**Intermountain West Health & Air Quality II**

*Utilizing NASA Earth Observations to Assist the National Park Service with Monitoring and Addressing Visibility in Intermountain Region National Parks*

**VPS Title:** Aerosols Around Us: Monitoring the Aerosol Optical Depth and Presence of Pollutants in the Intermountain West

**Project Team**

***Project Team*:**

Kaitlyn McHenry (Project Lead), kaitlyn.mchenry@gmail.com

Annsley Adams

Jared Goldbach Ehmer

***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

Dr. Richard Ferrare (NASA Langley Research Center)

***Past or Other Contributors*:**

Chet Warren

Zac Peloquin

Dr. Bruce Doddridge

**Project Overview**

***Project Synopsis*:** Officials from the National Park Service (NPS) are interested in understanding trends and changes in visibility across park landscapes as decreased visibility affects the experience and health of park visitors. The NPS currently utilizes a limited number of *in situ* instruments to calculate estimates of visible range based on measured amounts of airborne particles. This project focused on defining the empirical relationship between satellite-derived aerosol parameters and these on ground visibility estimates. Understanding this relationship will allow the NPS to estimate visibility in locations where they do not have *in situ* measurements, broadening their ability to understand and manage park lands.

***Abstract*:**

The National Park Service (NPS) currently utilizes an interagency network of *in situ* aerosol monitoring stations to estimate light extinction and determine visibility across the public lands that it manages. With these well-defined particle masses and concentrations, the NPS makes estimates of visibility; however, their process is limited in scope because of the small number of monitoring stations and the fact that they only record measurements once every three days. This project focused on defining the empirical relationship between light extinction, calculated from these ground measurements, and satellite derived aerosol optical depth (AOD). The project team tested the feasibility of calculating visibility from Suomi National Polar-orbiting Partnership (NPP)’s Visible Infrared Imaging Radiometer Suite (VIIRS) and Aqua and Terra’s Moderate Resolution Imaging Spectroradiometer (MODIS) AOD data from 2013 to 2017. Using various regression methodologies, which also incorporated meteorological and atmospheric parameters, the team found that the MODIS data product correlates with ground truth data, giving R2 values between 0.06009 and 0.3351. After applying the same methods to the VIIRS data product, R2 values ranged between 0.0004629 and 0.04104. The discrepancy between the two products suggests that the VIIRS product is not suitable for this particular application; however, the underlying reason for this it not fully understood. The team applied these methods to seven NPS locations across the western United States and noted significant variability park-to-park, even when using the same data product, which is likely the result of local physiographic and meteorological factors. These findings will help the NPS expand their efforts to monitor visibility more broadly.

**Keywords:**

Aerosol Optical Depth, Air Quality Related Values (AQRVs), MODIS, VIIRS, human health, air quality, National Park Service, remote sensing

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

***Study Location:*** Intermountain West Region: AZ, CO, NM, MT, OK, TX, UT, WY

***Study Period:*** January 2013 – August 2017

***Community Concern:***

* Aerosols and pollutants negatively affect air quality, visibility, and human health.
* The NPS is responsible for monitoring and managing public lands, including assessing the visibility of park landscapes.
* The NPS currently utilizes the Interagency Monitoring of Protected Visual Environments (IMPROVE) network of ground stations to assess visibility trends; however, this network is limited in its spatial distribution and only provides intermittent information across the American Intermountain West.
* The NPS is aware of the potential benefits that satellite borne aerosol products can provide for their monitoring and management practices, but do not currently employ satellite AOD data to assess visibility.

***Project Objectives:***

* Define the relationship between satellite derived AOD and ground truth IMPROVE data
* Assess the feasibility of utilizing VIIRS and/or MODIS data to expand NPS monitoring and management capabilities
* Assess the utility of various meteorological and atmospheric parameters when analyzing visibility via satellite derived AOD
* Assess visibility trends throughout the Intermountain West region of the NPS, as well as a set of specific key national parks

***Previous Term:*** 2018 Summer Term (LaRC) – Intermountain West Health & Air Quality I

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service,** **Intermountain Region** | Debbie Miller, Air Resource Specialist; Anthony Prenni, Chemist, Air Resource Division | End User | No |

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

The NPS currently monitors atmospheric pollutants and aerosols through the IMPROVE network following the revised methodology of Pitchford et al. (2007). The current methodology robustly assesses light extinction based on particle speciation data, but is not equipped to provide continuous monitoring and is only capable of providing information on the very small subset of NPS areas where IMPROVE monitors are maintained. For example, IMPROVE air quality measurements are only obtained every third day for a period of 24 hours. This style of data collection also limits decision making because current visibility estimates are essentially an average across that period of data collection. Currently, the NPS utilizes these data to manage its park resources and prescribe effective policy actions.

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

NPS officials are interested in the feasibility of augmenting their current air quality monitoring practices with satellite data, which could provide comprehensive information across all the parks they manage. Defining the empirical relationship between various satellite aerosol products and light extinction estimated from the IMPROVE procedure is the only way to adequately compare these two monitoring methods. The deliverables from this project provided a side-by-side comparison of MODIS and VIIRS data and demonstrated how well those products relate to IMPROVE data. Additionally, the project team experimented with incorporating various meteorological datasets, alongside AOD from satellite data that could provide the NPS with additional information when estimating visibility. The results of this project provide critical context for any future NPS efforts to monitor visibility trends with remote satellite data.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Terra MODIS** | AOD | MODIS data were used to assess visibility and measure total column aerosol optical depth. |
| **Aqua MODIS** | AOD | MODIS data were used to assess visibility and measure total column aerosol optical depth. |
| **Suomi NPP VIIRS** | AOD | VIIRS data were used to assess visibility and measure total column aerosol optical depth. |

***Software & Scripting:***

Esri ArcGIS – analyze data and produce visuals

Python – produce monthly and yearly averages of pollutant species

IDL – read access to data files

R Studio – produce regression models factoring all variables

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Visual Data Representations** | Aqua MODIS, Terra MODIS, and Suomi NPP VIIRS | Visual representations including methodology assessment data tables, comparison charts, and parameter comparison histograms. These visuals will be used to prioritize areas with heavier concentrations of pollutants for mitigation activities.  | I |
| **Regression Tables** | Aqua MODIS, Terra MODIS, and Suomi NPP VIIRS | Tables that focus on the regression outcomes seen within the Intermountain West coupled with weather data.  | I |

**Project Handoff Package**

**Transition Plan:**

The project was presented to project partners Debbie Miller and Anthony Preni via Google Hangouts during the week of November 12th, 2018. The project’s end products were sent to Debbie Miller and Anthony Preni through the NASA NOMAD Large File Transfer System.

**Team POC:** Kaitlyn McHenry, kaitlyn.mchenry@gmail.com

**Partner POC**: Debbie Milller, debra\_miller@nps.gov

**Handoff Package:**

* Project summary
* Technical paper
* Project poster
* Project video
* Visual Data Representations: AOD annual fluctuations; Data tables and sets detailing AOD and visibility trends within key parks; Histogram charts detailing visibility trends according to various parameters
* Regression Tables
* Different versions of visibility end products to communicate pertinent information to NPS officials and the public

**References:**

Clean Air Act of 1963, 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.

IMPROVE equation paper citation: Pitchford, M., Malm, W., Schichtel, B., Kumar, N., Lowenthal, D., & Hand, J. (2007). Revised algorithm for estimating light extinction from IMPROVE particle speciation data. *Journal of the Air & Waste Management Association, 57*, 1326-1336. <https://doi.org/10.3155/1047-3289.57.11.1326>

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, … & 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. (2015, April). Foundation Document. Shenandoah National Park. Luray, VA. Retrieved fromhttps://www.nps.gov/shen/getinvolved/upload/SHEN\_FD\_SP-Full-doc-final.pdf.