

Evolving Role of Black Carbon in Climate Change

**Briefing sponsored by EESI
Russell Senate Office Building
Washington, DC
November 9, 2010**



Benjamin DeAngelo
U.S. Environmental Protection Agency

Overview



- BC 101
- Some ongoing efforts
- Key messages with current state of knowledge

Black Carbon: Some basic points



- BC is most strongly light absorbing component of direct PM_{2.5} (emitted as a result of incomplete combustion)
- BC is a significantly different climate problem compared to GHGs
- Reductions in BC will have immediate benefits, both for health and – in some regions – for climate
- Some significant climate science uncertainties remain

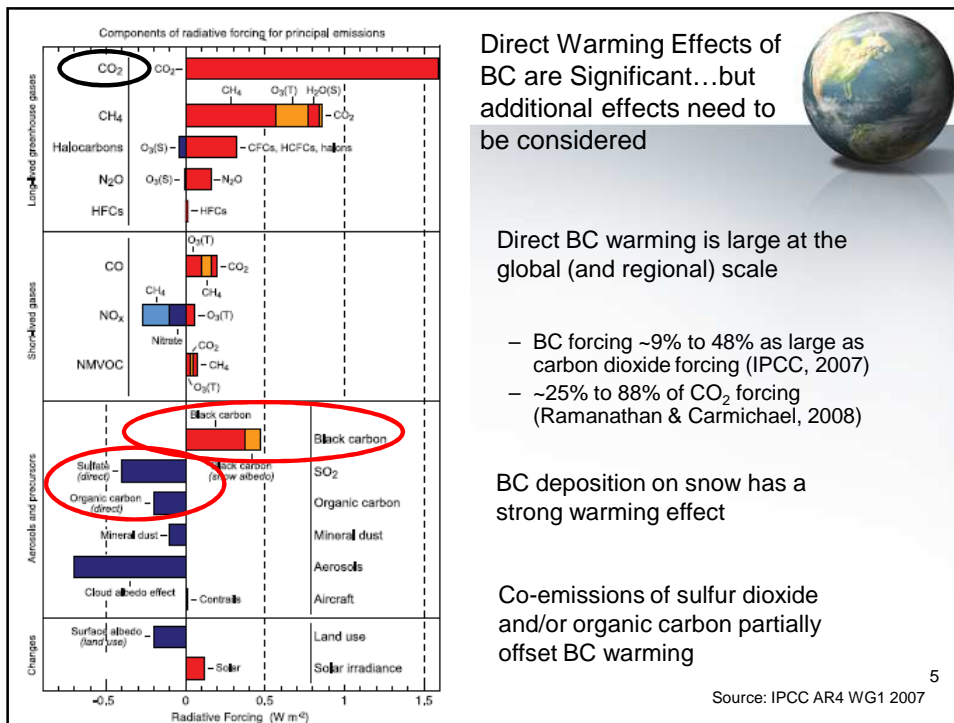
3

Key Differences Between BC and GHGs



- Distinguishing features of black carbon (BC):
 - Short-lived in atmosphere (not well mixed like GHGs)
 - Local/regional pollutant (not global)
 - Causes precipitation, “dimming”, and snow albedo effects not directly associated with GHGs
 - Co-emitted with other aerosols including organic carbon; depending on source & location, total emissions may have net cooling effect
 - No standard definition or measurement approach
- Practical implications relative to GHGs:
 - More immediate response (potential benefit) following mitigation of BC
 - Large, unequivocal public health benefits of reducing BC
 - But... magnitude and nature of BC climate effects more uncertain
 - Location of BC emissions and thus mitigation activity matters more
 - Climate benefit depends on specific source emissions mixture

4



Direct Warming Effects of BC are Significant...but additional effects need to be considered



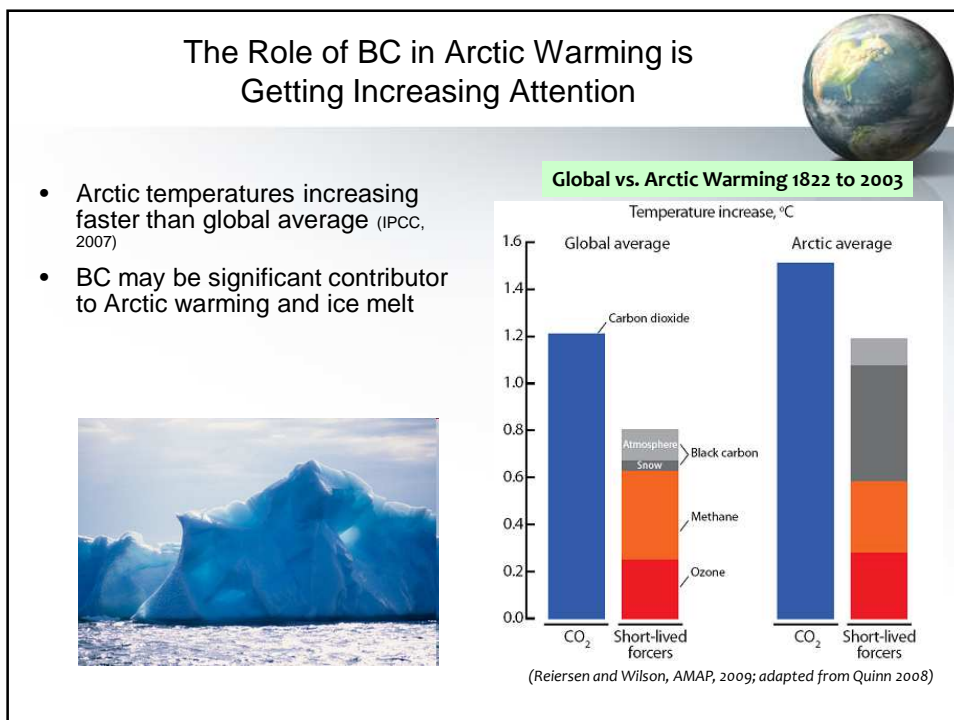
Direct BC warming is large at the global (and regional) scale

- BC forcing ~9% to 48% as large as carbon dioxide forcing (IPCC, 2007)
- ~25% to 88% of CO₂ forcing (Ramanathan & Carmichael, 2008)

BC deposition on snow has a strong warming effect

Co-emissions of sulfur dioxide and/or organic carbon partially offset BC warming

5



Other Snow and Glacier Dominated Regions May be Affected



In the Himalayan region, solar heating from **BLACK CARBON** at high elevations may be just as important as carbon dioxide in the melting of snowpacks and glaciers (Ramanathan & Carmichael, 2008)

Western U.S.

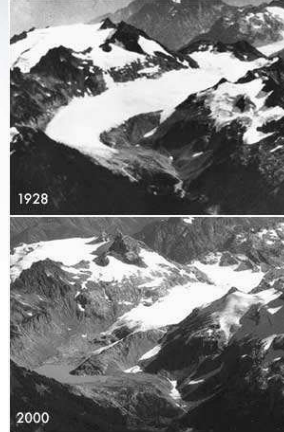
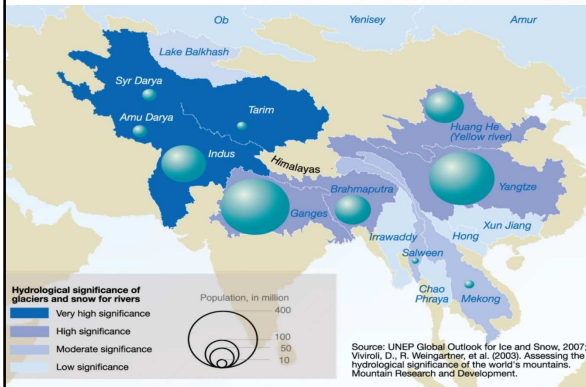


Photo: USGS

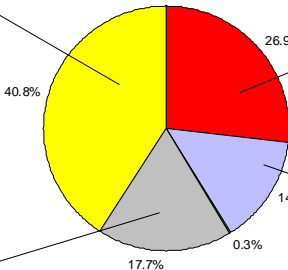


7

Global Sources of Black Carbon



BC Emissions, 1996 (8,038 Gg)



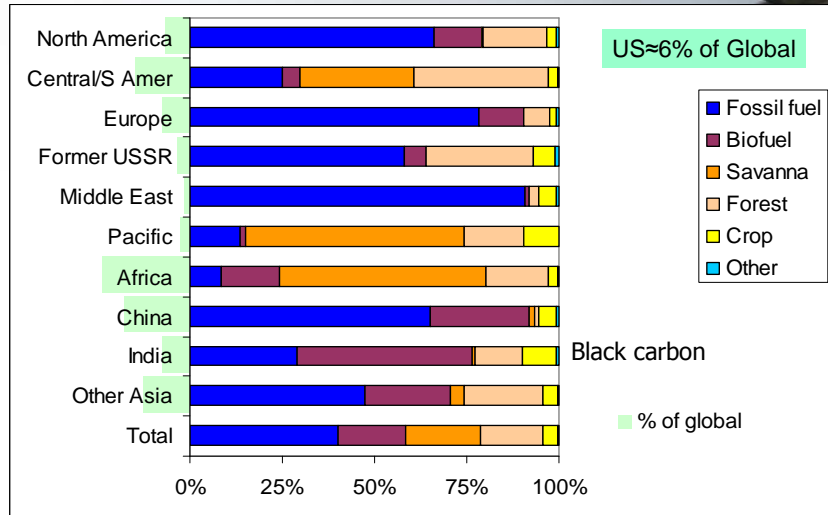
■ Residential
 ■ Power Generation
 ■ Transport
 ■ Biomass Burning
 ■ Industry



Source: Bond et al. 2004⁸

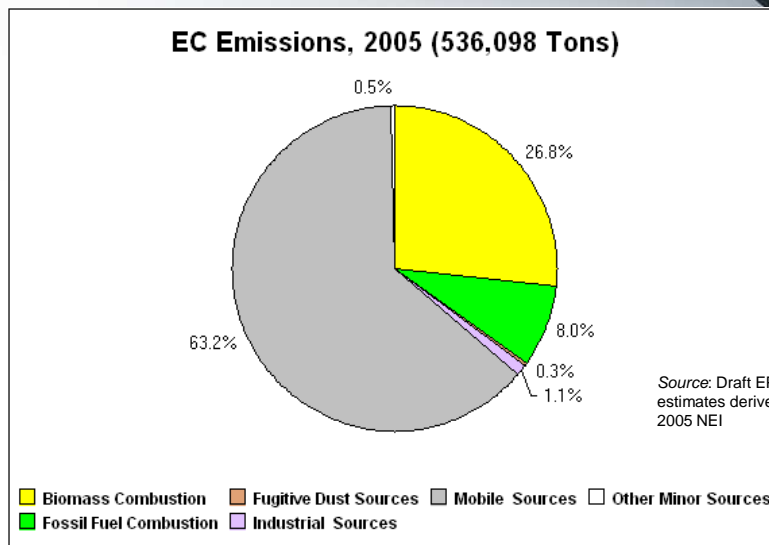
Global sources of BC by region and by major source (with open biomass burning)

** Green bar at left indicates % of Global Total Emissions



Source: Bond et al. (2004) "A technology-based global inventory of black and organic carbon emissions from combustion," *J. Geophys. Res.*

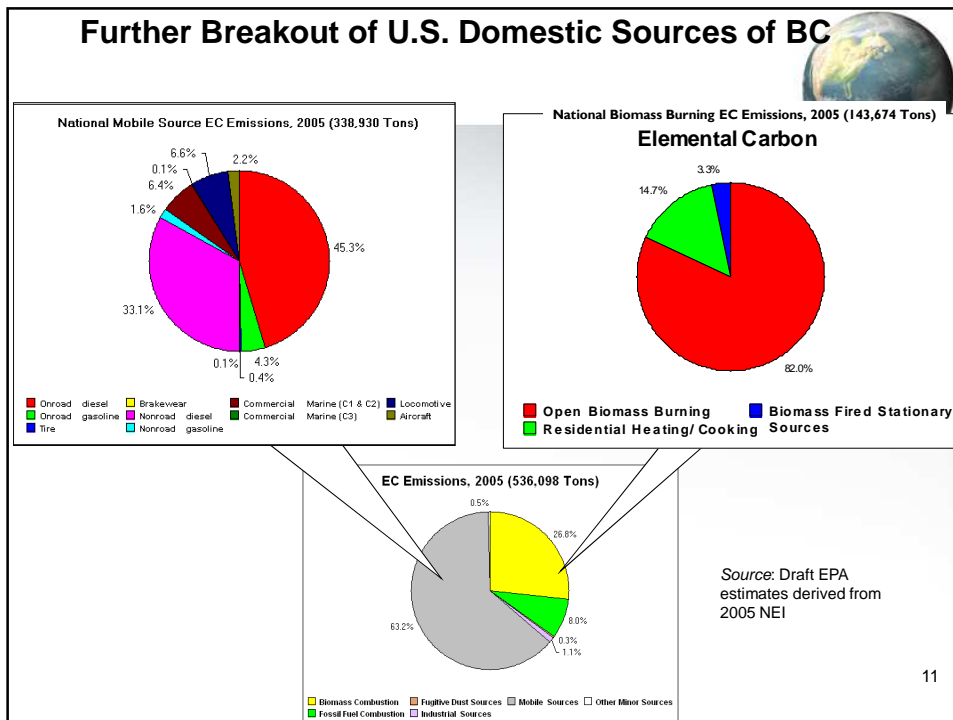
U.S. BC Emissions Breakdown



Source: Draft EPA estimates derived from 2005 NEI

10

Further Breakout of U.S. Domestic Sources of BC



11

EPA's Report to Congress on Black Carbon

October 2009 Interior Appropriations Bill Requirement

- "Not later than 18 months after the date of enactment of this Act, the Administrator, in consultation with other Federal agencies, shall carry out and submit to Congress the results of a study on domestic and international black carbon emissions that shall include
 - an inventory of the major sources of black carbon,
 - an assessment of the impacts of black carbon on global and regional climate,
 - an assessment of potential metrics and approaches for quantifying the climatic effects of black carbon emissions (including its radiative forcing and warming effects) and comparing those effects to the effects of carbon dioxide and other greenhouse gases,
 - an identification of the most cost-effective approaches to reduce black carbon emissions, and
 - an analysis of the climatic effects and other environmental and public health benefits of those approaches."

12

Other Ongoing BC Activities



- **EPA OAR/ORD-sponsored workshop on Short-Lived Climate Forcers;** March 3-4, 2010
- **Convention on the Long Range Transport of Air Pollution (LRTAP) Expert Group on Black Carbon**– assessing whether PM2.5 addition to the Gothenburg Protocol should include separate provisions for BC. Report completed; to be discussed by LRTAP Executive Body in December 2010
- **“Bounding BC” study** from International Global Atmospheric Chemistry (IGAC)/Stratospheric Processes and their Role in Climate (SPARC) projects– focus on reducing scientific uncertainties about BC. Draft Fall 2010
- **United Nations Environment Program (UNEP) Black Carbon and Ozone Assessment**– regional mitigation options. Draft early 2011
- **Arctic Council Task Force on Short Lived Climate Forcers**– covers emissions/impacts/mitigation options for BC in Arctic. recommendations for May 2011 foreign minister-level meeting
- **ClimateWorks-funded McKinsey study re: mitigation cost-curves for BC, methane and F-gases.** Release Fall 2010 ?

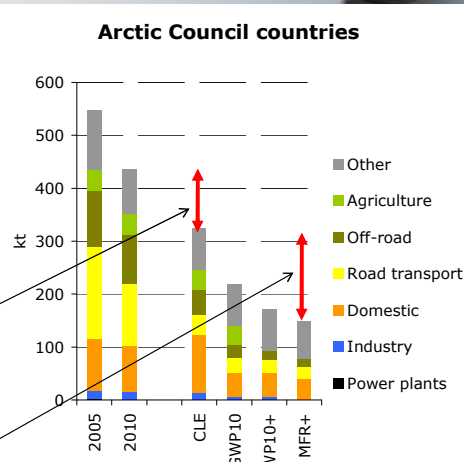
13

Arctic Council Task Force Work to Date

Summary Message on Black Carbon Emissions



- As a result of Task Force, some country emission inventories being estimated for first time, and compared with research community
- Largest emission sources can be identified
- Reductions from transport emissions account for almost all projected decline by 2030; other sources projected to remain largely unchanged without additional measures
- Additional reduction opportunities remain in transportation, residential and agricultural/forestry sectors, and possibly gas flaring



Source: draft analyses by IIASA GAINS model, 2010

Note that CLE represents expected 2030 reductions with current legislation and other bars assume progressively more measures beyond current legislation

14

Arctic Council Task Force Work to Date:

Recommendations being considered for Arctic Council countries on transport



- **On-road and off-road diesel vehicles and equipment**

- Appear to be the largest source in terms of gross emissions, and the only source forecast to decline significantly with existing measures
- Regulations that target particulate matter for new vehicles with filter-based standards, if fully implemented, are projected to reduce black carbon from new vehicles to near-zero
- This emissions decline could be accelerated by:
 - more retrofitting of older vehicles
 - enhancing current controls on existing vehicles and equipment
 - improving inspection and maintenance programs
 - accelerating the timeline or broadening the scope of existing regulations for new engines.

15

Arctic Council Task Force Work to Date:

Recommendations being considered for Arctic Council countries for residential burning



- **Residential burning for heat**

- Appears to be a major source of emissions that reaches the Arctic
- Source appears significant for all Arctic Council nations
- Projected to remain essentially unchanged in 2030 without new and additional measures
- Potential measures include:
 - Improved technology
 - Additional BC or PM standards
 - Change-out programs (e.g., pellet stoves)
- Jurisdictional issues to consider given role of sub-national governments

16

Arctic Council Task Force Work to Date:

Recommendations being considered for Arctic Council countries for open burning



- **Agricultural burning and wildfires**
 - Appear to be significant sources reaching the Arctic
 - Some Council nations already ban agricultural burning; others control when and where burning may occur; others rely solely on local regulation. Improvements are possible
 - Potential measures include no-burn and no-till methods, or highly controlled burns to prevent wildfires
 - Strong health, environment and public safety co-benefits
 - Jurisdictional issues to consider given role of sub-national governments

17

Arctic Council Task Force Work to Date:

Recommendations being considered for Arctic Council countries for shipping and gas flaring



- **Shipping**
 - Currently small source but potentially high future impact due to melting sea ice and consequential increased traffic
 - Council nations comprise 90% of current shipping activities in Arctic, so within-Council action has good opportunity to impact problem
 - Measures might also include broader engagement with IMO
- **Gas flaring**
 - Remains a large unknown, but potentially highly significant source of black carbon emissions, especially as oil and gas activities expand
 - Premature to identify measures. Improved emission estimates, private sector engagement and in-field measurements are needed

18

Summary of key messages



- Reducing emissions of black carbon provides health benefits
- Evolving climate science on black carbon means we cannot always say with confidence what the climate benefit of a mitigation action will be
 - Timing/location: regional benefits for hot spot areas very likely
 - Role of co-emissions by source
 - Role of cloud effects
- Ongoing efforts should provide greater understanding of this issue over coming months/year
- Emission sources and trends are different in US/industrialized countries vs. Asia and Africa
 - Particulate matter policies driving downward trend in industrialized countries
 - Transportation, residential burning, small industry might contribute to a possible upward trend in other world regions

19