**NASA DEVELOP National Program**

Wise County Clerk of Circuit Court’s Office

*Summer 2017*

**Short Title: Wyoming Cross-Cutting II**

**Subtitle:** Detecting Changes in Nighttime Sky Brightness over Grand Teton National Park with the Suomi NPP VIIRS Sensor

**Project Video Title:** Say No to the Glow: Using NASA and NOAA’s Suomi NPP Visible Infrared Imaging Radiometer Suite to Model Artificial Sky Brightness

**Project Team**

**Project Team:**

Veronica Warda (Project Lead), vwarda41@gmail.com

Ryan Avery

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**Advisors & Mentors:**

Dr. L. DeWayne Cecil (NOAA National Centers for Environmental Information, Global Science & Technology)

Dr. Kenton Ross (NASA Langley Research Center)

Bob VanGundy (The University of Virginia’s College at Wise)

**Past or Other Contributors:**

Benjamin Marcovitz

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Eric White

**Project Overview**

**80-100 Word Objectives Overview:**

The team monitored changes in light pollution in Grand Teton National Park using the Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) sensor and created Python software usable in Esri’s ArcGIS called the Skyglow Estimation Toolbox. This Toolbox produces Artificial Skyglow Maps of a given region that predict anthropogenic sky brightness using local parameters such as the viewing angle, helping park officials determine the current condition of the night sky, compare past and current trends, and identify directions where light is diminishing night sky quality.

**Abstract:**

As more outdoor lighting is installed for safety and development, light pollution has become a growing problem that threatens the quality of life for humans and wildlife. The onset of light pollution in cities and dark sky areas not only hinders humans from seeing the stars and the Milky Way but also has been linked to health disorders in humans and behavioral changes in flora and fauna. Grand Teton National Park is concerned about the scattering of light pollution and its associated impacts on visitor experience and the environment. Thus, in collaboration with the National Park Service and Wyoming Stargazing, the NASA DEVELOP Wyoming Cross-Cutting II team created the Skyglow Estimation Toolbox that utilizes data collected by the Suomi National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite Day/Night Band. This software used images of the park and a 300 km square buffer collected by the sensor from the summer months (July, August, and September) of 2014, 2015, and 2016 to calculate the effect of light scattering. By processing the pixel values in this image through convolution, the Toolbox applies Cinzano (2001) and Garstang’s (1989) model of light propagation to create Artificial Skyglow Maps in Esri’s ArcGIS that measure skyglow at various viewing angles and lines of sight in the park, helping park officials determine current sky quality and identify sources of light pollution that are diminishing its quality. Moreover, the data produced by the Toolbox will help government officials make informed decisions regarding lighting ordinances in nearby Teton County.

**Keywords:**

Suomi NPP VIIRS Day/Night Band, light pollution, skyglow, artificial light, National Park Service, remote sensing, Grand Teton National Park

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Park Service, Grand Teton National Park | Dan Greenblatt, Colter Bay District Interpreter | End User | No |
| National Park Service, Intermountain Region  | Randy Stanley, Natural Sounds and Night Skies Coordinator | End User | No |
| National Park Service, Natural Sounds and Night Skies Division | Sharolyn Anderson, PhD, Research Scientist, & Li-Wei Hung, PhD, Research Scientist | End User | No |
| Wyoming Stargazing | Samuel Singer, PhD, Executive Director | End User | Yes |

**Community Concerns:**

* Light pollution has rendered 97% of Americans unable to see the Milky Way from their homes at night, and the 6% annual increase of artificial lighting is expected to exacerbate this issue.
* Light pollution disrupts circadian rhythms and the production of the hormone melatonin in humans and has been linked to various health disorders such as obesity, tumor growth, depression, and insomnia.
* Since light regulates the day-night cycles of plants and animals, light pollution affects the growth of plants, disorients animals, and impacts breeding cycles.
* The night sky has played and continues to play an integral part in cultures across the globe, such as China, Australia, Egypt, United Kingdom, United States, and Chile, with documentation dating as far back as 35,000 BP.
* With nearly 200,000,000 outdoor light fixtures in the United States, an estimated $2 billion in energy costs is wasted every year due to poorly designed fixtures.

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

The National Park Service Intermountain Region and Grand Teton National Park (GRTE) use the Unihedron Sky Quality Meter (SQM) to take light measurements in scattered locations in the project study area, and these measurements are used to inform lighting practices within GRTE. Wyoming Stargazing also uses the Unihedron SQM to take light measurements in the project’s study area outside of the park. These measurements are used to help officials craft lighting ordinances that restrict power, color, and duration of nighttime lighting in Teton County, WY. Currently, the Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) is not used by any of the partners to evaluate artificial night sky brightness.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software****Release** |
| Artificial Skyglow Maps | Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) | This product will assist partners in the identification of areas where pristine sky conditions exist and areas where excessive lighting diminishes the quality of the night sky. Partners will also be able to make more informed decisions regarding local lighting ordinances to minimize the impacts of light pollution. | N/A |
| Skyglow Estimation Toolbox | N/A | This product will allow partners to produce an Artificial Skyglow Map in Esri’s ArcGIS and assess sky quality in locations of interest within the study area. | III |

**Project Benefit to End User**:

The National Park Service, Grand Teton National Park, and Wyoming Stargazing will use the Skyglow Estimation Toolbox and Artificial Skyglow Maps to better assess the quality of the night sky in GRTE and surrounding communities and to enhance the decision-making process for lighting ordinances.

**Project Details**

**Applied Sciences National Application Addressed:** Cross-Cutting

**Study Area:** Minimum bounding rectangle surrounding a 300 km buffer around Grand Teton National Park (CO, ID, MT, NV, UT, & WY)

**Study Period:** 2014-2016 (June - September)

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) | Day/Night Band (DNB) | This sensor identifies areas of artificial lighting that brighten the night sky in GRTE. |

**Ancillary Datasets Utilized:**

* National Park Service, Grand Teton National Park Sky Brightness Survey – used to validate Artificial Skyglow Maps
* Center for the Advancement of Science in Space (CASIS) International Space Station (ISS) Astronaut Photography – used to assess LED lights not sensed by Suomi NPP VIIRS DNB
* Partner In Situ Data Wyoming Stargazing Sky Quality Measurements – used to ground truth Artificial Skyglow Maps

**Software Utilized:**

* ERSI’s ArcGIS – raster manipulation, statistical interpretation, and map creation
* Python – development of artificial brightness model

**Project Handoff Package**

**Transition Plan:**

The team plans to conduct a project handoff to each partner POC via Google Hangout during the last week of the summer term, where the project presentation, poster, technical paper, along with the other deliverables and non-code end products, will be handed to the partners. The team will also incorporate a training session to discuss the details of the code and how the partners can use the Skyglow Estimation Toolbox in the future.

*Software Release Plan*: Since the Toolbox falls into Software Release Category III, the team has prepared the partners for delayed delivery of the code by giving them a rough timeline of the software release process and informing them about the uncertainty regarding the length of the delay. The team will ensure that a code handoff via Google Hangout will take place regardless of when the software release is completed and that extensive documentation for the code will be made accessible on GitHub once released.

*Project Continuation Plan*: A continuation of this project is proposed for the Fall 2017 Term and will move the study area to the Colorado Plateau region. The Wyoming Cross-Cutting II team will provide its technical paper along with other deliverables to guide the Southwest U.S. Cross-Cutting team as they are introduced to the topic. A thoroughly-commented code will also be provided to assist their team in adjusting the Skyglow Estimation Toolbox to the new study area.

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**Software Release POC**: Dr. Kenton Ross (NASA Langley Research Center), kenton.w.ross@nasa.gov

**Partner POCs**: Daniel Greenblatt (Grand Teton National Park Colter Bay District Interpreter), dan\_greenblatt@nps.gov

Samuel Singer (Wyoming Stargazing Executive Director), info@wyomingstargazing.org

Randy Stanley (National Park Service Intermountain Region Natural Sounds and Night Skies Coordinator), randy\_stanley@nps.gov

**Handoff Package:**

* Technical Paper
* Poster
* Presentation
* Project Video
* Technical Image
* Website Image
* Project Summary
* Artificial Skyglow Maps
* Skyglow Estimation Toolbox Tutorial and Support Documentation
* Brochure
* One-Pager
* Imagery Gallery