New GSMaP Over-Land Precipitation Retrieval Algorithm:
Forward calculation program introducing microwave properties of non-spherical frozen particles

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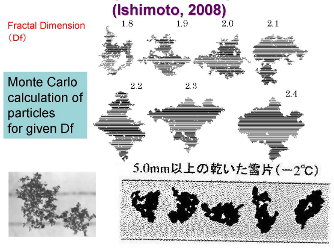
1. Introduction:

Passive microwave precipitation retrieval algorithms require forward calculation programs to calculate microwave brightness temperatures (TBs) from precipitation. The current forward calculation, however, has problems in parameterization of microwave properties (scattering properties in high frequency range, in particular) of precipitation in high latitudes. The objective of the present study is to improve the forward calculation by introducing microwave properties of non-spherical frozen particles into the fast Radiative Transfer Model (RTM) code used in the retrieval algorithm.

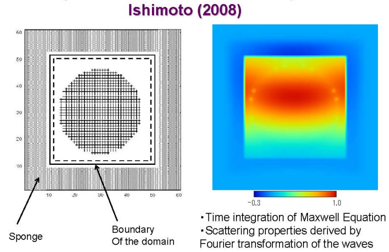
2. Microwave properties of non-spherical particles:

We constructed realistic non-spherical frozen particle models for fractal dimension (Df) of 1.8, 2.1, and 2.4, volume fraction (Vf) of 0.48 and 1, using Monte Carlo simulations. Then, we used the FDTD method to calculate the bulk microwave properties (scattering efficiency, asymmetry factor, etc).

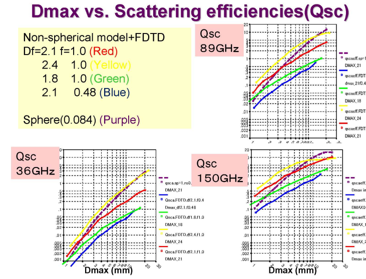
Realistic non-spherical frozen particle model (Ishimoto, 2008)



FDTD (Finite Difference Time Domain) Method Ishimoto (2008)



Dmax vs. Scattering efficiencies(Qsc)

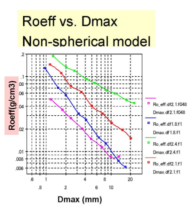


3. Improvement of the fast RTM code:

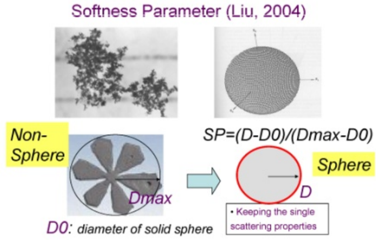
We introduced the effective density (Roeff) dependence on the maximum diameter (Dmax) and adjustment of Softness parameter (SP). This enabled the fast RTM code to parameterize the microwave properties (in particular, the scattering efficiencies) of the non-spherical frozen particle models. The approximation of Roeff contributed to parameterize the scattering efficiencies for smaller particles. The use of SP contributed to parameterize the scattering efficiencies for larger particles and the asymmetry factors.

Fast RTM Code (Liu,2004) and the improvement

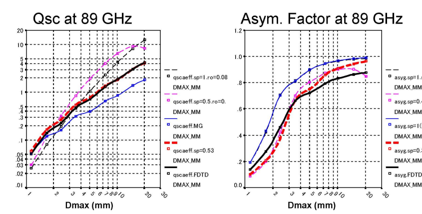
- One-dimensional model (Plane-parallel)
- 4 stream approximation
- Approximation of Roeff in terms of Dmax
- Adjustment of softness parameter in terms of the fractal dimension, the density parameter, and the frequency



Softness Parameter (Liu, 2004)



FDTD (black) and the fast RTM (red) (Df,Vf)=(2.1,1)

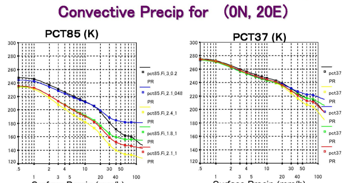


4. The results of the RTM calculation:

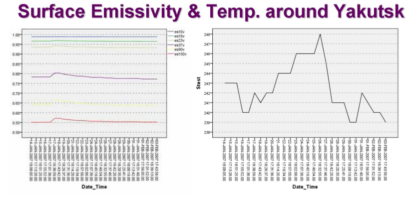
We performed some sensitivity tests to see TB depressions by non-spherical frozen particles with various physical properties (PSD etc.). The results show that TB depressions at 89 GHz were very sensitive to the fractal dimension, the volume fraction, and depth of frozen precipitation, while TB depressions at 36 GHz had low sensitivity to the frozen precipitation.

We incorporated the surface emissivity and temperature from the land surface algorithm of the University of Tokyo into this new forward calculation program. Then we calculated TBs for Advance Microwave Scanning Radiometer on EOS (AMSRE) and Special Sensor Microwave Imager/Sounder (SSMIS) over snow covered land around Yakutsk during Jan.-Feb. 2007. The results indicate that TB variations at 89 GHz were dependent on frozen precipitation rate and cloud liquid water content (CLWC) while TBs at 36 GHz were only sensitive to CLWC.

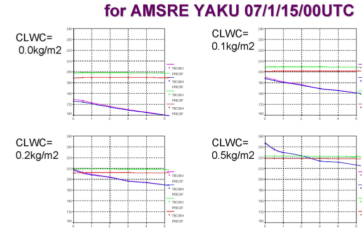
Forward Calculation for different (Df,Vf) Convective Precip for (0N, 20E)



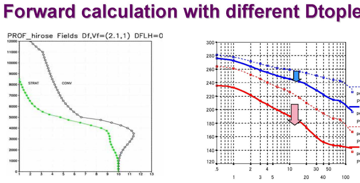
Surface Emissivity & Temp. around Yakutsk



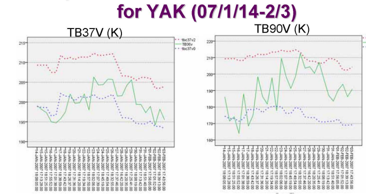
Forward Calculation for different CLWC for AMSRE YAKU 07/1/15/00UTC



Forward calculation with different Dtoplev



Comparison between AMSRE Obs. & Cal. for YAK (07/1/14-2/3)



Forward Calculation for SSMIS YAKU 07/1/15/00UTC