to use these tools to supplement its current drought-tracking methods.

**Keywords:**

corn, soybean, remote sensing, evapotranspiration, soil moisture, Landsat 8 TIRS, ISS ECOSTRESS ESI, Suomi NPP VIIRS

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

***Study Location:*** IA

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

***Community Concerns:***

* Twenty-seven percent of Iowa’s economy is dependent on agriculture, leaving the state vulnerable to environmental factors.
* Drought is the second most expensive disaster in the United States, costing an average of $9.4 billion per drought event.
* Between 2010 and 2014, a drought lasting 151 weeks placed Iowa in a “D3 extreme drought” classification, which led to shortages of water across the state that caused widespread crop loss and water emergencies.
* Corn yield per acre decreased 20% from 2011 to 2012 due to drought-induced vegetative stress.
* In the summer of 2018, southeast Iowa experienced a severe drought that stunted corn growth, dried up ponds and streams, burned pastures, and caused crop loss.
* Overuse of the state’s aquifers has led to dry wells and declining lake levels.

***Project Objectives:***

* Compare current drought monitoring methods with new techniques using ISS ECOSTRESS ESI and ALEXI ESI
* Analyze the differences between ISS ECOSTRESS ESI and ALEXI ESI to determine the added value of using an ESI product for current drought monitoring methods

**Partner Overview**

***Partner Organization:***

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

***Decision-Making Practices & Policies:***

The ICB currently relies on a “convergence of evidence” to indicate drought conditions, which is a time-consuming method of extensive data acquisition. Experts across the state email the ICB weekly precipitation measurements, impact reports, and community concerns. The ICB integrates this data with satellite-derived products like the Vegetation Drought Response Index and the Standard Precipitation Index to create weekly maps. The ICB is responsible for classifying drought and relaying this information to the US Drought Monitor (USDM) office every week. The USDM uses these maps to declare disasters and increase the state’s eligibility for low-interest loans during drought emergencies.

***Project Benefit to End User:***

The team’s end products will allow partners to determine if ALEXI ESI and ISS ECOSTRESS ESI will be valuable additions to their current methods. Detecting drought conditions before they cause crop stress will assist the ICB with protecting one of the state’s critical revenue sources. The Earth observations (EO) used in the county-wide analysis have a high spatial and temporal resolution that can help the ICB focus mitigation efforts on afflicted areas before the situation escalates to crop loss. By including ALEXI ESI and ISS ECOSTRESS ESI into the project analyses, which are sensitive to drought-induced vegetative stress, the team assisted the ICB in navigating the changing climate patterns that are plaguing agriculture in the American Midwest.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **ISS ECOSTRESS ESI** | Evapotranspiration | The team used the ESI calculated from ISS ECOSTRESS data to assess heat-induced crop stress for Fremont and Davis counties. |
| **Landsat 8 TIRS** | Land surface temperature (LST) | The team used LST to analyze drought for the statewide analysis. |
| **Suomi NPP VIIRS** | LST | The team used LST to analyze drought for the statewide analysis. |

***Ancillary Datasets:***

* NASA Short-term Prediction Research and Transition Center (SPoRT) ALEXI ESI – Conduct the statewide ESI analysis of drought
* NASA SPoRT Multi-Radar/Multi-Sensor System (MRMS) precipitation measurements – Use in the statewide drought analysis
* NASA SPoRT Soil Moisture 0-10cm measurements – Use in the statewide and countywide drought analyses

***Software & Scripting:***

* Esri ArcMap 10.5.1 *–* Raster manipulation and analysis, imagery processing, and cartography
* Python *–* Processing of ECOSTRESS data using the NASA-developed ECOSTRESS\_swath2grid script

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **ALEXI ESI Drought Assessment** | Landsat 8 TIRS  Suomi NPP VIIRS | The partner will use this product to determine if ALEXI ESI will be a beneficial addition to their statewide drought monitoring methodologies. | N/A |
| **ISS ECOSTRESS ESI Drought Assessment** | ISS ECOSTRESS ESI  Landsat 8 TIRS  Suomi NPP VIIRS | The partner will use this product to determine if ECOSTRESS will be a beneficial addition to their countywide drought monitoring methodologies. | I |
| **Comparative Drought Assessment** | ISS ECOSTRESS ESI  Landsat 8 TIRS  Suomi NPP VIIRS | The team compared both ALEXI ESI and ISS ECOSTRESS ESI to weekly drought maps. The partner will use this product to determine how each ESI product could contribute to their current methodologies. | I |
| **ArcGIS Online Story Map** | ISS ECOSTRESS ESI  Landsat 8 TIRS  Suomi NPP VIIRS | The partner will use this product as an outreach tool to inform the community of its drought monitoring efforts. | I |

**Project Handoff Package**

*Transition Plan:* At the end of the term, end products and results were presented to the project partner through a web conference. During this meeting, the team gave a presentation of the results and answered questions. The end products were compiled in a Google Drive folder that was shared with the partner.

**Team POC:** Brittany Greene, bgreene424@gmail.com

**Partner POC:** Dr. Justin Glisan, [justin.glisan@iowaagriculture.gov](mailto:justin.glisan@iowaagriculture.gov)

**Handoff Package:**

* ALEXI ESI Drought Assessment
* ISS ECOSTRESS ESI Drought Assessment
* Comparative Drought Assessment
* ArcGIS Online Story Map
* Project Summary
* Presentation
* Poster
* Technical Paper
* Project Video
* Website Image
* Technical Image

**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.

Eller, Donnelle. (2014). Growing water use threatens to drain Jordan Aquifer. *Des Moines Register.* Retrieved from https://www.desmoinesregister.com/story/money/agriculture/2014/11/15/water-use-jordan-aquifer-restrictions/19040407/

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 *Geoscience and Remote Sensing Symposium (IGARSS), 2017 IEEE International* (pp. 5494-5496). IEEE. doi:10.1109/IGARSS.2017.8128248

Iowa Economic Indicators. (2018, November 7). Retrieved from https://data.iowa.gov/Economy/Iowa-Economic-Indicators/qd3t-kfqg

Iowa State University Extension and Outreach. (2019). Study measures significance of agriculture to Iowa economy.Retrieved 13 March 2019 from https://www.extension.iastate.edu/soils/crop-and-land-use-statewide-data

NASA. (2018). *ECOSTRESS fact sheet*. Pasadena, CA: Jet Propulsion Laboratory, California Institute of Technology. Retrieved from https://www.jpl.nasa.gov/news/fact\_sheets/ecostress-factsheet.pdf

National Integrated Drought Information System. (2018). *Drought in Iowa.* Retrieved 15 February 2019 from https://www.drought.gov/drought/states/iowa

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.

Smith, A. B. (2019, February 7). *2018’s billion dollar disasters in context*. Retrieved from https://www.climate.gov/news-features/blogs/beyond-data/2018s-billion-dollar-disasters-context