Possibilities and Challenges of Using Satellite Data for PM2.5 Prediction and Monitoring

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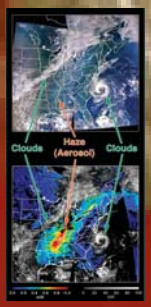
Introduction

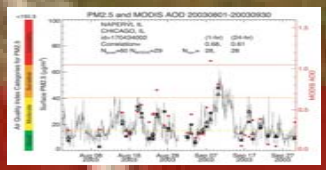
- PM2.5 (particulate matter, or aerosol particles, with diameter less than 2.5 μm) is a key component determining air quality
- Accurate PM2.5 forecasts require continuous extensive spatial and temporal monitoring of the current sates, a capability which only exists in a few places
- Remote sensing capability of atmospheric aerosol optical thickness (AOT) could lead to a quantum leap in our ability of air quality monitoring and prediction, especially for regions where surface monitoring network does not exist
- A recent NASA-NOAA-EPA prototype study has demonstrated the usefulness of using satellite aerosol data to guide local PM2.5 forecasts (Al-Saadi et al., BAMS, September 2005)
- We use satellite data, surface measurements, and a global model to answer the following questions:

1. ***Can satellite AOT data be quantitatively used to predict surface PM2.5?***
2. ***Can assimilation of satellite AOT data improve the PM2.5 prediction?***



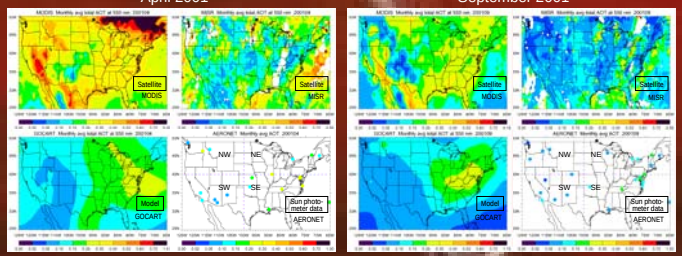
Satellite data (MODIS) tracks surface PM2.5, providing guidance for local PM2.5 forecast

(Figure from Al-Saadi et al., BAMS 2005)



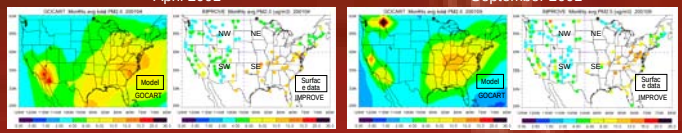
AOT from MODIS, MISR, GOCART, and AERONET

April 2001 September 2001



Surface PM2.5 from IMPROVE and GOCART

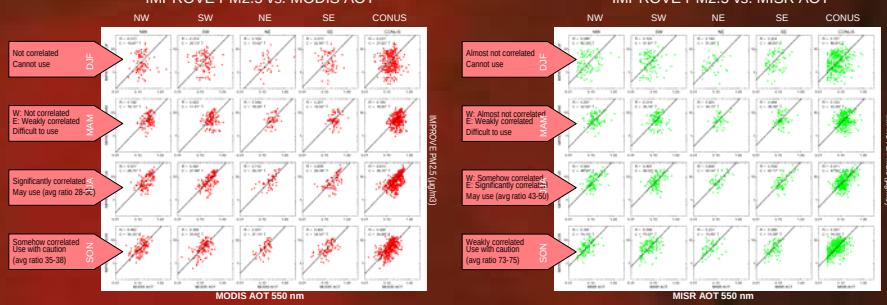
April 2001 September 2001



1. Can satellite AOT data be quantitatively used to predict surface PM2.5?

Relationship between AOT and PM2.5 over U.S.

IMPROVE PM2.5 vs. MODIS AOT IMPROVE PM2.5 vs. MISR AOT

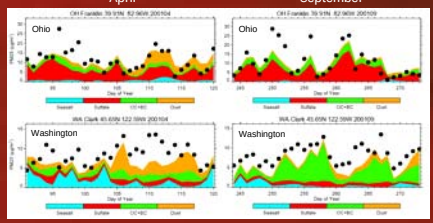


How can we explain the variation of the AOT-PM2.5 relationships?

Besides the uncertainties in satellite retrievals and surface measurements, the fundamental requirements for a robust AOT-PM2.5 relationship are (1) stable vertical distributions (e.g., most aerosol in the BL), and (2) constant aerosol compositions (thus their optical properties). However these requirements are only met in certain seasons and regions.

Aerosol composition changes with time and location:

April September

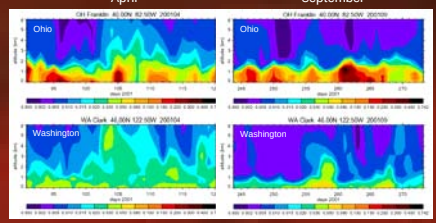


PM2.5 concentrations

(black circle: data Color shades: GOCART model)

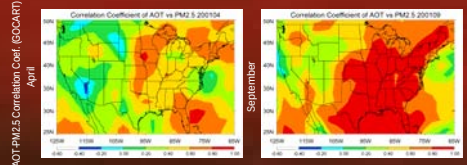
Aerosol vertical profile changes with time and location:

April September



Aerosol extinction at 550 nm

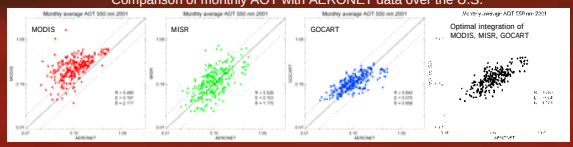
(GOCART model)



- **AOT and PM2.5 is better correlated in the eastern half of the U.S. than in the western half**
- **AOT and PM2.5 is better correlated in September than in April**
- **This is mainly because the change in composition and/or vertical structure**

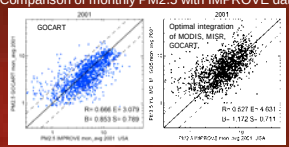
2. Can assimilation of satellite AOT data improve the PM2.5 prediction?

Comparison of monthly AOT with AERONET data over the U.S.



- **Optimal integration of MODIS, MISR, and GOCART AOT has improved the accuracy of AOT compared with AERONET…**

Comparison of monthly PM2.5 with IMPROVE data



- **…but the improvement of AOT does not necessarily improves the quality of surface PM2.5 !**

Conclusions

- **Satellite remote sensing of aerosol optical thickness provides important guidance for PM2.5 estimates, but quantitative use depends on location and season since the relationship depends on aerosol vertical profile and composition**
- **The quantitative use of AOT-PM2.5 over the U.S. seems possible during the summer and early fall and when most sources are "local", but more thorough statistics are needed**
- **Using aerosol assimilation of satellite data may not improve PM2.5 prediction compared with using model only, due to lack of constraints of vertical profile and composition**
- **With new satellite capabilities (e.g., CALIPSO on aerosol vertical distribution), future assimilation are likely to significantly enhance the PM2.5 estimation using the 3-D satellite data**

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