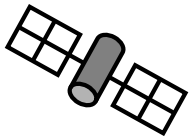

Using TEMPO products to study acute health impacts in the Megalopolis of Central Mexico

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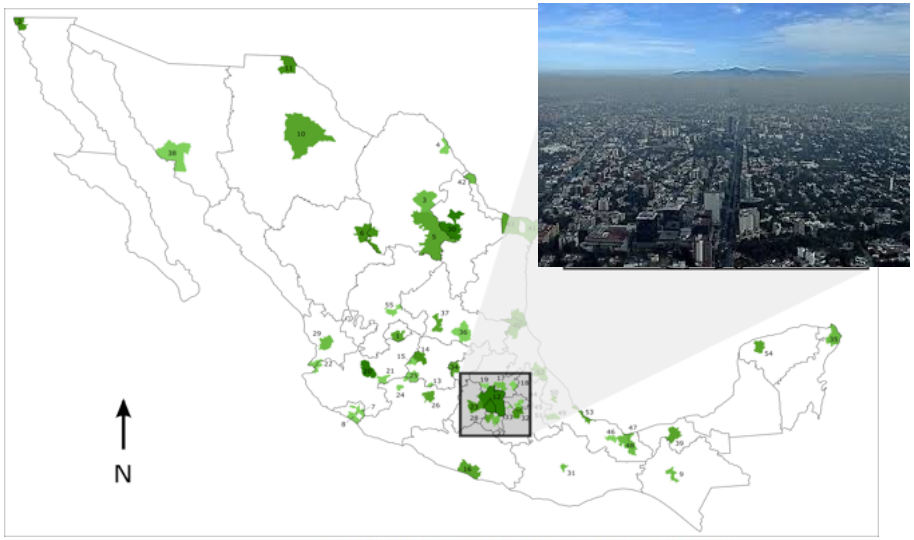
Air pollution in the Megalopolis of Central Mexico (MCM)

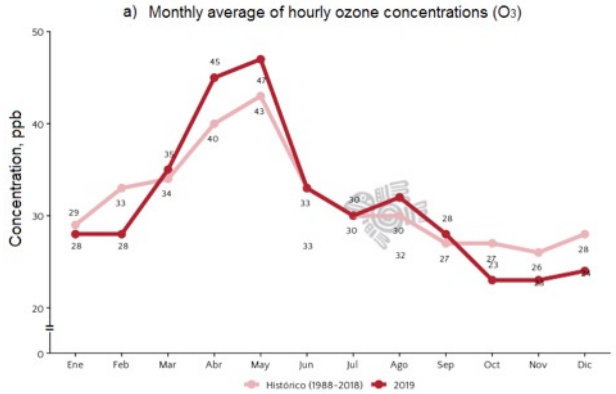
Largest city in North America

- 11 metro areas around Mexico City
- ~30 million people
- Frequent episodes of high O_3 and $PM_{2.5}$ levels trigger environmental contingencies



Complex air pollution patterns

- Irregular geography
- Heterogeneous sources: industrial areas in the north, traffic, volcano activity and fires in the south



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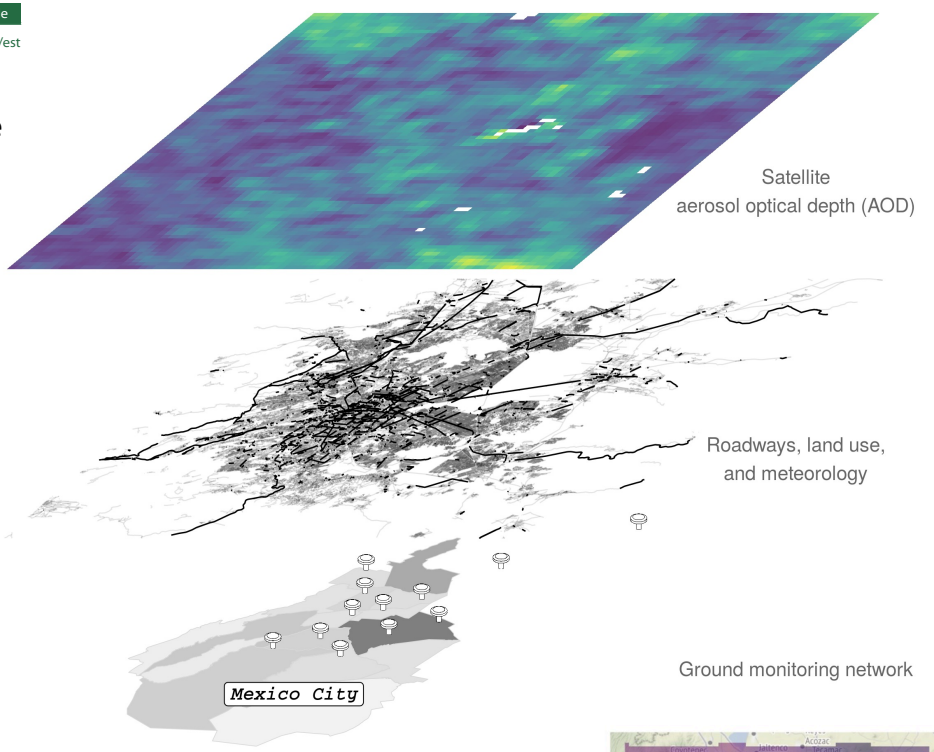
Using High-Resolution Satellite Aerosol Optical Depth To Estimate Daily $PM_{2.5}$ Geographical Distribution in Mexico City

Allan C. Just,*[,†] Robert O. Wright,[‡] Joel Schwartz,[†] Brent A. Coull,[§] Andrea A. Baccarelli,[†] Martha María Tellez-Rojo,[∥] Emily Moody,[⊥] Yujie Wang,[#] Alexei Lyapustin,[▽] and Itai Kloog[¶]



Key features of our model:

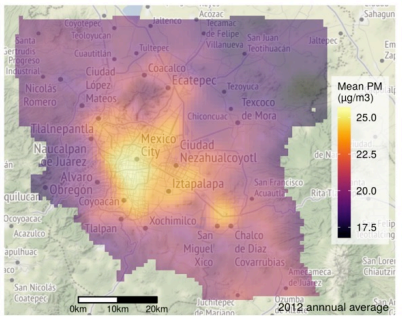
- Daily estimates
- On a 1km * 1km grid
- Spanning 2004-2014
- Cross-validated R^2 of 0.72

Just et al. *Environ Sci Technol*. 2015

Stroke

Cardiovascular and Cerebrovascular Mortality Associated With Acute Exposure to $PM_{2.5}$ in Mexico City

Iván Gutiérrez-Avila, MSc; Leonora Rojas-Bracho, ScD; Horacio Riojas-Rodríguez, PhD; Itai Kloog, PhD; Allan C. Just, PhD; Stephen J. Rothenberg, PhD



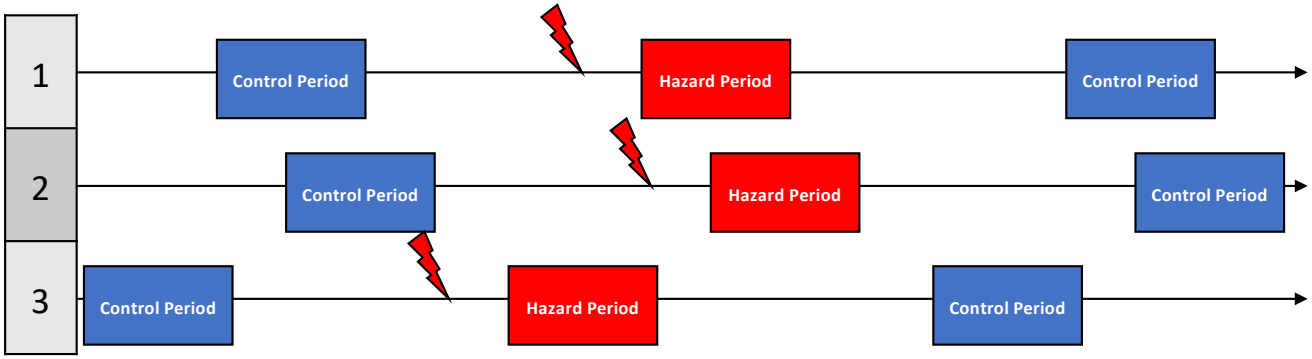
- 10 µg/m^3 higher $PM_{2.5}$ in lag 0-1 days associated with 3.43% (0.10-6.28) higher cerebrovascular mortality

Gutierrez-Avila et al. *Stroke*. 2018

Analyzing short-term exposures: ***Because no one breathes 24-hour averaged air***

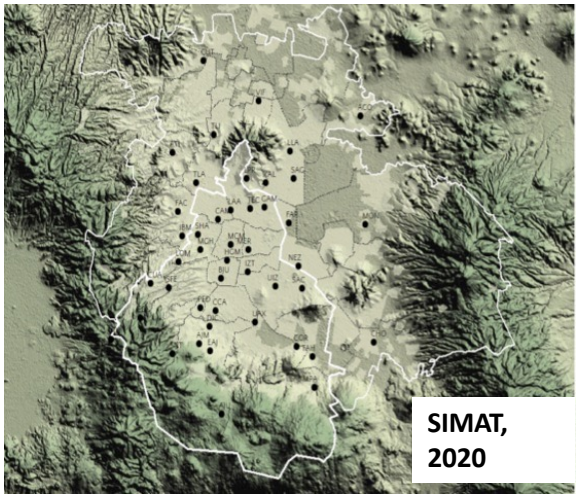
- *Goal*: Analysis of short-term pollutant concentrations and acute health events
- *Exposure*: Hourly pollutant estimates from hybrid satellite / LUR models over sub-county regions
- *Outcomes*: Asthma-related emergency dept visits, cardiovascular hospitalizations, non-external deaths
- *Method*: matched lagged case crossover analysis

a case-only design used to identify triggers of acute health events

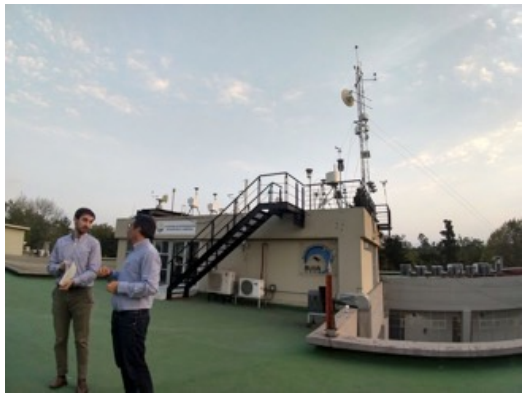


TEMPO data can leverage ground monitoring networks across Greater Mexico City

- Automatic Monitoring Network of Mexico City (RAMA)
  - Hourly averages from continuous measurement of:
    - **SO_2 (28 stations)**
    - **CO (27 stations)**
    - **NO_2 (29 stations)**
    - **O_3 (29 stations)**
    - **PM_{10} (22 stations)**
    - **$PM_{2.5}$ (20 stations)**

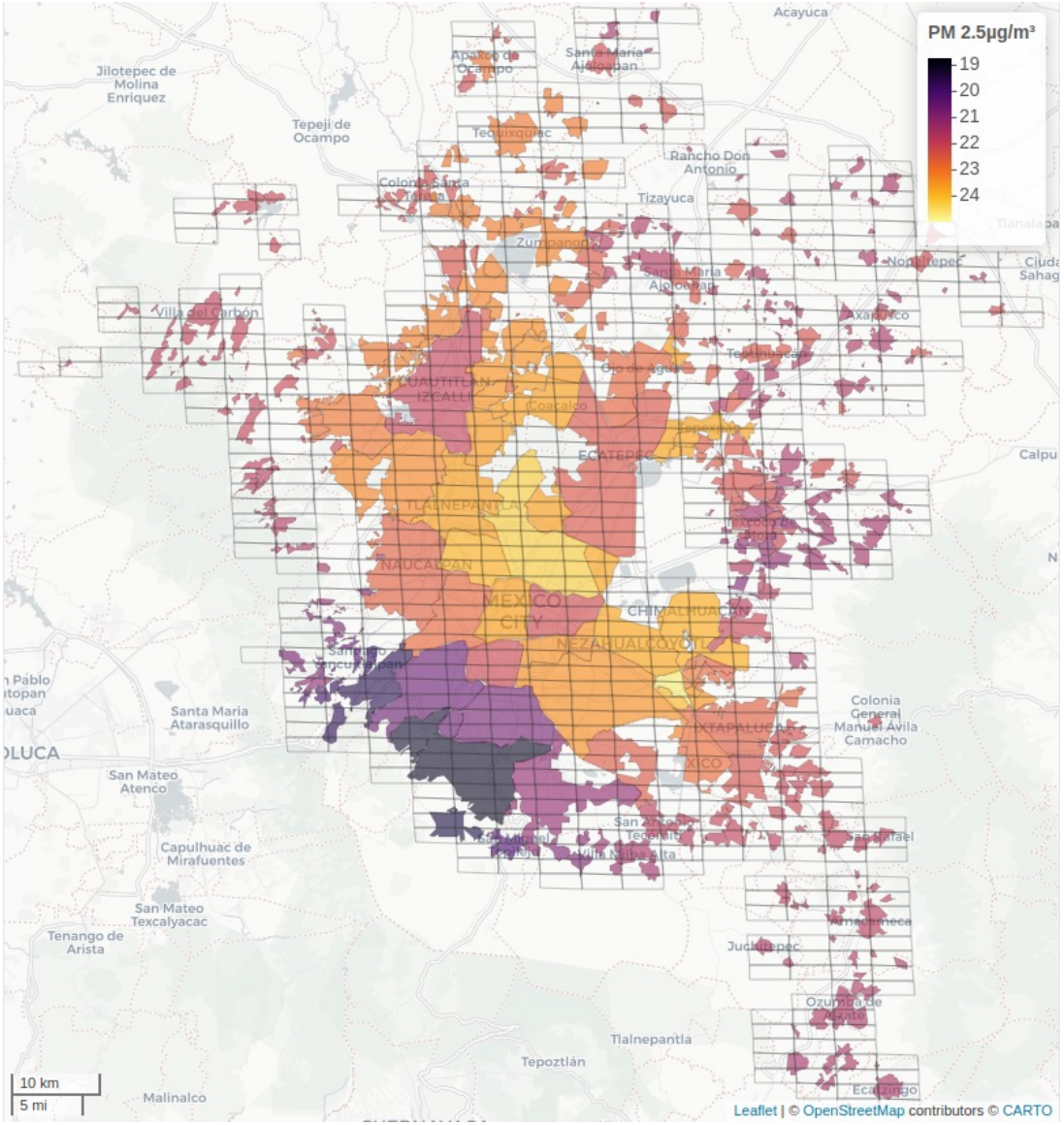


- Automatic Meteorology and Solar Radiation Network (REDMET)
  - Continuous measurements of temperature, relative humidity, wind direction, wind speed, solar radiation and barometric pressure (29 stations)



2019 annual average $PM_{2.5}$ in 586 sub-county regions

(showing 778 intersecting TEMPO cells)



Acute association of $PM_{2.5}$ and non-external deaths

- Time stratified case-crossover for $PM_{2.5}$ and temperature

  largest acute air pollution analysis in Mexico

- Daily exposures for each of 586 sub-county regions assigned from our spatiotemporal satellite/geostatistical model
- **1,516,442 deaths** (≥18 years-old) from 2004-2019

Mortality significantly associated, per 10µg/m^3 $PM_{2.5}$ increase:

- stronger effects for same day, lag0: 1.44% (1.37–1.50%), and
  prior day, lag1: 0.67% (0.60–0.75%)
- 1-week cumulative effect, lag06: 3.52% (3.41–3.63%)

Stratifying by age – stronger effects in the elderly, per 10µg/m^3:

Ages 18-64: lag06: 3.20% (3.03–3.38)

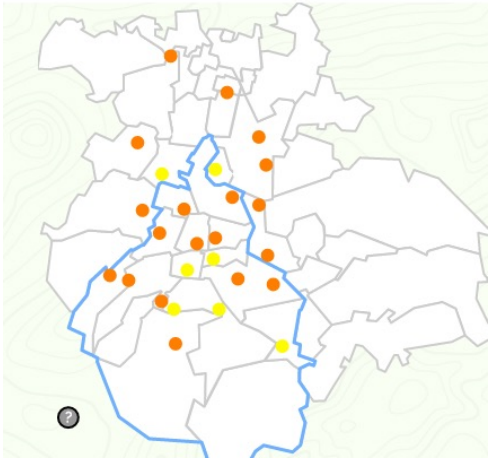
Ages 65+: lag06: 3.71% (3.58–3.85)

Preliminary results, Dr. Gutiérrez-Avila

TEMPO health application use case: An empirical and locally derived AQI

- Current Mexican AQI based on evidence about:
  - Exposure to single pollutants
  - Epidemiology in foreign populations
  - Linear relationships between exposure to AP and health outcomes
  - Only estimated at ground stations
  - Not informative about mixtures

- Opportunity to use TEMPO retrievals to estimate ground-level exposures in the MCM
  - for epidemiologic studies
  - early warning systems

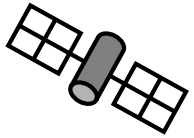


Analyzing mixtures:
Because no one breathes air with a single pollutant

- *Goal*: Construct an empirical Air Quality Index (AQI) for Central Mexico
- *Exposure*: TEMPO-based hybrid satellite exposure models ($PM_{2.5}$, NO_2, SO_2, O_3)
- *Outcome*: deaths, ED visits, or cause-specific hospitalizations by date and sub-county geographic units
- *Method*: Time series or Case Crossover Bayesian Weighted Quantile Sums (BWQS)
- *Results*: An empirically weighted and locally defined AQI

BWQS method from Colicino et al. *Env Epidemiology.* 2020

Opportunities and Challenges: TEMPO and environmental epidemiology



Opportunities for health studies

- Study the influences of within-day variation in air pollutants on health
- Assess the influences of peak exposures on health
- Assess the influence of air pollution mixtures on health
- Derive empirical multi-pollutant air quality indices
- Examine differences in individual and co-pollutants by area-level sociodemographics for environmental justice analyses
- Combine with diverse datasets at similar temporal resolutions, i.e. biometric trackers, cell phones, implantable cardioverter-defribillators, electronic health records, etc

Methodological/practical challenges

- Satellite estimates are integrated over an atmospheric column and must be transformed or trained based on ground-level estimates most relevant to human exposure
- Researchers must identify and gain access to relevant health datasets, which can require substantial administrative time, expense, and care for protection of private information
- Identification of proper epidemiological frameworks for fine-scale and repeated measure modeling
- Lack of retrievals in nighttime and under clouds, etc (but still breathing)
- Lack of historic data for existing cohorts (have to wait for health outcomes after exposure)
- Lack of finer resolution for intra-urban and near-source (e.g.roadway) exposure gradients

Acknowledgments

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