

**MACC Work Package G-AER 4**  
**New catalogue of aerosol data in the AEROCOM service**

**Deliverable D\_G-AER\_4.2**

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**Introduction**

The multi-component IFS aerosol model evaluation will benefit from a critical inspection of several different aerosol properties such as surface concentrations and deposition of the different aerosol components (sulfate, dust and organics), as well as multi-wavelength aerosol optical properties and particle size distributions inferred from different instruments. Recently new observational data and revisions of earlier introduced data have been incorporated in the observational data base which is available via the AeroCom service to help the MACC-AER model evaluation tasks. For brevity we call this the "AeroCom data set" hereafter. However, aerosol data have been obtained from very different sources. Authorship, responsibility and expertise on their quality remain with and belong to the institutions and scientists holding the original data. Data are purely held as a copy in the AeroCom data set in order to be able to process quickly new IFS aerosol model simulations with the AeroCom evaluation and visualization tools. A description of new and added observational data in the AeroCom data set is listed below.

## **Sun photometer derived aerosol parameters**

The AEROSOL ROBOTIC NETWORK (AERONET) is a global network of photometers that delivers numerical data to monitor and characterize the aerosols in a regional and/or global scale. The network has more than 300 stations distributed in the world measuring clean atmosphere in remote regions and polluted areas (Holben et al., 1998; Holben et al., 2001). Additional data have been obtained for the years 2003 and 2004 from the GAW sun photometers (Nyeki et al., 2009) and the Asian SKYNET (Sano et al., 2003). An important quantitative update of the AeroCom data set with respect to those from sun photometers is the recent extension in coverage, which in time spans now a period from 1996 until 2008.

In addition to total aerosol optical depth and Angstrom coefficient, the fine and coarse mode aerosol optical depth and the absorption optical depth have been added. These parameters are computed using a Mie code and the refractive index and size distribution provided by Aeronet. These latter are retrieved by inversion from the multiple-angle sun radiance measurements obtained when operating the photometer in the sky scanning mode (Dubovik et al., 2002). The requirement of completely cloud free skies for this type of measurement limits of course the amount of data as compared to the total AOD data amount obtained from direct sun radiance observations.

## **Satellite derived aerosol optical properties**

New data processings of satellite data have recently altered the data sets which can be obtained from MODIS, MISR and Parasol. For MODIS the collection 5 is now processed and available and has been included into the AeroCom database. AOD retrievals from the two satellites MODIS terra and aqua have been especially subject to improved corrections of land albedo (Levy et al., 2009). MISR version 22 has been proposed to be a stable new data version, for which all years of interest have been processed (Kahn et al., 2009). PARASOL joined the A-train suite of satellite sensors in 2005 as a follow-up satellite to the earlier POLDER instrument (Deuzé et al., 2000 and 2001). The AeroCom data set contains now from all these satellites gridded monthly or daily  $1^\circ \times 1^\circ$  data until the year of 2008.

## **Vertical profiles of aerosol extinction**

To better characterize the modelled vertical distribution of the aerosol on a global scale, profiles of extinction coefficient at 532 nm and 1064 nm from measurements made by the CALIOP satellite active lidar sensor have been assembled together with Francois-Marie Breon at the LSCE/CEA and with help by the ICARE center in Lille (Koffi et al., paper in preparation). Nocturnal data of aerosol extinction using the aerosol layer product from the years 2007-2009 were combined to obtain mean regional profiles of aerosol extinction. Several data processing procedures were tested and optimized to eliminate data having a poor discrimination between cloud and aerosol. The results obtained with the CALIOP data version 3 showed the influence of recent improvements in data processing algorithms at NASA, especially in the boundary layer, bringing about notably more homogeneous profiles near the ground.

Average profiles were then calculated for a monthly temporal and spatial resolution of  $1^\circ \times 1^\circ$  and 13 subcontinental regions distributed over the globe. These regions were chosen such that they can be considered representative of (i) pollution from the major industrialized regions of the world, (ii) areas of dust emission and (iii) regions of biomass burning and (iv) maritime areas. A vertical cloud mask from CALIOP was applied to the data to take advantage of all available data (cloud free and partially cloudy conditions) and thus obtain a climatology that is representative of the region and period. The mean vertical profiles are then calculated over the 0-10 km altitude range using a 100m vertical resolution.

## **Black carbon concentrations**

Surface observations which could serve to judge a simulated global black carbon (BC) distribution comprise elemental carbon concentration measurements and absorption coefficient measurements. Different instruments are available and show often rather variable results when intercompared. A first set of measurements were assembled in cooperation with the AeroCom groups for the joint paper of Koch *et al.* (2009). Recently the dataset has been augmented in the AeroCom database with those measurements stored in the EBAS database at NILU. These data contain for instance concentration measurements from the EMEP campaign in 2008, from the EUSAAR supersites and from the GAW stations. The data are currently under revision to obtain a dataset with better known quality.

BC vertical distributions have been recently obtained with the SP2 instrument flying on a research aircraft. Schwarz *et al.* (2010), using results from the HIPPO campaign, have shown that refractory black carbon (rBC) aerosol loadings and mass size distributions can be quantified above the remote Pacific from near the Arctic at 80N to almost the Antarctic at 67S. Over 100 vertical profiles of rBC loadings, extending from ~0.30 to ~14 km were obtained with a Single-Particle Soot Photometer (SP2) during a two-week period in January 2009. The dataset provides a striking, and previously unobtainable, pole-to-pole snapshot of rBC mass loadings. This complements the initial SP2 dataset used by Koch *et al.* (2009) from different aircraft campaigns over the Americas and the Arctic to illustrate the unconstrained BC mixing ratios in the upper troposphere.

## **Dust deposition and surface concentration**

A compilation of different datasets for the evaluation of dust models was prepared by Huneus *et al.* (2010) for the AeroCom database. This datasets touch upon optical properties, deposition and surface concentrations.

Prospero *et al.* (2010), presented the results of a three year deposition study in a nine-station network in Florida which is impacted by African dust every year. Wet deposition (WD) and bulk deposition (BD) rates of soil-related elements (Al, Fe, Mn) were highly correlated and remarkably uniform across Florida; they exhibited an extremely strong summer maximum that closely matched concurrently-measured dust concentrations in Miami. Dry deposition (DD), defined as the difference between BD and WD, was a minor component, about 20 - 30% of the total. The ratios of WD to

DD has been found to be an interesting test for the models, ranging from about 3:1 to 4:1.

Three further compilations give total deposition fluxes. We use the measured deposition fluxes given in Ginoux et al. (2001) based partly upon measurements taken during the SEAREX campaign (Prospero et al., 1989). Most of the sites are located in the northern hemisphere and far away from source regions. The measured values range from 450 [g/m<sup>2</sup>/yr] in the Taklimakan desert to 0.09 [g/m<sup>2</sup>/yr] in the equatorial Pacific and measurement periods vary according to the site. Mahowald et al. (2009) presented a compilation with a total of 28 sites measuring iron and/or dust deposition, mostly in the last two decades. We assume a 3.5% iron content in dust to infer dust deposition fluxes from iron deposition. Finally we use deposition fluxes derived from ice core data. These depositions have proven to be accurate to represent the current climate (Mahowald et al., 1999).

We then use deposition fluxes from sediment traps being part of the Dust Indicators and Records in Terrestrial and Marine Paleoenvironments (DIRTMAP) database (Tegen et al., 2002; Kohfeld and Harrison, 2001). We follow Tegen et al. (2002) and only use those stations with deployment period larger than 50 days and sites without contamination of suspected fluvial inputs or hemipelagic reworking. This database contains a set of comparable deposition fluxes providing a picture of the gradients in the intensity of the dust deposition to the Atlantic Ocean and the Arabian Sea. In addition, we also follow Tegen et al. (2002) and Mahowald et al. (2009) and do not use DIRTMAP deposition data derived from marine sediment cores since they represent the integrated dust flux to the ocean over a time span of hundreds to possible thousands of years and are thus inadequate to be used in the evaluation of simulation of the dust cycle for specific years (Tegen et al., 2002).

Surface concentrations are an alternative means to evaluate the transport and dispersion of simulated dust. We compare against monthly dust concentrations measurements taken at 19 sites managed by the Rosenstiel School of Marine and Atmospheric Science from the University of Miami (Prospero et al., 1989; Prospero, 1996; Arimoto et al., 1995). The measurements taken in the Pacific Ocean stem from the sea/air exchange (SEAREX) program (Prospero et al., 1989) whereas the measurements from the northern Atlantic are from the Atmosphere-Ocean chemistry experiment (AEROCE, Arimoto et al., 1995). The measuring sites are located in general remote from dust emission sources and downwind of them. The dust concentrations are derived from measured aluminium concentrations assuming an Al content of 8% in soil dust (Prospero, 1999) or from the weights of filter samples ashed at 500°C after extracting soluble components with water. This database has been largely used for the evaluation of dust models (Ginoux et al., 2001; Cheng et al., 2008; Tegen et al., 2002). The measurements were taken in the 1980s and 1990s with different measurement periods at each station. We extend this data set with monthly dust concentrations at Rukomechi, Zimbabwe (Maenhaut et al., 2000a; Nyanganyura et al., 2007) and Jabiru, Australia (Maenhaut et al., 2000b; Vanderzalm et al., 2003).

In addition, we complement the monthly averages with the data set of surface concentrations presented in Mahowald et al. (2009). These data correspond to measurements taken mostly during cruise but include also long term measuring stations. The measurements taken during cruise campaigns will be considered as

yearly averages even though they represent short-term data. Most of the annually averaged dust arrives on a few days (5% of days) (Mahowald et al., 2009). In order to account for the error of comparing model yearly averaged surface concentration with short-term measurements we follow Mahowald et al. (2008) and we use the range of values representing the median 66% of the daily averaged model concentration as an error bar for each cruise data.

Of special value are the measurements from the Barbados station. This is the most extensive long-term record of surface dust concentration available. Concentrations have been measured under on-shore wind conditions almost continuously since 1965 in an equivalent manner as described above (Prospero, 1999; Prospero and Lamb, 2003). The Barbados data have been used to study the long-range transport from African dust over the Atlantic and the factors influencing its variability (Prospero and Nees, 1986; Prospero and Lamb, 2003; Chiapello et al., 2005).

### **Deposition and surface concentration of sulphur compounds**

As indicated above large parts of the in-situ observational data were extracted directly from the EBAS database at NILU. Substantial progress for achieving a fast and reliable data flow was achieved by directly using the NASA-AMES format from EBAS in AeroCom model-data comparison and visualisation tools. This close link allows now a smooth and rapid update process in case of revisions of observational data, of the addition of new recent data, of the addition of higher-level quality data, of the addition of new parameters or new observational time periods. Dry surface scattering coefficient measurements made during the EUCAARI/EUSAAR campaign in the year 2008 are also included but first use showed that the data quality for non-standard aerosol data in the EBAS database is not yet homogeneous. The usage of these data requires work-intensive evaluation steps: Adaptations have been made to match irregular time periods, to extract optical properties at comparable wavelengths, to check units, to handle data at mountain sites and to find corresponding instruments (eg for the computation of an Angstroem coefficient, for the computation of wet deposition from precipitation and wet sulphate concentrations).

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