NWCG Smoke Committee (SmoC)
Whitepaper – Black Carbon and Wildland Fire
September 2009

Issue

Black carbon (BC), also known as elemental carbon, is a component of particulate matter (PM), and is released from the incomplete combustion of biomass (e.g. forests, savannahs, agricultural crops and residues), fossil fuels, and biofuels (solid, liquid or gaseous fuels made from plant matter). Recent research suggests that black carbon is a potent force in global climate change. Congressional hearings, EPA reports and several bills in Congress have discussed and targeted black carbon for potential control.

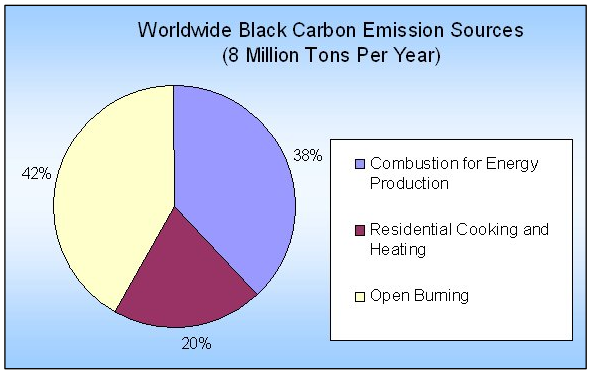
How does Black Carbon enhance the Greenhouse Effect?

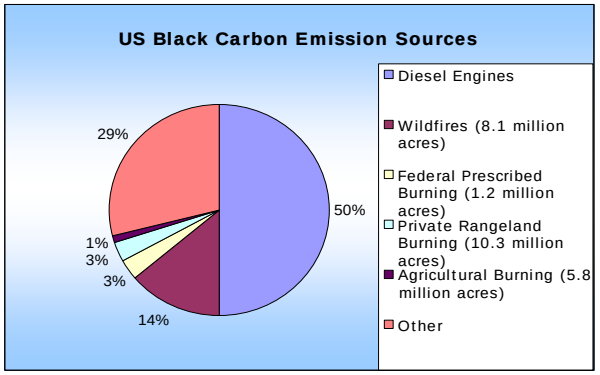
Black carbon has a two-fold warming effect on the atmosphere. It absorbs visible light and emits heat radiation to the surrounding air. This is different from greenhouse gases which absorb infrared radiation from the earth's surface and then emit that heat to the surrounding atmosphere. Secondly, black carbon can deposit on snow-covered areas, reducing reflectivity and leading to increased melting. Combined, these effects yield estimates that black carbon is second only to carbon dioxide (CO_2) in its global warming potential (Jacobson et al., 2007).

The atmospheric lifetime of black carbon is on the order of 1-4 weeks, unlike CO_2 which has an atmospheric lifetime of decades to even thousands of years. Thus the impacts of black carbon are usually regional to continental in scale and shorter-term in nature. Research suggests that reducing black carbon emissions will reduce temperatures over the short-term (10 years), while controlling CO_2 is necessary over the longer (100 year) timeframe (Jacobson et al., 2007, Jacobson, 2002). Thus, the thought is that by reducing black carbon emissions, climate change could be slowed over the short-term, essentially buying time to address CO_2 emissions.

What are the sources of Black Carbon?

Black carbon is not typically released by itself but instead is a component of soot particles which are comprised of black or elemental carbon, organic carbon, and other trace minerals from the combustion process. Not all sources of soot have the same chemical composition. Soot particles from fossil fuel sources have a higher percentage of black carbon than soot from biomass burning; they are also oily and much more hydrophobic. Biomass-burning particles are more hygroscopic, and serve as cloud condensation nuclei, forming clouds and scattering light. These attributes are discussed by Jacobson (2004) who found that while biomass and fossil-fuel burning emit approximately similar levels of black carbon globally, biomass burning particles cause a short-term cooling effect while particles from fossil-fuel burning cause short-term warming.





The Interagency Monitoring of Protected Visual Environments (IMPROVE) network measures the chemical composition of particulate matter, and has found that within the U.S., 4-10% of fine PM is black carbon. Between 70% and 80% of particulate matter in smoke from wildland fire is fine PM, and according to Urbanski (2009), 10% of that is black carbon, although the actual percentage varies by fuel type. The Figures show worldwide and U.S. black carbon emission sources. Research estimates that the United States emits 6-10% of the 8 million tons of worldwide black carbon emissions (Bond et al., 2004). Although U.S. biomass burning varies considerably from year to year, on average federal prescribed burning accounts for 3% of the total annual U.S. black carbon emissions and wildfires account for approximately 14% of the total annual U.S. black carbon emissions (Urbanski, 2009). Private rangeland burning and agricultural burning contribute approximately 3% and 1% respectively to the total annual U.S. black carbon emissions (based on fine PM estimates from the Regional Planning Organizations). The Other category includes other open burning, residential wood combustion, industrial processes (boilers), etc.

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Black Carbon and the Arctic

Transport of black carbon to the Arctic is of particular concern, especially in the spring when it can enhance snow melt. Several measurement campaigns and modeling studies are identifying sources and source regions of the pollutant in the Arctic. Measurement campaigns in April 2008 identified two episodes of Arctic incursions of smoke plumes from agricultural fires in Kazakhstan and southern Russia as well as forest fires from Siberia (Warneke et al., 2009). With a focus on anthropogenic emissions, Schindell et al. (2008) assessed pollution transport into the Arctic. Although they did not include emissions from Northern Asia (Russia) in their analysis (an important source region based on Warneke et al., 2009), they did identify North American emissions and European emissions as each being responsible for 40% of the annual black carbon deposition in Greenland. In non-winter seasons, black carbon deposition in Greenland is most sensitive to North American emissions. Conversely, Schindell et al. (2009) also found that the deposition of black carbon at all other areas of the Arctic (excluding Greenland) is most sensitive to emissions from Europe during every season of the year.

Stone et al. (2008) discusses the effects smoke has on atmospheric processes in the Arctic and identifies confounding effects of smoke versus black carbon. Smoke cools the atmosphere at the earth's surface which competes with the warming effect caused by black carbon deposition on snow. Smoke also warms the atmosphere in the upper layers it resides in. These warm/cool dynamics increase atmospheric stability, which can suppress cloud formation. Furthermore, smoke over the ocean results in cooling in the upper atmosphere (due to reduced net shortwave radiation) while smoke over ice warms the upper atmosphere (due to increased net shortwave radiation). This leads to changes in atmospheric circulation patterns that have not been studied well. Additional research is needed to understand these dynamics and interactions.

Potential Regulation of Black Carbon

While black carbon is a component of the regulated pollutant particulate matter, black carbon by itself is not currently regulated. This could change with the following:

- Congressional Testimony: In October of 2007, the House of Representatives' Committee on Oversight and Public Reform received testimony on the significant global and regional effects of black carbon, its sources, and the impact that emission reductions would have on climate change (Jacobson et al., 2007).
- Bills before the House of Representatives (HR) and Senate (S): HR2452, HR1769, HR1760, S849 and S1396: The American Clean Energy and Security Act of 2009 (HR2452) passed the House on June 26, 2009. If it passes the Senate, it will amend the Clean Air Act, requiring that EPA either promulgate additional regulations to reduce black carbon emissions, or issue a finding that existing particulate matter regulations adequately reduce black carbon emissions. In addition, the bill will require that within one year after enactment, EPA, in consultation with other appropriate Federal agencies, submit to Congress a report that includes an inventory of the major domestic and international sources of black carbon, as well as control technologies/operations/strategies for controlling the pollutant such as diesel retrofit technologies, programs to address residential cookstoves, and forest and agriculture based burning. The Administration is encouraging the Senate to pass this bill by the end of the year. Note: The USDA will have many responsibilities regarding the implementation of this bill. Bills S1396, S849, HR1760 and HR1769 also target black carbon for emission controls. S1396 focuses on promoting more fuel-efficient stoves in developing countries. S849, HR1760 and HR1769 all require EPA to study black carbon. S849 focuses on diesel engines, while HR1760 and HR1769 also targets forest and agricultural burning.
- EPA Greenhouse Gas Endangerment Finding: On April 24, 2009 EPA proposed the finding that greenhouse gases endanger public health. Although black carbon was not included in the definition of greenhouses gases, EPA did state that the agency is evaluating black carbon's role in climate change, and other non-mobile sources could be regulated in the future.
- The EPA 2008 National Emission Inventory (NEI) will be used to estimate black carbon emissions from wildland fire and agricultural burning. The NEI development process has begun and will proceed through June 2010 when a draft will be made available for review. This NEI will also serve as a basis for analyzing potential black carbon emission controls.

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Potential Implications for Prescribed Fire and Wildfire

Primary sources of BC emissions in the U.S. are diesel engines, residential wood and cook stoves, and biomass burning. Of these sources, diesel engines appear to be the likeliest target for required emission controls. Regulations are already in place requiring newer engines to meet more stringent emission standards. Currently, only California requires older diesel engines to have controls installed, although there are voluntary programs in place throughout the country to encourage retrofits of existing engines to reduce particulate pollution.

Reducing black carbon emissions from prescribed burning and wildfire management will likely not be ignored. Although such activities account for a small percentage of national emission totals, at least two bills introduced in the U.S. Congress (HR1760 and HR2452) specifically mention the possibility of controlling black carbon emissions from forest and other agricultural burning programs.

Testimony received during the October 2007 Congressional Hearings stated that snow and ice in the Arctic region are most vulnerable to the warming effects of black carbon during the spring, and that shifting prescribed burning activities to other seasons may help to combat warming.

Recommendations

Land Management agencies should remain engaged with this topic and closely monitor actions by the U.S. Congress that pertain to black carbon emission reductions. As appropriate, they should proactively work with EPA to develop acceptable strategies to deal with this emerging issue.

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