Air Quality Modeling and Health Benefits of a Woodstove Change-out Program- Sensitivity to Residential Wood Combustion Inventories

Brian Timin, Roy Huntley, Marc Houyoux, Larry Brockman, Gil Wood, Eric Crump, and Zachary Pekar

USEPA/OAQPS

May 18, 2006

Outline

- Goals of the study
- Emissions summaries
- Photochemical modeling results
- Conclusions/Recommendations

Goals of the Study

- Attempt to quantify the benefits of a woodstove change-out program
  - Air quality benefits
  - Health benefits
- Examine the range of answers and uncertainties given 2 different residential wood combustion inventories
- Recommend improvements to the inventory generation process

Residential Wood Combustion (RWC)

- Significant amounts of primary PM2.5 and VOC emissions from RWC
  - PM2.5 ~430,000 tons per year*
  - VOC ~1,660,000 tons per year*
- On average, ~80% of the RWC emissions come from woodstoves and fireplace inserts

*Numbers based on 2002 NEI

Modeling Platforms and Emissions

- EPA's 2001 photochemical modeling platform
  - MM5 (meteorological model), SMOKE (emissions model) and Community Multiscale Air Quality model(CMAQ) (photochemical model)
- Original version of the platform used EPA generated nationwide RWC emissions
- Revised modeling used State submitted RWC data (from 2002 NEI)
  - State submitted data for 29 States
  - EPA data for the remaining States

RWC Emissions

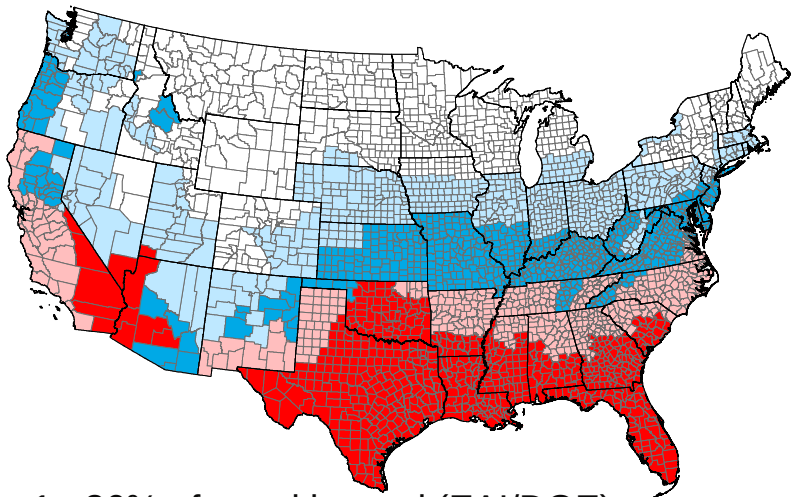
- EPA generated data
  - Nationwide top-down inventory
    - Nationwide emissions are assigned at the county level
      - Consistent methodology for all counties
    - Emissions for fireplaces, fireplace inserts (conventional and new low-emitting), woodstoves (conventional and low-emitting)
- State generated data
  - County level inventory
  - Limited information on how each State generated the inventory
    - Emission factors reported for 42 States
    - Inconsistent methods from State to State
  - 16 States only reported total RWC emissions
    - Not broken out by individual SCC

EPA Methodology- Woodstoves and Fireplace Inserts

1. Calculate fireplace emissions using DOE derived estimates for wood burned and census derived fireplace population

2. Subtract wood burned in fireplaces from total wood burned (remaining wood is burned in woodstoves/inserts)

3. Identify Climate Zone for each county



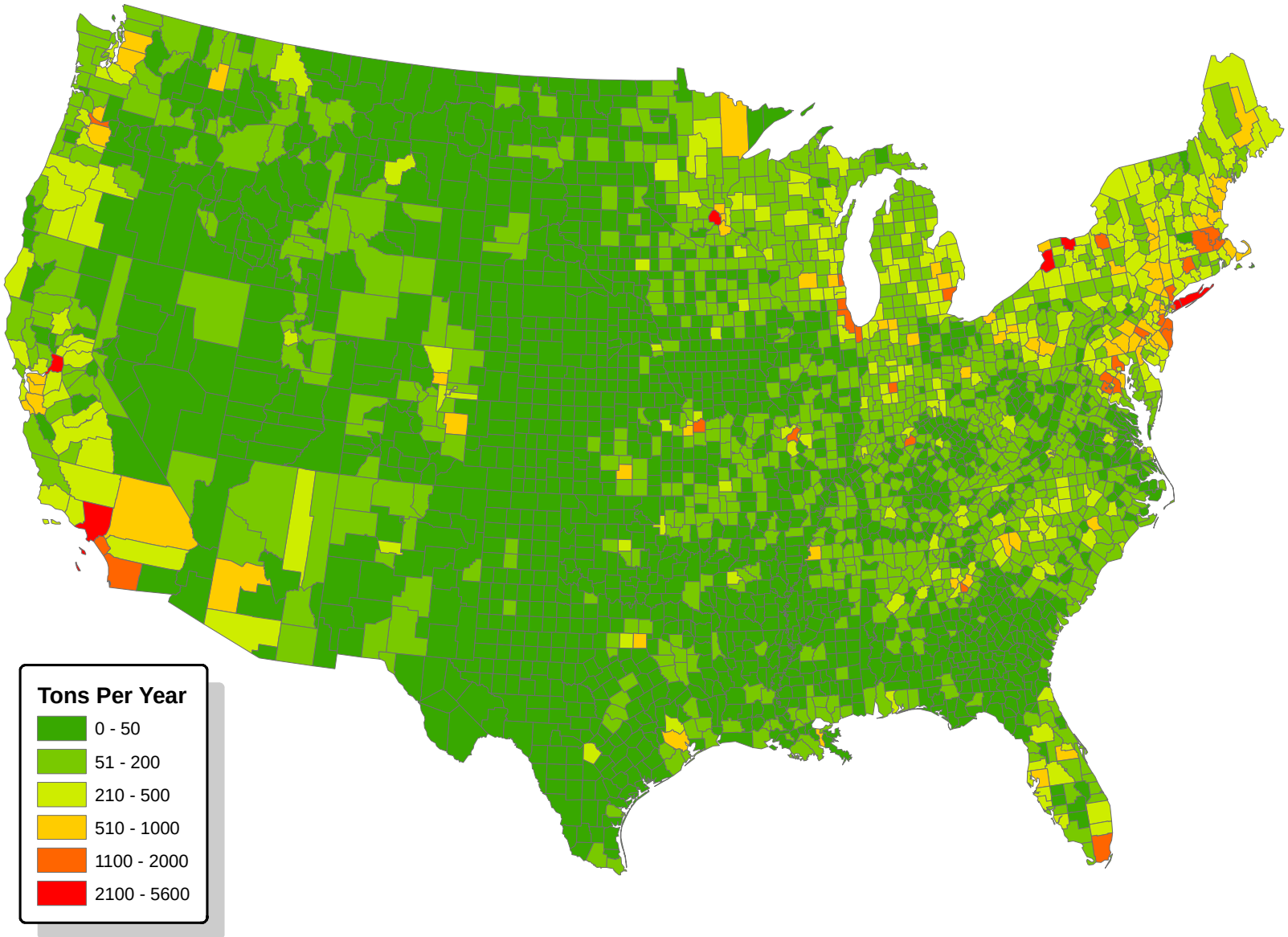
Zone 1= 36% of wood burned (EAI/DOE)
Zone 2= 19%
Zone 3= 21%
Zone 4= 15%
Zone 5= 9%

4. Within each climate zone, allocate wood consumption to county using relative percent of detached single family homes in the county to the total # of detached single family homes in the entire climate zone

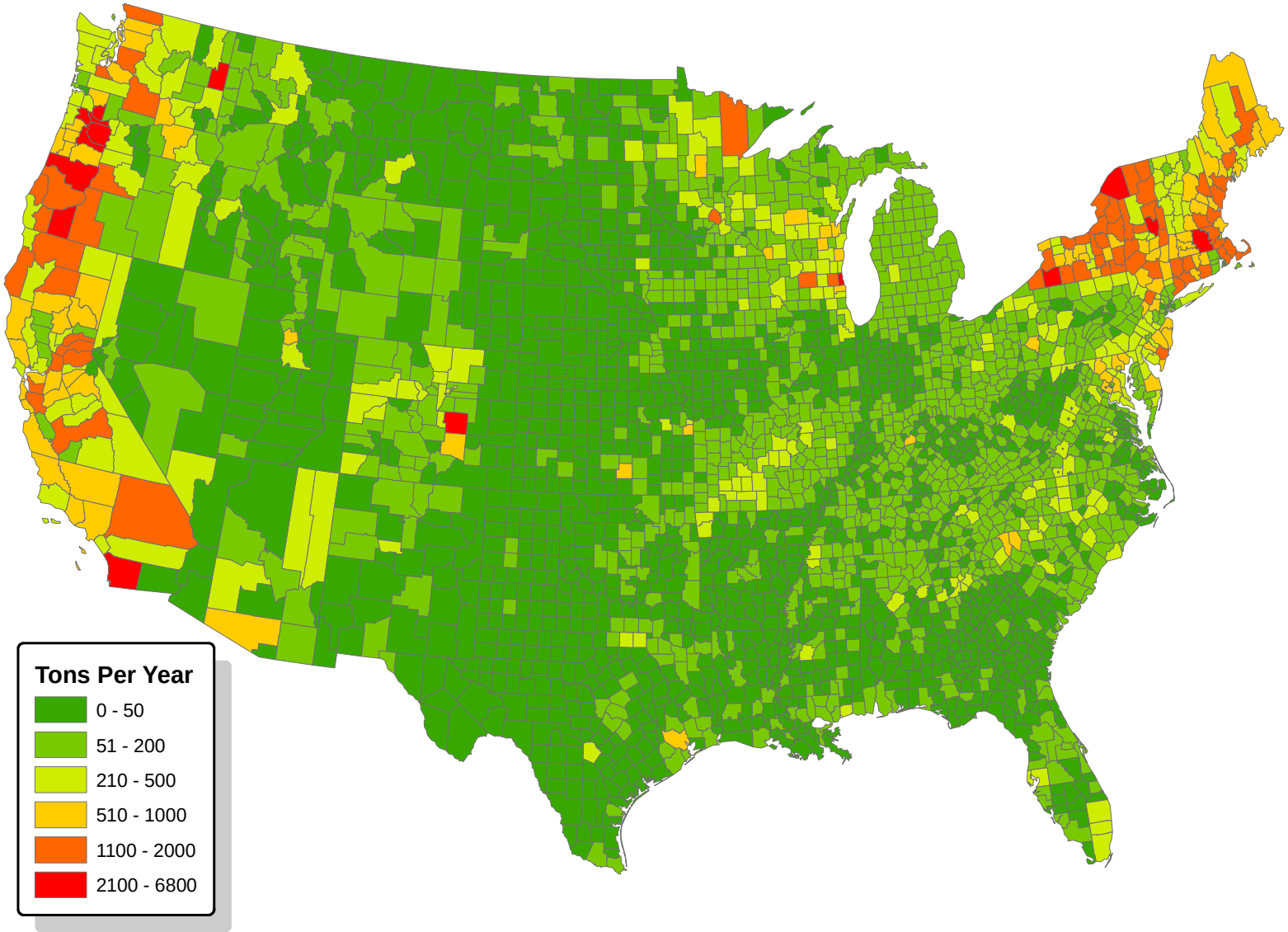
5. Adjust for:
   - Rural/Urban split
     - -Woodstoves 65% rural/35% urban
     - -Inserts 43% rural/57% urban
   - Non EPA certified/ EPA certified non-catalytic/ EPA certified catalytic

6. Apply AP-42 emission factors to get county emissions from each woodstove type (lbs emitted/ton wood burned)

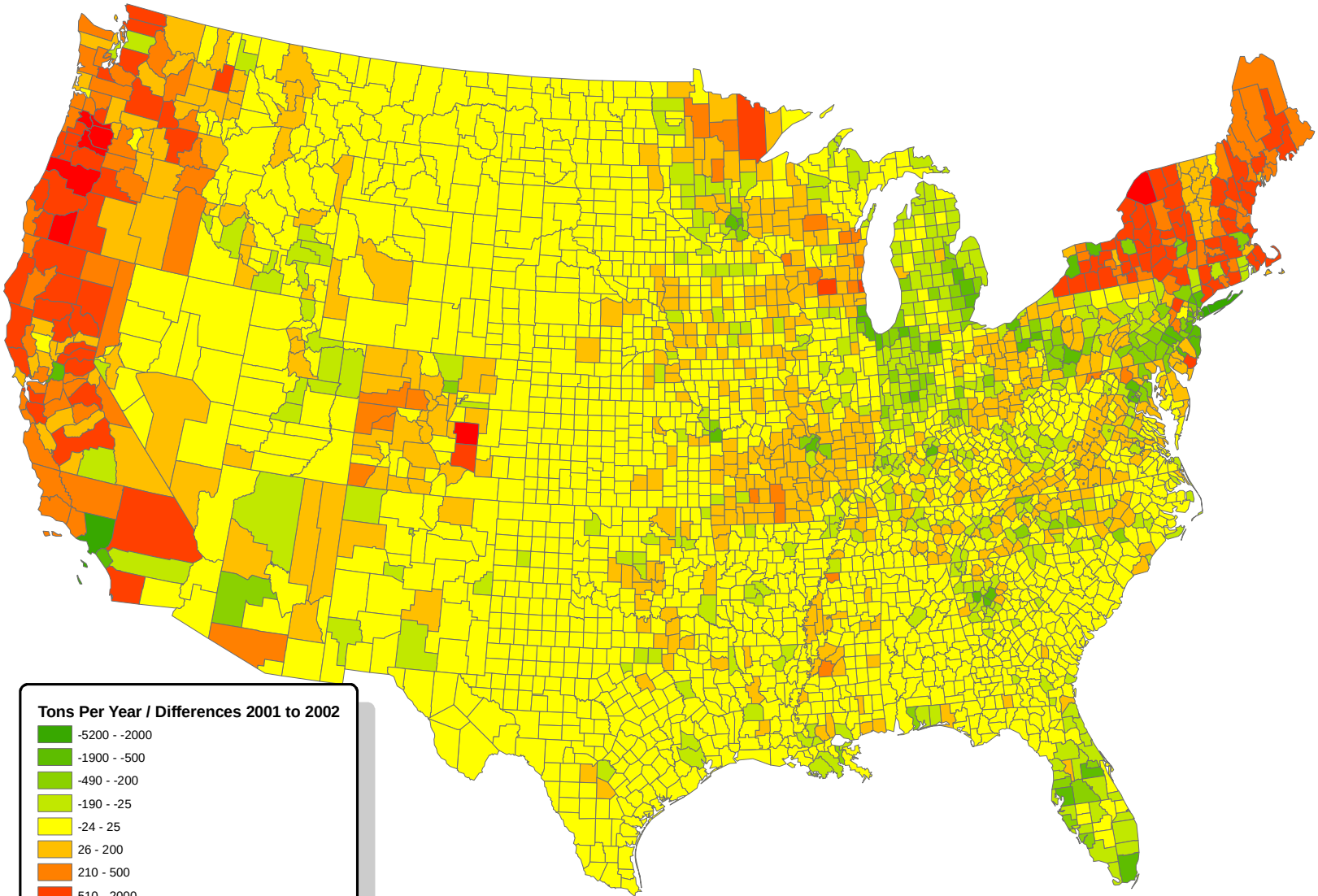
County Level RWC PM2.5 Emissions- EPA 2001



County Level RWC PM2.5 Emissions- State/EPA 2002

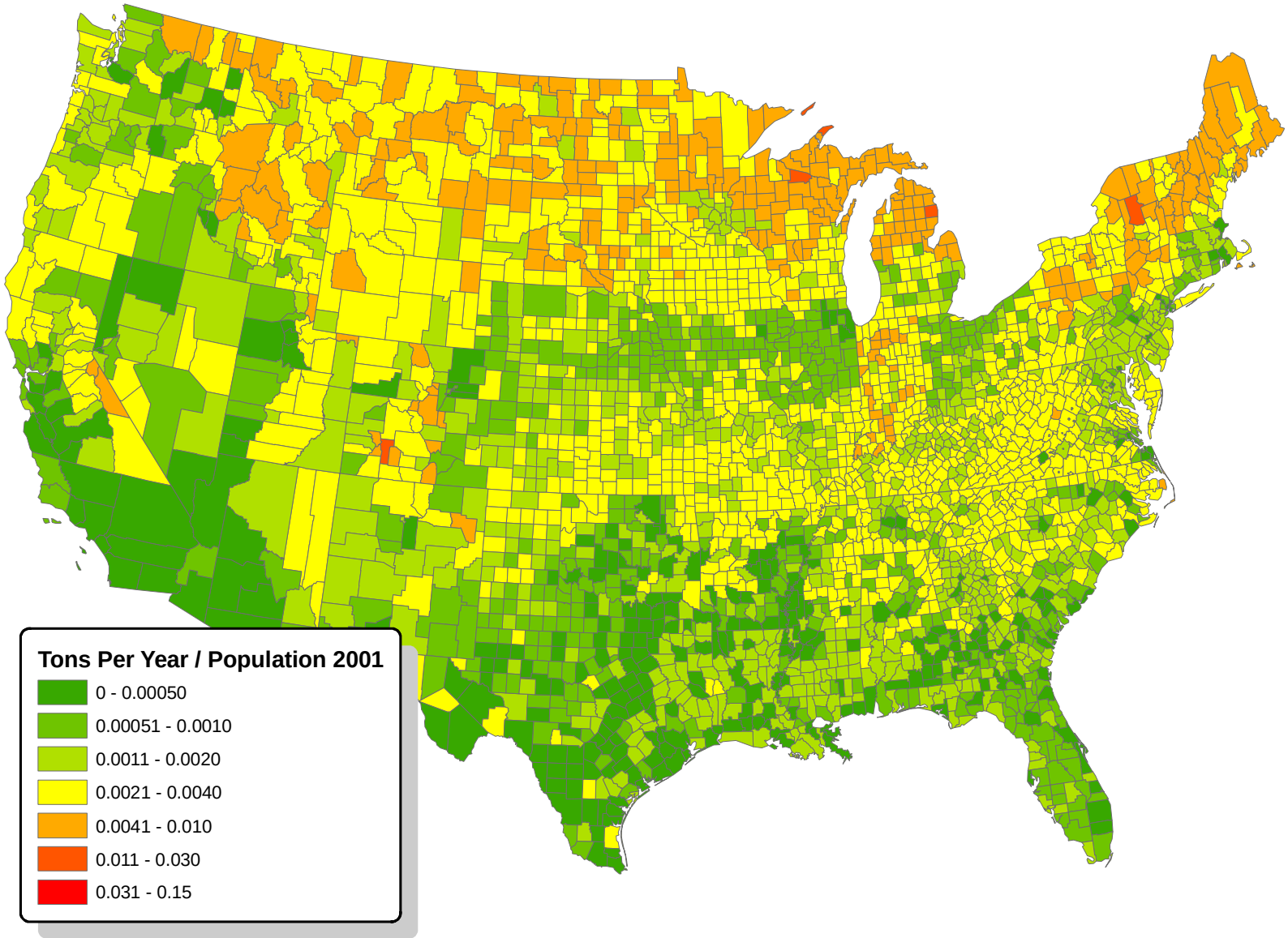


RWC PM2.5 Emissions Difference 2002 State/EPA – 2001 EPA

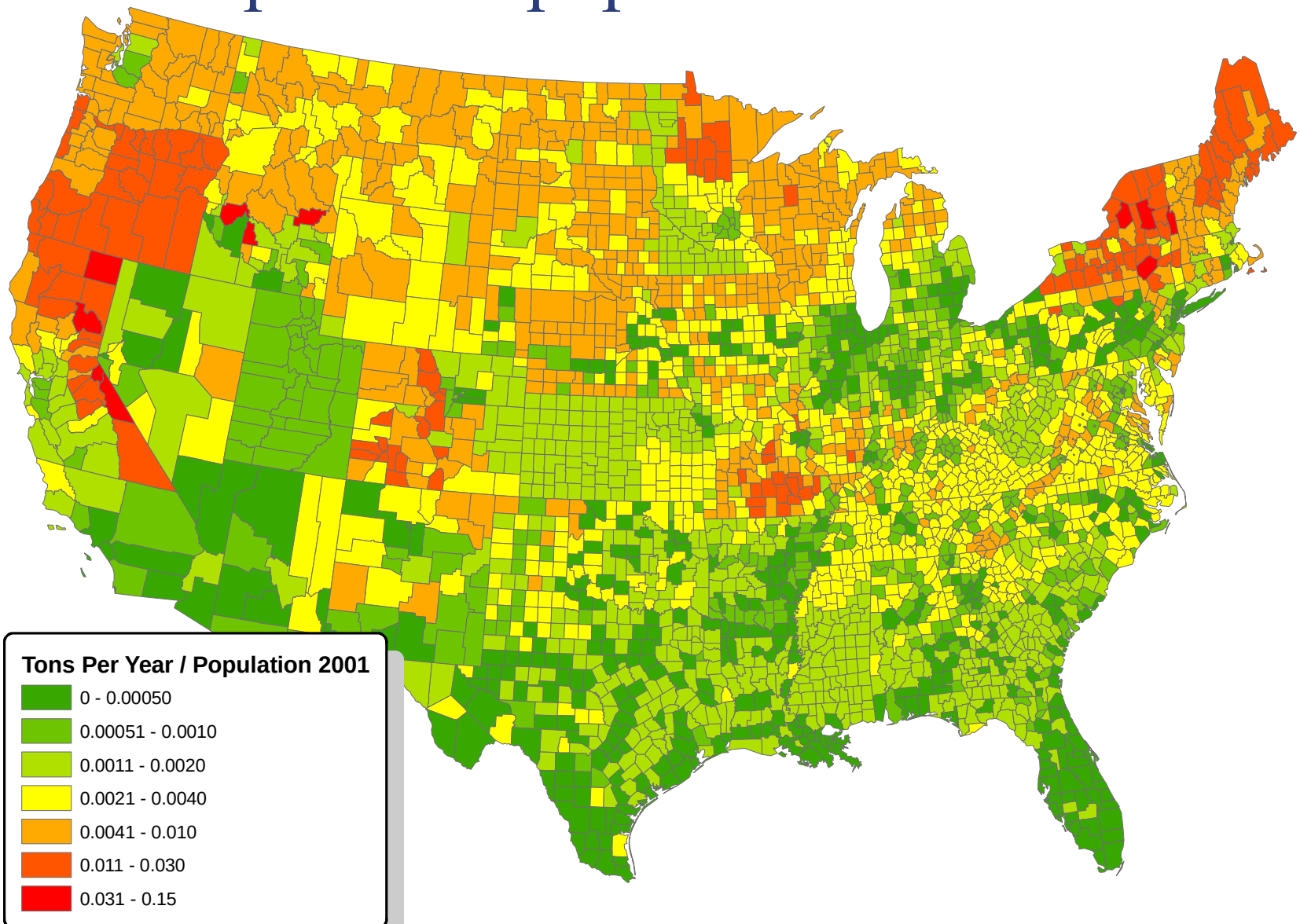


Red = higher emissions in 2002

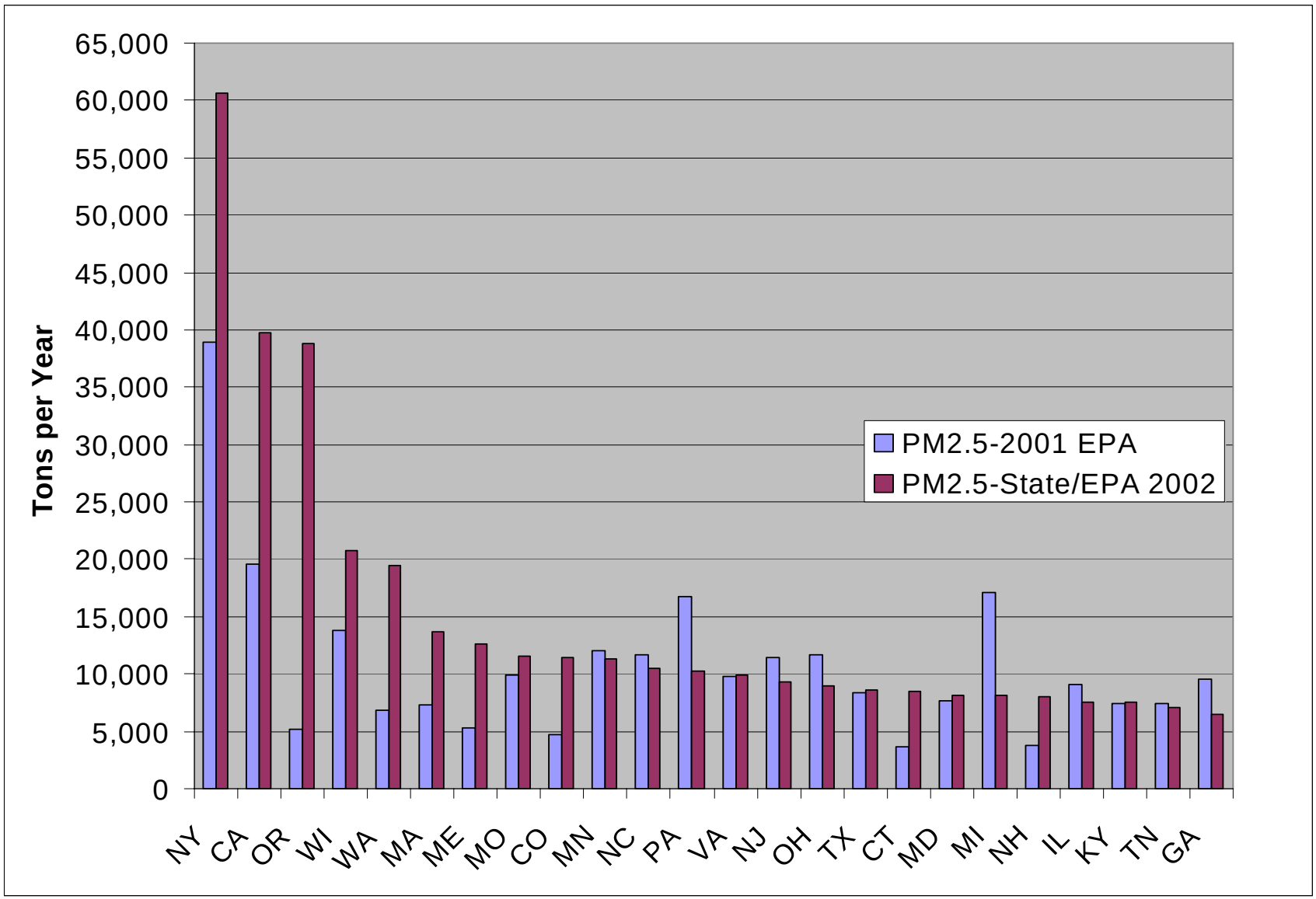
RWC PM2.5 Emissions- EPA 2001 Tons per Year/population



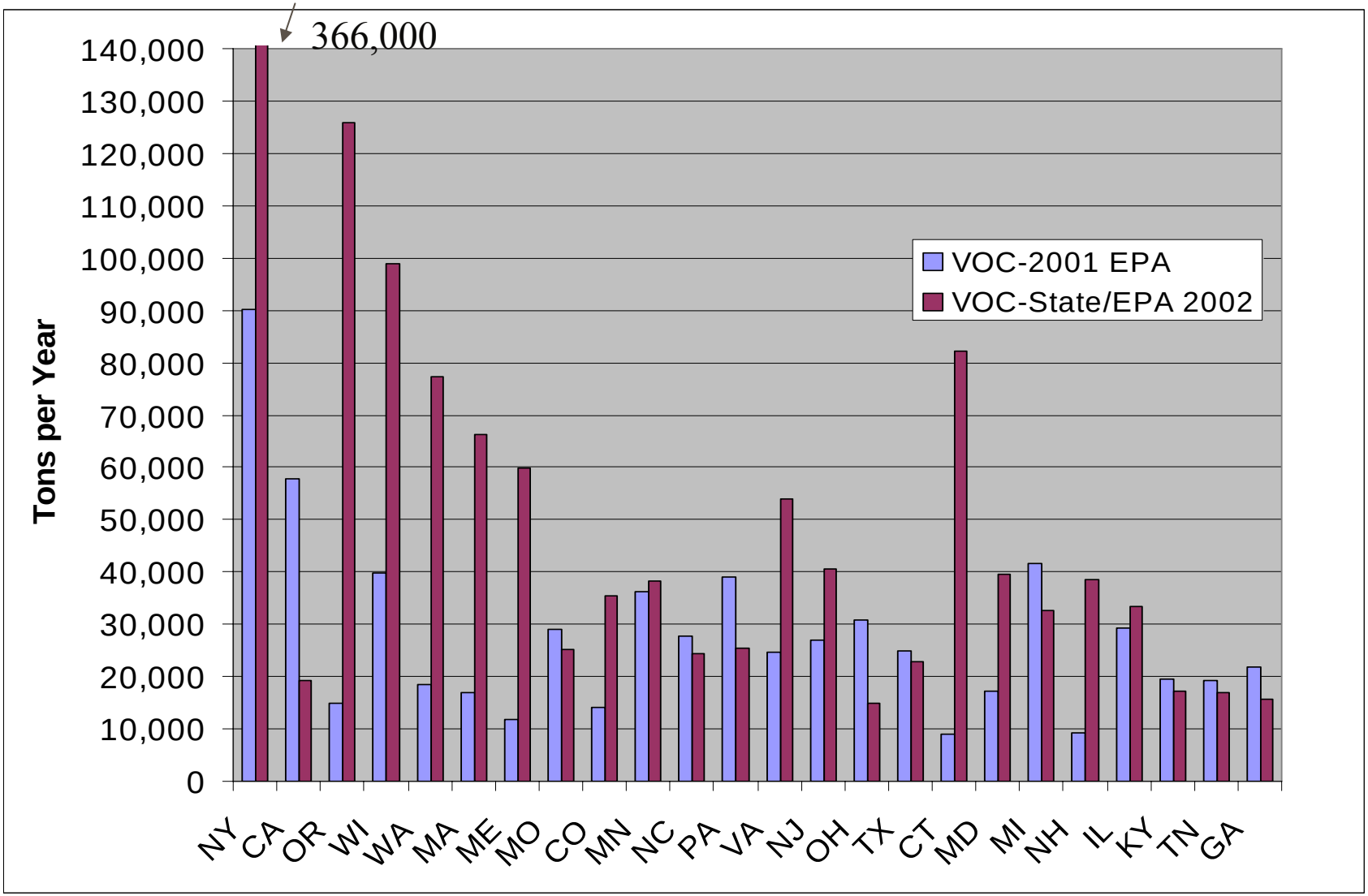
RWC PM2.5 Emissions- State/EPA 2002 Tons per Year/population



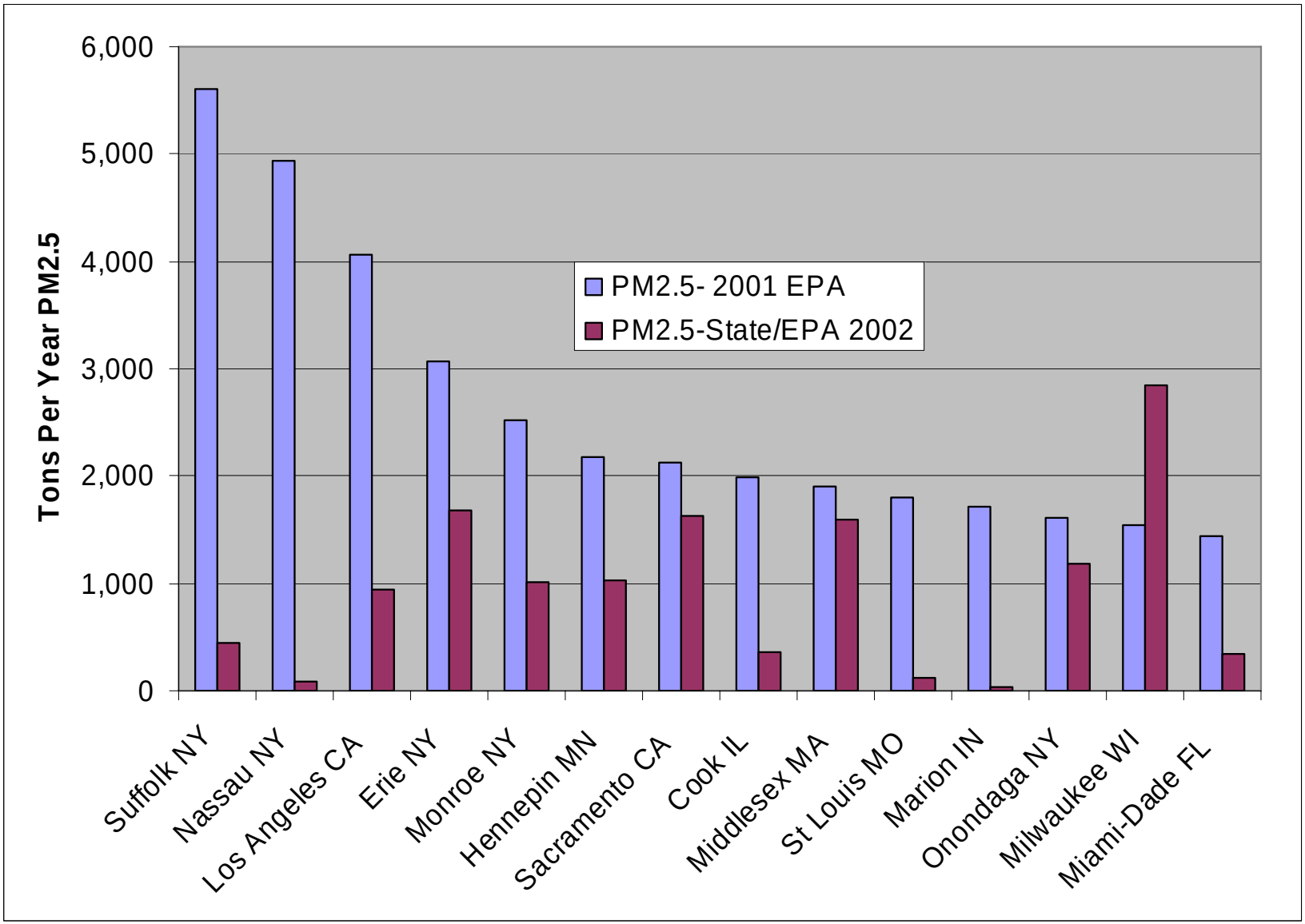
State Summaries for 25 Highest Emitting States (based on 2001)- RWC PM2.5



State Summaries for 25 Highest PM2.5 Emitters- RWC VOC



County Summaries for 15 Highest PM2.5 Emitting Counties (based on 2001 inventory)



Woodstove Change-out Modeling

- Attempted to model full implementation of a woodstove change-out program using CMAQ
  - Assumed that all conventional woodstoves and inserts would be replaced by new, low-emitting devices, or switched to gas
- The model run was done for a 2001 base year
  - This assumes that all of the replacement would occur immediately
  - This is obviously not realistic and therefore makes this purely a sensitivity run
    - A complete change-out may take 25 or more years (without incentives)

Woodstove Sensitivity Emissions-Methodology

- Overall ~69% reduction in woodstove/insert emissions
  - Conventional stove EF ~31 lb/ton → certified woodstove EF ~15 lb/ton
  - Assumed an increase in efficiency from 54% → 68%
  - Assumed 20% of old stoves went to natural gas
- Overall ~49% RWC reduction in States that only reported total RWC emissions (16 States)
  - Assumed ~80/20 split between woodstove and fireplace emissions

CMAQ Modeling

- Sensitivity runs at 36km grid resolution
  - First set using the "old" 2001 platform with EPA generated RWC emissions
    - 2001 base case
    - 2001 woodstove change-out case
  - Second set using "new" 2001 platform with 2002 NEI State/EPA generated RWC emissions
    - (new) 2001 base case*
    - 2001 woodstove change-out case

*The new 2001 base case has multiple emissions changes (besides the RWC emissions) compared to the original base case

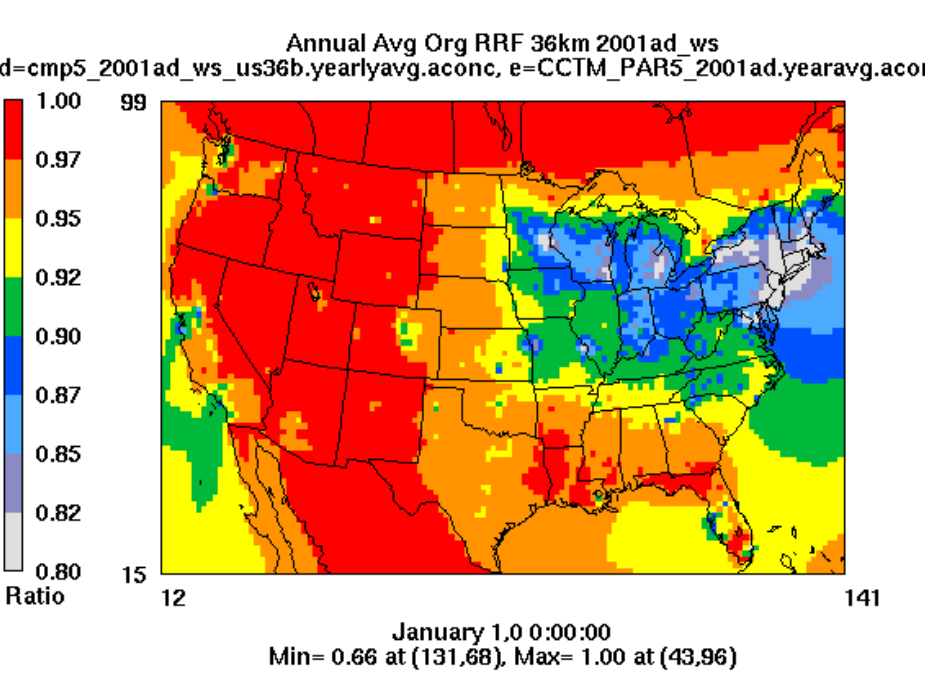
Modeling Postprocessing

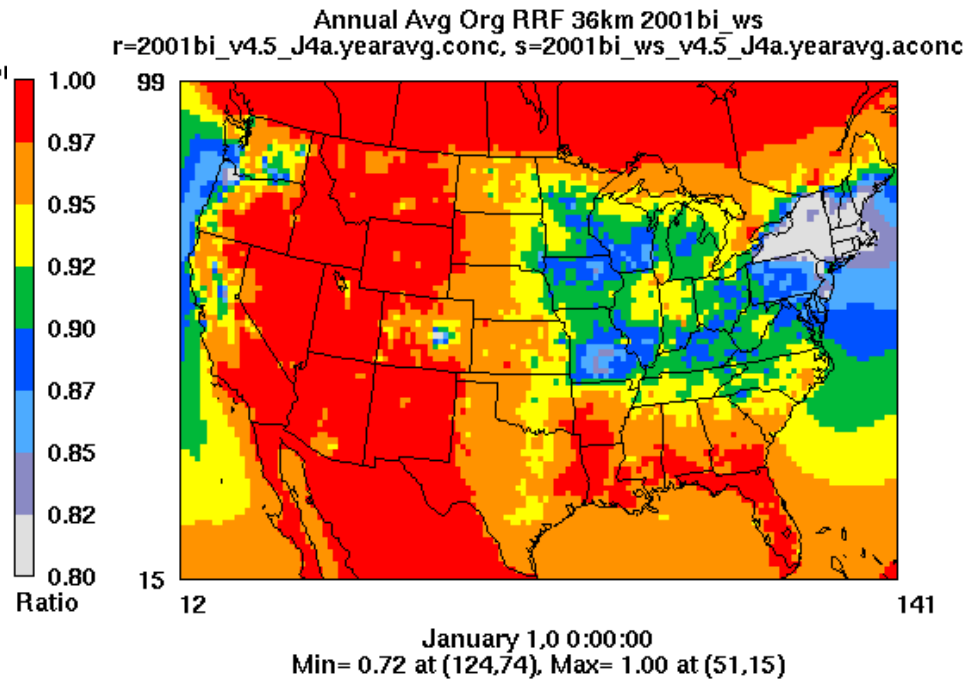
- Use model results in a relative sense
  - Percent change in PM2.5 species is applied to ambient data
    - Most of the change in PM2.5 from woodstoves is due to change in organic carbon
      - RWC PM2.5 is speciated as 57% organic carbon, 11% elemental carbon, 32% other
  - Modeling results (on the slides that follow) are focused on:
    - Percent change in total organic carbon
    - Absolute net change in PM2.5 (based on subtraction from ambient data)

Model Predicted % change in annual average **Total Organic Carbon** Concentration (Woodstove emissions reduction)

"Old" model run
2001 EPA data

"New" model run
2002 State/EPA data





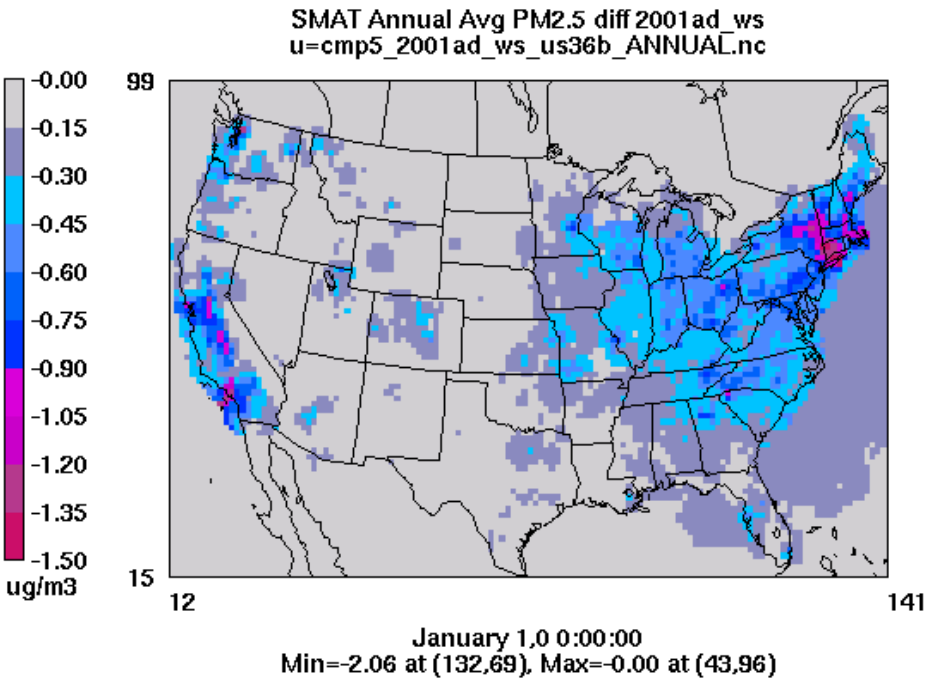
A ratio of 0.90 = a 10% reduction in annual average organic carbon

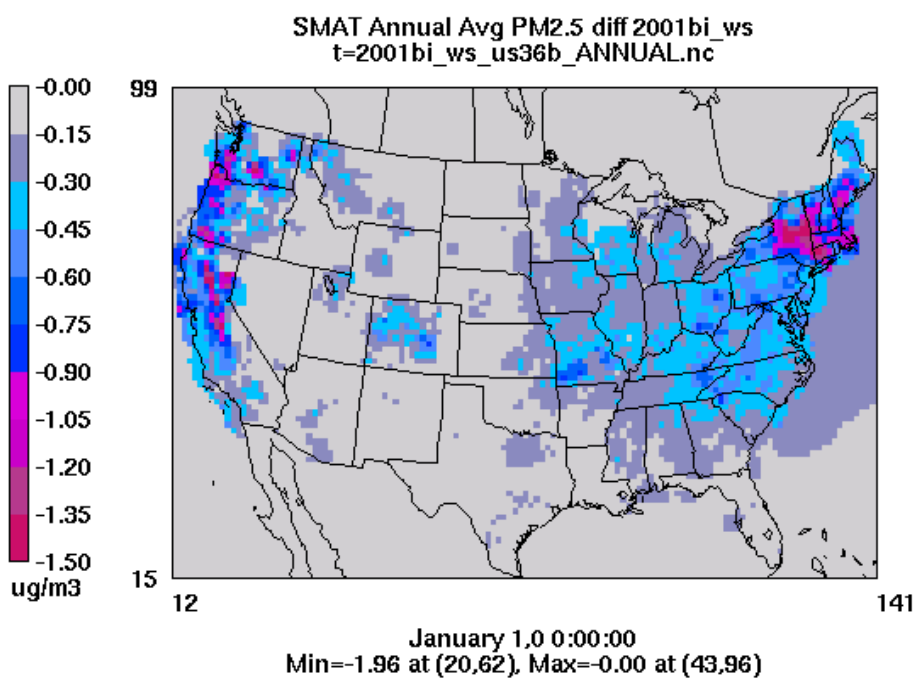
Absolute change in annual average total PM2.5 from Woodstove Change-out

Application of the modeled % change in PM2.5 components to the ambient PM2.5 concentrations (most of the reduction is due to organic carbon)

"Old" model run
2001 EPA data

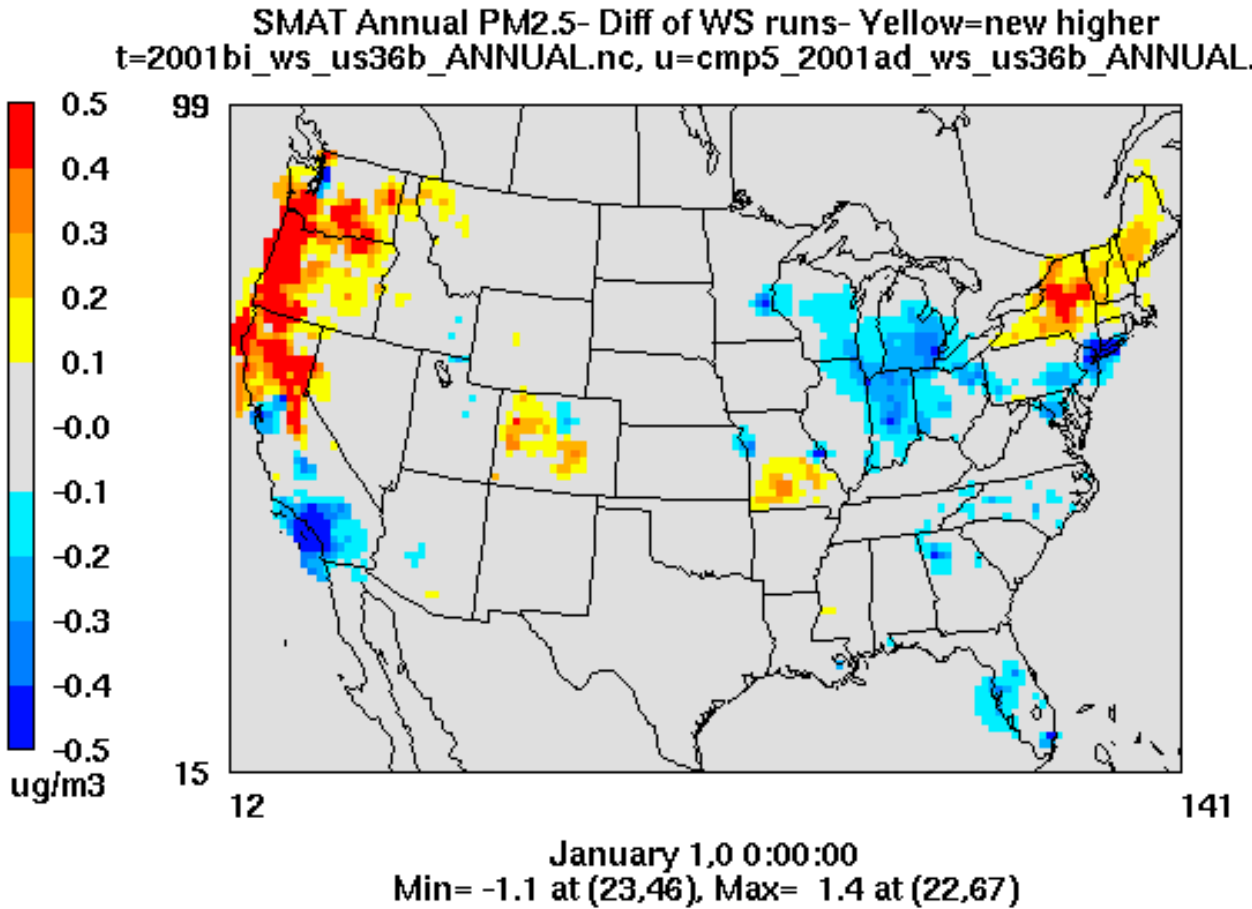
"New" model run
2002 State/EPA data





Absolute change in annual average total PM2.5 from Woodstove Change-out

Difference of the differences- Positive numbers mean larger reductions from new model run with State supplied data



Health Benefits

- Health benefits are based on population weighted change in PM2.5 concentration

	Population Weighted Change in Annual Avg. PM2.5 (ug/m3)
Original sensitivity case (EPA data)	0.498
Updated case (State/EPA generated data)	0.337

- Difference between the 2 model runs is ~2,000 lives saved per year
  - Less mortality benefit from the revised inventory

Conclusions- Woodstove Change-outs

- A woodstove change-out program is expected to have large air quality and health benefits
- The estimated magnitude and spatial allocation of woodstove emissions is critical in determining the benefits of controls
  - Multiple emissions estimation methods can cause a great deal of variation and uncertainty in the apparent benefits
    - Up to + - 1 ug/m3 difference in local annual average PM2.5
    - Nationwide mortality estimate difference of ~2000 lives per year
- Further refinement of the RWC inventory is needed

Recommendations for Generating Area Source Emissions

- Need new paradigm for calculating emissions for **important** area source categories (such as RWC)
  - Flaws in both EPA and State methods
  - Need more consistency between States
- Recommendation: EPA and States agree on emissions factors and basic methodologies
  - States calculate emissions based on local activity data, equipment populations, etc.
  - All deviations need to be documented
  - Agree to report emission factors, equipment populations, etc.
  - Agree to report emissions for a consistent set of SCCs (e.g. no reporting of total RWC)