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Black carbon in the atmosphere and deposition on snow, last 130 years

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The transport of Black Carbon (BC) in the atmosphere and the deposition of BC on snow surfaces for the last 130 years, with special emphasis on the last 8 years, are modeled with the Oslo CTM2 model. In addition regional contribution to BC deposition on snow in the polar region is evaluated for some years. The model results are compared with observations including our own recent measurement of BC in snow. Radiative forcing due to the direct effect as well as the snow-albedo effect is also calculated.

Oslo CTM2 is an offline chemical transport model with T42 horizontal resolution using meteorological data from the IFS model at ECMWF. The scheme for BC includes hydrophilic and hydrophobic particles, as well as emissions from fossil fuel, biofuel and open biomass burning. Data on snow fall, melt and evaporation from ECMWF are used to generate and remove snow layers in each grid box. In these snow layers the amounts of deposited BC are stored, and concentration of BC in each snow layer is calculated.

For the period 1870-2000 time slice simulations are done every 10th year. The period is simulated with constant meteorological data for the year 2000-2001 and vertical resolution of 40 levels. The emission data used is from Bond [1] for fossil fuel and biofuel, and data from Ito and Penner [2] for open biomass burning.

The period 2000 until present are modeled with real time meteorological data and vertical resolution of 60 levels. Fossil fuel emission data used are the year 2000 data from Bond [1] except for the Asian region where REAS emissions [3] are used. For biomass burning BC emission the GFED data set are used [4].

The results are compared with available BC measurements from ice cores, air and snow. The observed time history of the BC concentration in snow over Greenland, US, and Himalaya is compared to the model results. During the years 2006-2008 several measurements of BC concentrations in snow in the Arctic region have been done, showing significant spatial variability. Within the large spread in the observations of BC concentration in snow, the model gives results that are consistent with the observations.

In addition to evaluating total effect of BC in snow and its radiative effects, regional contribution to BC deposition on snow in the Arctic region are calculated. Today China is the region with largest BC fossil fuel emissions. Our results using the Olso CTM2 model show however that it is the 4th region in contribution to BC deposition on snow north of 65 degrees. The largest contributor is Russia, followed by Western Europe and North America. In the historical period, the share of emissions between these regions differs from the present situation. The BC emissions from fossil fuel in North America and Western Europe were respectively 3 and 2 times larger in 1920-30 than the present emissions from these regions. Therefore those regions had a higher contribution to BC in snow in the Arctic region 80 years ago than they have today.

References:

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