REMOTE SENSING MONITORING OF CANADIAN WILDFIRE SMOKE AND ITS IMPACT ON BALTIMORE AIR QUALITY

SHELBI TIPPETT, JULIO ROMAN, RUBEN DELGADO

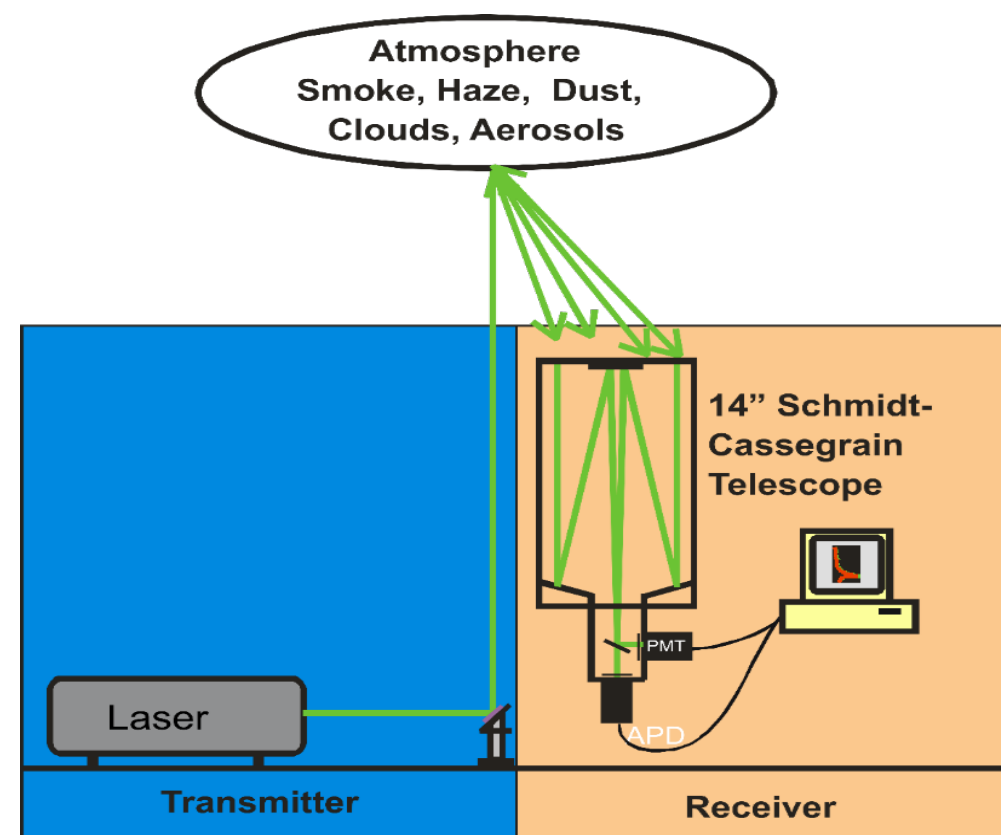UNIVERSITY OF MARYLAND, BALTIMORE COUNTY

Why lidar?

- Provide data for air quality management agencies.

- Aid the interpretation of satellite images and models.

- Awareness of local, regional, and national air quality
  - UMBC Smog Blog (http://alg.umbc.edu/usaq/)

- Identify causation for visibility conditions.

- To make people aware of the daily air quality index (poor air quality health risks).

- Differentiate between local pollution and long range transport.

Elastic Lidar Facility (ELF)

- Elastic light detection and ranging (lidar) measurements allows to monitor long-range transport of particulates, such as dust and smoke.

- Enhance our understanding on how vertical layering and long range transport of natural and anthropogenic particle pollution may alter the relationship between column aerosol optical depth (AOD) and surface particle pollution concentrations.

Atmosphere
Smoke, Haze, Dust, Clouds, Aerosols

14" Schmidt-Cassegrain Telescope

PMT

APD

Laser

Transmitter

Receiver

June 2015 Smoke Event

- During the week of June 7th of 2015, various wildfires in Alberta and Saskatchewan, Canada, produced smoke that was transported over the Baltimore area.

- Causing elevated AOD and particle pollution values.

- Aerial view of one such contributing wildfire in the Willmore Wilderness Park. It was discovered on June 8th and by June 12th the fire had spread out of control to approximately 14,000 hectares.

**Source:** Alberta Wildfire Facebook page

Lidar System Backscatter Image

ELF 532 nm Total Attenuated Backscatter [km^{-1} sr^{-1}]
10-Jun-2015

ELF 532 nm Total Attenuated Backscatter [km^{-1} sr^{-1}]
10-Jun-2015 19:00 - 11-Jun-2015 14:00 (UTC)
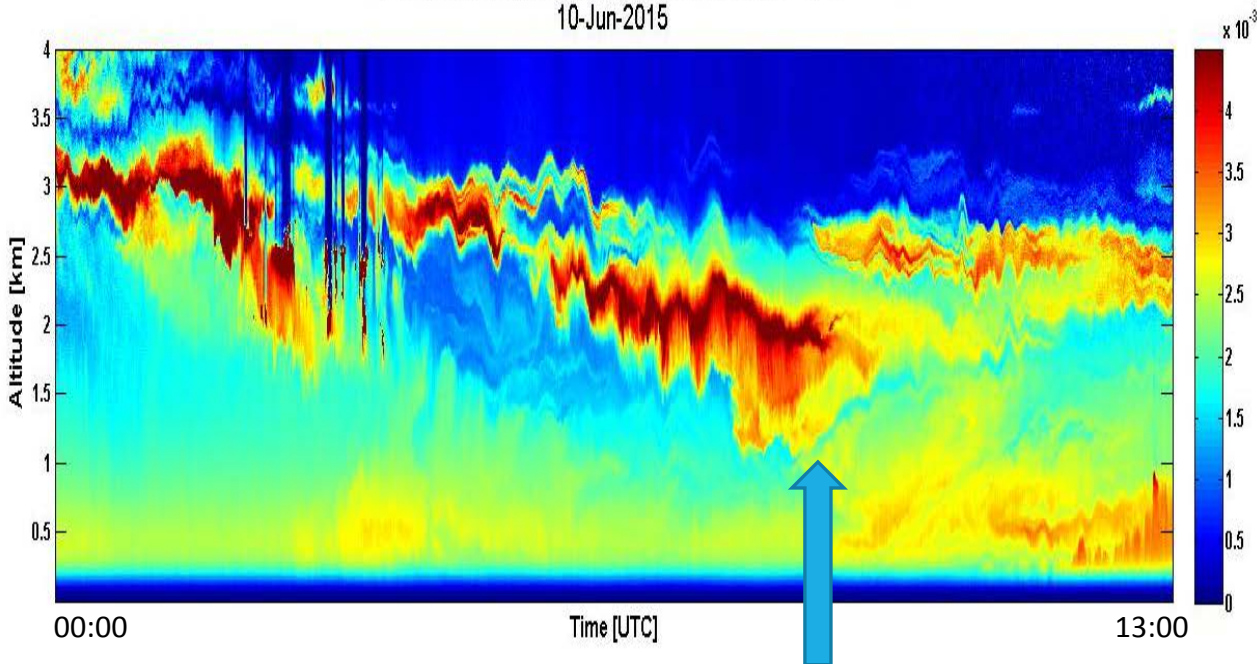
The elastic lidar backscatter image shows aerosols aloft (1.5-3 km) on June 10th. The particles began to mix causing increased near surface particle pollution.
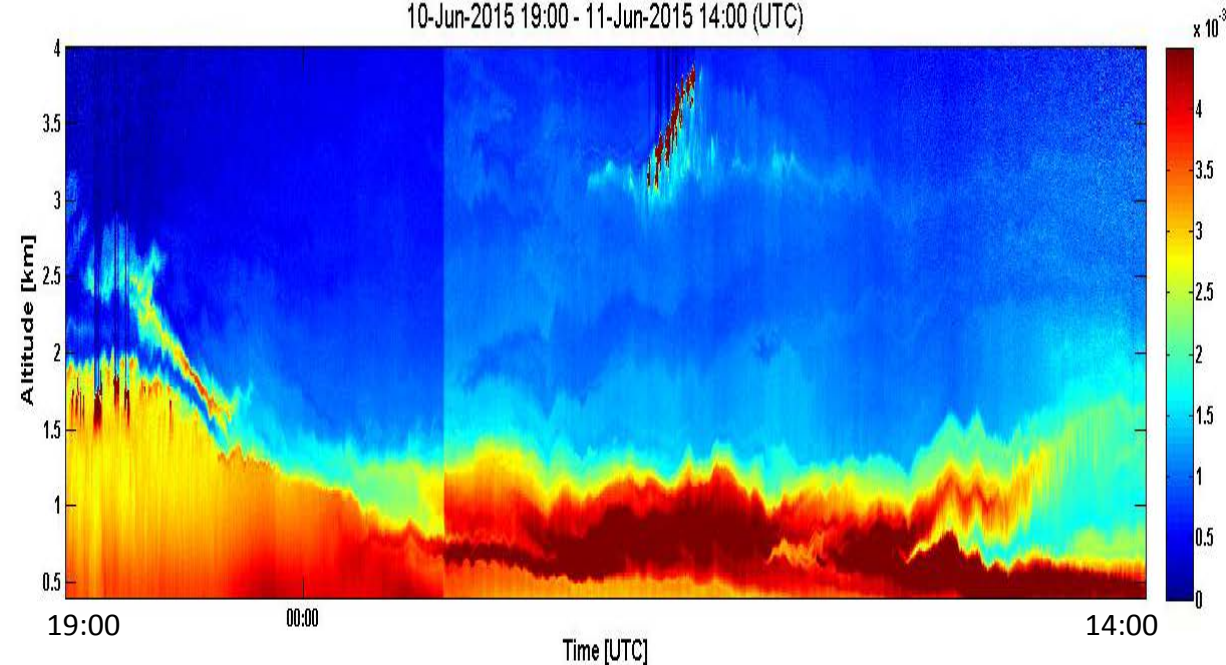
The 11th shows a homogenous layer, likely smoke mixed with the planetary boundary layer (PBL) which extends up to 1.5 km.

Extinction Data

- Extinction is the ratio of absorption to scattering when light passes a certain distance through the atmosphere.

- Extinction profile for June 10th-12th: the peaks in extinction correspond to the presence of aerosols shown in the previous lidar image.

June 10-12th Extinction Values
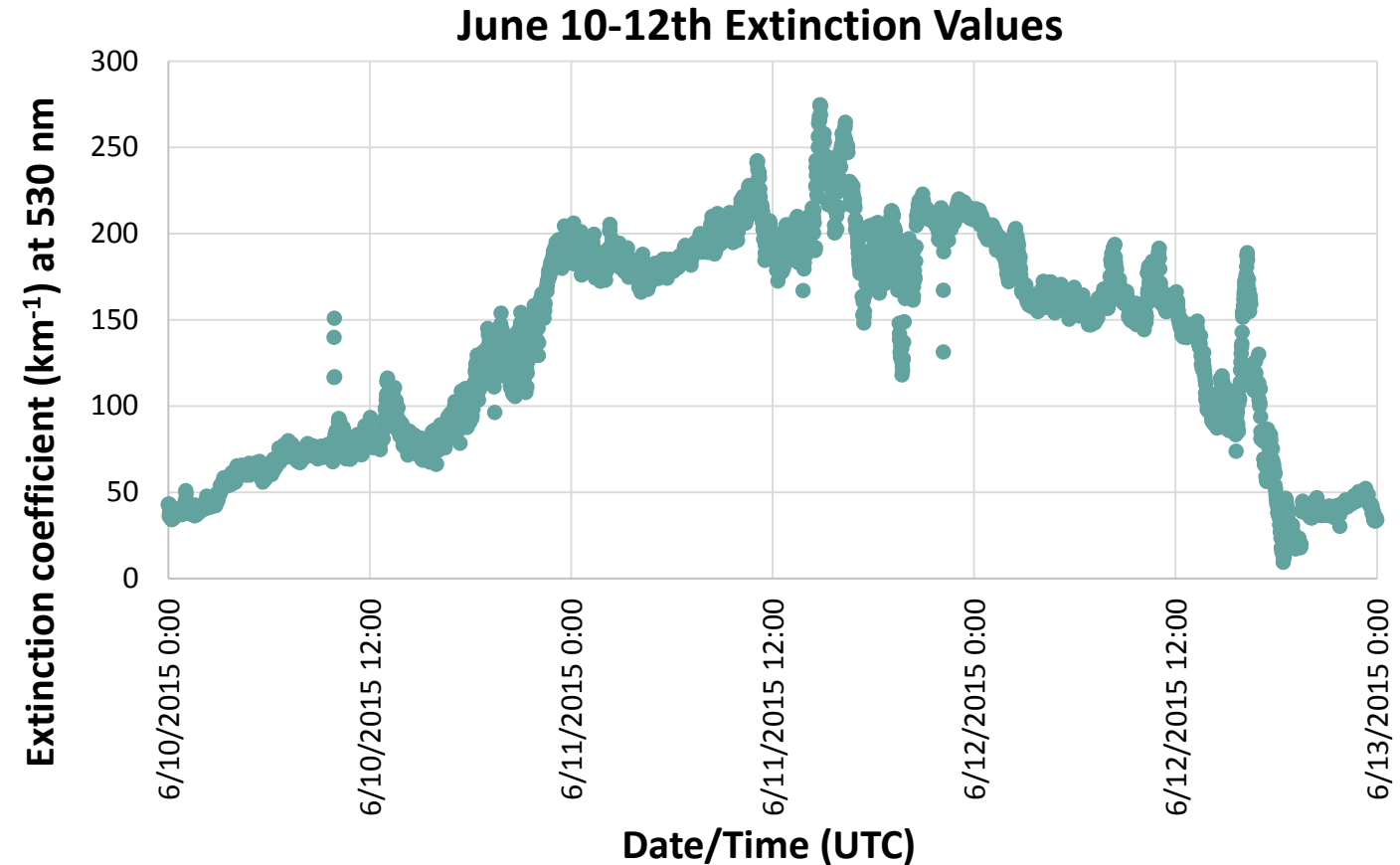
Extinction time series from measurements at UMBC.

Particulate Matter Concentration

- $PM_{2.5}$ particles have a diameter < 2.5 μm. They can travel hundreds of miles and remain in the air for days at a time. These characteristics, as well as their smaller size, make them potentially more harmful than other particles.

- $PM_{2.5}$ concentrations were elevated (25-35 μg/m³) throughout June 11th and most of the 12th.
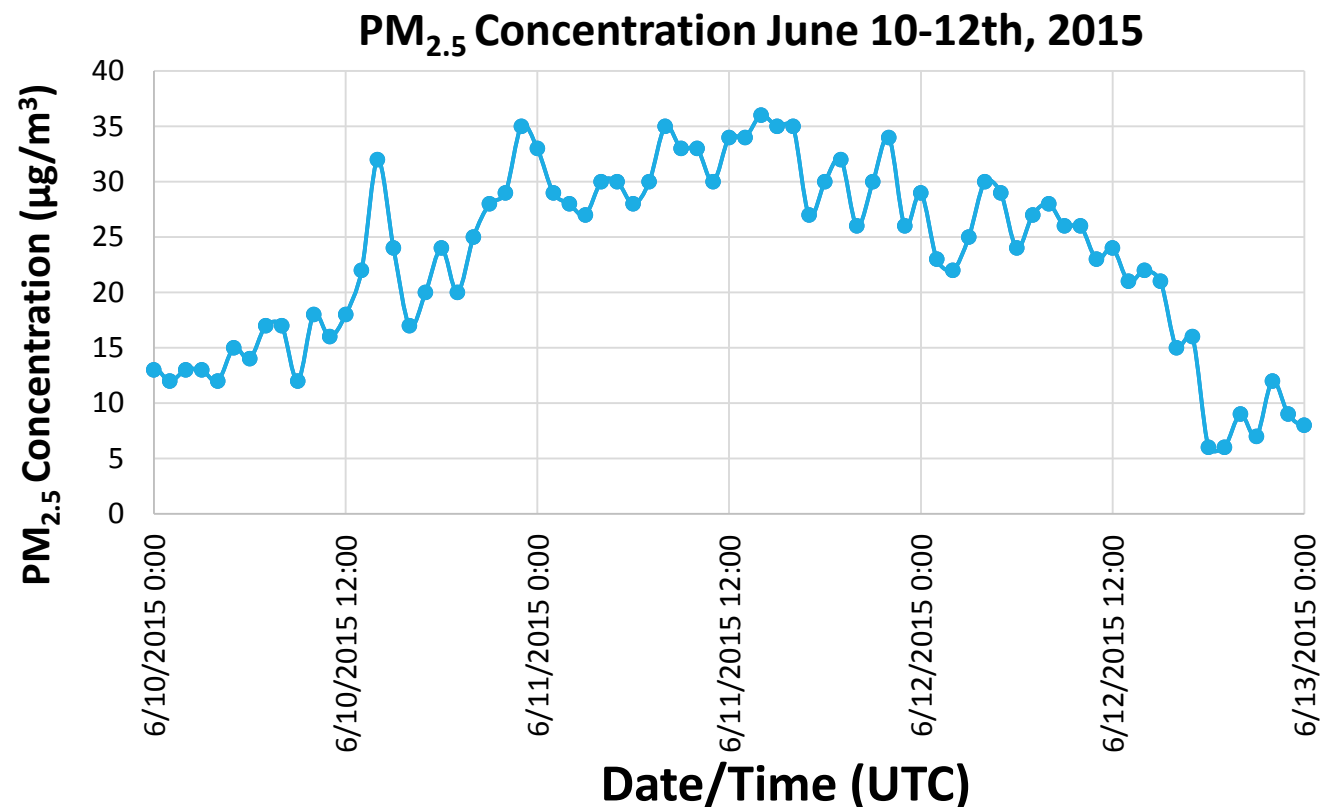
Data provided by AirNow Tech, Oldtown station.

Terra/MODIS Satellite Image

- Moderate Resolution Imaging Spectroradiometer (MODIS) is an instrument aboard the Terra satellite that continuously scans the Earth to create a spectral analysis of surface and atmospheric conditions.

- Spatial coverage captured by satellite showing smoke over the Mid-Atlantic US.
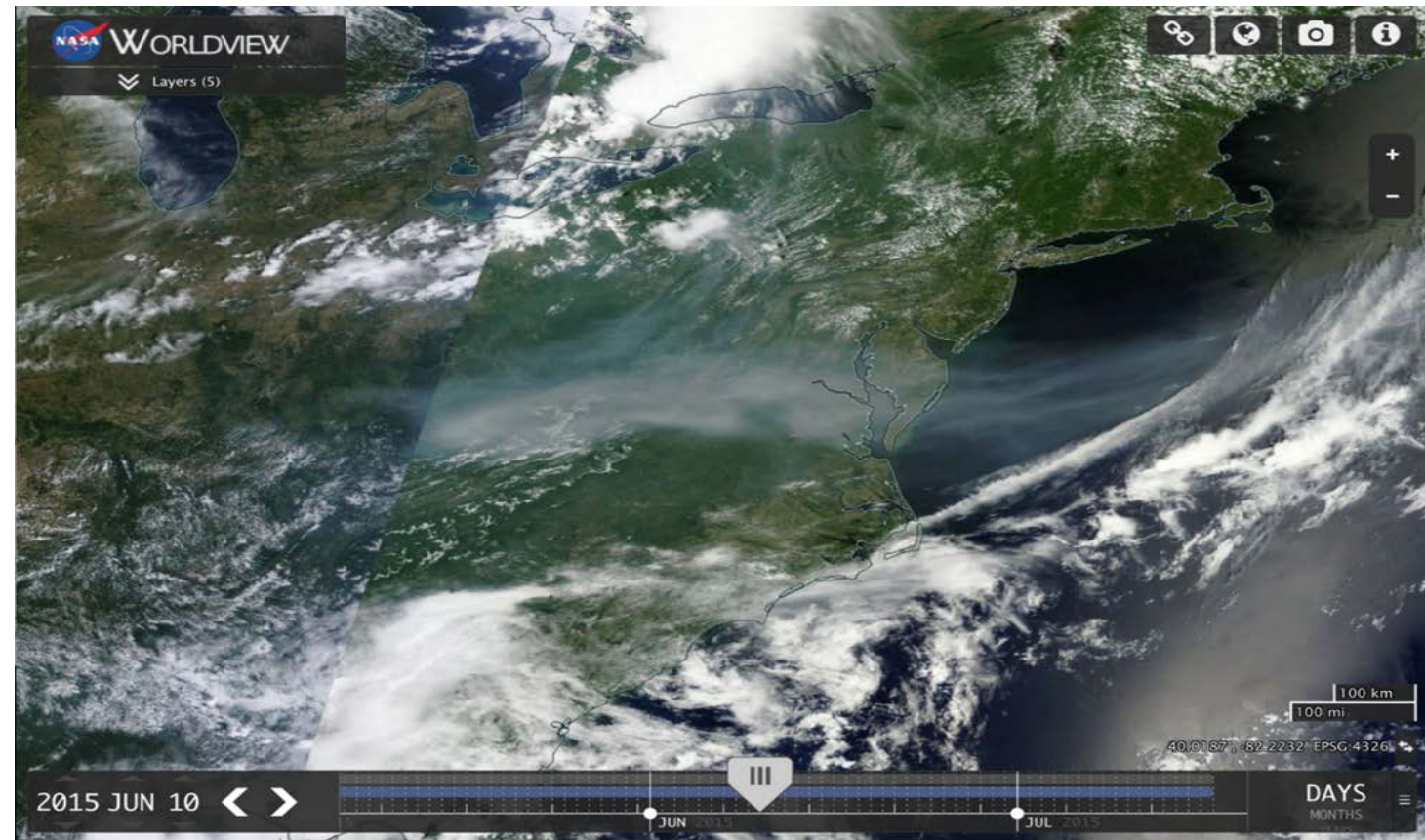
NASA's EOSDIS Worldview Image (MODIS sensor) from June 10, 2015.

Aerosol Optical Depth

- This image indicates heavy aerosol loading for Baltimore.

- The areas of elevated AOD are consistent with the shape of the smoke plume shown in the MODIS image.
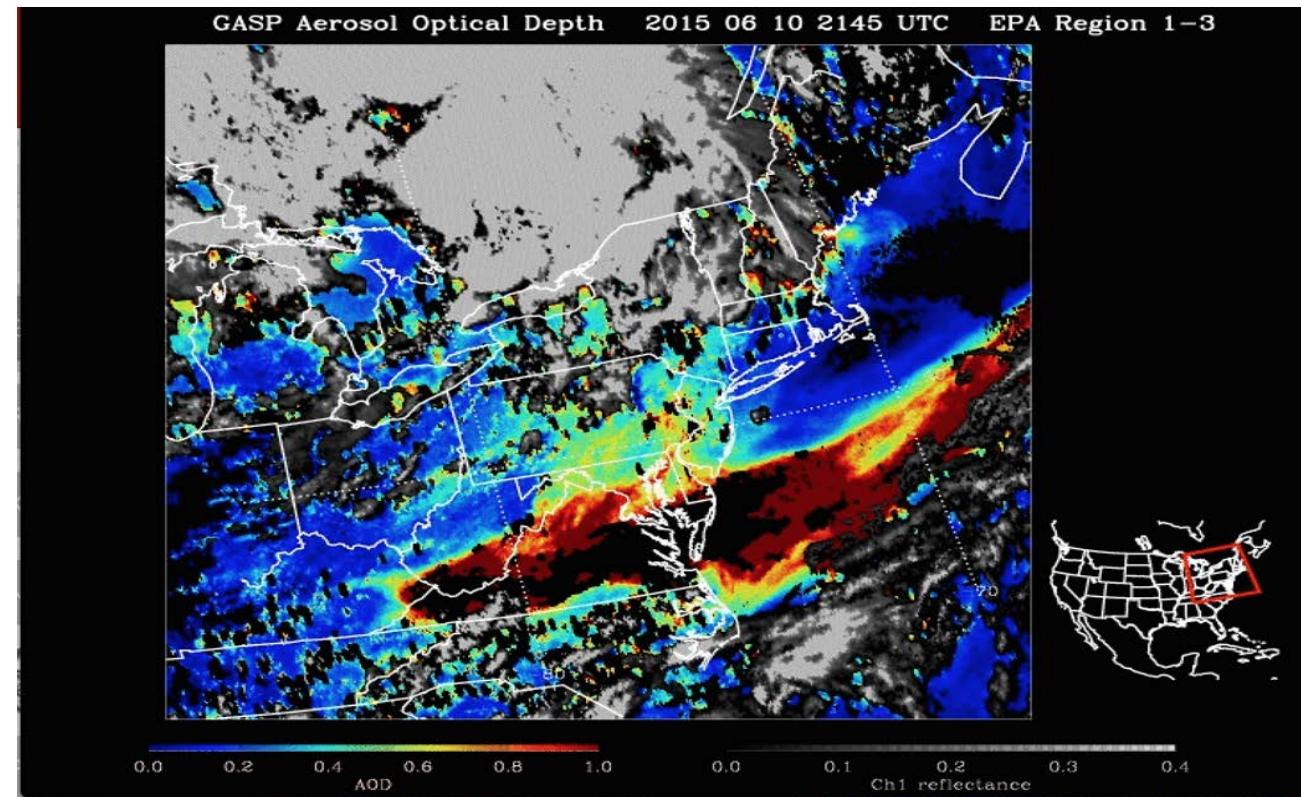
NOAA Geostationary Operational Environmental Satellite Aerosol Smoke Product (GASP) for the night of June 10th

Visible Infrared Imaging Radiometer Suite (VIIRS)

- VIIRS is a scanning radiometer that can be used to measure cloud and aerosol properties, fires, Earth's albedo, etc.

- VIIRS: Intermediate Product High and Degraded quality with the Dust/Smoke and Fire product overlay for June 10th.

- The plume of smoke shown is consistent with the one in the MODIS satellite image.

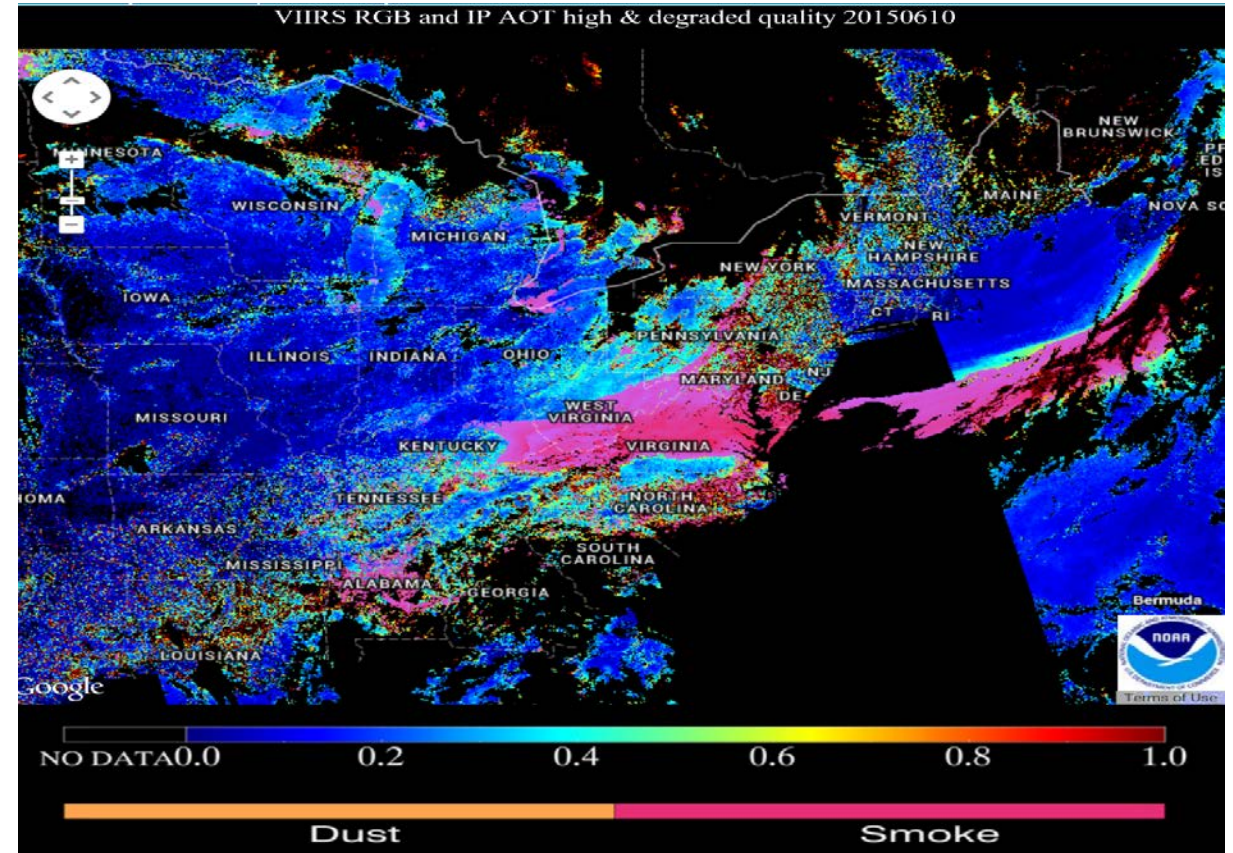- This also indicates increased AOD for the Baltimore area.

Image compliments of NOAA IDEA
(http://www.star.nesdis.noaa.gov/smcd/spb/aq/)

Backward Trajectory Modeling

- The Hazard Mapping System (HMS) overlay includes fire locations which are identified by satellite fire algorithms. The smoke product is an analysis determined from Geostationary Operational Environmental Satellites (GOES) imagery.

- Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model computes air parcel trajectories which allows us to determine the origin of particle pollution.
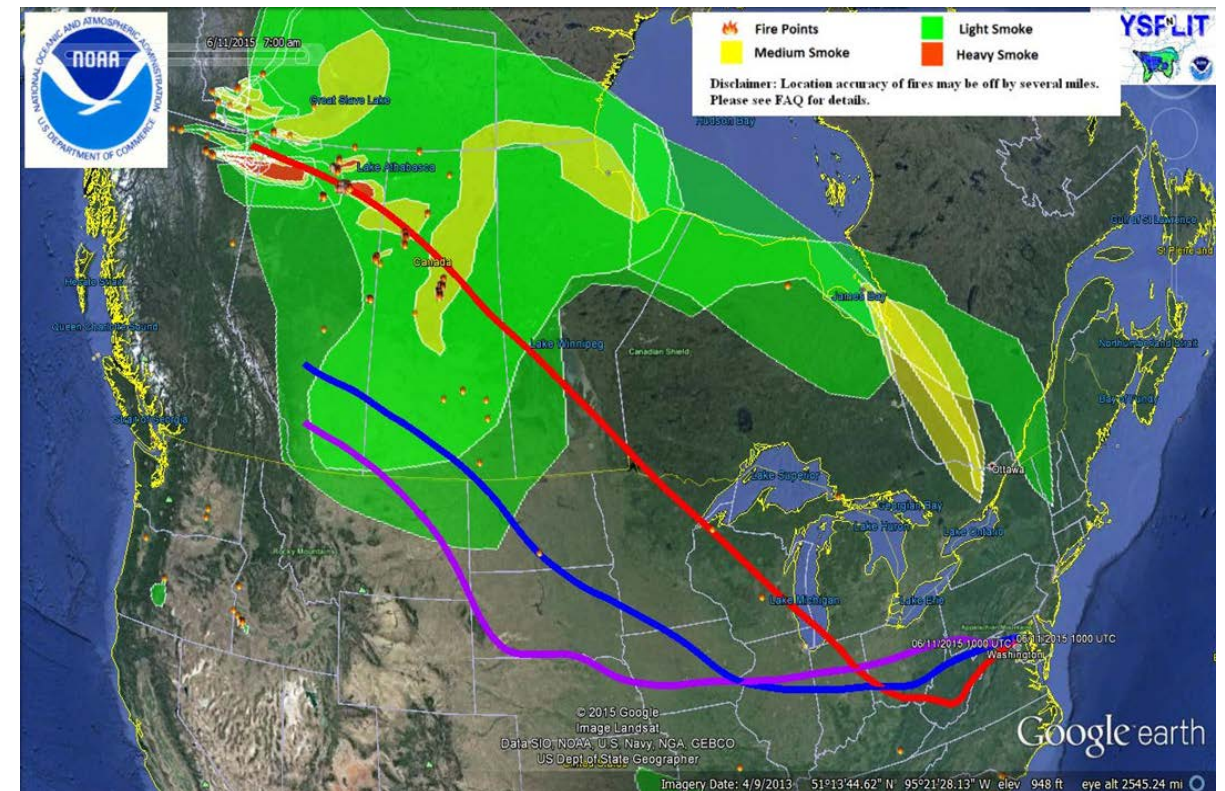
Google Earth overlay of HMS Fire and Smoke Product with NOAA HYSPLIT back trajectory for June 6, 2015.

Single Scattering Albedo (SSA)

- SSA is the ratio of scattering to extinction.

- Burning biomasses have been known to produce negatively sloped lines in Single Scattering Albedo plots (Russell et al. 2010), such as those shown in this graph.

- The values for June 11th appear to be slightly elevated from the rest of the days shown; this has also been known to occur with the presence of more organic material.
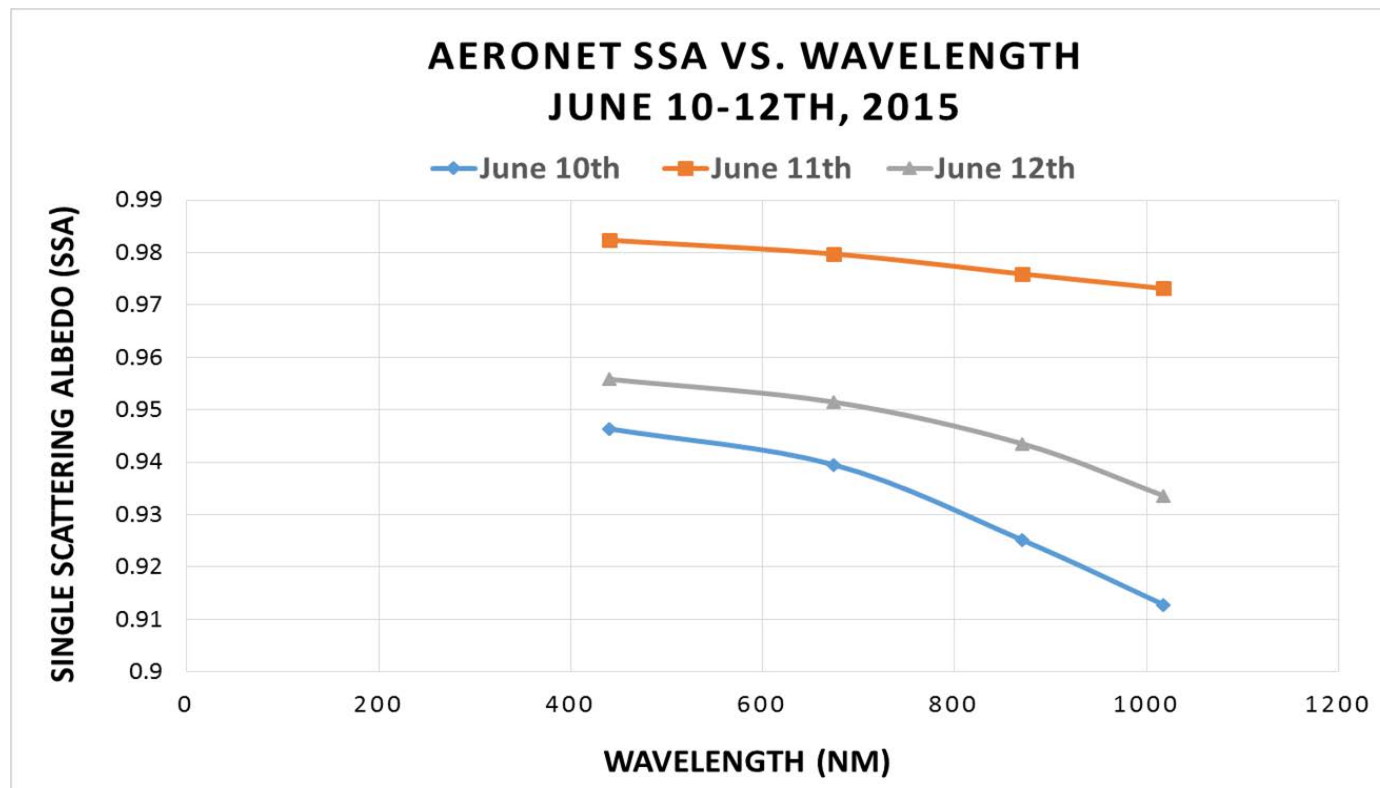
AERONET data collected by a UMBC and MD Science Center sun photometer stations.

Cluster Analysis of Sun Photometer Data

- Urban aerosols typically remain in the AAE range close to 1. (Russell et al. 2010)

- A dust event was being monitored on the days circled in green. Dust particles have been shown to have variable AAE and an EAE<1.

- Smoke was being monitored on the days circled in red. These points also have more absorption than any other particles.
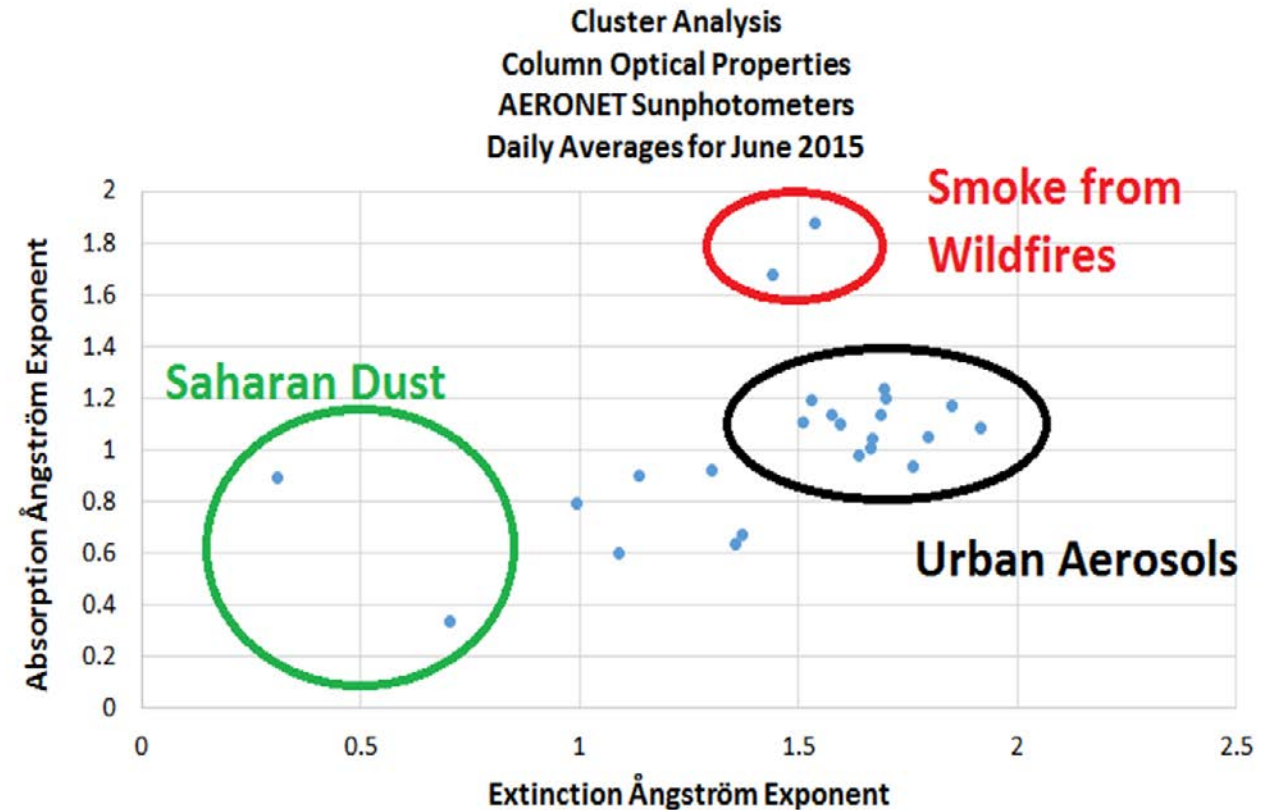
Cluster analysis, AERONET sun photometer, June 2015 measurements.

Summary

- Vertical and temporal resolution of lidar allows:
  - Assessment of long range transport of natural and anthropogenic aerosols vs. local sources to local air quality.

  - Aid source allocation of particle pollution during Air Quality Action Days.

  - Continuous monitoring of PBL –verification and validation of forecasts and models.

- Lidar and real time ground monitoring of pollutants:
  - Characterization of temporal and spatial changes of particle pollution, oxidants, and precursors.

Thank you! Questions?

This research is supported by:
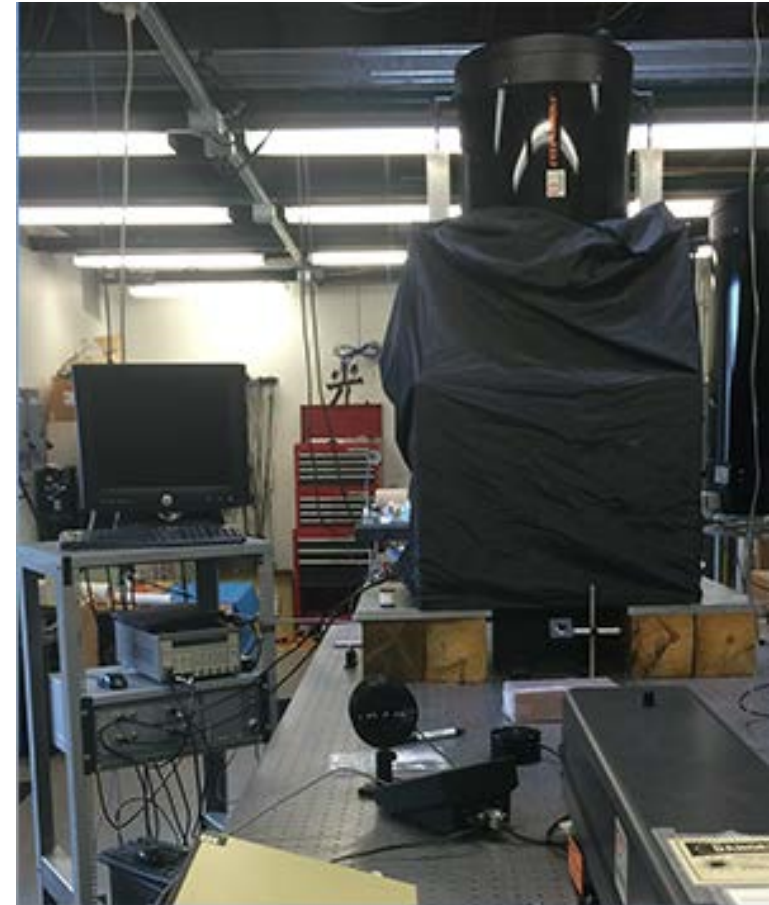
References

Alberta Wildfire Info. Facebook page June 11th [Online Image] . (2015). Retrieved July 26th, 2015 from https://www.facebook.com/AlbertaWildfireInfo

P.B. Russell, R. W. Bergstrom, Y. Shinozuka, A. D. Clarke, P. F. DeCarlo, J. L. Jimenez, J. M. Livingston, J. Redemann, O. Dubovik, and A. Strawa, 2010: Absorption Angstrom Exponent in AERONET and related data as an indicator of aerosol composition. *Atmospheric Chemistry and Physics,* 10: 1155-1164.