Black Carbon e-Bulletin

Volume 1, Number 1 | July 2009

UNEP

Non-CO_2 Emissions: Options for a way forward

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Scientific evidence on climate change is now well established. Data provided by the Intergovernmental Panel on Climate Change (IPCC) estimates that the atmosphere already contains enough long-lived greenhouse gases (GHGs) to raise global temperature by over 2˚C by the end of the century. The Panel's latest report also shows that it is possible to take corrective action, but this action must be taken immediately if we are to have a "reasonable chance" to avoid the worst impacts of climate change.

Urgent action to decrease the concentrations of black carbon and non-carbon dioxide GHGs that play a significant role in warming the atmosphere could provide opportunities for rapid climate benefits by helping to slow global warming and avoid crossing critical temperature and environmental thresholds. These gases include methane, nitrous oxide, the halocarbons (e.g. HFCs, CFCs and HCFCs typically contained in coolants), and tropospheric ozone (a component of photochemical smog). Estimates show that reducing black carbon emissions by a factor of five could slow the effects of climate change for a decade or two. Methane contributes 19 percent to global warming and also accounts for a quarter of tropospheric ozone production. Although methane is included in the basket of gases controlled under the Kyoto Protocol, the low weighting it has been assigned, compared to carbon dioxide, is misleading because a molecule of methane absorbs radiation much more strongly than carbon dioxide.

A significant climate threat is also posed by emissions and stockpiles from the continuing production of stratospheric ozone-depleting halocarbons

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Editorial: Double Dividends

Early actions on black carbon needed for win on climate

By Achim Steiner, Executive Director, UNEP

The chief culprit in global warming is carbon dioxide. But science tells us it is not the only climate change agent that we should be worried about if we are going to move fast enough to slow global warming. Scientists suggest that black carbon is the second largest contributor to global warming (after carbon dioxide). Interest in black carbon is not new. For years health impact studies have promoted the health benefits of reducing black carbon emissions. Now the warming effects of black carbon have caught the attention of climate scientists. Paying attention to black carbon should not distract people from the real issue at hand, carbon dioxide. At the same time, black carbon is emerging as a potent warming agent that needs to be reckoned with on its own terms, with the application of special measures to prevent releases to the atmosphere.

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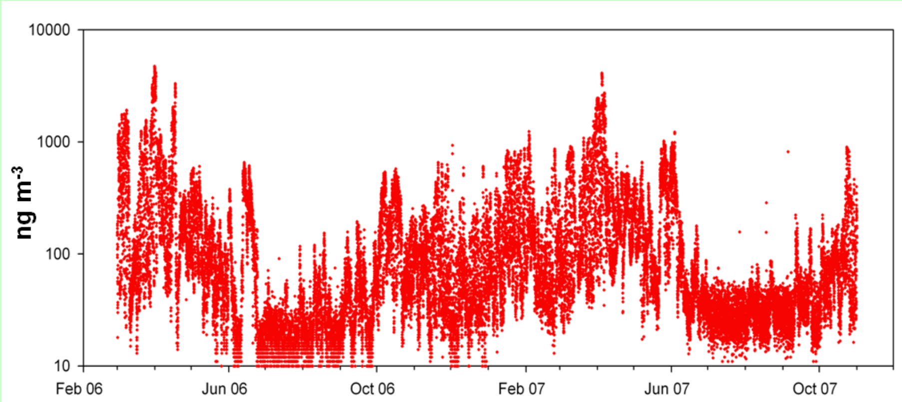
Message from Prof. Ramanathan, Chair, ABC International Science Team

The build-up of greenhouse gases (GHGs) and the resulting global warming pose major environmental threats to water and food security. Similarly causing major threats to the water and food security is the increasing amount of black carbon, sulphates and other aerosol components in atmospheric brown clouds (ABCs). There are clear signs of interactions between the climate change and ABCs and their impacts on the sustainable development. Now more than ever, there is a need to help policy makers and decision makers formulate an effective adaptation and mitigation response and for the science of climate change to address the impacts of atmospheric brown clouds. A lot of research work on atmospheric brown clouds is in progress. And the challenge to mitigate the impacts of atmospheric brown clouds is constantly being renewed. I believe that this bulletin will help to bring consensus among stakeholders in addressing atmospheric issues in an integrated manner. <

Published by the United Nations Environment Programme (UNEP) in collaboration with the Science Team of Atmospheric Brown Cloud (ABC)

Science of Black Carbon and Climate Change



Black carbon concentration measured at the Nepal Climate Observatory – Pyramid (5079 m a.s.l.) by EV-K2-CNR. Period of measure: February 2006 - October 2007 [4].

By Prof. Ramanathan

Black carbon (BC), a major component of soot, is emitted through cooking with solid fuels (wood, cow dung and crop residues), as well as through bio mass burning and fossil fuel combustion. In the atmosphere, BC is also mixed with other particles, such as sulfates, nitrates, dust and other pollutants. Together the mix of man-made particles are sometimes referred to as Atmospheric Brown Clouds (ABCs).

Global Warming

Some aerosols, like sulfates and nitrates reflect solar radiation and have a negative forcing (surface cooling effect) while black carbon absorbs solar radiation and has a net positive forcing (surface warming). In the atmosphere, since black carbon aerosols are mixed with sulfates and organics, it is not straight forward to untangling the effect of black carbon from that of the ABCs. Thus with few exceptions, the published estimates of black carbon are derived from climate models. Black carbon affects the radiative forcing of the planet in many different ways[1] :

i. Interception of direct sunlight: BC absorbs the direct solar radiation and this is the largest contributor to the surface dimming and atmospheric solar heating by ABCs. However, this effect, does not contribute too much to the top-of-the atmosphere forcing, and its main contribution being to reduce the surface solar heating and thus perturb the hydrological cycle. Globally, its effect is to reduce evaporation and rainfall.

ii. Interception of reflected sunlight: BC also absorbs the solar radiation reflected by the surface and clouds and thus reduces the solar radiation reflected to space by the earth-atmosphere system. It is this effect that is the main contributor to the positive radiative forcing by BC.

iii. Deposition in sea ice and snow: Deposition of BC over sea ice and snow, increases the absorption of solar radiation by ice and snow which is another source of positive radiative forcing.

Iv. In addition to the above direct effects, BC solar heating is linked with evaporation of low clouds which is another source of positive radiative forcing.

Based on the observationally constrained regional effects of ABCs [2,3], we estimate the net effect of BC (from items i and ii above) for the 2000 to 2003 period to be about +0.9 Wm^{-2}. This should be compared with the 1.6 Wm^{-2} due to CO_2 and 1.4 Wm^{-2} due to all other greenhouse gases (CH_4, N_2O, tropospheric ozone and halocarbons)[5]. The published estimates for item iii varies from + 0.05 to 0.3 Wm^{-2}. The most recent IPCC report(AR4) reports 0.35 Wm^{-2} for items I and ii and 0.1 Wm^{-2} for item iii. Thus, with a combined forcing (from items i, ii, and iii) of about 0.45 Wm^{-2} (IPCC) to the UNEP project ABC estimate of 1 Wm^{-2} (± 0.4 Wm^{-2}) BC is likely to be the second (next to CO_2) or third (next to methane) most important contributor to global warming.

The estimates of BC heating by ABC group suggests that the current (2000-2003) global solar warming effect of BCs may be as much as 60% of the current (2005) CO_2 greenhouse warming effect. Estimates of BC warming effect are uncertain by a factor of 3 or more.

Global Water Budget

Digressing to all particles in ABCs, ABCs enhance scattering and absorption of solar radiation and also produce brighter clouds that are less efficient at releasing precipitation. These in turn lead to large reductions in the amount of solar radiation reaching Earth's surface (also known as dimming) and a corresponding increase in atmospheric solar heating. Together the ABC dimming and microphysical effects can lead to a weaker hydrological cycle and drying of the planet which connects ABCs directly to availability of fresh water, a major environmental issue of the 21st century.

Regional Climate Impacts

The regional effects of BC are estimated to be particularly large over Asia, Africa and the Arctic. Since the dimming and atmospheric heating are non-uniform in space and time, BC leads to changes in north-south and land-ocean contrast in surface temperatures, in turn disrupting rainfall patterns. For example, the Sahelian drought, the decrease in monsoon rainfall over India and the drying of northern China are attributed by models to BC and other particles in ABCs. A recent study employing unmanned aerial vehicles showed that BC enhances atmospheric solar heating by about 50%. This heating as well as the deposition of snow on Himalayan glaciers[6] may have contributed as much as greenhouse warming to Himalayan glacier retreat.

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Editorial ...

Double Dividends

Science tells us that reducing black carbon emissions offers a nearly instant return in lowering the impact of the man-made greenhouse effect, because black carbon particles remain airborne for a few weeks before being removed from the air while carbon dioxide can stay in the atmosphere for over few decades to a hundred years. The good news is that reductions in black carbon can be accomplished with current, and relatively cheap, technologies.

Recent and ongoing research on the role of black carbon emissions in contributing to atmospheric warming is another reminder that the issue is more complicated than addressing carbon dioxide emissions alone. Current research suggests that cleaning up other global warming agents like black carbon may prove less expensive, more politically viable, and more effective in the short-term while other strategies are developed and implemented to address longer-term concerns.

By any means necessary

There is no question that control of carbon dioxide emissions is crucial for reducing global warming and a medium - long term strategy must be worked out in Copenhagen. However, this does not mean that we can ignore other factors associated with global warming. The science tells us that black carbon has a more significant impact on climate change than was previously understood. It also suggests that we will have to make monumental efforts to rapidly reduce greenhouse gases and prevent abrupt climate change. This means attacking the problem from all directions, through all available options. Thus, there is a need to craft the best response to address the problem as we know it in order to lead us to a clean-energy and low carbon, future. <

Science of Black Carbon...

Significance of BC Reductions

BC warming effect may offer an opportunity to reduce the projected warming trends in the *short term*. The life time of BC is of the order of days to several weeks. Thus the BC concentration and its global heating will decrease almost immediately after reduction of its emission. Reduction of BC emissions are also warranted from public health considerations. We need to conduct a careful and well documented scientific study of the impact of BC reduction. *The BC reduction proposal is not proposed as an alternative to CO_2 reduction. At best, it is a short term measure to buy a decade or two of time for implementing CO_2 emission reduction strategies.*

It is important to distinguish issues that are well understood from those that require confirmation. I would like to point out that, the first definitive study on the global warming magnitude of CO_2 increase was published 40 years ago and it required hundreds of model studies by numerous groups to reach the current level of consensus on the importance of CO_2 to climate change. By comparison, studies on climate effects of BC are in their infancy. There is reasonable consensus on the following issues:

- Life time of black carbon is of the order of few days to few weeks.
- Fossil fuel combustion, bio fuel cooking and biomass burning are the sources of BC.
- Globally, BC has a net warming effect on the climate system. The magnitude of its current warming effect is subject to a large uncertainty, ranging from about 25% to as much as 60% of the warming effect of CO_2 increase since the 1850s.
- BC adds solar heating to the atmosphere and causes dimming at the surface.
- Atmospheric Brown Clouds (i.e., BC and other man-made particles) lead to large dimming at the surface and the global average effect of this is to decrease rainfall.
- Deposition of BC on sea ice and snow darkens the surface and leads to more solar absorption and melting of sea ice and snow.

1. Ramanathan, V., et al., (2001), The Indian Ocean Experiment: An Integrated Assessment of the Climate Forcing and Effects of the Great Indo-Asian Haze, *J. Geophys. Res*., 106(D22), 28371, 10.1029/2001JC900133.
2. Chung, C.E., V. Ramanathan, D. Kim and I.A. Podgorny (2005), Global Anthropogenic Aerosol Direct Forcing Derived from Satellite and Ground-Based Observations, *J. Geophys. Res.*, 110, D24207, doi:10.1029/2005JD00635.
3. Ramanathan, V.(2007), Global Dimming by Air Pollution and Global Warming by Greenhouse Gases: Global and Regional Perspectives; Extended Abstracts of the Plenary lecture presented at the 17th International Conference on Nucleation and Atmospheric Aerosols, Galway, Ireland, August 13th-17th, 2007
4. Bonasoni, P., Laj, P., Angelini, F., Arduini, J., Bonafè, U., Calzolari, F., Cristofanelli, P., Decesari, S., Facchini, M.C., Fuzzi, S., Gobbi, G.P., Maione, M., Marinoni, A., Petzold, A., Roccato, F., Roger, J.C., Sellegri, K., Sprenger, M., Venzac, H., Verza, G.P., Villani, P. and Vuillermoz, E. (2008). The ABC-Pyramid Atmospheric Research Observatory in Himalaya for aerosol, ozone and halocarbon measurements. In Sci. Total Environ. 391:252-261
5. IPCC (2007), Climate Change 2007: The Physical Science Basis. Summary for Policy Makers. Contribution of WG1 to the fourth assessment report, IPCC Secretariat, Geneva.
6. Flanner, M.G., C.S. Zender, P.G. Hess, N.M. Mahowald, T.H. Painter, V. Ramanathan, and P.J. Rasch (2009). Springtime warming and reduced snow cover from carbonaceous particles. *Atmos. Chem. Phys., 9*, 2481-2497 <

ABC OBSERVATORY GROUP DISCUSSIONS

Project Atmospheric Brown Cloud (ABC) gathers longer term time series of evidence for long range transport of aerosols including black carbon. This time series will be of great value in validating climate models and thus reduce the large uncertainty in the black carbon forcing. Monitoring is being conducted through an integrated networks of strategically located state-of-the art ABC surface climate observatories. The ABC observatory group meets on an annual basis to discuss the progress in the implementation of the ABC observatories. This years' ABC Observatory Workshop was held on 7-8 July 2009 at Pathumthani, Thailand. The workshop, attended by Science Team and Observatory Team members, resulted in information and knowledge sharing on data, data management, observatory activities, and operations and maintenance of observatories. The workshop agreed on a data protocol for the ABC observatories. It is expected that the data protocol will harmonize the monitoring and reporting of aerosols at the regional and global levels. A detailed article on the ABC observatories and data availability will be published in the next issue of this Bulletin. <

Non-CO_2 Emissions ...

(including HCFCs, CFCs, halons, and methyl bromide), which are also powerful GHGs. Neither the Montreal Protocol nor the Kyoto Protocol control stratospheric ozone depleting substances (ODSs) that were produced prior to phase-out deadlines and which remain in use or storage. If these gases are not properly recovered and destroyed, they could leak into the atmosphere. This could result in significant damage not only to the ozone layer, but also to the global climate system. Action taken now will provide cost-effective benefits that may no longer be available later.

Mitigation options

The major global sources of black carbon vary greatly from region to region, but emission studies suggest that approximately one-third of black carbon emissions come from biomass burning sources, such as wood-fired stoves and open biomass burning, while the remainder comes from fossil fuel burning sources, such as diesel engines. This indicates that there are opportunities for minimising black carbon emissions in both developed and developing countries. There is also considerable room to focus on reducing black carbon emissions as part of international development projects.

As such, new and stronger efforts are needed to address black carbon, at all levels, from local to international. Opportunities will be missed if black carbon and other non-carbon dioxide emissions, because they are not considered to be among the areas traditionally targeted for mitigation, are ignored .

In addition to various carbon dioxide-related mitigation activities being undertaken by UNEP, there are opportunities to reduce emissions of black carbon in a cost-effective manner, potentially resulting in significant short-term impacts that reduce the effects of global GHG emissions. Unlike carbon dioxide, black carbon is typically amenable to lower cost end-of-pipe control or equipment fixes which are already well understood technologies that are available and readily deployable. Initial options for intervention by UNEP could focus on support for development projects that facilitate widespread adoption of technologies that improve energy efficiency and reduce emissions of black carbon. This would include mobilising resources for the transition to cleaner residential heating and cooking, reducing adoption costs for poor households and supporting the development of in-country supply and service infrastructure and programs. A key aspect of this is to ensure that multilateral climate funds and bilateral development assistance includes financing and technology transfer targeted to black carbon mitigation. In this regard, the Project Surya, which promotes the application of green technologies, could be expanded to cover a wider geographical area (a detailed article on the project Surya will be published in the next issue of this bulletin).

In terms of emissions from vehicles, UNEP's Partnership for Clean Fuels and Vehicles, which has successfully facilitated the transition to unleaded fuels in developing countries, could be expanded to address black carbon emissions from diesel engines. UNEP has also been effective in assisting countries in developing national environmental legislation and promoting opportunities for providing assistance to build on existing national and local laws and strengthening them to address black carbon emissions.

Considerable mitigation potential is also available from reductions in methane emissions in some agricultural systems through landfill methane recovery, waste incineration with energy recovery, composting of organic waste, controlled waste water treatment, recycling and waste minimisation. Like black carbon, methane requires a focus on local level technology and capacity building towards the deployment of small scale technology (i.e. landfill management technology for methane).

The recovery/recycling and destruction of CFCs and HCFCs may present an opportunity for both developed and developing countries to agree on binding commitments to reduce GHG emissions, currently being considered by the Montreal Protocol. Creating greater incentives to recover and destroy ODS stockpiles is technically and economically feasible and can be achieved through a variety of regulatory mechanisms. These include new requirements under the Montreal Protocol, including destruction offset requirements for use of existing exemptions, as well as through global carbon markets.

Conclusion

History has shown that given proper conditions and incentives, the elimination of polluting technologies can be quickly achieved. In some small-scale applications, such as residential cooking, health and convenience of alternatives will drive such a transition. For other sources, such as vehicles, regulatory approaches may be necessary to facilitate the transition to existing technology or the development of new technologies. The question for UNEP is how to facilitate acceleration of the transition.

UNEP recognises that great challenges confront the international community in seeking to establish an effective and meaningful international climate regime for the post-2012 period. The future climate regime will require innovations that go beyond the model adopted in Kyoto for the 2008-2012 period, least of which are new commitment mechanisms for developed and developing countries, innovative financing and technology transfer mechanisms.

Both developing and developed countries could make significant contributions to reductions in GHGs by undertaking commitments to reduce non-carbon dioxide emissions, while getting on a path for improving the efficiency of their economic activities so that carbon dioxide emissions are also reduced. <

Upcoming Events

- **23-24 November 2009: ABC-Asia Science Team meeting**

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