Identification and Tracking of Convective Modes based on Radar Data

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Convective Modes

A **Region of Precipitation (ROP)** is a contiguous region with reflectivity values $Z \geq 25\,\mathrm{dB}_Z$. A **reflectivity core (RC)** is a part of a ROP. It is a contiguous region with reflectivity values $Z \geq Z_{85}$, where Z_{85} is the 85^{th} percentile fo all reflectivity values in the ROP. The maximum reflectivity within a RC must reach 45 dB_Z.

In this study, each RC is assigned to a convective mode using the following key parameters:

Key parameters used to define the convective mode of a storm, applied in the algorithm described below:

N_{RC}: number of RCs in this ROP

a **and** b: length of first and second principal axis

A_{RC} **and** A_{ROP}: area of the RC and the corresponding ROP

Δ_{RC}: distance to next RC

E_{max}: maximum horizontal extent of the ROP

Ω: cyclonic ($\Omega = 1$), anticyclonic ($\Omega = -1$) or no rotation ($\Omega = 0$); in special cases both cyclonic and anticyclonic rotation are observed in a single RC ($\Omega = 2$). (See **Mesocyclone detection**).

An RC may then be described as

Clustering: A **MCS** is a non-isolated RC ($N_{RC} > 1$) with either a first principal axis $a > 50\,\mathrm{km}$ or $a > 25\,\mathrm{km}$ and a horizontal extent $E_{max} > 100\,\mathrm{km}$. Other Rcs (i.e. non-MCS) may be **clustered** ($N_{RC} > 1$) or **isolated** ($N_{RC} = 1$).

Embedding: If $A_{ROP}/A_{RC} > 100$ and $\Delta_{RC} > 15\,\mathrm{km}$, the RC is embedded in stratiform precipitation.

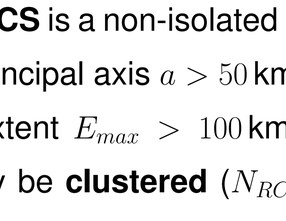
Shape: If $a/b > 3$, the RC is linearly shaped, otherwise circularly.

Rotation: May be cyclonic, anticyclonic, no rotation or both directions.

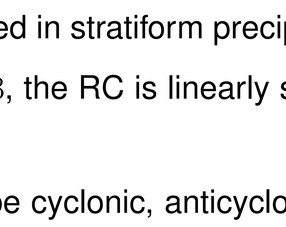
This leads to 3 × 2 × 2 × 4 = 48 different convective modes.

Examples of different convective modes

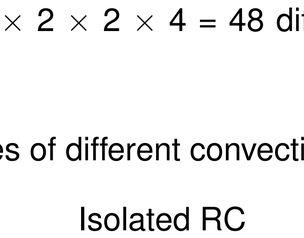
Isolated RC



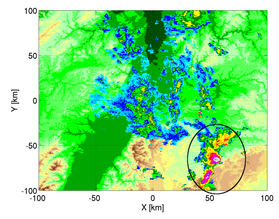
Isolated linearly shaped RCs



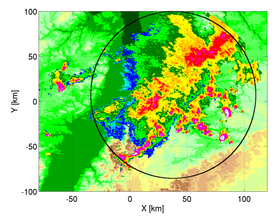
Cluster of RCs



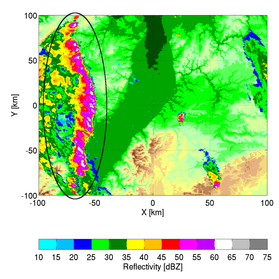
Linearly shaped cluster of RCs



Not linearly shaped MCS



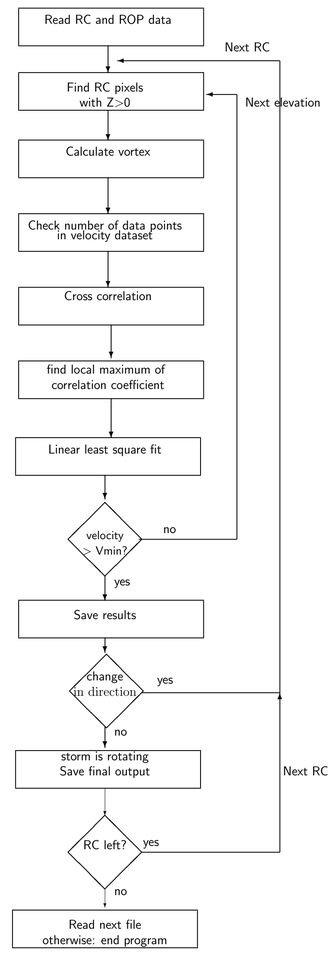
Linearly shaped MCS



Mesocyclone detection

To detect regions of cyclonic or anticyclonic rotation within the radar dataset, the radial velocity field of an idealized cyclonic vortex with constant angular velocity within a radius r_m from the vortex center at (R_0, φ_0) is computed for each grid cell of a reflectivity core (RC). A flow chart shows the subsequent procedures from dirty velocity data towards a detected mesocyclone.

Flow chart of mesocyclone detection



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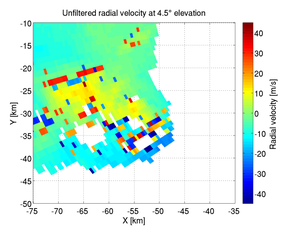
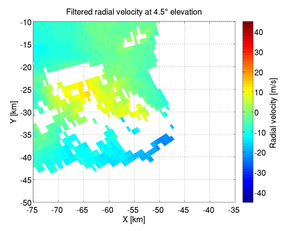
From velocity data to vortex signatures

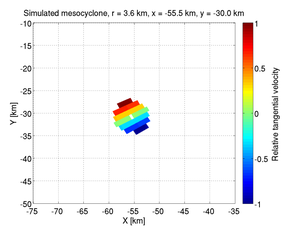
Raw velocity data



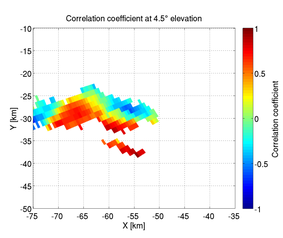
After noise removal



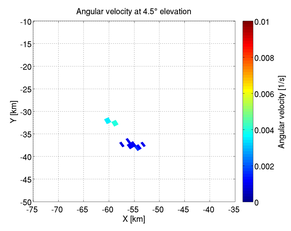
Idealized cyclonic vortex



Correlation analysis

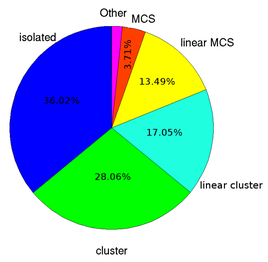


Linear least square fit



Outlook

12 days with a total number of 4070 RCs were examined to determine mean characteristics of convective modes. The most frequent observed convective modes are shown in a pie chart. With a frequency of less than 1.5 %, embedded stratiform RCs are the most infrequent convective modes which were observed. The reflectivity histograms did not show any significant difference between the most frequent convective modes.



The mesocyclone detection routine needs some improvement in performance and accuracy and therefore no results are shown yet. Cell tracking, e.g. with the routine **TRACE3D** (cf. Handwerker, 2002), is necessary to obtain the mean convective mode of an RC as frequent changes between isolated and clustered RCs have already been observed. All 12 case studies showed that convective modes are time-dependent and therefore not necessarily constant for a tracked RC.