### Black carbon: Emission sources & prioritization

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- 1. Present-day emission sources
- 2. (Aside: Timing)
- 3. Future emission sources
- 4. (Aside: Forcing values)







2000 energy data; Includes updates in: residential coal (Chen, Zhi meas); residential biofuel (Venkataraman, Roden meas); industrial coal (Zhang meas; Streets technology divs); coal for power generation (new DRI meas posted & discussion with Liousse group); two-stroke engines (Volckens meas); shipping (Lack meas); diesel vehicles in developing countries (World Bank DIESEL project)

Present-day Inventory uncertainties?

- Emission estimates ARE quite uncertain
  - Factor 2-10, depending on sector
- + BUT, models are semi-constrained
  - Remote measurements within ~x2
  - Urban measurements within ~x10 (spatial mismatch problem– could be only ~3)



# reduction

Significant emission plus low OC/BC ratio

- Industry: Possible
- Transport: Definite
- Residential: Maybe
  - Large OC/BC variability
- Open burning: Doubtful
  - Near-Arctic sources may be exception







## Major emission sources

- Change in major categories highly unlikely
- ← Sectoral contribution percentages uncertain by ~50%
  - i.e. 20% could be 30%
  - Atmospheric concentrations
- + Do we know enough to work on transportation sources?

## YES.

- Significant contribution of BC
- Inventories, if biased, are probably low
- OC/BC ratio is variable, but will not produce cooling
  - UNLESS we discover something weird & wild about the indirect effect





## Sub-sector contributions/transport

- + On-road
  - Normal vehicles well known on average
    - Some uncertainty caused by in-use versus laboratory
  - Contribution of "superemitters" uncertain
     Both emission rates & quantities unknown
- + Off-road, construction/industry
  - Average is NOT well known
    - Especially in Asia/Africa!
  - All questions above apply
- + Off-road, shipping
  - Normal operators well known on average
    - Corbett's guesses trump Bond's (including rail?)
- + BC fraction IS NOT the major uncertainty now
- + Ready to act? Just a minute...



# Priorities beyond "standard" on-road work

- Better assessment of emission distribution
  - Can we easily target a sub-set?
- Collect off-road activity data
- Initial assessment of off-road emission rates
- + Places to start:
  - U.S. EPA
  - Encourage countries to estimate non-road in addition to on-road







(good or bad)



IF metric is based on convolution of responses (*and maybe it should be*)
THEN timing of emission decrement matters

Imposes (messy) requirement: Determine BASELINE – not just HOW MUCH, but WHEN.

# Basic rules for projecting future emissions emissions

- 1. There are two opposing mechanisms
  - 1. **DECREASE** in emission intensity [pollutant per fuel]
  - 2. **INCREASE** in fuel consumption
  - Who wins? Matter of faith (and assumptions)
- 2. Everything that is uncertain today is uncertain in the future
  - Unless it vanishes.
  - In that case, the rate of vanishing causes the uncertainty.



**WEur** 

SAsia

#### World











**WEur** 

1990 1995 2000 2005 2010 2015 2020 2025 203(

Fuel (Mtonne

**SAsia** 

1990 1995 2000 2005 2010 2015 2020 2025 2030

#### World





EUROI

EUROI

OPAC

□ NONE

**Future emissions** 

## It's the economy, stupid

World – b1 (previous slides) 🗆 Japan 200000 Oceania 180000 South East Asia East Asia 160000 South Asia 140000 Middle East 120000 Former USSR Eastern Europe 100000 OECD Europe 80000 Southern Aftrica Fastern Africa 60000 Western Africa 40000 Northern Africa 20000 South America Central America 0 1000 USA 1990 200 200 201 201 201 202 202 203 Canada Japan 250 Oceania South East Asia East Asia 200 South Asia Middle East 150 Former USSR Eastern Europe OECD Europe 100 Southern Aftrica Eastern Africa Western Africa 50 Northern Africa South America Central America 0 USA 1000 Canada



1.89° 200 20° 2010 2010 2020 2020

0

1990

Central America

USA

Canada

, <sup>1</sup>030

Fuel (Mtonne)

BC (Gg)



## Future transport emissions (I)

- On-road relatively well constrained (compared to everything else)
  - We understand how normal vehicles could change
  - Many regulations already underway
- Sticky baseline question
  - What would have happened "anyway"?
    - ⇒ Economics is one of the biggest uncertainties
  - Somewhere between "current legislation" and "max feasible"

# Future transport emissions (II)

Off-road NOT well constrained

Future emissions

STATE OF

KNOWLEDGE

- Average emission rate not well known
  - ⇒ Affects MAGNITUDE, not total reduction
- Rebuild frequency & quality
  - → To original regs? to current regs?
- Regulation drivers no history, how to predict?
- Action OK, or uncertainty too high?
  - Large potential; low OC/BC ratio
  - On-road: Prove that more than incremental difference is possible
  - Off-road: Almost any action will reduce emissions





### Reductions are already planned for measured, quantified sources

To take advantage of "missed opportunities", need:

- a metric that is flexible but unbiased
- treatment of uncertainty that is rigorous but not repressive

Final note

## Modeled forcing values used in metrics

- + One model is not enough
  - Even if it is "best"
  - Everyone should learn from the best models
- + Multiple models are not enough
  - Highlight diversity/uncertainty, BUT...
  - ...agreement can indicate similar assumptions (mistaken or otherwise)
  - Intercomparisons typically done with simple models
- + Observations are not enough
  - Divergence from models must be explained, not adjusted



- + Three processes that increase positive forcing:
  - 1. BC mixing with other aerosol
  - 2. Deposition on snow and ice
  - 3. Lofting above clouds
- Many models do not include these (1 & 2) or corroborate them (2 & 3)





Emitter size

### More information

Reporting requirements more stringent

**Greater efficiency** 

For large actors, poor efficiency = greater financial losses improved technology or controls are relatively more affordable

High emissions from small sources with little information

More fuel consumed

More emissions per fuel





## Region-specific diesel impacts

Same emission rates, same properties Warning: Preliminary!







