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Chemistry in Ship Plumes – modelling and measurements

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The multiphase chemical reactions in ship plumes in marine boundary layer (MBL) were studied with a plume model and the results were compared with data from measurement campaign performed from aircraft in the vicinity of the heavily travelled ship lanes through the English Channel and in the exhaust trail of a major seagoing container ship. In the single ship plume measurement experiment the concentration and dilution of major emissions (CO_2, NO, NOy, SO_2) were measured.

The model is based on the box Model Of Chemistry Considering Aerosols (MOCCA). MOCCA model results were published for the polluted mbl (J. Geophys. Res. 101D, 9121-9138, 1996) as well as for the remote mbl (Nature 382, 327-330, 1996, Atmos. Chem. Phys. 4, 147-168, 2004). Further information about the model is available at http://www.mpch-mainz.mpg.de/∼sander/mocca/. The chemical mechanism considers reactions both in the gas phase, in deliquesced sea-salt and sulfate aerosols and on soot particles. Photochemical reaction rates vary as a function of solar declination. In addition to the standard tropospheric HOx, CH_4, NMHC (non-methane hydrocarbon) and NOx chemistry, the reaction mechanism includes S, Cl, Br, and I compounds. The NMHC chemistry scheme involves an extended version of CB-IV mechanism. Chemical processes involve aerosol population partitioned into several monodispersed size bins. The original box version of the model has been extended to perform plume trajectory simulations. The plume mixing is described by the Gaussian approximation (Konopka, 1995, Schumann et al., 1995). The 3-days back trajectories were calculated with NOAAs Hysplit model for the occasions of measurements. The trajectories were then followed with the plume model simulations. Effects of ship plume – MBL interactions were studied and results compared to measurements.