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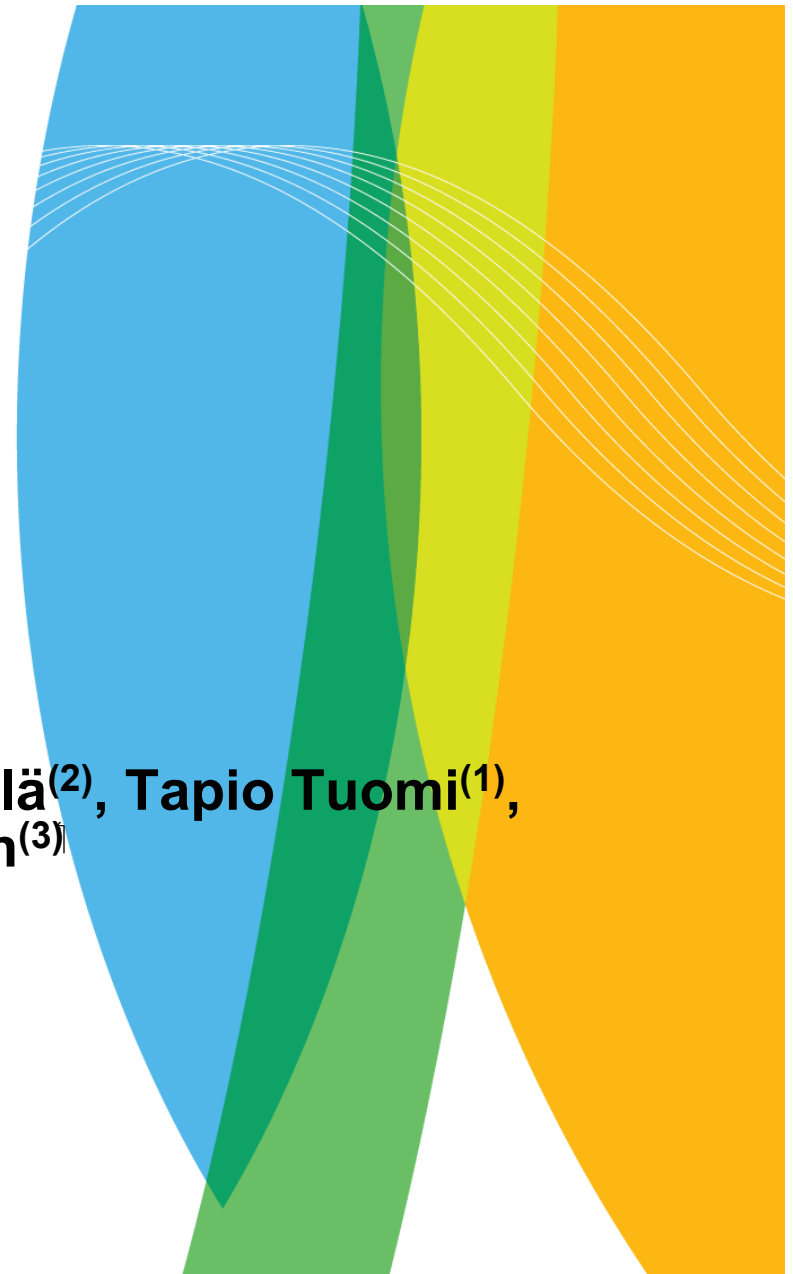
# Lightning location accuracy in Finland verified by strikes to trees

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**<sup>(3)</sup>University of Jyväskylä**





# Introduction

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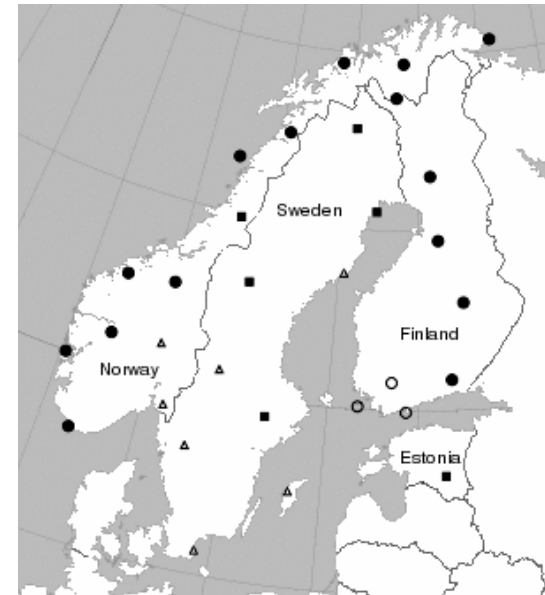


# Introduction

- 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, CP8000)

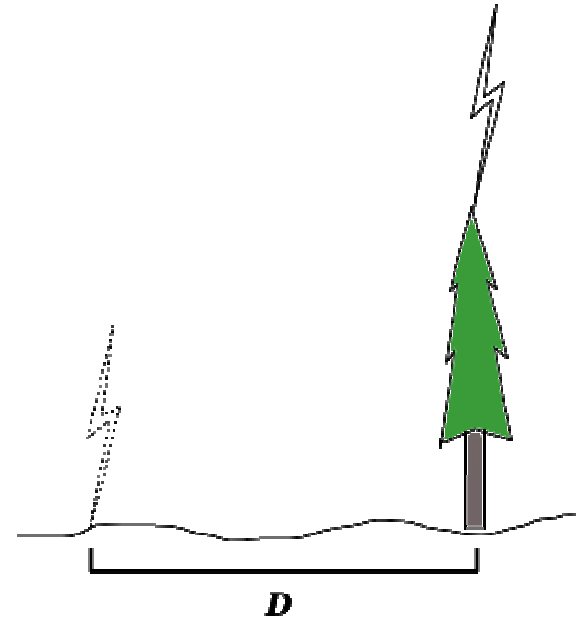


black circle = IMPACT ES,  
triangle = IMPACT ESP,  
square = LS7000,  
open circle = SAFIR3000



# Introduction

- Location accuracy = distance between the actual and estimated ground strike point = ***D***
- A way to analyze the location accuracy of a lightning location system (LLS) is to compare lightning locations to known strike points at ground
- Data sets are usually small because the exact strike point is only seldom known (at least in Finland)
- In this study, the location accuracy of the FMI LLS has been verified against lightning strikes to trees





Introduction

**Data and methods**

Results

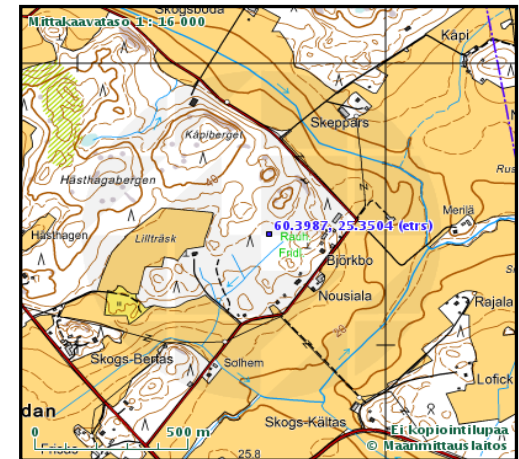
Examples

Conclusions



# Data and methods

- Two methods to obtain the data set:
  - observations from citizens via a web-based questionnaire
  - searching potential forested areas according to LLS data
- In 2007-2008, a total of 73 cases were obtained:
  - in 36 cases, the probable corresponding stroke in the LLS data was found
  - the rest 37 cases are ambiguous

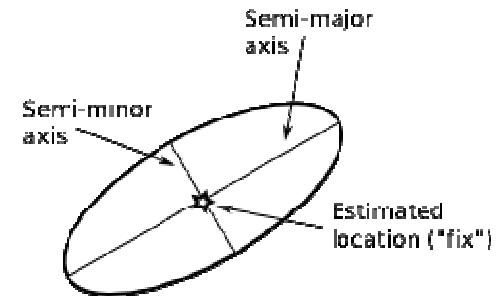




## Data and methods

090511 090305.8509 60.2486 23.4877 -22.9 1 **0.4** 9 12  
G

- Each located stroke has a unique set of parameters (time, lat, lon, peak current, multiplicity,...) and also the estimated location uncertainty
  - At FMI, the location uncertainty is operationally reported as the semi-major axis of the 50% confidence ellipse
- => the actual ground strike point should be inside this ellipse with 50% probability
- Motivation: if this uncertainty parameter is used operationally, how well does it correspond to the truth?





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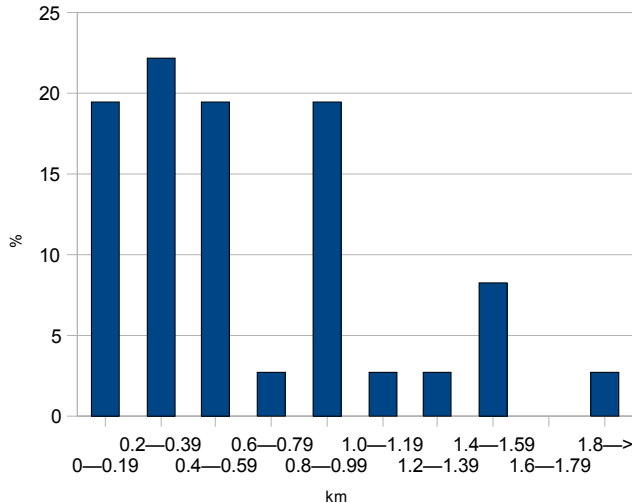
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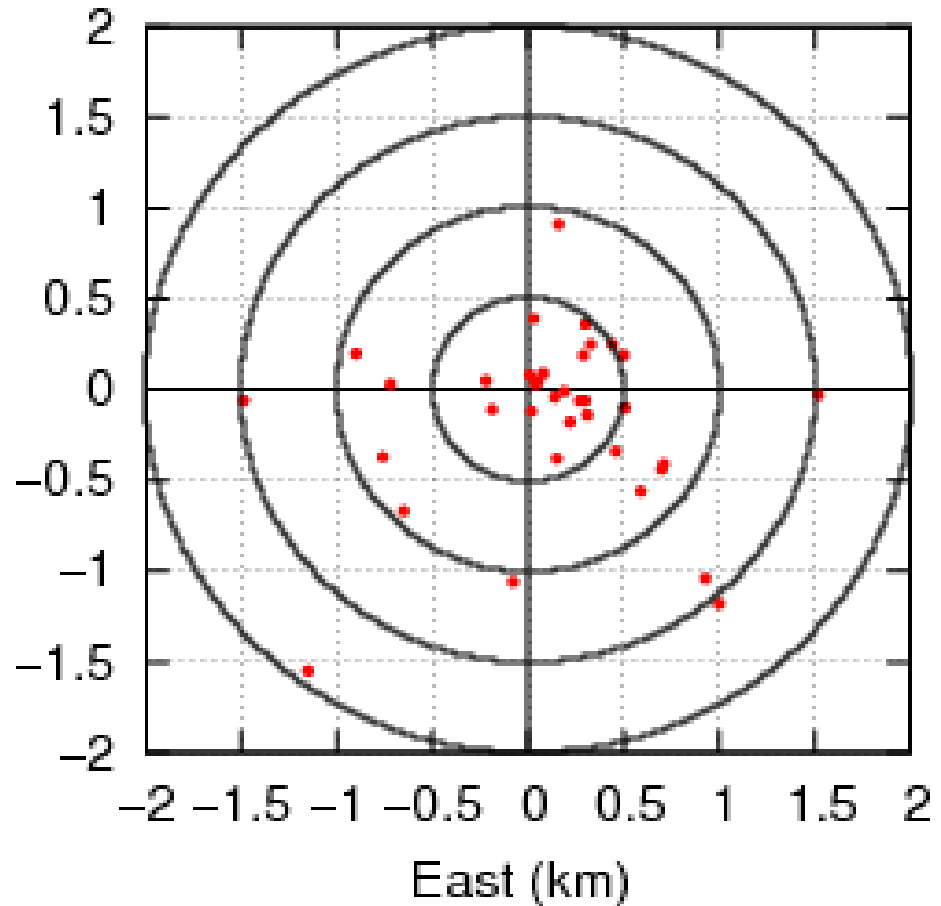


# Results

- 83% of strikes are located within 1 km (50% within 0.5 km)
- 75% are located in the eastern sector => systematic?



North (km)



*Left:* Histogram of the results.  
*Above:* Lightning locations for 36 strikes to trees (500 m range circles).



# Results

- $D$  = difference between the fix and the tree (km)
- $D_{LLS}$  = location uncertainty (50% estimate of the LLS (km))
- NSR = Number of Sensors Reporting

	Mean / Median / Stdev (km)	Mean / Median / Stdev (km)	Mean / Median / Stdev
	<b><math>D</math></b>	<b><math>D_{LLS}</math></b>	<b>NSR</b>
All strokes (36)	0.6 / 0.5 / 0.5	0.8 / 0.4 / 0.9	7.5 / 6.0 / 4.3
Neg. strokes (27)	0.6 / 0.4 / 0.5	0.8 / 0.4 / 1.1	6.6 / 6.0 / 3.1
Pos. strokes (9)	0.8 / 0.8 / 0.5	0.6 / 0.5 / 0.4	10.1 / 11.0 / 6.3



# Results

- $D$  = difference between the fix and the tree
- $D_{LLS}$  = location uncertainty (50%) estimate of the LLS
- NSR = Number of Sensors Reporting
- On average, the error estimates are reasonable
- Relatively high NSR

	Mean / Median / Stdev (km)	Mean / Median / Stdev (km)	Mean / Median / Stdev (km)
	<b><math>D</math></b>	<b><math>D_{LLS}</math></b>	<b>NSR</b>
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# Results

- $D$  = difference between the fix and the tree
- $D_{LLS}$  = location uncertainty (50%) estimate of the LLS
- NSR = Number of Sensors Reporting
- For positive strokes, the estimates are more optimistic, although NSR is on average larger
- However, only 9 positive strokes in the data set

	Mean / Median / Stdev (km)	Mean / Median / Stdev (km)	Mean / Median / Stdev (km)
	$D$	$D_{LLS}$	NSR
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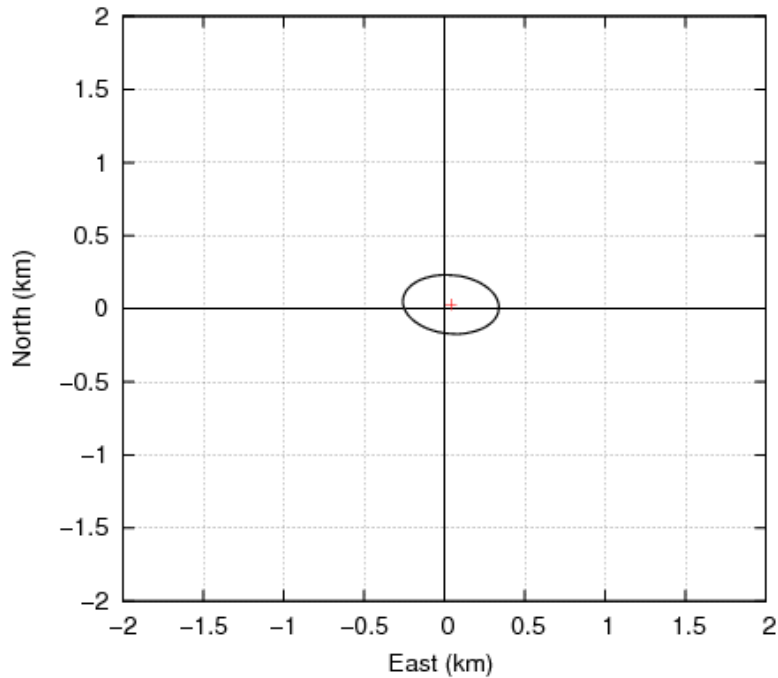
Conclusions



# Examples

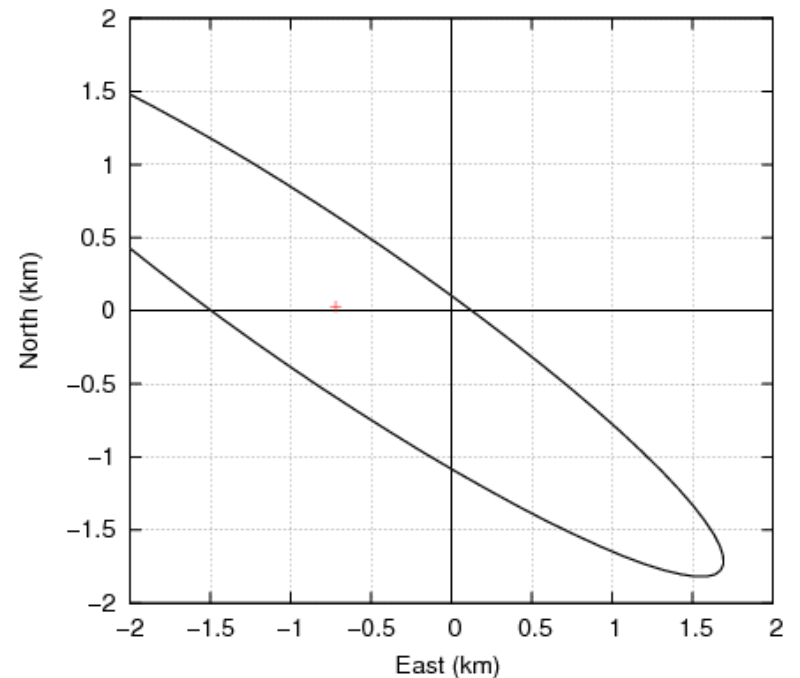
OK (excellent)

Stroke locations vs trees – P15



OK (large uncertainty)

Stroke locations vs trees – P26

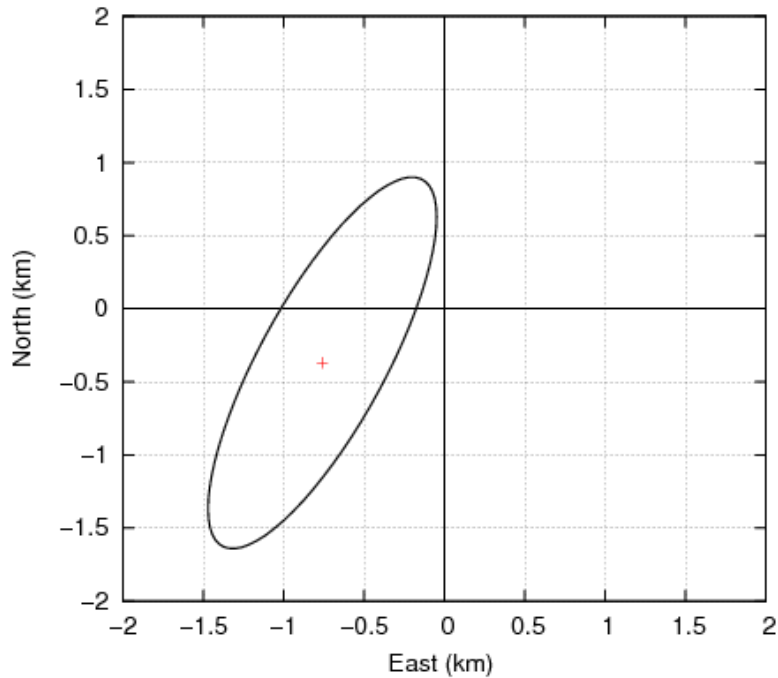




# Examples

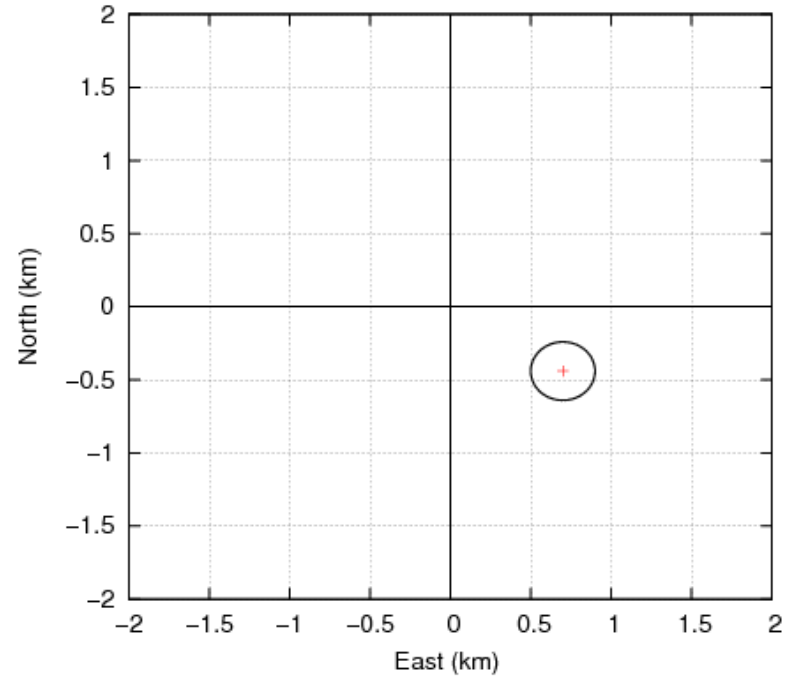
## Outside (barely)]

Stroke locations vs trees – P28



## Nominally accurate

Stroke locations vs trees – P25





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# Conclusions

- Location accuracy of the FMI LLS has been studied:
  - The distances between the fixes and the trees were between 50 m ... 1.9 km
  - In 50% of the cases (18/36), the tree was inside the 50% confidence ellipse
- The presented method is one way to collect material for verifying purposes, but there are difficulties:
  - often too many possible lightning locations
  - running after the flashes in the forest is an exhausting job => easier to collect via a questionnaire etc
- FMI will collect observations also in 2009



# Thank You!

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