1. Introduction

The melting of ice particles is known to produce distinctive radiative features at microwave frequencies such as the radar bright band and increased signal attenuation. An accurate characterization of the scattering properties of melting ice particles is not only relevant for precipitation retrievals from space but also for utilizing the observational fingerprints e.g. for model evaluation.

While the number of available datasets for complex aggregates and mixed inlets is rapidly increasing during recent years, the number of available scattering datasets for realistic melting particles is very limited (especially regarding the number of particle sizes, shapes, and melted fractions included). This is certainly connected to the high complexity of the melting process and the large computational cost of scattering simulations.

We used two recent scattering datasets of realistically shaped melting snowflakes to calculate triple frequency scattering signal from partially melted snowflakes using a simple melting layer model that assumes constant melted fraction for all particle sizes and compare with radar observations of the ML.

2. Melting Model

Both datasets use an heuristic approach (figure 1) to simulate observed characteristics of the melted snowflakes.

- Ori et al. (2014) used a stochastic aggregation algorithm to generate snow aggregates of various sizes that follows an observed mass size relation (Brandes et al. 2007). The melting phase statistically favors the melting of the particle from the areas with the smallest curvature.
- Johnson et al. (2016) different sizes are generated by linearly scaling (magnifying) the same shape, thus the m-D relations scales as $D^3$ (figure 2). The melting model advances from Ori (2014) by allowing water volumes to migrate to the inner parts of the aggregate, imitating the properties of water surface ten

3. Modeled triple frequency properties

We modeled the triple-frequency X (Ku for Johnson 2016), Ka and W properties by integrating the scattering properties over an inverse exponential PSD with different mean volume diameters $D_v$. We assume constant melting fraction over the whole PSD.

The predicted general effect of melting is to increase both DWRs and LDR (figure 4).

<table>
<thead>
<tr>
<th>Property</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWR (dB)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>LDR (dB)</td>
<td>0</td>
<td>1.5</td>
<td>3</td>
<td>4.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Here $D_v$ is increasing along the curves

By using LDR as an indicator of the melting stage we can better characterize the effect of melting on the triple-frequency scattering properties (figure 6).

4. Radar Observation

The backscattering cross section (figure 3) increases with melted fraction. For BJ aggregate the simultaneous reduction of particle size partially compensate for the increased scattering of water. The scattering augmentation is larger at lower frequencies

Conclusions

The scattering databases of melted snowflakes available so far are not able to fully reproduce the observed triple frequency characteristics in the melting layer.

General features and relation among observables can be reproduced, but the absolute values are affected by substantial biases.

The biases can be partially explained by the highly simplified melting layer model adopted (constant melted fraction) and more sophisticated assumption can be employed to evaluate the sensitivity of the scattering properties to the melting layer model.

The simplified melting model used produces too high LDR values.

More detailed melting models might help, but the scaling of the aggregate mass with size still plays a major role in defining the snow scattering properties.

References


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