

Developing Modeling-Ready Emissions Inventory for MATES-IV

Xinqiu Zhang, Sang-Mi Lee, Joe Cassmassi & Philip Fine

South Coast Air Quality Management District
21865 Copley Dr, Diamond Bar, CA 91765

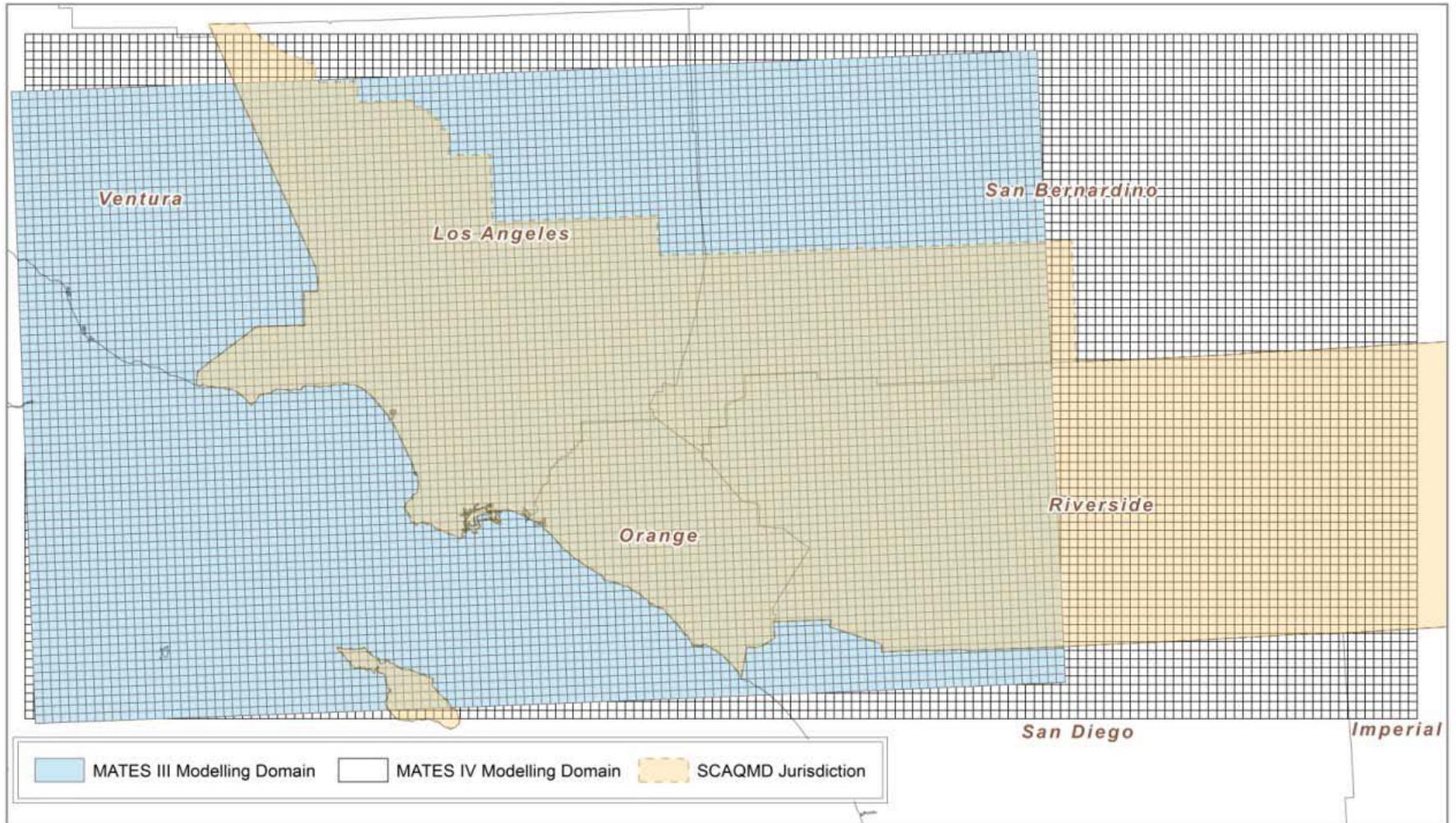
Multiple Air Toxics Exposure Study-IV

- MATES – combined monitoring and modeling assessment of local and regional toxic risk in the South Coast Air Basin
- MATES initial study conducted in 1987 focused primarily on data analysis
- MATES-II (2000), MATES-III (2008) & MATES-IV (2015) included regional modeling of toxic emissions to estimate risk
- Modeling platforms:
 - MATES-II: UAMTOX, ISCST3 (Point source analysis)
 - MATES-III & MATES-IV: Comprehensive Air Quality Model with Extensions (CAMx) enhanced with a reactive tracer modeling capability (RTRAC)

MATES-IV Toxic Emissions Inventory

- 2012 inventory: annual average day
- Focus on 31 toxic compounds
- Inventory structure
 - point sources (SCAQMD)
 - area sources (SCAQMD & CARB)
 - on-road mobile sources (CARB)
 - off-road (or other) mobile sources (CARB)
- Emissions
 - developed for a 2 km² grid
 - MATES-IV modeling domain 80 (N/S) by 160 (E/W)

MATES Modeling Domain



Point Source Emissions Annual Emission Reporting (AER) Program

- ~ 2,000 facilities required to report their annual criteria and toxics emissions
 - facility emitted
 - ≥ 4 TPY of VOC, SPOG, NO_x, SO_x, or PM, or
 - ≥ 100 TPY of CO.
- Consolidation of AB 2588 toxics emission inventory reporting requirements into the AER program (~ 177 toxics compounds)

AER Program (Cont.)

- Develop inventory for both criteria pollutants & toxics
- Develop inventory for point & area sources
 - For Point Sources:
 - Use emissions data reported by the facilities in the AER Program
 - For Area Sources (small emission sources ~ 400 area sources categories):
 - Emissions are estimated Jointly by the SCAQMD and CARB

Area Sources

Commonly Used Spatial Surrogates

Population

VMT

Length of rail per grid cell

Locations of unpaved rural roads

Total housing

Agricultural land cover

National forest > 5000 ft

Total employment

Industrial employment

Retail employment

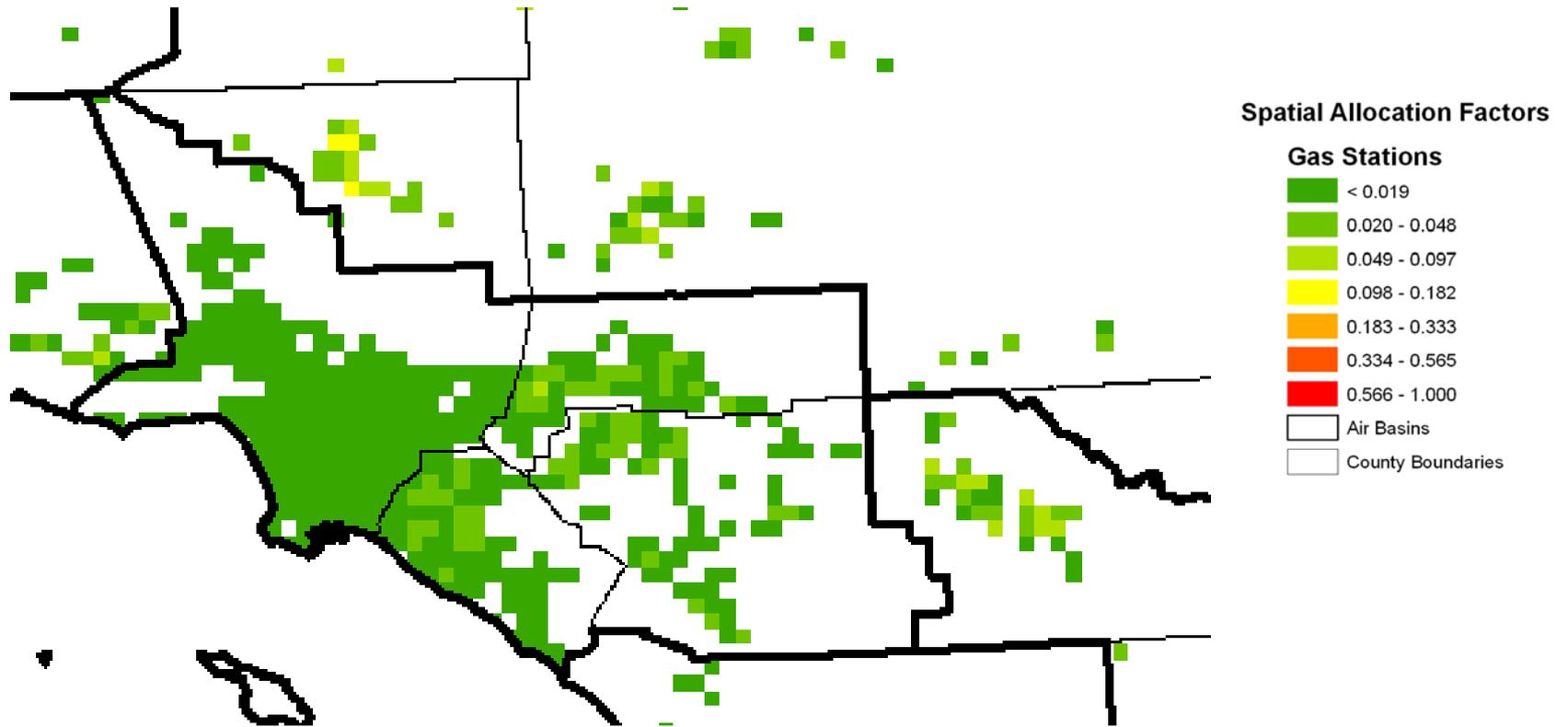
Single dwelling units

Rural land cover – forest

Rural land cover – range land

- Distributed by a surrogate that best represents location of emissions
- Small combustion sources (e.g. residential heating)
- Solvents/commercial products
- Off-road equipment
- Recreational equipment

Spatial Allocation of Gas Stations in the South Coast Air Basin



On-Road Emissions

- Vehicular activity combined with emission factors from EMFAC2011
- Link-based traffic volumes and speeds were obtained from the Southern California Association of Governments (SCAG) regional transportation modeling
- Direct Travel Impact Model (DTIM) was used to link emission factors and transportation modeling results and generate hourly gridded emissions of criteria pollutants.

On-Road Emission Rates

- EMFAC provides emission rates for a given calendar year for each vehicle class and for each county/air basin

Vehicle Class	Weight (lbs)	Vehicle Class	Weight (lbs)
Passenger cars	All	Heavy-Heavy-Duty Truck	33,001 – 60,000
Light Truck I	0 – 3,750	Motorcycle	All
Light Truck II	3,751 – 5,750	Urban Diesel Bus	All
Medium-Duty Truck	5,751 – 8,500	School Bus	All
Light-Heavy-Duty Truck I	8,501 – 10,000	Other bus	All
Light-Heavy-Duty Truck II	10,001 – 14,000	Motor Homes	All
Medium-Heavy-Duty Truck	14,001 – 33,000		

Travel Demand Model

- South Coast Air Basin comprised of multiple transportation analysis zones (TAZ)
- Each TAZ provides:
 - number of vehicles, their
 - average speed
 - time on the link

Table 3-3. Vehicle Activity Information for the Counties in the Basin.

Source: EMFAC2011 and SCAG 2012 RTP

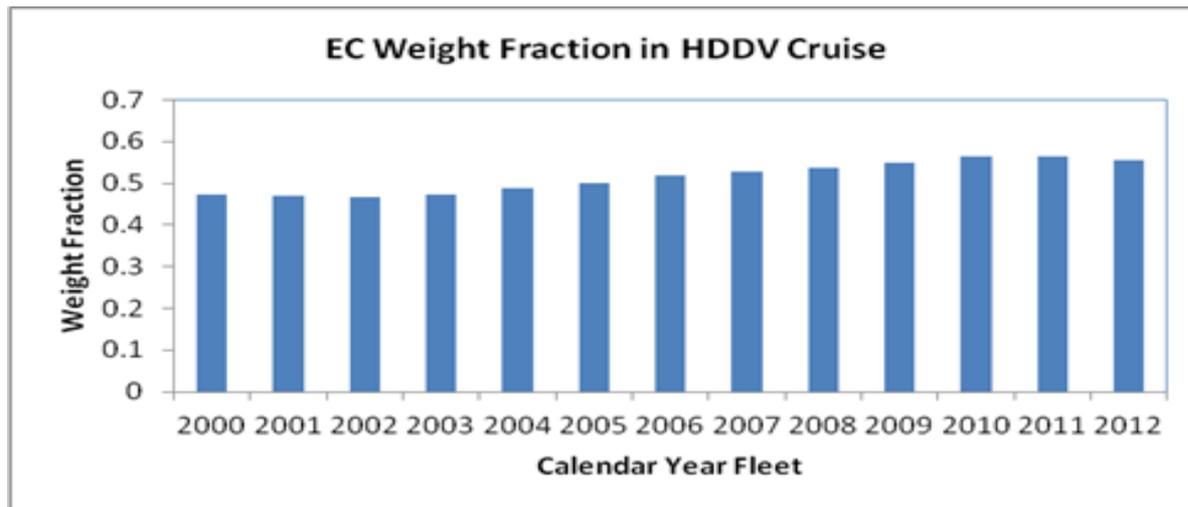
County	Vehicle Population	VMT/day	Trips/day	Miles per Vehicle-Day
Los Angeles	6,278,704	217,899,000	40,271,355	34.71
Orange	2,157,423	75,785,000	13,906,711	35.21
Riverside	1,342,704	45,651,000	8,704,550	34.00
San Bernardino	988,717	38,912,000	6,372,705	39.36

Direct Travel Impact Model (DTIM)

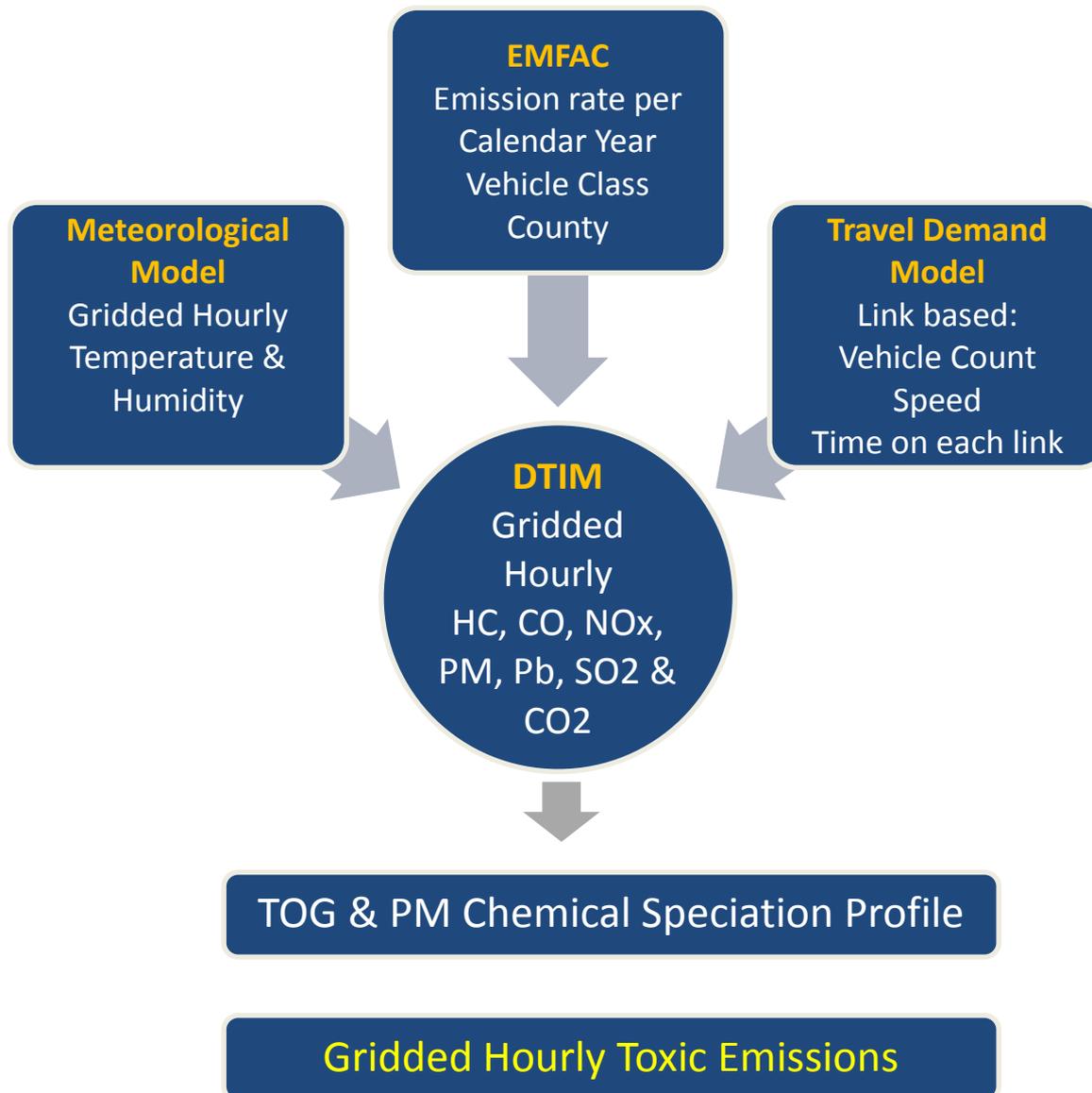
- Formats the emission rate file output from EMFAC into a DTIM compatible format
- Adjusts fleet average emission rates by ambient air temperature, relative humidity, and vehicle speed
- Grids hourly on-road emissions of HC, CO, NO_x, PM, lead, SO₂, and CO₂ allocated from each link in the transportation network

Chemical Speciation

- Specific profiles for TOG and PM
 - vehicle type
 - model year
 - control technology
 - fuel type
 - operation mode
- Fraction of Elemental Carbon from cruise mode of Heavy Duty Diesel Vehicle



Overview of On-Road Processing



Off-Road Emissions

- CARB's OFF-ROAD model was used to estimate emissions for all off-road categories (100+ source categories).
- Emissions from commercial ships, aircraft, locomotive, and recreational vehicles were calculated separately.
- The model combines population, activity, horsepower, load factors, and emission factors to yield the annual equipment emissions by county, air basin, or state.
- Spatial and temporal features are incorporated to estimate seasonal emissions.

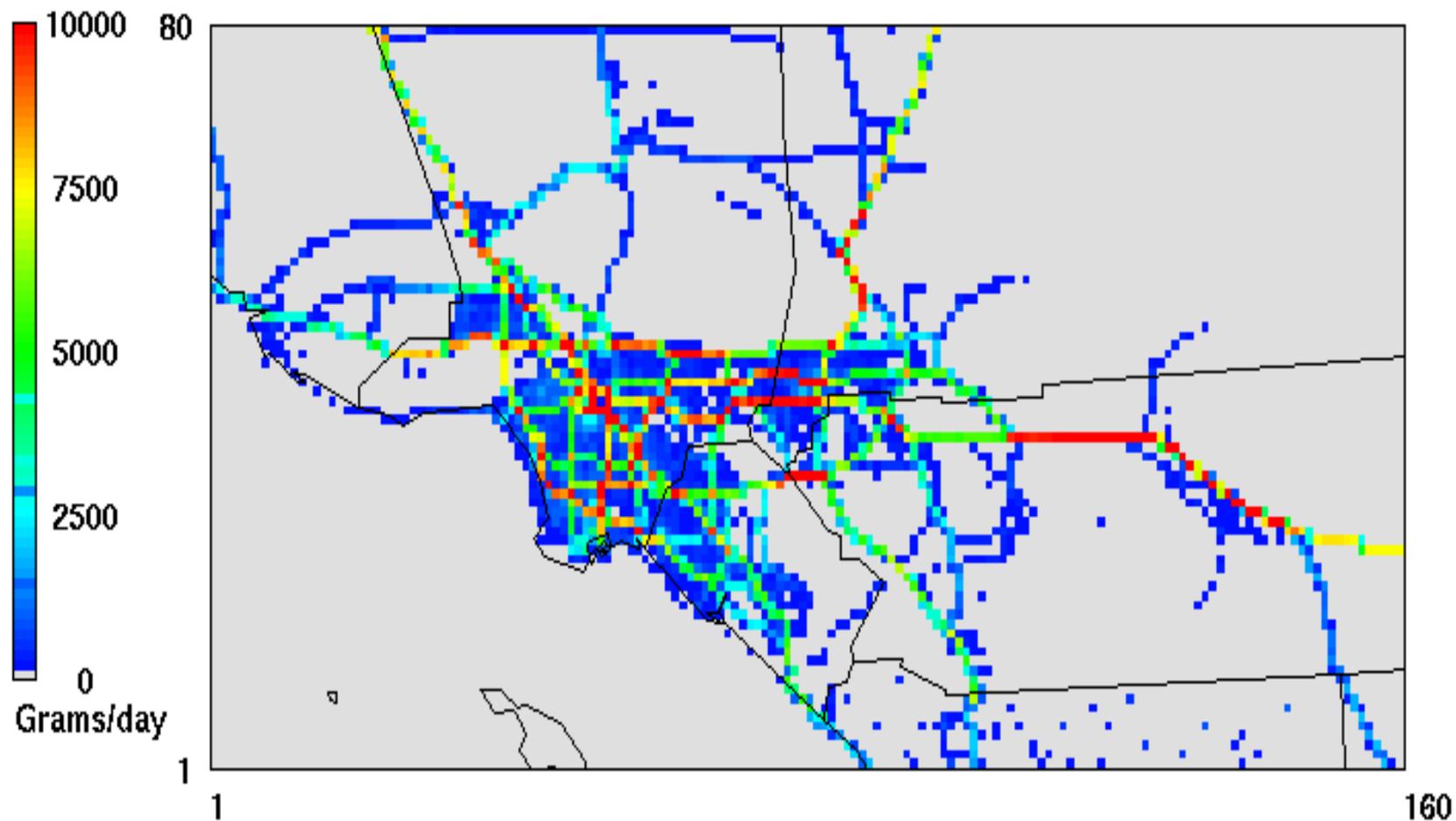
Annual Average Day Toxic Compound Emissions for the South Coast Air Basin

Pollutant	Emissions (lbs/day)				
	On-road	Off-road	Point	Area	Total
√ Acetaldehyde*	2066.9	3083.1	108.1	1378.7	6636.9
Acetone**	1796.1	2342.3	379.8	20569.3	25087.4
√ Benzene	5336.3	4477.1	711.8	1506.5	12031.7
√ 1,3-Butadiene	1002.5	1028.7	435.2	107.2	2573.6
√ Carbon tetrachloride	0.0	0.0	6.6	0.1	6.7
√ Chloroform	0.0	0.0	12.7	0.8	13.5
√ 1,1 Dichloroethane	0.0	0.0	0.3	65.3	65.5
√ 1,4 Dioxane	0.0	0.0	0.1	0.0	0.1
√ Ethylene dibromide	0.0	0.0	0.1	0.0	0.1
√ Ethylene dichloride	0.0	0.0	53.8	11.4	65.2
√ Ethylene oxide	0.0	0.0	4.9	0.0	4.9
√ Formaldehyde*	5159.8	7530.0	1678.2	4517.8	18885.8
Methyl ethyl ketone*	335.1	423.2	870.8	5425.6	7054.7
√ Methylene chloride	0.0	0.0	26.2	9874.3	9900.5
√ MTBE	0.0	1.1	0.1	0.0	1.2
√ Naphthalene	264.0	194.8	16.7	220.4	695.9
√ p-Dichlorobenzene	0.0	0.0	70.3	2945.1	3015.5
√ Perchloroethylene	0.0	0.0	805.0	5865.4	6670.4

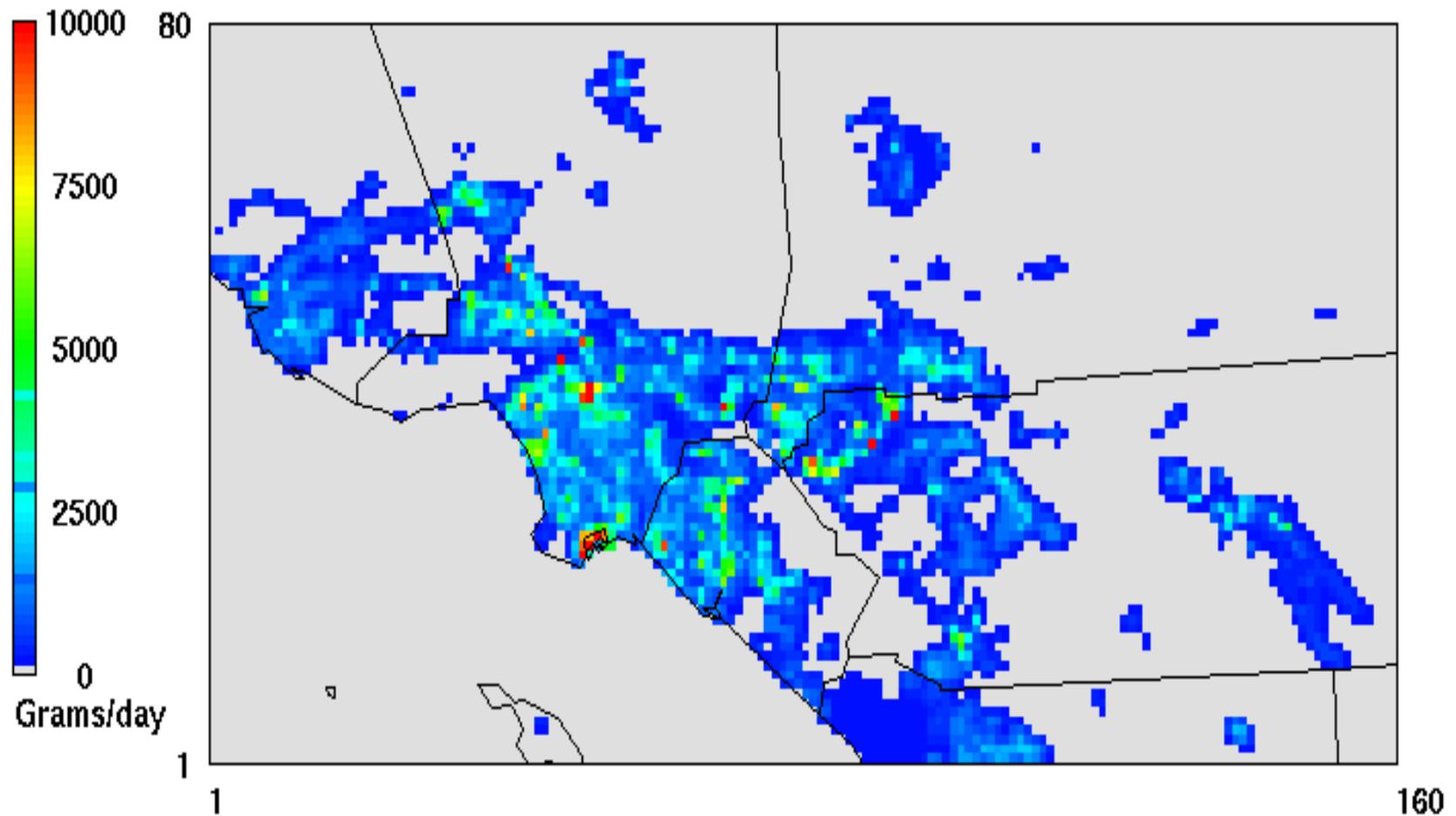
Annual Average Day Toxic Compound Emissions for the South Coast Air Basin (Continued)

Pollutant	Emissions (lbs/day)				
	On-road	Off-road	Point	Area	Total
√ Propylene oxide	0.0	0.0	0.5	0.2	0.7
Styrene	271.2	174.2	1222.3	12.5	1680.1
Toluene	15823.6	9233.1	4956.1	24497.6	54510.4
√ Trichloroethylene	0.0	0.0	735.3	886.1	1621.5
√ Vinyl chloride	0.0	0.0	37.9	128.6	166.5
√ Arsenic	0.4	0.0	18.6	5.3	24.3
√ Cadmium	0.3	0.3	5.0	3.0	8.6
Chromium	44.0	3.7	34.5	24.8	107.0
√ Diesel particulate	10798.7	9180.9	411.8	80.6	20472.0
Elemental carbon***	8873.4	6211.5	3286.8	11107.6	29479.3
√ Hexavalent chromium	2.2	0.5	0.4	0.0	3.1
√ Lead	4.8	8.7	30.9	73.1	117.5
√ Nickel	24.6	9.2	44.1	16.5	94.4
Organic carbon	11675.2	7865.6	197.3	45202.9	64940.9
Selenium	0.9	0.1	23.9	2.7	27.5
Silicon**	2473.0	140.4	2498.8	87588.5	92700.7

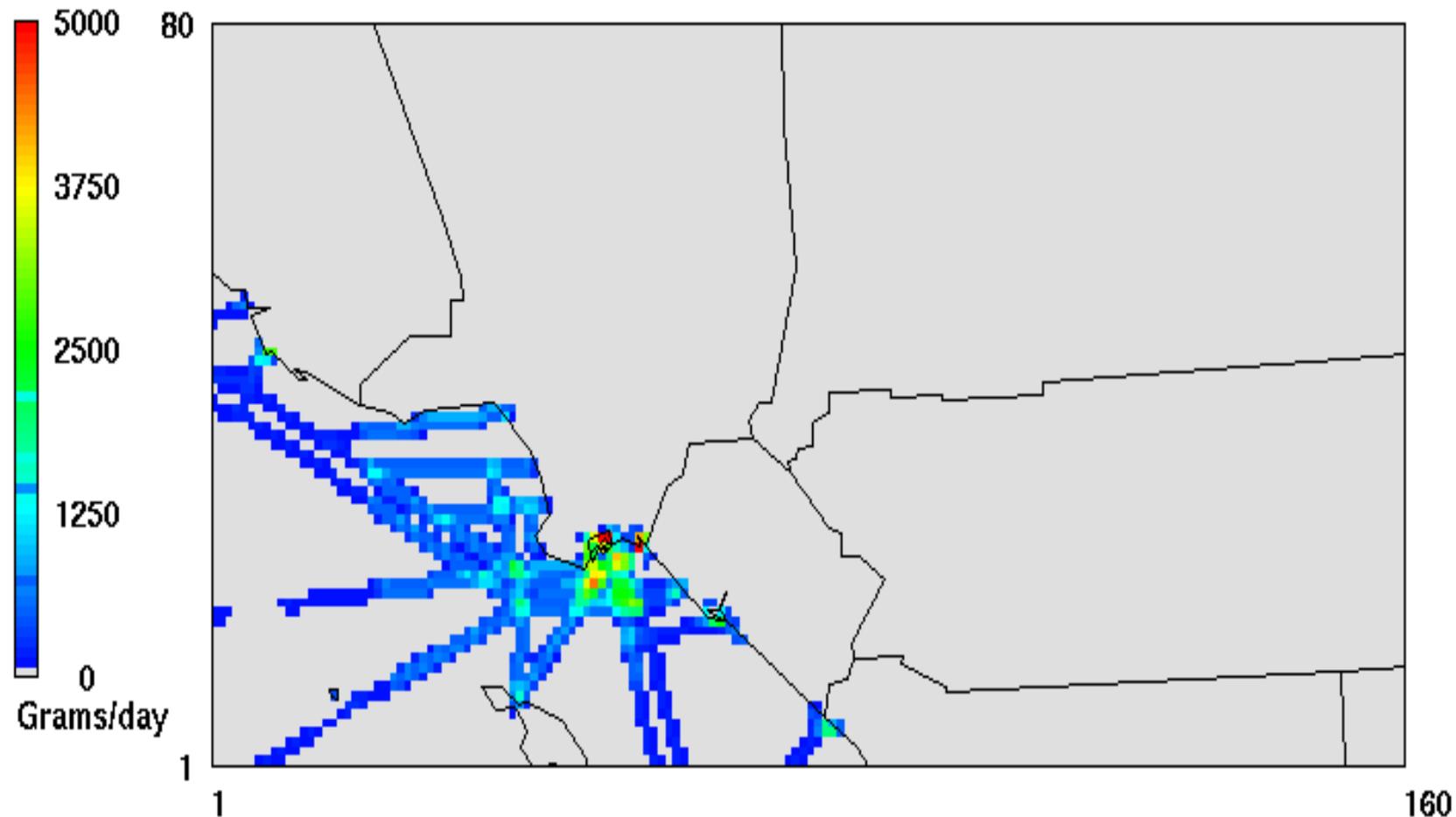
On-Road Diesel Emissions (PM2.5)



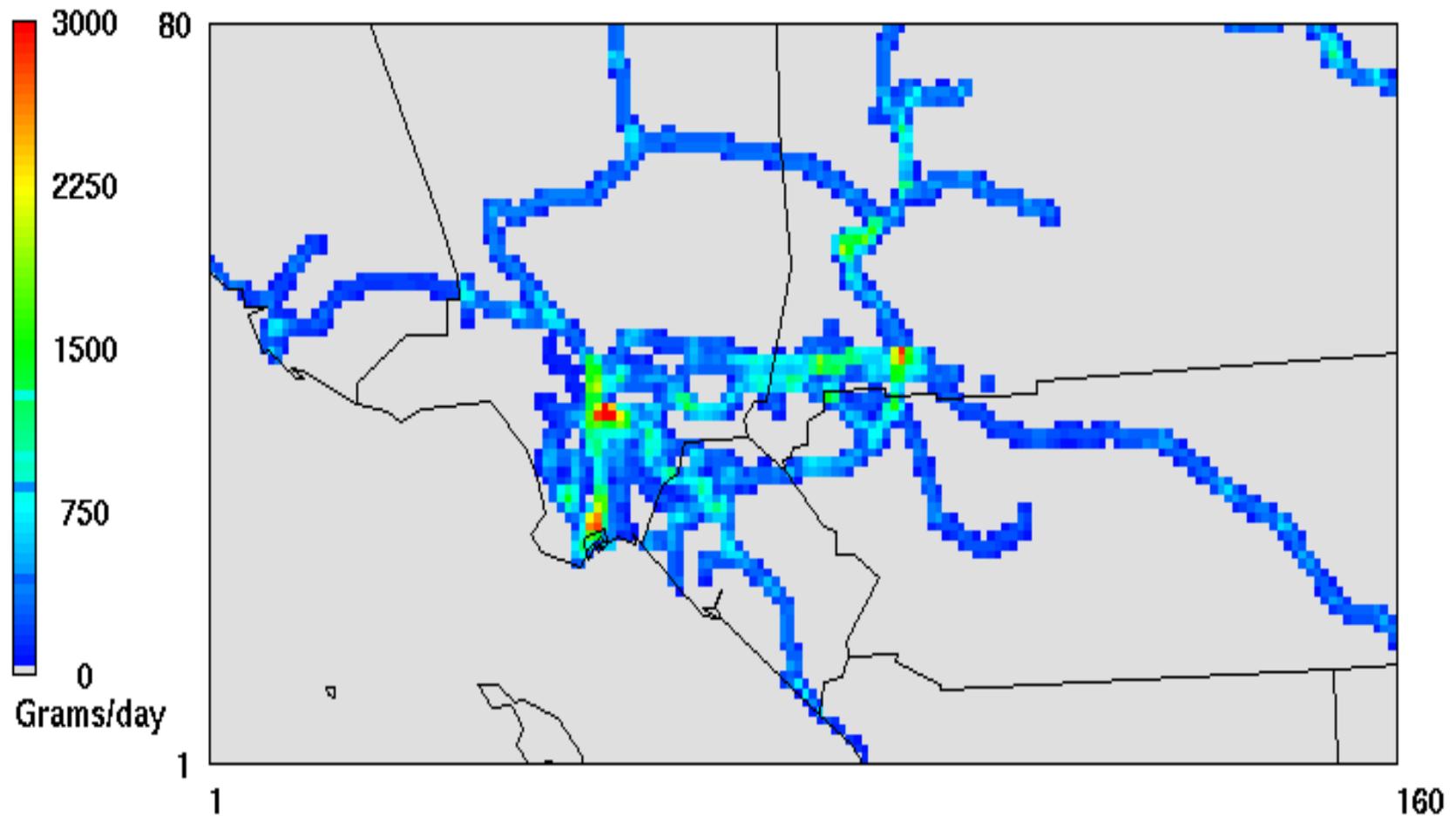
Off-Road Diesel Emissions (PM2.5)



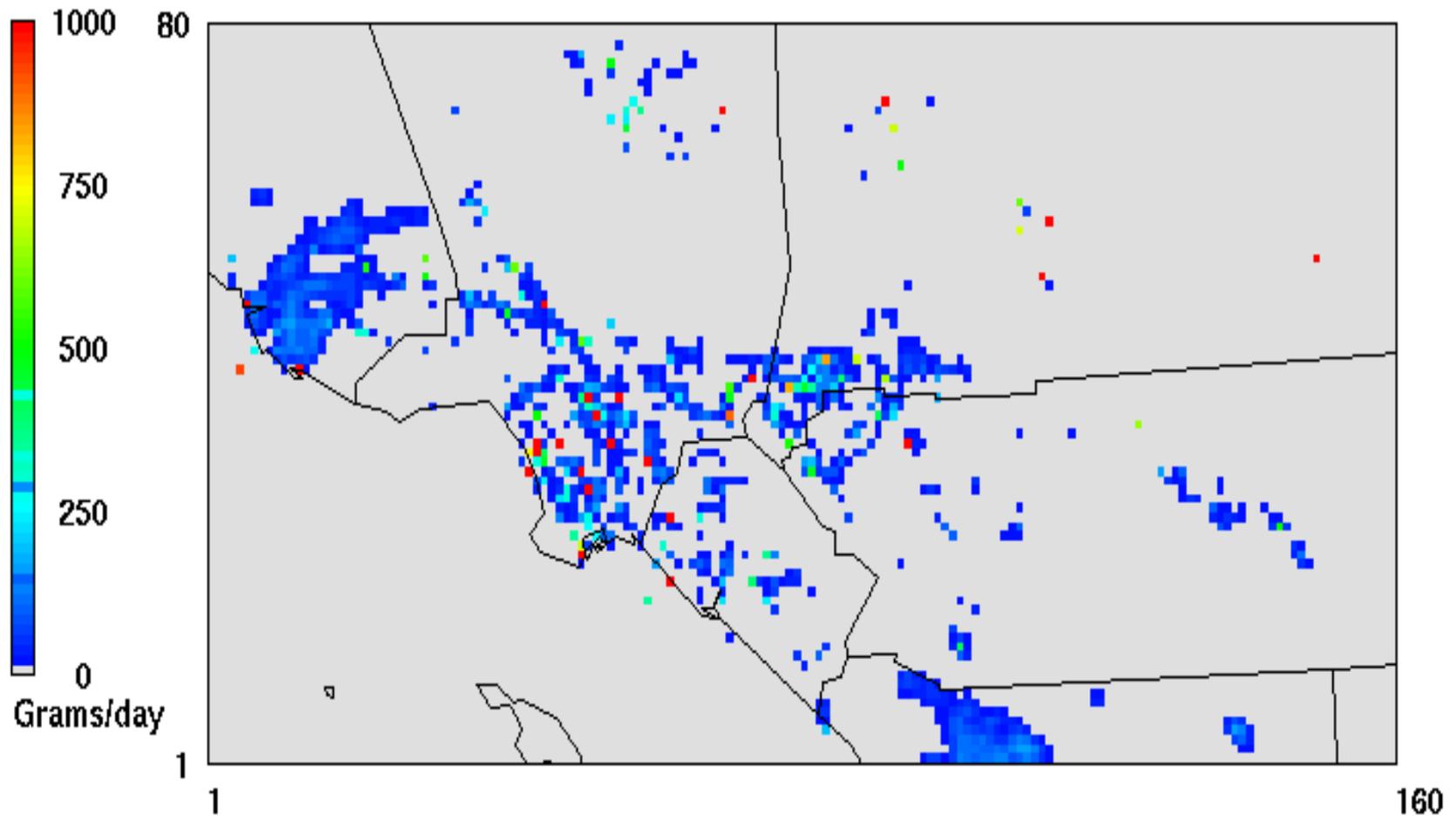
Pattern of Diesel Emissions (PM2.5) from Ships



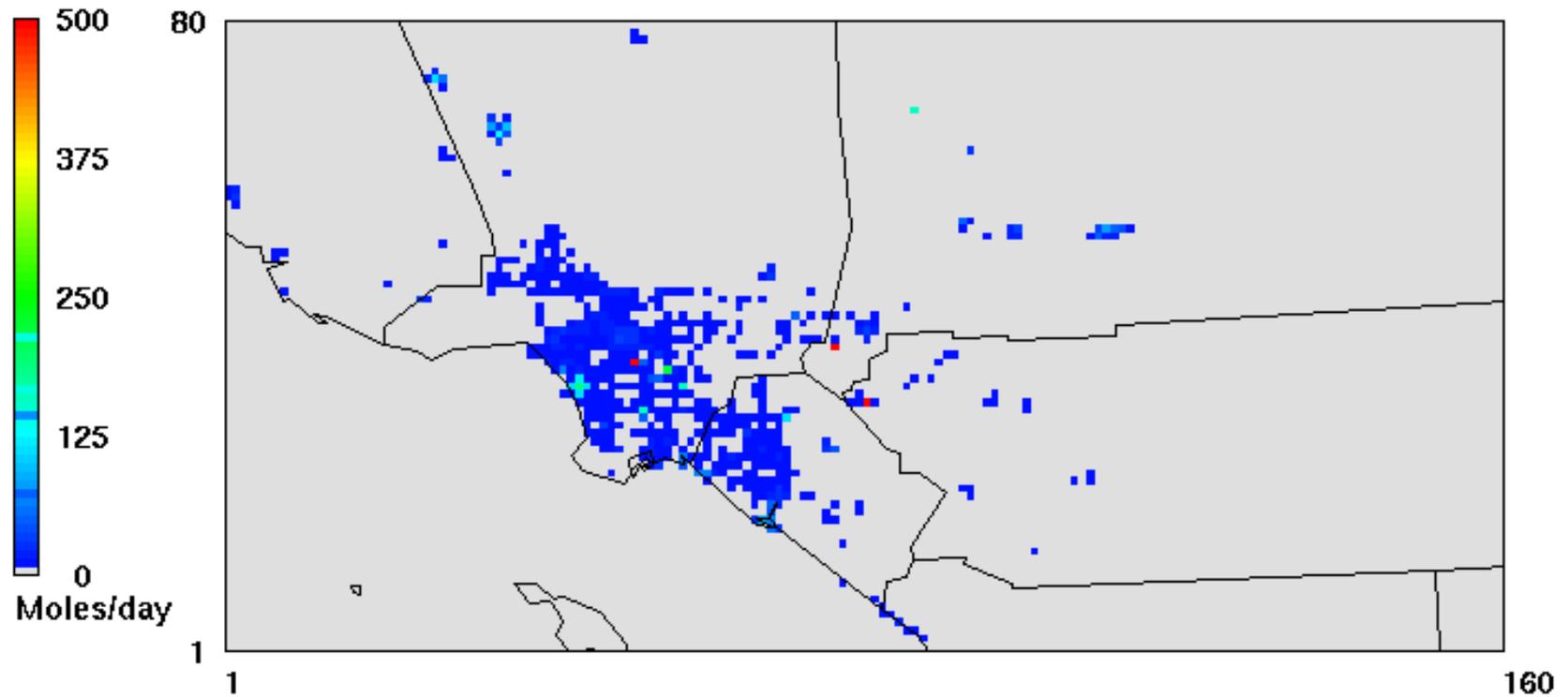
Diesel Emissions (PM2.5) from Trains



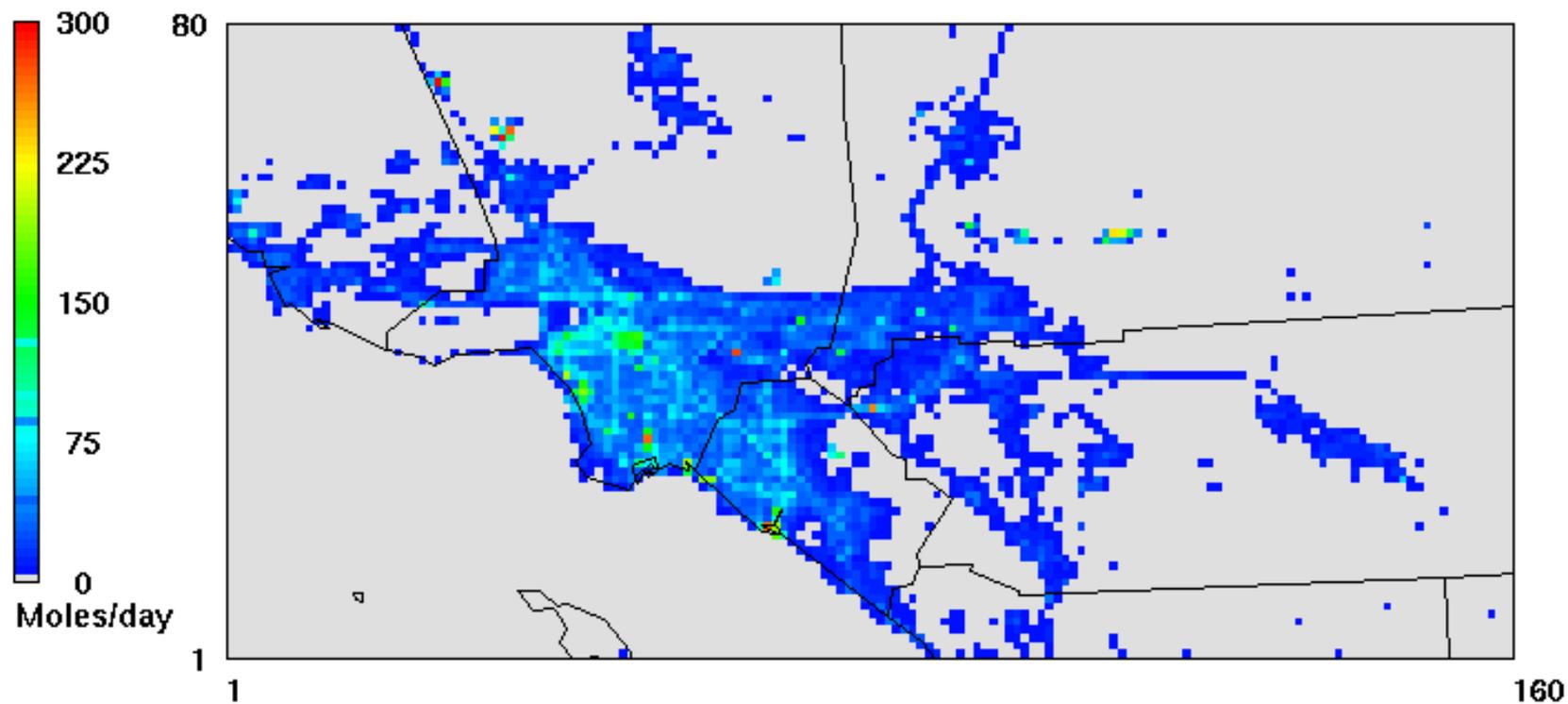
Stationary Diesel Emissions (PM2.5)



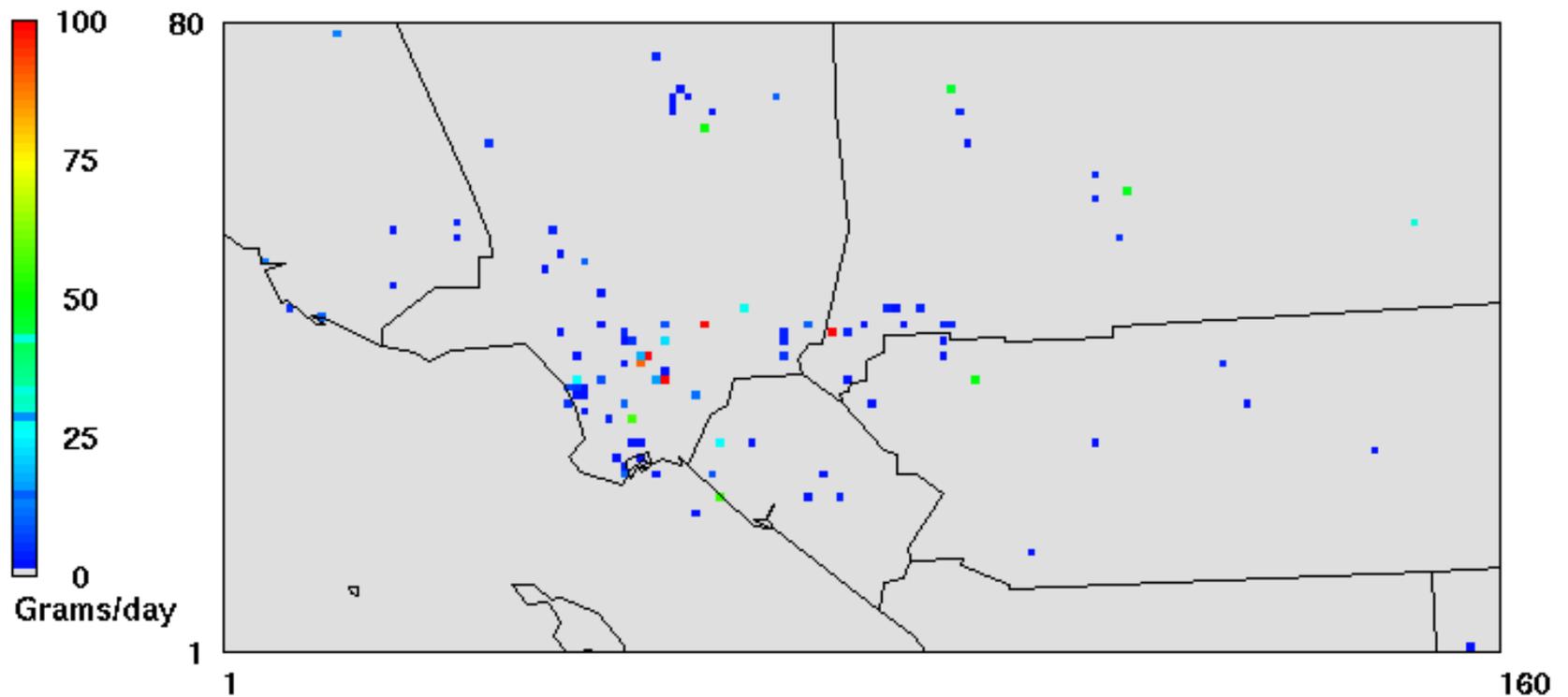
1,3Butadiene Emissions



Benzene Emissions



Arsenic Emissions (PM2.5)



Towards a More Comprehensive Mobile Emissions Inventory

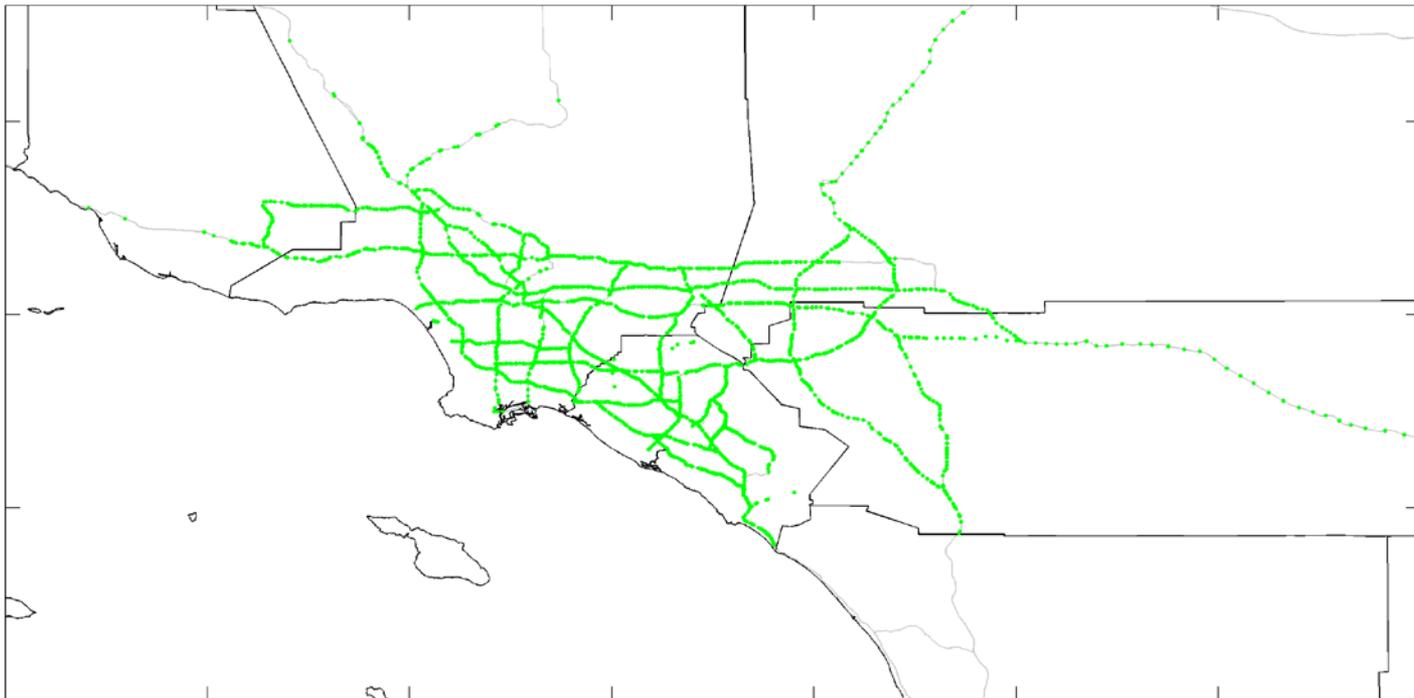
- Large fraction of NO_x and VOC emissions come from on-road mobile sources
- Accurate Spatial and temporal distribution of mobile emissions critical to predicting ozone episodes
- Current vehicular emissions inventories use standard hourly profiles dependant only on the day of week
 - Hourly profiles are not a function of location
 - Does not incorporate special events, weather, or holidays



Getty Images

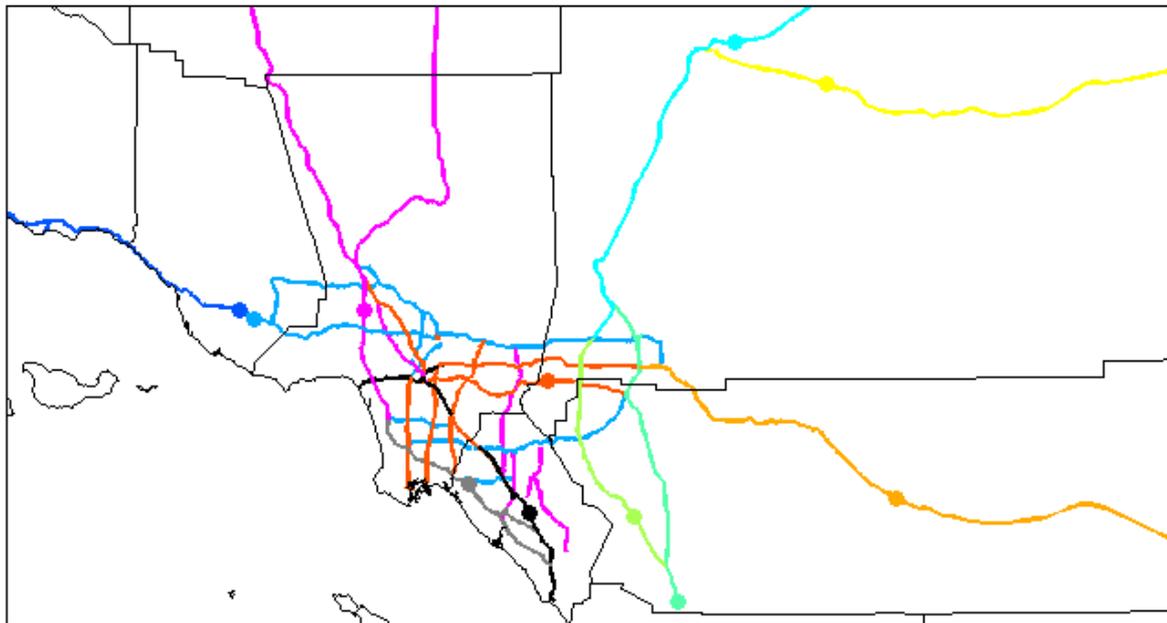
Incorporation of Daily Vehicle Flow

- Analyzed CalTrans PEMS data for 2012
- > 9,000 traffic monitoring stations in South Coast Air Basin
- Extracted traffic flow from each of the stations
- Hourly profiles as a function of each calendar day and location were assigned to each link in the SoCAB



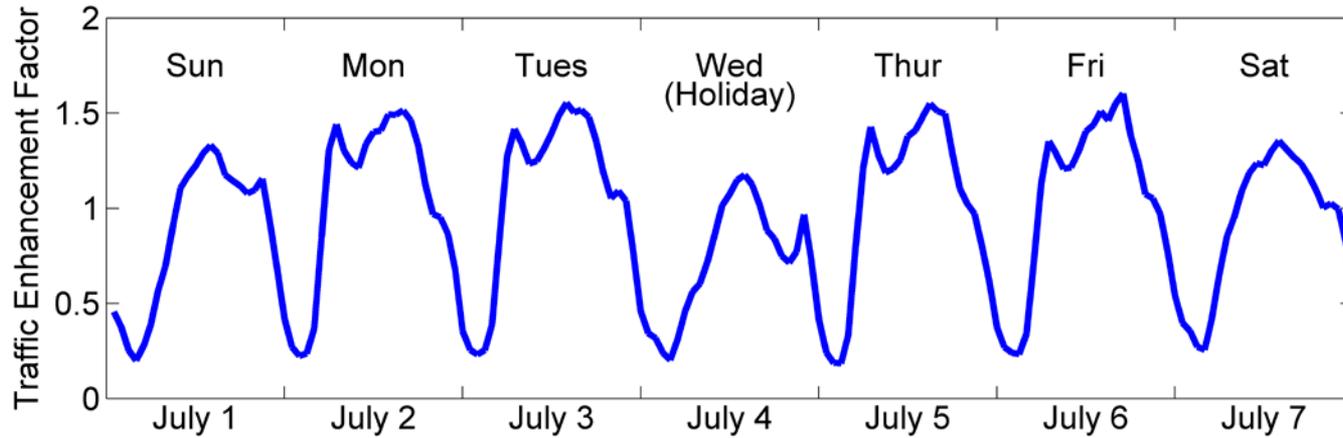
Incorporation of Truck Traffic Patterns

- Analyzed CalTrans PeMS weight-in-motion data for 2012
- Extracted traffic flow from each of the stations and categorized into heavy-light-duty, heavy-medium-duty, and heavy-heavy-duty.
- Extrapolated flow patterns along similar routes
- Hourly profiles as a function of each calendar day and location were assigned to each link in the SoCAB

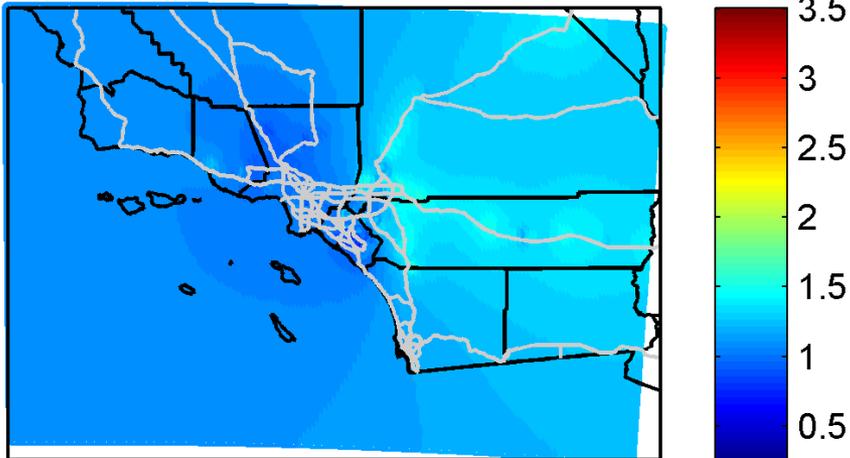


Spatial Distribution of Vehicular Traffic

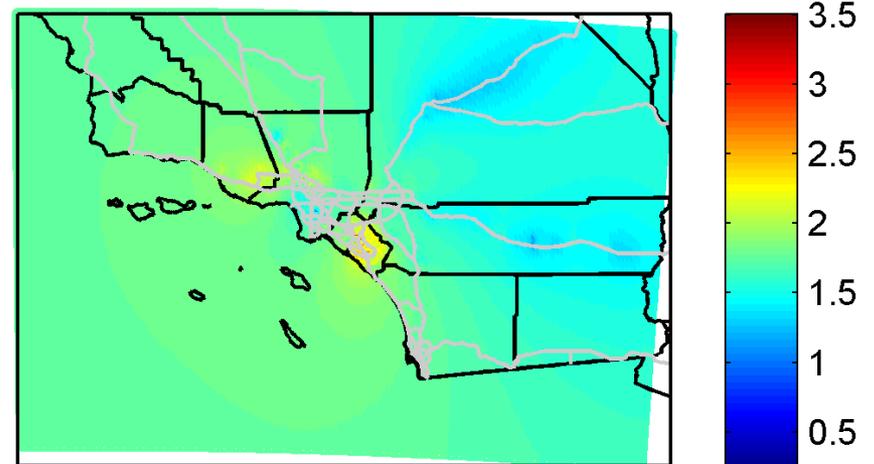
Downtown L.A. Normalized Vehicular Traffic Flow



Wednesday July 4th at 5:00 PM



Wednesday July 11th at 5:00 PM



Summary

- Criteria & Toxics emissions for the South Coast Air Basin were compiled from Point, Area, On-Road, Off-Road, and Biogenic sources
- Point and Area source data are based on SCAQMD's AER program
- On-Road emissions were processed using EMFAC, Travel Demand Model, DTIM, and Meteorological model outputs
- Off-Road emissions were calculated with CARB OFF-Road model
- Evaluate PEMS & WIM based on-road emissions for future inventory development