EGU24-8810, updated on 15 Feb 2025
https://doi.org/10.5194/egusphere-egu24-8810
EGU General Assembly 2024
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Investigating the life-cycle of convective clouds from 4D observational data

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Convective clouds play a crucial role for understanding the Earth's climate. Current advancements of remote sensing instruments allow us to obtain valuable information on the spatio-temporal dynamics of convective clouds on multiple scales. Nevertheless, a continuous coverage of high-resolved 4D observational data to investigate the 3D properties of rapidly developing convective clouds is generally not available.

In this study, we leverage 4D radar reflectivities (in dBZ) derived from the extrapolation of passive and active remote sensing sensors with machine learning to close this gap. Using data with a spatial resolution of 3 km and a temporal resolution of 15 minutes, we receive a continuous perspective on the evolution of the cloud vertical column along the different stages of the cloud life-cycle. For this purpose, we apply an object-based algorithm to detect the centroid of convective cores and their anvil at each time step. Based on these centroids, we extract the 3D cloud field and track the horizontal and vertical movement through space and time. Afterwards, we filter all tracks using the vertical extension and maximum reflectivity of the associated cloud field to exclude erroneous features.

Here, we present an evaluation of the algorithm and its ability to investigate the 4D spatio-temporal properties of convective clouds. We set out to compare convective systems of different sizes over both oceans and continents to analyze the impact of varying environmental conditions on the cloud vertical motions along the cloud life-cycle.