Current Domestic/International Control Programs on Ozone Precursors and Black Carbon

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MARCH 3, 2010





There are NO black carbon regulations

- There are no domestic and/or international control programs for black carbon. (some interpretation of CA laws suggests actual BC regulation)
- There are regulatory programs for primary and secondary particulates – Total Suspended Particulate (TSP); PM 10; and PM 2.5.
- These regulations are driven by health and ecological concerns; climate to date, is a co-benefit.
- Black carbon contributes in varying amounts to particulate matter
  - Actual contribution is dependent on sector, fuel, combustion conditions, transport and mixing.
  - Climate response depends on these factors

Outline of BC Policy Options

By Source

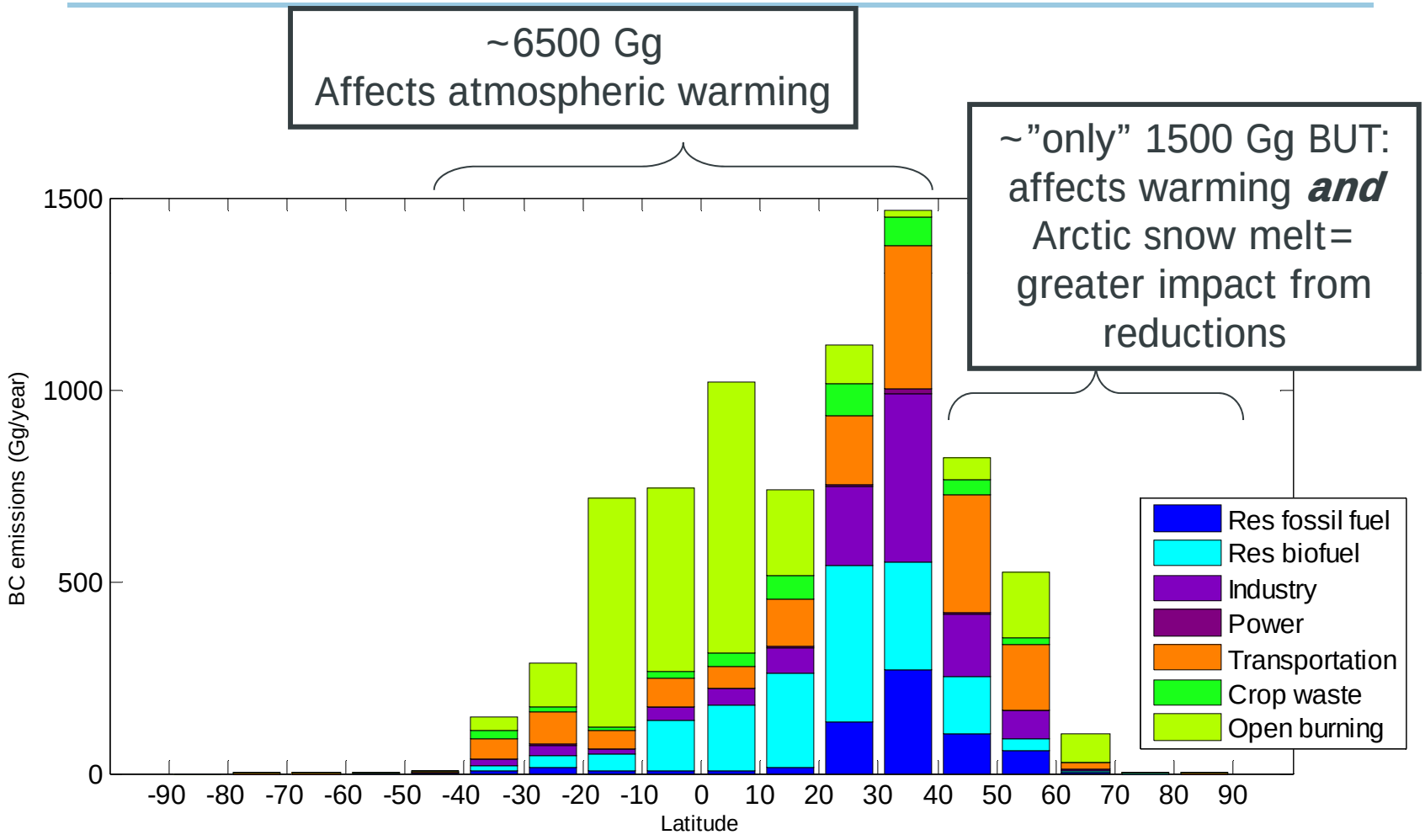
- Diesel –On and off road
- Cooking and heating stoves
- Agricultural Burning
- Industrial – coke ovens and brick kilns

What is being done?

What could be done?

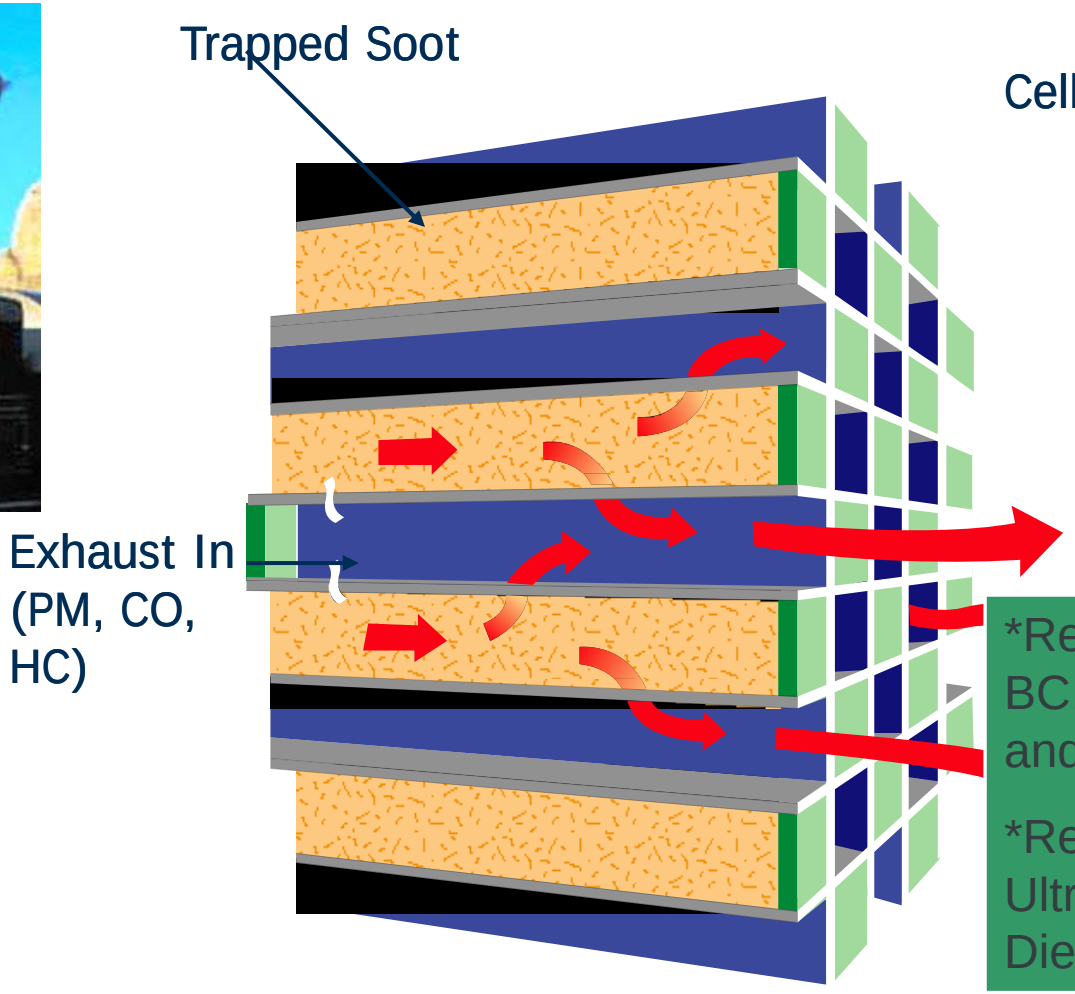
And a word about tropospheric ozone

Sources of black carbon by source & location



Source: Bond et al., 2004 (updated to year 2000 data); GFEDv2 (van der Werf, 2006)

Diesel Particulate Filters (DPFs) can reduce black carbon emissions by more than 90 percent relative to an uncontrolled engine.

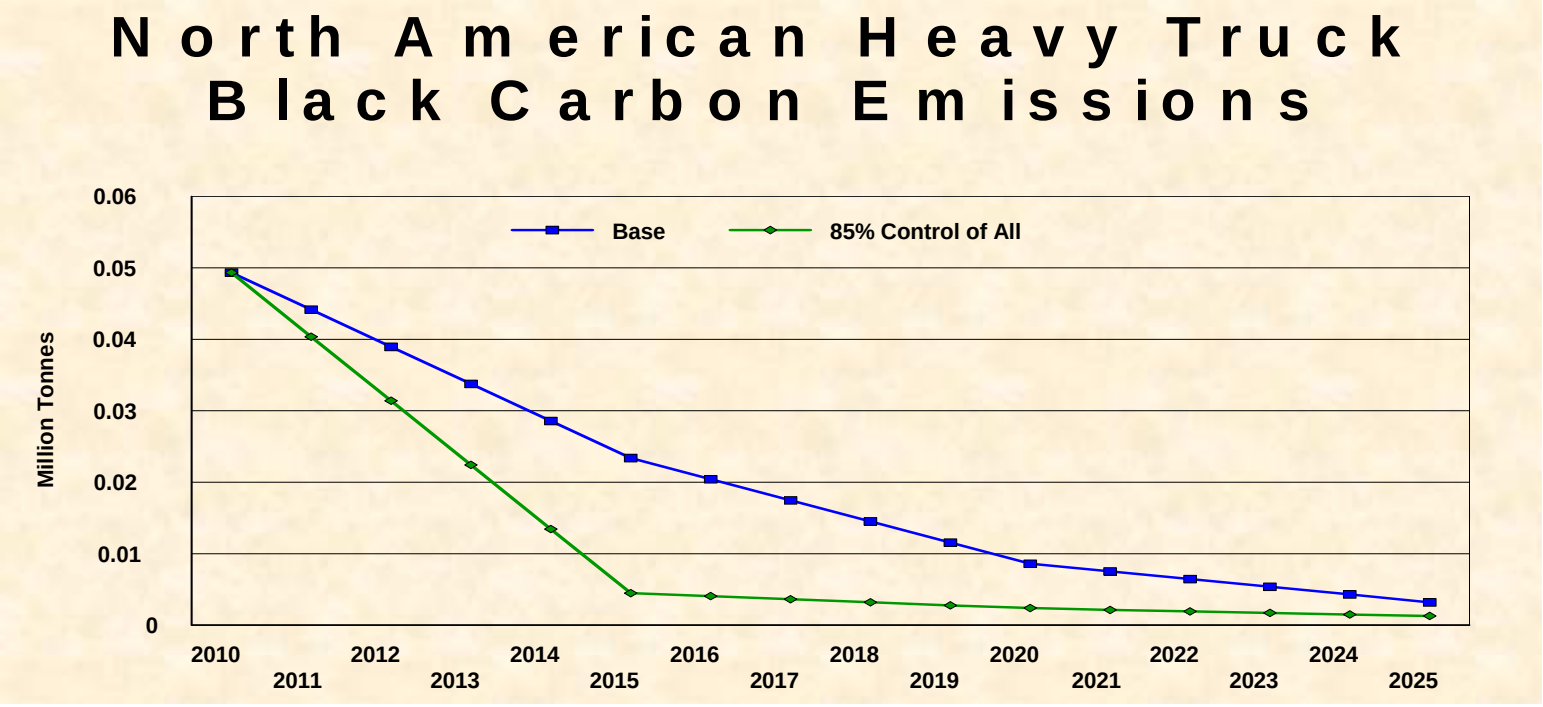


*Removes 90+% BC, PM; also HC and CO

*Requires Ultralow Sulfur Diesel (ULSD)

Diesel- Domestic Policy

- The U.S. has adopted standards for new engines that the U.S. EPA estimates will reduce particulate matter and black carbon emissions from diesel 90 percent by the year 2030.
- There remain 11 million diesel engines in use today in the US. The economic downturn has slowed the rate of fleet turnover, meaning potentially longer engine lifetime.



Courtesy of Michael Walsh

US opportunity for legacy fleet

- Under current Clean Air Act Sec. 202(a)(3)(D), EPA has the authority to require existing diesel vehicles to meet emission standards consistent with installation of a DPF whenever the engine is rebuilt.
  - A rule for engine model years 1998-2006 would cover about 1 million of the 11 million in-use diesel engines.
- EPA's National Clean Diesel Campaign is a voluntary effort that aims at 11 million legacy vehicles, but has very limited funds
  - In 2005, Congress passed the Diesel Emission Reduction Act (DERA), which authorized $1 billion over five years to a grant and loan program for diesel clean up. However, DERA has been chronically underfunded.
  - The American Reinvestment and Recovery Act (ARRA) did provide $300 million for DERA, but EPA has received $2 billion in project applications and so is sitting on $1.7 billion in unfunded projects that could cut black carbon.
- California has enacted or proposed extensive rules to require diesel retrofits or replacements; usually involve DPFs
  - Have set emissions standards and timetables that are targeted to achieve a 85 percent reduction in diesel particulate emissions by 2020.
  - For economic reasons, CARB has delayed off-road implementation and a delay for on-road implementation is proposed.

Diesel – International Policy

- EU and Japan have adopted similar light and heavy duty diesel standards as the US.
  - EU expects faster fleet turnover than is anticipated in the US
  - In Copenhagen, all commercial diesel trucks over 7 years old in must be equipped with a filter (~14,000 vehicles) and will be expanded to other Danish cities.
- India, China and Brazil have targeted most stringent European standards by 2015.
- Africa, Mideast and Latin America scheduled for less stringent standards by 2015.
- Major limiting factors is low sulfur fuel, since sulfur poisons particulate filter. Outside of the US and EU, with a few notable exceptions, low sulfur fuel is limited in most places in the world.
  - Maintaining implementation timelines is key
- In Beijing, scrappage of up to 150,000 high emitting trucks by mid 2010 and some retrofits.

Marine Vessels

- Marine vessels emit an estimated 2% of total global BC
  - Greatest concern is the release of BC in northern shipping routes close to the Arctic.
- Some estimates project that with a warming Arctic, shipping will increase by two to three times the global rate between now and year 2050.
- Air emissions from ships traveling in international waters are subject to international regulations set by the International Maritime Organization (IMO).
- On January 15, 2010, Norway, Sweden, and the US filed a joint paper to the Marine Environment Protection Committee (*MEPC*) of the *IMO* requesting that “the Committee discuss how to address BC by examining potential measures to be recommended or required to significantly reduce black carbon emissions from shipping having an impact in the Arctic.”

Measures to reduce BC from ships

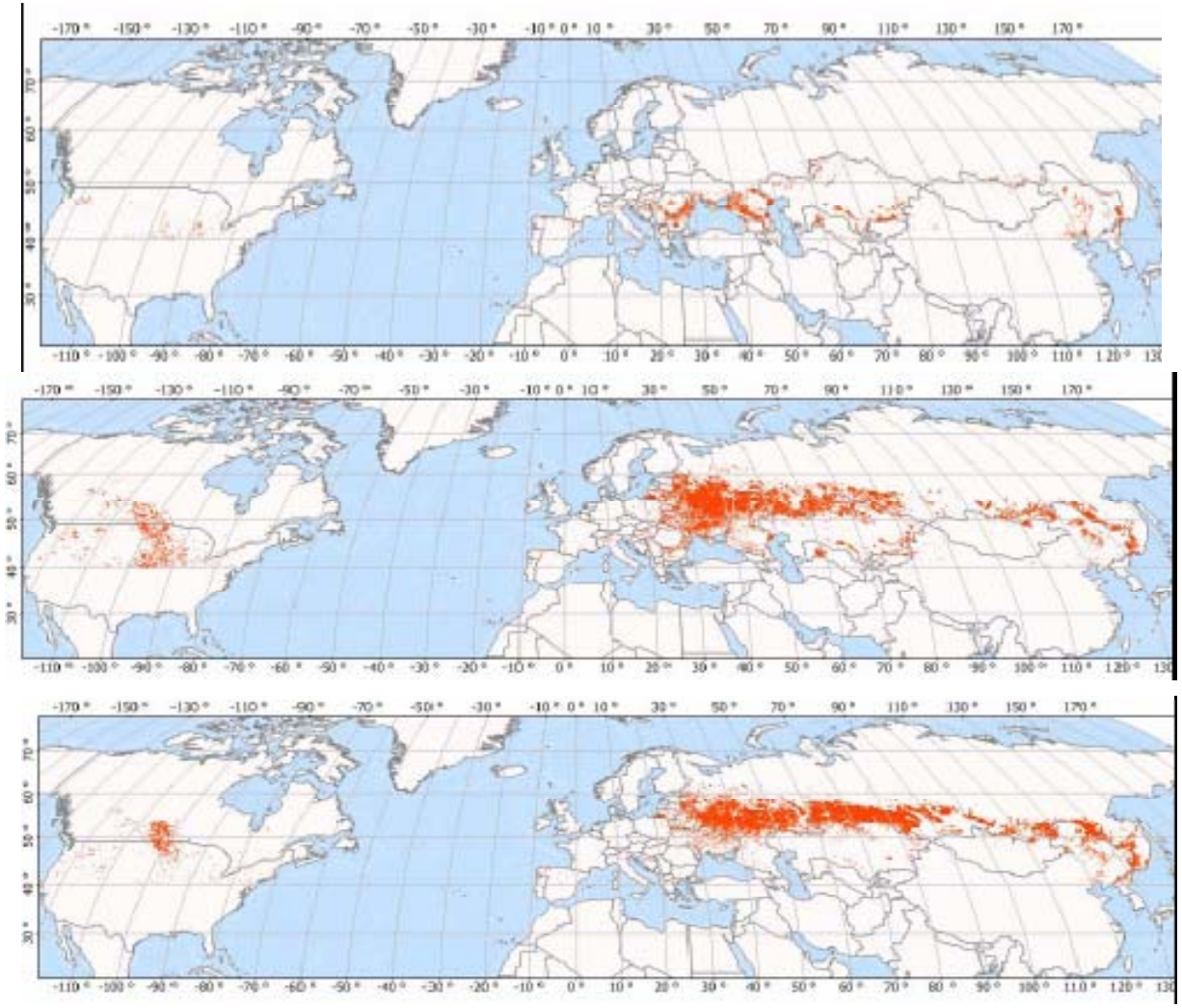
- Improved fuel injection systems and modified turbochargers.
- Water mixing and injection technologies,
- Slide valves produce more complete combustion than conventional valves, reducing PM and black carbon by 25% or more.
- Operational measures to increase fuel efficiency, such as vessel speed reduction.

Emissions from spring agricultural waste burns reaching the Arctic

March

April

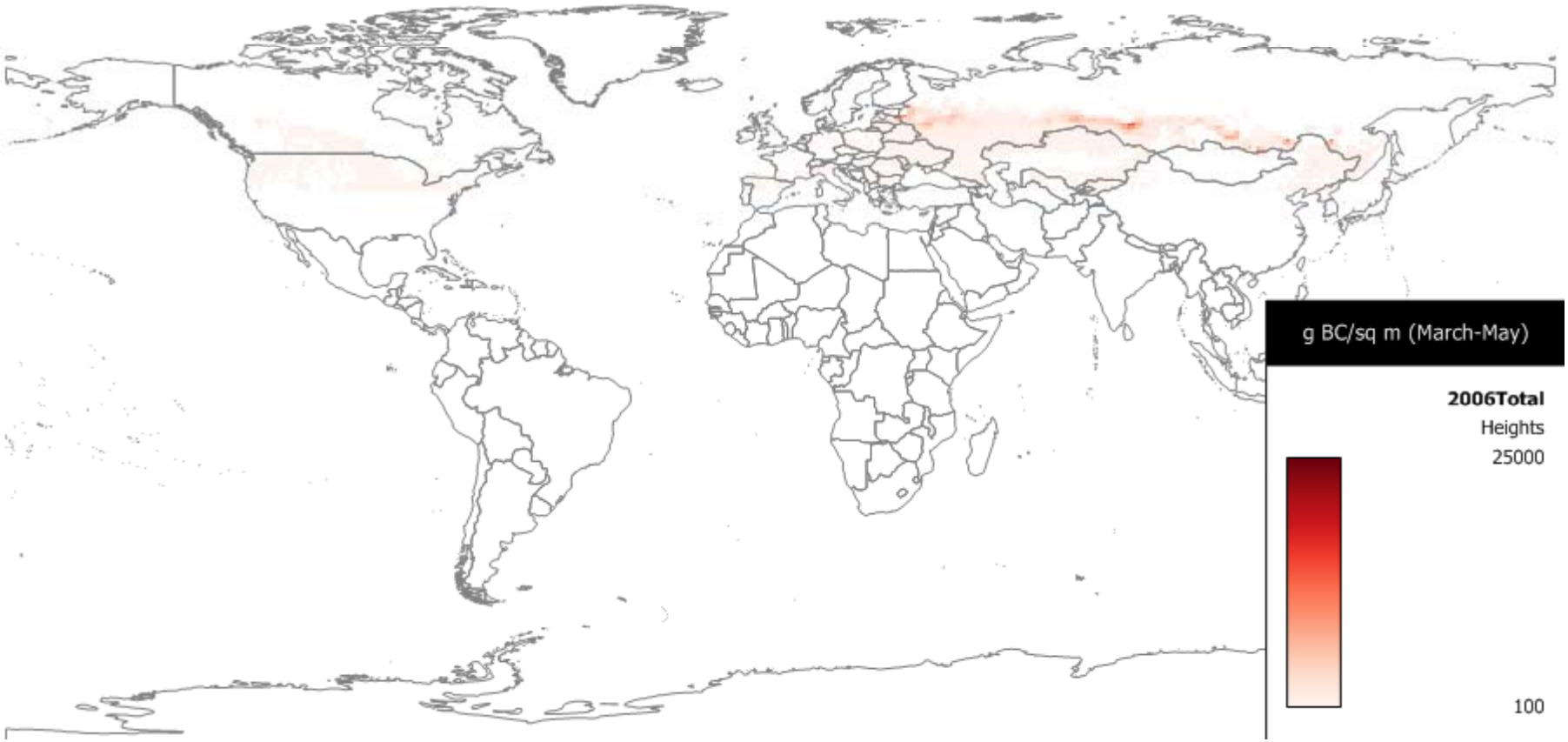
May



2006 fire burn locations, on croplands north of 40 degrees latitude, during spring months 2006 is a typical fire year.

From, MODIS Terra Global Land Cover and Burned Area, 1 km

Black carbon emissions from cropland burning, north of 40°, spring 2006



From Randerson JT, van der Werf GR, Gilgio L, Collatz GJ, Kasibhatla Global Fire Emissions Database, www.geo.vu.nl/users/gwerf/GFED/ index.html and Andreae MO, Merlet P. GBC

Options to reduce agricultural burning

- Ban spring time burning
- Expand uses for crop waste, including biochar production *via* pyrolysis.
- Timing and permit fires, based on meteorological conditions and forecasts to avoid transport of black carbon to the Arctic and other vulnerable snow covered areas.

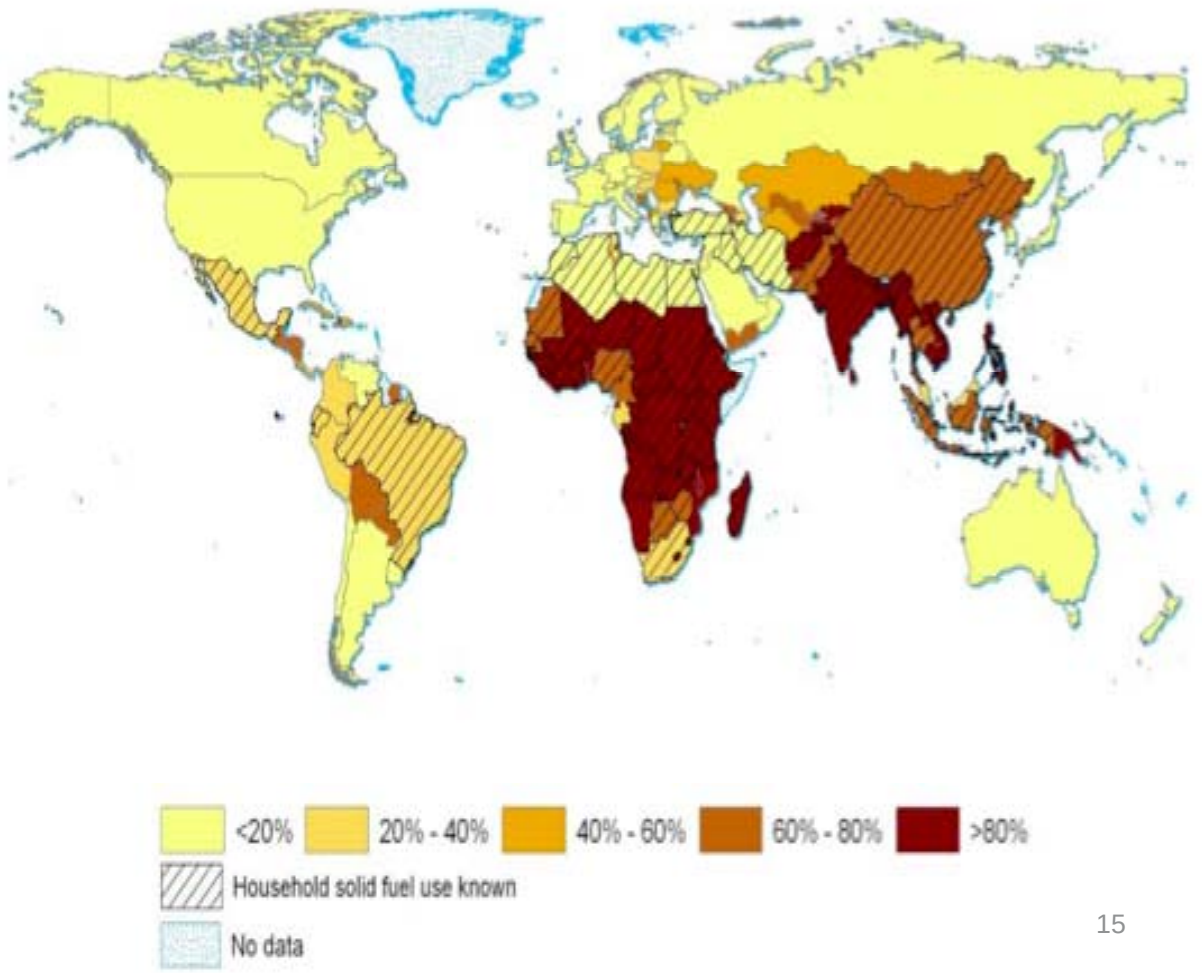
Burning Controls

- Burning is regulated at the state level, with requirements varying by state.
  - Many states require permits for open-field burning, and state officials post “no-burn” periods during dry and high wind conditions.
  - Some upper Midwest US states ban burning, although fire point data show field burning is occurring
- Burning has been banned in most European countries.
- There are burning bans and restrictions elsewhere, with varying levels of enforcement.

Solid fuels– cooking and heating Not just a lower latitude source

Household solid fuel use 2000

Solid fuels are the major source of back carbon in Scandinavian countries.



Domestic controls

- EPA regulates post 1992 wood stoves.
  - Under the Clean Air Act, all wood heating appliances offered for sale are subject to the New Source Performance and are required to meet emission limits.
- At issue is older stoves that are still in use.
- Also possible that new stoves do a better job of reducing organic carbon than black carbon.
- ***Also emissions from oil furnaces, which are poorly measured; would have regional impact, such as in NE US.*

Spare the air days

- The Bay Area Air Quality Management District (CA) issues a Winter Spare the Air Alert when : concentrations of PM2.5 will exceed the national health-based standard,
- On these days burning of wood, firelogs, pellets, or any other solid fuels in your fireplace, woodstove, or other wood-burning device is **illegal.**
- There are regions and communities throughout the US with similar programs.

Controls -- International

- A myriad international and country-specific programs exist to promote the use of cleaner cookstoves.
  - Few have reached the commercial scale needed to meaningfully address the nature of this global problem and have fail to achieve measurable improvements in health and safety, combustion efficiency, or reduced emissions of BC and other pollutants

Some specific program initiatives include:

- The UN Foundation seeks to build a Global Alliance for Clean Cookstoves, with the goal of deploying millions of stoves in target countries by 2015.
- EPA's Partnership for Clean Indoor Air (PCIA) has over 330 partners operating in 115 countries and is growing.
- In December 2009, India announced a major national initiative on biomass cookstoves, with a goal of scaling up to replacing over 150 million cookstoves.

Industrial BC Emissions

- Industrial sources are estimated to produce a significant fraction, 18 percent, of global black carbon emissions. Major source fractions are uncertain, but in order of contribution:
  - Kilns (mostly brick making)
  - Coke making
  - Boilers, industrial process, steel, lime
- ***Emissions information for most sources are extremely limited.***

Brick Kilns

- Many brick kilns ~ 300,000 worldwide
- Primary fuels are coal, plus any low-cost fuel that can be scavenged (tires, battery cases, dung, etc.)
- Most brick kilns in developing countries are primitive and appear to significant BC and other emissions.
- 75% global brick production
  - China: 54% 700 billion bricks/yr
  - India: 10% 144 billion bricks/yr
  - Pakistan: 8% 100 billion bricks/yr
  - Bangladesh: 4% 50 billion bricks /yr
- Shifting to improved technology kilns will typically reduce fuel consumption and CO_2 emissions.
- BC emissions control measures will ***likely*** occur by replacing kilns with improved technology.
- Measurement of climate-relevant emissions are needed to quantify the climate mitigation opportunity from improving brick kilns.

Brick kilns -- Controls

- Low fuel efficiency, high polluting continuous kilns have been banned by law in China since at least the mid 1990's because of their low fuel efficiency.
- Some highly polluting kiln designs, while widely used in South Asia, have been banned in India since 2002 and in Nepal, in Kathmandu Valley, since 2004.
- In January 2009, the Environmental Protection Agency of Pakistan (Pak-EPA) ordered brick makers in and around the capital to close their operation or switch to alternative technology because of the high level of pollution produced by primitive kilns.
- We have no additional information on the success of these orders and bans.

Coke Making

- Relatively small number of global coke making facilities ~ 1500 worldwide
- Recent – 2006 production – is dominated by China;
  - China 59%
  - Russian Federation 6%
  - Ukraine 4%
  - US 3%
  - India 2.5%
- China production represents 96% of global production growth since 2000.

- Most traditional coke ovens (prevalent through the late 1990s) are probably gone.
- Most coke ovens today support chemicals “recovery” -- need lots of emissions control measures – or “non-recovery” facilities – a much cleaner process.
- Plausible BC emissions reduction measures will come from a complex range of small particulate emissions control, most of which achieve or go beyond current US EPA control levels.

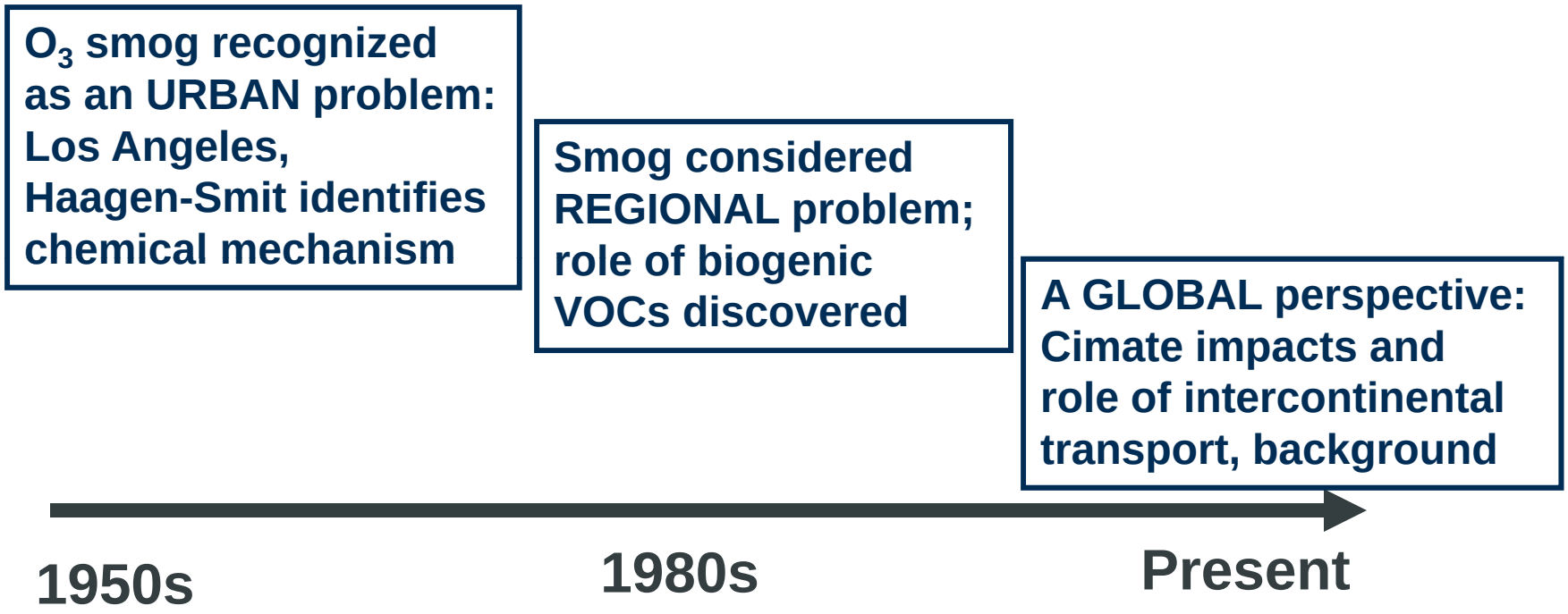
Coke Making -- Controls

- PM reductions will come from
  - Upgrading from primitive to modern kilns
  - Control measures during stages of processing and operation
  - Regular maintenance
  - Stacks on modern coke ovens allow for installation of pollution control equipment
- China is phasing out primitive ovens
- Need measurements of climate relevant properties

Flaring from oil and gas

- Oil and gas flaring is a source of PM and black carbon.
- Questions/Issues
  - How much PM and black carbon are produced?
  - How does this vary by location and conditions?
  - How will this change in the Arctic with increased oil and gas exploration?
- No accepted protocols for quantifying PM from these or other open sources
- Need a mechanism to insure methane capture to reduce BC emissions that can result from increased exploration that is likely to occur.

Ozone abatement strategies have evolved along with understanding of the O_3 issues

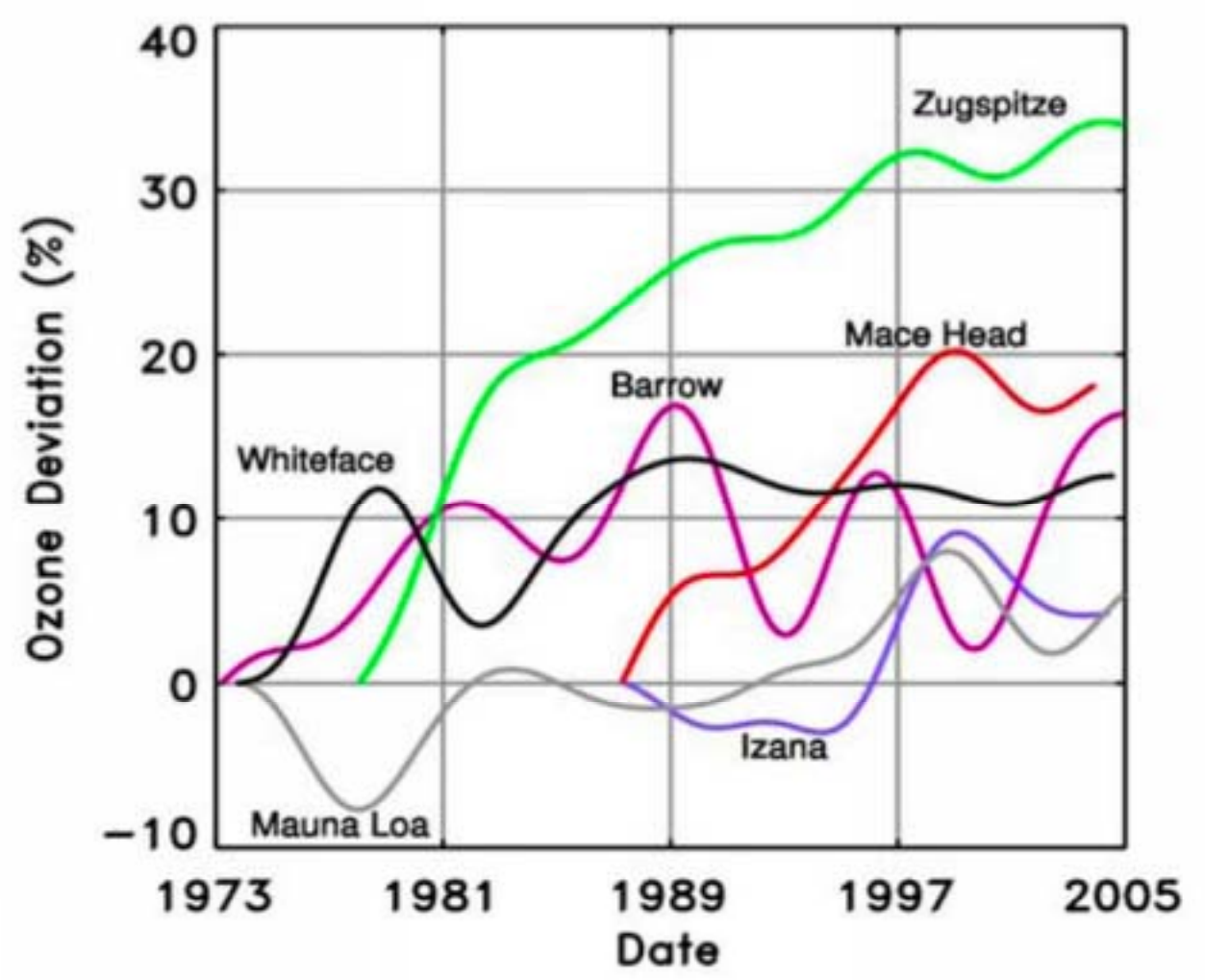


Abatement Strategy:

NMVOCs **+ NO_x** **+CH_4, CO**

adapted from Fiore, 2002

General upward trend for background ozone



Oltmans, 2006

EPA has recognized the need to

July 2007 staff paper: "The welfare impact of O3 on local, regional and global climates has received more attention in recent years. Ozone enhances the heat capacity of the atmosphere. The overall body of scientific evidence suggests that high concentrations of O3 on a regional scale could have a discernable influence on climate, leading to surface temperature and hydrological cycle changes. However… confirming this effect will require further advances in monitoring and improvement in chemical transport and regional-scale modeling."

Methane reductions needed for ozone climate control

- Unlike other ozone precursors, methane is not a typical, short-lived ozone precursor.
- Because methane has a long atmospheric lifetime (8-10 years), emissions become well mixed.
- Neither air quality nor climate benefits depend strongly on the location of the CH4 emission reductions, implying that the lowest cost emission controls can be targeted.

Conclusion

- No BC regulation
- BC is currently controlled via PM regulations
- BC varies in its contribution to particulate matter, which means the climate impact differs by source.
- Some sources offer large climate benefits
- Lack of measurements limit our ability to quantify impacts of emissions and reductions.
- Need to focus on strategies to reduce background tropospheric ozone