Gas/Diesel PM Split Study

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Overview

- Goals and objectives
- Sensitivity of OC and EC emissions
- Sensitivity of molecular marker emissions
- Day-of-the-week analysis
- Molecular marker CMB sensitivity
- Implications of the study

Goals

- Assess the accuracy of Molecular Marker Chemical Mass Balance (CMB) models to quantity the impact of primary gasoline spark ignition (SI) vehicles and diesel compression ignition (CI) vehicles on atmospheric particulate matter concentrations
- Determine the most important sources of uncertainties for the use of molecular marker CMB models on the primary contributions of particulate matter emissions from SI and CI engines

Objectives

- Estimate the uncertainty in the ratio of Elemental Carbon (EC) and Organic Carbon (OC) to total carbon (TC) emissions for the average Southern CA summertime SI and CI fleets
- Estimate the uncertainty in the average molecular marker fingerprint for the summertime SI and CI fleet in Southern CA
- Assess the primary variables impacting the EC/TC and OC/TC ratios for the SI and CI fleet in the context of Southern CA
- Assess the primary variables impacting the molecular marker fingerprint for the SI and CI fleet in the context of Southern CA
- Assess the impact of these uncertainties on the molecular marker CMB apportionment of SI and CI particulate matter emissions

Vehicle Testing

- Valid Data
  - SI vehicles: 53
    - Recruited non-smokers: 46
    - Recruited non-smokers that were smokers: 2
    - Recruited smokers: 5
    - All vehicles tested under Hot and Cold UDDS
  - CI vehicles: 34
    - Passenger Cars: 2
    - Class I (under 14000 lbs): 7
    - Class II (14000 to 33000 lbs): 7
    - Class III (over 33000 lbs): 16
    - Transit busses: 2

Chemical Analysis

- Diluted PM Emissions

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  – Organic Carbon (OC) – NIOSH 5040

  – Elemental Carbon (EC) – NIOSH 5040

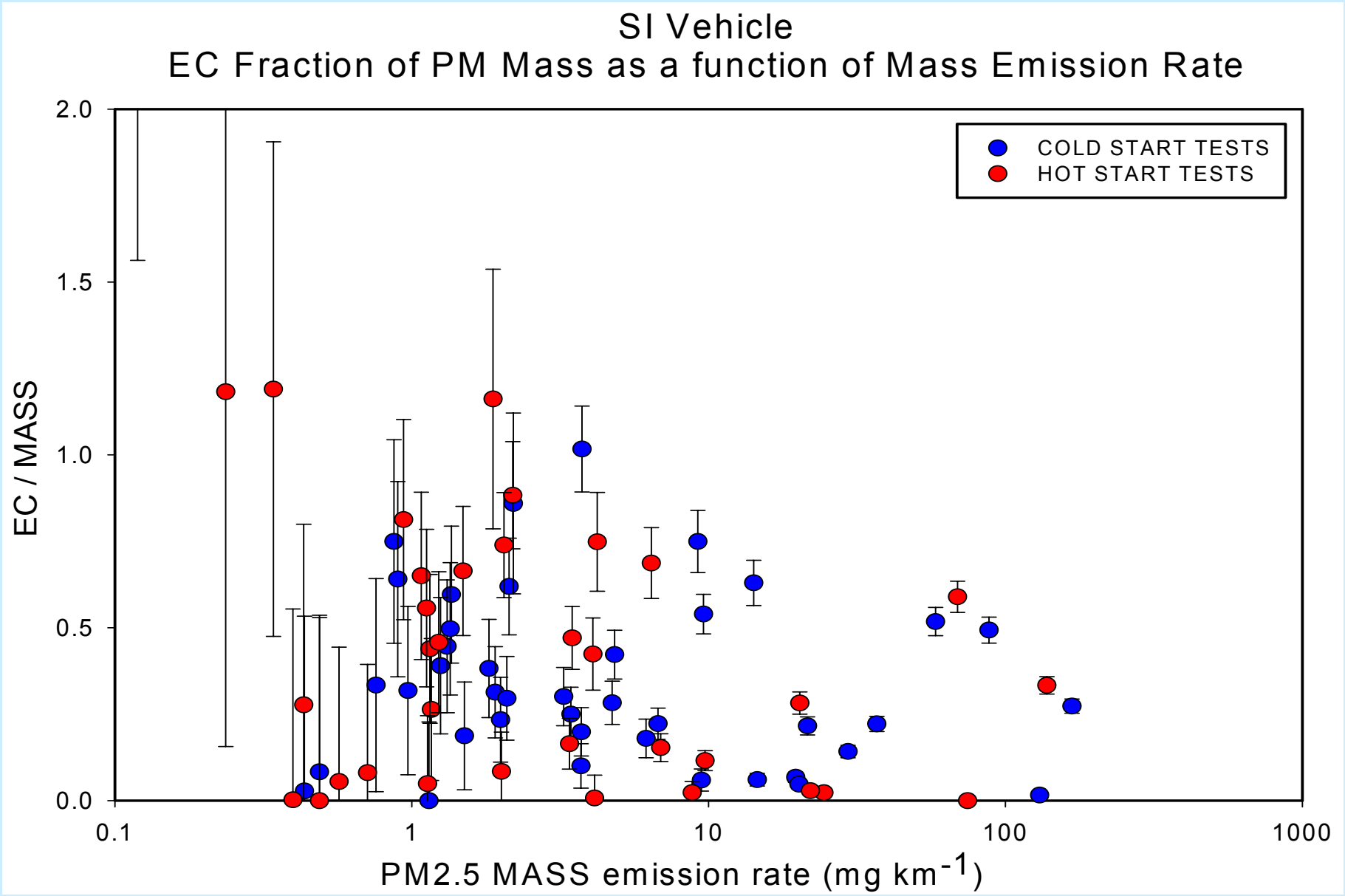
  – Molecular Markers – GCMS Methods

  DRI

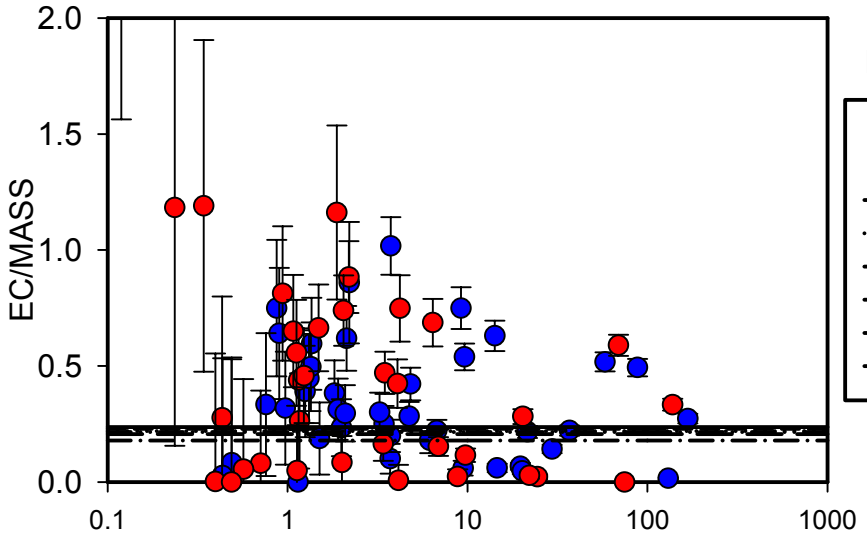
  – Mass – Gravimetric Analysis

  – Sulfate, Nitrate, and Ammonium – IC

  – Metals - XRF

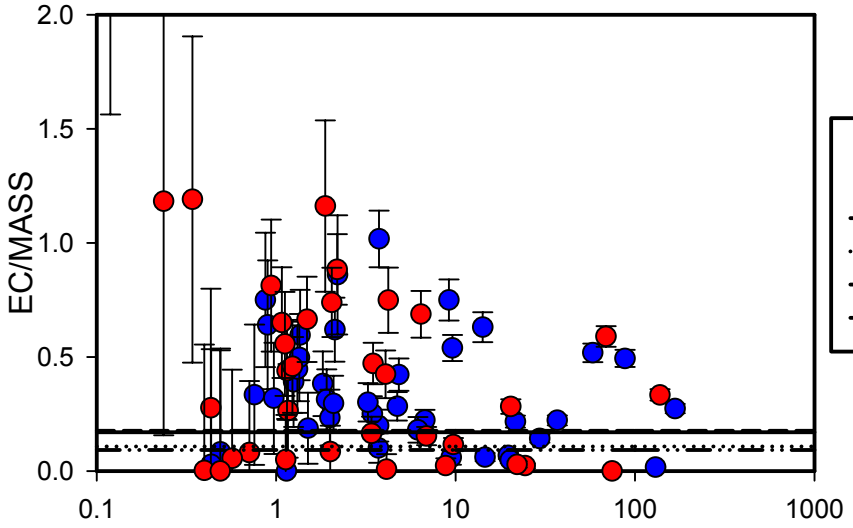

SI Vehicle
EC Fraction of PM Mass as a function of Mass Emission Rate
COLD START TESTS
HOT START TESTS
EC / MASS
2.0
1.5
1.0
0.5
0.0
0.1
1
10
100
1000
PM2.5 MASS emission rate (mg km-1)

SI Fleet Average
EC fraction of PM Mass



BASE CASES - MOST REALISTIC

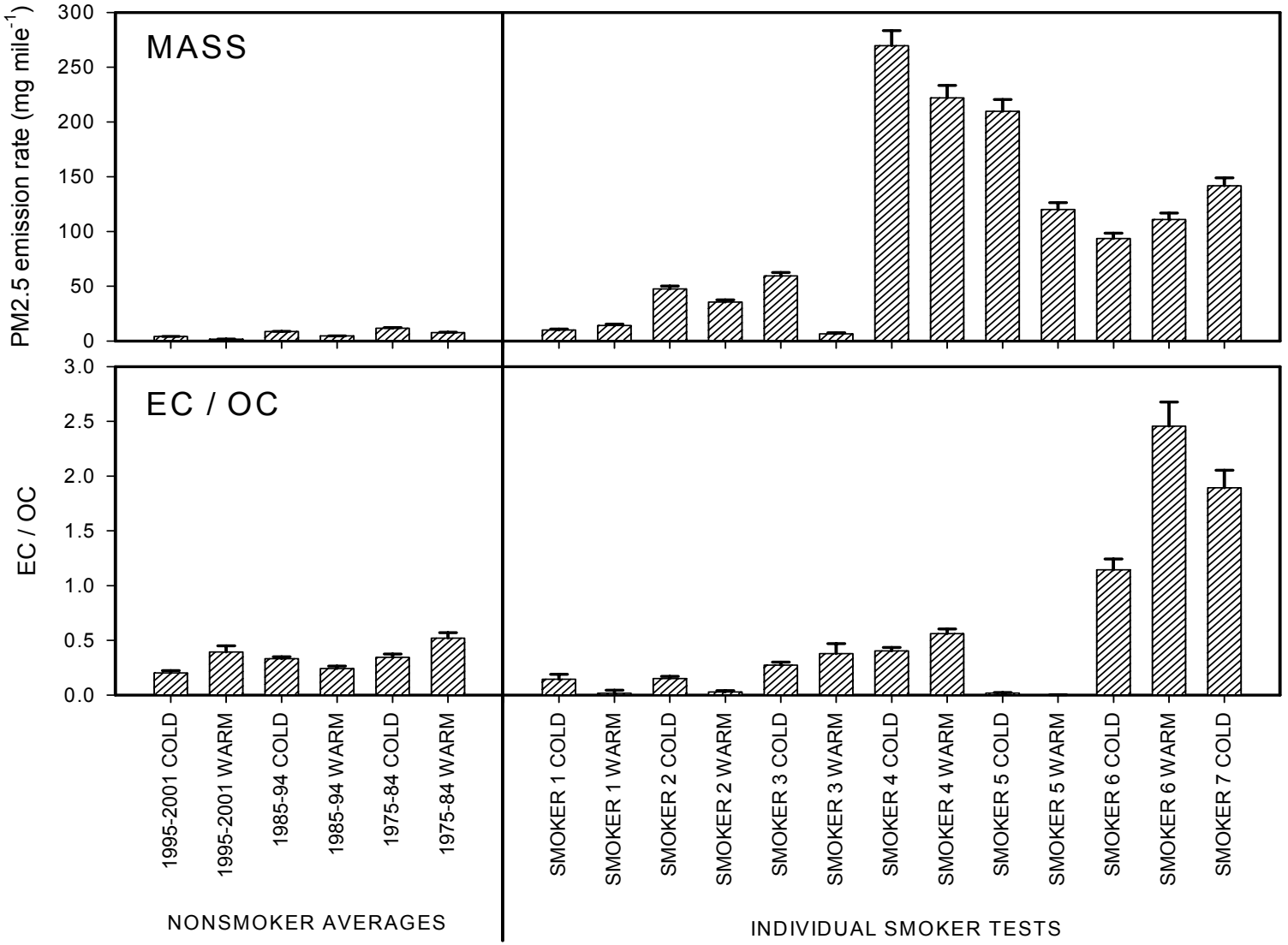
- COLD
- HOT
- Tested Vehicles Cold
- Tested Vehicles Warm
- 5% smoker LA age dist., Cold
- 5% smoker LA age dist., Warm
- 25% smoker LA age dist., Cold
- 25% smoker LA age dist., Warm



HIGH-EMITTER MICROENVIRONMENTS

- COLD
- HOT
- 50% smoker LA age dist, Cold
- 50% smoker, LA age dist, Warm
- High (75%) smoker area, Cold
- High (75%) smoker area, Warm

SI Vehicles
Comparison of Smokers and Non-Smokers



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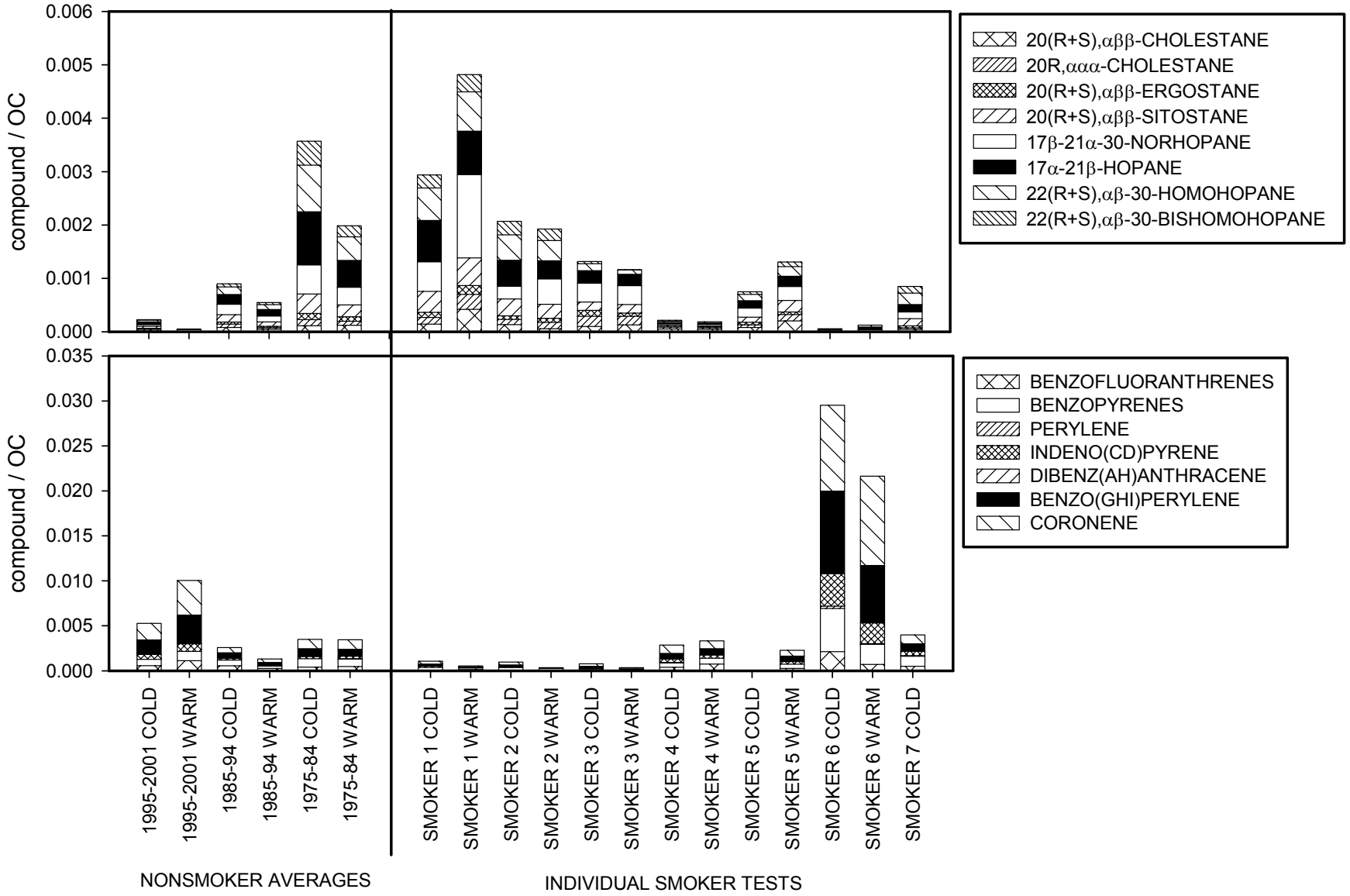
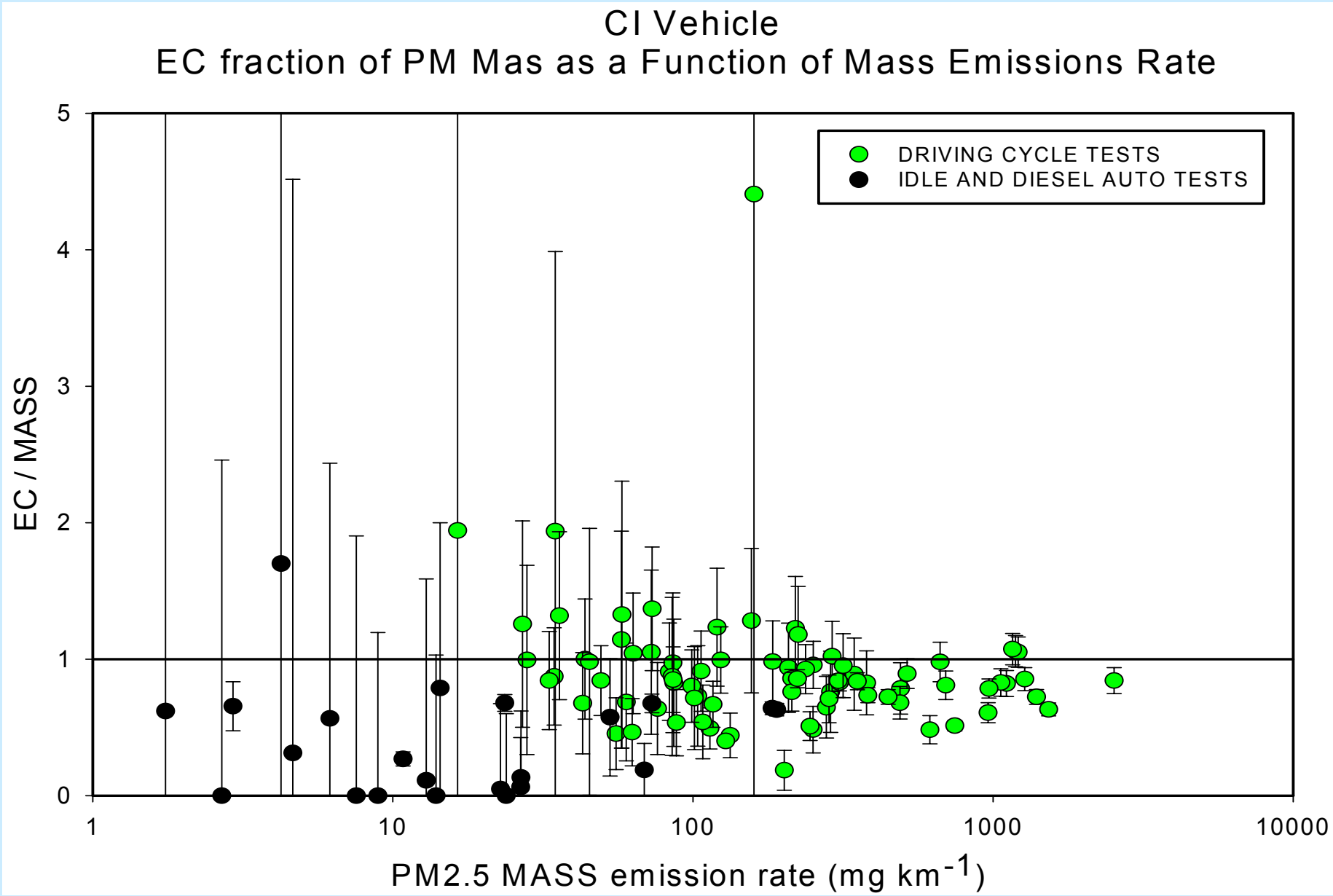
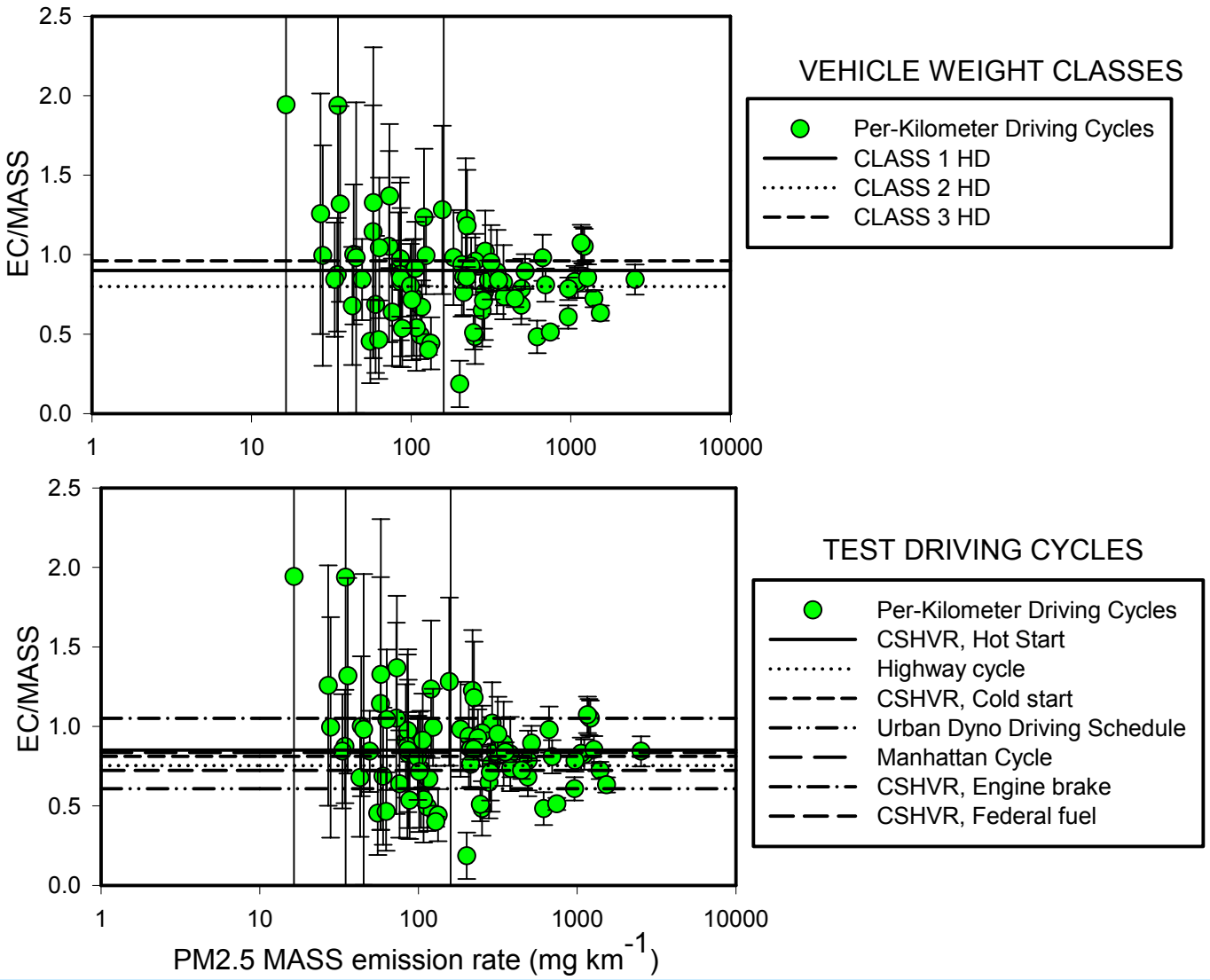
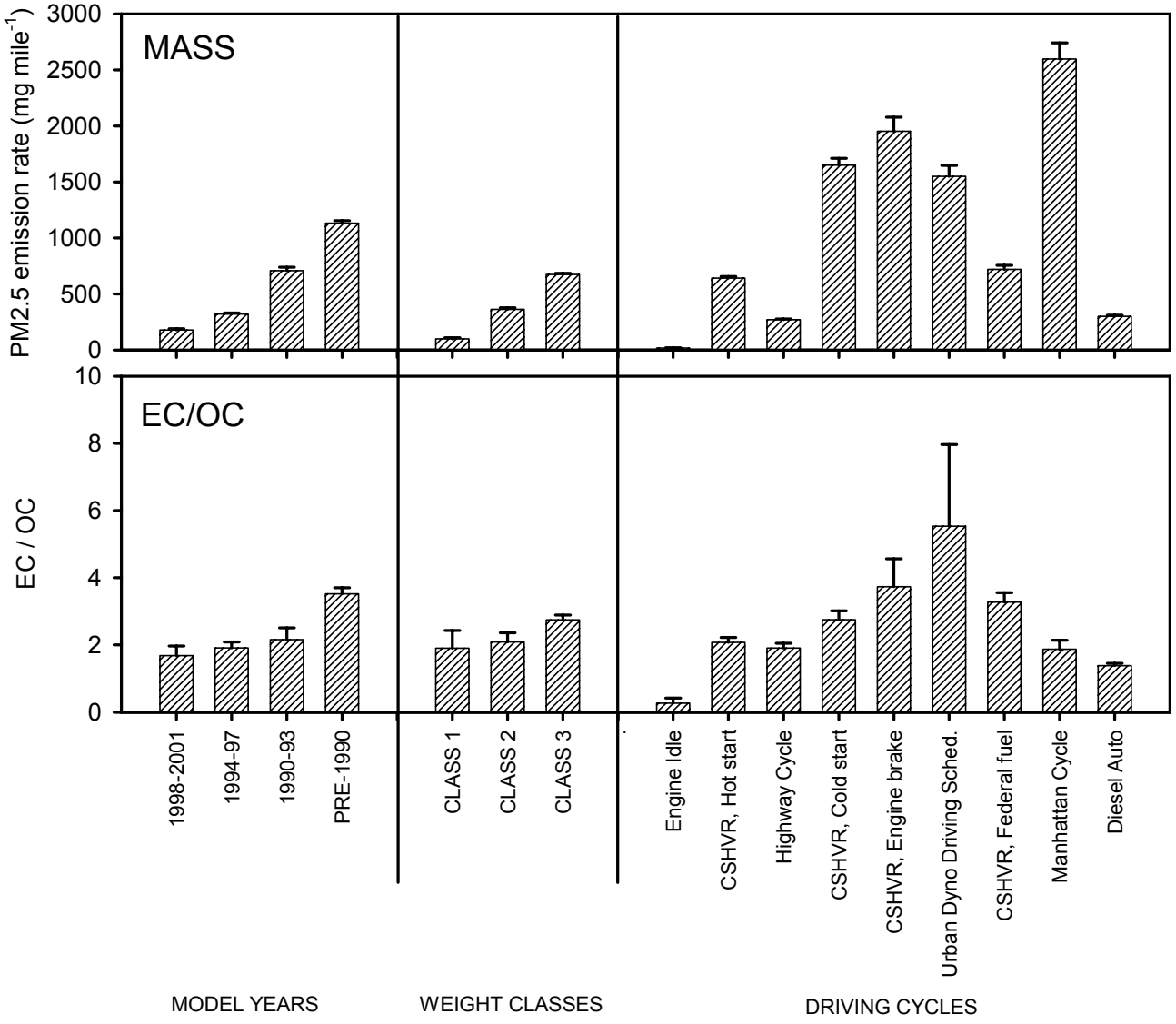



CI Vehicle
EC fraction of PM Mas as a Function of Mass Emissions Rate
DRIVING CYCLE TESTS
IDLE AND DIESEL AUTO TESTS
EC / MASS
0
1
2
3
4
5
1
10
100
1000
10000
PM2.5 MASS emission rate (mg km-1)

CI Vehicle Fleet
EC Fraction of PM Mass as a Function of Fleet Parameter



CI Vehicles
Effect of Model Year, Weight Class and Drving Cycle



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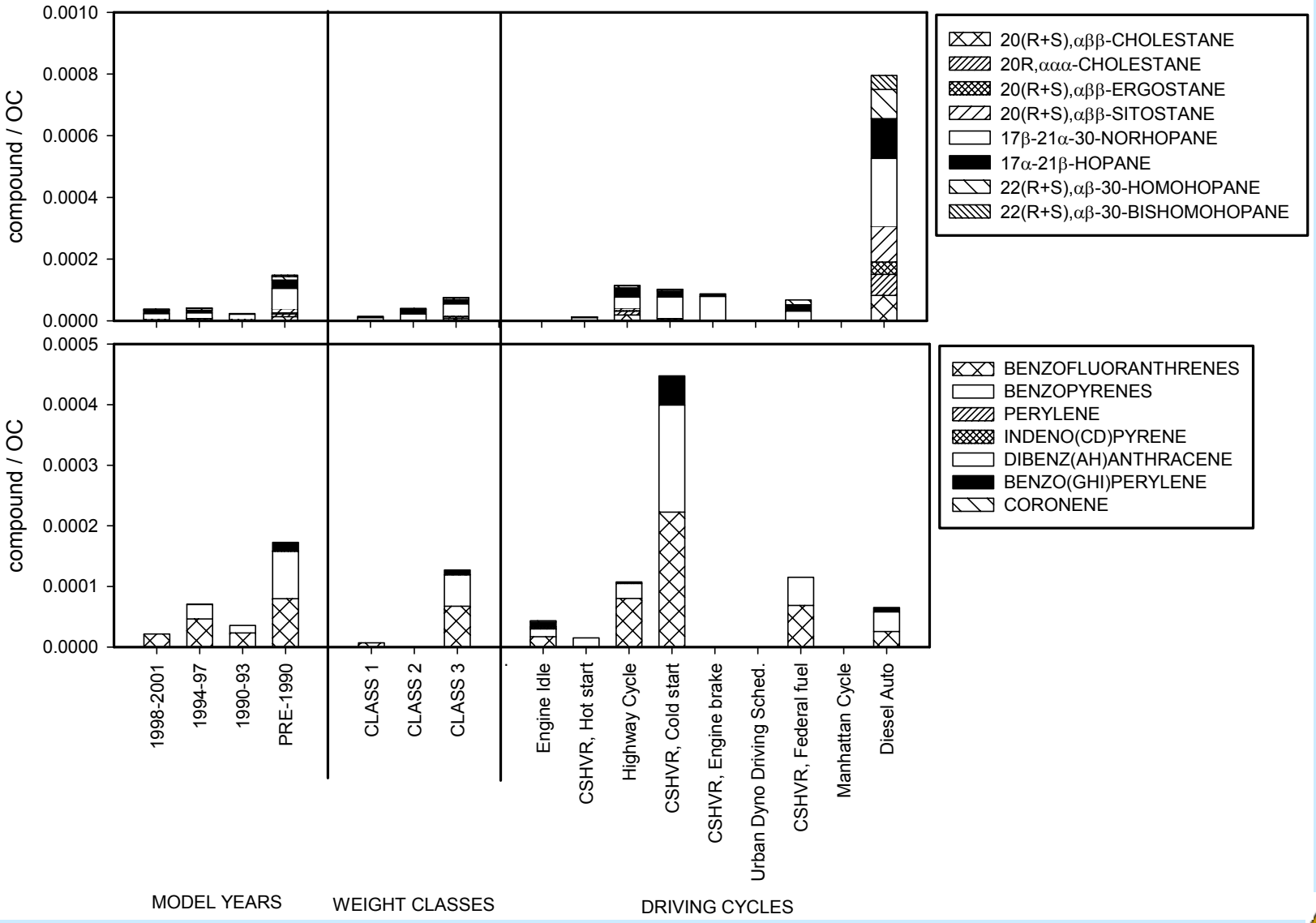


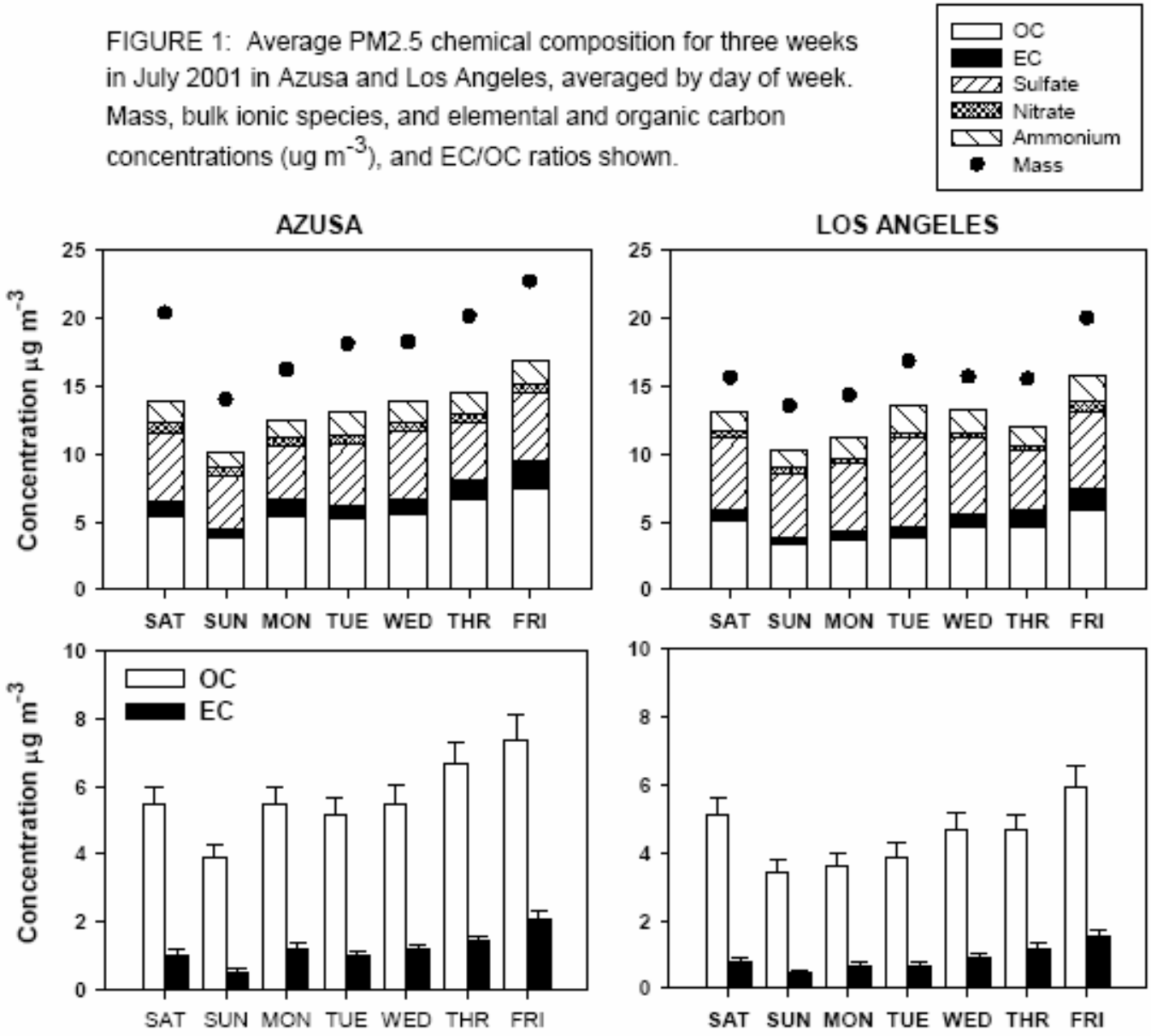
Uncertainty of Profiles

- For non-smoking gasoline vehicles, the composition of average PM emissions are reasonably stable as a function of the fleet mixture
- For smoking gasoline vehicles, there is considerable variability among the composition of different smokers
- The driving cycle is the predominate factor affecting average composition of PM emission from diesel vehicles

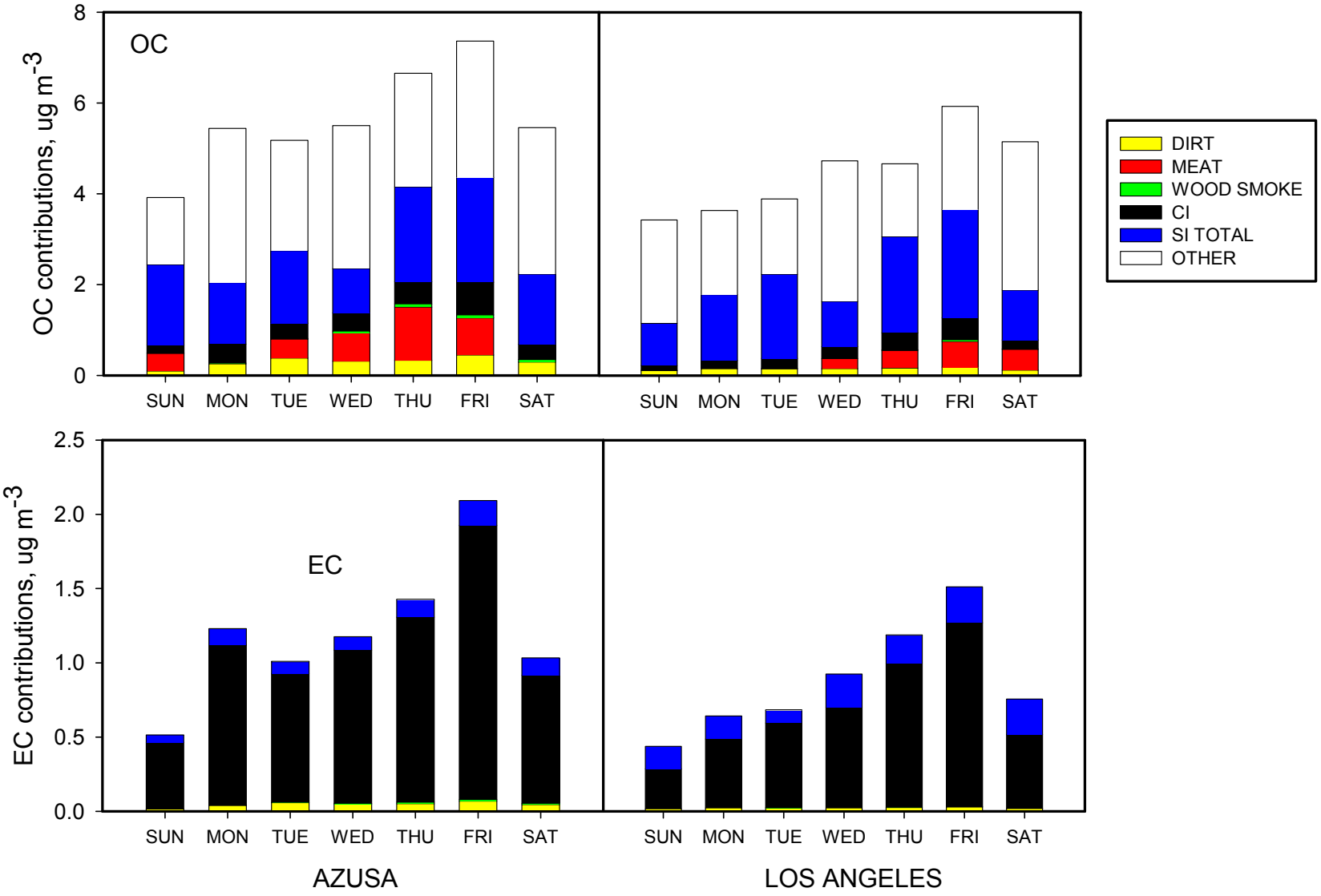
CMB Sensitivity

- Base Case Model
  - Average CI
  - Average SI
  - Oil Burning Smoker
- Sensitivity to Average SI
  - Average CI
  - Range of SI profiles
  - Oil Burning Smoker
- Sensitivity to Average CI
  - Range of CI profiles
  - Average SI Profile
  - Oil Burning Smoker
- Sensitivity to Smoker
  - Average CI
  - Average SI
  - Range of Smokers

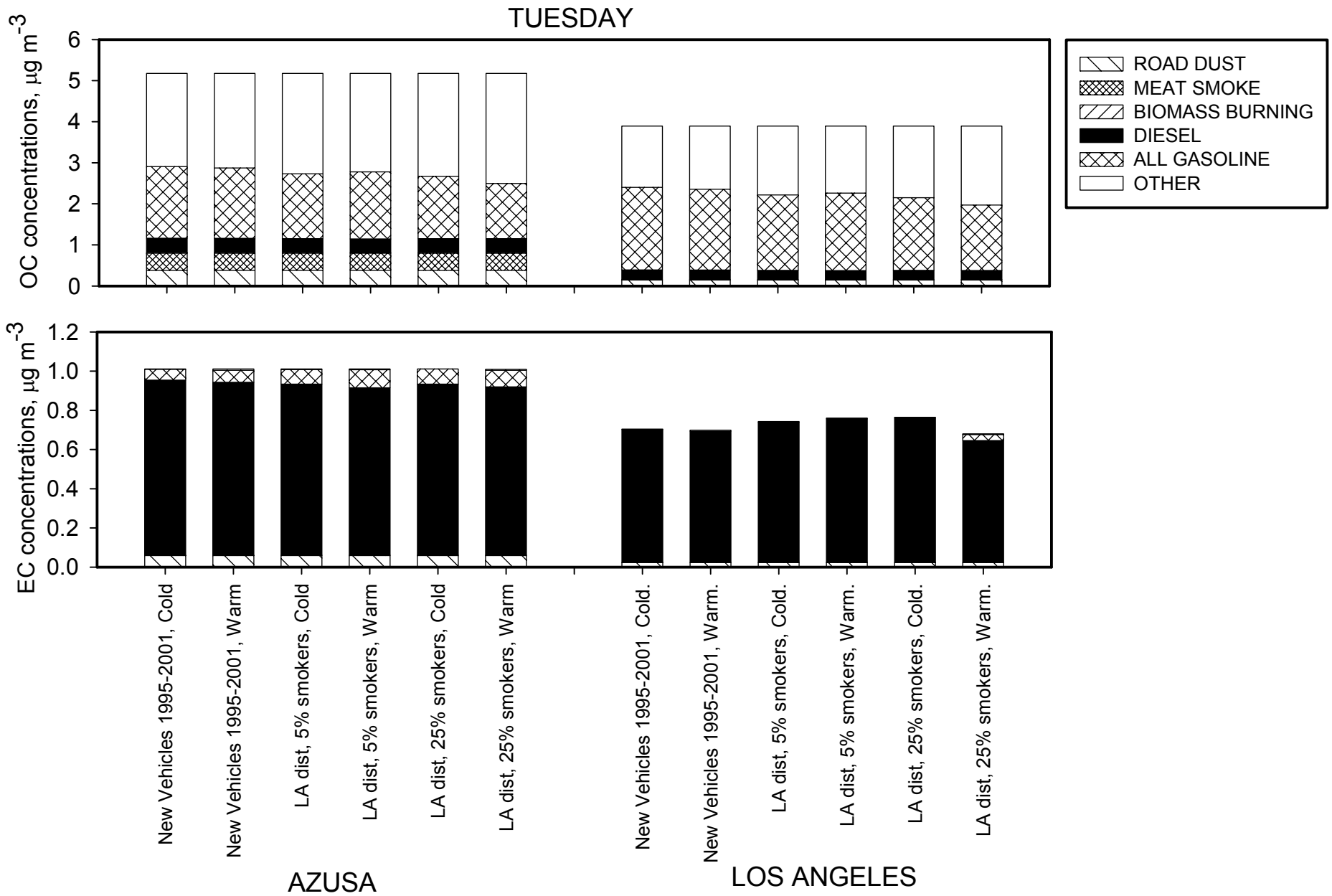
FIGURE 1: Average PM2.5 chemical composition for three weeks in July 2001 in Azusa and Los Angeles, averaged by day of week. Mass, bulk ionic species, and elemental and organic carbon concentrations (ug m^{-3}), and EC/OC ratios shown.



BASE CASE CMB: Source contributions to OC and EC concentrations (μg m^{-3}) in Azusa and Los Angeles by day of week



Sensitivity to SI Profile



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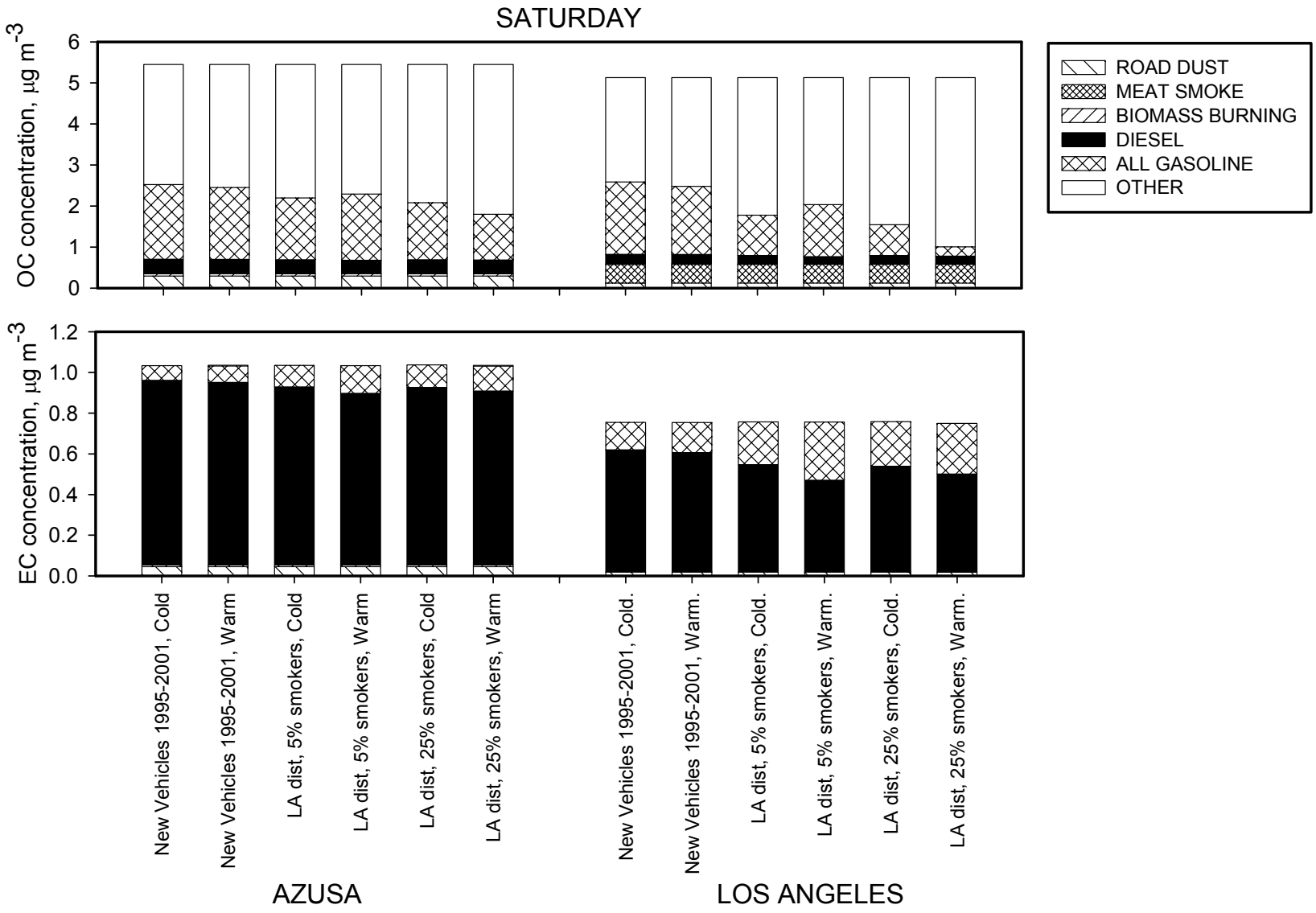
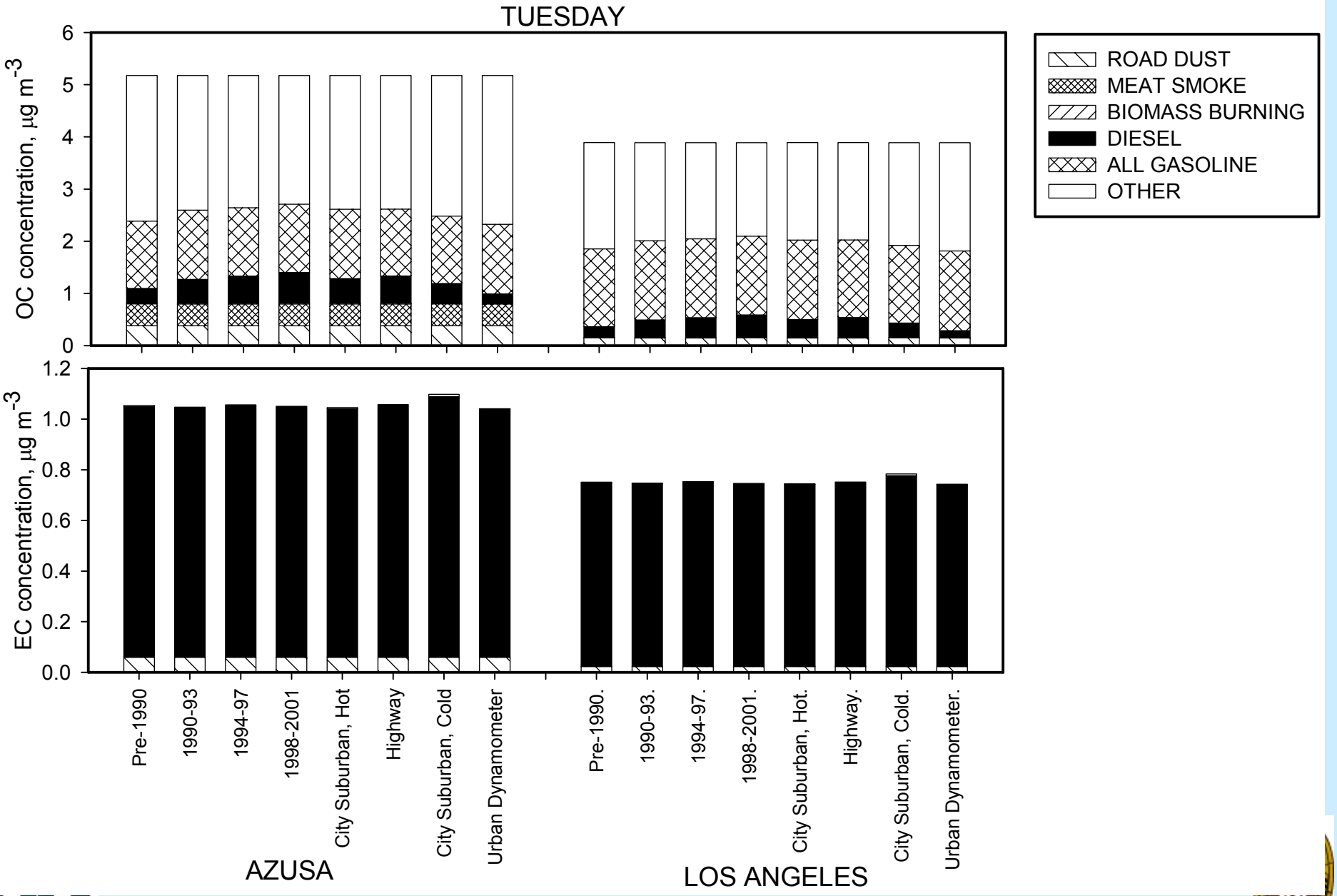
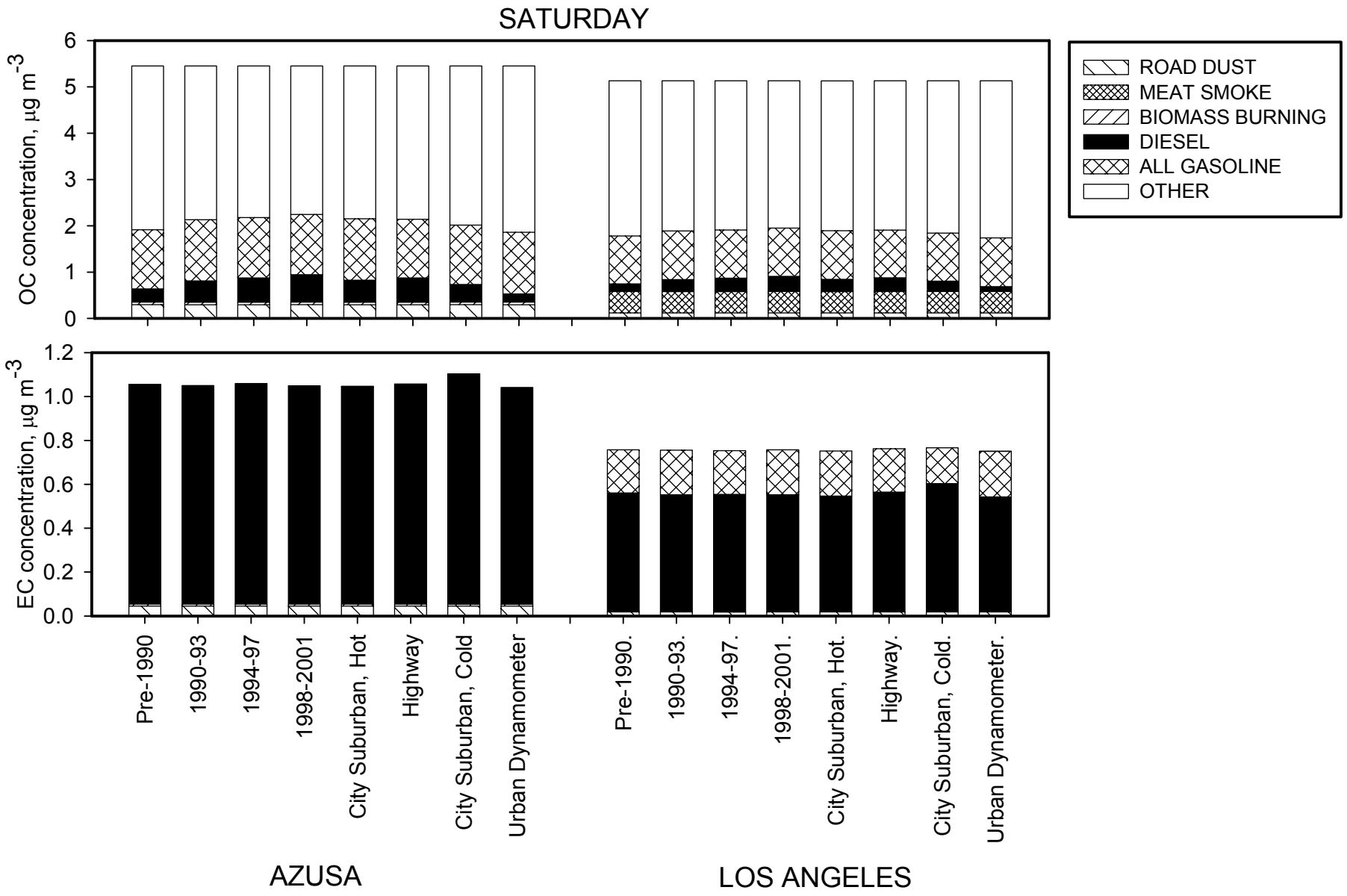


Sensitivity to CI Profile



Sensitivity to CI Profile



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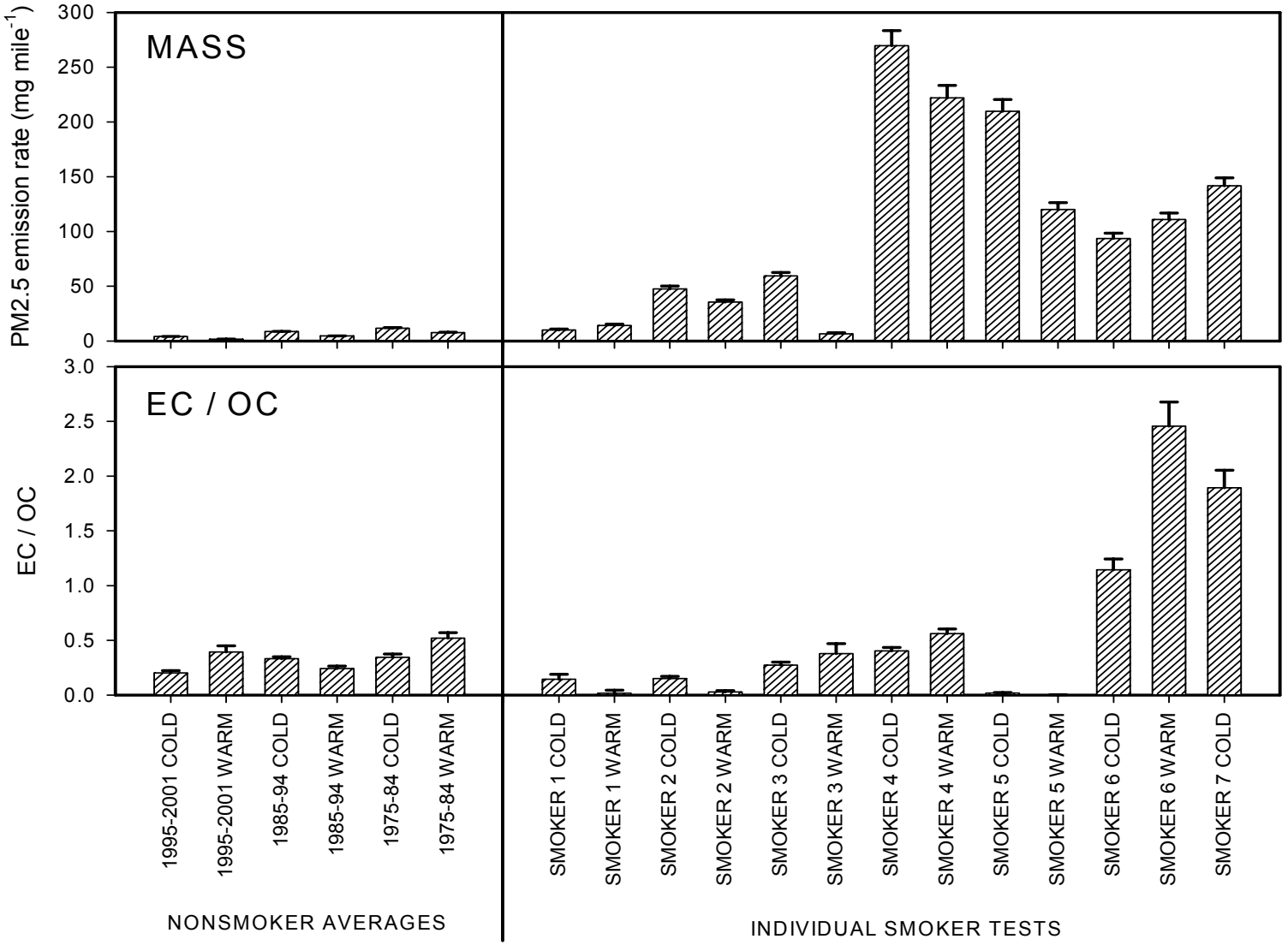
Comparison of Smokers and Non-Smokers



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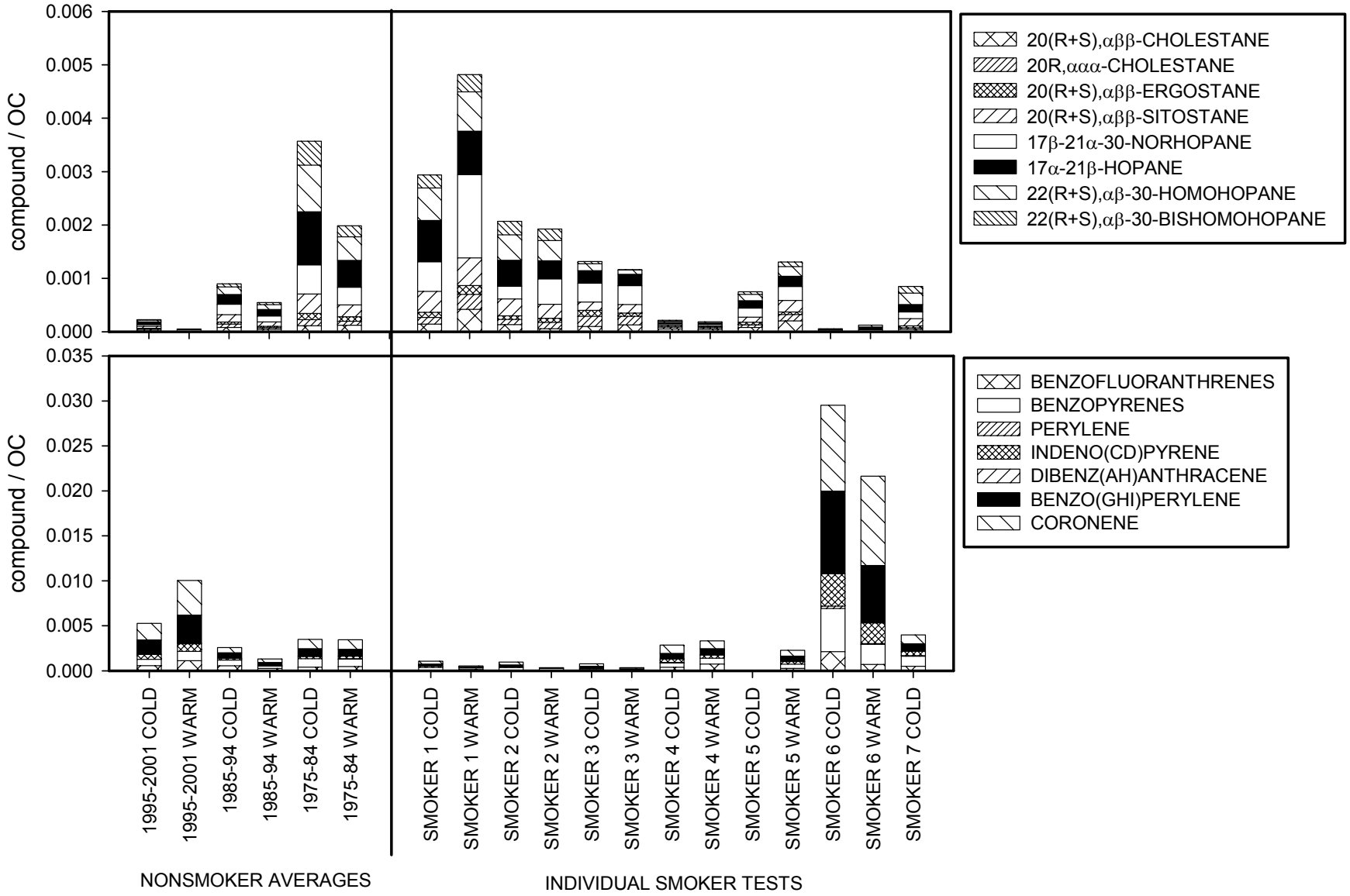
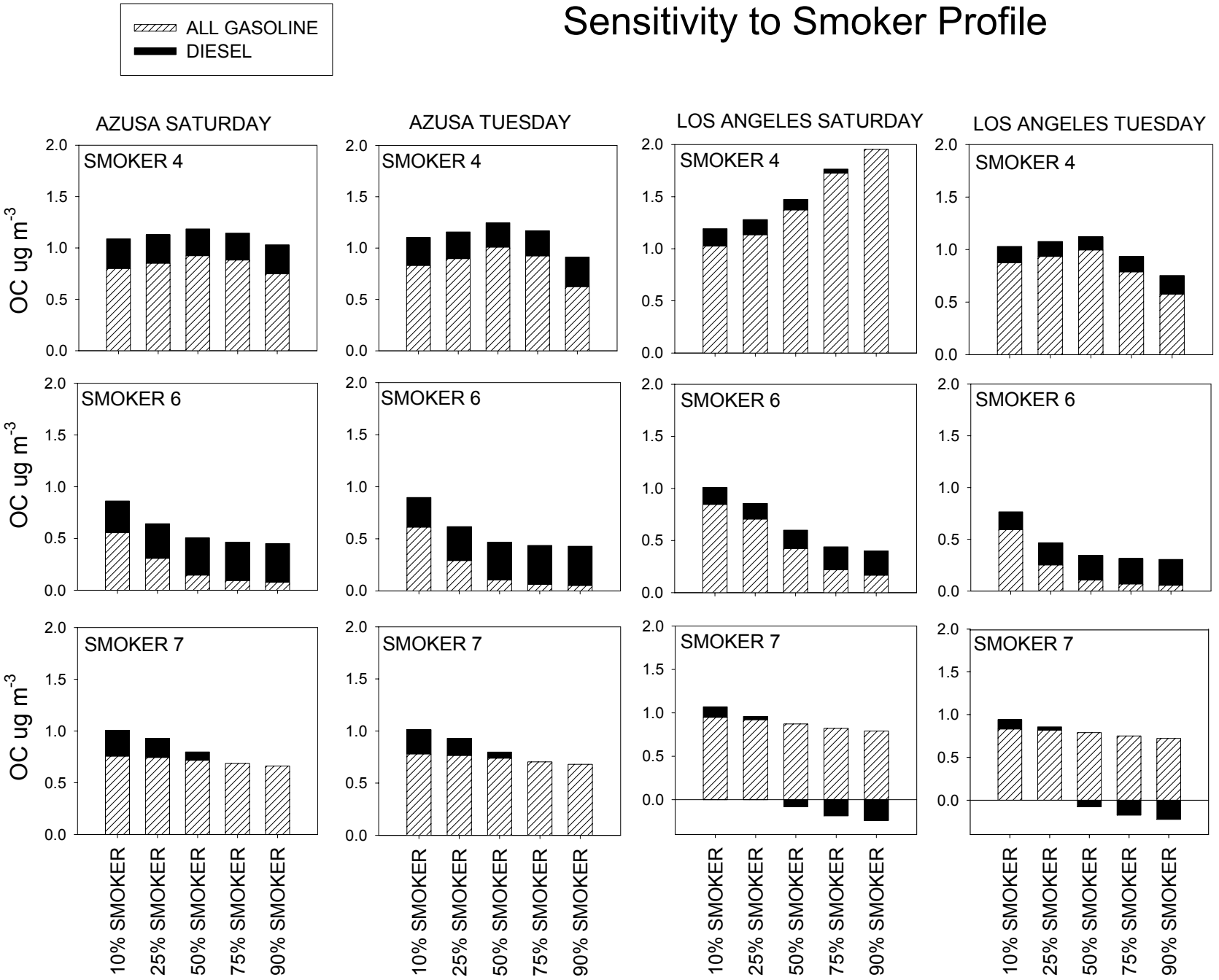


Sensitivity to Smoker Profile



CMB Sensitivity Analysis

- CMB model is relatively stable for all cases for non-mobile source emissions
- The largest uncertainty in the gasoline-diesel split is associated with the uncertainty in the smoker profile
- The “no smoker” scenario is not a good fit for the CMB model
- Given a constraint on the composition of the average smoker, the CMB Model is stable

Implications

- Molecular Marker CMB models do a good job with non-mobile source apportionments
- The composition of average CI fleet emissions is very sensitive to driving cycle
- The composition of average SI fleet emissions are very sensitive to smokers
- In the LA Basin, EC emissions are dominated by CI engines
- We need better information on the average composition of smoking gasoline vehicles to improve accuracy of CMB models

Implications

- In the LA Basin, reduction of EC emissions need to focus on CI engines
- Smoking vehicles are important contributors to the total OC emissions from mobile sources
- Preconceived constraints about the composition of smokers can lead to good source apportionment model stability
- The Gas/Diesel PM Split study raises considerable question about the composition of average smokers

Acknowledgements

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- SI vehicle testing was led by Peter Gable (US EPA)
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