UNEP

UNEP Science-Policy Brief

Towards an Action Plan for Near-term Climate Protection and Clean Air Benefits

Disclaimers

Mention of a commercial company or product in this report does not imply endorsement by the United Nations Environment Programme. The use of information from this publication for publicity or advertising is not permitted. Trademark names and symbols are used in an editorial fashion with no intention of infringement on trademark or copyright laws.

We regret any errors or omissions that may have been unwittingly made.

Citation: UNEP. 2011. Towards an Action Plan for Near-term Climate Protection and Clean Air Benefits. UNEP Science-policy Brief. 17pp.

Printing: UNON/Publishing Services Section/Nairobi, ISO 14001:2004-certified.

UNEP promotes environmentally sound practices globally and in its own activities. This publication is printed on 100% recycled paper using vegetable based inks and other eco-friendly practices. Our distribution policy aims to reduce UNEP's carbon footprint.

UNEP Science-Policy Brief

Towards an Action Plan for Near-term Climate Protection and Clean Air Benefits

February, 2011

ACKNOWLEDGEMENTS

UNEP Editorial Team: Joseph Alcamo, Kaveh Zahedi, Kilaparti Ramakrishna, Surendra Shrestha, Nick Nuttall, Marco Gonzalez, Bradnee Chambers, Peter Gilruth, Volodymyr Demkine

Author Team: Johan Kuylenstierna (Coordinator – Stockholm Environment Institute, SEI), Markus Amann (International Institute for Applied Systems Analysis, IIASA), Svante Bodin (International Cryosphere Climate Initiative, ICCI), Kevin Hicks (Stockholm Environment Institute, SEI), Richard Mills (International Union of Air Pollution Prevention and Environmental Protection Associations, IUAPPA), Pam Pearson (International Cryosphere Climate Initiative, ICCI), Drew Shindell (National Aeronautics and Space Administration Goddard Institute for Space Studies – NASA-GISS)

Staff Support provided by Sunday Leonard

Cover photographs credit: Shutterstock Images

TABLE OF CONTENTS

SUMMARY

Climate policy and research have mainly concentrated on long-term climate change and controlling the long-lived greenhouse gases, especially CO_2. Despite the rapid pace of developments in controlling these gases, the negative impacts of climate change are becoming increasingly evident. Hence, the growing interest in slowing the pace of global warming within the next few years. Reducing the tempo of global warming now would also help avoid irreversible changes in the climate system, and lower the risk of feedback effects in the environment that could accelerate the pace of climate change (e.g. the release of methane from melting permafrost), and offer society and nature a better chance to adapt to climate change.

Recent scientific results, including an assessment sponsored by UNEP and WMO, show that it is possible to slow down the pace of global warming very quickly (relative to a reference scenario) by reducing the concentrations of "short-lived climate forcers" in the atmosphere. These are substances that contribute to global warming and also have relatively short lifetimes in the atmosphere. They include methane, black carbon particles, tropospheric ozone and many hydrofluorocarbons.

Reducing short-lived climate forcers would not only enhance climate protection on the *global* scale, but also on the *regional* scale. Reducing black carbon particles in particular will mitigate their current impact on regional climate processes. There is evidence to suggest that they are altering regional rainfall patterns and cloud formation, and contributing to the accelerated melting of ice and snow in regions such as the Arctic and the Himalayas.

But beyond near-term climate protection, reducing these substances offers very important *co-benefits* because many of these substances are important air pollutants in their own right. Reducing black carbon and tropospheric ozone in particular will significantly reduce or avoid adverse impacts on health, crop yield and ecosystem functioning. The recent UNEP/WMO assessment showed that a package of measures to reduce black carbon and ground-level ozone would, as a side benefit, reduce exposure to outdoor air pollution and thereby avoid an estimated 0.7–4.6 million premature deaths, while also avoiding annual losses from four major crops of about 50 million tons each year after 2030.

An Action Plan for controlling short-lived climate forcers would operate at different geographic scales (global, regional or national) and build on many existing and related activities. Among the many policy options for such a Plan are the following:

On the global level, policies could be pursued through existing international agreements. One example is to work through the UNFCC and the Montreal Protocol to effectively regulate hydrofluorocarbon chemicals, many of which are short-lived climate forcers. Another idea is to take action on recovering and destroying existing "banks" of these chemicals, again through the two international agreements.

Also on the global level, countries could cooperate under the UN Framework Convention for Climate Change to develop a "shared vision" for controlling short-lived climate forcers. For example, institutions associated with the Climate Convention could provide a forum for countries to report on their own initiatives and actions at the regional and national level to reduce short-lived climate forcers. The Climate Convention could also be a vehicle for further speeding up action on reducing methane which is not only a short-lived climate forcer but also regulated under the Kyoto Protocol.

On the regional level, action could be scaled up to include control of short-lived climate forcers. For example, steps are now being taken to regulate black carbon emissions under the Convention on Long-Range Transboundary Air Pollution of the UN Economic Commission for Europe. In other parts of the world, regional frameworks are coming together to control transboundary air pollution and these might be appropriate *fora* for discussing policies to control short-lived climate forcers.

On the national level, action can be taken to tighten up air quality standards for ozone and other short-lived climate forcers. Although their motivation would be health protection, nations that lower the exposure of their population to black carbon and ground-level ozone could also make a significant contribution to global and regional climate protection. The national level in many cases is also the appropriate level to regulate and control emission sources of the short-lived climate forcers.

Independent of the geographic scale, many other policy options are available for controlling short-lived climate forcers, including:

- *Capacity building and awareness raising* to inform key stakeholders about the relationship between air pollution and climate change, as well as to bring together the separate communities concerned with these two subjects;
- *Improved monitoring* to assess the existing exposure of populations, for example, to black carbon and other particles posing a health risk;
- *Joint action by international organizations* to provide more information about short-lived climate forcers, to support the development of regional air pollution frameworks, and to promote capacity building, awareness raising, and monitoring;
- *Financing and partnership initiatives* to provide new institutional mechanisms and new sources of financing for assessing and reducing the short-lived climate forcers. Many are already underway including the Prototype Methane Financing Facility, Partnership for Cleaner Fuels and Vehicles, and the Global Alliance for Clean Cookstoves;
- *Encouraging research* to better understand the impact of different short-lived climate forcers particularly on regional climate. Also to identify the technical solutions that are most cost-effective in reducing emissions.

In sum, a wide palette of options is available for formulating an effective Action Plan for reducing short-lived climate forcers. The consequences of a successful Plan would be the slowing of global warming over the next few years, a reduction of regional climate impacts, and a reaping of co-benefits from reduced air pollution, including better health protection, reduced pollution-related crop losses, and lessened impacts on ecosystems.

GLOSSARY

Black carbon: Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability. Black carbon is formed through the incomplete combustion of fossil fuels, biofuel, and biomass, and is emitted as part of anthropogenic and naturally occurring soot. It consists of pure carbon in several linked forms. Black carbon warms the Earth by absorbing sunlight and re-emitting heat to the atmosphere and by reducing albedo (the ability to reflect sunlight) when deposited on snow and ice.

Capacity building: In the context of climate change, the process of developing the technical skills and institutional capability in developing countries and economies in transition to enable them to address effectively the causes and results of climate change.

Carbon dioxide equivalent (CO_2-eq): Describes how much global warming a given type and amount of greenhouse gas may cause at a particular time, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as the reference.

Clean Development Mechanism (CDM): One of the three market-based mechanisms under the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC), whereby developed countries may finance greenhouse gas emissions-avoiding projects in developing countries, and receive credits for doing so which they may apply towards meeting mandatory limits on their own emissions.

Ground-level ozone: Ozone at the bottom of the atmosphere, and the level at which humans, crops and ecosystems are exposed.

Near-term warming: In the terms of this document and the UNEP/ WMO Assessment, this refers to global warming from the present up to about the next 20 to 40 years (i.e., global warming during the 2010-2050 period).

Radiative forcing: Radiative forcing is a measure of the change in the energy balance of the earth-atmosphere system.

UNEP/ WMO Assessment reference scenario: This is the progression of emissions based on energy and fuel projections of the International Energy Agency (IEA) *World Energy Outlook 2009* and incorporating all presently agreed policies affecting emissions used in the UNEP/WMO Assessment for comparison with the scenarios where black carbon and methane measures have been implemented.

Short-lived climate forcers: Substances such as methane, black carbon, tropospheric ozone, and many hydrofluorocarbons which have a significant impact on climate change, and a relatively short lifespan in the atmosphere compared to CO_2 and other longer-lived gases.

Troposphere: That portion of the atmosphere from the earth's surface to the tropopause; that is, the lowest 10-20 km of the atmosphere (from American Meteorological Society Glossary).

Win-win measures: Mitigation measures which are likely to reduce global warming and at the same time provide clean air benefits by reducing air pollution.

ABBREVIATIONS AND ACRONYMS

ABC	– atmospheric brown cloud
ABC Project	– Atmospheric Brown Cloud Project
AMAP	– Arctic Monitoring and Assessment Programme
BC	– black carbon
CDM	– Clean Development Mechanism
CER	– Certified Emissions Reductions
CFCs	– chlorofluorocarbons
CH_4	– methane
CLRTAP	– Convention on Long-Range Transboundary Air Pollution
CO	– carbon monoxide
CO_2	– carbon dioxide
CO_2-eq	– carbon dioxide equivalent
COP	– Conference of the Parties
CRU	– Climatic Research Unit, University of East Anglia, UK
DPF	– diesel particle filter
EANET	– Acid Deposition Monitoring Network in East Asia
ECHAM	– European Centre Hamburg Model
FAO	– Food and Agriculture Organization of the United Nations
GACC	– Global Alliance for Clean Cookstoves
GAINS	– Greenhouse Gas and Air Pollution Interactions and Synergies
GCM	– General Circulation Model
GISS	– Goddard Institute for Space Studies
GMI	– Global Methane Initiative
GWP	– Global Warming Potential
HCFC	- hydrochlorofluorocarbons
HFC	– hydrofluorocarbons
IIASA	– International Institute for Applied Systems Analysis
IPCC	– Intergovernmental Panel on Climate Change
LRTAP	– Long-Range Transboundary Air Pollution
Malé Declaration	– Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia
NASA	– National Aeronautics and Space Administration
NOAA	– National Oceanic and Atmospheric Administration
O_3	– ozone
OC	– organic carbon
ODS	– (stratospheric) ozone depleting substances
PCFV	– Partnership for Clean Fuels and Vehicles
PM	– particulate matter
PMFF	– Prototype Methane Financing Facility
RF	– radiative forcing
SLCF	– short-lived climate forcers
SO_2	– sulphur dioxide
SO_4	– sulphates
UN	– United Nations
UNCED	– United Nations Conference on Environment and Development
UNDP	– United Nations Development Programme
UNECE	– United Nations Economic Commission for Europe
UNEP	– United Nations Environment Programme
UNFCCC	- United Nations Framework Convention on Climate Change
US-AID	– United States Agency for International Development
WHO	– World Health Organization
WMO	– World Meteorological Organisation

1. INTRODUCTION

This document is designed to inform decision makers about additional opportunities to slow the observed rate of climate change and at the same time achieve air quality benefits over the next two to four decades. This can be realised by implementing measures to reduce atmospheric levels of methane, black carbon and tropospheric ozone, as well as many hydrofluorocarbons. These substances are called "short-lived climate forcers" (or SLCFs) because of their relatively short lifetime in the atmosphere and significant impact on climate change. It is important to understand that the opportunities presented by action on short-lived climate forcers do not in any way preclude the necessity for immediate and concerted global action on long-lived greenhouse gases, such as CO_2, to protect the climate in the longer term.

The main goals of this document are to:

- lay out the options for a comprehensive strategy for reducing these short-lived climate forcers to slow the pace of global warming from the present up to about the next 20 to 40 years;
- highlight practical and available measures that can allow significant benefits to be realised in the near-term, if implemented widely;
- discuss strategies that could be adopted to ensure widespread implementation of the measures; and,
- examine how implementation of measures to control these substances would have multiple and achievable benefits for human well-being.

This paper builds upon many recent scientific publications. It especially draws on the soon-to-be-published UNEP/WMO assessment '*An Integrated Assessment of Black Carbon and Tropospheric Ozone*'[1] which reviews and assesses the science and potential benefits that can accrue from the wide implementation of a relatively small number of emission reduction measures. The UNEP/WMO Assessment builds further upon UNEP activities including the 'Atmospheric Brown Cloud' (or "ABC" Project[2]) which has been engaged for over a decade in the development of science, mitigation measures and capacity to address the issues of short-lived climate forcers under an integrated framework.

The 2007 IPCC assessment[3], and many scientific studies published since then, have affirmed that climate change is occurring now, and that its negative impacts on society and nature are likely to intensify. International climate negotiations have focused to date on long-term climate change, emphasising the impacts beyond the year 2050 and reductions in CO_2 and other long-lived greenhouse gases that are critical for avoiding significant temperature increases in the latter half of this century. However, near term climate change (the rate of change and the path that we follow over the next two to four decades) has important impacts that are not captured by this long-term framing.

Progress in the science around the influence of methane, black carbon, tropospheric ozone[4] precursors and hydrofluorocarbons (HFCs) has set the stage for the development of an integrated strategy to reduce the emissions of these substances. This is further supported by the fact that reducing black carbon and ozone concentrations in the lower atmosphere (or troposphere) would provide significant benefits to human health and agriculture, in addition to their potential for reducing the rate of warming projected over the next few decades.

Many recent studies, including the ABC Project and the UNEP/WMO Assessment, are providing a scientific basis for a global/regional Action Plan for reducing short-lived climate forcers[5]. One of the most important findings of the UNEP/WMO Assessment is that even relatively aggressive CO_2 reduction strategies may not keep temperature rise from approaching 2°C degrees by mid-century, or reduce

1 UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

2 Ramanathan, V., Agrawal, M., Akimoto, H., Aufhammer, M., Devotta, S., Emberson, L., Hasnain, S.I., Iyngararasan, M., Jayaraman, A., Lawrance, M., Nakajima, T., Oki, T., Rodhe, H., Ruchirawat, M., Tan, S.K., Vincent, J., Wang, J.Y., Yang, D., Zhang, Y.H., Autrup, H., Barregard, L., Bonasoni, P., Brauer, M., Brunekreef, B., Carmichael, G., Chung, C.E., Dahe, J., Feng, Y., Fuzzi, S., Gordon, T., Gosain, A.K., Htun, N., Kim, J., Mourato, S., Naeher, L., Navasumrit, P., Ostro, B., Panwar, T., Rahman, M.R., Ramana, M.V., Rupakheti, M., Settachan, D., Singh, K., St. Helen, G., Tan, P.V., Viet, P.H., Yinlong, J., Yoon, S.C., Chang, W.C., Wang, X., Zelikoff, J., Zhu, A. 2008. Atmospheric Brown Clouds: Regional Assessment Report with Focus on Asia. UNEP. Nairobi, Kenya. http://www.unep.org/pdf/ABCSummaryFinal.pdf

3 IPCC, 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

4 Sometimes referred to as 'ground-level ozone', though it is ozone throughout the troposphere that influences climate.

5 Also including: Anon. 2010. Hemispheric Transport of Air Pollution. Executive Summary Prepared by the Co-chairs of the Task Force on Hemispheric Transport of Air Pollution UN-ECE Convention on Long-range Transboundary Air Pollution, Doc.ECE/EB.AIR/2010/10 and Royal Society of the UK. 2008. Ground-level Ozone in the 21st century: Future Trends, Impacts and Policy Implications Science Policy RS Policy Document 15/08. royalsociety.org.

the rate of warming over this time period. This single finding – consistent with results from the 2007 IPCC Assessment - suggests that the global community needs to look at complementary approaches to current reduction strategies.

Policy makers now have the option to embark on a two-track, parallel, yet complementary Action Plan to address climate change in the 21st Century. One path of action will reduce emissions of carbon dioxide and other long-lived greenhouse gases and ensure the long-term stabilization of the earth's climate. Although the impacts of this strategy will be felt in the longer term, this path needs to be followed now to achieve this long-term goal. The second and concurrent path will reduce emissions leading to high levels of short-lived climate forcers in the atmosphere and ensure that the rate of climate change slows over the next few decades. This action, too, must begin now and has many co-benefits, if implemented.

As the UNEP/WMO Assessment demonstrates, meaningful reductions in short-lived climate forcers can be achieved by implementing a relatively small number of mitigation measures. Sixteen measures were identified that, if implemented on a wider scale using well-demonstrated and available technologies, could reduce a significant part of the warming influence of the short-lived climate forcers[6]. This reduction will also result in substantial co-benefits in terms of improved health and well-being of millions of people by improving access to energy and reducing mortality related to air pollution, crop yield losses, disrupted weather patterns, and damaged ecosystems. Many of the health, energy and agricultural benefits will be felt almost immediately by the regions in which the measures are implemented, providing a powerful incentive for action. Recognizing the variation among geographic regions, there are actions to be taken by developed nations as well as by developing countries to achieve these benefits.

6 UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

2. WHAT ARE SHORT-LIVED CLIMATE FORCERS?

Short-lived climate forcers include: methane (CH_4), black carbon (BC), tropospheric ozone (O_3), and a subset of hydrofluorocarbons (HFCs). These are 'short-lived' as they either remain for only days or weeks in the atmosphere (for ozone and black carbon) to about 12 years for methane. HFCs have lifetimes that vary between 0.6 and 270 years, although a substantial fraction of HFCs have lifetimes that can be considered "short-lived"[7]. The critical point is that these substances have a positive 'radiative forcing' (Box 1) and cause warming of the atmosphere through a number of different processes. The historical contribution of preindustrial to present-day increases in black carbon, ozone and methane to radiative forcing is ~1.1 W/m^2, 68% of the forcing from CO_2 over the same time period[8].

As noted above, some of these substances are air pollutants that negatively affect health, crop yields and ecosystems. BC and O_3 cause health impacts, while high levels of O_3 also cause crop and ecosystem damage. CH_4 and HFCs are not air pollutants by themselves, but are of concern chiefly as greenhouse gases. Methane is one of the most important precursors of ozone formation and thus contributes to air pollution in this way.

Complicating the development of policy options is the fact that some of the short-lived climate forcers are co-emitted with pollutants that cool, rather than heat, the atmosphere. These include sulphates (SO_4), derived from sulphur dioxide (SO_2) emissions, and organic carbon (OC) that is co-emitted with black carbon. Sulphate and organic carbon are particles that scatter light and hence reflect a portion of incoming sunlight back to space, cooling the Earth. However, over snow-covered reflective surfaces, OC can actually contribute to warming. In the atmosphere, the mixture of BC and other particles, such as sulphates and other pollutants, are sometimes referred to as "atmospheric brown clouds".

To understand the impact of short-lived climate forcers on net radiative forcing, and hence on climate, the cooling as well as the warming components of emissions need to be understood. As emission control measures affect many different gases and particles, determining their impact on climate and air quality requires careful analysis. Successful strategies for slowing climate change have to reduce emissions of the warming substances more than the cooling ones.

The increase of methane in the atmosphere has caused the largest radiative forcing by any greenhouse gas after CO_2. Methane concentrations have grown as a result of human activities related to agriculture, coal mining, natural gas distribution, rice cultivation, biomass burning and ruminant animals and landfills. Methane is also an important precursor of tropospheric ozone[9].

Box 1:
What is Radiative Forcing?

Radiative forcing is a measure of the change in the energy balance of the Earth-atmosphere system with space. That is, it is a change in the balance between incoming solar radiation and outgoing infrared radiation, which ultimately controls the Earth's surface temperature. Factors influencing climate change, such as greenhouse gas changes, are often evaluated in terms of radiative forcing. This forcing is given in watts per square meter, the rate of energy conversion (watts), over an area of one square meter.

[7] Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D.W., Haywood, J., Lean, J., Lowe, D.C., Myhre, G., Nganga, J., Prinn, R., Raga, G., Schulz., M., Van Dorland, R. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[8] IPCC AR4 Chapter 2 - Forster, P., et al. 2007. Changes in Atmospheric Constituents and in Radiative Forcing, in Climate Change 2007: The Physical Science Basis. [Solomon, S (ed.)]. Cambridge University Press, New York.

[9] Ozone (O_3) is a reactive gas that exists in two layers of the atmosphere: the stratosphere (the upper layer) and the troposphere (ground level to ~10–20 km). O_3 is a significant greenhouse gas. In this paper we also refer to "ground-level" ozone which is at the bottom of the troposphere and which is the level at which humans, crops and ecosystems are exposed to ozone.

Ozone (O_3) is also a significant greenhouse gas. The threefold increase of O_3 concentration in the northern hemisphere in the lowest layer of the atmosphere, or "troposphere", during the past 100 years has made it the third most important contributor to the human enhancement of the global greenhouse effect, after CO_2 and CH_4. Ground-level ozone also negatively affects crop yields, human health and ecosystems.

Black carbon (BC) is not a gas, but occurs as particles in the atmosphere and is a major component of soot. It warms the atmosphere by intercepting and absorbing sunlight. BC and other particles are emitted from many common sources, such as cars and trucks, residential stoves, forest fires and some industrial facilities. The size of BC particles makes them particularly dangerous to human health because they are small enough to be inhaled but big enough to become lodged in the respiratory system where they can cause damage.

Hydrofluorocarbons (HFCs) are a type of fluorinated greenhouse gas intentionally made as replacements for stratospheric ozone depleting substances (ODS), for use in the same applications (air conditioning, refrigeration, solvents, foam blowing and aerosols).

Although, the abundance of HFCs in the atmosphere is currently small, recent scientific papers project substantial growth in their use during the next few decades as a result of increased demand for refrigeration and air-conditioning (particularly in developing countries). If left unchecked, some researchers project a doubling of HFC consumption by 2020, and that HFC emissions could very substantially contribute to radiative forcing in the atmosphere by the middle of the century[10]. Another important point to note is that it would make sense from the perspective of climate protection to design and implement strategies, policies and measures for HFCs to target the whole group of these chemicals rather than focusing solely on the short-lived subset of them.

[10] Growth of HFCs is anticipated to continue well beyond 2020 if left unconstrained or weakly regulated, which would create another substantial anthropogenic forcing of climate change. It has been estimated that by 2020 HFC emissions could reach about 2.0 $GtCO_2$-eq per year and by 2050 5.5 to 8.8 $GtCO_2$-eq per year. Source: Velders, G., Fahey, D., Daniel, J. McFarland, M. Andersen, S. 2009. The Large Contribution of Projected HFC Emissions to Future Climate Forcing. Proceedings of the National Academy of Sciences. www.pnas.org_cgi_doi_10.1073_pnas.0902817106.

3. BENEFITS TO CLIMATE AND CLEAN AIR FROM REDUCING EMISSIONS

3.1 Slowing Global-scale Warming

3.1.1 The two-degree target

Since the pre-industrial era, the annual average global mean temperature of the Earth has increased by approximately 0.9ºC[11] and the IPCC has stated that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations". UNEP's 'Emissions Gap Report'[12], released at COP-16 in Cancun, indicated that the pledges made as a follow up to the Copenhagen Accord imply a global temperature rise at the end of the century of 2.5°C to 5°C as compared to pre-industrial times, with a best estimate around 3.5ºC. Even the low end of this range is significantly above the 2°C target agreed to in the Cancun Agreement.

The effects of emissions of short-lived climate forcers up through to the present day have been large, contributing a substantial fraction of the warming experienced to date, especially in the Northern Hemisphere. As to the future, there have been many suggestions that control of these emissions could be a useful way to mitigate near-term climate change, as they are short-lived[13]. For example, we show shortly that reducing the emissions of methane, black carbon and precursors of tropospheric ozone (which include methane) is expected to slow the rate of global warming in the near-term and increase the chance of staying below the 2°C Cancun Agreement target.

3.1.2 Why is it important to slow near-term global warming?

There are a number of reasons why near-term global warming is of concern:

- Impacts of climate change are already observed and increasing, as in the case of diminishing Arctic summer ice or the shifting of ranges of various plants and animals[14]. Slowing down near-term climate change will dampen the quickening pace of impacts and help avoid the risk of irreversible changes;
- If some impacts are allowed to continue, they could trigger positive feedback effects leading to more rapid climatic changes. For example, in the case of the melting Arctic summer ice, these changes will modify the reflectivity of the earth and this could significantly alter regional and global climate. Warmer temperatures in the Arctic are also melting permafrost and this process could release additional quantities of methane and carbon dioxide to the atmosphere, further accelerating climate change;
- Reducing near-term climate change will also allow more time for ecosystems to adapt to the changing climate and for societies to plan and implement adaptation measures. In general, the slower the tempo of climate change, the easier it will be to adapt.

---

[11] According to analyses from NASA, NOAA, UK Met Office / CRU – NASA-GISS: http://data.giss.nasa.gov/gistemp/; NOAA-NCDC: http://www.ncdc.noaa.gov/sotc/global/; UK Met Office/CRU: http://www.cru.uea.ac.uk/cru/data/temperature/

[12] UNEP. 2010. The Emissions Gap Report – Are the Copenhagen Accord Pledges Sufficient to Limit Warming to 2°C or 1.5°C? UNEP. Nairobi. http://www.unep.org/publications/ebooks/emissionsgapreport/

[13] As explained in the following four references: Shindell, D.T., Levy II, H., Schwarzkopf, M.D., Horowitz, L.W., Lamarque, J.F., Faluvegi, G. 2008. Multi-model Projections of Climate Change From Short-lived Emissions due to Human Activities. J. Geophys. Res., 113, D11109, doi:10.1029/2007JD009152.
Hansen, J., Sato, M., Ruedy, R., Lacis, A., Oinas, V. 2000. Global Warming in the Twenty-first Century: An Alternative Scenario. Proc. Natl. Acad. Sci., 97, 9875-9880.
West, J.J., Fiore, A.M., Naik, V., Horowitz, L.W., Schwarzkopf, M.D., Mauzerall, D.L. 2007. Ozone Air Quality and Radiative Forcing Consequences of Changes in Ozone Precursor Emissions. Geophys. Res. Lett., 34, L06806, doi:10.1029/2006GL029173.
Jacobson, M.Z. 2010. Short-term Effects of Controlling Fossil-fuel Soot, Biofuel Soot and Gases, and Methane on Climate, Arctic Ice, and Air Pollution Health. J. Geophys. Res., 115, D14209, doi:10.1029/2009JD013795.

[14] IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 104 pp.

3.1.3 What is the impact of reducing short-lived climate forcers on near-term warming?

Scientists are only now beginning to investigate the effectiveness of specific scenarios for reducing short-lived climate forcers. Of interest to this paper, test calculations were carried out as part of the UNEP/WMO Assessment.

In order to identify the climate benefits of actions to reduce short-lived climate forcers in the atmosphere, scientists involved in the Assessment evaluated the collective impact of a small number of measures to reduce methane and black carbon emissions (See Table 1 in Section 4. Note that HFCs were not addressed in this assessment). These emission scenarios were then used as input to climate models[15] which computed the resulting concentrations of black carbon, tropospheric ozone and methane in the atmosphere, as well as the progression of warming until 2070 as illustrated in Figure 1.

The first important result is that reducing concentrations of black carbon, ozone and methane in the atmosphere has an almost immediate effect on slowing the pace of global warming compared to the Assessment reference scenario. Note, however, that the pace of global warming picks up again after a few decades if no major action is taken to reduce carbon dioxide and other longer-lived greenhouse gases in the atmosphere.

The second is that reducing CO_2 emissions slows global warming mostly over the medium- to long-term rather than in the near-term.

A third important result is that the best option is apparently to combine immediate reductions of black carbon and other short-lived climate forcers with reductions of CO_2. In this way the pace of global warming is slowed both in the near- and longer-term and society improves its chances of meeting the 2ºC Cancun Agreement target. This is a significant result showing the potential for such strategies to mitigate climate change.

It was also found that a package of 16 measures led to a slowing of global warming of around 0.5°C by 2050 (range: 0.2–0.7°C) relative to a reference scenario (Figure 1)[16]. This is half the potential increase in global temperature projected for 2050 by the reference scenario which assumes a continuation of current policies and medium energy projections (Figure 1).

We note that scientific confidence in these projections varies by pollutant and other factors as explained in Box 2. Also note that these are only preliminary calculations, and much more work needs to be done to evaluate the effectiveness of reducing short-lived climate forcers.

Box 2:
Confidence in the assessment of impacts of reducing short-lived climate forcers

The UNEP/WMO Assessment concludes that immediate and multiple benefits will be realized upon implementation of the identified measures. The degree of confidence varies according to pollutant, impact and region. For example, there is higher confidence in the effect of methane measures on global temperatures than in the effect of black carbon measures, especially where these relate to the burning of biomass. There is also high confidence that benefits will be realized for human health from reducing particles, and to crop yields from reducing ozone concentrations. Given the scientific complexity of the issues, further work is required to investigate near-term strategies in different regions

[15] This analysis was carried out by running two different global composition-climate models (GCMs) that describe global climate and atmospheric chemistry. One, GISS, was developed at the NASA-Goddard Institute for Space Studies and the other, ECHAM, developed by the Max Plank Institute in Hamburg, Germany, and run at the Joint Research Centre of the European Commission.
In the Assessment, these were used for new runs using values for key parameters from the peer-reviewed literature. To assess the effectiveness of reduction measures, runs were made with an assumption of full implementation of CH_4 and BC measures and without them (according to a Reference scenario). It was assumed that the implementation of the measures causing emission reductions began to occur immediately and they were in full force by 2030. For details of GISS model see: Shindell, D.T., Faluvegi, G., Unger, N., Aguilar, E., Schmidt, G.A., Koch, D., Bauer, S.E., Miller, R.L. 2006. Simulations of Preindustrial, Present-day, and 2100 Conditions in the NASA GISS Composition and Climate Model G-PUCCINI. Atmos. Chem. Phys., 6, 4427-4459, 2006. For details of ECHAM see: Pozzoli, L., Bey, I., Rast, S., Schultz, M.G., Stier, P., Feichter, J. 2008. Trace Gas and Aerosol Interactions in the Fully Coupled Model of Aerosol-Chemistry-Climate ECHAM5-HAMMOZ: 1. Model Description and Insights From the Spring 2001 TRACEP Experiment. J. Geophys. Res., 113,– , http://dx.doi.org/10. 1029/2007JD009007, 2008.

[16] UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

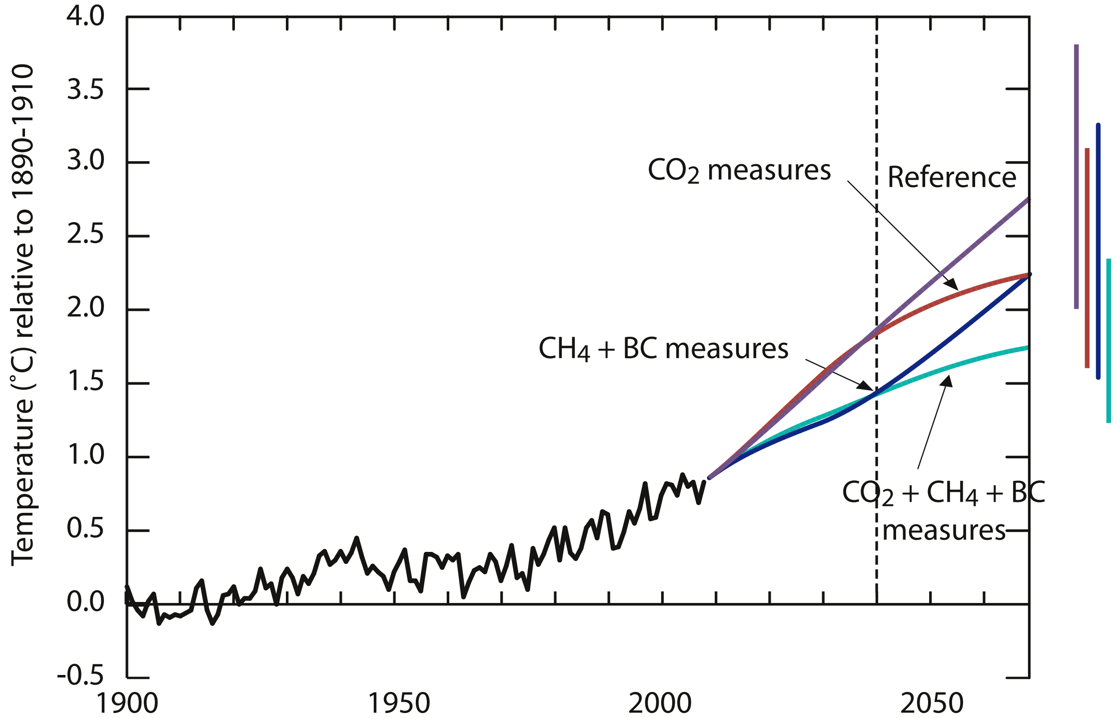

Figure 1. Observed deviation of temperature to 2009 and projections under various scenarios. Implementation of the identified BC and CH_4 measures, together with measures to reduce CO_2 emissions, would greatly improve the chances of keeping Earth's temperature increase to less than 2˚C relative to pre-industrial levels. The bulk of the benefits of the assumed CH_4 and BC measures are realized by 2040 (dashed line).

Explanatory notes: Actual mean temperature observations through 2009, and projected under various scenarios thereafter, are shown relative to the 1890–1910 mean temperature. Estimated ranges for 2070 are shown in the bars on the right. A portion of the uncertainty is common to all scenarios, so that overlapping ranges do not imply a lack of difference between scenarios. For example, if climate sensitivity is large, it is large regardless of the scenario, so temperatures in all scenarios would be towards the high-end of their ranges (Source: UNEP/WMO Assessment 2011).

3.2 Reducing Regional Climate Change

Of the short-lived climate forcers, black carbon particles have particularly discernible impacts on regional climate change. They disturb rainfall and regional circulation patterns, such as the Asian monsoon, and thereby affect the well-being and livelihoods of millions of people. Black carbon's darkening of snow and ice surfaces increases their absorption of sunlight (and reduces albeldo - the ability to reflect sunlight), which, along with atmospheric heating, exacerbates melting of snow and ice around the world, including in the Arctic, the Himalayas and other glaciated and snow-covered regions. This melting in turn affects the water cycle and may increase the risk of flooding.

The model runs depicted in Figure 1 also showed that measures targeted to reducing short-lived climate forcers would have substantial benefits in the Arctic, the Himalayas and other glaciated and snow-covered regions. For example, warming could be reduced in the Arctic by about two-thirds compared to the Assessment's reference scenario over the next 30 years[17]. A reduced rate of warming reduces the risks of climate impacts in the Arctic including undesirable changes in weather patterns as well as the possible acceleration of global warming from the release of methane from melting permafrost.

[17] UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

3.3 Co-benefits to Health, Crop Production, and Ecosystems

Black carbon particles and ground-level ozone pose a serious public health risk, causing premature deaths primarily from heart disease and lung cancer. Exposure to high enough concentrations of O_3 causes deaths, primarily from respiratory illness. Fine particles and ground-level ozone also have other major health impacts including acute and chronic bronchitis and other respiratory illnesses, non-fatal heart attacks, and low birth weight.

Implementing the reduction measures in Table 1 would substantially improve air quality and reduce premature deaths globally due to significant reductions in indoor and outdoor air pollution. According to the UNEP/WMO Assessment, the reductions in black carbon and other fine particles resulting from the particle-reducing measures in Table 1 would help avoid an estimated 0.7-4.6 million outdoor air pollution-related premature deaths per annum by and beyond 2030[18].

A very significant public health risk occurs in Asia and Africa due to high indoor levels of black carbon and other fine particles caused by cooking or space heating with biomass fuels. High concentrations of fine particles indoors are linked to acute respiratory infections among children under five and a significant proportion of child deaths worldwide. Project *Surya* found that using clean stoves in a village in India led to improved health and living conditions for women and children (Box 3).

Besides its health impacts, ground-level ozone also poses a threat to crop production and ecosystem functioning. A vast body of literature reviewed in the UNEP/WMO Assessment describes experiments and observations showing the substantial negative effects of O_3 on the growth and productivity of a large number of crops, trees and ecosystems. Ozone also affects vegetation composition and diversity.

Globally, the full implementation of CH_4 measures shown in Table 1 would result in significant reductions in O_3 concentrations leading to avoided yield losses of about 25 million tonnes of four staple crops (maize, rice, soybean and wheat) each year. The implementation of the BC measures would also have an important side benefit on crop production because reducing emission from BC sources also reduces the carbon monoxide and nitrogen oxides that contribute to the production of ground-level ozone. Accounting for this linkage, model experiments indicate that adopting the BC-reduction measures in Table 1 would avoid about a further 25 million tonnes of ozone-related yield losses in comparison with the reference scenario[19]. Therefore, full implementation of the identified measures could avoid crop-yield loss of about 50 million tonnes (with an uncertainty range of 30–140 million tonnes). This is equivalent to around 1 to 4 percent of total global production of these crops each year. The most substantial benefits will be felt in or in the vicinity of regions where action is taken to reduce emissions. The greatest health and crop benefits would be expected to occur in Asia.

Box 3:
Project Surya

Project *Surya* aims to provide the enabling environment for reducing indoor and outdoor air pollution by switching to more efficiently-burning stoves. *Surya* has successfully completed a pilot phase in a village with 2,500 inhabitants. Households in the village traditionally cook with stoves using locally available biomass, which is either collected or (in some cases) purchased. Introduction of improved stoves to these families had three immediate benefits: (1) reduced black carbon emissions which significantly improved the kitchen air quality; (2) less time spent by women collecting biomass fuel because the improved stoves require less fuel than traditional stoves; and (3) reduced cooking time because the stoves are more energy efficient. The Project is now embarking on the demonstration phase in which improved stoves will be introduced to a rural area of approximately 100 square kilometres with around 50,000 inhabitants.

[18] *Estimated in* UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

[19] These estimates of avoided yield loss result from changes to the ground-level ozone concentrations as calculated by the ECHAM and GISS models from the reductions in precursor emissions of methane (due to the CH_4 measures) and changes to the precursors CO and NO_x that occur due to implementation of measures to reduce BC emissions *in* UNEP and WMO. 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. UNEP, Nairobi (pre-publication version).

4. TECHNICAL MEASURES TO REDUCE SHORT-LIVED CLIMATE FORCERS

There is a wide range of options for reducing concentrations of black carbon and tropospheric ozone. As explained earlier, an important precursor of tropospheric ozone is methane, so the options that reduce methane in the atmosphere also tend to reduce tropospheric ozone. A comprehensive list of technical measures for reducing methane emissions are reviewed in the Fourth Assessment Report of IPCC, Working Group III[20] which also contains information on their costs and their mitigation potentials in different world regions.

At the regional scale, the Ad-Hoc Expert Group on Black Carbon of the Convention on Long-range Transboundary Air Pollution (CLRTAP) has estimated the potential to reduce black carbon emissions in Europe and North America[21]. These estimates rely on the same data sources of the GAINS model that have been used for the UNEP/WMO Assessment. The report concluded that BC emissions in the region of the United Nations Economic Commission for Europe (UNECE) are expected to decline between 2000 and 2020 by about one third, primarily as a result of ongoing implementation of current emission control legislation in the transport sector. The report identifies feasible measures that can reduce black carbon emissions in the region by 40% by 2020 (relative to 2005). The residential heating sector was found to have the largest BC reduction potential. Issues here are implementation barriers and the practical feasibility of implementing specific measures within a given time horizon. The sector with the next greatest potential for reducing BC emissions was off-road machinery. Also promising is the accelerated introduction of particle traps for light duty and heavy duty vehicles, as well as retrofitting existing vehicles. The burning of agricultural wastes was found through remote sensing to be an important emissions source even where it has been legally banned. Hence, enforcement of existing burn regulations may be another way to lower emissions.

Also at the regional scale, the Arctic Monitoring and Assessment Program (AMAP) and the Arctic Council's Short-lived Climate Forcer Task Force have examined options for reducing short-lived forcers having an impact on the Arctic environment[22]. The AMAP report recommends a focus on near-Arctic black carbon sources such as diesel emissions, as well as global sources of methane (reducing oil, gas and coal-bed methane in particular). The Task Force will present its recommendations at a May 2011 ministerial meeting in Nuuk, Greenland. Measures under consideration for Arctic Council nations include decreasing emissions from wood burning stoves, reducing diesel emissions, decreasing springtime agricultural burning, and giving greater attention to controlling potential emissions from shipping and the oil and gas industries.

On the global scale, few studies have examined the potential of reducing BC or other short-lived climate forcers (other than methane). The few existing studies come from the US Environmental Protection Agency, the PEW Center on Global Climate Change, and US-AID[23].

Also on the global scale, we mentioned earlier that the UNEP/WMO Assessment evaluated the impact on global warming of a worldwide package of 16 measures for controlling BC and CH_4 (Table 1). The identified measures were chosen from about 2 000 separate measures considered in IIASA's GAINS

[20] Barker T., Bashmakov, I., Bernstein, L., Bogner, J.E., Bosch, P.R., Dave, R., Davidson, O.R., Fisher, B.S., Gupta, S., Halsnæs, K., Heij, G.J., Kahn Ribeiro, S., Kobayashi, S., Levine, M.D., Martino, D.L., Masera, O., Metz, B., Meyer, L.A., Nabuurs, G.J., Najam, A., Nakicenovic, N., Rogner, H.H., Roy, J., Sathaye, J., Schock, R., Shukla, P., Sims, R.E.H., Smith, P., Tirpak, D.A., Urge-Vorsatz, D., Zhou, D. 2007. Technical Summary. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[21] Report by the co-chairs of the Ad Hoc Expert Group on Black Carbon.
UNECE, Convention on Long-range Transboundary Air Pollution, Doc. ECE/EB.AIR/2010/7

[22] Arctic Council Task Force on Short-Lived Climate Forcers: Progress Report and Recommendations for Ministers Progress Report by the Co-chairs of the Arctic Council Task Force on Short-lived Climate Forcers (Unpublished. Submitted to the Arctic Council in spring 2011) (see www.amap.no/publications)
US EPA. 2006. Global Mitigation of Non-CO_2 Greenhouse Gases. EPA 430-R-06-005. Washington DC.

[23] US-AID. 2010. Black Carbon Emissions in Asia: Sources, Impacts, and Abatement Opportunities International Resources Group (IRG) report prepared under the ECO-Asia Clean Development and Climate Program. US-AID, Bangkok Thailand.
Bachmann, J. 2009. Black Carbon: A Science/Policy Primer. Pew Center on Global Climate Change.

Table 1: Package of measures that mitigate climate change and improve air quality and have a large emission reduction potential. [1] Used for analysis presented in Figure 1. Note, methane measures improve air quality by reducing the production of tropospheric ozone.

Sector	Measure
Methane measures (also reduce tropospheric ozone)	
Extraction and transport of fossil fuel	Extended pre-mine degasification and recovery and oxidation of CH_4 from ventilation air from coal mines
	Extended recovery and utilization, rather than venting, of associated gas and improved control of unintended fugitive emissions from the production of oil and natural gas
	Reduced gas leakage from long-distance transmission pipelines
Waste management	Separation and treatment of biodegradable municipal waste through recycling, composting and anaerobic digestion as well as landfill gas collection with combustion/utilization
	Upgrading primary wastewater treatment to secondary/tertiary treatment with gas recovery and overflow control
Agriculture	Control of CH_4 emissions from livestock, mainly through farm-scale anaerobic digestion of manure from cattle and pigs
	Intermittent aeration of continuously flooded rice paddies
Black carbon measures (affecting black carbon and other co-emitted compounds)	
Transport	Diesel particle filters for road and off-road vehicles
	Elimination of high-emitting vehicles in road and off-road transport
	Replacing coal by coal briquettes in cooking and heating stoves
Residential	Pellet stoves and boilers, using fuel made from recycled wood waste or sawdust, to replace current wood-burning technologies in the residential sector in industrialized countries
	Introduction of clean-burning biomass stoves for cooking and heating in developing countries[2, 3]
	Substitution of clean-burning cookstoves using modern fuels for traditional biomass cookstoves in developing countries[2, 3]
	Replacing traditional brick kilns with vertical shaft kilns and with Hoffman kilns
Industry	Replacing traditional coke ovens with modern recovery ovens, including the improvement of end-of-pipe abatement measures in developing countries
Agriculture	Ban of open burning of agricultural waste[2]

[1] There are many other measures that would reduce methane and black carbon emissions. For example electric cars would have a similar impact as diesel particle filters but they have not yet been widely introduced; forest fire controls could also be important but are not included due to the difficulty in establishing the proportion of fires that are anthropogenic.
[2] Motivated in part by its effect on health and regional climate, including areas of ice and snow.
[3] For cookstoves, given their importance for BC emissions, two alternative measures are included.

model[24]. These measures pertain to the sectors (i) fossil fuel extraction and transport, (ii) waste management, (iii) agriculture, (iv) residential and (v) transport (Table 1). Successful examples of these measures exist throughout the world and this experience provides a considerable body of knowledge for others to build on. Nevertheless, these measures would have to be implemented much more widely to achieve full climate benefits.

The main criteria for selecting particular measures were that they have a high likelihood of reducing global warming and at the same time provide clean air benefits by reducing air pollution (win-win measures). The selection of measures took into account the fact that BC and O_3 precursors are co-emitted with different gases and particles, some of them causing warming and some cooling *(see section 2)* (cooling agents include organic carbon and sulphate derived from sulphur dioxide). Those measures that reduced air pollution but increased global warming were not included in the selection of measures. For example, technical options that primarily reduce emissions of sulphur compounds were not included.

Full implementation of these measures by 2030 would lead to significant reductions of emissions relative to their current level or their reference level in 2030.

[24] GAINS, developed at IIASA: http://gains.iiasa.ac.at, is an integrated assessment model that explores cost-effective emission control strategies to reduce greenhouse gases and/or improve local and regional air quality. The model has been applied to analyze strategies in a number of regions and countries and, recently, for the whole world. The emission calculation in GAINS draws on the available literature and has been reviewed by experts from academia, governments and industry that work on source-specific issues and national aspects of emissions.

5. A SURVEY OF POLICY OPTIONS FOR REDUCING SHORT-LIVED CLIMATE FORCERS

Up to this point we have seen that reducing levels of short-lived climate forcers supports global and regional climate protection over the next two to four decades and provides co-benefits to health, crops and ecosystems. Here we review the vast array of policy options available to decision makers and stakeholders for reducing short-lived climate forcers in the atmosphere.

Two common themes run through these options, and could form the basis for an Action Plan for reducing short-lived climate forcers.

The first are the *multiple benefits* that could be gained through reaping health and other benefits of clean air. As stressed previously, black carbon and tropospheric ozone have an impact not only on climate change, but also on health, crops, and ecosystems. By acting on both problems together, policies that address short-lived forcers can significantly reduce the costs of achieving targets in both areas.

The second is that an Action Plan could be *built on the global, regional and national frameworks and policies that already exist* and which could be scaled-up to include stronger action on short-lived climate forcers. For each of the short-lived climate forcers, there are existing agreements and measures at the international level that could be strengthened and focused towards a strategy for near-term climate protection. As many of the climate, health and crop impacts are national or regional in scale, regional cooperation and supporting national action will be important.

5.1 Global Level: Working through Existing Global Instruments

Sometimes new agreements are needed for emerging areas and global problems. However, negotiating new international agreements is both a costly and time-consuming exercise. Therefore it is fortunate that short-lived climate forcers lend themselves, for the most part, to already existing international frameworks. These frameworks could be used to focus action on climate change while also addressing the primary objectives of the agreement; alternatively they could be could be adjusted to include a shared vision for near-term action.

5.1.1 Working with the Montreal Protocol

The Montreal Protocol has a successful track record for phasing out 97% of almost 100 ozone-depleting chemicals. It is also well-suited for the effective reduction/phasing-out of HFCs, one of the short-lived climate forcers.

Some governments have proposed an approach to control HFCs jointly under the Kyoto and Montreal Protocols. HFCs are currently included in the basket of GHGs to be reduced under the Kyoto Protocol, but the experience, institutions and expertise for regulating ozone depleting substances under the Montreal protocol could also be used to control the production and consumption of HFCs while keeping the emission controls and accounting obligations under the UNFCCC. Governments have also recognized that "perverse incentives"[25] must be prevented under the Clean Development Mechanism.

There could be greater scope for collaboration between the Montreal and Kyoto Protocols. By working in coordination with the Montreal Protocol,

[25] For example, HCFC-22, which is being used as an interim replacement for much more ozone depleting CFCs, has a GWP 1,810 times higher than carbon dioxide, and HFC-23, a by-product of HCFC-22's manufacturing process, has a warming potential 14,800 times higher than CO2 (according to IPCC AR4 Chapter 2 - Forster, P., et al. (2007), Changes in Atmospheric Constituents and in Radiative Forcing, in Climate Change 2007: The Physical Science Basis, edited by S. Solomon, Cambridge University Press, New York. While HCFC-22 was left out of the Kyoto Protocol in deference to the Montreal Protocol's long-term phase-out objectives, certified emissions reductions credits are available for HFC-23 capture and destruction under the Kyoto Protocol, and this has created a contradiction that pits the two agreements directly at odds.

the UNFCCC could achieve the emission reduction of high-GWP HFCs using the existing structures of the Montreal Protocol. This would be both cost- and time-effective.

It may also serve as a model for financial and technology transfer mechanisms being developed by the UNFCCC under the Bali Strategic Plan. For example, the Executive Committee of the MLF (Multilateral Fund) is currently considering the creation of a new funding window that could address control of HFCs.

5.1.2 A near-term shared vision to compliment the climate convention longer-term commitments

Section 3 has already identified how a near-term strategy could help slow global warming and increase the likelihood that global warming stays within the 2°C target agreed to in Cancun. While a long-term vision of reducing greenhouse gases is the principal way of preventing dangerous climate change over the long-term, a shared short term vision under the Climate Change Convention could assist and complement a longer term strategy to meet its objectives.

As the principal global instrument for climate change, the Convention could provide a platform for taking stock and monitoring progress towards reducing short-lived climate forcers. For example, through its Subsidiary Body for Science and Technology Advise (SBSTA), adequate dialogue could be established regarding efforts being achieved under other global instruments, as well as under regional agreements and by other UN organisations. It might also provide a specific monitoring window for countries to report their initiatives and actions at the regional and national level on a voluntary basis.

A second role could be to provide a menu of policies and measures that countries could use to develop national actions on short-lived climate forcers. Such a menu, along with some understanding of best practices, could be an important tool to assist countries in developing their own national strategy for short-lived climate forcers and could become part of an Action Plan on near-term climate protection and clean air benefits.

The third role of the Convention could be to raise awareness of the dual importance of methane as part of both a long-term and short-term strategy for climate change. This dual role could become a rationale for strengthening and scaling up CDM projects already under way, e.g. in the mining, municipal wastes, and agricultural sectors. The importance of black carbon and methane to a near-term strategy could warrant a dedicated near-term implementation fund for methane and black carbon mitigation. If a fund was created, it could support small-scale projects that focus on facilitating widespread adoption of technologies that improve energy efficiency and reduce emissions of black carbon and methane.

To an extent, both methane and black carbon require local capacity building to support deployment of small-scale technology that has potential for quick uptake by local communities. (e.g. new cooking/heating technology for reducing black carbon emissions, landfill management techniques for controlling methane) Alternative low-emissions technology exists and could have large impacts on greenhouse gas emissions over a relatively short period (i.e. over 20 years). The benefits to least-developed countries are potentially great, particularly for those countries which have difficulty generating large-scale mitigation projects for Certified Emissions Reductions (CERs).

Another issue where international cooperation can be achieved is the potential to reduce emissions from international shipping. These emissions are currently outside the regulatory framework for climate change, but account for around 1.7% of the global black carbon inventory. Given the expected increase in shipping throughout regions especially sensitive to black carbon like the Arctic, it still represents an attractive option for black carbon reductions[26].

5.2 Regional Level: Scaling Up Existing Regional Cooperation

There are two reasons why action at the regional scale will be critical to the success of any Action Plan for short-lived climate forcers: First, the principal pollutants involved are transported at the regional or hemispheric scale. Hence, there is some justification

26 Lack, D., Lerner, B., Granier, C., Baynard, T., Lovejoy, E., Massoli, P., Ravishankara, A.R., Williams, E. 2008. Light Absorbing Carbon Emissions from Commercial Shipping. Geophysical Res. Letters 35, L13815.

for regulating these pollutants at that scale. Second, there may be marked regional variation in the measures that are appropriate and effective – while some will be globally relevant, others will not be. Priority setting and monitoring will still need to occur at the global scale, but much of the implementation can be best pursued at the regional or national levels.

Action on short-lived climate forcers is already underway in the region of the United Nations Economic Commission for Europe under the Convention on Long-Range Transboundary Air Pollution (CLRTAP). In December 2010, the Executive Body of the Convention decided to include black carbon as a component of particulate matter in their ongoing process of revising the Protocol. This decision marks the first time an international agreement has attempted to address the issue of short-lived climate forcers in the context of air pollution policy. The Executive Body further decided to look at the impacts of ozone and all its precursor emissions, including methane, from a broader perspective in terms of benefits and measures to reduce emissions of the precursors. Outreach by countries of the Convention on LRTAP to other regions and countries could be an important contribution to global action on short-lived climate forcers.

The December decision was supported by findings of the *Ad-Hoc* Expert Group on Black Carbon which assessed the science of black carbon with respect to both climate and public health. While recognizing that scientific uncertainties remain, the Expert Group agreed on several key findings:

- There is general scientific consensus that mitigation of black carbon will lead to positive regional impacts by reducing black carbon deposition in areas with snow and ice;
- There is virtual certainty that reducing primary particulate matter [containing black carbon] will benefit public health;
- The Arctic, as well as alpine regions, may benefit more than other regions from reducing emissions of black carbon;
- Climate processes unique to the Arctic have significant effects that extend globally, so action must be taken in the very near term to reduce the rate of warming;
- Impacts on the Arctic and alpine areas will vary by country, but all countries will benefit from local emission reductions of black carbon and other co-emitted pollutants.
- The report made no assertions regarding the net global radiative forcing associated with black carbon.

We noted in Section 4 that the Expert Group found that emissions could be reduced by an additional forty percent by the year 2020 using known technology. The Expert Group concluded that because of the public health benefits of reducing black carbon, as well as the location of the countries across the Convention regions in relation to the Arctic, the Convention should consider taking additional measures to reduce black carbon.

Arctic Council nations (USA, Russian Federation, Canada, Sweden, Norway, Denmark, Finland and Iceland) could play a special role in controlling short-lived climate forcers through voluntary actions. Council Ministers in 2009 created a Task Force on Short-lived Climate Forcers, and additional efforts on research and mitigation are ongoing in a variety of Council working groups. The Arctic countries are highly motivated by the fact that the Arctic is warming at a rate about 2.5 times the global rate. Melting of land-based ice and snow in the Arctic could in addition have global ramifications by speeding up sea level rise.

Other parts of the world have also been developing regional networks to control transboundary air pollution and these efforts have started to move towards the development of fully-fledged regional instruments. Adding the goal of slowing near-term global warming could accelerate this development. Linking regional agreements with some of the financial incentives coming from the climate change regime could also become an important means for implementing these instruments and covering incremental costs of climate protection. This could result in regional air pollution agreements that address regional concerns for human health and crop protection while also becoming the backbone of a strategy for short-lived climate forcers.

While regional efforts have varied greatly in their resources, capacity and focus, almost all recognise the critical linkage between climate and air pollution, and hence the need to address short-lived climate forcers. In Africa and Latin America, recent policy declarations on air pollution have all emphasised the importance of developing integrated strategies for climate and air pollution. In the Malé Declaration[27] and EANET[28] - covering regions of South and Eastern Asia - there is widening awareness of the potential

[27] Malé Declaration – Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia.
[28] EANET – Acid Deposition Monitoring Network in East Asia.

scale and significance of climate/air pollution co-benefits. In many of these regions black carbon poses a major risk to health, but air quality management systems are in a relatively early stage of development. In this situation, it is still feasible to build governance systems that regulate both climate change and air pollution in an integrated fashion and this could help these countries get a quick grip on both greenhouse gases and air pollutants.

5.3 National Level: Strengthening National Standards and Measures

At the national level a great deal of effort is already being invested in reducing smog and other types of air pollution in order to reduce their impacts on human health and ecosystems. These efforts could be expanded to include the reduction of short-lived climate forcers. One option would be for countries to comply with the guidelines of the World Health Organization (WHO) on tropospheric ozone. In so doing they would not only reduce the health threat from this important air pollutant, but also reduce its impact on global warming. But tropospheric ozone is not a new problem and there is a relative large amount of policy knowledge and policy choices. The key is choosing the most appropriate policies for national circumstances and maximising co-benefits for climate and air pollution.

A second option would be to support measures to reduce black carbon emissions at the national level. The challenge to mitigating and controlling black carbon emissions is, as mentioned previously, that many emission sources are small-scale, and spread out over large areas (sources include: diesel engines, small-scale industries, coal and solid biofuel heating and cooking, and open biomass burning). This requires developing and applying policies and new technologies that target key sources of black carbon.

A third option would be to strengthen national strategies to reduce methane given its dual importance as a precursor of ozone and a potent greenhouse gas in its own right. Efforts in this direction could focus towards methane recovery programmes in key sectors such as mining, refineries, waste disposal and raising livestock. As with tropospheric ozone and black carbon, there are many positive spin-offs from reducing and retrieving methane emissions. For example waste methane can be combusted as an alternative energy source, and retrieving methane from mines reduces the dangers of mining explosions.

5.4 Other Important Options

5.4.1 Capacity building and improved monitoring

Capacity building is urgently needed at the national level. There is a particular need to expand the monitoring and assessment of black carbon in Africa and Latin America where the population is exposed to black carbon particles but where monitoring facilities and networks are limited. UNEP's Atmospheric Brown Cloud Project is particularly concerned with this task.

There is also an urgent need for developing scientific capacity to better understand the combined impacts of air pollution and climate change. Enhancing these capacities will become an important prerequisite for developing countries to successfully undertake there own strategies on short-lived climate forcers.

5.4.2 Joint action by international organizations

A range of institutions can help to promote and facilitate action on short-lived climate forcers. These include UNEP, UNDP, FAO, WMO, and WHO. The World Bank and other financing institutions could be invited to take part in policy development and funding.

There are many ways in which these organizations could work together. For example:

- Enhancing information services and programs on short-lived climate forcers. An example of such a program is UNEP's Atmospheric Brown Cloud Project;
- Further development of regional air pollution frameworks to include considerations of short-lived climate forcers;
- Promotion of capacity building and awareness raising to support and promote short-lived climate forcer policies;
- Coordination and promotion of international action on short-lived climate forcers and contributions by relevant organizations to the development and implementation of policies and measures to reduce emissions.

Another important point is that actions to control short-lived climate forcers will, in principle, promote sustainable development since they will improve human well-being and protect nature by mitigating climate change and reducing air pollution. Thus it is important to engage the development community in the development of these policies and establish how relevant overseas development assistance can contribute to reducing short-lived climate forcers.

5.4.3 Financing and partnership initiatives

One of the more rapid mechanisms available for financing abatement of emissions is public-private partnerships. New financing mechanisms for methane are particularly promising to meet near-term climate mitigation needs. Targeted methane financing would both support long-term climate structures and goals under the UNFCCC, while moving methane abatement forward to meet the challenge of near-term global warming.

Besides the Partnership for Cleaner Fuels and Vehicles (Box 4), other current and proposed financing and partnership mechanisms include:

- The Prototype Methane Financing Facility (PMFF)[29] is a test mechanism aimed at stimulating additional methane abatement by supporting methane projects under the Clean Development Mechanism, and (potentially) certain regional and voluntary carbon markets, through provision of a price floor for carbon credits (Certified Emissions Reductions, or CERs). It would serve as a guarantee mechanism, and thus would require minimal up-front financing. It has the potential of becoming entirely self-financing within a few years by receiving some portion of CERs generated above the guaranteed floor price. Its initial focus would be clearing the current logjam of registered (but held up for lack of financing) methane projects under the CDM, with additional windows for new methane projects in least developed nations and small island developing states, and for cookstoves (see below). Analysis by carbon market specialists indicates that this mechanism should generate 6 to 15 million CERs for each $10 million in PMFF pledges.
- The Global Alliance for Clean Cookstoves (GACC)[30] was created in late 2010 to stimulate the replacement of highly-polluting stoves with models that have less deleterious impacts on human health and the surrounding environment, as well as on regional and global climate. Its work will focus on enabling activities, such as standardization of stove testing methods, as well as helping to create financing opportunities under existing mechanisms such as the CDM. For example, one stream of guarantees under the PMFF might be reserved for cook stove projects that abate methane as well as CO_2, with black carbon abatement as a co-benefit.
- The Methane to Markets Partnership[31], launched by 14 governments in 2004, empowers governments and the private sector to provide

Box 4:
Partnership for Cleaner Fuels and Vehicles

UNEP serves as the clearinghouse for the Partnership for Clean Fuels and Vehicles (PCFV)[32]. Launched at the 2002 World Summit on Sustainable Development, PCFV now has about 100 members, including governments, civil society, international organisations and institutions of higher learning. The goals of the PCFV are to assist developing countries to reduce vehicular air pollution through the promotion of lead-free, low sulphur fuels and cleaner vehicle standards and technologies. Low sulphur fuel content is needed for the efficient performance of diesel particle filters (DPFs) that remove black carbon and other particles.

There are tens of millions of diesel vehicles in use throughout the world and the vehicle populations in developing countries are growing dramatically. With a combination of low sulfur fuel and diesel particulate filters, particulate matter reductions of 90% or more are realistic, and while numbers vary, black carbon makes up a very large fraction of the particulate matter emissions from diesel engines. While not part of its current charge, black carbon reduction programs could build on the success of PCFV.

---

29 http://www.globalmethane.org/
30 http://cleancookstoves.org/
31 http://www.globalmethane.org/
32 http://www.unep.org/transport/pcfv/
http://www.unep.org/transport/pcfv/corecampaigns/campaigns.asp#sulphur.

technical and market expertise, financing, and technology necessary for projects to capture and use methane. Projects under this partnership aim to reduce the market barriers to methane projects through training and capacity building, technology demonstration, and direct project support. In October 2010, Methane to Markets expanded in scope and scale to become the Global Methane Initiative (GMI). Continuing with a project-based emphasis, but adding additional sectors and features such as National Action Plans, GMI serves as an important example of how governments and the private sector can work together, promoting technology transfer and achieving real emission reductions and economic benefits.

5.4.4 Awareness-raising

Policies focusing on short-lived climate forcers have so far evolved along two parallel tracks: one driven by the need to mitigate climate change, and the other by the desire to abate air pollution impacts on health, crop yield, and ecosystems.

Most often, these two tracks are represented by different organizations and institutions, with different attitudes and experiences in controlling and managing emissions of greenhouse gases and air pollutants. In many countries, they represent entirely different communities, with their own references and political drivers. However, bringing these two tracks and two communities together would certainly make the abatement of short-lived climate forcers more effective.

An Action Plan for near term climate protection must also consider that the issue of short-lived climate forcers is not very well known in many regions and countries but air pollution policy needs and climate change are. This implies that the Action Plan must stress initially:

- *General awareness raising,* particularly on the relationship between air pollution and climate change. It must also highlight that there are cost-effective and win-win measures in all regions with the greatest benefits appearing in the regions and countries where action is taken.
- Stressing the importance of *engaging both the air pollution and climate change communities* in integrating policies and measures to achieve cost-efficiency, realizing that many of the control measures are actually best managed and implemented in air pollution policy frameworks;
- Building on global and regional *frameworks for scientific cooperation* to further develop the scientific foundation for actions on short-lived climate forcers.

5.4.5 Pilot projects

An important part of a comprehensive strategy to control short-lived climate forcers is to organize mitigation pilot projects in different regions and countries. These pilots could cover a broad range of different activities to develop a pool of experience that can then be used to scale up actions. These could range from projects to demonstrate alternatives to burning of agricultural wastes to the introduction of new and more efficient cookstoves and controlling the release of methane from coal mines. The *Surya* project is a good example of a project that demonstrates the potential of improved cookstoves and monitors the benefits delivered at village level (see Box 3).

5.4.6 Encouraging research

Although early actions to reduce short-lived climate forcers are already justified by the science, more research is needed to clarify the relative roles of different short-lived climate forcers in different regions, in particular their impact on regional climate and weather patterns. Also the global role of black carbon needs to be better understood.

UNEP, the UN Economic Commission for Europe, the Arctic Council, and various other national and international institutions could help set research priorities and provide support for research.

www.unep.org

United Nations Environment Programme
P.O. Box 30552 - 00100 Nairobi, Kenya
Tel.: +254 20 762 1234
Fax: +254 20 762 3927
e-mail: uneppub@unep.org
www.unep.org

UNEP