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Sea ice as a source of sea salt aerosol: A trajectory study of 25 years of year-round sea salt aerosol record at Neumayer, Antarctica

X. Tian-Kunze (1), L., Kaleschke (1), R. Weller (2), G. König-Langlo (2), D. Wagenbach (3), S. Rast (4), G. Santos (4), A. Richter (5), and M. Begoin (5)

(1) Institute of Oceanography, ZMAW, University of Hamburg, Germany (xiangshan.tian-kunze@zmaw.de), (2) Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, (3) Institute of Environmental Physics, University of Heidelberg, Germany, (4) Max Planck Institute of Meteorology, Hamburg, Germany, (5) Institute of Environmental Physics, University of Bremen, Germany

Recently it was recognized that sea ice is a source of sea salt aerosols in coastal Antarctica, playing a more important role than open ocean during winter time. Frost flowers which grow on the surface of newly-formed sea ice are considered to contribute to the generation of sea salt aerosols. The exact mechanism of the release of sea salt aerosols from frost flowers is unknown. In this study, a statistical analysis of backward trajectories was carried out to investigate the meteorological parameters which play major roles in the process of sea salt generation over sea ice surface. Aerosol samples have been collected at Neumayer Air Chemistry Observatory, Antarctica since 1983. Neumayer is the only coastal station in the Antarctic which delivers year-round measurements of aerosol over such a long period. Backward trajectories were calculated on the surface layer based on the long-term global atmospheric reanalysis data from Japanese Meteorological Agency (JRA-25) every 6 hours. Along each trajectory contact times of an air parcel with sea ice, potential frost flower area and open water area were calculated. Potential frost flower areas were calculated from the sea ice concentration and the surface air temperature with a model parameterized with the growth rate of frost flowers from laboratory experiments. The monthly variation of sodium in the aerosol samples shows more aerosols in winter than in summer. The seasonal cycle of contact time over potential frost flowers showed the best agreement with that of measured aerosol sodium. The trajectories that arrived at Neumayer have both Antarctic continental and marine influences. Two major pathways can be seen from trajectory analysis: one is from the continent southeasterly from Neumayer, the other from the Weddell sea. Both pathways often carried more sea salt aerosols if they travelled along the coastline near Neumayer before arriving, accompanied by wide opening of polynyas near coast. The comparison of local measured wind direction and velocity at Neumayer station with sea salt aerosol data showed: if there is a shift of weak south wind to strong east wind often more sea salt aerosols were observed. Based on the results from trajectory study, we performed simulations with the Aerosol Atmospheric General Circulation Model ECHAM5-HAM to estimate the influence of sea salt aerosol emissions from sea ice on the sea salt aerosol burden in the Antarctic region. In these simulations, as the first step, we assume a constant emission rate of sea salt aerosols from sea ice. This constant was estimated based on contact times of air with newly formed sea ice and measured sea salt aerosol concentrations. The new sea salt aerosol distribution allows for a better estimate of bromine sources in the Antarctic region and their influence on tropospheric chemistry.