

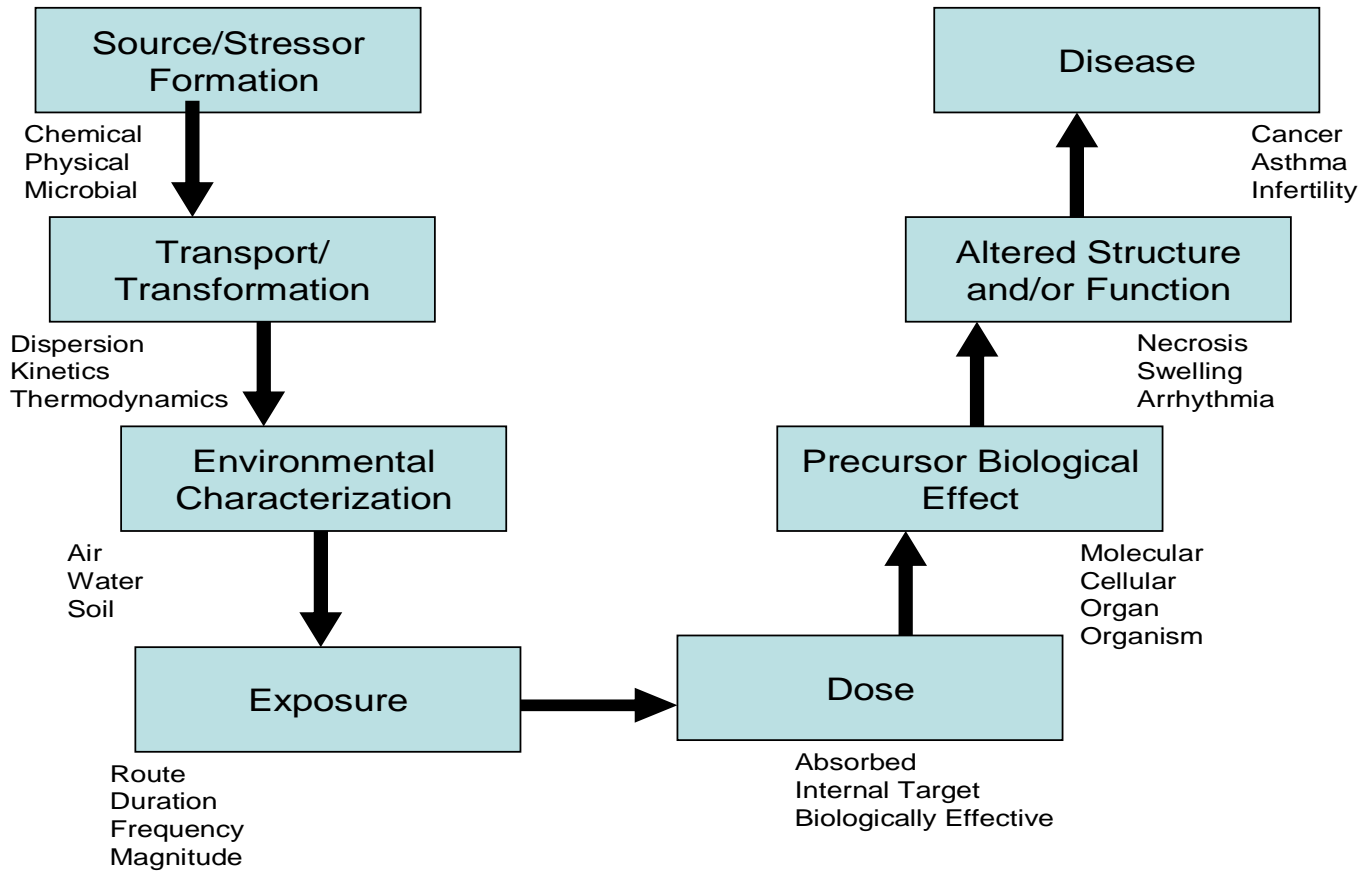
# Public Health Impacts of Risk Management Decisions: Linkage and Process Models

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*January 22, 2008*

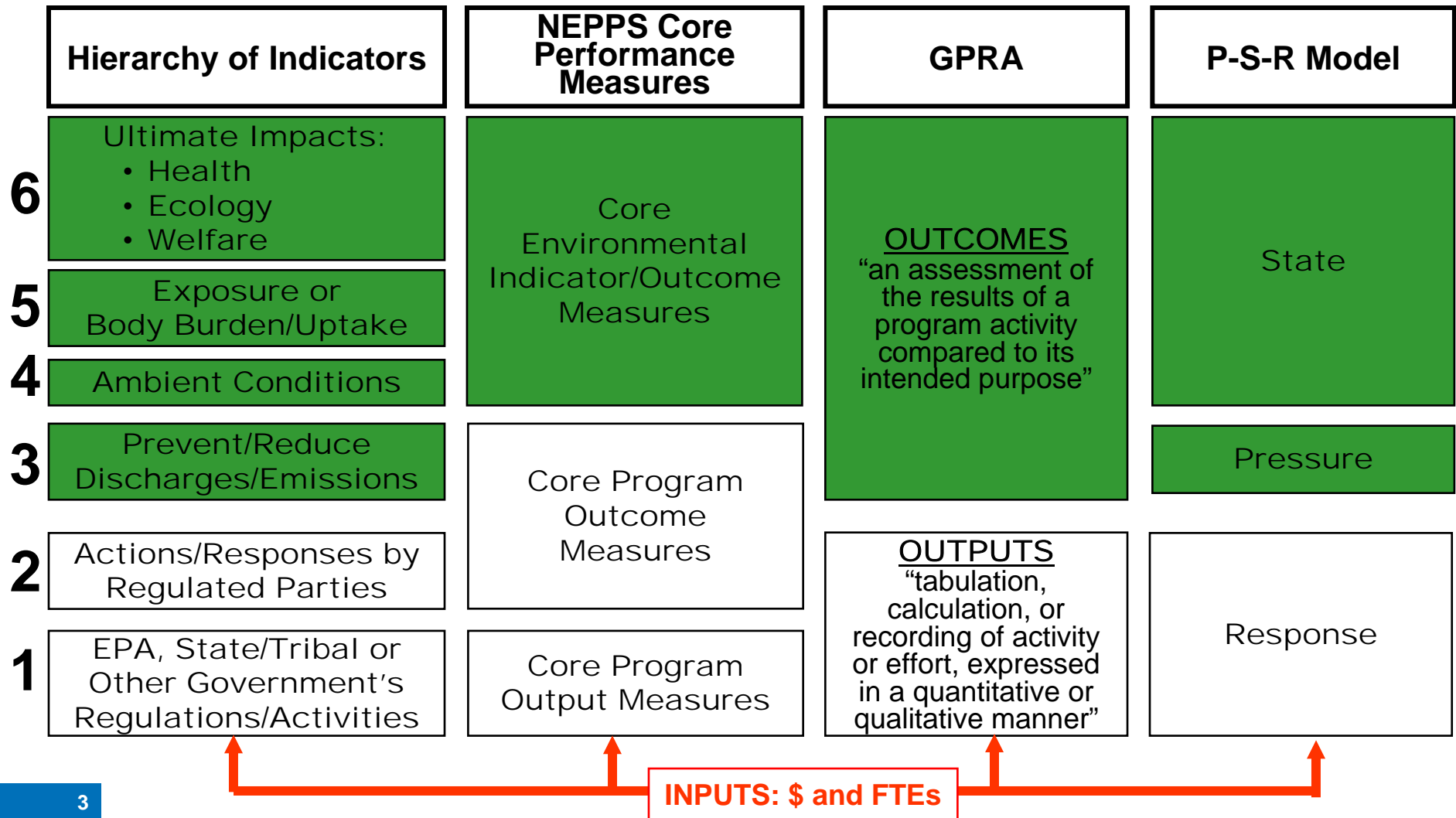




**Figure 2 The Source-Exposure-Dose-Effects Continuum**

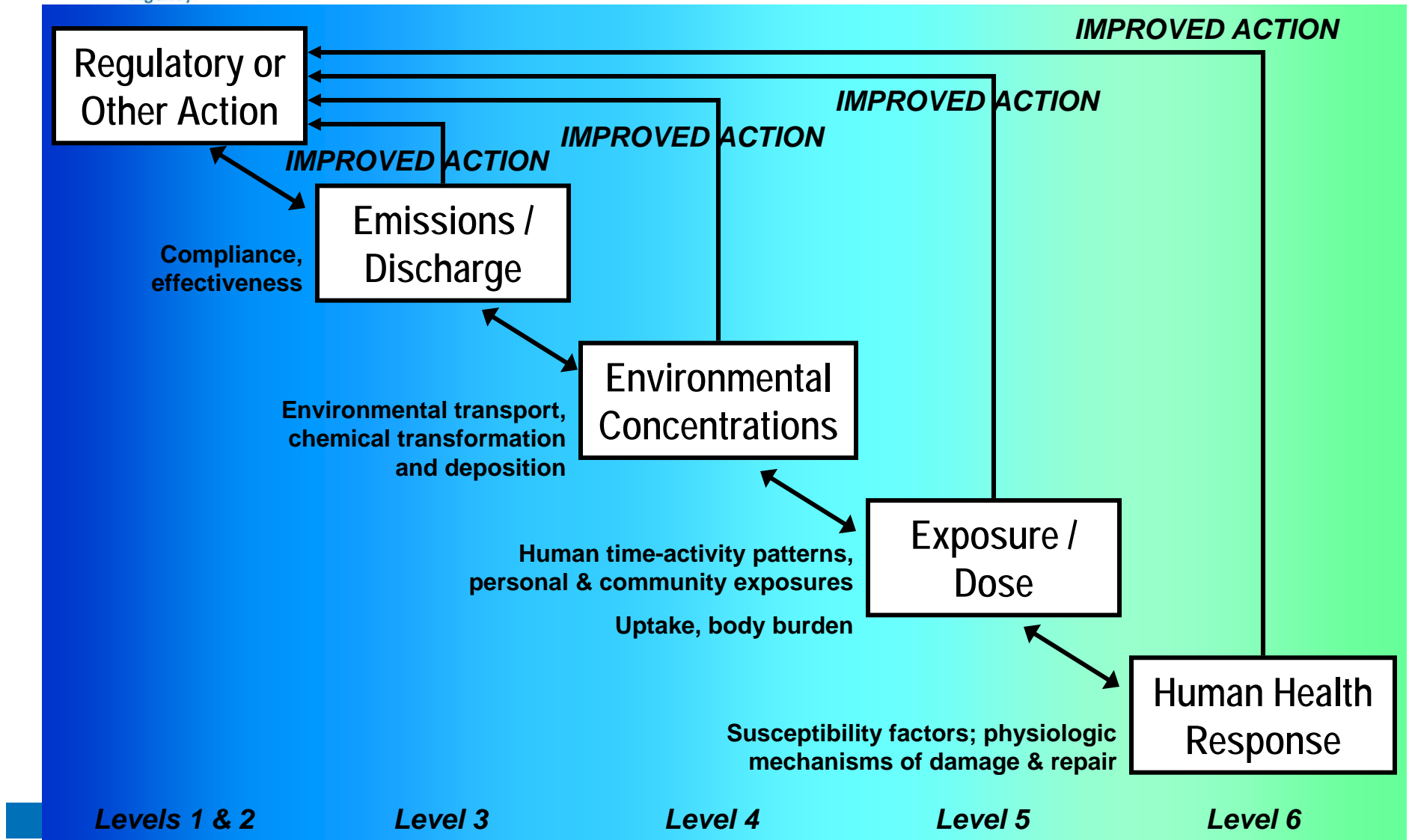


# Classifications of Performance Information





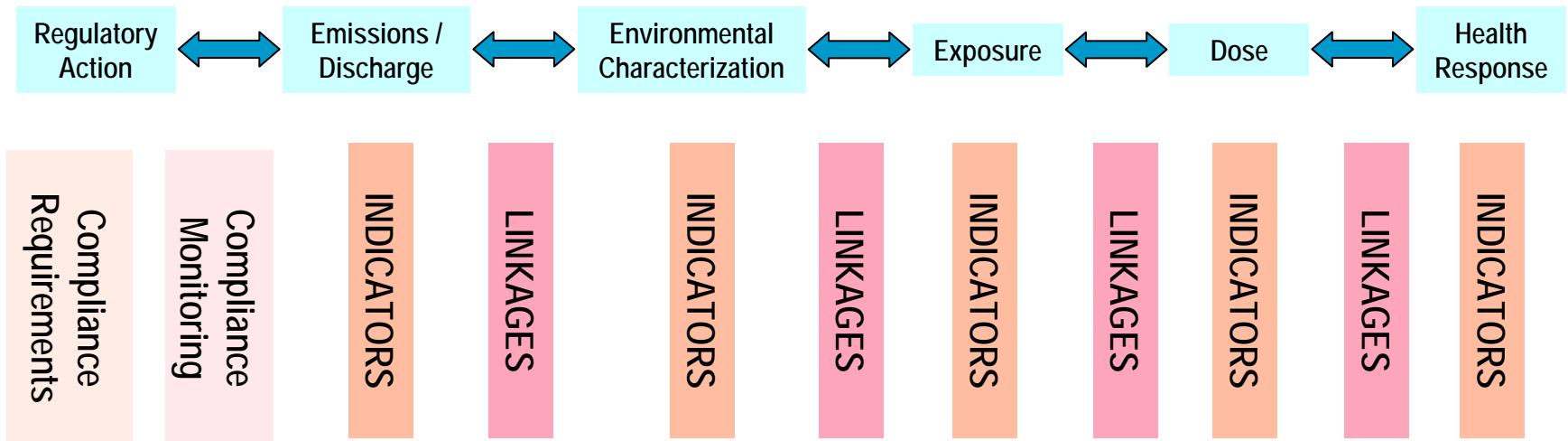
# Framework for Indicator Research



## Five areas of focus in the framework

- Indicator Development (Indicators)
- Methods (Measurements)
- Networks and Databases (Monitoring Systems)
- **Linkages of Indicators (Analysis, Synthesis, & Models)**
- Communication of Results (Visualization, Technology Transfer & Knowledge Translation)

# Framework paradigm: role of indicators & linkages



# Scientific knowledge depends on understanding processes & linkages



↑ ↓ Air Exchange Rates

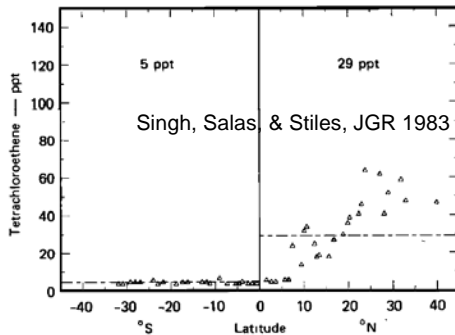
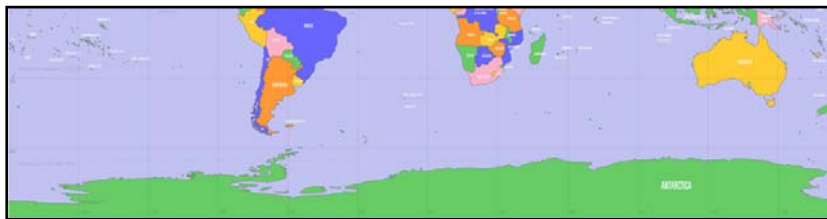
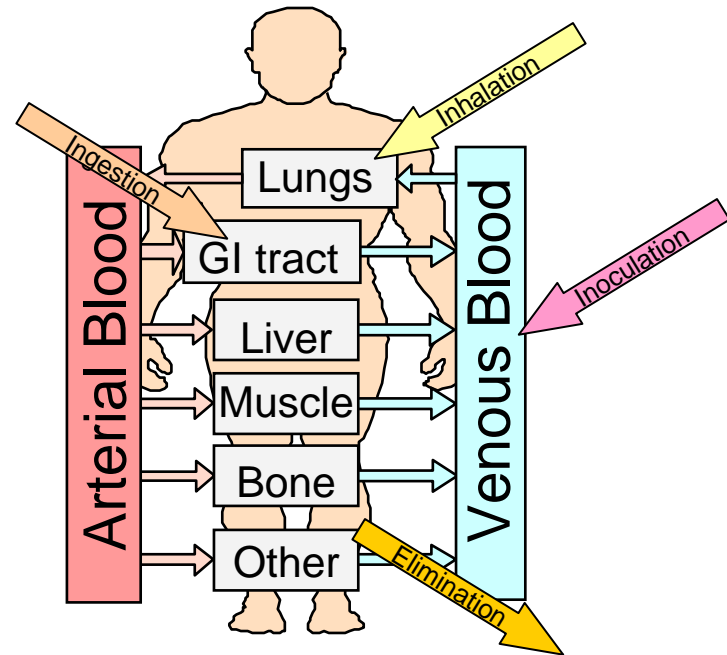
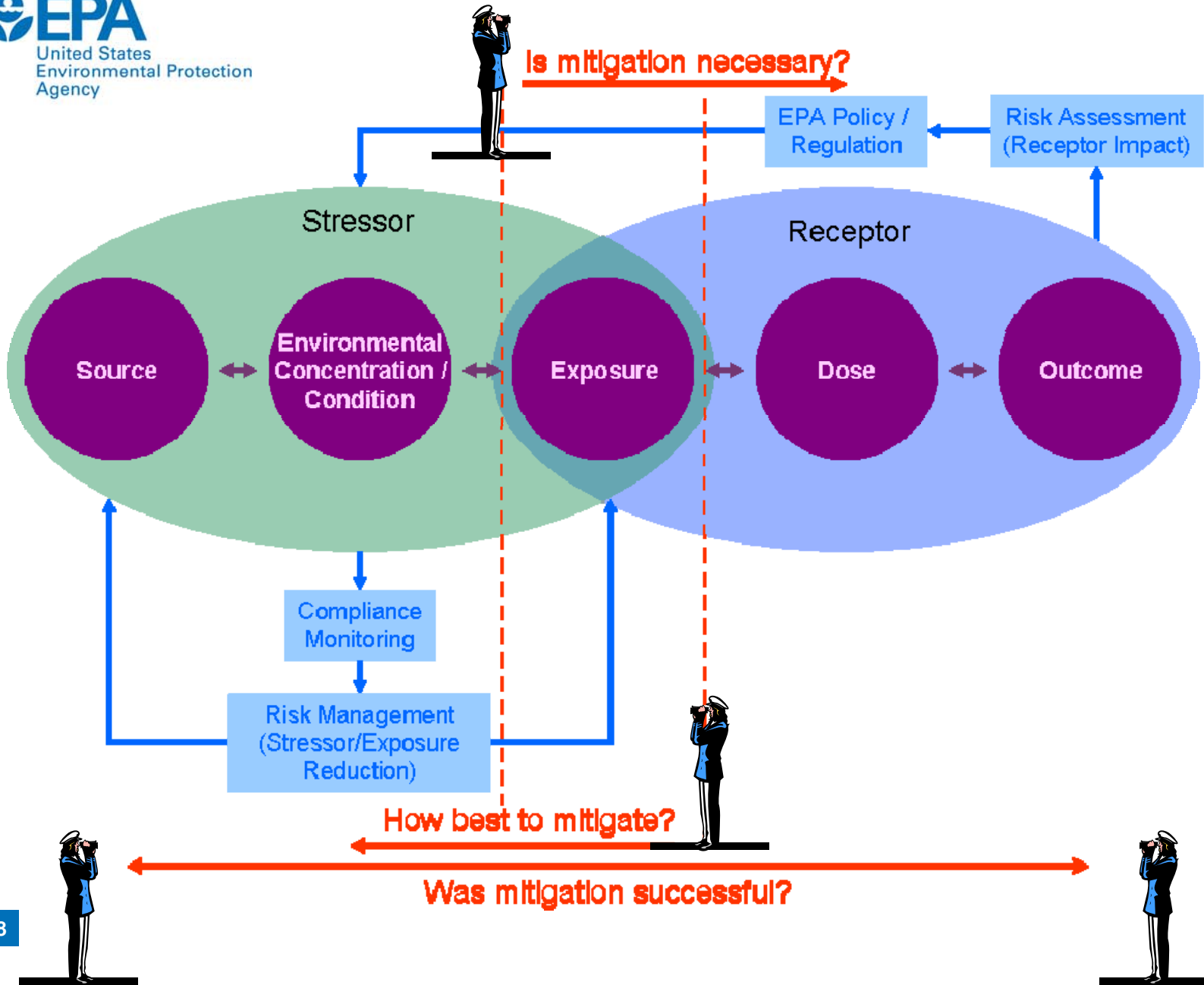


Fig. 9. Latitudinal distribution of tetrachloroethene over eastern Pacific.

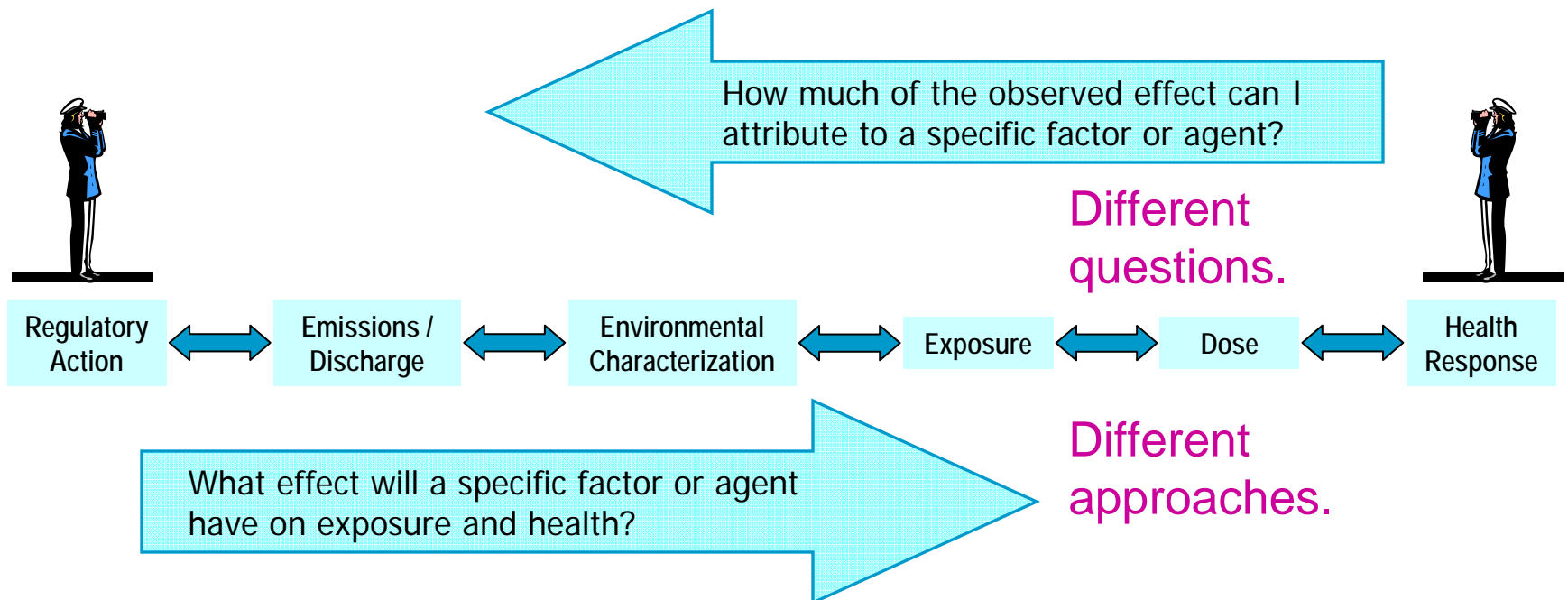


- PBPK Modeling
  - Physiology, including compartment volumes, blood flows
  - Absorption, inhalation, ingestion, inoculation
  - Distribution, partition coefficients
  - Metabolism, rate constants
  - Elimination, including urinary elimination rates

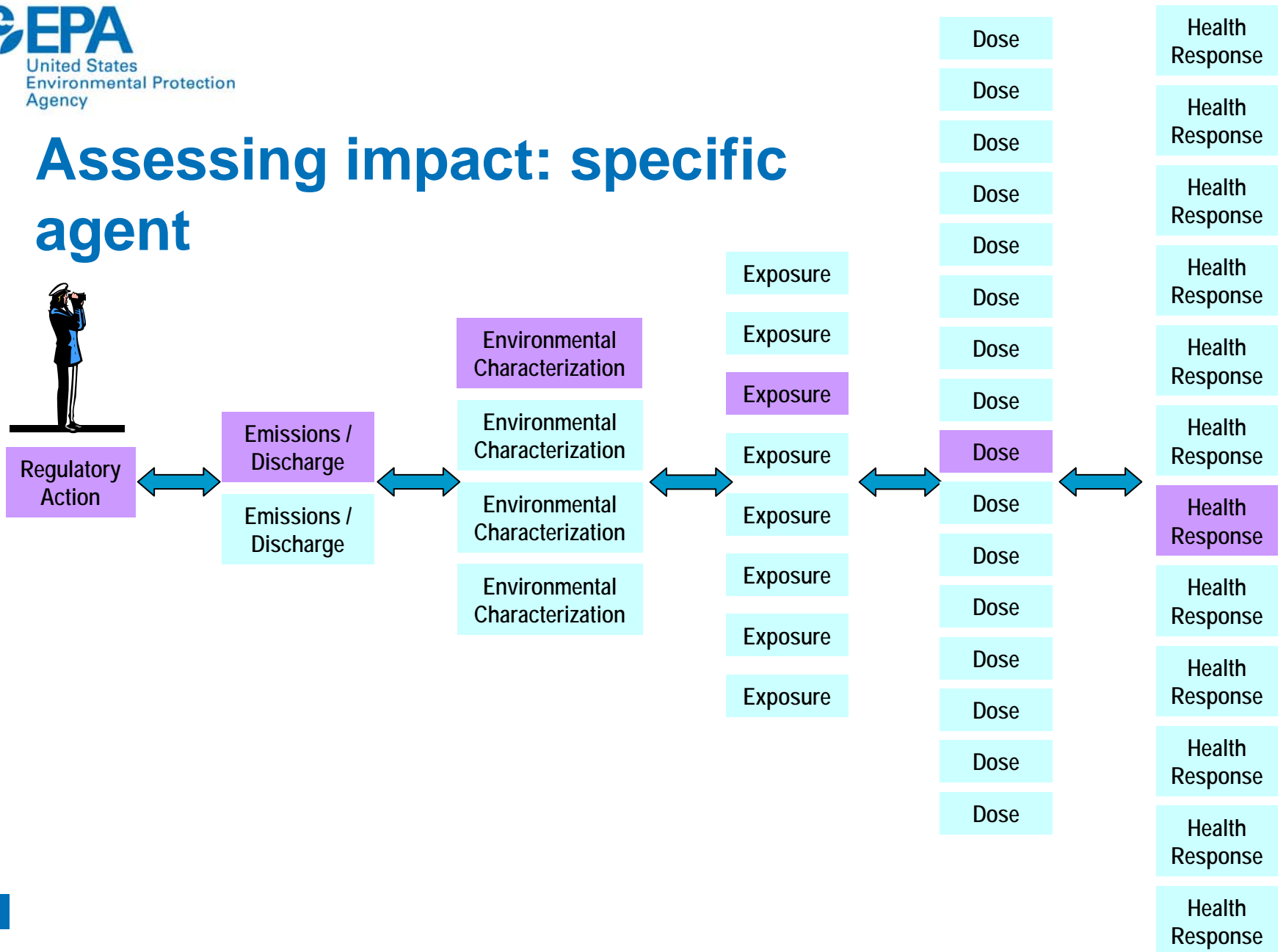




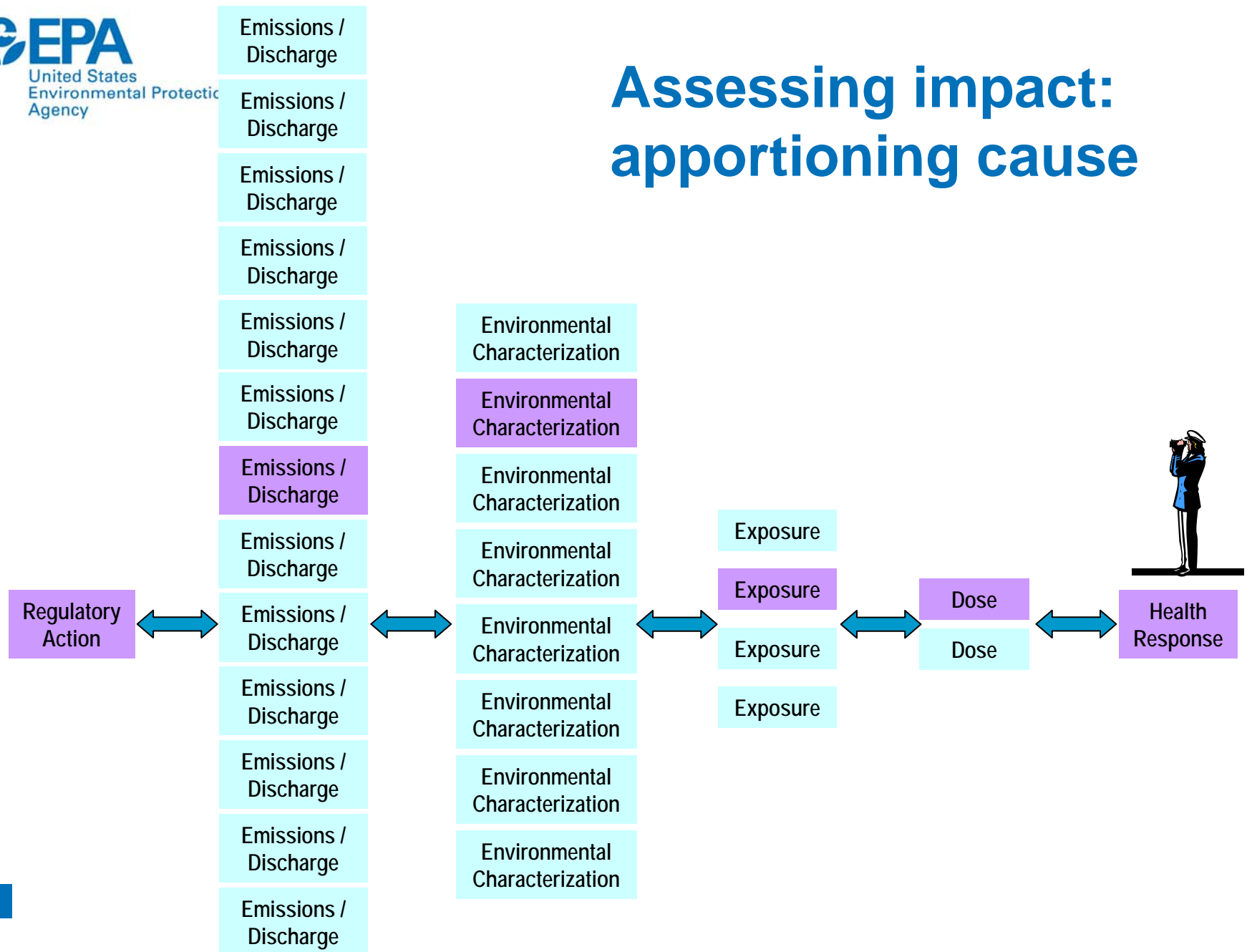
# Framework paradigm: assessing impact



# Assessing impact: specific agent



# Assessing impact: apportioning cause



# Assessing evidence for causation

- **Bradford-Hill criteria**

- “None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required sine qua non”.
- **Strength:**
  - A small association does not mean that there is not a causal effect.
- **Consistency:**
  - Consistent findings observed by different persons in different places with different samples strengthens the likelihood of an effect.
- **Specificity:**
  - Causation is likely if a very specific population at a specific site and disease with no other likely explanation. The more specific an association between a factor and an effect is, the bigger the probability of a causal relationship.
- **Temporality:**
  - The effect has to occur after the cause (and if there is an expected delay between the cause and expected effect, then the effect must occur after that delay).
- **Biological gradient:**
  - Greater exposure should generally lead to greater incidence of the effect. However, in some cases, the mere presence of the factor can trigger the effect. In other cases, an inverse proportion is observed: greater exposure leads to lower incidence.
- **Plausibility:**
  - A plausible mechanism between cause and effect is helpful (but Hill noted that knowledge of the mechanism is limited by current knowledge).
- **Coherence:**
  - Coherence between epidemiological and laboratory findings increases the likelihood of an effect. However, Hill noted that “... lack of such [laboratory] evidence cannot nullify the epidemiological affect on associations”
- **Experiment:**
  - “Occasionally it is possible to appeal to experimental evidence”
- **Analogy:**
  - The effect of similar factors may be considered

## Examples in assessing causation

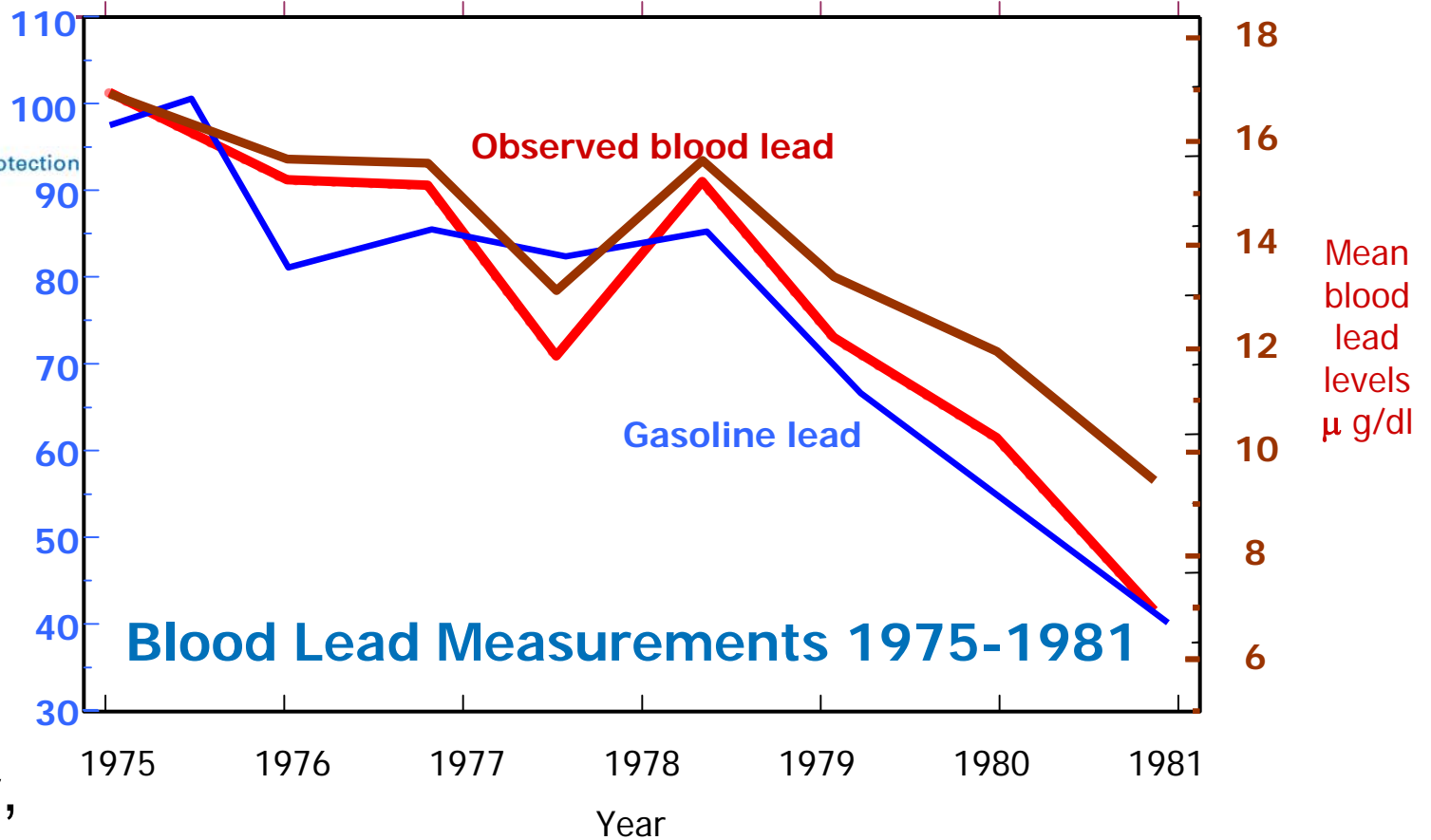
- Gasoline lead & blood lead levels
- Mortality and church weddings in the UK
- PM epidemiology and potential causal agents



Lead used in gasoline (thousands of tons)

Source: Pirkle et al JAMA 272:284-91, 1994

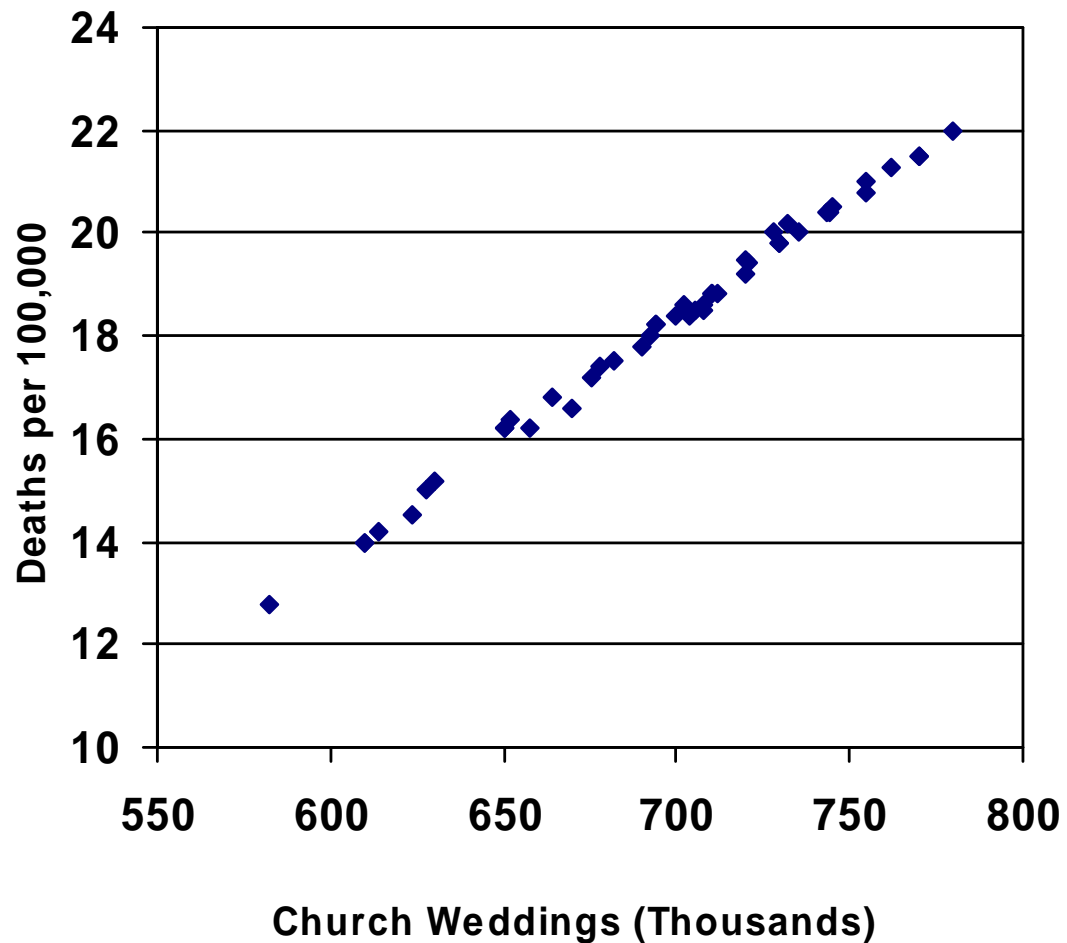
Strength, Temporality, Gradient, Plausibility Experiment



# Mortality Increases with Church Weddings

## Death vs. Life

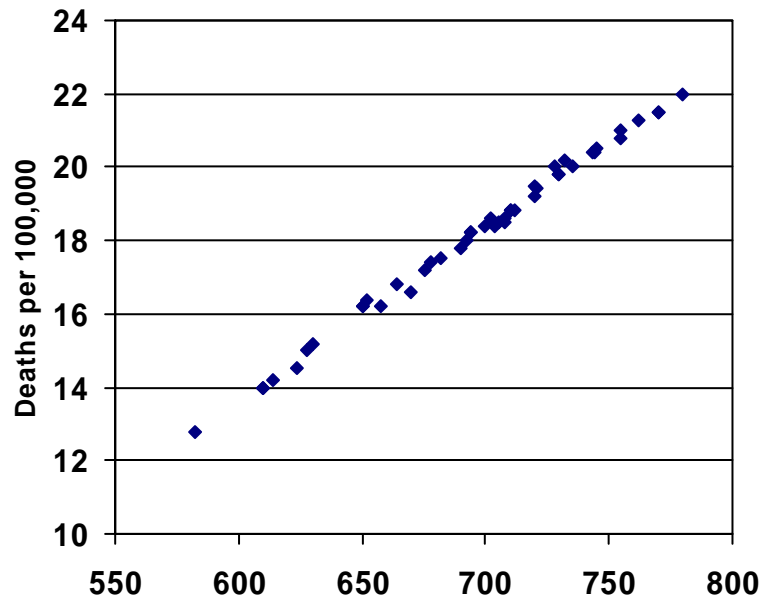
Strength  
Temporality  
Gradient



$r = 0.99$   
Data from UK

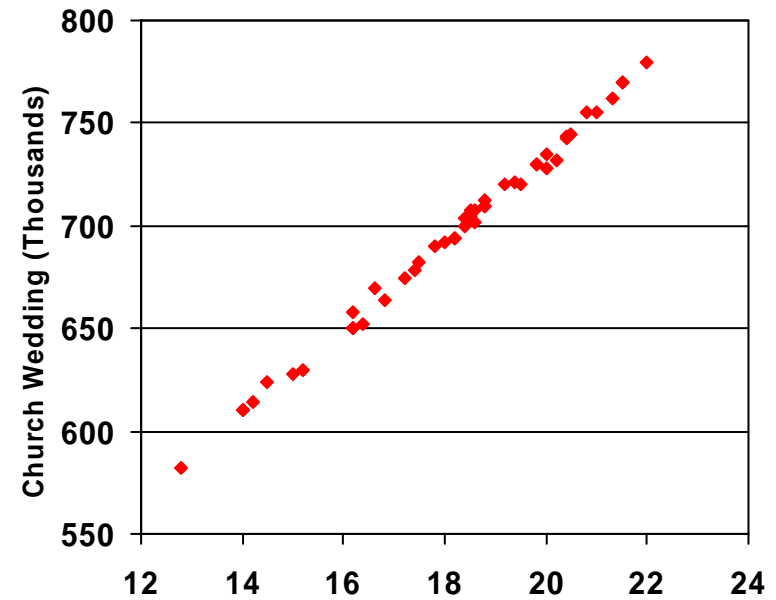
# Mortality and Church Weddings *(UK data)*

Death vs. Life



$r = 0.99$  Church Weddings (Thousands)

Life vs. Death



$r = 0.99$  Deaths per 100,000

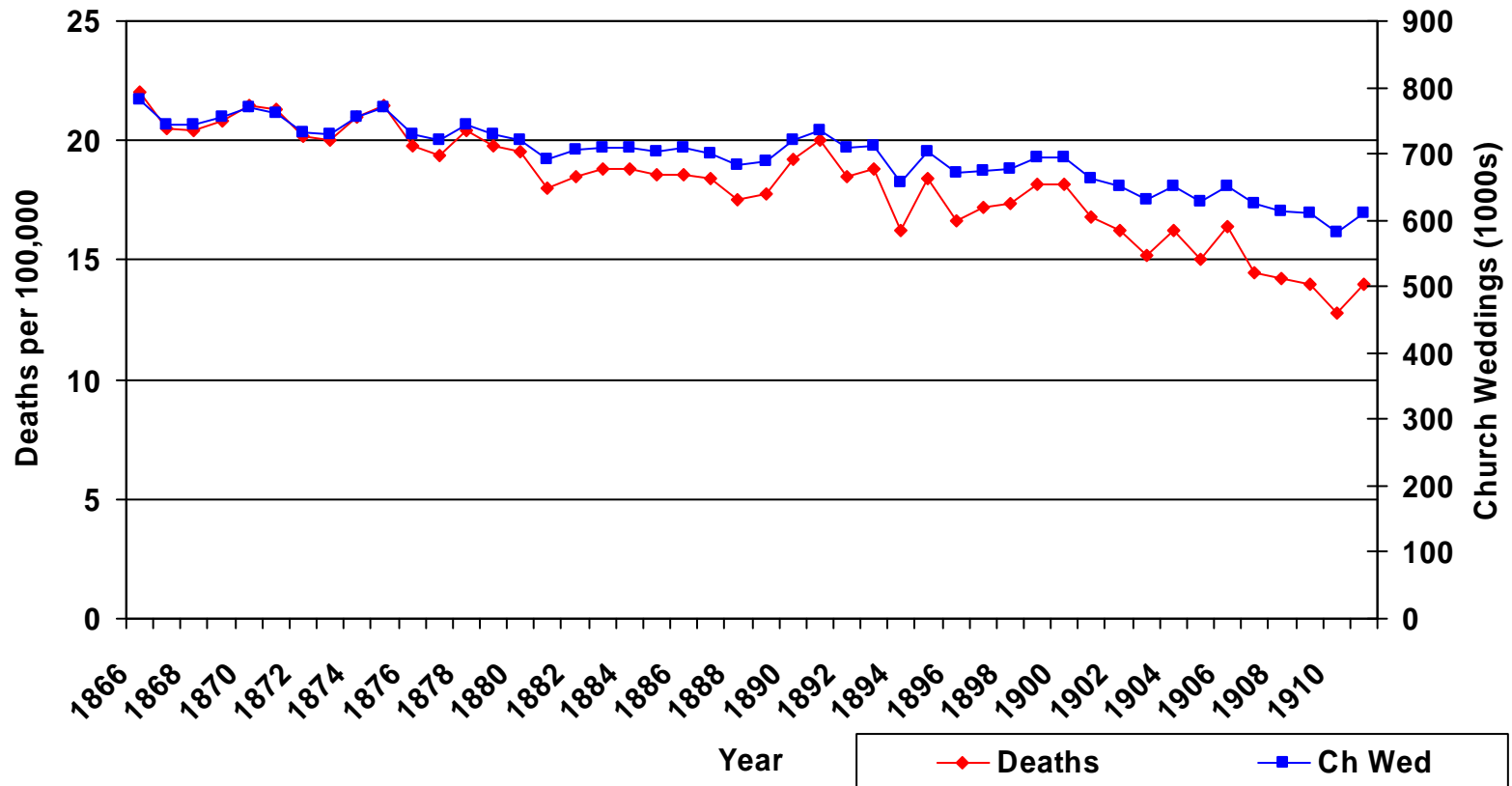
Marriage is fatal in UK?

Imminent death encourages weddings?

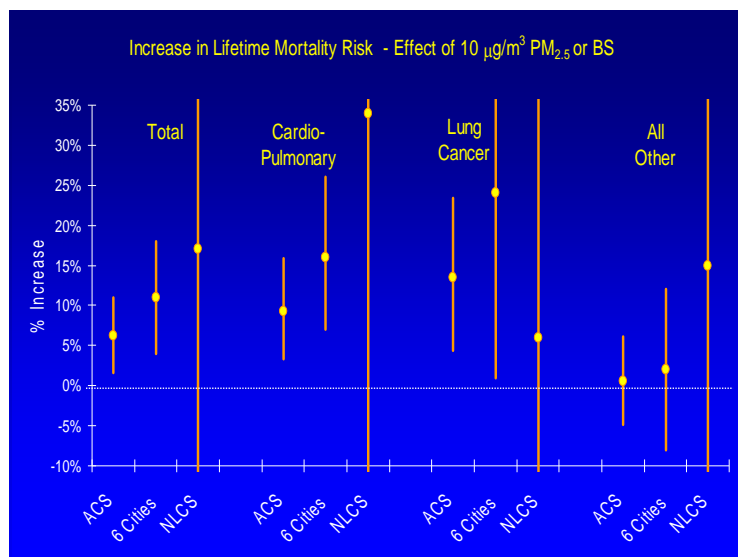


# But no plausibility for the correlation

Time as a lurking factor



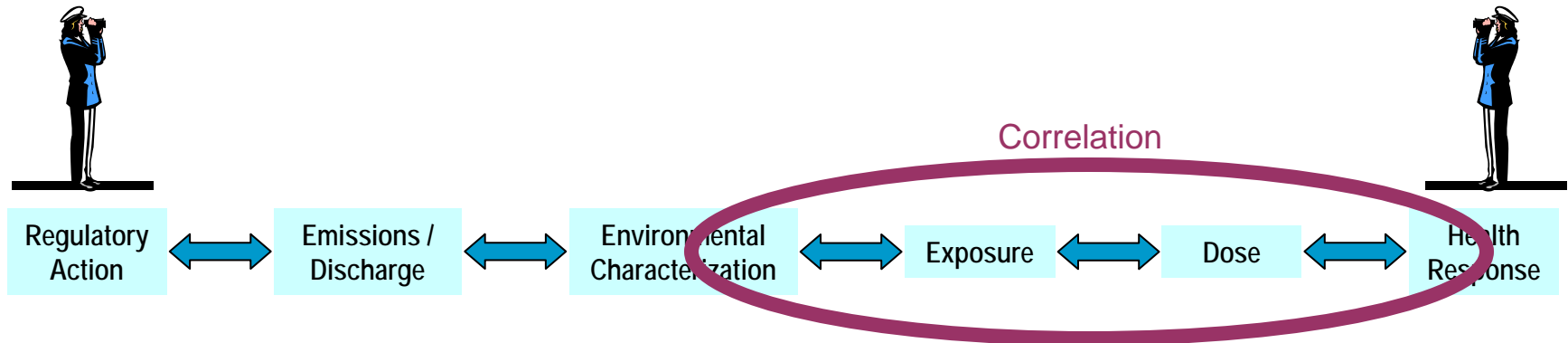
## Characteristics of PM epidemiology data



Based on extension of 6 Cities (unpublished) ACS (Pope et al, 2002), NLCS background BS (Hoek et al. 2002) From Dockery

- Observed population is large
  - Needed for statistical power to separate out effects
- Population lives over a large area
  - Spatially distributed across metropolitan area
- Effects from across area correlate with pollutant measures across area
  - Implies some level of spatial correlation
- Integrated over population and area (and time)

## Framework and PM issues

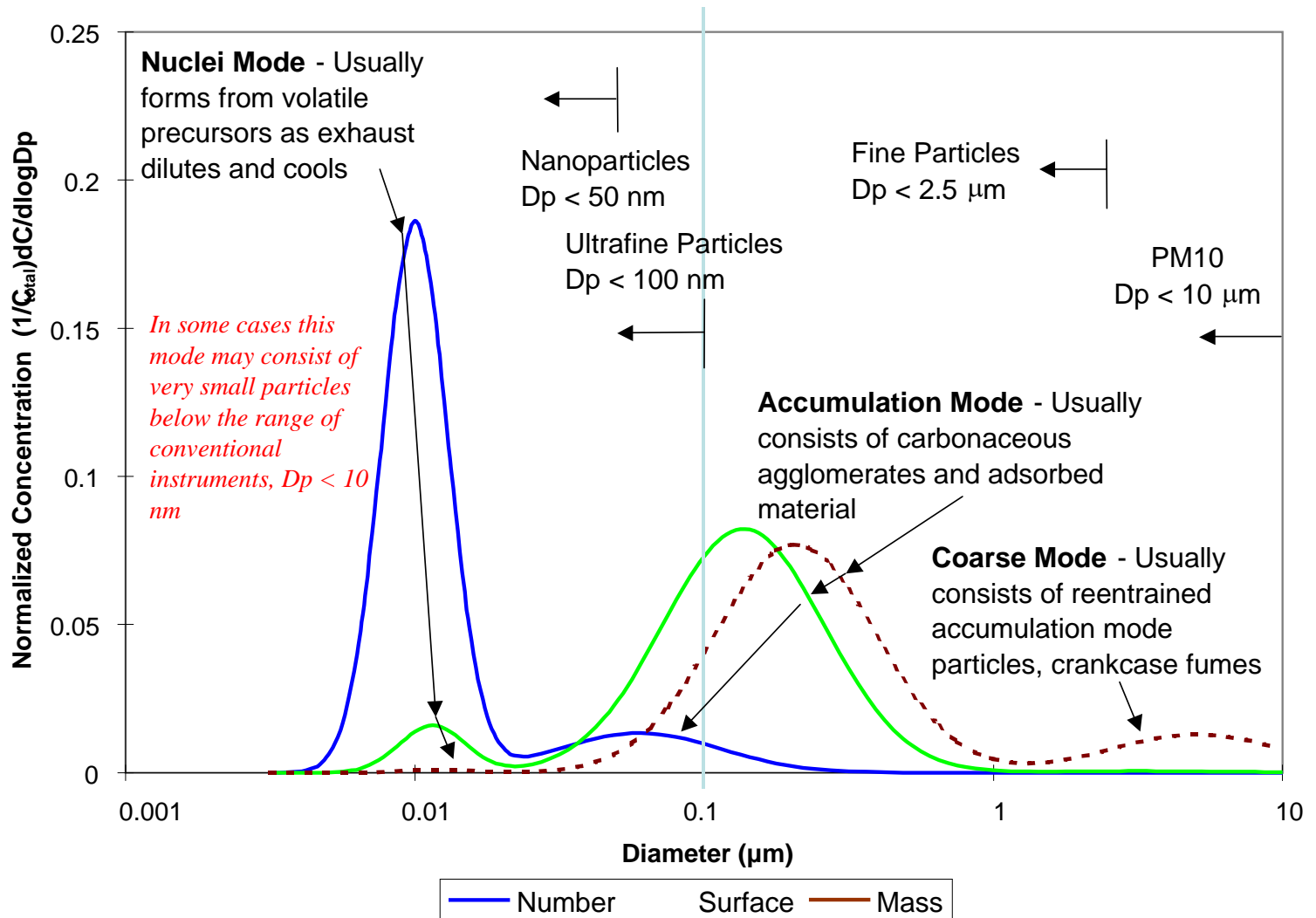


### Postulated Causal Agents

- Particulate matter mass
  - PM<sub>2.5</sub>, PM<sub>coarse</sub>, PM<sub>10</sub>
- Associated gases
  - CO, NO<sub>2</sub>
- Ultrafine particles
  - Number
- Metals
  - Soluble, transition
- Organics
  - Oxygenates, SOA

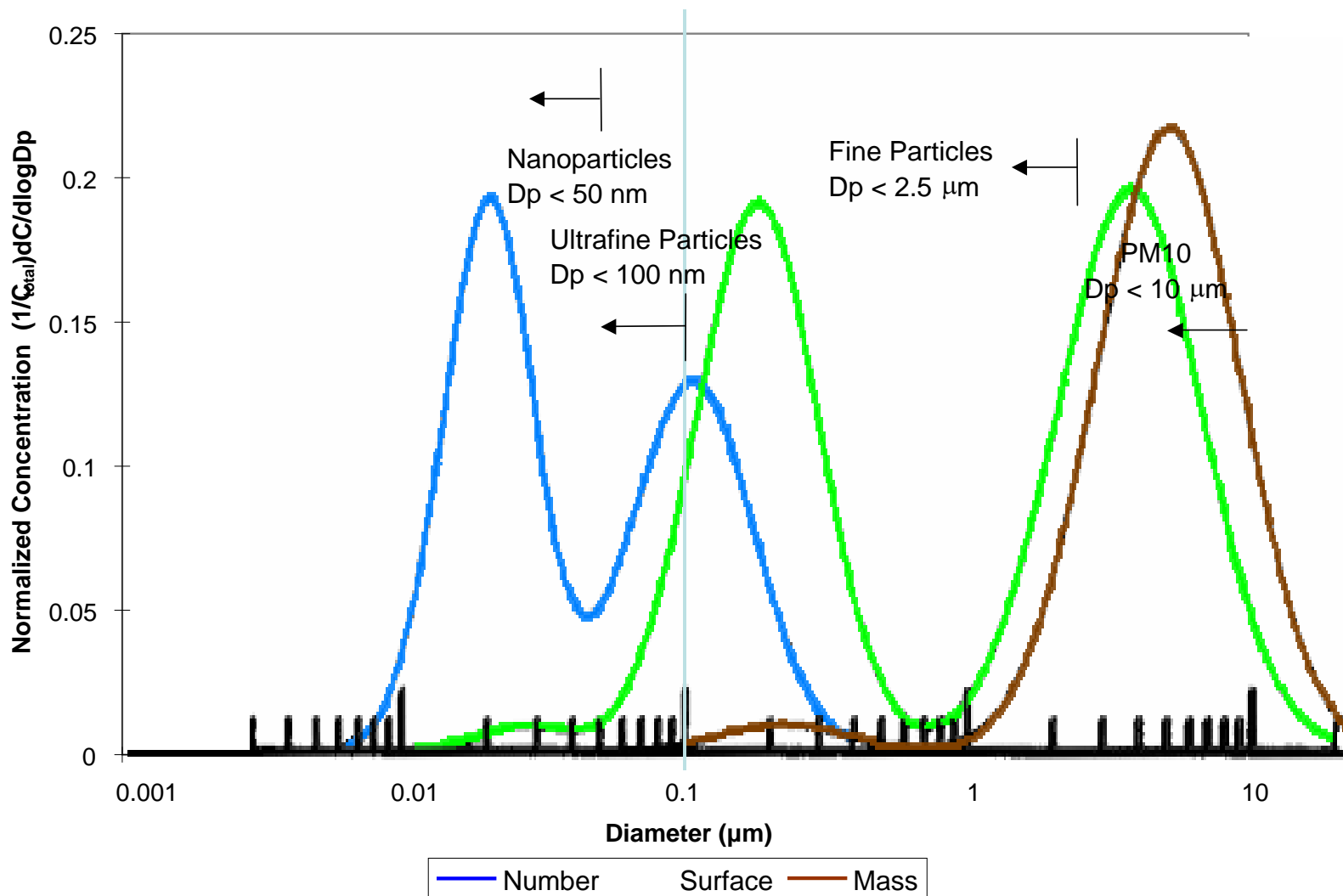
# Particle Size Distributions using Number, Surface Area, and Mass

Typical  
Engine  
Exhaust

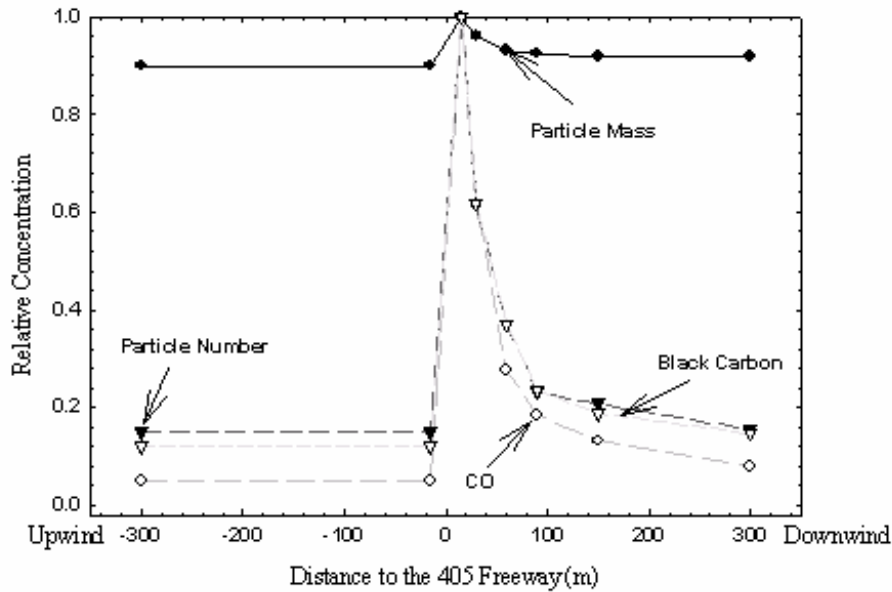


# Particle Size Distributions using Number, Surface Area, and Mass

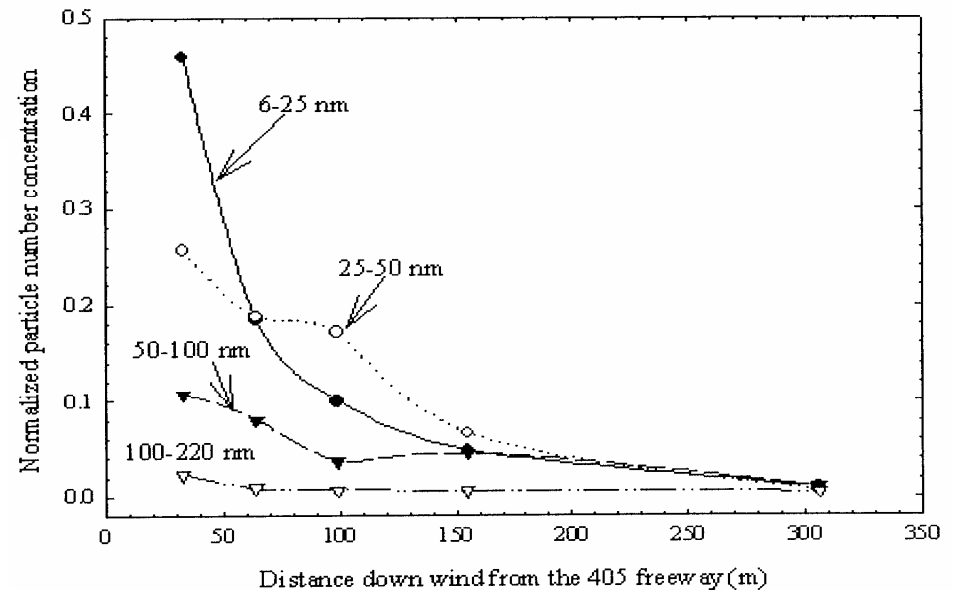
Typical Urban Aerosol



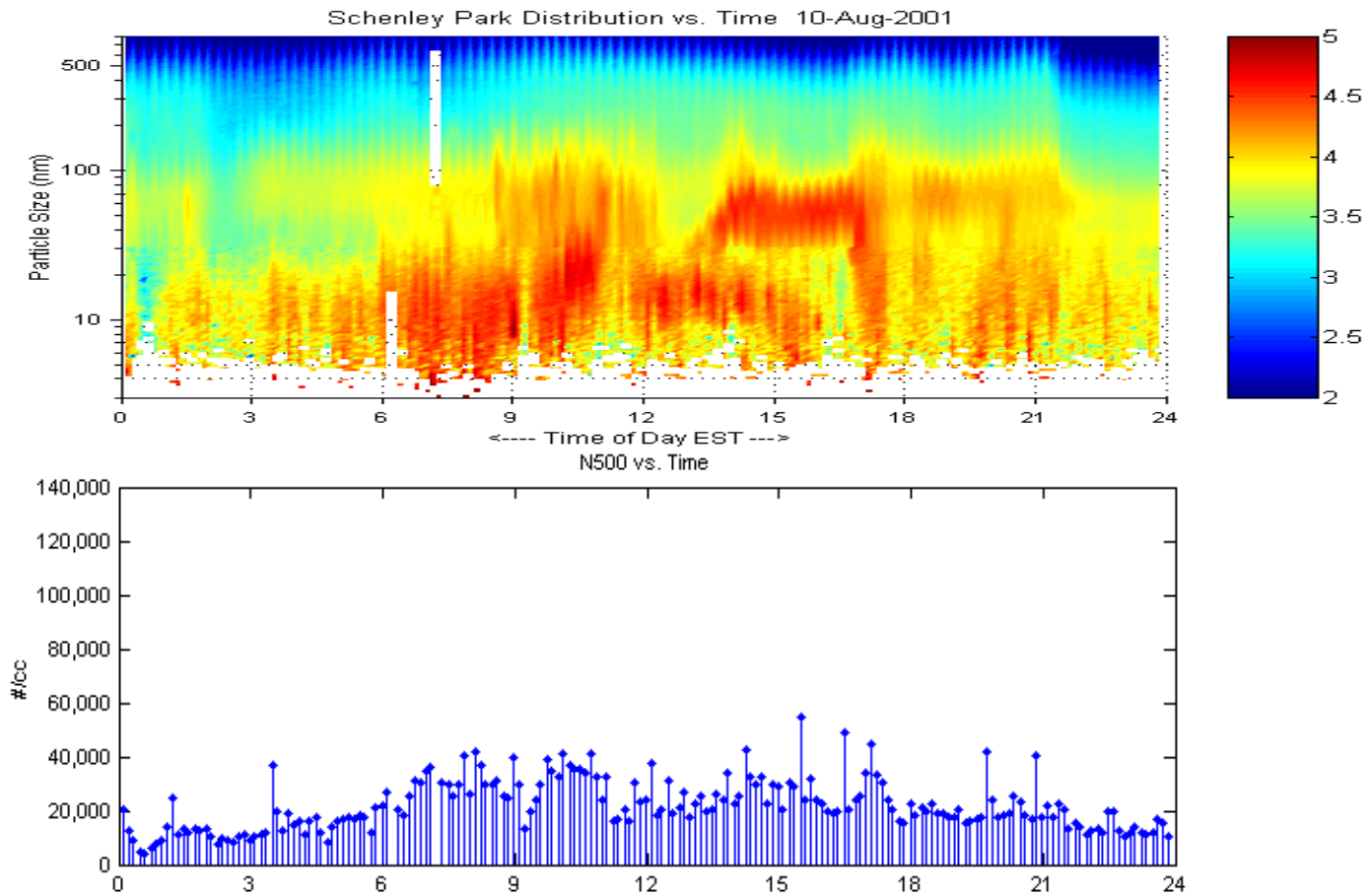
# Near-Source Exposure Problem: Sharp Gradients for UF Particles



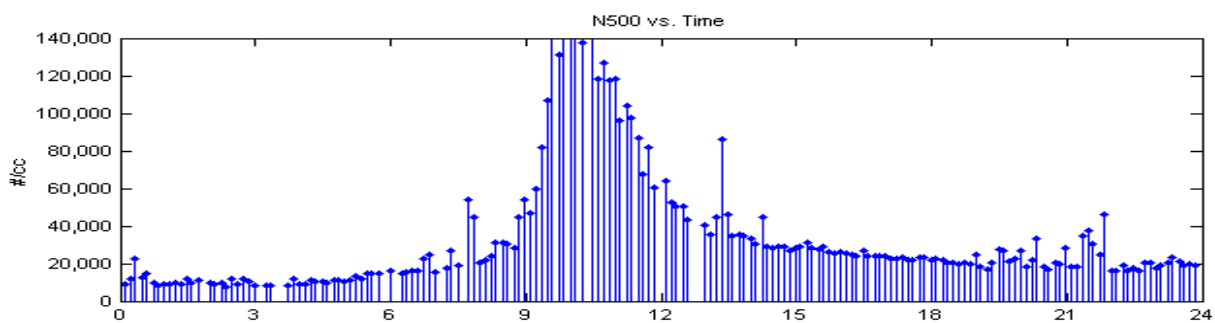
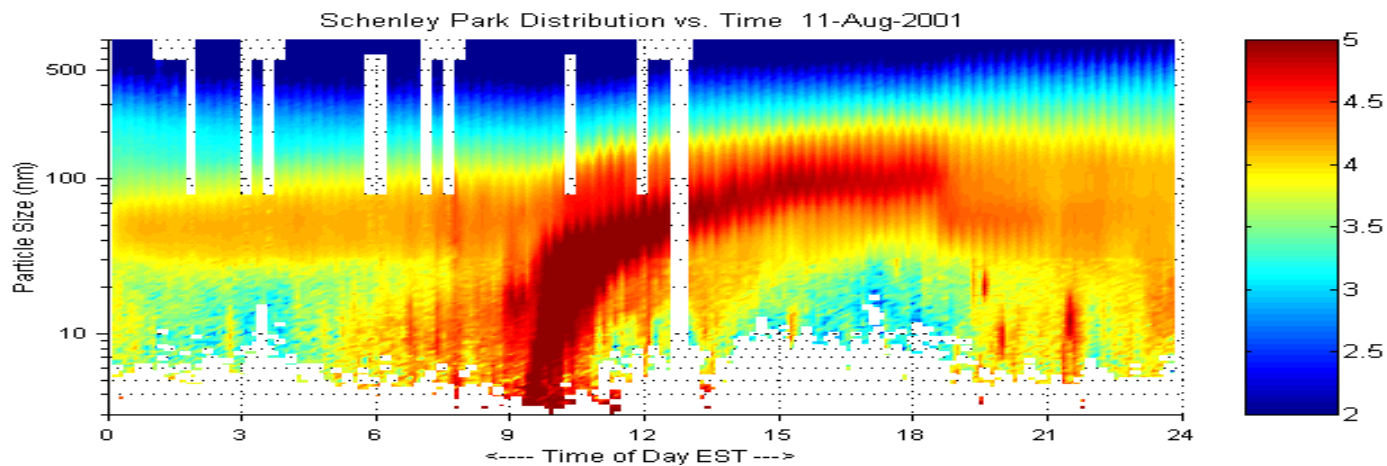
(Zhu et al., 2001)



# Typical PM Size Distribution Evolution



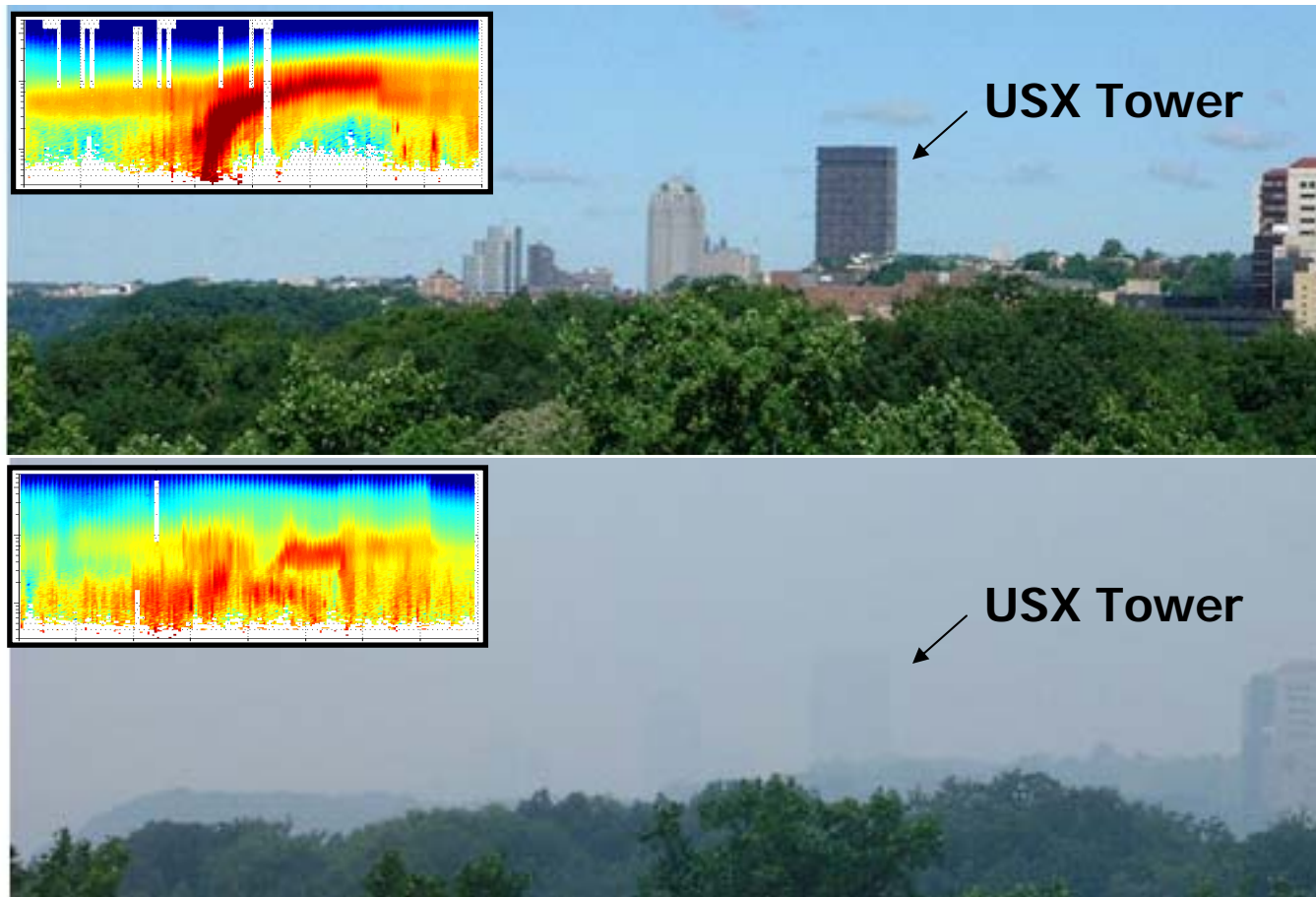
# Nucleation and Growth a Few Hours After Sunrise



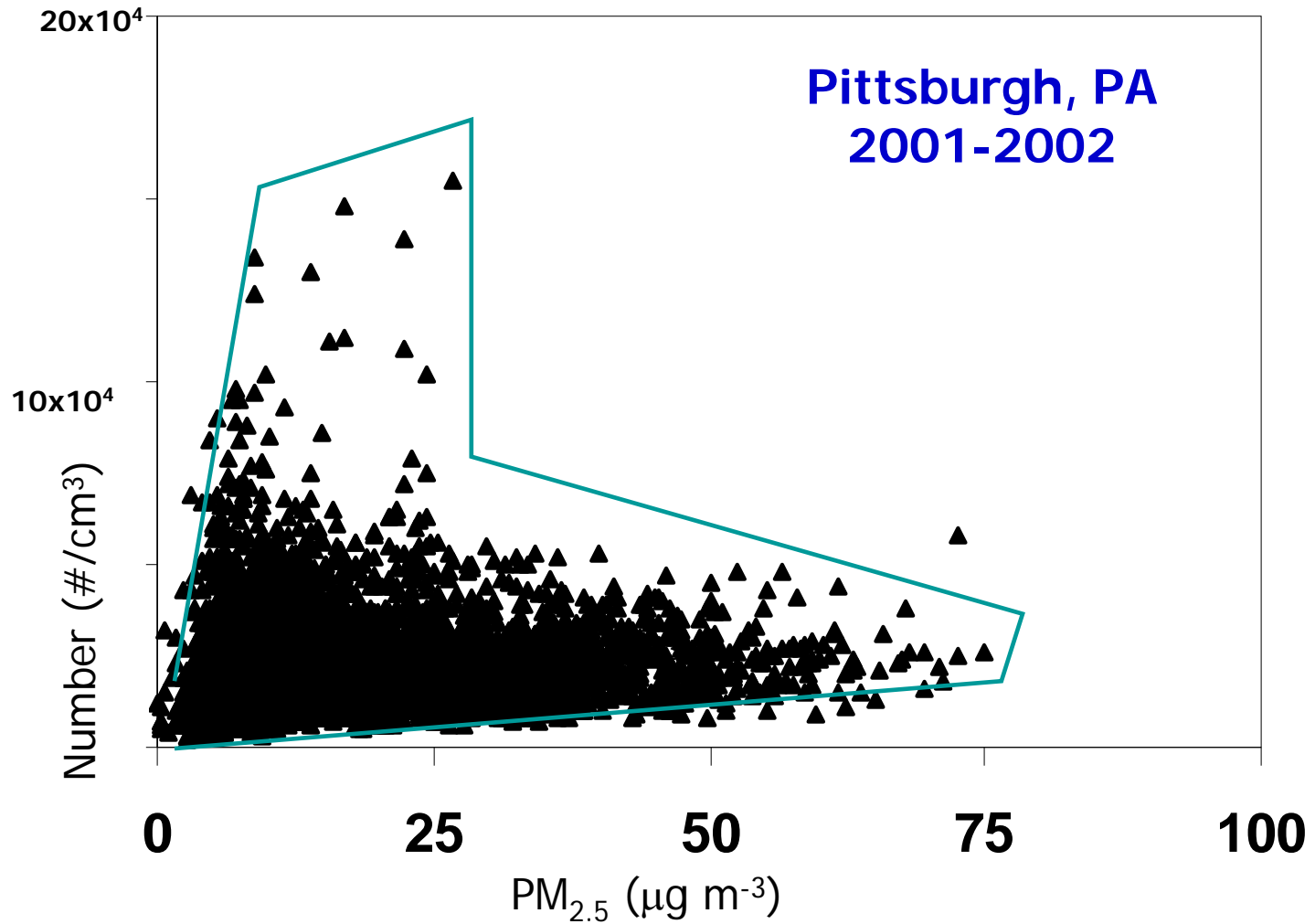
August 11, 2001, Pittsburgh Supersite, from Spyros Pandis



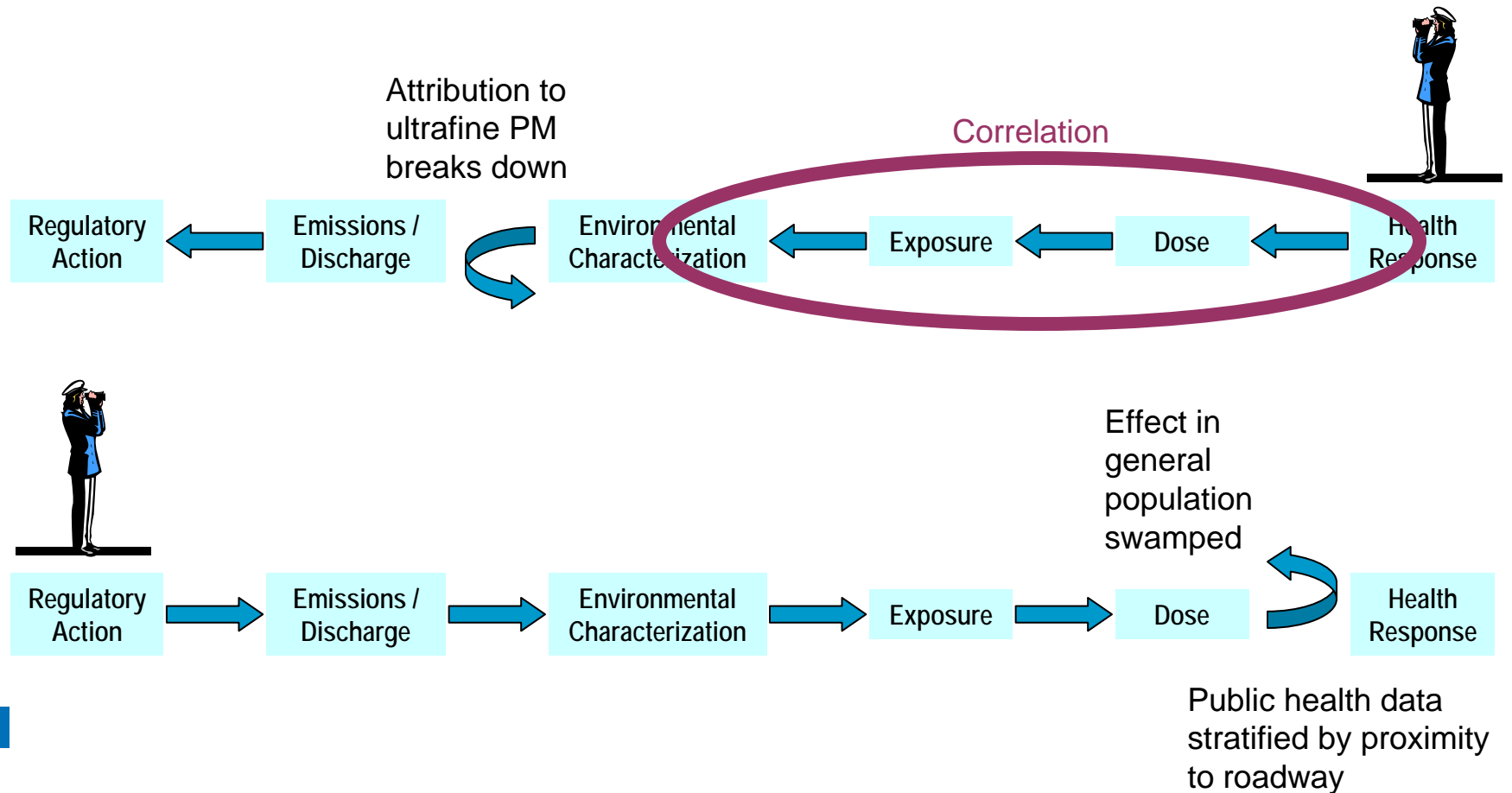
# Nucleation and Visibility



# Aerosol Number & Mass



# Framework and ultrafine PM issues



# NOx SIP results in lower ozone

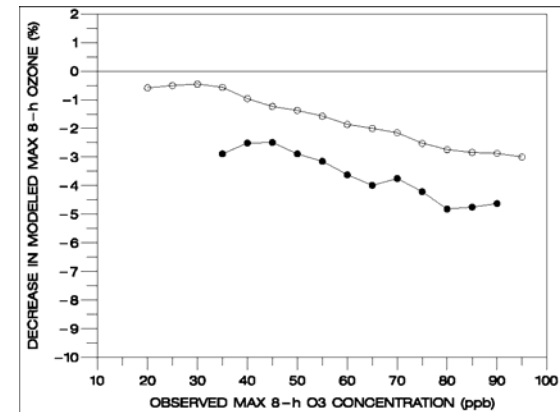
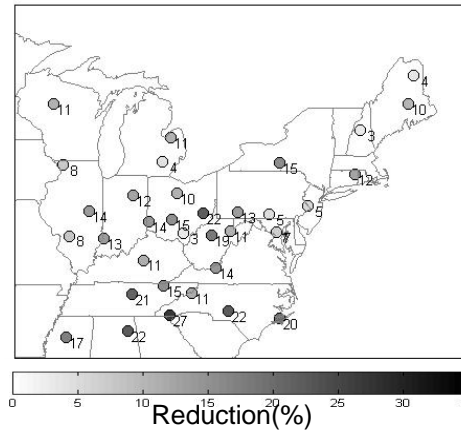
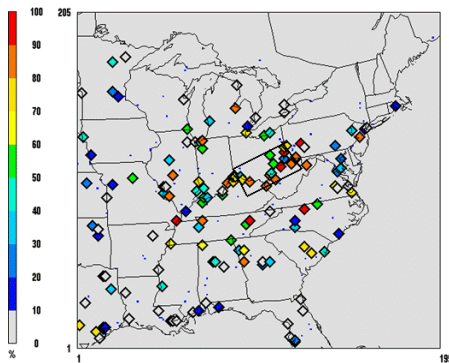
Reduced NOx emissions  
(measured)



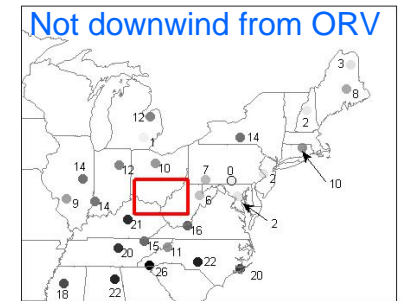
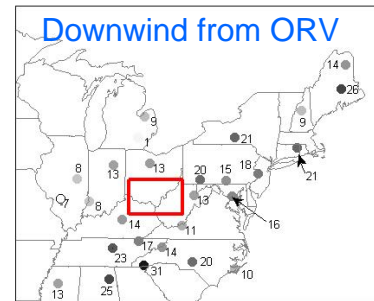
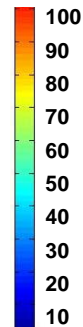
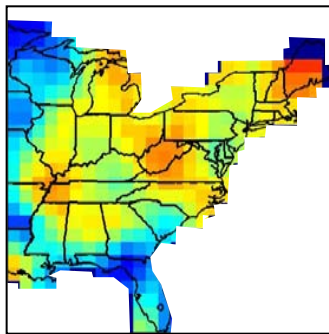
Lower Ozone Concentrations  
(measured)



Attributed to factors / linkages  
(modeled)



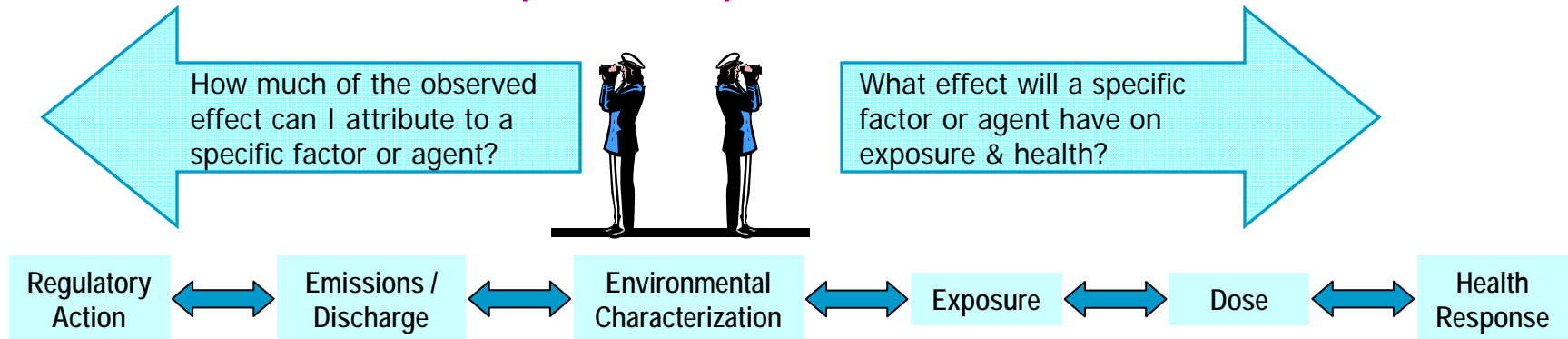
Emission reduction(%)



Reduction(%)

# Framework paradigm: assessing impact

Combine attribution approaches with predictive, specific impacts.



- Understanding processes and linkages between indicators is critical for indicator selection and for indicator interpretation.