Evaluating the Contribution of PM2.5 Precursor Gases and Re-entrained Road Emissions to Mobile Source PM2.5 Particulate Matter Emissions

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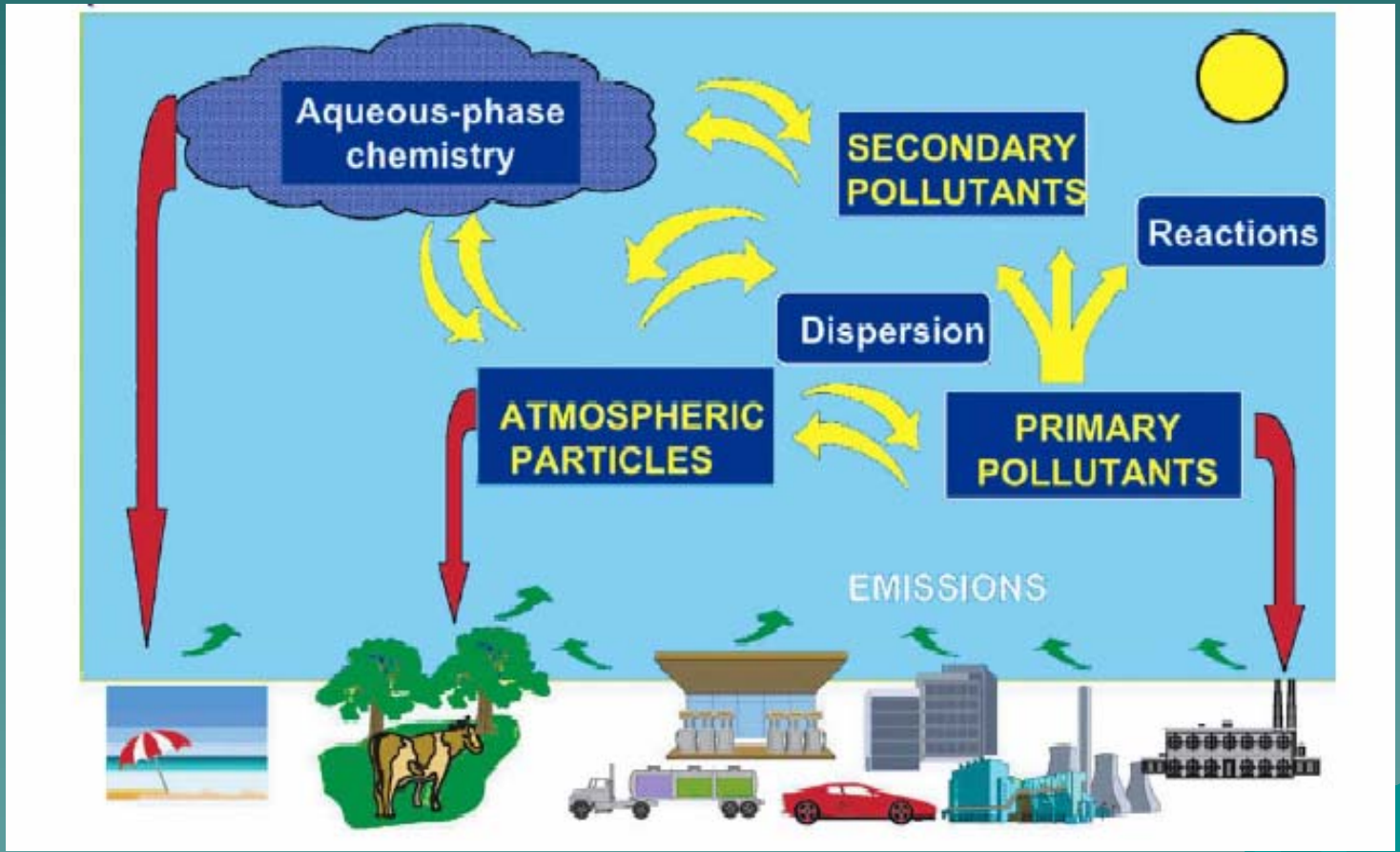
Pathways and Reactions Leading to Atmospheric Particulate Loadings



From Figure 3.1 of the "Particulate Matter Science for Policy Makers – A NARSTO Assessment" February 2003 Part 2 report

Ambient PM2.5 Concentration: Contribution from Mobile Sources

- Generated by three processes:

1. Directly emitted from tailpipes (primary)
2. Re-entrained from fugitive dust on roadway (primary)
3. Created by secondary formation from precursor compounds (secondary)

Approach

- Literature search conducted to locate the most recent publications on ambient PM2.5 resulting from mobile sources
  - Approximately 70 sources of recent literature were located and analyzed

Question

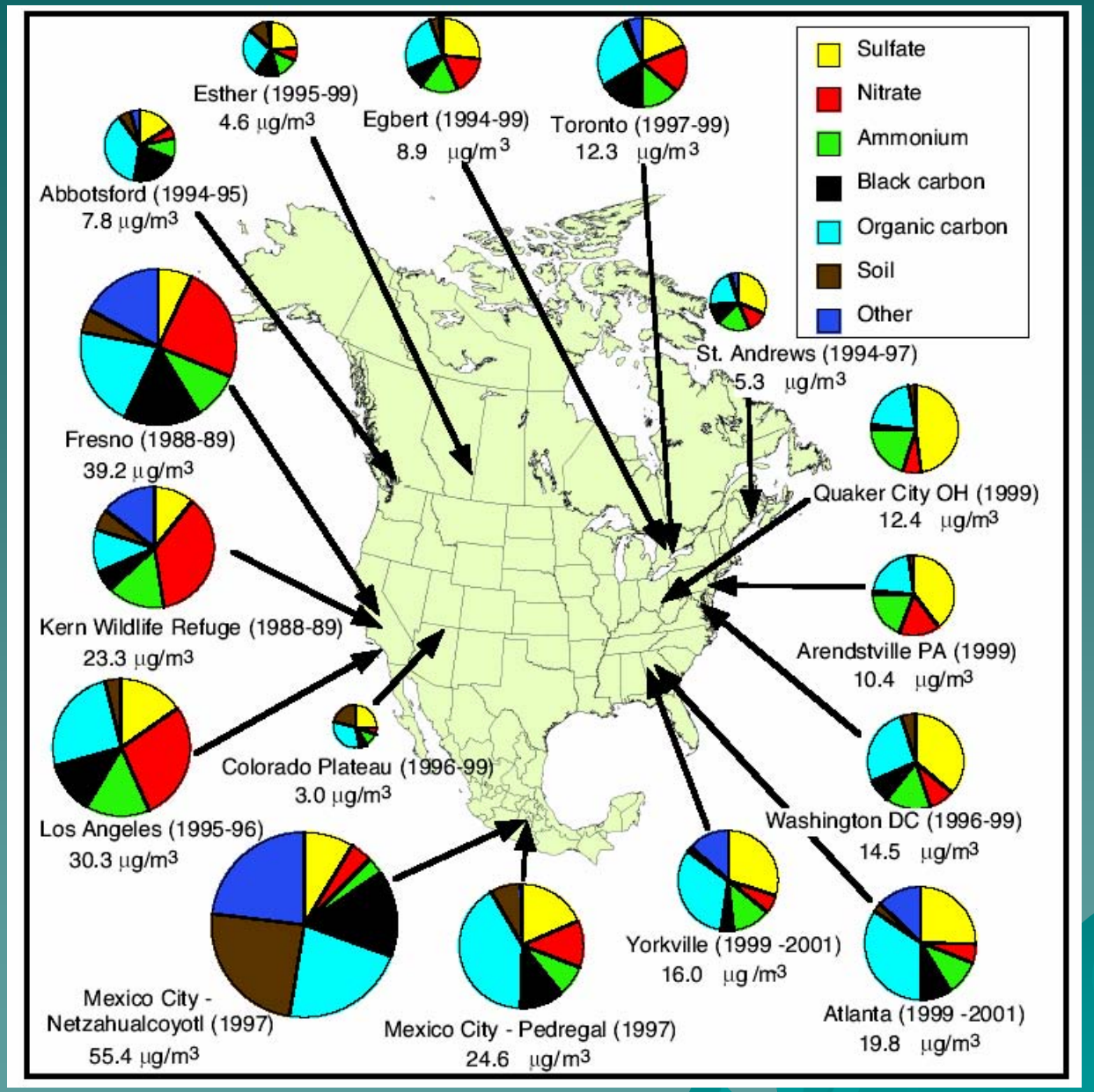
1. What is the percentage and variability of atmospheric PM2.5 as measured on monitors? What percentage forms from PM2.5 precursor NOx and VOC versus direct emission?

Answer from Literature Analysis

- Percentage and variability show large differences depending on location and region
- PM2.5 ambient concentrations in the US vary between 3.0µg/m3 and 39.2 µg/m3 – higher measurements in the western US
- Secondary emissions account for between 30% and 90% of PM2.5
- Direct emissions of PM account for between 10% and 70% of PM2.5

PM2.5 composition at selected locations

From Figure 6.12 of the "Particulate Matter Science for Policy Makers – A NARSTO Assessment" February 2003 Part 2 report



Question

2. What is the percentage and variability of precursor NOx and VOC gases forming PM2.5 particles generated by on-road mobile sources?

Answer from Literature Analysis

- Formation of PM2.5 from NOx and VOC gases from on-road mobile sources is not a constant or conversion factor

Minimum, maximum and average contributions of major species to ambient PM2.5 concentration levels.

PM2.5 Component	Min.	Max.	Avg.
Sulfate (secondary)	7%	47%	24%
Nitrates (secondary)	4%	37%	13%
Ammonium (secondary)	3%	20%	13%
Black Carbon (primary)	2%	22%	10%
Organic Carbon (secondary)	11%	41%	27%
Soil (primary)	2%	25%	7%
Other (primary/secondary)	0%	23%	6%

Question

3. What does the research and data indicate is the percentage and variability of re-entrained road dust emissions as a contributor to PM2.5?

Answer from Literature Analysis

- Difference in the calculation of re-entrained road dust as a contributor to PM2.5 depending on estimation method: estimated emission rates applied to VMT results in much higher estimate than receptor models
  - Inventory estimates: Paved roads contribute between 3% and 16% of directly emitted PM2.5 and unpaved roads contribute between 9% and 22%
  - Receptor model analysis indicate that re-entrained dust probably contributes just a few percent of all PM2.5

Question

4. What factors such as geographic region of the country does the research indicate is associated in the variability of these percentages?

Answer from Literature Analysis

- Geographic and seasonal factors have a major influence on determination of PM2.5 formation from precursors
- Nitrates are more important in the western US and sulfates are more important in the eastern US

Regional Percentage Contributions of Primary PM2.5 From All Sources
Source: EPA 1999 NEI version 2

Emission Source	MA (PM2.5 %)	MW (PM2.5 %)	NE (PM2.5 %)	NW (PM2.5 %)	SC (PM2.5 %)	SE (PM2.5 %)	SW (PM2.5 %)	WE (PM2.5 %)
Stat. Src. Fuel Comb.	21	11	40	5	13	15	12	6
Industrial	8	6	7	4	6	8	9	1
Solv/Store/ Waste/ Misc.	13	5	11	4	5	13	6	4
Non-road Mobile	5	5	5	2	5	4	5	2
On-road Mobile	4	2	4	1	3	3	2	1
Ag. Crops	5	28	3	8	17	6	4	0
Ag. Livestck	2	1	0	1	3	1	1	0
Fires	6	10	1	56	11	16	21	72
Paved	16	8	14	4	5	14	7	3
Unpaved	8	17	9	12	21	15	21	9
Other Fug.	11	7	8	3	10	6	11	1
TOTAL	100	100	100	100	100	100	100	100

Specific Questions

5. Is there general consensus on these questions or is there significant uncertainty among the research reports?

Answer from Literature Analysis

- There is a consensus that PM2.5 formation from precursors is highly uncertain and varies regionally and seasonally due to atmospheric conditions
- No consensus on differences in PM2.5 emission estimates from re-entrained dust. Emission inventory calculations lead to higher values than values derived from receptor models

Table 3-1. 1999 National emissions of particulate precursors and primary particulates from various sources (All values in tons/year. Data Source 1999 NEI version 2)

SOURCE CATEGORY	VOC	NOx	SO2	NH3	PM10-PRIMARY	PM25-PRIMARY
Fuel Comb. Elec. Util.	55,435	5,664,757	12,531,092	16,272	265,300	169,734
Fuel Comb. Industrial	175,404	2,850,530	2,404,596	48,568	342,143	266,294
Fuel Comb. Other	1,216,254	1,070,838	578,282	9,248	625,222	604,561
Chem. & Allied Product Mfg.	292,343	112,280	312,824	94,873	51,455	43,866
Metals Processing	65,821	86,961	327,083	2,129	157,605	130,776
Petroleum & Related Inds.	413,585	124,666	302,549	10,218	37,882	25,751
Other Industrial Processes	494,820	457,319	371,332	47,886	371,627	246,963
Solvent Utilization	4,996,335	3,532	777	321	4,429	111
Storage & Transport	1,216,822	9,751	5,440	4,596	81,165	37,994
Waste Disposal & Recycling	525,456	161,043	33,229	84,911	475,214	448,660
Highway Vehicles	5,612,344	8,347,746	300,093	263,776	241,100	184,390
Off-Highway	2,829,261	4,417,707	444,302	35,825	347,712	318,398
Miscellaneous	1,497,327	367,309	12,284	4,315,189	8,908,924	2,688,554
Unpaved Roads	0	0	0	0	7,290,847	1,097,294
Paved Roads	0	0	0	0	2,511,293	628,863

San Joaquin Valley 2000 Inventory (tons/day)

Source Category	Emissions (tons/day)	Percent of Total
Stationary Sources	32	20.6%
Agricultural Waste Burning	41	26.5%
Mobile Sources	15	9.7%
Paved Road Dust	16	10.3%
Unpaved Road Dust	17	11.0%
Construction & Demolition	4	2.6%
Farming Operations	22	14.2%
Windblown Dust	8	5.2%
Subtotal Fugitive Dust Sources	67	43.2%
Total All Sources	155	

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