8-year statistical analysis of 3D radar storm tracks

Edouard Goudenhoofdt and Laurent Delobbe

Royal Meteorological Institute of Belgium

edouard.goudenhoofdt@meteo.be

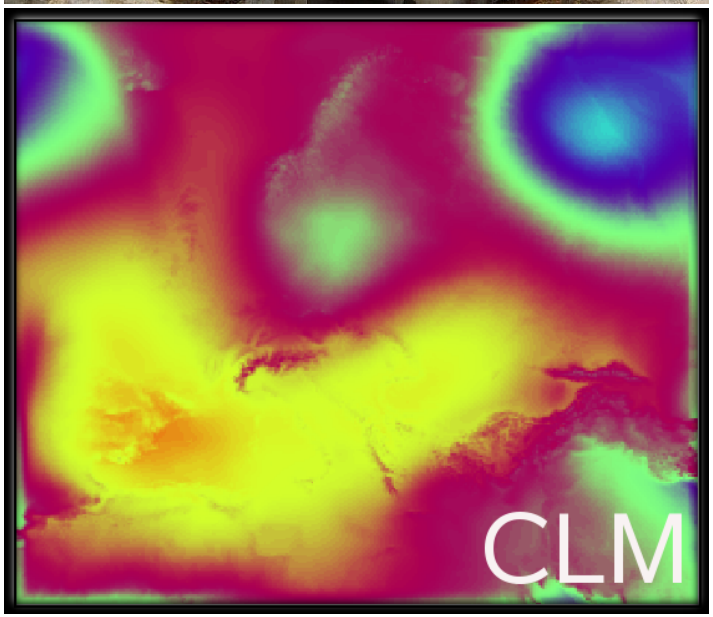
October 5, 2011
6th European Conference on Severe Storms
Palma de Mallorca - Spain

To improve knowledge of convective storm activity in Belgium.

To improve knowledge of convective storm activity in Belgium.

- Sewer system design

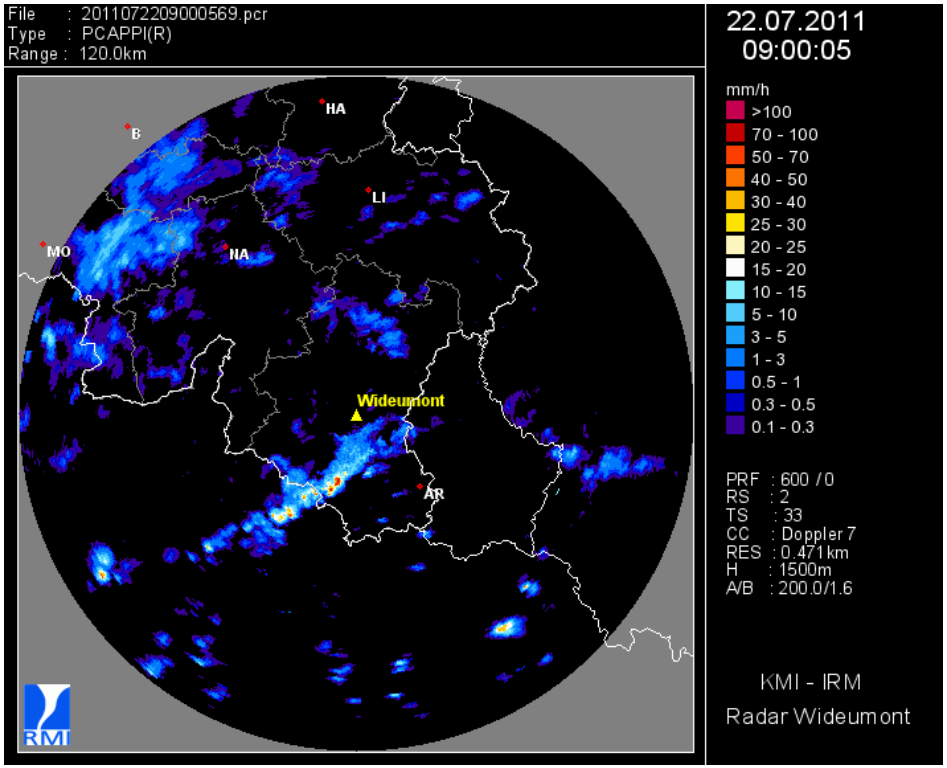
To improve knowledge of convective storm activity in Belgium.



- Sewer system design
- Regional climate model verification

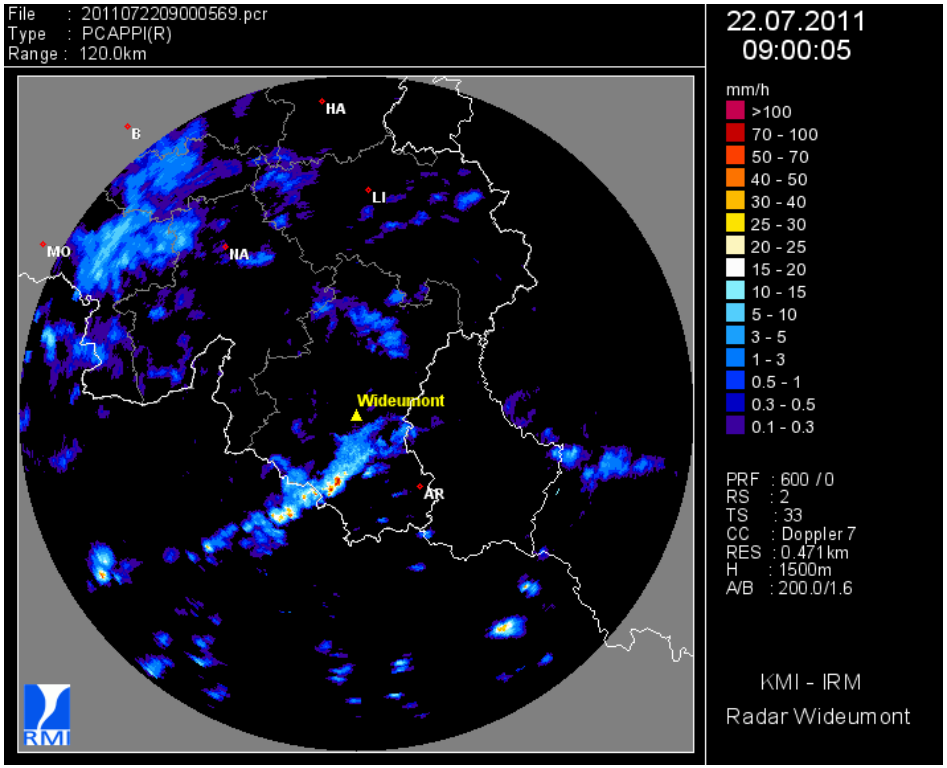
To improve convective storm nowcasting.

- By studying the factors that influence their development.



To improve convective storm nowcasting.

- By studying the factors that influence their development.

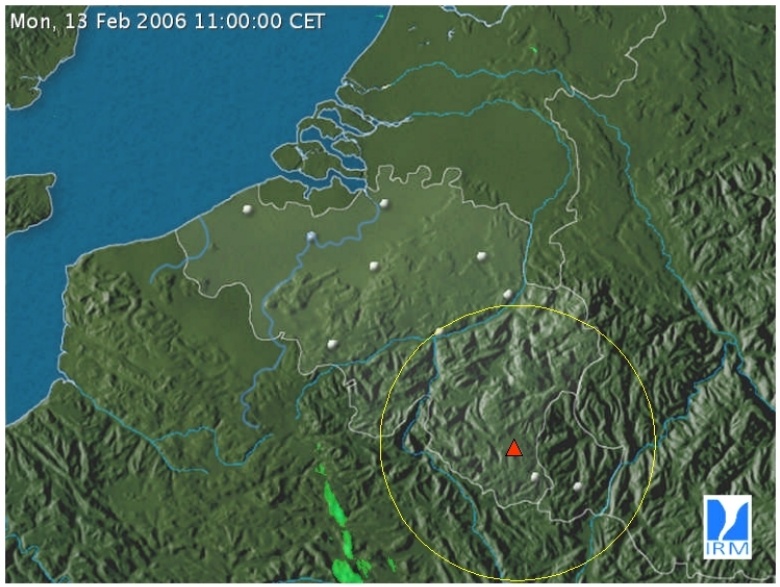


- Weather radar can monitor their precipitation activity with relatively good accuracy.

RMI operates a C-band radar in South-East Belgium

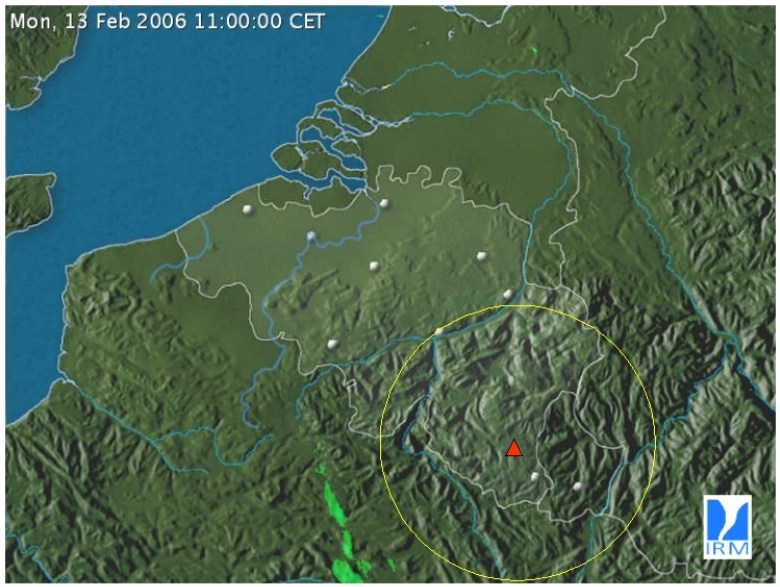
- Single-polarisation, Doppler

RMI operates a C-band radar in South-East Belgium



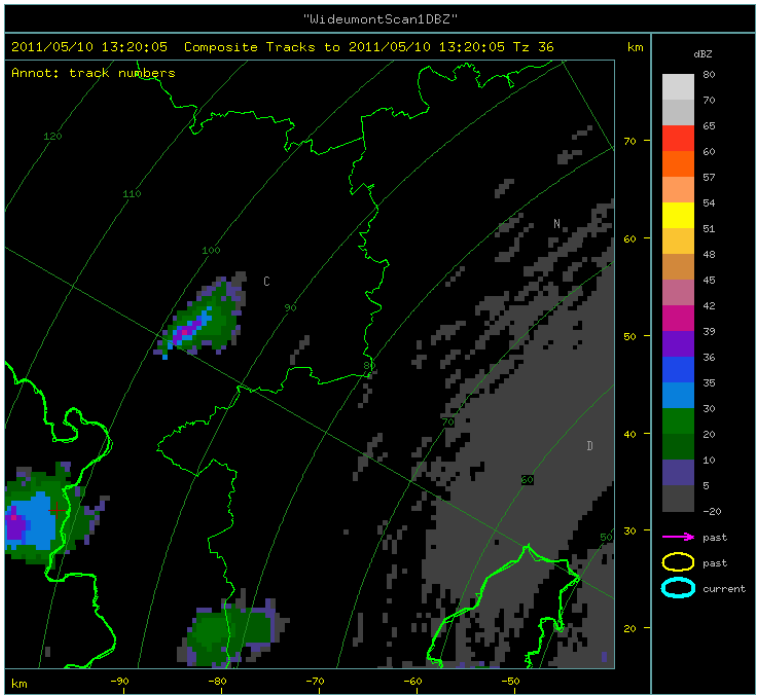
- Single-polarisation, Doppler
- Located in Wideumont : 600m asv, range of 240 km

RMI operates a C-band radar in South-East Belgium



- Single-polarisation, Doppler
- Located in Wideumont : 600m asv, range of 240 km
- Scan 1 : 5-elevation (0.3°, 0.9°, 1.8°, 3.3°, 6.0°)
  - Spatial resolution : 1°in azimuth, 250 m in range
  - Time resolution : 5 min
- Scan 2 : 10-elevation every 15 min (too long for CS tracking)
- Scan 3 : Doppler (120 km, every 15 min) for velocity estimation

TITAN tracks convective cells across successive radar scans



- Developed by NCAR (Dixon and Wiener, 1993)
- Freely available for research purpose
- Large suite of software, in constant development

1. **Filtering** of non-meteorological echoes by fuzzy logic
2. **Transformation** from polar to Cartesian grid (0.5 km cubic mesh)
3. **Storm identification** based on reflectivity (T_z) and volume (T_v) thresholds
4. **Storm tracking** based on combinatorial optimisation and cell overlap

After sensitivity tests : $T_z = 36\,dBZ$, $T_v = 10\,km^3$

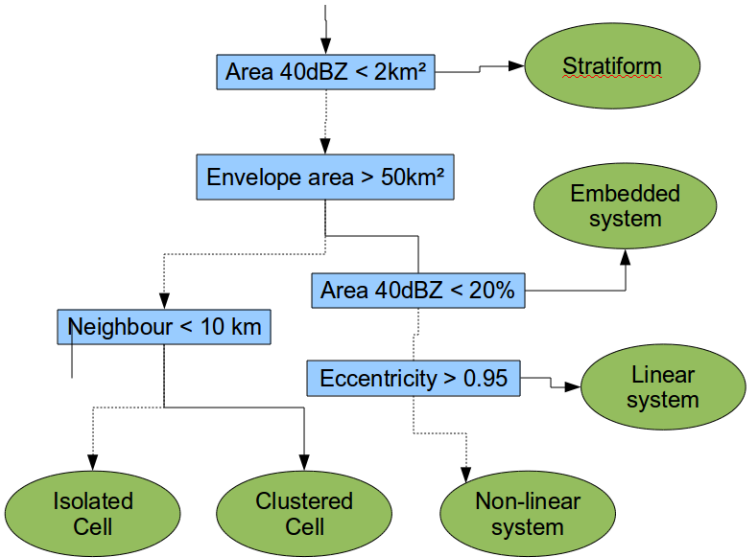
8 years of reflectivity data have been processed by TITAN

- Study area : 20 to 180 km from the radar.
- 90799 storm tracks : simple and complex (mergers and spliters)

8 years of reflectivity data have been processed by TITAN

- Study area : 20 to 180 km from the radar.
- 90799 storm tracks : simple and complex (mergers and spliters)

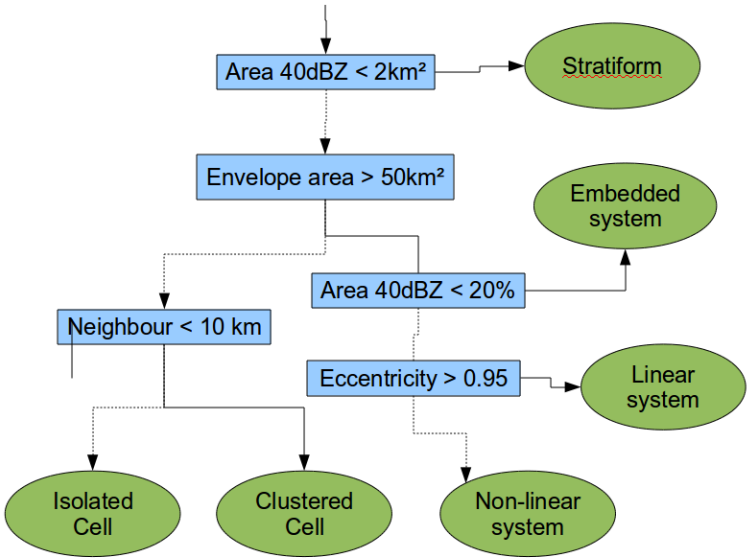
- An empirical storm classification based on storm properties is proposed

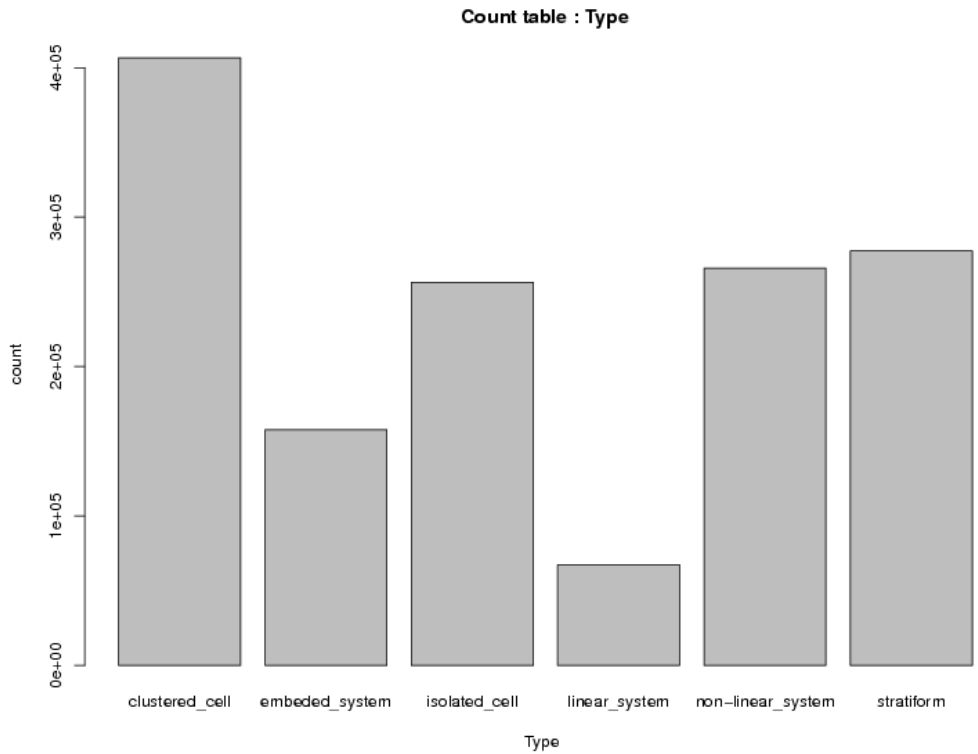


8 years of reflectivity data have been processed by TITAN

- Study area : 20 to 180 km from the radar.
- 90799 storm tracks : simple and complex (mergers and spliters)

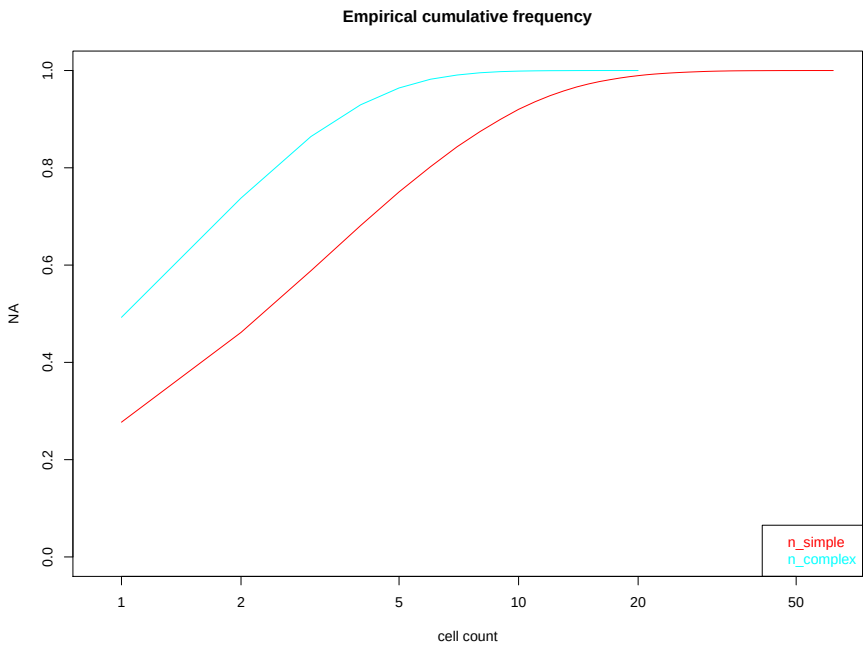
- An empirical storm classification based on storm properties is proposed





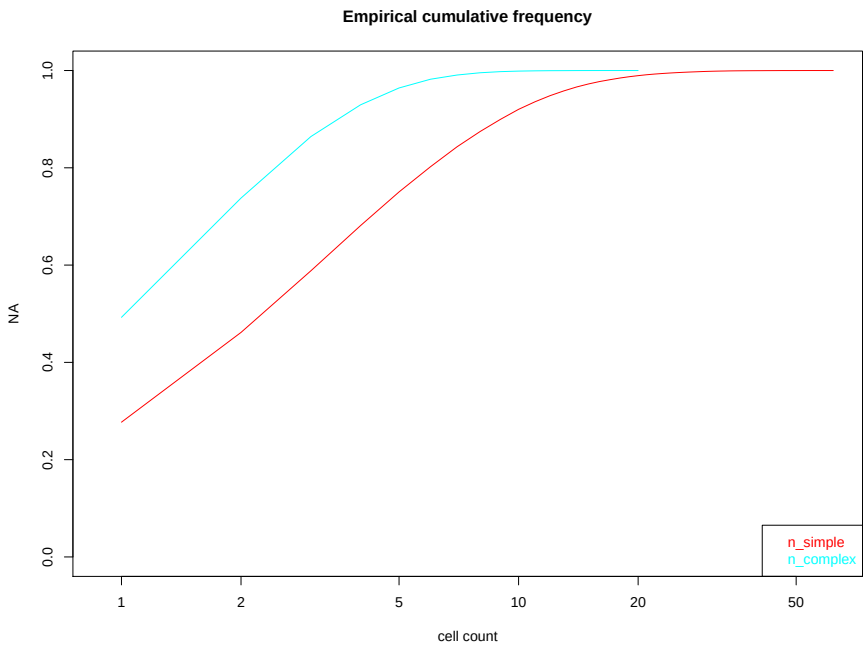
2 types of indicator to measure the instantaneous convective activity

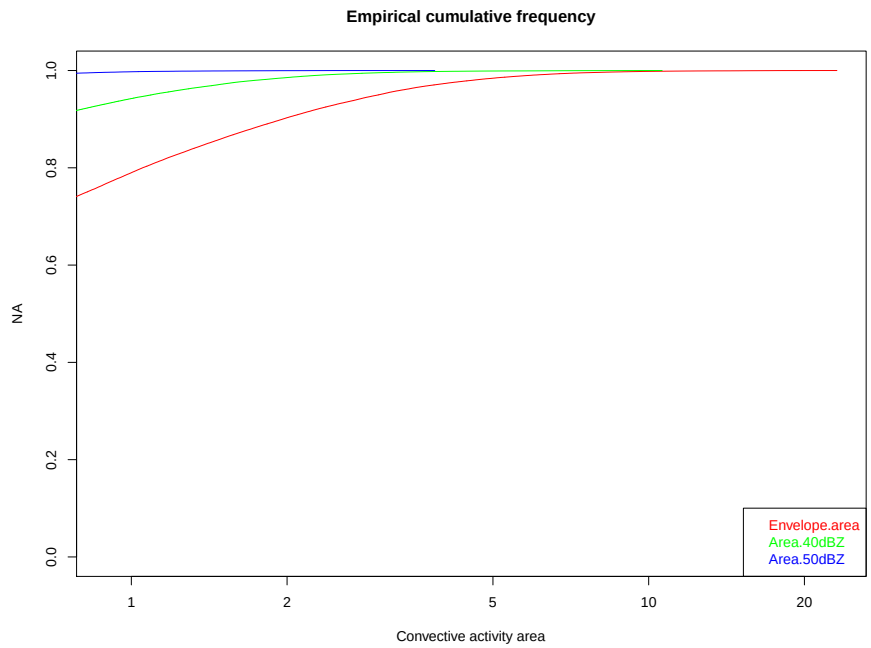
1. **Number of cells** : count of cells (or systems) in the study area



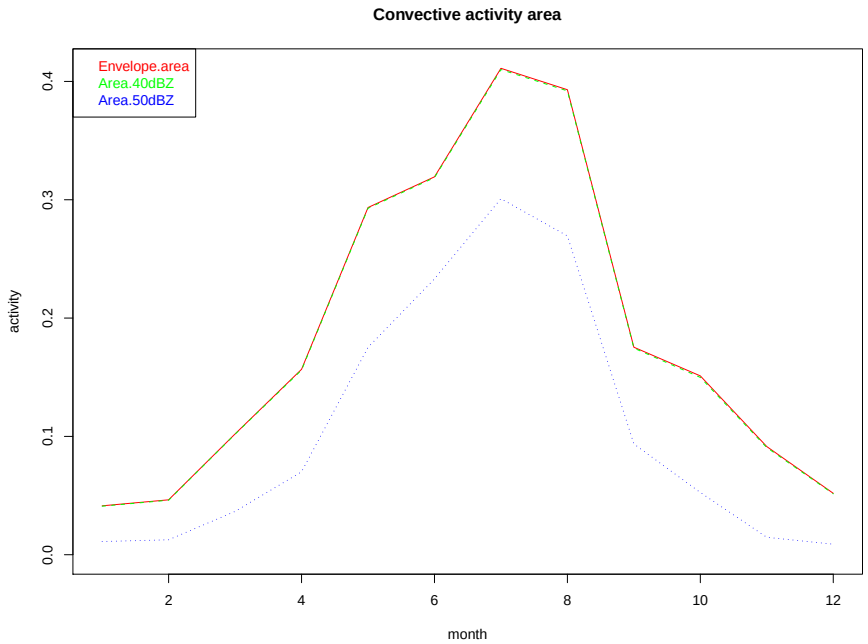
2 types of indicator to measure the instantaneous convective activity

1. **Number of cells** : count of cells (or systems) in the study area
2. **Total envelope area** : at 36,40 and 50 dBZ thresholds.



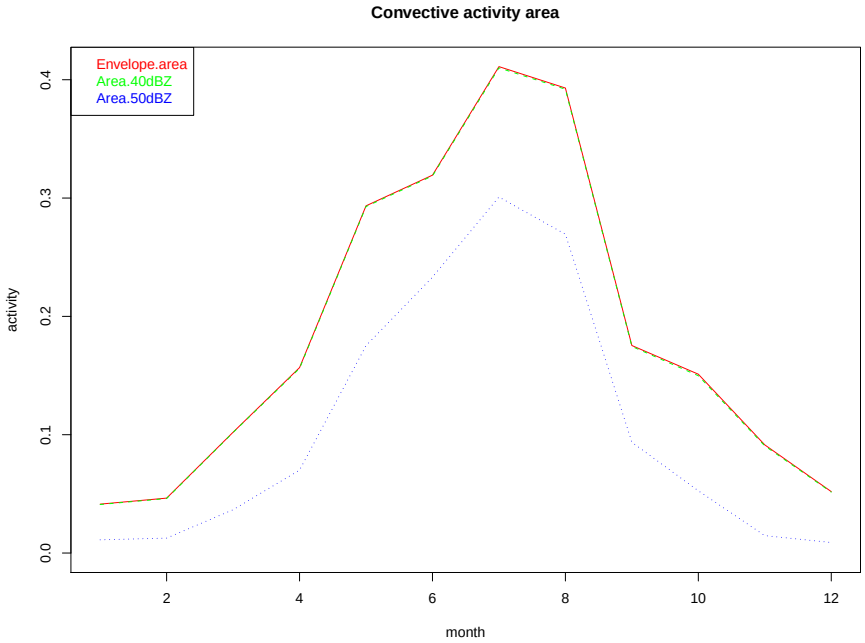


Seasonal variation of the convective activity

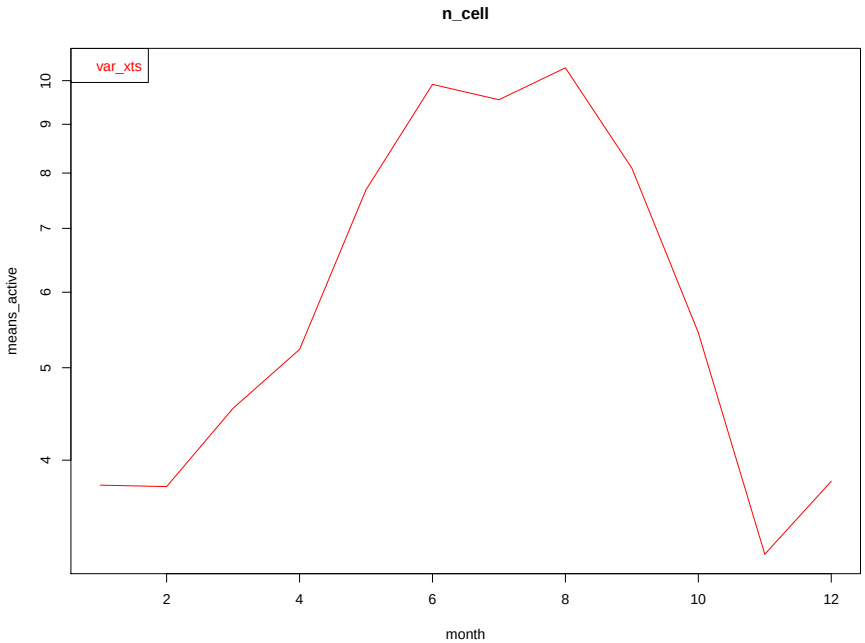


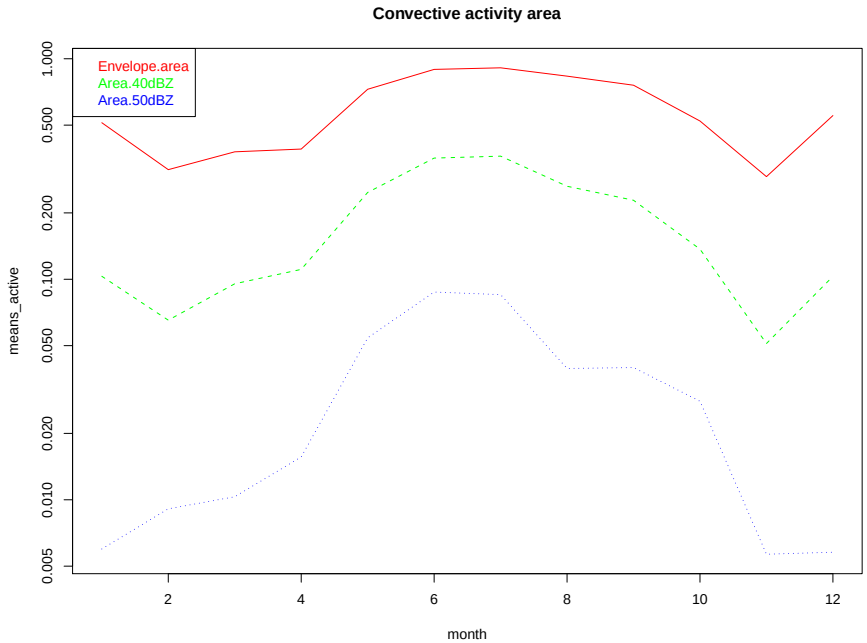
- Most of the activity between May and August with maximum in July and August.

Seasonal variation of the convective activity

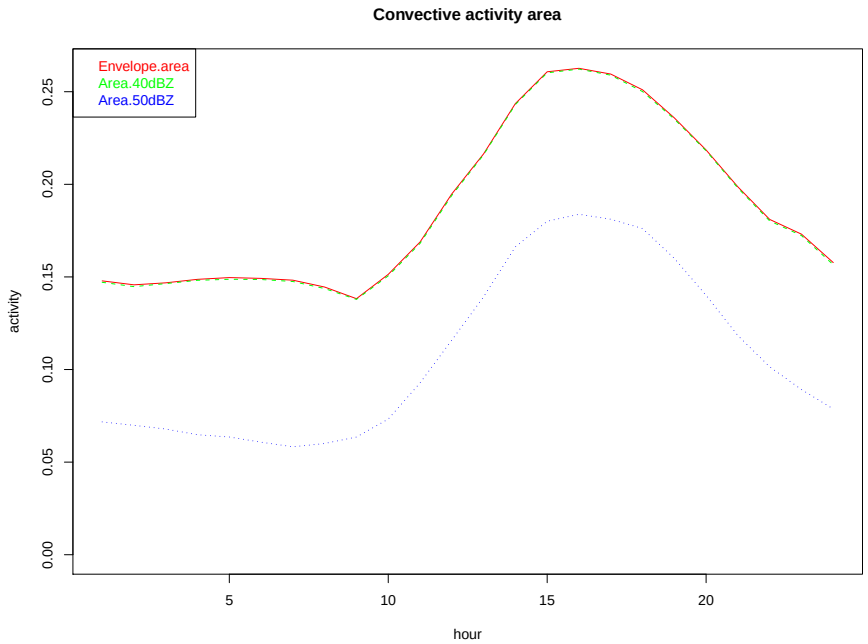


- Most of the activity between May and August with maximum in July and August.
- The mean intensity of the activity peaks in June for 40 and 50 dBZ areas and from June to August for the cell count.



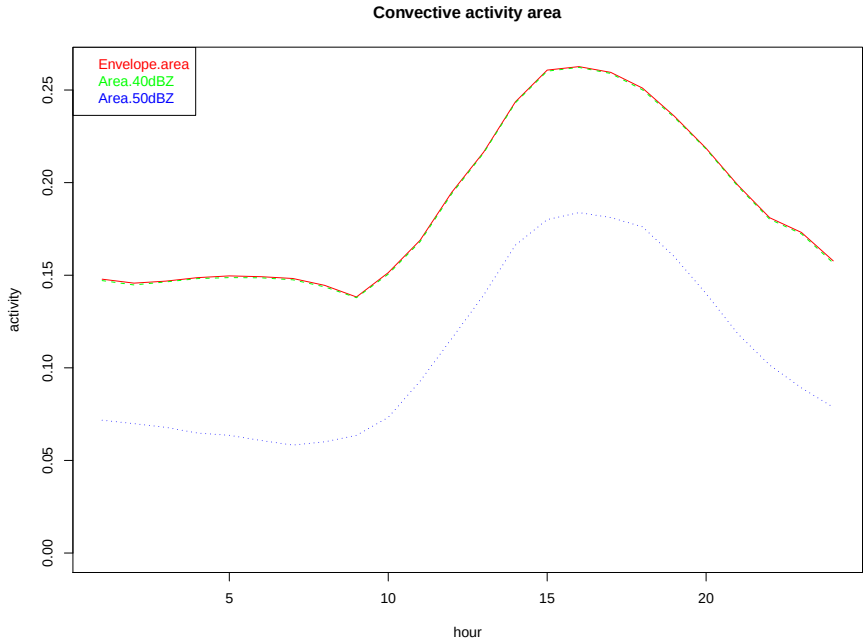


Diurnal variation of the convective activity

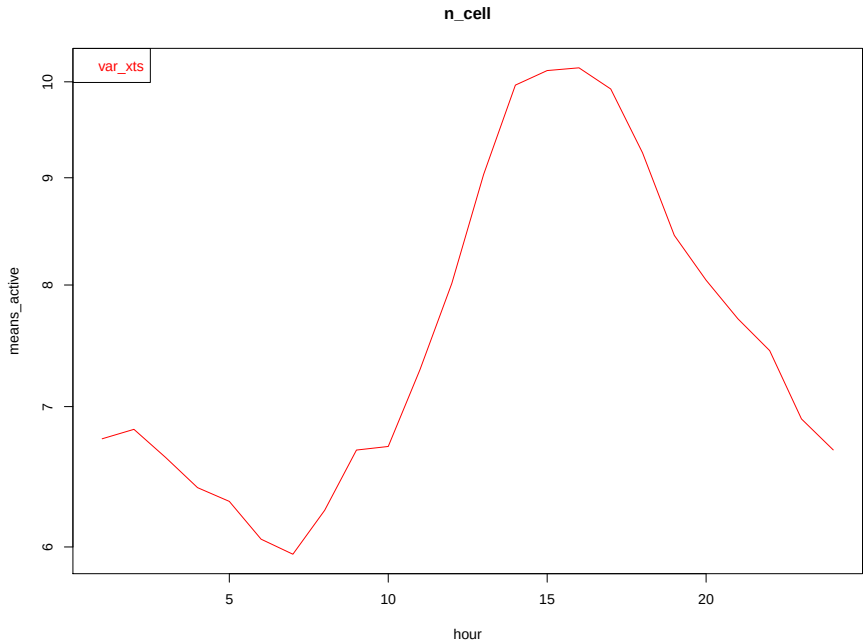


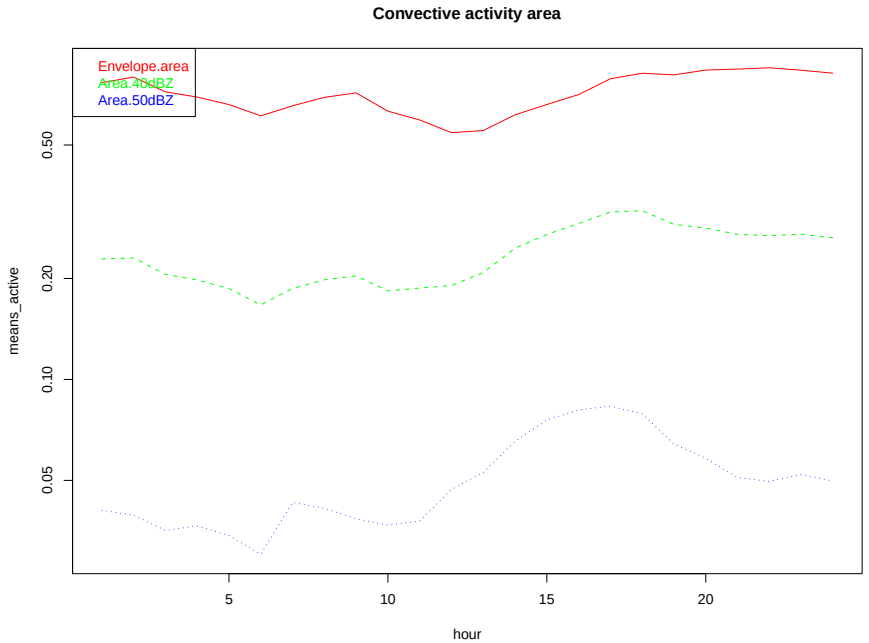
- Maximum activity (15pm to 17pm), 2 times the minimum activity (0pm to 9pm).

Diurnal variation of the convective activity

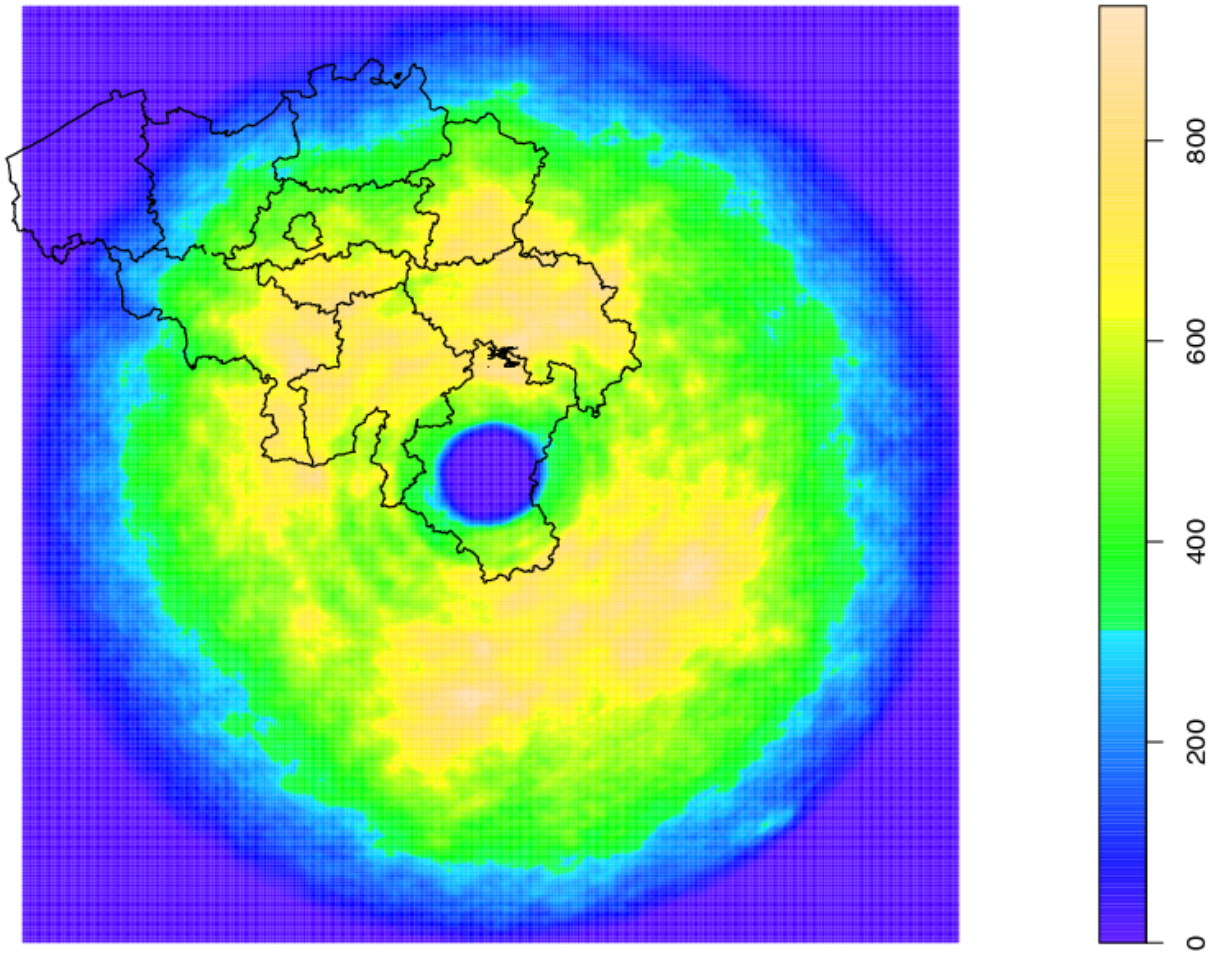


- Maximum activity (15pm to 17pm), 2 times the minimum activity (0pm to 9pm).
- The mean intensity is roughly (1 hour bias) proportional to the activity.



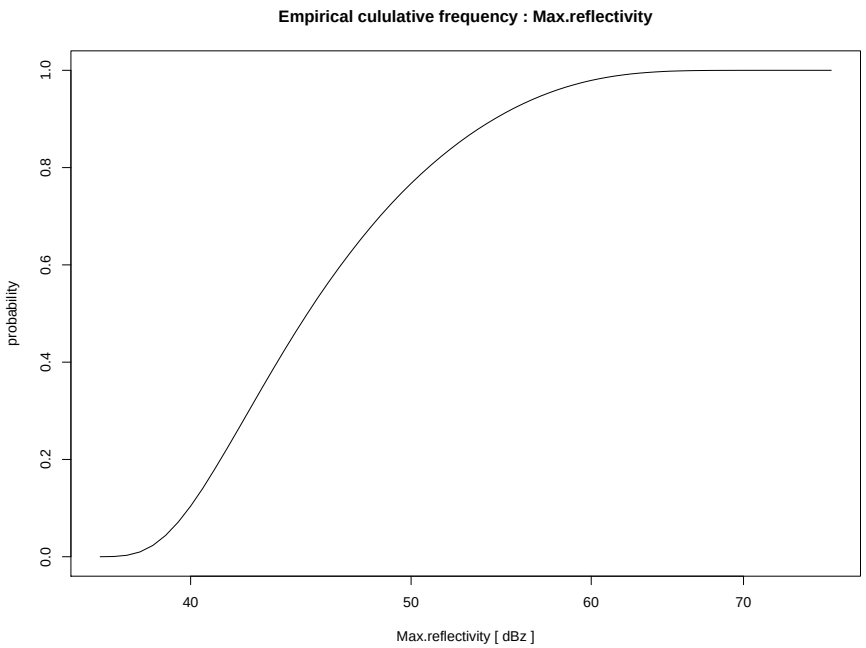


Spatial variation of the convective activity



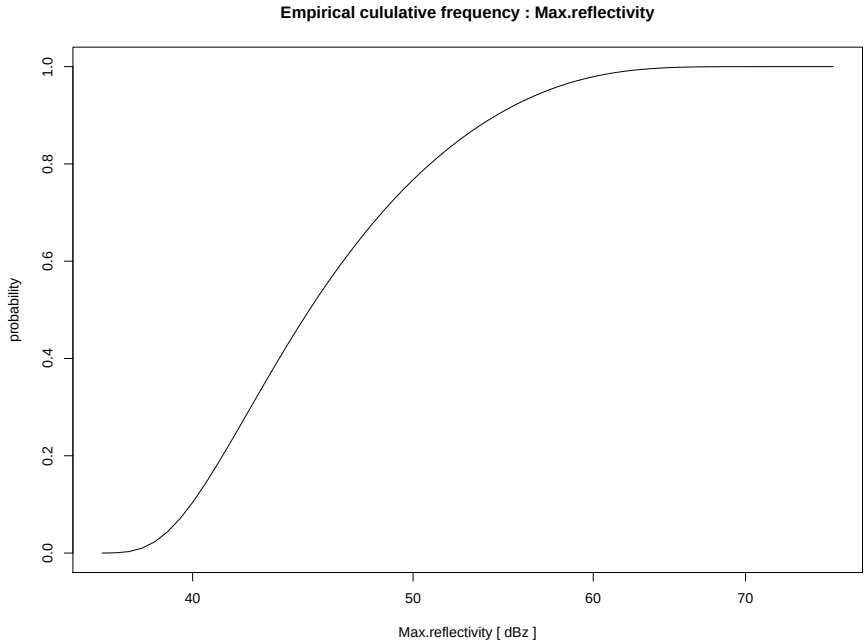
- Besides artificial range effect, slightly higher frequency on the north of the radar and also on the south west (orographic effect?)

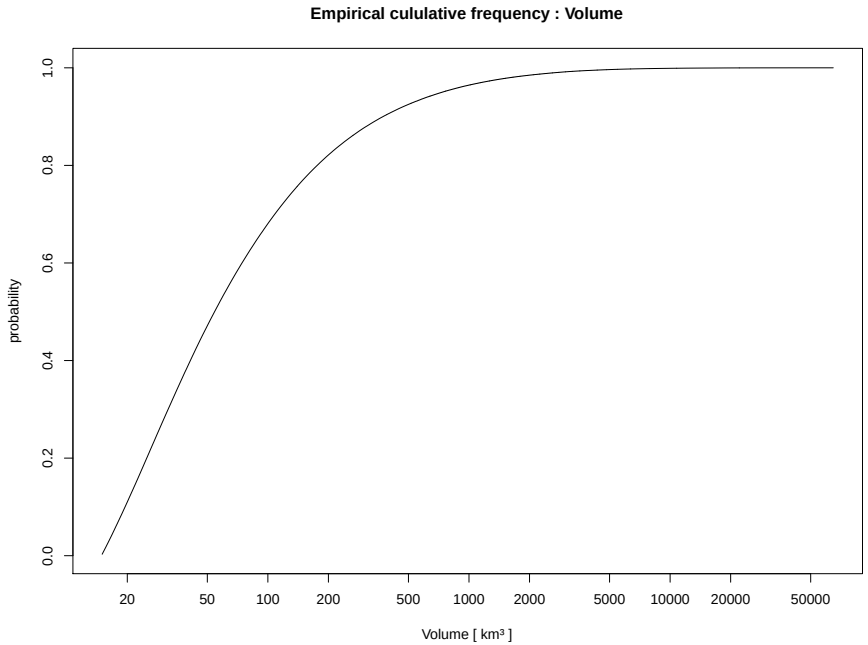
Distribution of instantaneous properties



- max reflectivity follows a log-normal distribution (mean = 46,4 dBZ)

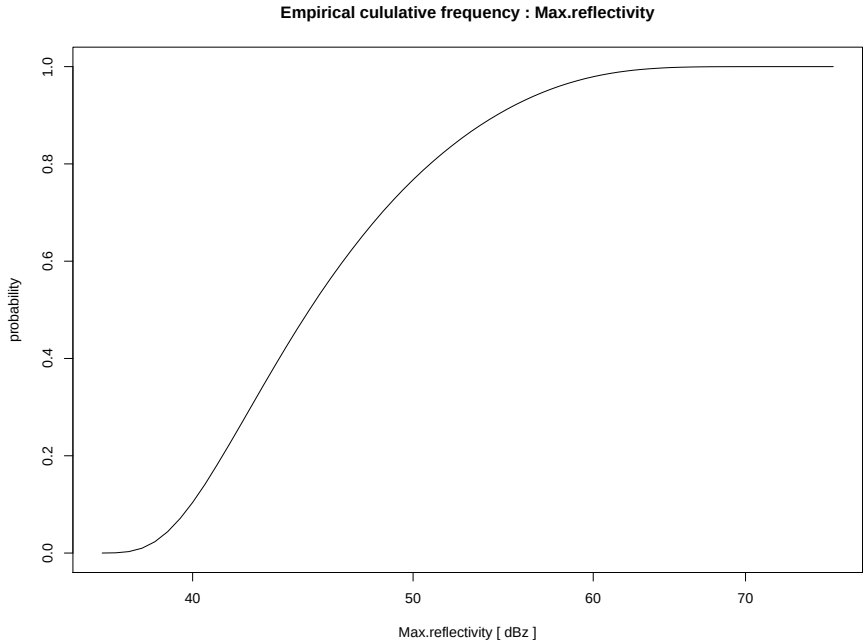
Distribution of instantaneous properties



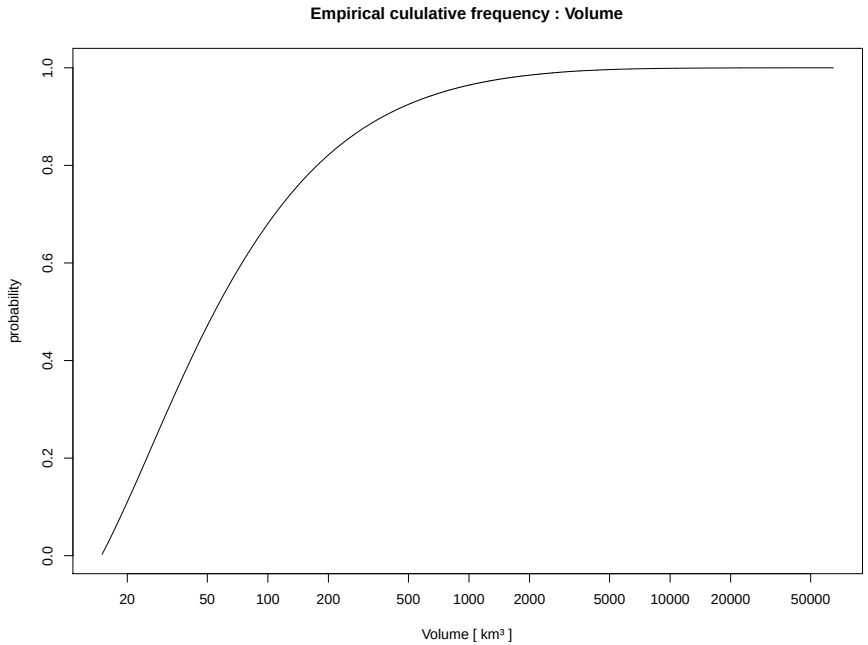


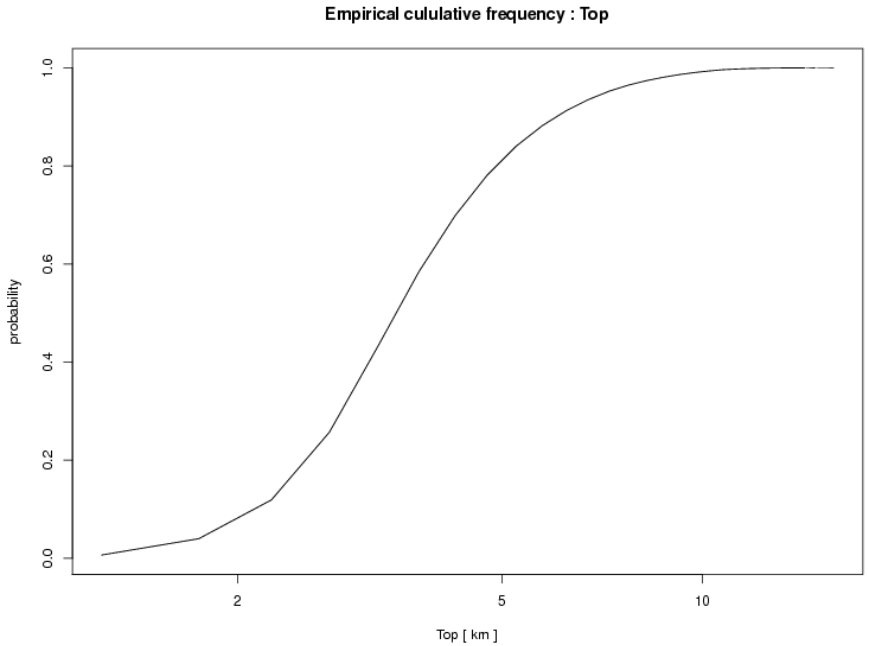
- max reflectivity follows a log-normal distribution (mean = 46,4 dBZ)
- volume follows a log-normal distribution (mean = $205 km^3$)

Distribution of instantaneous properties

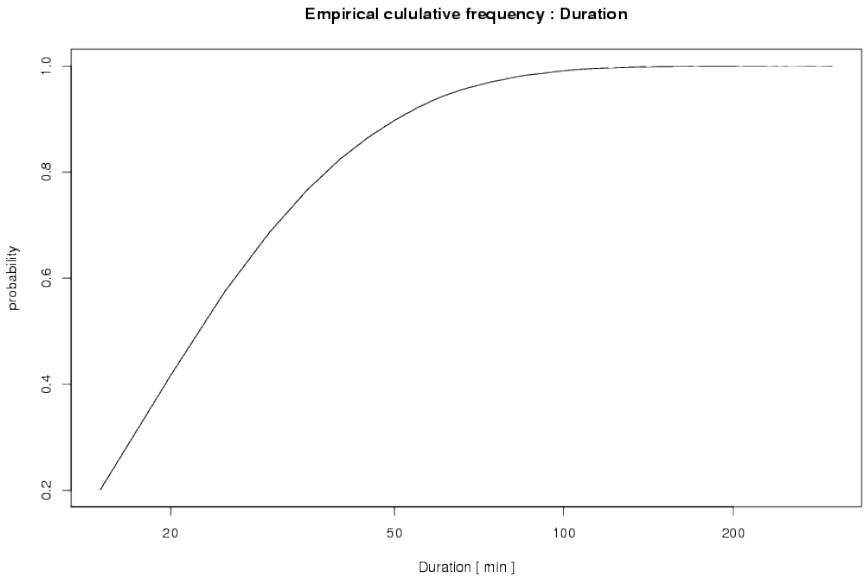


- max reflectivity follows a log-normal distribution (mean = 46,4 dBZ)
- volume follows a log-normal distribution (mean = $205 km^3$)
- 36 dBZ echo-top exhibits a positive skew



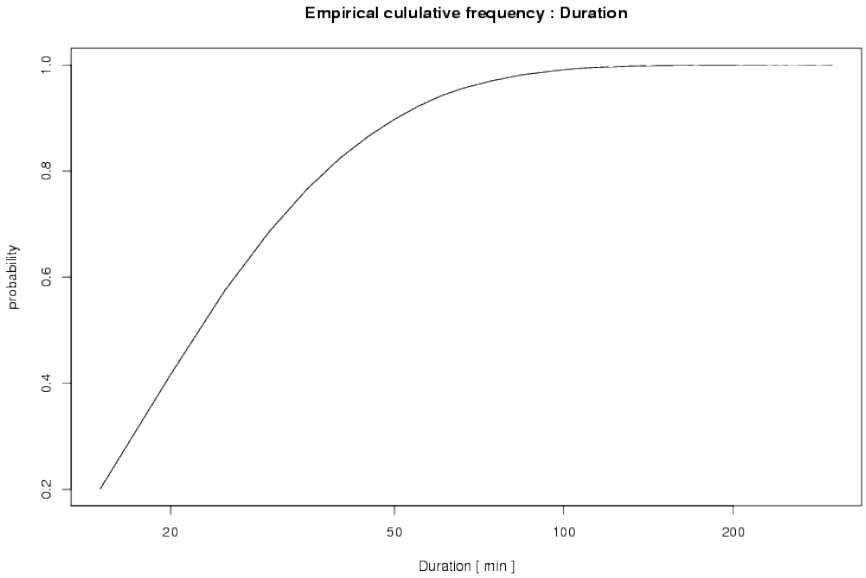


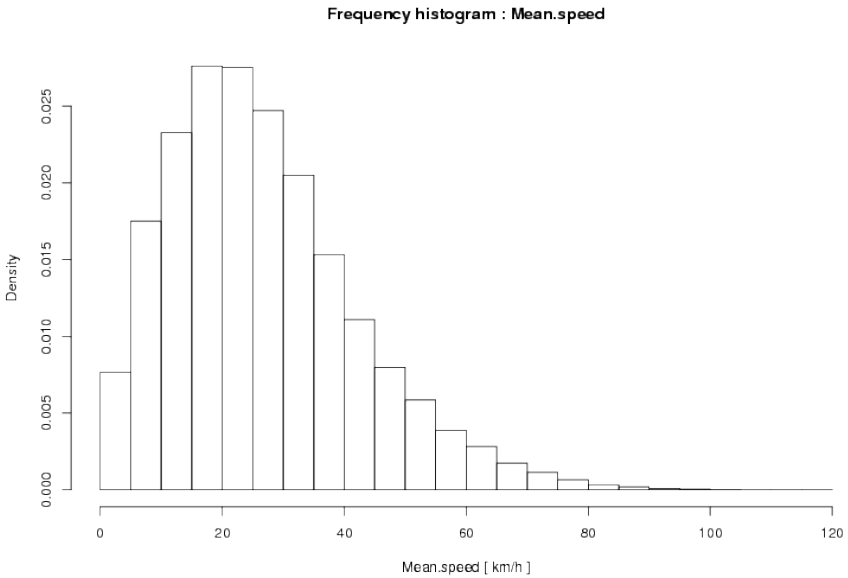
Distribution of storm tracks properties



- CS are mostly short lived.

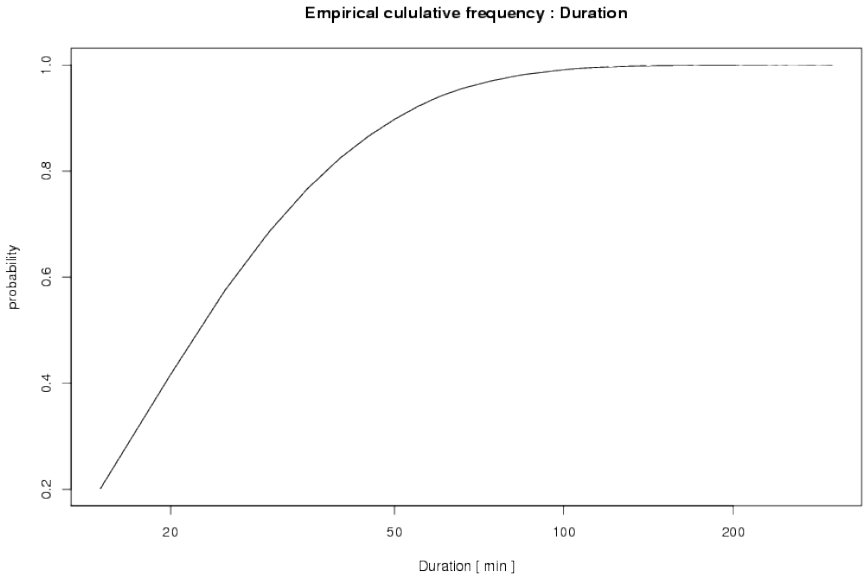
Distribution of storm tracks properties



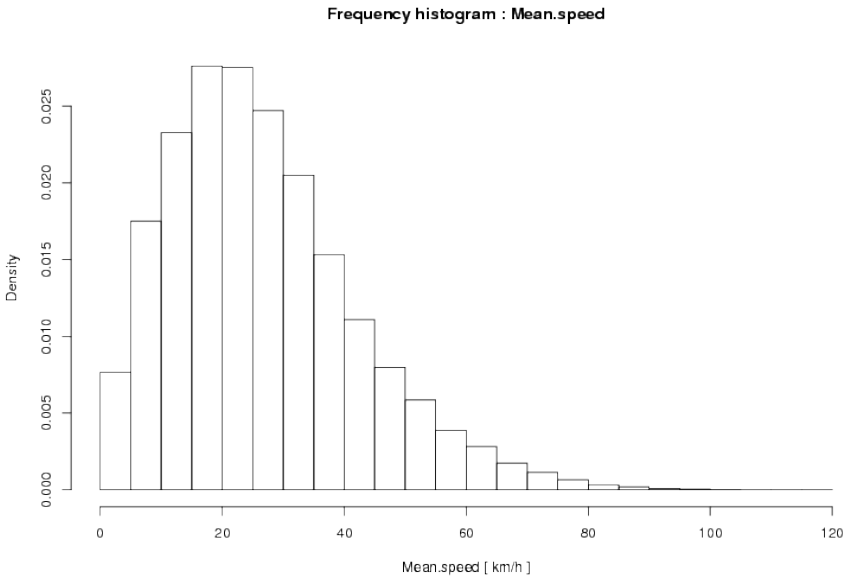


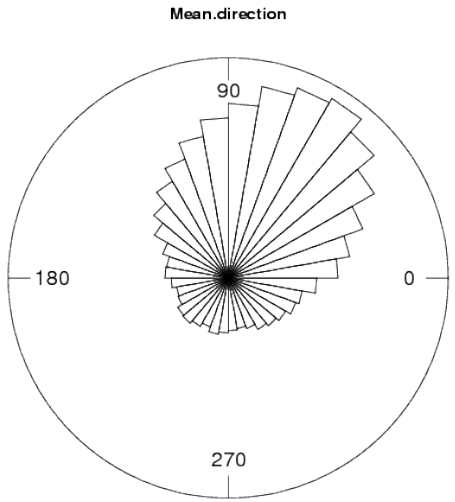
- CS are mostly short lived.
- CS mean speed, like wind, follows a Weibull distribution.

Distribution of storm tracks properties

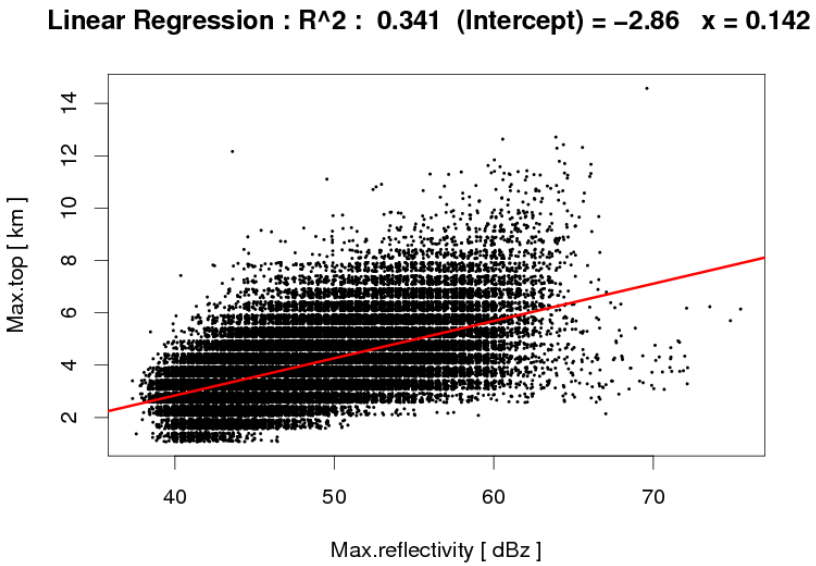


- CS are mostly short lived.
- CS mean speed, like wind, follows a Weibull distribution.
- CS mean direction is also consistent with dominant wind (SSW) during convective season.





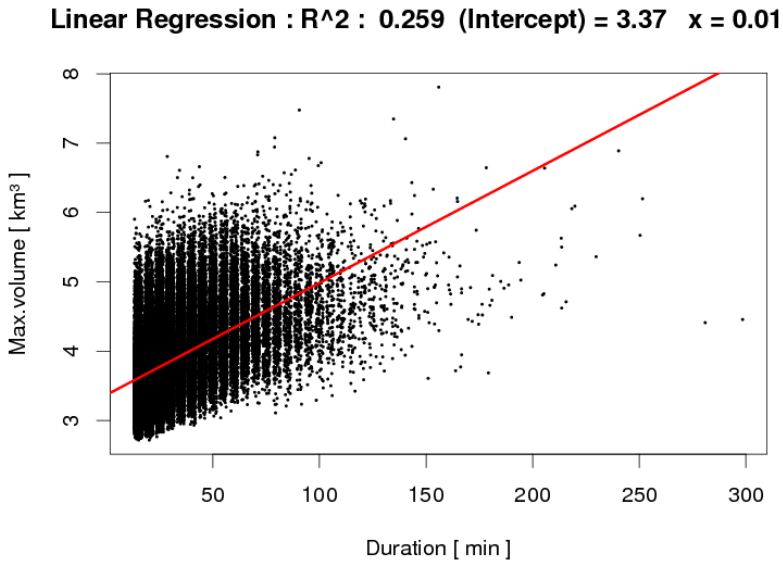
Relation between track properties?

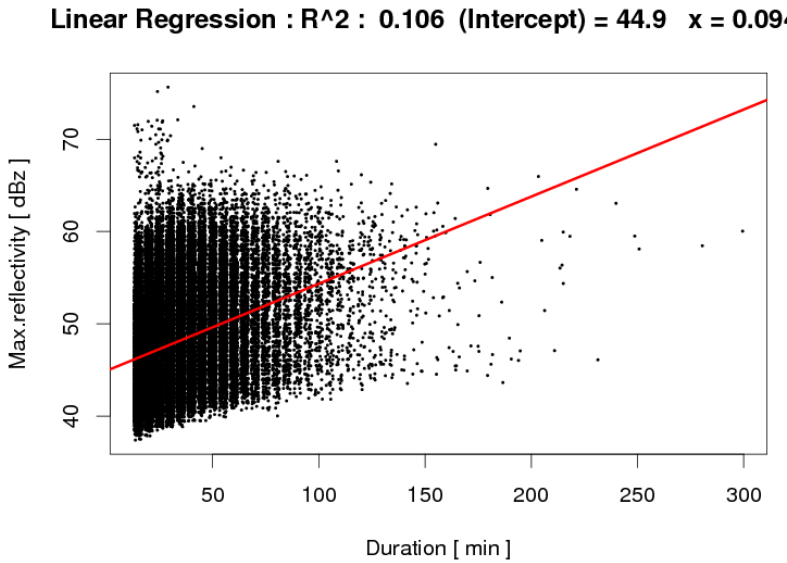


- Positive correlation between max top and max reflectivity

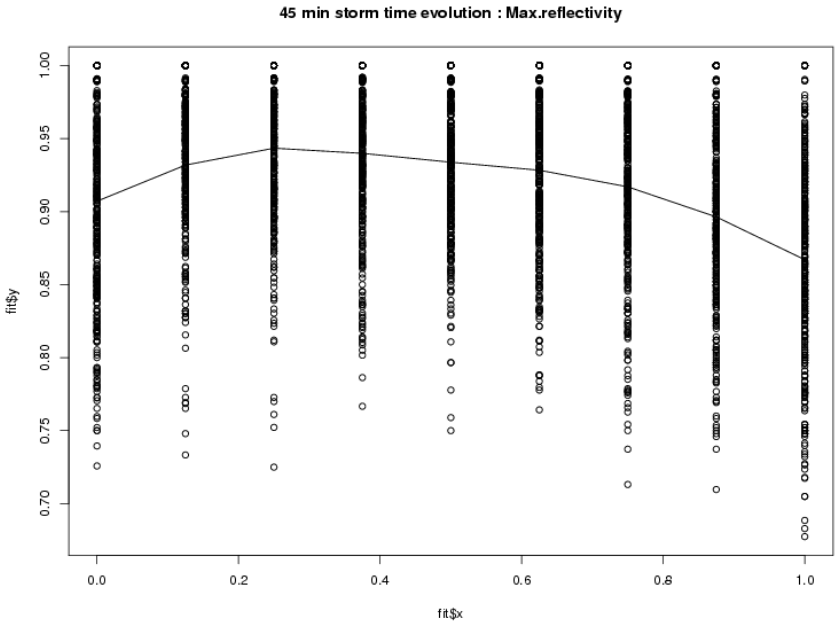
Relation between track properties?

- Positive correlation between max top and max reflectivity
- Strom duration tends to increase when max volume/reflectivity increases



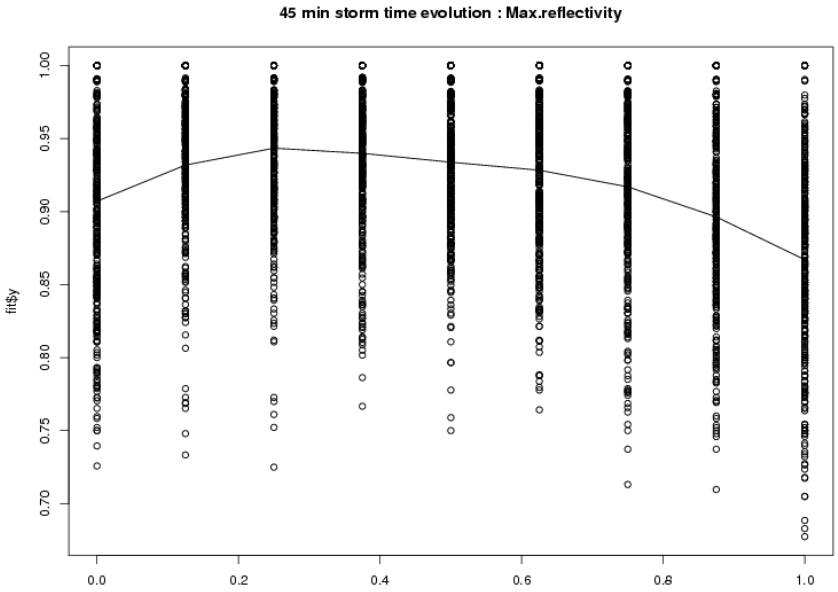


Evolution of storm properties

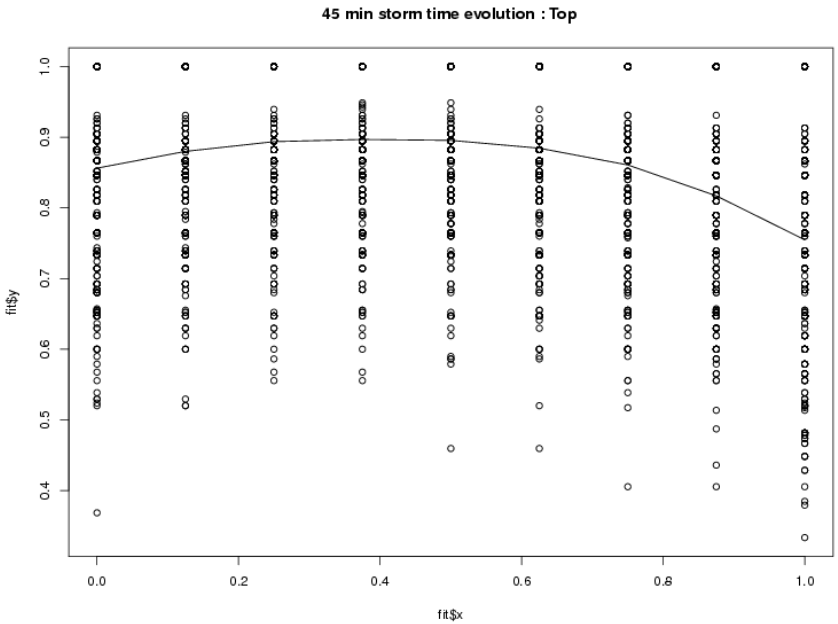


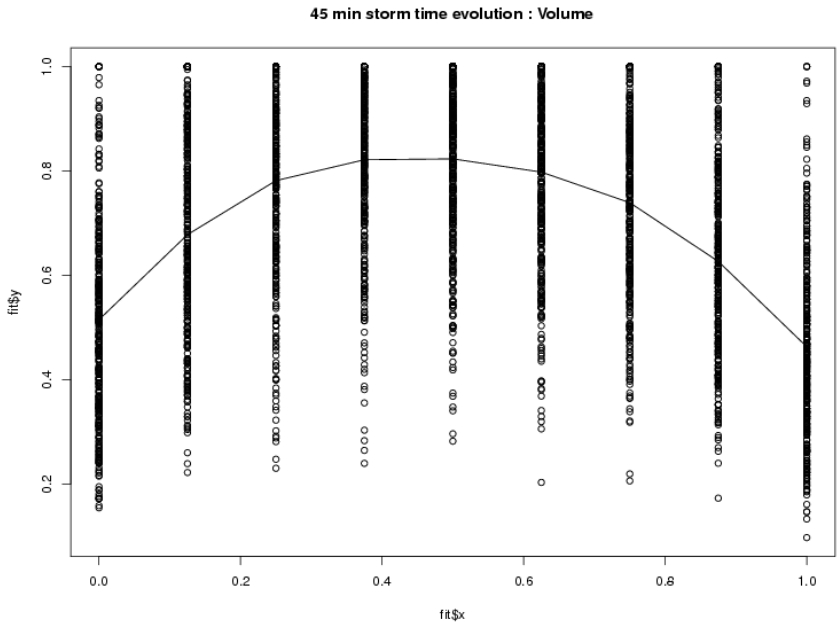
- Isolated storm maximum reflectivity tends to grow quickly before a slight decay

Evolution of storm properties



- Isolated storm maximum reflectivity tends to grow quickly before a slight decay
- Same behaviour for top but volume has a more parabolic shape





Conclusions and outlook

8 years of convective storm tracks from 3D radar reflectivity have been analysed

- There is a higher frequency in summer and a significant diurnal effect.
- There is a slight indication for preferred regions of convection.
- Small, weak and short-lived storms are predominant while the intensity of the storms tend to increase when the echo-top increases.
- Storms tend to reach their maximum intensity quickly before a slow decay.

Conclusions and outlook

8 years of convective storm tracks from 3D radar reflectivity have been analysed

- There is a higher frequency in summer and a significant diurnal effect.
- There is a slight indication for preferred regions of convection.
- Small, weak and short-lived storms are predominant while the intensity of the storms tend to increase when the echo-top increases.
- Storms tend to reach their maximum intensity quickly before a slow decay.

Outlook

- Deeper analysis : spatial distribution, dynamic of complex tracks
- Use of a second radar to confirm the results and mitigate radar artefacts.
- Use additional data : lightning information, cloud characteristics (satellite), NWP model variables