



# >40'000 storm biographies: tracking hail swaths on radar data between 2002 and 2016

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# Outline



## Part 1: hail in the Alps

- Storm tracks climatology
- Diurnal cycle
- Lightning Jump



*et al.*

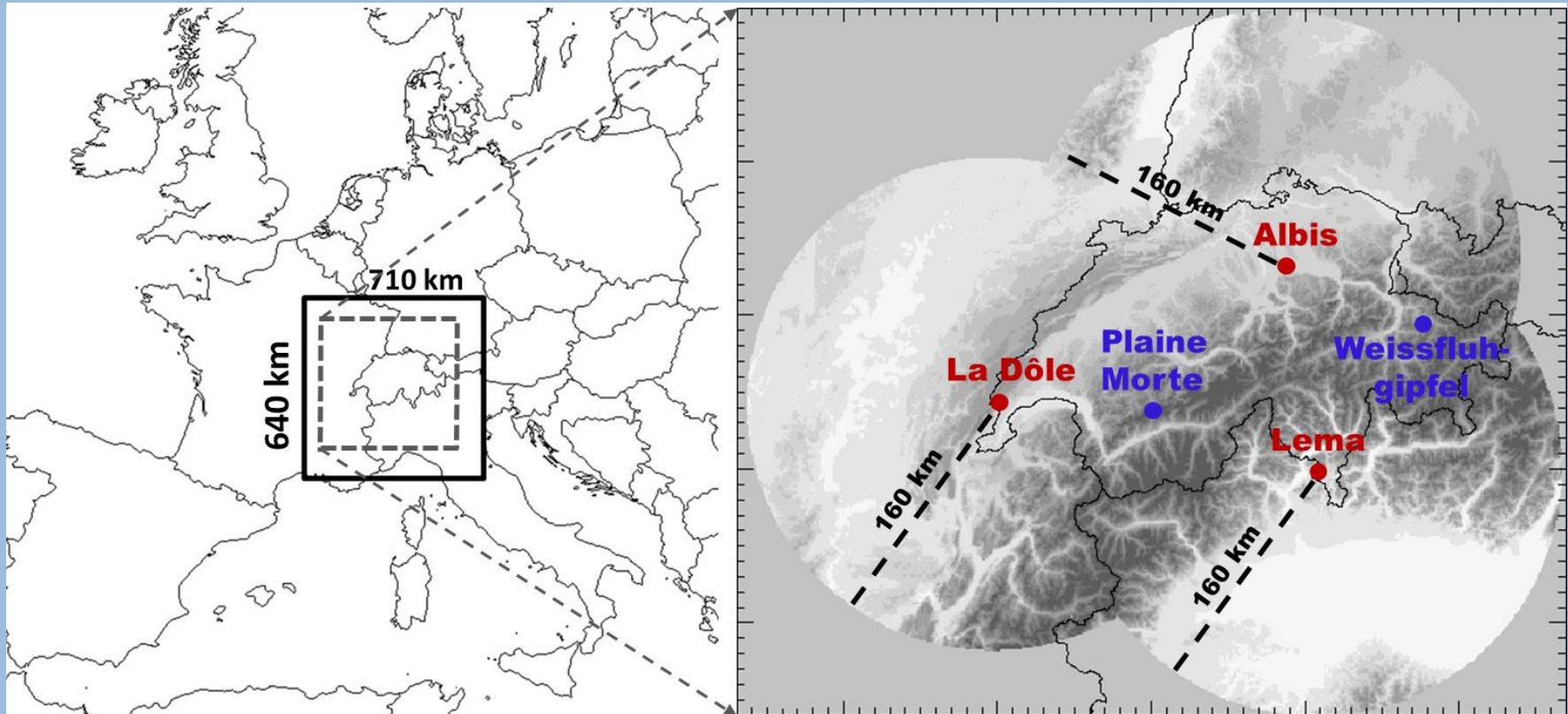
## Part 2: satellite research activities @ MeteoSwiss

- New satellite rain rate retrieval using Artificial Neural Networks (ANN)
- COALITION-2 operational at MeteoSwiss



*et al.*

# Research domain



● radar sites included in the analysis

● new radar sites (after 2014);  
not included in the analysis

# Algorithms

- **POH** (*Foote et al., 2005 ; Waldvogel et al., 1979*)

(**P**robability **O**f **H**ail)

→ EchoTop 45dBz, freezing level

→ operational in several Met.Services

→ HAIL PROBABILITY

- **MESHS** (*Joe et al., 2004; Treloar, 1998*)

(**M**aximum **E**xpected **S**evere **H**ail **S**ize)

→ EchoTop 50dBz, freezing level

→ operational: BoM, Canada, MeteoSwiss (..)

→ HAIL SIZE

- **TRT** (*Hering et al., 2004; Rotach et al., 2008*)

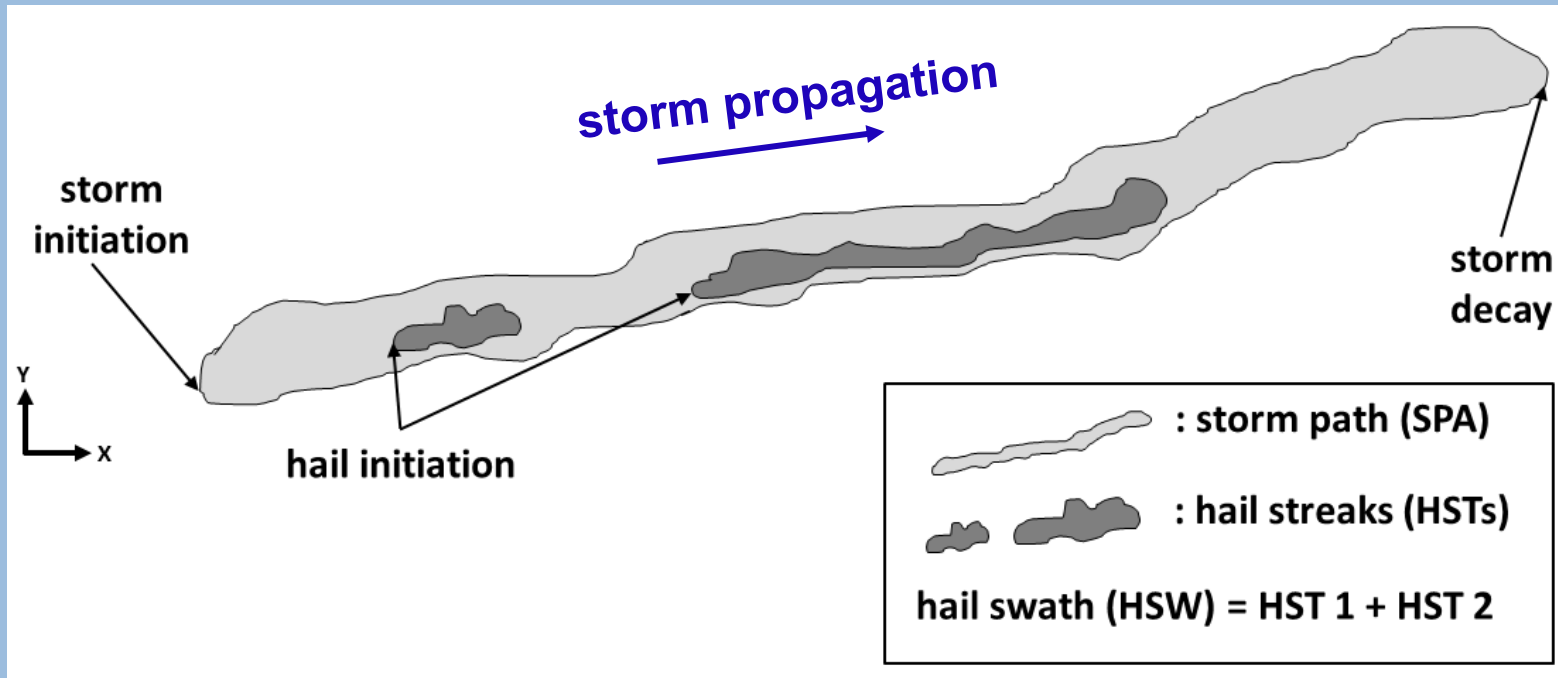
(**T**hunderstorm **R**adar **T**racking)

→ 3D-radar parameters

→ operational: MeteoSwiss

→ STORM TRACK

# Definitions



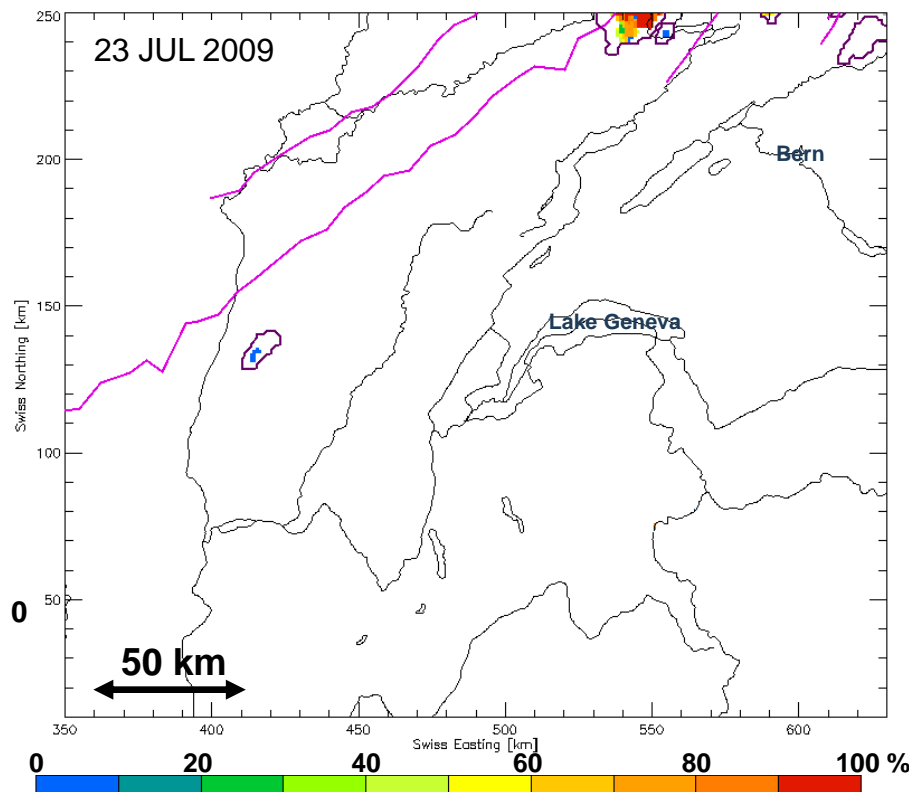


# Storm and hail swath tracking

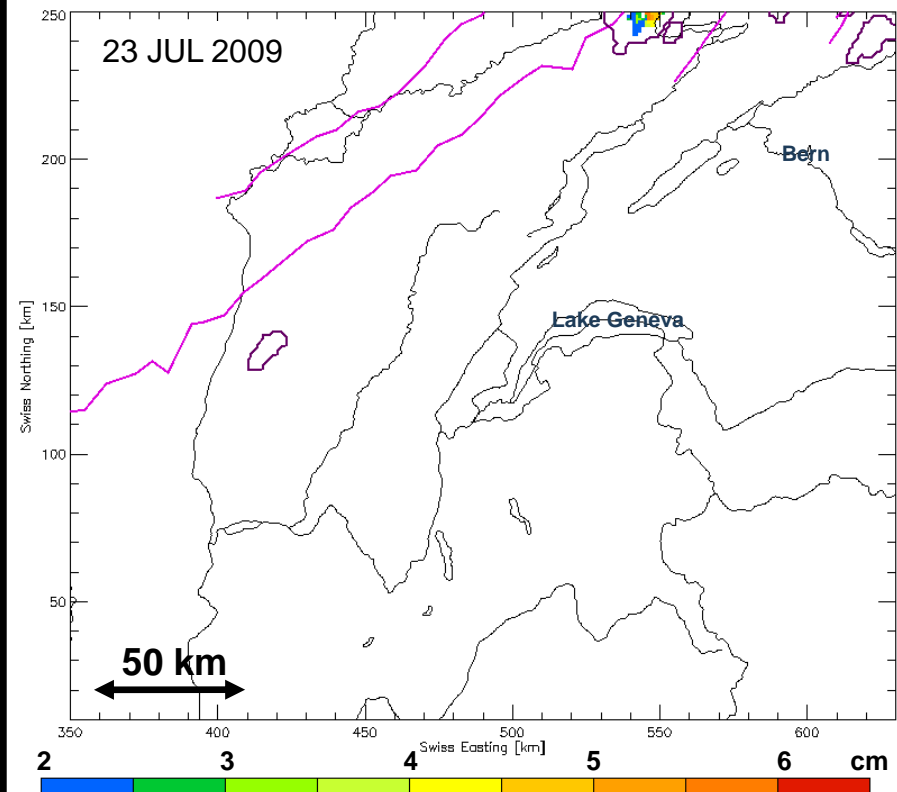
- Thunderstorm Radar Tracking algorithm (TRT)
- 1 km<sup>2</sup>, 5min, APR-SEP 2002-2016

**'object  
based'**

## Probability of Hail (0-100%)



## Maximal Expected Size of Hail (>2cm)

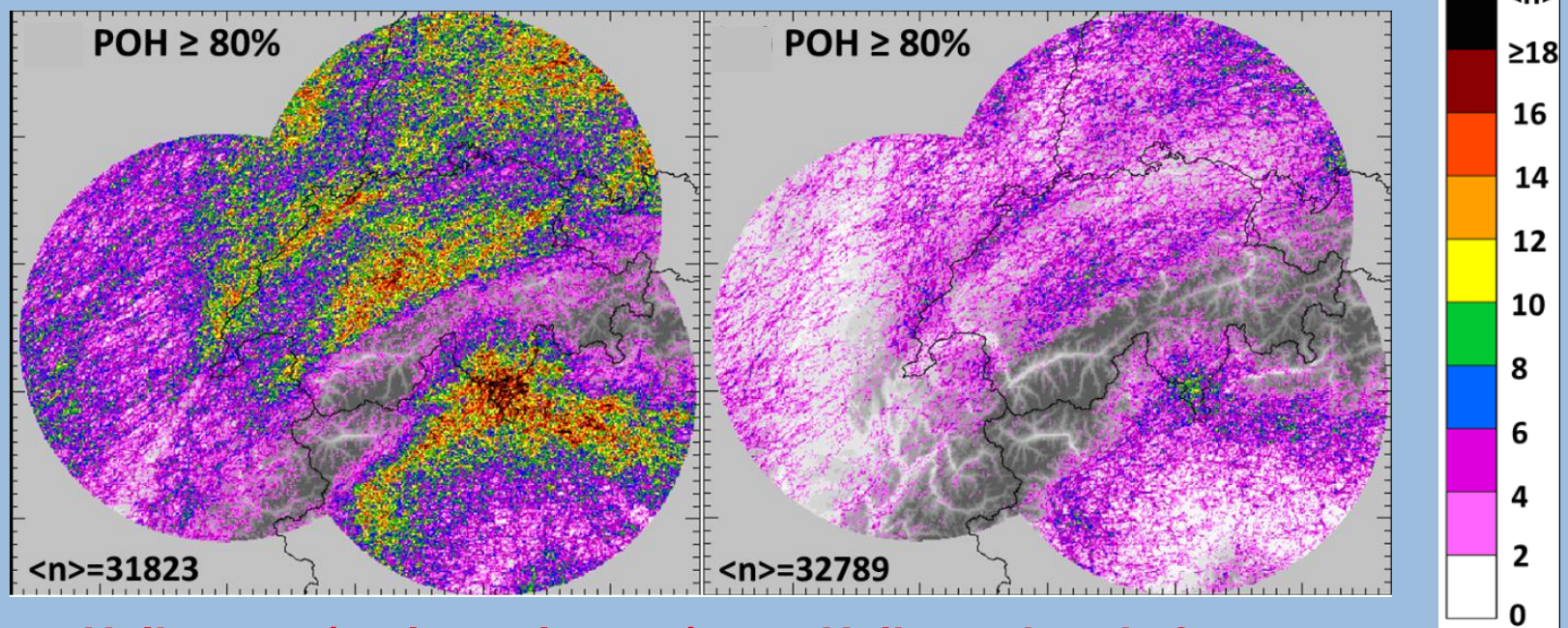




# Trajectory climatology

- Thunderstorm Radar Tracking algorithm (TRT)
- 1 km<sup>2</sup>, 5min, APR-SEP 2002-2016

**‘object  
based’**



→ Hail storm (entire trajectory)  
frequency

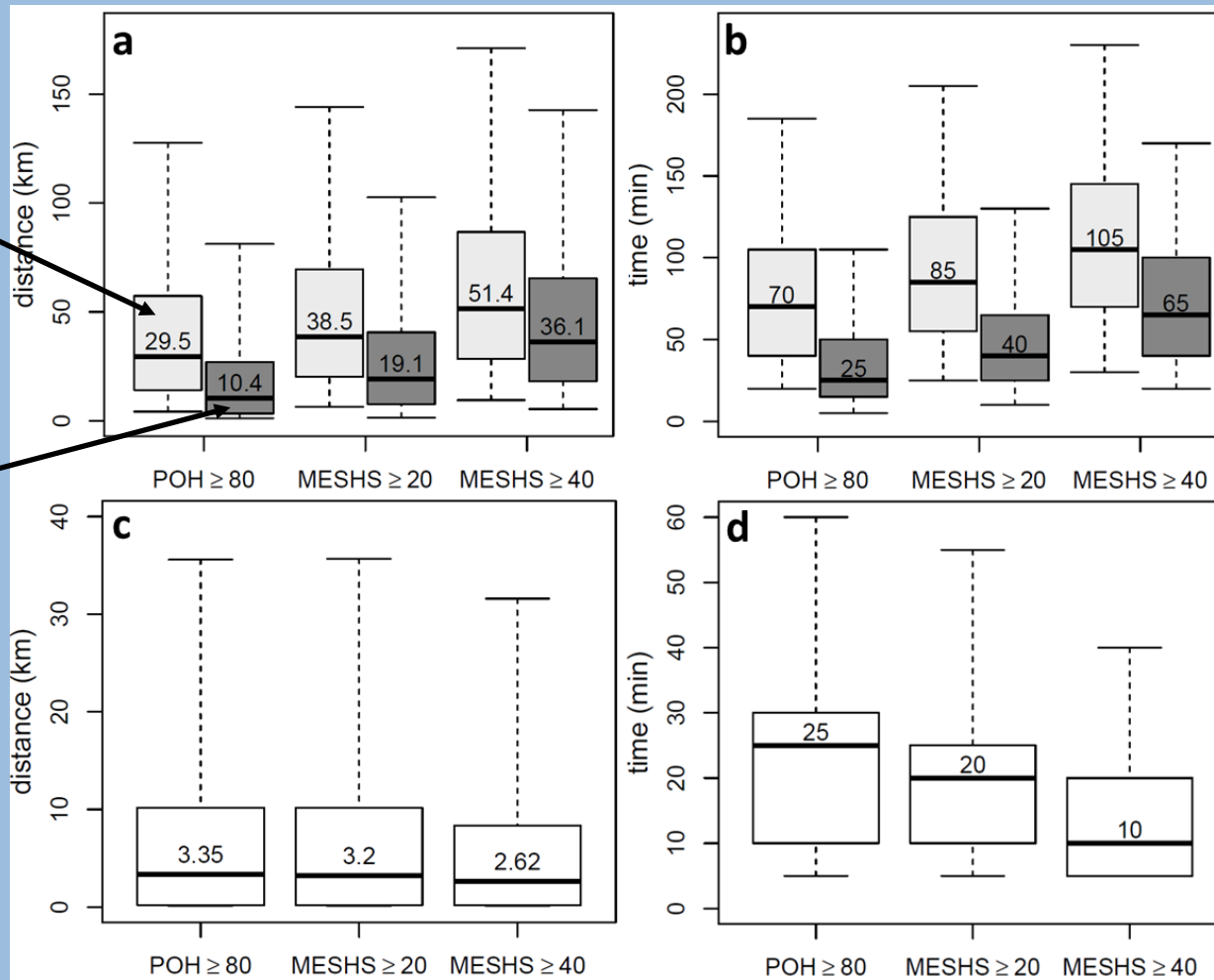
→ Hail swath only frequency



# Trajectory length, duration, explosivity

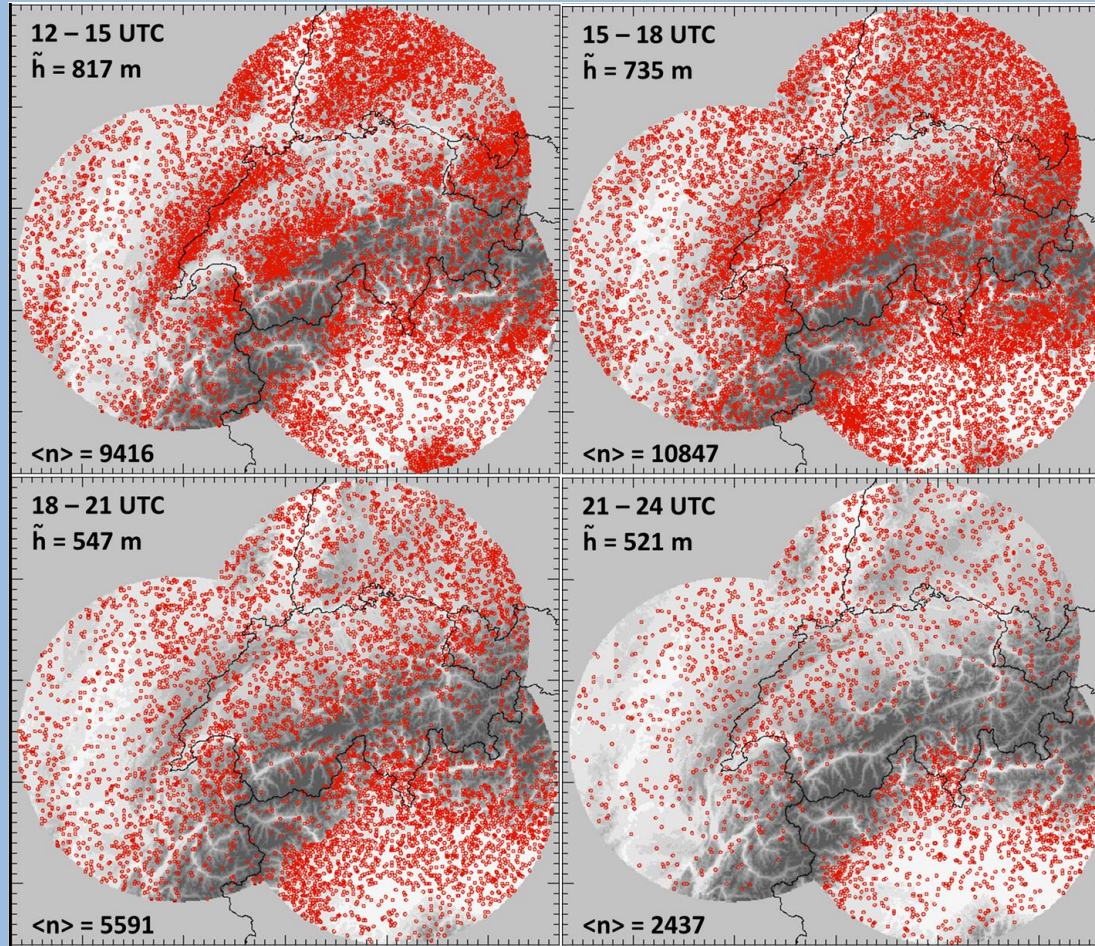
light grey:  
entire  
storm path

dark grey:  
hail swath  
only





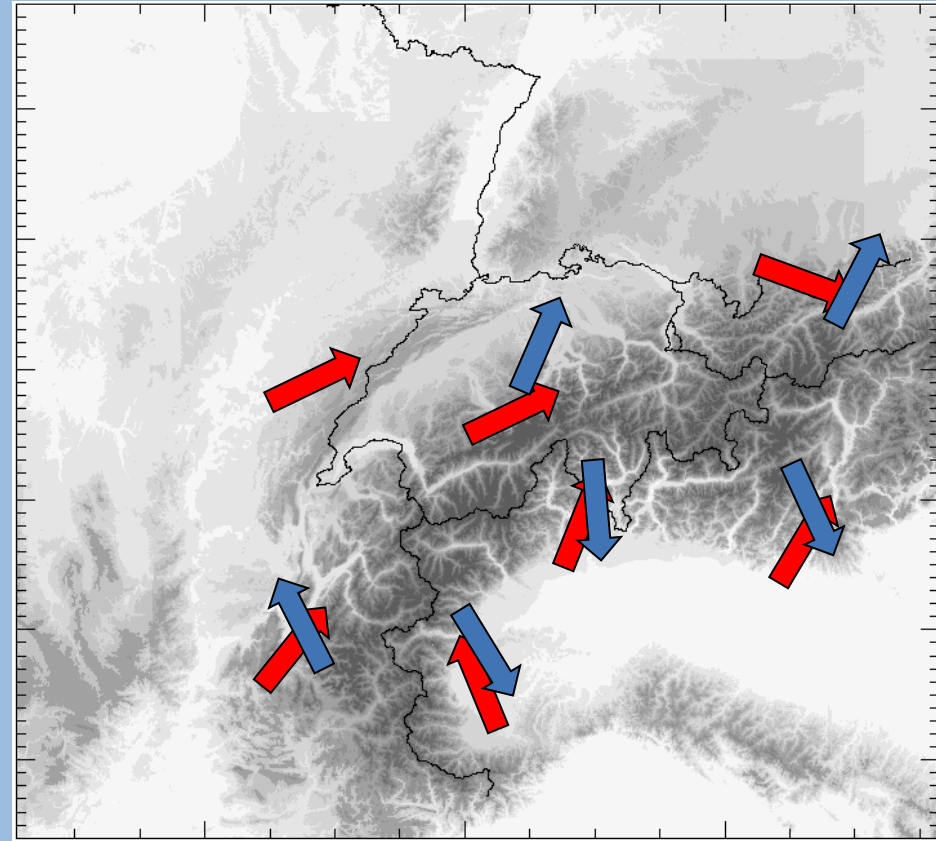
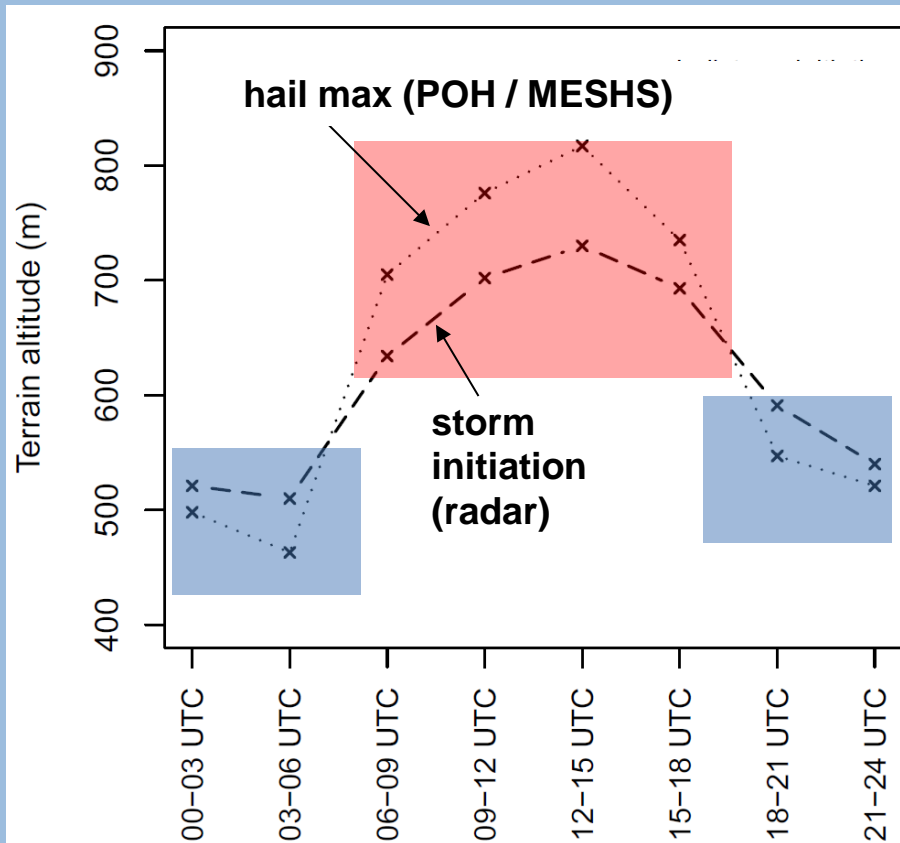
# Diurnal cycle of hail storms in the Alps



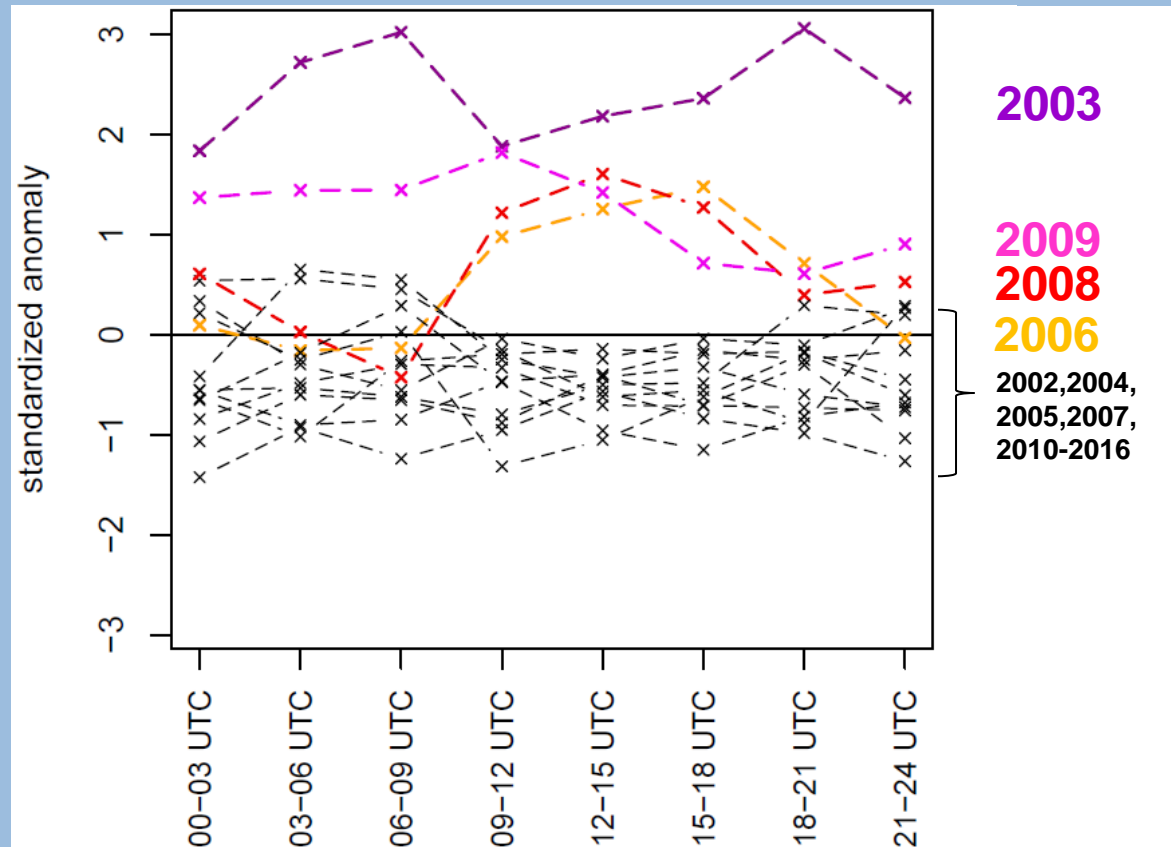
● hail storm initiation

→ **Alpine pumping and orographic triggering: during the day hail storm initiation and hail max are closer to the alpine main ridge.**

# Diurnal cycle of hail storms in the Alps

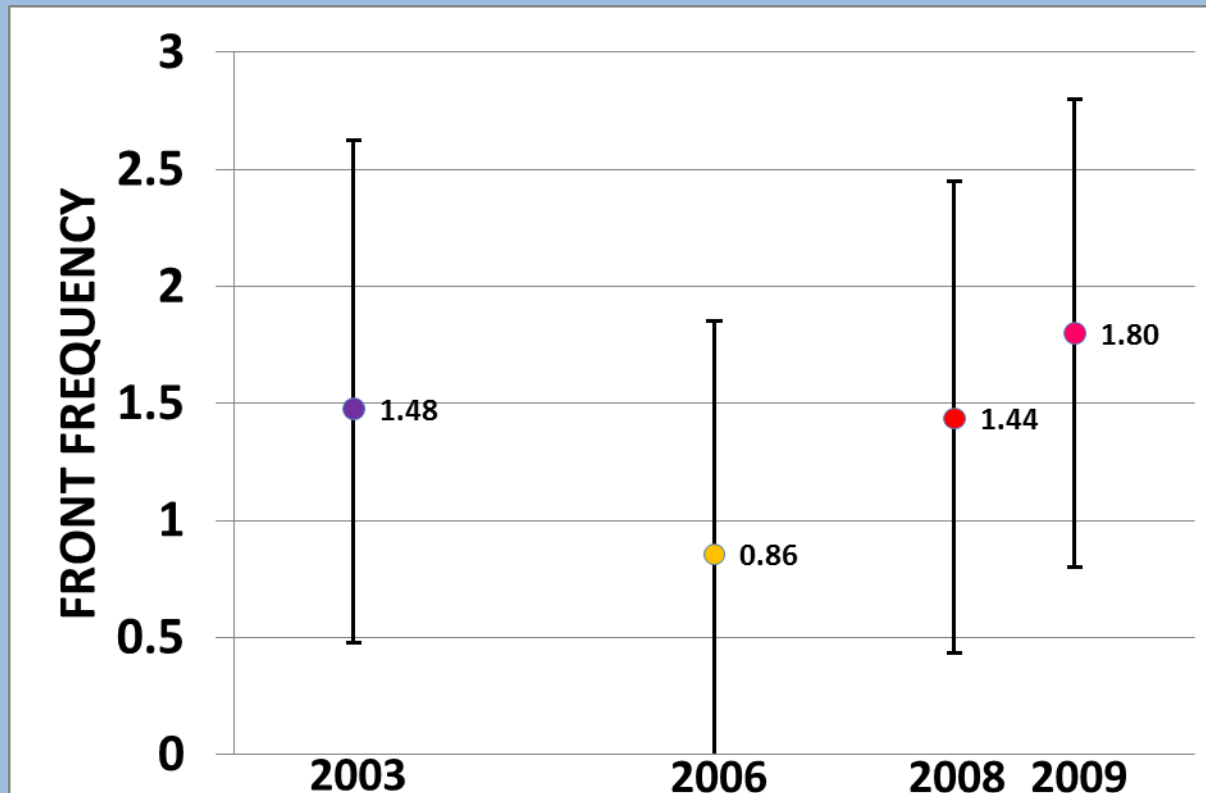


# Diurnal cycle of hail storms in the Alps



- **2006, 2008: greater fraction of airmass convection**
- **2003, 2009: diurnal cycle not present**

# Diurnal cycle of hail storms in the Alps



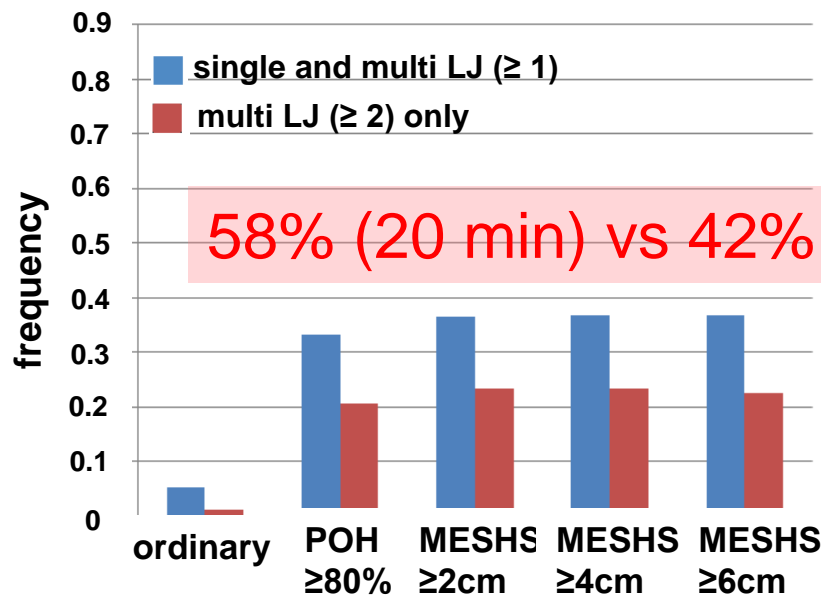
ERA-Interim

- 2006, 2008: greater fraction of airmass convection
- 2003, 2009: diurnal cycle not present

# Lightning Jumps vs. hail storms (2013-2017)

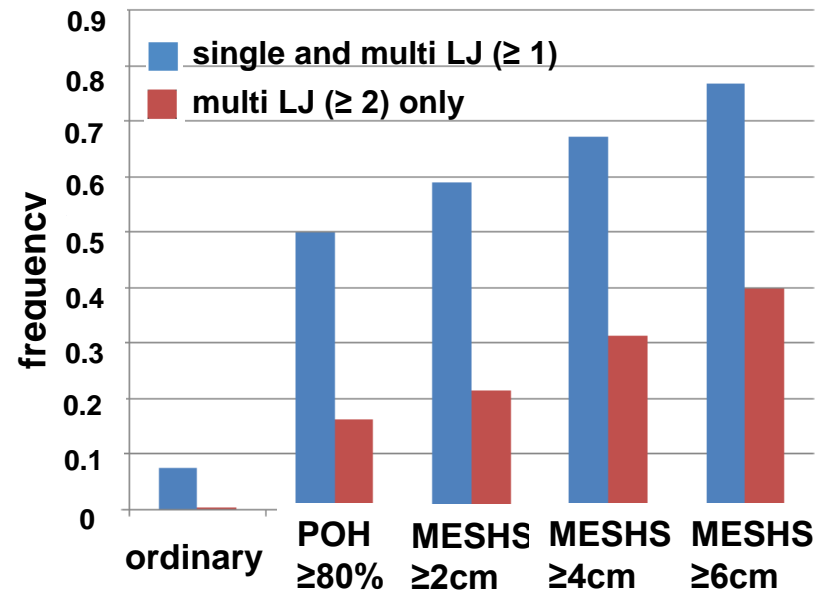
(total lightning)

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



storms  
number: (36211) (5724) (3874) (1370) (266)

**LJ during entire storm life cycle:**



- LJ algorithm: **Schultz et al., 2009**, modified (Lightningrate<sub>min</sub>: 30 flashes / 5 min,  $\alpha = 2$ )
- LJ intensity: **Wapler, 2017**





# New satellite rain rate retrieval using Artificial Neural Networks (ANN)

## Input data

- Brightness temperature
- Brightness temperature differences
- NWC SAF products (CMA, CT, CTTH)

## Reference data

quality checked

European OPERA radar composite

## Study period

2017-05-16 00:00 – 2017-07-30 23:45

800 time slots for training,

400 for validation and 400 for testing

## Methods

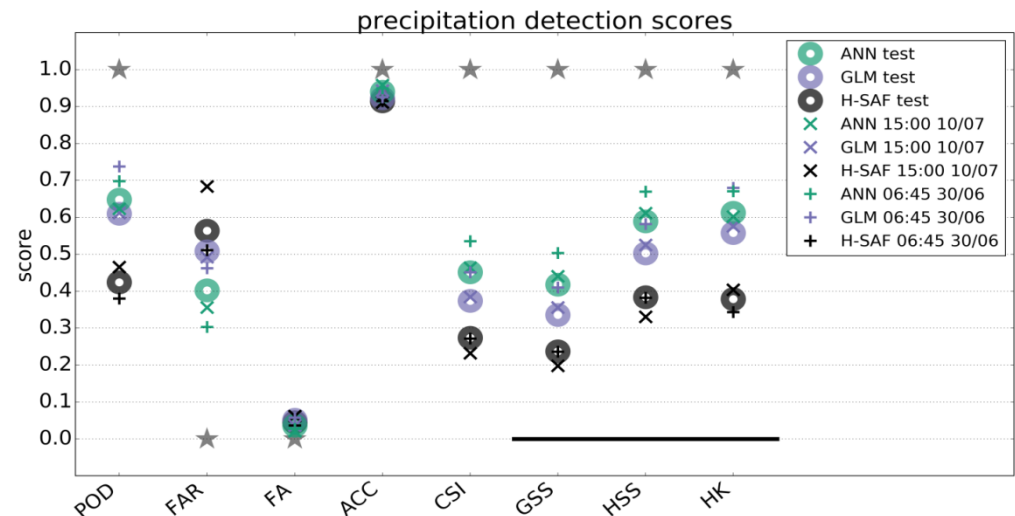
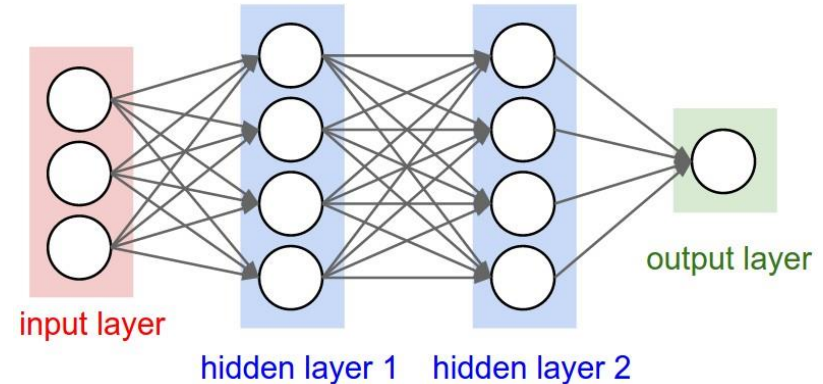
2 Multi-Layer Perceptron (MLP) ANNs

1<sup>st</sup> rain detection

2<sup>nd</sup> rain rate retrieval

both 2 hidden layers

**Beusch, et al. (in prep)**



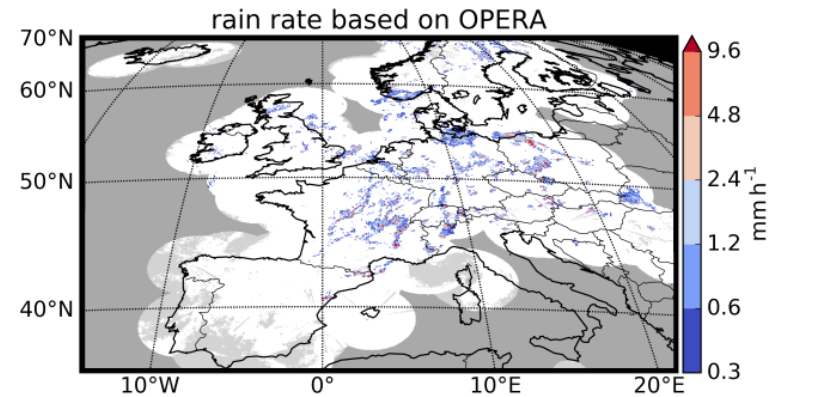
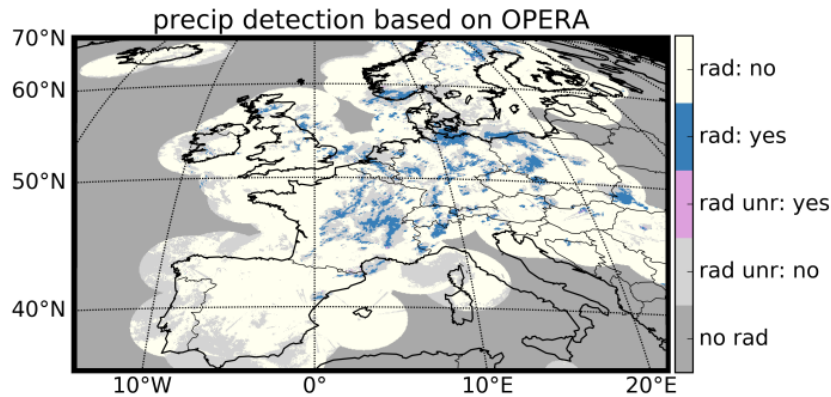
Probability of detection (POD), False alarm ratio (FAR), False alarm rate (FA), Accuracy (ACC), Critical success index (CSI), Gilbert skill score (GSS), Heidke skill score (HSS), Hanssen-Kuipers discriminant (HK) for the summer 2017 test set (circles) and the single scene case study of 10 July 2017, 15:00UTC (as x) and 30 June 2017 06:45UTC (crosses).



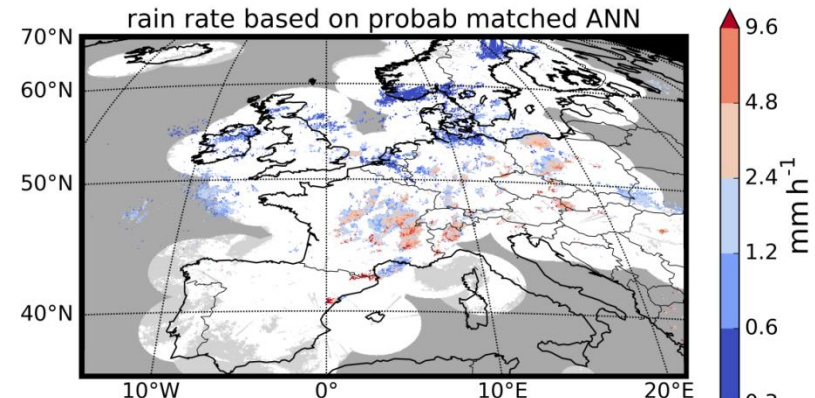
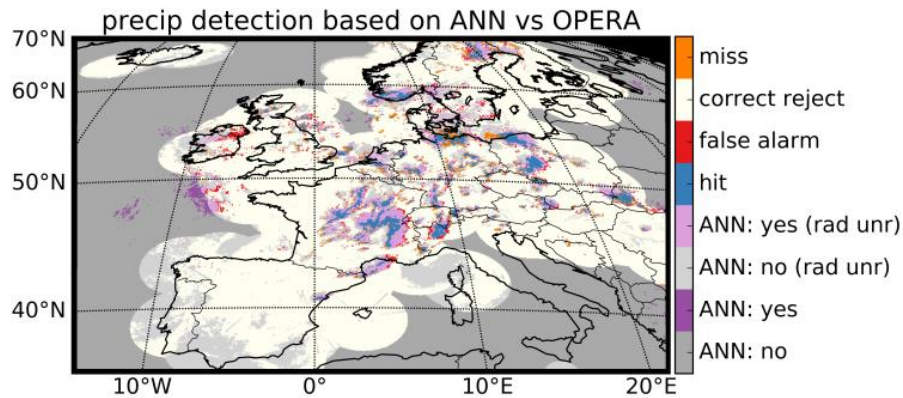


# Case study 10 July 2017 15:00 UTC

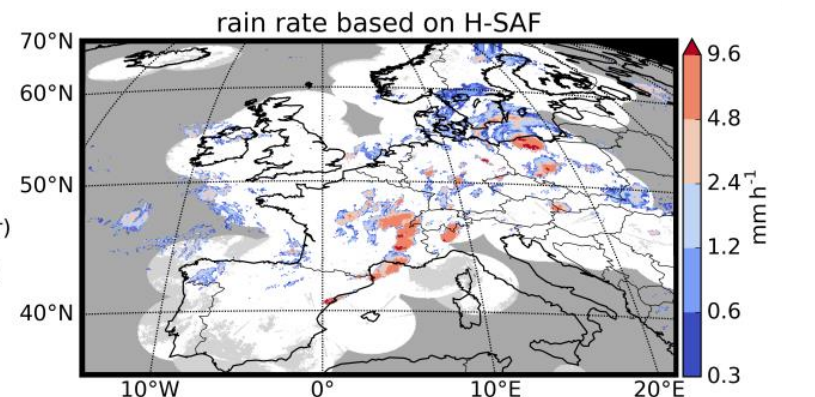
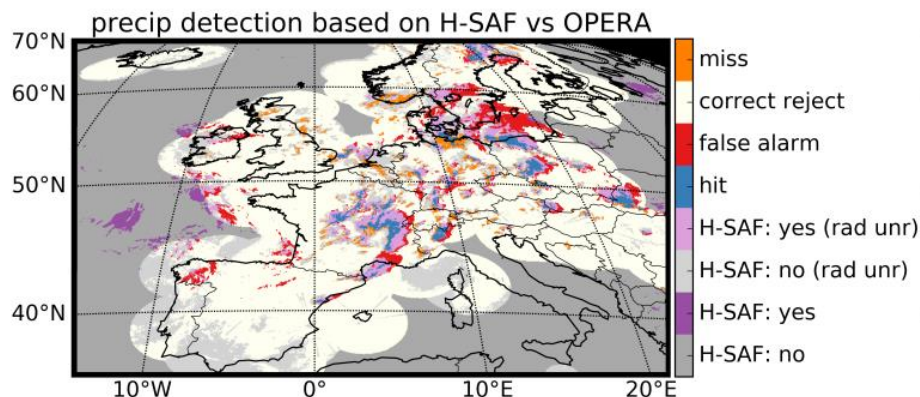
Odyssey  
Radar



artificial neural  
network (ANN)

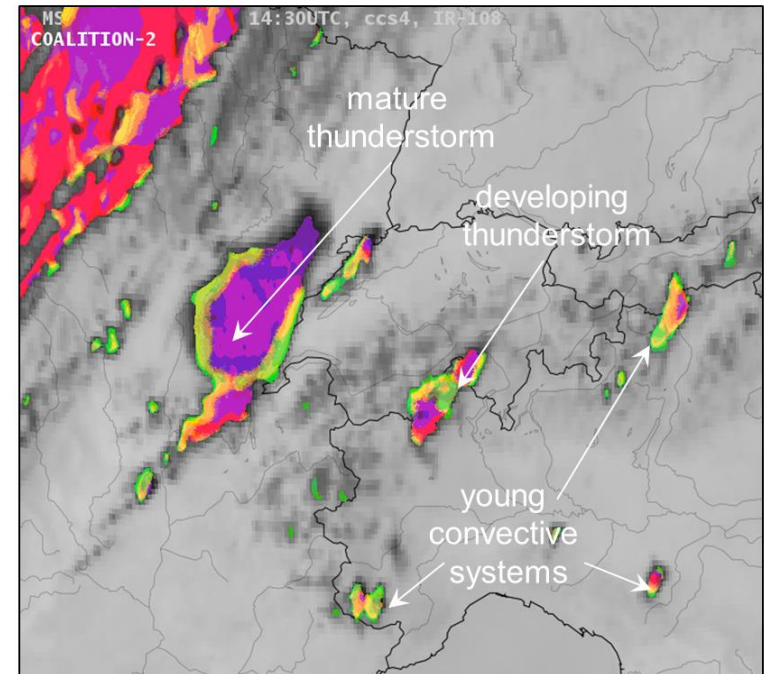


H03  
HSAF







# Thunderstorm detection COALITION2

- Mandate of the National Weather Services to issue warning of severe weather
- COALITION-2 supports thunderstorm warnings by forecasters
- Monitoring and Nowcasting of intense thunderstorm based on MSG/SEVIRI satellite observations
- Early thunderstorm detection (about 10 min before radar detection)
- Updated information every 5 min
- Spatial resolution 1 km x 1 km (for Europe 3 km x 5 km)



## COALITION2 colour interpretation

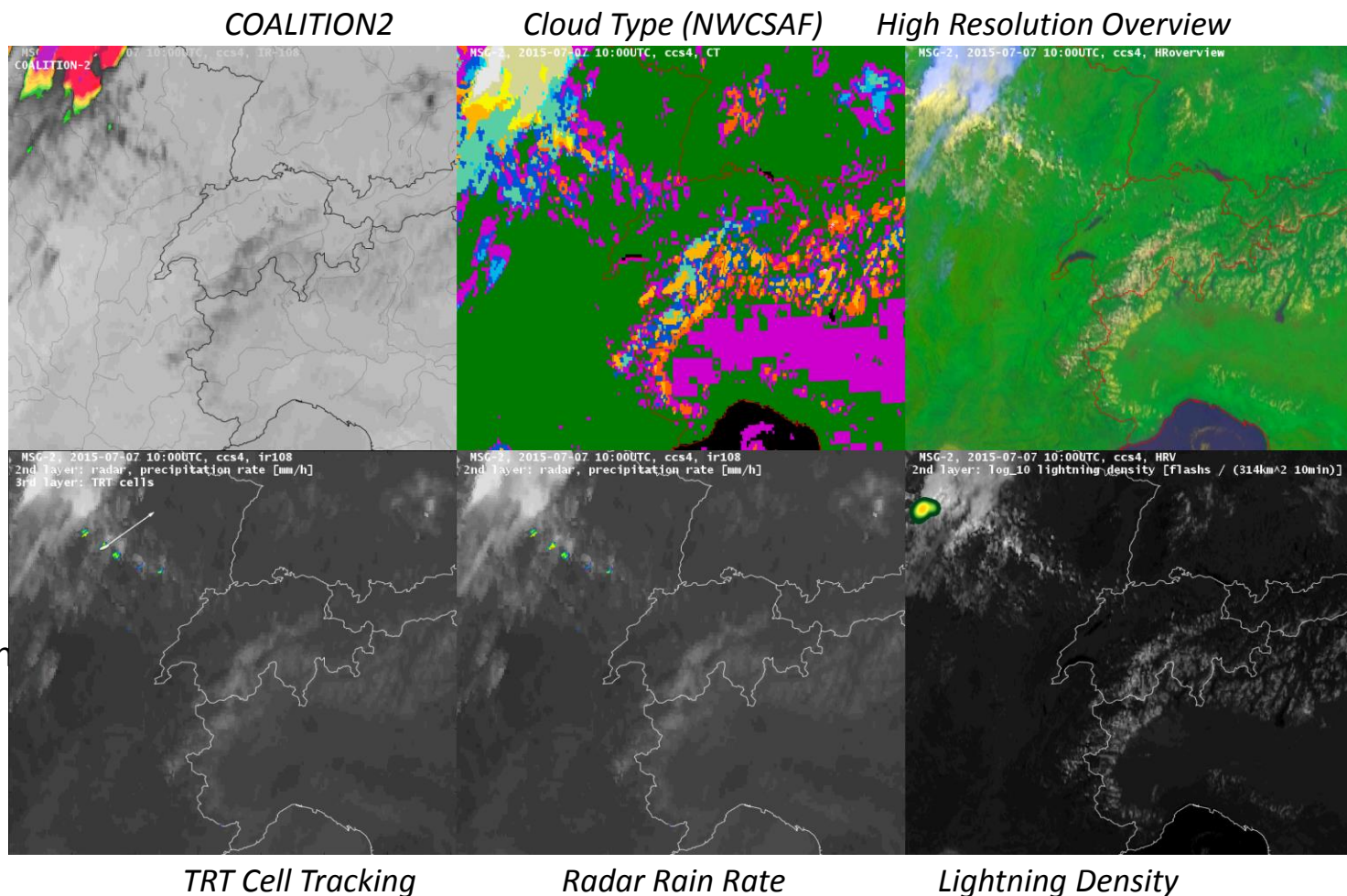
- |   |                                |
|---|--------------------------------|
|  | Strong developing water cloud  |
|  | Cloud top glaciation           |
|  | Optical thick ice cloud        |
|  | Active thunderstorm (day only) |





# COALITION-2 Swiss version

- High spatial resolution (1 km x 1 km)
- Covers Switzerland and surrounding (same as radar)
- Optimal for Thunderstorm Nowcasting and Warnings
- Used in combination with Radar and Lightning observation
- parallax correction





# References

**Thank you!**

Beusch et al., 2017. ***Thunderstorm nowcasting by applying machine learning to a multi-sensor observation and NWP model data base.*** 9<sup>th</sup> European Conference on Severe Storms 2017, Pula, Croatia

Beusch et al., (in prep). ***Satellite-based rainfall retrieval: from generalized linear models to machine learning techniques*** (in prep).

Hamann et al., 2017. ***Nowcasting of thunderstorms and severe convection in Switzerland.***

2nd European Nowcasting Conference 2017, Offenbach, Germany

Nisi et al., 2016. ***Spatial and temporal distribution of hailstorms in the Alpine region: a long-term, high resolution, radar-based analysis.*** QJRMS, 142: 1590–1604.

Nisi et al., 2018. ***A 15-year hail streak climatology for the Alpine region.*** (accepted QJRMS)