**NASA DEVELOP National Program**

**Virginia – Langley**

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*Project Summary – Fall 2017*

**Shenandoah Health & Air Quality II**

*Monitoring Air Quality in Shenandoah National Park to Address National Park Service Initiatives Using NASA Earth Observations*

**VPS Title:** O Say, Can You See: Monitoring Air Quality in Shenandoah National Park

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

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***Past or Other Contributors*:**

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**Project Overview**

***Project Synopsis*:**

This project sought to analyze air quality trends in Shenandoah National Park (SHEN) over the past decade, and produced a tutorial for park officials to utilize NASA Earth observations to better understand the temporal and spatial variability of tropospheric ozone and visibility in the park. Shenandoah National Park receives more air pollution than nearly any other national park, which impacts the vitality of park ecology and visitor experience. This park currently relies on a single air quality monitoring station to observer visibility and ozone levels for the entire park. By integrating NASA Earth observations with *in situ* data, park officials can better educate stakeholders on air quality concerns and continue their efforts to mitigate the effects of air pollution on human and ecological health.

***Abstract*:**

Air quality is considered one of Shenandoah National Park’s most fundamental resources. The park’s ecological health and visitor attendance is dependent on maintaining high air quality standards. This project utilized the NASA’s Aerosol Optical Depth (AOD), aerosol extinction profile, and Tropospheric Ozone Residual (TOR) datasets to create a long-term analysis of air quality in the park from May 2007 to August 2017. This analysis was used to identify trends in visibility and tropospheric, or ground-level, ozone throughout the park. *In situ* station data from Big Meadows monitoring station and 29 Automated Surface Observing System (ASOS) stations located within a 120 mi radius from Shenandoah National Park were used to validate the NASA Earth observations. A tutorial of how to download, subset, and analyze TOR and AOD datasets was created to help park staff incorporate remote sensing data into their management practices related to air quality concerns. This project provided statistical and quantitative support for incorporating satellite data into Shenandoah National Park’s current air quality monitoring efforts and will aid in future decisions related to visitor education and ecological management.

**Keywords:**

Ozone, visibility, MODIS, MERRA-2, AOD, remote sensing, Shenandoah National Park

***National Application Area Addressed:*** Health & Air Quality

***Study Location:*** Shenandoah National Park, VA

***Study Period:*** May 2007 – August 2017

***Community Concern:***

* Shenandoah National Park experiences some of the highest air pollution levels of any national park despite special monitoring and research afforded by the Clean Air Act.
* Increased haze from pollution greatly reduces visitors’ ability to see distant landscapes across the Shenandoah Valley.
* Ground-level ozone is a pollutant that poses significant health risks to plants, wildlife, and humans.
* Ground-level ozone causes more damage to plant life than all other atmospheric pollutants combined, making vegetation less vibrant.
* The effects of increasing tropospheric ozone heightens vegetation’s susceptibility to drought, invasive species infestation, and wildfire.
* Increased ground-level ozone concentrations pose health risks for park visitors, especially children, older adults, and those with preexisting respiratory issues. These health risks include coughing, chest pain, worsened asthma, and permanent lung damage.

***Project Objectives:***

* Create trend maps displaying visibility levels in Shenandoah National Park based on Terra MODIS and Aqua Aerosol Optical Depth (AOD) data from May 2007 to August 2017
* Create trend maps displaying tropospheric ozone levels in Shenandoah National Park based on NASA Goddard’s Tropospheric Ozone Residual from May 2007 to December 2016
* Create a tutorial using NASA Earth observations for partners to continue to monitor and predict future visibility conditions within Shenandoah National Park

***Previous Term:*** 2017 Summer (LaRC) – Shenandoah Health & Air Quality

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service,** **Shenandoah National Park** | Jalyn Cummings, Physical Scientist, Air & Water Quality Program Manager | End User | No |
| **National Park Service, Air Resources Division, Research & Monitoring Branch** | Barkley Sive, Chemist, Gaseous Air Pollution Monitoring Program Manager | Collaborator | No |

***Decision Making Practices & Policies***:

Shenandoah National Park is classified as a Class I federal land under the Clean Air Act. The park must therefore maintain strict air quality and visibility standards. Park managers need to be able to monitor and evaluate air pollution to mitigate its effects within the park. Shenandoah National Park currently relies on a single air quality monitoring station, Big Meadows, located in the middle of the park to assess air quality for the entire park.

***Project Benefit to End User***:

This project will give park managers’ access to NASA’s Earth observing tools which can be used address spatial and temporal trends in visibility and ozone pollutants within the park. This project will provide park managers with the information needed to issue visibility and pollutant alerts and to identify geographically-specific visibility concerns. Visibility and ground level ozone trend maps of Shenandoah National Park will provide the park with a tool for understanding how their efforts to minimize and mitigate the impacts of pollution have impacted the park’s air quality over the past decade. These maps can also be used by the park’s interpretation and education program to inform visitors of health and air quality issues.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Aqua MODIS** | Aerosol Optical Depth (AOD) | AOD was utilized at a 500 m spatial resolution from May 2007 – Aug 2017 to create visibility trend maps. |
| **Terra MODIS** | Aerosol Optical Depth (AOD) | AOD was utilized at a 500 m spatial resolution from May 2007 – Aug 2017 to create visibility trend maps. |
| **Aura OMI** | Tropospheric Ozone Residual (TOR) | TOR data derived from Aura OMI/MLS were used to create tropospheric ozone trend maps. |
| **Aura MLS** | Tropospheric Ozone Residual (TOR) | TOR data derived from Aura OMI/MLS were used to create tropospheric ozone trend maps. |

***Ancillary Datasets:***

Colorado State Interagency Monitoring of Protected Visual Environments (IMPROVE) data – visibility *in situ* data

EPA Clean Air Status and Trends Network (CASTNET) data – ozone *in situ* data May 2007- December 2016

NASA Goddard Space Flight Center Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)

NOAA NCEI Automated Surface Observing Systems (ASOS) – airport ground station data

***Software & Scripting:***

Esri ArcGIS – used for raster manipulation and analysis, data processing, image enhancement, and map creation

HDF-EOS to GeoTIFF Conversion Tool 2.14 – tool used to batch convert Aqua and Terra MODIS HDF files to GEO-TIFF

Python 2.7 – produce monthly averages of visibility and ozone levels

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Visibility Trend Maps of Shenandoah National Park** | Aqua MODIS, Terra MODIS, MERRA-2 extinction values | These maps will aid the partners in identifying areas of the park where visibility levels are lowest. | N/A |
| **Tropospheric Ozone Trend Maps of Shenandoah National Park** | Aqua OMI, Aqua MLS | These maps will aid the partners in identifying areas of the park where tropospheric ozone levels are highest. | N/A |
| **Tutorial for Mapping visibility and ground-level ozone**  | N/A | This tutorial will aid partners in incorporating remote sensing data into their management decisions related to health and air quality concerns in the park. | N/A |

**Project Handoff Package**

**Transition Plan:**

There was a presentation and deliverables handoff at the end of the fall term. Monthly visibility and tropospheric ozone trend maps were provided along with a tutorial on how to use NASA Earth observations to conduct visibility monitoring.

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**Handoff Package:**

* Technical Paper
* Project Poster
* Project Video
* Monthly Trend Maps of Visibility and Tropospheric Ozone, May 2007 – August 2017
* Tutorial for using NASA Earth observations to monitor visibility in Shenandoah National Park

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