**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Virginia – Langley**

**US Urban Development II**

*Utilizing Sky Glow Estimation Tools to Assist in the Management of US National Parks*

**Project Overview**

***Project Synopsis*:** This project will finalize, validate, and demonstrate the effectiveness of DEVELOP’s Sky Glow Estimation Toolbox (SET). SET utilizes Suomi NPP VIIRS Day/Night band data and will help the National Park Service’s Night Skies Program assess artificial sky brightness across a variety of park service units. This project will focus on validating the tool to make it functional and ready for practical use by the NPS. The team will demonstrate the use of the tool by analyzing a series of park lands. Once complete, National Park Service land managers will be able to incorporate the tool into their current monitoring and management procedures.

***Community Concern:*** Artificial sky brightness in wilderness areas of national parks can have harmful effects on both wildlife and visitor experience. When skies brighten as a result of anthropogenic activity, they disrupt the cyclic behavior of wildlife and can lead to ill-timed breeding, feeding, and nesting activities. Degraded night sky quality disrupts astronomical and aesthetic viewing and can have negative effects on human health. The park service is specifically tasked with maintaining landscapes that are untrammeled by the effects of humans; this effort includes effectively monitoring and managing artificial sky brightness. Robust remote sky glow estimation tools will help the NPS monitor and manage artificial light, even in areas where *in situ* assessments are not feasible.

***Source of Project Idea:*** This project is an extension of previous DEVELOP work with the National Park Service (Wyoming Cross-Cutting I & II, Colorado Plateau Urban Development I, US Urban Development I). The previous term, US Urban Development in summer 2018, continued the work from earlier teams to refine the SET tool to estimate sky brightness across NPS lands in different geographic regions. DEVELOP has worked with the NPS Night Skies Program on this tool since summer 2017.

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

***Study Location:*** United States; AR, FL, IN, ME, MS, NE, VA, WV

***Study Period:*** June 2014 – May 2019

***Advisor:*** Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service, Natural Sounds and Night Skies Division, Night Skies Program** | Sharolyn Anderson, Physical Scientist; Li-Wei Hung, Night Skies Research Scientist | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Night Skies Program provides field data, modeled data, and tools to help support the management of natural spaces across the entire NPS network. This team provides decision support tools, scientific materials, management plans, and park planning documents to stakeholders at various national parks. The project staff also maintain the NPS Night Skies Monitoring Database, which includes information on nighttime sky viewing based solely on *in situ* measurements. These data are used to generate monitoring reports and provide tangible metrics upon which the NPS can make management decisions to preserve natural nightscapes. These monitoring metrics and reports are currently spatially limited to parks with access to specialized monitoring equipment.

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

*National Park Service, Natural Sounds and Night Skies Division, Night Skies Program* – The Night Skies Program is a relatively small subset of the NPS, but employees within the program are very familiar with geospatial datasets and have occasionally used NASA Earth observations in the past. The specific partners on this project are key authors on several papers that utilized Suomi NPP VIIRS DNB data, but their research was largely specific to individual areas and did not incorporate the projected capabilities of SET. Others in the NPS are familiar with the use of Landsat and MODIS data for vegetation assessment. The partners from the Night Skies Program will be well positioned to incorporate the results of this project into their preexisting methods.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The LaRC Center Lead and Project Lead will coordinate with project partners and serve as the primary DEVELOP points of contact. The team will conduct either weekly or biweekly telephone calls using the NASA DEVELOP teleconference line to give project updates and receive feedback from the Night Skies Program staff.

***Transition Plan*:** The LaRC Center Lead and Project Lead will coordinate with project partners to plan a comprehensive and detailed webinar-based project handoff. This will serve as an extended opportunity for the project team to walk partners through download, setup, and use of all SET tools. If the project partners desire and if timing allows, the project team will also give an in-person tutorial to NPS staff at Shenandoah National Park or another NPS managed land relatively proximal to LaRC. The Skyglow Estimation Toolbox has been previously released on DEVELOP’s GitHub account.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Suomi NPP VIIRS** | Day/Night Band (DNB) | Suomi NPP VIIRS data will be used to highlight areas of artificial lighting, which indicate encroachment upon national park units. |

***Ancillary Datasets:***

NPS Night Skies Program Night Sky Monitoring Database – validate Suomi NPP VIIRS data

NPS Natural Sounds and Night Skies Division field data – calibrate Sky Glow Estimation Toolbox

NPS Integrated Resource Management Applications (IRMA) park boundaries – use to identify park boundaries at the time of analysis

***Software & Scripting:***

Esri ArcGIS – raster manipulation, statistical interpretation, map creation

Python – light path calculations, summation of sky glow contributions, and creation of regional skyglow estimates

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Sky Glow Estimation Toolbox (SET)** | The updated Sky Glow Estimation Toolbox will be used to assess how sources of anthropogenic light affect national park units across the country. | Python will be used to run the model over various NPS sites. | IV |
| **3D Hemispheric Artificial Brightness Maps** | Radiance maps for a series of national parks will help project partners identify areas of excess artificial light and prioritize their management strategies. Several park locations were chosen based on the availability of NPS *in situ* data, which can be used for validation. Several other park locations were chosen to demonstrate the utility of in a variety of geographic areas. | Suomi NPP VIIRS DNB data will be used within SET to assess changes in nighttime artificial light during the study period. | N/A |
| **SET Validation Summary Report** | The SET Validation Summary Report will allow NPS staff to directly compare SET outputs to the *in situ* assessments that they typically use for monitoring and management. | The NPS Night Skies Monitoring Database and Night Skies Division field data will be used to validate sky glow estimates generated from Suomi NPP VIIRS DNB data within SET. | N/A |
| **SET Tutorial and Training Document** | This document will serve as a tutorial during partner handoff and as a reference for project partners to use when implementing SET in the future. | N/A | N/A |

***End-User Benefit*:** The project partners currently rely on *in situ* measurements to make monitoring and management decisions in regard to artificial sky brightness. Their current data sources are limited in scope, expensive to implement, and only assess sky brightness directly above the monitoring instrument rather than across the entire sky. This project will provide a reproducible method for sky glow monitoring and assessment that can be implemented at any location the partner manages. One significant advantage of SET over current *in situ* assessment methods is its ability to display sky glow information at a specified altitude, horizon to zenith. SET is also particularly advantageous because of the fact that it can be easily implemented in multiple locations on a recurring basis.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Summer to 2019 Summer

***Multi-Term Objectives:***

* **Term 1:** 2018 Summer (LaRC) – US Night Skies Urban Development I
  + The first term of this project focused on toolbox development and the implementation of the 3D hemispheric visualization capability. The first project team created sky glow estimates and 3D visualizations for Denali National Park & Preserve (AK), Scotts Bluff National Monument (NE), Indiana Dunes National Lakeshore (IN), and Gulf Islands National Seashore (FL, MS). The team found that the tool did not function properly at high latitudes or in cases where snow was likely present (Denali National Park & Preserve). The team created sky glow estimates for the other parks but were unable to finalize and validate the SET tool.
* **Term 2 (Proposed Term):** 2019 Summer (LaRC) – US Night Skies Urban Development II
  + The second term of this project will correct any remaining errors in the tool, conduct validation, refine usability, and focus on partner handoff. In order to facilitate the adoption of the toolbox by the end users, the team will conduct a half-day webinar handoff with the partners and possibly demonstrate the tools use in-person at an NPS location. The current project team will run SET and produce sky glow estimates and 3D visualizations for a series of parks, some of which will be used for validation purposes (due to abundant *in situ* data) and some of which will demonstrate the utility of the tool in various settings. These include: Scotts Bluff National Monument (NE), Indiana Dunes National Lakeshore (IN), and Gulf Islands National Seashore (FL, MS), Acadia National Park (ME), Shenandoah National Park (VA), New River Gorge National River (WV), and Buffalo National River (AR).

***Previous Terms:***

2018 Summer (LaRC) – US Urban Development I: Validating Sky Glow Estimation Tools Using Suomi NPP VIIRS to Support Lighting Policies and Management Strategies in National Parks

***Related DEVELOP Work:***

2017 Fall (VA) – Colorado Plateau Urban Development: A Perspective on Nighttime Sky Glow over the Colorado Plateau by Integrating the Suomi NPP VIIRS Day Night Band Sensor with a Customized Geolocation Data Processing Program

2017 Summer (VA) – Wyoming Cross-Cutting II: Detecting Changes in Nighttime Sky Brightness over Grand Teton National Park with Suomi NPP VIIRS Sensor

2017 Spring (VA) – Wyoming Cross-Cutting: Utilizing NASA Earth Observations to Detect Changes in Nighttime Sky Brightness in Grand Teton National Park

2013 Spring (SSC) – Continental United States Climate: Determining the Feasibility of Using VIIRS Global Combustion Source Detection Products to Estimate the Regional Contributions of Natural Gas Flaring to U.S. Greenhouse Gas Emissions

**Notes & References:**

***Notes*:** The project team should move quickly to familiarize themselves with the current SET tool and be aware that the current tool fails to adequately assess sky brightness on an azimuth of 180˚ from any given location. Assessing and correcting this error will be important early steps in this project.

Link to Night Sky Monitoring Database: <https://www.nps.gov/subjects/nightskies/skymap.htm>

This project will utilize open source code, approved through NASA software release. Relatively minor alterations to the code will not need to go through release again.

Link to DEVELOP Github where SET can be accessed: <https://github.com/NASA-DEVELOP/SET>

***References:***

Cinzano, P., Falchi, F. and Elvidge, C.D. (2001). The first world atlas of the artificial night sky brightness. *Monthly Notices of the Royal Astronomical Society, 328*, 689–707. doi:10.1046/j.1365-8711.2001.04882.x

Falchi, F., Cinzano, P., Kyba, C., & Portnov, B. A. (2015). The new world atlas of artificial sky brightness. *IAU General Assembly, 22*, 47038.

Garstang, R. H. (1989). Night-sky brightness at observatories and sites. *Publications of the Astronomical Society of the Pacific, 101*, 306-329.