Geophysical Research Abstracts
Vol. 16, EGU2014-11440-1, 2014
EGU General Assembly 2014
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How well is black carbon in the Arctic atmosphere captured by models?

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A correct representation of the spatial distribution of aerosols in atmospheric models is essential for realistic simulations of deposition and calculations of radiative forcing. It has been observed that transport of black carbon (BC) into the Arctic and scavenging is sometimes not captured accurately enough in chemistry transport models (CTM) as well as global circulation models (GCM).

In this study we determine the discrepancies between measured equivalent BC (EBC) and modeled BC for several Arctic measurement stations as well as for Arctic aircraft campaigns. For this, we use the output of a set of 5 models based on the same emission dataset (ECLIPSE emissions, see eclipse.nilu.no) and evaluate the simulated concentrations at the measurement locations and times. Emissions are separated for different sources such as biomass burning, domestic heating, gas flaring, industry and the transport sector. We focus on the years 2008 and 2009, where many campaigns took place in the framework of the International Polar Year.

Arctic stations like Barrow, Alert, Station Nord in Greenland and Zeppelin show a very pronounced winter/spring maximum in BC. While monthly averaged measured EBC values are around 80 ng/m̂3, the models severely underestimate this with some models simulating only a small percentage of the observed values. During summer measured concentrations are a magnitude lower, and still underestimated by almost an order of magnitude in some models. However, the best models are correct within a factor of 2 in winter/spring and give realistic concentrations in summer.

In order to get information on the vertical profile we used measurements from aircraft campaigns like ARCTAS, ARCPAC and HIPPO. It is found that BC in latitudes below 60 degrees is better captured by the models than BC at higher latitudes, even though it is overestimated at high altitudes. A systematic analysis of the performance of different models is presented. With the dataset we use we capture remote, polluted and fire-influenced conditions.

We estimate the impact of model deficiencies on calculated BC radiative forcing by introducing scaling factors based on the model-measurement comparisons.