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

## Abstract

Air quality is considered one of Shenandoah National Park's most fundamental resources. The park's ecological health and visitor attendance are dependent on maintaining high air quality standards. This project utilized 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 through August 2017. This analysis was two-fold: to identify trends in visibility, and tropospheric, or ground-level, ozone throughout the park. *In situ* station data from Big Meadows monitoring station and 30 Automated Surface Observing System (ASOS) stations located within a 200 km radius of Shenandoah National Park were used to validate NASA's Earth observations. A tutorial on how to download, subset, and analyze AOD and TOR 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.

## Objectives

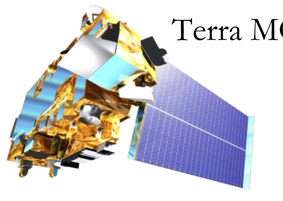
- **Continue** to introduce applications for NASA's Earth observations to Shenandoah National Park to supplement current air quality monitoring efforts
- **Assess** the effectiveness of current NASA satellites to measure surface visibility and ground-level ozone ($O_3$)
- **Create** a tutorial for park officials to help incorporate NASA Earth observations into their management decisions related to park health and air quality concerns
- **Display** trend maps showing historic visibility and ozone levels in Shenandoah National Park

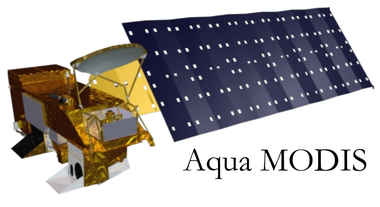
## Study Area

Shenandoah Airshed


Shenandoah National Park Boundary


## Earth Observations


Terra MODIS


Aqua MODIS

## Project Partners

- National Park Service, Shenandoah National Park
- National Park Service, Air Resources Division, Research & Monitoring Branch

## Methodology

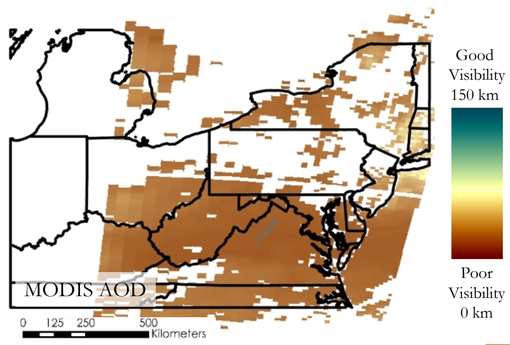
**Data Acquisition** — CASTNET (ozone measurements); Tropospheric Ozone Residuals (TOR); IMPROVE and ASOS (*in situ* visibility measurements); Aqua & Terra MODIS AOD; MERRA-2 extinction profiles

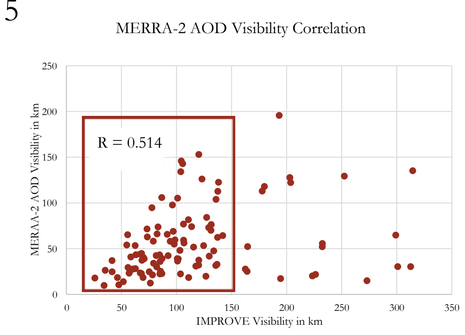
**Data Processing** — Convert TOR, MODIS, MERRA-2 into GIS-ready formats; extract 1pm timeframe for ASOS; convert TOR Dobson units to ppbv (parts per billion volume); apply Koschmieder's Law

**Data Analysis** — Compare Earth observations and model-based estimations of visibility with ASOS reference data; create time series and trend maps; calculate statistics

## Results

*Case Study #1:* Visibility, June 10, 2015



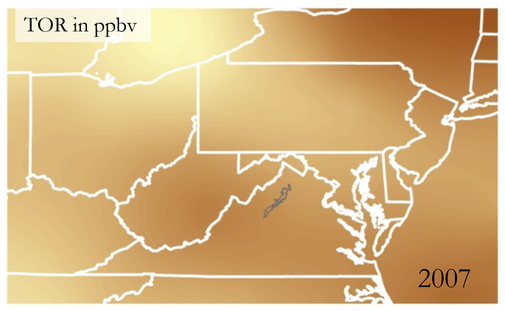



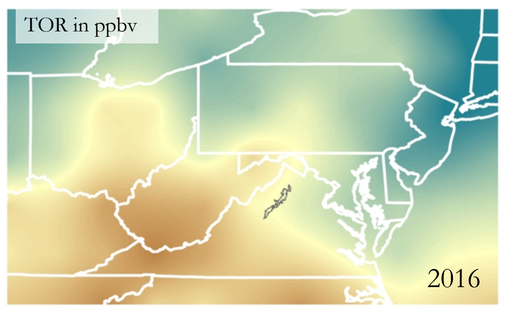






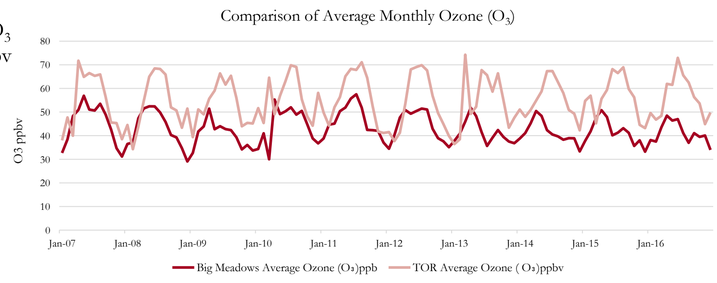

*Case Study #2:* Ozone, June 2007 and 2016





Correlation between *in situ* and satellite measurements:
R = 0.526




## Conclusions

- Visibility calculated from AOD provides a more accurate measurement of surface visibility than visibility calculated from MERRA-2 extinction profiles.
- Shenandoah National Park experiences ground-level $O_3$ highs in late spring.
- NASA Earth observations can indicate where in the atmosphere $O_3$ originates.
- NASA Earth observations can provide the park with big-picture, long-term data to foresee trends in air pollutants that affect the park; however, higher resolution imagery will provide more accurate results.

## Acknowledgements

**Subject Research Contributors:**

**Dr. Hongyu Liu,** NASA Langley Research Center
**Dr. Jerry R. Ziemke,** NASA Goddard Space Flight Center

**Science Advisors:**

**Dr. Bruce Doddridge,** NASA Langley Research Center
**Dr. Rich Ferrare,** NASA Langley Research Center
**Dr. Kenton Ross,** NASA Langley Research Center

**Partners:**

**Jalyn Cummings,** National Park Service, Shenandoah National Park
**Dr. Barkley Sive,** National Park Service, Air Resources Division, Research & Monitoring Branch

**Previous DEVELOP team:**

Ellen Bubak, Amanda Clayton, Doug Gardiner, Nicholas Lenfant, Julie Terhune

## Team Members


Emily S. Doerner
Project Lead


Andrew A. Bonifas


James Ficklin


Nick Gulston


Roger Johnson


Sarah K. Philips

Virginia – Langley
Fall 2017

*This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.*

Shenandoah Health & Air Quality II