**NASA DEVELOP National Program**

**2019 Fall Project Proposal**

**Alabama – Marshall**

**Tennessee Valley Energy**

*Assessing the Hydrothermal Outputs of Nuclear Power Plants with NASA Earth Observations*

**Project Overview**

***Project Synopsis*:** The Tennessee Valley Authority (TVA), a corporate agency, provides electricity for 10 million people in seven southeastern states. In the 2018 fiscal year, 40% of the TVA’s power portfolio included nuclear energy from its 3 nuclear plants. Thermal discharge from cooling towers can increase the ambient water temperature and harm fluvial ecosystems as a result. This project seeks to supplement the Hydrothermal Group’s models with products assessing water surface temperature before and after the facility expansion at both upstream and downstream locations along with a seasonal comparison of water temperature by using temperature products from Landsat 7 ETM+ and Landsat 8 OLI, as well as data from Aqua MODIS, Terra ASTER, and ISS ECOSTRESS. In addition, the team will create tutorials to help the TVA’s Hydrothermal Group better understand the project's methods and assess the feasibility of incorporating remotely sensed data products long term.

***Community Concern:*** This spring, the Browns Ferry Nuclear Plant (BFNP) in northern Alabama increased its power production by 465 megawatts, an expansion powerful enough to power an additional 280,000 homes in the Tennessee Valley. The Browns Ferry site, alongside other TVA nuclear plants, rely on the Tennessee River to cool the facility; however, after the water has entered the plant, it often returns to the river at a higher temperature than when it was extracted. Despite the increase in energy production, the TVA must continue to meet the preexisting water temperature regulations. These regulations ensure a healthy environment for a balanced, indigenous population of fish and wildlife in the Tennessee River. The Tennessee River Basin is home to 47 mussel and 57 fish species considered at-risk, including the endangered Palezone Shiner and the threatened Snail Darter. The Paint Rock River, a major tributary of the Tennessee River, is one of those most diverse streams in the county and is known for its diverse mussel and snail populations. The largest nesting population of Bald Eagles in the U.S. inhabits the Tennessee River Basin

***Source of Project Idea:*** This idea came out of discussions with our science advisor, Dr. Robert Griffin, and a meeting with the TVA’s Hydrothermal Group. The partner is always looking for additional methods to monitor the water temperatures around the nuclear power plants they have recently expanded and supplementing current methods with NASA Earth observations can provide additional evidence.

***National Application Area Addressed:*** Energy

***Study Location:*** Tennessee River Valley, TN, AL

***Study Period:*** January 2018 – July 2019

***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?** |
| **Tennessee Valley Authority, Hydrothermal Group**  | Jeffrey Ogden, Program Manager;Colleen Montgomery, Civil Engineer | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Currently, the TVA’s Hydrothermal Group assesses water temperature outputs with ground-truth methods and internal modeling. This modeling approach relies on *in situ* data collected from steam gauges and estimates temperature outputs. However, these models only account for ambient water temperature and flow, but do not include precipitation, air temperature, and nearby land temperature. The TVA’s Hydrothermal Group is looking for a way to 1) validate its predictive models, and 2) assess the impact that the TVA is having on the Tennessee River to determine if water release schedules should be adjusted. The TVA is capable of adjusting its hydroelectric dams on the Tennessee River to provide enough flow to maintain water temperature.

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

*Tennessee Valley Authority, Hydrothermal Group* – The TVA’s Hydrothermal Group does not employ NASA Earth observations in its current work. While the group frequently uses models and maps, its staff is less familiar with remote sensing products. The products provided by NASA DEVELOP team at Alabama – Marshall could help the group better understand the feasibility of incorporating remotely sensed products into its procedural decision-making.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Tennessee Valley Authority, Hydrothermal Group* – The TVA’s Hydrothermal Group will disseminate the results from this project within its organization and to the communities it serves. The organization has stressed the importance of showcasing the efforts being exerted to responsibly manage the environmental resources of the region.

***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 point of contact for the partner throughout the term and will update the project POCs weekly via email as well as organizing meetings via teleconference weekly or biweekly.

**Transition Plan:** At the end of the term, 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 partner may have. This will be followed by a tutorial explaining how to use the end products.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface temperature | The provisional surface temperature products will be used to evaluate water surface temperature. |
| **Landsat 7 ETM +** | Surface temperature | The provisional surface temperature products will be used to evaluate water surface temperature. |
| **Aqua MODIS** | Surface temperature | These data will be used to calculate water surface temperature. |
| **ISS ECOSTRESS** | Surface temperature | These data will be used to calculate water surface temperature at a finer resolution for narrower sections of the river and case studies of smaller tributaries. |
| **Terra ASTER** | Surface temperature  | These data will be used to compare to the provisional Landsat surface temperature products for validation purposes. |

***Ancillary Datasets:***

* Meteorological Assimilation Data Ingest System (MADIS) Integrated Mesonet Data – Provide precipitation and air temperature data for use in creating hydrothermal analyses
* TVA Hydrothermal Group Water Temperature Monitor Station Data– Validate the water surface temperature calculated by the team
* USGS National Water Information System – Provide *in situ* measurements for the TN River Valley and validate the water temperature calculated by the team

***Software & Scripting:***

* Esri ArcGIS – Raster manipulation and analysis, imagery processing, and map production
* Python – Preprocessing of ECOSTRESS data

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Hydrothermal Output Time Series** | This time series will depict the change in water surface temperature around the Browns Ferry Nuclear Plant before and after the expansion. This will assist the TVA in meeting the preexisting water temperature regulations. | This product will use the thermal bands from Landsat 7 ETM+, Landsat 8 OLI, and Aqua MODIS to assess water surface temperature. Ancillary *in situ* data and Terra ASTER will be used to validate the water surface calculations. | N/A |
| **Facility Comparison** | This product will compare the hydrothermal outputs of two different facilities: one in Alabama and one in Tennessee. This will help the TVA assess the feasibility of implementing these practices across the watershed. | This product will use the thermal bands from Landsat 7 ETM+, Landsat 8 OLI, Aqua MODIS, and ISS ECOSTRESS to assess water surface temperature. Ancillary *in situ* data will be used to validate the water surface calculations. | N/A |
| **Seasonal Water Difference Analysis** | The TVA monitors the difference in water temperatures, as well as the maximum temperature of water outputs. This product will assess the water difference during the winter and summer seasons and assess the impact of the expansion on this seasonal difference.   | This product will use the thermal bands from Landsat 7 ETM+, Landsat 8 OLI, and Aqua MODIS to assess water surface temperature. Ancillary *in situ* data will be used to validate the water surface calculations. | N/A |
| **Water Surface Temperature Tutorial** | The team will create a series of tutorials explaining how to download, process, and use NASA Earth observations to calculate water surface temperature. This will build the TVA’s capacity to use NASA Earth observations and help determine the feasibility of incorporating this analysis. | This product will use the thermal bands from Landsat 7 ETM+, Landsat 8 OLI, Aqua MODIS, and ISS ECOSTRESS to assess water surface temperature. Ancillary *in situ* data will be used to validate the water surface calculations. | N/A |

***End-User Benefit*:** The TVA’s Hydrothermal Group will use the results of this project to expand its assessments of its facility outputs into the Tennessee River. The Hydrothermal Group hopes that the projects remotely sensed products will save it time and expedite its process, as it will not have to collect and rely on limited *in situ* measurements. The end products will also demonstrate the feasibility of incorporating remotely sensed data into its assessments and help refine its models with real-time data.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Summer

***Related DEVELOP Work:***

2018 Fall (GA) – Osa Conservation Water Resources III: Evaluating Potential Sites for Coral Reef Restoration in the Gulf of Dulce, Costa Rica Based on Turbidity and Sea Surface Temperature

**Notes & References:**

***Notes*:** Concern was expressed about calculating water surface temperature using Landsat. Dr. Maury Estes, a hydrology professor at the University of Alabama in Huntsville, says it is possible and a good study of feasibility for the DEVELOP team.

***References:***

Ding, H., & Elmore, A. J. (2015). Spatio-temporal patterns in water surface temperature from Landsat time series data in the Chesapeake Bay, USA. *Remote Sensing of Environment*, *168*, 335-348.