Summary Recommendations: Addressing Short-Lived Forcers of Arctic Warming and Melting

AMAP Workshop on Non-CO_2 Forcers
Oslo, Norway, September 15-16, 2008

The Arctic is at a critical juncture due to recent unprecedented warming. Arctic temperatures have increased at almost twice the average global rate over the past 100 years, accompanied by earlier and longer melt seasons, increasing melt from Greenland's ice sheet, and large reductions in summer sea ice. These unexpectedly-rapid changes have raised the specter of reaching Arctic and Arctic-influenced global tipping points that might lead to impacts such as sea level rise and methane release from melting permafrost; the consequences of which would reach far beyond the Arctic region itself. Such rapid change has severely challenged the ability of Arctic indigenous communities to adapt, and the environmental impacts of swiftly rising temperatures threaten regional biodiversity as local species cannot evolve quickly enough to survive.

Global forcing has driven most of this Arctic warming, and reductions in CO_2 will serve as the backbone of any meaningful effort to reduce long-term warming in the Arctic region. However, even if all CO_2 emissions ceased today, the reduction in global warming would not occur quickly enough to prevent the increasingly-rapid changes we see in today's Arctic environment. At the same time, several shorter-lived climate agents – black carbon, tropospheric ozone, and methane -- collectively have nearly the same estimated temperature impact on the Arctic as CO_2 in the near term. Research on these short-lived forcers has developed rapidly in the past five years, building on the earlier work of the IPCC and air pollution control communities, with an emerging consensus that addressing these agents may bring significant Arctic climate benefit. Targeting these short-lived forcers has the added potential of delaying the beginning of spring melt, which has begun earlier each year. With their relatively short lifetimes (days to years), reductions in these pollutants should more rapidly benefit the Arctic than that from CO_2 reductions alone.

Although scientific uncertainties remain in terms of precise mechanisms and magnitude of impact, Workshop participants reached consensus that certain early measures to address short-lived forcers, in conjunction with parallel reductions in CO_2 and actions based on additional research, have a sufficiently high potential to slow Arctic warming and melting as to motivate Council action now. These measures can take place within existing national and international climate and air quality structures, within which enhanced action aimed at short-lived forcers could benefit the Arctic. Reductions in these forcers also would bring significant health co-benefits to Arctic populations.

Such early Council actions could provide the basis of future additional efforts to stabilize Arctic sea and Greenland sheet ice, lowering appreciably the near-term risk of reaching Arctic tipping points; facilitating adaptation by indigenous communities and preserving biodiversity by slowing the rate of warming in this critical near-term period.

<u>Recommendations for SAO and/or AMAP HOD Consideration</u>:

Monitoring and Research:

1. Arctic member and observer nations should identify current national activities related to the most critically needed observations and research as described in the Workshop Science Overview, and develop additional recommendations for the April 2009 Ministerial for those research needs.

2. Arctic members should work to enhance and expand networks of monitoring and observation points for short-lived forcers, building on existing and planned networks [SAON].

Early National and Council Action:

1. Ministers should consider a commitment to undertake maximum feasible reductions of methane within Arctic nations and globally in the near term for the purpose of achieving rapid Arctic climate benefits. Focus should include methane sources of significance in the Arctic and globally (oil and gas, coal mines, agriculture and landfills) and emphasize both additional national action and international cooperation such as active participation in the Methane-to-Markets partnership, the Clean Development Mechanism, and Joint Implementation. These measures will have the additional benefit of reducing background levels of tropospheric ozone.

2. SAOs should as a matter of urgency consider tasking a working group to evaluate the black carbon mitigation options discussed in the background paper and identify further potential options, to develop a pan-Arctic implementation strategy to reduce the levels of black carbon reaching the Arctic, reporting back to the Council.

3. Ministers should consider Member state commitments, and invite similar commitments from Observers, to enable measures to limit agricultural crop residue burning, especially in springtime, in order to decrease deposition of black carbon during the sensitive Arctic melt season. Council members with existing limits may consider providing in-kind technical and regulatory expertise.

4. Council members and interested Observers should perform domestic national-level analysis of the feasibility of the recommended and additional mitigation opportunities for all short-lived forcers; and initiate implementation actions, with reporting back to Council bodies no later than 2011.

Outreach to Other Forums:

1. The SAOs should consider a joint Arctic nation or Council approach to the December 2008 Executive Body of the Convention on Long-Range Transboundary Air Pollution to request consideration of the impact of short-lived forcers during the current revision of

the Gothenburg Protocol, in light of their environmental impact on the Arctic climate; as occurred in the early 1990's for heavy metals and POPs.

2. Consider a joint approach by Council members to the International Maritime Organization, recommending it introduce strict limitations on emissions of black carbon and ozone precursors to limit their contribution to Arctic warming and melting.

3. Consider sponsoring side events at COP-14 and/or COP-15 to bring the need to address short-lived forcers for near-term Arctic climate benefit to the attention of the global community.

4. Consider a request to UNEP to incorporate into its climate change programming information on black carbon and the need to mitigate emissions for Arctic climate benefit.

Background:
Addressing Short-Lived Forcers of
Arctic Warming and Melting

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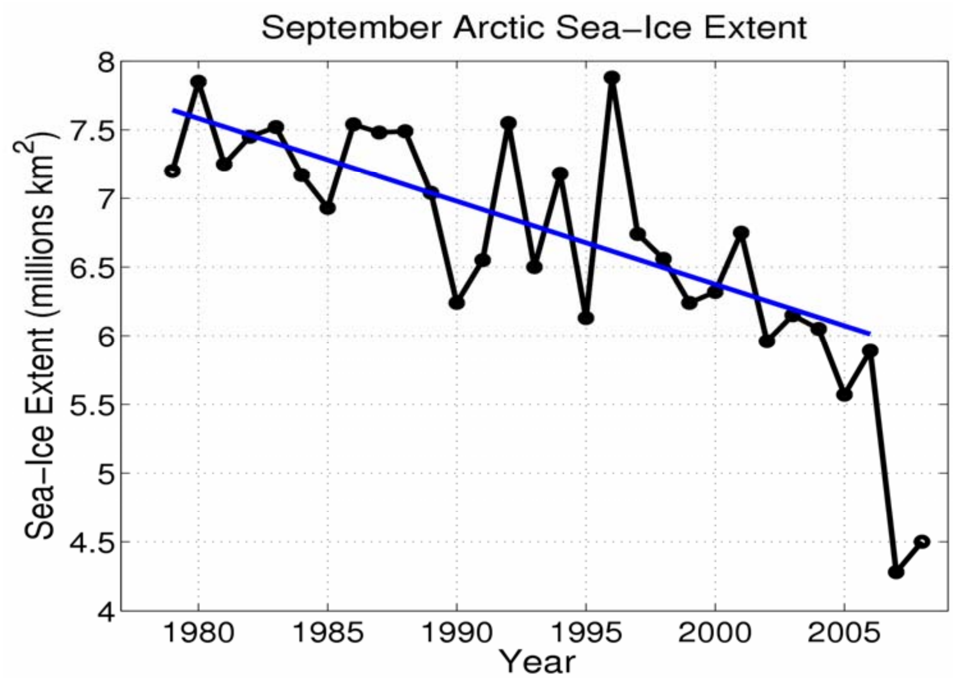
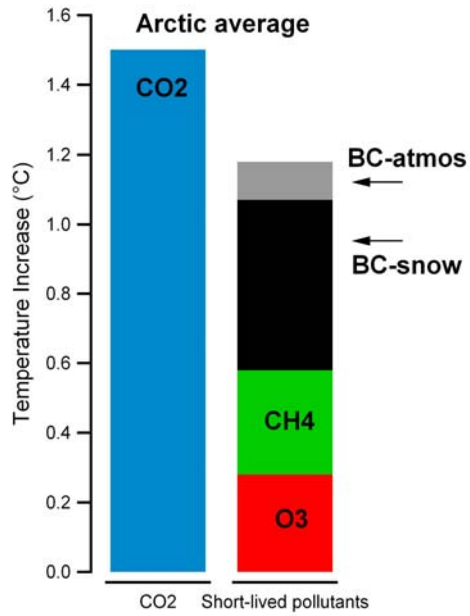


<u>Basic Impacts of Short-lived Forcers</u>:

Part of the powerful Arctic impact of short-lived forcers comes from their seasonal nature, with the strongest impacts coming from late winter through mid-summer, at the time of the spring melt. Each forcer however has unique characteristics important to designing any appropriate future mitigation measures. All three of these pollutants, however, also damage human health as particles and smog, so that reductions also bring important health co-benefits:

Black carbon (BC) consists of small dark particles arising from inefficient burning, for example from diesel engines or wood burning stoves. BC warms the Arctic in two ways. First, as a haze layer in the atmosphere its dark color absorbs sunlight, contributing to overall global warming that also warms the Arctic. Most of this global impact comes from sources in more southerly latitudes such as cookstoves. Of greater relevance to the Arctic however, some of the airborne BC that reaches the region deposits out of the atmosphere onto the ice and snow, making it darker and changing its structure, resulting in more rapid melting. Recent extensive modeling indicates that the majority of the BC that deposits in this manner comes from the northern latitudes, placing this figure at 80%

on Greenland (with 40% each coming from North America and Europe), and near 70% on sea ice (with a greater proportion from Europe and possibly North Asia).



Warming in the Arctic since Pre-industrial Times, Quinn et al (2007). Best estimate of calculated temperature increase for deposited (surface) black carbon.
(Note: The uncertainty in the potential effect of black-carbon deposited on snow is estimated at -87% to +240% for the global situation, compared with ca. ± 10% for the CO_2 forcing component).

Greater snow and ice sampling would help confirm these modeling results. Deposition in late winter and springtime has the greatest impact on spring melt, indicating greater importance for seasonal reductions such as springtime agricultural burning.

Black carbon however is usually emitted in a mix that includes organic carbon and other aerosols (such as sulfates, nitrates and ammonium) that actually cool the climate because they reflect sunlight. Any black carbon reduction efforts would therefore need to focus on sources where sufficient black carbon exists in the mixture to result in overall warming.

Tropospheric ozone (O3) forms in the atmosphere from emissions of its precursor pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic carbons (NMVOCs) and methane. Like methane, ozone warms the Arctic as a global warming agent; but warms regionally as well in winter and early spring, when ozone from northern lower latitudes gathers over the Arctic to form a warming "blanket" of smog. This can occur because in the greater darkness of winter, ozone persists in the atmosphere for up to two months (as opposed to a lifetime of at most 1-2 weeks in summer). Such winter-to-spring warming appears to contribute to earlier spring melt. This effect means that winter and early spring reductions in ozone in middle-to-high northern latitudes will have a somewhat greater benefit in the Arctic than reductions elsewhere. Most Arctic tropospheric ozone comes from North America.

Methane (CH4) is considered a greenhouse gas (GHG) under the Kyoto protocol, but has a relatively short lifetime (about 9 years). Methane contributes to Arctic warming however not only as part of overall global warming, but by producing ozone. Where reductions in BC and ozone in northern latitudes give additional Arctic benefit compared to reductions elsewhere, reductions in methane anywhere on the globe and in any season provide benefit for the Arctic, by slowing overall global warming much more quickly than would reductions in the long-lived GHGs.

<u>Near-Term as Well as Long-Term Arctic Impact Timelines</u>:

Determining Arctic climate benefit includes evaluations of near-term, as well as long-term, measures of effectiveness, because some of the changes occurring in the Arctic (such as sea ice melt) may well reach a critical "tipping point" within a more near-term horizon as well; and unlike CO2, short-lived forcers have their greatest impact in the near term. An illustrative comparison of estimated 20-year versus 100-year CO_2 equivalents is indicative of this greater impact (averaged values from recent studies). Determining Arctic benefit also requires analysis of which reductions carry the greatest weight per unit of reduction. The comparison below would indicate that the greatest reduction potential lies with methane and black carbon, with tropospheric ozone precursors having an appreciable but far lesser effect. (Note that this analysis compares global emissions. For Arctic sources of BC, the deposition effect should result in even greater impact; as would to a lesser extent early spring ozone emissions in the mid- and high latitudes.)

Absolute and Weighted Anthropogenic Emissions of Short-Lived Climate Forcers[1]

Pollutant	Absolute Emissions (as of 2000, in Teragrams)	20 Year CO_2 Equivalents including range	100 Year CO2 Equivalents including range
Methane	287	20664	7175
Black carbon (1996)	5	11000 (3450 - 23500)	3400 (1050 - 7500)
CO	549	3294 (1647 - 4941)	1098 (549 - 1647)
NMVOC	140	1540 (420 - 2520	560 (140 - 840)
NOx[2]	102	0	0
CO2	27173	27173	27173

[1] Source: IPCC Fourth Assessment, 2007
[2] The impact of NOx is complicated, especially over longer time frames. In isolation, reductions in NOx likely would lead to neither warming nor cooling; but in concert with reductions in methane and other ozone precursors should provide Arctic climate benefits

Most Promising Mitigation Options:

The "first line" mitigation recommendations below reflect those sources and measures which the Workshop believes has the most potential for early action, grounded in our current level of understanding of their unique impact on the Arctic climate, as well as availability of existing technology. The other, "second line" measures may become equally important as either the science and/or mitigation technologies advance.

Black Carbon: Reductions of BC north of 40 degrees latitude (i.e., Europe, Canada, parts of the U.S. and northern Asia[3]) have priority, as they can impact both forcing and ice/snow melt within the Arctic and lie within the purview of Arctic Council member nations. Since BC is almost always emitted with other, more cooling agents, the most promising options include those sources known to emit primarily BC:

- Adopting diesel particulate control measures (ultra-low sulfur diesel (ULSD) fuel plus particulate traps);
- Reduce BC (and some CO) emissions by limiting agricultural crop residue burning, especially in springtime, in order to decrease deposition of black carbon during the sensitive Arctic melt season; as it becomes feasible, convert to biochar production and utilization;
- Address BC emissions from regional oil and gas flaring and marine transport.

Methane: Although a short-lived forcer, methane still has a much longer atmospheric lifetime than the other four pollutants discussed above; thus reductions made anywhere can have significant Arctic benefits. With this in mind, Arctic nations should strongly consider additional and substantial efforts to reduce methane emissions not only within the Arctic but worldwide, focusing on the following measures:

- Coal mine degasification and mine ventilation air capture.
- Target oil and natural gas production systems through leak reduction activities.
- Improved agricultural practices and use of anaerobic digesters.
- Adopting solid waste management activities to capture and flare or, preferably, productively use landfill gas.
- Improving wastewater treatment practices, especially in countries where wastewater is not treated aerobically; if anaerobic treatment used, collect and flare offgas.

Tropospheric Ozone: Methane reductions listed above also would serve as the most promising options for reducing background ozone levels.

Second-line efforts, which may become recommended or feasible within 1-2 years with sufficient effort (such as additional modeling or measurement, implementation planning or technology development) include:

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[3] Northern Asia is defined as areas north of 40 degrees latitude - Mongolia, North Korea, and the northern 1/3 to ¼ of China (areas north of Beijing).

Black carbon:

- Identification and reduction of industrial BC emissions in North America, Europe and Northern Asia; technology exists to address these emissions, but sources remain largely unidentified.
- Improvements in the efficiency of household energy use (coal and biomass) in Northern Asia, and to a lesser extent in Northern and Eastern Europe.

Tropospheric Ozone:

- Reduce CO, NO_x, and NMVOC emissions by adopting vehicle (exhaust catalysts, vehicle inspection and maintenance) and fuel storage emissions control measures.
- Reduce NO_x emissions by installing/requiring vehicle and small combustion source exhaust catalysts and other control devices; many techniques already used to reduce vehicle CO and NMVOC emissions also reduce NO_x emissions.
- Curb NO_x emissions through more stringent regulations, such as emission performance standards for all new generation emitters and use of cleaner fuels.
- Reduce NMVOCs emissions through industrial process capture and incineration systems and solvent recovery systems and by reducing consumer product emissions.