

Total Lightning in the VLF/LF Regime: Results from LINET with 21 Sensor Sites and Small Baselines

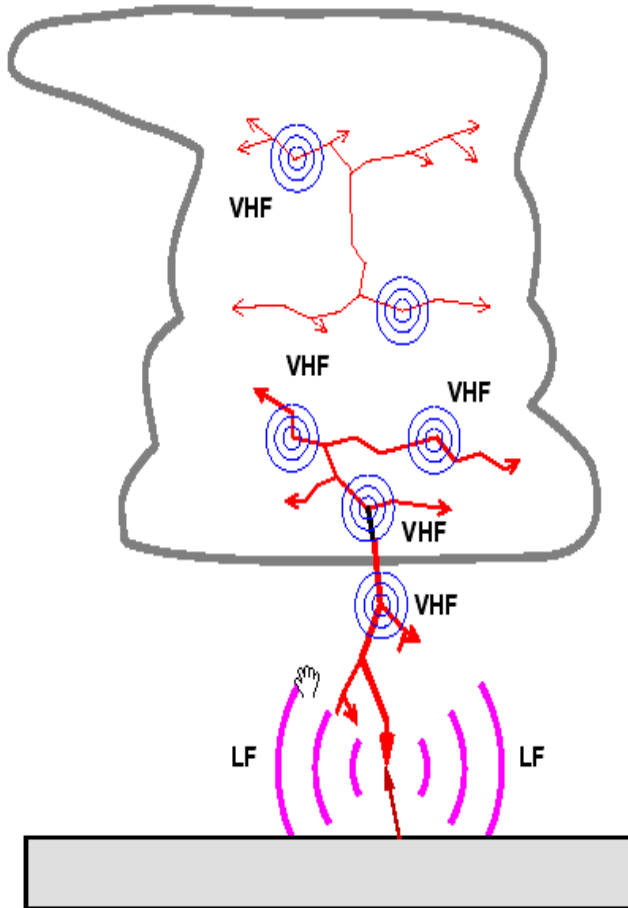
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D-Wessling

Some Questions In Lightning Research

- IC types and observable radiation band in the VLF/LF-regime
- true amplitude distributions of IC and CG discharges
 - how weak are the weakest discharge currents
- mechanism of initial discharge:
 - cosmic rays or high electrical fields
- quantitative recombination channels
 - relative importance of lightning for the global electrical circuit
- physics and chemistry of convective cells
 - role of lightning for NO_x production
 - scaling of lightning data in local and global networks

VHF and LF Radiation



„classical picture“

CG-related

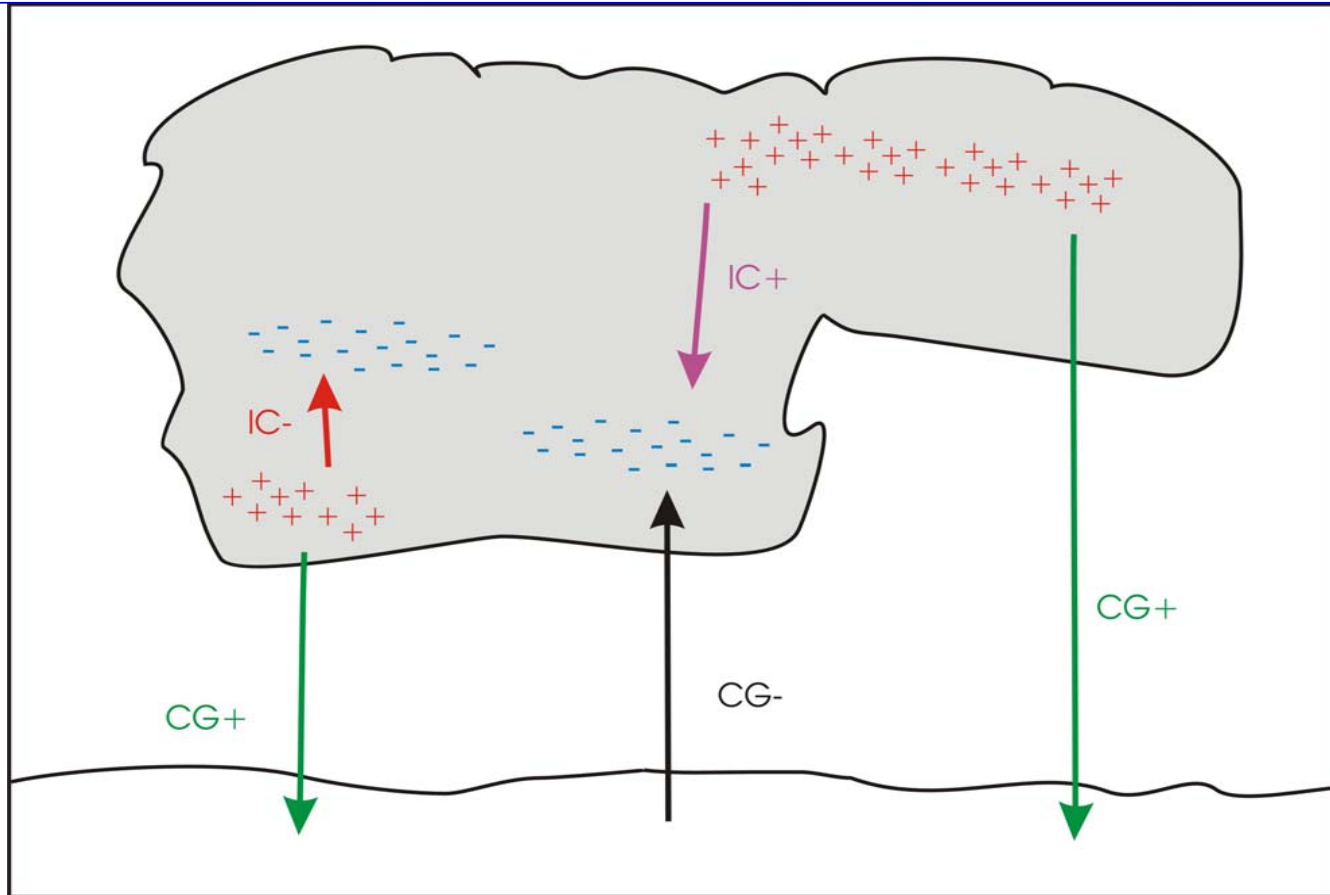
IC – activity (PBL)	VHF, LF
stepped leader	VHF
attachment	
return stroke	LF
IC – activity	VHF
dart leader	VHF
subsequent strokes	LF

IC-related

IC - stepped leader	VHF
IC - ???	LF

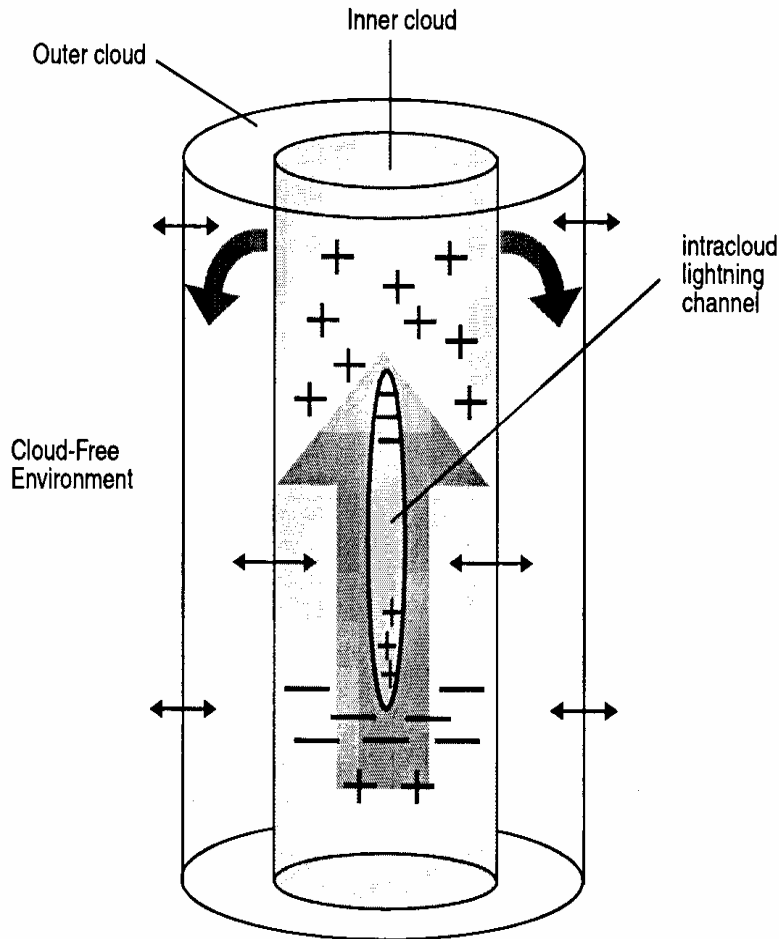
simplified more realistic picture

VLF/LF Emission of IC and CG



IC discharges radiate in the VLF/LF regime, just as CG strokes

EMTM: numerical ElectroMagnetic Thunderstorm Model



Initiation of Discharge?

- > high E-field (hardly measured)
- > runaway-discharge due to cosmic rays

Length of Discharge:

very short (50 m)

VHF

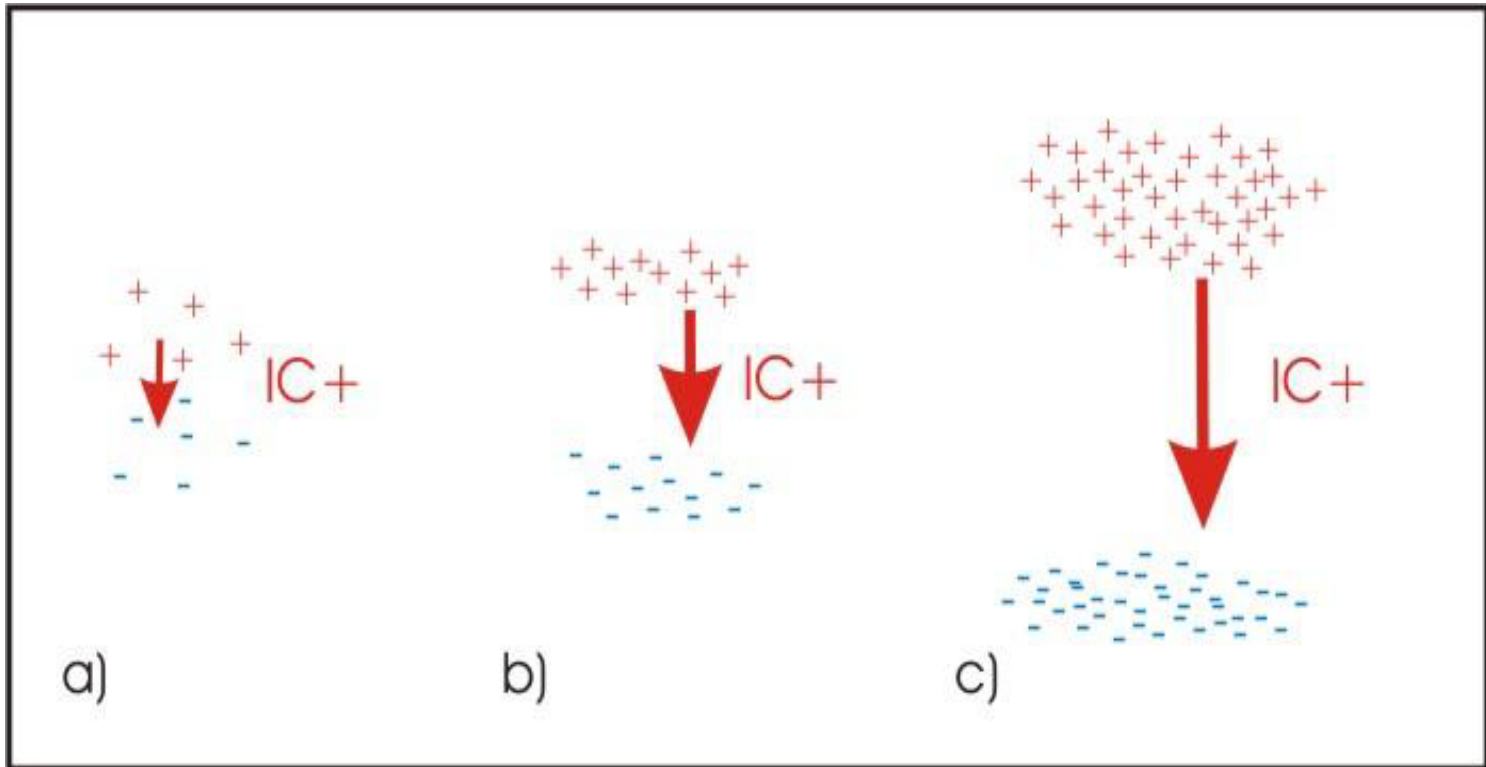
longer (km), IC+
frequent, weak current

VLF

long (km), IC+
rare, strong current

VLF

Amplitude Variation of IC (VLF/LF)



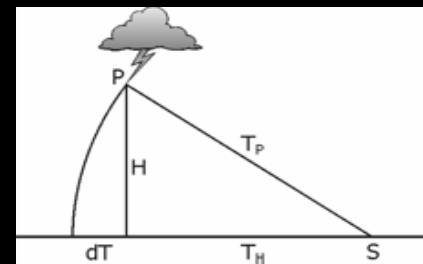
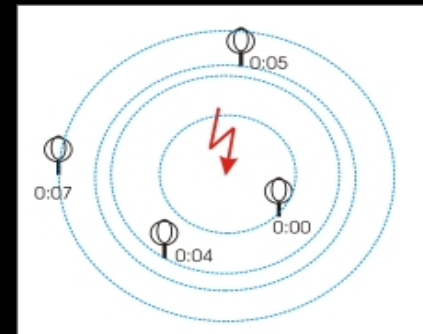
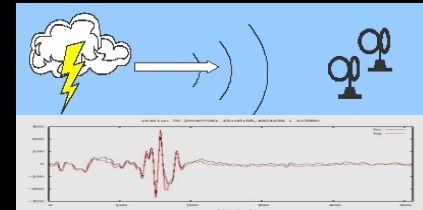
concept: critical fields require more charge for an initiation of discharges in longer channels and, thus, longer channels tend to produce stronger currents

Total Lightning – VLF/LF

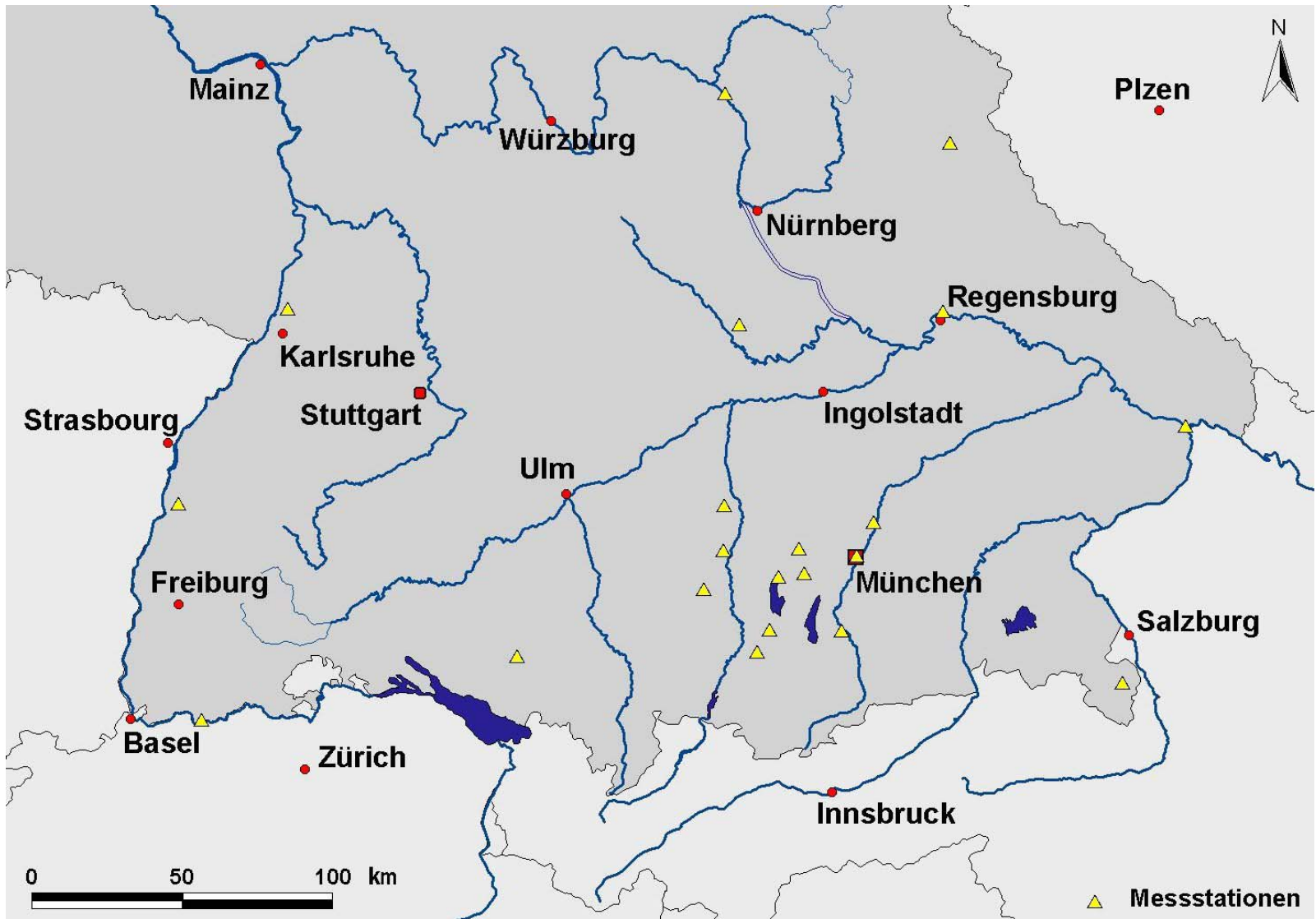


LINET System Features

- ▶ **Measurement of Magnetic Induction**
 - no deadtime
 - all signals utilized
 - high efficiency for low amplitudes
 - equally sensitive to CG and IC
- ▶ **TOA Locating**
- ▶ **3D Discrimination of CG - IC**
- ▶ **Height Determination of IC-Sources**



LMU – Network 2005



IC – Waveforms

Signal shapes of intracloud discharges can vary greatly:

- relatively clean bipolar signals
- near-bipolar signals, trend to monopolar, but with rapid repetition of pulses
- multipolar signal train

Identification of IC discharges in the LINET network:

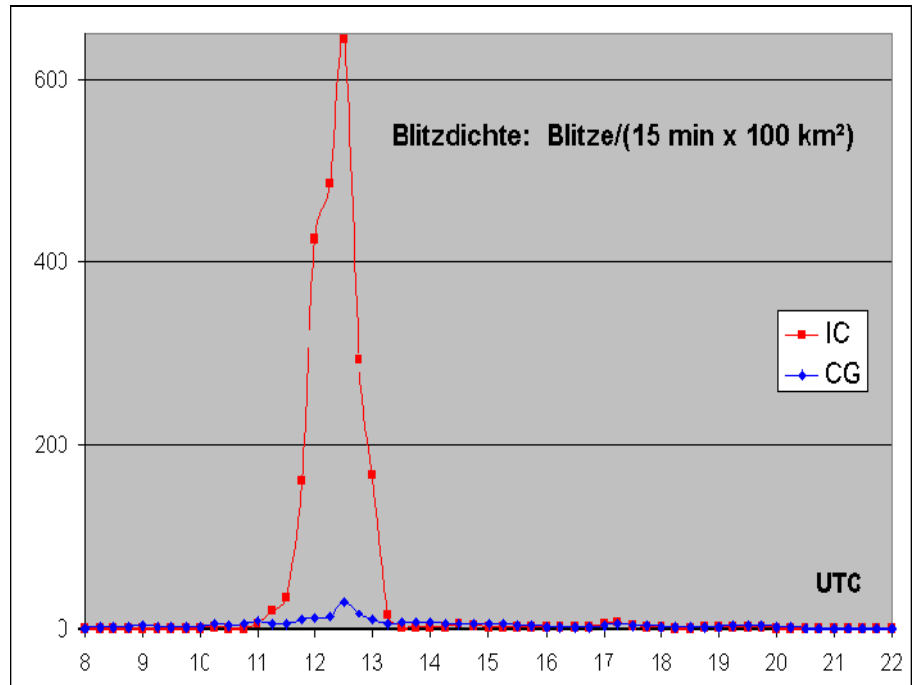
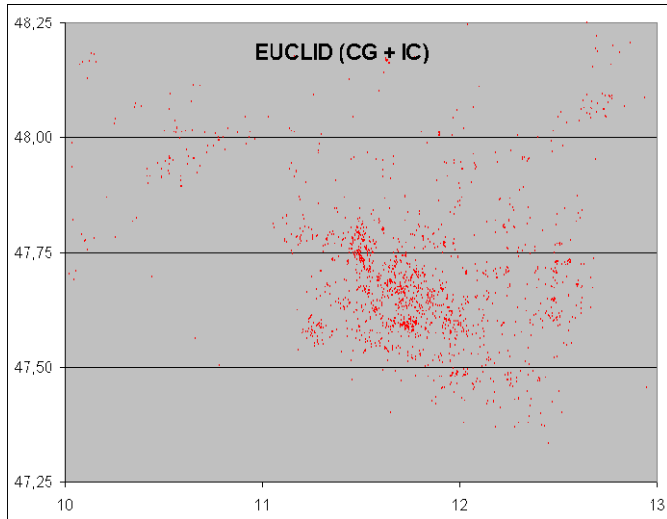
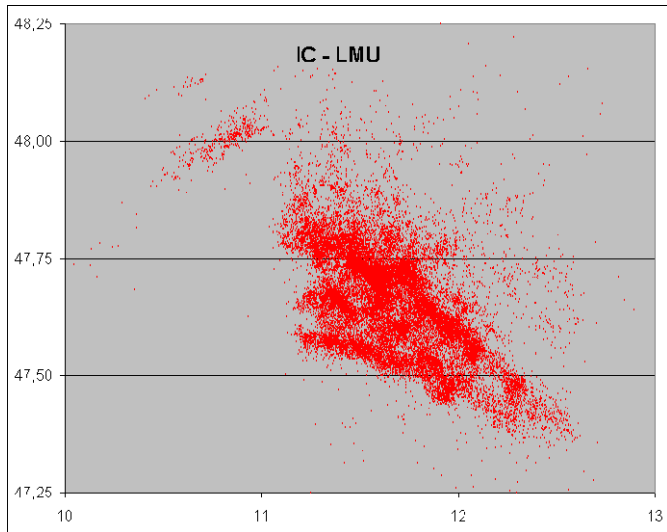
- direct 3D-locating
- observation of time shifts from double reflections on ground and ionosphere, recorded at many sensor sites

Use of IC-information:

Early detection of convective cells

Recognition of severe weather conditions (e.g. super-cells)

Supercell July 25, 2005 (Munich area)



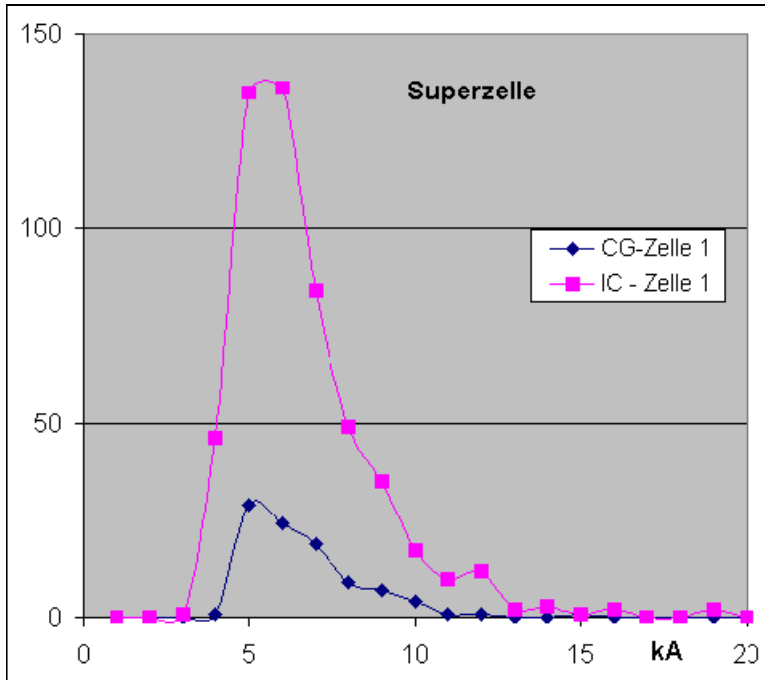
LMU Network:

records IC lightning

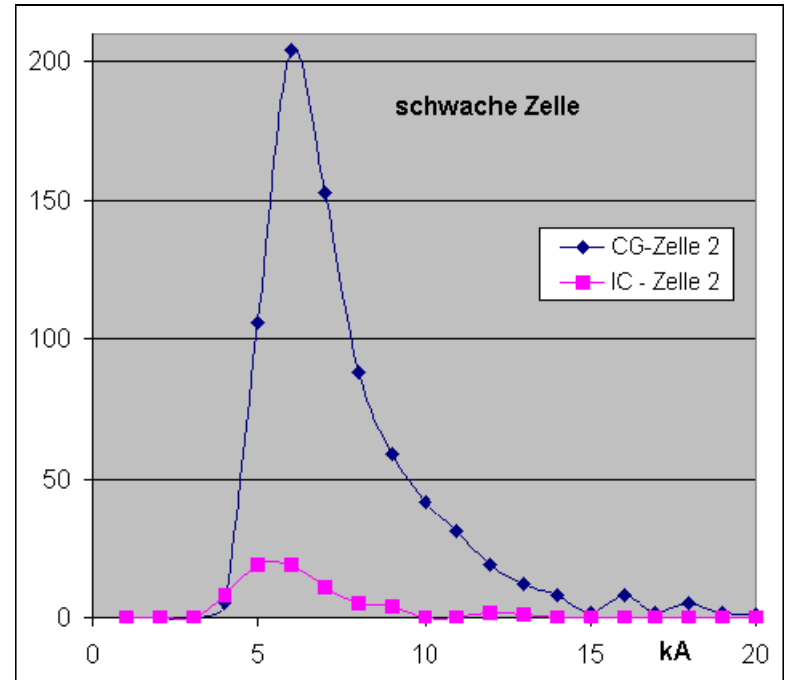
detects super cells

(hail, micro-bursts, heavy rain)

Distribution of CG and IC Lightning

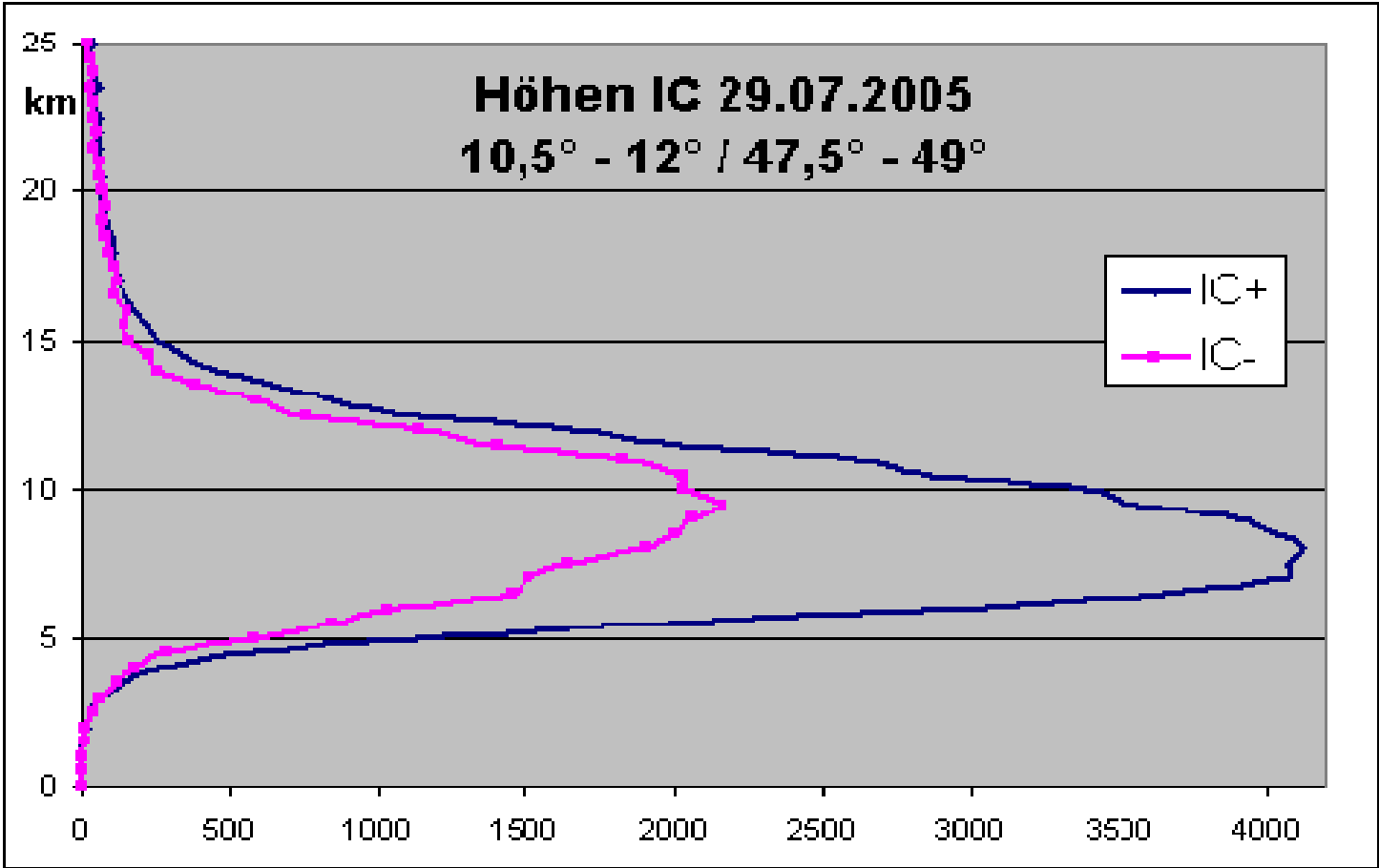


strong convection:
IC dominates

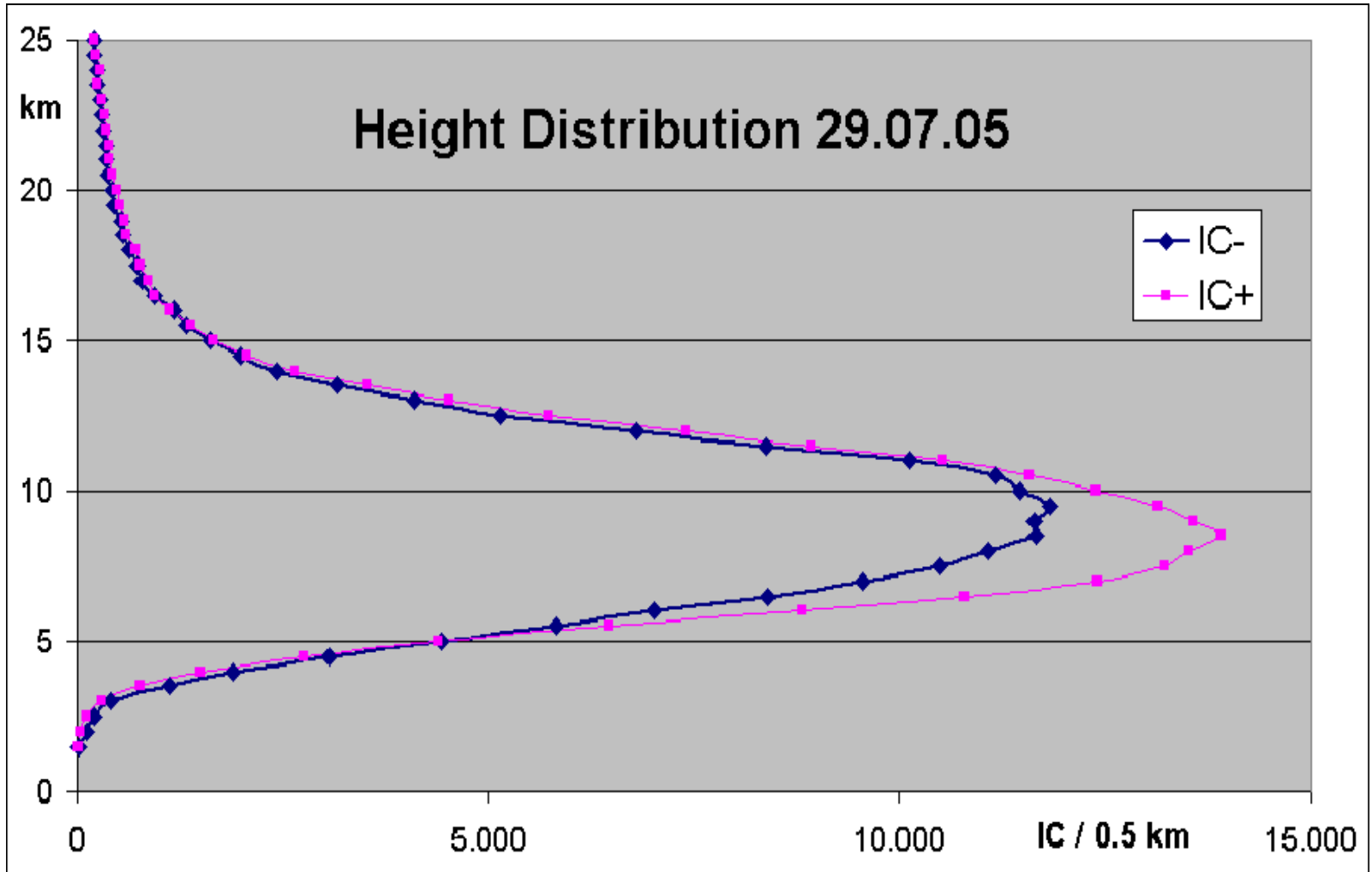


weak convection:
CG dominates

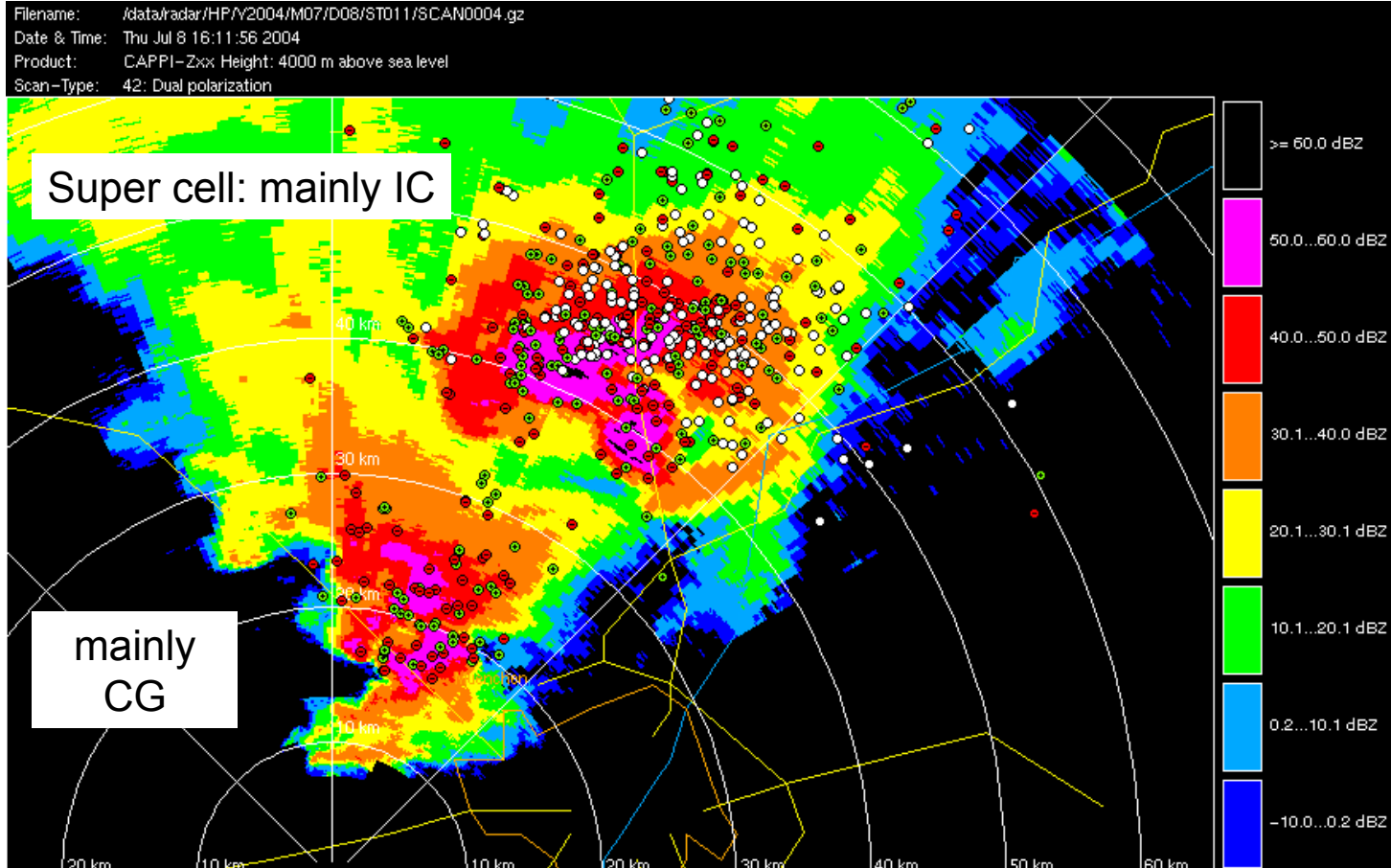
Distribution of IC Source Heights



IC Lightning, Munich area 7-29-2005



Radar and Lightning



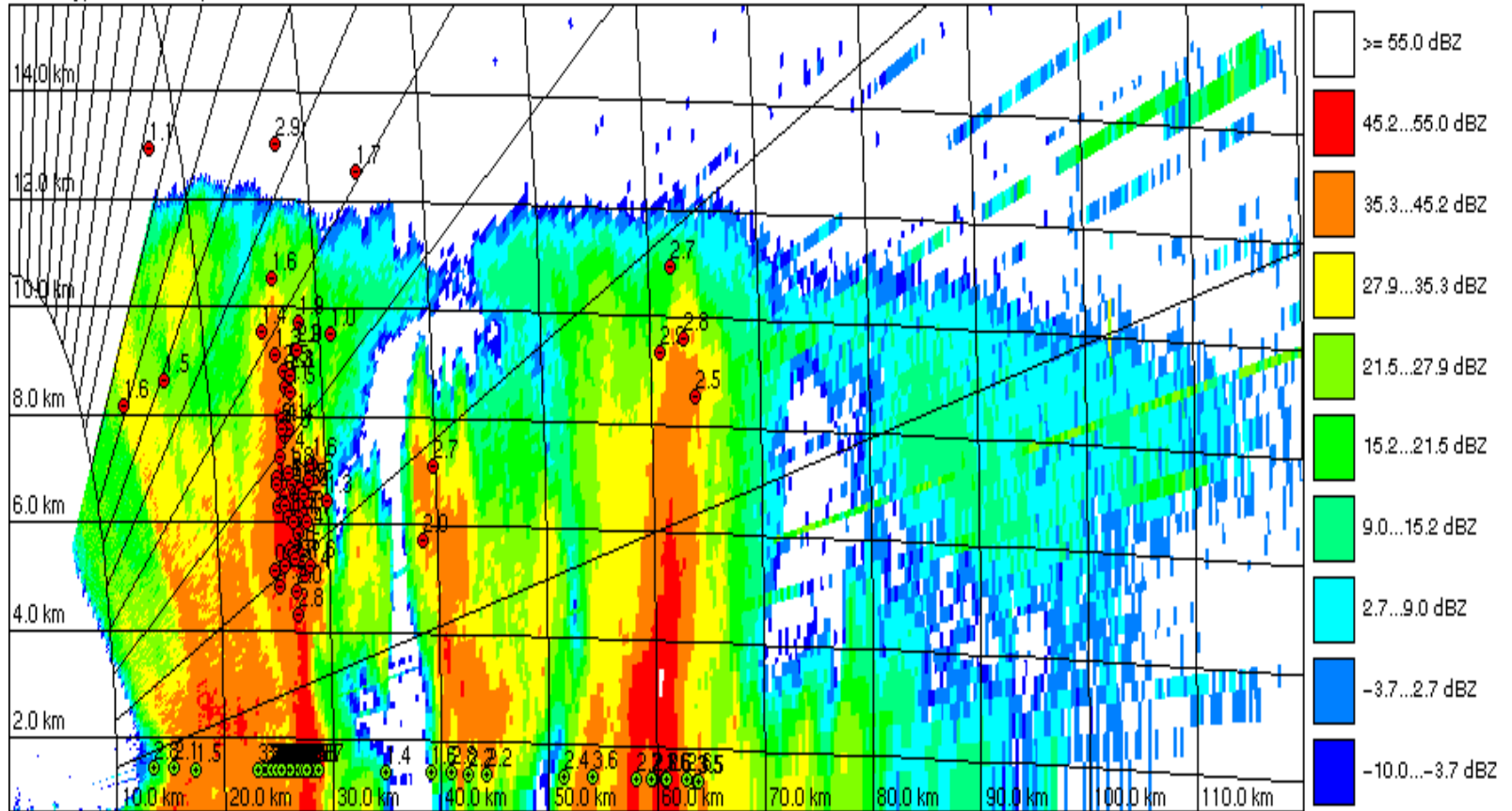
Radar and IC Source Height

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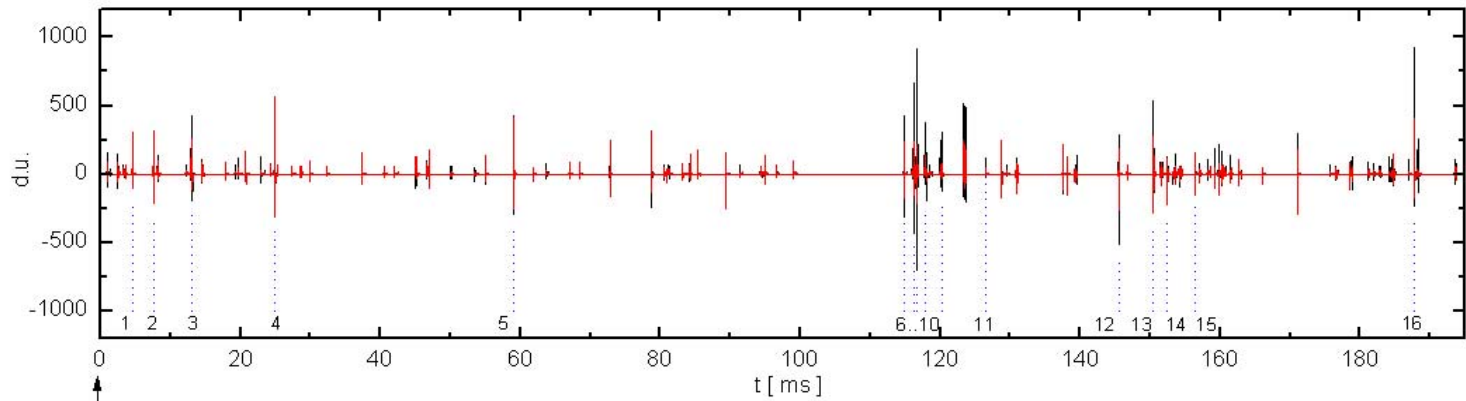
Date & Time: Wed Jun 29 13:22:31 2005

Product: RHI-Zxx Azimuth: 100.0 deg

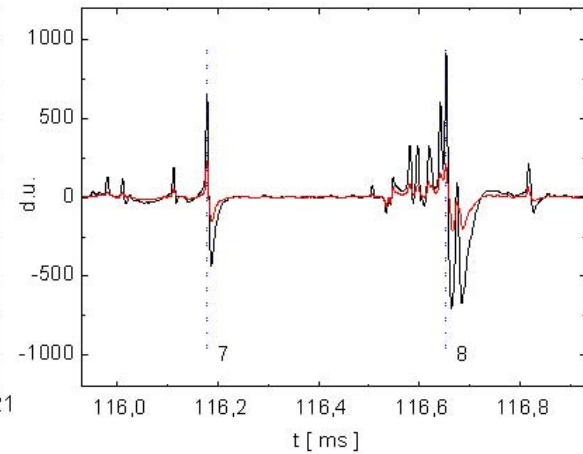
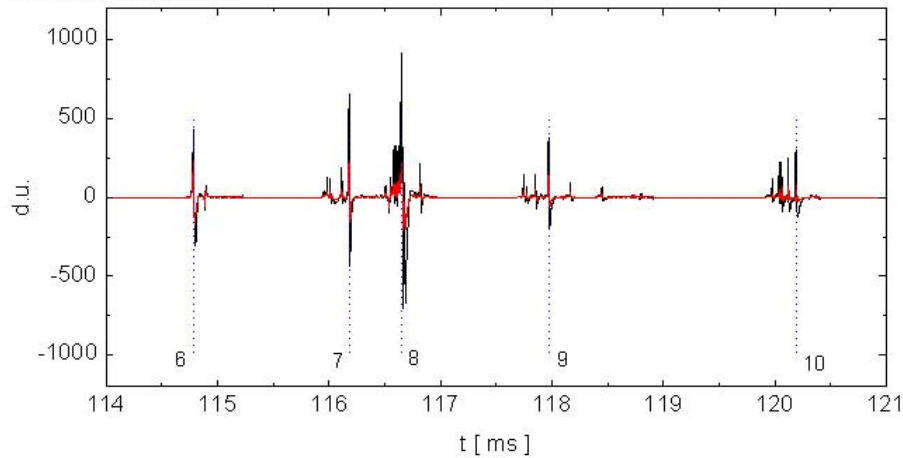
Scan-Type: 42: Dual polarization - PRF: 1200 Hz



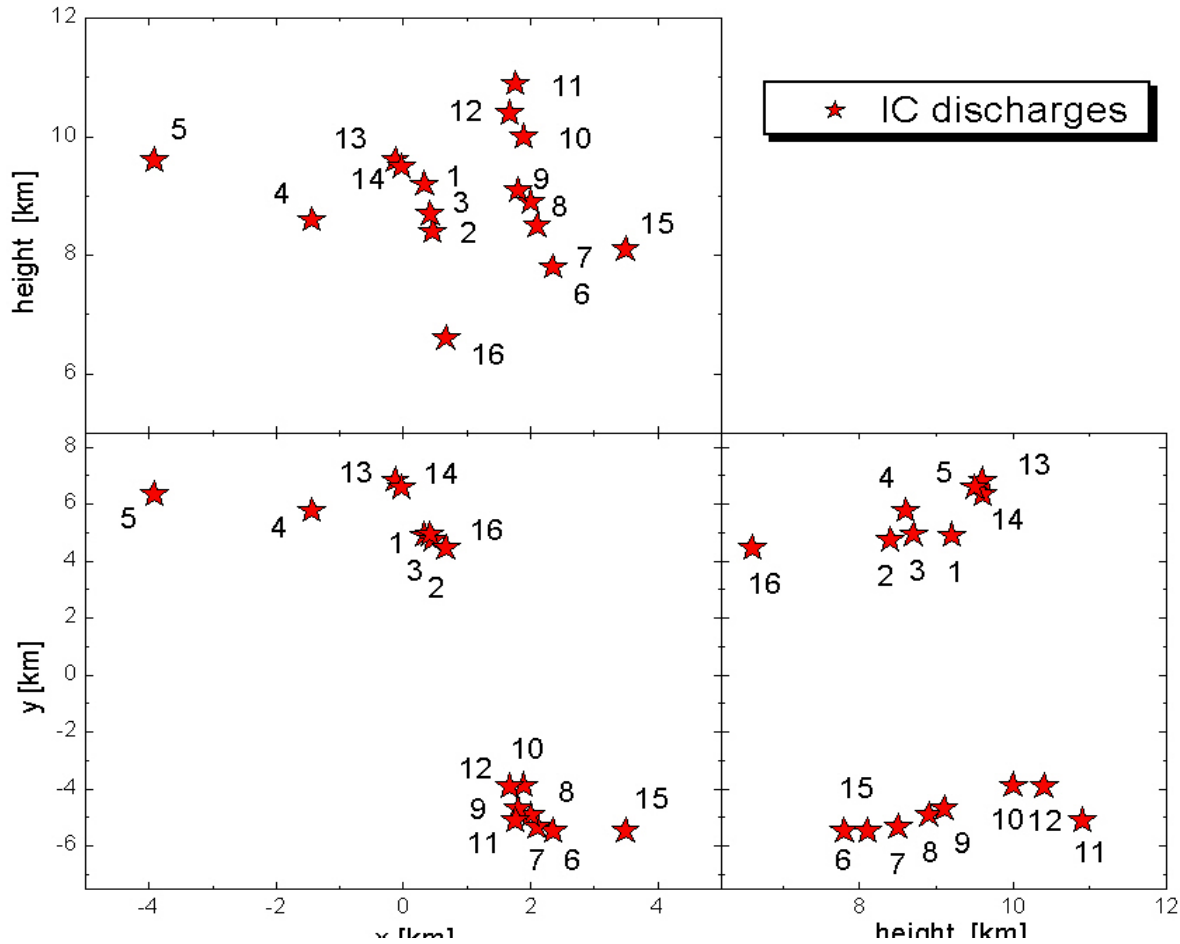
Multiple IC Flash



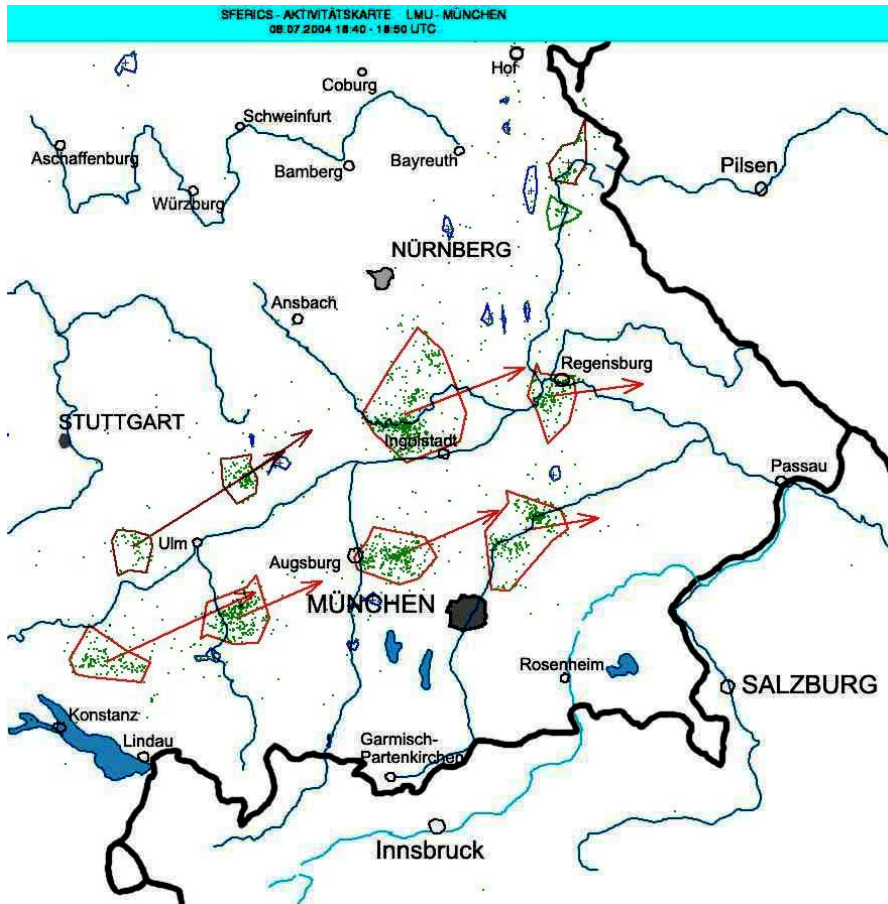
17:05:38.2468289 UTC



Multiple IC Flash



Cell-Tracking



Grouping of
Signals to Clusters

Tracking of each
Cluster in Time and Space

Nowcasting
by Extrapolation