Mobile Source Black Carbon Emissions

Black Carbon Emissions and Climate Change: A Technical Workshop

San Diego, CA

October 13-15, 2004

EPA Office of Transportation and Air Quality

- Several Divisions work on black carbon issues
- In Assessment and Standards Division, this staff includes
  - Chad Bailey
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  - Marion Hoyer
  - Joe Somers

Mobile Source PM Emissions

- EPA emission inventories
- Mobile sources: about 20% of total PM-2.5 (not including miscellaneous emissions), more in urban areas
- Mobile source PM
  - On-road gasoline (light duty vehicles and trucks)
  - On-road diesel (mostly heavy-duty diesel)
  - Non-road gasoline (lawn/garden, recreational marine)
  - Non-road diesel (construction, farm, trains, boats)

Mobile Source Particulate Emissions - Role of Black Carbon

- **Mass of gasoline PM**
  - automotive: **decrease from 0.3 g/mile to 0.001 g/mile** from 1970 to 2004 for properly operating vehicles
  - not accounting for high emitters
- **Mass of diesel PM**
  - light-duty diesel vehicles
  - heavy-duty diesel vehicles (trucks)
  - **decrease from about 2-3 g/mile to about 0.02 g/mile**
  - not accounting for high emitters

Mobile Source Particulate Emissions - Role of Black Carbon

- **Composition of gasoline PM**
  - with leaded gasoline: significant lead halides
  - organic carbon including PAH, nitro-PAH
  - elemental carbon - about 20% overall (can be higher for cold starts)
  - sulfates
  - other trace metals
- **Composition of diesel PM**
  - organic carbon including PAH, nitro PAH
  - higher molecular weight VOC associated with PM
  - elemental carbon - about 50-80%
  - sulfates

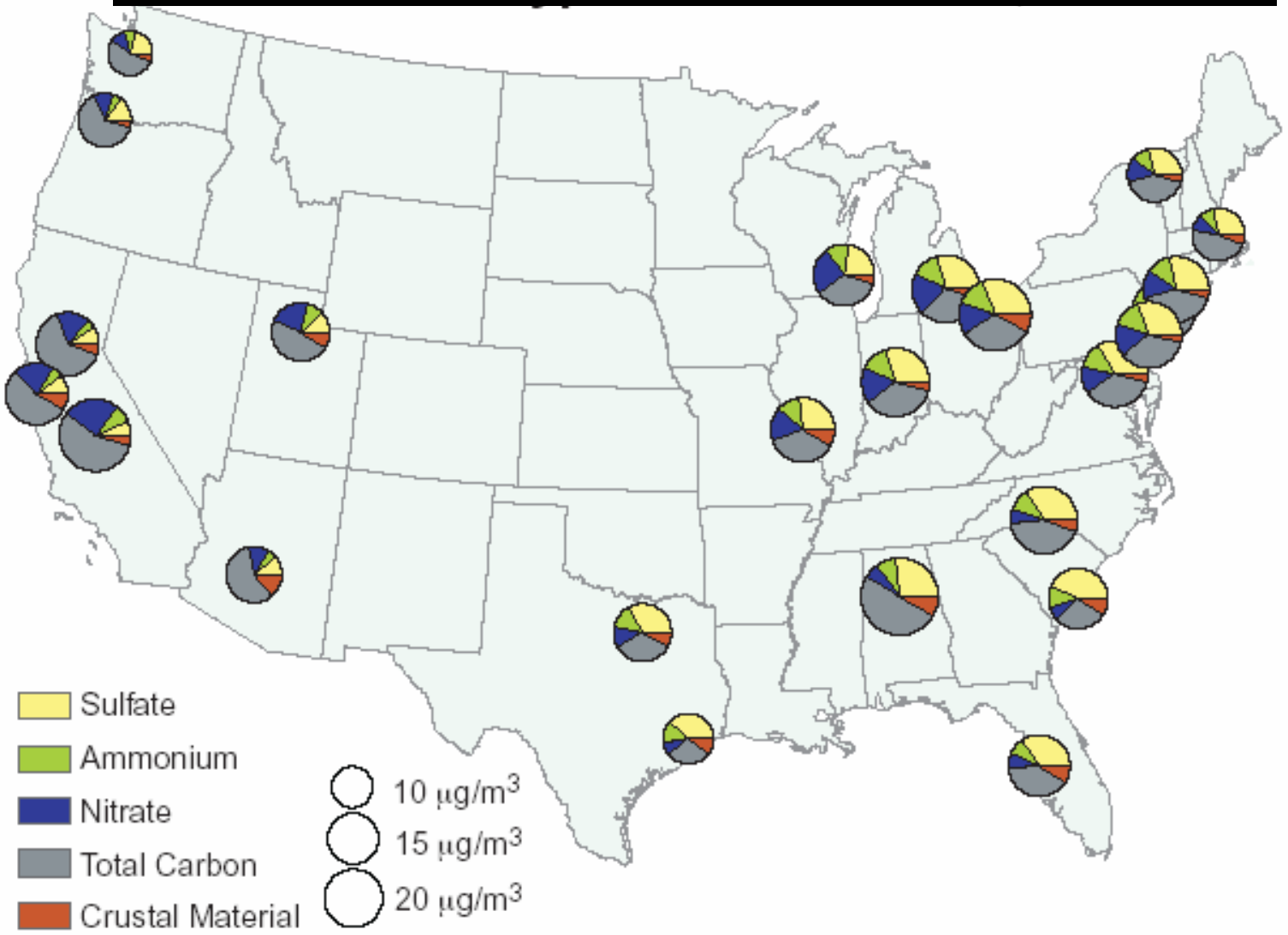
Mobile Source Black Carbon

- Elemental/black carbon assumed to be identical
- There are issues in measurement methods
- Need to review/consolidate emission data
- Initial numbers
  - diesel: 50-80% (assume 70% for inventories)
  - gasoline: about 20% - number uncertain

Ambient PM - Role of Carbon

- **Mobile sources are primary source of carbonaceous PM in ambient air**
- **Some carbonaceous PM formed from atmospheric reactions - amount not known**
- **Carbonaceous compounds represent a large fraction of PM-2.5**
  - exact contribution varies from area to area
  - work underway to better quantify amounts
- Carbonaceous PM is becoming increasingly important to EPA
- Issue: what fraction of carbonaceous PM is black carbon versus organic carbon?

Carbonaceous PM is important in urban areas (as are sulfates)!

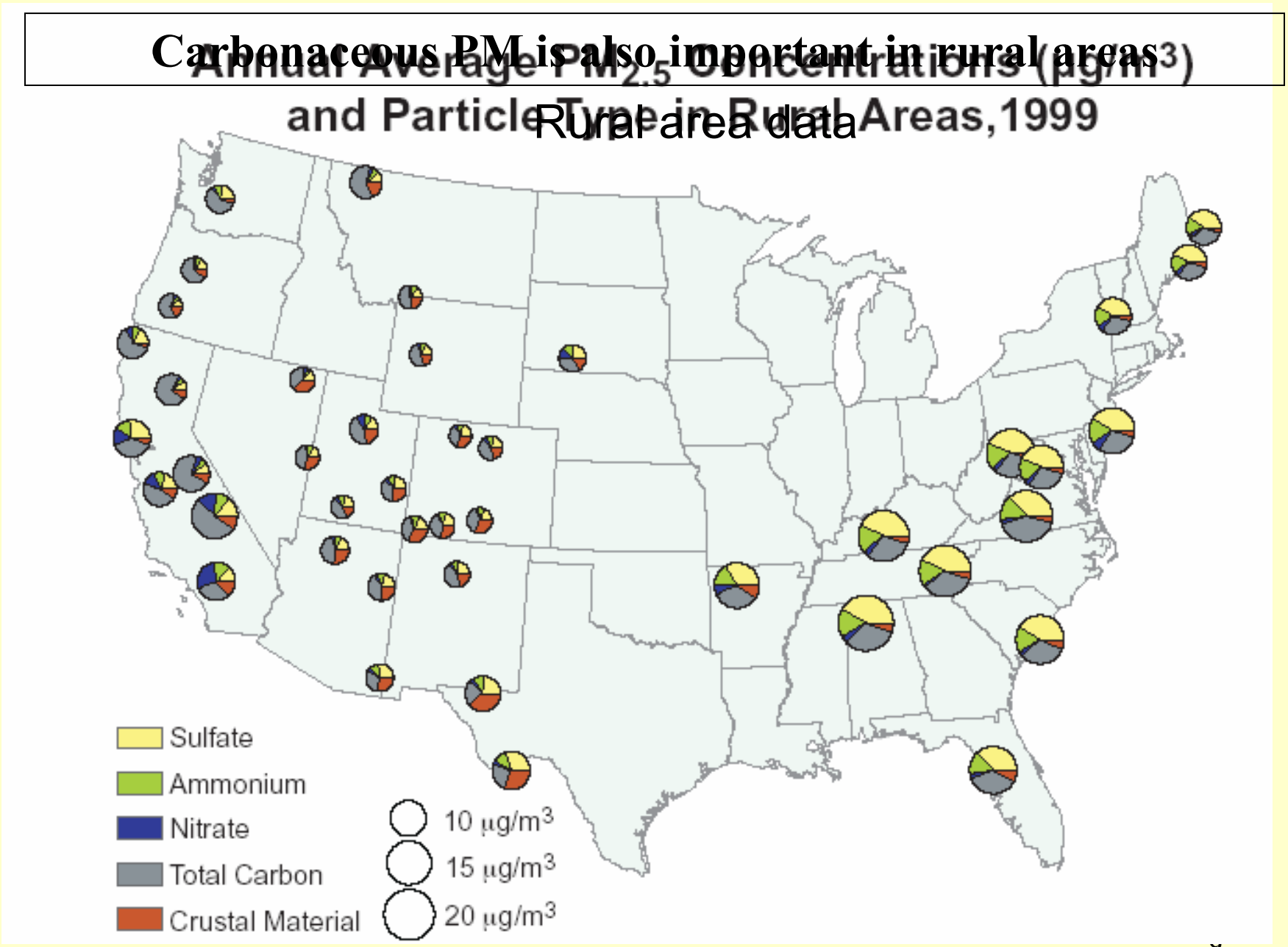


Source: EPA Speciation Network, 2001.

From: "Latest Findings on National Air Quality: 2001 Status and Trends"

Carbonaceous PM is also important in rural areas

Rural area data

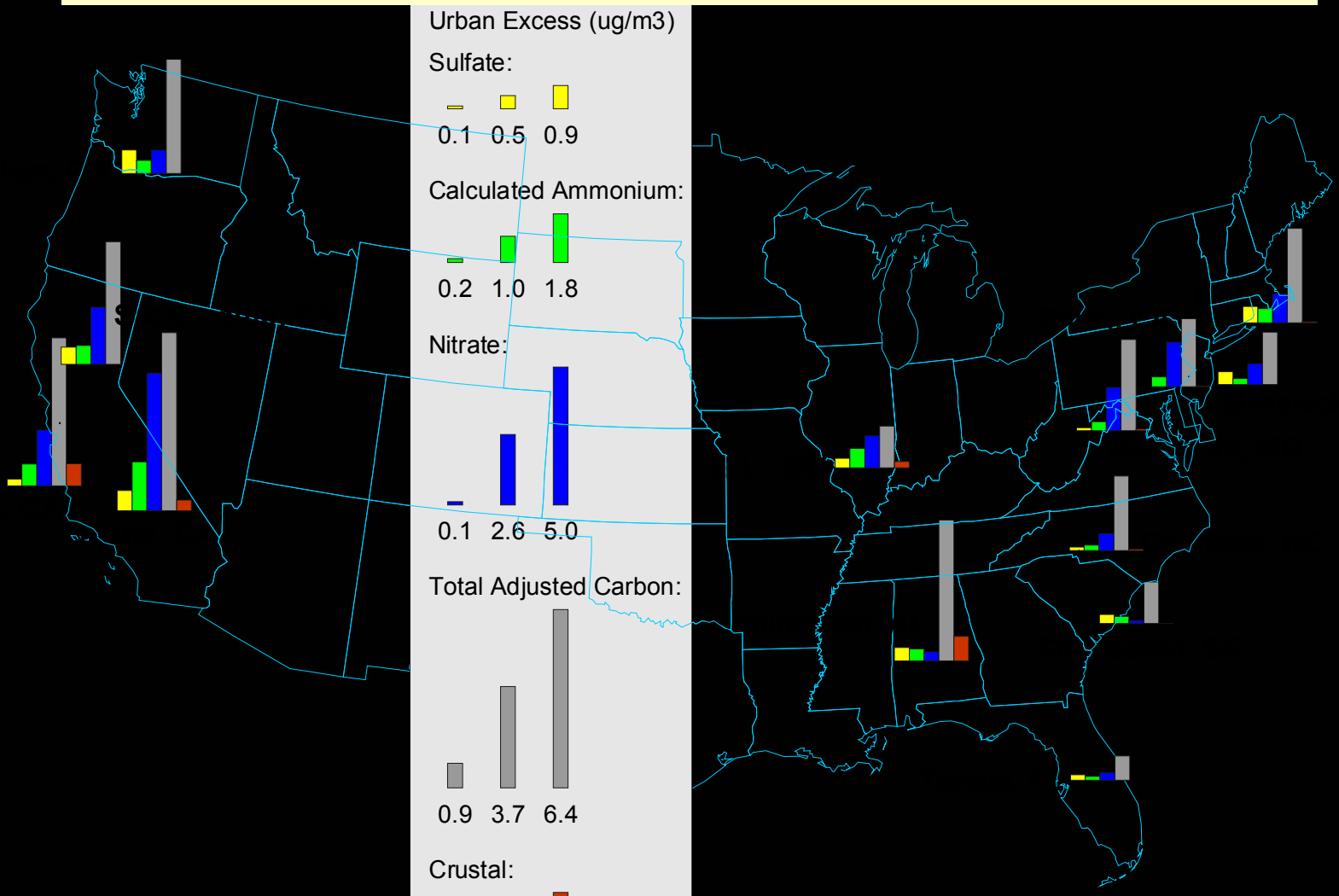


Source: IMPROVE Network, 1999

From: "Latest Findings on National Air Quality: 2001 Status and Trends"

There is an excess of carbon and other components of PM2.5 in urban areas

STN urban measurement minus nearby IMPROVE regional background



Preliminary estimates based on Jan-Nov 2001 data

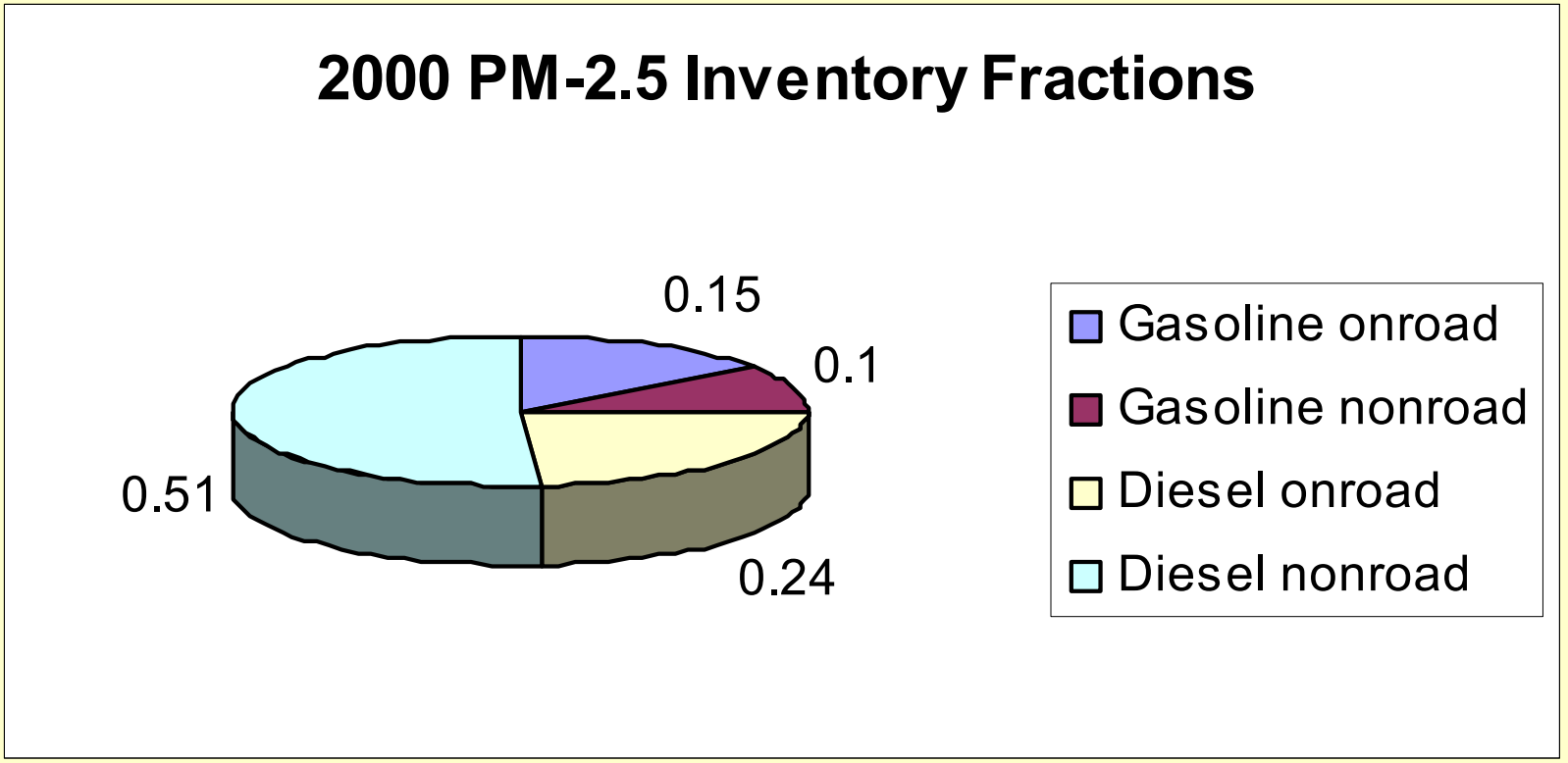
Ambient PM Information

- Recent source apportionment studies give conflicting results on gasoline/diesel contributions
- NFRAQS Denver, three Phoenix, Washington DC studies indicate gasoline greater than diesels
- California, Texas, and southeast US studies generally indicate diesel greater than gasoline
- DOE-NREL gasoline/diesel split study - Los Angeles

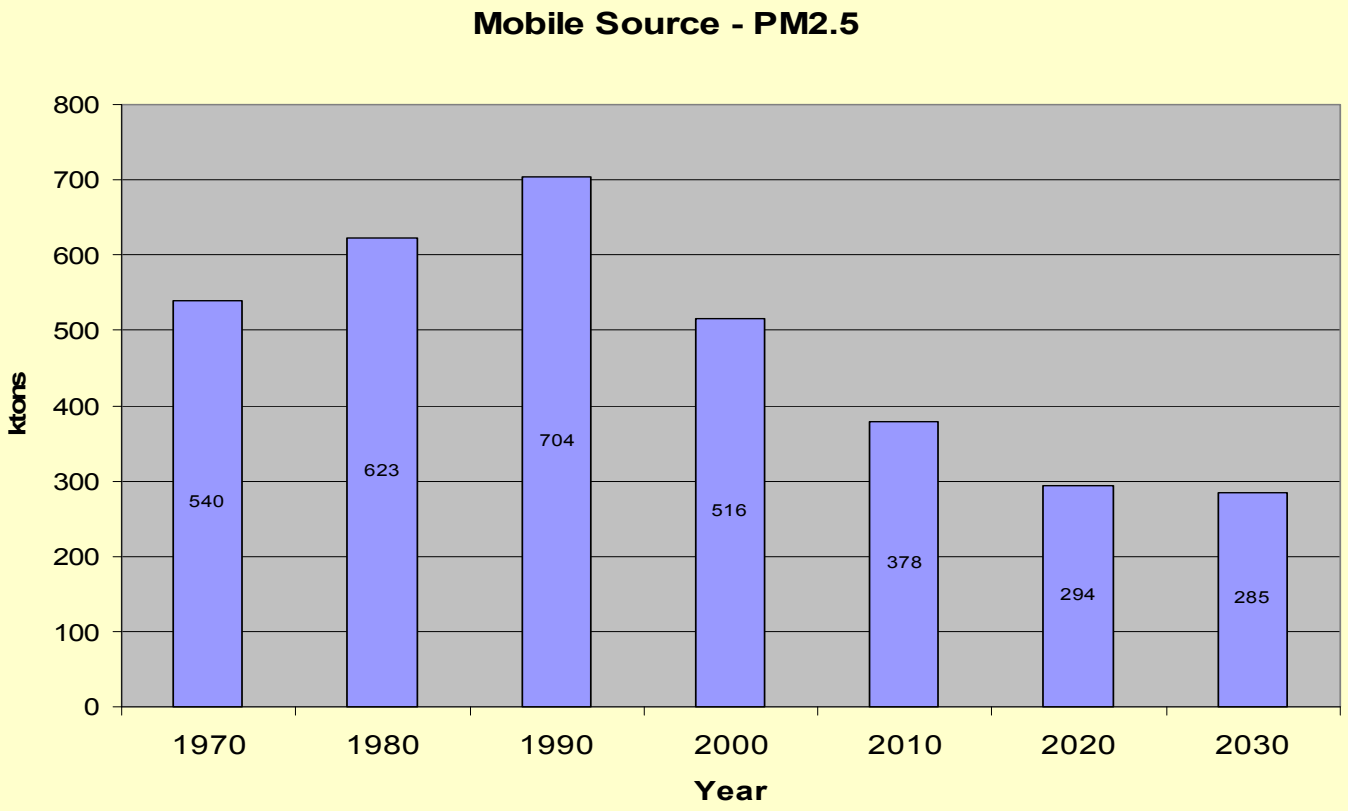
EPA Emission Inventories

- Include only directly emitted PM
- Do not include secondary PM formed in atmosphere such as sulfates, nitrates, and organics
- Mobile source estimates based on models
  - emission factors
  - usage (miles traveled or fuel consumed)

Contributions to PM-2.5



Future Mobile Source PM-2.5 Emissions with EPA Rules Implemented



Black Carbon Sources - Open Burning

- Wildfires
- Prescribed Burning
- Land clearing
- Residential house and yard waste burning
- Agricultural field burning
- About 26% of total in 1999

Black Carbon Sources - Other

- Fugitive dust
- Residential combustion
- Industrial processes, incineration
- Utility, industrial, commercial combustion
- About 18% in 1999 with fugitive dust being the highest

Mobile Source Black Carbon Inventories

- EPA has models (MOBILE6.2 and NONROAD) to estimate direct PM-2.5 emissions
- EPA presently has no model specifically for black carbon
- Some preliminary black carbon numbers can be derived from PM-2.5 estimates
- Emission models do not include high PM emitters

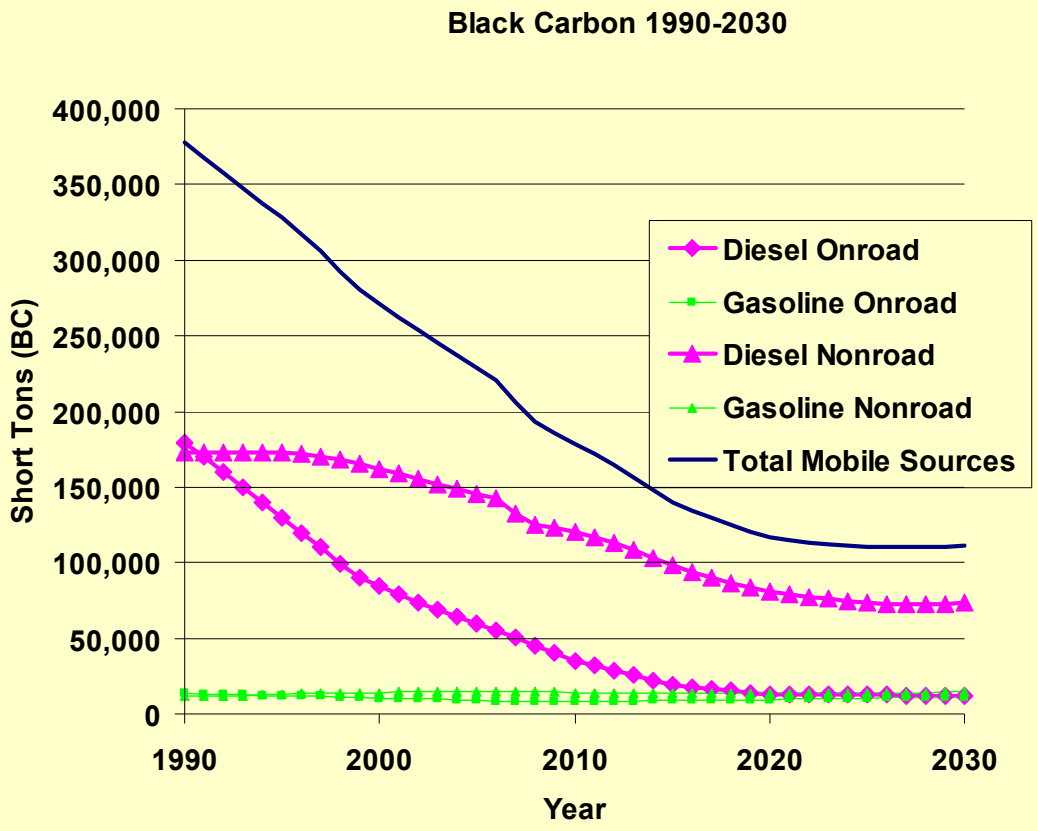
Mobile Source Black Carbon Inventories

- Major assumption is that a constant % of PM-2.5 is black carbon
- About 70% for diesel
  - # supported by Diesel Health Assessment Document
  - # used in MOBILE 6.2
- About 20% for gasoline but not in MOBILE6.2
- These numbers do not consider that, especially for diesel, the % declines in future years

Emission Inventory Issues

- **Diesel**
  - **Nonroad inventory larger than on-road**
  - **EPA has regulated onroad diesel PM for many years; nonroad diesel regulations are more recent but, for future years, very stringent**
- **Gasoline**
  - **Onroad has been decreasing with time**
  - **Nonroad is important, data are limited**
    - **2 stroke engines burning oil**

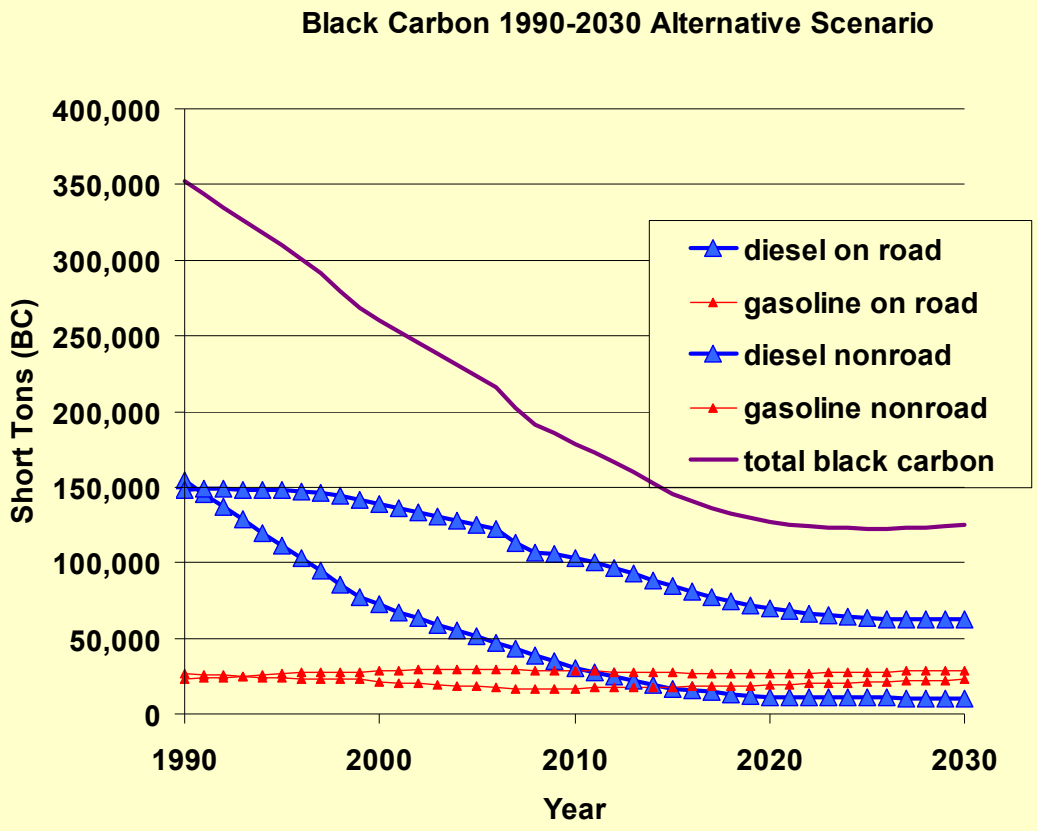
Black Carbon Inventories



Alternative Inventory

- Done for **sensitivity** analysis
- Assumes gasoline PM is 40% black carbon
- Diesel PM is 60% black carbon
- **This gives an high-end estimate of gasoline PM contribution**
- Still does not account for high emitters

Alternative Black Carbon Inventories



Gasoline PM Contribution to Black Carbon

- Gasoline PM study in Kansas City
  - about 500 randomly chosen gasoline vehicles
  - will be used to update emission factors in EPA models
- Numerous sponsors
  - DOE, DOT, EPA, state/local agencies through EIIP
  - Coordinating Research Council (and its members)

Conclusions

- Mobile sources are probably the major contribution to black carbon
- Diesels result in more black carbon than gasoline engines
- Nonroad diesel is an especially important source
- Black carbon emissions decrease greatly in the future going to 2030 due to EPA regulations

Future Work - Needs

- **Develop fully accepted quantitative measurement method for black carbon**
- **Compile all available gasoline/diesel elemental/black carbon emission data**
- **Develop emission model for black carbon**
- **Obtain better emission data for gasoline vehicles/engine**
- **Need to account for high emitters in inventory**
  - **Including high emitters will increase mobile source contribution**
  - **Will also alter relative contributions of diesel/gasoline**