Particle size distributions of dust during the Mineral Dust Campaign 2008 at the AIDA facility Karlsruhe: How well compare different sizing methods?

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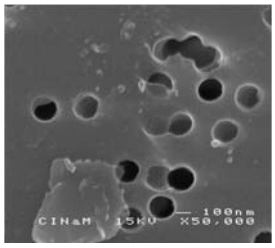
What's so interesting about Dust Particle Size Distributions ?

Dust particles are highly irregularly shaped
- Equivalent diameter concept applies

Uncertainties in dust particle properties used in climate models impact
- dust optical properties,
- dust radiative properties,
- atmospheric transport mechanisms, processing and lifetime.

Observational data on dust size distribution and properties are needed
- for investigating long-range transport of dust,
- for determining dust - climate interactions,
- for improving the representation of dust in global climate models.



Electron microscopy image of dust sampled during the Mineral Dust camapign 2008.

Particle size

Particle size is defined by the applied measurement method or considered particle property, respectively.

Primary measure

diameter of a sphere.

Equivalent diameter

diameter of the sphere that has the same value of a particular physical property as that of an irregularly shaped particle.

Applied Sizing Methods

SMPS - APS

Movement of particles in an electrostatic field according to the electrical mobility (D_p < 1 µm).

$$Z = \frac{n\, e\, C_c(D_{mob})}{3\,\pi\,\eta_{air}\; D_{mob}\; \chi_{dust}}$$

Terminal velocity for particles of unit density in an accelerated airflow (D_p > 1 µm).

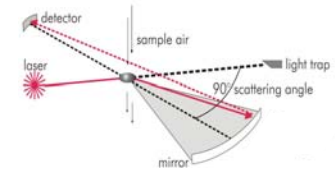
$$V_{TS} \cong \frac{C_c\,(D_{ae})}{18\,\eta_{air}\;\chi_{dust}}\,\rho_0\,D_{ae}^2\,a_{APS}$$

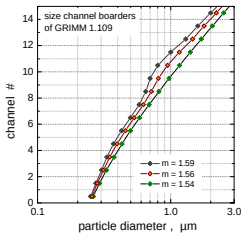
Data analysis using ρ_{dust} = 2.6 g cm^{-3} ,χ_{dust} = 1.20 with aerodynamic diameter D_{ae} and volume equivalent diameter D_{ve}.

$$D_{ae} = D_{ve}\sqrt{\frac{1}{\chi_{dust}}\,\frac{C_c\,(D_{ve})\,\rho_{dust}}{C_c\,(D_{ae})\,\rho_0}}$$

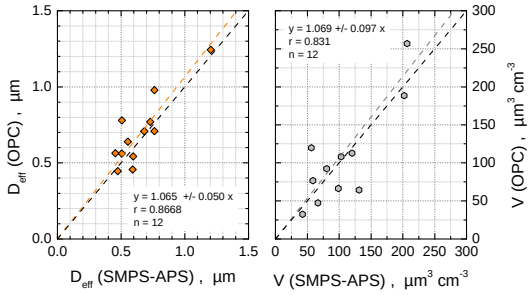
Optical Particle Counter GRIMM 1.109

Light scattered by particles (λ = 650 nm).





Method Evaluation Results

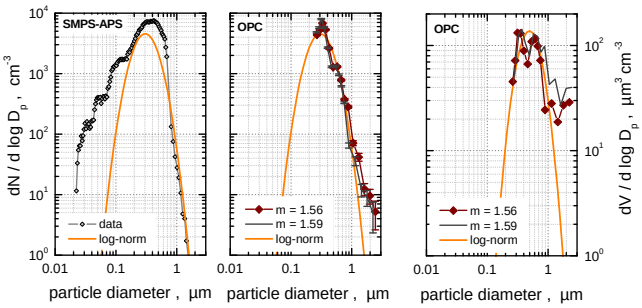


Size distributions are evaluated for effective diameter $D_{eff} \propto$ volume / surface aerosol volume

Plotted OPC data refer to m = 1.56; field data report m = 1.55 + 0.0013 *i* .

Petzold, A., Rasp, K., Weinzierl, B., Esselborn, and co-authors, 2009: Saharan dust refractive index and optical properties from aircraft-based observations during SAMUM 2006. Tellus 61B, 118-130.

Site Distribution Analysis



SMPS-APS data are given as log-normal size distributions

OPC data are analysed for refractive indices
m = 1.59 (manufacturer) m = 1.56 (dust) m = 1.54 (amm. sulphate calibration)

Log-normal size distributions are scaled to $N_{log\text{-}norm} = N_{OPC}$ for D_p > 0.260 µm

Evaluation Summary

Dust Type	Volume (OPC) / Volume (SMPS-APS)			Deff (OPC) / Deff (SMPS-APS)		
	m = 1.56	m = 1.54	m = 1.59	m = 1.56	m = 1.54	m = 1.59
SAMUM B2	1.05	1.50	0.81	1.31	0.99	1.11
SAMUM B2	0.71	0.95	0.58	1.07	0.86	0.94
Morocco	0.67	0.95	0.52	1.07	0.81	0.91
Morocco	1.15	1.71	0.86	1.38	1.02	1.16
Morocco	2.12	3.25	1.55	1.84	1.35	1.54
Burkina Faso	1.31	1.87	1.01	1.45	1.10	1.24
SAMUM B1	0.76	1.15	0.57	1.11	0.82	0.93
SAMUM B1	1.49	2.29	1.08	1.52	1.13	1.29
SAMUM B3	0.94	1.42	0.69	1.26	0.92	1.05
SAMUM B3	1.24	1.91	0.90	1.21	0.92	1.03
Cairo 2	0.49	0.66	0.40	0.88	0.71	0.78
Cairo 2	0.93	1.40	0.69	1.24	0.91	1.04
average	1.07	1.59	0.81	1.28	0.96	1.09
standard deviation	0.44	0.70	0.31	0.25	0.17	0.20
slope of regression line	1.07 ± 0.10			1.07 ± 0.05		
correlation coefficient	0.83			0.87		

For an appropriate value of the refractive index m, average properties like D_{eff} and volume from optical methods agree with values from SMPS-APS within 30%.

Details of size distributions may differ significantly.

A mismatch of the refractive index may cause deviations in average properties of 40 - 60% of data from light scattering methods from SMPS-APS data.