# Mitigation of Arctic warming by controlling European black carbon emissions (MACEB): modelling results

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Black carbon (BC) is a light absorbing aerosol formed in incomplete combustion of biofuel, fossil fuels and biomass. Besides the absorption, BC particles influence on the radiation balance by deposition on snow and decreasing the snow albedo. This leads to heating and as a result the snow cover melts. Artic areas, for example, have already suffered from the global warming and different methods to protect these areas are being studied.

One of the main goals of MACEB project is to find the best approach to mitigate the warming of Arctic climate by different black carbon emission reductions. To achive this goal, several model simulations are conducted with the global aerosol-climate model ECHAM5-HAM2 (Stier *et al* (2005), Zhang *et al* (2012)). We implemented a new anthropogenic emission dataset for BC, organic carbon (OC) and sulfur dioxide ($SO_2$) which all have been derived from the GAINS model output (operated by the International Institute for Applied Systems Analysis, IIASA). In addition, we have updated the ship emissions (OC, BC and $SO_2$) and introduced aviation emissions (BC).

A series of different simulations have been carried on with different emission scenarios using both freely running, and nudged model. We have chosen the year 2005 to be the reference year and done scenario simulations for the years 2020 and 2030. The different scenarios used in this study are called CLEC, CLECC, BCadd and MTFR. CLEC and CLECC scenarios include all presently agreed policies affecting air pollutant emissions, but CLECC is further designed to keep the total forcing due to long-lived greenhouse gases at 450ppm $CO_2$-eqv level by the end of the century via $CO_2$ mitigation measures mostly targeting the energy production and industrial sectors. BCadd scenario includes a portfolio of most important measures that could yield the largest reductions in radiative forcing from short-lived climate forcers (SLCFs) at the global scale in 2030. Measures with a relatively small net impact or increase in radiative forcing have been excluded from this portfolio. MTFR implements the maximum reduction potential of aerosol and $SO_2$ emissions with currently available technologies. In addition to these scenarios, we study the influence of Finland's and EU's (EU-27 countries) emissions on Arctic climate by removing the BC and OC emissions from these areas.

Figures 1 and 2 show how the BC burden changes between normal simulation and CLEC 2020 scenario (in nudged mode). Within the CLEC scenario the reduction of BC is clearly seen in Europe. The burden seems to increase mostly in Africa, Middle-East and India. It is important to notice that although the reductions works in Europe, the polar region might still be influenced by a positive bias (please note the different units in Figs. 1 and 2). It is known that Arctic region is an area of clean air so even a relatively small increment in BC concentration might lead to noticeable changes in the regional climate. One of the biggest uncertainties is how much will the deposited BC influence on the snow albedo. Based on our results the Arctic area will be under more BC concentrated air masses already in 2020, if the scenario for the current European legislation with the Climate Policy is used.

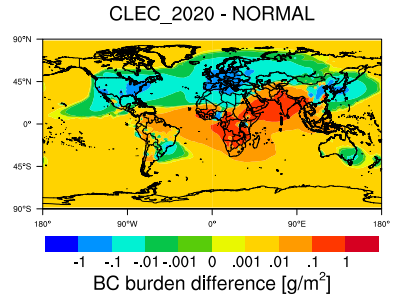


Figure 1: BC burden difference between CLEC 2020 scenario and current climate.

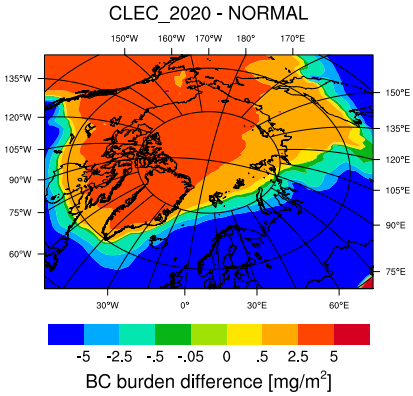


Figure 2: Same as in Fig. 1, but for Arctic area (different units).

During the conference we will present the rest of our results in more details and show how well the different reduction methods actually work for the Arctic region.

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Stier et al. (2005) *Atmos. Chem. Phys.*, 5, 1125-1156.
Zhang et al. (2012) *Atmos. Chem. Phys.*, 12, 8911-8949.