**Midwest Water Resources II**

*Evaluating Evapotranspiration with NASA Earth Observations and In Situ Observations to Understand Water Balance in Midwest Agriculture*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

Evapotranspiration plays a critical role in the seasonal hydrologic cycle, especially in the agriculturally intensive region of the Midwest. Building on a previous DEVELOP term, this project compared remotely sensed evapotranspiration products from Terra MODIS and gridMET with *in situ* observations and evaluated evapotranspiration variability across the landscape. Partnering with the United States Department of Agriculture (USDA) Midwest Climate Hub, the Minnesota Department of Agriculture, Michigan State University, and the Illinois State Water Survey, this evaluation of evapotranspiration products and variability will enable climate-informed decision-making surrounding water resource allocation, land management practices, and drought mitigations strategies.

***Abstract:***

Seasonal water variability in the midwestern United States extensively affects the agricultural community, as it impacts irrigation schedules, growing seasons, and overall ecosystem function. Evapotranspiration (ET) is a critical climatic variable in the water cycle and is used to evaluate spatiotemporal trends in drought and flood conditions. The NASA DEVELOP team partnered with the United States Department of Agriculture (USDA) Midwest Climate Hub, the Minnesota Department of Agriculture, the Illinois State Water Survey, and Michigan State University to compare remotely sensed ET products with *in situ* observations from January 2001 through December 2020. Remotely sensed actual ET (aET) data were sourced from NASA’s Terra Moderate Resolution Imaging Spectroradiometer (MODIS), and reference ET (refET) data were derived from the Gridded Surface Meteorological (gridMET) dataset. For *in situ* comparison, aET data were downloaded from the AmeriFlux database while refET data were collected from the Illinois Climate Network and Michigan State University’s Enviro-weather database. For a holistic assessment of ET, this project generated comparisons between remotely sensed and *in situ* observations, calculated descriptive statistics for validation between refET datasets, and spatially produced statistical validation maps regarding *in situ* sites. The temporal and spatial gaps of AmeriFlux data limited aET analysis. This comparative assessment of ET products across the Midwest can be used by project partners to assess regional water trends and guide future land management decisions.

***Key Terms:***

reference evapotranspiration, actual evapotranspiration, MODIS, gridMET, drought

***National Application Area Addressed:*** Water Resources

***Study Location:*** MI, MN, OH, WI, IA, IL, MO, IN, KY

***Study Period:*** January 2001 to December 2020

***Community Concerns:***

* The Midwest’s economy relies heavily on agricultural practices and has been affected by past disruptions in agriculture due to increased drought. The role of evapotranspiration (ET) during drought periods has been understudied and is essential to better understanding drought evolution.
* An increase in extreme weather events, such as droughts and floods, is predicted for future years; such events in recent years have equated to upwards of $40 million in losses during a single growing season.
* Satellite imagery has uncertainty issues, while *in situ* data lacks continuity both temporally and spatially. This emphasizes the importance of validation between the two for understanding regional water variability on a spatially comprehensive scale in areas dependent on agricultural economies.

***Project Objectives:***

* Evaluate remotely sensed ET products with *in situ* observations to provide a holistic assessment of product suitability across the Midwest
* Analyze and illustrate ET during the 2012 drought case study throughout the Midwestern Region
* Calculate statistics to validate comparisons of reference ET (refET) from remotely sensed and *in situ* observations

***Previous Term:***

2021 Fall (NC) – Midwest Water Resources I

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USDA**​,​ **Midwest Climate Hub** | Dr. Dennis Todey, Director | End User | Yes |
| **Minnesota Department of Agriculture, Pesticide and Fertilizer Management Division** | Dr. Jeppe Kjaersgaard, Research Scientist | End User | Yes |
| **Michigan State University, Department of Geography, Environment, and Spatial Sciences** | Dr. Jeffery Andresen, Professor and Michigan State Climatologist | Collaborator | Yes |
| **Illinois State Water Survey** | Dr. Trenton Ford, Illinois State Climatologist; Dr. Jennie Atkins, Water and Atmospheric Resources Monitoring Program Manager | Collaborator | Yes |
| **National Integrated Drought Information System** | Molly Woloszyn, Regional Drought Information Coordinator | Collaborator | Yes |

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

Using evapotranspiration to assess climate impacts on agricultural water budgets is a constantly evolving practice. The USDA Midwest Climate Hub provides agricultural and natural resource managers with science-based information on climate and weather conditions in the Midwest. Each month, the Hub hosts climate and drought outlook webinars to inform the region's stakeholders of potential and ongoing impacts from climate phenomena. and the Hub also supports recommendations to the United States Drought Monitor for classifying and monitoring drought in the Midwest. The Hub uses remotely sensed and *in situ* information in their outlooks, reports, and recommendations, however, they currently do not incorporate ET data products in their climate and drought monitoring practices. The Minnesota Department of Agriculture uses satellite and ground-based data in an active monitoring program to support informed decisions on agricultural contaminants; challenges with data accessibility and frequency of imagery limit their use of ET products.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Terra MODIS** | Evapotranspiration | The MODIS evapotranspiration latent heat flux (MOD16A2, version 6) product from 2001 to 2020 was used to quantify actual evapotranspiration and calculate spatiotemporal variability. Derived ET data were compared to *in situ* observations. |

***Ancillary Datasets:***

* University of Idaho Gridded Surface Meteorological (gridMET) dataset – Reference ET data from 2001 to 2020 were used to generate refET, calculate spatiotemporal variability, and compared with *in situ* observations
* AmeriFlux Network – *In situ* latent heat flux observations at specified tower locations used for comparison with actual evapotranspiration measurements derived from MODIS
* Water and Atmospheric Resources Monitoring Program Illinois Climate Network – Daily *in situ* reference evapotranspiration used for comparison with reference evapotranspiration measurements derived from gridMET
* Michigan State University Enviro-weather dataset – Daily *in situ* reference evapotranspiration used for comparison with reference evapotranspiration measurements derived from gridMET
* USDA Cropland Data Layer (CDL) – Land cover dataset tailored to agricultural regions used to determine land cover land use classification
* USGS National Land Cover Database (NLCD) – National land cover and land use dataset used for land cover land use classification

***Software & Scripting:***

* Google Earth Engine Python API – Data acquisition, preprocessing, and analyses
* Google Colab Notebook – Scripting and coding collaboration
* ESRI ArcGIS Pro 2.6.2 – Cartography

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Actual Evapotranspiration Product Comparison** | Terra MODIS | A comparison of actual evapotranspiration *in situ* and remotely sensed products will provide project partners with a more robust understanding of product performance across geographic space. | II |
| **Reference Evapotranspiration Product Comparison** | N/A | A comparison of reference evapotranspiration products *in situ* and remotely sensed products will provide project partners with a more robust understanding of product performance across geographic space. | II |
| **Statistical Analyses & Distribution Maps** | Terra MODIS | This product will be used to understand the relationship between remotely sensed and *in situ* refET data and will provide partners with quality measurements to implement into future analyses. | II |
| **ArcGIS StoryMap** | N/A | The StoryMap will be used as an outreach tool to communicate the impacts of evapotranspiration variability and describe how the project's methodology and results may be used for water resource management in the future. | N/A |

***Product Benefit to End User:***

End users of this project will use these improved products to aid in their own decision making, but also that of natural resource management organizations throughout the Midwest. A comparison of ET satellite products with *in situ* data will provide a more detailed regional assessment of ET and increase partners’ confidence in remotely sensed evapotranspiration products to estimate water use across the landscape. The USDA Midwest Climate Hub and Minnesota Department of Agriculture will be able to assess water variability and advise agricultural managers with a spatially comprehensive assessment of ET across the Midwest.

**References**

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