EASIUR Tutorial v0.3

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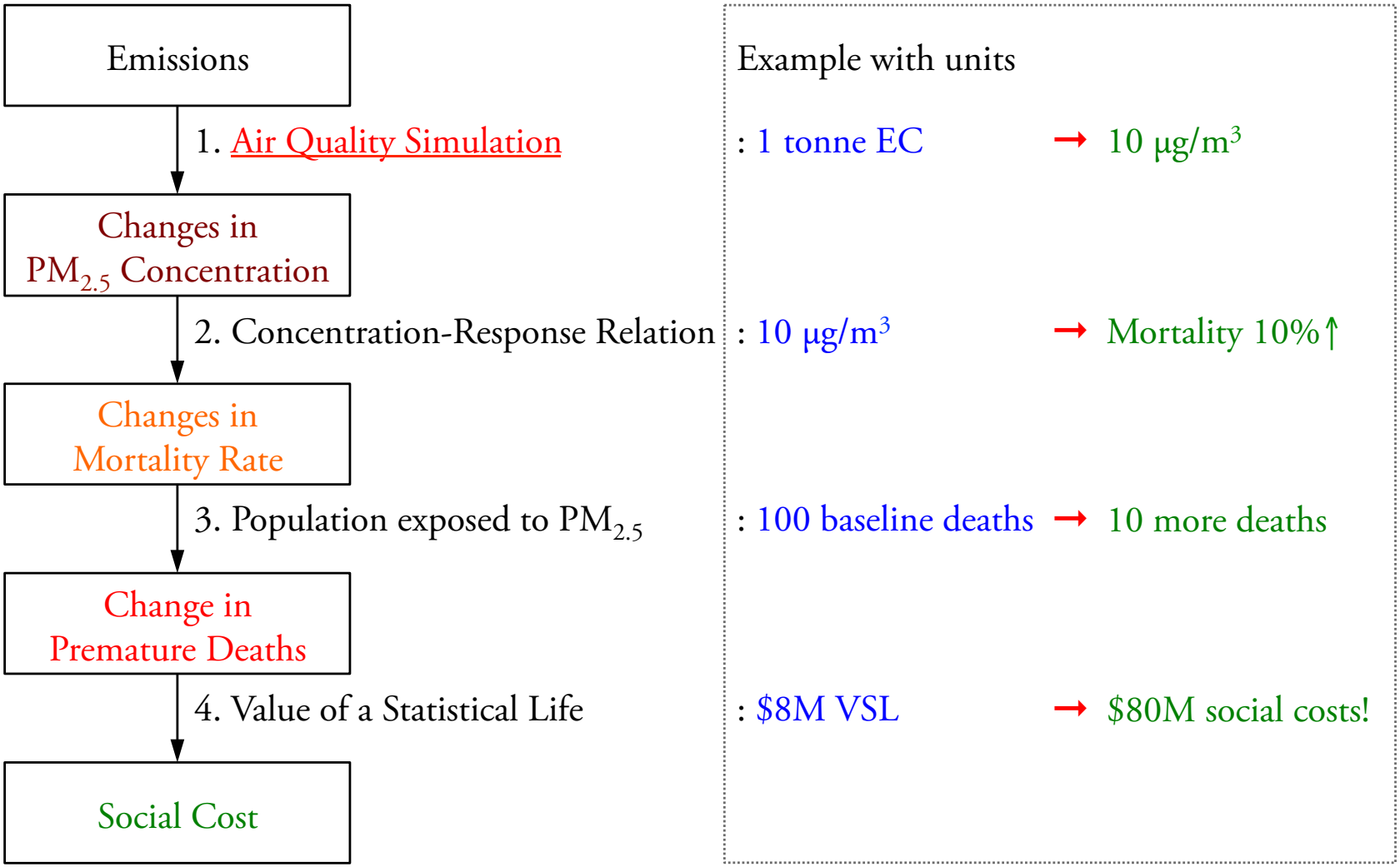
The Social Cost of Air Quality



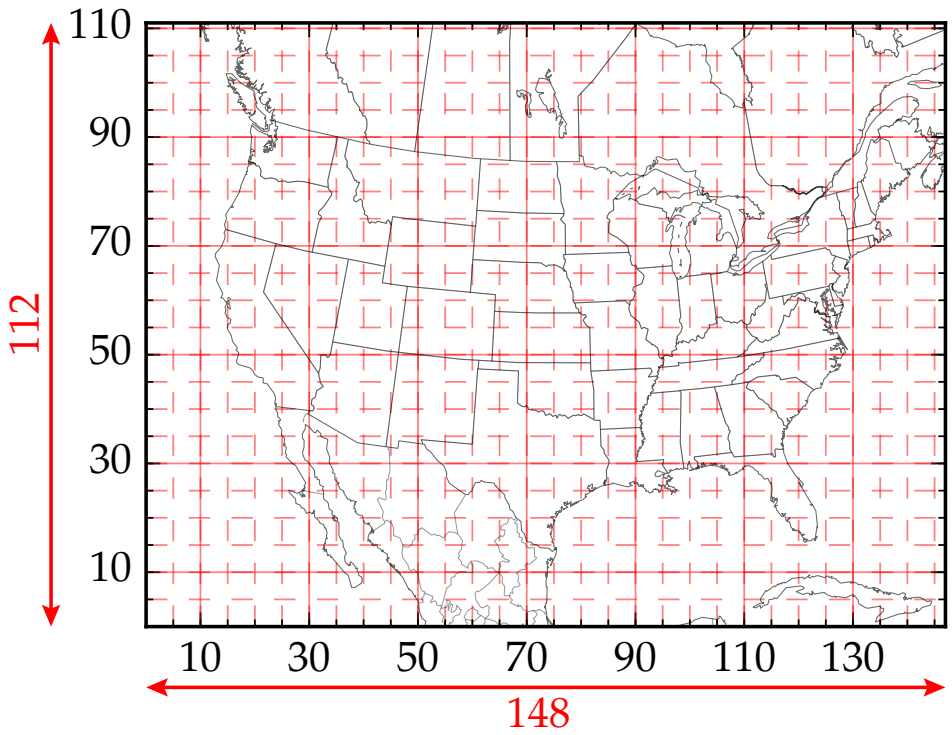
EASIUR Model

(Estimating Air pollution Social Impact Using Regression)

- EAISUR estimates marginal damages [$/t] of emissions in the United States
- Species: currently four species
  - EC: direct or "primary" $PM_{2.5}$
  - SO_2, NO_x, and NH_3: precursors to "secondary" $PM_{2.5}$
  - Volatile organic compounds (VOCs): important missing species
- Time resolution: four seasons
- Spatial resolution: 148 × 112 grid (one cell = 36 km × 36 km)
- Three stack heights: Ground-level area emissions, Point emissions at 150 m, and Point emissions at 300 m
- Where to get? `<http://barney.ce.cmu.edu/~jinhyok/easiur/>`

How to use EASIUR

- User interface: spatial lookup tables
  - CSV (Comma-separated value) file
  - Shapefile for GIS software
  - Other format? (Need county-based?)
- A 148×112 array per species per season (16 arrays in total)



How to use EASIUR

- CSV (Comma-separated value) file
  - Filename format: `(species)_(season)_(height).csv`
  - `species`: `PEC` (Primary $PM_{2.5}$), `SO2` (Sulfur dioxide), `NOX` (Nitrogen oxides), `NH3` (Ammonia)
  - `season`: `Winter` (Jan-Mar), `Spring` (Apr-Jun), `Summer` (Jul-Sep), `Fall` (Oct-Dec), `Annual` (Average of four seasons)
  - `height`: `area` (ground-level), `point150` (150 m stack height), `point300` (300 m stack height)
  - Unit: USD per metric ton ($/t)

How to use EASIUR

- Shapefile for GIS software
  - Look at Attribute table.
  - Field name format: `(species)(season)(height)`
  - `species`: PEC: Primary $PM_{2.5}$, SO2: Sulfur dioxide, NOX: Nitrogen oxides, NH3: Ammonia
  - `season`: `Wi` (Jan-Mar), `Spr` (Apr-Jun), Su (Jul-Sep), `Fa` (Oct-Dec), An (Average of four seasons)
  - `height`: A (ground-level), M (150 m stack height), H (300 m stack height)
  - (Field names are shortened because shapefile allows only up to 10 characters for field name.)

- Caveats:
  - EASIUR grid index starts with (1, 1), not (0, 0).
  - EASIUR uses metric ton, not short ton.

Example: 3 tonne of SO_2 emitted in Pittsburgh in Winter?

1. Convert Pittsburgh (Lat, Lon) to EASIUR grid coordinate (x, y)
   $\Rightarrow (-80.00^\circ, 40.44^\circ) = (116.62, 63.49) \simeq (117, 63)$
   $\Rightarrow$ A bit complicated, see the next slide.
2. Find (117, 63) in Winter SO_2 array ($\text{EASIUR}_{SO_2}^{\text{Winter}}$)
   $\Rightarrow \text{EASIUR}_{SO_2}^{\text{Winter}}\,[117, 63] = \$240{,}000\ /\text{t}\ SO_2$
3. Multiply 3 t SO_2
   $\Rightarrow$ Social Cost $= \$240{,}000\ /\text{t}\ SO_2 \times 3\ \text{t}\ SO_2 = \$720{,}000$

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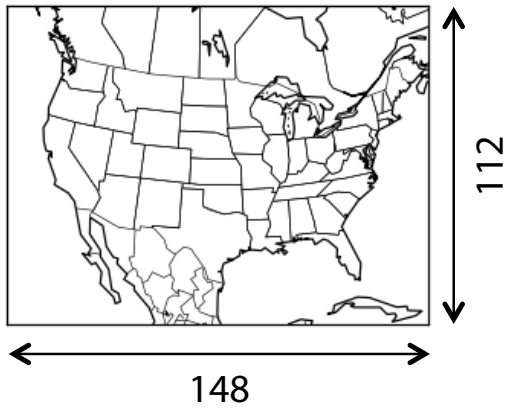
Converting (latitude, longitude) to EASIUR grid

(a) Emissions information on an ellipsoid (NAD83)

(b) Earth as a spheroid



(c) EASIUR grid in Lambert conformal conic projection

Step 1: Ellipsoid to Spheroid

Step 2: Spheroid to Lambert conformal conic

- EASIUR website provides conversion tools:

  ⇒ <http://barney.ce.cmu.edu/~jinhyok/easiur/>

Three major sources of uncertainties

- Air quality simulation:
  - EASIUR provides 95% prediction intervals (about a factor of two or three)
- Concentration-Response relation
- Value of a Statistical Life

Uncertainty: Concentration-Response relation (1)

- Epidemiological studies on $PM_{2.5}$ mortality provide 95% confidence intervals of relative risk ($RR \equiv \frac{\text{increased mortality rate}}{10\ \mu g\ PM_{2.5}/m^3}$)
  - Log-linear relation: Mortality $\propto \ln(RR)$
- Two landmark cohort studies:
  - American Cancer Society study (Krewski et al, 2009):
    $\Rightarrow$ Bigger sample (or cohort), not random
    $\Rightarrow$ $RR = 1.06$ (1.04-1.08)
  - Harvard Six Cities study (Lepeule et al, 2012):
    $\Rightarrow$ Smaller sample in eastern U.S., but random
    $\Rightarrow$ $RR = 1.14$ (1.07-1.22)

Uncertainty: Concentration-Response relation (2)

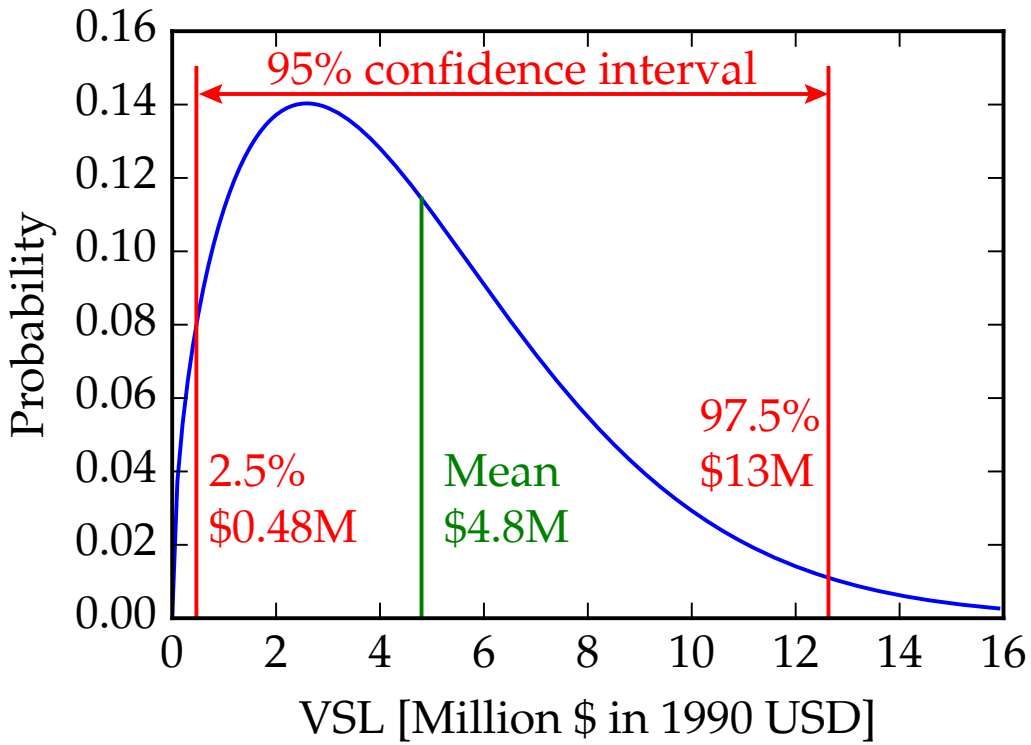
- EASIUR default relative risk: 1.06
  - Adjustment factor (F_{RR}) for other *RR*:

$$F_{RR} = -15.1 + 15.2 \cdot RR \tag{1}$$

  - e.g. for $RR = 1.08$, $F_{RR} = -15.1 + 15.2 \times 1.08 = 1.3$.
    Multiply 1.3 to default EASIUR estimate.
- Uncertainty analysis
  - Simple: Use Eq. 1 to calculate 95% confidence interval.
  - Monte Carlo: Look at Appendix C: Deriving Health Impact Functions in BenMAP User's Manual.

Uncertainty: Value of a Statistical Life (1)

- U.S. EPA's official VSL: $4.8M in 1990 USD and 1990 income level (= $6.3M in 2000 USD = $8.0M in 2010 USD)
- a mean of a Weibull distribution (scale=5.32, shape=1.51) based on 26 value-of-life studies



Uncertainty: Value of a Statistical Life (2)

- EASIUR's default VSL: $8.8M in 2010 USD and 2010 income
- need to adjust for dollar year and for income growth.
  - A table of U.S. EPA's adjustment factors is provided.
- Uncertainty analysis
  - Simple: Use 95% confidence interval of the Weibull distribution
    $\Rightarrow$ [$0.46M, $13M] in 1990 USD
    $\Rightarrow$ Adjust for your dollar year and income year
  - Monte Carlo: Use the Weibull distribution directly.

Thanks! Any question?

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