Retrieval of complex refractive index and size distribution of spherical particles from Dual-Polarization Polar Nephelometer data

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Introduction

Aerosols can affect weather and climate and have complex properties. Depending upon their shapes, sizes and composition they can reflect sunlight back to space and cool the atmosphere, they can also absorb sunlight and warm the atmosphere. The laboratory Dual-Polarization Polar Nephelometer (D2PN) measure the parallel and perpendicular polarized components of light scattered by an ensemble of aerosol particles. Measurements are made in the range of scattering angles from 10° to 169° with step of 1°. This study is based from data of spherical aerosols with different refractive index generated by different generators.

Retrieval code

For inversion of the D2PN data, we employed the following code. When a value of the refractive index is assigned, a code, based on the method developed by Dubovik (2004), is used to retrieve the particle size distribution. The dependence of kernel matrices on the real *n* and imaginary χ part of the refractive index is considered through the look-up table, that is, the kernel matrices were precomputed in grid points of index, which cover for sure the whole range of expected values. The lookup table covers the range from 1.1 to 1.9 for *n* and from 1E-10 to 1E+1 for χ. The real-part range is divided into 40 intervals with the linear steps of 0.02. The imaginary-part range is divided into 50 intervals with the logarithm step. For each value of the refractive-index grid, a size distribution is retrieved. The value of refractive index is derived using the condition of minimum of the root mean squared relative errors. The corresponding size distribution and complex refractive index are considered as the retrieved ones.

Results

The presented results was obtained with data set of 5 values of refractive index and 3 generators. The limitations of retrieve possibility was determined by Verhaege et al. (2008)

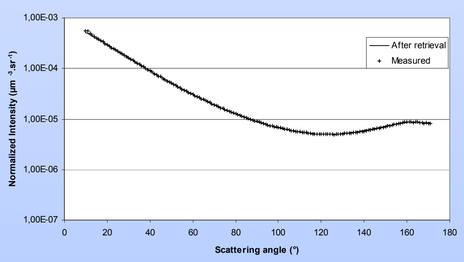
Index

	Real Retrieved	True Real	Imaginary	Mean Diameter	D03	True
0Blind3_1	1,46	1,45	2,16E-05	4,07E-01	1,68	Small
0Blind3_2	1,44	1,41	1,98E-04	2,53E+00	77,11	Large
0Blind3_3	1,38	1,37	8,81E-11	1,83E+00	54,39	Large
0Blind3_4	1,31	1,33	8,81E-11	1,57E+00	2,00	Small
0Blind3_5	1,32	1,33	5,48E-11	2,88E+00	10,89	Mean
0Blind3_6	1,35	1,36	1,90E-09	1,51E+00	2,62	Small
0Blind3_7	1,46	1,41	1,76E-03	5,54E-01	1,45	Small
0Blind3_8	1,33	1,33	4,62E-05	2,63E+01	79,34	Large

	Water
	DEHS
	Ethanol
	50%+50%
	5%+95%

DEHS (small droplets)

Phase function



Retrieved Values :

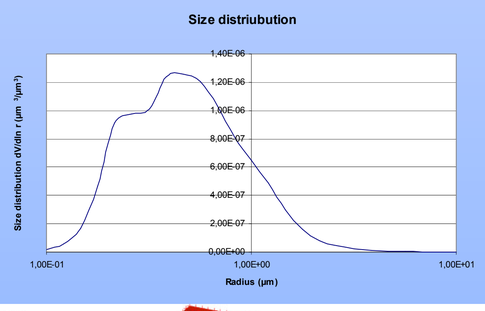
Refractive index : 1.455 + i2E-05

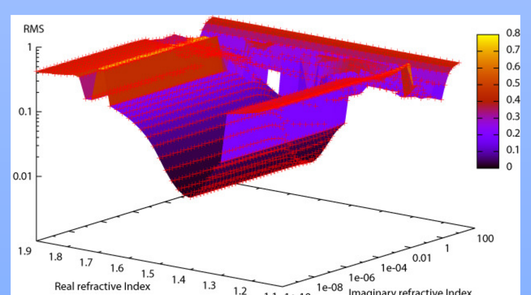
Volume concentration : 2.11 g/cm^3

Mean Diameter : 0.47 µm

Median Volume Diameter : 0.85 µm

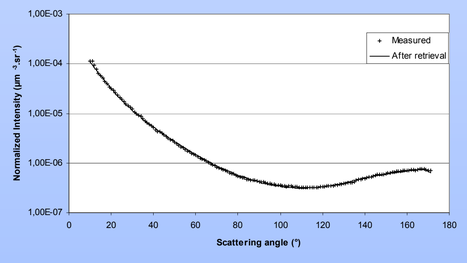
Size distriubution





Water (small droplets)

Phase function



Retrieved Values :

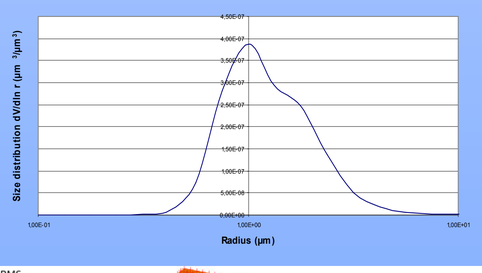
Refractive index : 1.311 + i9E-11

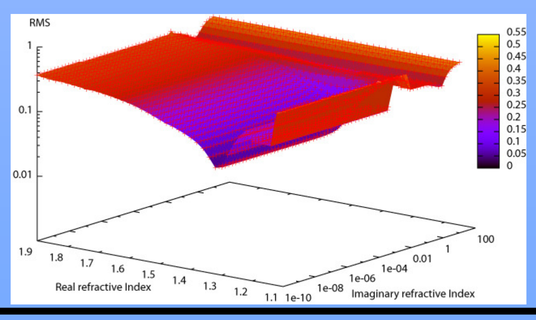
Volume concentration : 0.44 g/cm^3

Mean Diameter : 1.57 µm

Median Volume Diameter : 2.01 µm

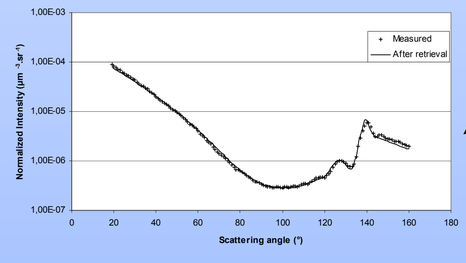
Size distriubution





Water (large droplets)

Phase function



Retrieved Values :

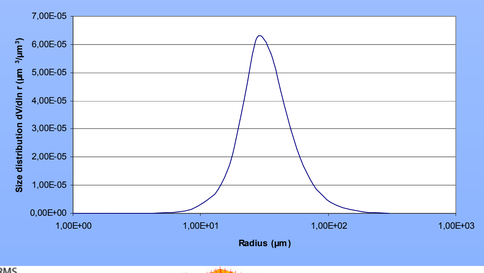
Refractive index : 1.329 + i5E-11

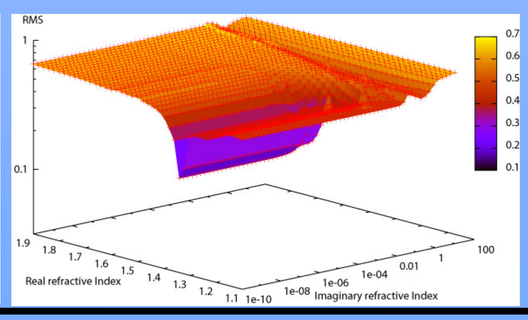
Volume concentration : 67.08 g/cm^3

Mean Diameter : 33.48 µm

Median Volume Diameter : 56.41 µm

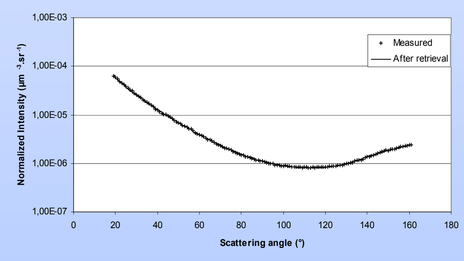
Size distriubution





Ethanol (small droplets)

Phase function



Retrieved Values :

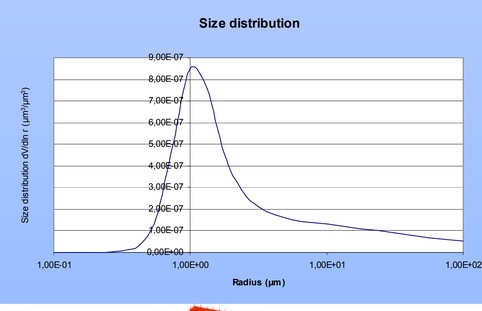
Refractive index : 1.350 + i2E-10

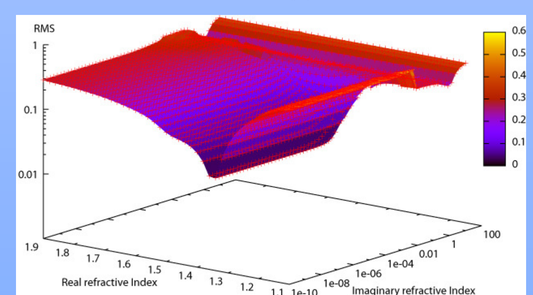
Volume concentration : 1.31 g/cm^3

Mean Diameter : 1.51 µm

Median Volume Diameter : 2.62 µm

Size distribution





Conclusion and discussions

D2PN data along with the employed inversion algorithm provide possibility to estimate the complex refractive index and size distribution of ensembles of spherical particles. All retrieved parameters are in the expected ranges and in good agreement with the nature of particles and the specifications of the generators. The long term objective of the D2PN designed at LaMP is to develop a database (like the light scattering facility in Amsterdam) of optical and microphysical characteristics of spherical and non spherical aerosols and to test inverse codes against it. It is promising to adapt the inverse method developed by Dubovik and colleagues (2006) to retrieve complex refractive index and size distributions of spherical aerosols and ensembles of prolate and oblate particles from D2PN data.

References

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Dubovik, O., Sinyuk, A., Lapyonok, T., Holben, B.N., Mishchenko, M., Yang, P., Eck, T.F., Volten, H., Muñoz, O., Veihelmann, B., van der Zande, W.J., Leon, J.-F., Sorokin, M., and Slutsker, I. Application of spheroid models to account for aerosol particle nonsphericity in remote sensing of desert dust. J. Geophys. Res., 111, D11208, (2006).

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