Reconciling Fugitive Dust Emission Inventories with Ambient Measurements

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Outline of Presentation

- Background
- Progress since 2001
- Case Study: San Joaquin Valley, CA
- Conclusions

Background

To reconcile ambient fugitive dust concentrations with emission inventories one needs to account for:

- contribution from secondary aerosols
- contribution from sources from outside the study area
- deposition losses

Background (contd)

WRAP Expert Panel's Recommendations (2001):

- account for near source removal of particles in model predictions of ambient concentrations
- develop estimates of deposition losses for different ground cover categories and different seasons for the US at the county level
- conduct field studies to measure the transportable fraction of fugitive dust

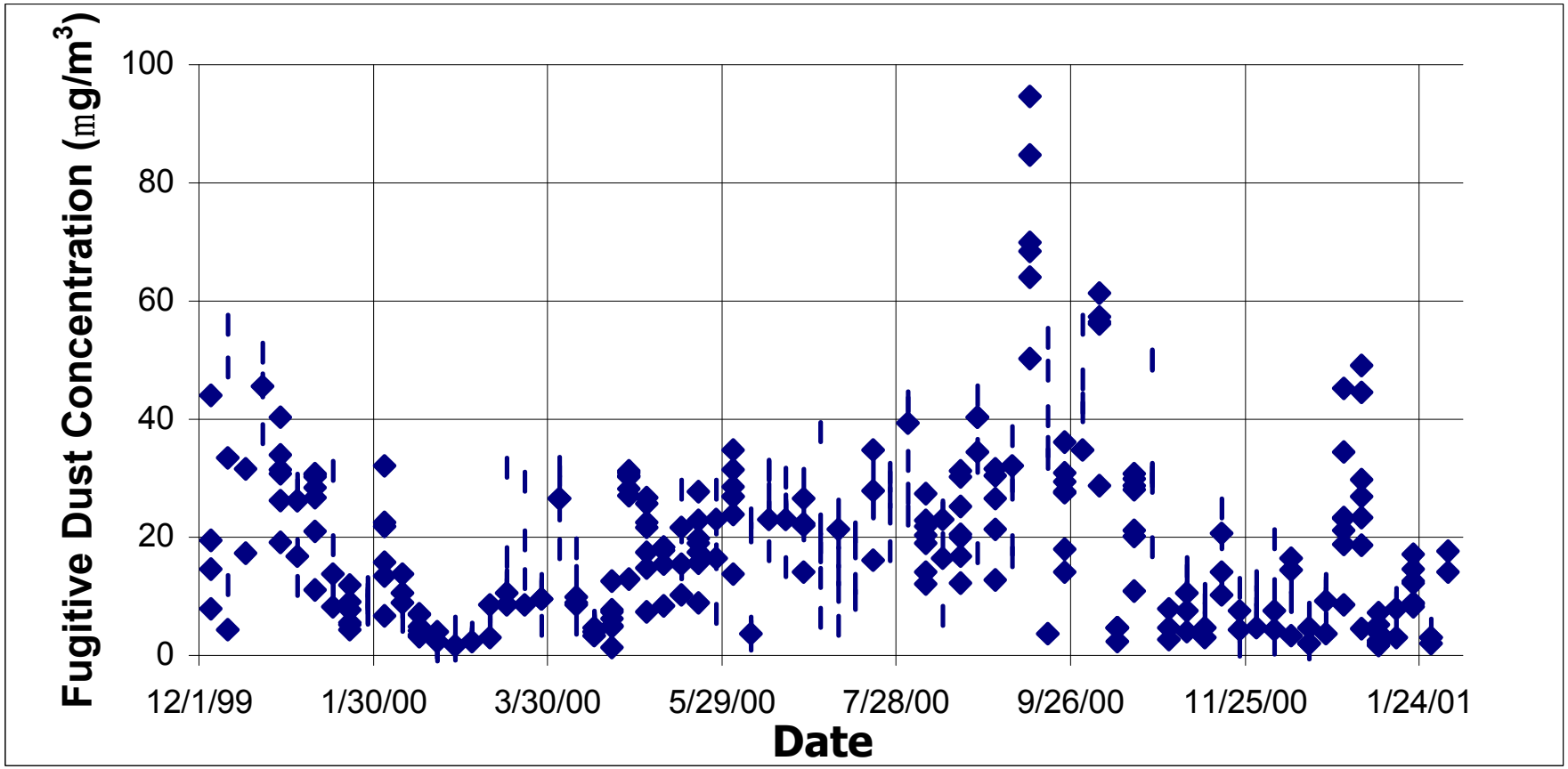
Progress Since 2001

- Estimates of transportable fraction (TF) have been developed by Cowherd and Pace for different ground cover categories
- TF has been measured downwind of unpaved road for two different ground cover scenarios by DRI and University of Utah
- TF has been estimated from neighborhood scale ambient PM10 monitoring network in San Joaquin Valley by Countess Environmental

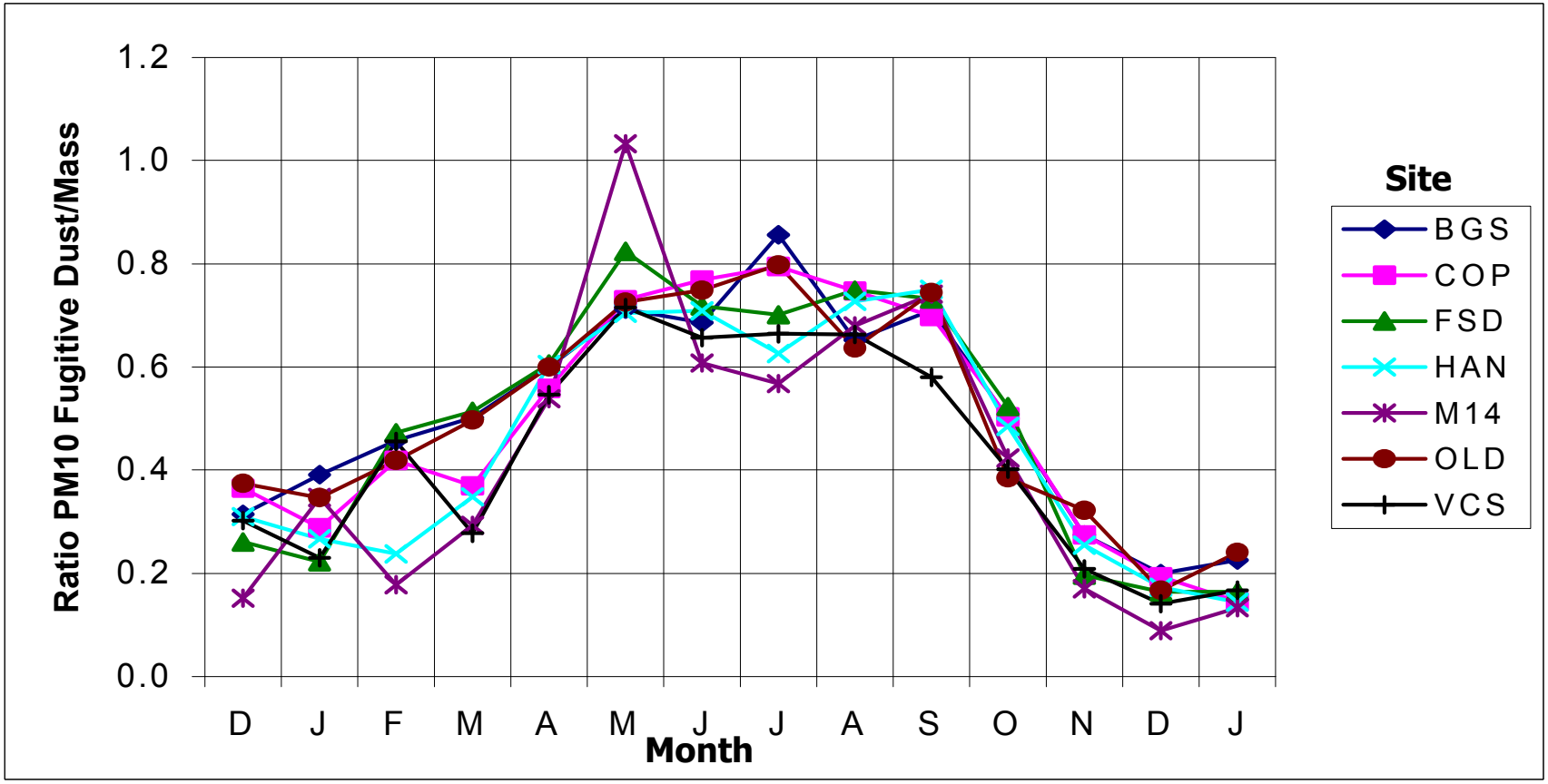
San Joaquin Valley Study: Overview

- Fugitive dust concentrations
- Fugitive dust to mass ratios
- PM10 and PM2.5 emission estimates
- Transportable fraction for SJV based on individual TFs for different land cover categories
- TF for SJV based on ambient measurements
- Relative abundance of elements associated with fugitive dust in PM2.5 and PM10 size fractions

Temporal Variation in Fugitive Dust Concentrations in PM10 Size Fraction



Temporal Variation in Ratio of Fugitive Dust to PM10 Mass



Contribution of Fugitive Dust to PM10 Mass

- Based on Emissions Inventory: 0.78
- Based on Ambient Measurements: 0.51

Ratio of Ambient Measurements to Emissions = 0.65

Primary PM Emissions Inventory for SJV for 2000, tons/day

SOURCE CATEGORY	PM10	PM2.5
Stationary Sources	42	32
Agricultural Waste Burning	42	41
Mobile Sources	16	15
Paved Road Dust	64	16
Unpaved Road Dust	114	17
Construction & Demolition	24	4
Farming Operations	111	22
Windblown Dust	51	8
Subtotal Fugitive Dust Sources	365	67
Total All Sources	465	155

Precursor Emissions of Secondary PM2.5 for San Joaquin Valley

Assumptions:

- Sulfate, nitrate and ammonium in excess of regional background levels are secondary
- Secondary OC equals total OC in excess of background levels minus primary OC in excess of background levels
- OC sampling artifacts are negligible
- OC/EC split is correct
- Agricultural waste burning with a primary OC/EC ratio of 3.47 is the dominant source of OC

Annual Avg. PM2.5 Concentrations in San Joaquin Valley for 2000, μg/m^3

	Ammonium Nitrate	Ammonium Sulfate	Organics	EC	Total Mass
SJV Sites	6.9	2.1	8.0	2.0	17.1
Background Site	3.2	1.7	3.9	1.3	8.2
Net Conc. due to local sources	3.7	0.4	4.1	0.7	8.9

Secondary PM2.5 Emissions for SJV

- PM2.5 concentration from 2^o emissions relative to PM2.5 concentration from $1^o + 2^o$ emissions:

$$2^o/(1^o + 2^o) = (3.7 + 0.4 + [4.1 - 3.47 \times 0.7])/8.9$$
$$= 0.65$$

- 2^o emissions = (0.65/0.35) x 1^o PM2.5 emissions
  = 1.84 x 155 ton/day = 286 ton/day

Fugitive Dust Contribution

- Based on Emissions Inventory (assuming ag waste burning is dominant source of organics)
  - FD/(1^{o} PM10) = 365/465 = 0.78
  - FD/(1^{o} + 2^{o} PM10) = 365/(465 + 286) = 0.49
- Based on Ambient Measurements
  - FD/(PM10 Mass)= 19.9/39.0 = 0.51

Fugitive Dust Contribution for Different Scenarios re. the Dominant Source of OC

Dominant Source of OC	OC/EC	FD/(1^o+2^o)
Ag waste burning	3.47	0.49
Light duty autos	3.64	0.50
Heavy duty diesel trucks	1.13	0.30
RWC, fireplaces	2.45	0.41
RWC, wood stoves	5.83	0.61

Transportable Fraction Based on Fractional Land Cover and TF Estimates for Different Land Cover Categories

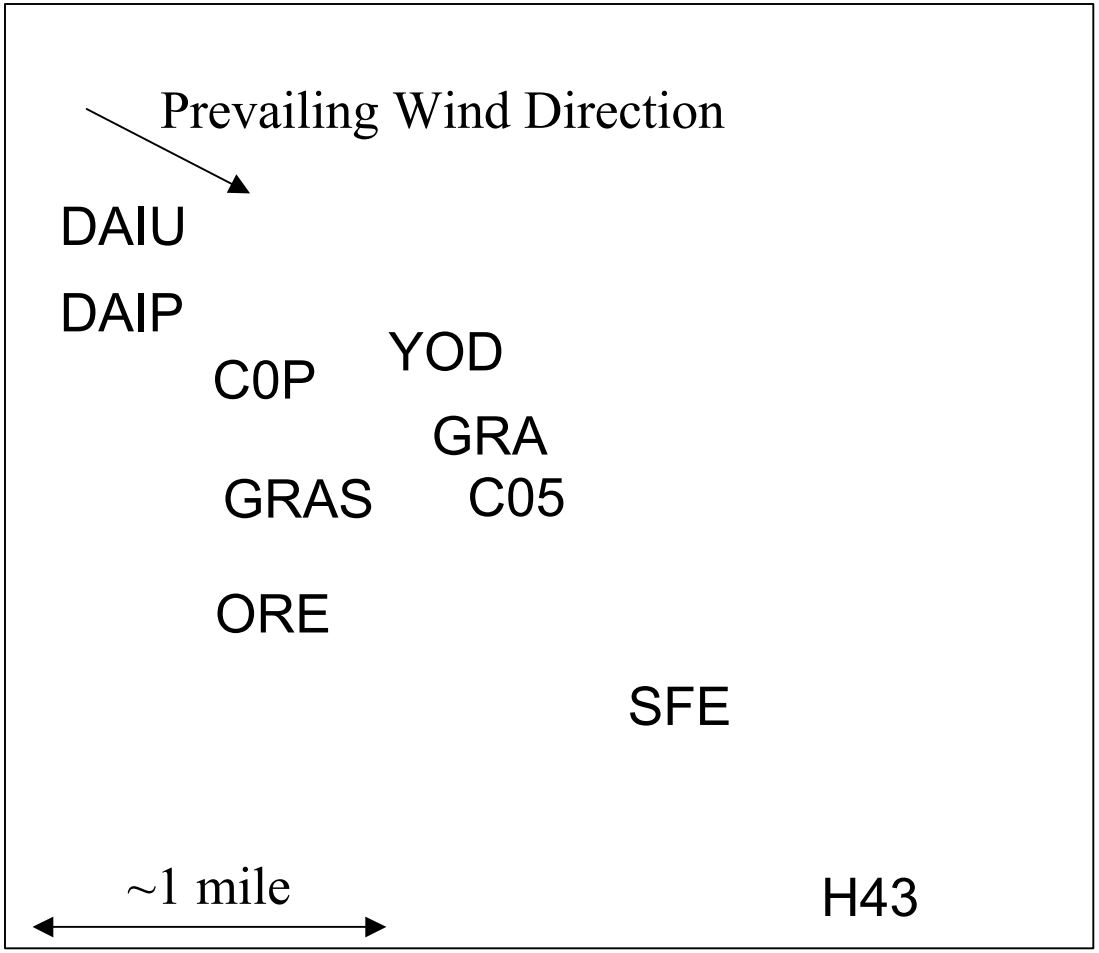
Land Cover Category	Transportable Fraction	Fractional Land Cover for SJV
Barren, Water	0.97	0.019
Crops	0.85	0.43
Grass	0.70	0.16
Urban	0.40	0.014
Scrub, Sparse	0.30	0.08
Forest	0.05	0.32
OVERALL	0.54	

TF by County Based on Land Cover

(calculated from TF estimates for different land cover categories)

Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
0.50	0.58	0.74	0.42	0.73	0.74	0.66	0.34

Neighborhood Scale Monitoring Network in Kings County (Fall 2000)



TF Based on Ambient Measurements

Ratio of concentrations at far downwind site (H43) versus near downwind site (SFE), 1 mile apart

- Mass: 0.85
- Fugitive dust: 0.72
- Ammonium nitrate & ammonium sulfate: 0.98
- Organic aerosol species: 0.85
- Elemental carbon: 1.00

Relative Abundance of Soil Elements in PM2.5 and PM10 Size Fractions

- PM2.5/PM10 Ratio Based on SJV Measurements
  - Aluminum and Silicon: 0.05
  - Calcium, Titanium, Iron: 0.10 to 0.16

    \ Fugitive Dust: ~0.06
- PM2.5/PM10 Ratios from AP-42
  - Fugitive Dust: 0.15 to 0.25

Si/Fe Ratio in PM2.5 & PM10 Size Fractions

Ambient Measurements in SJV

- PM2.5: 1.5
- PM10: 4.5

Source Profiles for PM10 Samples

- Paved road dust: 2.0
- Unpaved road dust: 3.6
- Earth's crust: 5.0
- Crustal sediment: 6.7

Conclusions

- Based on ambient measurements the contribution of fugitive dust to ambient PM10 concentrations is significantly less than primary PM10 emission inventory estimates
- Accounting for near source deposition losses is superior to the "divide-by-four" approach previously used to reconcile emission inventory estimates with ambient measurements

Conclusions (contd)

- To reconcile ambient fugitive dust concentrations with emission inventories one needs to account for secondary aerosol formation and for sources from outside the study area
- Estimating the transportable fraction for fugitive dust based on individual TF estimates for different land cover categories gave a value that was in good agreement with ambient measurements

Conclusions (contd)

- Relative abundance of elements associated with fugitive dust of geological origin is very different in the PM2.5 size fraction compared to the PM10 size fraction, yielding a ratio of fugitive dust in the PM2.5 size fraction relative to the PM10 size fraction that is approximately one-third that reported in AP-42