Issues for Health Metrics Related to Ambient Air Pollution

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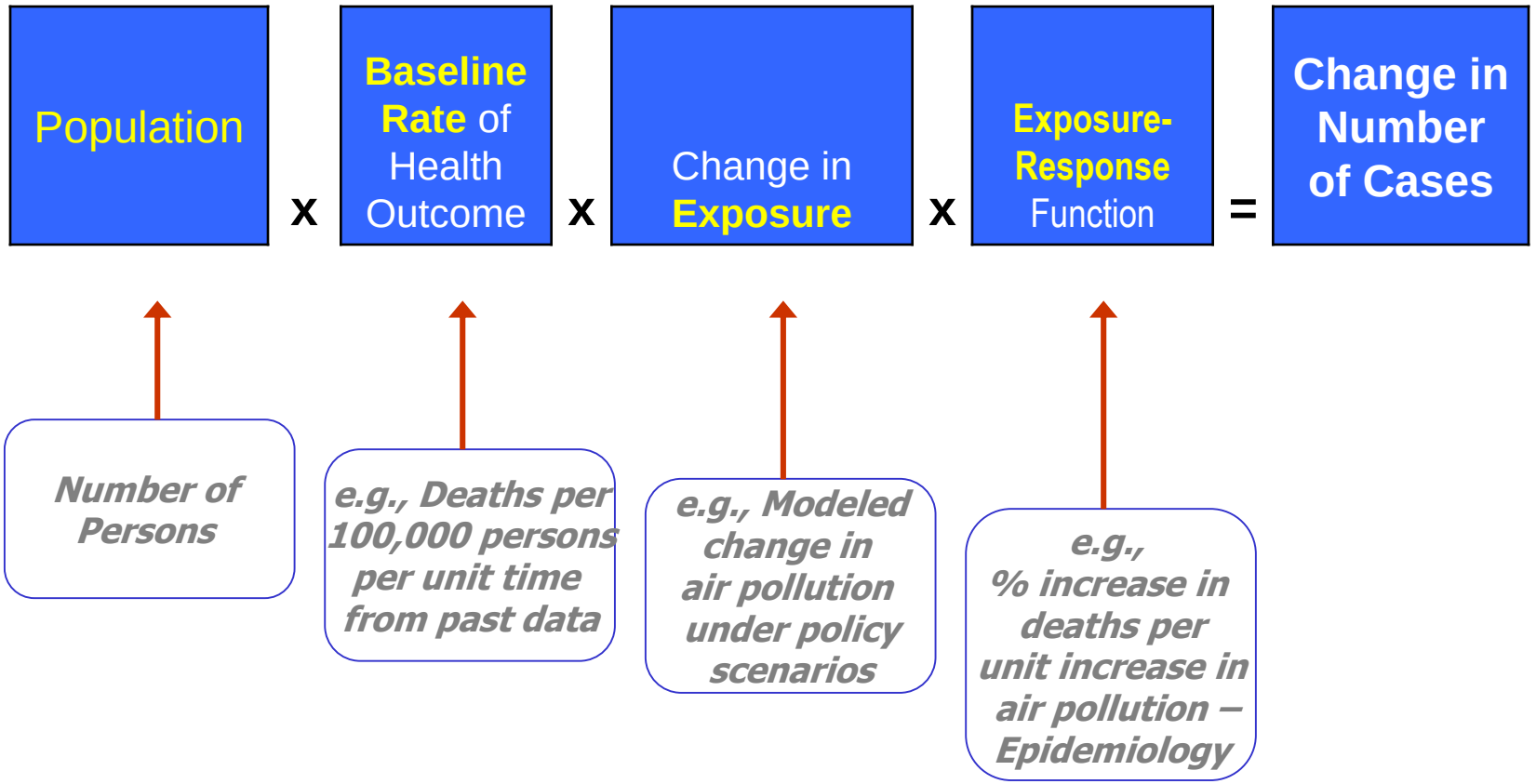
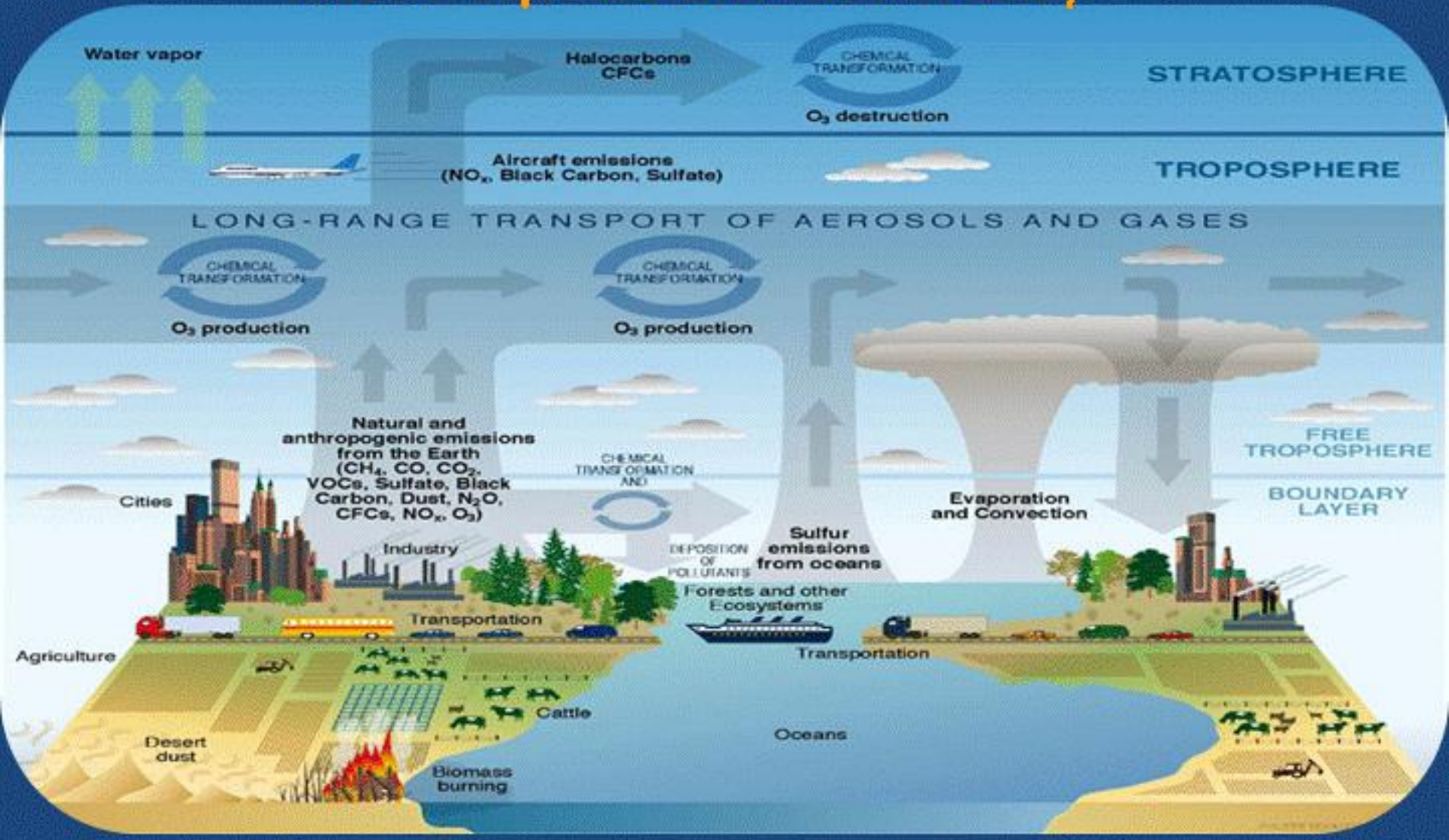
Health Risk Assessment Methodology



Modeling Exposure

- Translates emission changes resulting from policy intervention to changes in ambient air pollution exposures for populations of interest
- Various approaches that range in complexity and robustness
  - Forward chemical transport modeling
  - Inverse (also called “adjoint”) chemical transport modeling
  - Reduced form models
- Spatial scales of analysis
- Temporal scales of analysis

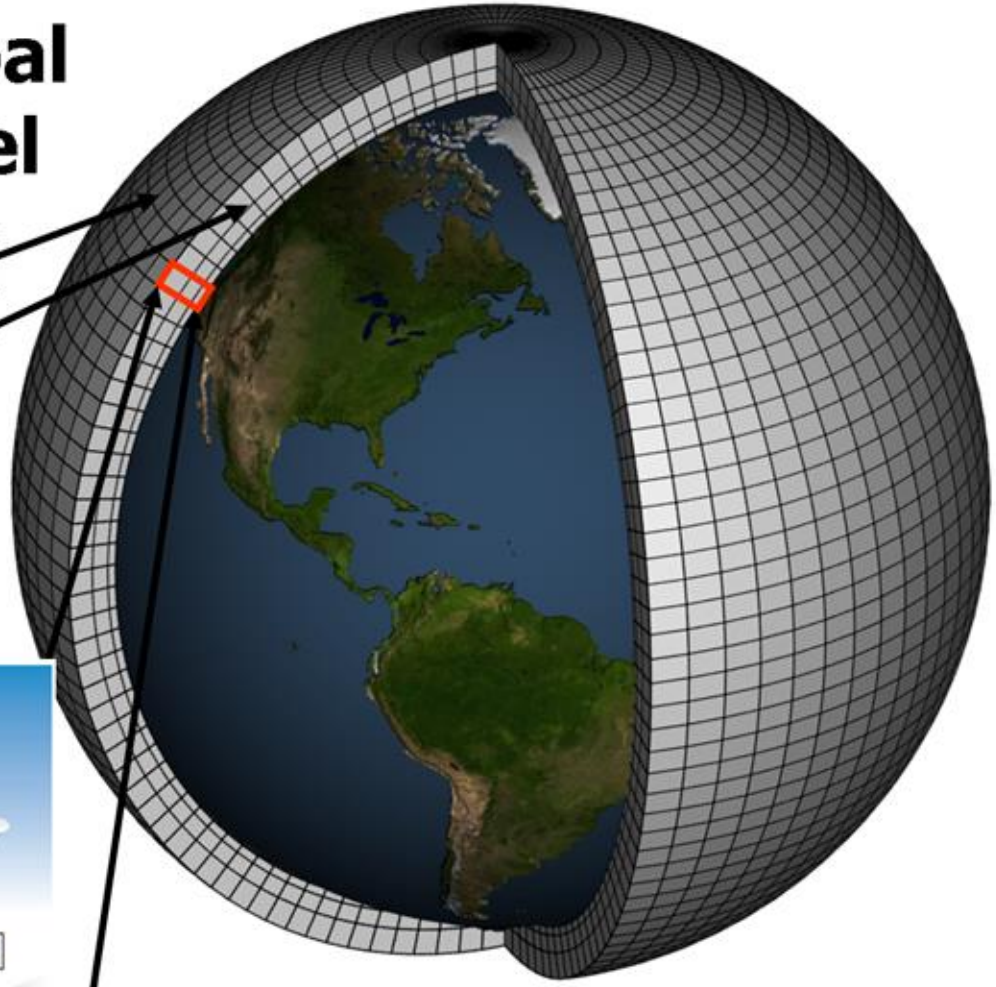
Atmospheric Chemistry

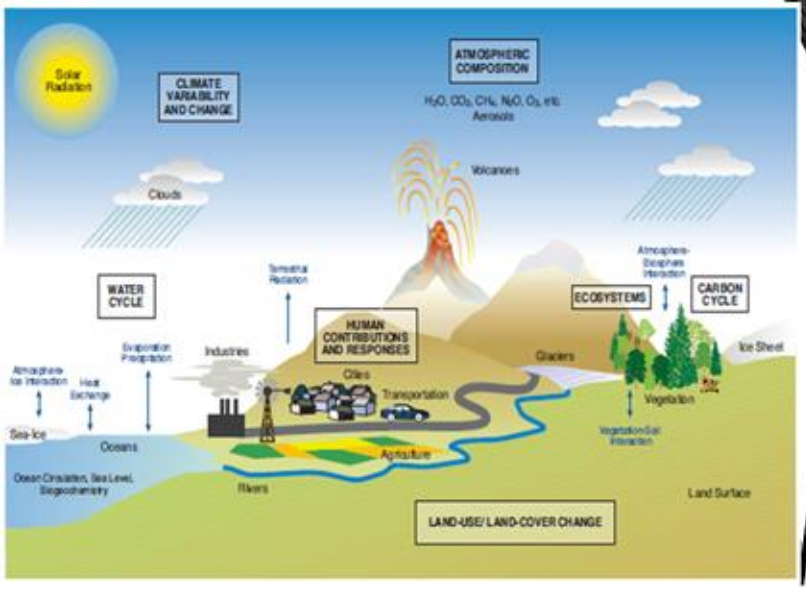


Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)

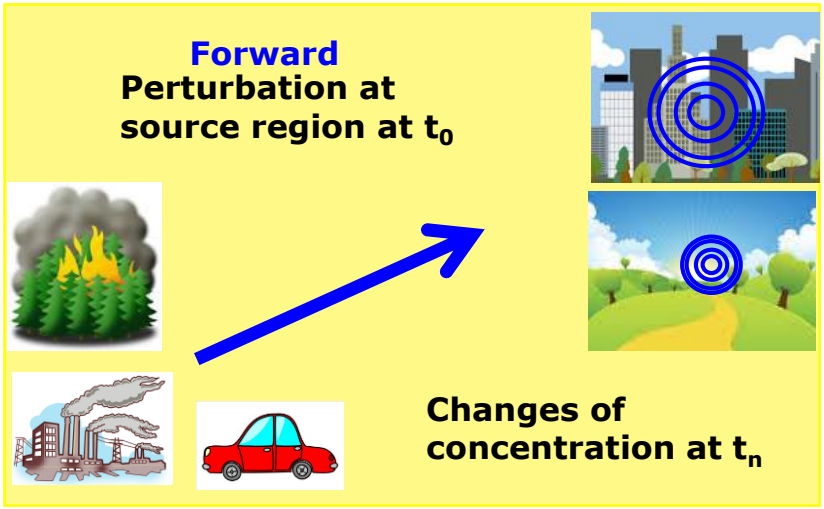




Chemical Transport Modeling – 2 Ways

Forward Model (source-oriented)

Sensitivity of all model concentrations to one model source

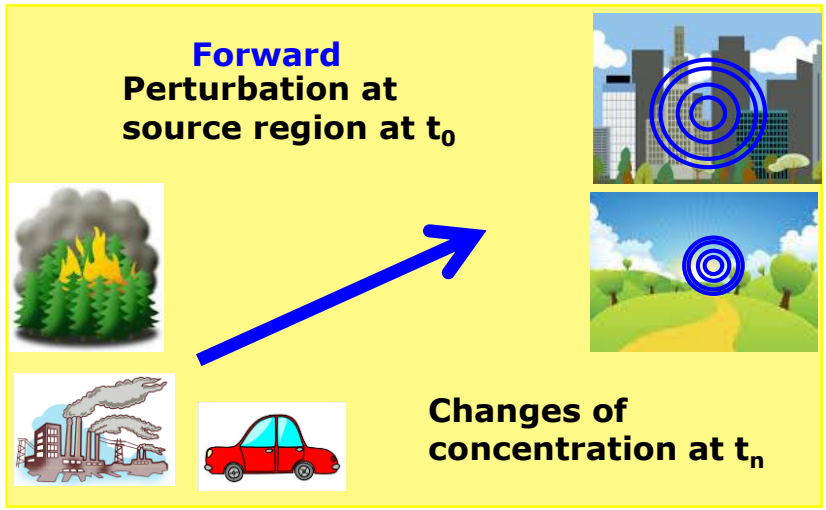


Modeling cost scales with # of sources and scenarios

Adjoint modeling for source-receptor analysis:

Forward Model (source-oriented)

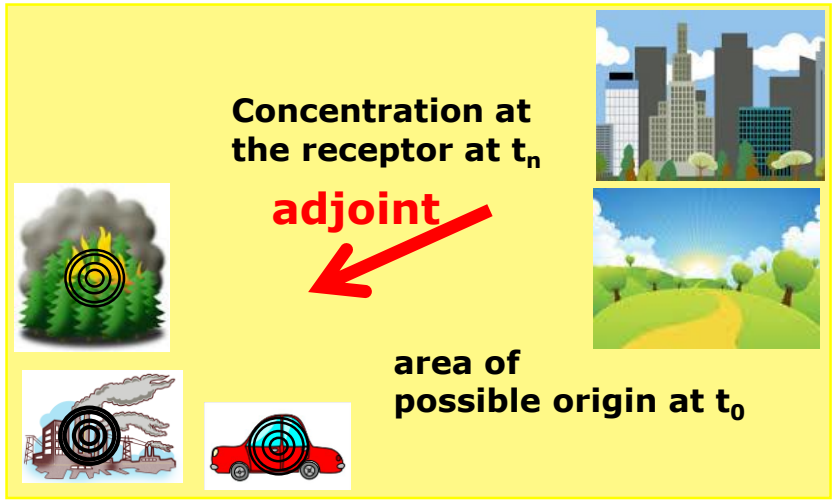
Sensitivity of all model concentrations to one model source



cost scales with # of sources

Adjoint Model (receptor-oriented)

Sensitivity of model concentration in specific location to many model sources

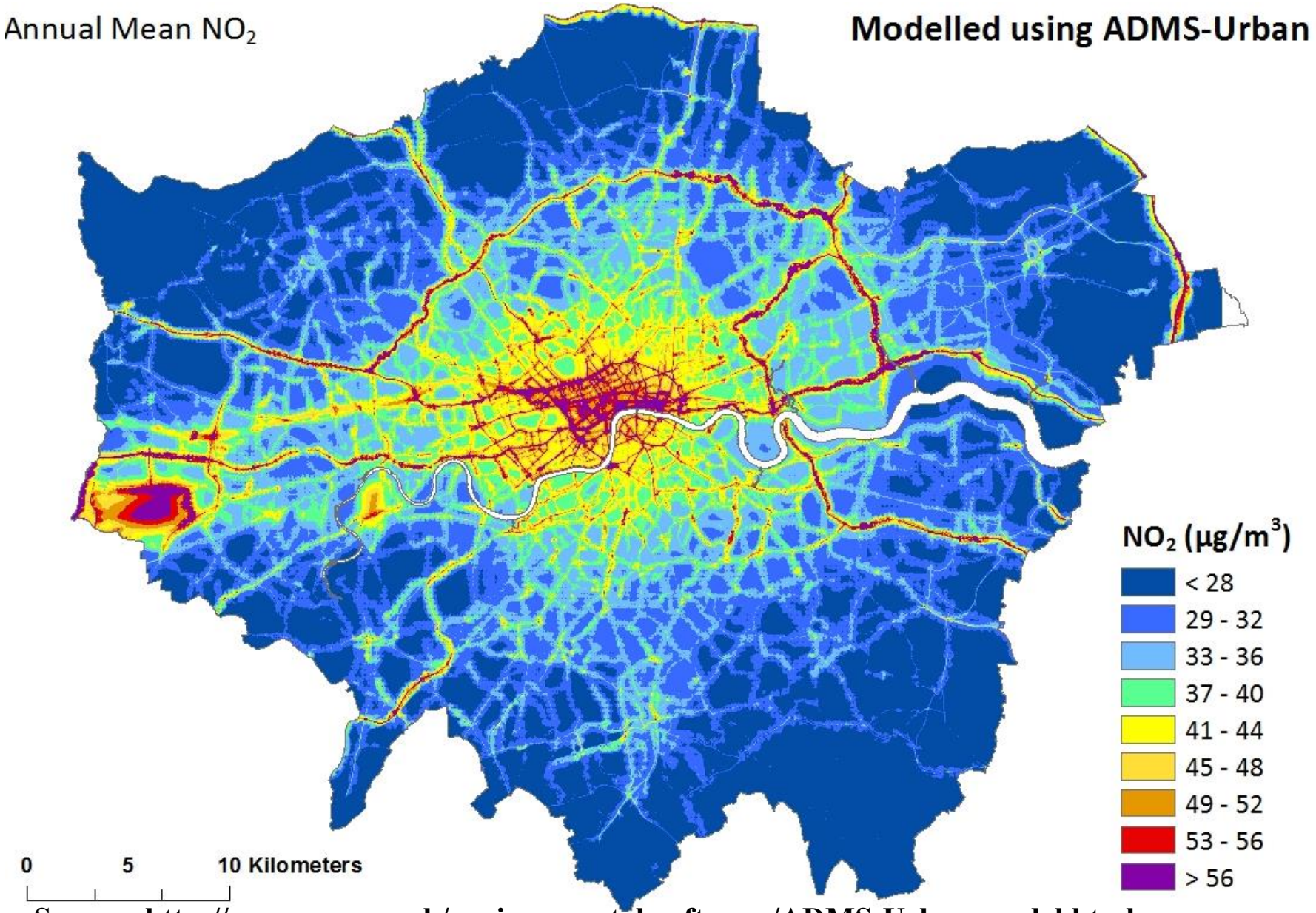


Can estimate source contributions to 1 receptor metrics with 1 adjoint run instead of 100,000 forward runs

Issues of Spatial Scale

- Much air pollution health impact/benefit modeling has been done at the global or continental scales, using models that give answers on a coarse grid, e.g., 50 to 200 km^2 grid boxes
- Some policy interventions are more local, e.g.,
  - Conversion of an urban vehicle fleet to cleaner technology
  - Village-level clean cooking fuel intervention
- These problems call for new and different modeling tools to get from emissions to exposures
- For ambient air, new tools are attempting to push down to 1 km^2 and finer, but still a work in progress

Modeling NO2 over greater London



Source: http://www.cerc.co.uk/environmental-software/ADMS-Urban-model.html

Which Health Outcomes and Metrics?1. Global Burden of Disease

Health outcomes

- PM2.5
  - Ischemic heart disease (MI and angina) – age specific
  - Stroke ("cerebrovascular disease") – age specific
  - COPD (Chronic Obstructive Pulmonary Disease)
  - Lung Cancer
  - Lower respiratory infection
- Ozone
  - COPD

Metrics

- Mortality – count of pollution-related deaths
- YLL – # of years of life lost due to mortality at various ages
- YLD – # of years lived with disability (i.e., years with disease)
- DALY – YLL plus (YLD x disability weight (ranging from 0 to 1))
- HALE – healthy life expectancy (years)

2. BenMAP US Health Impact Metrics

$PM_{2.5}$

- Long-term mortality – various causes of death
- Chronic bronchitis
- Acute Myocardial Infarction
- Hospital admissions – various cardiovascular and respiratory causes (e.g., congestive heart failure, COPD, asthma)
- Emergency department visits for asthma
- Acute bronchitis, work loss days, restricted activity days, lower respiratory symptoms (e.g., cough, shortness of breath, wheeze)

Ozone

- Short-term mortality – various causes
- Long-term respiratory mortality
- Hospital admission – various respiratory causes
- Emergency department visits for asthma
- Missed school days, restricted activity days

Health Outcome Challenges

- As noted, there is a high "entry barrier" for inclusion of new health outcomes. This derives from the historical attitudes about what constitutes sufficient biomedical evidence to, e.g., approve new drugs.
- As a result, list of outcomes we include in HIAs is surely too short.
- Over time, the list grows.
- Should we adopt biologic metrics such as oxidative potential of PM, as suggested in one paper that was provided?
- Can we differential the health impacts of different $PM_{2.5}$ components, e.g., BC?

Temporal Issues

- Depending on the health outcome, changes in health resulting from interventions may occur immediately or may roll out of many years
- For cardiovascular effects, we think health benefits occur fairly quickly, i.e., same year
- For chronic lung disease, benefits may occur for 3-5 years
- Lung cancer benefits may occur for a decade or two
- These “cessation lags” are often ignored

Other Issues

- The increasing role of satellite remote sensing in air pollution health analyses
  - Plays key role in GBD study
  - Available tools continue to improve
- Most ambient air health burden studies to date don't separate impacts by emission sources
- Most studies focus on mortality; increasing need for morbidity assessments for local policy making

Summary

- Modeling of exposure changes faces challenges related to technical complexity and spatial scales
  - Need simpler-to-use tools at finer scales
- Health outcome list varies by region of analysis, and underestimates total burden in all cases
- Evidence will continue to emerge on new health metrics and relative importance of different PM components