MICROWAVE RADIATIVE TRANSFER AT FREQUENCIES OF AMSU-B: EFFECTS OF UNCERTAINTIES IN ICE PERMITTIVITY ON BRIGHTNESS TEMPERATURES

Xinxin Xie, Jungang Miao and Wei Wang

xiexinxin@ee.buaa.edu.cn

Electromagnetics Laboratory, School of Electronic and Information Engineering, Beihang University, Beijing 100191, P.R.China

ABSTRACT

Accurate knowledge of scattering properties of ice particles is required in microwave radiative transfer calculations since performing microwave radiative transfer has been validated as an efficient tool to obtain the microphysical parameters of clouds. The scattering characteristics of ice crystals can be determined by many factors, like permittivity, orientation, size parameter, shape, etc [1]. However, the complex permittivity of pure ice can be affected by environmental factors, and it is hard to obtain the true value for the variance of the environment. A model for ice permittivity [2], which was proposed by Hufford in 1991, suggests that the real part of ice complex permittivity is a constant and the imaginary part is a function of temperature and frequency.

Jiang and Wu [3] found that the ice permittivity model of Hufford has uncertainties of about 12% in the imaginary part and of 5% in the real part at the frequency range of 100–1000GHz, compared with laboratory data. They calculated the errors of extinction coefficient and single scattering albedo for a typical particle size of 200 μm diameter, assuming 20% uncertainty in the imaginary part and 5% uncertainty in the real part of ice permittivity at the Upper Atmosphere Research Satellite (UARS) and Earth Observing System Microwave Limb Sounder (EOS MLS) radiometer frequencies. Kim [4] employed another ice permittivity model [5] and calculated the extinction and absorption cross sections and asymmetry factors for spherical crystals based on ±20% uncertainty in the imaginary part of permittivity of another model [5], and the results showed that the differences of extinction efficiency and asymmetry factor are less than 3% for size parameters less than 12 at 340 GHz.

We calculated the effects of uncertainties in complex permittivity on upwelling brightness temperature at the channel frequencies of Advanced Microwave Sounding Unit-B (AMSU-B), 89GHz, 150GHz, and 183

GHz in this study. The ice crystals are all shaped in spherical particles for simplification and the diameter is chosen in the range of 40 to 4000 μm. The particle layers are placed at the height from 9.7 to 11.7 km. All the particles are in Gamma-size distribution. The effective diameter is 150 μm, and the effective variance [6] is 0.25. The cloud ice mixing ratio of each layer is from 0.0001 kg/kg to 0.01 kg/kg. Assuming complex permittivity of ice particles has an uncertainty of ±20% in the imaginary part and of ±5% in the real part, absolute errors of brightness temperatures are calculated using vector discrete ordinate radiative transfer method (VDISORT) [7]. The results in this paper are given at horizontal polarization at a zenith angle of 0°, 30° and 53°, respectively.

The emerging brightness temperature is declined with the increase in the cloud ice mixing ratio. The window channels (89 GHz and 150 GHz) are less sensitive to cloud ice mixing ratio than the water vapor channel (183 GHz). In addition, The uncertainty of ±5% in the real part of ice permittivity results in greater error of brightness temperature than the uncertainty of ±20% in the imaginary part when the effective diameter is 150 um at the frequencies of AMSU-B. The absolute errors of upwelling brightness temperature caused by the uncertainties in the permittivity are greater with the increase of the ice mixing ratio and at higher channel frequencies. The absolute variations of the emerging brightness temperature from the cloudy atmosphere due to uncertainties in the permittivity were found to be more than 1 K.

REFERENCES

[1] C. F. Bohren and D. R. Huffman, *Absorption and scattering of light by small particles*. New York: Wiley-Interscience, 1983.

[2] G. Hufford, "A model for the complex permittivity of ice at frequency below 1THz," *International Journal of Infrared and Millimeter Waves,* vol. 12, pp. 677-682, 1991.

[3] J. H. Jiang and D. L. Wu, "Ice and water permittivity for millimeter and sub-millimeter remote sensing applications," *Atmospheric science letter,* vol. 5, pp. 1416-151, 2004.

[4] M.-J. Kim, "A physical model to estimate snowfall over land using microwave." vol. Ph.D Dissertation Washington: University of Washington, 2004, p. 176.

[5] C. Matzler and U. Wegmuller, "Dielectric properties of fresh-water ice at microwave frequencies," *Journal of Physics D: Applied Physics,* vol. 20, pp. 1623-1630, 1987.

[6] J. E. Hansen and L. D. Travis, "Light scattering in planetary atmospheres," *Space science review,* vol. 16, pp. 527-610, 1974.

[7] F. M. Schulz, K. Stamnes, and F. Weng, "Vdisort: an improved and generalized discrete ordinate method for polarized (vector) radiative transfer," *Journal of quantitative spectroscopy and radiative transfer,* vol. 61, pp. 105-122, 1999.