Using Epidemiological Studies in Health Impact Assessment

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Inputs Needed for the Estimation of Health Effects

1. Change in pollution concentration being considered
   a) What is full burden of air pollution?
   b) What is impact of a small change in pollution?
2. Population impacted
3. Concentration– response functions (CRF) (β = % change in outcome per unit pollution or temperature)
4. Baseline incidence of the health effect being estimated: (e.g. deaths per 100,000)

Inputs (cont.)

4. Incorporation of uncertainties – sensitivity analysis

5. Economic valuation?

How CRF derived?

- **Typically reviewed by expert panel which sets up inclusion guidelines**
  - **Quality of data and study**
  - **Replicated studies, meta analysis**
  - **Expert elicitation**
  - **Importance of endpoint**
  - **Biological plausibility (support from clinical, toxicological studies)**
  - **Causality**
  - **Availability of data on baseline incidence**

Health impacts: Choosing an Index Pollutant

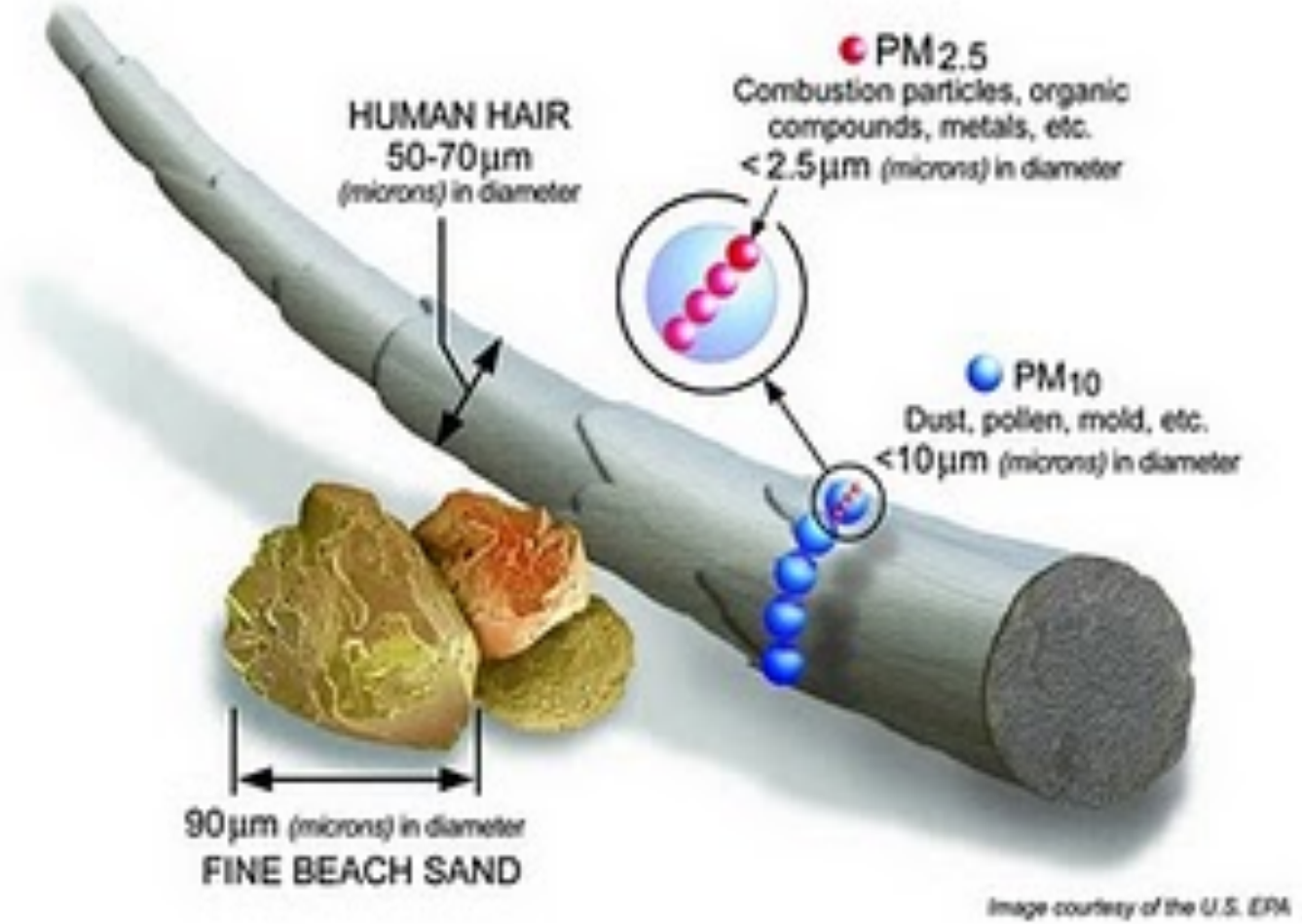
Criteria:

- Index of multiple combustion processes
- Compelling evidence of health effect
- Widely available exposure measure
- Reasonably represented exposure

Common index: PM2.5 (PM < 2.5 microns)

Does not include:

- Uncorrelated ozone or toxic air pollutants
- Some primary pollutants (ultrafines)
- "Hot spot" pollutants


HUMAN HAIR
50-70µm
(microns) in diameter
PM2.5
Combustion particles, organic compounds, metals, etc.
<2.5µm (microns) in diameter
PM10
Dust, pollen, mold, etc.
<10µm (microns) in diameter
90µm (microns) in diameter
FINE BEACH SAND
Image courtesy of the U.S. EPA

Depending on the outcome and data, existing air pollution epi studies, with different methodologies, include:

*** acute exposure (one or more days)**

*** long-term exposure (months to multiple years)**

Acute exposure Associated with both Mortality and Morbidity

- Hospitalization or emergency room visits for cardiovascular or respiratory disease
- Non-fatal heart attacks and strokes
- Work loss or restricted activity days
- School Absences
- Respiratory symptoms
- Asthma exacerbation

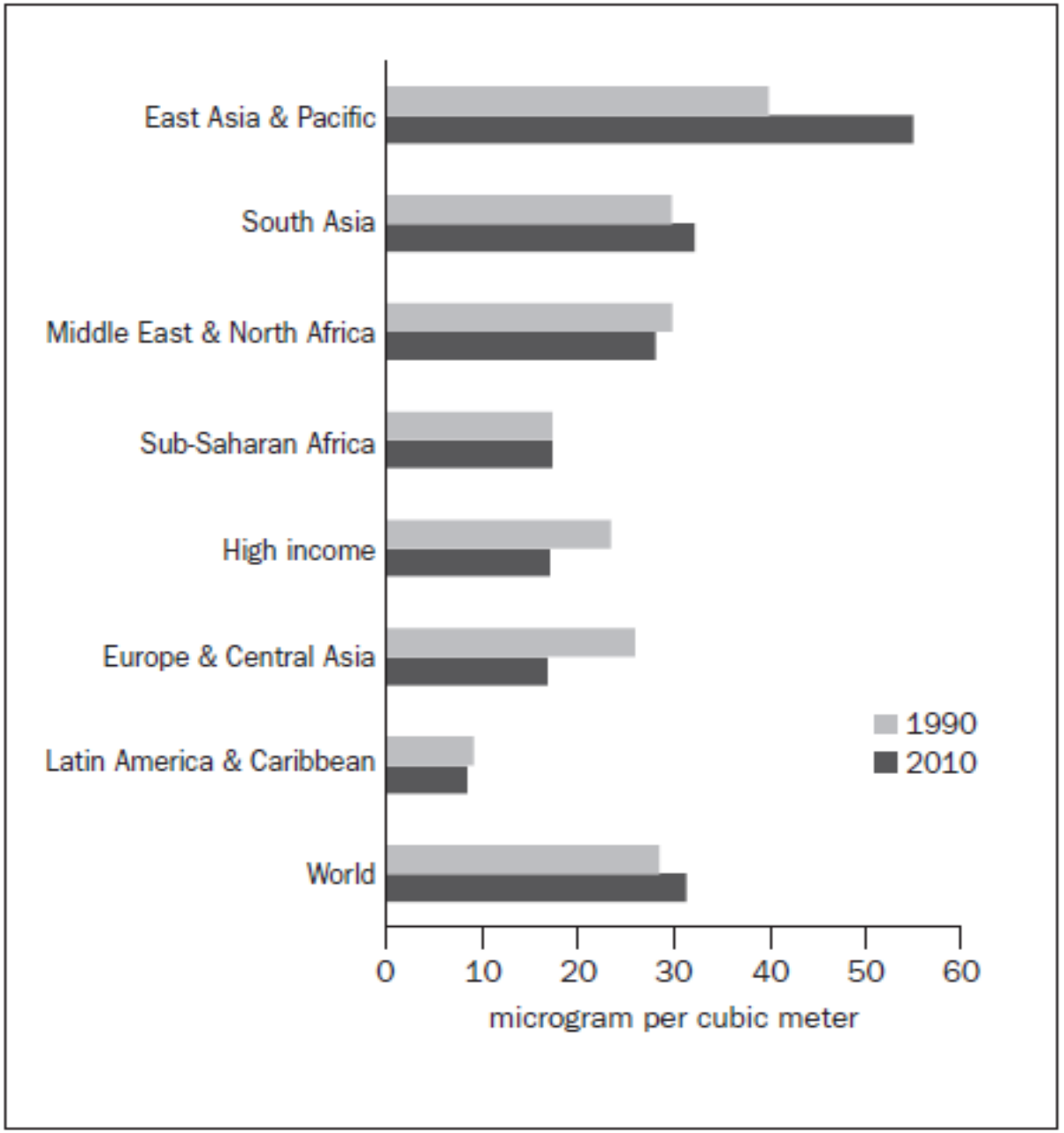
Studies of Long-Term Exposures Using Prospective Cohort

- Usually 80-90% of total effects
- Follow cohort over time and across cities
- Controls for other mortality risk factors (e.g., age, sex, education, BMI, smoking, alcohol use, medical history, etc)
- Able to determine mortality effects and calculate life-years lost

Long-term exposure (cont.)

- **For PM2.5, effect estimate is about 6 - 10x that of acute exposure studies**
- **Risk of 6% per 10 $\mu g/m^3$ for all-cause (ACS) versus 0.6% - 1% for short-term**

Ambient $PM_{2.5}$ pollution, population-weighted exposure



Source: *World Development Indicators 2015.*

Issues in Applying CR function

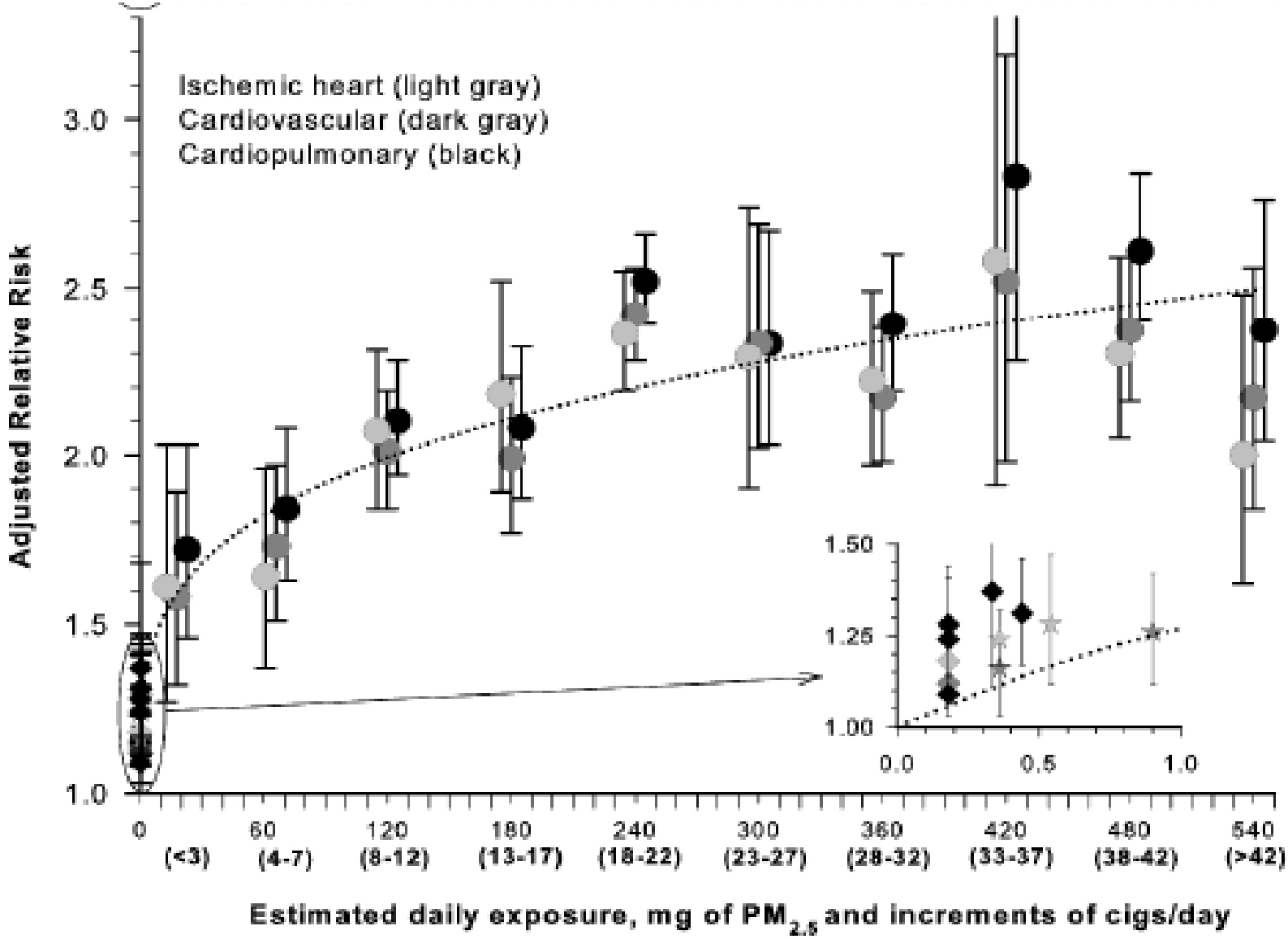
1. **Transferability of the CRF**
2. **Use of Amer Cancer Society studies (Pope et al., 2002, Krewski et al. 2009)**
3. **Which mortality endpoint to use? All-cause, cardiovascular or CV subclasses**
4. **Shape of the function: linear?**
5. **Which pollutant metric? PM2.5 vs BC, others**

Of course, judgement involved, which needs to be well supported and justified

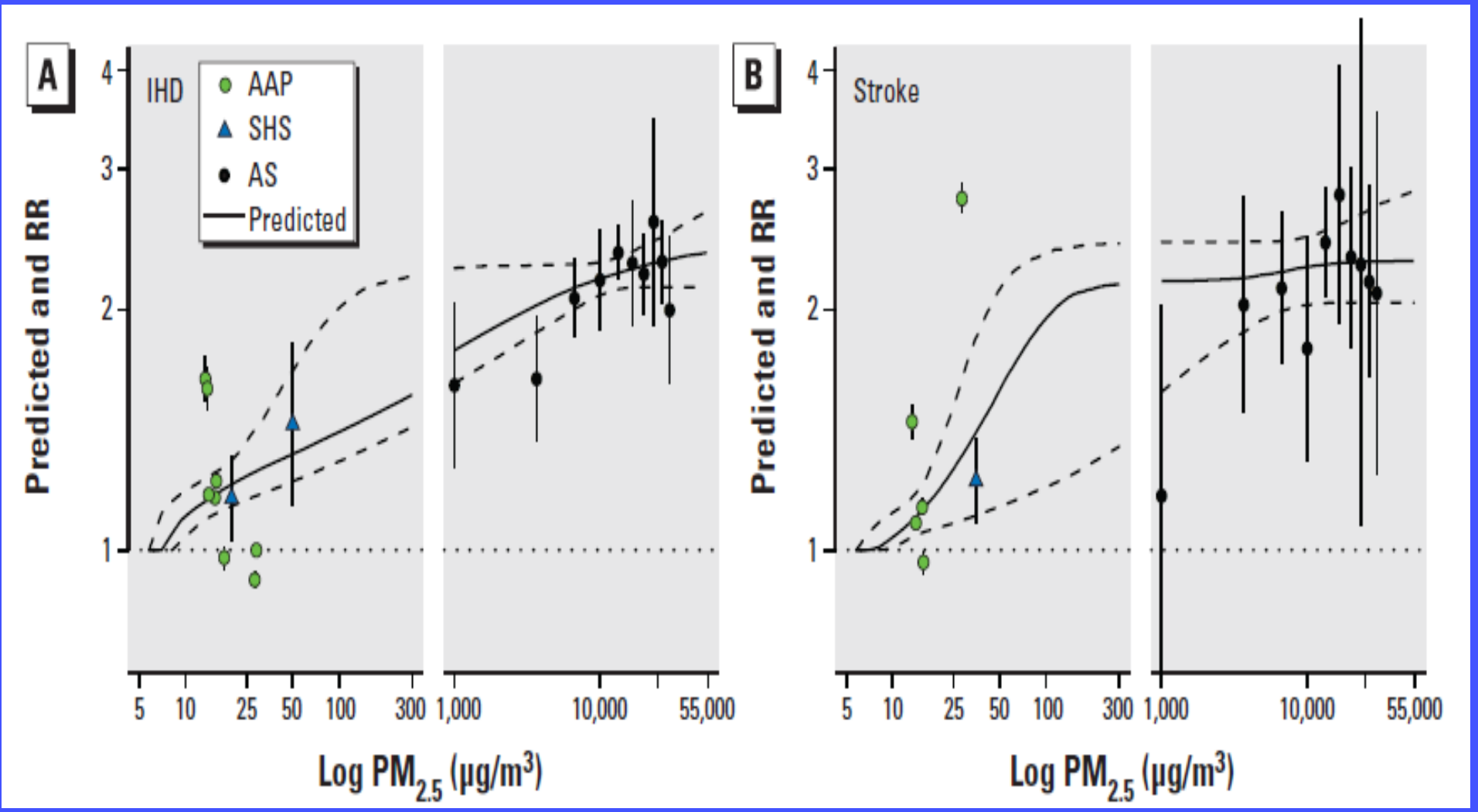
Examples from WHO GBD

- GBD in early 2000s used (a) cardiopulmonary mortality rather than all-cause since relative contribution varies greatly among countries (b) linear function with arbitrary max risk at higher levels
- Now evidence of subclass of cardio- and respiratory-specific risks
- New hybrid non-linear CRF developed which incorporated risks from secondhand and active smoking
- CRF estimated for IHD, stroke, COPD, lung cancer and ALRI (0-5 years) mortality

Adjusted CV risks from air pollution, SHS and smoking (Pope et al., 2011) **Assumes: (1) risk is a function of $PM_{2.5}$ inhaled dose regardless of source (2) CRF consistent with risk observed in current cohort studies**



Risks of IHD, Stroke (COPD and lung cancer) from pollution, SHS and smoking (Burnett et al., 2014)



But for small changes, linear might be ok

What about other pollutants or specific components of PM2.5?

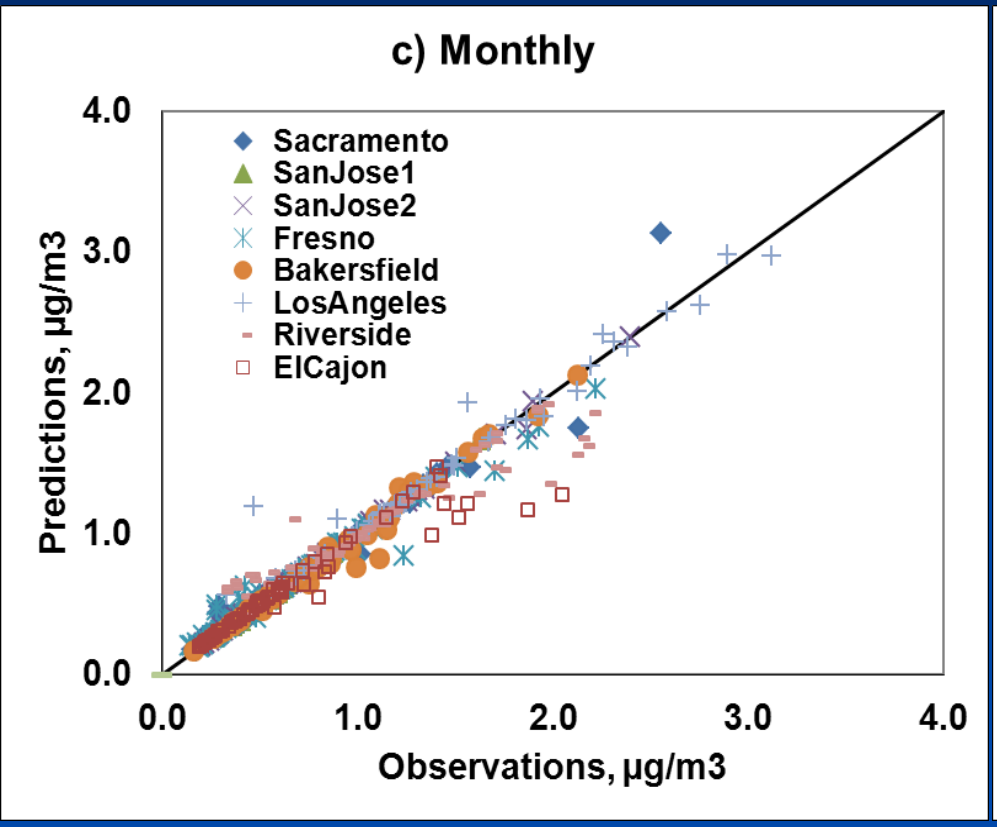
- Ozone mortality from both short- and long-term exposure, but only increases global mortality by ~ 5%
- Studies of effects of traffic (sometimes measured as NO2) but only a part of the combustion sources
- Until recently, few studies of PM components; EPA Chemical Speciation Network has one monitor per metro area
- Ostro et al. (2015) uses modeled estimates of EC/BC at finer spatial level

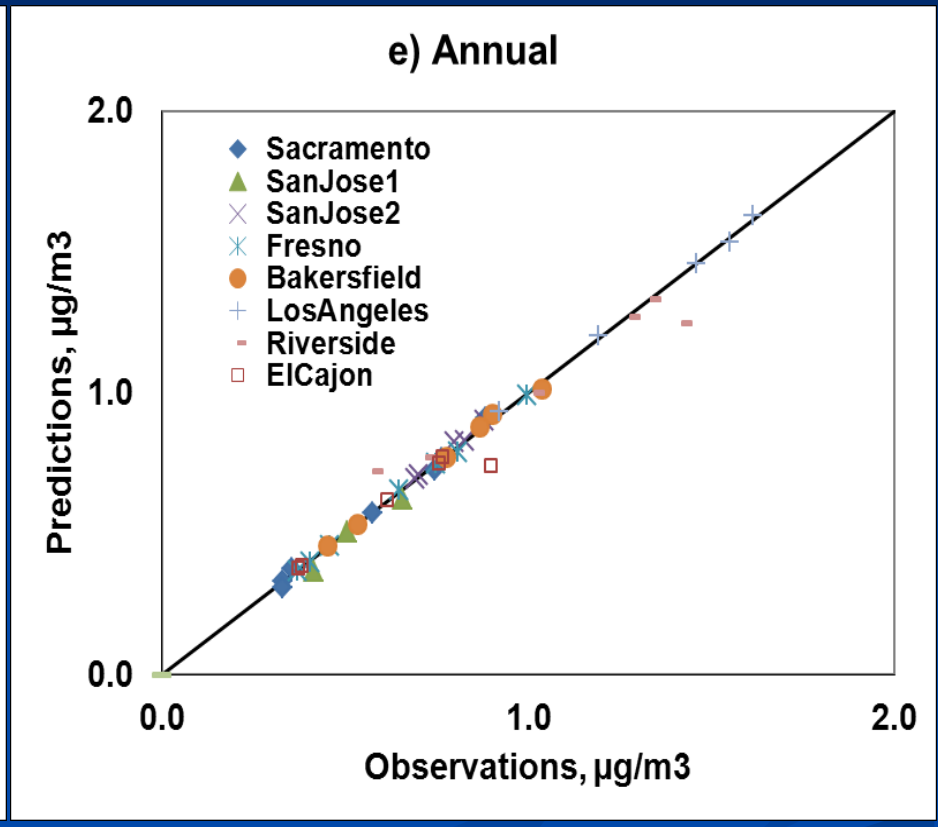
Study combines:

- **Health Data: California Teachers Study Cohort (130,000 middle aged women followed since 1996)**

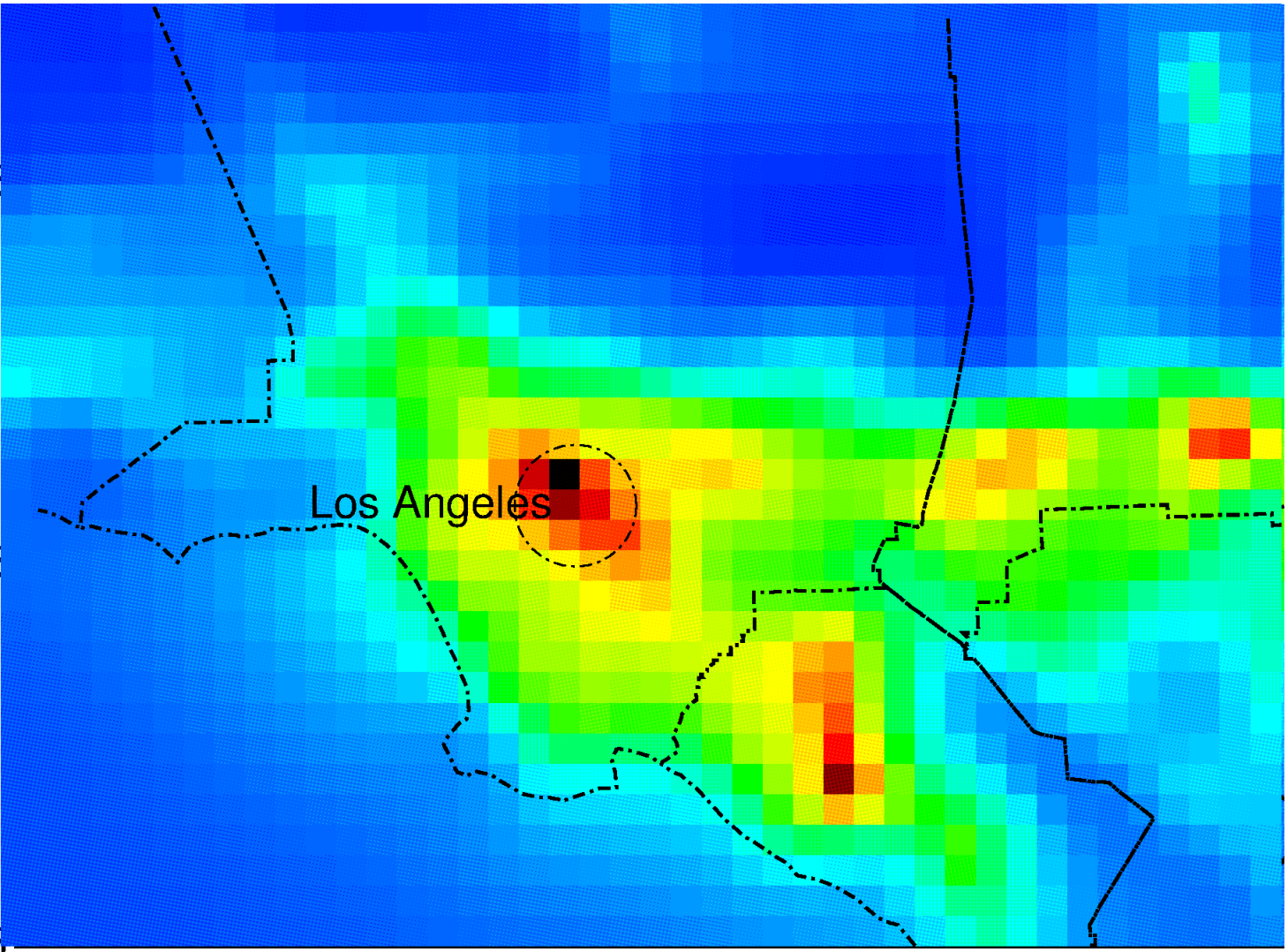
- **Exposure Data on Fine Particles and their Constituents and Sources: UCD/CIT Source Oriented Chemical Transport Model (modeled dozens of species, including EC, at 4k grid for all of California)**

Comparison of UCD/CIT Model Estimated versus Observed EC



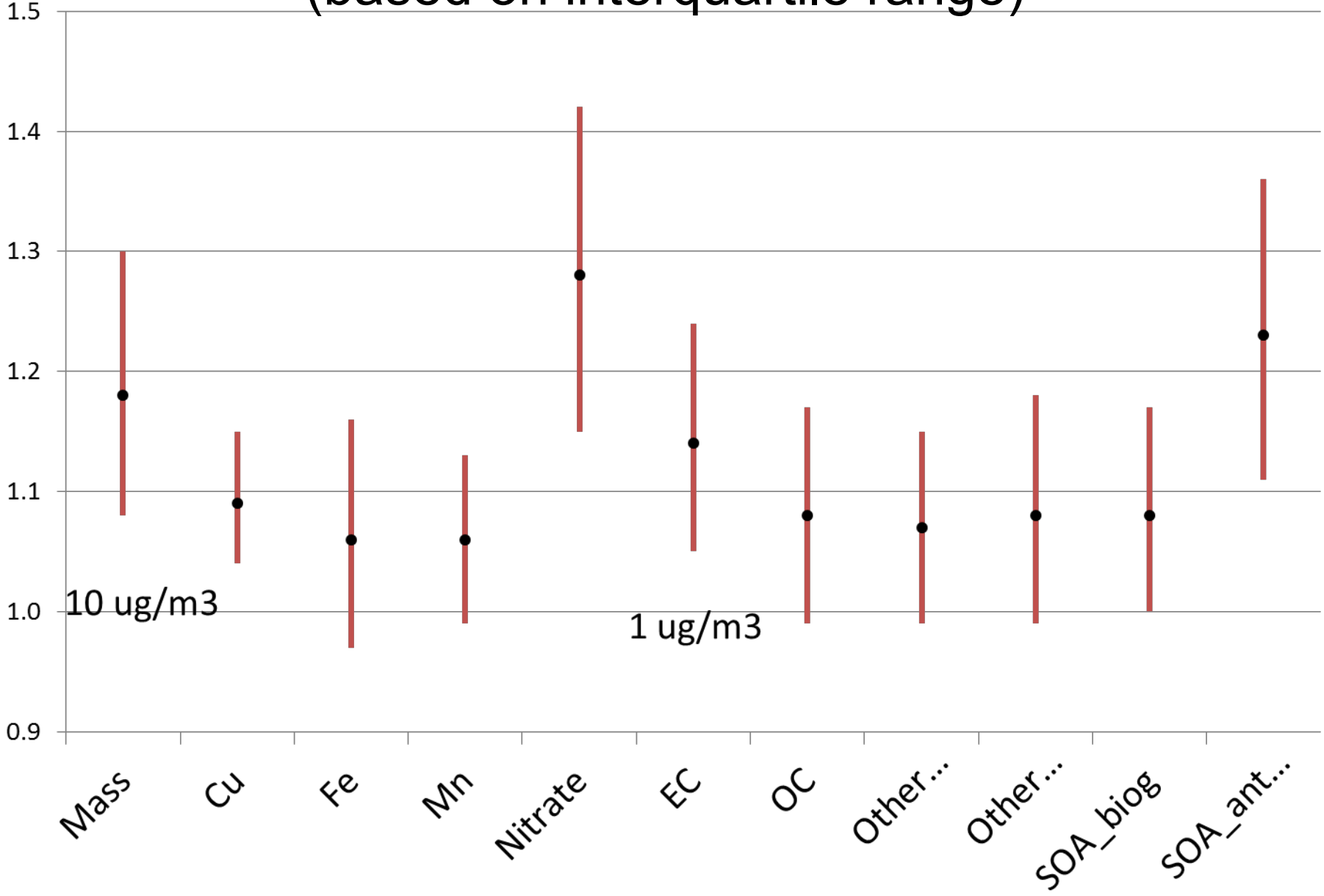


Spatial representation of concentrations of EC in Los Angeles and Surrounding Counties (μg/m^3)



Results indicate that central monitor may not be representative of exposure for nearby population.

Associations of PM2.5 species with IHD mortality (based on interquartile range)



Risks of long-term exposure to EC on IHD Mortality (% change and 95% CI per one μg/m^3)

- Ostro (2015): EC: 16% (6, 27)
- Ostro (2015): PM2.5: 1.9% (0.8, 3.1)
- Pope (2002): PM2.5: 1.8% (1.4, 2.3)

Effects of long-term exposure to EC/BS on Cardiovascular Mortality

(% change and 95% CI per one μg/m^3)

Author	Cohort	Effect	Measurement
Beelan 2008 (BS)	Dutch	4 (-0.5,12)	Multiple monitors
Smith 2009 (EC)	ACS	11 (3,19)	One metro monitor
Gan 2011 (EC)	Canada	8 (4,12)	LUR based on summer days mobile monitor
Beverland 2012 (BS)	Scotland	6 (0,11)	One monitor for Glasgow metro area
Ostro 2015 (EC)	Calif	5 (-0.2, 11)	Modeled for 4k grid for state

Pope 2002 (PM2.5)	**ACS**	**1.7 (1, 2.4)**

Effects of short-term exposure to EC equivalent on all-cause Mortality

(% change and 95% CI per one μg/m^3)

Author	Study area	Effect
Janssen (BS) 2011	7 Euro cities	1.5 (1.3, 1.6)
Maynard 2007 (BC)	Boston metro	3.8 (2, 5.7)
Krall (EC) 2011	72 U.S. cities	0.6 (0,1.2)
Ostro (BC) 2015	2 Euro cities	2.5 (0.7, 4.3)

Ostro 2015 (PM2.5)	2 Euro cities	0.25 (0.1, 0.4)
Multiple Authors (PM2.5)	Worldwide	Central: 0.06 – 0.10