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A statistical evaluation of cloud microphysics schemes in a numerical weather prediction model with polarimetric radar observations

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Accurate representation of microphysical processes in clouds is crucial for reducing uncertainty in precipitation forecasts. Towards improving the prediction of convective precipitation, we developed a systematic framework for statistically evaluating cloud microphysical parameterizations in a numerical weather model using polarimetric radar observations from the German C-band radar network. Polarimetric radar observations are sensitive to cloud particle properties, such as particle shape, phase, or density, and are thus well suited for evaluating cloud microphysics. This study specifically targets high-impact weather events, such as hail and convective rain. Convective weather is particularly difficult to predict and the choice of the microphysical parameterizations significantly impacts the prediction of important characteristics of convective systems. At the same time, high-impact weather events have the potential to cause massive damage to both people and property.

The observational data for this study were collected using two polarimetric research radar systems in the Munich area of southern Germany, operating at C- and Ka-band frequencies, and a complementary polarimetric C-band radar operated by the German Meteorological Service (DWD). To evaluate the performance of cloud microphysics parameterizations in predicting high-impact weather events, a convection-permitting regional weather model setup has been developed, employing five microphysics schemes of varying complexity (double-moment, spectral bin, particle property prediction (P3)). The simulation of polarimetric radar signals consistent with the simulated cloud properties was achieved by applying a polarimetric radar forward operator. Convective cell objects are identified and tracked in both the model and radar data sets using an automated cell tracking algorithm. This facilitates Lagrangian tracking of individual convective cells, which permits the statistical assessment of simulated convective cell properties throughout their life cycles.

The resulting data set of convective cell objects is statistically analyzed in several ways. 1) Macrophysical properties, including the frequency, intensity, and area of high-impact weather situations, are compared. 2) The distribution into stratiform and convective precipitation is examined. 3) The ability of the model to reproduce statistical distributions of polarimetric signals is evaluated. 4) The results are related to the spatio-temporal development of the identified convective objects.

Presenting Author

Gregor Köcher

Email Address of Presenting Author

gregor.koecher@physik.uni-muenchen.de

Affiliation of Presenting Author

Meteorologisches Institut, Ludwig-Maximilian-Universität München, Germany

Address of Presenting Author

Theresienstraße 37, 80333 München

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DE811205325

Author: KÖCHER, Gregor (Meteorologisches Institut, Ludwig-Maximilians-Universität München, Germany)

Co-authors: HESKE, Christian (Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany); EWALD, Florian (Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany); ZINNER, Tobias (Meteorologisches Institut, Ludwig-Maximilians-Universität München, Germany)

Presenter: KÖCHER, Gregor (Meteorologisches Institut, Ludwig-Maximilians-Universität München, Germany)