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The Reconstruction of Atmospheric Particle Size Distributions Using Optical Sensing Data and Some Regularization Methods I : Direct Methods

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1. Introduction

Atmospheric particles have a great deal of influences on the climate and the air quality, which change the living and industrial environments of a specific area. Especially, the suspended dusts and aerosols can often have a harmful influences on workers' health, equipments at working places. For this reasons, the measurement of atmospheric particle size distributions is of considerable current interest.

The available measurement techniques pose problems related to obtaining a sample in many situations. For this, optical techniques are of special interest. Optical techniques depend on Mie scattering and can be broadly divided into imaging and non-imaging types. The latter can be subdivided into two classes : those which measure on a large number of particles simultaneously, and those which count and size individual particles one at a time. This paper is based on the second type, above mentioned.

2. Theory and Methodology

Inversion algorithms for the reconstruction of atmospheric aerosol particle size distribution with 4 imaginary refractive indices are presented and compared each other. In simulations, three ac-errors with dc-component and without it are included in the scattered intensities. To obtain the linear equation systems, eleven angular and fifteen wavelength samplings are performed and they have each two measurement times at every sampling positions. Samplings are divided into two types, square and rectangular samplings, and we use gauss-like quadrature rule in linearizing Fredholm integral equation. We use least square method and regularization method to solve the linear equation systems. In this paper, the regularization method has four types called as direct method, Tikhonov, DSVD(and DGSVD), TSVD(and TGSVD), MTSVD and each types are related to five regularization parameter choice methods, generalized cross-validation, quasi-optimality criterion, L-curve criterion, Newton-type method. Also in regularizations, 9 discrete derivative operators are used.

3. Results and Conclusions

We established that the regularized solutions are superior to least square solutions and the angular sampling gives the closer to an original solution than the wavelength sampling does and so optimum inversion algorithms for the reconstruction of atmospheric aerosol particle size distribution with 4 refractive indices exist. Below tables display the best algorithms.

Table 1. Algorithm trees of the regularized solutions for angular sampling without dc-error

ac error	2 %				12 %				30 %			
refrac. index	0	0.001	0.01	0.1	0	0.001	0.01	0.1	0	0.001	0.01	0.1
samp. group	square	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
regul. meth.	DSVD	Tikh	〃	DGSVD	Tikh	〃	〃	〃	〃	〃	DSVD	Tikh
param.choice	ls.sq	〃	〃	discrp	ls.sq	〃	discrp	ls.sq	〃	〃	〃	〃
derive. opera	L_0	L_6	L_0	L_9	L_2	L_4	L_4	L_4	L_0	L_0	L_2	L_0
wavelength	416	500	407	532	416	〃	〃	660	355	400	632.8	532
meas. times	10000	100	100	10000	〃	〃	〃	〃	〃	〃	〃	〃
sampling	10th	11th	10th	2nd	1st	10th	〃	〃	〃	〃	11th	10th

Table 2. Algorithm trees of the regularized solutions for angular sampling with dc-error

ac error	2 %				12 %				30 %			
refrac. index	0	0.001	0.01	0.1	0	0.001	0.01	0.1	0	0.001	0.01	0.1
samp. group	square	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
regul. meth.	MTSVD	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
param.choice	L-curve	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
derive. opera	L_4	L_2	L_3	L_2	L_3	L_2	L_0	L_1	L_4	L_2	L_0	L_1
wavelength	387	355	407	500	400	355	632.8	400	387	355	632.8	400
meas. times	100	〃	〃	10000	100	10000	100	〃	10000	〃	100	〃
sampling	2nd	1st	4th	3rd	10th	1st	3rd	〃	2nd	1st	3rd	〃

References

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