Estimating Fine Particle SO4 Concentrations Using MISR Aerosol Properties

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Research Objective and Plan

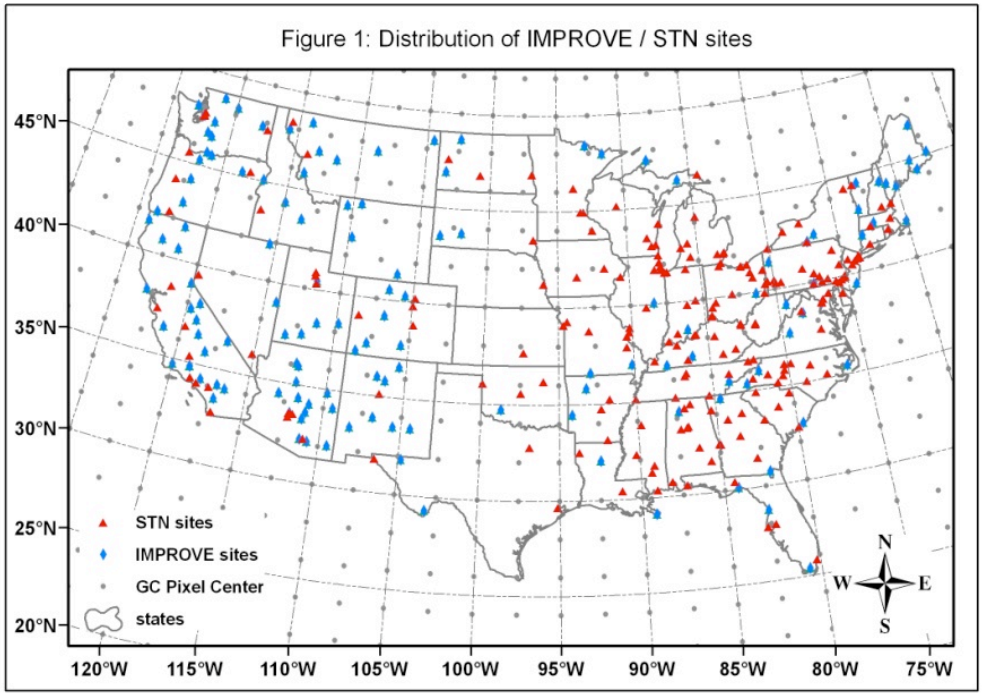
Evaluate how GC aerosol profiles and nonlinear structure improve model predictability

1. Develop MISR fractional AODs from MISR aerosol microphysical data
2. Collect STN/IMPROVE daily SO4 as ground truth
3. Build alternative statistical models using fractional AODs as predictors to estimate the SO4 concentrations

Data and Domain

- MISR L2 ASAE in 2001 and 2005, v17
- GC aerosol simulations, v7-3-6
- STN / IMPROVE daily SO4 (~ 300 sites)

Two networks produce consistent SO4 measurements so no network indicators are needed.



Model Structure

$$Step\,1: Fractional\ AOD_i = \frac{\sum_{j=1}^{74} \alpha\ AOD_{\text{mixture j}} \times Fraction_{component\ i\ in\ mixture\ j}}{No.\ of\ "Successful\ Mixtures}$$

$$Step\,2: MISR\ surface\ fractional AOD = \frac{GC\ surface\ loading}{GC\ column\ loading} \times MISR\ fractional AOD$$

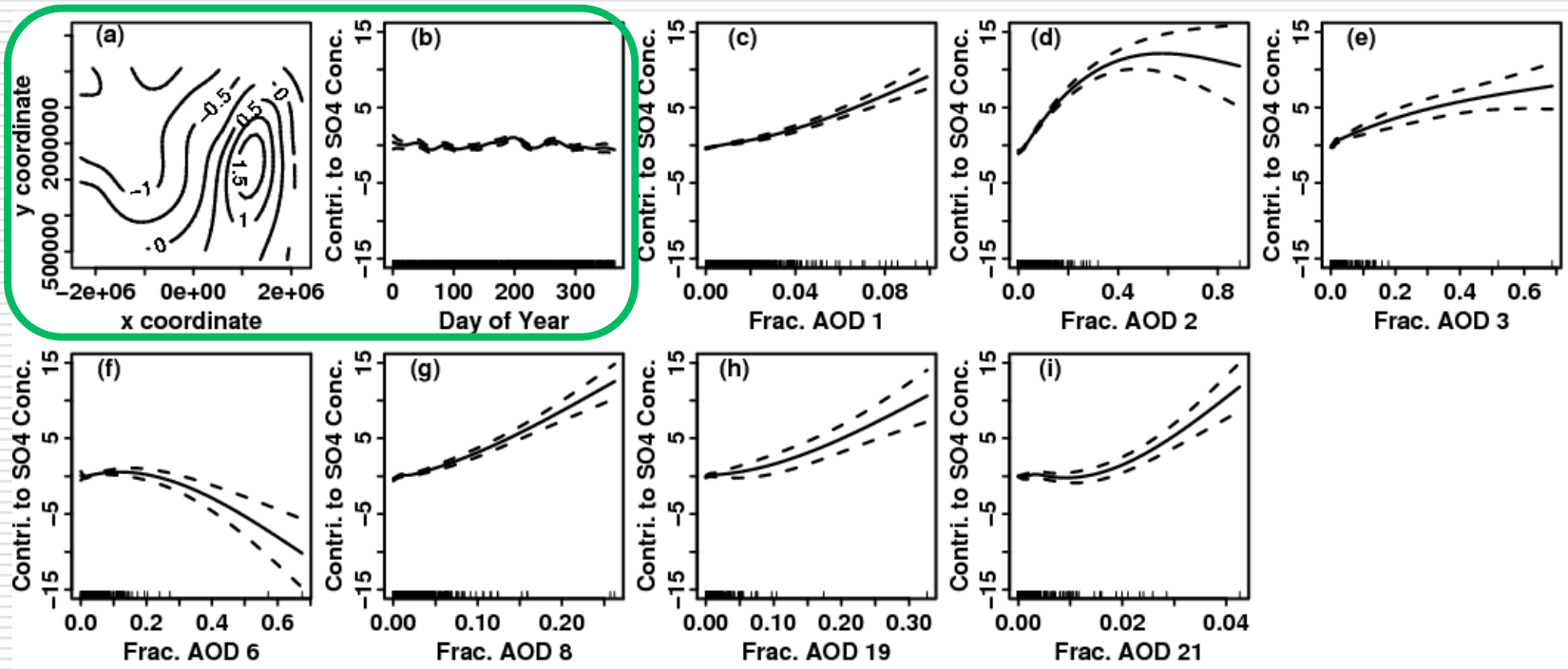
Step 3 :

$$Full\ GAM: \quad [SO4] \sim N(f_{x,y}(x,y) + \sum f_i(surface\ fractional AOD_i) + f_t(t), \sigma^2)$$

$$Alternative\ GAM: [SO4] \sim N(f_{x,y}(x,y) + \sum f_i(column\ fractional AOD_i) + f_t(t), \sigma^2)$$

$$Alternative\ GLM: [SO4] \sim N(\mu + \sum \beta_i \times surface\ fractional AOD_i + \beta_s \times season, \sigma^2)$$

Full GAM Parameter Estimates



1. **Spatial and temporal biases are significant but their influences on predicted SO4 are not large (~10%).**
2. **All significant fractional AODs have, to various degrees, nonlinear relationships with SO4 concentrations.**

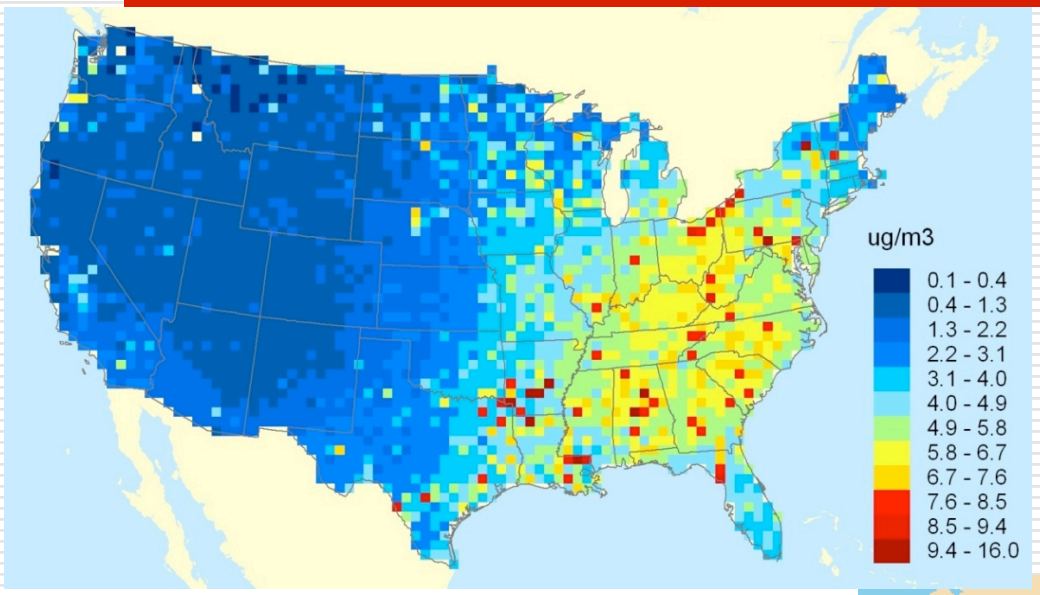
Model Fitting Comparisons

Sample size	Whole continental U.S., n = 1429	
Full GAM Significant predictors Model adj. R^2	AOD_1, AOD_2, AOD_3, AOD_8, AOD_{19}, AOD_{21}, DOY, (x,y) 0.70 (0.62)	
Sample size	Eastern U.S, n = 798	Western U.S., n = 631
Full GAM Significant predictors Model adj. R^2	AOD_1, AOD_2, AOD_3, AOD_8, AOD_{19}, AOD_{21}, DOY, (x,y) 0.70 (0.64)	AOD_1, AOD_2, AOD_3, AOD_8, AOD_{19}, AOD_{21}, DOY, (x,y) 0.66 (0.48)
Alternative GAM Significant predictors Model adj. R^2	AOD_{1c}, AOD_{2c}, AOD_{3c}, AOD_{8c}, AOD_{19c}, AOD_{21c}, DOY, (x,y) 0.65 (0.54)	AOD_{1c}, AOD_{2c}, AOD_{3c}, AOD_{8c}, AOD_{19c}, AOD_{21c}, DOY, (x,y) 0.59 (0.30)
Alternative GLM Significant predictors Model adj. R^2	AOD_1, AOD_2, AOD_3, AOD_8, AOD_{19}, AOD_{21}, season 0.51	AOD_1, AOD_2, AOD_3, AOD_8, AOD_{19}, season 0.44

Summary

- Full GAM can predict daily SO4 with reasonable accuracy in entire US (r ~ 0.8, low bias ~ 15%)
- GC aerosol profiles improve adj. R2 by 15 – 30% by removing upper signals in the AOD values.
- Nonlinear model structure improve adj. R2 by 10 – 15% by providing more degrees of freedom.

Spatial Prediction



Predicted annual average SO4 concentrations

STN/IMPROVE interpolated annual SO4 concentrations