Modeling Transportation-Related Emissions Using GIS

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Outline

- Introduction
- Methodology
- Case Study
- Conclusion

Transportation-related Pollutions

Greenhouse Gases
- CO_2

Haze

Ozone
(VOC + NOx)

Fine Particles
(PM10/PM2.5)

Toxics
- Diesel particles
-Benzene
-etc.

Carbon Monoxide
(CO)

Contributions of Transportation-related Pollutants in U.S.

In 2000, on-road vehicles were responsible for

- 44 % Carbon Monoxide (CO)
- 33 % Nitrogen Oxides (NOx)
- 25 % Volatile Organic Compounds (VOC)

Findings of Literature Review

- Numerous GIS applications in transportation or air quality analysis alone but limited in vehicular emissions modeling
- Most of relevant existing attempts were small-scale pilot studies
- New GIS technologies were rarely found for the purpose of emissions inventory modeling

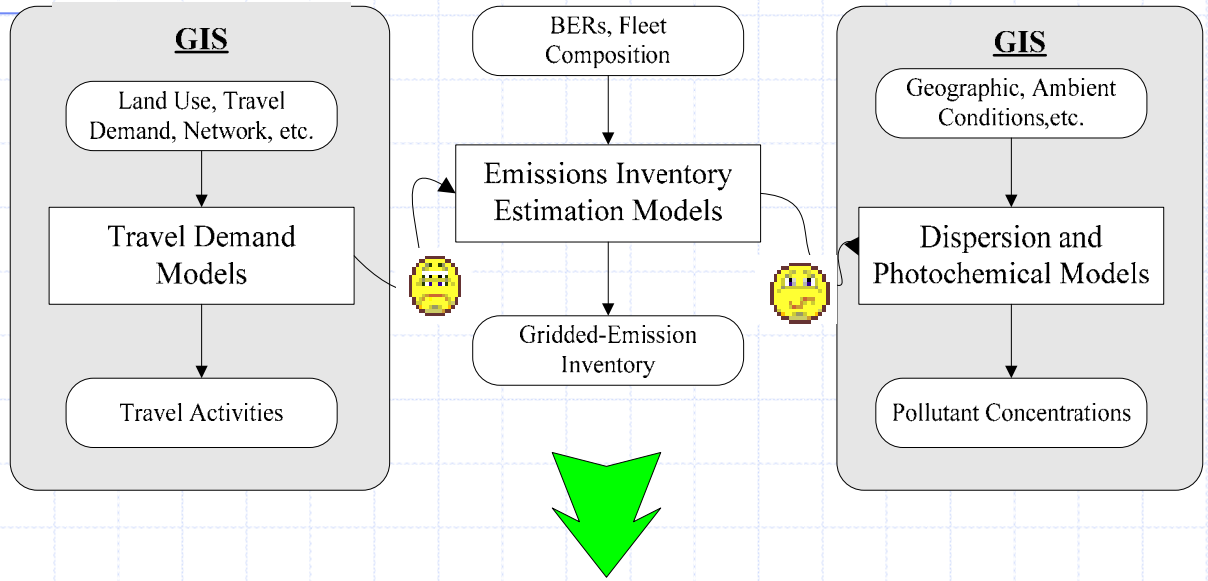
Study Objectives

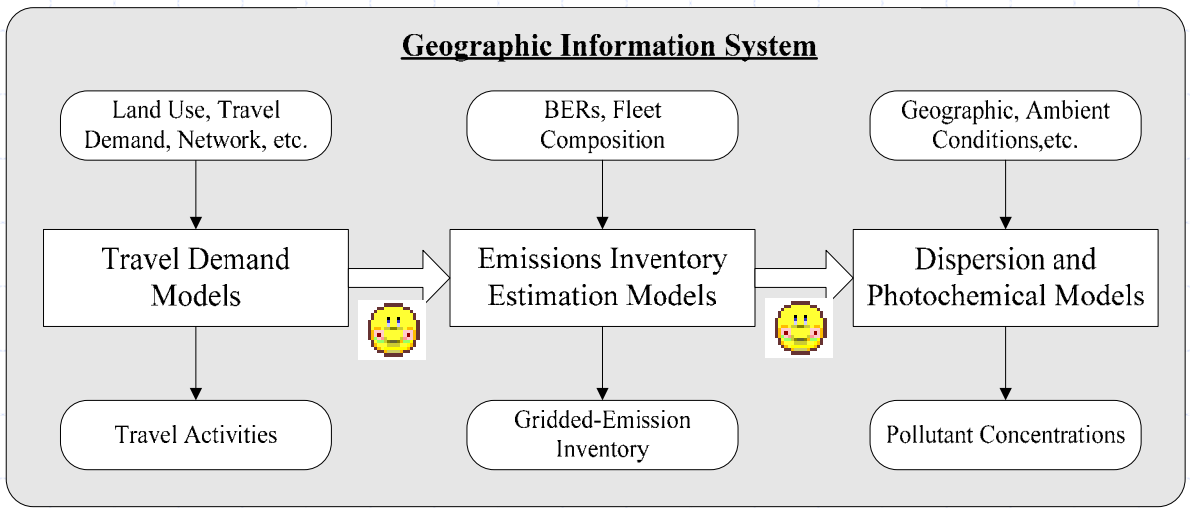
- to move transportation-related emissions modeling towards a GIS based method
- to enhance the resolution and accuracy of emissions inventory modeling
- to improve the computational efficiency of modeling and the spatial representation of modeling results

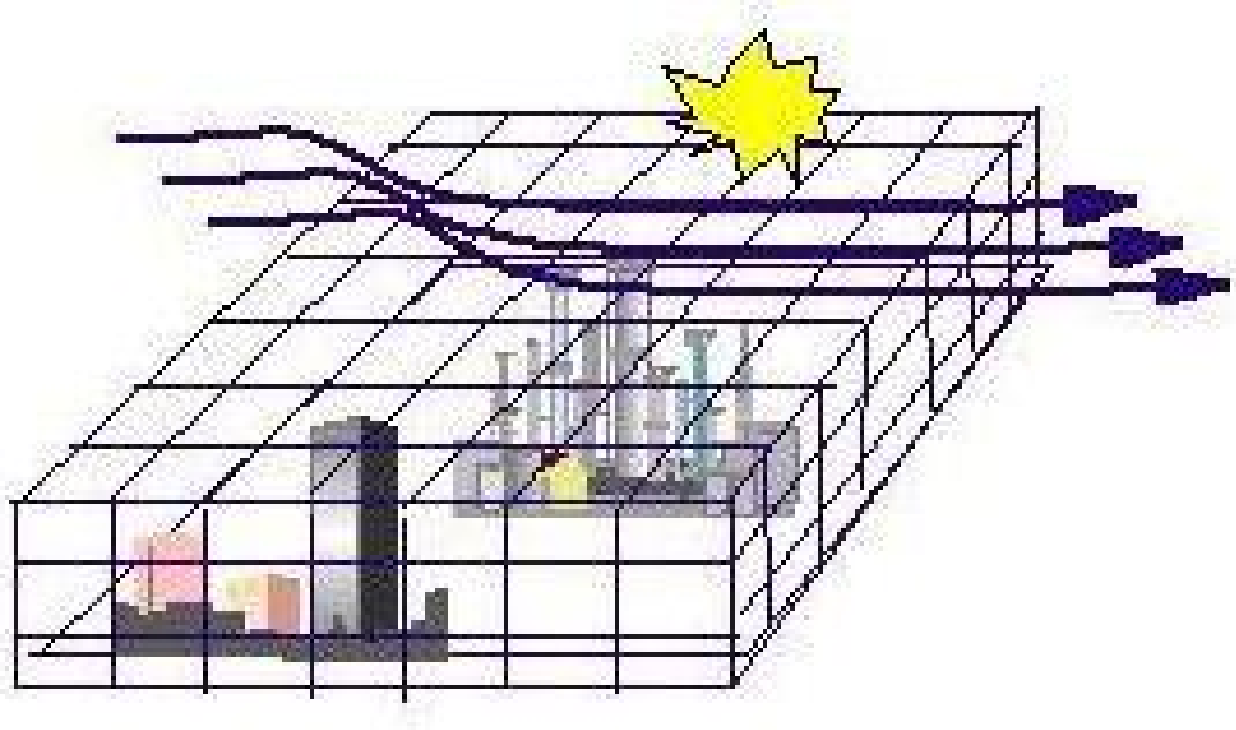
Methodology

- Methodology overview
- Data Needs
- Developing locality-specific emission factors
- Disaggregating travel activities
- Calculating emissions inventories

Methodology Overview







Grid-based Air Quality Modeling

Data Needs

- GIS-based Transportation data
  - Travel activities (e.g. speeds, volumes, trip ends, path)
  - Network, TAZs
- Base emission rates (BERs) from EMFAC
  - By age,
    - By vehicle class, and
      - By technology type
- Detailed vehicle population data
  - Address at the zipcode level
  - Vehicle characteristics
    - age, vehicle class, technology type, etc.

Generating Zipcode-specific Composite Emission Factors

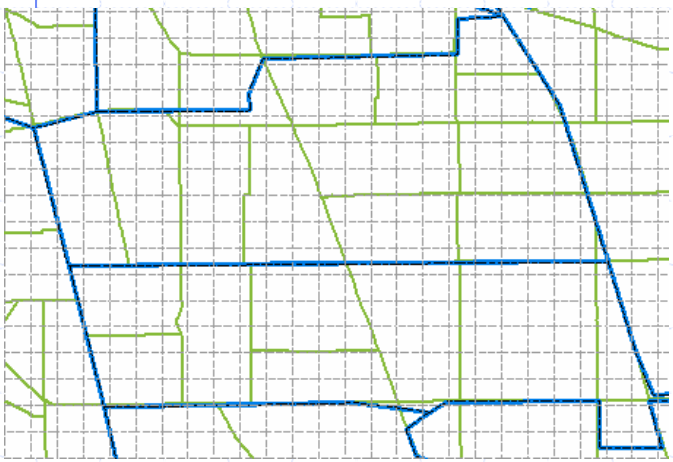
$$EF^{i}_{fleet} = \sum_{vc=1}^{13} \left(\sum_{tec=1}^{3} EF^{i}_{vc,tec} \times TECWT^{i}_{vc,tec} \right) \times VMTMIX^{i}_{vc}$$

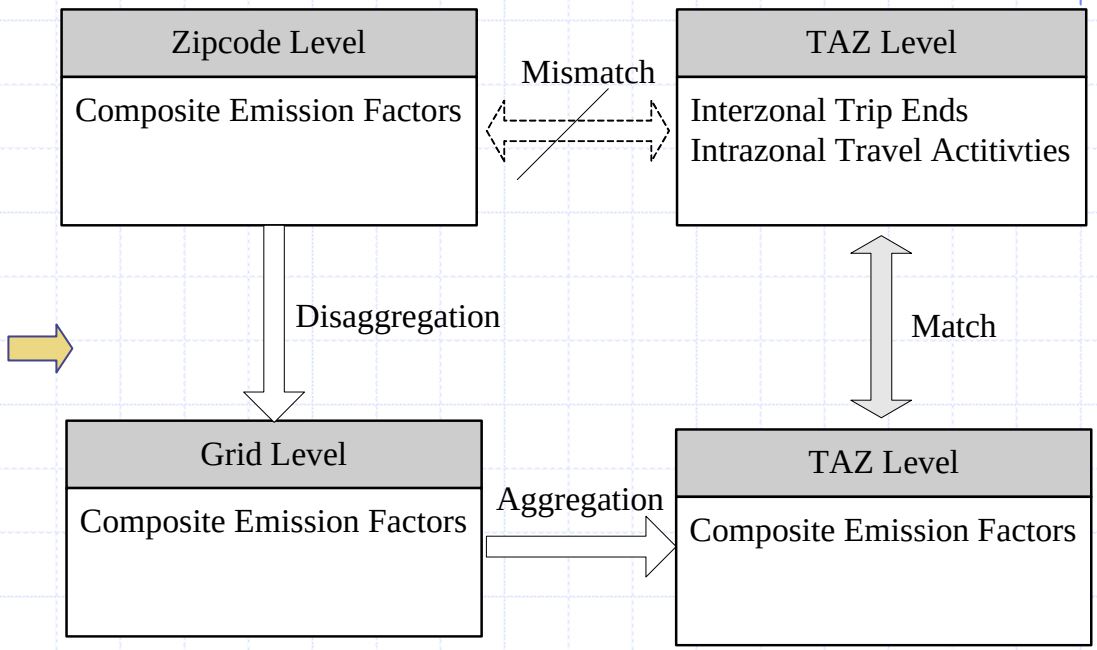
Equation 5

where,

EF^{i}_{fleet}	=	zipcode specific fleet average emission factor;
$TECWT^{i}_{vc,tec}$	=	zipcode specific fraction of travel for a specific technology type in a vehicle class;
$VMTMIX^{i}_{vc}$	=	zipcode specific fraction of travel for a vehicle class (user input);
vc	=	vehicle class identification code; and
tec	=	technology identification code.

Matching Different Zoning Systems

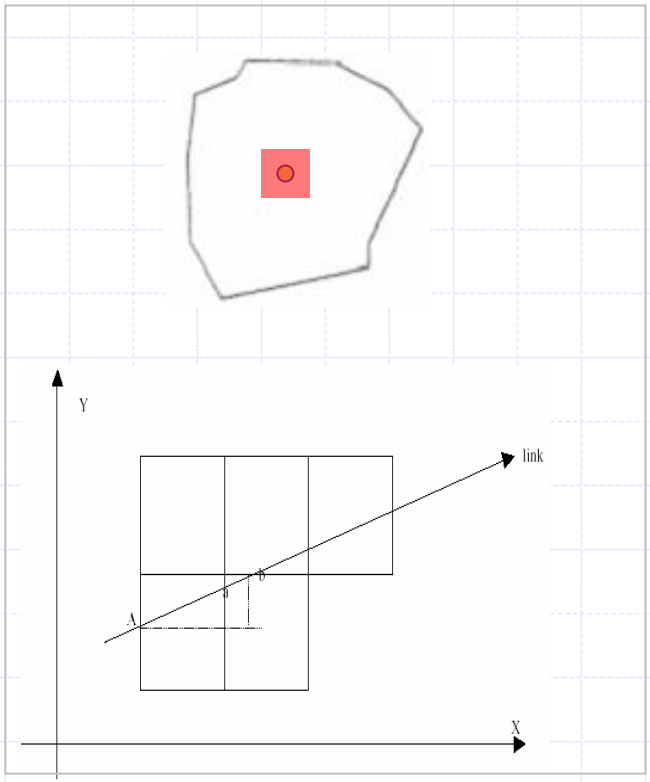


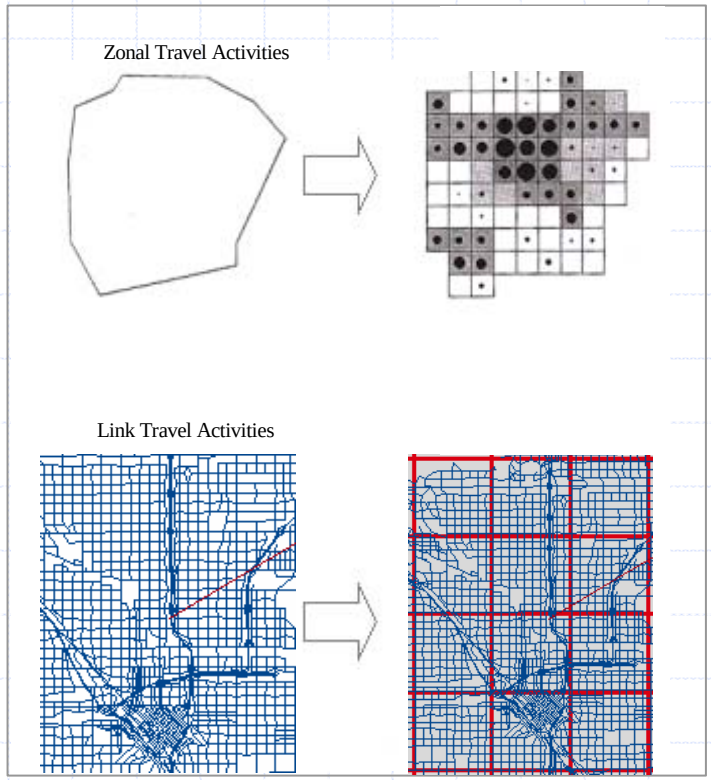


Free Zonal Mismatch Using Grids

Disaggregating Travel Activities

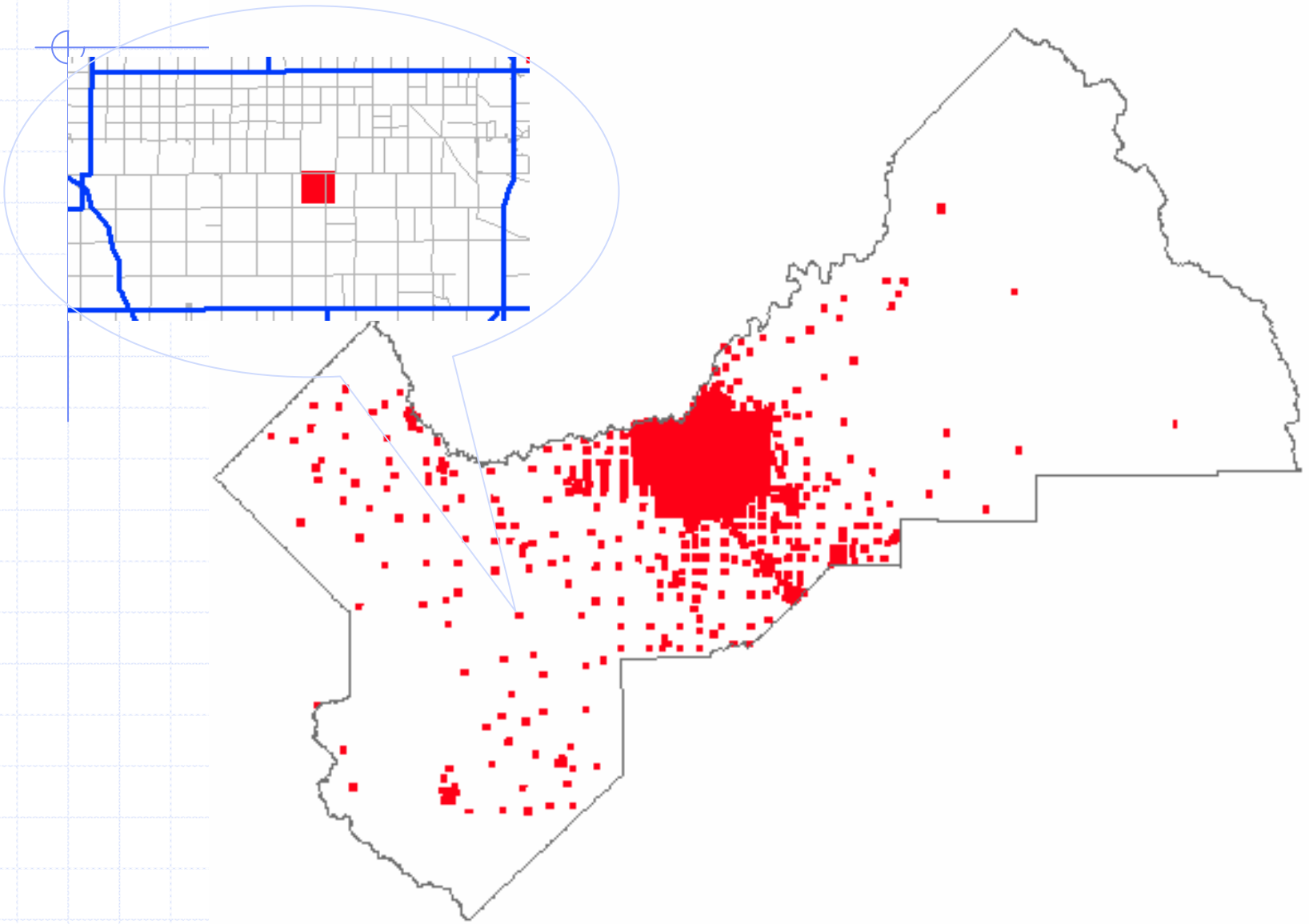
- Disaggregating zonal and link-based data to grid cells



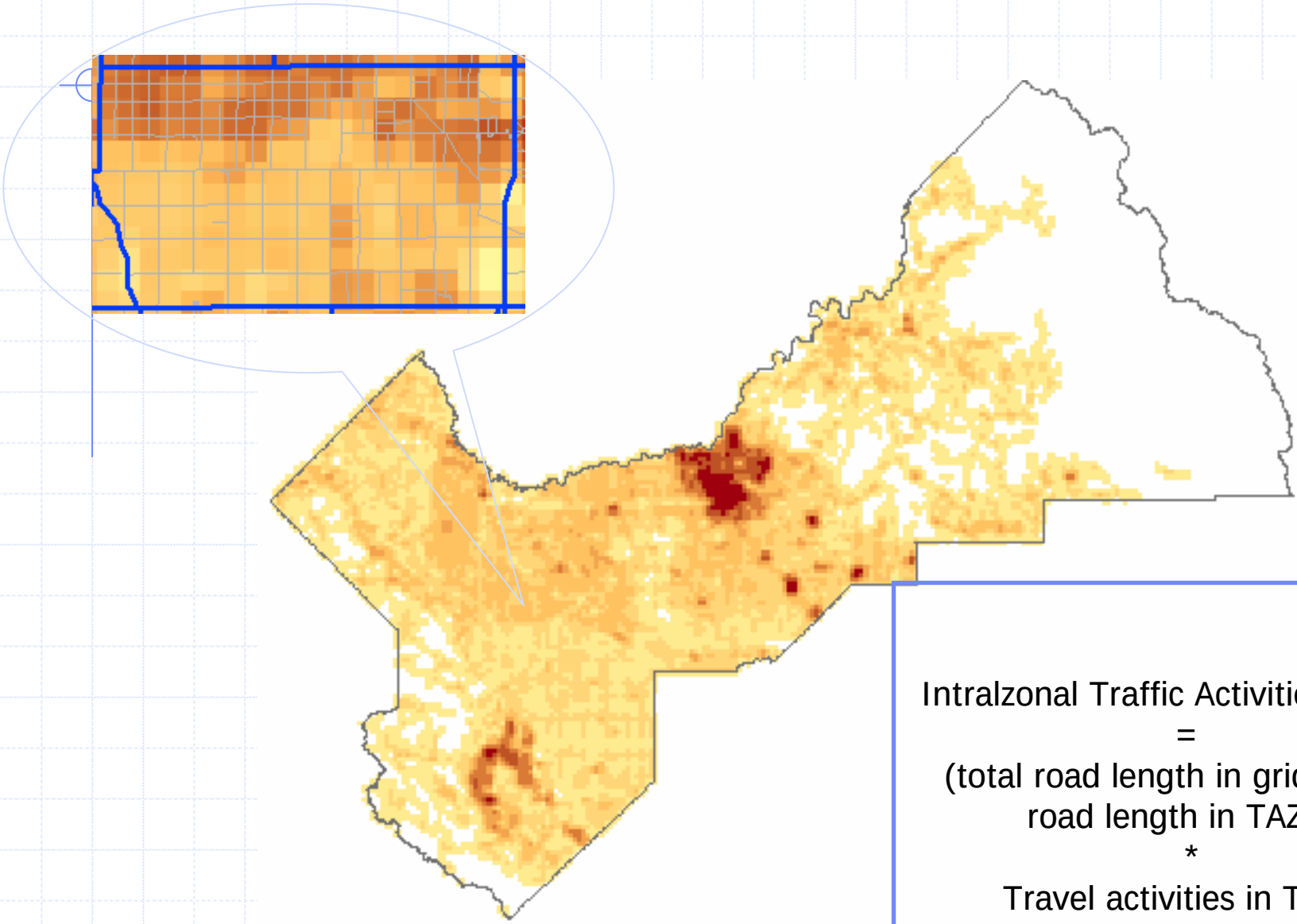


Vector Methods in a non-GIS method VS. a GIS Method

Intrazonal Emissions in a non-GIS method



Gridded Intrazonal Emissions in a GIS Model



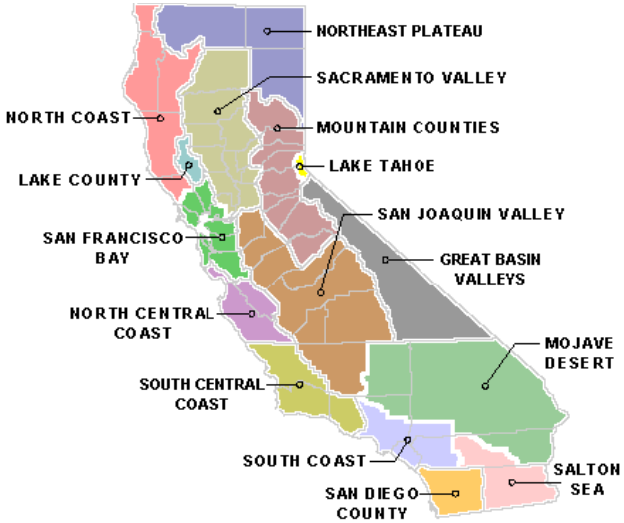
Intralzonal Traffic Activities of grid *i*
=
(total road length in grid *i* / total road length in TAZ *k*)
*
Travel activities in TAZ *k*

Calculating Emissions Inventories

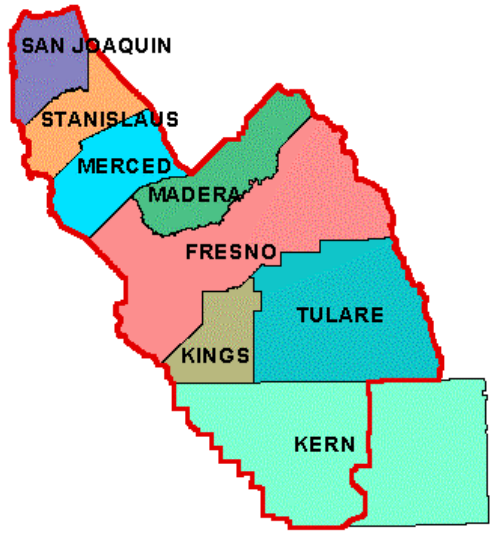
Emissions Inventory [gm] =
*composite emission factors * transportation activity*

- Emissions to be calculated
  - Interzonal emissions
    - running emissions,
    - trip-end emissions,
    - diurnal and resting loss emissions
  - Intrazonal emissions
    - running emissions,
    - trip-end emissions,
    - diurnal and resting loss emissions

Study Region



California Air Basins

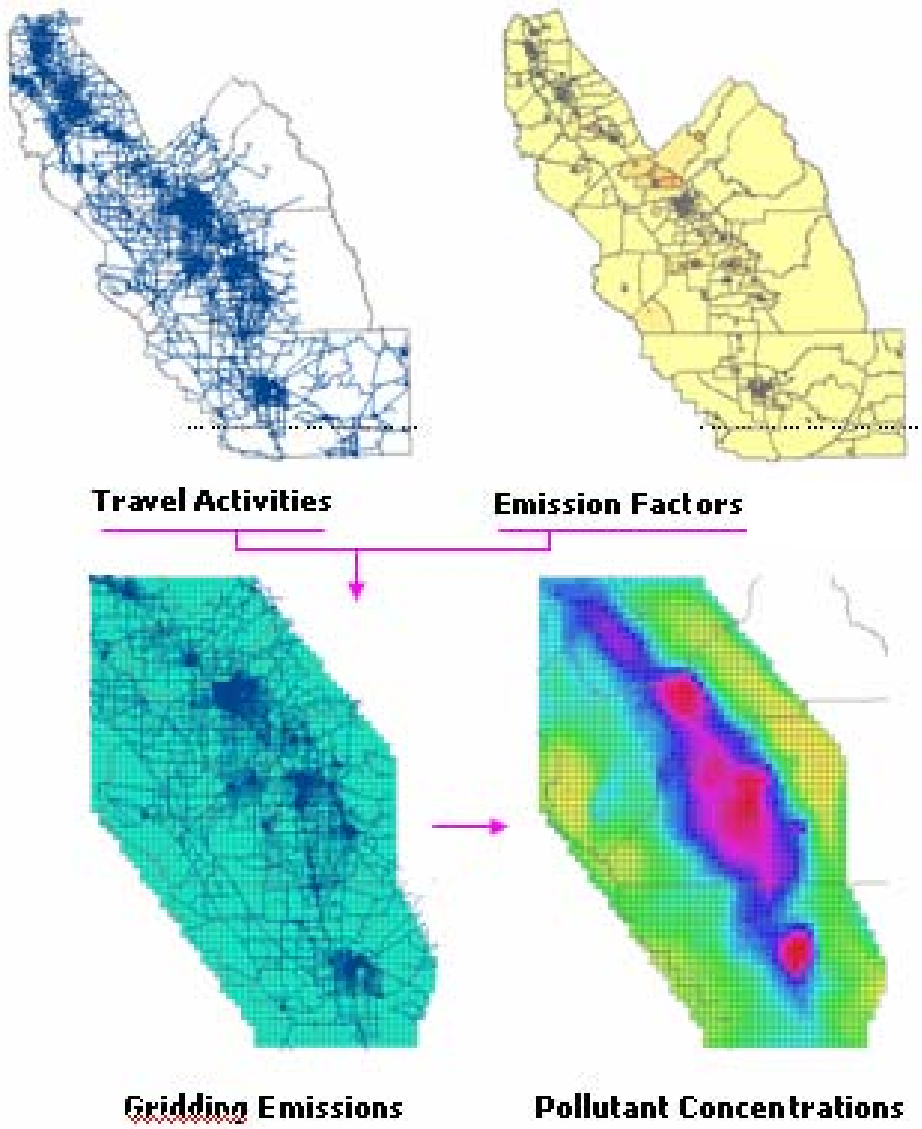


San Joaquin Valley Air Basin

Study Region: the San Joaquin Valley

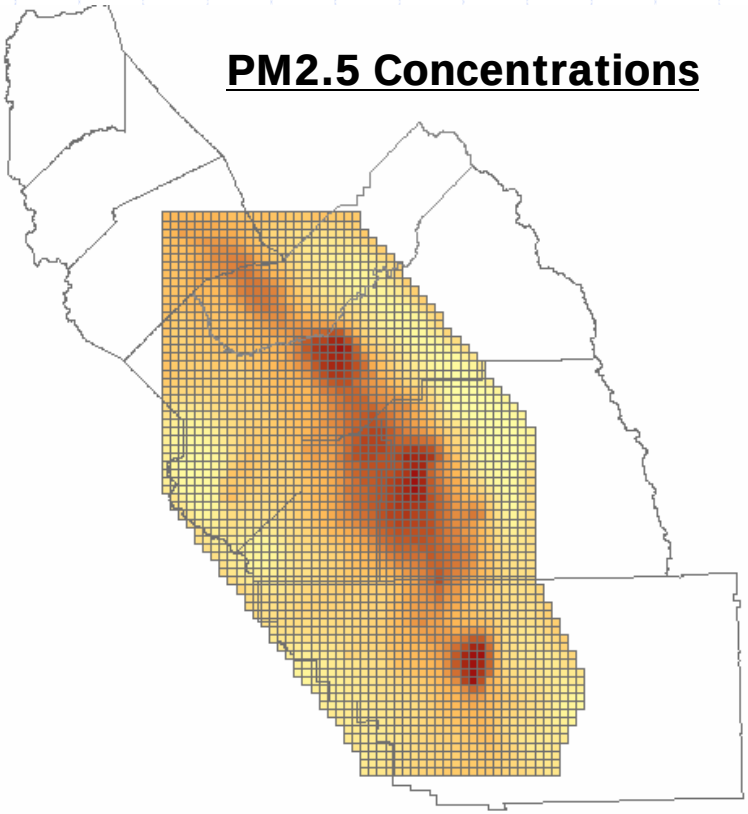
Map Source: CARB

Modeling Procedure and Results



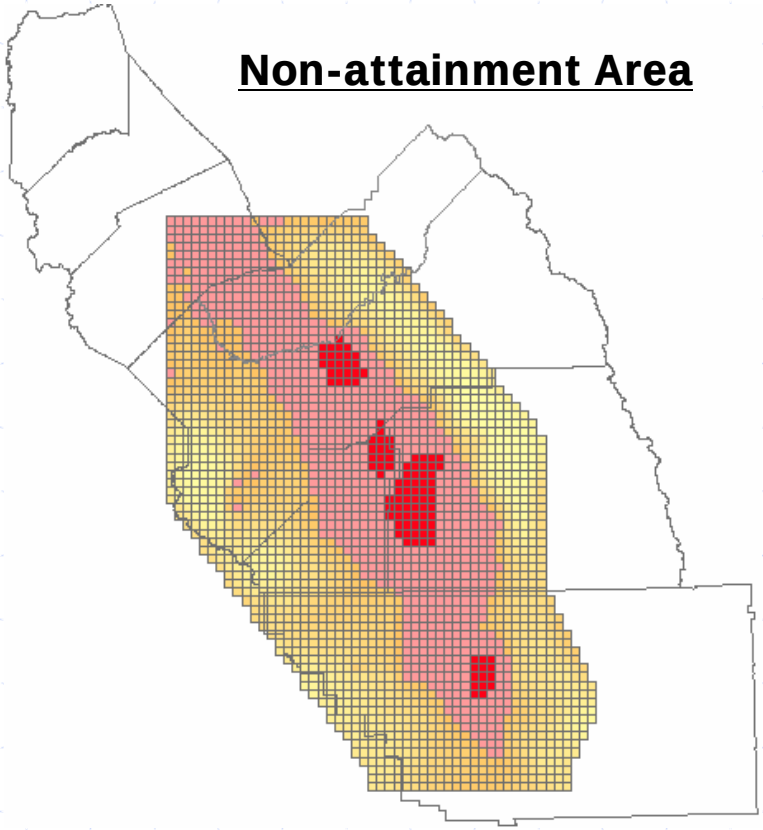
Further GIS-based Analyses

PM2.5 Concentrations



24hr average PM 2.5 concentrations within the modeled area

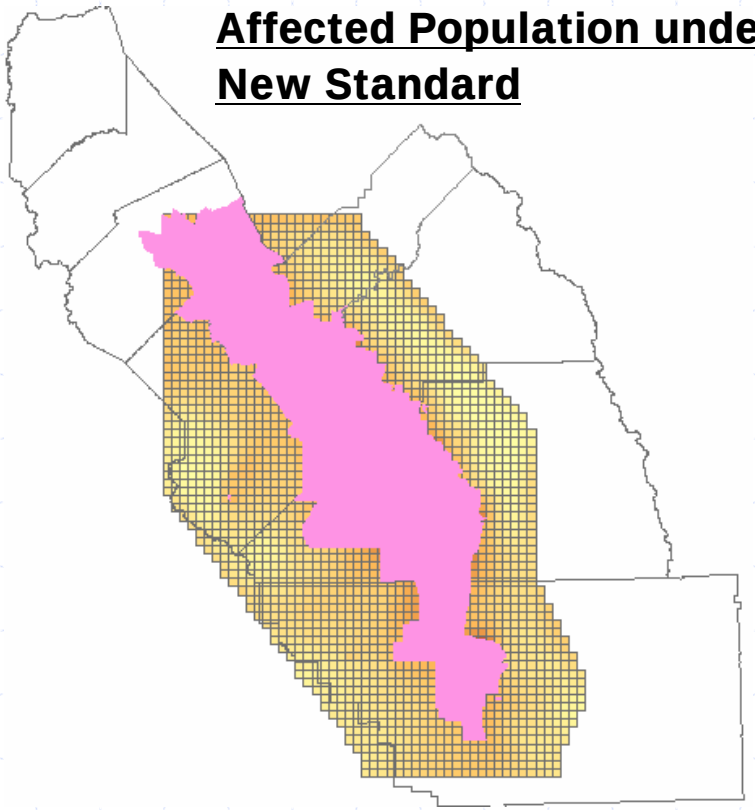
Non-attainment Area



Red area exceeds 24hr PM2.5 federal standard , 65 micrograms per cubic meter; Pink area exceeds new standard, 35ug/m3

Further GIS-based Analyses

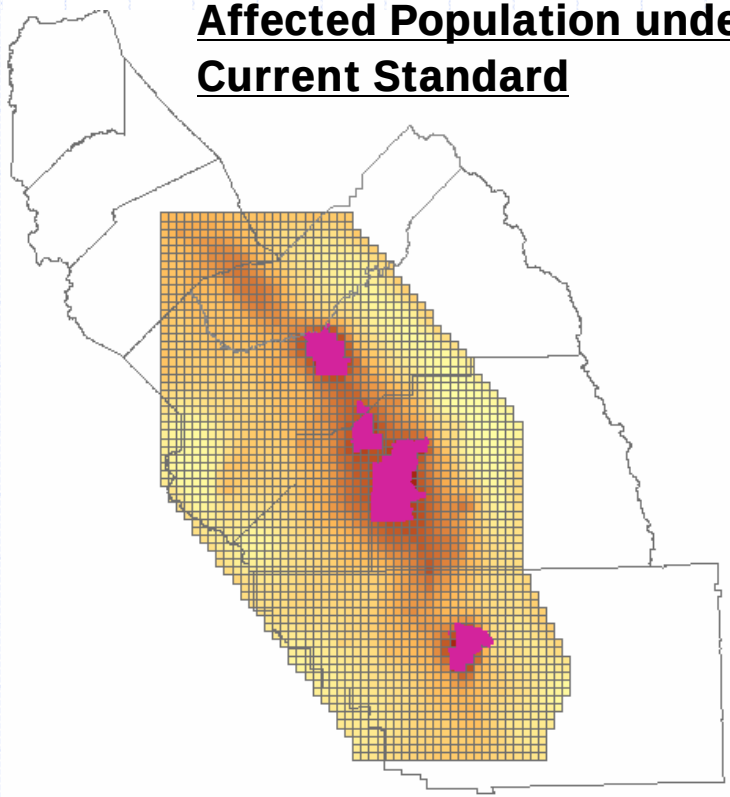
Affected Population under New Standard



Census blocks exposed to the area that exceeds the new 24hr PM2.5 federal standard , 35ug/m3

Affected population: 1,853,742

Affected Population under Current Standard

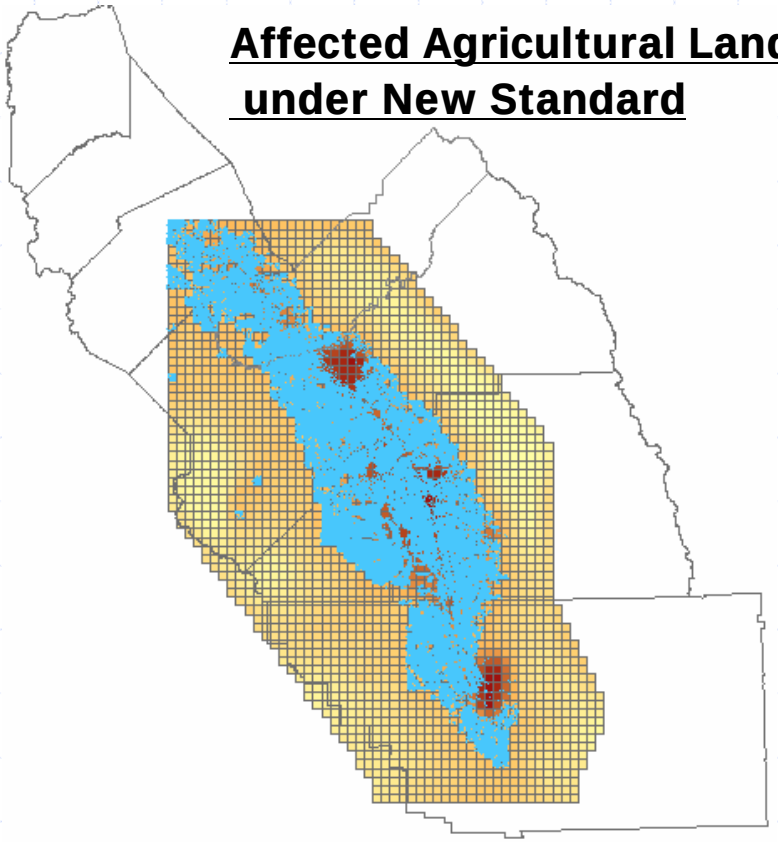


Census blocks exposed to the area that exceeds the current 24hr PM2.5 federal standard , 65 ug/m3

Affected population: 770,574

Further GIS-based Analyses

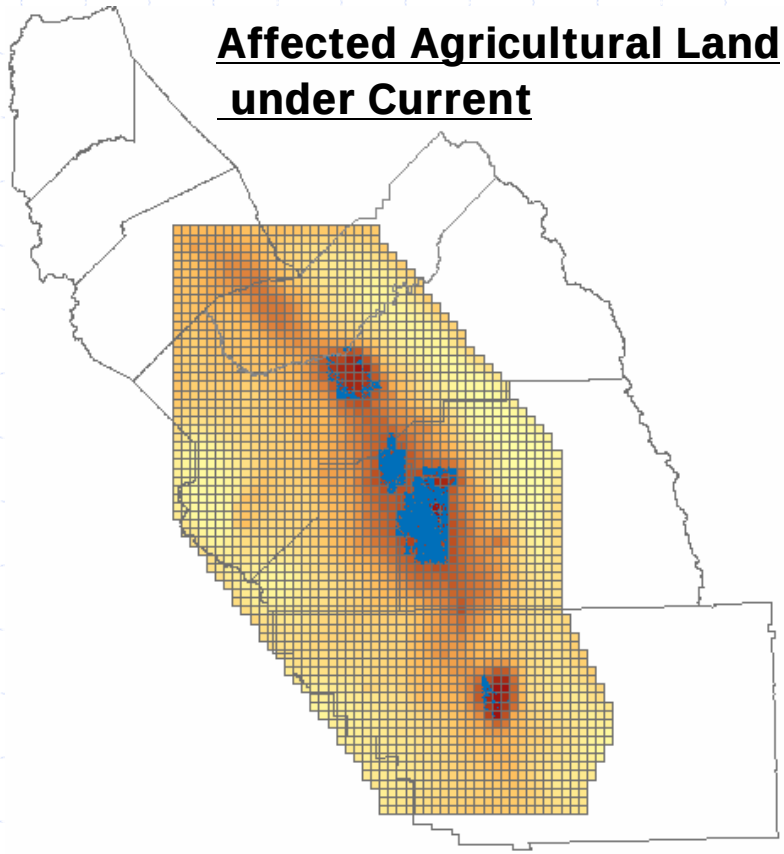
Affected Agricultural Land under New Standard



Agricultural land exposed to the area that exceeds the new 24hr PM2.5 federal standard , 35 ug/m3

Affected agricultural land: 2,711,934 acres

Affected Agricultural Land under Current



Agricultural land exposed to the area that exceeds the current 24hr PM2.5 federal standard , 65 ug/m3

Affected agricultural land: 268,616 acres

Conclusion

- Respond to the EPA's call for integrating GIS in emissions modeling
- Improve the accuracy and resolution of emissions inventory models
- Address the modeling uncertainties related to the spatial variation of vehicle characteristics
- Serve as an intermediate step towards an integrated transportation and air quality analysis
- Represent a concrete step towards developing a GIS-based emission inventory system in California


QUESTIONS
or
COMMENTS