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# Lightning-jumps in convective cells tracked by radar as a nowcasting tool in complex orography

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# Lightning Jump

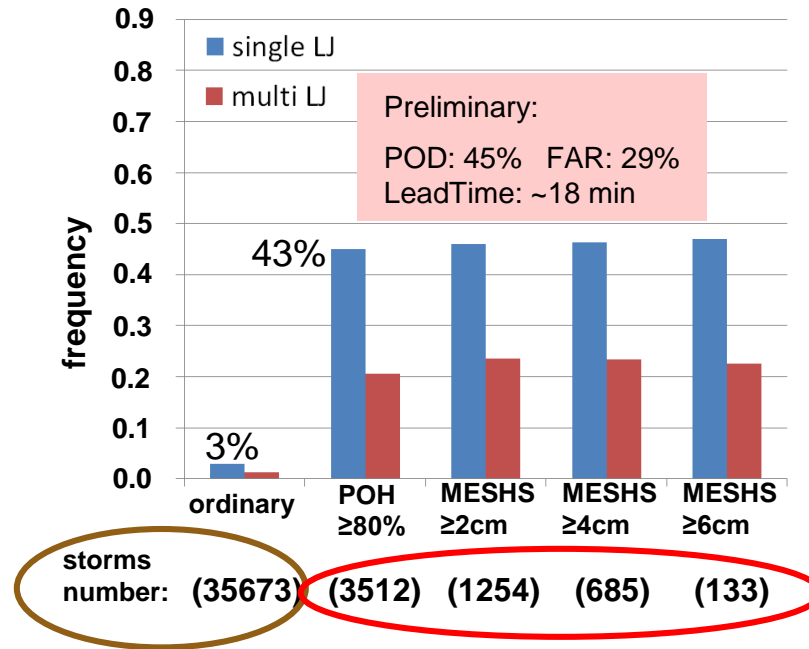
- **Lightning Jumps (LJ)**: sudden increase in **total lightning (CG+IC) flash** rate within thunderstorm cells
- **LJ** based on trends in **total lightning** as a **bulk** thunderstorm property
- **LJ** associated with rapid intensification of the **updraft**, increasing number of ice particle collisions, greater charge separation and lightning number
- **LJ** can occur from **few minutes to tens of minutes before** the onset of severe weather (hail, heavy rain, wind gusts,...)
- Last decade: several publications ***LJ detection algorithms*** (e.g.)
  - **USA**: Williams et al. (1999), Schultz et al. (2009-2017), Darden et al. (2010), Gatlin and Goodman (2010), Chronis et al. (2015),...
  - **EU**: Farnell et al. (2017, 2018), Wapler (2017),...
- Goals
  - **Real-time** implementation of **LJ** algorithm: ✓ since summer **2018**
  - Assess the **nwc potential** in case of **real-time, operational** use



# Lightning Jumps vs. hail storms (2014-2017)

(total lightning: CG + IC; cell duration  $\geq 30$ min)

LJ **before** hail initiation (POH  $\geq 80\%$ ) or MaxEcho (ordinary storms)



LJ algorithm: Schultz et al., 2009, modified  
(LightningRate<sub>min</sub>: 15 flashes / 5 min; Sigma-level = 1)

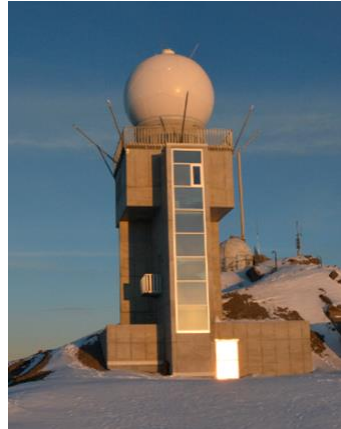


# Lightning Jump: real-time algorithm (1)

- **LJ algo** originally built/tested to run on 3D Lightning Mapping Arrays
- Main sources of **total lightning** data for LJ algorithms (literature):
  - **LMAs** (Lightning Mapping Arrays); 3D, acc. <100 m
  - **GOES-R GLM** (Geostationary Lightning Mapper); acc. <10 km



- MeteoSwiss (operational)
- 1) Total Lightning Detection Network: **METEORAGE / EUCLID** →
    - *VLF/LF, CG+IC, triangulation+time-of-arrival*
    - resolution: **30 sec**, acc. <1 km
  - 2) Thunderstorm **cells** by **TRT** (Thunderstorms Radar Tracking) →
    - *5 radars, dual-pol, C-Band, 20 elevations (-0.2°/40°)*
    - standard resolution: **5 min**, 1km

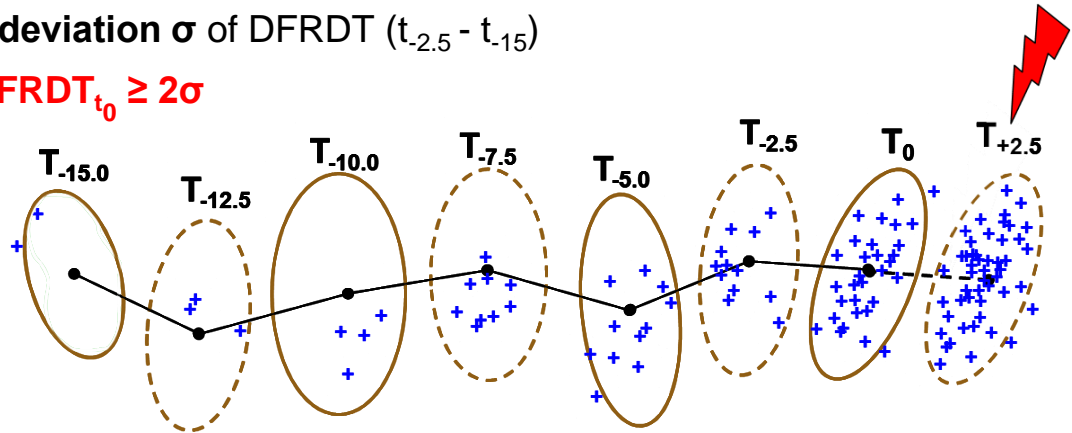




# Lightning Jump: real-time algorithm (2)

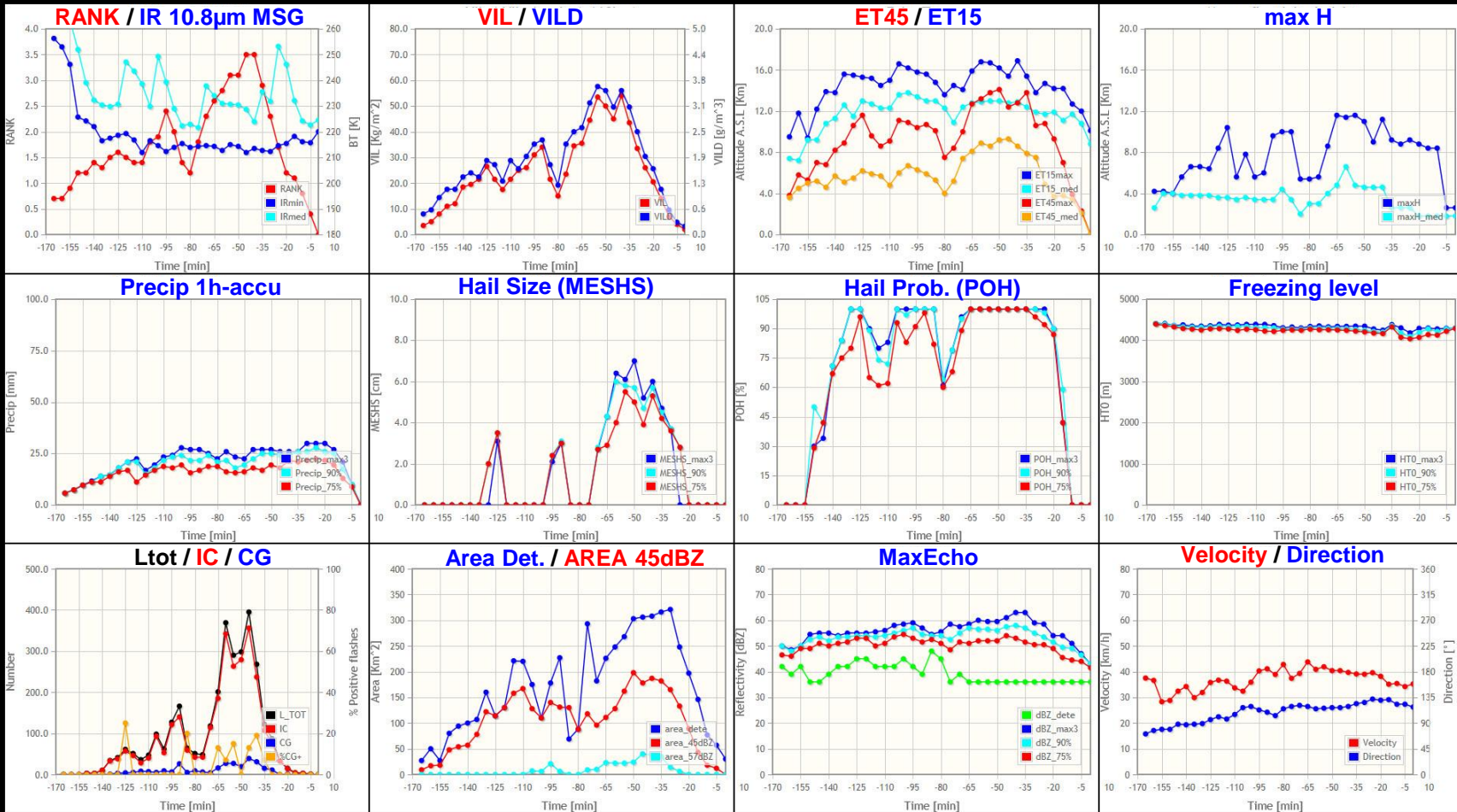
Modified **2 $\sigma$  Lightning Jump algorithm** (Schultz et al. 2009-2017): compute **increase** in total flash rate **relative** to **standard deviation** of last **15min**

- Approximate TRT cells by an **ellipse** (last 15min)
- Interpolate/extrapolate between two **5min** ellipses  $\rightarrow$  **2.5min** time resolution
- Every **2.5min**: compute **total flash rate** (flashes  $\text{min}^{-1}$ ) of each storm
- Activation threshold Lightning Jump algorithm:  **$\geq 10$  flashes  $\text{min}^{-1}$**  (current cell)
  - Compute for last 15 min: time rate of change of tot. flash rate (DFRDT) every 2.5min
  - Compute **standard deviation  $\sigma$**  of DFRDT ( $t_{-2.5} - t_{-15}$ )
  - **Lightning Jump:  $\text{DFRDT}_{t_0} \geq 2\sigma$**

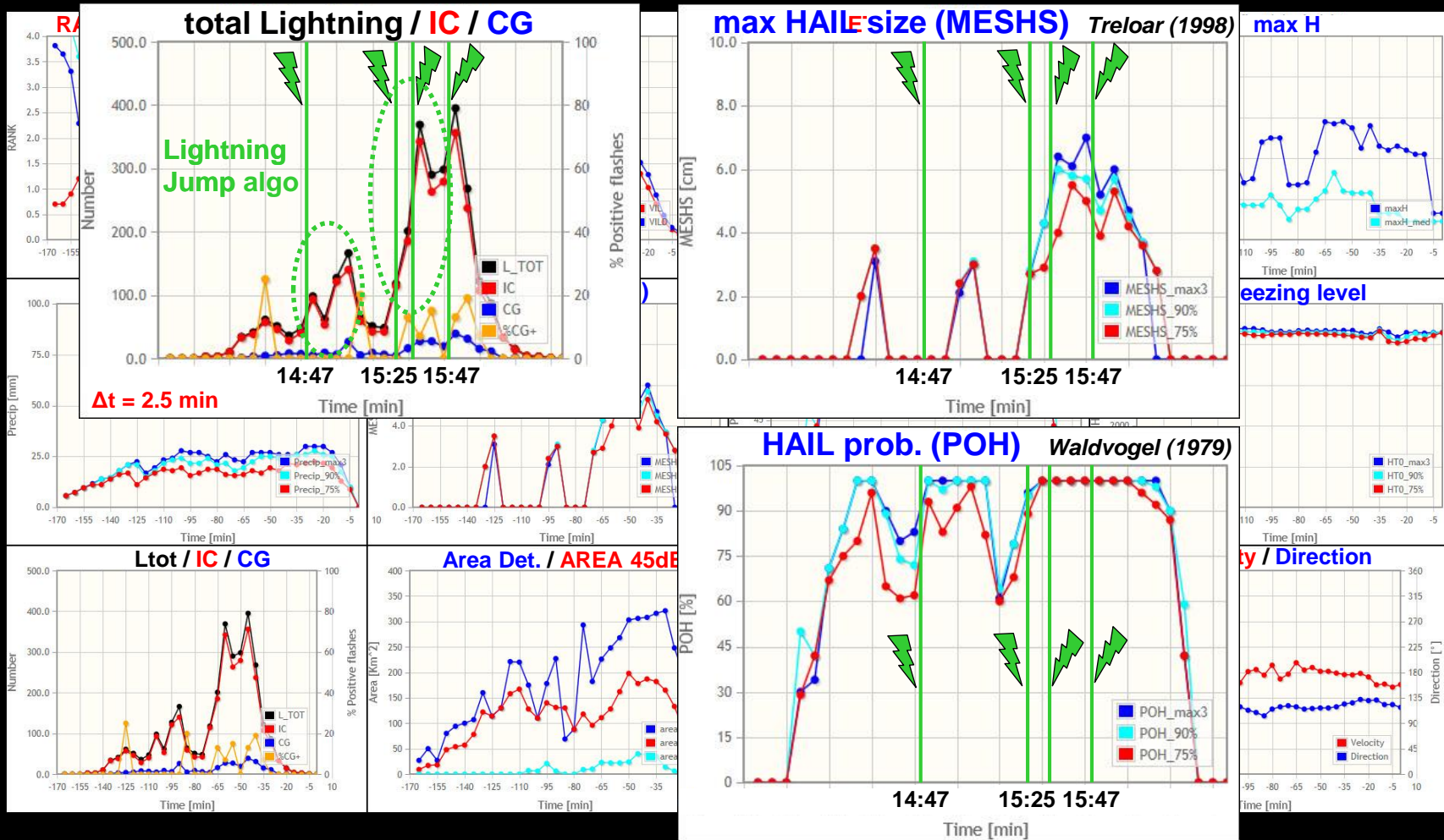




# Lightning Jump: real-time application



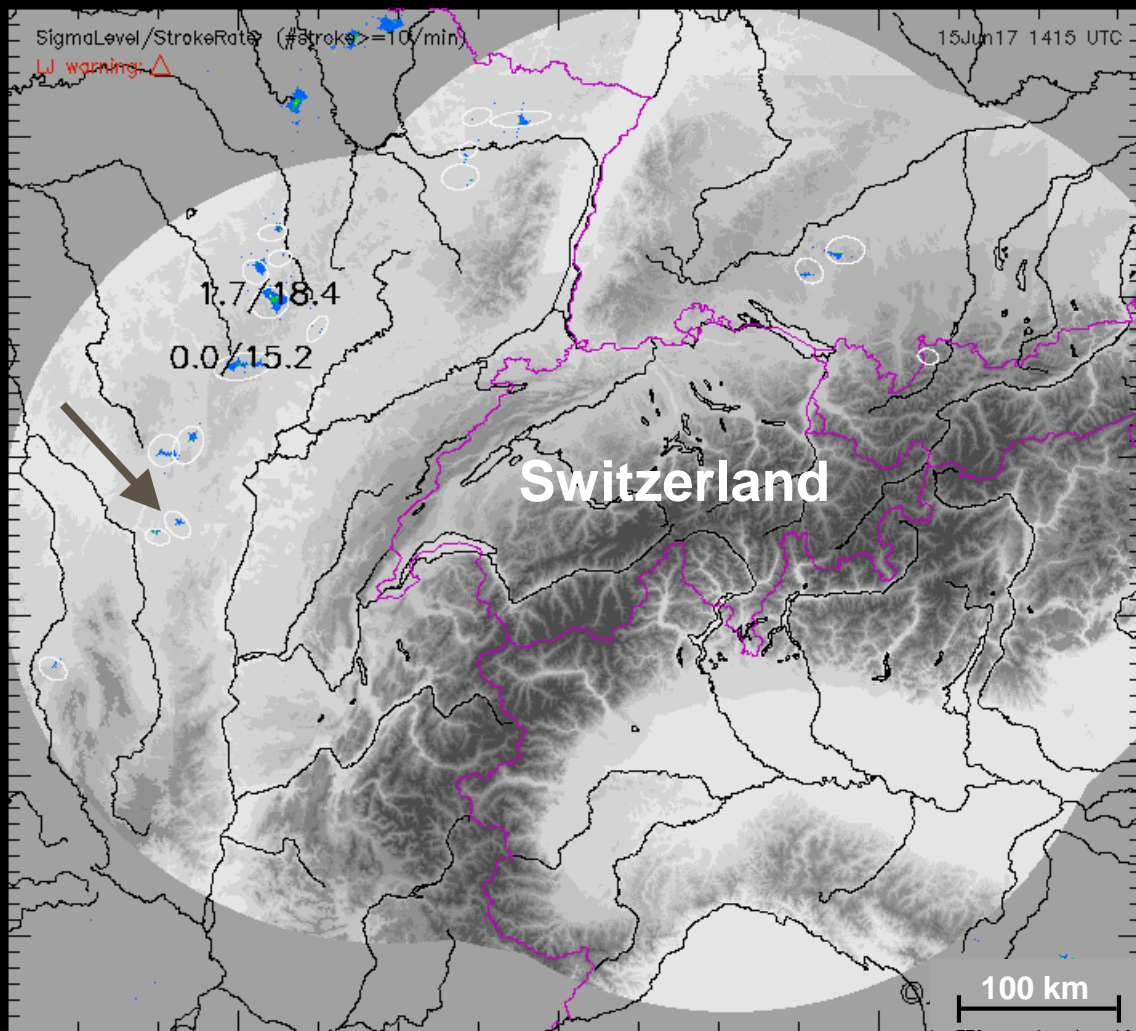






Sigma-level/Flash-rate  
( $\geq 10/\text{min}$ )

LJ warning:  $\Delta$

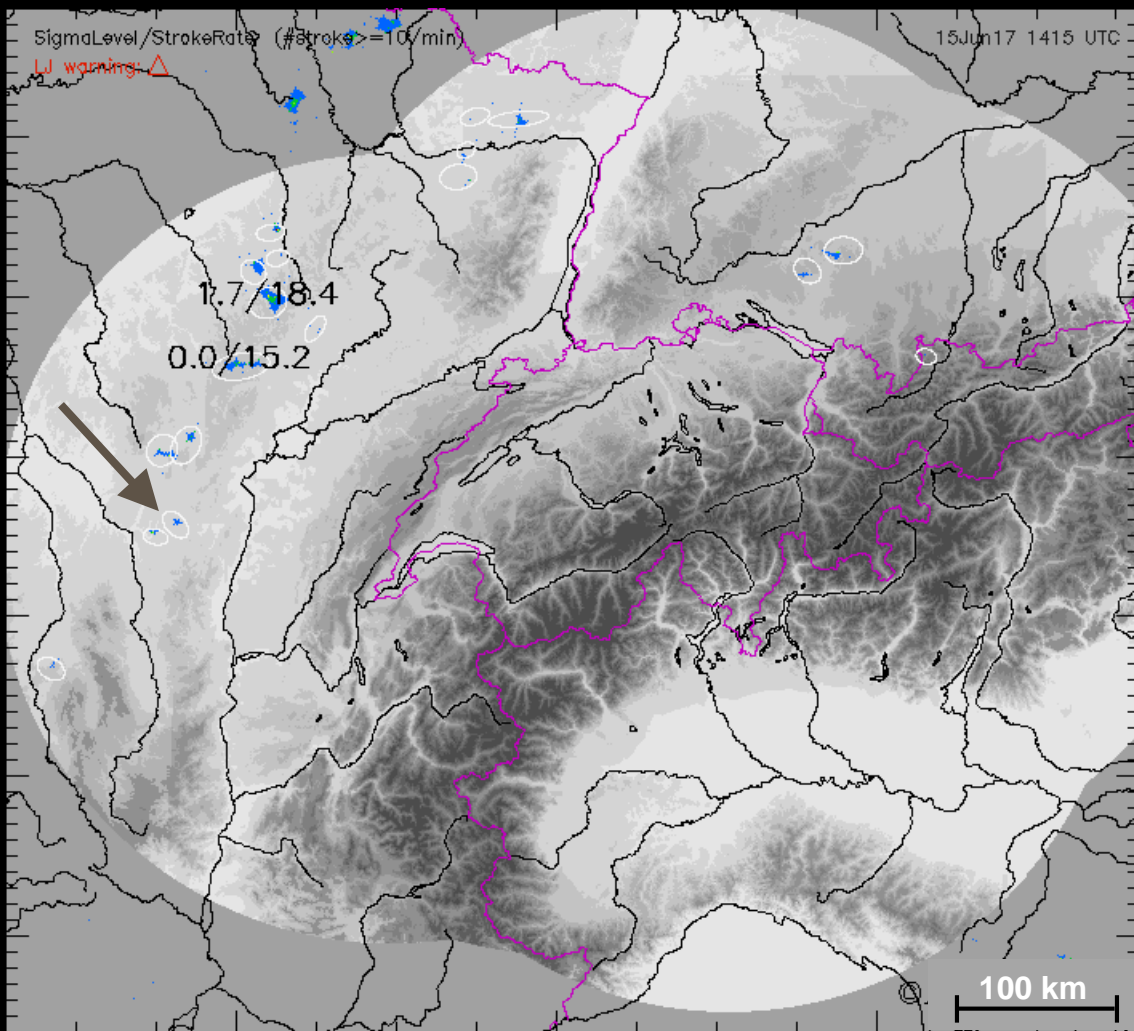


15 June 2017  
14:15-16:25 UTC

$\Delta t = 2.5 \text{ min}$

Sigma-level/Flash-rate  
( $\geq 10/\text{min}$ )

LJ warning:  $\Delta$



SigmaLevel/StrokeRate (#stroke  $\geq 10/\text{min}$ )

LJ warning:  $\Delta$

1.7/18.4

0.0/15.2

15Jun17 1415 UTC

15 June 2017  
14:15-16:25 UTC

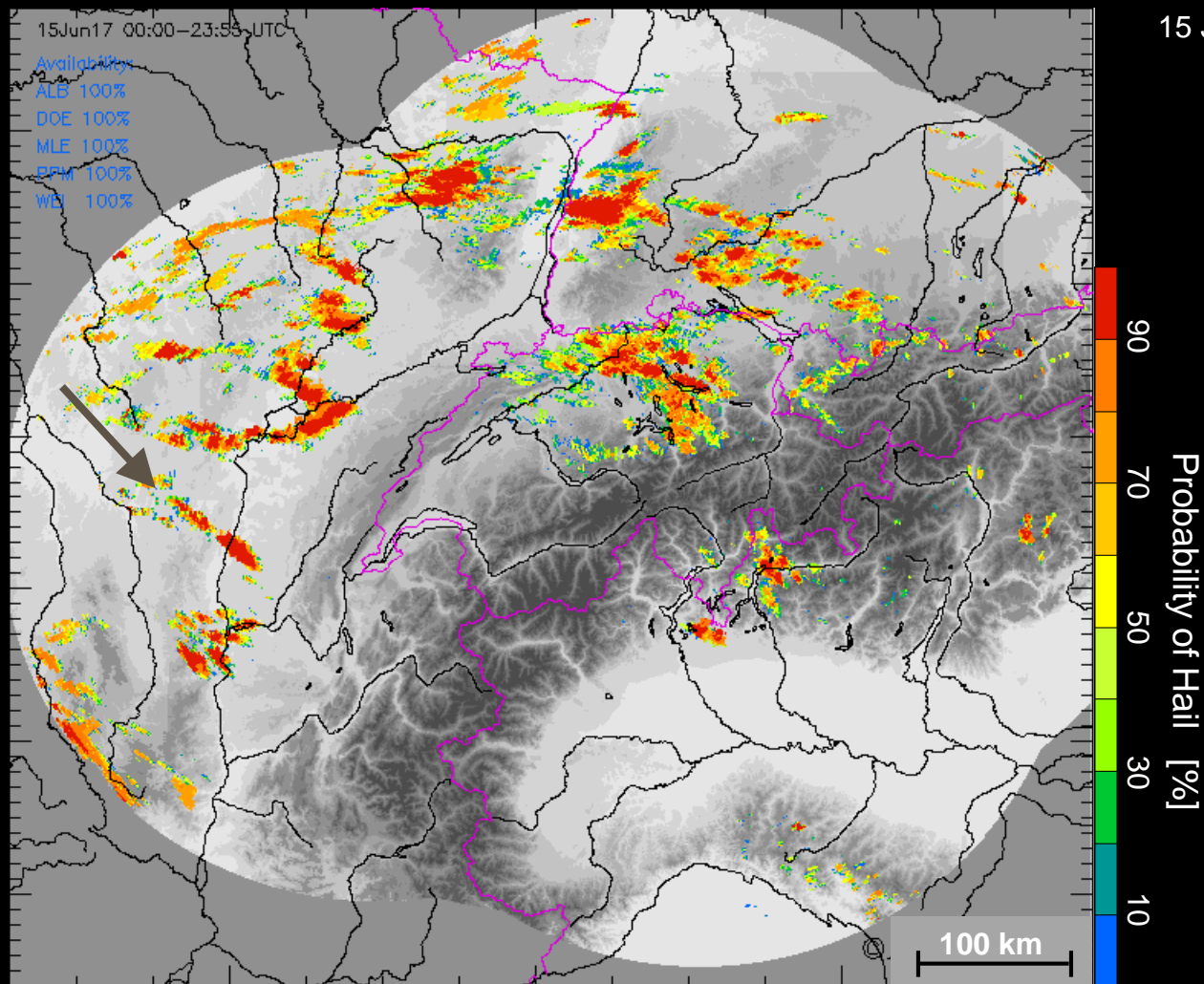
$\Delta t = 2.5 \text{ min}$



100 km

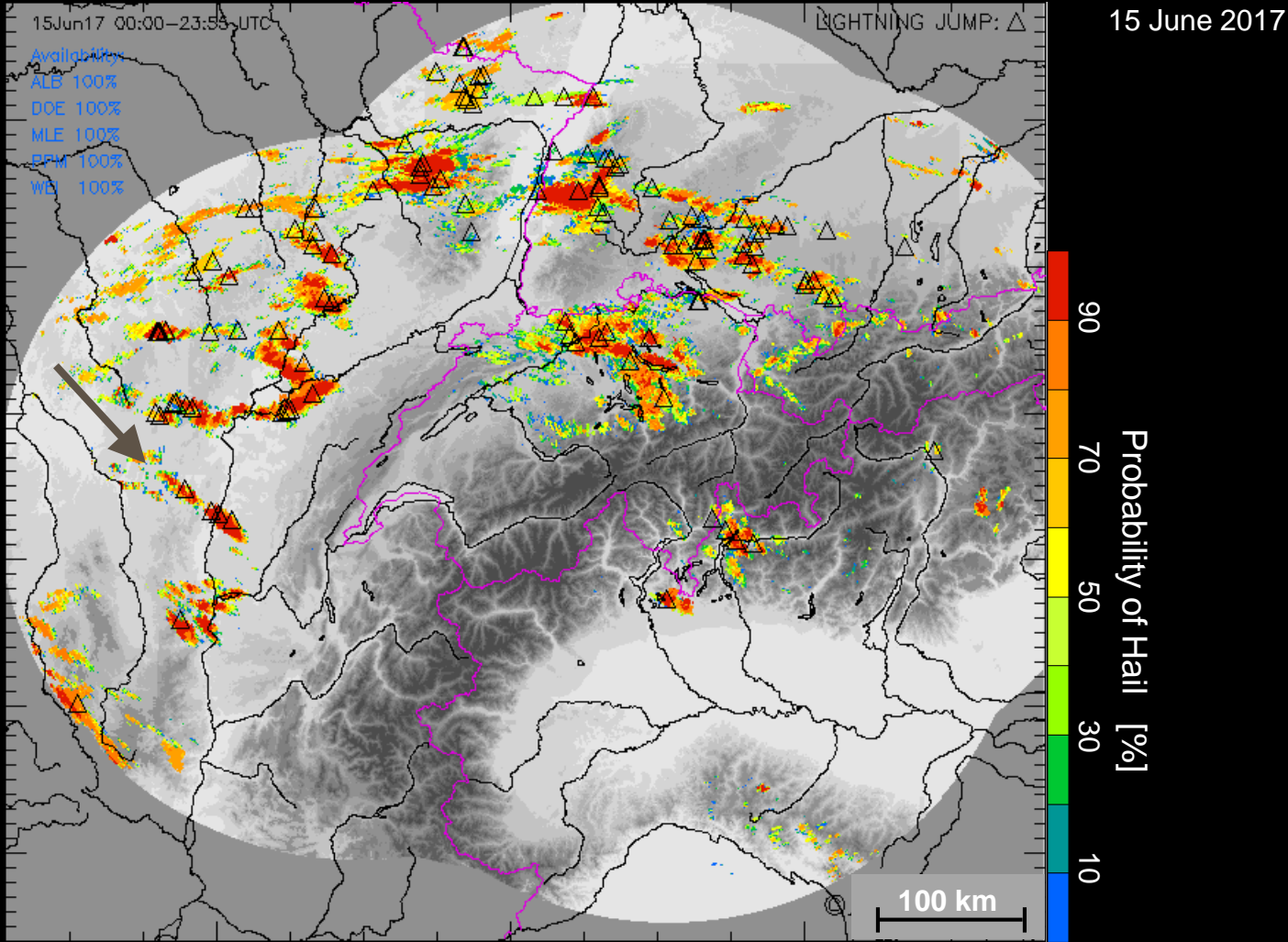
# Daily maximum POH

15 June 2017



Daily maximum POH

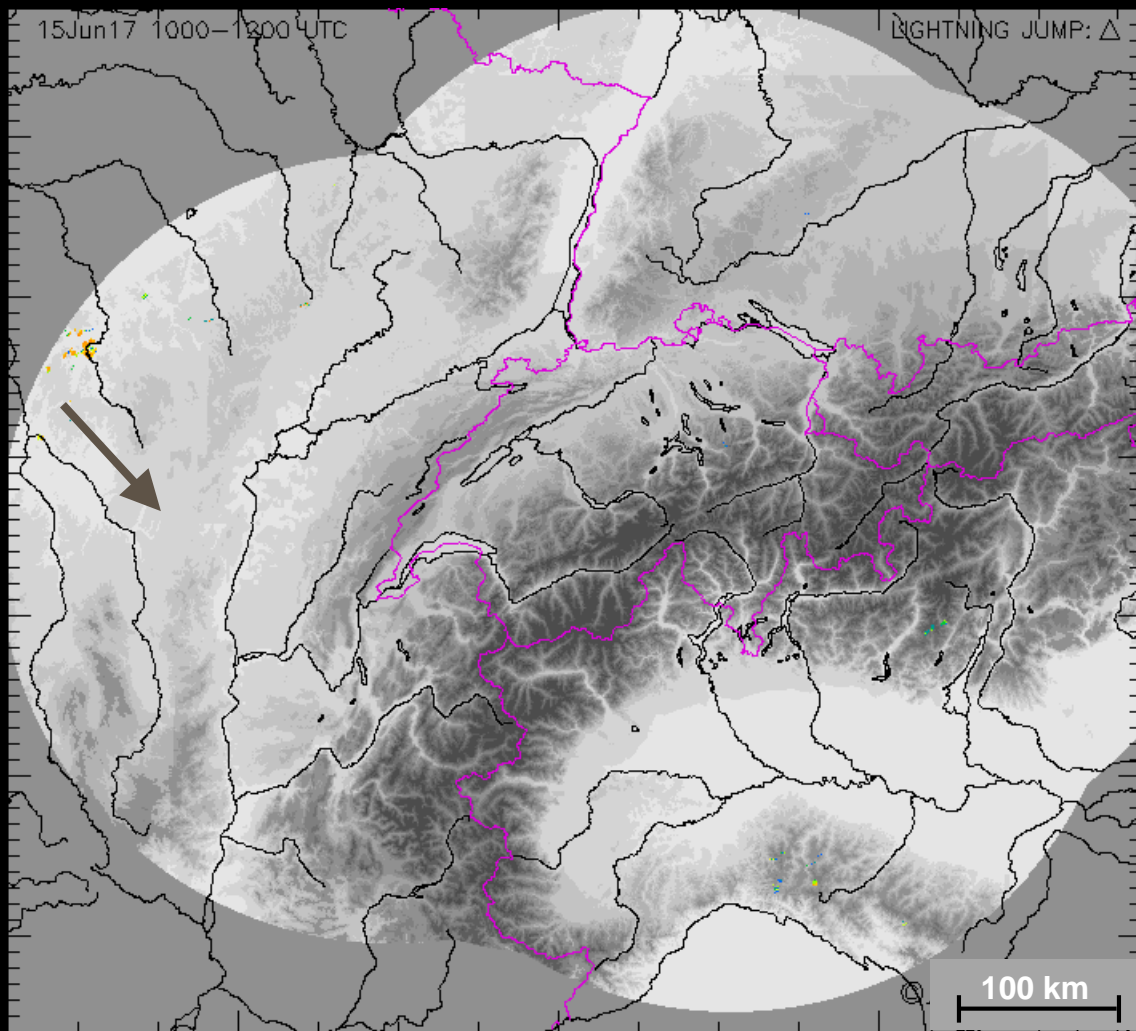
LJ warning:  $\Delta$





Daily maximum POH

LJ warning:  $\Delta$



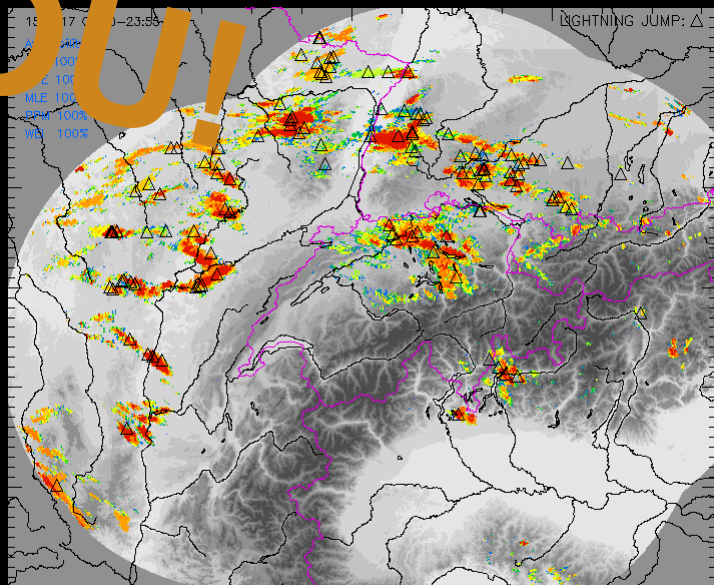
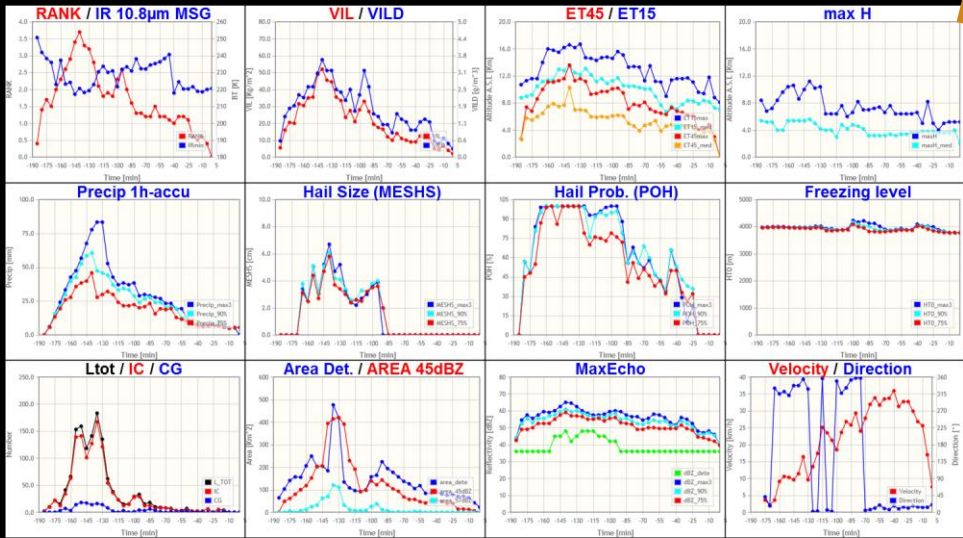
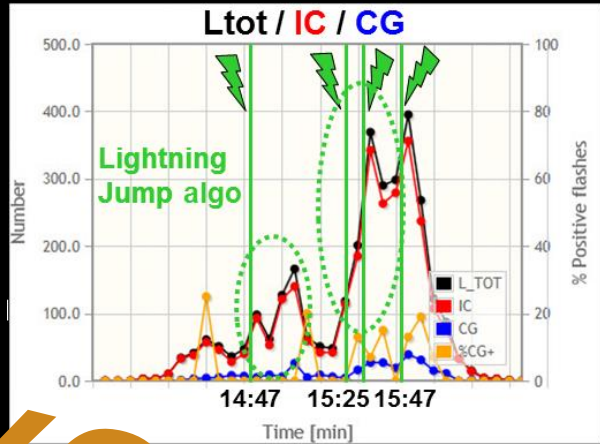
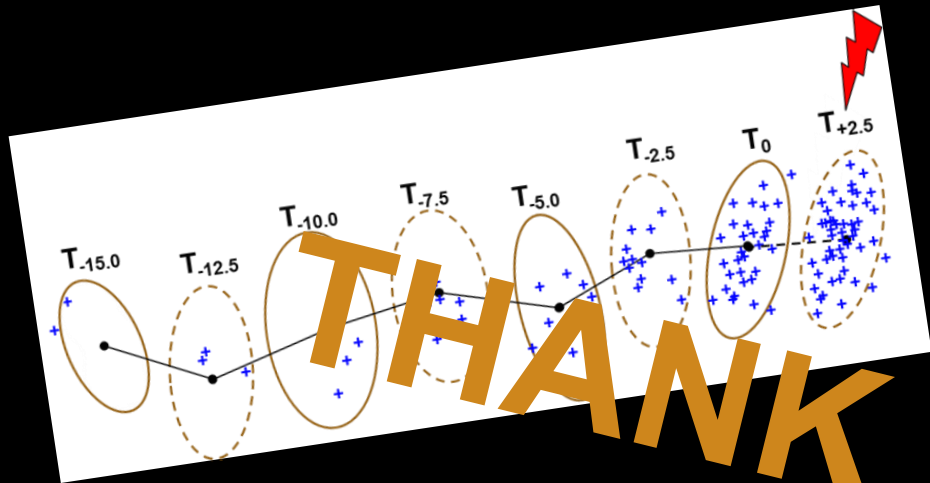
15 June 2017  
10:00-21:00 UTC

$\Delta t = 2.5$  min



# Summary and conclusions

- Modified **2 $\sigma$  Lightning Jump Algorithm** implemented, **real-time** (summer 2018)
- Time resolution: **2.5min**; 1km
- **Real-time Lightning Jump Algorithm:**
  - also works with a **conventional** VLF/LF Total Lightning detection network
  - **promising** performance, can be used as **complementary nwc tool** for **severe weather** (e.g. hailstorms) also in **complex orography**
  - can help to increase **lead time** of **real-time** TS warnings
  - caveat: **LJ** can occur also **during/after** hail occurrence (no lead time) and in **sub-severe** storms (no hail)
  - so far only few feedback from forecasters, comprehensive evaluation of the real-time algorithm is still pending
- Outlook:
  - integrate LJA in the convection nowcasting and warning systems already in use at MeteoSwiss such as **TRT**, **COALITION**, **NowPAL**, **NowPrecip** and **INCA**
  - explore **large LJ** data archive



THANK YOU!