The NAAQS: Substantial Successes and the Challenges Ahead

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Major advancements seen in providing information to support NAAQS reviews!

- Studies targeting lower level exposures (e.g., MAPLE, ELAPSE, Dominici et al.)
  - Important because studies done near or below the current standard are particularly helpful for NAAQS reviews
- Exposure Estimation
  - Satellites, low-cost monitors, mobile
  - Low cost monitors
  - Ensemble products
    - Bringing the power of each approach
  - Increased attention to vulnerable and susceptible communities/populations
  - **Fields more widely available to the community**
- More molecule-level investigations supporting traditional health studies
  - Metabolomics
- Causal modeling methods
  - Accountability framework

Dominici et al., 2019

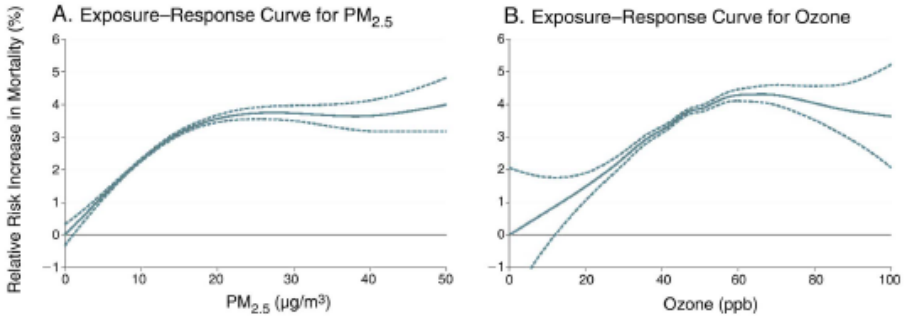
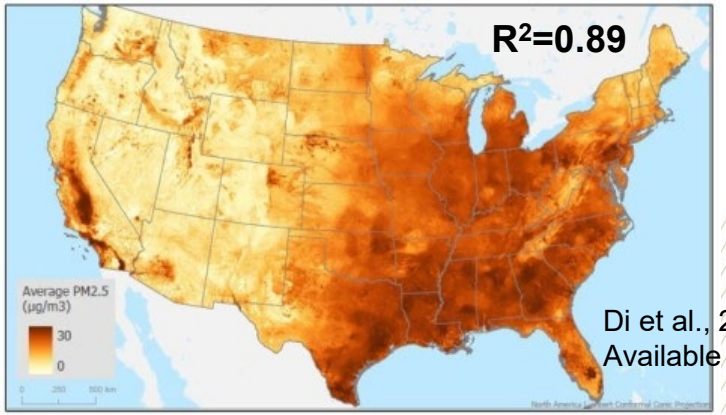
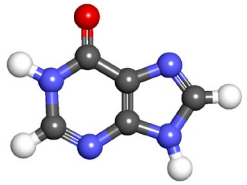
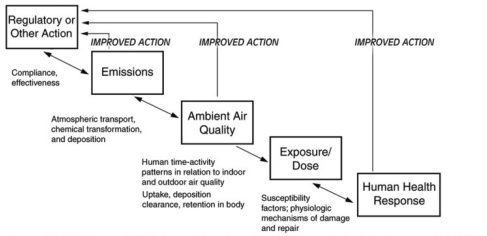


Figure 8. Estimated exposure–response curves for short-term exposures to $PM_{2.5}$ and O_3 (Di et al. 2017a). A two-pollutant analysis with separate penalized splines on $PM_{2.5}$ (A) and ozone (B) was conducted to assess the percentage increase in daily mortality at various pollution levels. Dashed lines indicate 95% CIs. The mean of daily exposure on the same day of death and 1 day prior (lag 01-day) were used as metrics of exposure to $PM_{2.5}$ and ozone. Analysis for ozone was restricted to the warm season (April to September). (ppb = parts per billion.) (Reprinted with permission from Di et al. 2017a, © 2017 American Medical Association. All rights reserved.)



Di et al., 2019, Env. Int. Available at SEDAC





Chain of accountability. Each box represents a link between regulatory action and human health response to air pollution. Arrows connecting the links indicate possible directions of influence. Text below the arrows identifies general indices of accountability at that stage. At several stages, knowledge gained from accountability assessment can provide valuable feedback for improving regulatory or other action.

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Opportunities ahead

- Satellites!
  - TEMPO, MAIA
    - TEMPO: Finer resolution, diurnal coverage over North America
      - Europe and Asia, have their own
    - MAIA: more aerosol properties
- Measurements
  - Instruments getting better and more “compounds”
    - Continuous metals, organic carbon type
  - Networks
    - Europe: ACTRIX; US: ASCENT
      - ACSM (species), XACT (metals), aethalomter (BC), SMPS (size, e.g., ultrafines)
    - Low cost monitors
      - Even more ubiquitous
- Modeling
  - Machine learning (and people-learning about machine learning)
    - Bigger data driving big data

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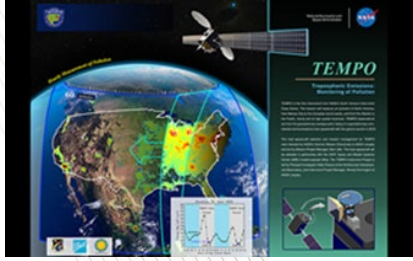
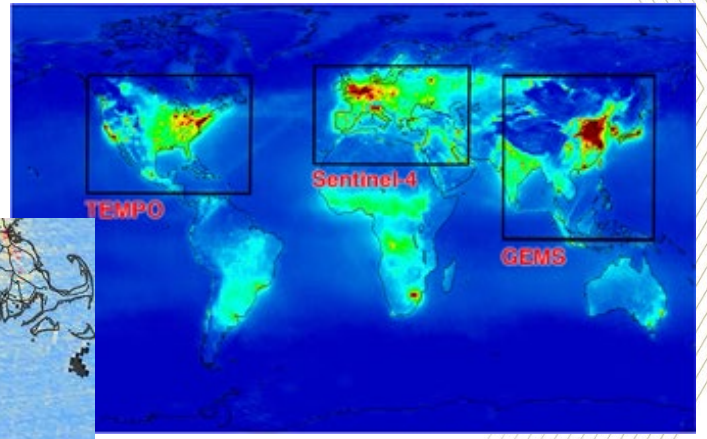
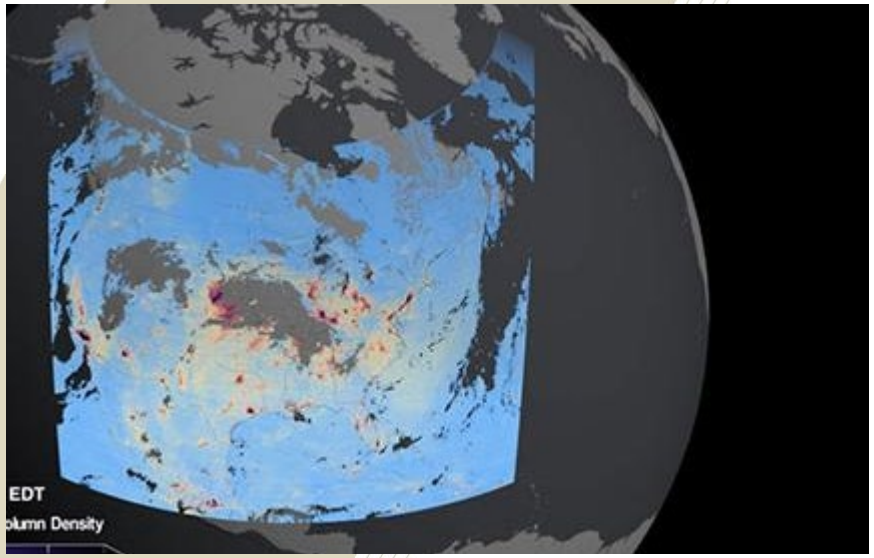
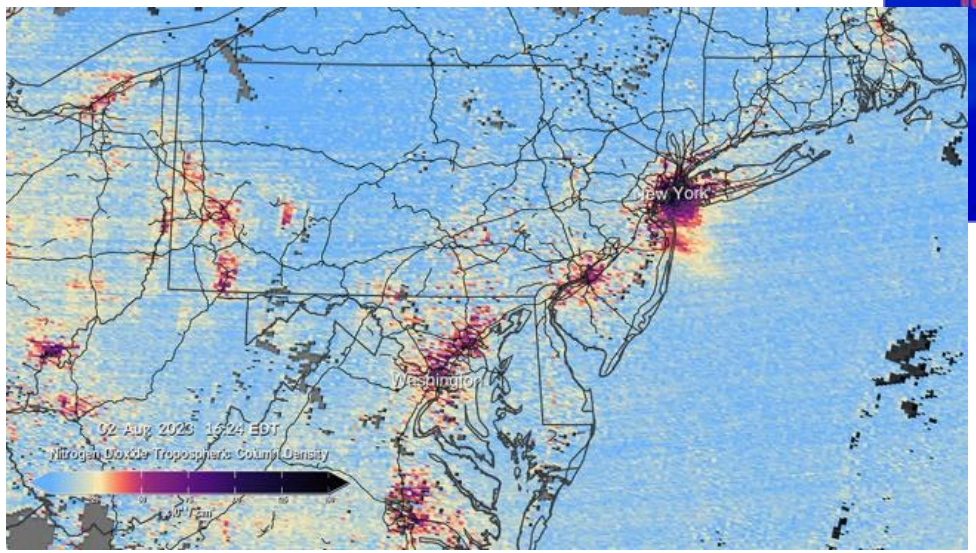
TEMPO



- Tropospheric Emissions: Monitoring of Pollution is up and producing data
  - Geostationary: Provide “continuous” observations (not just during a flyover)
  - Higher resolution
    - Ability to focus in
  - NO2, HCHO, SO2, **0-2km** O3, …
  - One of three (also GEMS:Asia, Sentinal-4: Europe)







TEMPO NO2 VCDs
From NASA

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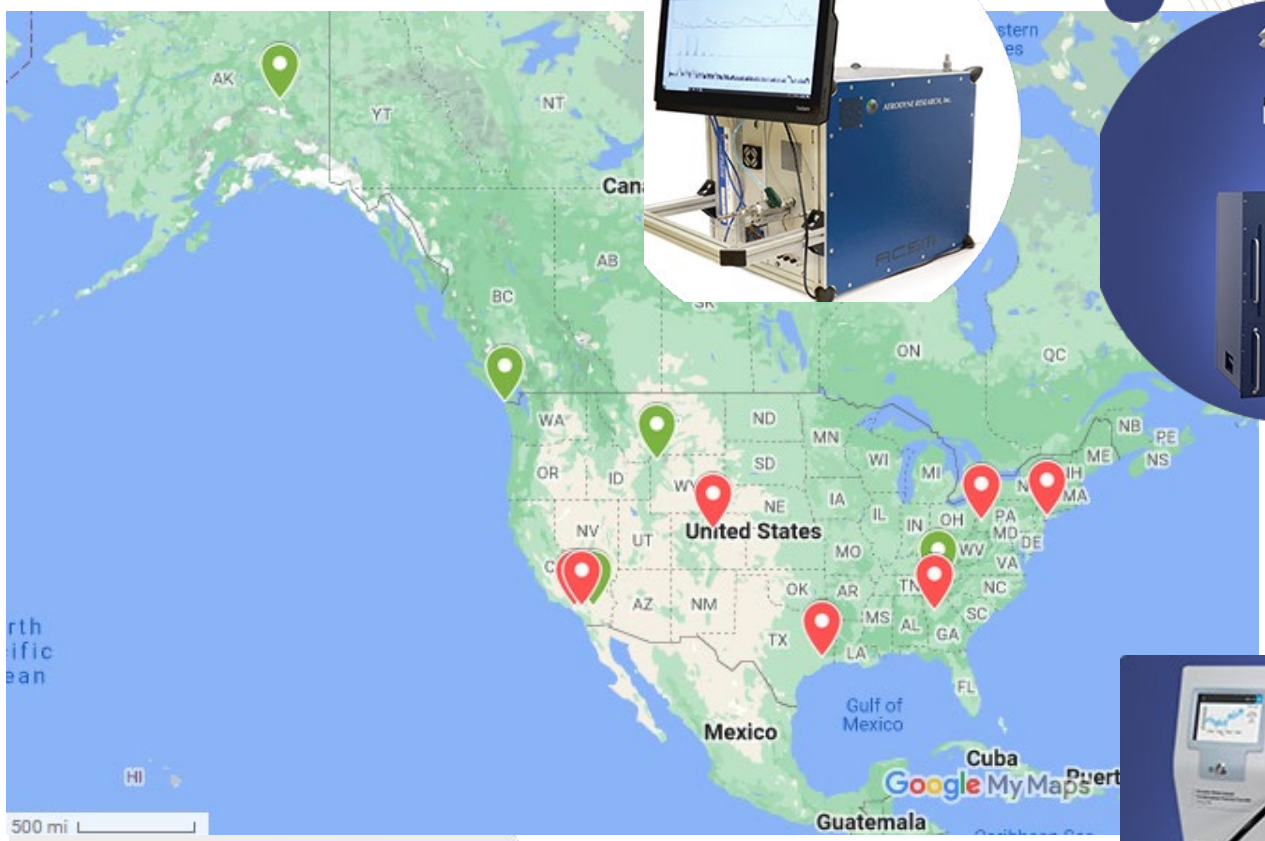
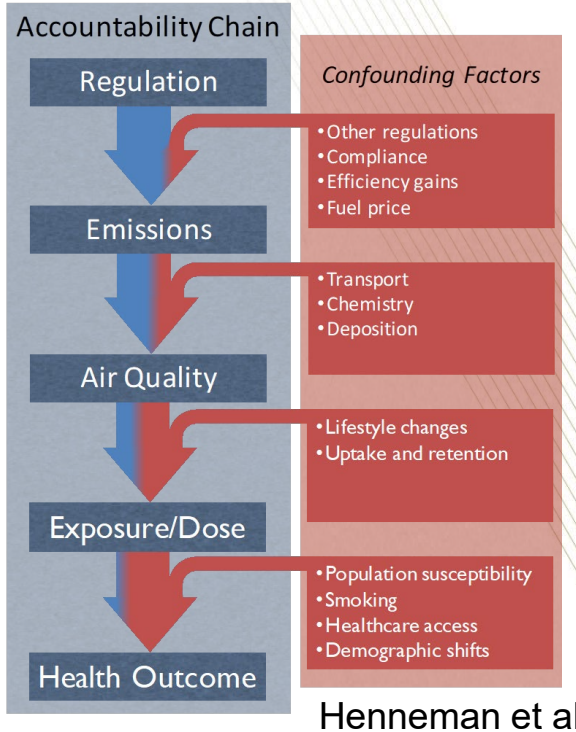
ASCENT: The Atmospheric Science and Chemistry mEasurement NeTwork

- 12 (+) sites across the US
- Co-sited with other networks
  - IMPROVE, NCore, NEON
- Detailed aerosol characteristics
  - ACSM: Speciation (inc. OC)
  - XACT: Metals
  - Aethalometer: BC
  - SMPS: Size distribution
- Near-real time source apportionment

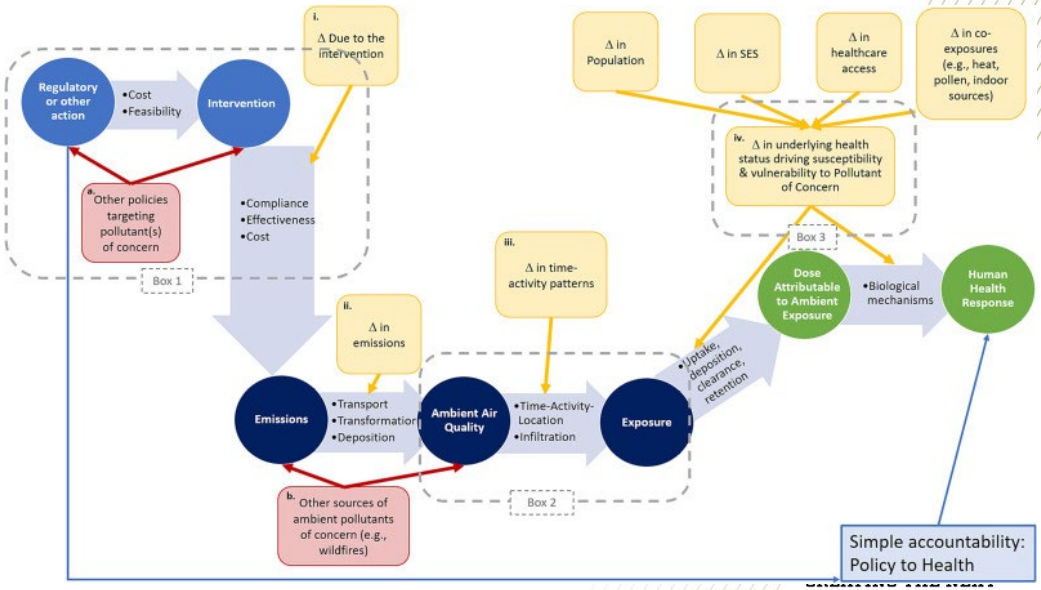


Challenges ahead

- Standard is comprised of Indicator, Form, Level and Averaging Time
  - Need information to support each aspect
    - Lack observational support in some cases
  - New/additional indicators
    - Ultrafines, BC (are they needed?)
  - Averaging times
    - Shorter averaging time for PM?
      - Harder to estimate exposure accurately
  - Multipollutant standards and studies?
- More molecule-level investigation
  - Metabolomics
- Exposure Estimation
  - Fully integrating all exposure modeling tools
    - Molecular and mobile and personal monitoring
  - Dealing with low cost monitoring information
  - Ensemble products
    - Bringing the power of each approach
- Causal modeling methods
- Limits on clinical exposure studies
- Funding is often for new endpoints
  - Deeper knowledge on specific endpoints vs. broader
- Estimation and use of uncertainties



Henneman et al.



Ebelt et al., (2023) Global Epidemiology

Some questions for our panel

- If you were to give the community one piece of advice on how to make their research more informative for supporting NAAQS reviews, what would it be?
- Which is more helpful: Deeper knowledge on specific endpoints or broader knowledge (e.g., additional endpoints)?
- Mixtures vs. single components?
- What specific information or statistics should be included in manuscripts (or supporting materials) and how does this influence how studies are utilized?
- Exposure modeling: how good is good enough (particularly given other activities and other uncertainties)?
- Single vs. multipollutant studies?
- How can we better estimate & express uncertainties?

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