

# Observation of Initial Breakdown in Cloud Lightning

Comparisons between VLF/LF and VHF Lightning Location Network Data

Investigation of Strong VLF/LF Cloud Lightning

University of Munich, Germany

nowcast GmbH, Germany

LERMA Observatory de Paris, France

ONERA, France

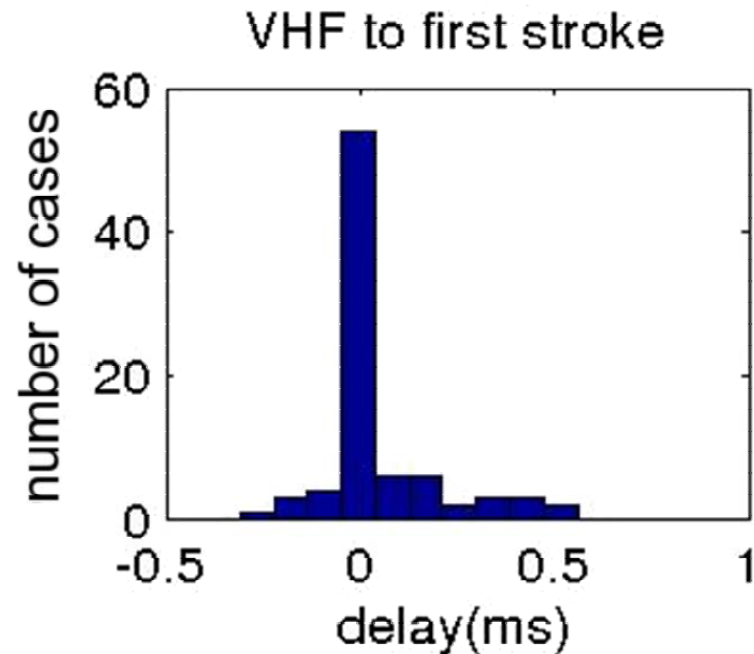
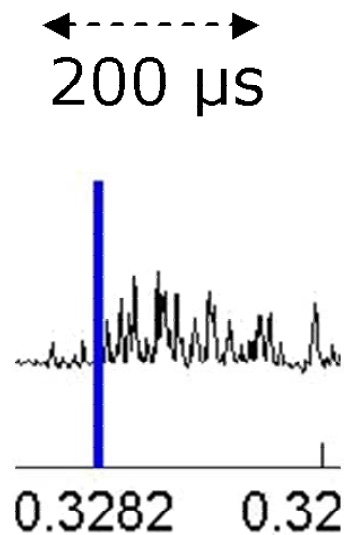
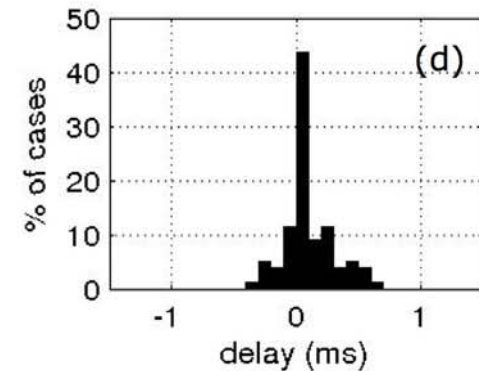
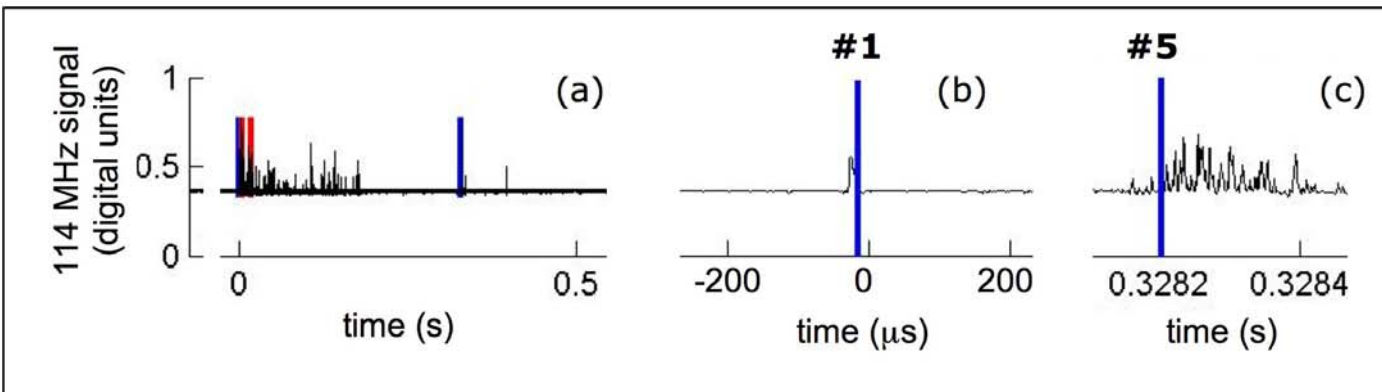
IMGW, Poland

HMS, Hungary

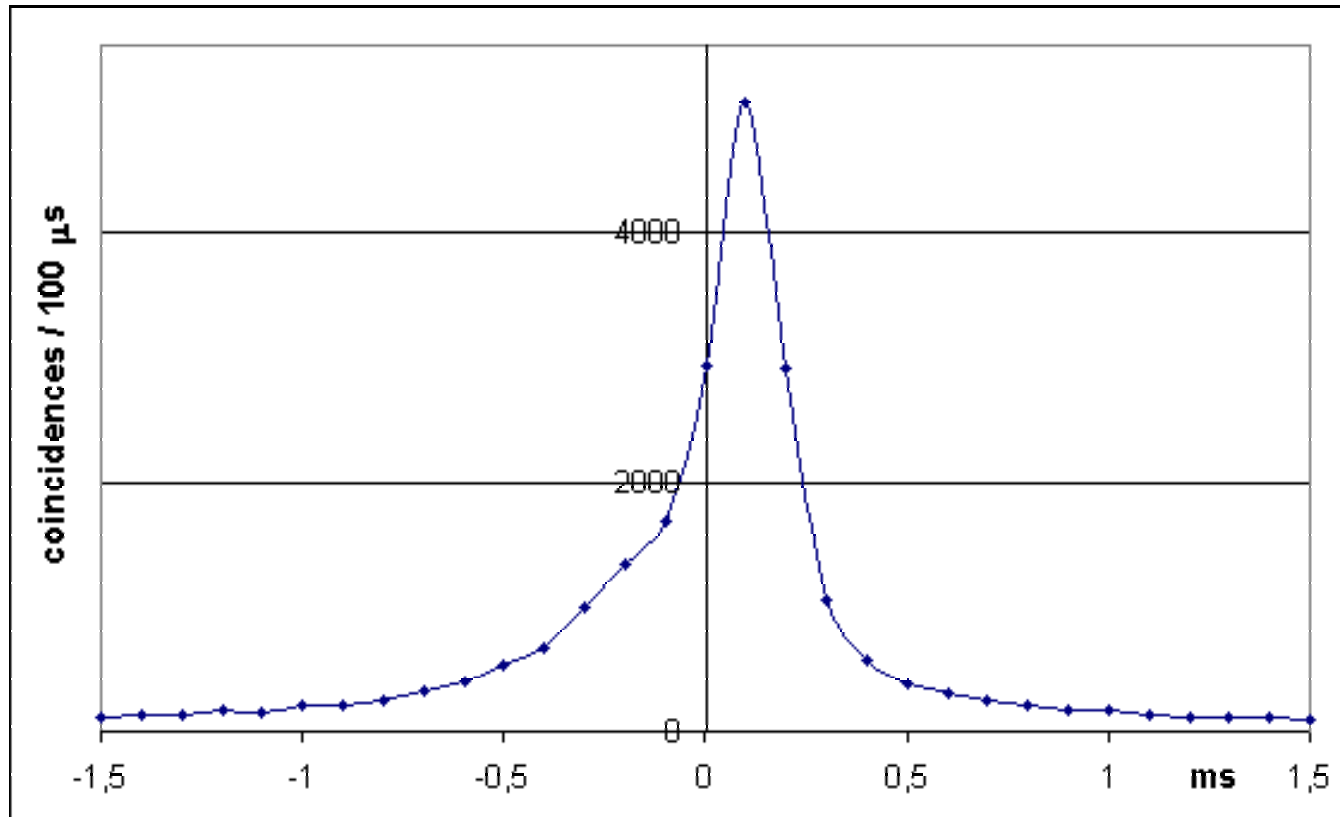
Warsaw University of Technology, Poland

# Merging ONERA and LINET Data (Laroche, AGU 2006)

(independent ONERA and LINET data)

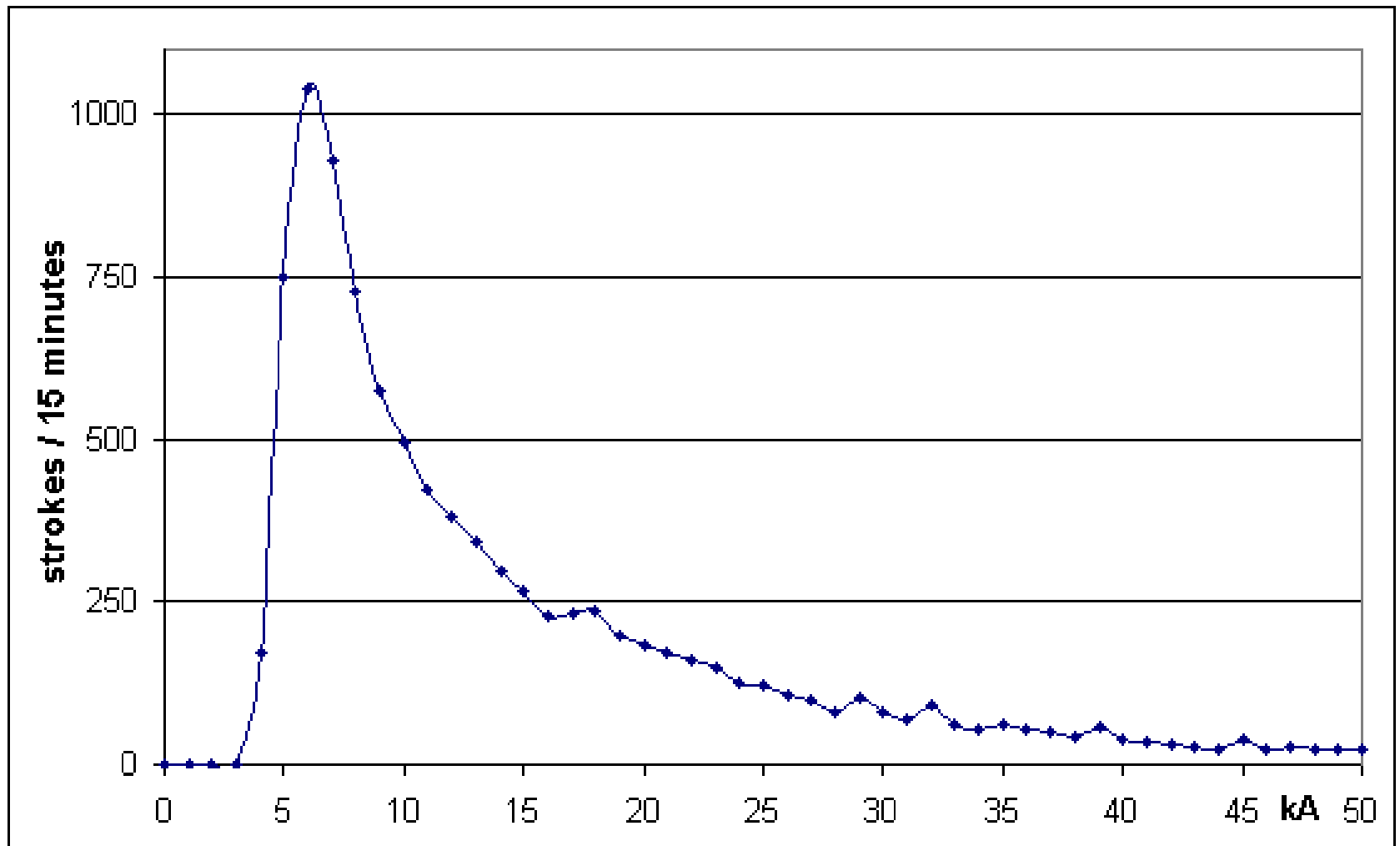


## Coincidences VLF/LF – first VHF source



Example for the quantitative time-difference between VLF/LF and first VHF signals. Positive differences signify that the VLF/LF signal appeared earlier than the VHF signal.

# Current-amplitude distribution of LF IC-strokes coincident with a first VHF-source in an IC flash



CG-equivalent current

# Cloud Lightning: Simultaneous VHF and VLF/LF Emission

## Historic findings

### Ogawa and Brook, 1964:

K-changes have 1 – 4 kA currents, can be termed recoil strokes, and represent major IC contributions

*„The K-change, because of its length, short duration, and direction of propagation must be viewed as an **intracloud** return **stroke**.“*

### Shao and Krehbiel, 1996:

They show for a cloud flash that the slow and fast E-field records have field changes that occur at about equal times as VHF signals (during both the active and the final stage)

note:

quantitative IC-information was sparse, locations and CG-equivalent IC-currents have not been determined

# Cloud Lightning: Simultaneous VHF and LF Emission

New **quantitative** observations of IC discharges demonstrate:

- VHF and LF signals show up simultaneously on a  $\sim 100 \mu\text{s}$  scale
- time coincidences are abundant
- VLF/LF signal-amplitudes extend to the same order of magnitude as for CG-strokes

## Conclusion:

VLF/LF IC-strokes are associated with initial breakdown

# Cloud Lightning: Observation of IC-Strokes

## Conventional lightning:

- bidirectional leader, many steps, ~10 ms,
- IC : K-change, streamer
- CG: return stroke

main emission

VHF

VHF + VLF/LF

VLF/LF

## Observation:

- sudden charge neutralization without measured precursory EM-activity
- large current within a short time
- reminds of NBE (rare, different from classical lightning)

## Questions / Interpretations:

- what is detected by -> VHF (DF/TOA) and -> VLF/LF systems ?
- is there undetected precursory EM-activity ?
- VLF/LF radiation from long channels, adequately termed as IC-stroke ?



**Thank you for your attention**