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An object-based approach to weather analysis and its applications

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The research group ‘Object-based Analysis and SEamless prediction’ (OASE) within the Hans Ertel Centre for Weather Research programme (HErZ) pursues an object-based approach to weather analysis. The object-based tracking approach adopts the Lagrange perspective by identifying and following the development of convective events over the course of their lifetime. Prerequisites of the object-based analysis are a high-resolved observational data base and a tracking algorithm. A near real-time radar and satellite remote sensing-driven 3D observation-microphysics composite covering Germany, currently under development, contains gridded observations and estimated microphysical quantities. A 3D scale-space tracking identifies convective rain events in the dual-composite and monitors the development over the course of their lifetime. The OASE-group exploits the object-based approach in several fields of application: (1) For a better understanding and analysis of precipitation processes responsible for extreme weather events, (2) in nowcasting, (3) as a novel approach for validation of meso-γ atmospheric models, and (4) in data assimilation. Results from the different fields of application will be presented.

The basic idea of the object-based approach is to identify a small set of radar- and satellite derived descriptors which characterize the temporal development of precipitation systems which constitute the objects. So-called proxies of the precipitation process are e.g. the temporal change of the brightband, vertically extensive columns of enhanced differential reflectivity ZDR or the cloud top temperature and heights identified in the 4D field of ground-based radar reflectivities and satellite retrievals generated by a cell during its life time. They quantify (micro-) physical differences among rain events and relate to the precipitation yield.

Analyses on the informative content of ZDR columns as precursor for storm evolution for example will be presented to demonstrate the use of such system-oriented predictors for nowcasting. Columns of differential reflectivity ZDR measured by polarimetric weather radars are prominent signatures associated with thunderstorm updrafts. Since greater vertical velocities can loft larger drops and water-coated ice particles to higher altitudes above the environmental freezing level, the integrated ZDR column above the freezing level increases with increasing updraft intensity.

Validation of atmospheric models concerning precipitation representation or prediction is usually confined to comparisons of precipitation fields or their temporal and spatial statistics. A comparison of the rain rates alone, however, does not immediately explain discrepancies between models and observations, because similar rain rates might be produced by different processes. Within the event-based approach for validation of models both observed and modeled rain events are analyzed by means of proxies of the precipitation process. Both sets of descriptors represent the basis for model validation since different leading descriptors – in a statistical sense- hint at process formulations potentially responsible for model failures.