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Towards accurate Monte Carlo radar modeling including coherent backscattering

C. Pause (1), B. Mayer (2), R. Buras (3), and C. Emde (4)

(1) Meteorologisches Institut, Ludwig-Maximiliams Universität, München, Germany (christian.pause@lmu.de), (2) Meteorologisches Institut, Ludwig-Maximiliams Universität, München, Germany (bernhard.mayer@lmu.de), (3) Meteorologisches Institut, Ludwig-Maximiliams Universität, München, Germany (robert.buras@lmu.de), (4) Meteorologisches Institut, Ludwig-Maximiliams Universität, München, Germany (claudia.emde@lmu.de)

The goal of this work is to implement full radar simulation capabilities including all orders of multiple scattering as well as coherent backscattering into the 3D Monte Carlo radiative transfer model MYSTIC (Mayer 2009).

To achieve this goal, an existing lidar simulation code is extended with a coherent backscattering-algorithm. Coherent backscattering (also known as "weak localization") is an interference effect arising from multiple scattering in disordered media. This kind of interference originates from two photon paths going over the same scatterers in reverse directions and it results in an increase of backscattered energy in the form of a backscattering cone whose concrete shape depends on the properties of the medium.

This effect has been observed under various circumstances and while mostly being negligible for lidar it is not negligible for radar due to the much greater wavelengths used by radar. The algorithm uses an approach by Muinonen (2004) where an additional coherent backscattering Stokes vector is calculated from the combination of the Stokes vectors of the normal and the reverse photon paths and added to the normal Stokes vector. This approach can be readily derived using a coherency matrix approach for the Stokes vector.

Additionally an importance sampling method has been implemented to improve the simulation of microwave scattering at cloud droplets since the scattering mean free path in this case can be on the scale of several kilometers. This method artificially increases the scattering coefficient of the clouds to obtain better photon statistics, otherwise even with the use of a local estimate technique no practicable radar simulations would be possible.

The finished radar code is going to be compared to other existing radar codes and to real cases for validation. Furthermore we are planning ground-based remote sensing of cloud sides using combined cloud radar and cloud spectrometer measurements which will be compared to simulations to obtain information about microphysical cloud properties and the three-dimensional cloud structure.