Black Carbon e-Bulletin

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Black Carbon Particles Spread over Large Areas

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Aerosol particles in the atmosphere are carried away with the winds and are eventually brought back to the surface through either wet or dry deposition. Wet deposition, most often the dominant removal process, is caused by the uptake in cloud droplets and subsequent deposition in rain. Dry deposition is a process in which particles settle during dry periods. The distance over which pollutants are transported is determined by the efficiency of the removal processes. For water soluble pollutants, like sulphates and nitrates, the residence time in the atmosphere typically is from a few days to several days (depending on how often it rains) corresponding to a travel distance of up to a few thousand km.

While freshly emitted black carbon particles are known to be hydrophobic, that is, slightly prone to absorb water and be incorporated in cloud droplets and scavenged by precipitation, it is often assumed that within a few days such particles are coated by water soluble materials, including sulphates and organics. Systematic measurements of black carbon in both rainwater and airborne aerosol particles at the Maldives Climate Observatory on Hanimaadhoo (MCOH) have

Figure 1: Wet deposition monitoring facilities at the Maldives Climate Observatory on Hanimaadhoo (MCOH)

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Editorial: Beyond Cancun

Achim Steiner, Executive Director, UNEP

In December 2010, the Government of Mexico hosted the 16th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 16) in Cancun. As we move from Bali to Poznan and on to Copenhagen and Cancun, the ambitions of all nations throughout the world are increasing, raising the need to bridge a widening gap between these ambitions and scientific pursuits, if we are to ensure the world a chance to keep the rise in global temperature below the 2°C limit set in the Copenhagen Accord, as anchored in the Cancun Agreement.

The Cancun outcomes clearly indicate that the international community recognizes the importance of undertaking further steps for collaborative action to address climate change. However, it is critical that governments accelerate their efforts in taking forward the Cancun Agreement, alongside parallel mitigation strategies focusing on emission reduction opportunities in other sectors; including increasing efforts to tackle the impact of black carbon. A growing body of scientific evidence indicates that black carbon is a climate forcing agent and a significant contributor to climate change. In addition to its warm-

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ABC–BC14 Programme Helps Identify Sources of Black Carbon

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Black carbon (BC) aerosol particles are emitted from the incomplete combustion of biomass and fossil fuel, yet the relative source contributions are poorly constrained. BC is the principal aerosol component absorbing solar radiation in the atmosphere and BC emissions probably constitute the second most important contribution to anthropogenic climate warming, after carbon dioxide emissions (Chung *et al*., 2005; Forster *et al*., 2007; Ramanathan and Carmichael, 2008). BC In the atmosphere combines with sulphates, nitrates, organic matter, and mineral dust to form atmospheric brown clouds (ABCs). There are direct health effects, such as bronchitis and asthma, from particulate air pollution. Despite these disturbing effects, large uncertainties have remained regarding sources of atmospheric BC. Source forensics is a useful decision-support information to guide the efficient mitigation of BC emissions.

It is the primary objective of the ABC BC Radiocarbon (14C) Programme (ABC-BC14), embedded within the larger ABC network, to provide observational determination of the relative contribution to atmospheric BC from contemporary biomass/biofuel burning versus fossil fuel combustion. The major source categories of atmospheric BC are fossil fuel combustion (including using diesel as vehicular fuel and coal combustion for energy), biofuel combustion (for example, wood and animal waste as fuel for household heating and cooking), and open biomass burning (for example, forest and savanna fires and agricultural crop residue burning). Taking South Asia as an example, there is unfortunately a large discrepancy in suggested source contributions, based on previous approaches using chemical composition of ambient aerosols ("top-down") and emission inventories ("bottom-up"), with suggested contributions from biomass/biofuel combustion to South Asian BC ranging from 20 to 80%.

The radiocarbon approach of the ABC-BC14 Programme is ideal to alleviate the current dichotomy regarding BC sources. The analysis of the long-lived naturally radioactive ^{14}C in atmospheric BC offers a possibility to unambiguously separate fossil sources (extinct or "dead" ^{14}C signal) and from biofuel+biomass sources (contemporary or "alive" ^{14}C signal).

The first ABC-BC14 campaign took place in the winter of early 2006 at two ABC stations, the Maldives Climate Observatory at Hannimaadhoo (MCO-H) and the Sinhagad station of the Indian Institute of Tropical Meteorology, near Pune, India. Our ^{14}C measurements of a soot-BC isolate emanating primarily from the Indian Subcontinent suggested that 68±6% of South Asian BC was from biofuel/biomass burning (Gustafsson et al., 2009). This is in reasonable agreement with emission inventory models by Bond *et al*., 2004; and Venkataraman *et al*., 2005.

The ABC-BC14 Programme has since been expanded. Results from observations over a 16-month period at MCO-H and ABC-Sinhagad in 2008-2009 confirm that two-thirds of soot-BC is form biomass burning. The ABC-BC14 Programme at MCO-H will cover the period December 2010 – March 2011, to provide records of BC abundance and sources for a fifth winter period. The goal is to build a decade-scale time series of BC abundance and sources in the South Asian region.

The development of the ^{14}C-based aerosol source apportionment programme has also involved ongoing sampling since December 2009 with Korean counterparts at the Korean Climate Observatory at Gosan (KCO-G), which is the key ABC node for East Asia. A method has been recently developed for the $^{13}C/^{14}C$-based source apportionment of water soluble organic carbon (WSOC) (Kirillova *et al*., 2010). WSOC is a major constituent of carbonaceous aerosols that is relevant to the ability of aerosols to act as cloud condensation nuclei (CCN). ABC effects on the cloud albedo is another indirect climate effect. This method will be added to samples that have been collected in South Asia (MCO-H) and East Asia (KCO-G).

We acknowledge the support and constructive collaboration at all three locations of the ABC-BC14 Programme with colleagues from the UNEP-ABC Programme, the Maldives EPA and Meteorological Services, the Indian Institute of Tropical Meteorology, Korea University and Seoul National University and Stockholm University Departments of Applied Environmental Science (SU-ITM) and Meteorology (SU-MISU).

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Strategies for containing climate change below dangerous levels: Beyond Copenhagen

A public seminar entitled, "Strategies for containing climate change below dangerous levels: Beyond Copenhagen" was organized on 23 August 2010 in Nairobi. Prof. V. Ramanathan, Chair of the ABC International Science Team, delivered the keynote address. An abstract of the keynote address is provided below.

Warming can be contained below 2° C as agreed upon in Copenhagen

There is about a 50 percent probability that the blanket of manmade greenhouse gases surrounding the planet is already thick enough to warm the planet by 2.5°C. With continued consumption of fossil fuels at current rate, the warming could even exceed 4° C. Irreversible and iconic changes to the earth system are likely during this century and beyond. The warming can be contained below 2°C as agreed upon in Copenhagen, but it would require simultaneous pursuit of three avenues: (i) reduce the rate of thickening of the blanket by stabilizing CO_2 concentration below 441 ppm during this century (a massive decarbonization of the energy sector is necessary to accomplish this Herculean task), (ii) ensure that air pollution laws that reduce the masking effect of cooling aerosols be made radiant energy-neutral by reductions in black carbon and ozone, and (iii) thin the blanket by reducing emissions of short-lived GHGs. Methane and hydrofluorocarbons have emerged as prime targets. The talk concluded with a description of Project Surya which is an ambitious rural intervention project sponsored by UNEP to slow down climate change with co benefits on human health and rural economy.

Observatory Group Meeting in Asia

Atmospheric Brown Cloud (ABC) observatory and modeling groups met in Bangkok during 21-23 October 2010 under the chairmanship of Prof. Nakajima, Chair of ABC-Asia Science Team. The meeting reviewed the operation of ABC observatories and developed plans for an inter-comparison study of black carbon measurements and an intensive ABC modeling study. The meeting also reviewed activities of the regional data center, where data is archived, and the regional data analysis center. A data summary report will be published to disseminate the interpreted data to a wider audience. The data summary report will be in addition to the ABC data CD, which is being disseminated to the scientific community.

Participants of the ABC observatory group meeting held in Bangkok, Thailand

ABC Africa Consultation

A consultative meeting on Atmospheric Brown Clouds (ABCs) related activities in Africa was held on 23 August 2010. The meeting focused on the following objectives:

(i) Possible effects of ABCs in the regional environment and climate and understanding the needs of the region with respect to ABCs and their climate and air quality links;

(ii) Establishment of a network of scientists to study emerging ABC issue in Africa; and

(iii) Identification of the possible location of ABC observatory (ies) in Africa and their operational arrangements.

Recognizing the need for building the science and capacity to study the emerging issue of ABCs in Africa, the meeting agreed to establish a small group of experts and to prepare a roadmap (in the form of a white-paper) for an ABC-Africa programme.

Upcoming Events

21-25 March: ABC Training School

23-24 March 2011: ABC Asia Science Team meeting

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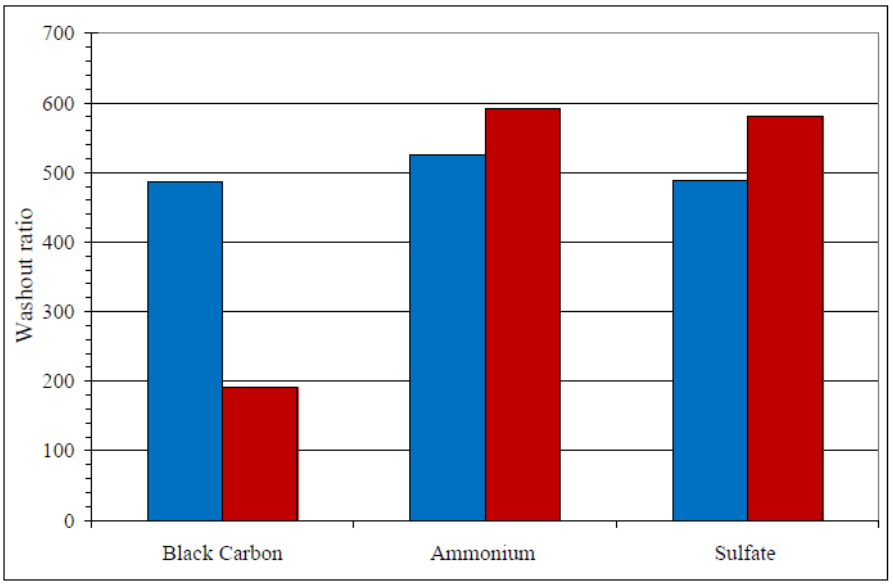

Figure 2: Comparison of washout ratio (WR) for black carbon, ammonium, and sulphate.

revealed that these particles retain much of their hydrophobic property even after a travel time of 3-5 days from source areas at the Indian Subcontinent (Granat *et al*. 2010). This finding implies a longer residence time and a wider geographical dispersion of black carbon particles than has been previously assumed.

This conclusion is based on a comparison between the concentration of black carbon in rainwater and in the air. This ratio, commonly referred to as the washout ratio (WR), is a measure of the scavenging efficiency by precipitation. Comparing the WR for black carbon and the WR for ammonium and sulphate – two highly water soluble components of aerosol particles – in air masses reaching MCOH from the Indian Subcontinent, Granat *et al*. found a systematic difference with the WR for soot being lower than the WR for sulphate by about a factor of three lower. (See red bars in the figure 2).

On the other hand, black carbon particles coming from a southward direction during the monsoon season (in very low concentrations) have WR values close to that of sulphate and ammonium. (See blue bars in the figure 2). In this situation, the black carbon - containing particles appear to be associated with adequate soluble materials to make them as easy to scavenge as sulphate and ammonium.

Reference:
Granat, L., Engström, E., Praveen S. and Rodhe, H. 2010: Light absorbing material (soot) in rainwater and in aerosol particles in the Maldives. J. Geophys. Res. 115, VOL. 115, D16307, doi:10.1029/2009JD013768, 2010

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ing and health effects, black carbon is also thought to be partly responsible for recent warming in the Arctic, contributing to the acceleration of Arctic sea ice melting. Black carbon is also hastening the melting of the Himalayan glaciers, which are major sources of freshwater for millions of people in the region.

Available evidence suggests that appropriately targeted black carbon mitigation strategies, used to complement overall climate strategies centred on reduction of carbon dioxide emissions, have the potential to accelerate and enhance climate and air quality and thus provide public health benefits.

As noted in this Bulletin, there is a 50 percent probability that the blanket of manmade greenhouse gases surrounding the planet is already thick enough to warm the planet by 2.5°C. Taking action on other climate forcing agents, through, for example, strong policy support, fast–track funding and technology transfer for low carbon energy sources, infrastructural development and research, could help build an international framework. However, this should by no means undermine progress towards reaching a post-2012 agreement.

All nations will need to collectively contribute to a plateau in emissions growth in the near future and over the coming decades. Partnerships among all stakeholders; governments, businesses, civil society and consumers, in all avenues available for effective action, are vital to help deliver progress towards reducing emissions of climate forcing agents, including greenhouse gas, and transitioning to a low carbon economy.

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