Deutsches Zentrum für Luft- und Raumfahrt e.V.

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Lightning Evolution and Thunderstorm Dynamics for the 21 July 1998 EULINOX Supercell Storm

Conference on European Tornadoes and Severe Storms

ONERA

Toulouse, 1–4 February 2000

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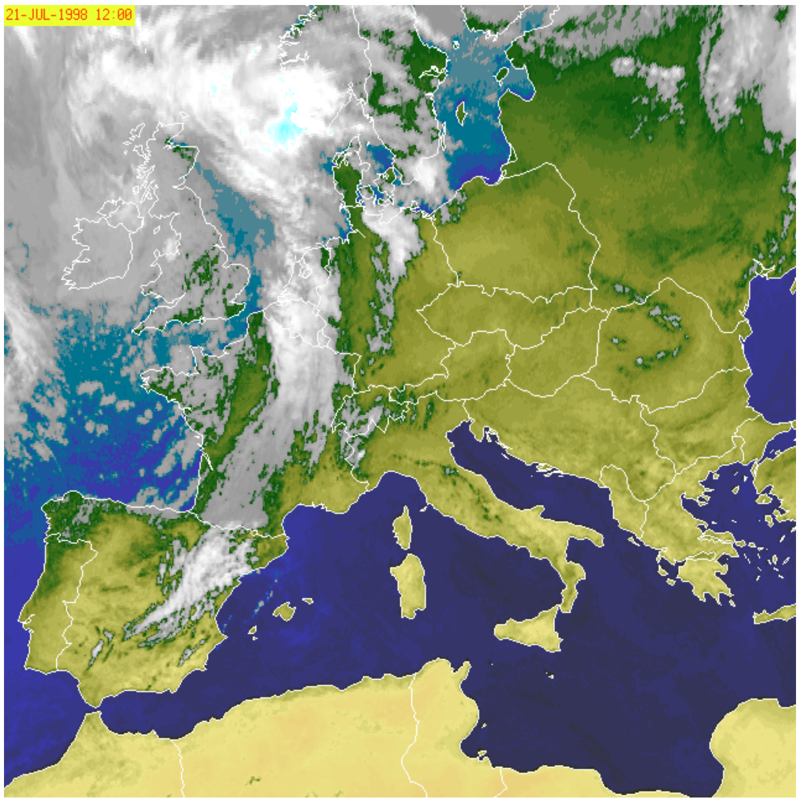
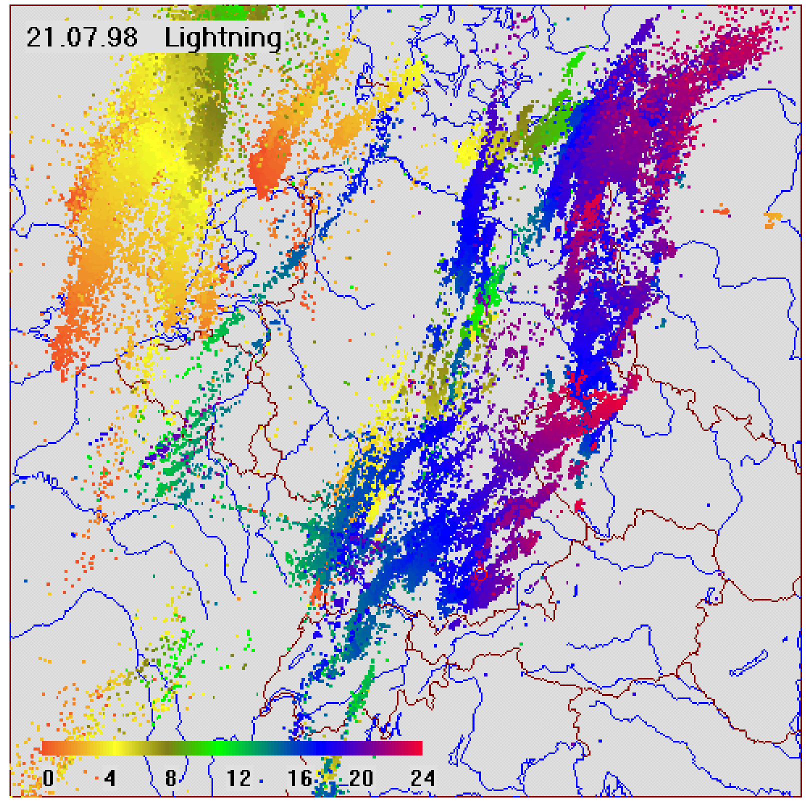
Overview

- The field campaign EULINOX
- Synoptic setting of 21 July 1998
- Observation areas
- Life cycle of the supercell
- Lightning activity
- Relation to hydrometeor fields
- Relation to temperature levels
- Summary
- Conclusions

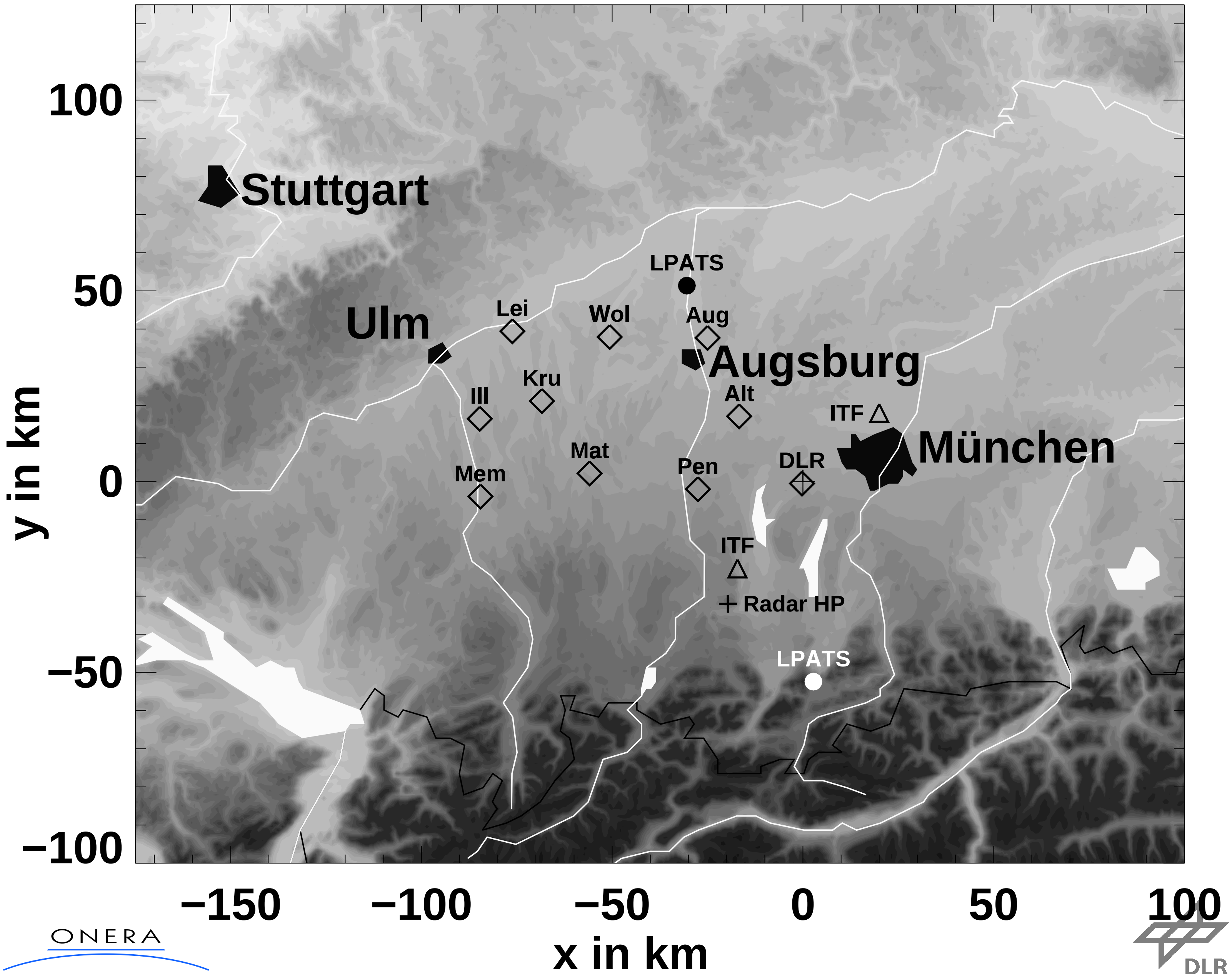
Synoptic situation of 21 July 1998

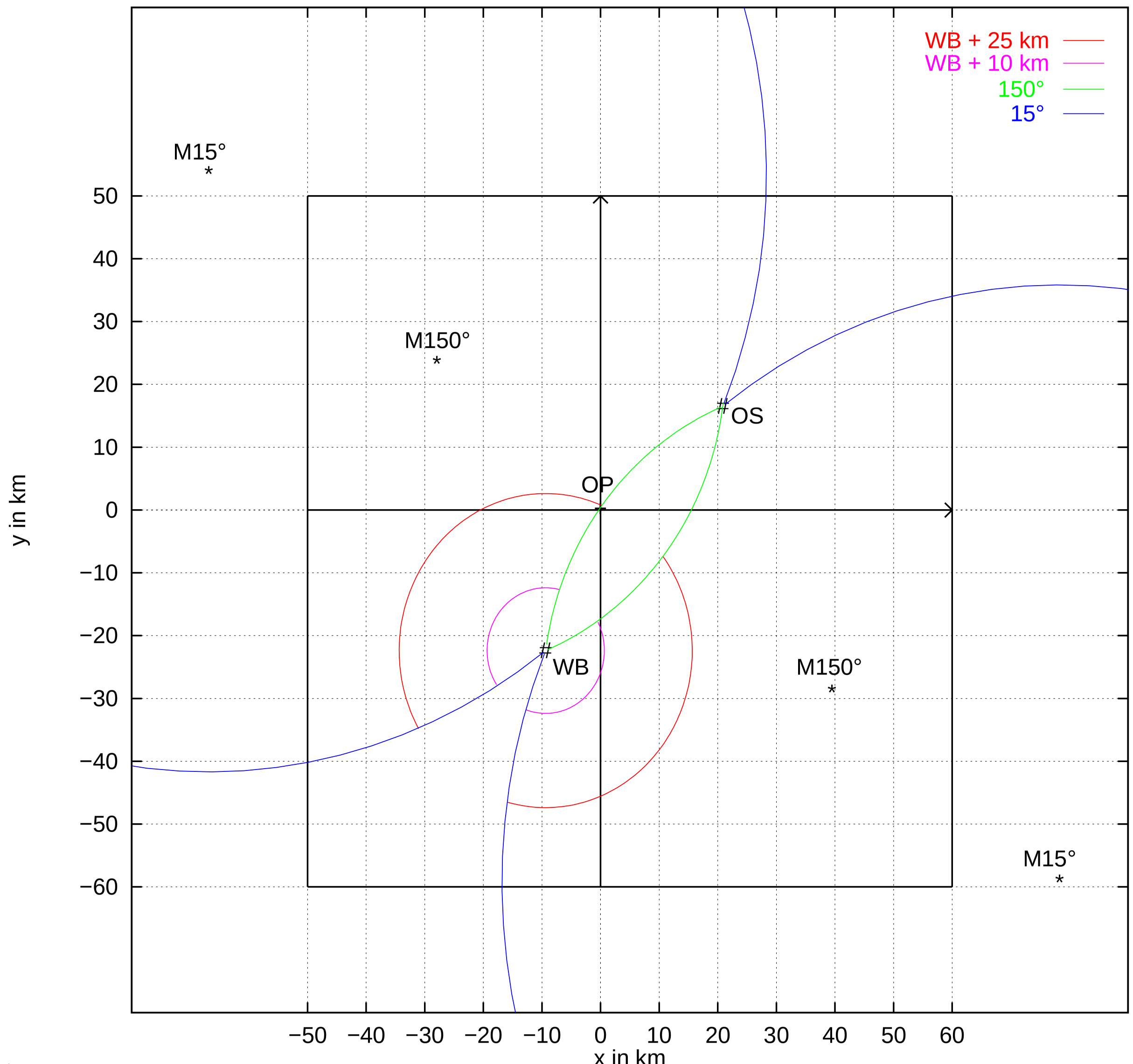


Satellite picture at 12:00 UTC

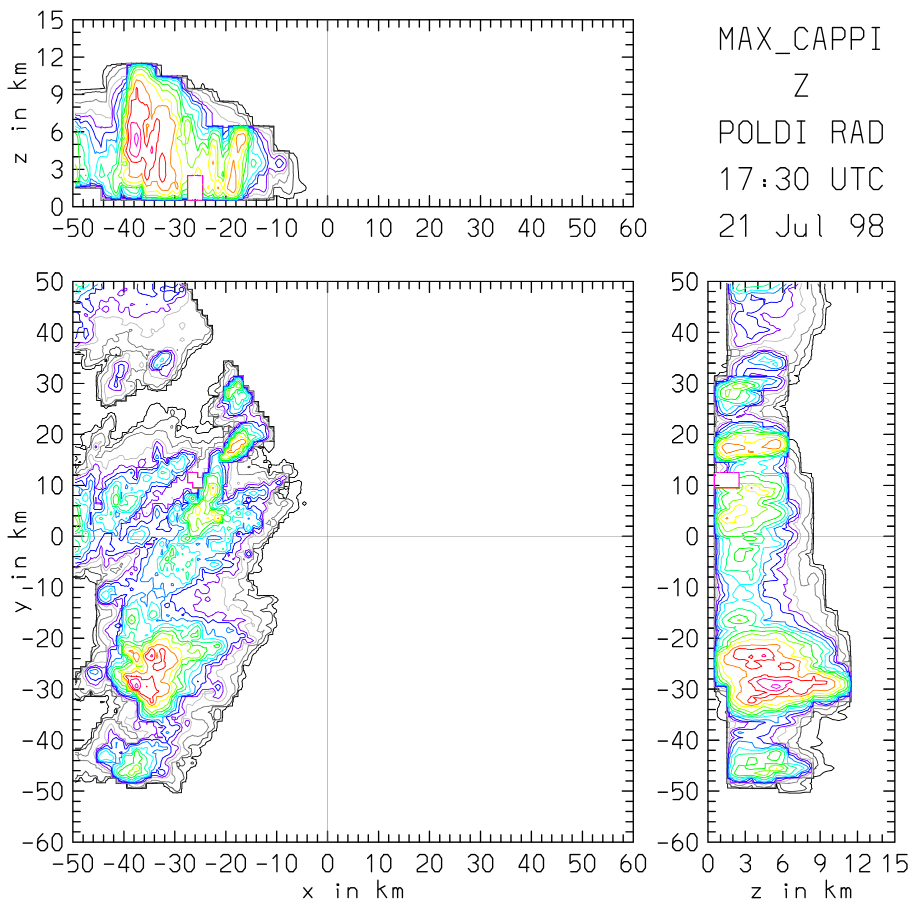


24 h composite of LPATS data


Stuttgart
Ulm
Augsburg
München
LPATS
Lei
Wol
Aug
Kru
Ill
Alt
ITF
Mat
Mem
Pen
DLR
ITF
+ Radar HP
LPATS
100
50
0
−50
−100
y in km
−150
−100
−50
0
50
100
x in km


WB + 25 km
WB + 10 km
150°
15°
M15°
M150°
OP
OS
WB
M150°
M15°
y in km
x in km
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−50 −40 −30 −20 −10 0 10 20 30 40 50 60

Life cycle of the supercell storm



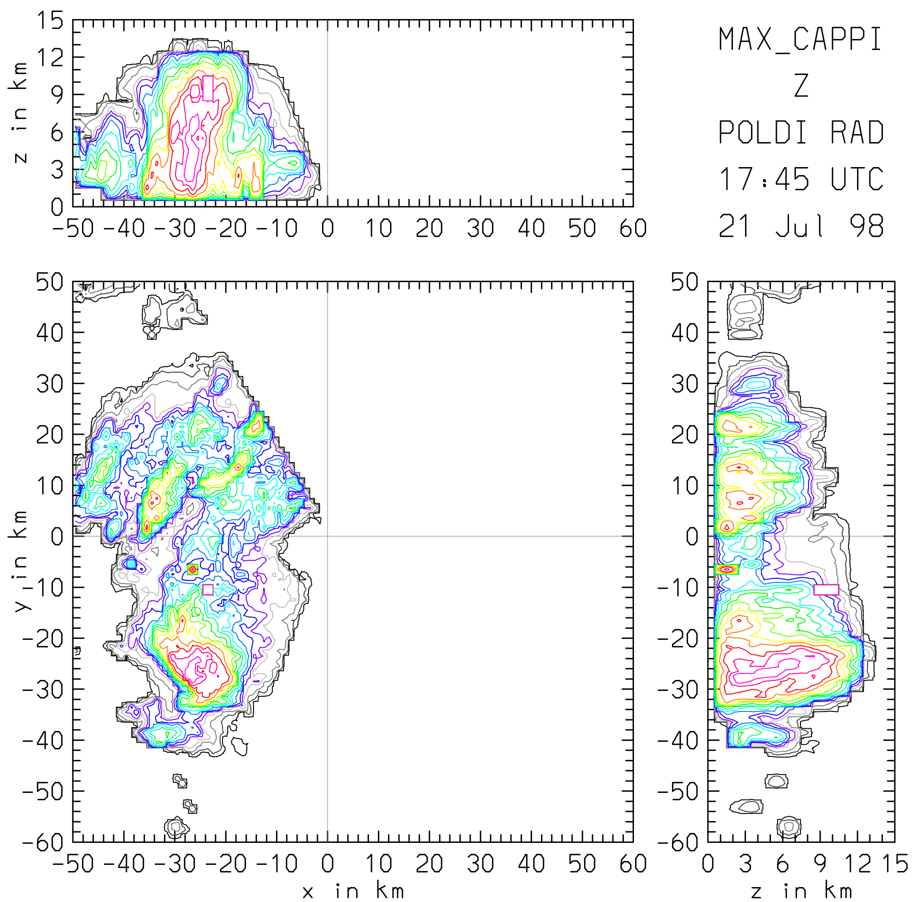
17:30 UTC

N: decaying left mover cells

S: right mover developing to supercell

Colors yellow and red denote
Z larger than 40 dBZ

Life cycle of the supercell storm



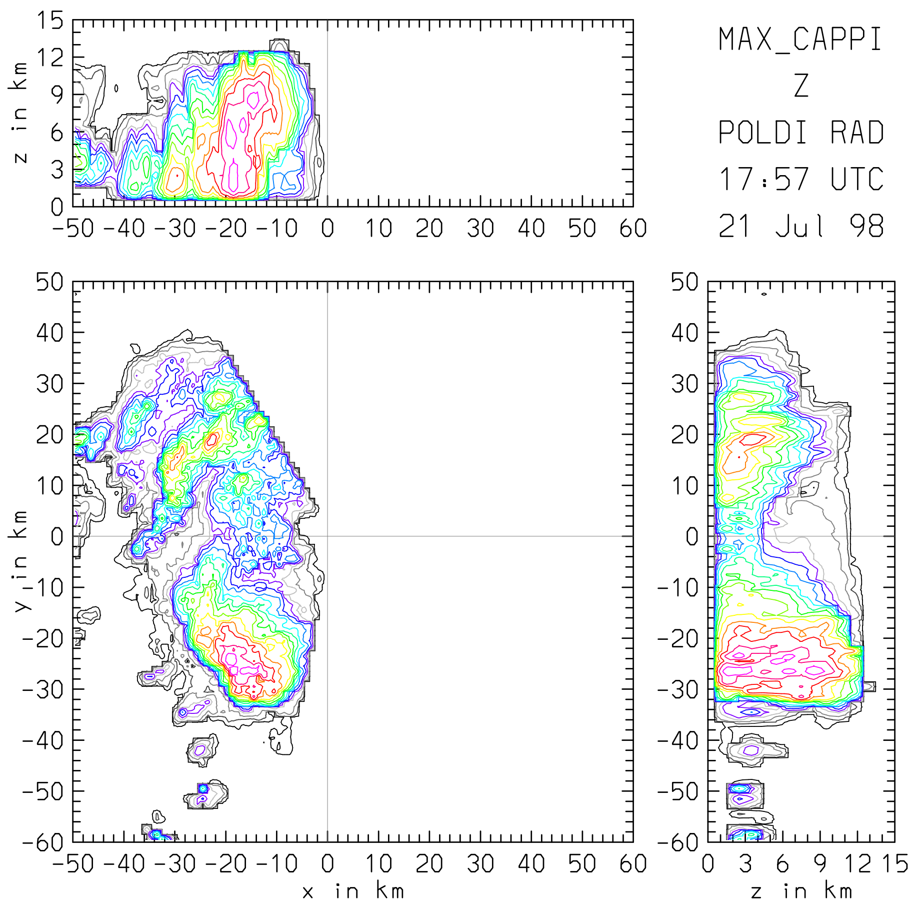
17:45 UTC

Rapid growth of supercell

Overshooting top

Maximum flash rate

Life cycle of the supercell storm



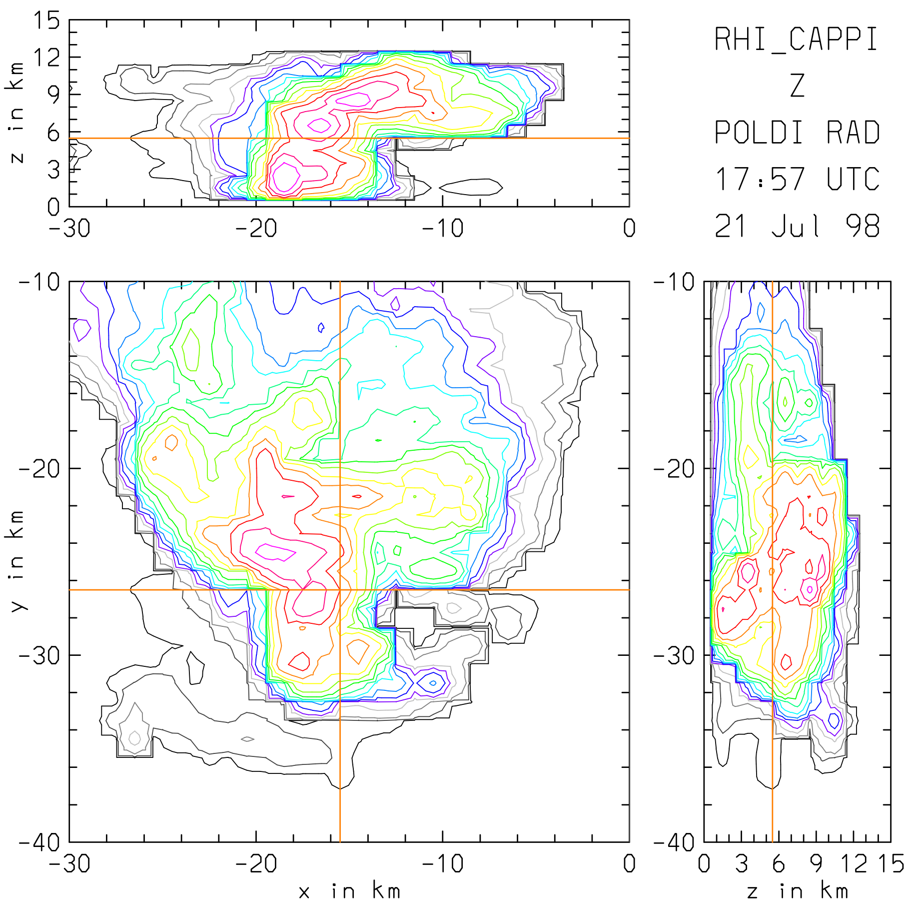
17:57 UTC

Supercell in mature stage

Flash rate still high

Bounded weak echo region and echo overhang

Life cycle of the supercell storm



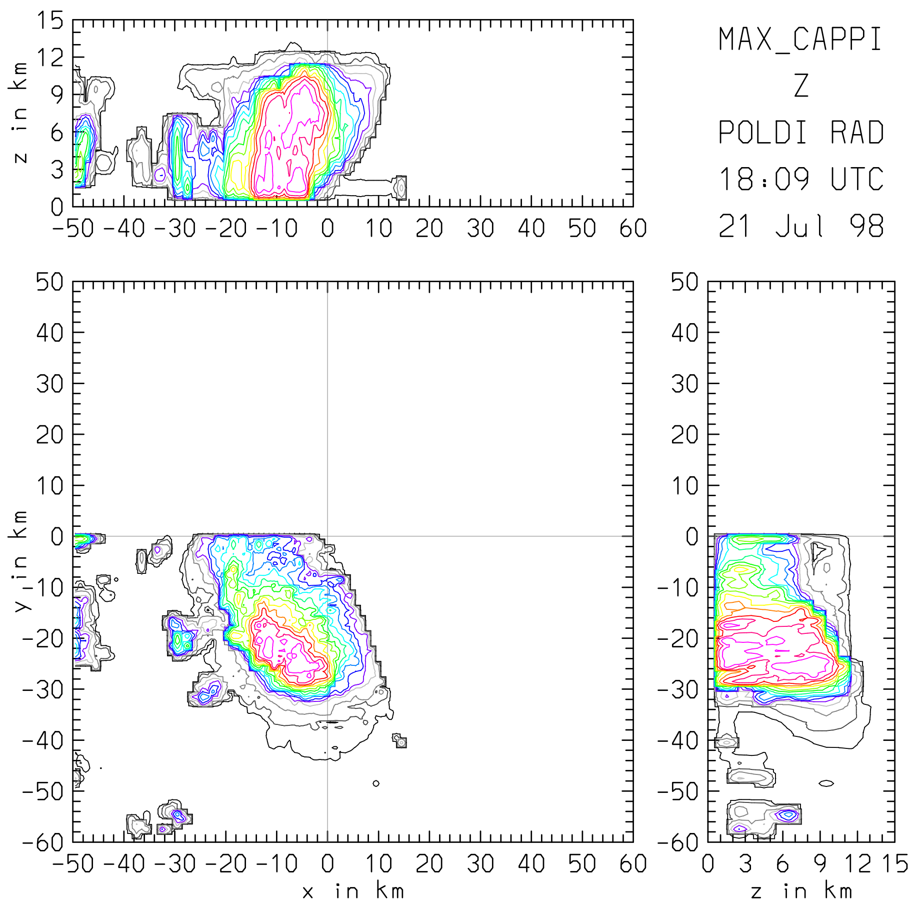
17:57 UTC

W–E VCUT: echo overhang

S–N VCUT: upper–level divergence

CAPPI: low–level inflow from the SE

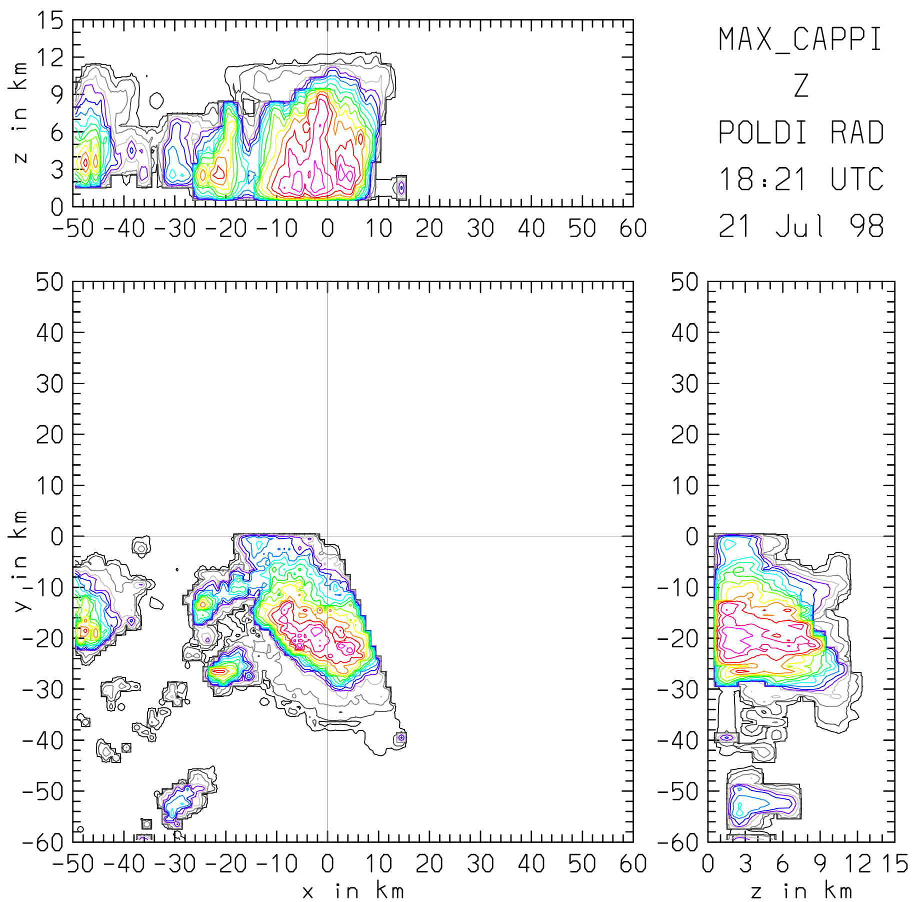
Life cycle of the supercell storm



18:09 UTC

Supercell begins to decay

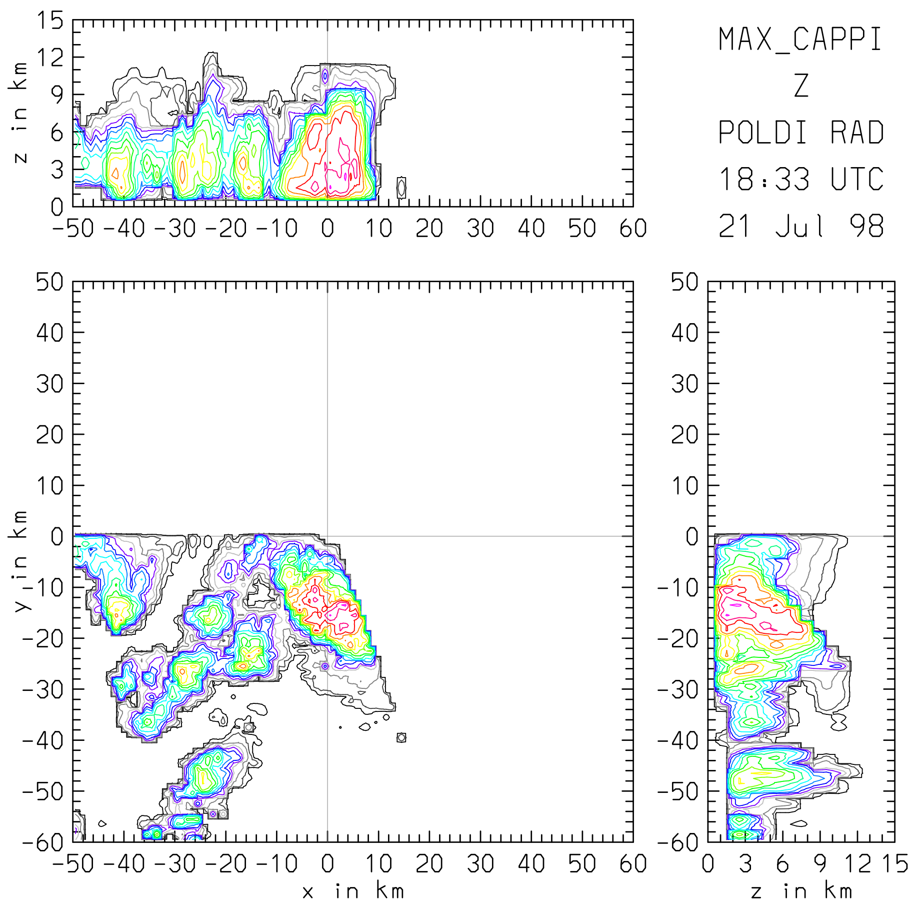
Life cycle of the supercell storm



18:21 UTC

New cells develop SW of the old cell

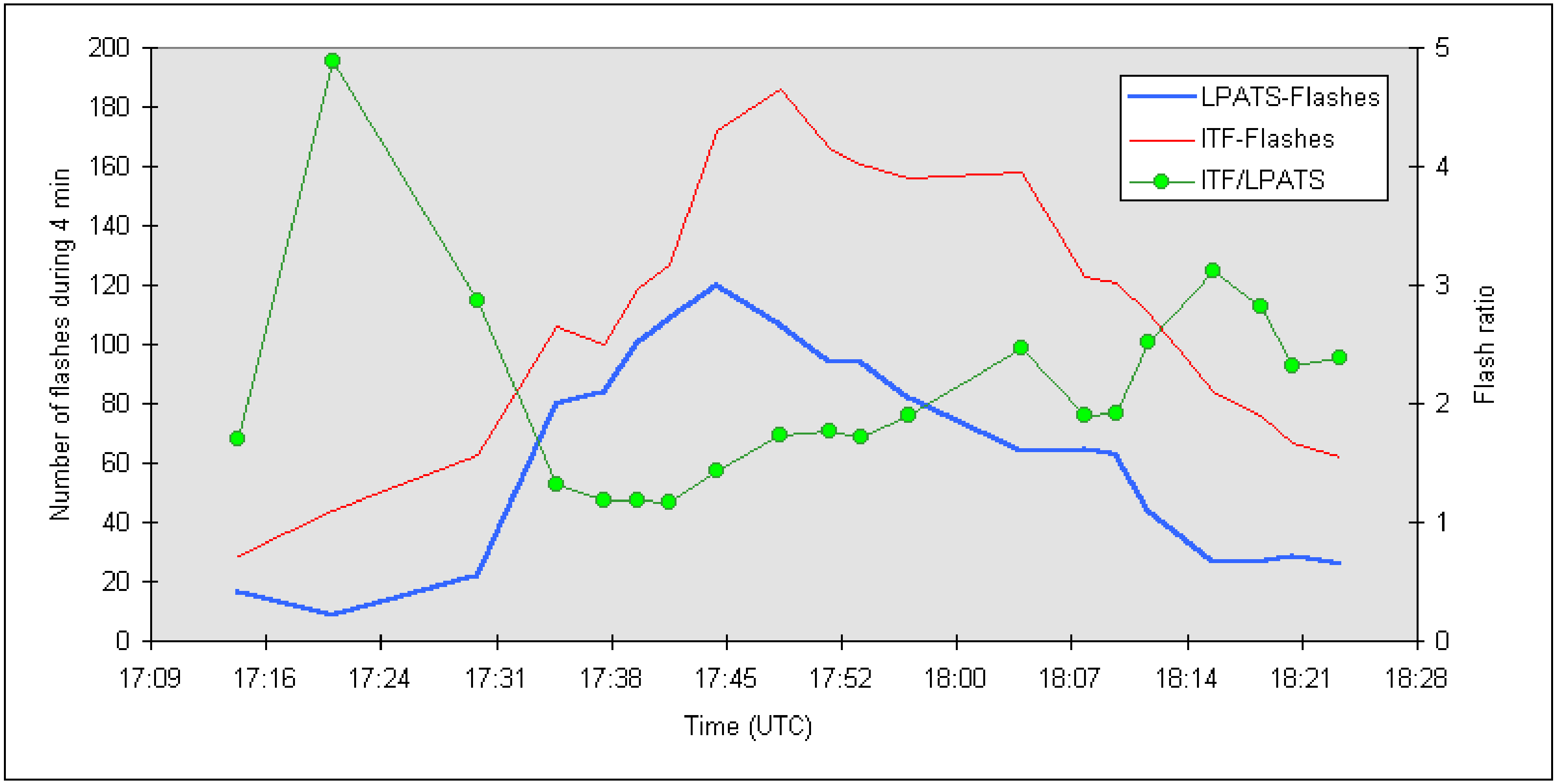
Life cycle of the supercell storm



18:33 UTC

New cells larger than the decaying supercell

Flash frequency on 21 July 1998



⇒ **Divide flash rate by 4 to obtain unit flashes per minute**
⇒ **ITF sensor with higher detection efficiency than LPATS, especially for IC**
⇒ **On average only 15 % of all flashes were CG, i. e. IC / CG ≈ 7**

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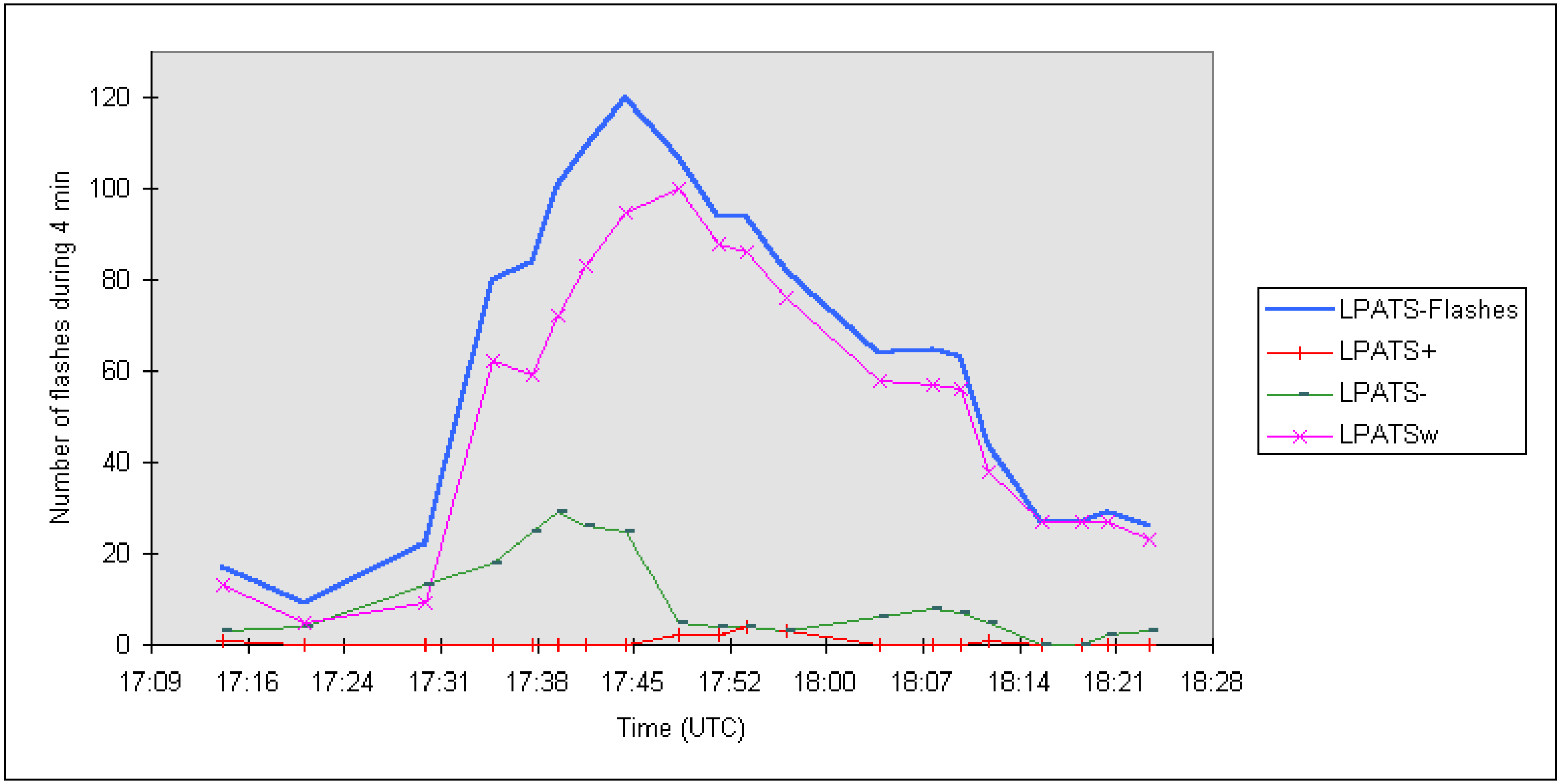
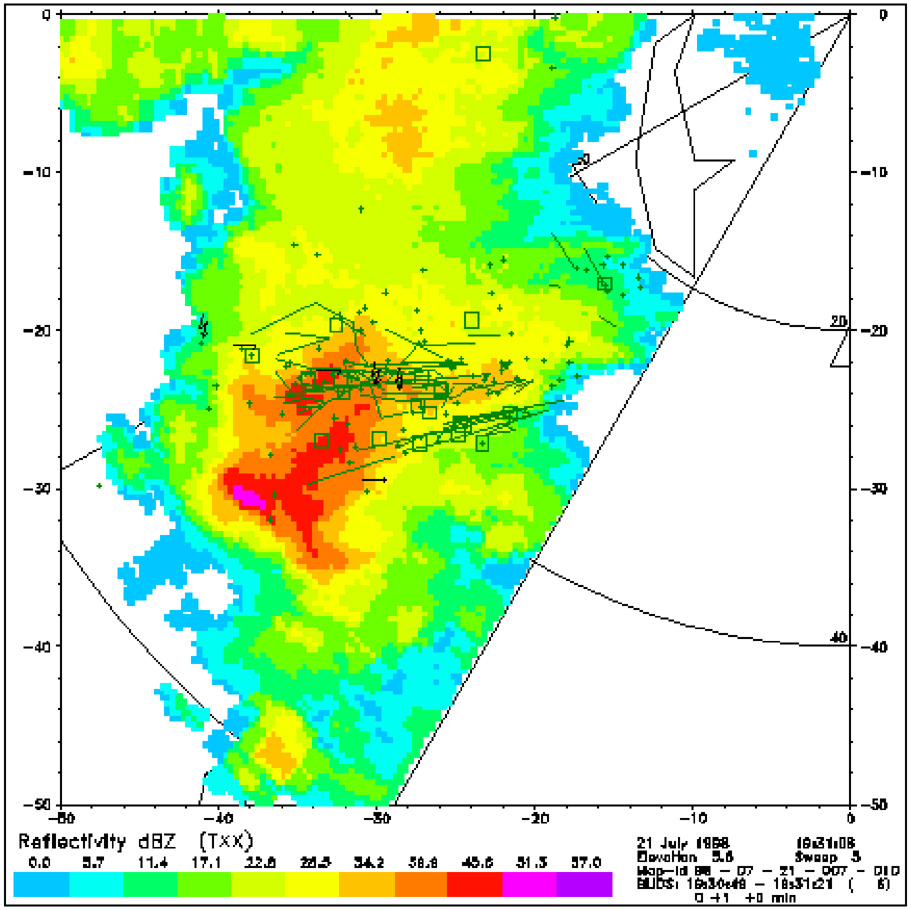
Flash frequency on 21 July 1998



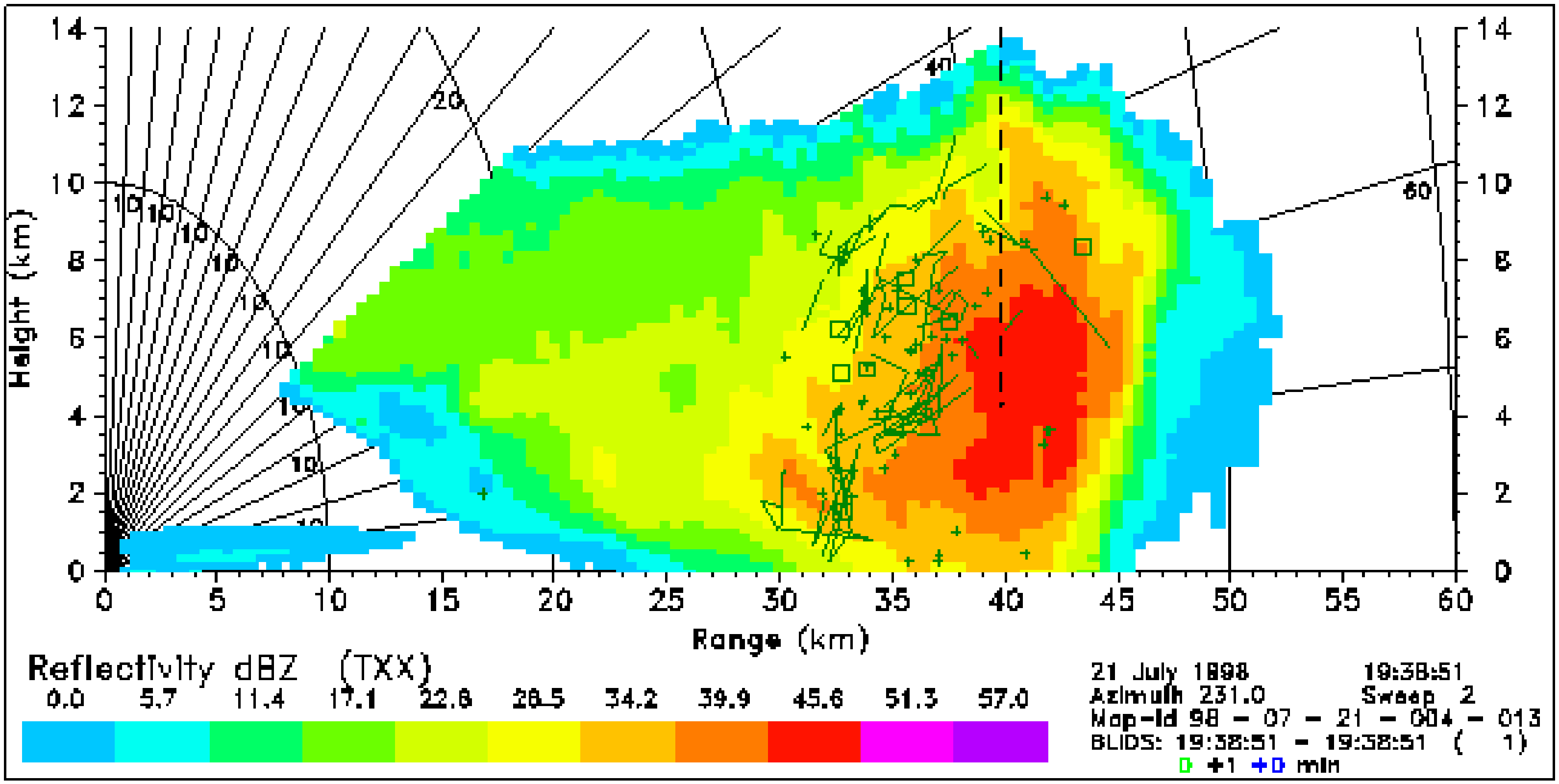
Divide flash rate by 4 to obtain unit flashes per minute

Reflectivity PPI



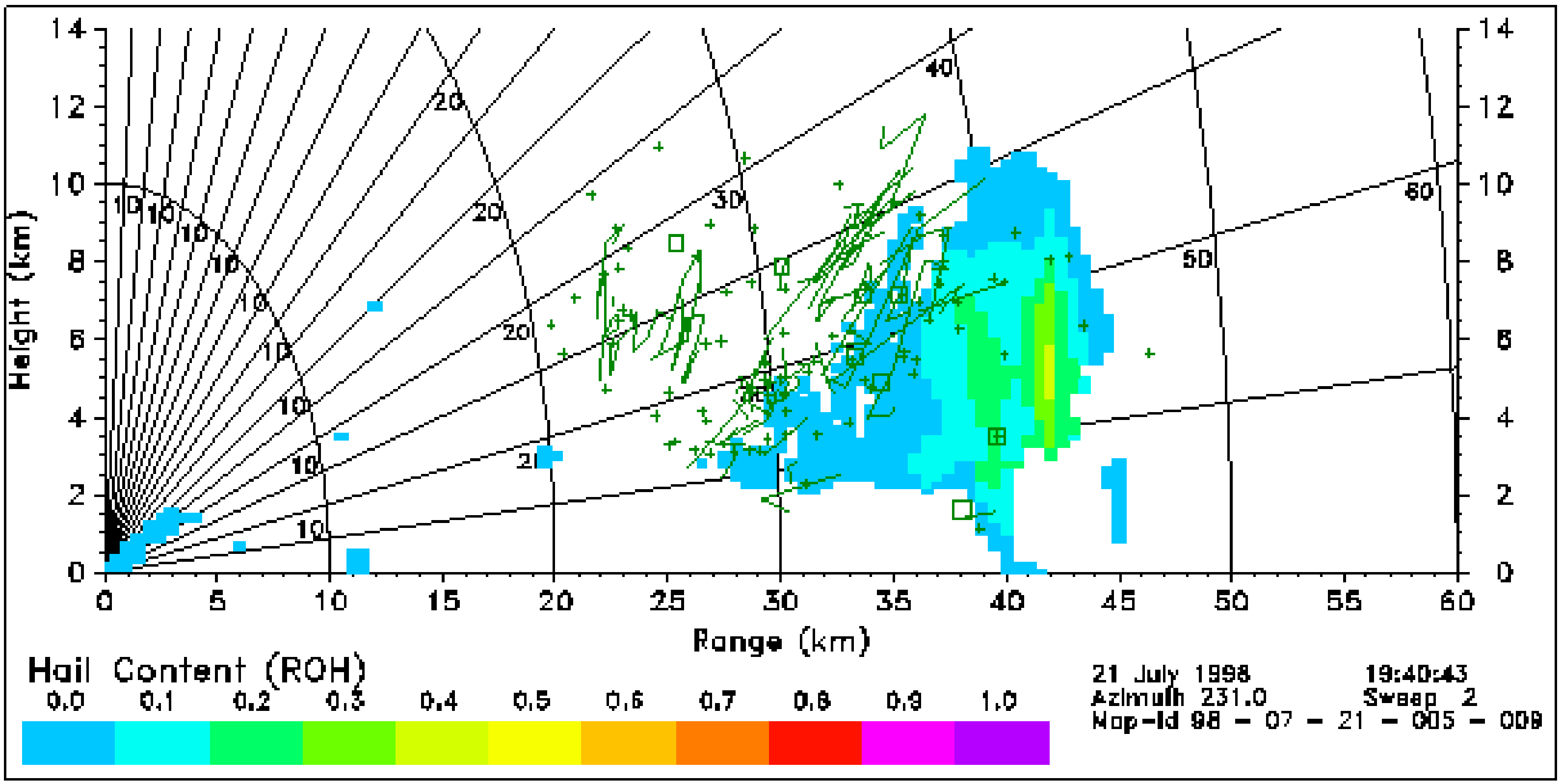
17:30 UTC, 5.0° elevation, 4–5 km AGL, nearby flashes

Reflectivity RHI



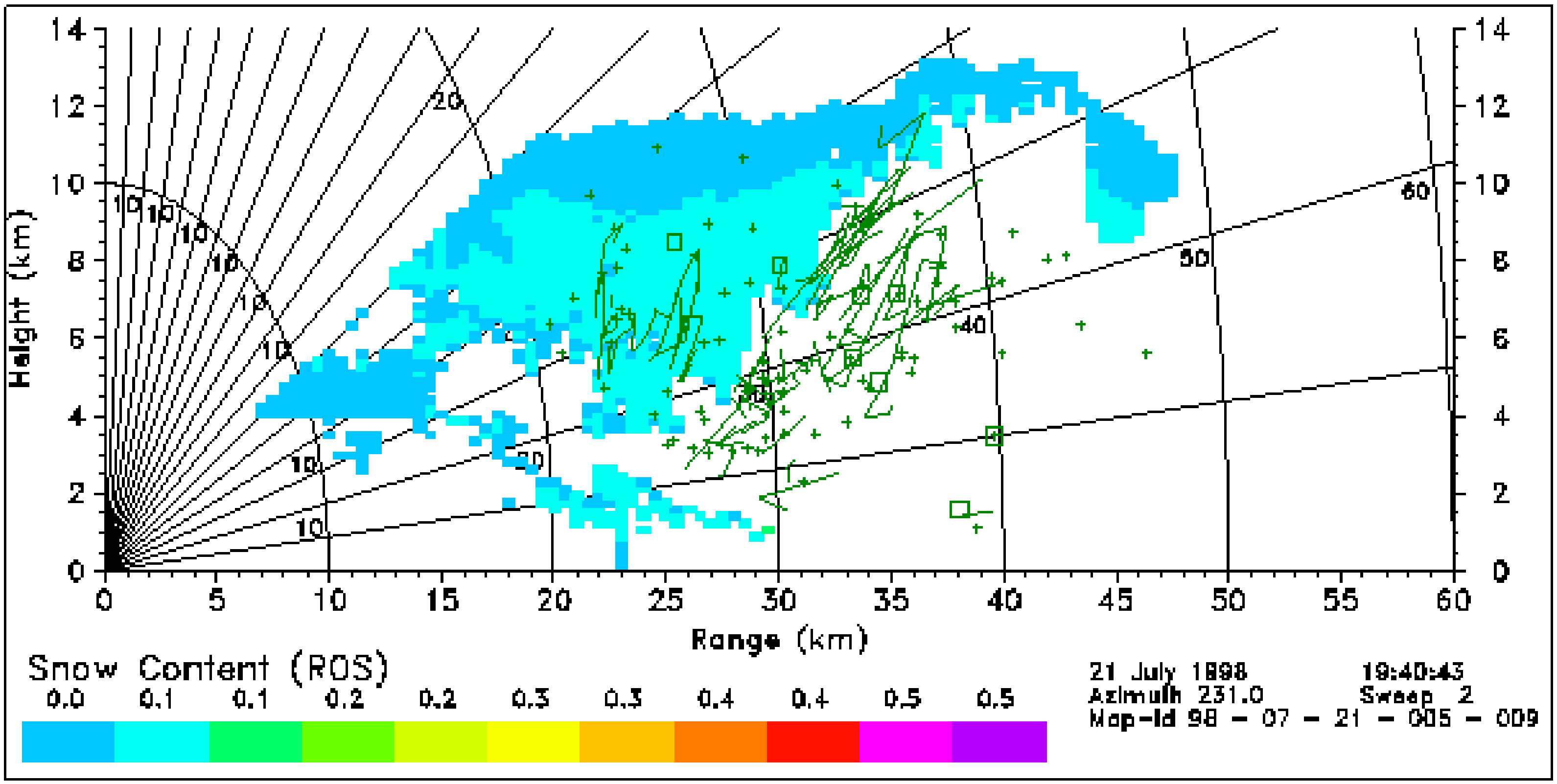
17:38 UTC, 231° azimuth, nearby flashes

Flash correlation with hail mass



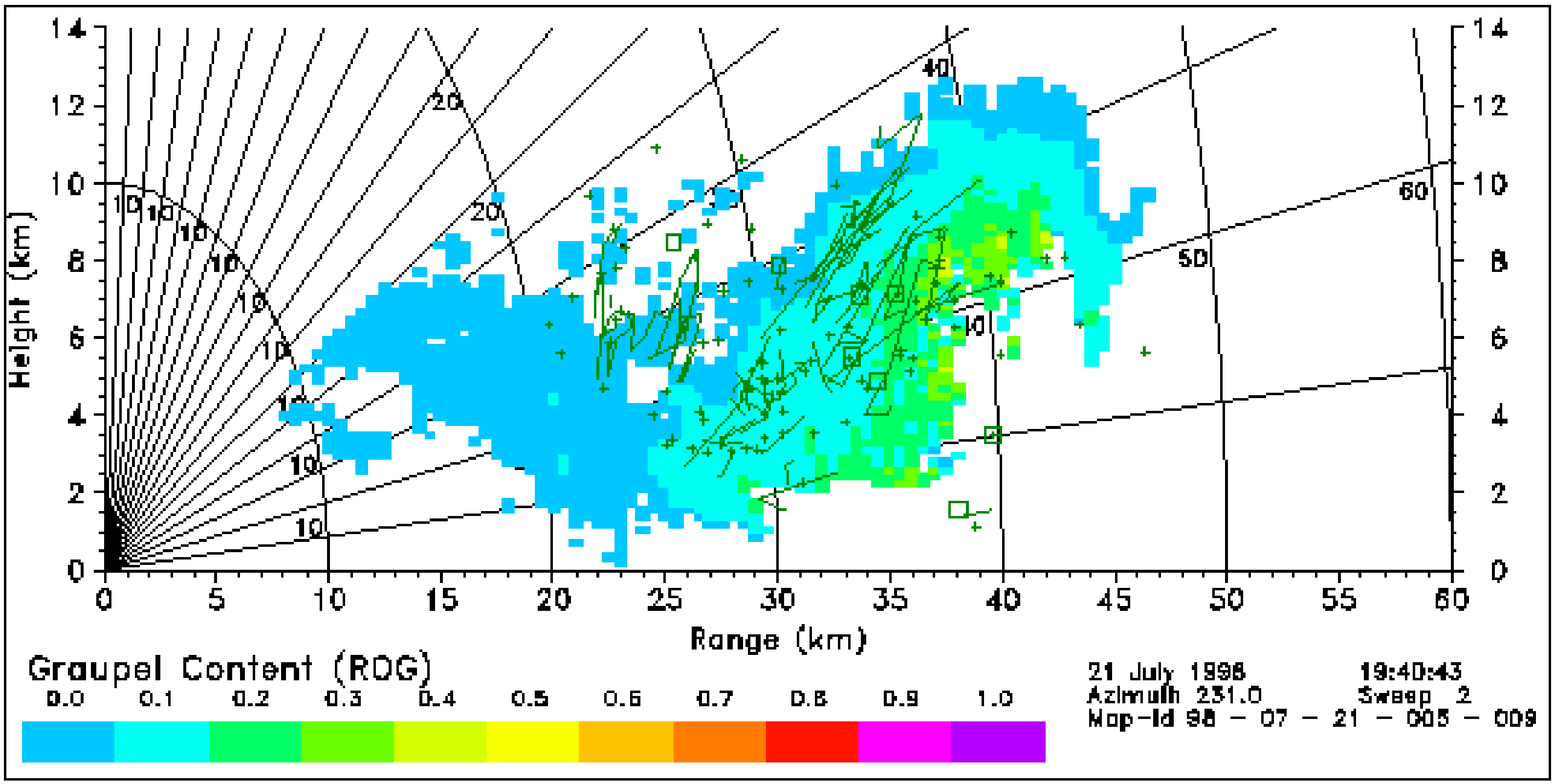
17:40 UTC, 231° azimuth, nearby flashes

Flash correlation with snow mass



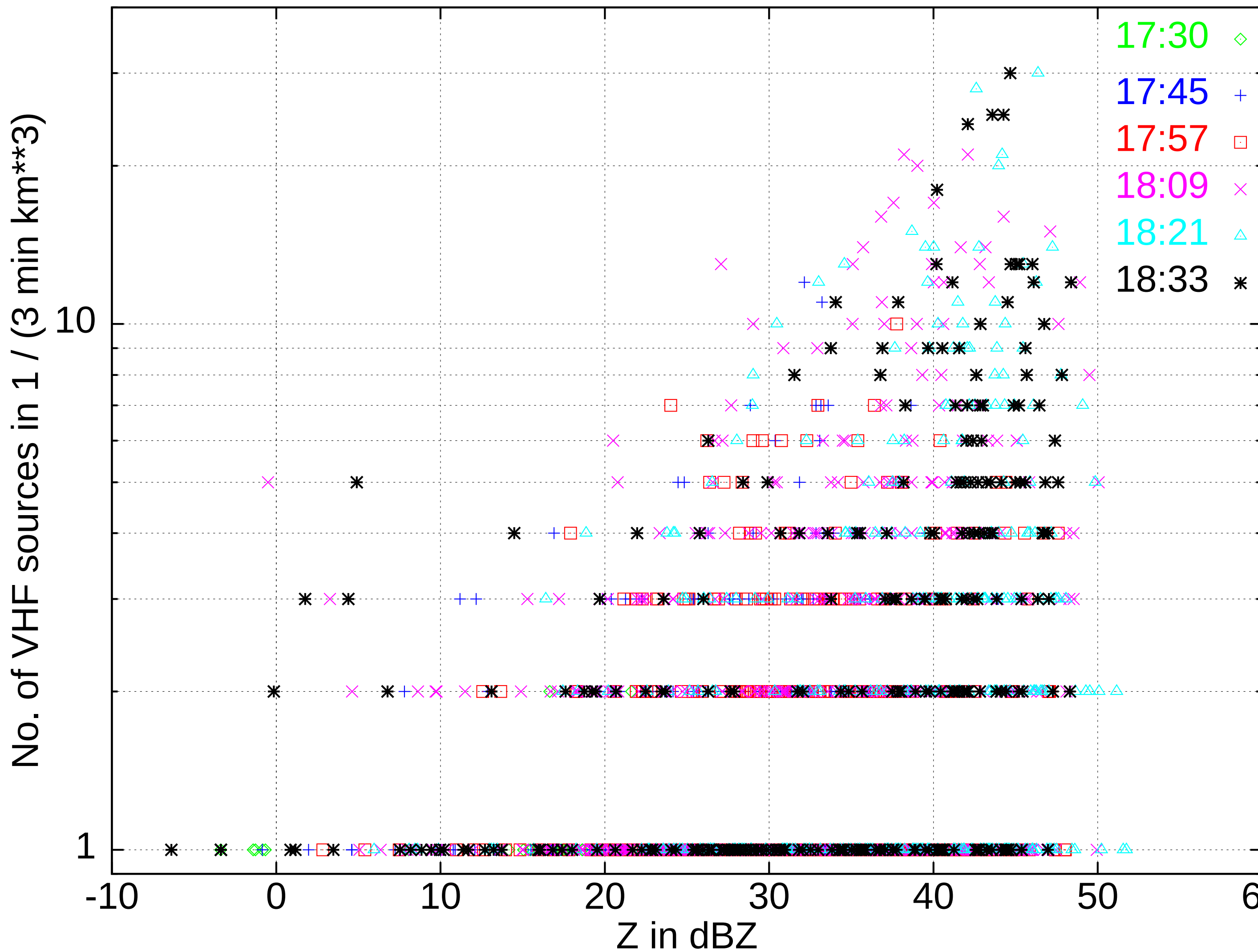
17:40 UTC, 231° azimuth, nearby flashes

Flash correlation with graupel mass



17:40 UTC, 231° azimuth, nearby flashes

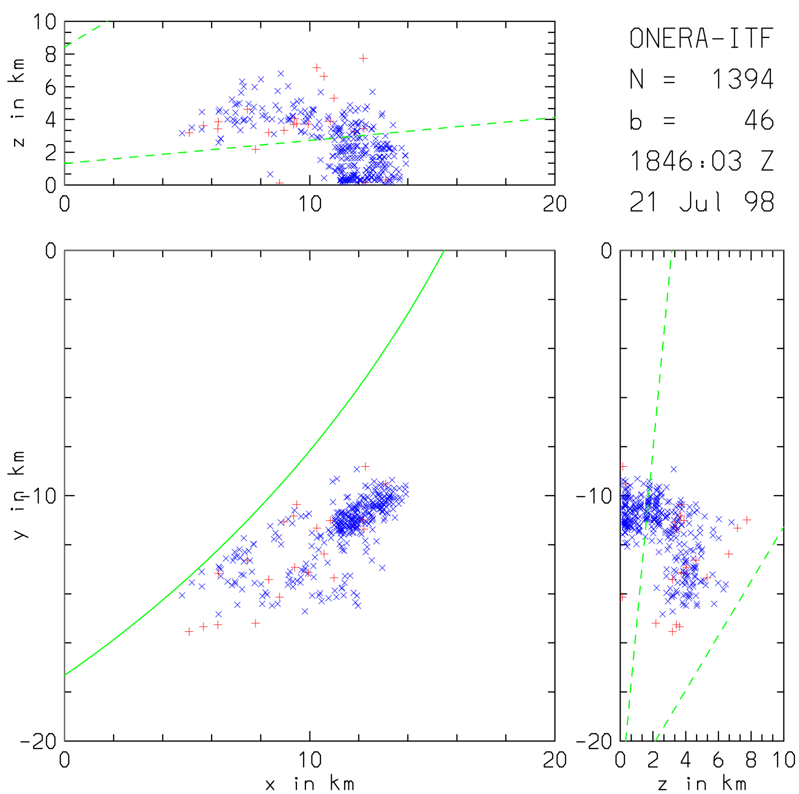
⇒ **best correlation with lightning**

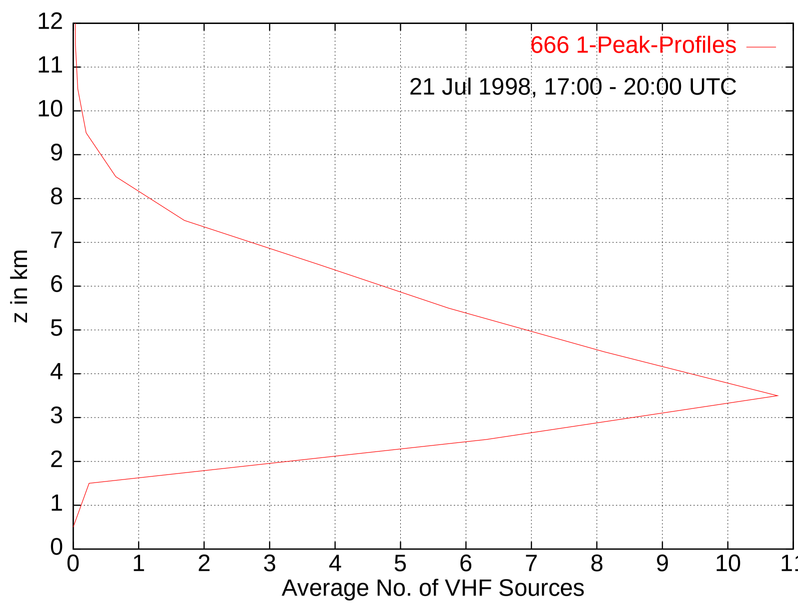


During storm evolution, the peak of the skewed distribution shifts from 32 dBZ to roughly 45 dBZ

Flash signatures in VHF–band

Low–level VHF maximum at 3.5 km.
Example: cloud to ground lightning

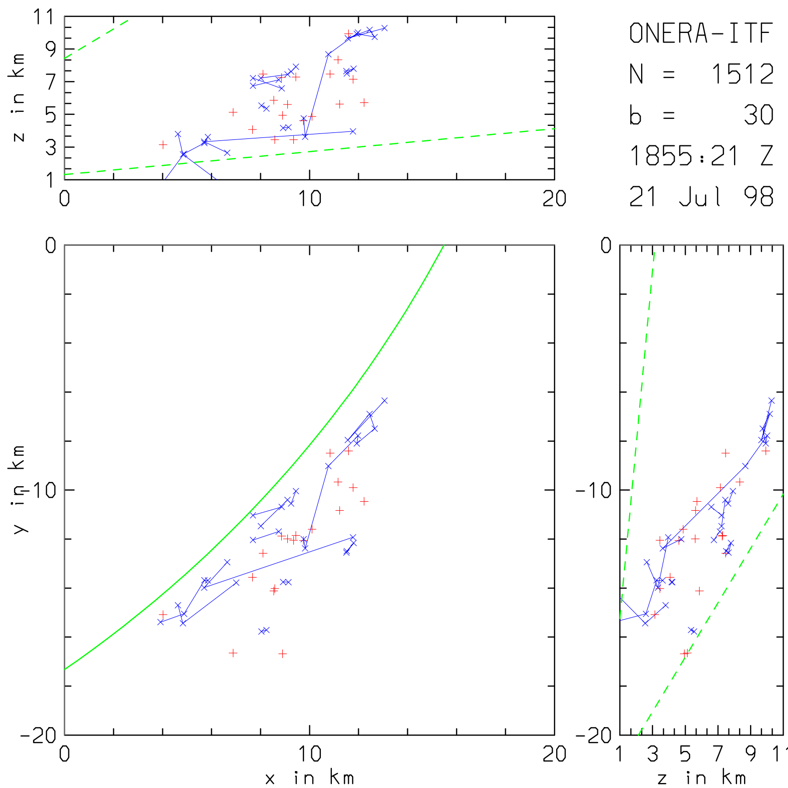


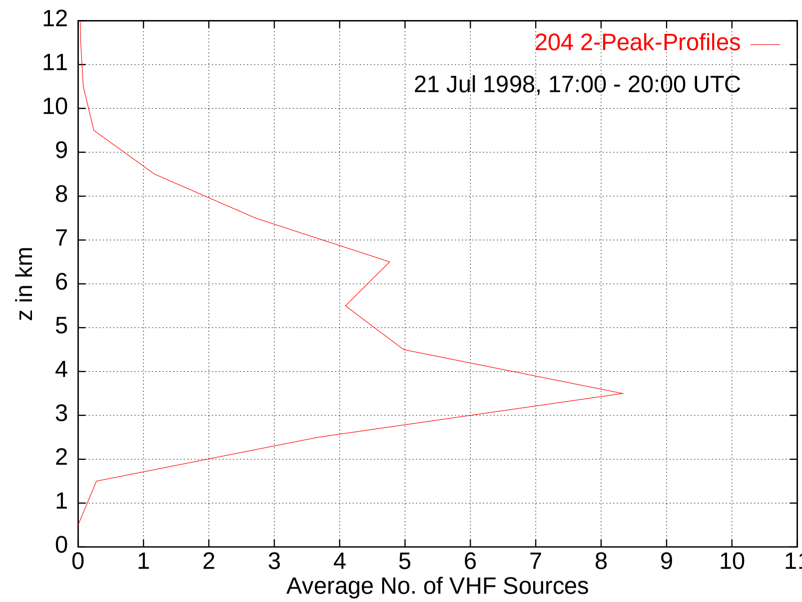


This maximum roughly corresponds to the freezing level where dry and wet ice particles and droplets coexist.

Flash signatures in VHF–band

Secondary VHF maximum at 6.5 km.
Example: Intracloud Lightning





This maximum corresponds to the height of the -15°C–level. The level 9 km, i. e. -30°C shows no peak on average.

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Summary

Supercell of 21 July 1998 showed the following characteristics

- **flash rate between 10 and 50 min^{-1} for 4 min averaging, up to 80 min^{-1} for 1 min averaging**
- **high IC / CG ratio of about 7**
- **highest spatial correlation of flashes with graupel mass**
- **weaker correlation exists for hail and snow mass**
- **distribution of VHF sources with reflectivity is strongly skewed and peaks at ever higher reflectivity as the storm decays: near 32 dBZ at 17:45 UTC and around 45 dBZ from 18:21 dBZ on**
- **distinct peak levels of VHF activity near the freezing level and the -15°C level (approx. 4 km and 7 km AGL)**

Conclusions

1. EULINOX database not only valuable to quantify $LiNO_X$ production, but also from a cloud–microphysical view
2. Radar and ITF data help to get a 3D picture of the in–cloud processes that lead to lightning discharges
3. The ITF has a higher detection efficiency and greater reliability than 2D systems like LPATS in determining the flash type (CG, IC, polarity) as well as the flash rate
4. Analysis can aid in developing / improving lightning parameterizations for atmospheric models
5. As 21 July 1998 was a special case, other EULINOX days have to be compared with it to verify and further evaluate these preliminary results