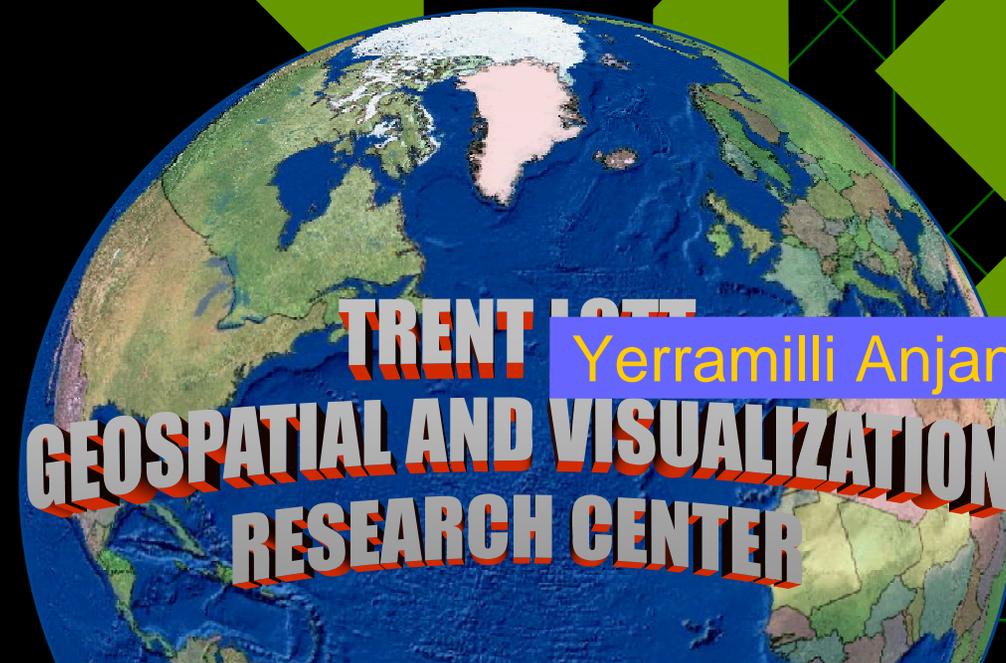


GIS assisted Emission inventory Development for Variable grid Emission database for Mississippi region



TRENT LOTT

Yerramilli Anjaneyulu,

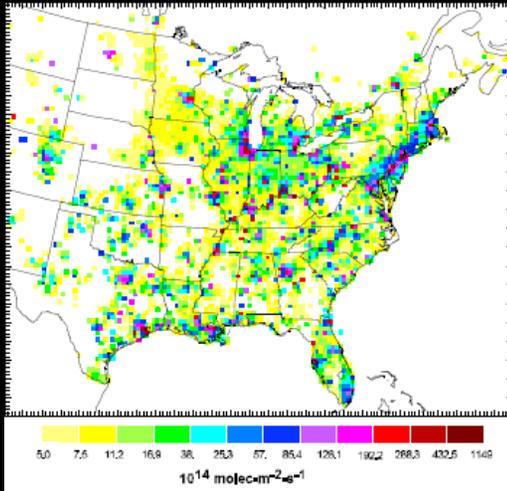
GEOSPATIAL AND VISUALIZATION
RESEARCH CENTER

Agenda

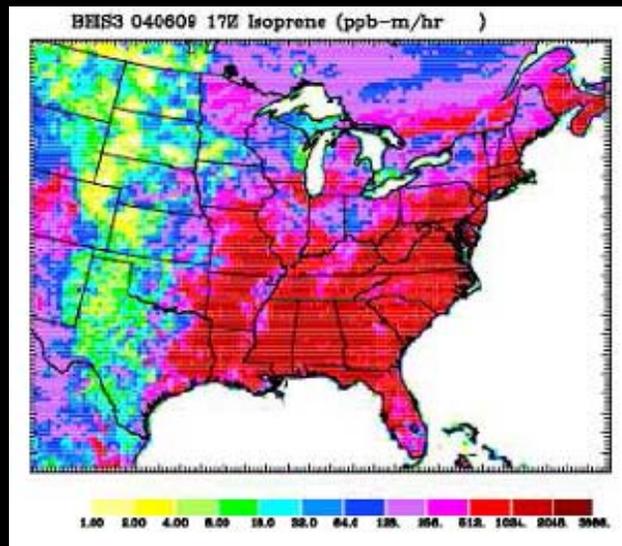
- ◆ Micro scale – Mesoscale Modeling
- ◆ Variable grid emission inventory development requirements
- ◆ Methodological framework
- ◆ GIS layer development
- ◆ Calculation and Querying in GIS
- ◆ Output map generation
- ◆ Future scope of the work



Microscale – mesoscale Modeling

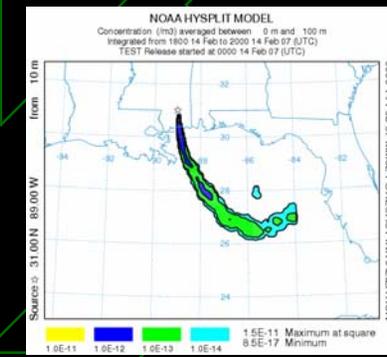
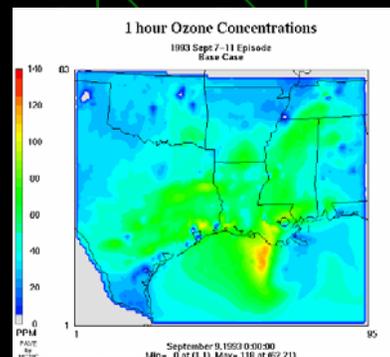
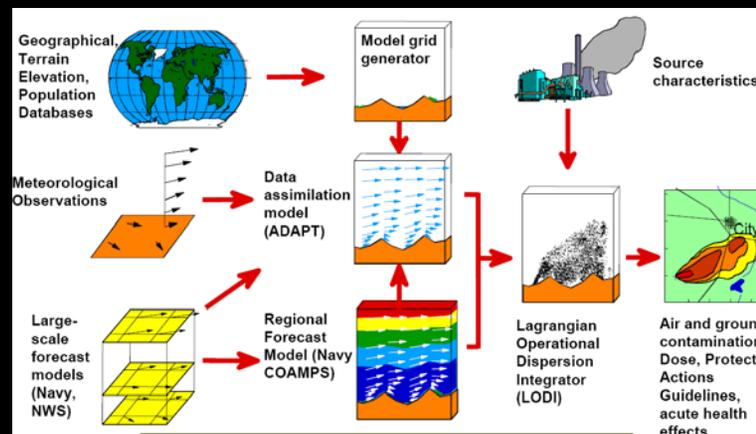
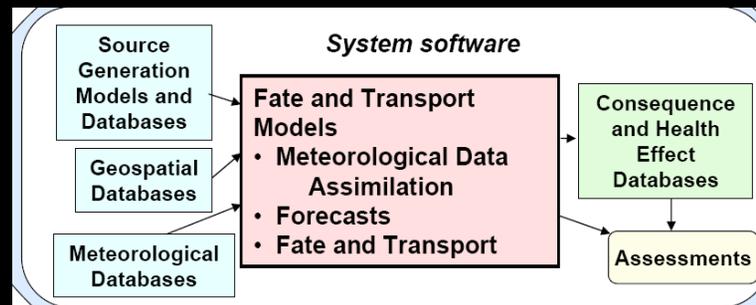
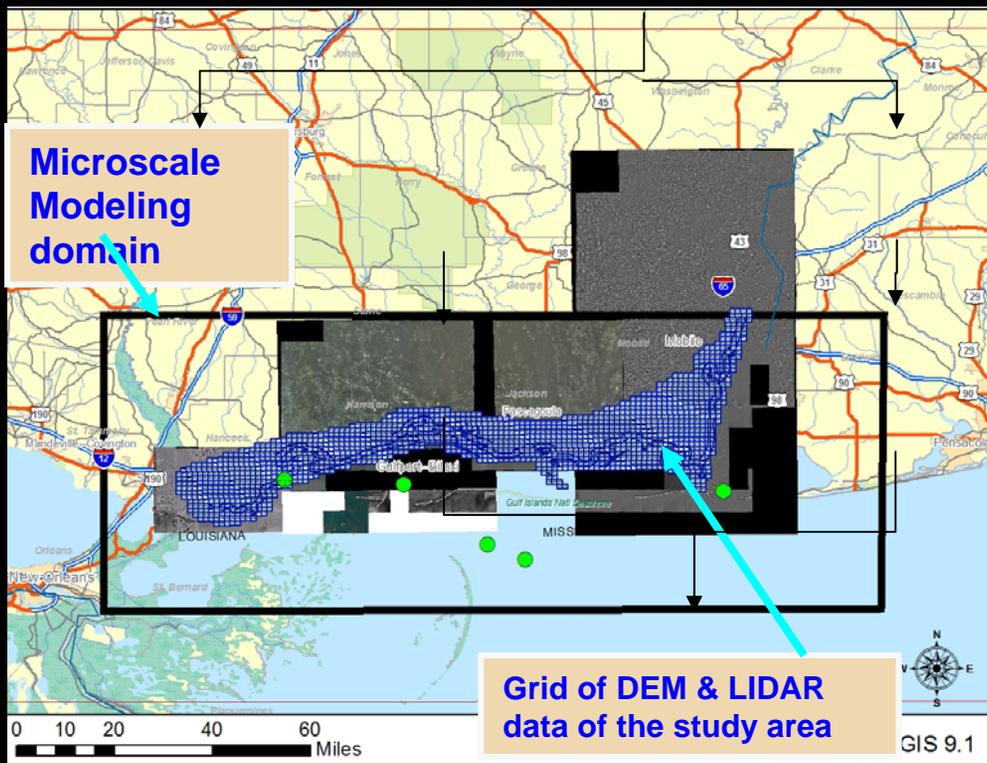


This is a study of atmospheric dispersion in the coastal zone using regional ensemble models and multi-model ensemble systems to develop the meteorological fields necessary to predict the movement and dispersal of pollutant plumes in the coastal environment.



The goal of the project is to construct a dispersion forecasting capability tailored for application in the Gulf Coast region.

Microscale – Mesoscale modeling domain



CMAQ

Hysplit

Problem Identified..

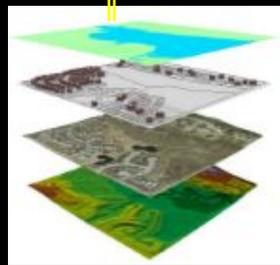
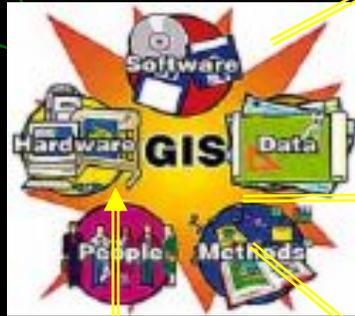
- ◆ Chemical simulations in most of the models require surface emissions in a grided format
- ◆ Simple interpolation of broader level emissions to obtain gridded data lead to erroneous results
- ◆ A GIS based methodology for distributing emissions from broader level inventory to finely grided emissions values is developed.
- ◆ Local micro-scale features such as activity and grid size is considered for modeling

Emission estimation using GIS

- ◆ Sources of pollution and activity are generated as a thematic layers in GIS
- ◆ The sources are linked to attribute database and emission factors using SCC code
- ◆ The emission levels are calculated using activity and emission rate equation mentioned above
- ◆ Statistical local interpolation – Natural neighbor local interpolation technique has been used to generate emission prediction in local scales for which data is not available.
- ◆ Grided emission database of selected area is selected using Raster overlay method

Methodological Framework

GIS



Maps



Area



Mobile



Point

urban



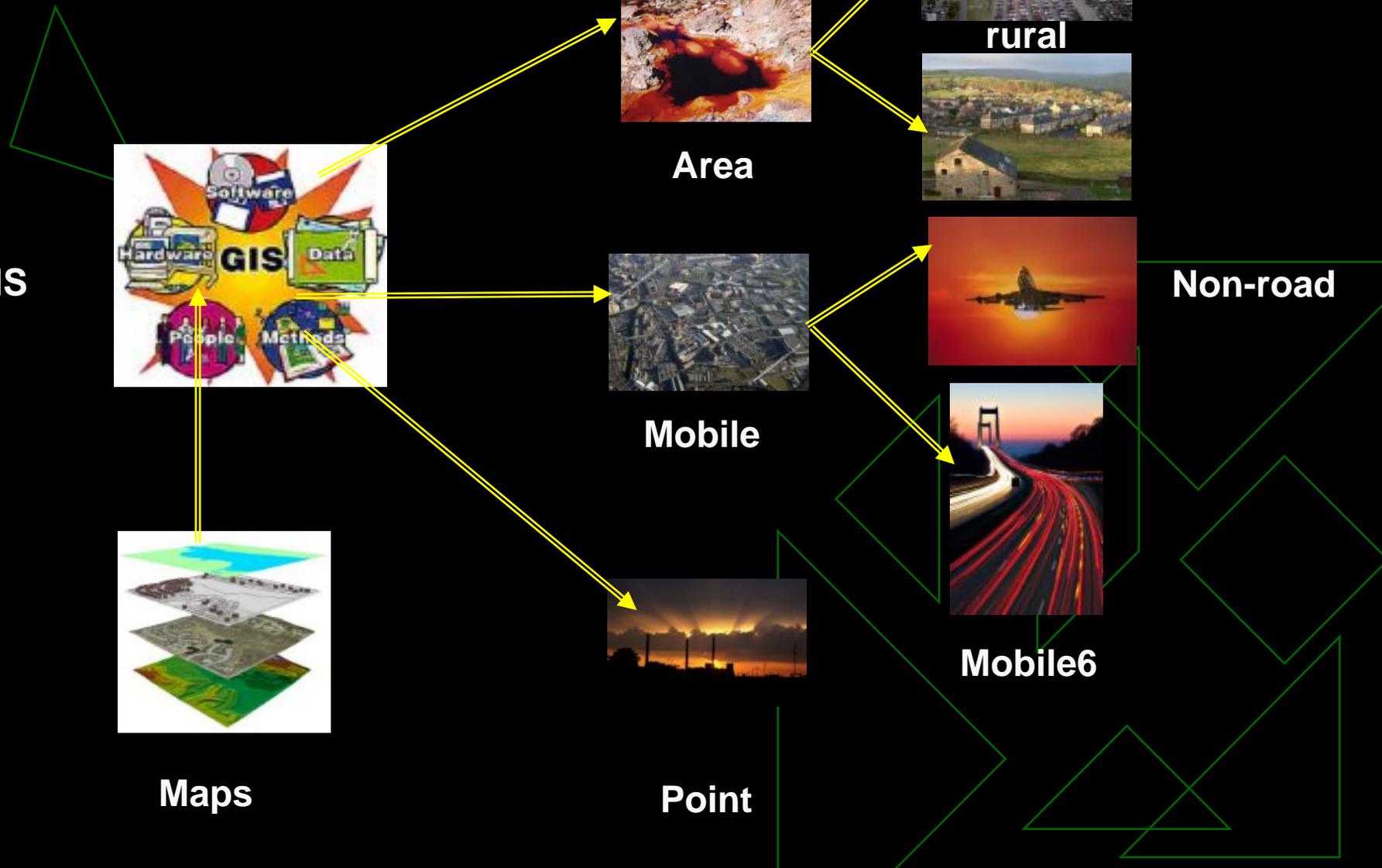
rural



Non-road



Mobile6



Database structure

Point
NEI/NIF2.0 Point

Emission calculation

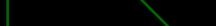
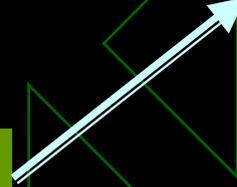
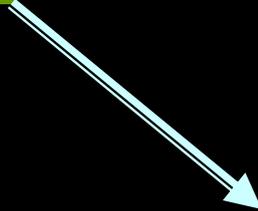
Area
NE/NIF2.0 Point

Area type emissions

Mobile
NE/NIF2.0 Mobile
Non road
Mobile data

Mobile emissions

GIS compatible Database Preparation



Importing Emission database and AP42 factors into GIS

Feature Class To Feature Class

Input Features: E:\WorkSpace\lab4\country020_48_Project.shp

Output Location: E:\WorkSpace\lab5\Clark_Geodatabase.mdb

Output Feature Class Name: country020_48_Project

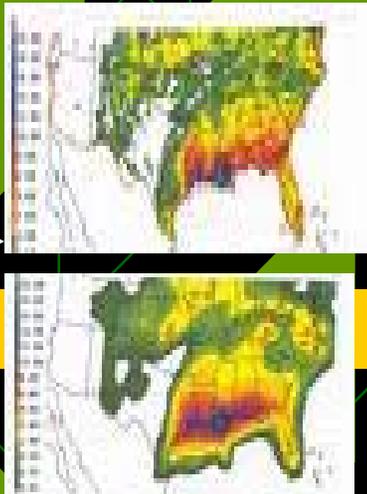
Field Info (optional)

FieldName	NewFieldName	Visible	SplitPolicy
AREA	AREA	TRUE	NONE
PERIMETER	PERIMETER	TRUE	NONE
COUNTYP0...	COUNTYP020	TRUE	NONE
STATE	STATE	TRUE	NONE
COUNTY	COUNTY	TRUE	NONE
FIPS	FIPS	TRUE	NONE
STATE_FIPS	STATE_FIPS	TRUE	NONE
SQUARE...	SQUARE_MIL	TRUE	NONE

Emission calculation codes (AP42)

Feature locations
Relational Join

Spatial Analyst



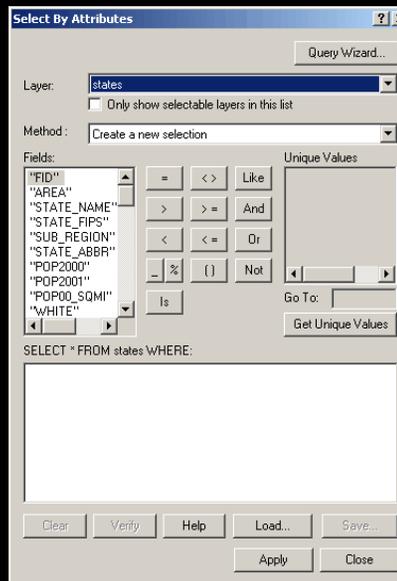
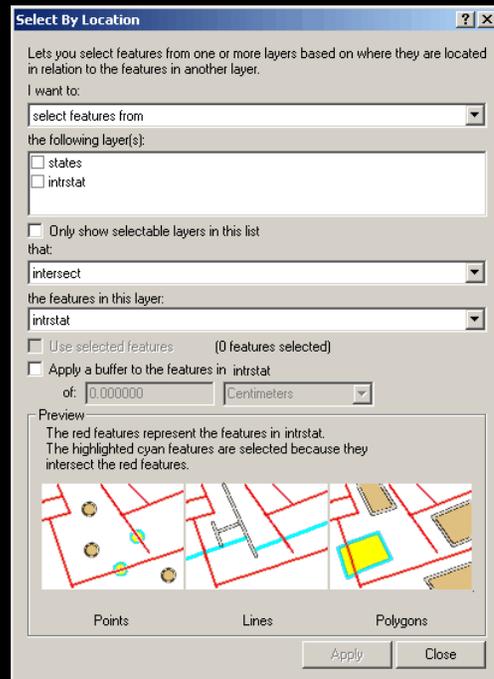
Emission calculation codes (AP42)

Attribute information for the feature class

- ◆ Attributes are the building blocks for computing emissions
- ◆ Each facility whether line, point, polygon are associated with descriptive attribute information namely facility type, SCC code, emission rate etc.
- ◆ It will also have control factor option for manipulating the emission levels

Linkage between feature class and emission factor

- ◆ Source Classification Codes (SCC) are used to develop linkage between feature class and facility
- ◆ It is used to allocate the emissions



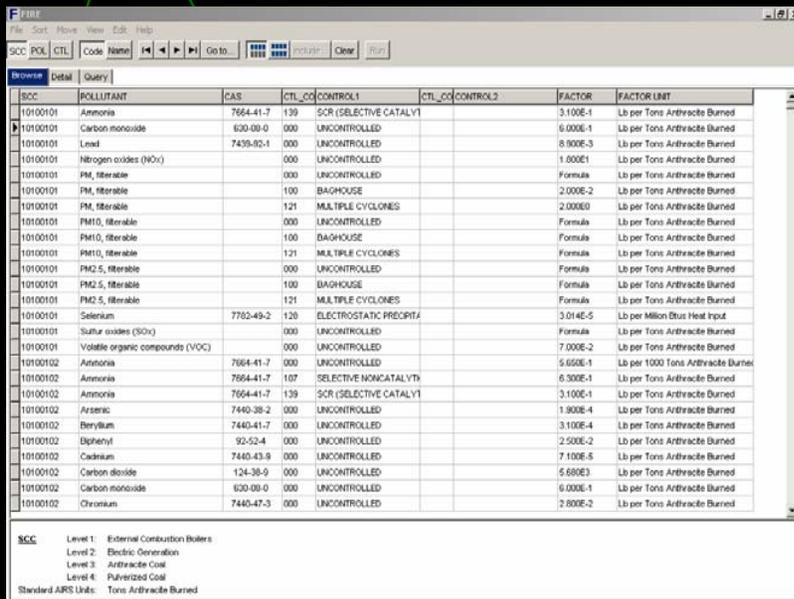
General querying and mathematical tools are used to compute emissions

Emission Inventory Sources

To start with actual 2002 data developed by the RPOs for the U.S., version 2 of the year 2000 were used in the present study. Latest point emission data from MSDEQ is used to calculate gridded point emission database



Calculation methodology



The screenshot shows the FIRE database interface with a table of pollutants. The table columns are: SCC, POLLUTANT, CAS, CTL_CO, CONTROL1, CTL_CO, CONTROL2, FACTOR, and FACTOR UNIT. The table lists various pollutants such as Ammonia, Carbon monoxide, Lead, Nitrogen oxides (NOx), PM, filterable, PM10, filterable, PM2.5, filterable, Selenium, Sulfur oxides (SOx), Volatile organic compounds (VOC), and others, along with their respective CAS numbers, control methods, and emission factors.

SCC	POLLUTANT	CAS	CTL_CO	CONTROL1	CTL_CO	CONTROL2	FACTOR	FACTOR UNIT
10100101	Ammonia	7664-41-7	139	SCR (SELECTIVE CATALYT)			3.100E-1	Lb per Tons Anthracite Burned
10100101	Carbon monoxide	630-00-0	000	UNCONTROLLED			6.000E-1	Lb per Tons Anthracite Burned
10100101	Lead	7439-92-1	000	UNCONTROLLED			8.900E-3	Lb per Tons Anthracite Burned
10100101	Nitrogen oxides (NOx)		000	UNCONTROLLED			1.000E1	Lb per Tons Anthracite Burned
10100101	PM, filterable		000	UNCONTROLLED			Formula	Lb per Tons Anthracite Burned
10100101	PM, filterable		100	BAGHOUSE			2.000E-2	Lb per Tons Anthracite Burned
10100101	PM, filterable		121	MULTIPLE CYCLONES			2.000E0	Lb per Tons Anthracite Burned
10100101	PM10, filterable		000	UNCONTROLLED			Formula	Lb per Tons Anthracite Burned
10100101	PM10, filterable		100	BAGHOUSE			Formula	Lb per Tons Anthracite Burned
10100101	PM10, filterable		121	MULTIPLE CYCLONES			Formula	Lb per Tons Anthracite Burned
10100101	PM2.5, filterable		000	UNCONTROLLED			Formula	Lb per Tons Anthracite Burned
10100101	PM2.5, filterable		100	BAGHOUSE			Formula	Lb per Tons Anthracite Burned
10100101	PM2.5, filterable		121	MULTIPLE CYCLONES			Formula	Lb per Tons Anthracite Burned
10100101	Selenium	7702-49-2	120	ELECTROSTATIC PRECIPIT			3.014E-5	Lb per Million Btus Heat Input
10100101	Sulfur oxides (SOx)		000	UNCONTROLLED			Formula	Lb per Tons Anthracite Burned
10100101	Volatile organic compounds (VOC)		000	UNCONTROLLED			7.000E-2	Lb per Tons Anthracite Burned
10100102	Ammonia	7664-41-7	000	UNCONTROLLED			5.650E-1	Lb per 1000 Tons Anthracite Burned
10100102	Ammonia	7664-41-7	107	SELECTIVE NONCATALYT			6.300E-1	Lb per Tons Anthracite Burned
10100102	Ammonia	7664-41-7	139	SCR (SELECTIVE CATALYT)			3.100E-1	Lb per Tons Anthracite Burned
10100102	Arsenic	7440-38-2	000	UNCONTROLLED			1.900E-4	Lb per Tons Anthracite Burned
10100102	Beryllium	7440-41-7	000	UNCONTROLLED			3.100E-4	Lb per Tons Anthracite Burned
10100102	Biphenyl	92-52-4	000	UNCONTROLLED			2.500E-2	Lb per Tons Anthracite Burned
10100102	Cadmium	7440-43-8	000	UNCONTROLLED			7.100E-5	Lb per Tons Anthracite Burned
10100102	Carbon dioxide	124-38-9	000	UNCONTROLLED			5.680E3	Lb per Tons Anthracite Burned
10100102	Carbon monoxide	630-00-0	000	UNCONTROLLED			6.000E-1	Lb per Tons Anthracite Burned
10100102	Chromium	7440-47-3	000	UNCONTROLLED			2.800E-2	Lb per Tons Anthracite Burned

SCC: Level 1: External Combustion Boilers
Level 2: Electric Generation
Level 3: Anthracite Coal
Level 4: Pulverized Coal
Standard ARS Units: Tons Anthracite Burned

◆ The general equation for emissions estimation is:

$$E = A \times EF \times (1 - ER/100)$$

where:

E = emissions;

A = activity rate;

EF = emission factor, and

ER = overall emission reduction efficiency, %

AP42 / FIRE database

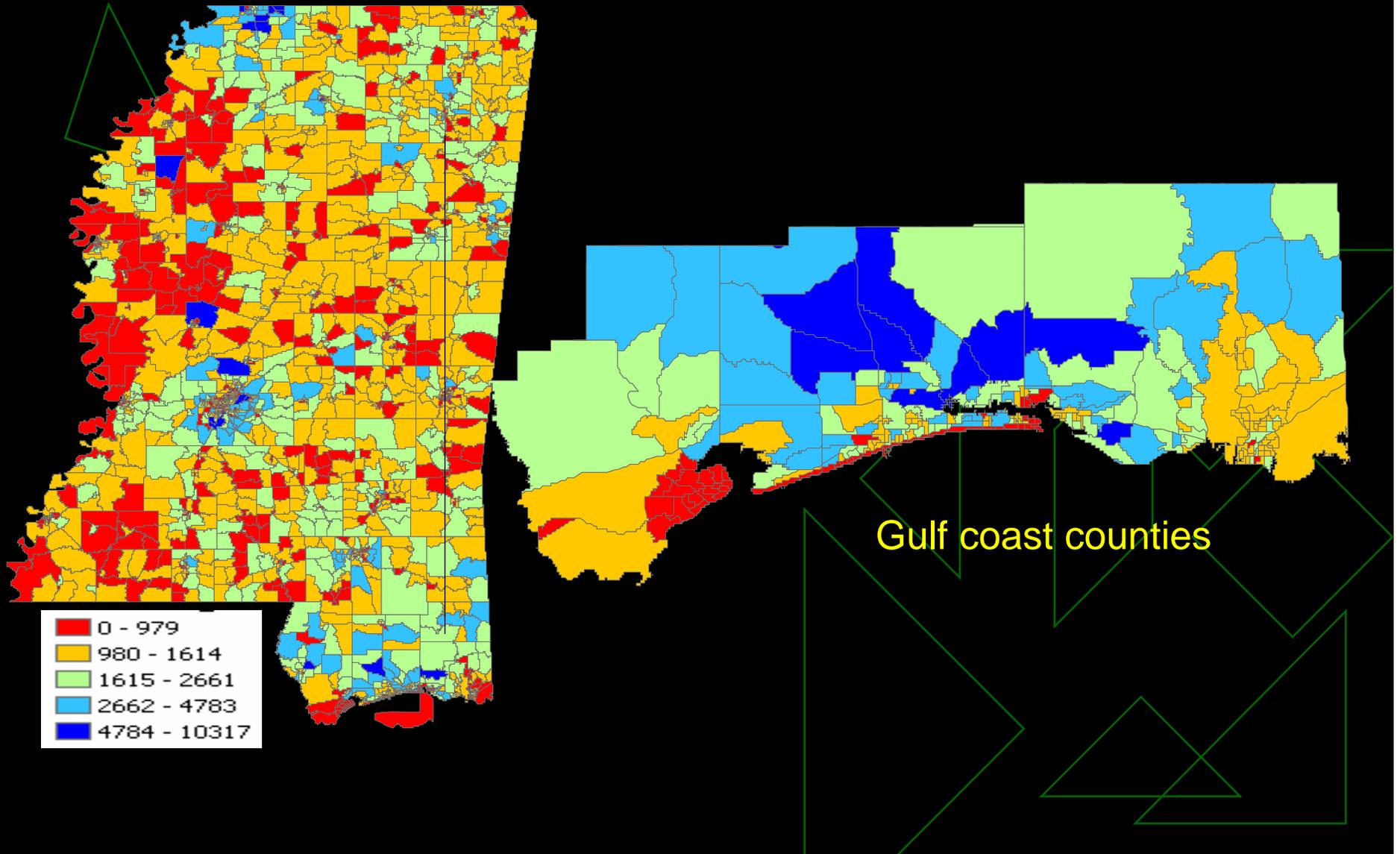
Activity

- ◆ Processes that cause emissions to be released
- ◆ Calculated using emission factor and measurable value
- ◆ Number of people per household
 - Road network (number of lanes and vehicular number)
 - Number of people in a given location
- ◆ Attribute database is created in GIS as a number of layers

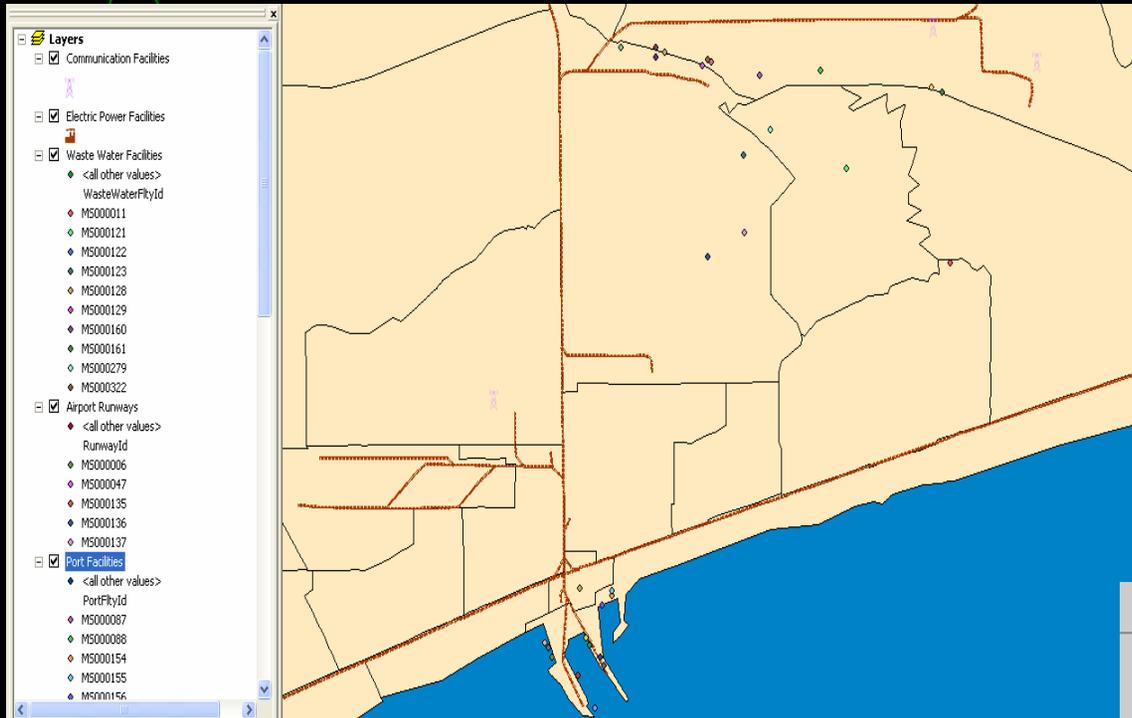
Infrastructural mapping of the study area

- ◆ Infrastructural facilities namely Electricity generating units, Industrial locations, live stock facilities
- ◆ Political units namely counties, municipalities, census tracts, province
- ◆ Land use, demographic profiles of the study area
- ◆ Transportation facilities etc
- ◆ Infrastructural data is important for manipulating and developing the emission database

Population size in the study area



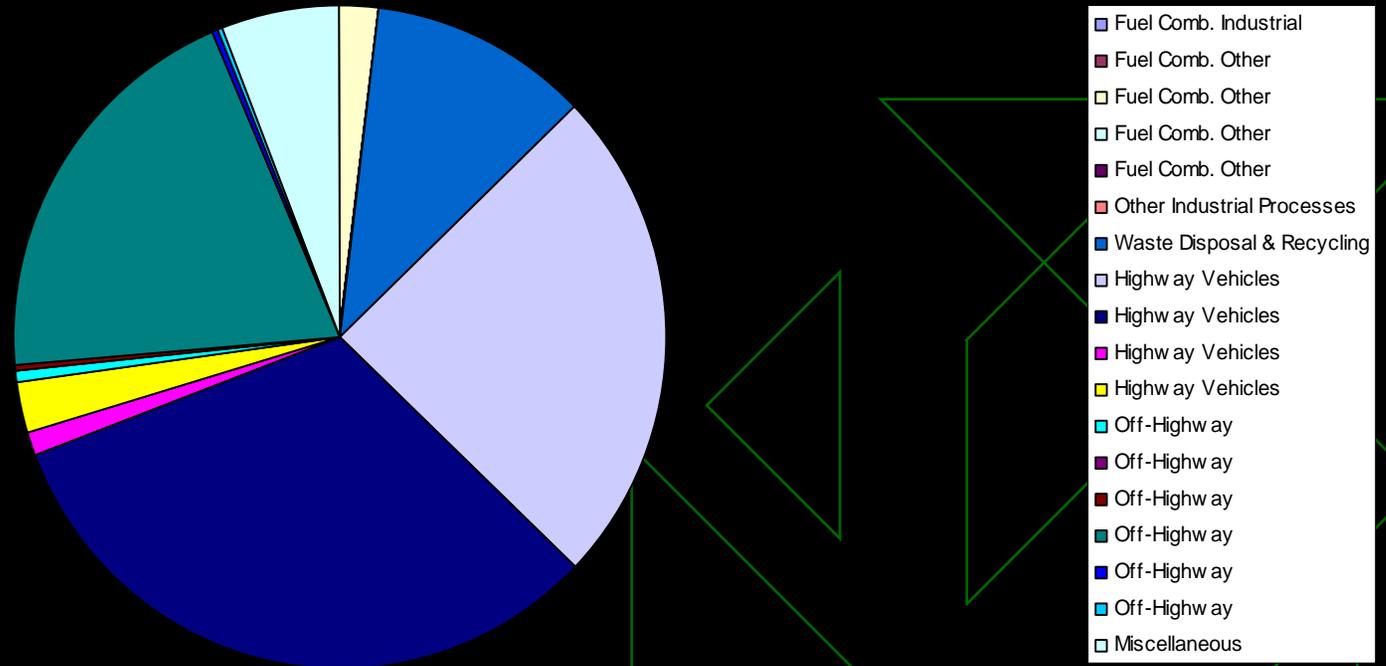
Calculation example Emissions from Utilities



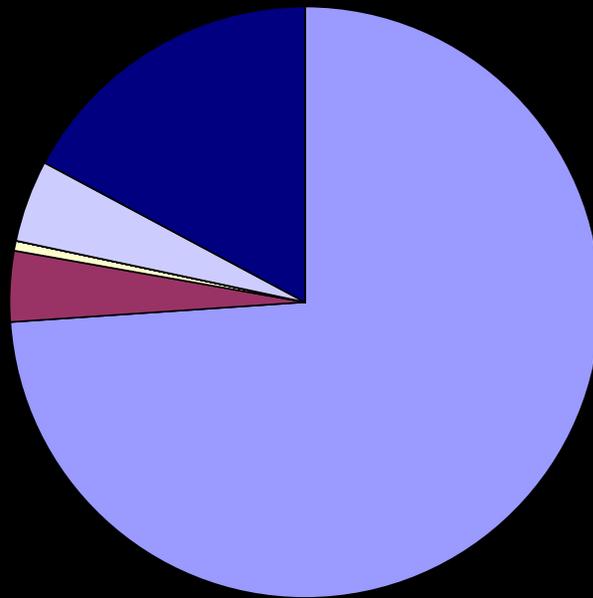
EMISSIONS	STAT	CAP	E	Pollutant	category	NAP	CO2	FRES	100 ALM	Nfres	ONROAD	PF	Area	PF Major
ANNUAL	000	24231	NAAP	Acrylonitrile	0.002413477									0.010278
ANNUAL	000	24231	NAAP	Aldrich Chloride	0.0040207993									0.2826484
ANNUAL	000	24231	NAAP	Antimony Compound	3.400065-05									0.78466072
ANNUAL	000	24231	NAAP	Arsenic Compound	10.00023430					0.002043729	147.36078906	205.4521145	0.004	0.3997
ANNUAL	000	24231	NAAP	Benzene (Including)	139.25007086									0.0211448
ANNUAL	000	24231	NAAP	Benzyl Chloride	0.0019536762									0.0000707
ANNUAL	000	24231	NAAP	Beryllium Compound	0.004717793									0.041963
ANNUAL	000	24231	NAAP	Bipheryl	0.0024820744									0.022009
ANNUAL	000	24231	NAAP	Bis(2-Ethylhexyl)Pb	0.0006202919									0.0146448
ANNUAL	000	24231	NAAP	Bromobenzene						0.0004802911				0.022009
ANNUAL	000	24231	NAAP	Calcium Compound	8.0071603080									0.012962
ANNUAL	000	24231	NAAP	Carbon Dioxide	1.0242821986									0.07425
ANNUAL	000	24231	NAAP	Carbon Tetrachloride	0.200079557									0.012962
ANNUAL	000	24231	NAAP	Chlorobenzene	29.457466179									0.030009
ANNUAL	000	24231	NAAP	Chloroform	48.233340777									0.042348
ANNUAL	000	24231	NAAP	Chloroethane	0.0000000002									0.0071
ANNUAL	000	24231	NAAP	Chloroacetylene	0.010230095					0.0001246229	0.0000000000	0.0000000000		0.000000
ANNUAL	000	24231	NAAP	Chromium Compound	0.0001930155									0.000000
ANNUAL	000	24231	NAAP	Coal Compounds	11.00790705									1.4275
ANNUAL	000	24231	NAAP	Cresol/Creosote Ass	1.0010796423									0.027408
ANNUAL	000	24231	NAAP	Cumene	33.11703365									0.003062
ANNUAL	000	24231	NAAP	Cyanoacrylate	0.0004186224									0.0004186224
ANNUAL	000	24231	NAAP	Dibutyl Phthalate	0.0000000000									0.000000
ANNUAL	000	24231	NAAP	Dimethyl Phthalate	0.0000000000									0.000000
ANNUAL	000	24231	NAAP	Dimethyl Sulfoxide	0.0000000000									0.000000
ANNUAL	000	24231	NAAP	Ethylbenzene	36.90397727					0.3480000000	07.4100000000	83.82980156		0.001192024
ANNUAL	000	24231	NAAP	Ethylene Dichloride	0.1107000000									0.0004186224
ANNUAL	000	24231	NAAP	Ethylene Glycol	124.00420946									1.04
ANNUAL	000	24231	NAAP	Ethylene Oxide	6.616547024									0.0004186224
ANNUAL	000	24231	NAAP	Formaldehyde	664.80084472					2.0000000000	70.3635462000	109.00000000	0.67	0.1489104
ANNUAL	000	24231	NAAP	Glycol Ethers	67.67000000									1.96



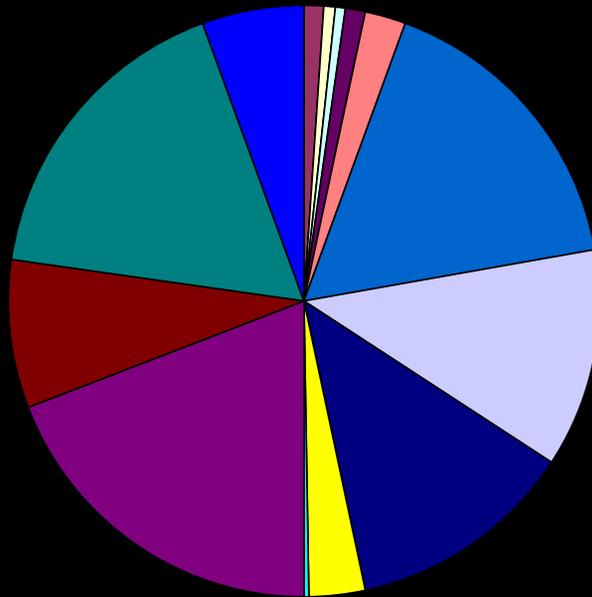
Total area based CO emissions in the study area (%)



Point sources of sulfur dioxide in the study area

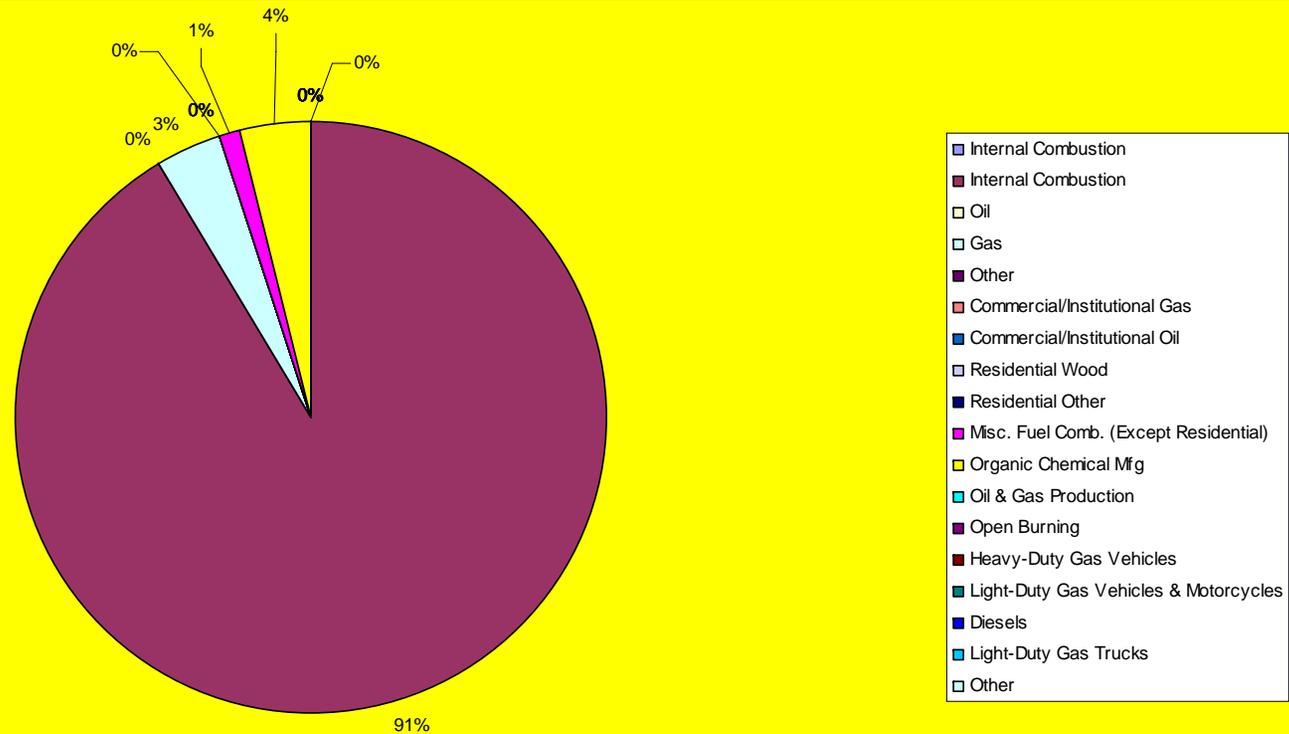


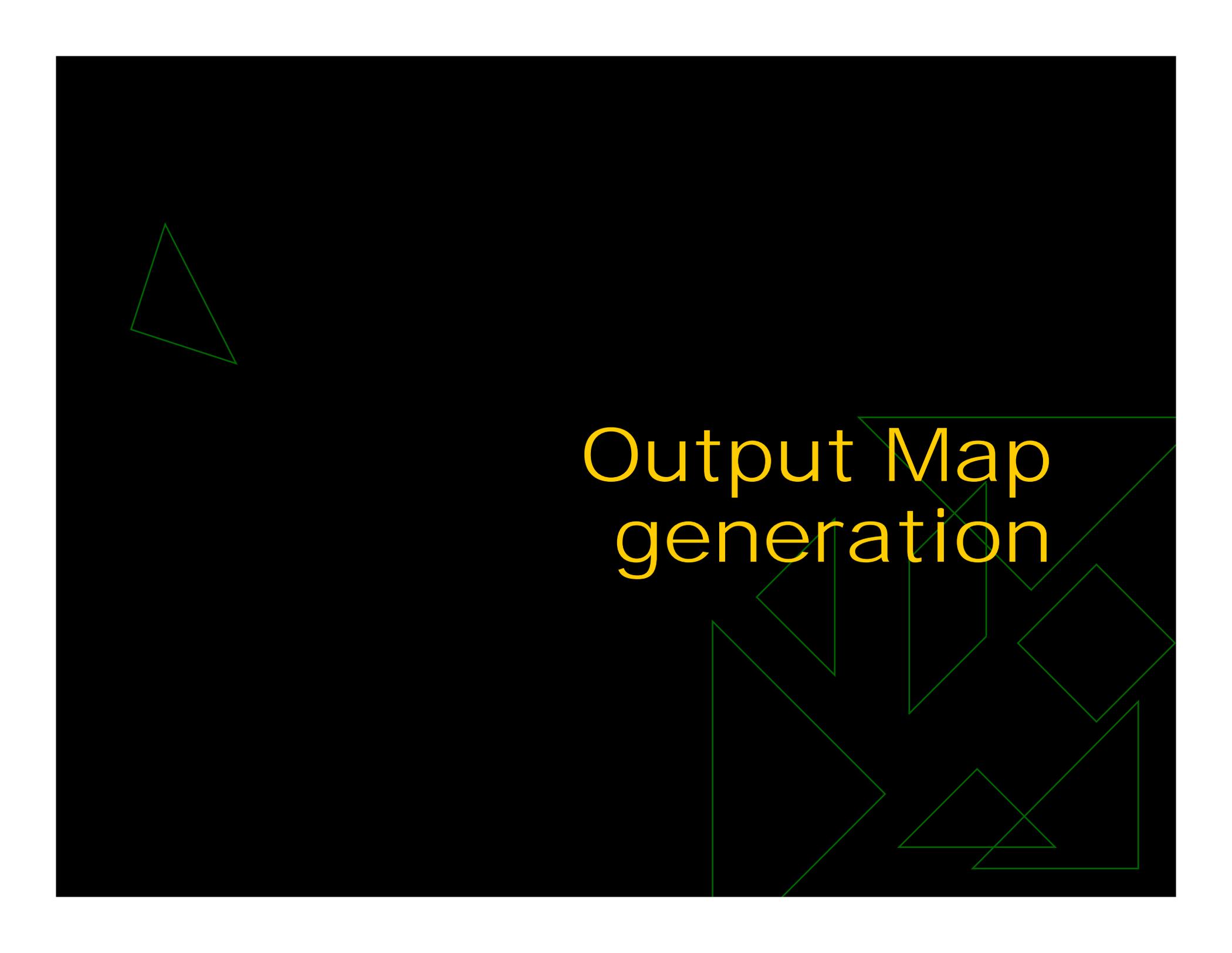
Area based sulfur dioxide in the study area



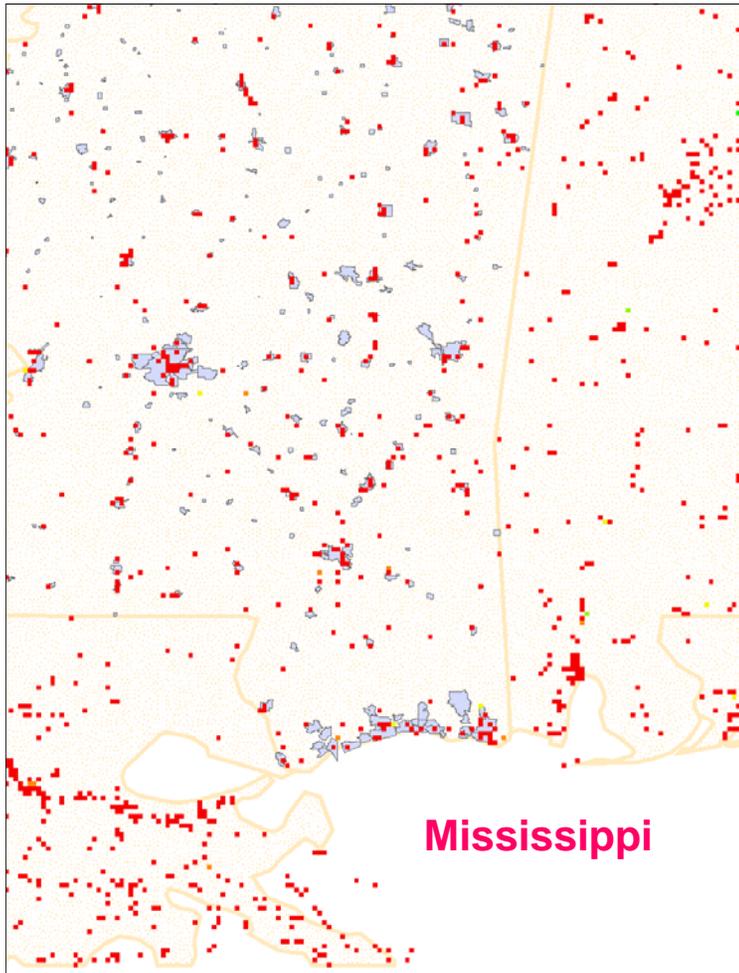
- Commercial/Institutional Gas
- Commercial/Institutional Oil
- Residential Wood
- Residential Other
- Open Burning
- Heavy-Duty Gas Vehicles
- Light-Duty Gas Vehicles & Motorcycles
- Diesels
- Light-Duty Gas Trucks
- Other
- Non-Road Gasoline
- Aircraft
- Non-Road Diesel
- Marine Vessels
- Railroads
- Other Combustion

Area based Oxides of the study area



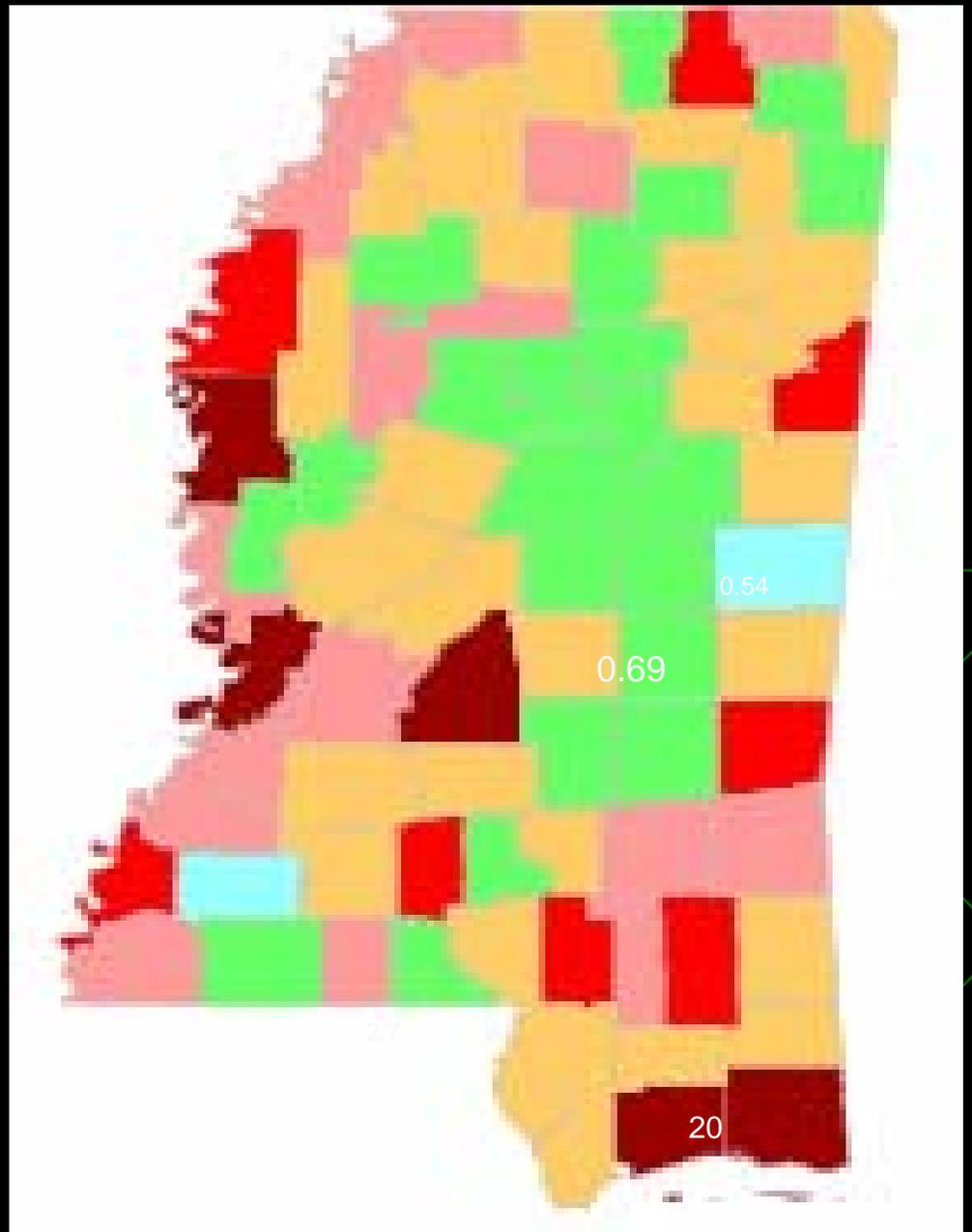


Output Map generation

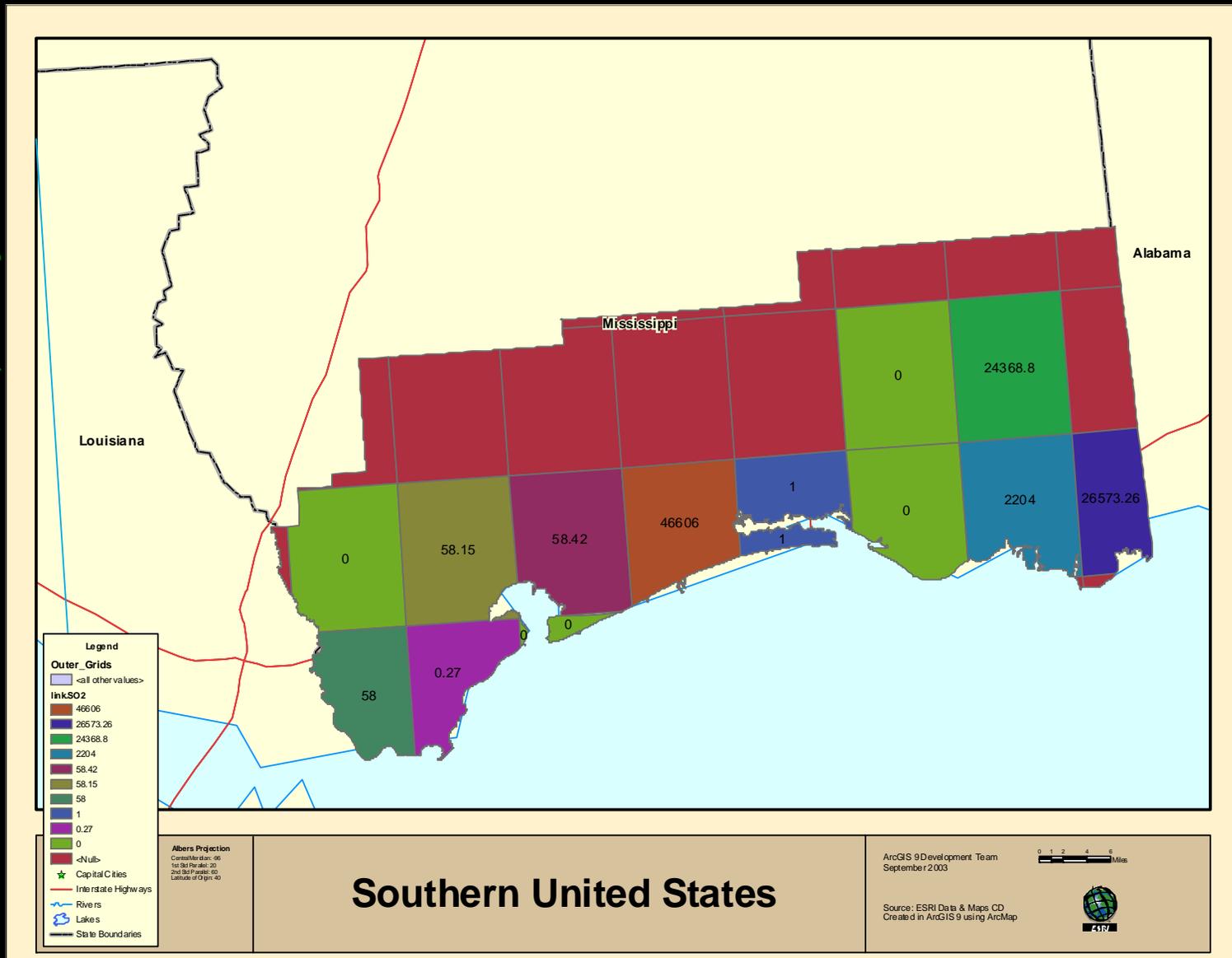


- GulfSOx
- Value
- 0 - 5,771.050919
- 5,771.05092 - 29,679.69044
- 29,679.69045 - 70,077.04687
- 70,077.04688 - 121,192.0693
- 121,192.0694 - 210,231.1406
- Gulfnox
- city
-
- NOX
- nox
- epa

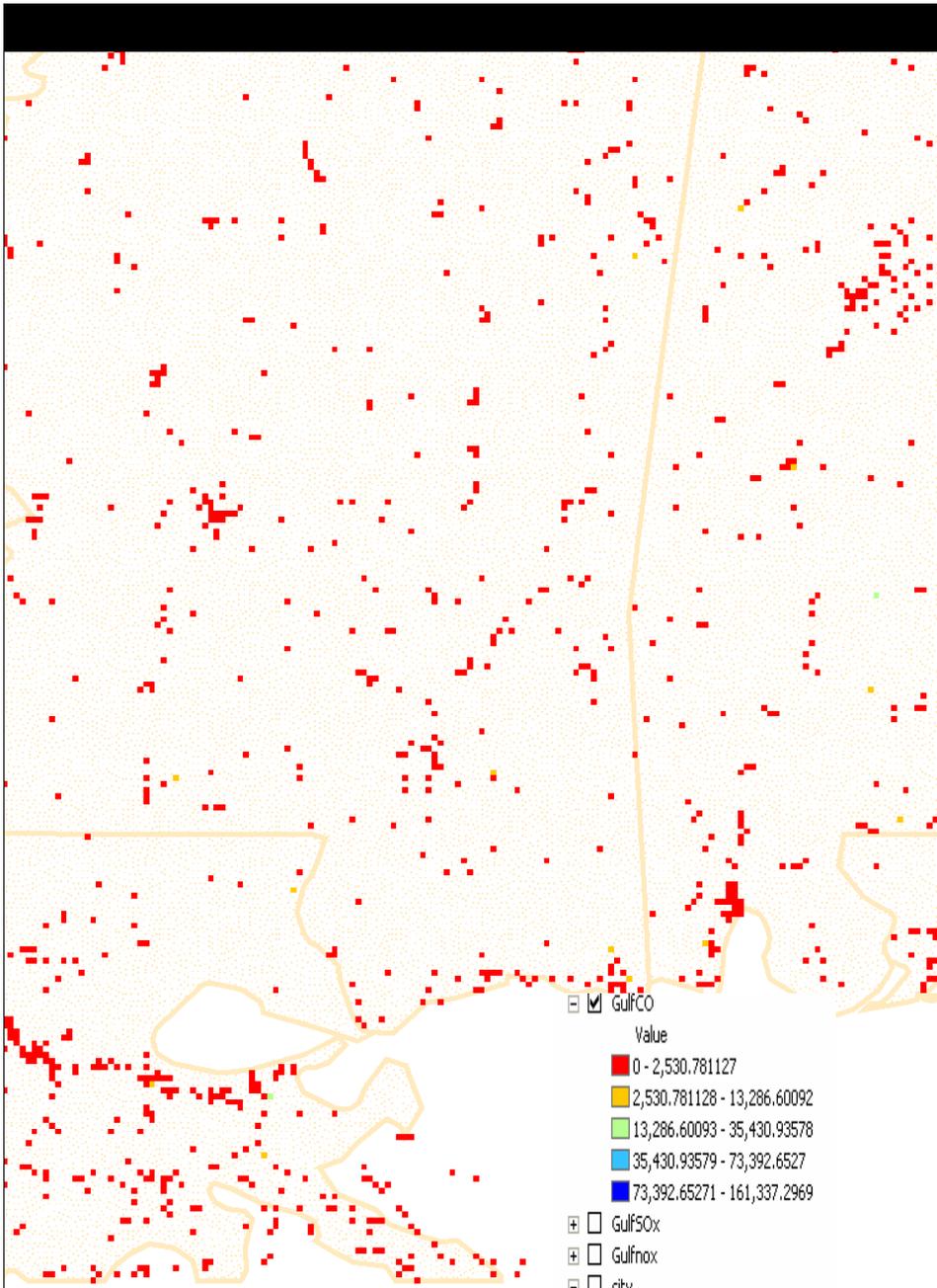
Grided emissions of Sulfur dioxide



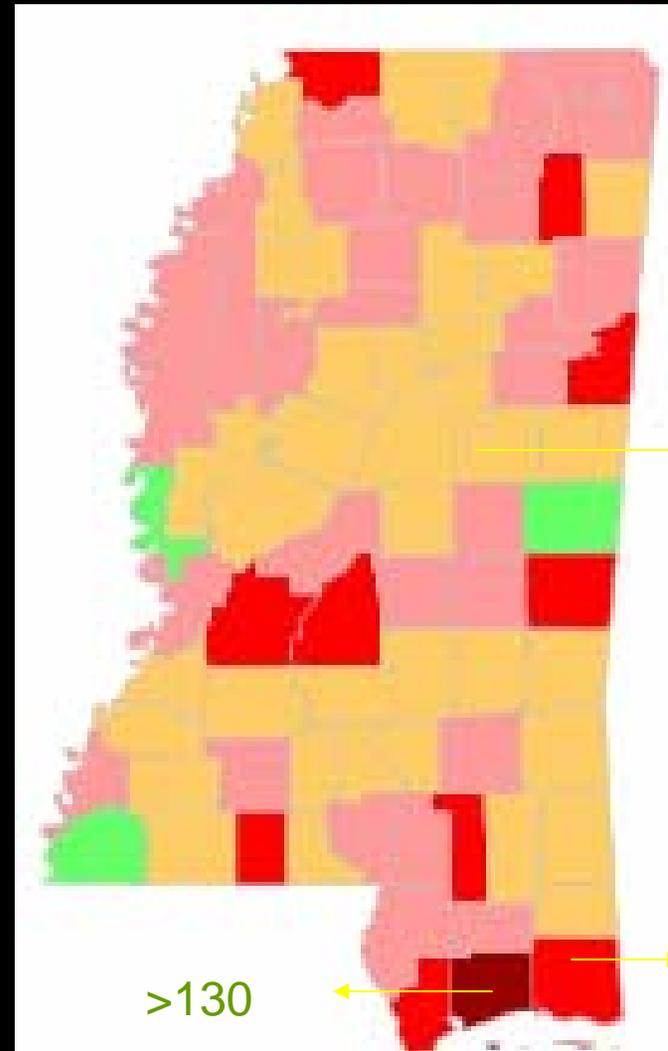
Source: EPA



Sulfur dioxide Emission database



Mississippi



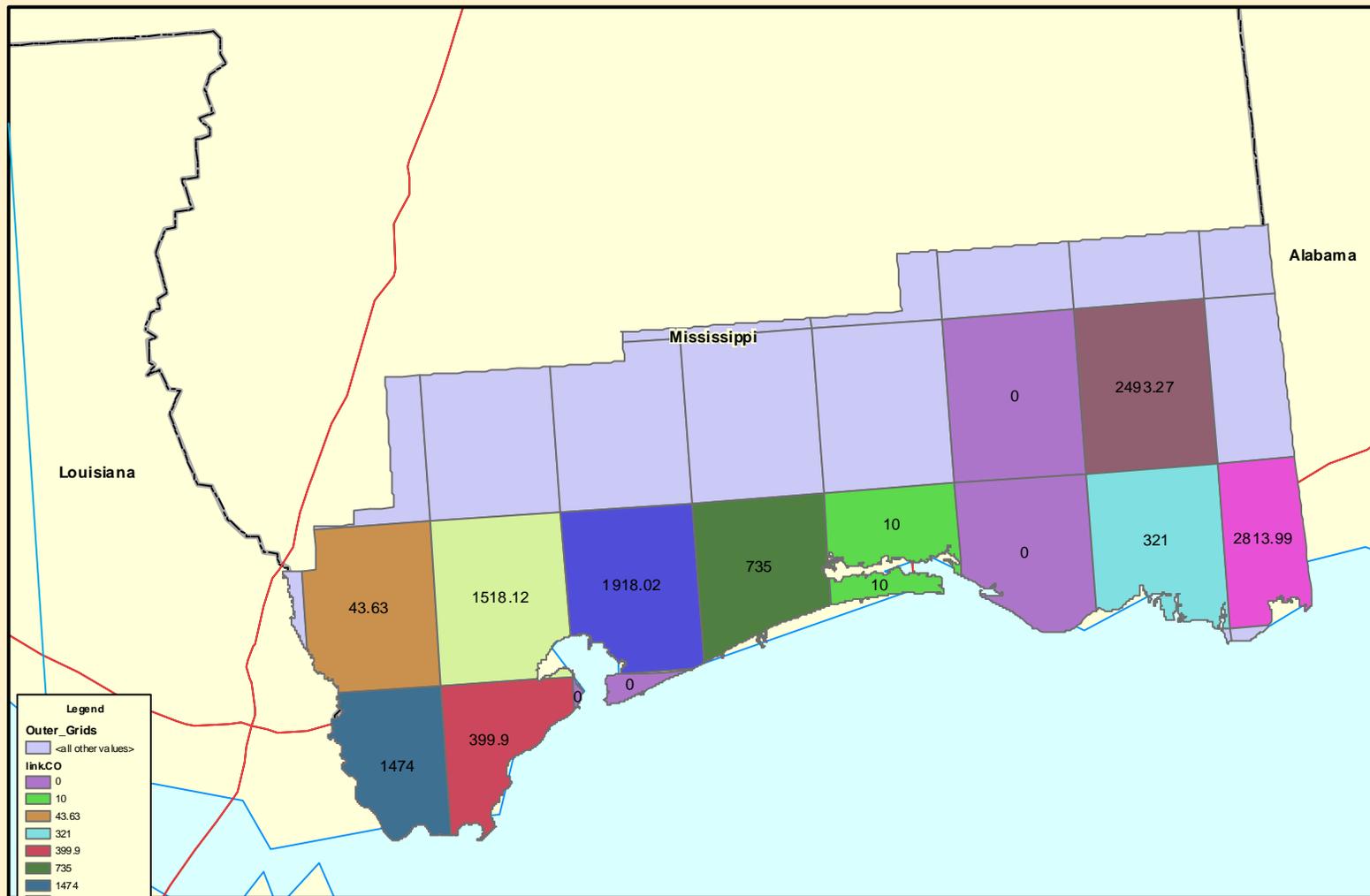
9.9 to 21

>130

51 - 130

Total Carbon Monoxide emissions (Tons per SqMi)

Carbon monoxide



Legend

Outer_Grids
 <all other values>

InkCO

- 0
- 10
- 43.63
- 321
- 399.9
- 735
- 1474
- 1518.12
- 1918.02
- 2493.27
- 2813.99

★ Capital Cities
 Interstate Highways
 Rivers
 Lakes
 State Boundaries

Albers Projection
 Central Meridian: 96
 1st Standard Parallel: 20
 2nd Standard Parallel: 30
 Latitude of Origin: 40

Southern United States

ArcGIS 9 Development Team
 September 2003

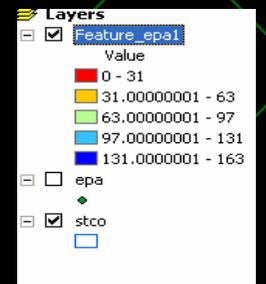
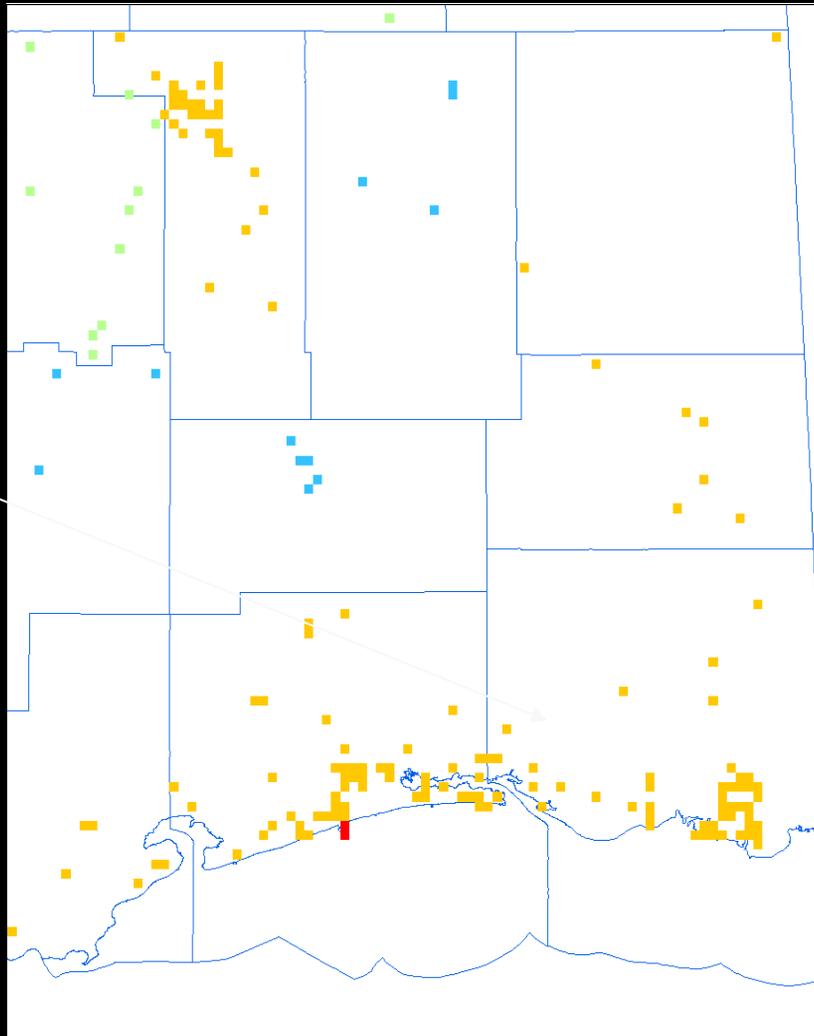
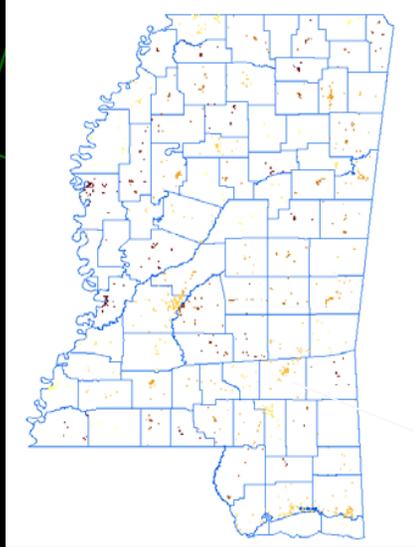


Source: ESRI Data & Maps CD
 Created in ArcGIS 9 using ArcMap



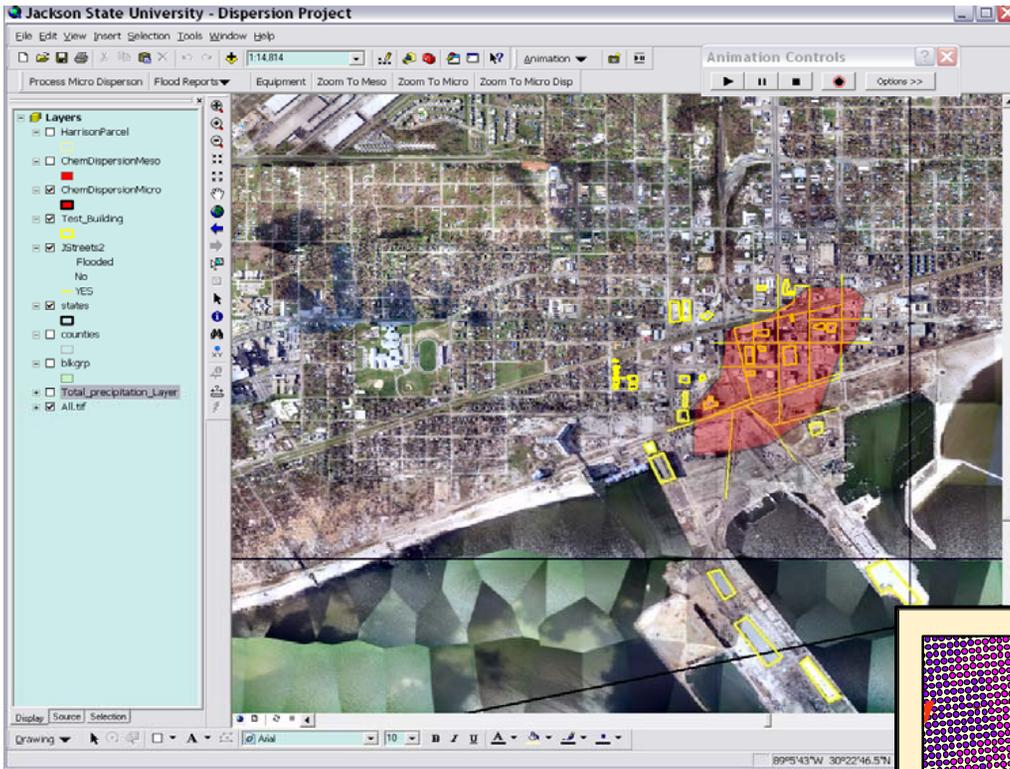
Carbon monoxide emission database

Sulfur dioxide emission quantities from Point source

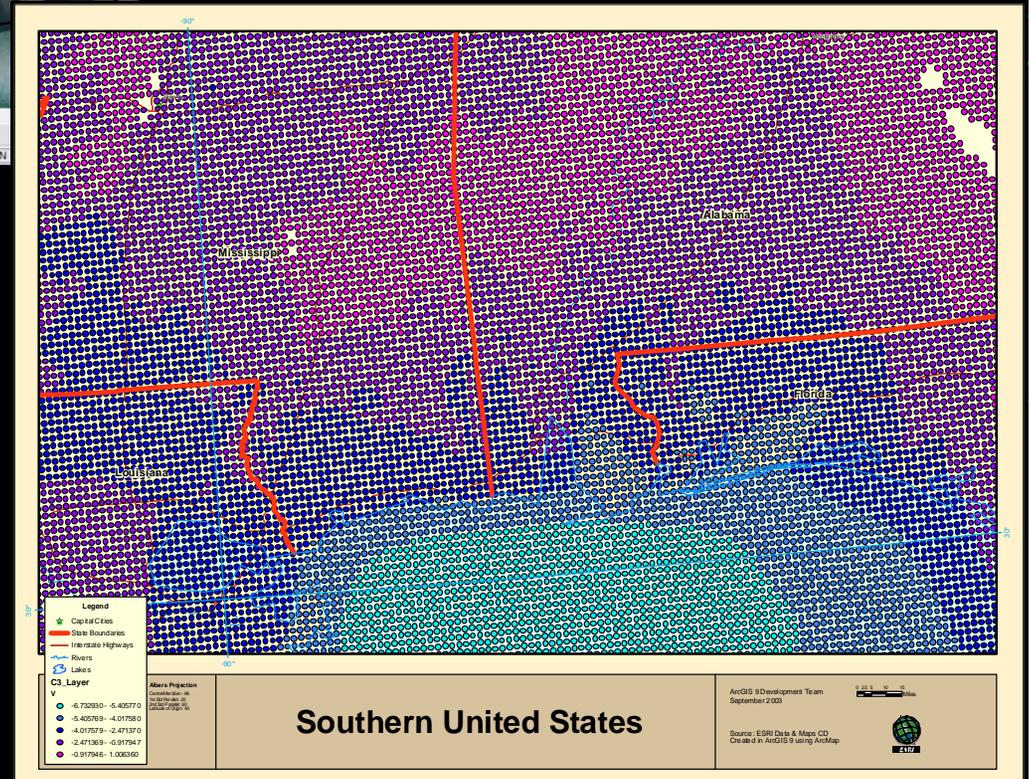


Emission estimation

- ◆ Currently no elements are developed for automated emission estimation
- ◆ Manual commands based emission estimation algorithm is developed
- ◆ Emission levels are shown in Map as a chloropleth map.
- ◆ Feature output can be saved as dbf format for converting to other formats

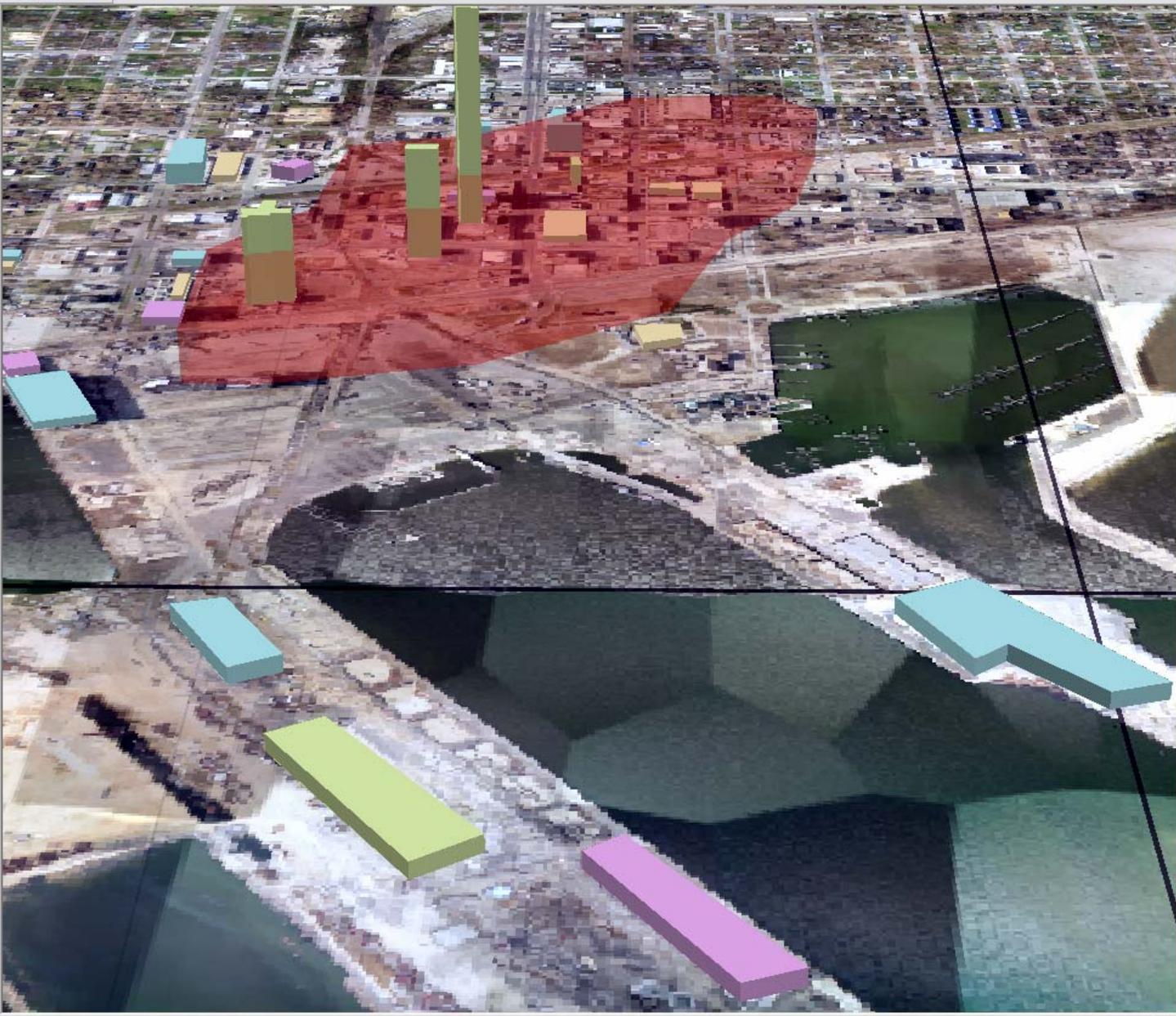


Model output



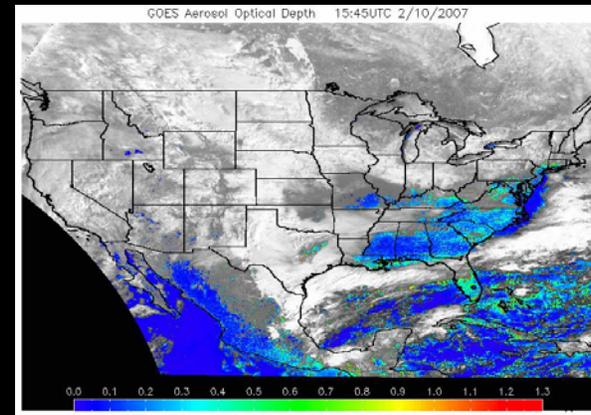
WRF output

- Scene layers
 - JStreets2
 - ChemDispersionMicro
 - Red
 - Test_Building
 - BuildType
 - FastFood
 - Hotel
 - Retail
 - Warehouse
 - All.tif
 - RGB
 - Red: Band_1
 - Green: Band_2
 - Blue: Band_3



Future Scope

- ◆ Use high resolution satellite products to correlate the emission sources and developing emission inventory
- ◆ Develop GIS assisted emission inventory preparation and processing system for directly coupling to Mesoscale models
(Implementing Sparse matrix algorithms into GIS)
- ◆ Incorporate Biogenic emission inventory into the model and use Satellite derived products



Acknowledgements

- ◆ Thanks for the support of the Atmospheric Dispersion Project (ADP) funded by the National Oceanic and Atmospheric Administration through the U.S. Department of Commerce (Silver Springs, MD); Contract #NA06OAR4600192.

Mississippi e-Center @ JSU - *Where Technology Works For You*



THANK YOU

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