3D convective-stratiform echo type classification and convectivity from radar reflectivity

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Abstract

Different physical and microphysical processes dominate in convective vs. stratiform clouds and precipitation. Given that the heating profile of the atmosphere differs substantially in areas with different types of processes, knowing the type of cloud and precipitation is important for quantitative precipitation estimates from radar observations and for improving the accuracy of numerical models. Distinguishing between convective and stratiform regions in radar observations has a long history and many echo classification algorithms have been developed. One challenge with existing methods is their relative complexity - more parameters means that more variables need to be tuned. They were often developed with a single application in mind, for specific climatic conditions, and to answer specific research questions. To our knowledge, the existing algorithms generate a two-dimensional product, with a single class for each horizontal (x, y) grid point representing the whole vertical (z) grid column. Furthermore, they provide qualitative classes of convective and stratiform echo (and sometimes subcategories) rather than providing a quantitative measure of how convective or stratiform a specific grid point is likely to be.

We present the newly developed ECCO (Echo Classification from COnvectivity) algorithm which makes use of the intensity and the heterogeneity of the radar echoes on the horizontal axes. It introduces the concept of convectivity, which is designed to be a quantitative measure of the convective nature of each radar grid point. By thresholding convectivity, the more traditional qualitative categorization is obtained, classifying radar echoes as convective, mixed, stratiform, and subcategories thereof. In contrast to previous algorithms, convectivity and the echo-type classifications are provided on the full 3D grid of the reflectivity field. We applied ECCO to 3D radar observations from the United States, and used lightning data to demonstrate its skill. We also applied it to 3D radar observations collected onboard the GPM satellite and showed that the results are similar to the widely used GPM precipitation-type product. ECCO was then applied to 3D radar grids from the United Arab Emirates and Australia, illustrating its robustness and adaptability to different radar grid characteristics and climatic regions. ECCO was also adapted for the 2D European OPERA radar grid. A separate version of the algorithm (ECCO-V) was optimized for vertically pointing radars using observations from the airborne NCAR HIAPER Cloud Radar. ECCO-V was then applied to ground based vertically pointing systems and the radar onboard the CloudSat satellite.