Analytical Delta-Four-Stream Doubling-Adding Method for Radiative Transfer Parameterizations

Feng Zhang[*]

Chinese Academy of Meteorological Sciences, Beijing, and Shanghai Typhoon Institute, Shanghai, China

Zhongping Shen

Shanghai Climate Center, Shanghai, China

Jiangnan Li

Canadian Center for Climate Modeling and Analysis, University of Victoria, Victoria, British Columbia, Canada

Xiuji Zhou

Chinese Academy of Meteorological Sciences, Beijing, China

Leiming Ma

Shanghai Typhoon Institute and Laboratory of Typhoon Forecast Technique/China Meteorological Administration, Shanghai, China

ABSTRACT. Though the single-layer solutions have been obtained for the delta-four-stream discrete ordinate method (DOM) in radiative transfer (Liou et al 1988), there lacks a four-stream doubling-adding method (4DA), which enables us to calculate the radiative transfer through a vertically inhomogeneous atmosphere with multiple layers. In this work, based on the Chandrasekhar's invariance principle (Chandrasekhar 1950), a analytical method of delta-4DA is proposed.

   Applying delta-4DA to an idealized medium with specified optical property, the results in reflection, transmission and absorption are the same by treating medium as a single layer or dividing it into multiple layers. This indicates that delta-4DA is able to solve the multi-layer connection properly in a radiative transfer process. In addition, the delta-4DA method has been systematically compared with the delta-two-stream doubling-adding method (delta-2DA) in the solar spectrum.

By applying delta-4DA to a realistic atmospheric profile with gaseous transmission considered, it is found that the accuracy of delta-4DA is superior to that of delta-2DA in most of cases, especially for the cloudy sky. It is shown that the relative errors of delta-4DA are generally less than 1% in both the heating rates and fluxes, while the relative errors of delta-2DA can be as high as 6%.

[*]Dr. Feng Zhang
E-mail: feng_zhang126@126.com

REFERENCES

1. Liou, K.N.,, Q. Fu, and T. P. Ackerman, A simple formulation of the delta-four-stream

   approximation for radiative transfer parameterizations. *J. Atmos. Sci.,*vol. 45, pp1940-1947.

   1988.

2. Chandrasekhar, S., *Radiative Transfer.* Oxford University Press, Oxford, pp 393, 1950.