Statistical analysis of convective storms based on C-band radar observations

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Abstract

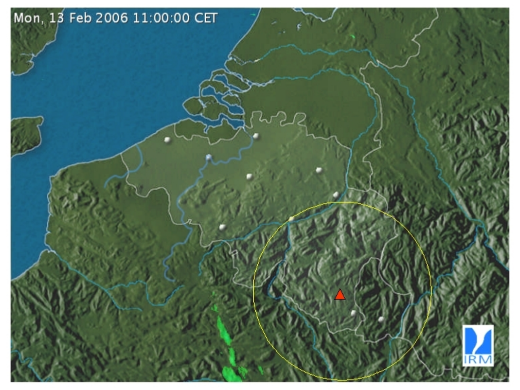
Several years of volume reflectivity measurements from a C-band weather radar are used to study the characteristics of convective storms observed in Belgium. These data are analysed with the TITAN cell tracker which has been recently installed at the Royal Meteorological Institute of Belgium (RMI).

First encouraging results are obtained from a 3-year dataset. The distribution of different storm properties such as duration, maximum reflectivity, echo-top heights are analysed. Statistics on the kinematics of the storms are shown. The influence of the diurnal and seasonal cycles is presented as well.

The final goal of this study is to analyse the relation between storm evolution and some relevant parameters with the aim of improving convective storms nowcasting.

Radar observations

RMI operates a weather radar in South-East Belgium :



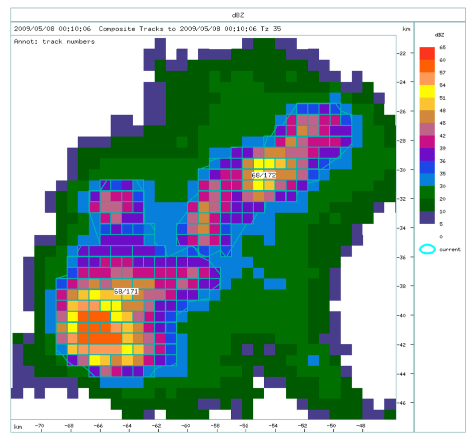
- Antenna height : 592 m above sea level
- C-band (5 Ghz), single-pol, Doppler
- Detection range : 240 km
- Resolution : 250 m in range, 1 ° in azimuth and elevation
- 5-elevation scan every 5 minutes
- Doppler filtering of ground clutter

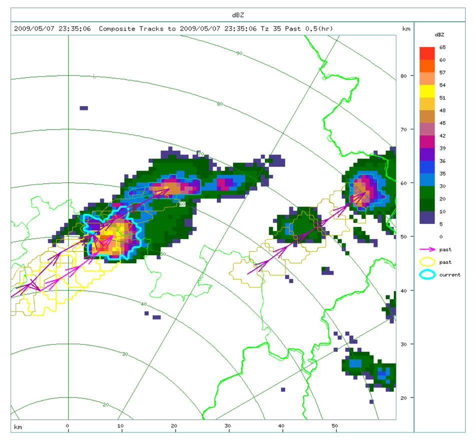
Titan cell tracker

The cell tracker TITAN (Dixon and Wiener, 1993) is designed to identify and track convective cells from radar observations.

The radar polar data are first interpolated on a Cartesian grid using nearest neighbour principle.

TITAN is in constant development and it has been updated several times.





Storm identification :

- A storm is identified as a 3D region exceeding a given reflectivity threshold (35 dBz)
- A higher dual threshold (45 dBz) is used inside the storm envelope to distinguish between different storm entities.

Storm tracking :

- Overlapping technique to match storm shape at two succesive scans.
- Remaining storms are logically matched by combinatorial optimisation.
- Additional handling of mergers and splits

Storm track analysis

A side application of the TITAN system allows generating ASCII tables of storm track properties. Two categories of properties are produced :

- Instantaneous storm properties such as position, volume or echo-top.
- Aggregate track properties such as duration, mean/max value of instantaneous properties.

The tracks are sorted into two categories :

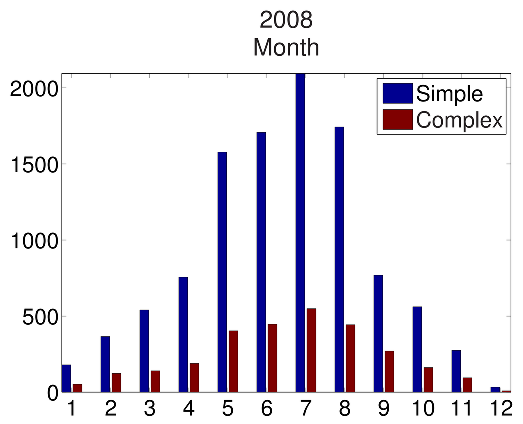
- simple track : for individual cells
- complex track : for track when splitting and/or merging occurs. The properties are aggregated amongst all cells.

Some parameters allow selecting a subset of the detected storms :

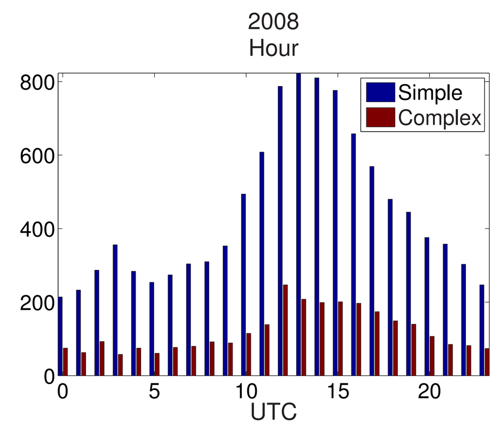
- The minimum duration is fixed at 900 sec which corresponds to 3 consecutive scans.
- The quality of the radar observations decreases with the distance from the radar due to e.g. attenuation, overshooting or beam broadening. Storm tracks lying outside the range limit of 180 km are removed.

Results

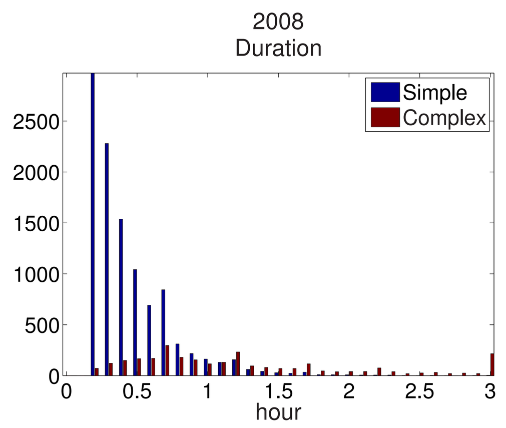
Storm tracks obtained from year 2006 to 2008 have been analysed. The frequency distribution of several properties of the storm tracks as well as spatial statistics have been obtained. The results for the different years are relatively similar (only 2008 is shown here).



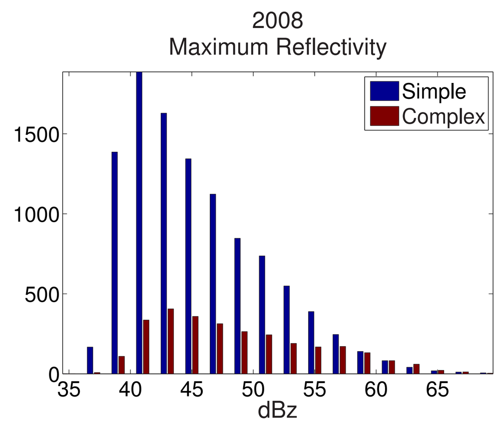
Looking at the number of storm tracks detected for each month of the year, it appears that convective storms mainly occur between May and August.

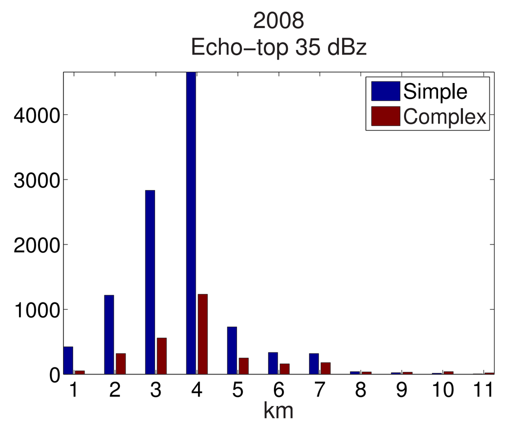


The effect of the diurnal cycle is clear : there is a significant maximum between 12 and 16 UTC.

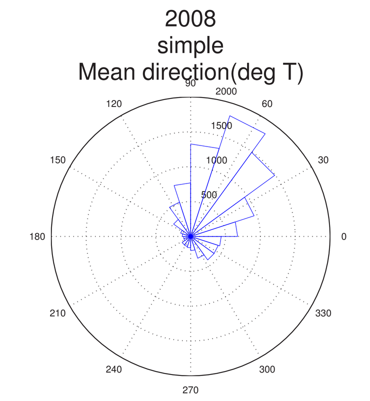


Simple cells are mostly short lived while about half of the complex cells last more than 1 hour.

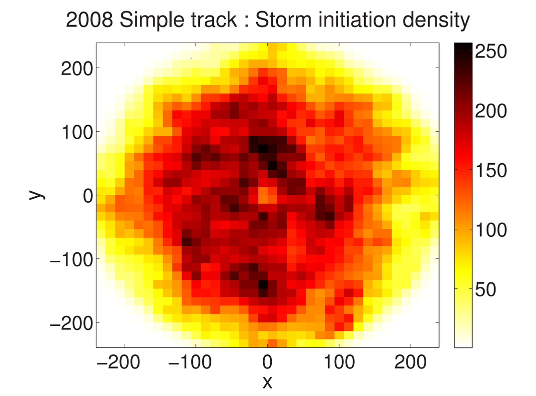




Plotted are the maximum reflectivity and the maximum height of the 35-dBZ threshold (echo-top 35 dBz). At first sight, both properties exhibit log-normal distributions.



The mean displacement of the storms is consistent with the dominant wind recorded in the study area for convective situations (South-South-West).



For the storm initiation, there is a clear effect of the range. The non uniform density suggests the existence of preferred areas for convection initiation.

Conclusions and perspectives

A 3 year dataset from a C-band radar has been analysed to get a better insight of the convective activity in Belgium. The capabilities of the tracking and analysis system TITAN have been showed. Promising preliminary results have been obtained from this long-term dataset. Realistic empirical distributions of storms properties have been obtained.

More robust results will be obtained through :

- Improvement of ground clutter removal (e.g. static clutter map)
- Sensitivity study to the storm tracking parameters (e.g. reflectivity thresholds)
- Deeper analysis of the storm initiation density map

Further research :

- Find possible relation between storm evolution and storm track properties
- Use a second radar to verify the results
- Use numerical weather prediction models output
- Use data from lightning detection or satellite imagery

Acknowledgements

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