CZECH
HYDROMETEOROLOGICAL
INSTITUTE

DEPARTMENT OF
ATMOSPHERIC PHYSICS
CHARLES UNIVERSITY

SEVERE STORM NOWCASTING

SATELLITE AND LIGHTNING DATA COMBINATION

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Convection Working Group Workshop

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OUTLINE

- motivation of this work
- data used in this study (software, source)
  - satellites (McIDAS-V)
  - lightning detection network (R)
  - ESWD (ESSL)
- possible usage in nowcasting

MOTIVATION

- **<u>objectives</u>:**
  - better understand processes inside the storm
    - » use remote sensing to monitor the storm life-cycle
  - connect satellite and lightning observations
  - application in severe weather nowcasting

Total lightning is the best early indicator of a strengthening updraft within a storm.

European Conference on Severe Storms 2013, Helsinki
Schultz, Petersen, Carey (2011) in Weather and Forecasting

SATELLITES

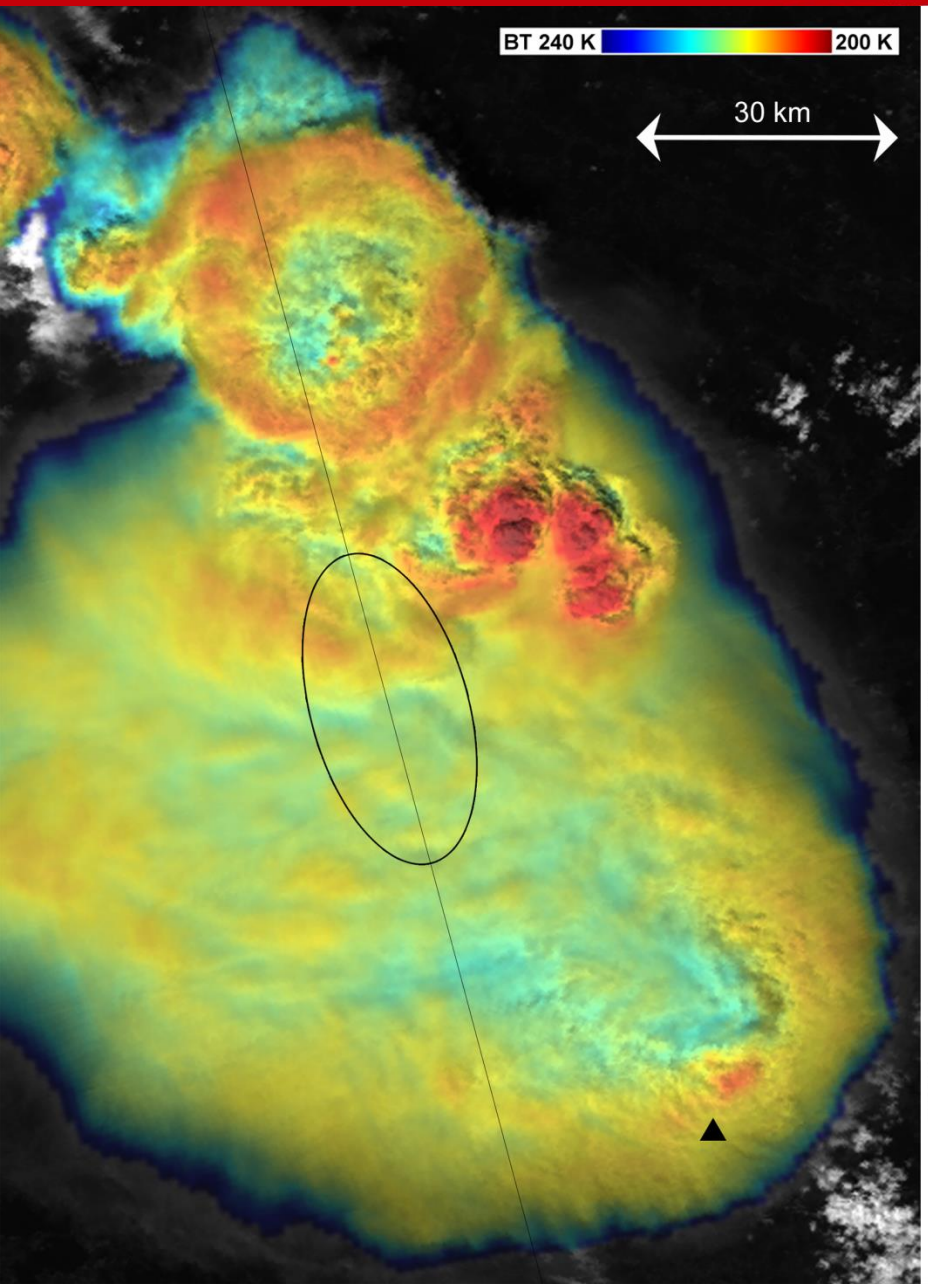
- microphysical properties and dynamics

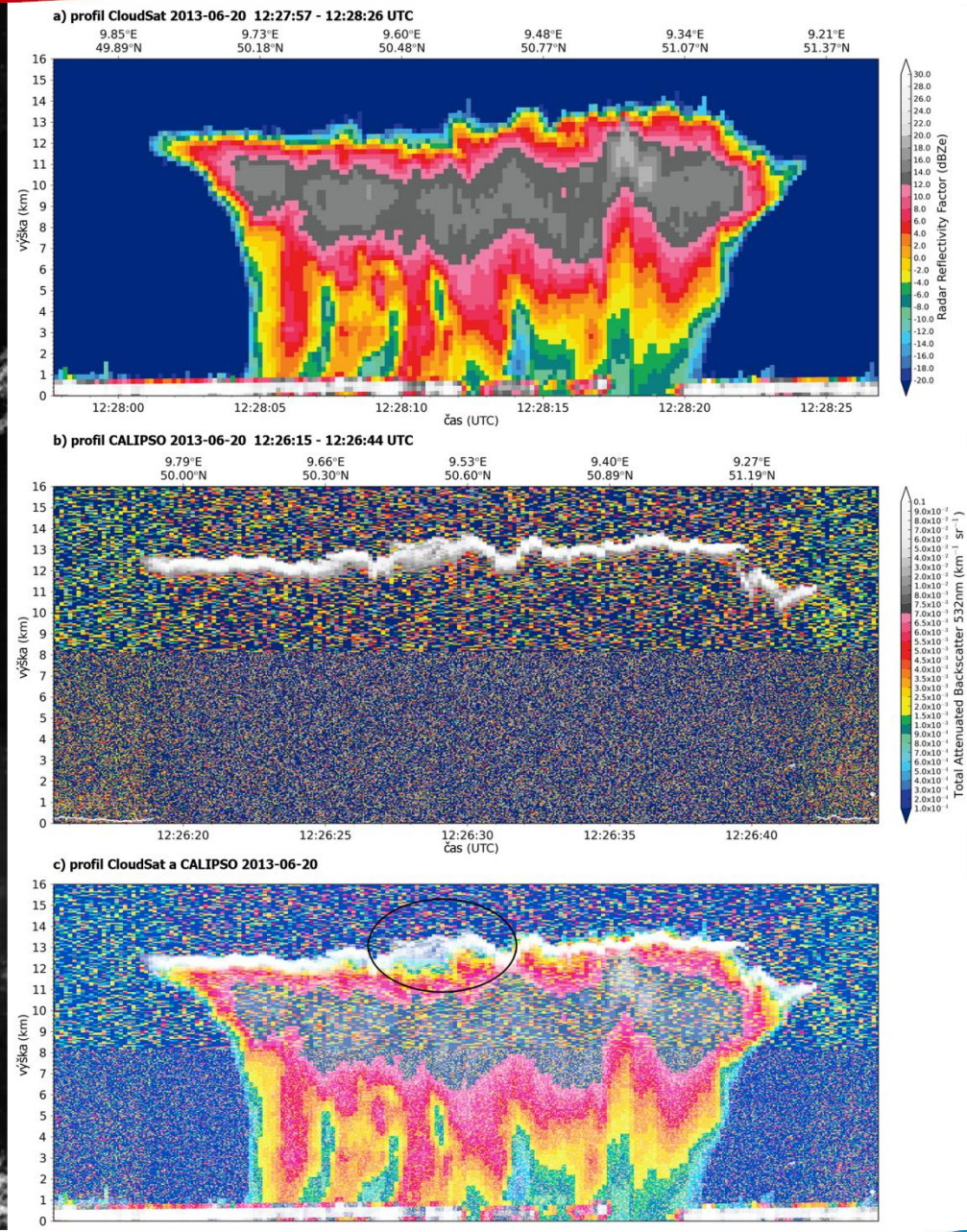
geostationary – temporal resolution:

- Meteosat/SEVIRI RSS
  - » 2.5 min (experimental), 5 min

polar orbiting – spatial resolution:

- Suomi NPP/VIIRS
  - » Image bands, Day/Night Band
- Aqua/MODIS
- CloudSat/radar and CALIPSO/lidar, imagers



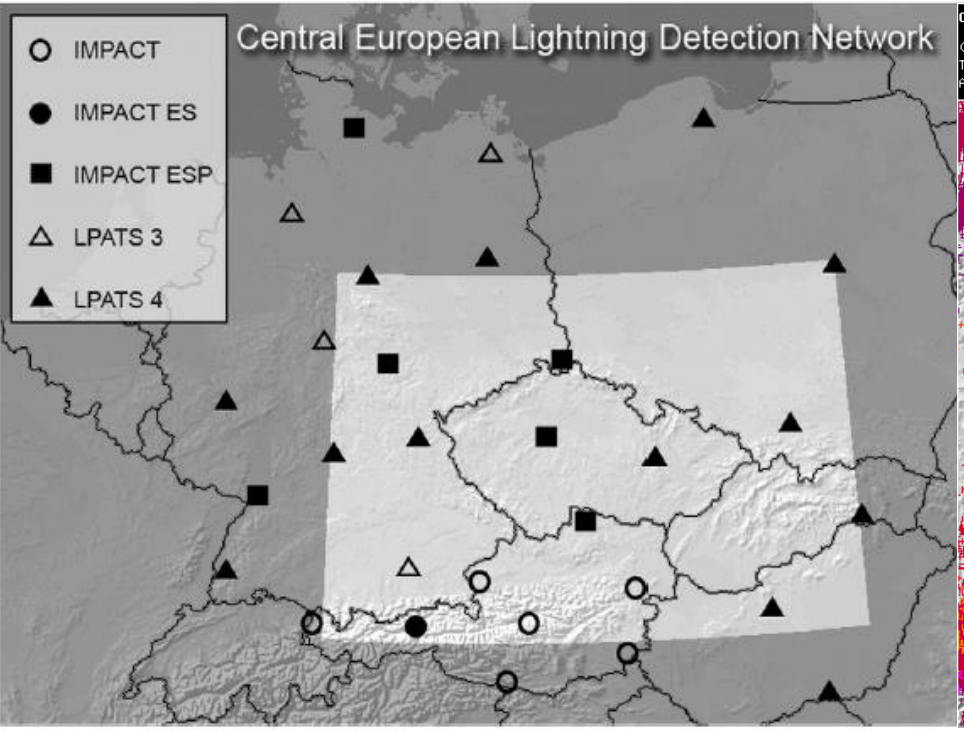


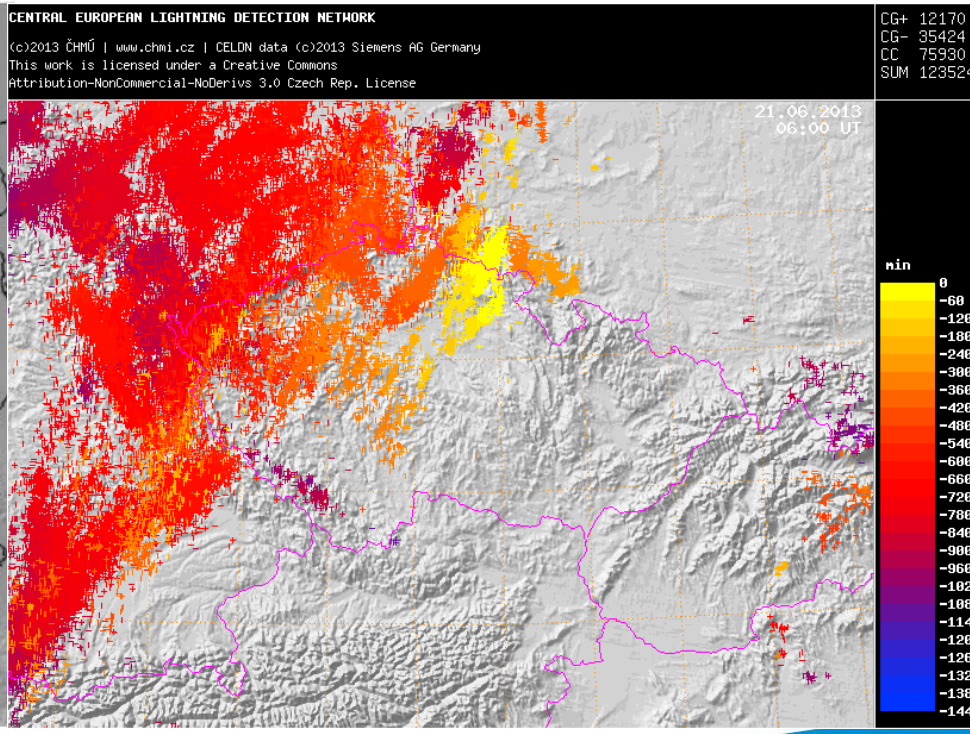
Aqua/MODIS 2013-06-20 12:25 UTC; hail occurrence at 12:26 UTC

LIGHTNING DETECTION

CELDN (Central European Lightning Detection Network)

- part of EUCLID, operated by Siemens AG
- operatively used in CHMI





LIGHTNING DETECTION

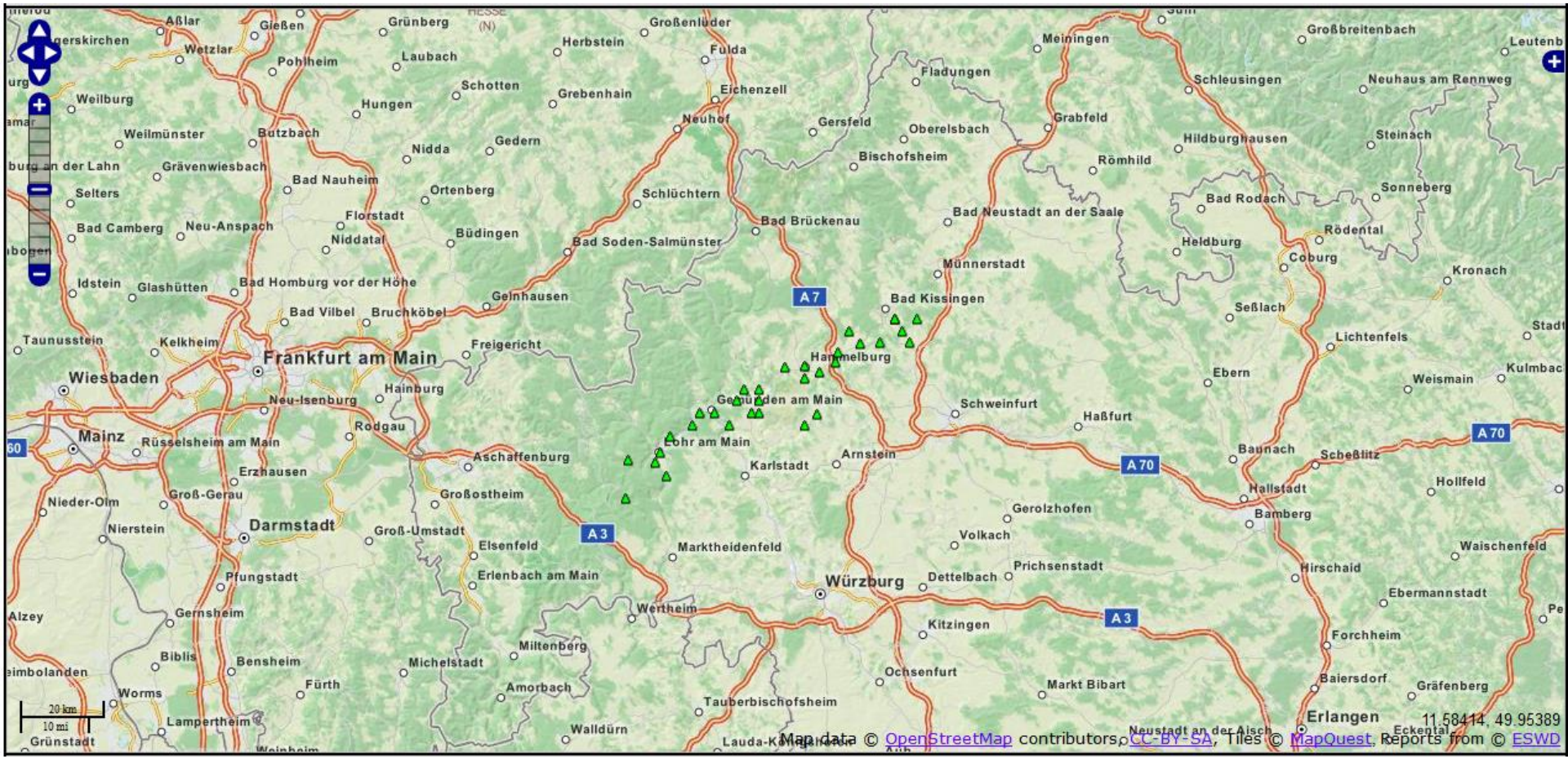
- microphysical properties, strength of updraft

every stroke: type (CC, CG), time [ms], location, current amplitude estimation [kA] and polarity

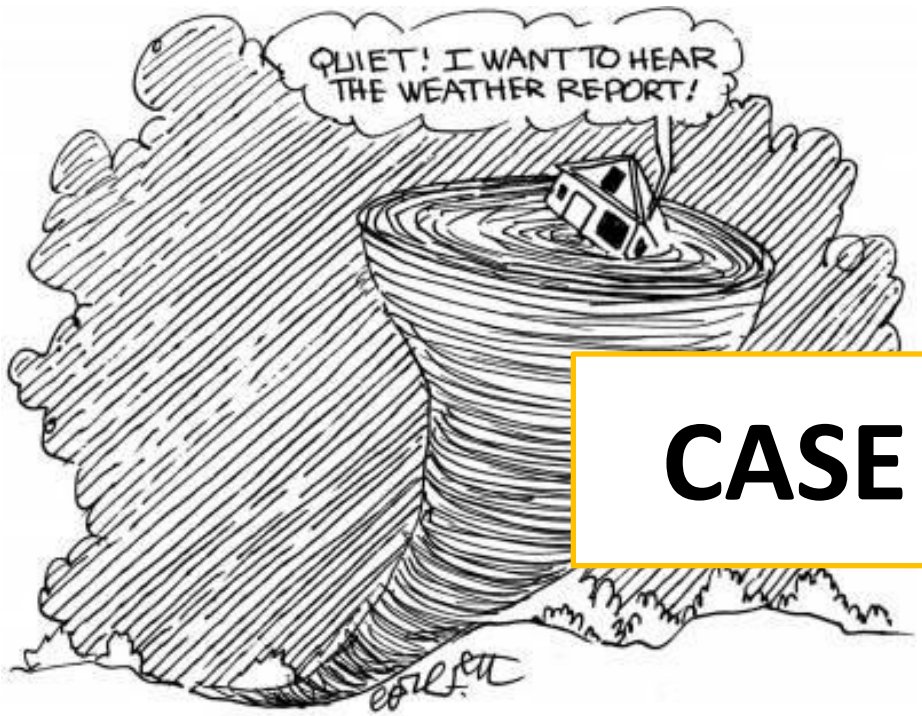
3 2013 6 20 15 13 45216 10.67651 48.01096 -12

- very long waves → detection efficiency
  - 70 % for CG × 5-30 % for CC
- location accuracy about 1 km for CG
- uncertain estimate of current amplitude ~ tens of %
- no stroke clustering into flashes

SEVERE WEATHER



- severe weather report updating



CASE STUDIES

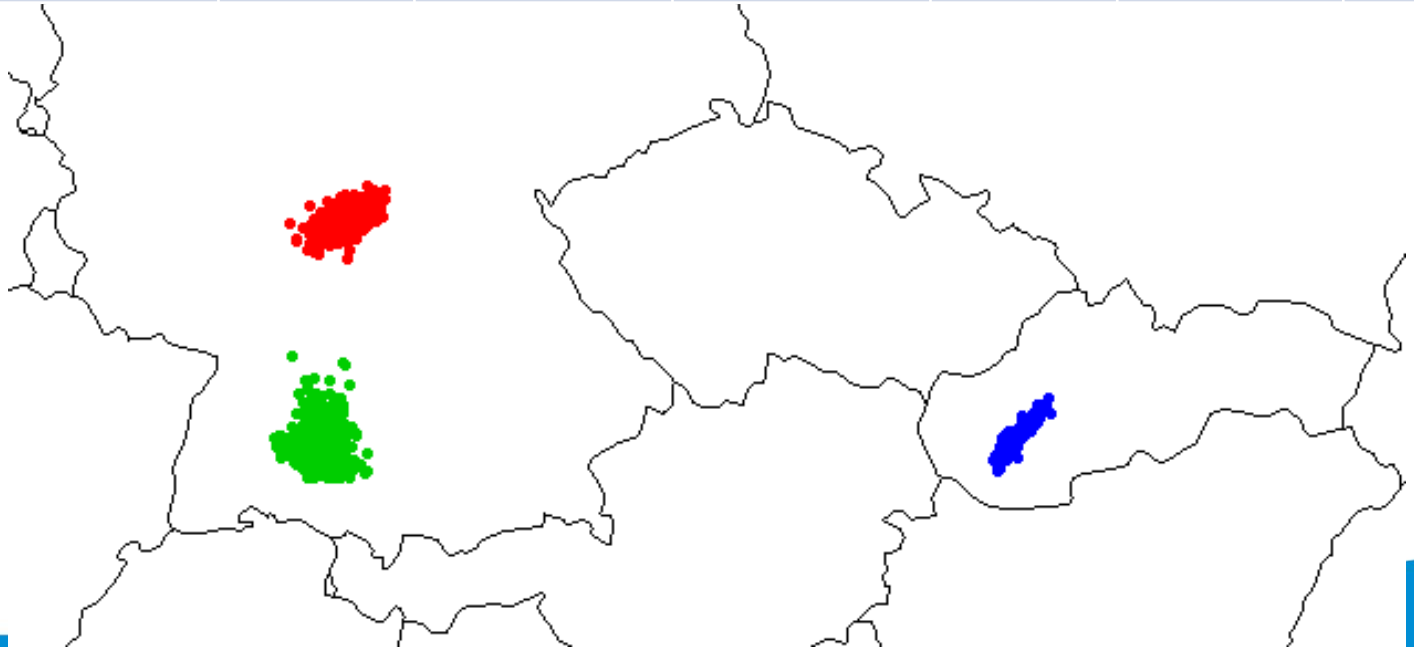
CASE STUDIES – FIRST STEPS

- storm selection:
  - occurrence within CELDN area (with exceptions)
  - long-lasting and isolated storms
  - during the daylight → RGB products creation

- connections during the storm life-cycle:
  - cloud top features determination
  - amplitude of strokes
  - pulsation in the number of strokes
  - severe weather occurrence

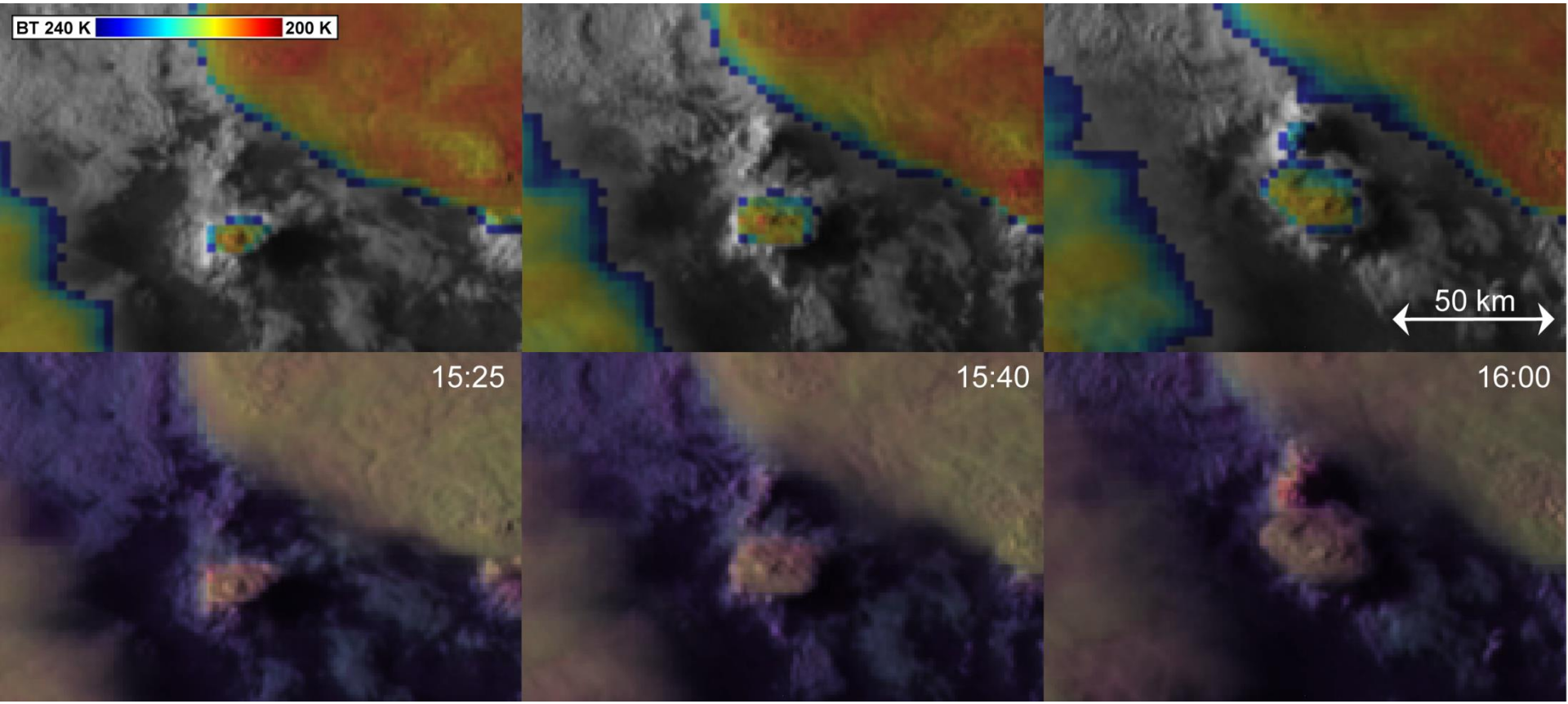
CASES OF SEVERE STORMS

case	date & time [UTC]	MSG RSS	number of all strokes	CC [%] of all strokes	CG+ [%] of all CG	amplitude max [kA]	hail (report status)
Hessen	20. 6. 2013 10:30 – 13:00	2.5 min	926	78.6	36.9	59	6 cm (QC1)
Baden	20. 6. 2013 14:00-16:00	2.5 min	2267	68.1	7.7	78 (247)	5.5 cm (QC0+)
Nitra	20. 5. 2015 14:40-16:45	5 min	873	71.4	10.0	83	2 cm (QC1)



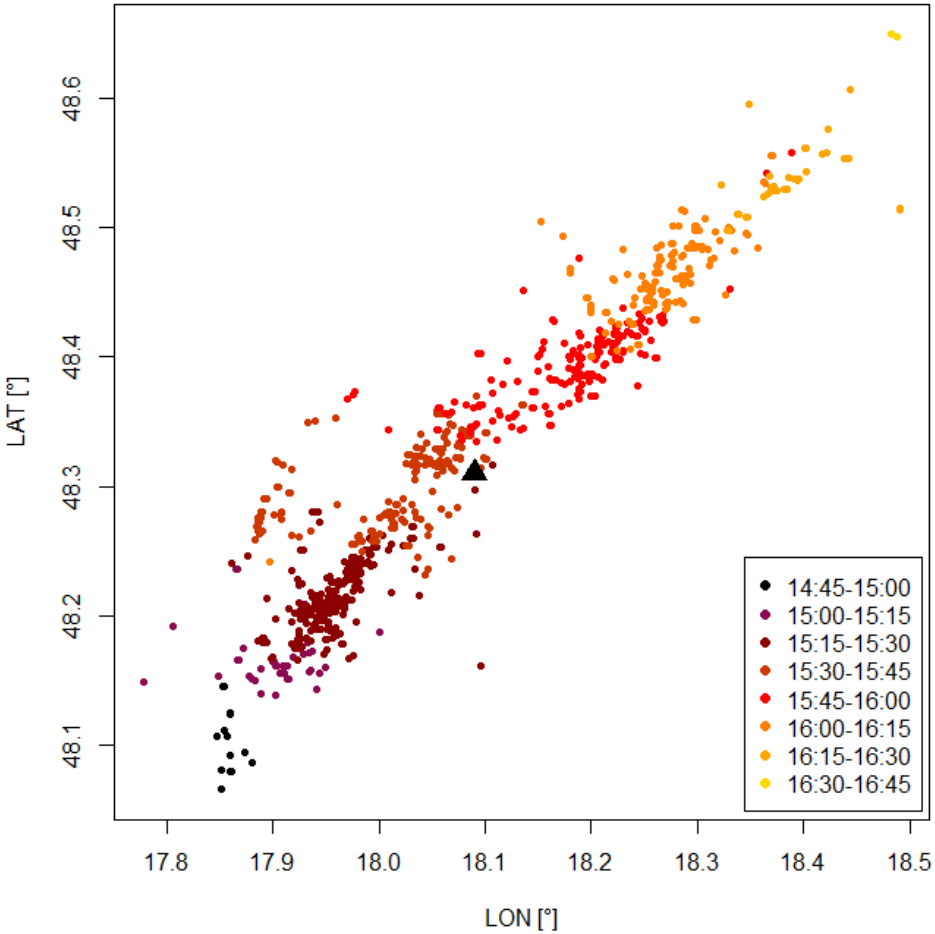
NITRA STORM

20 May 2015, 14:50 – 16:40 UTC, Slovakia

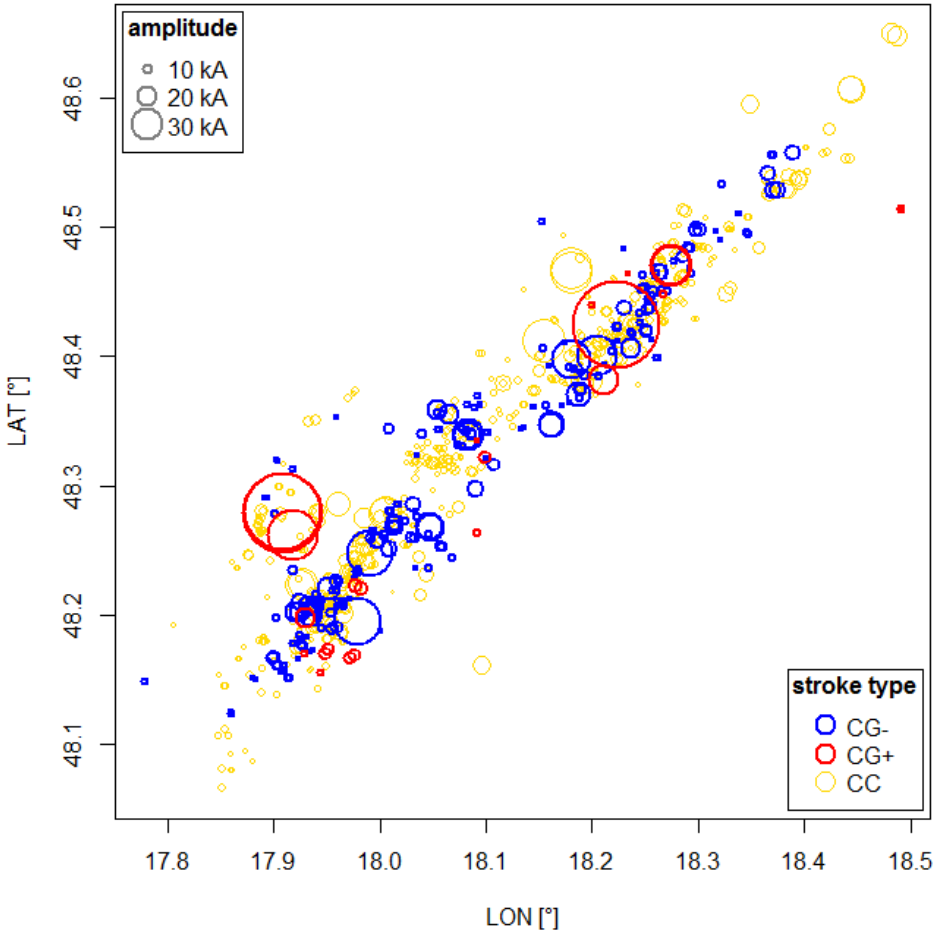


sandwich IR-BT & Storm RGB products

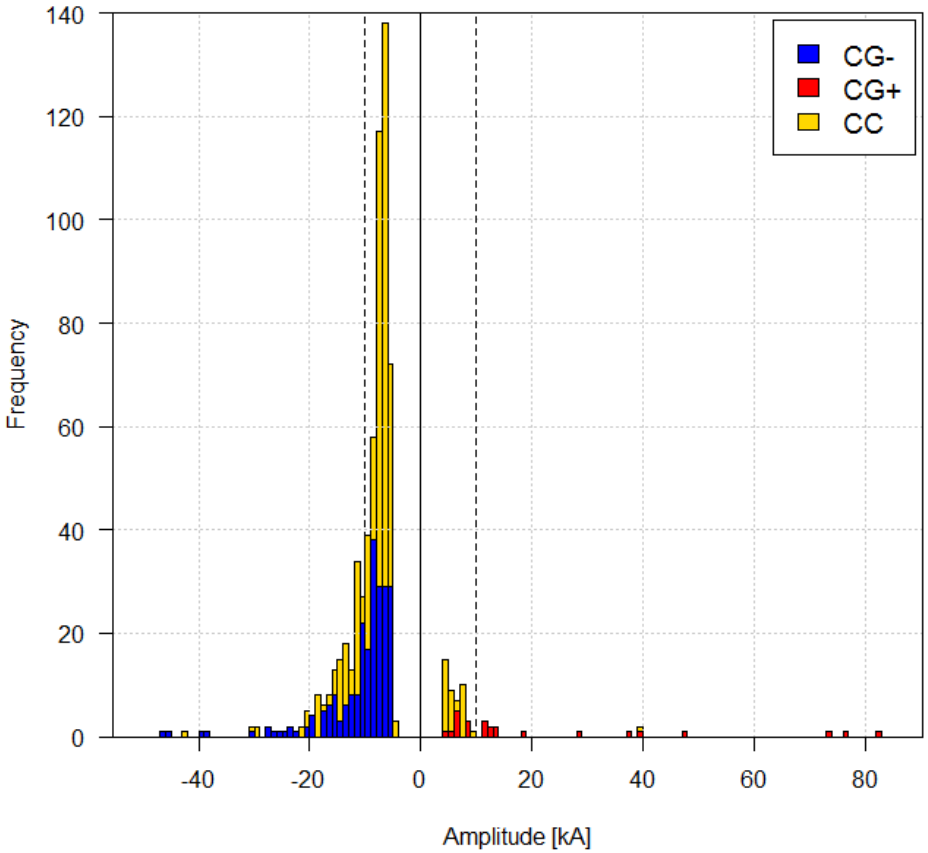
Time evolution of all strokes



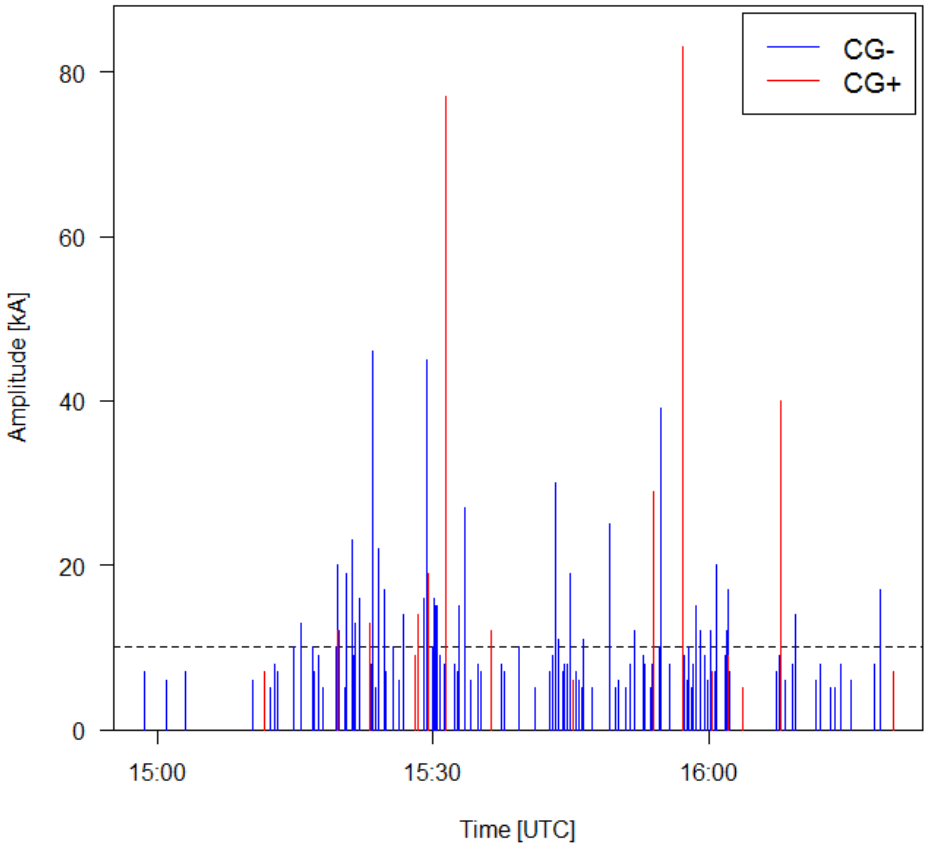
Distribution of different types of strokes



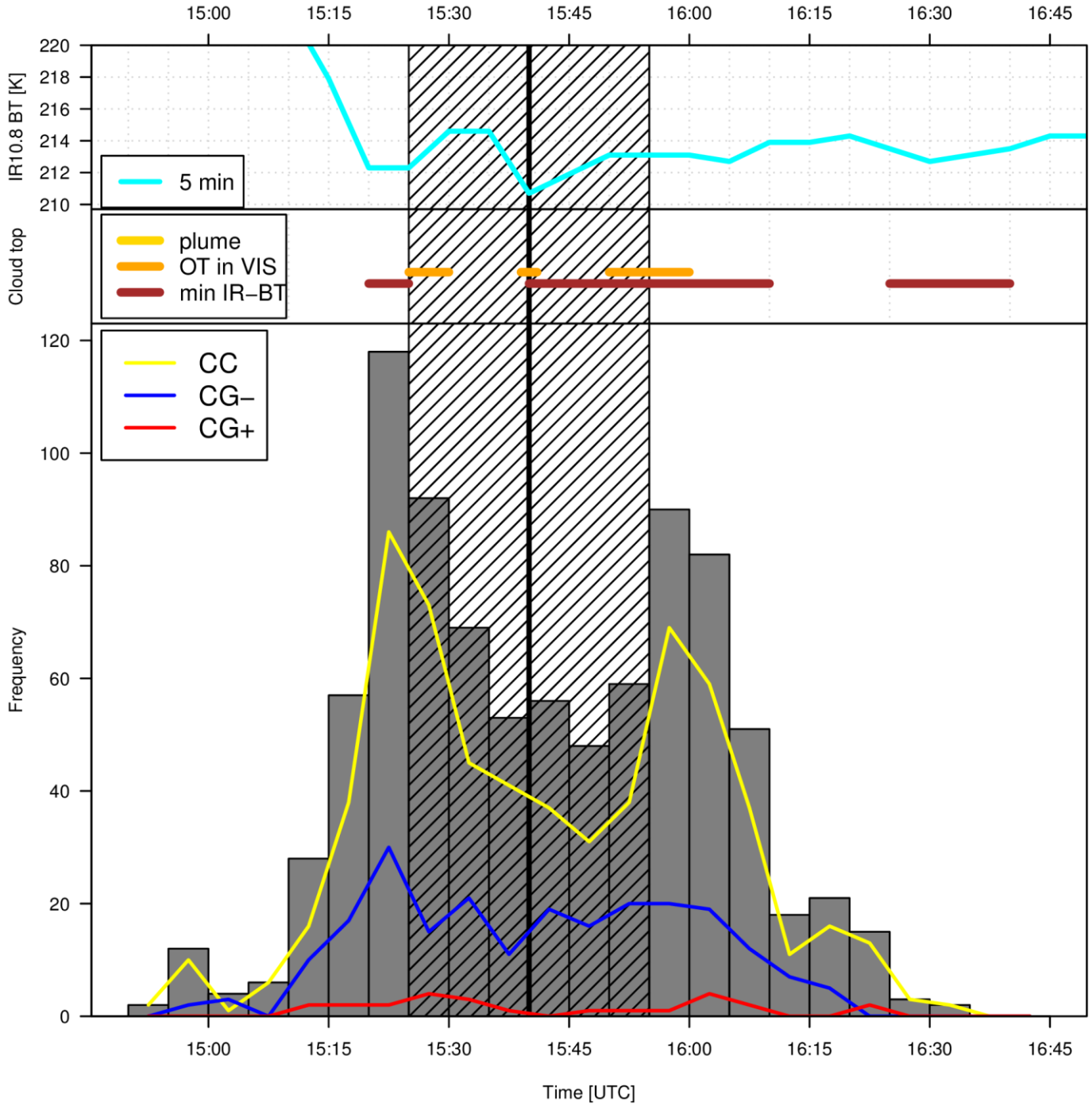
Amplitude characteristics



Frequency of amplitudes
of different types of strokes

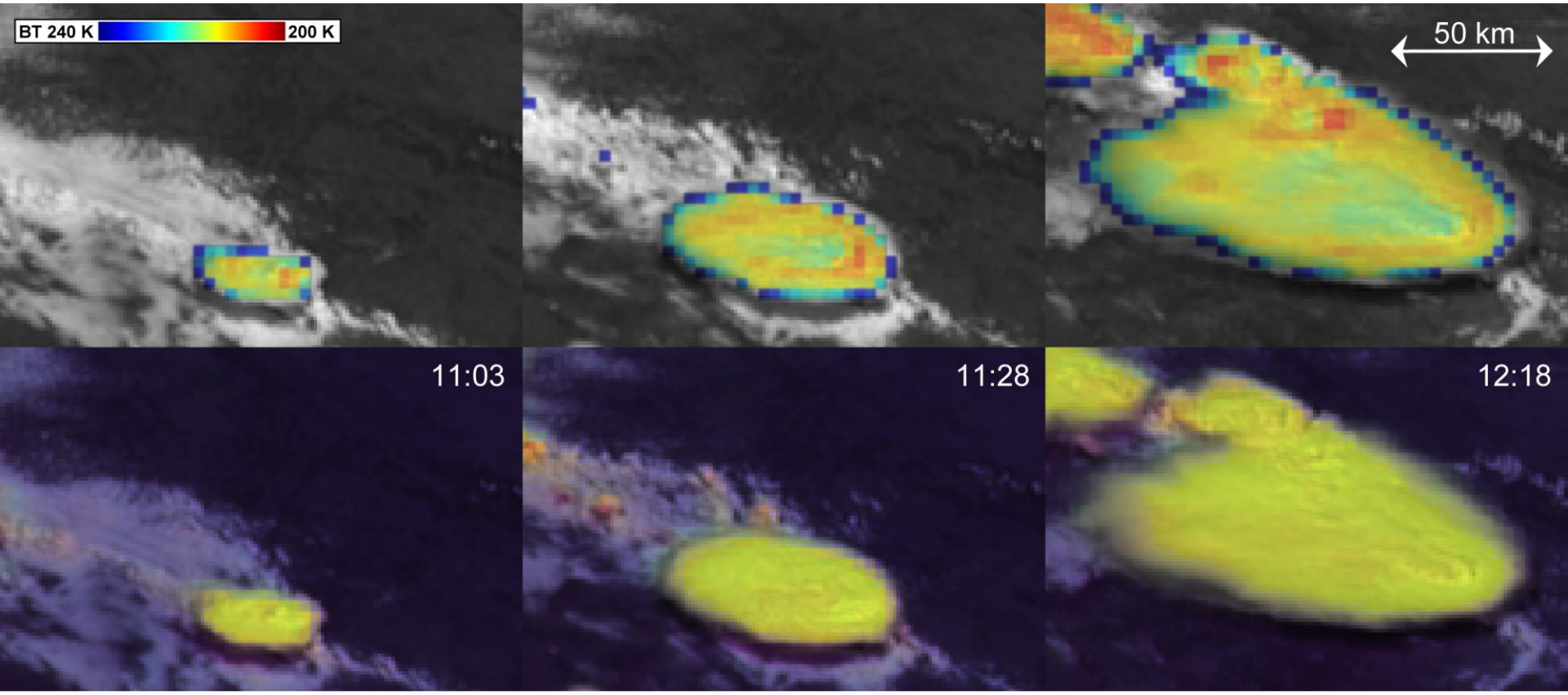


Evolution of CG amplitudes

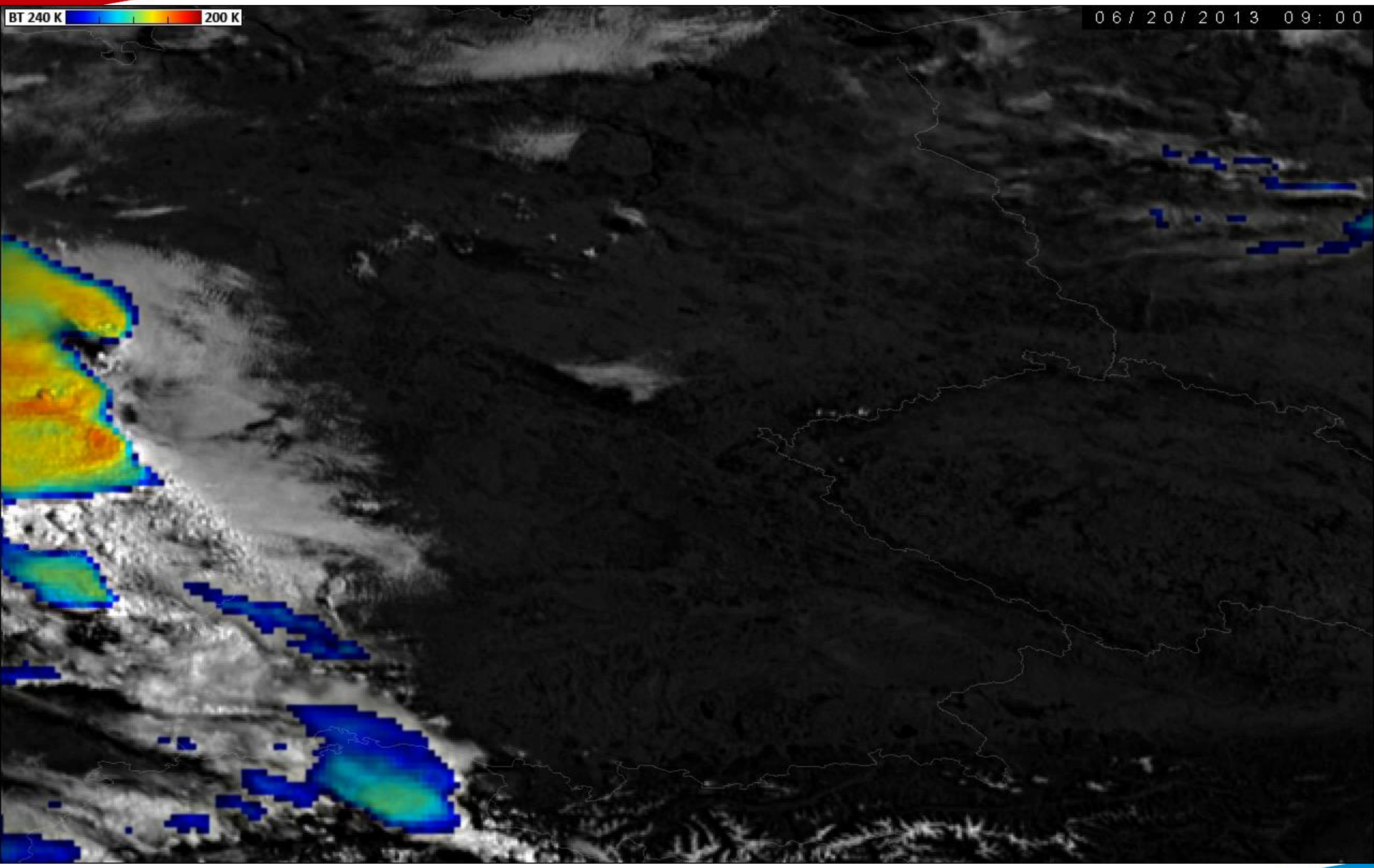

15:00
15:15
15:30
15:45
16:00
16:15
16:30
16:45
IR10.8 BT [K]
220
218
216
214
212
210
5 min
Cloud top
plume
OT in VIS
min IR−BT
Frequency
120
100
80
60
40
20
0
CC
CG−
CG+
Time [UTC]

HESSEN STORM

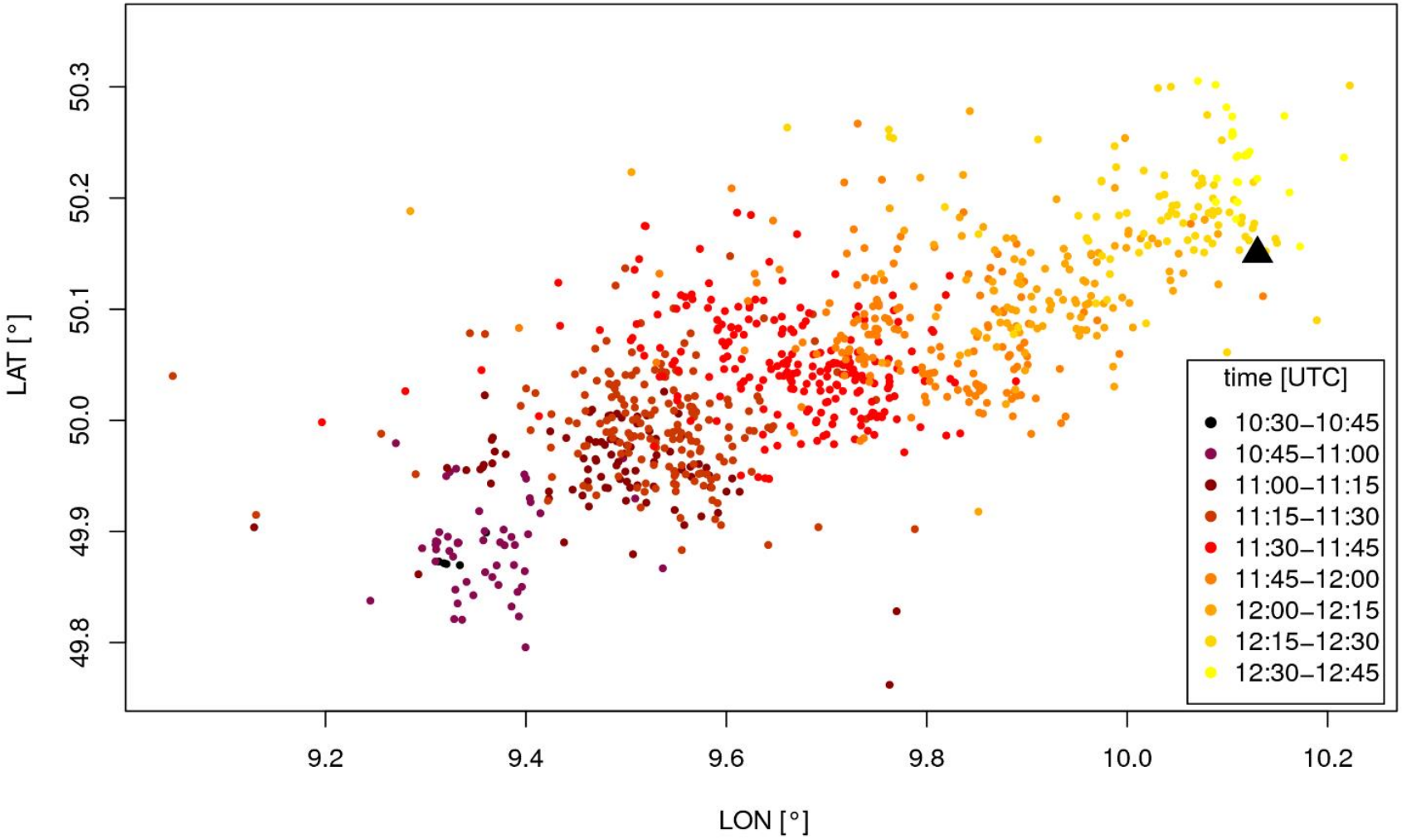
20 June 2013, 10:30 – 13:00 UTC, Germany



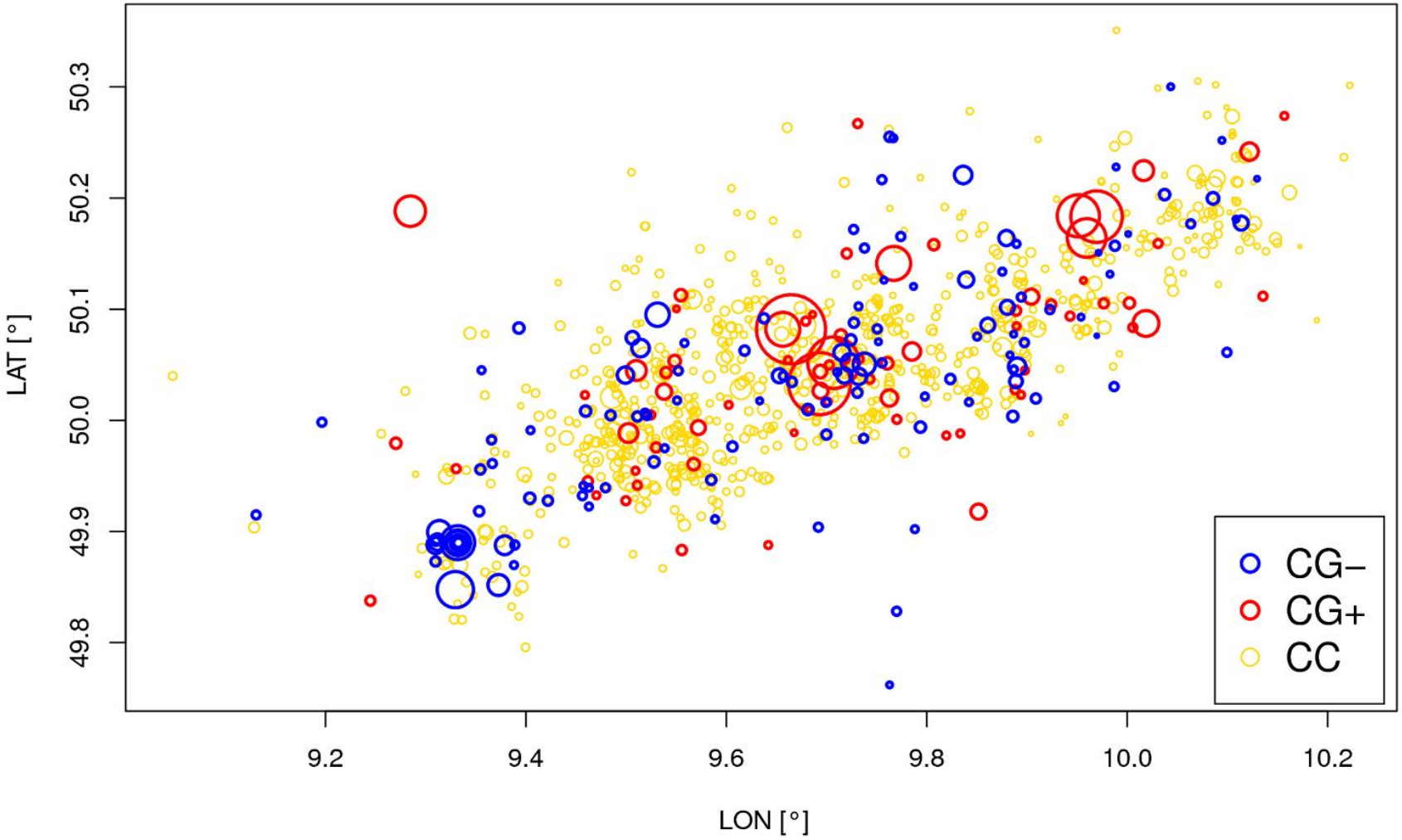
sandwich IR-BT & Storm RGB products


BT 240 K
200 K
06/20/2013 09:00

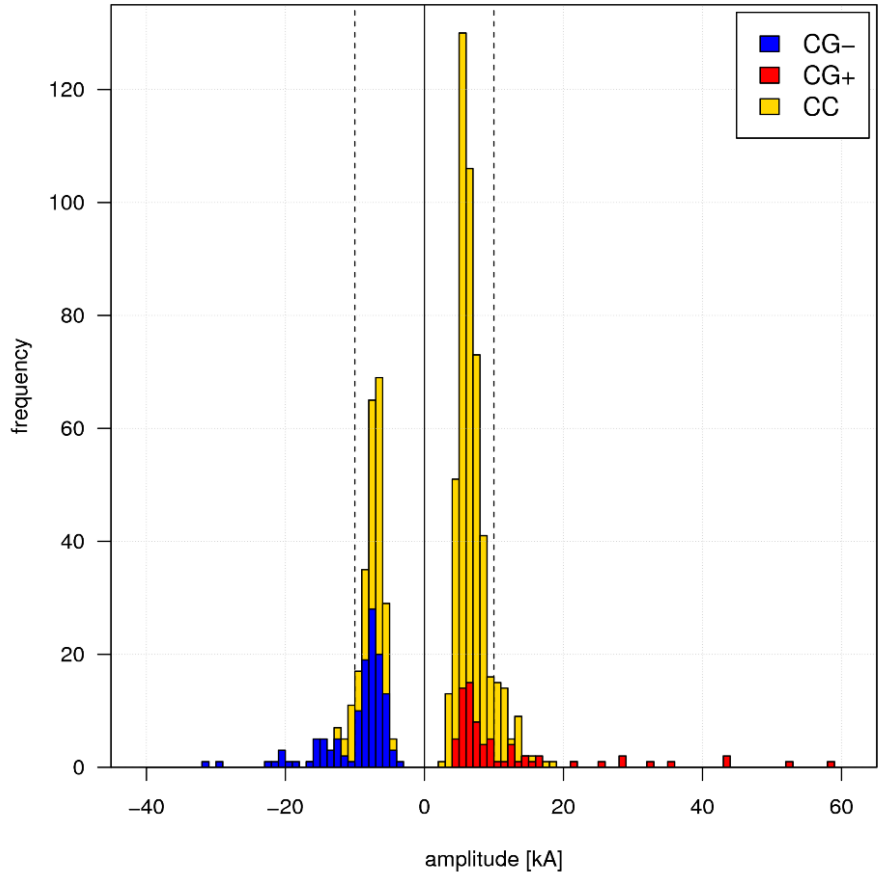
Time evolution of all strokes



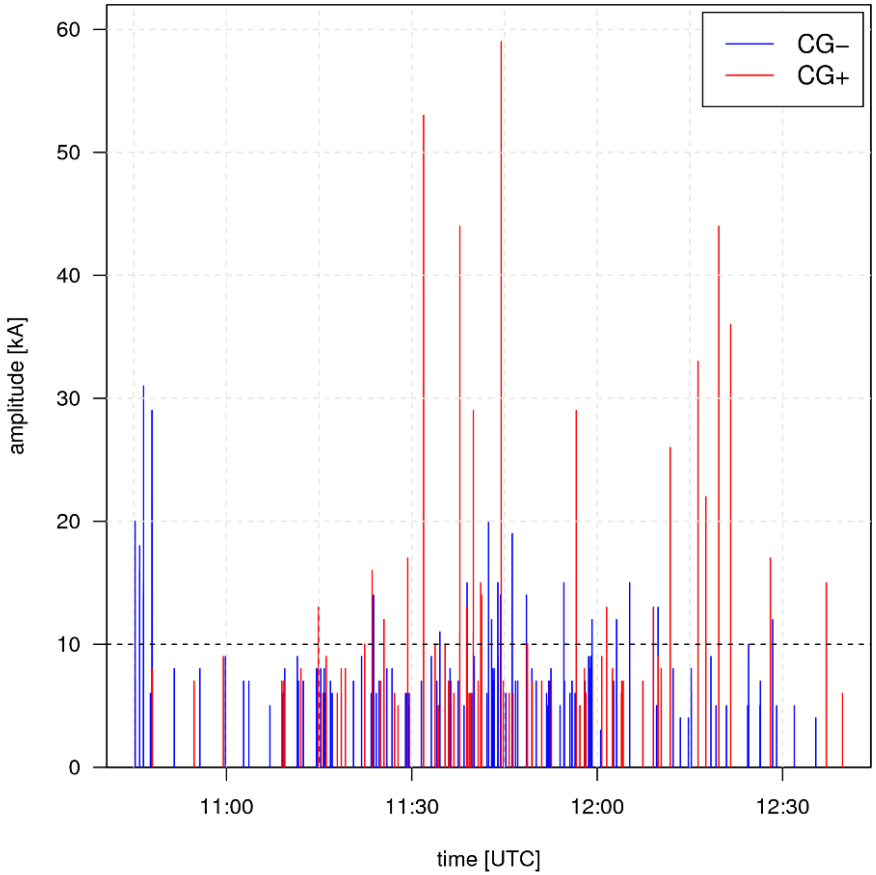
Distribution of different types of strokes



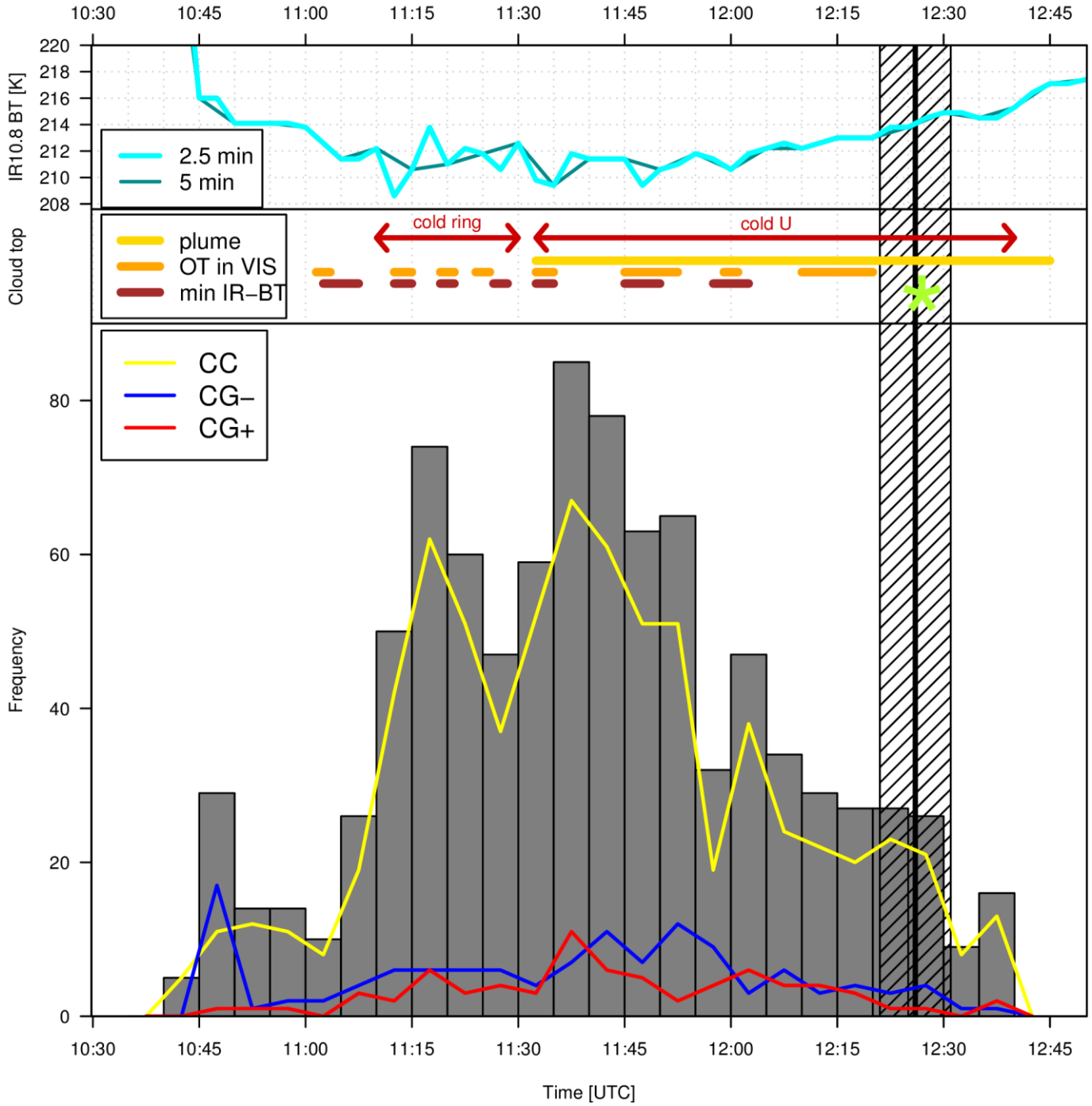
Amplitude characteristics



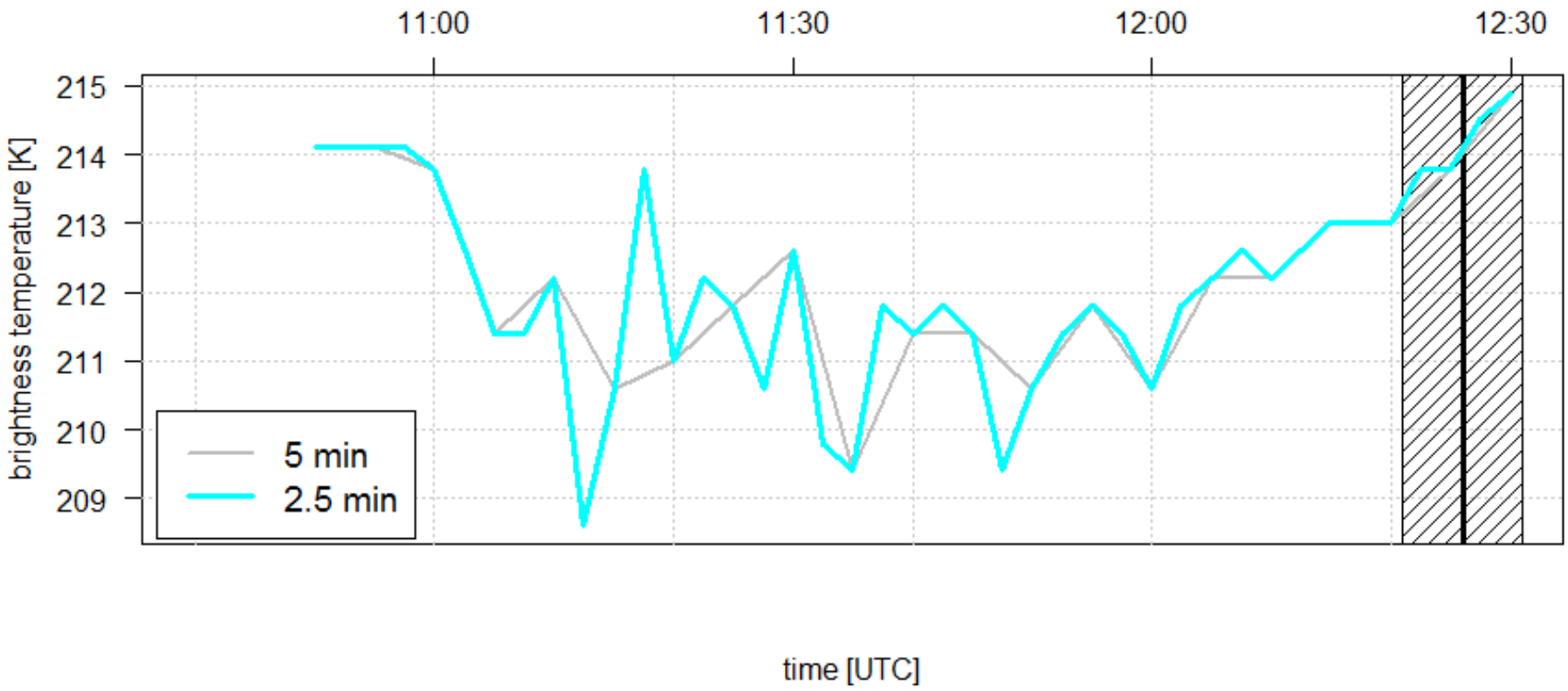
Frequency of amplitudes
of different types of strokes



Evolution of CG amplitudes

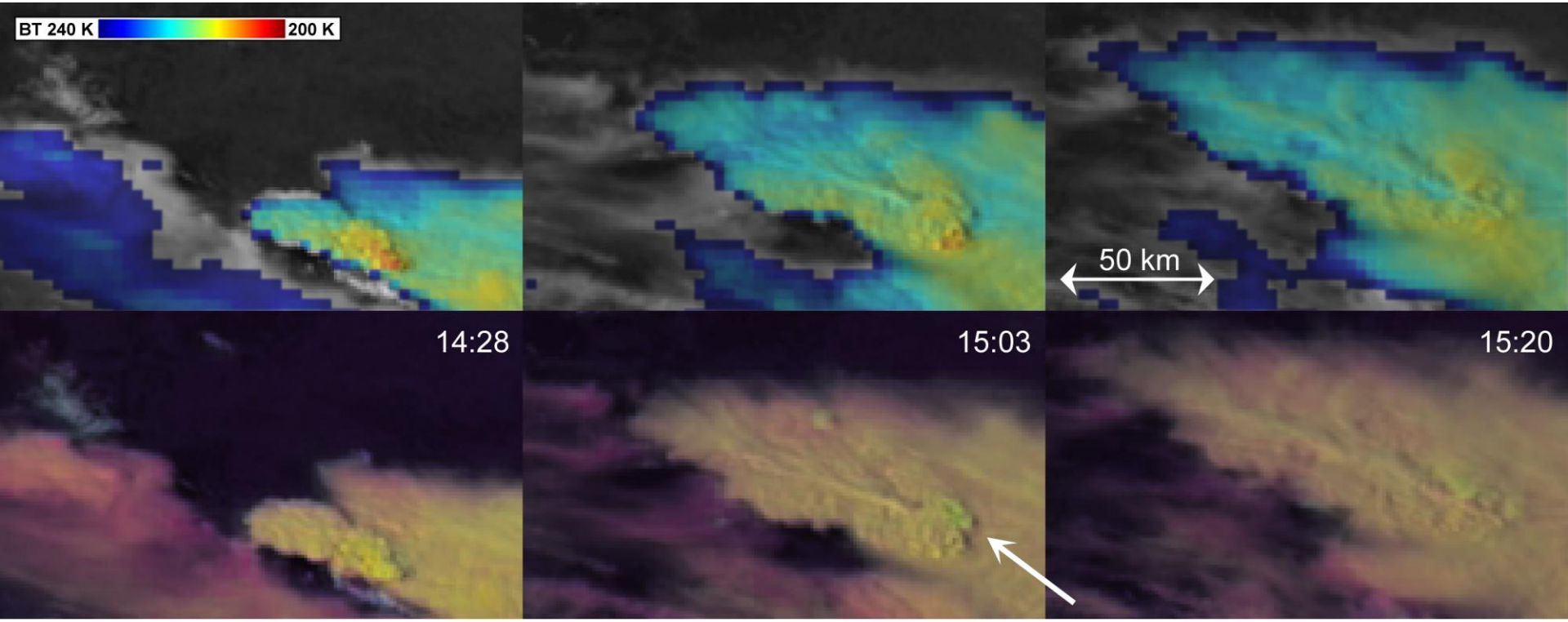

10:30
10:45
11:00
11:15
11:30
11:45
12:00
12:15
12:30
12:45
IR10.8 BT [K]
220
218
216
214
212
210
208
2.5 min
5 min
Cloud top
plume
OT in VIS
min IR−BT
cold ring
cold U
CC
CG−
CG+
Frequency
80
60
40
20
0
Time [UTC]

THE COLDEST PIXELS

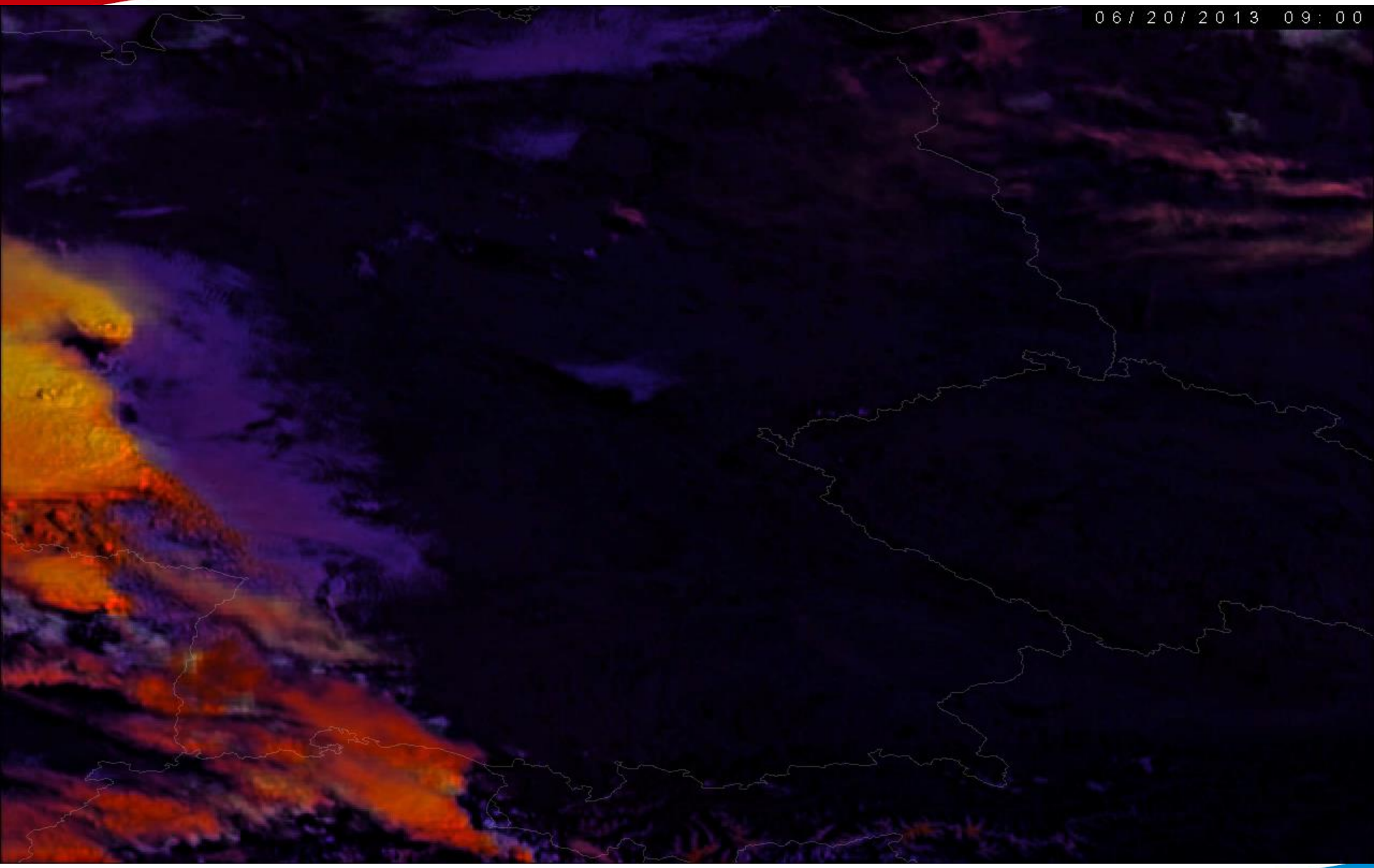


BADEN STORM

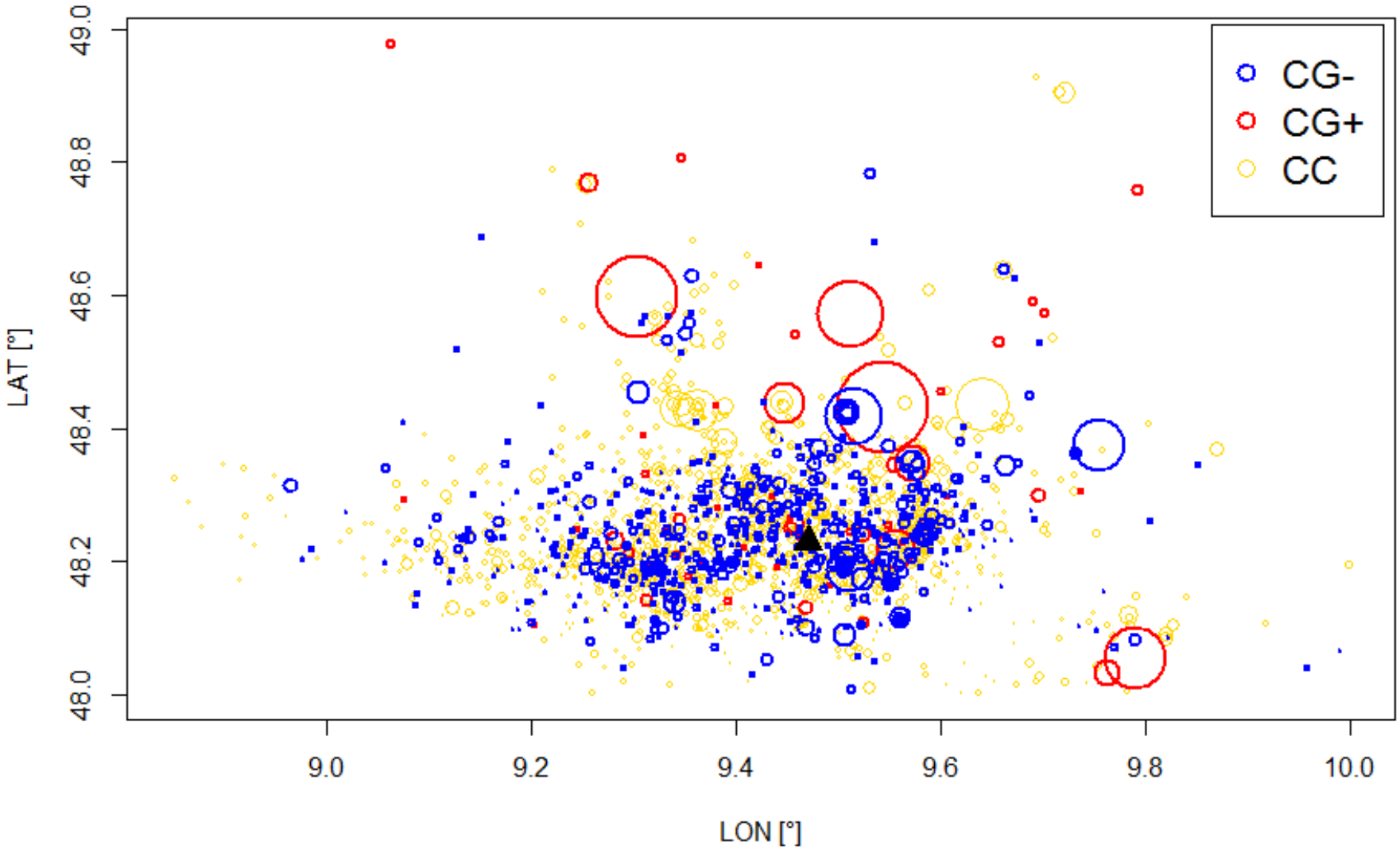
20 June 2013, 14:00 – 16:00 UTC, Germany



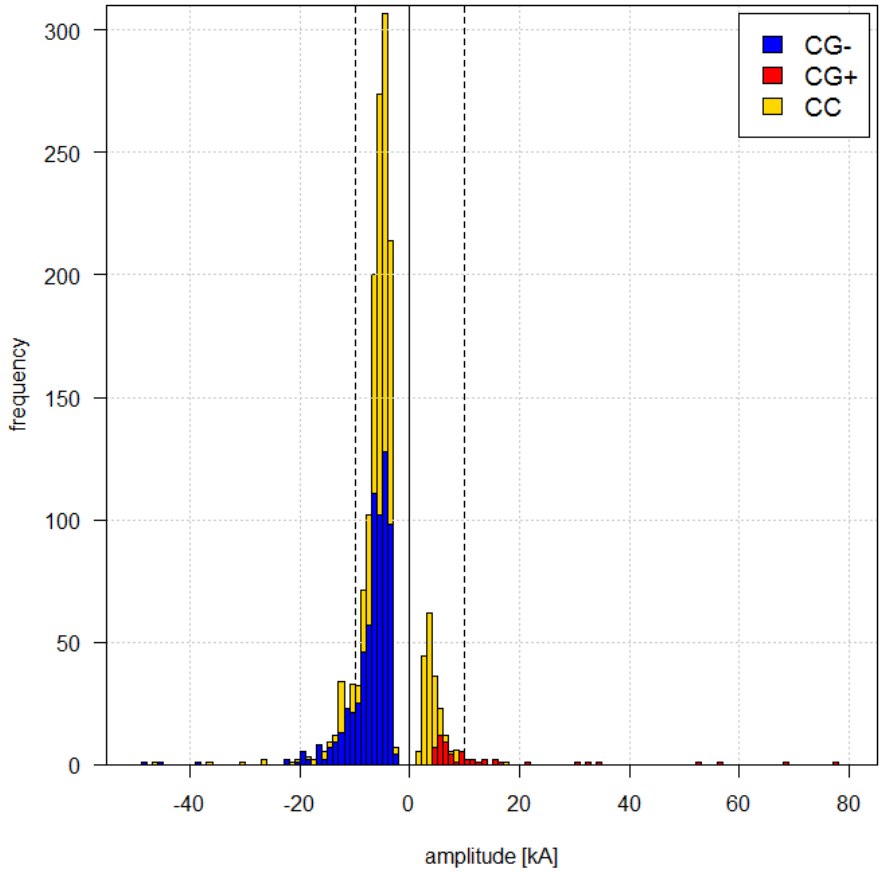
sandwich IR-BT & Storm RGB products


06/20/2013 09:00

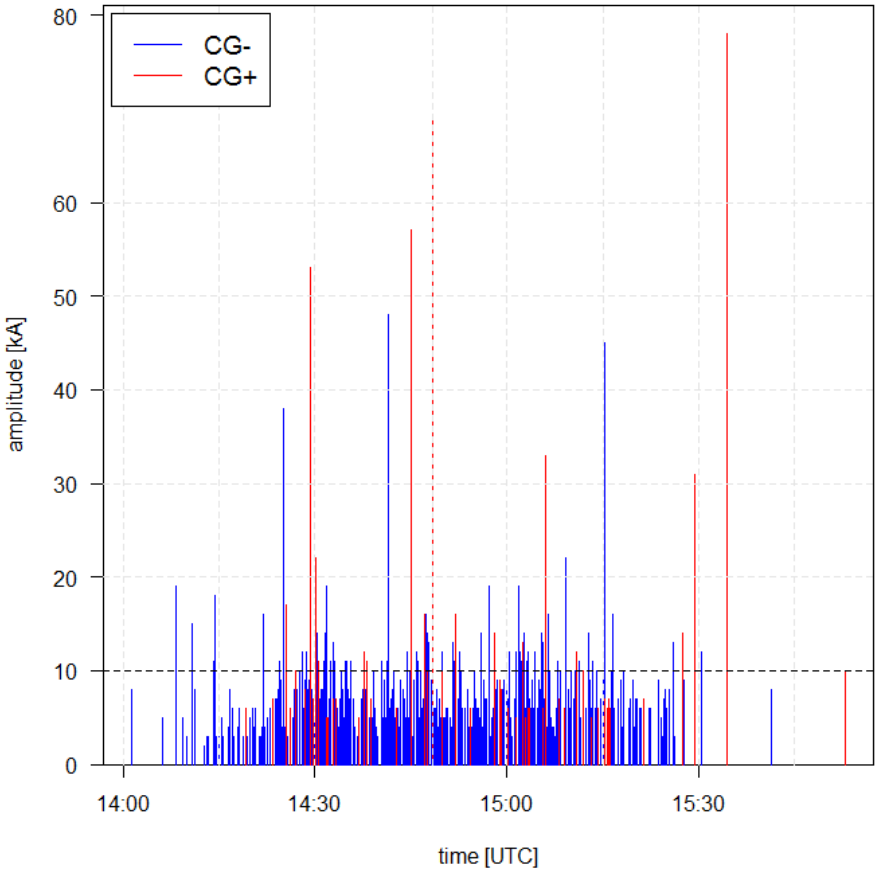
Distribution of different types of strokes



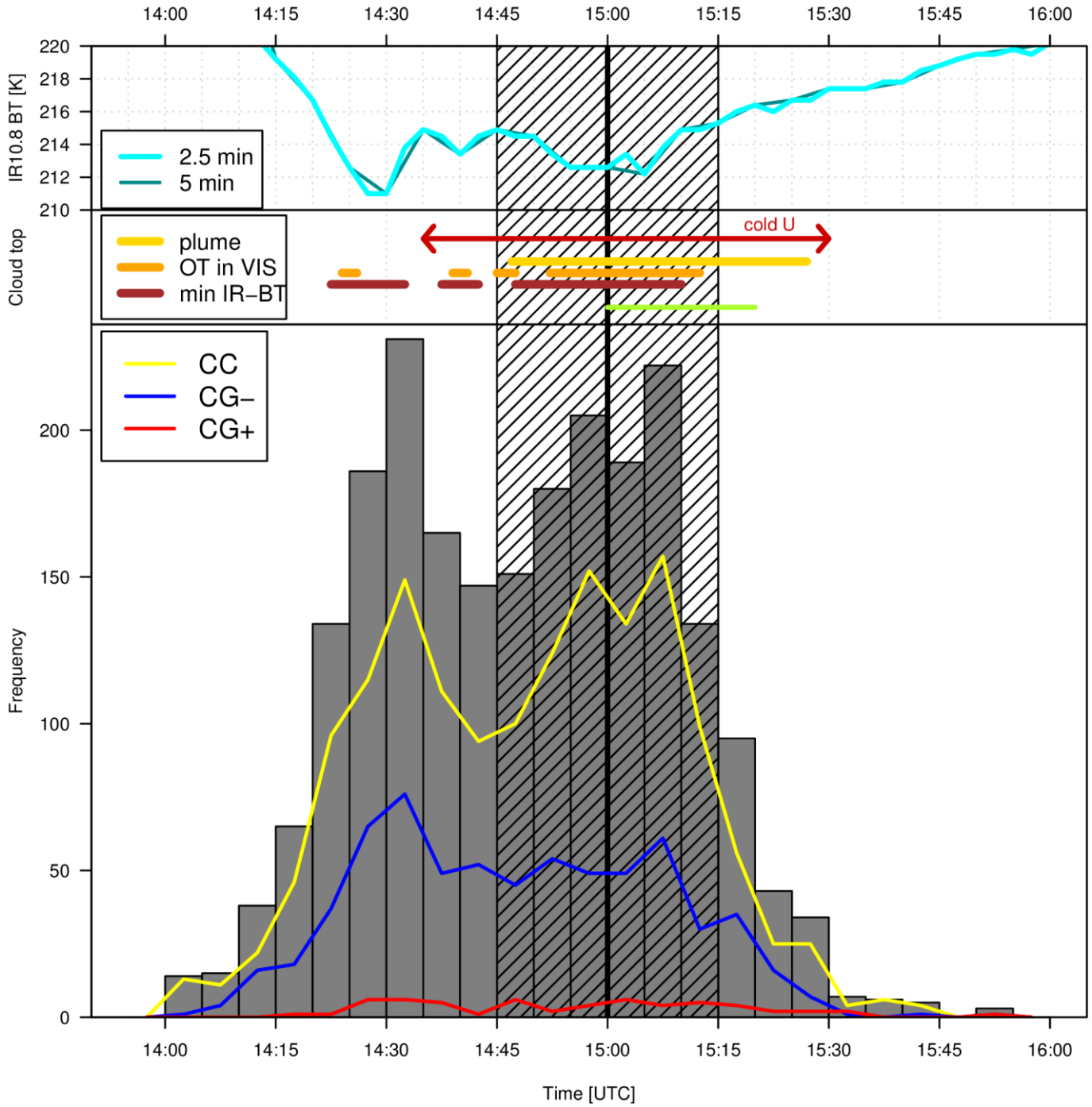
Amplitude characteristics



Frequency of amplitudes
of different types of strokes



Evolution of CG amplitudes


14:00
14:15
14:30
14:45
15:00
15:15
15:30
15:45
16:00
IR10.8 BT [K]
220
218
216
214
212
210
2.5 min
5 min
Cloud top
plume
OT in VIS
min IR−BT
cold U
CC
CG−
CG+
Frequency
200
150
100
50
0
Time [UTC]

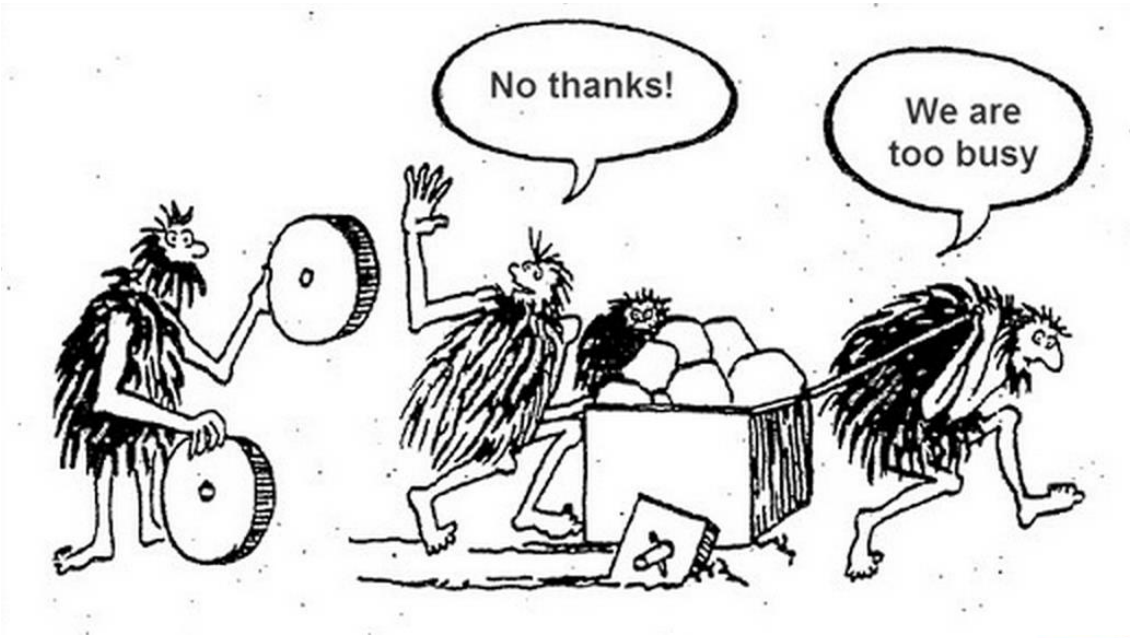
POSSIBLE UTILIZATION

- electrification, dynamics and microphysics connected → changes also in lightning activity
- clear, when the storm strengthen or weaken (two independent sources)
- indicators of severe storm:
  - distinctive OT, cold-U or cold-ring, plume
  - CC jump, CG+ amplitudes, number of strokes →

powerful tool for nowcasting

NOWCASTING

- nowcasting algorithm
  - no wheel reinventing → NWC SAF RDT, CELLTRACK
  - testing during this convective season in CHMI
    - » cooperation with Remote Sensing Section



SUMMARY

- pulsation in number of strokes
  - bimodal histograms – 2 processes, spacing ~ 30 min
  - the first OT ~ the first peak in all strokes
- amplitude of strokes
  - non-severe storms usually low amplitudes (< 20 kA)
  - the first CG+ amplitude > 20 kA when a significant change inside storm appears
    - CC increase, plume formation, OT more frequent, …
- severe weather occurence
  - abrupt increase of CC as a precursor

FUTURE WORK

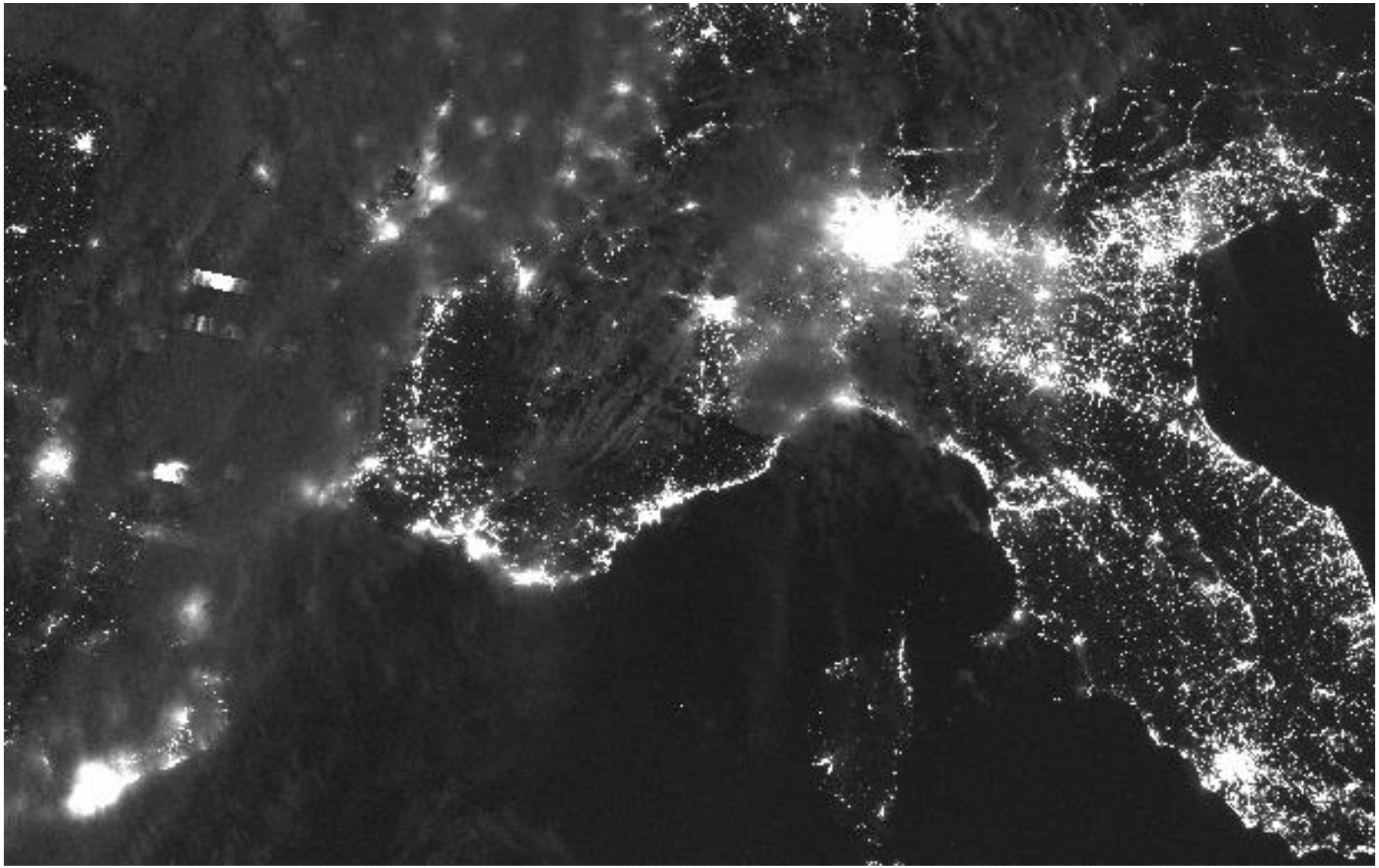
- more and more cases (severe vs. non-severe)
- radar observations
  - distinguish particular storm cells → updrafts
- regression analysis, neural network
  - estimate relationships among variables
  - **predictors**:

    IR-BT min, cloud-top glaciation

    CC jump, max CG+ amplitude, stroke current

    CAPE

THANK YOU



Suomi-NPP/VIIRS Day/Night Band 2014-07-20 01:20 UTC