Geophysical Research Abstracts
Vol. 13, EGU2011-2910-1, 2011
EGU General Assembly 2011

Nearly Global Aerosol Mapping in the Upper Troposphere and Lowermost Stratosphere with Data from the CARIBIC Project

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The CARIBIC (Civil Aircraft for Regular Investigation of the Atmosphere Based on an Instrument Container) aerosol data set comprises measurements of sub-micrometer particles in the upper troposphere and lowermost stratosphere (UT/LMS) and is currently the largest in-situ aerosol data set for this atmospheric region. In this study we use the CARIBIC aerosol data from 1997 until June 2008 in combination with backward/ foreword trajectories and satellite cloud images from ISCCP (International Satellite Cloud Climatology Project) to compose large scale maps and vertical profiles of sub-micrometer particles number concentrations in the UT/LMS. Therefore particle number concentrations were extrapolated backward respectively forward in time along the trajectories until a cloud contact occurred or the trajectory ended two days from the measurement, whichever occurred first. To account for the aging of the aerosol along the trajectory, an exponential aging function was implemented in the extrapolation algorithm. The methodology of extrapolating the CARIBIC measurements along trajectories was validated with two methods, once by comparing extrapolated values with measured CARIBIC data (internal validation) and once by comparing extrapolated CARIBIC data to measurements made by research aircraft during the measurement campaigns PEM-T A/B and TRACE-P (external validation). Interestingly the best agreement is achieved with particle lifetimes larger than the maximum length of utilized trajectories (48 h), which at least for the nucleation mode particles seems to be surprisingly long.
The resulting geographic maps reveal regions of strong and frequent new particle formation, namely the Tropical Central and Western Africa with the adjacent Atlantic, South America, the Caribbean, and South-East Asia. These regions of particle formation coincide with those of frequent deep convective clouds, as indicated by ISCCP data. These maps (and derived vertical and meridional profiles) constitute valuable information for comparison with global models. The data can be used to evaluate for instance their capability to predict regions of new particle formation, which is important considering the proposed influence of new particle formation in the free troposphere for CCN concentrations and hence for global climate.