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Processing polarimetric X-band weather radar data with an Extended Kalman Filter framework

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Individual polarimetric quantities measured by weather radar systems are closely related to each other. Such relations can be used to constrain the estimates of the different quantities and hence to improve the quality of weather radar data. In the proposed approach, an extended Kalman filter framework is developed, which takes into account relations between individual radar variables as well as their spatial structure in order to simultaneously estimate the specific differential phase shift on propagation K_{dp}, the attenuation corrected radar reflectivity at horizontal polarization Z_h, the attenuation corrected differential reflectivity Z_{dr}, and the differential phase shift on backscattering δ_{hv}.

Simulated 2D fields of raindrop size distributions are used to test the proposed algorithm. In this simulation experiment, it is found that K_{dp} and δ_{hv} are retrieved with an excellent accuracy, outperforming existing estimators solely based on smoothed measurements of the total differential phase shift ψ_{dp}. Attenuation corrected reflectivities retrieved with the new algorithm exhibit an improved accuracy with respect to estimates from the standard Z_ϕ algorithm, while the attenuation corrected differential reflectivity is retrieved with a similar accuracy. By comparing the directly retrieved differential phase shift on propagation ϕ_{dp} with the cumulated K_{dp} estimate, the algorithm can also be used for radar calibration. The extended Kalman filter estimation scheme is applied to measurements collected by an X-band polarimetric radar in the swiss Alps in 2010. The calibration capability of the algorithm makes possible the estimation of the radome attenuation, which appears to be significant in moderate and intense rainfall (up to 5 dB). It is hence crucial to correct for radome attenuation in order to obtain reliable quantitative rain rate estimates. Once the radome attenuation has been removed, radar measurements are converted in to rain rate R using a new functional form of the relation between R, K_{dp} and Z_{dr}. The good agreement between radar estimates and ground observations from a disdrometer indicates the reliability of the proposed radar processing technique.