



MAPLE: Mortality Air Pollution Associations in Low Exposure Environments

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Background

- Fine particulate matter (PM_{2.5}) is a causal mortality risk factor, even in Canada where most of the population lives in areas with low ambient concentrations (<12 µg/m³)

Study objectives

- Apply novel satellite-based estimates of PM_{2.5} exposure to 4 large population-based cohorts in Canada
 - Canadian Community Health Surveys (CCHS)
 - Long-form census: 20% mandatory response
 - 1991: 2.5M 1996: 3.5M 2001: 3.5M
 - Nationally-representative
 - Death registry & annual residential history (tax records) to 2016
 - Many socioeconomic covariates
 - Size: ~10 million subjects Up to 25 yrs follow-up
 - Baseline = 2001-2012
 - n=540,900
 - Depth: Self-reported health behaviours (BMI, diet, physical activity, smoking, alcohol consumption)
 - Canadian Census Health & Environment Cohorts (CanCHEC)
- Characterize shape of the PM_{2.5} mortality relationship

- Satellite-based PM_{2.5} estimates highly correlated with ground monitors (R² = 0.82) across North America; Root-mean-squared-error = 1.5 µg/m³.

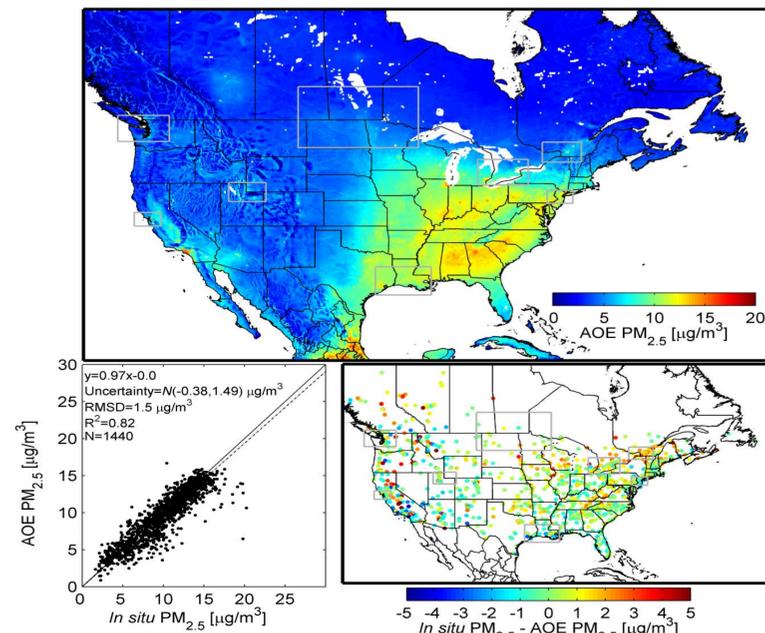


Figure 2. Satellite-derived PM_{2.5} estimates and ground monitors. Top: mean 1 km satellite-derived estimates (2004–2008). Lower right: difference between in situ and satellite-derived observations.

Satellite-based PM_{2.5} exposure estimates

- Annual ~1km x 1km estimates for 1981-2016 across North America
- Further refinements by incorporating information on spatiotemporal aerosol optical depth (AOD) : PM_{2.5} relationship from measurements at 5 SPARTAN Network sites in Canada¹

- Apply historical PM_{2.5}, PM₁₀, and TSP measurements to back-cast remote-sensing based estimates
- PM_{2.5} dataset developed to calibrate satellite-based estimates and GEOS-Chem simulations historically to estimate average annual concentrations between 1981-1998²

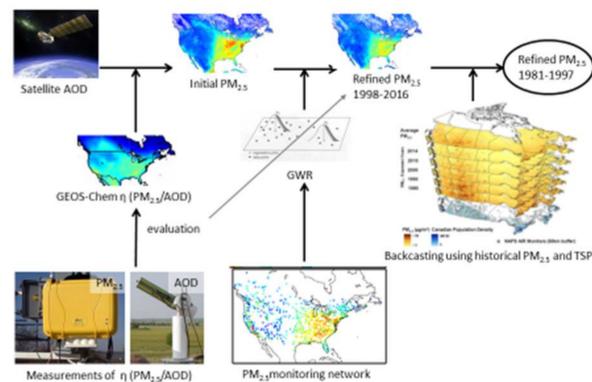


Figure 1. PM_{2.5} exposure estimation development process

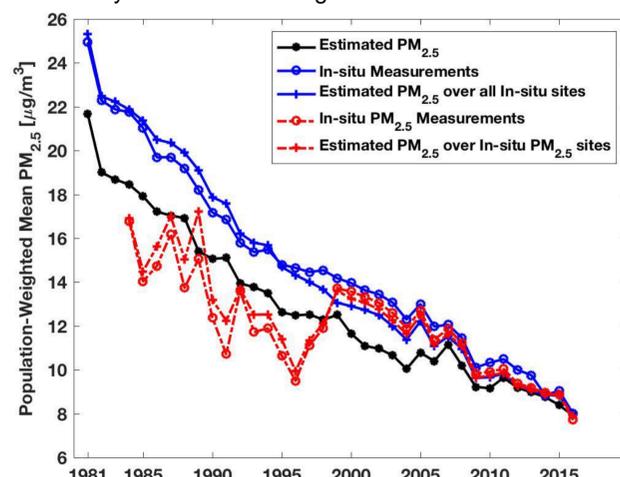


Figure 3. North American population-weighted average annual PM_{2.5} concentrations time series

Epidemiologic analyses

- Models stratified by age, sex, airshed, and census/CCHS cycle; adjusted for income quintiles, educational attainment, marital status, indigenous identity, visible minority status, immigrant years spent in Canada, Census area size, 3 dimensions of marginalization index.
- Additional adjustment in CCHS for fruit and vegetable consumption, leisure exercise frequency, alcohol consumption, smoking.

Table 1. PM_{2.5} mean (3-year average) concentrations by selected covariate categories for pooled (1991, 1996, 2001) CanCHEC and CCHS cohorts

Covariate	Category	CanCHEC PM _{2.5} (µg/m ³)	CCHS PM _{2.5} (µg/m ³)
Full cohort	(all p-y follow-up)	7.4	5.9
Immigrant Status	Non-Immigrants	7.1	5.8
	Immigrants	8.6	7.0
Education	< High School	7.3	5.7
	University	7.8	6.2
Indigenous Identity	Non-Indigenous	7.5	6.0
	Indigenous	5.3	4.9
Residential Instability (Can-MARG)	Lowest	6.6	5.3
	Highest	8.8	7.2
Ethnic Concentration (Can-MARG)	Lowest	6.2	6.0
	Highest	8.9	5.3
Community Size	<10,000	5.3	4.7
	>1.5 million	9.1	7.5
Urbanization	Low	6.1	5.5
	High	9.2	7.6

Table 2. Cox proportional hazard ratios for non-accidental mortality per 10 µg/m³ increase in PM_{2.5} concentration. ^a Excludes immigrants living in Canada < 10 years

	CanCHEC (pooled)		CCHS	
	HR	95% CI	HR	95% CI
Full cohort	1.05	1.04 - 1.05	1.11	1.04 - 1.18
Non-immigrants	1.07	1.06 - 1.08	1.14	1.07 - 1.23
Immigrants ^a	1.02	1.00 - 1.03	0.98	0.83 - 1.16

Conclusions and future work

- In large population-based cohorts exposed to low levels of air pollution with extended follow-up, **evidence of associations between PM_{2.5} and non-accidental mortality for concentrations as low as 5 µg/m³**
- Future work: refined exposures, specific causes of death, restricted exposures, shape of the concentration-response function, stratified models

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References: ¹Snider et al. Atmos Meas Tech 2015;8:505-21; ²Meng et al. Environ Sci Technol. 2019; doi: 10.1021/acs.est.8b06875