MACEB

Mitigation of Arctic warming by controlling European black carbon emissions

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WHAT IS BLACK CARBON?

Black carbon particles, the major constituent of soot, absorb solar radiation and thus in the air heat the atmosphere. In addition, when deposited on snow and ice they darken the surfaces and accelerate melting. It has lately been estimated that black carbon is the second most important pollutant, after carbon dioxide, forcing the climate change.

Black carbon emissions are mostly caused by human activities, such as heating and transportation, when fossil fuels, biofuels and biomass are burnt incompletely.

Because of the short life-time, reductions of black carbon emissions could slow down the warming relatively quickly. Aerosols containing black carbon as well as methane (CH_4) and ozone (O_3) are commonly identified as short-lived climate forcers (SLCF). Aerosols remain in the atmosphere only from several days to few weeks.

Soot-contaminated snow in the MACEB field experiments.
Photo: Aki Virkkula

SELECTED KEY FINDINGS

Aerosol emissions from the European countries cause currently a cooling effect in the atmosphere*. The effect is largest in central Europe and extends to over Arctic.

Compared with the present-day situation, **currently agreed policies affecting air pollutant emissions will reduce the aerosol cooling effect* (i.e. enhance warming)** over both Europe and Arctic areas during the next couple of decades. **Less future warming will be expected if emission reductions target the sources with high share of black carbon.**

There is a significant reduction potential for black carbon emissions with technologies that are currently available.

It is not possible to reduce the emissions of warming black carbon alone. Emission reduction technologies and policies affect also cooling components, i.e. organic carbon and sulfur emissions.

Residential wood combustion is a major source of black carbon emissions. In addition to stove technology, user's behavior in the form of stove operation and fuel quality has substantial impact on residential wood combustion emissions.

Black carbon emissions are at highest in winter and thus their effect on melting of snow and ice is pronounced.

The largest uncertainties in estimating the climatic effects of black carbon in Arctic areas arise from the difficulties in

- modeling the efficiency by which black carbon particles are transported from their source areas to the Arctic atmosphere
- understanding how the particles interact with Arctic clouds.

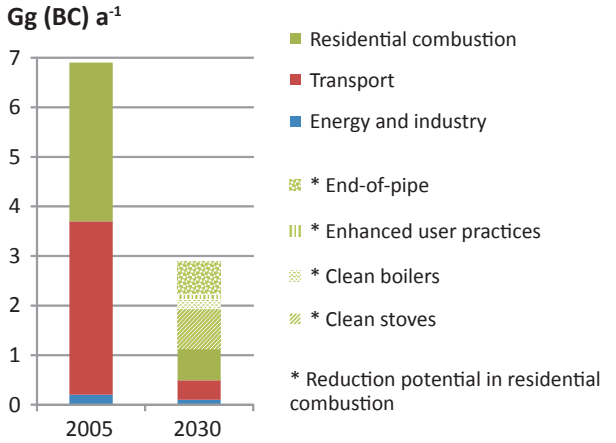
* A negative top-of-the-atmosphere direct aerosol forcing

MODELING BLACK CARBON IN THE ARCTIC

EMISSIONS

The biggest emission sources in Europe and Northern America are households that burn solid fuels for heating and diesel engines in the transport sector. In developing countries also cooking stoves and traditional coke and brick making kilns are significant emission sources.

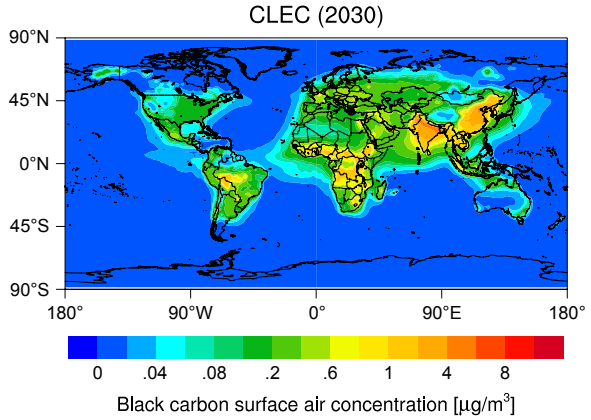
Efficient black carbon mitigation options include cleaner fuels and enhanced combustion devices for household heating and cooking and particulate filters for diesel engines. The MACEB project introduced emission mitigation by different scenarios, source sectors and world regions. An example of black carbon emissions and reduction potential is shown below.



Black carbon emissions in Finland in 2005 and 2030 in the reference scenario (entire bar). The maximum reduction potential in the residential combustion sector is shown by the transparent segments.

BLACK CARBON CONCENTRATIONS

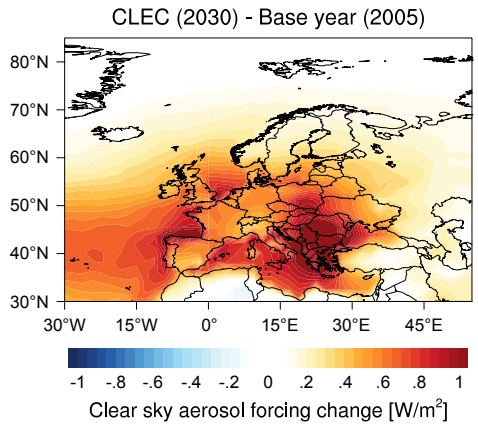
Black carbon concentrations will decrease in the future in Europe, North America and China, whereas substantial increases are predicted over India and Africa under the influence of current air pollution policies and legislation (CLEC scenario). With a scenario tailored for black carbon mitigation (BCadd), concentrations will decrease almost everywhere in the world.



Global black carbon surface air concentrations in 2030 in the current air pollution policies and legislation scenario.

CLIMATE EFFECTS

Although black carbon emissions will decrease in the Arctic countries in the future, the decrease of other air pollutants, especially sulfur dioxide, will cause a net positive top-of-the-atmosphere forcing compared to present day.



Change in the top-of-the-atmosphere forcing from 2005 to 2030 in Europe in the current air pollution policies and legislation scenario.

In the future, less black carbon will deposit onto snow in both Europe and most of the Arctic areas which will reduce Arctic warming during the spring and summer seasons.

More results: **www.maceb.fi** ▶ **Result viewer**

MACEB

The mitigation of climate change caused by global warming is the most important environmental challenge for the moment.

To find solutions to mitigate Arctic warming, the MACEB project integrates black carbon emissions from different sources and areas with black carbon concentrations in surface and snow over Arctic areas and further with corresponding radiative forcing.

The method used in this project combines information from global (GAINS) and national (Finland, FRES) emission models, global (ECHAM5-HAM2) atmospheric model, and actual measurements of black carbon concentrations in surface air and snow.

PROJECT OBJECTIVES

- To demonstrate the approach to mitigate warming of Arctic climate by black carbon (BC) emissions reduction at mid latitudes, especially in Europe.
- To assess the impact of the current air quality and climate relevant legislation in the northern hemisphere on BC emissions, their transport to the Arctic, and eventually Arctic warming.
- To transfer action procedures and experiences to assess and mitigate BC emissions from most important source sectors, e.g. small-scale wood burning.

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