NARROWBAND LIGHTNING DETECTION: CAPABILITIES AND LIMITATIONS

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CONTENTS

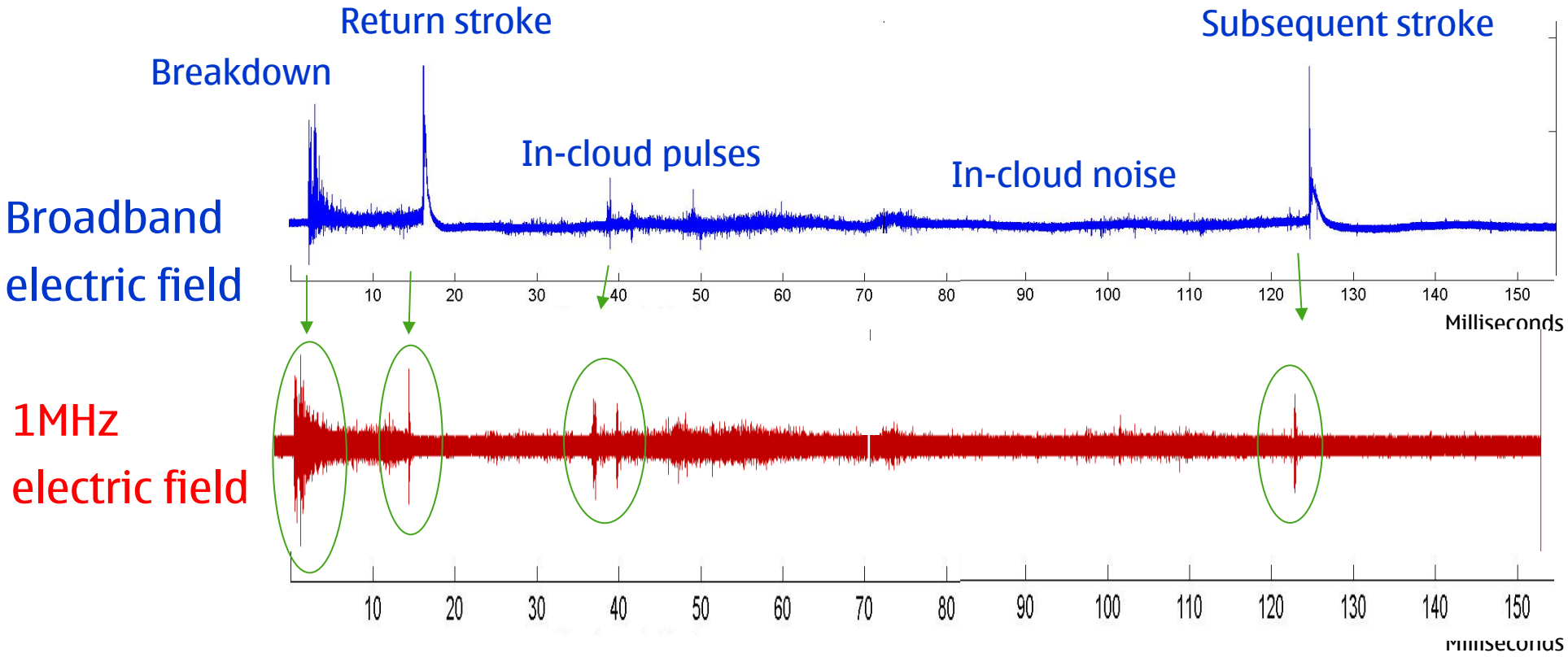
- Introduction
- System description
- Results for separately identified CG flashes
- Results when no IC/CG differentiation made
- Discussion
- Conclusions

WHAT IS THE POTENTIAL OF NARROWBAND?

- Somewhat outside mainstream of lightning research
- Possibility: Simple diagnostic and warning tool for lightning risk (devices exist, but unverified).
- World is full of antennas for wireless communication. If such systems could be modified for lightning detection, added cost could be minimal.

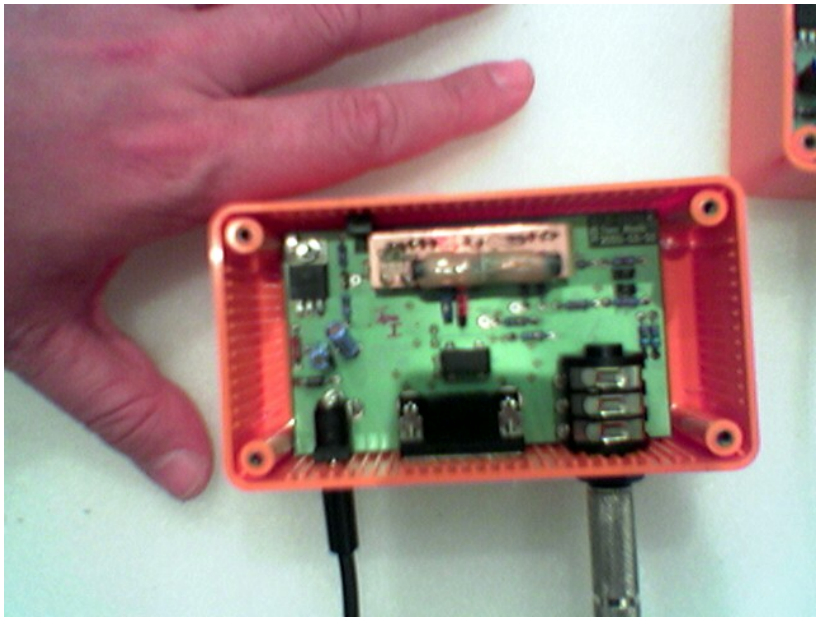
LIMITATIONS OF NARROWBAND MEASUREMENTS

- At any specific frequency, the return stroke may not be the most intense emitter.
- Difficult to identify individual processes (not impossible)

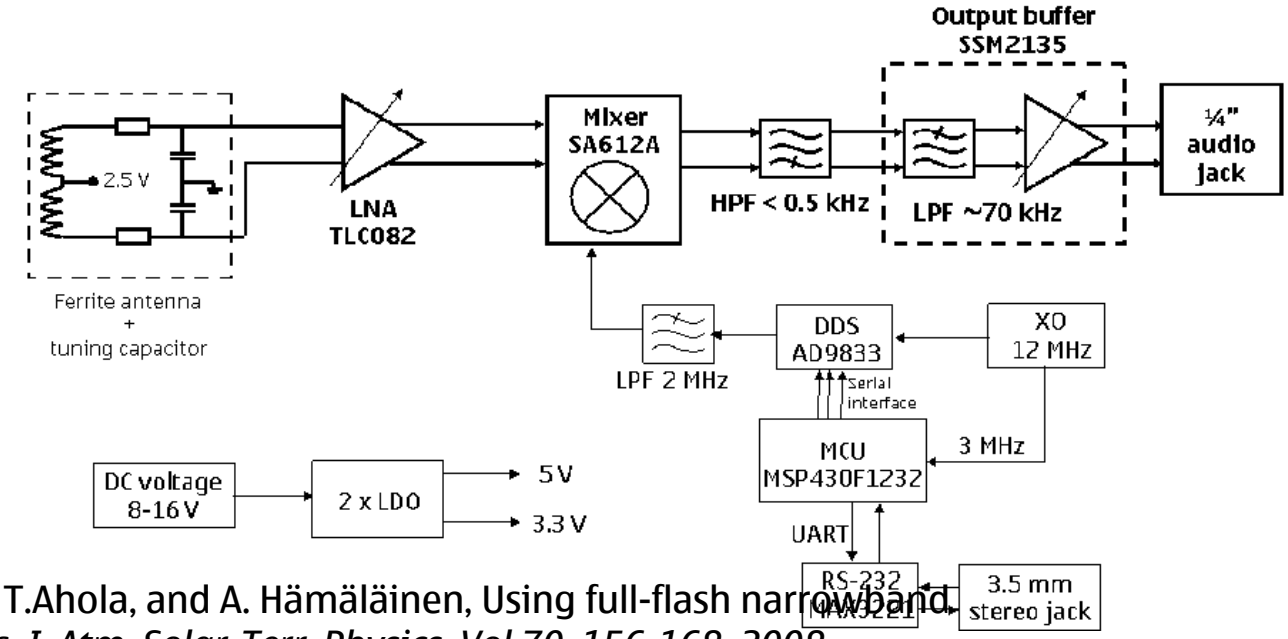


SYSTEM DESCRIPTION

- Essentially: generic AM radio, small ferrite coil (4cm x 4 mm), tuned to ~1MHz
- Data collected and processed as audio signal on ordinary PC



- Downmixing multiplies original signal by unknown phase, thus phase information is lost

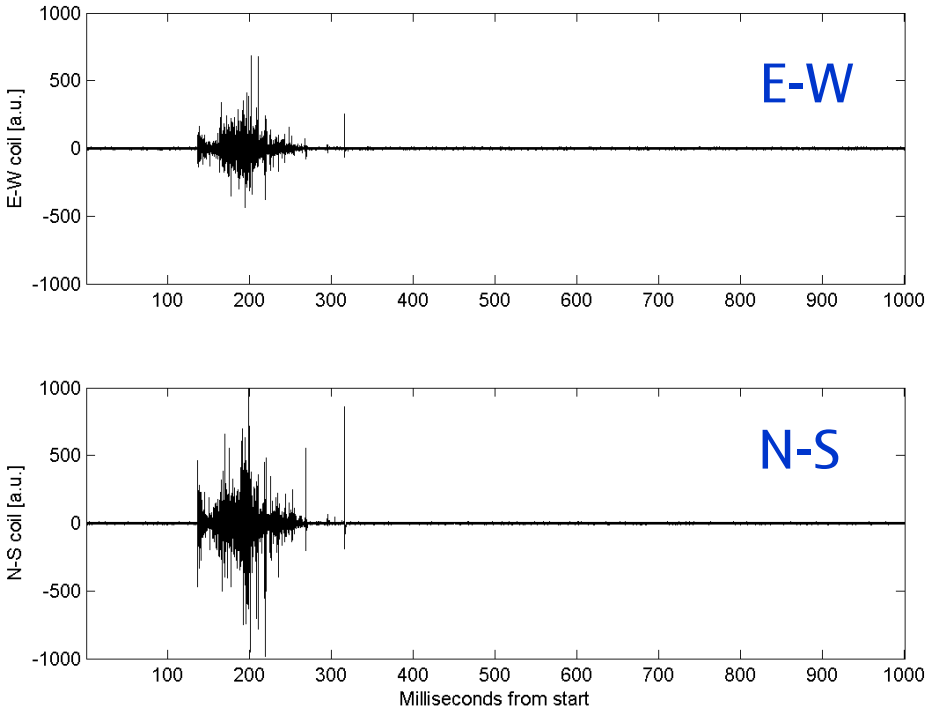


More details: Mäkelä, J.S., N. Porjo, J. Jantunen, T.Ahola, and A. Hämäläinen, Using full-flash narrowband energy for ranging of lightning ground strokes, *J. Atm. Solar-Terr. Physics, Vol 70, 156-168, 2008*

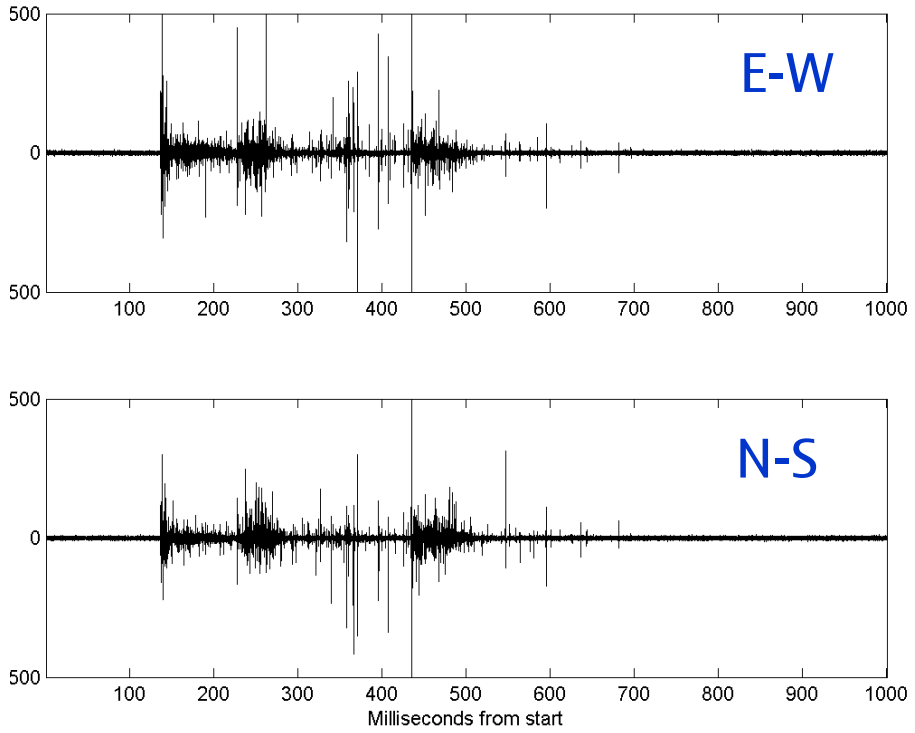
SYSTEM OUTPUT

- Outputs are 1-second audio clips
- Two coils arranged orthogonally
- Verified against broadband electric field system

Cloud-to-ground flash

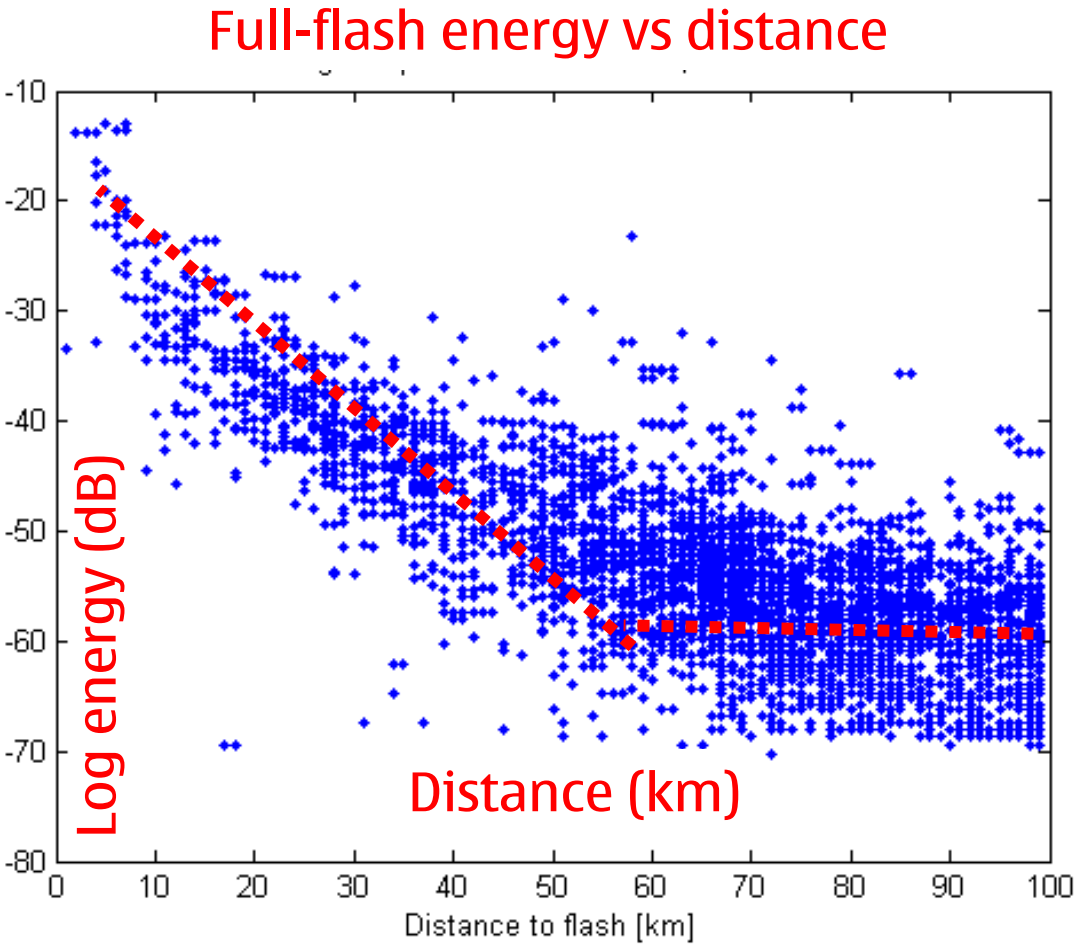


Intracloud flash



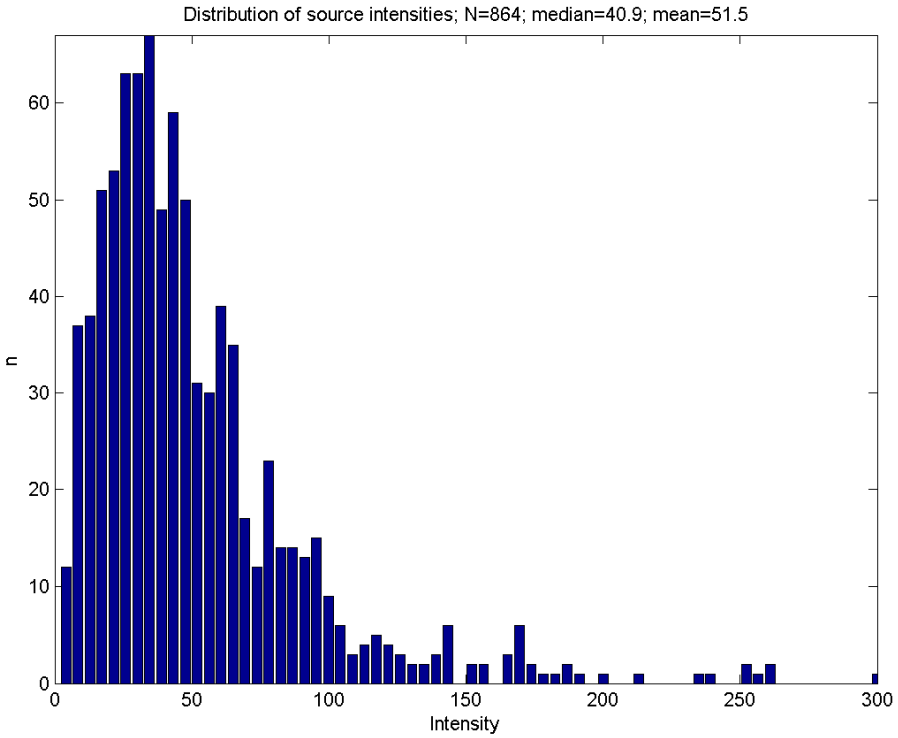
EMPIRICAL RESULTS: ENERGY VS DISTANCE

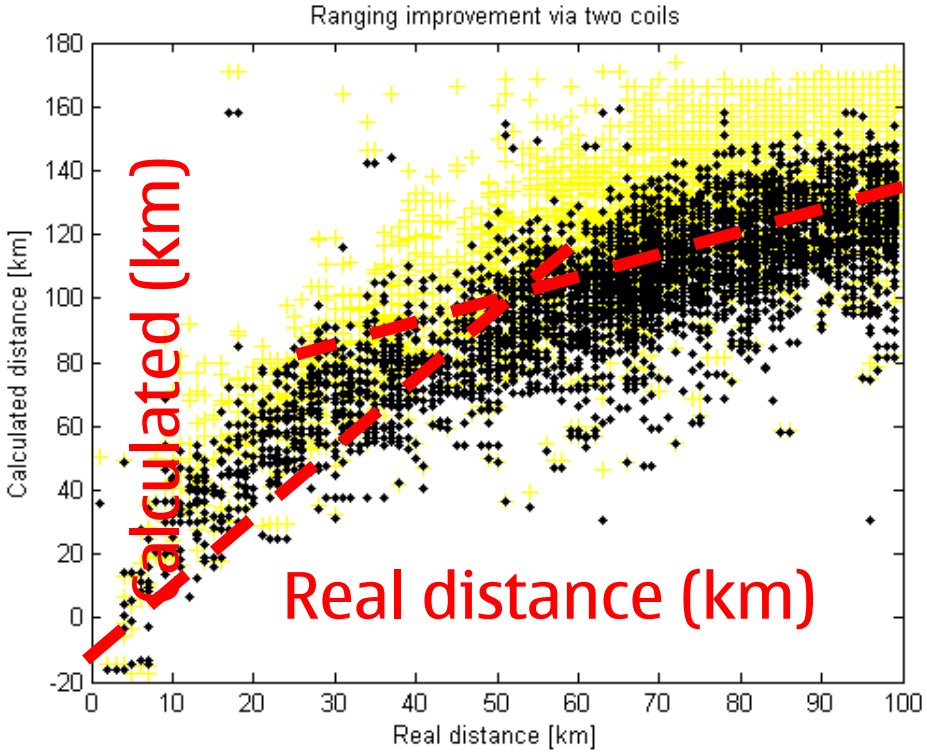
- A subset of CG flashes chosen (identified from network data)
- Energy over the full flash integrated
- Proportional to $1/R^3$ at least to 50 km
- Above 50 km, noise becomes significant



EMPIRICAL RESULTS: RANGING

- Orthogonal coils improve ranging: Reasonable accuracy to ~50 km
- Scatter in source intensities limits accuracy (work in progress)





THEORY

- The fast drop in intensity was unexpected, but is consistent with theory
- In ground propagation, signal strongly attenuated. Space-wave signal attenuated less.
  - <20km: cloud processes propagate as space-wave
  - >20km: all processes propagate as ground-wave

Mäkelä, J.S., N. Porjo, A. Mäkelä, T. Tuomi, and V. Cooray, Properties and propagation characteristics of preliminary breakdown processes in Scandinavian lightning, submitted to JASTP, 2008

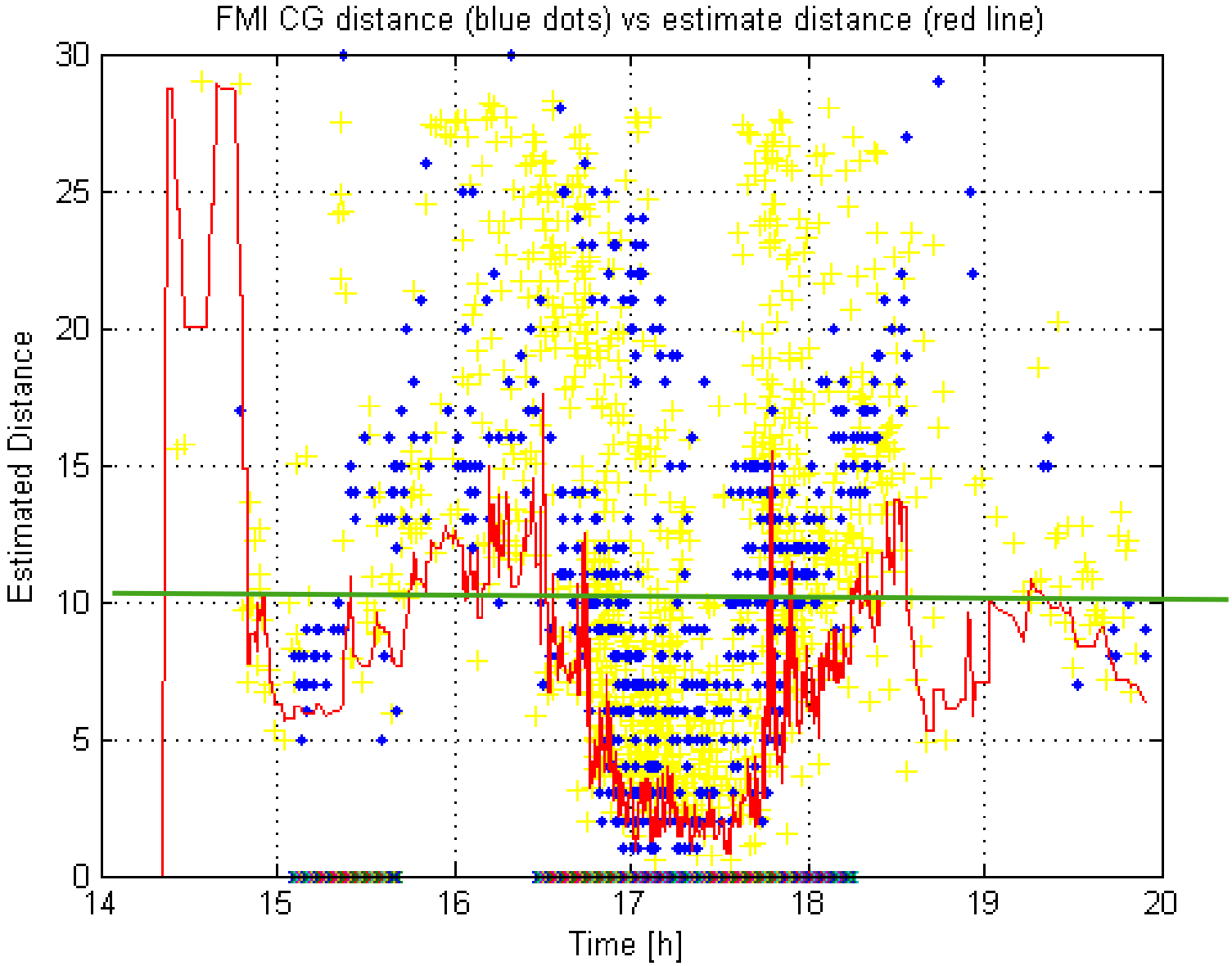
CAN WE IGNORE IC/CG DIFFERENTIATION?

- Is there a real need to have IC/CG differentiation?
- From risk viewpoint, perhaps not?
  - If IC exists, there is always a risk of CG
- Advantages if no differentiation made
  - IC & CG appear to have very similar energies (W.I.P.)
  - Larger data set improves ranging
    - IC is 3-10 times more numerous than CG

WORK IN PROGRESS: TRACKING OF STORM CELLS WITHOUTH IC/CG DIFFERENTIATION

One Finnish storm cell

- Blue: real distances to ground flash
- Yellow: estimated distances (from full-flash energy)
- Red: floating average



IF NO CG/IC DIFFERENTIATION IS MADE, WHAT IS THE PARAMETER BEING MEASURED?

- Not trivial at all to quantify
  - Ideally should be predictive: probability that CG strikes closeby (e.g. within 1km) within a certain time (e.g. 15 min)
  - Realistic proxy: presence of IC within ~10 km
- System most comparable to electric field mill
  - Less reliable; Simpler & portable, somewhat larger radius
- To verify the system, CG still needed to give ground truth
  - VHF tracking could be used equivalently

CONCLUSIONS

- Proof-of-principle shown, not fully functioning system
- Narrowband system could detect & evaluate storm risk
- If no IC/CG differentiation needed, performance could improve dramatically
- Under work: if this is accepted, how should one quantify what is being measured?