Summary of discussion of Session 2 "Chemical and physical properties of dust aerosols"

Chairs: Formenti (France) and Kandler (Germany)

Session 2, held on Monday 15 September afternoon, focussed on the state of current knowledge on the chemical and physical properties of dust aerosols. Six oral presentations were presented, followed by one hour of open audience discussion.

P. Formenti (LISA, France) presented a review on *"Recent progress in understanding the regional characteristics of mineral dust composition"*. The presentation focussed on the regional variability of elemental and mineralogical tracers of the composition of mineral dust, in linkage with the source region of emission. It was shown that a combination of simple indicators such as the Fe/Ca and illite/kaolinite ratios can be used to trace the suspended aerosol to the region of origin, even if atmospheric transport tends to homogenise the differences of composition from one point source to the other. It was pointed out during the discussion session that a transfer function whcih allows the prediction of the aerosol composition from of the respective the soil is not available yet. Future wind-tunnel experiments are foreseen to do that. Models try to take this process into account. Finally, it was recommended that future research would focus on the speciation and state of mixing of iron oxides. This is relevant to the prediction of absorbing properties of dust aerosols in the visible. To make this point, field measurements from recent field campaigns in western Africa were used to illustrate that knowledge of the total content of iron oxides does not suffice to predict the to single-scattering albedo, in addition the mineralogical phases must be known.

In his talk on *"Particle size distributions of airborne dust: Facts, gaps and constraints by instrumentation and observation"* **A. Petzold (DLR, Germany)** revisited the current methods for particle sizing in the dust mode size range and discussed instrumental issues. The measurement of size distribution is a very challenging task due to instrumental limitations, and due to the fact that particle size is an operational definition which depends on the physical principle of the measurement technique (optical, aerodynamic,…). He discussed the consequences of these instrumental limitations on the basis of optical closure studies on desert dust during recent field studies. Agreement between microphysical based models of aerosol extinction and direct measurements were only achieved when the full size distribution was considered. The artefacts of some popular sizing techniques such as the FSSP optical counter or the AERONET inversion algorithm were intensively debated during the open-audience discussion. Despite the debaters' different experiences in reaching optical closure, consensus was achieved on the fact that sizing instruments should only be used to determine quantities related to the physical principles of the instrument, e. g., optical counters should be used to obtain number size distributions, but not volume/mass size distribution, etc. A still serious issue in sizing dust aerosols is the design of inlets, especially for aircraft measurements.

K. Kandler (Darmstadt Univ. of Technol., Germany) presented the *"Capabilities and needs of mineral dust composition measurements using single particle analysis for characterization of direct and indirect effects"* using examples of observations and modelling from the SAMUM field experiment. High-resolution individual particle analysis is used to derive the dust composition as a function of particle size. When the composition is used for optical calculations, then a discrepancy is observed between chemically and optically derived refractive indices, possibly due to mixing with absorbing non-dusty components such as soot.

Questions were raised on the transferability of refractive indices obtained from particular field samples from specific source regions to other source areas, as well as the aptitude of specific mixture rules for mineral dust. Mixing with non-dusty component is observed very often as coating on dust particles. The remark was made that the occurrence of coatings might be overestimated because aerosols samples were more commonly collected in the boundary layer. The observation of mainly uncoated Asian dust during PACDEX was named. Regarding particle shape, very few measurements exist on three-dimensional particle shape. However, they show that the describing ellipsoid usually has three different main axes. More data exist for the two-dimensional aspect ratio, which show an increase of aspect ratio with increasing source distance. There is no clear explanation for this observation. However, it may be related to agglomeration of the particles during aging.

Y. Balkanski (LSCE, France) presented a talk titled *"Heterogeneous reactions on dust: results and uncertainties from the laboratory, field work and modelling"*. A comprehensive research strategy combining experimental work (in field and in laboratory) and modelling is needed to constrain uncertainties of the occurrence and the efficiency of heterogeneous reactions on mineral dust particles. Despite recent advances, many challenges remain: although sticking coefficients of several trace gases have been determined experimentally for several gas species, results from several groups can differ on the same gas by several orders of magnitude. Recent findings point to a new ensemble of potentially important photo-induced heterogeneous reactions between trace gases and metal oxides such as TiO_2, Fe_2O_3, FeO, MgO which are present in mineral dust aerosol and absorbing in near-UV/VIS. Very few of these reactions have been documented until now. Investigators showed that photo-induced conversion of NO_2 into HONO and HNO_3 occurs on TiO_2/SiO_2 and mineral dust. Qualitatively similar results have also been observed by a different group on light-absorbing organic films.

In her talk, *"Water soluble fraction of dust: a critical chemical property to estimate dust impact?"*, **K. Desboeufs (LISA, France)** presented the state of knowledge concerning the solubility of major and trace compounds in mineral dust. The highly water soluble species (carbonates (CO_3^{2-}), sulphate (SO_4^{2-}), chloride (Cl^-), fluoride (F^-), nitrate (NO_3^-) and phosphate (PO_4^{3-}) anions, and Ca^{2+} and other alkaline and alkaline earth cations) constitute the quasi-totality of dissolved mass fraction of dust in contact with water and hence determining to estimate the hygroscopicity of dust. However, weakly soluble species such as Al, Si or Fe, are also found in the water-soluble fraction. These have little interest for dust radiative impact estimates, but can play an important role in the biogeochemical cycles. Results on the Fe solubility from dust issued from different Saharan sources (Morocco, Tunisia, Niger…) show a large range of values (0.009% to 0.15% by mass). A number of intrinsic factors, such as size distribution or dust mineralogy - in particular the iron-rich clay content (like illite or smectite) - have been suggested to explain this variability.

D. Zhang (Prefectural Univ. Kumamoto, Japan) presented a systematic overview of results from individual particle analysis of the shape (?), size, and composition of dust particles collected during atmospheric transport. These data illustrate the modifications that can occur due to aging and mixing of dust with concurrent aerosol species. Uptake of sulphate and nitrate on dust particles occur depending on the mineralogy of the particles; nitrate accumulation more favours on calcium-rich dust while sulphate accumulation more favours on aluminosilicate-rich dust. Dust particles frequently become mixtures of mineral dust and sea salt during their transport in the marine boundary layer. This will consequently

result in the changes of the particles in size, hygroscopicity, and other physical-chemical characteristics. This mixing is frequently observed in Japan (up to 60% of occurrences). Reason is most probably not cloud processing, but rather turbulent mixing.