VALIDATION OF DM-PACT MODELED SNOW BACKSCATTERING COEFFICIENT FOR ARBITRARY SHAPED PARTICLES IN KU-BAND

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1. INTRODUCTION

In scattering modeling of the snow cover individual snow particles are often assumed to be spherical and, depending on the frequency range, either Rayleigh approximation or Mie-scattering is used for the calculation of the phase matrix. However, the complex shapes of realistic snow crystals can have a significant effect on the scattering properties at higher frequencies, especially for the cross-polarized component. In this study homogeneous snow cover is modeled with arbitrary snow crystals and the scattering properties of these particles are compared with Mie-scattering utilizing the dense medium assumption from DM-PACT method [1,2] and both results are compared against experimental data to be gathered in the coming winter with the Snowscat-instrument (polarimetric X- to Ku-band scatterometer owned by European Space Agency) in the NoSREx-measurement campaign (October 2009 through June 2010). The campaign is organized in support of the preparation of CoReH2O mission.

2. METHOD

A realistic looking precipitating snow crystal can be modeled as a simple fractal [3] (Fig.1.) and newly fallen snow on the snow cover can be illustrated with similar shapes. The scattering amplitudes can be calculated with the volume integral equation (VIE) directly or with a very similar method called discrete-dipole-approximation (DDA) [4]. In the volume integral equation the dielectric scatterer is described as a collection of small subunits.

These subunits behave as dielectric dipoles in terms of their response to an applied electronic field and, in addition, the dipoles interact with each other.

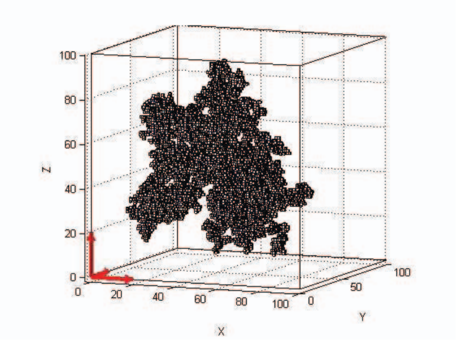


Figure 1. An illustration of a 3D-fractal particle with fractal dimension of 2.3 and the number of subunits is 70239.

The scattered electric field of the particle is then calculated as a linear combination of excited fields of each dipole as a function of incident electric field. DDA has been widely used in optical studies and also in modeling precipitating snow crystals [5-7] and its assumptions for spherical particles have been validated against Mie-theory [8,9].

As snow is a dense medium and conventional radiative transfer theory cannot be applied, other methods are developed for calculating the multiple-scattering effect in snow cover, like Dense-Medium Radiative Transfor theory (DMRT) [10] and Dense Medium Phase and Amplitude Correction Theory (DM-PACT) [1,2]. In this study the phase correction term is adopted from the DM-PACT and the amplitude correction term is considered inside the volume integral equation of the single particle. The backscattering coefficient is calculated according to Ewe *et al.* [2] to the first and second order for homogeneous snow cover. The modeled particles, fractal shaped, ellipsoids and spheres, follow a normal size distribution for the defined size parameter and averaged scattering amplitudes are used for the phase matrix calculation.

3. RESULTS

The model was validated in spring 2009 without the phase correction term [11]. A sensitivity analysis to various snow parameters was carried out for like- and cross-polarizations in X- and Ku-band, and the results were compared with the second-order DMRT (i.e. in Fig 2.). A comparison with measured data was performed in the SARALPS-2007 measurement campaign (Fig.3) [12]. At this time the model performed reasonably well for the co-polarizations, but it underestimated the cross-polarization terms by several dB [11]. The results with the phase correction term together with the new campaign data are presented in the conference.

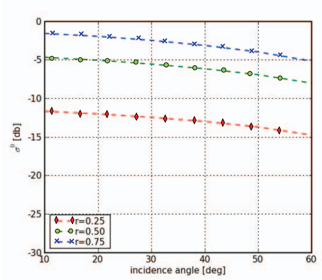
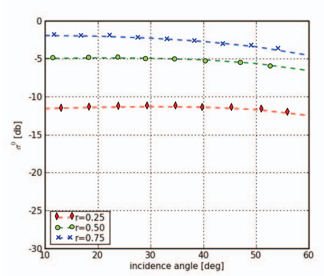
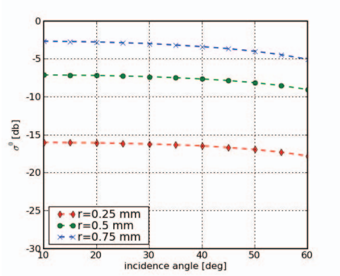
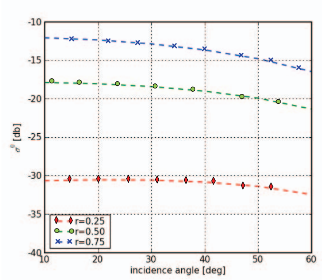
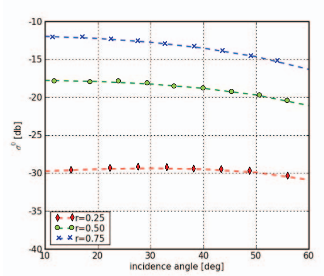
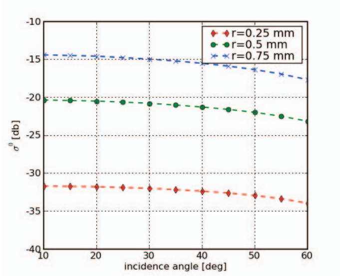
Ku	RT-DDA – Disk	RT-DDA – Needle	DMRT
VV			
VH			

Figure 2. Model comparison of volume backscatter at Ku-band calculated with the studied model and DMRT [13]. Snow parameters: depth 100 cm, density 250 kg/m³, snow temperature -5°C, equivalent grain radius 0.25 (♦), 0.5 (●) and 0.75 (⊗) mm. For the studied model disk and needle shaped scatterers with b/a 0.25 are used and ten orientation of snow grains are averaged and for DMRT ellipsoids with b/a = 0.25 are used. [11]

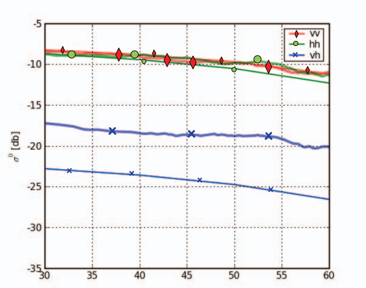
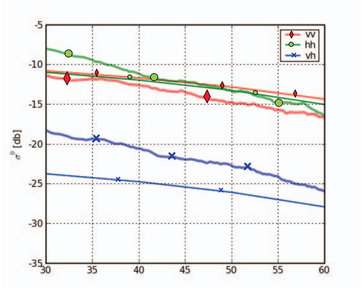
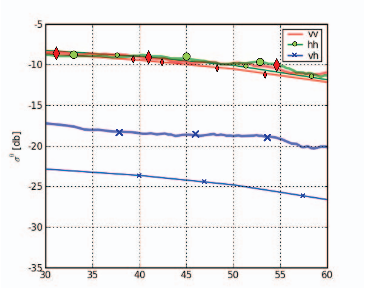
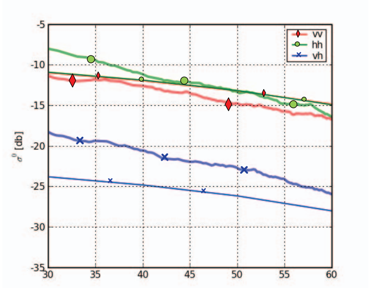
Case	Ku-Band	X - Band
1		
2		

Figure. 3. Comparison of measured (thick lines, big symbols) and modelled (thin lines, small symbols) backscattering coefficient for test site Kühtai, 5 February 2007. Case 1: needles with b/a = 0.5 (a=0.794 mm, b=0.397 mm, equivalent radius 0.5 mm)), case 2: disks with b/a=0.5 (a=0.63 mm, b=0.315 mm equivalent radius 0.5 mm). Surface scattering contributions from the snow-ground and air-snow interface are modelled using the Oh surface model [14]. For the model ten orientations of snow grains are used.[11]

4. REFERENCES

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