VERTICAL DISTRIBUTION OF AEROSOL PROPERTIES AT MIDLATITUDES – OBSERVATIONS AND MODEL STUDIES

A. MINIKIN, A. LAUER, J. HENDRICKS, M. FIEBIG and A. PETZOLD

Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt Oberpfaffenhofen, 82234 Wessling, Germany

Keywords: TROPOSPHERIC AEROSOL, AEROSOL PROFILES, AEROSOL PROPERTIES.

INTRODUCTION

Despite the recognised importance of aerosol particles in the global climate system, the vertical distribution and variability of aerosol properties are still not well documented in field observations. This hampers the validation of vertical aerosol distributions simulated by global models. In recent years, an extensive set of field observation data of aerosol vertical profile was collected by DLR from airborne measurements particularly for midlatitudes in the northern and southern hemisphere (e.g., Petzold et al., 2002; Minikin et al., 2003). The instrumentation operated during in total 8 field campaigns between 1998 and 2003 was almost identical, ensuring comparability of the obtained results. The deployed aerosol instrumentation covered Nucleation mode (NUC: 5 nm < D < 15 nm), Aitken mode (AITK: 15 nm < D < 100 nm), Accumulation mode (ACC: 100 nm < D < 1000 nm), and nonvolatile (NONV) aerosol particles. Simultaneous to the improving data basis, the capabilities of general circulation models were further developed in order to better represent the aerosol in global climate simulations (e.g., Feichter et al., 1996). This contribution reports on a first comparison of a sophisticated global model system and field observations in order to evaluate the treatment of the tropospheric aerosol in the model and to identify gaps in the applied sources, transformation and sink processes of the aerosol.

METHODS

The data sets of the vertical distribution of aerosol properties were analysed for each mode (NUC, AITK, ACC, NONV) separately, providing median number concentration and variability as a function of altitude from 300 m above ground to approx. 11.5 km altitude. The variability was defined as (75-precentile – 25-percentile) / median. Available data sets cover central Europe in different seasons and years, western Europe with marine influence, and southern Chile, again with marine influence. Median number concentration values and variability were in all cases calculated for the entire data sets without distinguishing for different air masses and weather situations in order to get the full variability as occurred during the field experiment.

In a recent attempt, the global climate model ECHAM was coupled with the aerosol dynamics module MADE (Lauer et al., 2003) in order to examine the role of aerosol dynamical processes, sources and sinks on the vertical and regional distribution of aerosol modes. For the comparison of model data with observations, the ECHAM/MADE model was run for a 10-year period following a 4-year model spin-up. Median vertical profiles and variability were calculated from the climatological model data for the given region and season where the field experiment had taken place.

Comparison studies of observations and results from the model run were performed for the case of continentally influenced aerosol on the northern hemisphere and for marine influenced cases in the northern and southern hemisphere. Thus, the relevant cases for different aerosol sources (marine, continental) and different impact of particle formation and cloud scavenging processes on the tropospheric aerosol are covered by the comparison studies.

RESULTS AND DISCUSSION

An exemplary result of the model-observation comparison is presented in Figure 1. Since ECHAM4/MADE was developed for modelling the lower tropospheric aerosol population, the agreement between model and observations is good for the Aitken and Accumulation mode particles up to an altitude of approx. 2 km. For these cases, sources, transformation and sink processes of the aged aerosol modes seem to be well represented in the model. For higher altitudes, clear deviations between observation and model occur, which reflects the need for a better implementation of relevant aerosol processes in the free troposphere. The largest deviations occur in the case of the young nucleation mode aerosol. The comparison shows that the model has to be further improved concerning the representation especially of nucleation mode particles in the lower free troposphere as well as the average number concentrations observed in the upper free troposphere. The model is well suited for simulations of the particle number concentrations in the lower troposphere.

Based on the analysis of measured and modelled data for different environments and seasons, source strengths, transformation and sink processes of aerosols and aerosol precursors will be discussed.

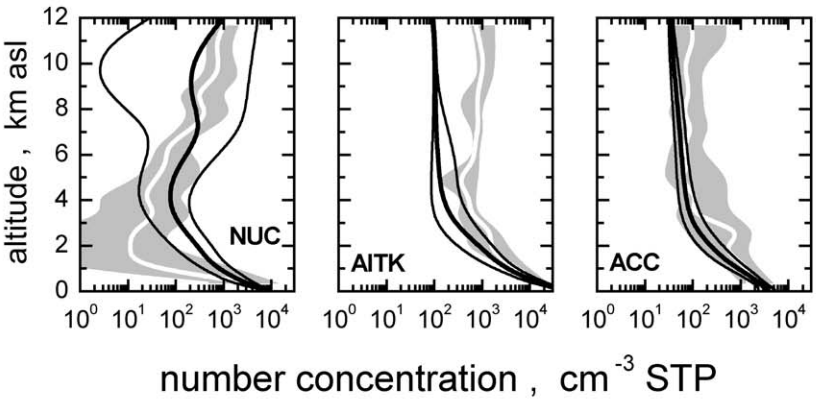

Figure 1. Vertical profiles of Nucleation mode (left), Aitken mode (mid), and Accumulation mode (right) particle number concentration and variability: Measurements (25- and 75-percetiles bound grey-coloured area, white line indicates median values) refer to central Europe in Summer 1998; climatological model data extracted for comparable conditions are presented as median (thick line) and 25- and 75-percetiles (thin lines). Data are given for standard conditions (STP = 273.15 K, 1013 hPa).

REFERENCES

Feichter, J., E. Kjellström, H. Rodhe, F. Dentener, J. Lelieveld, G.-J. Roelofs (1996). Simulation of the tropospheric sulfur cycle in a global climate model, *Atmos. Env.*, 30, 1693-1707.

Lauer, A., J. Hendricks, H. Hass, B. Schell, J. Feichter, S. Metzger (2003), Global modelling of tropospheric aerosols with ECHAM4/MADE, Proc. of the Eur. Aerosol Conference 200*3, J. Aerosol Sci*., 1005-1006.

Minikin, A., Petzold, A., Ström, J., Krejci, R., Seifert, M., et al. (2003). Aircraft Observations of the Upper Tropospheric Fine Particle Aerosol in the Northern and Southern Hemispheres at Midlatitudes. *Geophys. Res. Lett., 30*, doi 10.1029/2002GL016458.

Petzold, A., M. Fiebig, H Flentje, A. Keil, U. Leiterer, F. Schröder, A. Stifter, M. Wendisch, P. Wendling (2002). Vertical variability of aerosol properties observed at a continental site during LACE 98, *J. Geophys. Res.*, *107* (10.1029/2001JD000470), LAC 10-1 – LAC 10-18.