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Some comparisons between weather radar and lightning data in Finland in the summer of 2005

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FMI

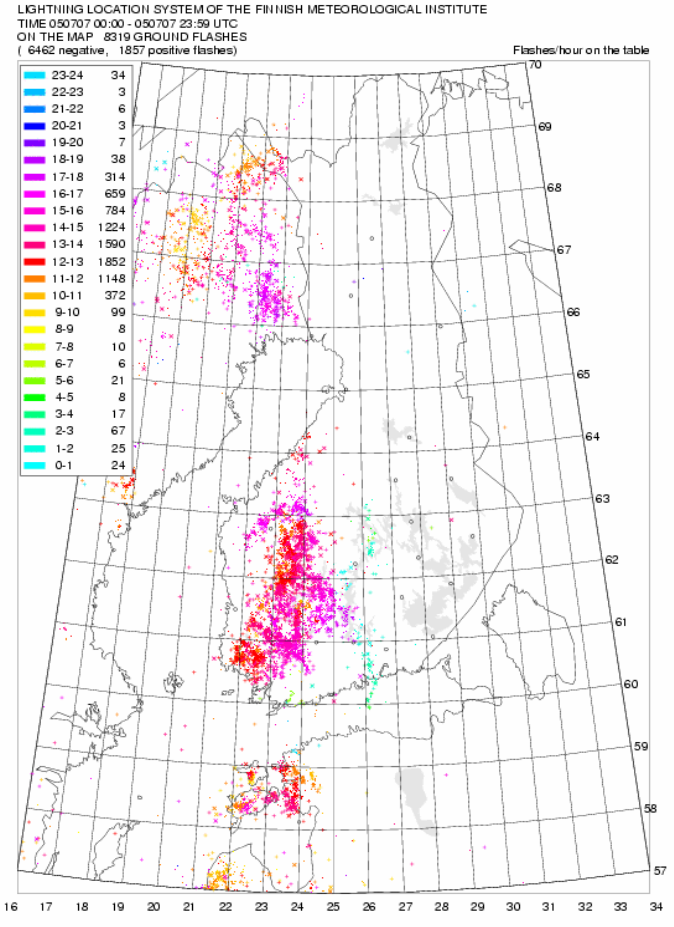
- Efficient electrification of thundercloud depends on the formation of large graupel in the cloud and so lightning is almost always associated with rain

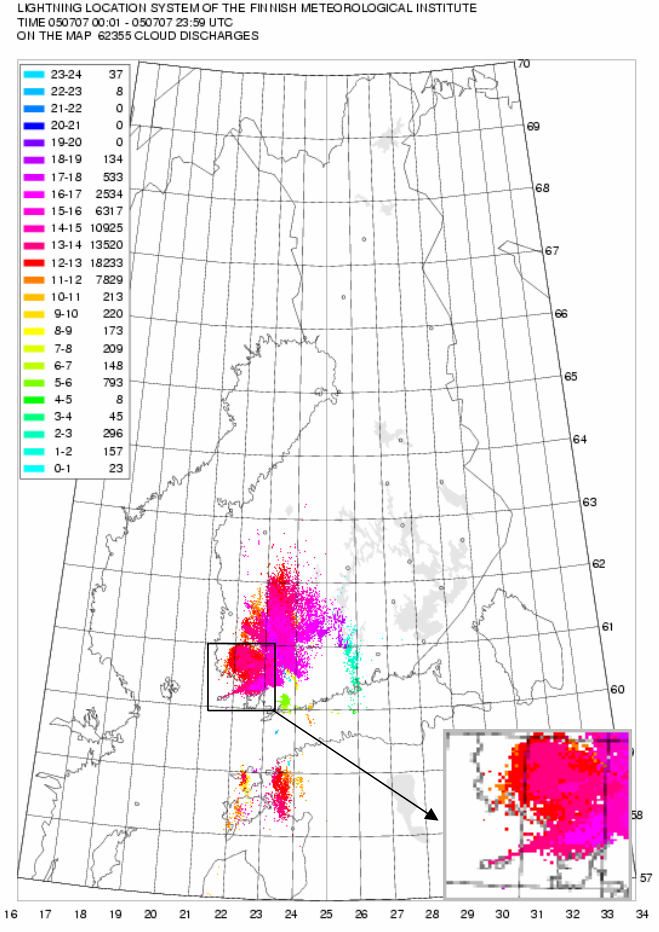
- *Weather radar provides a good overview of the particle sizes in the cloud:*

  - ***If we detect large particles (large radar reflectivity), the possibility of lightning increases***

  - ***With weather radar one can predict the possibility of lightning***

- The lightning location network in Finland consists of 5 IMPACT sensors for the detection of ground flashes and 3 SAFIR sensors for total lightning
- Norway, Sweden and Finland form the NORDLIS-lightning detection network (for ground flashes), which has improved the detection accuracy and efficiency a lot
- Due to the low number of SAFIR sensors, the effective area for the detection of cloud flashes is quite small (South-Western Finland)

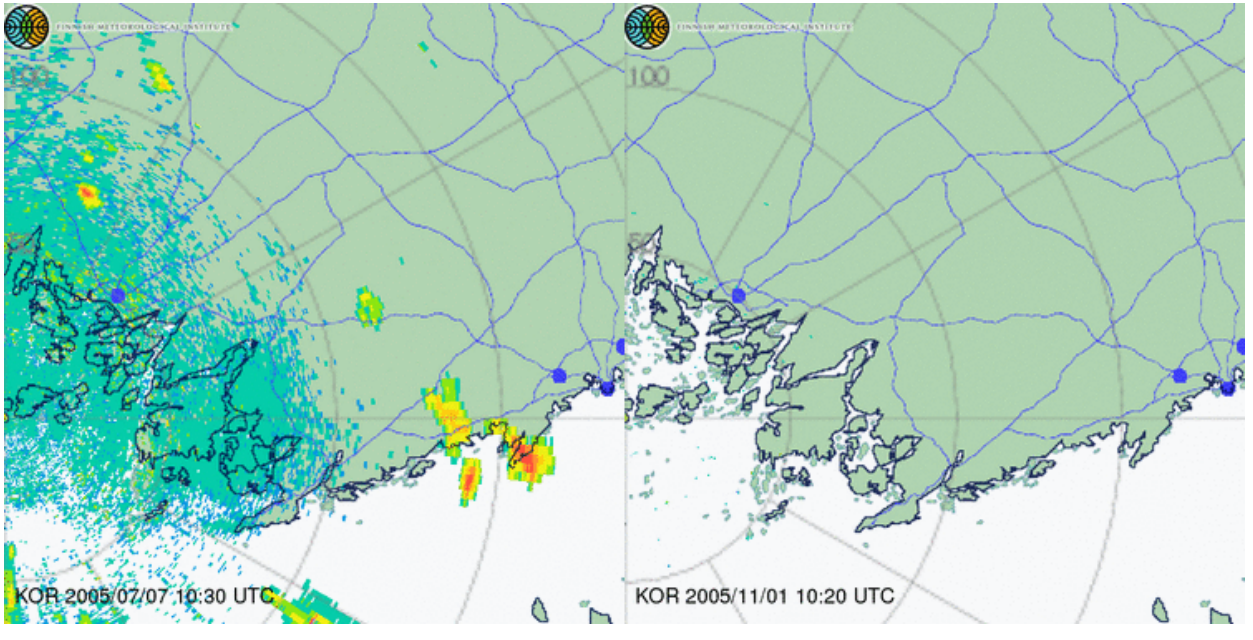

LIGHTNING LOCATION SYSTEM OF THE FINNISH METEOROLOGICAL INSTITUTE
TIME 050707 00:00 - 050707 23:59 UTC
ON THE MAP 8319 GROUND FLASHES
(6462 negative, 1857 positive flashes)
Flashes/hour on the table
23-24 34
22-23 3
21-22 6
20-21 3
19-20 7
18-19 38
17-18 314
16-17 659
15-16 784
14-15 1224
13-14 1590
12-13 1852
11-12 1148
10-11 372
9-10 99
8-9 8
7-8 10
6-7 6
5-6 21
4-5 8
3-4 17
2-3 67
1-2 25
0-1 24
70
69
68
67
66
65
64
63
62
61
60
59
58
57
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34


LIGHTNING LOCATION SYSTEM OF THE FINNISH METEOROLOGICAL INSTITUTE
TIME 050707 00:01 - 050707 23:59 UTC
ON THE MAP 62355 CLOUD DISCHARGES
23-24 37
22-23 8
21-22 0
20-21 0
19-20 0
18-19 134
17-18 533
16-17 2534
15-16 6317
14-15 10925
13-14 13520
12-13 18233
11-12 7829
10-11 213
9-10 220
8-9 173
7-8 209
6-7 148
5-6 793
4-5 8
3-4 45
2-3 296
1-2 157
0-1 23
70
69
68
67
66
65
64
63
62
61
60
58
57
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

- The mission was to obtain time differences between the observation of some radar reflectivity values and the first cloud discharge and ground flash
- Chosen reflectivity values were 24, 32, 40 and 48 dBZ
- The dataset consists of 90 cases from the summer of 2005 (case = convective cell whose development could be followed)
- The monitored area was confined to the vicinity of SAFIR sensors

Rain vs. lightning activity 2005-07-07 10:30-11:15

- Left: weather radar (CAPPI) images (every 5 minutes), right: cloud discharge densities (colors) and ground flashes (black spots)]
- Colors (radar): white = 48 dBZ, purple = 40 dBZ, red = 32 dBZ, and orange = 24 dBZ
- Colors (densities): purple = 4-> , red = 3, yellow = 2, and green = 1 discharge(s)/km^2



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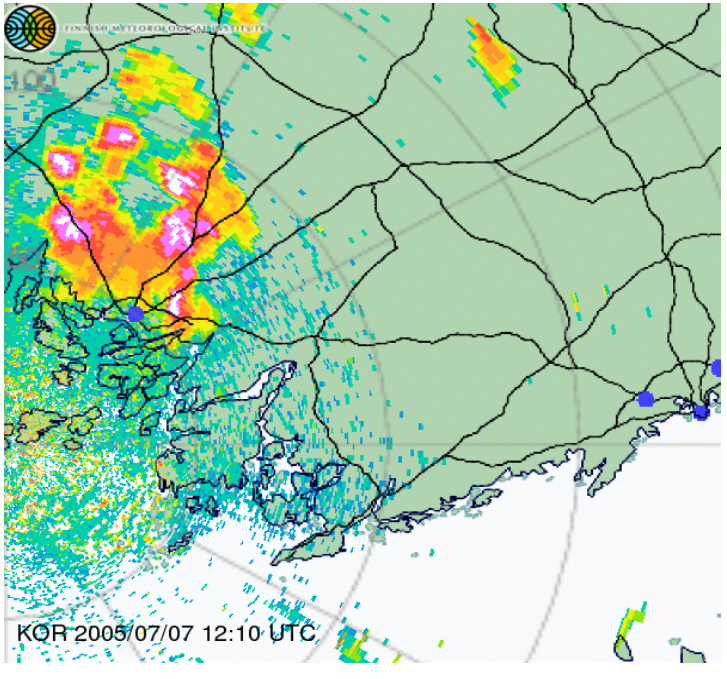
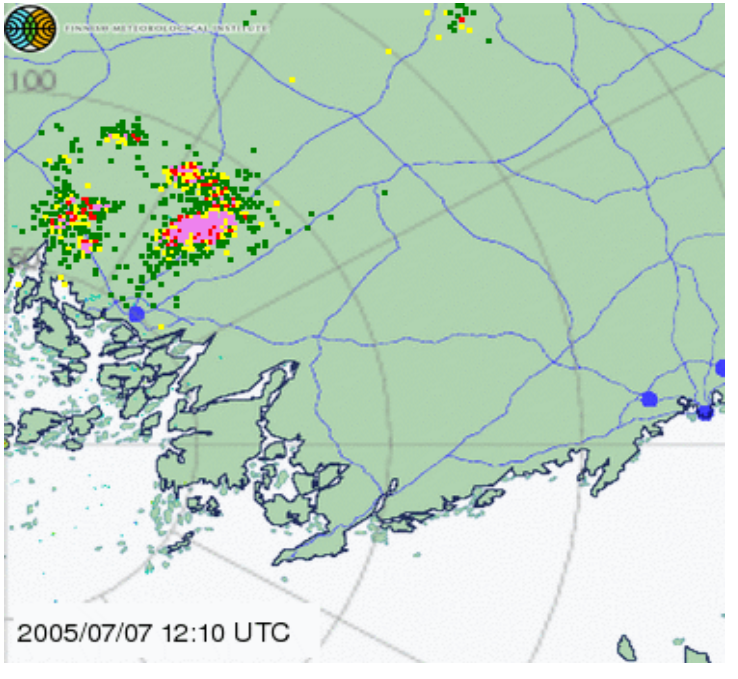
Rain vs. lightning activity 2005-07-07 12:10 UTC

- Weather radar image (left) and cloud disharge densities (right) during a 5 min period
- Intense cloud lightning activity correlates well with the highest reflectivity values





- Summary of the cases:
  - At least one cloud discharge had been detected
  - At least 40 dBZ had been detected in every case
  - 48 dBZ was detected in 60 cases
  - 17 cases out of 90 were such that no ground flash was detected
- The reflectivity value 40 dBZ seems to be somekind of “critical” value for the efficient electrification

- Time differences between certain reflectivity values and lightning calculated from all cases (reflectivity value has been detected first):

	Cloud flashes		Ground flashes	
	Δt(mean)	Δt(median)	Δt(mean)	Δt(median)
24 dBZ	29.1	25	30.8	25
32 dBZ	25.6	23	27.3	23
40 dBZ	19.2	15	21.2	15
48 dBZ	6.8	6	10.4	8.5

- Time differences for those 17 cases which produced only cloud flashes:

	Cloud flashes	
	Δt(mean)	Δt(median)
24 dBZ	35.8	28
32 dBZ	31.7	26
40 dBZ	24.4	23
48 dBZ	10.2	9

- It seems that cases which produce only cloud flashes develop more slowly
- So, in these cases:
  - Convection (and hence electrification) is weaker
  - Enough charge for the occurrence of cloud flash is acquired, but not for ground flash
- However, 17 cases is too small number of cases to make any solid conclusions

- Time differences between the first cloud and ground flash was also obtained from the cases:
  - 56% of the cases were such that the first cloud discharge and ground flash were detected almost simultaneously
  - There were also cases in which the time difference was more than 10 minutes
  - The mean time difference was 193 seconds (3.2 minutes; cloud discharge precedes)

- There were also 11 cases in which the first ground flash was detected well before the first cloud discharge
- This seems rather odd because every ground flash is associated with in-cloud processes as well
- This must be due to the sensitivity of SAFIR sensors?

- Some statistics about the studied days in the SAFIR area:
  - 11 795 cloud flashes (127 097 cloud discharges)
  - 6120 ground flashes
  - Cloud flash/ground flash ratio ~ 1.9
  - 74% of ground flashes was associated with at least one cloud discharge

Summary:

- Cloud discharges provide a good image about the strength of convection in the cloud
- Cloud lightning activity often precedes the first ground flash by a few minutes
  - With cloud flashes one can predict the occurrence of the first ground flash
- With weather radar one can predict lightning activity in general

- Future tasks:
  - Make a more detailed study with greater amount of cases (i.e. at least one whole summer)
  - To include also cases with a large reflectivity but no lightning
  - This would give more information about the predictability of the first flash

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