Near-Real-Time Surface PM2.5 Estimates from MODIS and VIIRS AOD over CONUS

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Introduction

Satellite retrieved aerosol optical depth (AOD) has been used to estimate surface PM2.5 because AOD is found to be correlated with PM2.5. The advantage of the PM2.5 estimates from satellite AOD is its large spatial coverage that can fill the gaps between surface PM2.5 stations. A daily near-real-time PM2.5 estimates over United States from MODIS (Moderate Resolution Imaging Spectroradiometer) AOD and VIIRS (Visible Infrared Imaging Radiometer Suite) AOD has been running on NOAA (National Oceanic and Atmospheric Administration)'s IDEA (Infusing satellite Data into Environmental Applications)/eIDEA (enhanced IDEA) websites and further being used by EPA (Environmental Protection Agency) to combine with surface PM2.5 measurements. The PM2.5 is estimated from a daily pre-calculated PM2.5-AOD relation using model simulations and in-situ data corrections. In this poster, the performance of this method over the past several years is evaluated.

The AOD to PM2.5 conversion Algorithm (van Donkelaar et al., 2012)

Re-grid AOD into fixed grid with 4km spatial resolution covering CONUS region

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Apply predefined AOD filter to remove areas with poor AOD accuracy (based on validation with AERONET)

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AOD to PM2.5 conversion using Look-up-table:
Linear relation PM2.5=A×AOD+B
Daily temporal resolution and 4 km spatial resolution on fixed grid

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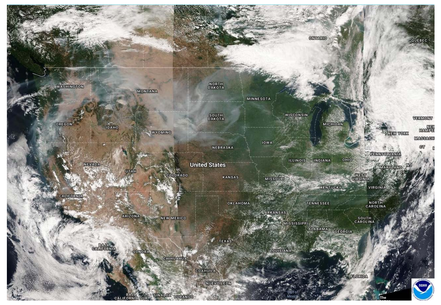
Smooth the estimated PM2.5 using inverse distance weighting and PM2.5 climatology

$$\mathrm{PM}_{2.5,\mathrm{SBC}} = \frac{\sum_{i=1}^{m}\left(\frac{N}{d^2}\right)_i \times \left(\frac{\mathrm{PM}_{2.5,\mathrm{SBC}}}{\mathrm{PM}_{2.5,c}}\right)_i}{\sum_{i}^{m}\left(\frac{N}{d^2}\right)_i} \times \mathrm{PM}_{2.5,c}$$

↓

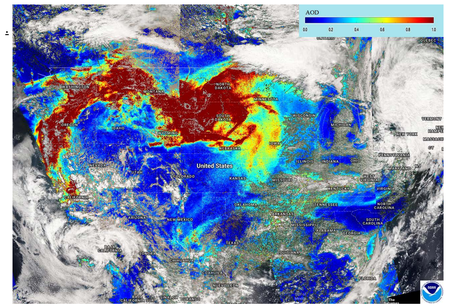
Apply weight threshold map to remove areas with small weights or bad performance

An Example of PM2.5 derived from VIIRS AOD – Smoke event over western US



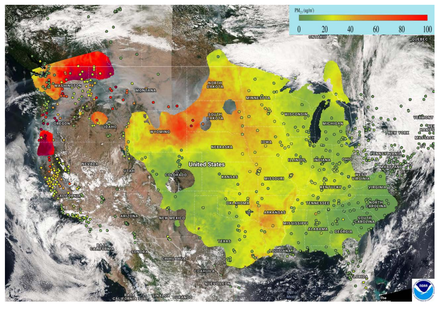
VIIRS RGB true color image on 20170903

Large areas of CONUS were covered by smoke from northwestern US and western Canada.



VIIRS AOD over RGB image on 20170903

The smoke covered areas have high AOD retrievals.

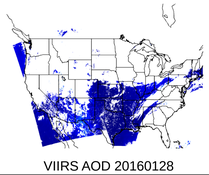


PM2.5 estimates from AOD and AIRNOW PM2.5 over VIIRS RGB image on 20170903

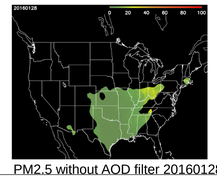
High PM2.5 are estimated from AOD. PM2.5 estimates are smooth and many places masked

PM2.5 estimates performance evaluation

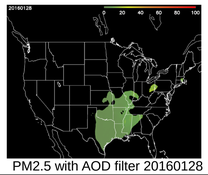
- Three years data: 2015-2017
- Daily PM2.5 estimates from MODIS Terra and Aqua AOD combined
- Daily PM2.5 estimates from VIIRS Enterprise AOD product
- In-situ AIRNOW daily surface PM2.5 measurements ~ 800 sites
- To understand the effect of the AOD filter, a separate run with the AOD filter removed using VIIRS AOD. Following images shows an example of the differences between the PM2.5 estimates coverage (20160128)



VIIRS AOD 20160128

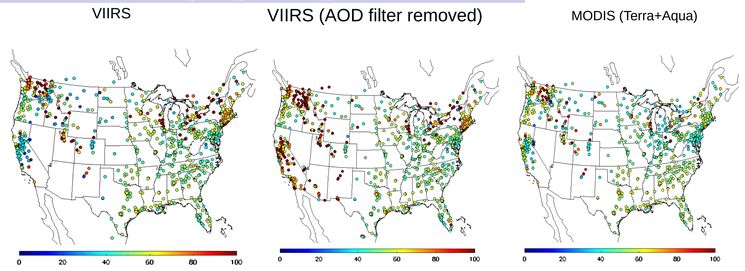


PM2.5 without AOD filter 20160128



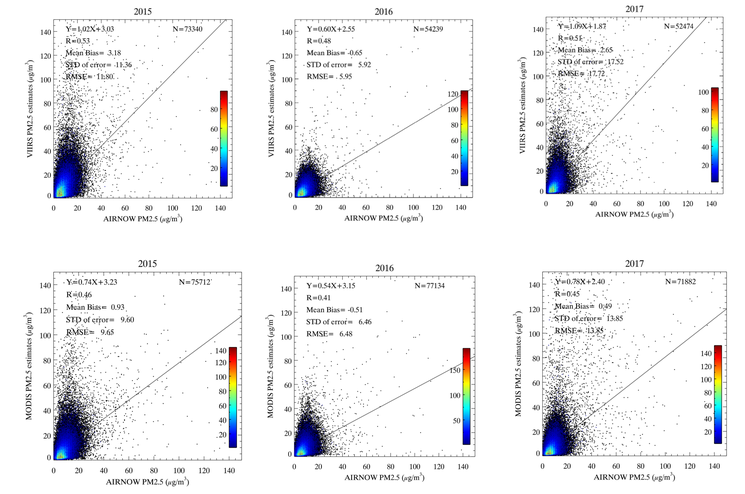
PM2.5 with AOD filter 20160128

1-σ uncertainty ±(1+xx%) for 2015-2017



	VIIRS	VIIRS(AOD filter removed)	MODIS	On the paper (van Donkelaar 2012)
1-sigma uncertainty	± (1 μg/m³ + 56%)	± (1 μg/m³ + 63%)	± (1 μg/m³ + 54%)	± (1 μg/m³ + 41%)
Number of matchups	180,053	275,241	224,728	

Scatter Plots



Summary

- PM2.5 estimates from VIIRS AOD have similar performance as those from MODIS AOD
- The AOD filter used improves the performance
- The accuracy of PM2.5 estimates varies in different years
- We are working with NCEP to use this approach to estimate surface PM2.5 from GOES-16 AOD.

Acknowledgment
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Reference

Van Donkelaar, et al., 2012: Improving the Accuracy of Daily Satellite-Derived Ground-Level Fine Aerosol Concentration Estimates for North America, Environ. Sci & Tech., 46, 11971−11978.