Particulate Matter Air Quality Assessment using Combined Satellite and Ground Measurements

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Introduction

Main focus: Can satellite data provide assessment of air quality?

Recent work with MODIS: Wang and Christopher, *GRL*, 2003; Chu et al., *JGR*(2003); Engel-Cox et al., *AE*(2004); Hutchinson, *AE*(2003), and MISR (Liu et al., 2004, 2005).

Premise: Satellite derived column AOT related with PM2.5 ground measurements and could be a cost effective way for monitoring air pollution and possibly forecasting.

MODIS AOD captures spatial extent of large scale aerosol events during cloud free conditions
Fig. courtesy, J. Szykman
Surface Aerosol Rayleigh Scattering Water vapor + other gases (absorption) Ozone 10km

Aqua Satellite

Aerosol Optical Thickness: Basis

Column Satellite Measurement

Sun

0.47, 0.55, 0.65, 0.86, 1.24, 1.64, 2.13 µm 10X10 km² Res.

Seven MODIS bands are utilized to derive aerosol properties: 0.47, 0.55, 0.65, 0.86, 1.24, 1.64, and 2.13 µm 10X10 km² Res.

Rayleigh Scattering

Water vapor + other gases (absorption)

Aerosol

\[ AOT(\tau) = \int \beta_{ext} \, dz \]

Particle size Composition Water uptake Vertical Distribution

Satellite retrieval issues - inversion (e.g. aerosol model, background).
4 day sequence showing transport of regional pollution event. Posts show EPA PM2.5 ground-based measuring site. Color contours are MODIS aerosol optical depth.
MODIS AOD vs. PM2.5: Texas

Time Series shows agreement of hourly PM2.5 Concentrations (Surface Monitor) and Aerosol Optical Depth in Coincident MODIS pixel. Correlation Coefficient > 0.88.

Fig. Courtesy, J. Szykman, (EPA), A. Chu, NASA
Results

Study area. Circles: PM$_{2.5}$ observation stations. Triangles: power plants.

Hourly PM2.5 correlated well with MODIS Terra and Aqua AOT

Daily PM2.5 and AOT relationship used to obtain AQI categories from MODIS

Excellent correlation between 24-hr PM2.5 and MODIS AOT

Global PM2.5 – MODIS AOT

Gupta, Christopher et al., submitted to AE.
Very few PM2.5 measurements available – especially in other countries. MODIS is an excellent tool for Monitoring air pollution.

Gupta, Christopher et al., submitted to AE.
Forecasting PM2.5 using mesoscale model

RAMS-AROMA

Regional Atmospheric Modeling System (RAMS) - CSU + Assimilation and Radiation Online Modeling of Aerosols (AROMA)

- WF_ABBA Fires
- FLAMBE smoke emission
- RAMS model
- SCAR-B aerosol
- NCAR/NCEP fields
- Four-stream RT mode
- Online RT calculations

Wang, Christopher, et al., 2005 - in press, JGR

RAMS-AROMA is a fully coupled meteorology, aerosol and radiation model. It assimilates the hourly smoke emission derived from geostationary fire products.
Simulated PM2.5 mass compares well with PM2.5 mass reported at the ground.

Wang, Christopher, et al., 2005 JGR – in press.
Summary

Good correlation between MODIS column AOT and PM$_{2.5}$ mass – especially 24-hr. averages.

- Current satellite data has tremendous potential for air quality applications – world wide!

- Sensitivity studies indicate that low cloud cover, low humidity and aerosols near the surface are ideal conditions for using MODIS data for monitoring air pollution.

- AOT data can be used to develop AQI categories, However, further research needed to examine vertical distribution of aerosols, hygroscopicity and chemical composition. Ground and space-borne lidars needed.

- Satellite data can be used where PM$_{2.5}$ measurements are not available. However cloud cover is a problem for satellites.

- Assimilation of satellite-derived smoke emission and AOT data in provides information to forecast pollution when sources are from outside the U.S.

- Combination of satellite and regional models will be successful for forecasting pollution.

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