Black Carbon and Arctic Policy

Science informing policy

Marcus C. Sarofim
EPA Climate Change Division

EPA STAR Black Carbon Progress Review

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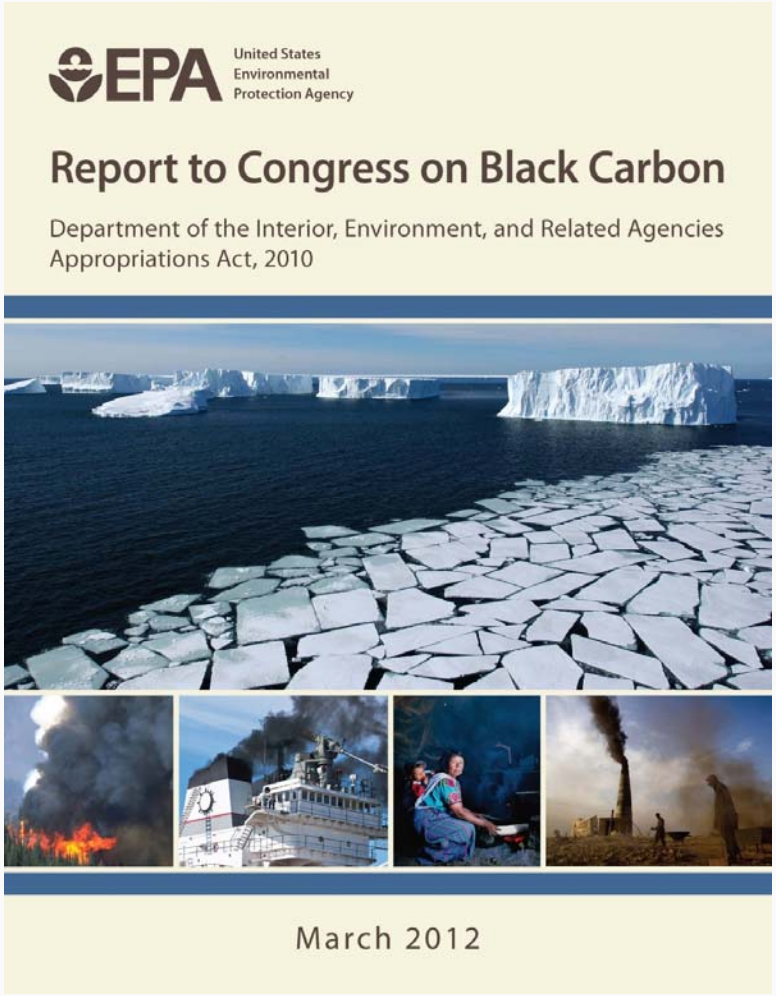
Arctic Council's Kiruna Declaration, May 2013

- Recognize that reduction of short-lived climate forcers, could slow Arctic and global climate change, and have positive effects on health, and welcome the report on short lived climate forcers, and support its recommendations including that national black carbon emission inventories for the Arctic should continue to be developed and reported as a matter of priority
- Decide to establish a Task Force to develop arrangements on actions to achieve enhanced black carbon and methane emission reductions in the Arctic, and report at the next Ministerial meeting in 2015
- In response, EPA has been engaged in this task force to develop a voluntary agreement that will encourage improved quality and transparency of black carbon emissions reporting and mitigation actions among Arctic Council countries, plus some observers.

Motivations for BC Mitigation in an Arctic Context

- Near-term climate change and SLCFs
- Amplified Arctic effects
  - snow & ice deposition
  - Albedo effects
  - Arctic haze
- Contribution of near-Arctic emissions
  - Arctic Council nations have greater relative contribution
- BC health effects imply co-benefits

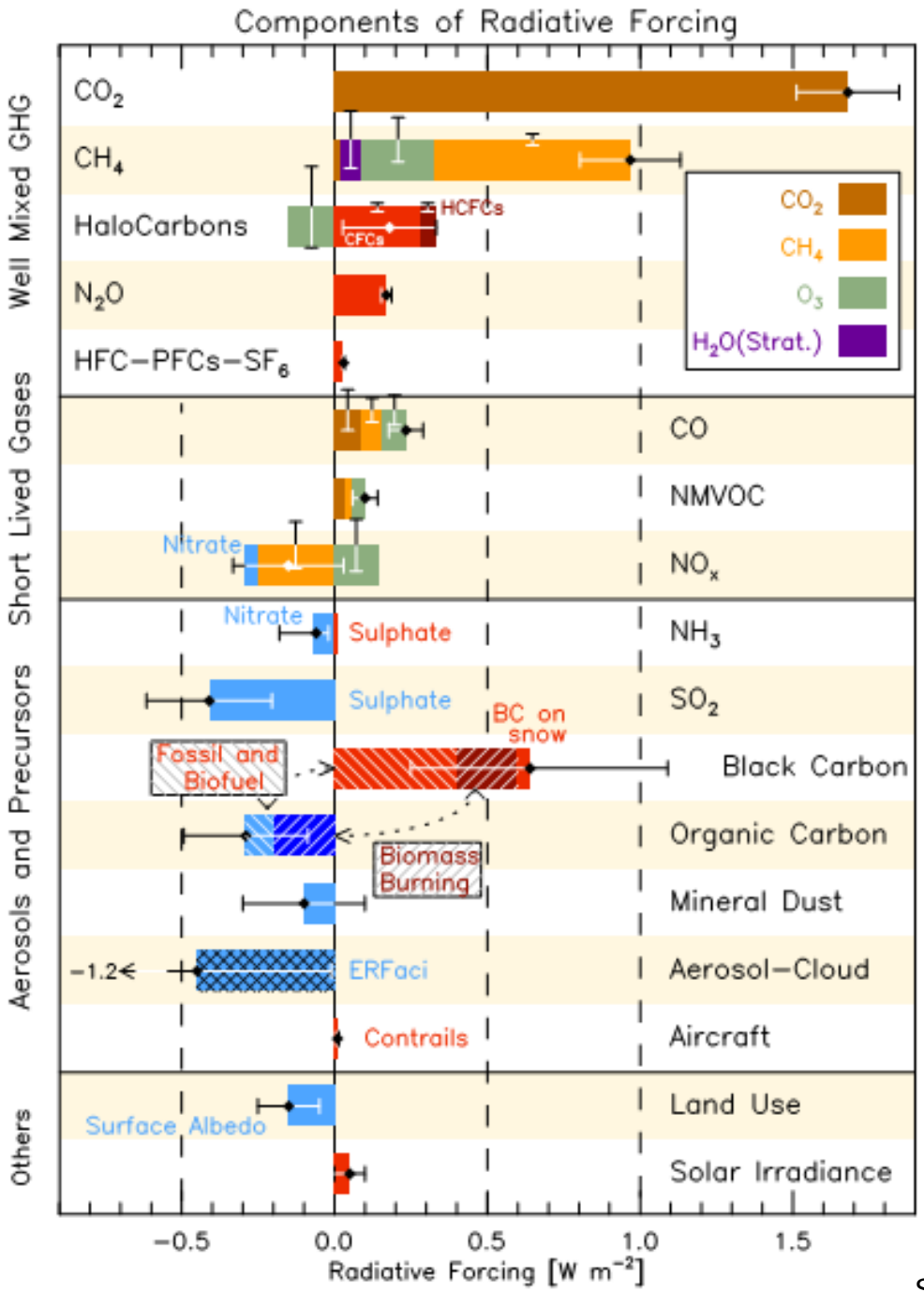
Assessment Reports Informing Government Actions



- **IPCC AR5 WGI (2013)** reviews most of climate science, includes updated estimates of BC forcing and some impacts
- **Bond et al. (2013)** ***Bounding the Role of Black Carbon*** published in academic journal, focused mainly on science; gained attention due to its very high estimate for black carbon radiative forcing
- **EPA Report to Congress (2012)** was significant report covering climate science, health effects, emissions, and effectiveness of PM regulations and programs
- **UNEP/WMO (2011)** ***Integrated Assessment of Black Carbon and Ozone*** demonstrated near-term climate and health benefits of SLCF mitigation scenarios; led in part to formation of CCAC
- **World Bank and International Cryosphere Climate Initiative (2013)** ***On Thin Ice*** concludes significant health benefits and significant Arctic and Himalayan climate benefits can be achieved through BC and methane mitigation, particularly via clean cooking solutions
- **Arctic Council Reports:** The Task Force on Short-Lived Climate Forcers produced reports in 2011 and 2013 regarding BC mitigation options, and the Arctic Monitoring and Assessment Program produced 2008 and 2011 reports and will release a 2015 report.

Key Scientific Issues

- Global BC impacts
- Key Emissions Sources & Trends
- Timing of effects (SLCF vs. long-lived)
- Arctic specific impacts
- Confidence in effects
  - including model/observation comparisons

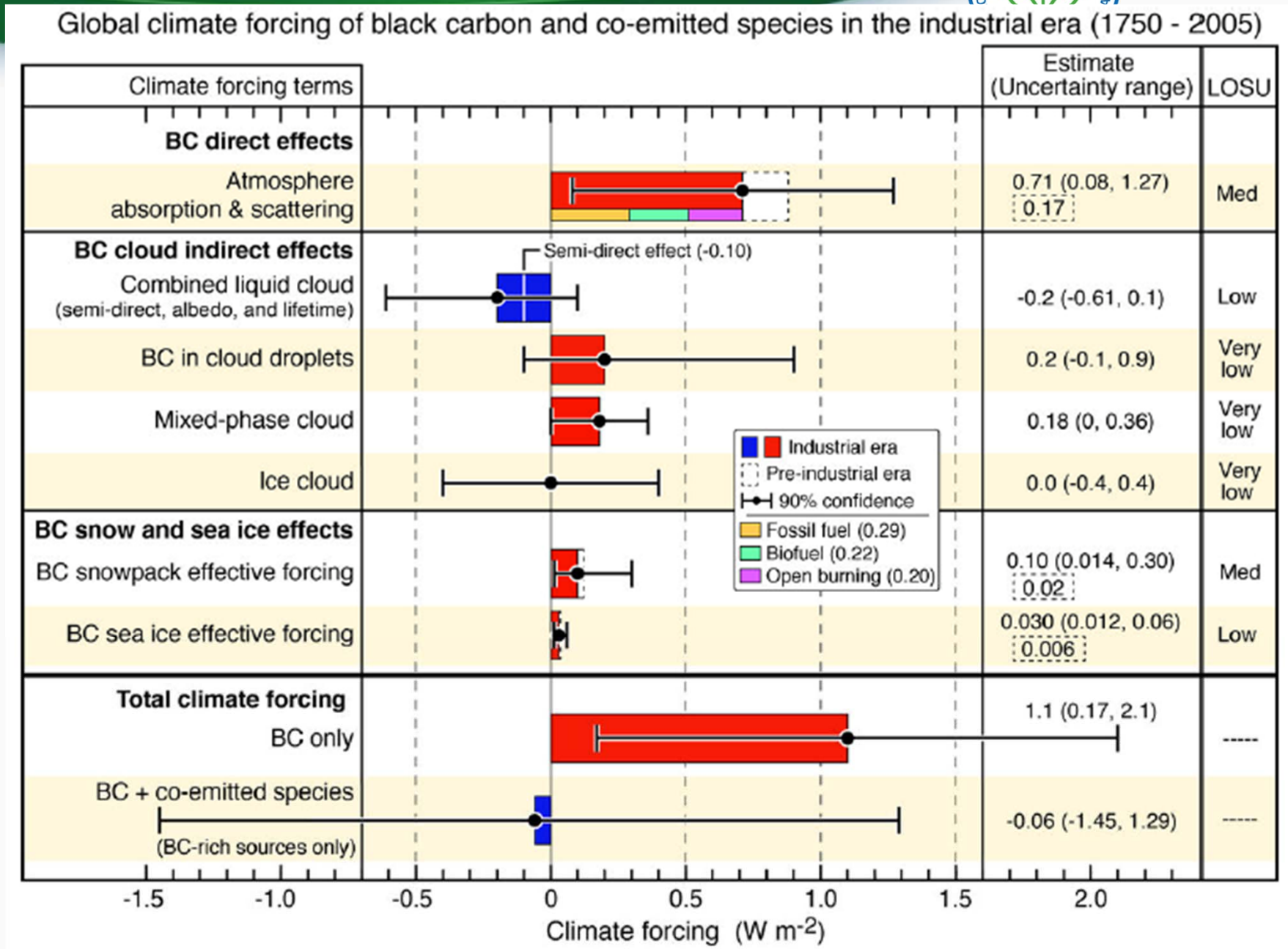


Global BC Impacts: IPCC

- CO_2, CH_4 and BC are largest warming agents
- BC estimate is about twice as large as previous IPCC AR4 estimate
  - BC warming effect remains less certain than well-mixed GHGs
  - Most recent reports, such as EPA's Report to Congress (2012) and Bond et al. (2013) generally consistent with new IPCC estimate
  - Bond et al. (2013) also estimate that cloud interactions may increase net BC forcing by 50% (with even larger uncertainty).

Source: IPCC AR5 WG1, Chapter 8, 2013

Global impacts: Bond et al. 2013



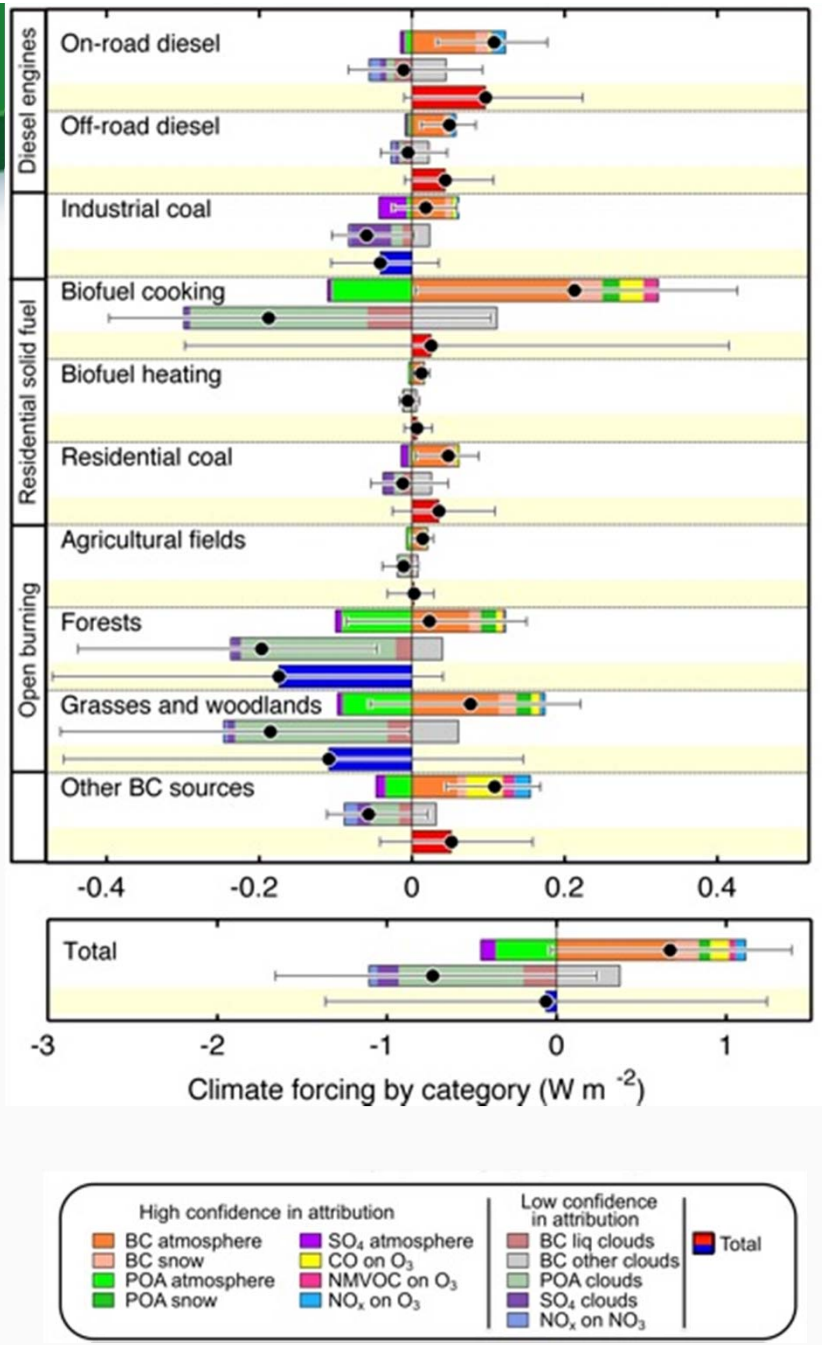
Global BC Impacts: Bounding: Including Co-emissions

When only considering very short-lived species (BC + Organic carbon and sulfur)

- Some categories are net positive (red) such as **diesel** and **some residential cookstoves**
- Some are net negative (blue) such as **forest fires**
- Some are uncertain – sign unknown

<u>However location could change this globally averaged picture (e.g., Arctic implications)</u>

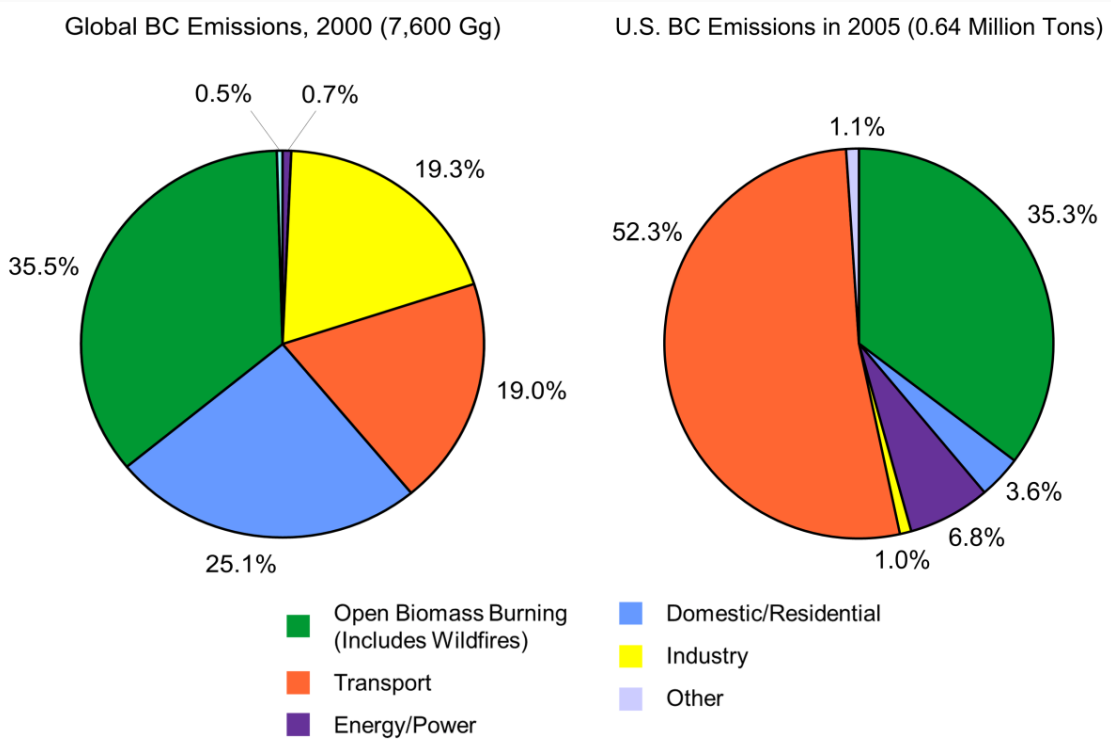
Additional consideration of CO_2 and methane can change long-term view of potential climate benefits of mitigation



Source: Bond et al. (2013)

Global vs. U.S. black carbon emissions

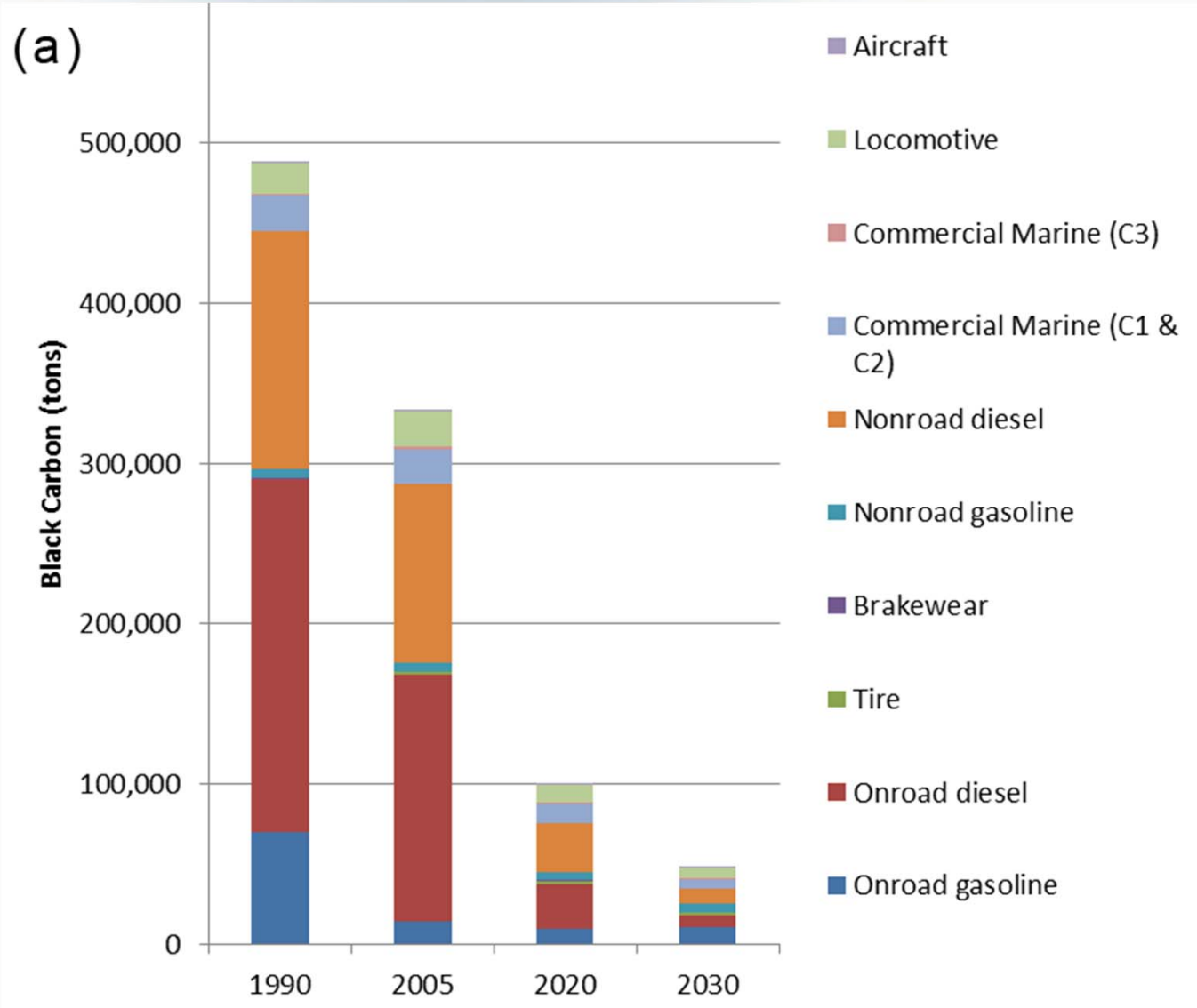
- The United States currently accounts for approximately 8% of the global total, and this fraction is declining.
- Industrial sources (e.g., brick kilns, industrial coal burning) and residential cooking are large globally but not in U.S.



- U.S. 2005 BC emissions = 640,000 tons, or approximately 12% of all direct $PM_{2.5}$ emissions nationwide.
- Mobile sources are the largest U.S. BC emissions category.
  - Diesel engines and vehicles account for 93% of mobile source BC emissions.
- Power generation is a small source both in the U.S. and internationally.

Source: EPA (2012) Report to Congress on Black Carbon

U.S. mobile source black carbon emissions projected to decrease significantly; trends will vary by world region



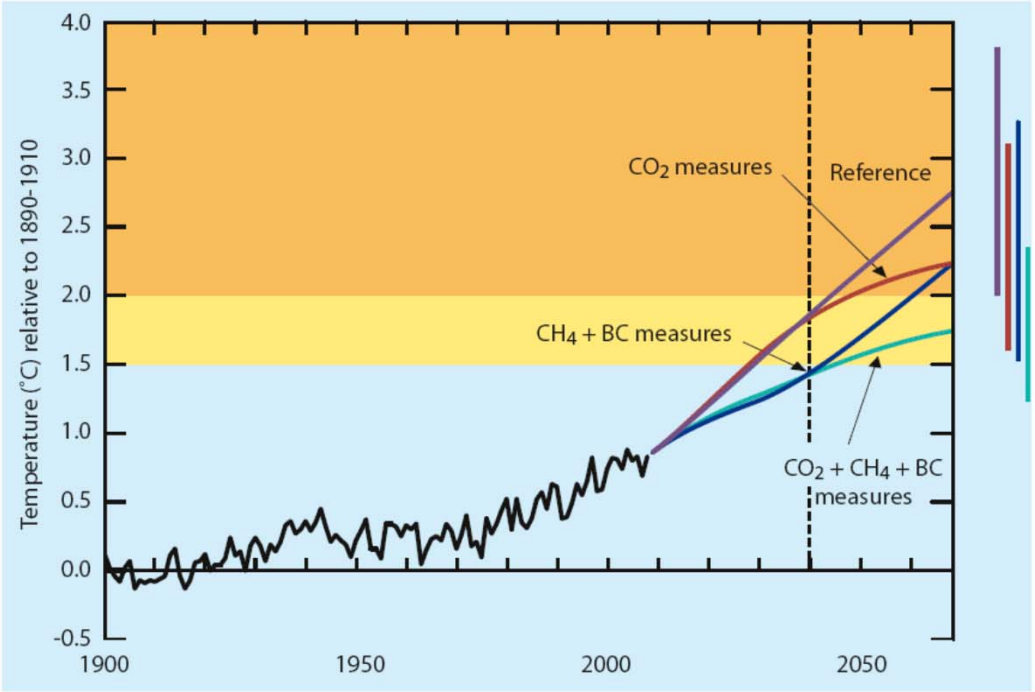
Total U.S. mobile source BC emissions are projected to decline by 86% between 2005 and 2030 (by 90% from 1990 levels) due to regulations already promulgated.

Reductions also projected in other industrialized countries, driven largely by reductions in transportation sector. (EPA, 2012)

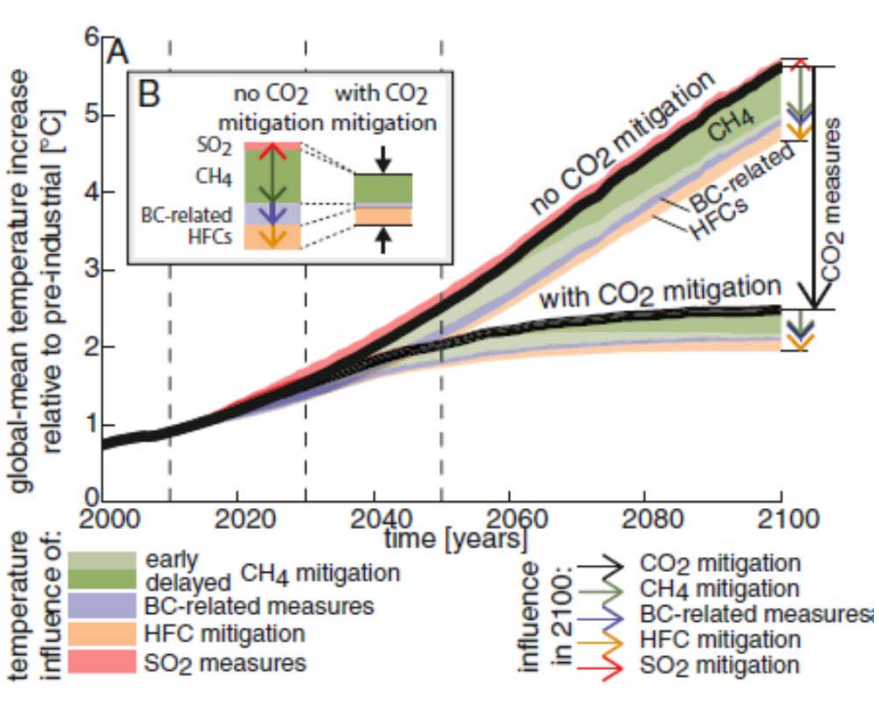
Emissions in some developing nation regions & sectors may increase in near term: transportation emissions generally, residential emissions in Africa, and open biomass burning emissions in South America. (Bond, 2013)

Timing of Effects: SLCF v. CO2 mitigation

UNEP/WMO 2011



Rogelj et al. 2014



- Similarities and differences
  - UNEP/WMO shows more relative benefits of SLCF mitigation
  - Both studies agree that CO_2 mitigation is required to slow warming over the long term, and that mitigation of both CO2 and SLCFs yield largest benefits
  - (health co-benefits are not highlighted in this talk, but very important in either case)

BC and the Arctic: Forcing

- Implications of snow and ice coverage in the Arctic:
  - BC has an increased warming impact, especially due to deposition
  - OC a reduced cooling impact
- AMAP investigated the Arctic forcing resulting from BC+OC emissions by latitude
  - Note that red bars are net BC+OC

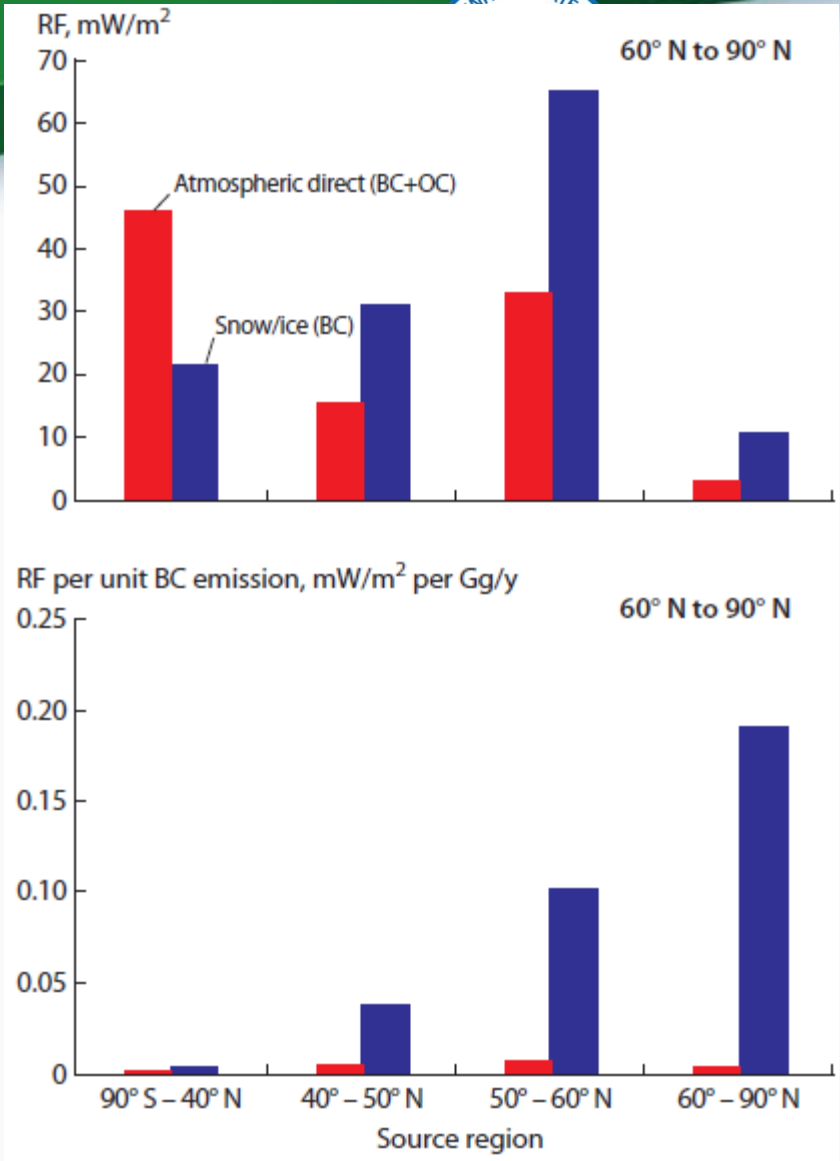
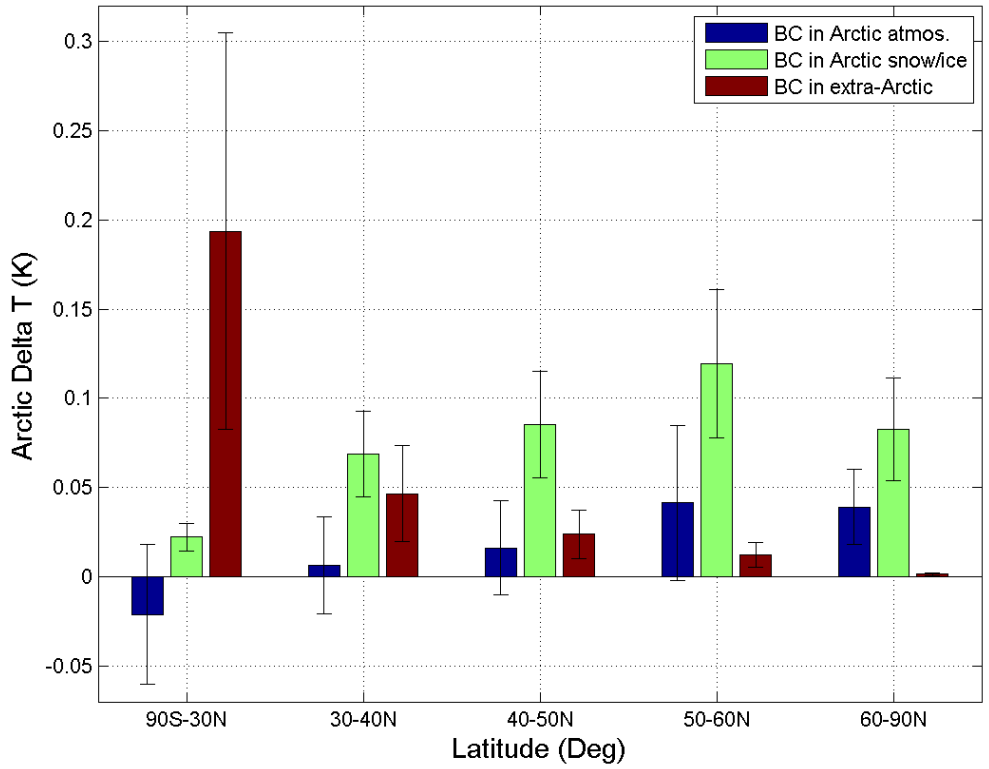


Figure 8.9. Absolute (upper) and normalized per unit emission (lower) atmospheric direct RF due to BC + OC and BC-snow/ice RF as a function of latitude band. The NCAR CCSM model was used for these calculations.

Source: AMAP (2011)

BC and the Arctic: Temperature

- Arctic temperature change is slightly more complicated than forcing calculations alone
  - Altitude dependence
  - Extra-Arctic heat transport



Source: Flanner et al. (in prep)

Confidence in Results

- Uncertainty bars in a number of previous slides are large
- Discrepancies exist between model projections and observations (AMAP 2015 will review these)
- So, where do we have confidence in sign of effects of mitigation options?