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Simulation of polarimetric radar variables in rain at S-, C- and X-band wavelengths

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A variety of physical and empirical approaches exists to estimate the rain rate R from polarimetric radar observables like reflectivity factor for horizontally polarized waves Z_H, differential reflectivity Z_{DR}, or specific differential phase K_{DP}, resulting in a wide range of relationships. At C-band the situation is more complex since resonance occurs for larger rain drop sizes. Some polarimetric variables exhibit non-monotone dependence on the rain drop diameter. This resonance effect generally increases with increasing raindrop temperature.

Also several raindrop shape models exist and are still published. There seems to be no consensus on what the most appropriate model for natural rain is.

In this study the drop size distributions of hundreds of rain events were obtained from 2D-Video-Distrometer measurements in the mountains of Styria, Austria. For each event an averaged radar unit volume was modeled and the polarimetric radar variables Z_H, Z_{DR}, and K_{DP}, were calculated by a point matching scattering algorithm.

Radar rainfall estimators of the form $R(K_{DP})$, $R(Z_H, Z_{DR})$, and $R(K_{DP}, Z_{DR})$ were established for S-, C- and X-band wavelengths by regression analyses between the measured rain rate and the calculated polarimetric radar variables. The sensitivity of these variables and of radar rainfall estimators to temperature, and different rain drop shape models is investigated. It is also shown how the simulated radar variables change for different elevation angles of the radar antenna.