

US EPA ARCHIVE DOCUMENT

The Road to PM Understanding

“Are we there yet?”

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The Road to PM Understanding

- The Questions in 1997
- The Road We're On
- Progress and the Roads Not Yet Traveled
 - Epidemiology
 - Exposure
 - Mechanisms and Susceptibility
 - Toxicity of PM Components and Sources
- *Are we there yet?*



The Questions in 1997

1. How strong is the short and long term epidemiology?
 - Statistics, other pollutants, harvesting, exposure
2. Exposure
 - Do central monitors represent personal exposure?
3. Mechanisms and Susceptibility
 - Can there be a plausible biological mechanism?
Who's affected?
4. Are all particles created equal?
 - The toxicity of PM components and sources



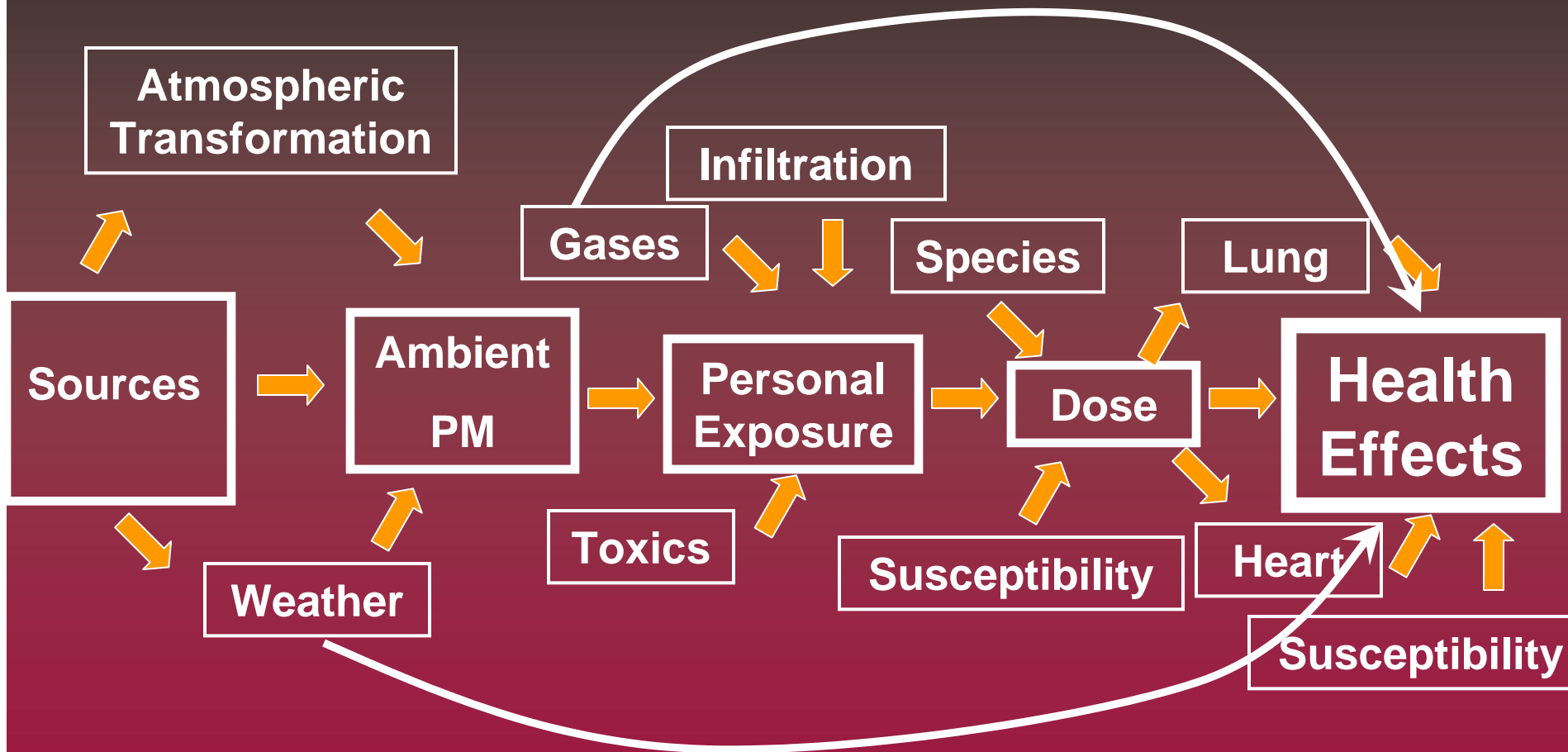
The Straight and Narrow Road

*A General Framework for Integrating PM Research from the
NAS report on PM research Priorities 2004*



The Real Route

AAA Never Saw Anything Like It



Measuring Progress

- Good Science is messy and takes time
 - Multiple paths (and dead ends...)
 - Understanding grows with the number of studies
- The NRC Committee identified a 13-year plan in 1998
 - We are only 6 years into that
- We are going to be at the PM NAAQS for 10 - 20 years
 - SIPs, NAAQS reviews, Accountability



1. Epidemiology

The Questions in 1997

- Could the time series studies be right?
 - Statistical methods
 - Other pollutants, PM sizes
 - Exposure
 - “Harvesting”
- Could the few longer term studies withstand close scrutiny?
- NRC Topics 7, 10



Epidemiology: Progress on Short Term Effects

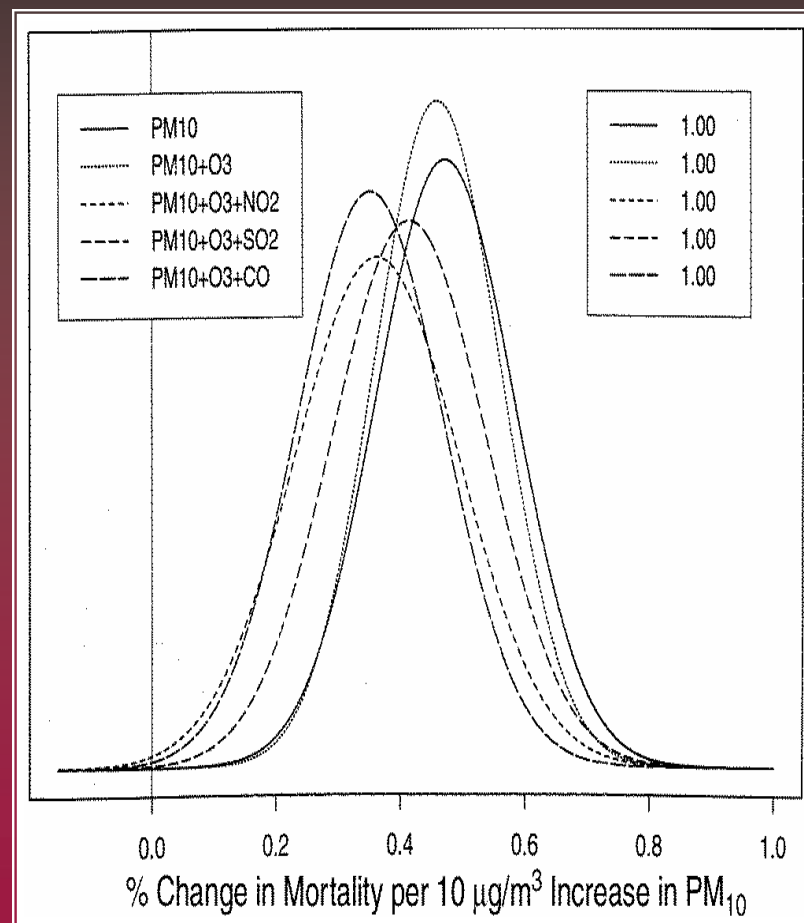
- Systematic Multi-city studies
 - National Morbidity, Mortality and Air Pollution (NMMAPS) funded by HEI
 - APHEA in Europe funded by EU
- More studies with PM_{2.5}, and the gaseous pollutants
- First efforts on components, sources



NMMAPS

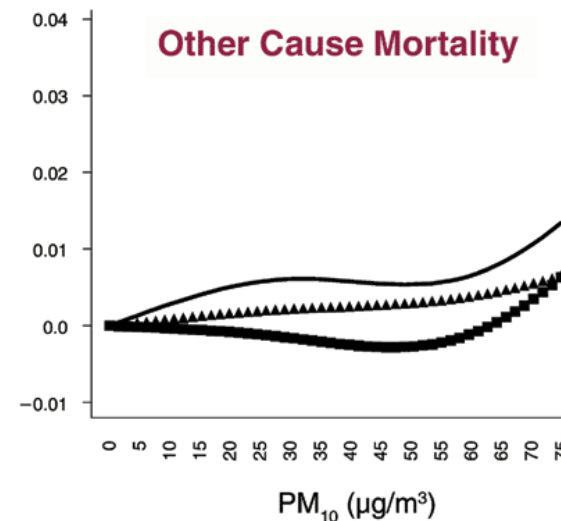
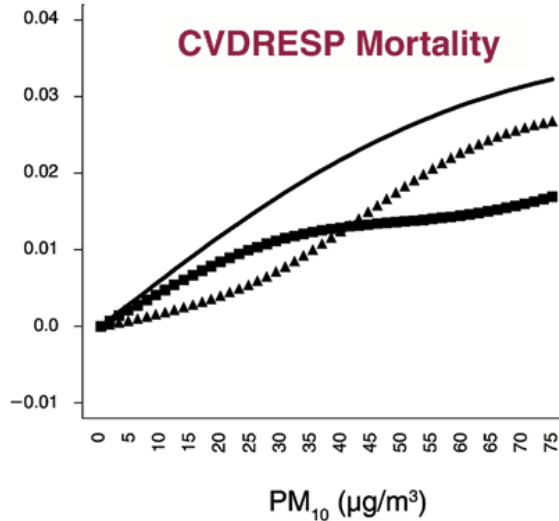
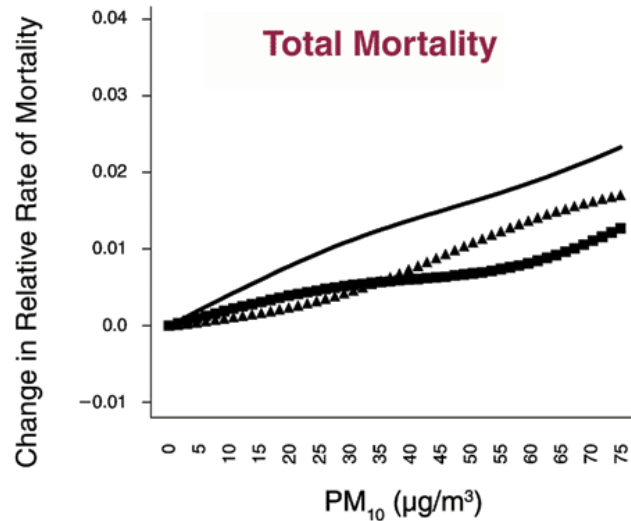
The Original Results (HEI 2000)

- Relatively Consistent Increase in Mortality:
 - 0.4% per $10 \mu / m^3$ of PM_{10}
- Smaller results than previous U.S. analyses
- Apparently not sensitive to inclusion of other pollutants
- Enhanced confidence in results
- Some continuing questions
 - Especially different results in different regions



NMMAPS

Concentration - Response for the 20 Largest US Cities (Daniels et al HEI 2004)



Epidemiology: Progress on Long-term Effects

- Reanalysis by HEI of two major long-term studies
 - Harvard 6 Cities and American Cancer Society (ACS)
- Follow-up of the ACS cohort (JAMA 2002)
- A few additional studies reported
 - Southern California Children's Study
 - Veteran's Study
 - Netherlands Cohort Pilot Study



Reanalysis Results

Sensitivity Analyses with Additional Variables

- Overall, the reanalysis:
 - Assured the quality of the data
 - Replicated the original results,
 - Tested those results against alternative explanations *without substantively altering the original findings of an association between indicators of particles and mortality*
- However, also identified:
 - Relationship with education
 - Effects of SO₂

Results from ACS Study Reanalysis

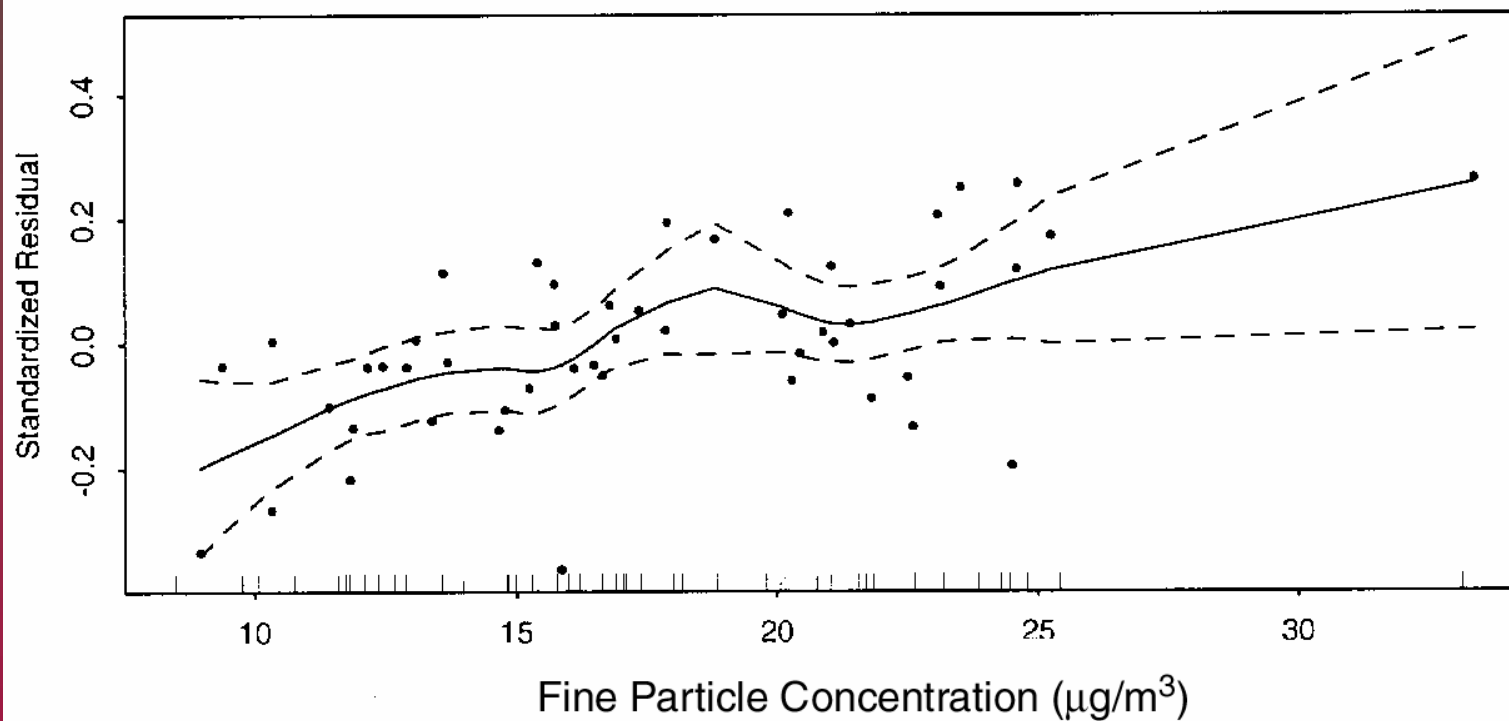
<u>Analysis</u>	<i>PM2.5</i>	<i>Sulfates</i>
Original	1.17(1.08,1.27)	1.15(1.08,1.22)
Full	1.18(1.09,1.26)	1.15(1.09,1.21)
Extended	1.18(1.09,1.26)	1.15(1.09,1.21)



Reanalysis Results

ACS Cardiopulmonary Mortality $PM_{2.5}$

Cardiopulmonary Disease Mortality (Excluding Boise City, Idaho)



Epidemiology: Continuing Challenges

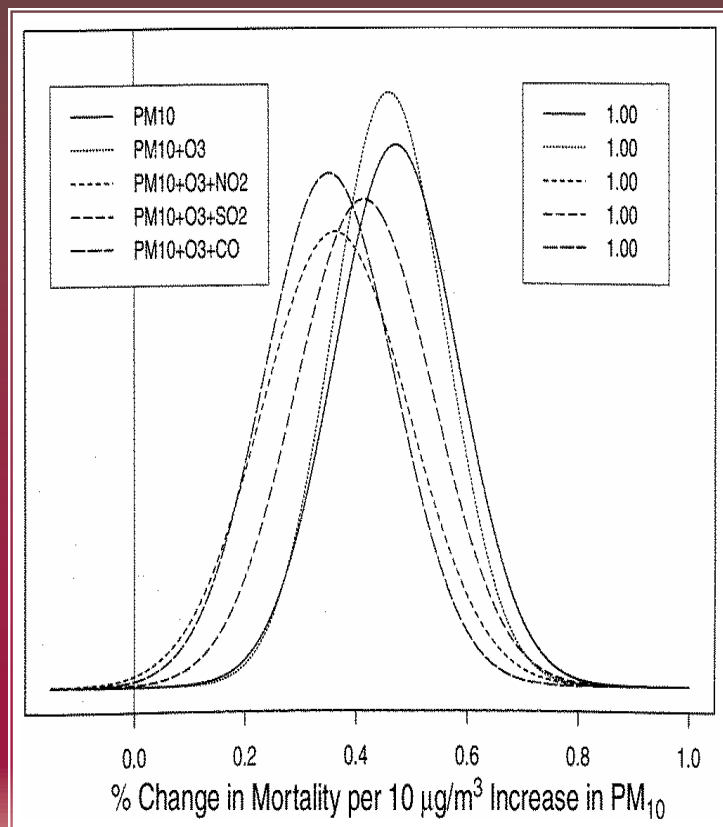
- Need for continuous improvement in time series models, how to deal with weather
- We need more long-term studies
 - Still only a handful
- The gases have not gone away
 - Do not seem to eliminate PM effect
 - But several also show associations (SO₂, NO₂)
 - Does this mean independent effects? A surrogate for something else? Co-effects?



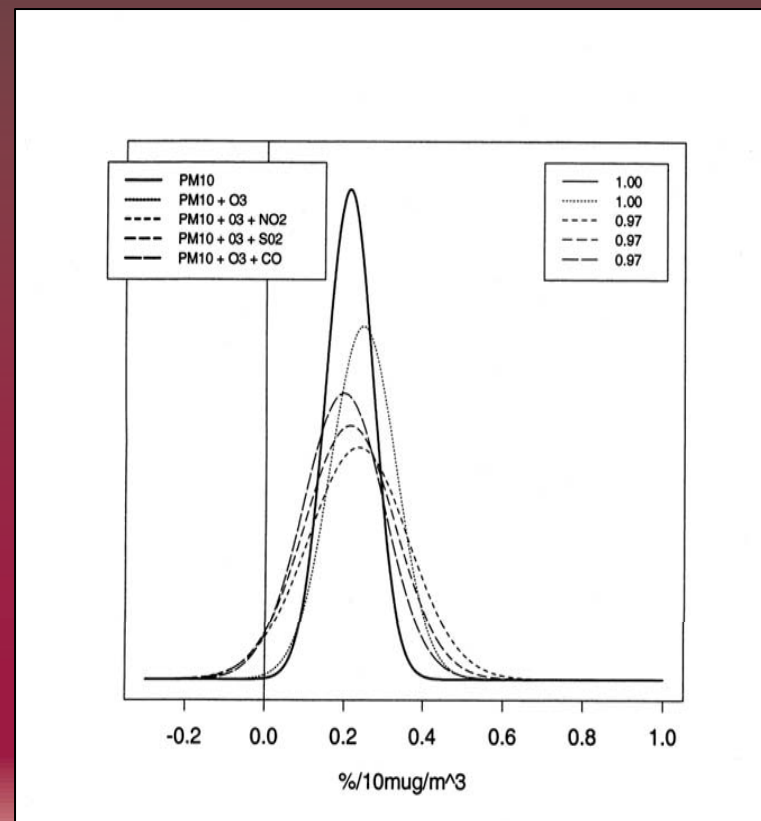
The Time Series Models Challenge (GAM)

NMMAPS: Revised Results

Original Results



Revised Results

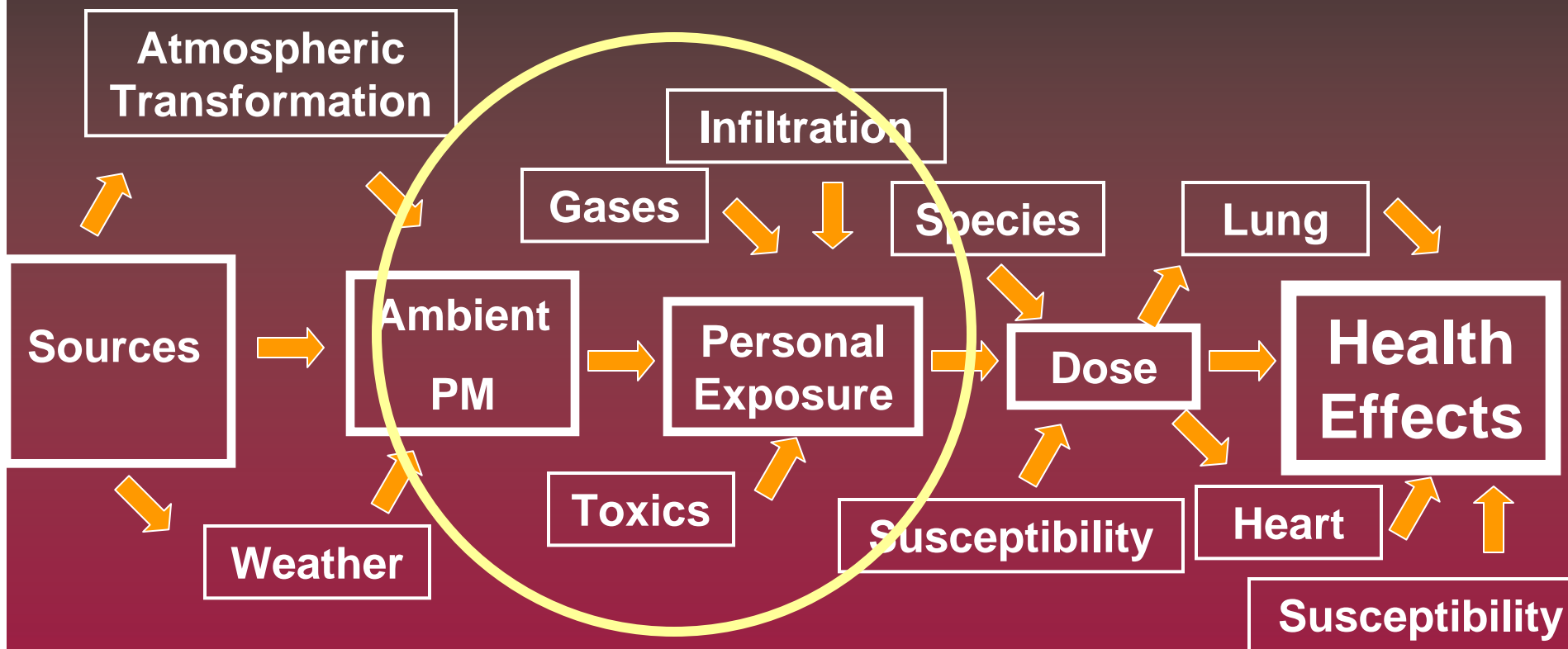


Revised Analysis

- Over 30 studies identified by CASAC, EPA for reanalysis
- Mean estimates of effects in revised analyses generally smaller
 - 5% to 35% reduction
- Effect for PM10 still does not appear to be affected by co-pollutants
- Reanalyses renewed questions about the role of other factors (especially weather)
- ***HEI Review Panel Bottom Line:***
 - Studies continue to find associations with PM
 - some benefits estimates will be smaller
 - Need for continuous improvement



2. Exposure

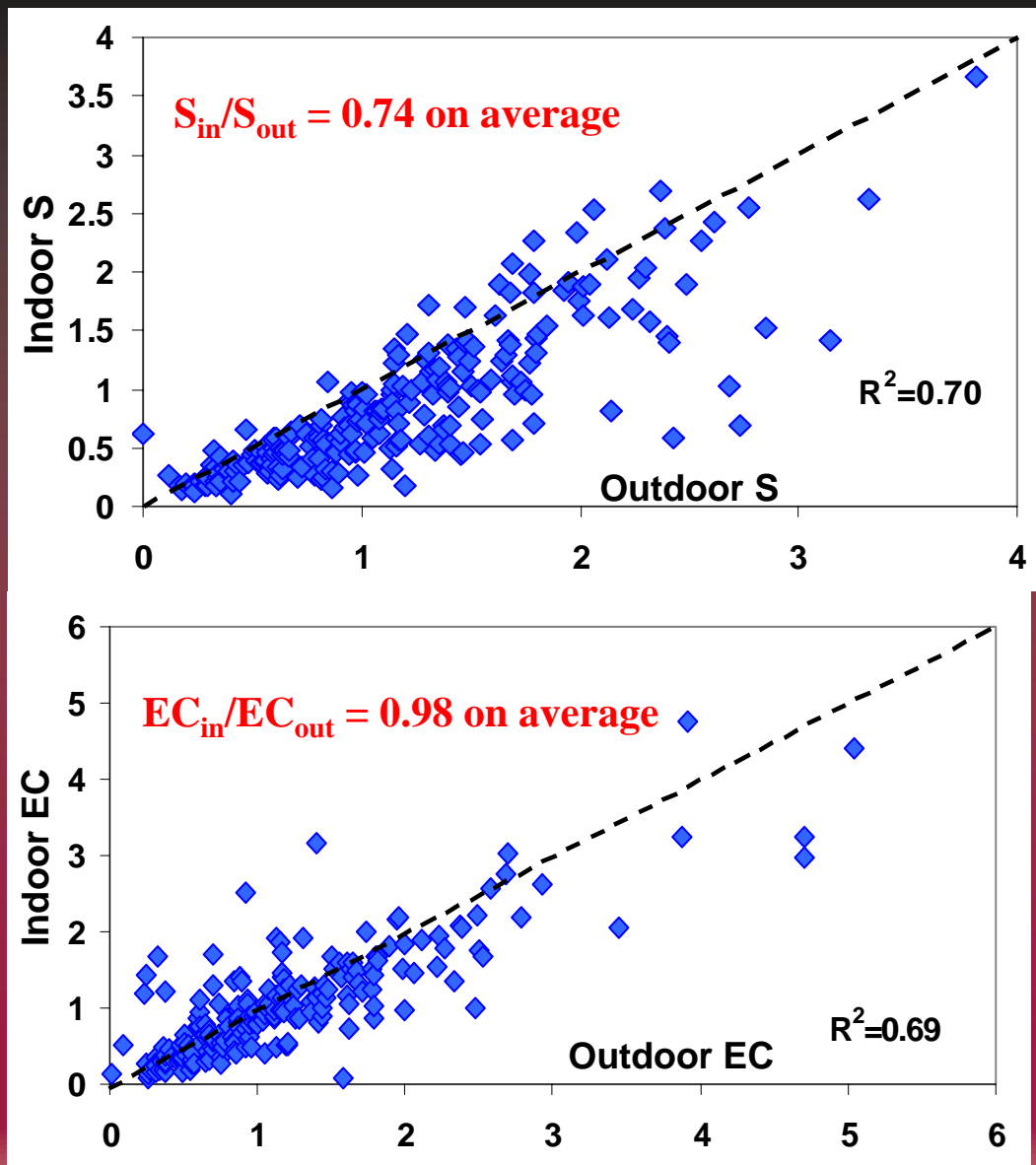


Exposure Progress

- Can central monitors reflect actual personal exposure? (NRC Topics 1, 2)
 - Few studies available in 1997
- A number of new studies now completed
 - EPA, HEI, API, EPRI
 - Outdoor, indoor and personal monitors
 - Elderly, children, asthmatics
- Outdoor PM contributes significantly to PM exposure
 - Other sources not correlated day-to-day with PM



Tracers of Outdoor Contribution to Indoor PM(RIOPA)



Courtesy of B Turpin (RIOPA study), presented at AAAR 2003 PM Colloquium

✓ S used as a tracer to determine the contribution of outdoor PM to indoor PM (Outdoor contribution to indoor PM = $S_{in}/S_{out} * PM_{out}$).

✓ S tracer for regional PM

✓ In RIOPA, indoor and outdoor EC are highly correlated.

✓ Few homes appear to have indoor sources of EC.

✓ EC tracer of local combustion.

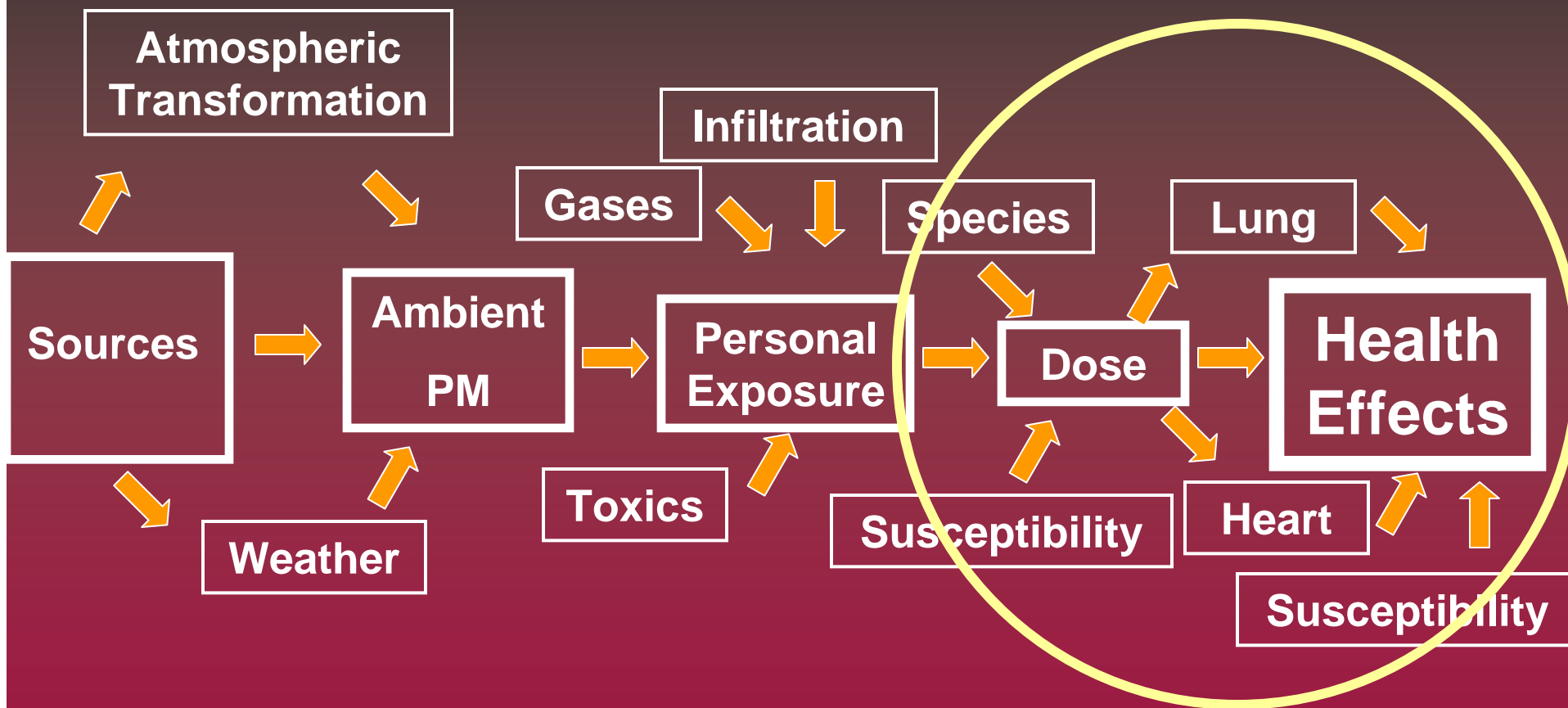


Exposure: Continuing challenges

- Need to expand:
 - the number of subjects
 - the types of potentially susceptible individuals
- Better measurement of components and sources of personal exposure
 - NRC Topic 2
- New measurement techniques
 - to enhance ability to detect exposures
 - at lower cost with more precision



3. Mechanisms and Susceptibility



Mechanisms/Susceptibility Progress

- 1997: Few studies suggesting plausible mechanisms
 - NRC Topics 6, 8, and 9
- Today:
 - Many potential pathways
 - Some toxicology or epidemiology for each
- Growing number of potential susceptibles
 - Elderly, children
 - Lung disease
 - Cardiovascular disease
 - Other diseases (e.g. diabetes found by Goldberg (2000), confirmed by Zanobetti (2002))



Mechanisms/Susceptibility: Continuing Challenges

- We are in the early stages
 - Latest draft CD notes this in Chapters 7 and 8
 - Need to look at long term mechanisms
 - Need better dose-response info
- First human controlled exposure studies have shown few or modest effects
 - Need more human data (of necessity initial studies have been in healthy or only mildly ill volunteers)
- Draw more experts from other health fields into air pollution (e.g. CVD)



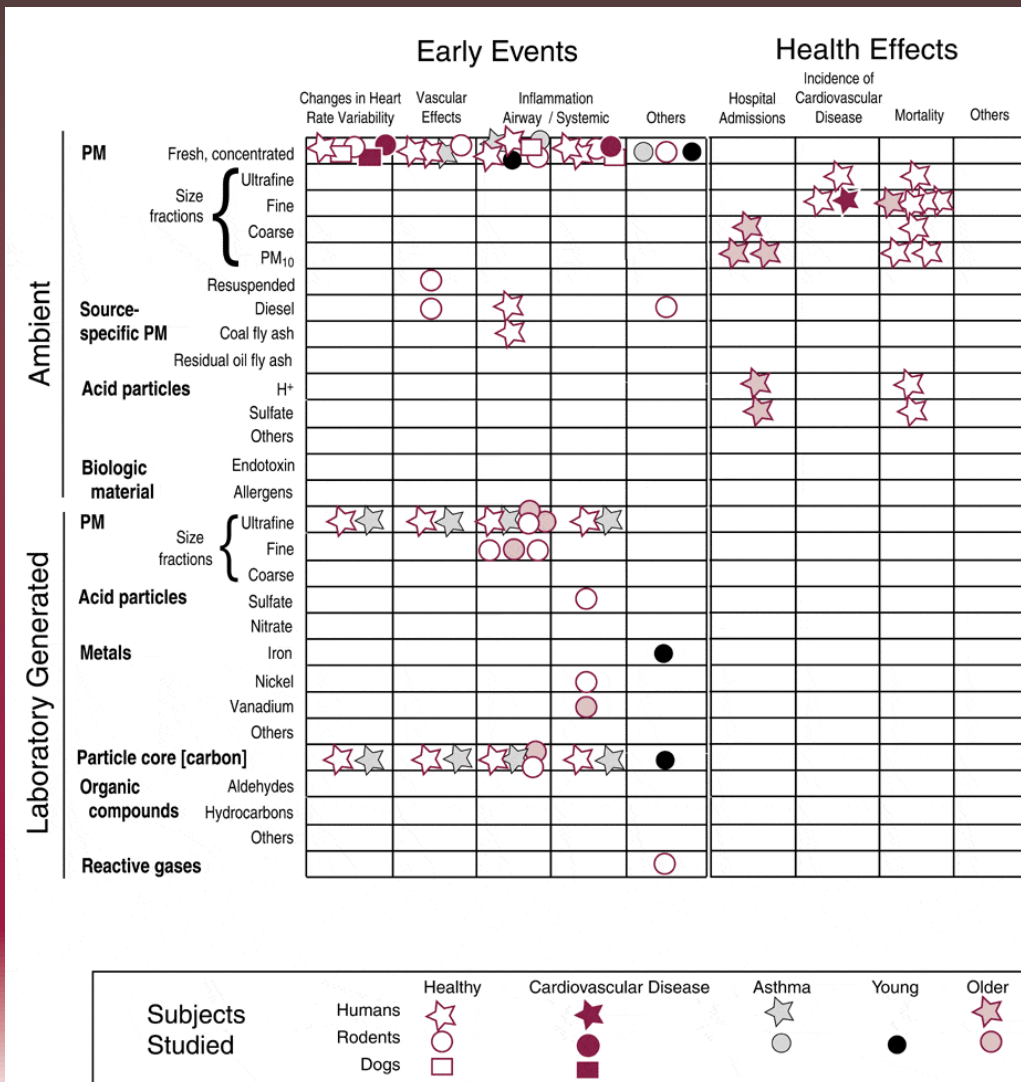
4. Toxicity of PM Components and Sources

- 1997 questions (NRC Topic 5):
 - Is all PM equally toxic?
 - How can we ensure that we control the components and sources with the highest public health effects?
- Progress
 - More epidemiology and toxicology studies on this topic
 - To date:
 - High dose toxicology - most things toxic
 - Many correlated components in epidemiology
 - As yet, few systematic approaches

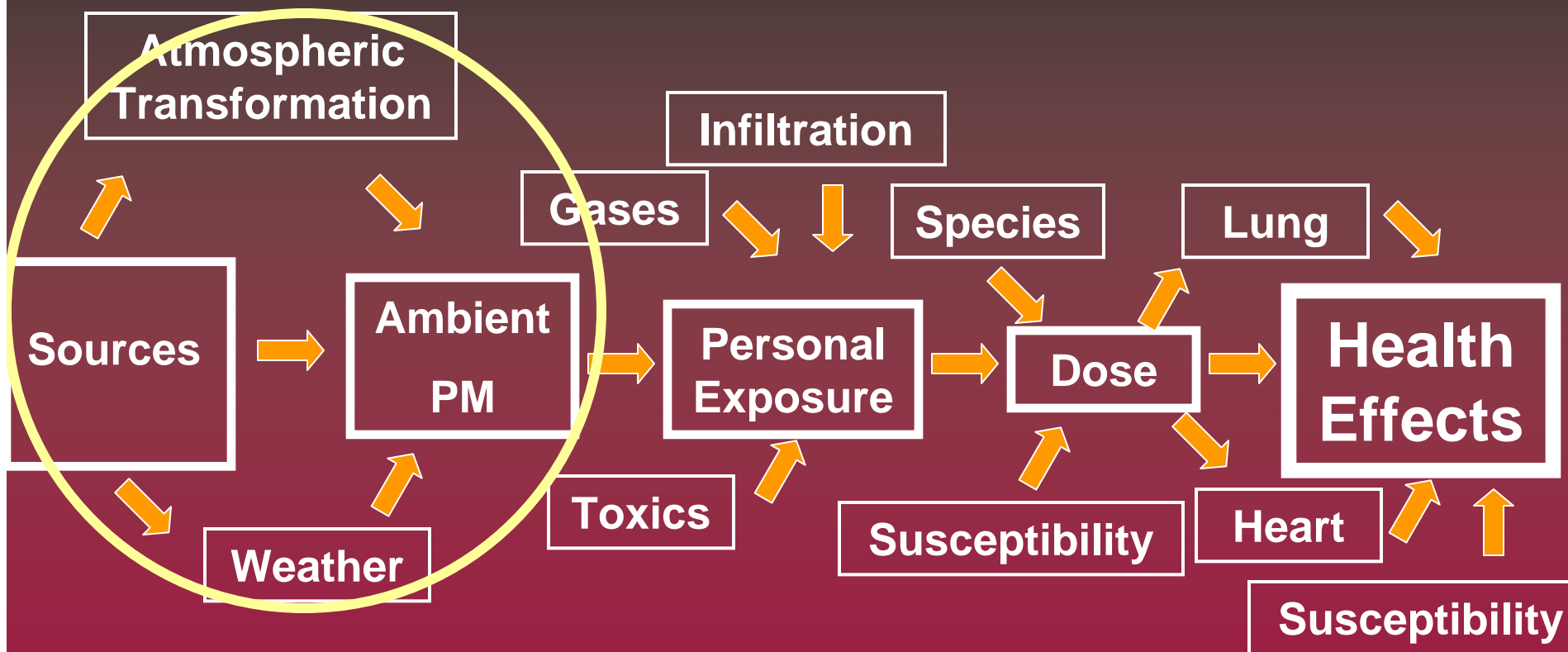


Toxicity of Components and Sources Challenges

- Many empty boxes in the “matrix”
- Systematic approaches:
 - Tox: comparable tests of all components; realistic exposures
 - Epi: systematic multi-city approaches
 - Better tools for linking effect, components, gases, and sources



5. Tools for Source Apportionment

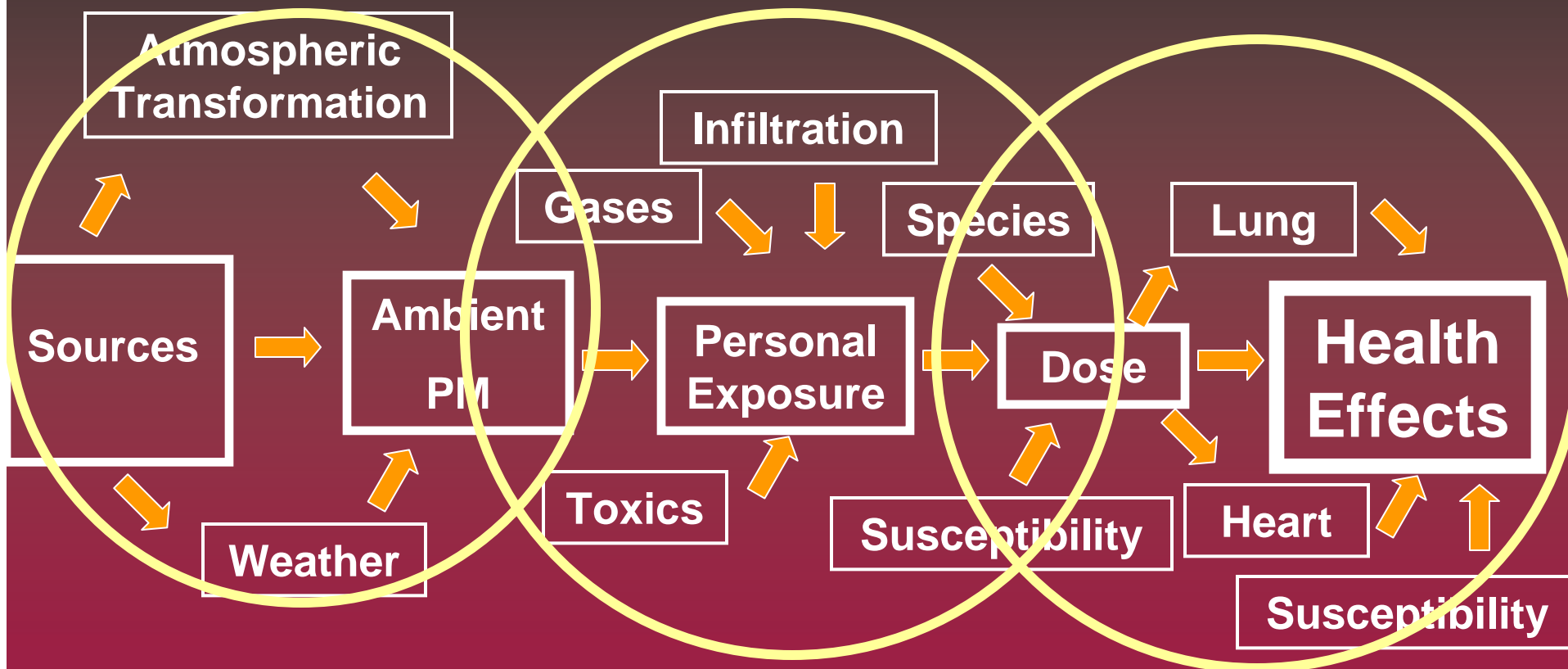


Tools for Source Apportionment A Challenge Going Forward

- A key challenge for successful implementation of PM SIPs, controls
 - NRC Topics 3 and 4
- Need:
 - Enhanced emissions characterizations and factors for all primary and precursor emissions
 - Improved models for source apportionment and assessment of potential control strategies



Are we there yet?



Are we there yet?

- We've made progress on the road to PM understanding
- We know more about:
 - The epidemiology
 - Exposure
 - A series of possible mechanisms and susceptible populations



Are we there yet?

- To reach our final destination – *cost effective public health strategies for PM over the next 10 years* – we will need:
 - Continuous improvement in epidemiology (models, more long term studies)
 - Improved mechanistic understanding (dose-response, long term)
 - A systematic approach to toxicity of PM components and sources (and the gases!!!)
 - Enhanced tools for source apportionment



Thank You!

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