LONG-RANGE TRANSPORT OF ATMOSPHERIC BLACK CARBON TO SUB-ARCTIC REGIONS, COMPARISON OF MODELING AND MEASUREMENTS

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INTRODUCTION

Black carbon (BC), a by-product of fossil fuel combustion and biomass burning, is an important component of atmospheric particulate matter. Being a strong absorber of solar radiation, BC has potentially large effects on the climate and the hydrological cycle. Atmospheric heating by BC causes a strong positive radiative forcing at the top of the global atmosphere, offsetting a large fraction of the cooling by other aerosol components (E.G. Haywood et al. 1997). Deposited BC reduces the reflectance of snow, which might significantly influence on local and regional climate (e.g. Flanner et al. 2009).

Concerning remote, northern parts of Europe, little information on the concentration levels and temporal variability of BC is available (Ricard et al., 2002; Eleftheriadis et al., 2009; Yttri et al. 2007). This paper provides an overview on the temporal and spatial variability of BCe in atmospheric aerosols over Finland in Northern Europe. The analysis is based on equivalent black carbon (BCe) measurements made at five Finnish background stations (Fig. 1) until the end of 2008. In addition, we compared the results of global (ECHAM5-HAM) and regional (REMO) atmospheric models against the measured BCe surface concentrations .

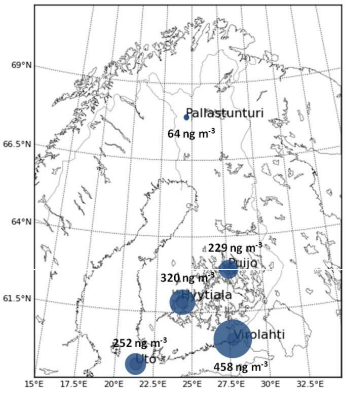

Figure 1. Locations of the measurement stations with annual average concentrations.

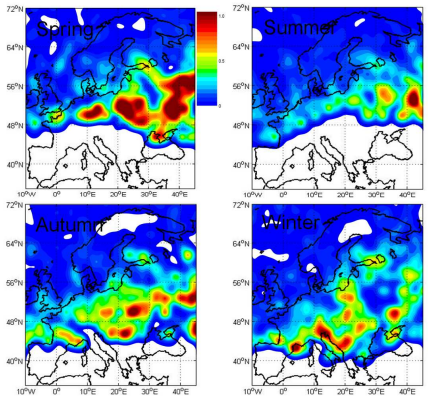

Figure 3. Source region maps according to different seasons. Color scale in a.u. White color means there was an insufficient number of trajectories (< 10) from the area.

RESULTS

The BCe concentrations observed in the southern part of Finland are comparable to European natural background values of about 320-480 ng m^{-3}, but lower than European rural background values of 640-1600 ng m^{-3} (Putaud *et al.* 2004). Somewhat lower background concentrations (<200-300 ng m^{-3} of EC) have been reported for more western parts of northern Europe (Yttri et al., 2007). The average BCe concentration measured at Pallastunturi is about half of that reported for north-eastern Finland (146 ng m^{-3}; Ricard et al. 2002), and roughly twice that observed in Spitzbergen (39 ng m^{-3}; Eleftheriadis et al. 2009).

The BCe concentrations exhibit a clear seasonal trend (Fig 2). At all the stations, BCe concentrations were at their highest during the spring and winter, and lowest during the summer. This can be attributed to a reduced boundary layer height during winter and more effective vertical mixing during summer. In addition, domestic wood burning is utilized for heating purposes during winter in Finland, and plumes from Central and Southern Europe are more susceptible to reach the high latitudes during winter.

Preliminary results suggest that the seasonal variation of BCe can be qualitatively estimated by using the ECHAM5-HAM and the REMO models. However, during winter months, the measured BCe concentrations are underestimated up to a factor of three. In general, ECHAM yields higher concentrations than REMO for autumn, whereas REMO gives higher concentrations than ECHAM for February - March.

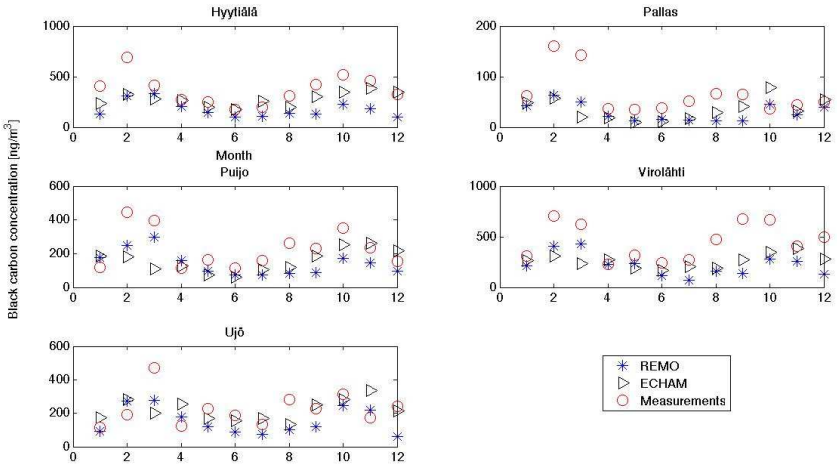

Figure 2. Annual variation of BCe concentrations at different stations from observations and models. Observations are averages from 2004-2008, depending on station. Model runs were made for the year 2005.

A source region analysis based on backward trajectories was performed for all the stations. The black carbon concentrations of the source regions were determined separately spring, summer, autumn, and winter. On the basis of this analysis the source areas of BCe seem to mostly reside in Central and Eastern Europe (Fig. 3). During the spring and summer, increased source contribution can be seen in Eastern Europe. This is mostly due to the fire season. Due to evolution of the Arctic front, the source region emphasis moves towards south during the winter, allowing the strong emission from Southern Europe to be transported to higher latitudes.

CONCLUSIONS

This study demonstrates the importance of long-range transport in establishing background BCe concentrations in northern Europe. In addition, it shows the importance in comparing the results from atmospheric models against long term measurements. The seasonal variation of BCe in Finland can be qualitatively estimated by using the ECHAM5-HAM and the REMO models. However, the wintertime concentrations are underestimated by the models. A plausible reason for this is the uncertainty of domestic wood burning emissions. Pinning down the reasons for the differences is essential when assessing the role of BCe in Arctic climate change.

ACKNOWLEDGEMENTS

This study is funded by the EU LIFE+ Programme, project number LIFE09 ENV/FI/000572 MACEB, The Academy of Finland, and the Maj & Tor Nessling foundation

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