

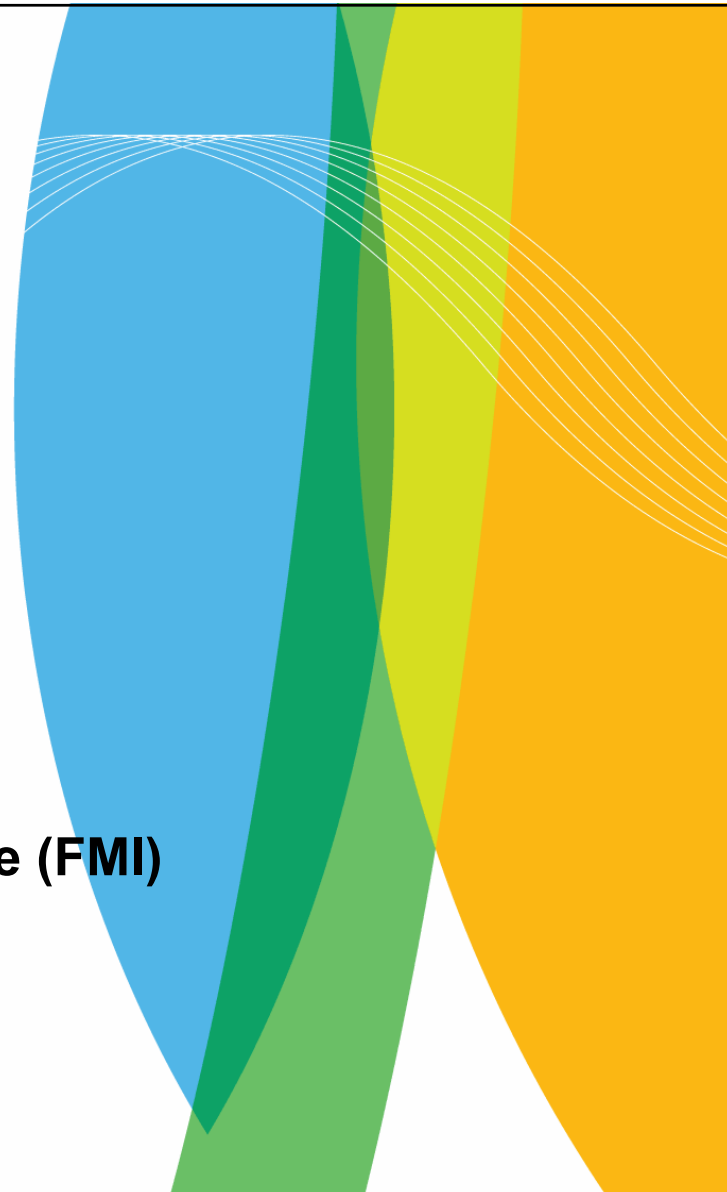


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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

VHF lightning location statistics in Finland in 2006

Antti Mäkelä

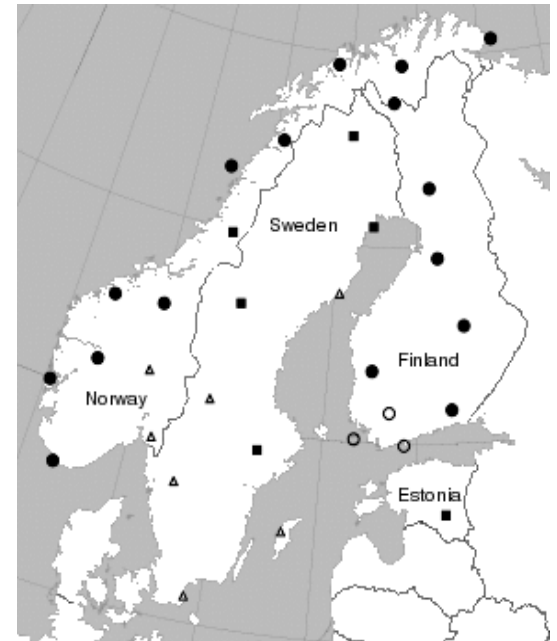
Finnish Meteorological Institute (FMI)





Introduction

- The central processor of the FMI LLS receives reports from about 30 IMPACT LF-sensors (NORDLIS-cooperation + one sensor in Estonia)
- Furthermore, three SAFIR VHF-sensors are located in the SW Finland:
 - *SAFIR LF reports (time) are combined in the overall ground lightning detection*
 - *VHF information used for cloud lightning detection (using the same central processor)*

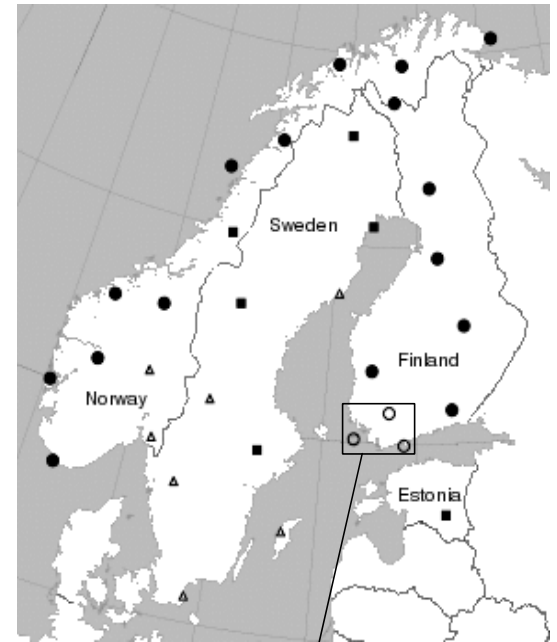


black circle = IMPACT ES,
triangle = IMPACT ESP,
square = LS7000,
open circle = SAFIR



Introduction

- Total lightning (VHF+LF) statistics in Finland for year 2006 have been analysed
- The study area has been narrowed to about 150 km x 100 km to ensure ~homogenous DE for VHF data
- During 24 days there were at least moderate VHF activity in the study area



Study area



Data analysis

- Located VHF and LF events have been compared temporally (time window 500 ms) to find out which VHF events are correlated to ground flashes (first stroke)
- Correlated and uncorrelated groups are analysed
- Three kind of groups:

Correlated – temporally (and spatially) close ground flash

060530	174343.4877	60.6839	22.9591	C
060530	174343.4878	60.6722	22.9833	C
060530	174343.4879	60.6839	22.9591	C
060530	174343.4881	60.6899	22.9769	C
060530	174343.4882	60.6832	22.9903	C
060530	174343.4882	60.6519	22.9292	G
060530	174343.4883	60.6792	22.9984	C

Uncorrelated – no ground flash

060530	173245.8609	60.6467	23.1074	C
060530	173245.8610	60.6405	23.0792	C
060530	173245.8611	60.6545	23.0894	C
060530	173245.8612	60.6373	23.0471	C
060530	173245.8613	60.6380	23.1057	C
060530	173245.8614	60.6307	23.0608	C
060530	173245.8615	60.6618	23.1036	C
060530	173245.8616	60.6521	23.0531	C
060530	173245.8629	60.6799	23.1149	C
060530	173245.8630	60.6689	23.0845	C

Uncorrelated – no VHF

060530	162204.2073	60.7781	24.1001	G
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Statistics

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
Total	36933	5964	3488	3536	2428	1060
Avg. (per case)	1539	249	145	147	101	44

VHF event = located VHF discharge (i.e. basic unit of SAFIR data)

VHF group = temporally and spatially coherent collection of VHF events

CG = ground flash (presented by the first reported stroke)



Statistics - interpretation

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
Total	36933	5964	3488	3536	2428	1060
Avg. (per case)	1539	249	145	147	101	44

- 59 % (3536/5964) of VHF groups doesn't contain a CG
→ these groups are cloud flashes



Statistics - interpretation

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- 59 % (3536/5964) of VHF groups doesn't contain a CG
→ these groups are cloud flashes
- The rest 41 % (2428/5964) contain a CG
 - *these VHF groups are associated with the incloud processes of CGs*
 - *the average (temporal) position of CG is 3.9*
 - *CG is the first in 49 % of the groups*



Statistics - interpretation

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
Total	36933	5964	3488	3536	2428	1060
Avg. (per case)	1539	249	145	147	101	44

- 30 % (1060/3488) of CGs are without VHF
 - *located on average with 6.2 sensors*
 - *avg. peak currents -14.7 kA and +15.6 kA*
 - *88 % negative, 12 % positive*



Statistics - interpretation

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
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- 30 % (1060/3488) of CGs are without VHF
 - *located on average with 6.2 sensors*
 - *avg. peak currents -14.7 kA and +15.6 kA*
- CGs with VHF
 - *7.0 sensors, -21.2 kA and +26.0 kA*



Statistics - interpretation

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
Total	36933	5964	3488	3536	2428	1060
Avg. (per case)	1539	249	145	147	101	44

- If we use the observed values, the cloud flash-ground flash ratio is about 1.0 (3536/3488)



Should this be 30 % higher?

Statistics - interpretation

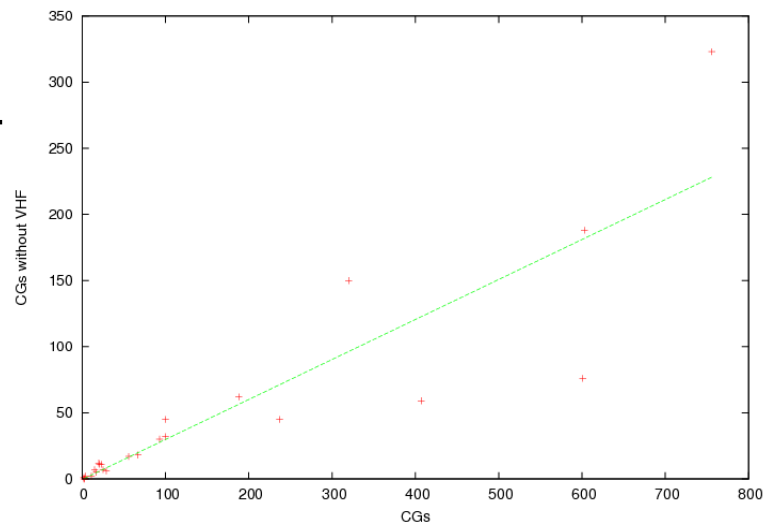
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- If we use the observed values, the cloud flash-ground flash ratio is about 1.0 (3536/3488)
- If we consider the number of CGs as a “ground truth”, and assume that SAFIR should detect VHF for every CG, can we assume that SAFIR misses about 30 % of cloud flashes? → cloud flash-ground flash ratio is 1.3

Statistics - interpretation

	VHF events	VHF groups	CGs	VHF groups without CGs	VHF groups with CGs	CGs without VHF
Total	36933	5964	3488	3536	2428	1060
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- There is a good linear correlation ($r = 0.89$) between the number of CGs per case vs. the number of CGs without VHF per case
- Meaning: about 30 % of CGs are without VHF no matter of the storm intensity (a bit more scattering for the more intense storms)





Discussion

- The nature of ground flashes without VHF is peculiar:
 - *insensitiveness of FMI's SAFIR sensors?*
 - *errors (overestimations) in the LF locations?*
 - ...
- The avg. peak current, polarity and number of reporting sensors suggest the CGs to be “real”
- However, CGs without VHF had smaller avg. peak current and number of sensors → SAFIR is more likely to miss the VHF for weaker CGs?
- Comments from other VHF-technique users (similar observations etc)?



Thank You!

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