Simulations of Cloud Radar Spectral Polarimetric Variables with T-matrix

I. Tsikoudi[1,2], A. Battaglia[3], C. Unal[4], K.A Voudouri[1,5], I. Koutsoupi[1,2], P. Kollias[6] and E. Marinou[1]

[1]Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, 15236 Athens, Greece
[2]Department of Physics, Section of Environmental Physics-Meteorology, National and Kapodistrian University of Athens, 15772 Athens, Greece
[3]Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, 10129 Turin, Italy
[4]Department of Geoscience and Remote Sensing, Delft University of Technology, Delft, the Netherlands
[5]Department of Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[6]School of Marine and Atmospheric Sciences, Stony Brook University, New York, NY 11790, USA
Keywords: spectral polarimetry, cloud, radar, T-matrix.
Presenting author email: jtsik@noa.gr

Cloud radar observations and simulations are crucial for advancing our knowledge on cloud microphysics. The T-matrix method has emerged as a powerful tool for computing the electromagnetic scattering properties and simulating the radar response of complex ice and water particles. This work focuses on generating simulations of a 94 GHz cloud radar observations with T-matrix and comparing between the simulated results and observations.

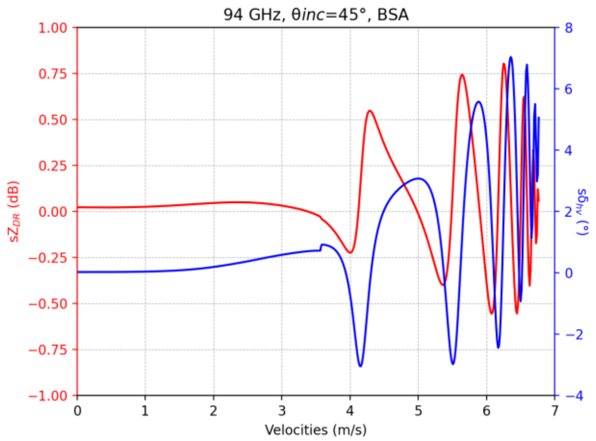

Figure 1. 94 GHz Doppler Radar pointing at 45 degrees. Spectral differential reflectivity sZ_{DR} (red line) and spectral differential phase $s\delta_{hv}$ (blue line).

Spectral polarimetry is to combine Doppler and polarimetric measurements in order to obtain the distribution of polarimetric variables as a function of radial velocity (Yanovsky, 2002, Unal, 2001, Unal, C. and Van den Brule, 2023). The 94 GHz frequency is particularly relevant for probing clouds with a high sensitivity to small particles, making it an ideal choice for investigating cloud microphysics in detail. In this study, we produce spectral polarimetric variables and compare them with real measurements of a 94GHz cloud radar pointing at 45 degrees. The T-matrix method (Mishchenko, 2000) is employed to accurately capture the complexities of cloud particles, enabling realistic simulations. Spectral differential reflectivity sZ_{DR}, copolar correlation coefficient $s\rho_{hv}$ and differential phase $s\delta_{hv}$ are the variables of interest. The study explores diverse conditions, allowing for the modification of rain rate, white and spectral noise, and turbulence parameters within the simulation tool.

An example is presented in Figure 1, where the spectral differential reflectivity (red line) and differential phase (blue line) are simulated by using the T-matrix method. These variables are also affected by atmospheric turbulence, by blurring of the spectral features. Simulating the impact of atmospheric turbulence is a complex task. The attempt for inclusion of turbulence in the simulations is also discussed.

Comparisons between simulations and measurements reveal a good correlation, validating the efficacy of the T-matrix method in reproducing spectral polarimetric variables.

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This research was partly financially supported by PANGEA4CalVal (Grant Agreement 101079201) funded by the European Union. I.K. acknowledges support by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "3nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers" (Project Acronym: REVEAL, Project Number: 07222).