U.S. EPA Short-lived Climate Forcer Emissions and Methods

U.S. Environmental Protection Agency
Office of Air and Radiation
11 October 2021

Follow up questions: Rob Pinder (pinder.robert@epa.gov)

Overview

- Quick overview of EPA SLCF emission inventory approach
- Thoughts on uncertainty
- Differences with GHG methods
- Applicability to other countries
- Known gaps and questions

Short-lived climate forcer emissions data

- National Emission Inventory
  - Criteria pollutants: NO_x, SO_2, CO, $PM_{2.5}$, PM_{10}, Pb
  - Precursors: NH_3, Volatile organic compounds (VOC)
  - Many hazardous air pollutants
  - Annual, county level emissions, developed over a 3-year cycle

- Modeling inventories
  - Temporal allocation: monthly, day of week, hourly
  - Spatial surrogates: population density, highways
  - Profiles for chemical speciation of VOCs and PM (including organic carbon / elemental carbon)
  - Future year projections

- Emissions from vegetation and geological processes are calculated within the chemical transport modeling system: sea spray aerosol, lightning NO, biogenic VOC, etc.

What are the data used for?

- Input for use in regulatory and research air quality models
- Assess health and environmental risks of ozone, $PM_{2.5}$, and air toxics
- Quantify risks and benefits of U.S. air quality regulatory options
- Prioritize air quality management based on sources and trends
- Global assessments of long-range transport of air pollutants and short-lived climate forcers
- Requires detailed representation of
  - sectors and control technologies
  - chemical speciation
  - location and timing of emissions

What are the data sources?

- Data provided by State, Local, and Tribal air agencies
  - Supplemented by data developed by the US EPA
  - Quality assurance programs
- Emission estimation methods described in technical support and guidance documents

Point sources
Power plants, industrial facilities

Facility-level data
Largest sources require continuous emission monitors
Some large sources require stack tests

Non-point sources
Residential heating, agriculture, oil and gas production

County totals

Sector-specific databases of emission factors and functions

Mobile sources
Vehicles, trains, planes, ships

Location-specific activity data
Emissions from fuel combustion as well as evaporation and tire-wear

Event sources
Prescribed & wildfires

Day and location-specific activity data

Combines data from satellite-based detections and reports on acreage burned

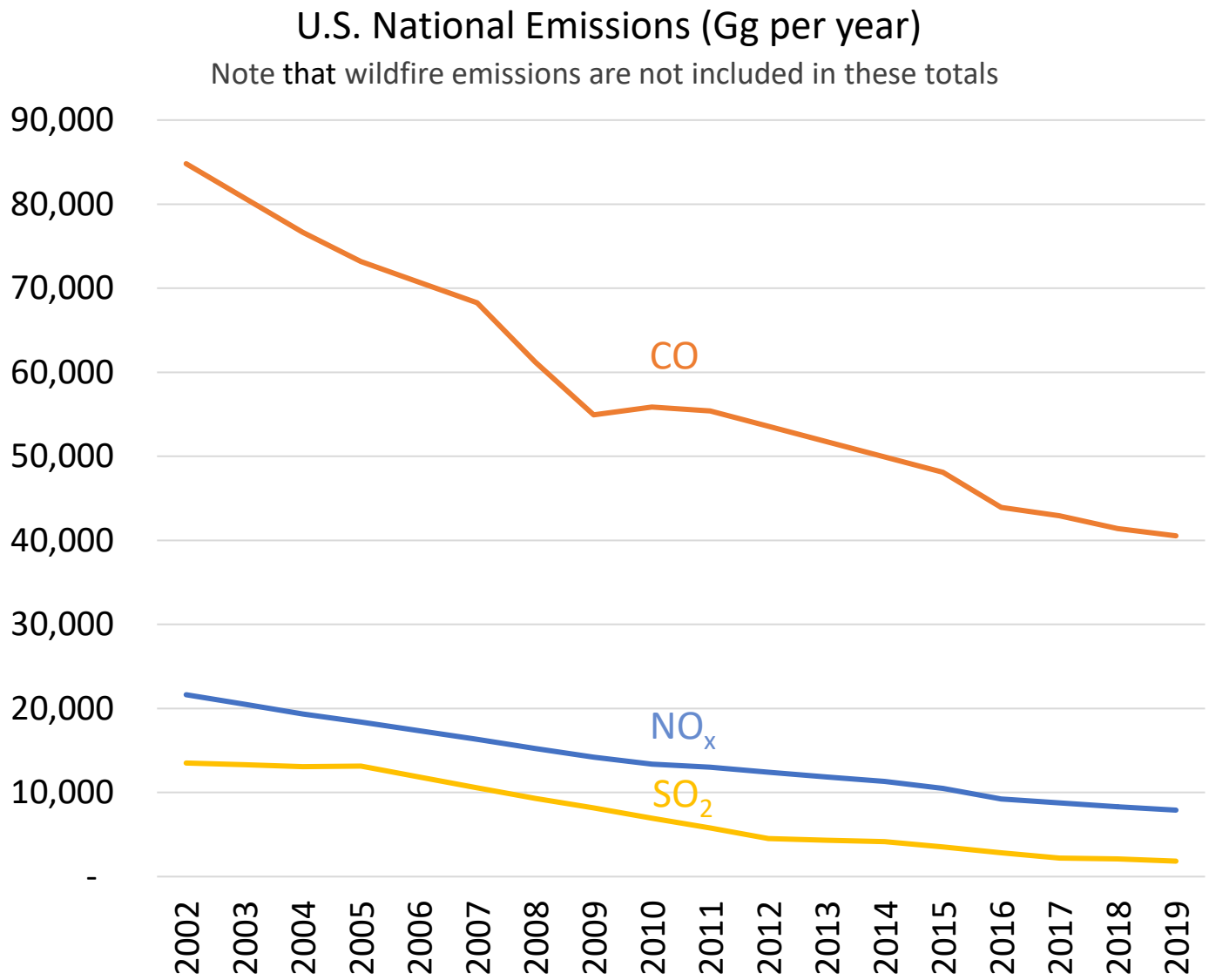
Chemical speciation of PM and VOC

- Used to disaggregate total VOC and PM emissions compiled in the NEI into their component species for air quality models
- SPECIATE database of profiles on a percent mass basis
- What are the data sources?
  - Peer-reviewed literature
  - Emission source tests by government or industry
  - New data rigorously reviewed with quality scoring criteria
  - Bray et al. (2019) reviewed profiles and recommended priority updates

- Pros and Cons of this approach
  - Can fill in the gaps for sources where no speciated emission tests are available
  - Profiles require review when emission estimates are updated to ensure that the profiles are representative of the sources they are assigned to
  - Potential issue: profile and emission factor may be measured under different conditions

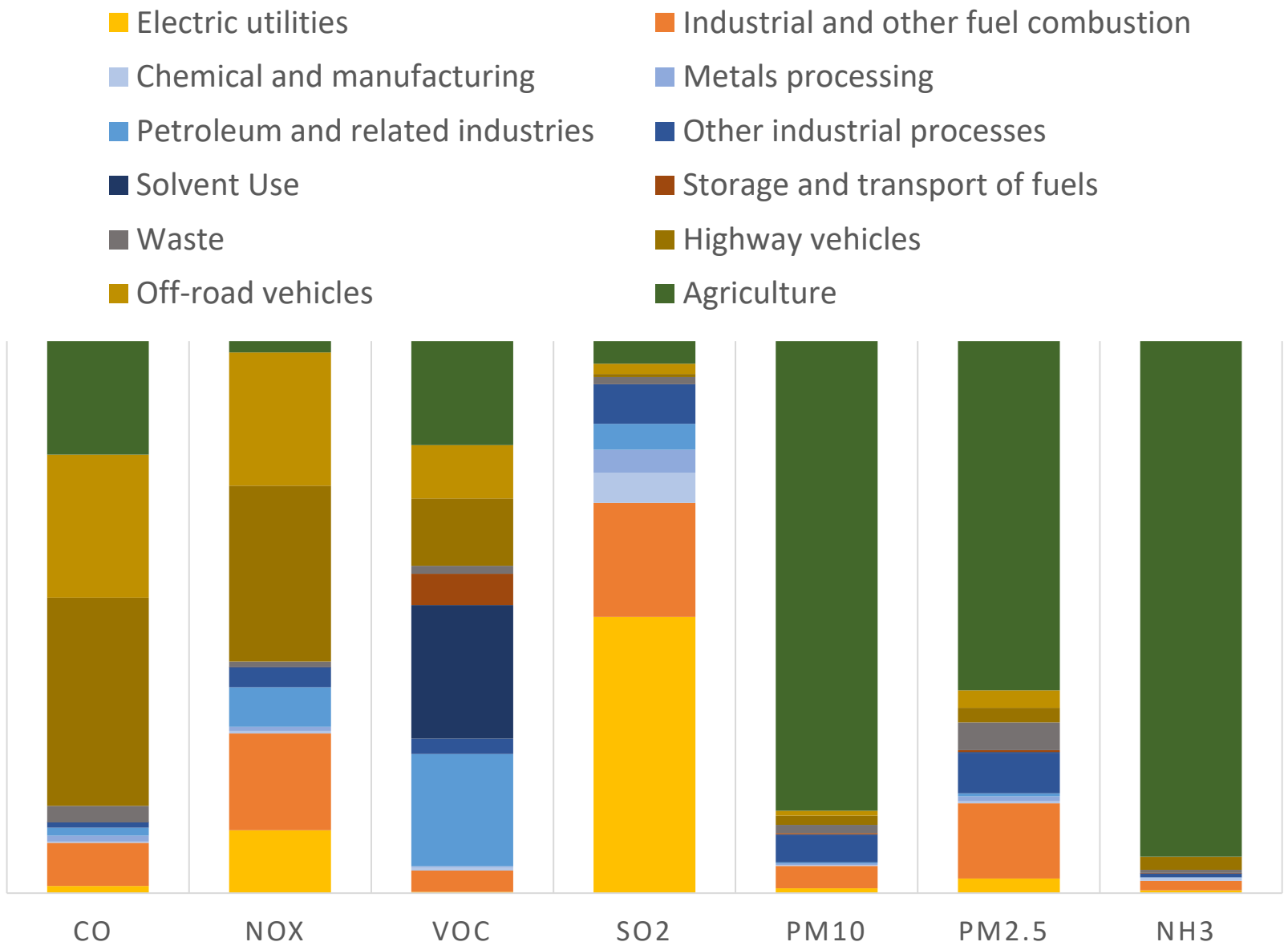
How are the data organized?

- Source Classification Code (SCC)
  - Four-tiers starting with broad sectors, down to resolving specific equipment and control technologies
  - More than 9,000
  - WebFIRE emission factor database lists existing emission factors, including AP-42 emission factors, for some SCC codes
  - Cross-reference tables map SPECIATE profiles to SCC codes
- Example for Residential Wood Heating Appliances
  - 19 different SCCs
  - Tier 1: Fuel Combustion Other
  - Tier 2: Residential Wood
  - Tier 3: Woodstoves
  - Tier 4: Woodstove: Non-catalytic Woodstoves: Pellet Fired [2104008053]



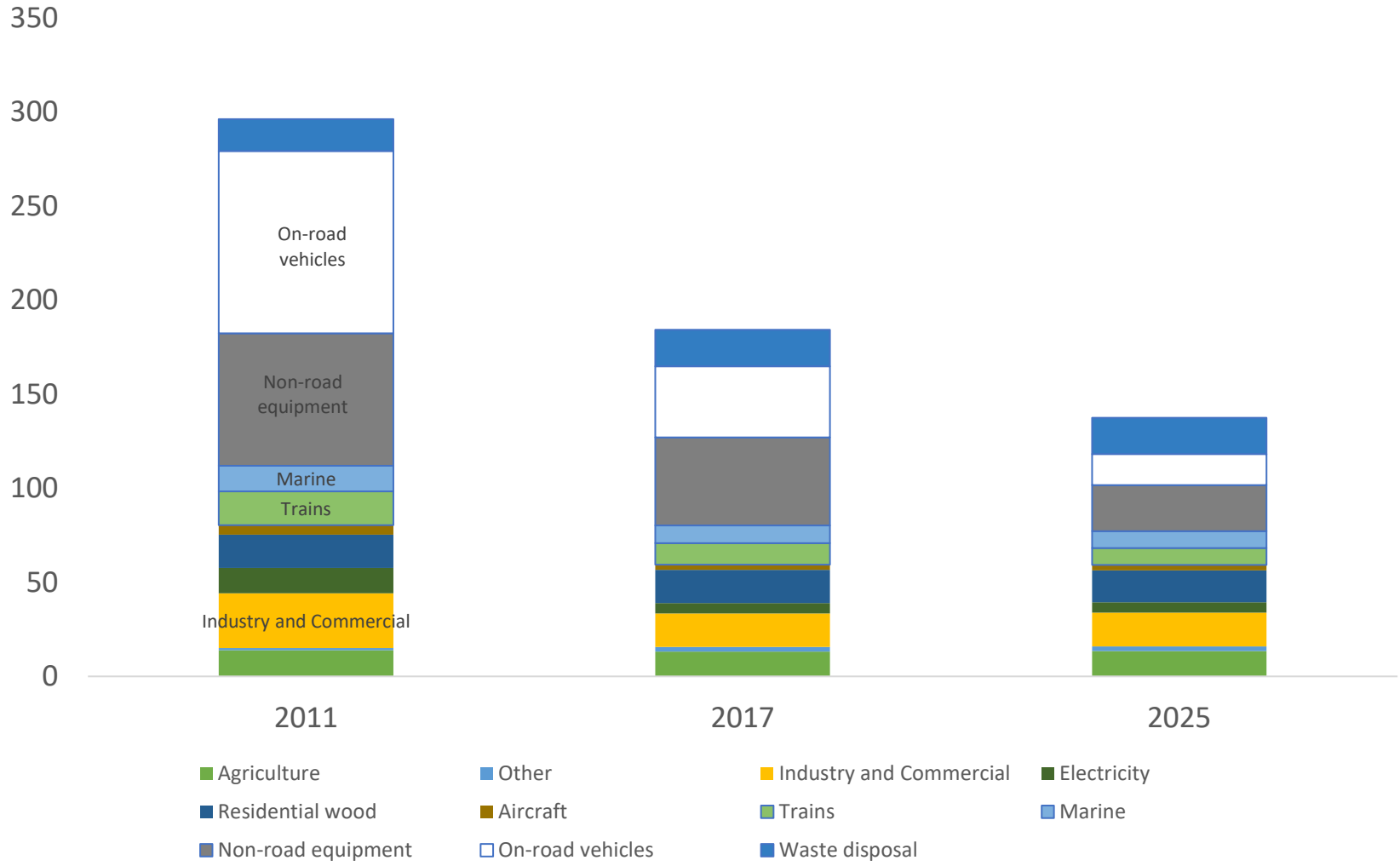
Source: U.S. Emission Report to the Convention on Long-range Transboundary Air Pollution (2021)

US 2019 EMISSIONS BY SECTOR AND POLLUTANT



Source: U.S. Emission Report to the Convention on Long-range Transboundary Air Pollution (2021)

U.S. Black carbon emissions (Gg per year)



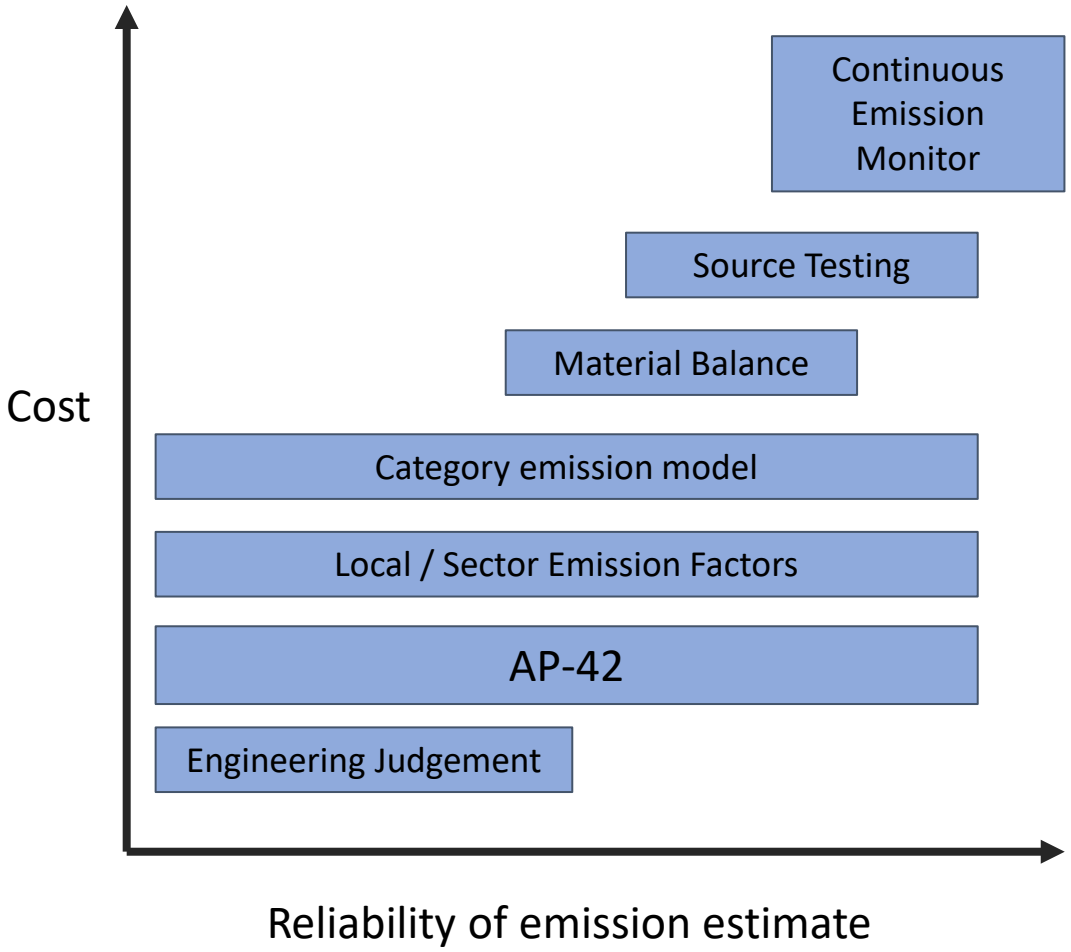
Source: U.S. National Report to Arctic Council's Expert Group on Black Carbon and Methane (2021)

Uncertainty

- Challenges
  - Many large datasets
  - Difficult to independently assess with observations
  - Quantifying uncertainty requires resources
- Types of uncertainty
  - Unknown emissions
  - Unresolved variability
  - Incomplete activity data
  - Errors (can be reduced through quality assurance techniques)

- Recent assessment by Day et al. (2019)
  - Trend: models or direct measurements are replacing emission factors
  - Opportunities to compare across inventories for outliers
  - Continuous assessment and frequent updates are essential

Uncertainty example: Stationary sources



- Emissions from stationary industrial facilities can vary depending on operating procedures, equipment type, and emission control technologies
- Default emission factors may not match specific practices at a facility
- Material balance may only be accurate in processes where nearly all the material is converted to emissions
- Recommend large sources are directly measured, and continuously measured if there is considerable temporal variability

Differences with GHG emission methods

- The time and place of emissions is important, not just annual total
  - This requires more activity data
  - May require time- and spatially-varying emission factors
- For some sectors where GHG methods use fuel-based emission factors, some SLCF emission factors use a different basis
  - Ship emissions are tracked using distance travelled between satellite-based automatic identification system checks
  - NEI includes aircraft take-offs and landings, but not cruise emissions
- Sector aggregations can differ, for example industrial combustion and process emissions

Applicability to other countries

- Methods and guidance can be applicable in other contexts
  - Emission System Structure
  - Data management and quality assurance
- Many globally important emission sources are highly variable and U.S. emission test conditions may not be applicable
  - Open burning: types of materials and burning conditions
  - Residential cooking: large range of conditions
  - Rare in U.S.: for example, brick kilns, three-wheeled motor vehicles
- Very challenging to develop representative Tier I methods using fuel-based emission factors for many sources, given diversity of emissions processes

Gaps and questions

- EPA methods are a hybrid of state-provided emissions data and emissions developed using nationally consistent methods – what is the right mix for the international community?
- Do existing IPCC emission categories have enough specificity to facilitate evaluation of reported inventories?
- To what extent do emission factors resolve the differences between particulate matter, condensable PM, intermediate volatility compounds, and volatile organic matter?