CLIMATIC EFFECTS OF BLACK CARBON

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Writing as background for their work, Kaspari *et al.* (2011)[1] state that "black carbon (BC, the absorbing component of soot) produced by the incomplete combustion of biomass, coal and diesel fuels can significantly contribute to climate change by altering the Earth's radiative balance," noting that "BC is estimated to have 55% of the radiative forcing effect of CO_2 (Ramanathan and Carmichael, 2008)," which is in line with the approximately 1 Wm^{-2} radiative forcing of black carbon reported by Hansen (2002)[2]. Nevertheless, and in spite of these facts, Kaspari *et al*. note that BC still remains "one of the largest sources of uncertainty in analyses of climate change."

> *Black carbon (BC, the absorbing component of soot) produced by the incomplete combustion of biomass, coal and diesel fuels can significantly contribute to climate change by altering the Earth's radiative balance … Nevertheless, and in spite of these facts, Kaspari et al. note that BC still remains "one of the largest sources of uncertainty in analyses of climate change."*

In an effort to reduce some of this uncertainty, Kaspari *et al*. developed a high-resolution BC record spanning the period AD 1860-2000 from a Mt. Everest ice core extracted from the East Rongbuk glacier located on the mountain's northeast ridge on the north slope of the Himalaya, which record, in their words, "provides the first pre-industrial-to-present record of BC concentrations from the Himalayas." So what did the record reveal?

The seven scientists determined that "BC concentrations from 1975-2000 relative to 1860-1975 have increased approximately threefold, indicating that BC from anthropogenic sources is being transported to high elevation regions of the Himalaya." In addition, they report that "the increase in Everest BC during the 1970s is simultaneous with a rise in BC emissions as estimated from historical records of energy-related combustion in South Asia and the Middle East (Bond *et al*., 2007)."

[1] http://www.co2science.org/articles/V14/N14/C1.php.
[2] http://www.co2science.org/articles/V5/N29/EDIT.php.

Commenting on these findings, Kaspari *et al*. say they suggest that "a reduction in BC emissions may be an effective means to reduce the effect of absorbing impurities on snow albedo and melt, which affects Himalayan glaciers and the availability of water resources in major Asian rivers." And since (1) Ramanathan and Carmichael (2008)[3] note that the majority of BC emissions (60%) arise from "cooking with biofuels such as wood, dung and crop residue" and from "open biomass burning (associated with deforestation and crop residue burning)," and since (2) Venkataraman *et al*. (2005)[4] note that control of BC emissions through cleaner cooking technologies alone could help in "reducing health risks to several hundred million users," it would seem that reducing biofuel sources of BC emissions would be a prudent goal.

Also working in Asia, Kopacz *et al*. (2011)[5] write as background for their study that "the Himalayas and the Tibetan Plateau, also collectively known as the Third Pole, represent a large area of seasonal and permanent snow cover," which is "surrounded by growing emissions of Asian air pollutants," and they say that observations of black carbon (BC) content in snow "show a rapidly increasing trend," citing the work of Xu *et al*. (2009).

Clearly, the current snow-albedo-altering impact of BC wafting over the Himalayas and the Tibetan Plateau vastly overshadows its direct radiative warming impact.

In their own study of the subject, Kopacz *et al*. used a global chemical transport model to identify the location from which the BC arriving at a variety of locations in the Himalayas and the Tibetan Plateau originates, after which they calculated its *direct* and *snow-albedo* radiative forcings.

According to the six U.S. scientists who conducted the work, the results indicate that "emissions from northern India and central China contribute the majority of BC to the Himalayas," and that "the Tibetan Plateau receives most BC from western and central China, as well as from India, Nepal, the Middle East, Pakistan and other countries." In addition, they report that the radiative forcing due to the *direct* effect of BC at five glacier sites has "a *global annual* mean of +0.32 W/m^2, while "the *local monthly* mean radiative forcing due to changes in snow-albedo ranges from +3.78 to +15.6 W/m^2" [italics added]. Clearly, the current snow-albedo-altering impact of BC wafting over the Himalayas and the Tibetan Plateau vastly overshadows its direct radiative warming impact.

Researching a much larger region of the globe, for the period 1875-2000, Novakov *et al*. (2003)[6] presented "estimates of past fossil-fuel BC emissions from the United States, United Kingdom, Germany, Soviet Union, India and China," which conglomerate of nations in 1990 accounted for

[3] http://www.co2science.org/articles/V11/N34/EDIT.php.
[4] http://www.co2science.org/articles/V8/N18/EDIT.php.
[5] http://www.co2science.org/articles/V14/N20/C3.php.
[6] http://www.co2science.org/articles/V6/N20/C3.php.

"about 70% and 60%, respectively, of the world consumption of coal and diesel fuel, which are the principal BC-producing fossil-fuels." And what did those estimates indicate?

Modern trends in BC have presented a significant radiative forcing across many parts of the globe, which forcing merits serious examination and future study, especially by the IPCC, in order to correctly interpret past, present and future climate trends.

Qualitatively, in the words of the authors, their results showed a "rapid increase [in BC] in the latter part of the 1800s, ... leveling off in the first half of the 1900s, and ... re-acceleration in the past 50 years as China and India developed." *Quantitatively*, they estimate the climate forcing by BC aerosols to be "of the order of +0.5 W m^{-2}." They also note that "estimates of the current anthropogenic BC climate forcing are of the order of 1/3 to 1/2 of the current CO_2 forcing."

In considering all of the above, it is apparent that modern trends in BC have presented a significant radiative forcing across many parts of the globe, which forcing merits serious examination and future study, especially by the IPCC, in order to correctly interpret past, present and future climate trends.

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