**Ohio River Basin Water Resources**

*Monitoring Flash Drought Potential and Quantifying the Hydrologic Impacts in the Ohio River Basin Utilizing NASA Earth Observations*

**VPS Title:** Flash Drought in the Ohio River Valley

**Project Team**

***Project Team:***

Adelaide Schmidt (Project Lead)

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***Advisors & Mentors:***

Ronald Leeper (NOAA National Centers for Environmental Information, North Carolina Institute for Climate Studies)

**Project Overview**

***Project Synopsis:*** September 2019 was the warmest and driest September on record for much of the Ohio River Basin (ORB) and southeastern US. The record dry September event was preceeded by a 12-month record wet period. The rapid onset of such hot and dry conditions resulted in a regional flash drought that caused detrimental effects for agricultural yields and the availability of winter feed for livestock. Modeled and satellite-derived drought indices, as well as gauge-based environmental data, were analyzed and compared to better understand flash drought dynamics and to guide early forecasting efforts.

***Abstract:***

Flash drought conditions emerge in a matter of weeks following persistent weather anomalies, such as high temperatures or large vapor pressure deficits, that drive increased evaporative demand. Vegetation response rapidly depletes soil moisture, threatening surface water supplies, triggering significant crop loss, and increasing wildfire risk. Drought indices sensitive to flash drought are currently not included in drought forecast models in the Ohio River Basin (ORB). The team assessed and compared drought indices, gauge-based data, and satellite measurements over the course of the September 2019 flash drought event in the Ohio River Basin to investigate environmental fingerprints throughout flash drought evolution. Potential leading flash drought indicators were compared to the Standardized Precipitation Index (SPI) to aid the National Weather Service (NWS) Ohio River Forecast Center and Kentucky Climate Center in producing early warning flash drought forecasts. These drought indices included Evaporative Demand Drought Index (EDDI), Standardized Precipitation Evapotranspiration Index (SPEI), and Landscape Evaporative Response Index (LERI) (derived from Terra Moderate Resolution Imaging Spectroradiometer (MODIS)). Drought index behavior inherently varies based on parameters incorporated - EDDI measures evaporative demand through potential evapotranspiration, and and demonstrates more variations due to sensitivity to seasonal changes in evaporative demand throughout the 2010-2019 study period. Conversely, LERI measures evaporative response through actual evapotranspiration, representing different environmental changes. Soil moisture response was evaluated using Soil Moisture Active Passive (SMAP) L-band radiometer data and Kentucky Mesonet gauge-based measurements. This analysis enables climatologists and weather forecasters to keep decision-makers and stakeholders better informed about drought risks to implement the appropriate actions for preparation of drought onset.

***Keywords:***

drought index, EDDI, LERI, flash drought, Kentucky Mesonet, soil moisture, SPI, SPEI

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

***Study Location:*** Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, West Virginia

***Study Period:*** January 2010 to October 2019

***Community Concerns:***

* The ORB is home to 27 million people, and its rivers and other water bodies provide freshwater resources to manufacturing, energy, recreation, and agricultural industries.
* The region has experienced cycles of excess moisture followed by drought for the past several decades; these cycles are predicted to intensify in the coming decades.
* Flash droughts are under-studied events that trigger rapid decline in soil moisture, particularly detrimental to crop yields in the fall season when vegetation is already stressed.
* Currently, the Ohio River Forecast Center and Kentucky Climate Center do not employ flash drought indicators in their dissemination of water resources and drought risk information to stakeholders.

***Project Objectives:***

* Compare drought indices to identify leading and reacting flash drought indicators
* Investigate environmental responses of drought to better understand the nature of flash drought in the ORB
* Demonstrate the use of SMAP-derived soil moisture to enhance *in-situ* data observations

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **NOAA National Weather Service, Ohio River Forecast Center** | James Noel, Service Coordination Hydrologist | End User | Yes |
| **Kentucky Climate Center** | Stuart Foster, Kentucky State Climatologist | End User | Yes |

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

The National Weather Service (NWS) Ohio River Forecast Center calculates and disseminates hydrologic data to stakeholders in the Ohio River Basin. Preemptive drought efforts and water resource management are guided by flood and drought warnings, streamflow measurements, and hydroclimate forecasts. Similarly, the Kentucky Climate Center works with stakeholders, such as agriculture extension specialists, to communicate climate information and to provide climate information services. The Kentucky Climate Center manages and produces the Kentucky Mesonet data, a system of gauge-based climate and weather observations for local and statewide coverage.

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

The NWS Ohio River Forecast Center and Kentucky Climate Center currently use the Standardized Precipitation Index (SPI), a precipitation-based drought index to develop drought warnings. Forecasts do not include indices derived from evapotranspiration, a key process associated with flash drought onset and evolution, especially in the Ohio River Basin. Analysis of several modeled and satellite-based drought indices computed using evapotranspiration parameters will provide end users confidence in new potential flash drought prediction tools to aid forecasting efforts. Comparison between gauge-based and satellite-based soil moisture measurements provide insight on environmental response to flash drought, which is critical toward helping agricultural industries in preparing for and responding to flash drought events.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Terra MODIS** | Land Surface Temperature (LST) | The team utilized Landscape Evaporative Response Index (LERI), derived from Terra MODIS LST, as a flash drought indicator to assess weekly and monthly anomalies in actual evapotranspiration as a metric of soil moisture. |
| **SMAP L-Band Radiometer** | Surface Zone Soil Moisture | The team measured water availability in soil and soil moisture anomalies as a component of hydrologic drought. |

***Ancillary Datasets:***

* Kentucky Mesonet – The team used gauge-based observations from the Kentucky Mesonet as ground-truthing measurements for surface zone soil moisture.
* NOAA Earth System Research Lab Evaporative Demand Drought Index (EDDI) – The team utilized EDDI as a flash drought indicator to assess weekly and monthly anomalies in evaporative demand. The data are derived from the NASA National Land Data Assimilation Systems (NLDAS-2).
* NOAA National Centers for Environmental Information nClimGrid – The team used nClimGrid derived from the Gridded 5-km Global Historical Climatology Network – Daily (GHCN-Daily) Temperature and Precipitation data to assess the Standardized Precipitation Index and Standardized Precipitation Evapotranspiration Index.

***Software & Scripting:***

* Esri ArcGIS Pro2.5.0 – map generation, raster analysis
* Esri ArcMap 10.6.1 – map generation, raster analysis
* R – 1.2.5033 data analysis and visualization

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **2010-2019 Flash Drought Index Analysis Atlas** | Terra MODIS, SMAP L-Band Radiometer | Qualitative comparisons and statistical analyses of potential flash drought indicators and gauge-based vs. satellite-surface soil measurements will enable end users to improve early drought warnings. | N/A |
| **2019 Flash Drought Story Map** | Terra MODIS, SMAP L-Band Radiometer | A visual collection of flash drought impacts will be used to facilitate communication of flash drought preparedness to stakeholders and the public. | N/A |

**Project Handoff Package**

***Transition Plan:*** The team presented the final results to the end users at the end of the project over video chat and transferred the data products to the partners via Google Drive.

***Team POC:*** Adelaide Schmidt, aschmidt@okramail.deltastate.edu

***Partner POC:*** James Noel, james.noel@noaa.gov

***Handoff Package:***

* Flash Drought Index Analysis
* 2019 Flash Drought Story Map
* Technical Paper
* Flash Drought in the Ohio River Valley Project Video

**References**

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