***Spring 2022 Project Summary***

**Mississippi Embayment Water Resources**

*Utilizing NASA Earth Observations to Understand Groundwater Recharge in the Mississippi Embayment Regional Aquifer System*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Mississippi Embayment is a system of four aquifers spanning nine states, which includes the Memphis Sand Aquifer (MSA) that supplies freshwater resources to the Memphis area. Unsustainable use and land cover changes could threaten the longevity of the aquifer. Protect Our Aquifer (POA) is a non-profit that protects the MSA and larger aquifer system from unsustainable use, which is especially necessary as the region becomes popular for its water availability and potential for land development. This project partnered with POA to evaluate changes in factors influential to groundwater recharge to identify thriving areas within the aquifer system.

***Abstract:***

The Memphis Sand Aquifer (MSA) is located in the Mississippi Embayment which extends 250,000 square kilometers across nine states. Groundwater recharge factors that influence the narrow recharge zone of the MSA include precipitation, potential evapotranspiration, and landcover changes. The unsustainable water practices and increasing landcover change from urban development in the MSA's narrow recharge zone threaten the aquifer’s groundwater storage. In partnership with Protect Our Aquifer, the team used data from Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (GPM IMERG), National Land Cover Dataset (NLCD), and Gravity Recovery and Climate Experiment (GRACE). These datasets included annually-averaged precipitation, evapotranspiration, potential evapotranspiration, biannual landcover change, and monthly total water storage which were used to create groundwater recharge factors maps and timeseries. The evaporative stress index map, water balance map, and landcover change maps were used to identify thriving areas. The team found precipitation did not express a strong linear trend and showed high precipitation years in 2017 and 2018, and a drought year in 2011. The potential evapotranspiration showed a weak negative linear trend. The landcover change showed shifts in forested areas and urban development. The team identified four thriving areas in the western side of Tennessee that successfully contribute to aquifer recharge due to increased forest area, sufficient water use, low changes in total water storage, and lateral positioning to streams. These end products allowed our partners to make informed decisions about areas that are thriving in the Mississippi Embayment recharge zone for conservation efforts of the aquifer.

***Key Terms:***

precipitation, evapotranspiration, potential evapotranspiration, landcover change, evaporative stress index, water balance, total water storage, thriving index

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

***Study Location:*** Mississippi Embayment: AL, AR, IL, KY, LA, MS, MO, TN, & TX

***Study Period:*** 2001 – 2021

***Community Concerns:***

* The MSA provides water for domestic, agricultural, and industrial use for western Tennessee and the surrounding states, and recent land cover changes and unsustainable use could lead to reduced groundwater for the community.
* A large Ford plant called “Blue Oval City” is currently being built on the Memphis Regional Megasite, which would likely make changes to landcover and bring additional infrastructure development to the region, which could have impacts on runoff patterns and groundwater recharge.
* The Mississippi Embayment currently has one of the highest irrigation pumpage rates of aquifers in the U.S., which may suggest unsustainable irrigation practices. As drought conditions in other parts of the U.S. worsen, this may push more agriculture towards this region. It is critical that there is a sustainable supply of freshwater, which is of considerable age and quality, for future generations.
* The MSA has a very narrow recharge zone, and increased pumpage and infrastructure development could pose threats to the aquifer’s long-term ability to recharge and provide groundwater, especially considering the age and quality of the water contained in this aquifer.

***Project Objectives:***

* Map and quantify changes in factors influential to groundwater recharge
* Identify thriving areas of the Mississippi Embayment recharge zone to prioritize for protection

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Protect Our Aquifer** | Sarah Houston, Executive Director; Ward Archer, President; Jim Kovarik, Board Member | End User | Yes |

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

POA is a decision-making group that monitors groundwater supply and use of the MSA and larger aquifer system in the Mississippi Embayment. In addition to the building of the large Ford plant in the Mississippi Embayment recharge zone, the Mississippi Embayment will likely experience increased pumping for agricultural use and further development of the infrastructure and land. POA is particularly interested in how the development will affect recharge, specifically in critical recharge zones where land cover changes and pollutants could more directly affect the aquifer. While POA is not a regulatory group, they have advised the Tennessee Governor to develop a statewide plan for future water availability in Tennessee. POA uses ground-based monitoring and GIS mapping techniques to monitor groundwater supply and water availability but does not utilize any remote sensing or NASA Earth observations.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **GPM IMERG/TRMM** | Precipitation | These data will be used to calculate annual average precipitation anomalies and track changes over time. |
| **Terra MODIS** | Potential and actual evapotranspiration | These data will be used to calculate annual average actual and potential evapotranspiration anomalies and track changes over time. |
| **GRACE/GRACE-FO** | Total water storage | These data will be used to quantify averaged monthly and annual total water storage in the ME and provide background information. |

***Ancillary Datasets:***

* National Land Cover Dataset (NLCD) - Surface reflectance will be used to characterize land cover change
* Mississippi Embayment Regional Aquifer System Shapefile – Boundary of the Mississippi Embayment Regional Aquifer System
* Recharge Zone Shapefile – Boundary of the recharge zone of the Mississippi Embayment Regional Aquifer System
* Ford Plant Shapefile – Location of the Ford Plant

***Software & Scripting:***

* Google Earth Engine – Collect and preprocess NLCD datasets
* MATLAB R2021a – Collect and preprocess GRACE and GPM IMERG data, and raster visualization and a monthly time series of total water storage
* Esri ArcGIS Pro 2.8.4 – Raster visualization and analysis of NLCD datasets to create biannual land cover change maps
* RStudio 4.1.2 - Collect, preprocess, and analyze Terra MODIS and GPM IMERG datasets and create raster visualization and time series of evapotranspiration, potential evapotranspiration, precipitation, evaporative stress index and water balance

***End Product(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Groundwater Recharge Factors Change Map and Time Series** | Terra MODIS GPM IMERG  | This map will quantify changes in groundwater recharge factors. The timeseries will quantify the spatiotemporal distribution of groundwater recharge factors. This will allow end users to identify thriving areas that are prioritized for protection. | N/A |
| **Total Water Storage Map and Time Series** | GRACEGRACE-FO | These maps will visualize the spatiotemporal distribution of changes in total water storage across the ME and eastern United States. The timeseries maps and plots will allow end users to support analysis of groundwater recharge factors by incorporating GRACE total water storage information.  | N/A |
| **Evaporative Stress Index Map and Time Series** | Terra MODIS | These maps will visualize the spatiotemporal distribution of the ratio of evapotranspiration to potential evapotranspiration in the form of an evaporative stress index. The timeseries plot will depict and quantify this index over the long- term time period. These maps and timeseries will allow end users to determine areas in the embayment that are efficiently evapotranspirating and how this relationship progresses over time.  | N/A |
| **Water Balance Map and Time Series** | Terra MODISGPM IMERG | These maps will visualize the water balance distribution of the ME by depicting the spatiotemporal distribution of the difference between the precipitation and evapotranspiration groundwater recharge factors.  | N/A |
| **Thriving Index Map****(2019)** | Terra MODIS GPM IMERG | This map will visualize the spatial distribution of a computed thriving index by using a 2019 evaporative stress index, water balance map and landcover change map. This will allow end users to identify areas to prioritize for conservation. | N/A |

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

Groundwater recharge is greatly influenced by several factors, including precipitation, potential evapotranspiration, and landcover changes. POA is interested in the protection of areas within the ME that are thriving and using their water resources efficiently, especially in the context of new and proposed development within the ME recharge zone. By evaluating changes in these factors through the use of maps and time series, a thriving index may be calculated to identify potentially thriving areas for groundwater recharge. POA will be better equipped to identify thriving areas of groundwater recharge and make informed decisions to protect the sensitive ME recharge zones to advise policy.

**References**

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