**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Arizona – Tempe**

**Ohio Energy**

*Restructuring the Energy Balance in Ohio by Quantifying Energy Loss and Solar Potential using NASA Earth Observations and LiDAR*

**Project Overview**

***Project Synopsis*:** In partnership with the City of Cleveland and Cuyahoga County, this project will assess solar power potential to support our partner’s green energy initiatives. This project will utilize Terra and Aqua CERES to quantify solar insolation and Terra MISR to account for aerosol effects. The team will integrate these NASA Earth observation data with high-resolution LiDAR and Planet Labs RapidEye data. These data will be used to map rooftops and vacant parcels to identify both city- and citizen-owned buildings and brown spaces that have the greatest solar power potential and least amount of diffuse radiation effects. As the partners are also interested in solar initiatives for low-income communities, the team will use U.S. Census Bureau TIGER datasets to identify regions best suited for these initiatives based on solar power potential. This feasibility project will assess the efficacy of using NASA Earth observations in identifying potential solar power sites while assisting both regions with their solar initiatives.

***Community Concern:*** Cleveland and Cuyahoga County have committed to 100% renewable energy by 2050 and 2035, respectively. Cleveland, which was once considered one of the most polluted U.S. cities, seeks to improve the city with renewable energy. Cuyahoga County is developing a “Green Bank” to develop and fund clean energy projects with a partnership with the Cleveland Foundation and the Gund Foundation. Cuyahoga County and Cleveland plan to use LiDAR-based terrain data to estimate solar potential and hope to integrate NASA Earth observation data to enhance the LiDAR estimations. NASA satellite data can provide data for solar marketing efforts to potential project owners.

***Source of Project Idea:*** This project was designed in response to DEVELOP’s goal to impact all U.S. states within 3 years. The Arizona – Tempe Node leadership contacted Michael Forrester, Energy Manager for the City of Cincinnati, with a project idea concerning solar energy potential in Ohio. The project evolved to include the City of Cleveland and Cuyahoga County as the primary end users. After learning about DEVELOP, the partners were interested in how NASA Earth observations can enhance their decision-making processes regarding solar energy development.

***National Application Area Addressed:*** Energy, Urban Development

***Study Location:*** City of Cleveland, OH and Cuyahoga County, OH

***Study Period:*** January 2016 – August 2019

***Advisor:*** Dr. Nicholas B. Rajkovich (University of Buffalo)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Cleveland, Office of Sustainability** | Anand Natarajan, Energy Manager;  Elizabeth Lehman, Energy Analyst | End User | Yes |
| **Cuyahoga County, Department of Sustainability** | Mike Foley, Director;  Dan Meaney, County Planning | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Cleveland and Cuyahoga County are actively investigating options for marketing solar opportunities within their jurisdictions. Both governing organizations have a goal of achieving 100% clean, renewable energy by 2050 and 2035, respectively. Currently, Cuyahoga County supports a strategic plan model based primarily on outreach to residents and small businesses interested in solar. It is only after potential customers opt into the group that an analysis is completed through Google Project Sunroof or the National Renewable Energy Laboratory’s (NREL) PVWatts Calculator tool for likely solar output at their addresses. Beyond these initiatives, neither Cleveland nor Cuyahoga County has a formal decision-making process for marketing solar opportunities to the public.

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

*City of Cleveland, Office of Sustainability –* The City of Cleveland has not used NASA Earth observations in the past. It has previously completed on a short-term project called ‘Solarize Cleveland’ that utilized LiDAR data for assessing solar potential and marketing solar projects to interested property owners. The City believes NASA Earth observations will assist other decision-making processes by expanding their its mapping and assessment abilities.

*Cuyahoga County, Department of Sustainability –* While Cuyahoga County has not previously used NASA Earth observations, it has used LiDAR data for tree canopy assessments. By incorporating NASA Earth observations in this solar project and future endeavors, the County plans to expand its capacity to develop and validate decisions.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*City of Cleveland, Office of Sustainability* – The City will share information from this project with several local and regional stakeholders, including school districts, community development corporations, land bank organizations, libraries, foundations, and commercial, health, and educational institutions.

*Cuyahoga County, Department of Sustainability –* Cuyahoga County is home to over 1.2 million people, 59 local governments, and 27 school districts. To transform the County’s energy system, Cuyahoga County seeks to disseminate the project results to all residents, governments, and schools within its jurisdiction.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Communication between the team and project partners will occur every other week via teleconference calls. During these meetings, partners will be updated regarding project development. For questions between meetings, the team and partners will communicate via email. The node leadership will schedule biweekly meetings prior to the start of the term, and the Project Lead will act as the main POC. In addition to partner meetings, the team will meet weekly with their Science Advisor.

***Transition Plan*:** Upon completion of the project, the end products will be sent to the City of Cleveland and Cuyahoga County through email or NASA Large File Transfer. The team will present its final presentation over a video teleconference with the partners. Software release is not anticipated at this time. As the end users’ energy initiatives are ongoing, the end products will be implemented as soon as possible.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Aqua CERES** | Solar radiation | The Level 3 Synoptic TOA and surface fluxes and clouds (SYN1deg) and Level 4 Energy Balanced and Filled (EBAF) product will be used to identify regions with high solar radiation values in the state of Ohio. If the team uses the POWER products, this sensor will be included via POWER. |
| **Terra CERES** | Solar radiation | The Level 3 Synoptic TOA and surface fluxes and clouds (SYN1deg) and Level 4 Energy Balanced and Filled (EBAF) product will be used to identify regions with high solar radiation values in the state of Ohio. If the team uses the POWER products, this sensor will be included via POWER. |
| **Terra MISR** | Aerosol depth | MISR Level 3 Component Global Aerosol Product data (MIL3MAE) will be used to identify aerosol compositions and as potential input data into ESRI’s Area Solar Radiation tool. |
| **RapidEye** | Spectral reflectance | Planet Lab RapidEye imagery will be used to classify the top 20 buildings/rooftops with the greatest energy potential in the City of Cleveland and Cuyahoga County by estimating the maximum number of solar panels per roof. |

***Ancillary Datasets:***

USGS LiDAR Point Cloud Dataset – build a Digital Elevation Model to calculate solar insolation for Ohio

City of Cleveland Owned Properties Database – quantify solar power potential for properties owned by the City of Cleveland

Cuyahoga County Building Outlines Database – 2017 footprint data used for estimating surface area and number of panels that could be installed

Cuyahoga County Land Cover Dataset – determine brownfields and other vacant areas

Cuyahoga County LiDAR Digital Surface Model – input into the ESRI Area Solar Radiation tool to calculate a high-resolution map of insolation in Cuyahoga County

Cuyahoga County Leaf-Off 0.5 Feet Aerial Imagery Geotiffs – this spring 2017 leaf-off high resolution imagery will be used to classify rooftops in addition to or replacement of RapidEye imagery

U.S. Census TIGER/Line with Selected Demographic and Economic Data – used to look at socioeconomic data and identify low income areas that overlap with high solar power potential

***Software & Scripting:***

Esri ArcMap – image and map creation and object-based classification

Esri ArcGIS Pro – image and map creation and solar radiation calculations

Harris Corporation ENVI – raster manipulation and analysis, image enhancement, and image classifications

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Solar Power Potential Map** | This product will be used to quantify solar radiation received in Ohio. These data will allow the partners to identify regions with the highest energy potential per building in the City of Cleveland and Cuyahoga County. | This map will be created using measured solar radiation from Terra and Aqua CERES, and account for aerosols with Terra MISR. These data will be further refined using both LiDAR data to include structure interference and RapidEye to determine the maximum number of panels per building. Potential kilowatt per hour calculations will be estimated based on the number of panels that could fit on the rooftops. | N/A |
| **Modeled Solar Radiation with Diffuse Radiation Effects Maps** | The output from ESRI’s Area Solar Radiation tool will provide project partners with information on the effect of shadows and aerosols on solar radiation in Cuyahoga County and Cleveland. | The map will be developed using available solar radiation tools in Esri ArcGIS Pro using the Digital Surface Model derived from LiDAR. Diffuse radiation effects will be determined from observed aerosols from Terra MISR data. | N/A |
| **Solar Power Potential Map with Socioeconomic Factors** | The City of Cleveland and Cuyahoga County are interested in initiatives that support equity in green energy distribution. Thus, this end product aids in identifying regions of low socioeconomic status and high solar power potential where they can test these initiatives. This is a lower priority end product, so its completion will be time-dependent. | This map will combine U.S. TIGER Census socioeconomic data with the Solar Power Potential Map. | N/A |

***End-User Benefit*:** This project will provide data for solar energy marketing efforts by helping validate Cuyahoga County LiDAR data. It will identify the most suitable sites for solar development, thereby increasing the likelihood of future solar power development. Additionally, this project will help the partners compare the results from NREL’s PVWatts tool to the proposed kilowatt per hour calculations from the Solar Power Potential Map. This will offer insight to the partners if the PVWatts outputs are off and if the team’s outputs are better to use for their decision making. This project will build the partners capacity to use NASA Earth observations and provide additional methods of using remotely sensed data to help identify locations that have a high potential for solar energy.

**Project Timeline & Previous Related Work**

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

***Related DEVELOP Work:***

2017 Fall (GA) – Georgia Energy II: Reducing Conflicts in Siting Solar Power Generating Facilities by Identifying Sensitive Habitats and Wildlife Populations in Areas with High Generation Potential

2017 Summer (GA) – Georgia Energy: Reducing Conflicts in Siting Solar Power Generating Facilities by Identifying Sensitive Habitats and Wildlife Populations in Areas with High Solar Power Potential

**Notes & References:**

***Notes*:**

* The County has planned to use LiDAR-based terrain data with off-the-shelf modeling to gauge solar potential but see a potential benefit from integrating NASA satellite data to enhance the output, primarily in accounting for atmospheric effects (if not also providing direct measures of solar intensity).
* The City of Cleveland, through its Climate Action Plan, is committed to increasing the amount of clean energy that is generated locally as well as making that energy affordable and equitable.
* The City of Cleveland has completed solar assessments of select sites and distributed those reports to the relevant owners. Cleveland is also a designated Solsmart Bronze city for advancing solar energy growth by developing a “Cleveland Solar Guide” with the intent of making it faster, easier, and more affordable for homes and businesses to go solar. See <http://www.city.cleveland.oh.us/11.27.2017SolSmartDesignation>
* Cleveland Climate Action Plan: <https://www.sustainablecleveland.org/climate_action>
* Cuyahoga County Climate Change Action Plan: <http://www.countyplanning.us/projects/climate-action-plan/>
* NASA Prediction of Worldwide Energy Resources (POWER) dataset: <https://power.larc.nasa.gov/data-access-viewer/>
* NREL’s PVWatts tool:

<https://pvwatts.nrel.gov/index.php>

* The team will look at the data products available on NASA POWER and will meet with the POWER team to decide whether to leverage this dataset in this project.

***References:***

Mahtta, R., Joshi, P. K., & Jindal, A. K. (2014). Solar power potential mapping in India using remote sensing inputs and environmental parameters. *Renewable Energy, 71*, 255-262. <https://doi.org/10.1016/j.renene.2014.05.037>