**DEVELOP National Program**

**2019 Summer Project Proposal**

**California – Ames**

**Powder River Basin Transportation & Infrastructure**

*Monitoring the Land Disturbances Caused by Coal Mining in the Wyoming Powder River Basin over Time by Utilizing Landsat and Sentinel Imagery*

**Project Overview**

***Project Synopsis*:** The Wyoming coal mining industry is responsible for approximately 41% of all coal production in the United States and is home to one-third of the country’s coal reserves. The impacts of mining land disturbances and coal-fired power plant toxic disposals have been a major environmental concern for the communities and conservation officials in the state. This project is partnering with the Powder River Basin Resource Council, Clemson University’s Energy-Economy-Environment (E3) Systems Analysis Group, and SkyTruth. The project will generate a coal mining assessment tool by applying Landsat, Terra ASTER, and Sentinel imagery to map geographic features associated with the southeast Powder River Basin coal mines since 1985. The end products will assist the partners with geospatially monitoring mining land disturbances and reclamation practices to improve future land conservation and mining regulation strategies.

***Community Concern:*** Approximately 11.3 billion tons of coal have been mined in Wyoming since 1865. Most of these mining operations have occurred during the last 20 years. The primary environmental concerns regarding Wyoming’s coal-fired electricity fuel cycle revolve around mining land disturbances, deforestation, groundwater depletion, and decreased air quality from dust and blasting. Additionally, the financial condition of the coal industry and its long-term ability to properly finish reclamation processes has become a rising concern. In 2018, approximately 293,462,565 short tons of coal were mined by 12 active facilities in Campbell County, Wyoming. Currently, monitoring of the environmental impacts of Powder River Basin coal mining is done at the level of individual facilities, but geospatial assessments of these impacts are needed to better inform land conservation efforts and mining reclamation strategies.

***Source of Project Idea:*** The preliminary idea for this project developed from conversations between Dr. Mik Carbajales-Dale, director of the Clemson Industrial Assessment Center and head of the Clemson’s E3 Systems Analysis Group, Jonathan O’Brien, DEVELOP Ambassador at Clemson University, and the leadership team at the California – Ames Node. Additionally, the Powder River Basin Resource Council supported the formation of this project due to its aligned objectives with a variety of their coal mining permit actions at the state and federal levels.

***National Application Areas Addressed:*** Transportation & Infrastructure, Energy

***Study Location:*** Campbell County, Wyoming

***Study Period:*** January1985 – January 2019

***Advisor:*** Dr. Juan Torres-Pérez (Bay Area Environmental Research Institute, NASA Ames Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Powder River Basin Resource Council** | Jill Morrison, Executive Director; Shannon Anderson, Staff Attorney | End User | Yes |
| **Clemson University, Energy-Economy-Environment Systems Analysis Group** | Dr. Mik Carbajales-Dale, Director  | Collaborator | Yes |
| **SkyTruth** | Christian Thomas, Geospatial Engineer | Collaborator | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Powder River Basin Resource Council seeks to protect land, air, and water resources during coal mining cycles by regulating effective land use, bonding, and reclamation standards and by enforcing proper practices to minimize mining impacts on public health and ecosystems. The organization actively works with other stakeholders on a variety of mining permit actions at the state and federal levels, including the Wyoming Department of Environmental Quality and the Office of Surface Mining Reclamation and Enforcement permits, as well as federal coal leasing through the Department of Interior and Bureau of Land Management.

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

*Powder River Basin Resource Council* – The end user’s organization is familiar with the capabilities of NASA Earth observations but currently does not have the staff expertise to obtain and process remotely sensed data.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Clemson University, Energy-Economy-Environment Systems Analysis Group* – Dr. Carbajales-Dale will assist the team by providing information about coal-fired electricity fuel life cycle assessments (LCAs) and potential machine learning toolkit methods for developing a model that replicates the land classifications.

*SkyTruth* – Christian Thomas, the Geospatial Engineer from the SkyTruth, will collaborate with DEVELOP team to provide information about a previously conducted SkyTruth project that generated Google Earth Engine JavaScript codes for identifying surface mining in Central Appalachia and the Powder River Basin.

***Dissemination by Boundary Organizations*:**

*Powder River Basin Resource Council* – The end user may disseminate the project results to the Natural Resources Defense Council (NRDC), Sierra Club, Wyoming Outdoor Council, and a variety of other Wyoming-based, regional, and national conservation organizations.

*Clemson University, Energy-Economy-Environment Systems Analysis Group* – The collaborator may use the results and remote sensing platforms from this project during classroom activities at Clemson University. The group may also disseminate the end products publicly through its research website and other open sources for energy-related projects, such as OpenEI. Additionally, the collaborator participates in public meetings conducted by the South Carolina State Energy Office where many academic institutes and policy makers present and share information on energy-related projects and environmental conservation policies.

*SkyTruth* – Collaborators may disseminate the project results to the Western Organization of Resource Councils, Western Mining Action Network, and Environmental Integrity Project. Additionally, they are interested in sharing the results on the SkyTruth website and social media channels.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the term, the team will have biweekly teleconferences with the partners to provide updates on project methodologies and analysis. Additionally, an in-term remote sensing webinar may be arranged to further enhance the end users’ capacity in Earth observations. The Project Lead and the Center Lead at the California – Ames Node will be the primary points of contact for in-term communications with project partners.

***Transition Plan*:** A formal end-user handoff will take place at the end of the project term in the form of a videoconference via Google Hangout or WebEx. Project end products and deliverables will be sent to partners via NASA Large File Transfer (LFT) within two weeks after the project ends. This project may require to go through the NASA software release process.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI)  | Landsat multispectral data will be used to identify four major land classifications, including coal mine land disturbances, waterlogged areas, vegetation canopies, and urban infrastructures associated with the mining facilities in Campbell County at a 30 m resolution from 1985 to 2013. |
| **Landsat 8 OLI** | Surface reflectance, NDVI, NDWI | Landsat multispectral data will be used to identify four major land classifications, including coal mine land disturbances, waterlogged areas, vegetation canopies, and urban infrastructures associated with the mining facilities in Campbell County at a 30 m resolution from 2013 to 2019.  |
| **Sentinel-2 MSI** | Surface reflectance, NDVI, NDWI | Sentinel multispectral data will be used to identify four major land classifications, including coal mine land disturbances, waterlogged areas, vegetation canopies, and urban infrastructures associated with the mining facilities in Campbell County at a 10 m resolution from 2015 to 2019. |
| **Terra ASTER** | Digital elevation model (DEM)  | ASTER DEM data will be used to evaluate changes in surface elevation and slopes across the southeast Powder River Basin to understand the impacts of coal mining on the region’s topography over time.  |

***Ancillary Datasets:***

Wyoming State Geological Survey (WSGS) Coal Maps & GIS Data – Downloadable GIS Coal dataset from WSGS will be used to obtain coal mine facilities’ shapefiles

Wyoming State Geological Survey Coal Production & Mining – Wyoming’s quarterly coal mine production files derived from the Mine Safety and Health Administration will be used to identify the primary coal mine production facilities in Campbell County, Wyoming

United State Geological Survey (USGS) National Land Cover Database (NLCD) Gap Analysis – Provide map-based data on the vegetation types and land cover of Wyoming’s Powder River Basin region

***Software & Scripting:***

Esri ArcGIS Pro – Raster manipulation, spatial analysis, automation of geoprocessing tools, image classification development, and use of ModelBuilder

Google Earth Engine API – Construct a web-based tool for calculating trends in NDVI and NDWI classifications to monitor coal mine land disturbances overtime in Campbell County, Wyoming

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Coal Mining Assessment Tool (CMAT)** | CMAT will provide a geospatial platform that allows the partners to access remote sensing imagery, process geospatial data, and identify changes in land cover classifications, vegetation health, and topography surrounding the coal mine facilities in the Campbell County, Wyoming since 1985.  | The tool will utilize Landsat, Sentinel, and Terra ASTER data to compute land cover classifications, evaluate trends in NDVI and NDWI, and integrate the DEM data to map coal mining land disturbances in the southeast Powder River Basin overtime.  | IV |
| **Mining Land Disturbances & Reclamation Analysis**  | This product will provide the partners with a series of generated maps that allow them to visualize the impacts of mining on land disturbances and further monitor the progress of recovering lands by mining companies during the reclamation process.  | Landsat 5 TM, Landsat 8 OLI, and Sentinel-2 MSI data will be classified to map coal mining land disturbances over time and monitor vegetation canopies as a proxy to effective reclamation practices.  | N/A |

***End-User Benefit*:** The Powder River Basin Transportation & Infrastructure project will provide partners with sets of analyses that identify land modifications caused by coal mining activities in Campbell County, WY since 1985. The results will help the end users recognize the transformation of the land cover into mining and urban infrastructures associated with coal mine facilities, monitor vegetation health, and observe overall topography alterations in this region over time. Additionally, the results may allow partners to generate a machine learning tool that replicates the project methodologies to monitor the environmental impacts of coal-fired electricity generation in the state through upstream, operational, and downstream life cycle phases.

**Project Timeline & Previous Related Work**

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

***Related DEVELOP Work:***

2014 Spring (VA) – Virginia Ecological Forecasting: Using NASA’s Earth Observing Systems and Statistical Model Analysis to monitor vegetation and habitat rehabilitation in Southwest Virginia’s Reclaimed Mine Lands

2014 Summer (VA) – Appalachian Energy: NASA Earth Observation Detection of Burned and Blighted Areas for Creation of an Unhealthy Forest Index to Prioritize Forest Harvest for Biofuel Production

2014 Summer (AL) – Central Africa Energy: Utilizing NASA Earth Observations to Explore Flared Gas as an Energy Source Alternative to Biomass in Central Africa

**Notes & References:**

***Note:***

More information about OpenEI can be found here: htpps://openei.org/wiki/apps

***References:***

Carbajales-Dale, M. (2018). CAREER: System-Wide Environmental Evaluation of Power Systems (SWEEPS). Environmental Engineering & Earth Sciences, Clemson University, SC 29634.

Wyoming State Geological Survey. (2019). *Coal production & mining.* Retrieved from http://www.wsgs.wyo.gov/energy/coal-production-mining

Pei, W., Yao, S., Knight, J. F., Dong, S., Pelletier, K., Rampi, L. P., … Klassen, J. (2017). Mapping and detection of land use change in coal mining area using object-based image analysis. *Environmental Earth Sciences*, *76*(125). doi:10.1007/s12665-017-644409