Uncertainties in estimating health effects of PM$_{2.5}$ exposure

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Motivation

Exposure to particulate matter (PM$_{2.5}$) has negative impacts on human health
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“Satellite-based” PM$_{2.5}$

Exposure and Health Effects:
- Burden of disease (Evans et al., 2013)
- Global childhood asthma (Anderson et al., 2012)
- Lung cancer in Canada (Hystad et al., 2012)
- etc.

(van Donkelaar et al., 2010)
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“How Satellite-based” PM$_{2.5}$

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Questions:
1. How much does potential uncertainty in the model impact these results?
2. How does this model uncertainty compare to other sources of uncertainty?
Factors that influence health burden estimates

- PM$_{2.5}$ Concentration
- Risk estimates from epidemiology studies
- Population data
Factors that influence health burden estimates

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Factors that influence satellite-based PM$_{2.5}$ estimates

\[
\text{PM}_{2.5} = \eta \times \text{AOD}_{\text{satellite}} \quad \text{where} \quad \eta = \frac{\text{Model PM}_{2.5}}{\text{Model AOD}}
\]

Function of:
- vertical distribution
- aerosol types
- optical properties
- meteorology
Potential Model Uncertainty

*Model-to-Model Comparison*

- Variability in AOD and $\eta$
- Impact of vertical profile:
  - Seasonally-representative Profile
  - Seasonally-representative Relative Humidity Profile
  - No Nitrate
- Optical Properties
  - Sulfate vs. Hydrophobic Black Carbon
- Model Resolution
Potential Model Uncertainty

*Model-to-Model Comparison*

Substantial regional differences
Important to simulate variability and longer term means
Concentration-Response Function and Risk Ratio Uncertainty

Average Mortality Due to Chronic Exposure: USA

Mortality estimates using different RRs, C-R functions, and threshold values
- **4%** of total deaths in the U.S., **22%** in China attributable to PM$_{2.5}$ exposure.
- Difference between standard model and satellite-based estimates falls within range of potential model uncertainty ($\eta$) (decreases with less reliance on the model).
- RR and C-R function leads to largest source of uncertainty in burden estimates.

→ *Uncertainty decrease as product more widely used*