**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**Virginia - Langley**

**Shenandoah Health & Air Quality II**

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

**Project Overview**

***Project Synopsis*:** Building on previous work with Shenandoah National Park (SHEN), this project targets air quality and visibility issues experienced by park visitors as a result of aerosols and other air pollutants. The National Park Service (NPS) is responsible for preserving the natural resources of the park through the Clean Air Act, which designated SHEN as a “Class I” area, providing special protection for air quality, sensitive ecosystems and clean, clear views in these areas. Understanding air pollutants is critical for visitor health, the ecological health of the park’s flora and fauna, and the preservation of the park’s extensive vistas as mandated by Congress. Currently, the park has only one regionally-representative air quality monitoring station to represent the entire extent of the park region. This project will utilize OMI, MODIS, and Suomi-NPP OMPS and VIIRS data in order to track visibility levels and atmospheric pollutants throughout SHEN and the surrounding region, producing trend maps and other visual aids to communicate this research to park staff and visitors.

***Community Concern:*** Air quality is of particular importance to Shenandoah National Park because clean air is considered one of the park’s fundamental resources and values, essential to achieving the purpose of the park and maintaining its significance. Over the past 30 years, across all NPS areas, 90% of visitors surveyed say that scenic views are extremely to very important to their visit. As visitor attendance is increasing – for example, in 2016, Shenandoah National Park had 1.45 million visitors – it is important to better understand how impaired visibility will inhibit those views, and how they will affect park attendace.

***Source of Project Idea:*** This project is based off previous DEVELOP work (Appalachian Trail Health & Air Quality, Summer 2016), and further investigates atmospheric pollutants and air quality issues affecting the park and surrounding region as requested by Shenandoah National Park.

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

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

***Study Period:*** January 2005 - December 2016

***Advisors:*** Dr. Bruce Doddridge (NASA Langley Research Center), Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organization:***

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

***End User Overview***

***End User’s Current Decision-Making Process:***The National Park Service currently relies on one air quality monitoring station near Big Meadows in the park’s Central District to assess air quality within Shenandoah National Park. As a Class I park, SHEN land managers have the “affirmative responsibility to protect the air quality related values (including visibility) of any such lands” (42 U.S.C. §7475(d)(2)(B)). To achieve this task, SHEN managers use the best available science to evaluate the impact new and existing sources of air pollution have on the park, monitor current air pollution impacts to the park, and provide information about air pollution impacts in parks to NPS management, air regulatory agencies, the public, scientific community and other stakeholders. Currently, Shenandoah National Park utilizes the Big Meadows air quality station and other permitted research collected within the park to assess trends in air quality and accomplish its mandates.

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

*National Park Service, Shenandoah National Park* – A previous DEVELOP project (Appalachian Trail Health & Air Quality) introduced Shenandoah National Park to the applications of the Aura and Aqua satellite products to assess tropospheric ozone. SHEN hopes to use this research and utilize any Earth observations to assess visibility or pollutant species over its entire area.

***Collaborator Organization Overview***

***Collaborator Support:***

*National Park Service, Air Resources Division, Research & Monitoring Branch* – Barkley Sive is an expert in atmospheric pollutants and air quality for the NPS at the national level. He will contribute subject matter expertise and ideas on how to more broadly apply NPS air quality resources to compliment the NASA data in this project.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Project updates and discussion will occur biweekly through telephone or video calls and the end-users will be updated weekly on progress made. The main POCs for the project will be the team lead and the LaRC Center Lead.

***Transition Plan*:** Project handoff will occur at the end of the second term of the project (fall 2017). Initial products were provided to the partners at the end of summer 2017.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Aura OMI** | NO2 and SO2 | Aura OMI will be used to create trend maps and other assessments of pollutant species. |
| **Aura TES** | Total column ozone, tropospheric ozone | Total column ozone will be used to supplement our understanding of atmospheric pollutants in the region. |
| **Suomi-NPP OMPS** | NO2 and SO2 | Suomi-NPP OMPS will be used to create trend maps and other assessments of pollutant species. |
| **Aqua MODIS** | Aerosol optical thickness (AOT) | AOT will be utilized to assess visibility trends in Shenandoah National Park and the surrounding region. |
| **Aqua Airs** | Atmospheric ozone | Ozone will be used to supplement our understanding of atmospheric pollutants in the region. |
| **Terra MODIS** | Aerosol optical thickness (AOT) | AOT will be utilized to assess visibility trends in Shenandoah National Park and the surrounding region. |
| **Suomi-NPP VIIRS** | Aerosol optical thickness (AOT) | AOT will be utilized to assess visibility trends in Shenandoah National Park and the surrounding region. |

***Ancillary Datasets:***

Environmental Protection Agency – Clean Air Status and Trends Network (CASTNET) data – ground station data from Big Meadows monitoring station in Shenandoah National Park used to validate Earth observation

***Software & Scripting:***

Esri ArcGIS – analyze data and produce visuals

Python – produce monthly and yearly averages of pollutants species

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Annual Trend Maps of Pollutant Species | Annual trend maps will be used to assess spatial and seasonal trends in pollutant species over SHEN and the surrounding park region. | Aura OMI and Suomi-NPP OMPS will be processed to create annual trend maps, and will be compared to *in situ* station data for validation. | I |
| Annual Trend Maps of Visibility | Annual visibility maps will be used to assess spatial and seasonal visibility trends over the park and surrounding areas across the study period, including an assessment of spatial variability of AOT across the region. | Aqua and Terra MODIS and Suomi-NPP VIIRS will be processed to create annual trend maps, and will be compared to *in situ* station data for validation. | I |

***End-User Benefit*:** The NPS Organic Act and the Wilderness Act provide additional authority to consider and protect visibility in Shenandoah National Park is provided by the NPS Organic Act and the Wilderness Act. SHEN is very interested in the development of best available science and tools to address spatial and temporal trends in visibility and other atmospheric pollutants within the park. This project would benefit the park by potentially offering an application enabling park managers to notify park guests of visibility and atmospheric pollution. This would give the park another tool to protect park resources, and provide an increased understanding of trends in visibility and atmospheric pollutants. Additionally, trend maps will be used by the park’s interpretation and education programs to inform visitors. Further, these results could help identify if there are large or potentially significant sources that the NPS is currently missing, and provide additional insight on mixing, dilution, and transport.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2017 Summer to 2017 Fall

***Multi-Term Objectives:***

* **Term 1:** 2017 Summer (LaRC) – Shenandoah Health & Air Quality
  + The first term of the project focused on developing a methodology to create visual aids assessing trends in atmospheric pollutants (nitrogen dioxide and sulfur dioxide), in addition to associated air quality parameters like ozone that can help to better understand transport, dilution, and mixing of atmospheric pollutants. Initial end products were provided to the partners for review, including the standard project deliverables, visual aids, and communication and outreach information to share with park managers and the public.
* **Term 2 (Proposed Term):** 2017 Fall (LaRC) – Shenandoah Health & Air Quality II
  + The second term of the project will further refine the methodology created in the first term regarding atmospheric pollutants (specifically sulfur dioxide), but will expand to also create visual aids assessing trends in visibility (as impacted by aerosols). Further, the team will write up their methodology to create a tutorial to continue the park’s use of NASA Earth observations. Finally, all result products will be validated with *in situ* monitoring station data. All of this information will be packaged to communicate with park officials and the general public, and thus will likely be created in two forms.

***Previous Terms:***

2017 Summer (LaRC) – Shenandoah Health & Air Quality

***Related DEVELOP Work:***

2016 Summer (LaRC & VA) – Appalachian Trail Health & Air Quality: Monitoring Ozone and Atmospheric Pollutants in the Troposphere to Help Regulate Point Source Emissions and to Improve Ozone Advisory Messages by the National Park Service

2016 Spring (GFSC) – Gulf of Mexico Health & Air Quality: Utilizing NASA Earth Observations to Manage Air Quality and Pollutants over the Gulf of Mexico

2016 Fall (AZ) – Maricopa County Health & Air Quality I: Monitoring PM10 Concentrations for Enhanced Maricopa County Department of Public Health and Maricopa County Air Quality Department Decision Making and Epidemiology

2016 Fall (AZ) – Maricopa County Health & Air Quality II: Modeling a Decade of PM10 Concentrations in Maricopa County, Arizona for Air Quality and Epidemiological Analysis

**Notes & References:**

***Notes*:**

Papers comparing satellite observations to surface: http://www.nsstc.uah.edu/~sundar/publications.html

Building on previous work with Shenandoah National Park (SHEN), this project targets air quality and visibility issues experienced by park visitors as a result of aerosols and other air pollutants (reactive oxides of nitrogen and sulfates, in addition to other atmospheric parameters). The National Park Service (NPS) preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations (Organic Act, 1916). The Clean Air Act has set forth the responsibility “to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic or historic value” (42 U.S.C. §7470(2)). This goal applies to all units of the National Park System. The CAA further designates 48 NPS units, including Shenandoah National Park, as “Class I” areas, providing special protection for air quality, sensitive ecosystems and clean, clear views in these areas. Understanding air pollutants is critical for visitor health, the ecological health of the park’s flora and fauna, and the preservation of the park’s extensive vistas as mandated by Congress. Additionally, a better understanding of how different pollutant species affect the entire park can enhance the park’s effort to notify visitors of potentially hazardous conditions. Currently, the park has only one regionally-representative air quality monitoring station to represent the entire extent of the park region. This project will utilize OMI, MODIS, and Suomi-NPP OMPS and VIIRS data in order to track visibility levels and atmospheric pollutants throughout Shenandoah National Park and the surrounding region, and to determine what times of year are most impacted so that park managers can better plan and inform visitors of park conditions.

***References:***

42 U.S.C. §7475(d)(2)(B)).

Alston, E. J., Sokolik, I. N., & Doddridge, B. G. (2011). Investigation into the use of satellite data in aiding characterization of particulate air quality in the Atlanta, Georgia metropolitan area. *Journal of the Air & Waste Management Association, 61*(2), 211-225.

Kessner, A.L., J. Wang, R.C. Levy, & P.R. Colarco. (2013). Remote sensing of surface visibility from space: A look at the United States East Coast. *Atmospheric Environment,* *81*, 136-147.

Murray, G. L. D., Kimball, K., Hill, L. B., Allen, G. A., Wolfson, J. M., Pszenny, A., Seidal, T., Doddridge, B. G., & Boris, A. (2009). A comparison of fine particle and aerosol strong acidity at the interface zone (1540 m) and within (452 m) the planetary boundary layer of the Great Gulf and Presidential-Dry River Class I Wildernesses on the Presidential Range, New Hampshire USA. *Atmospheric Environment,* *43*(22), 3605-3613.

National Park Service. April 2015. Foundation Document. Shenandoah National Park. Luray, VA. https://www.nps.gov/shen/getinvolved/upload/SHEN\_FD\_SP-Full-doc-final.pdf.