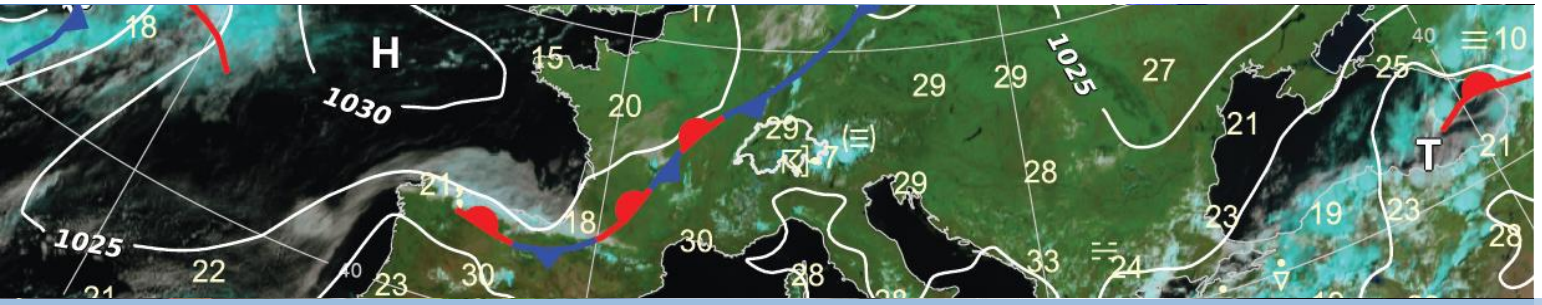

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Swiss Confederation
Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology
MeteoSwiss

A severe hail storm in complex topography

Multi-data process study

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Motivation / Key questions 6 June 2015

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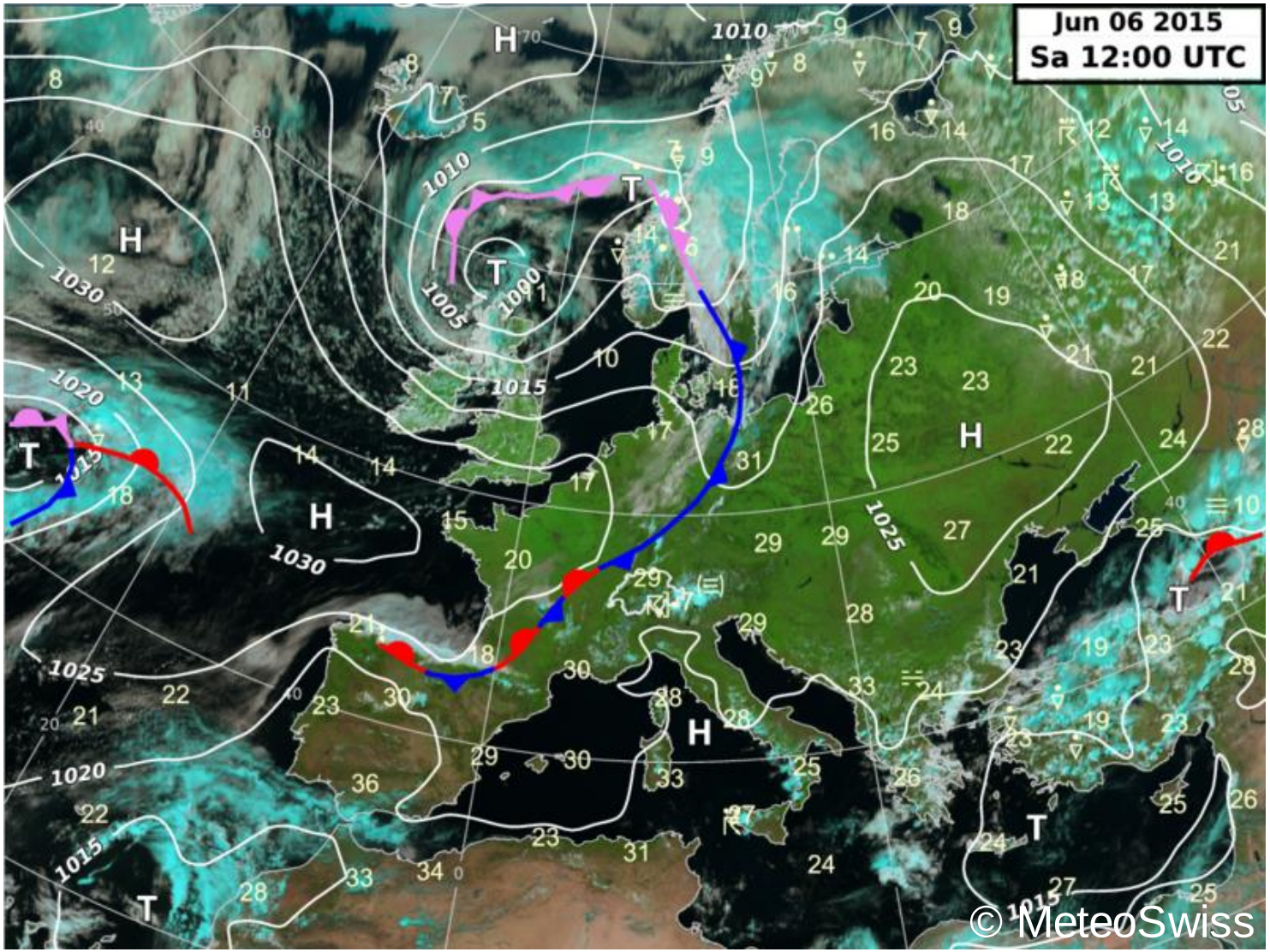
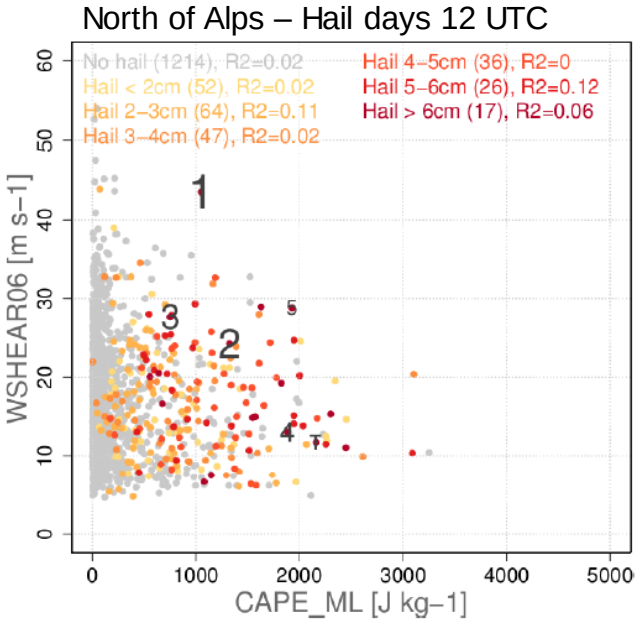


Motivation / Key questions 6 June 2015

> Importance of **orography** and **cold front**?

> Availability of **many direct and indirect hail observations** for severe hail storm 6 June 2015. Did they match?



> What did the **wind shear** look like in this particular case?

Data

- **Atmospheric environment characterisation**:

- Mesoscale:
  - **COSMO-2** analysis (2.2 km, hourly)
  - **WRF** simulation (1 km, 5 min)
    talk yesterday, A. Martynov, 15^{00}
  - **Radio-sounding** Payerne (1200 UTC)

- Large/synoptic scale:
  - **ERA-Interim** reanalysis (1°, 6 h)

Data

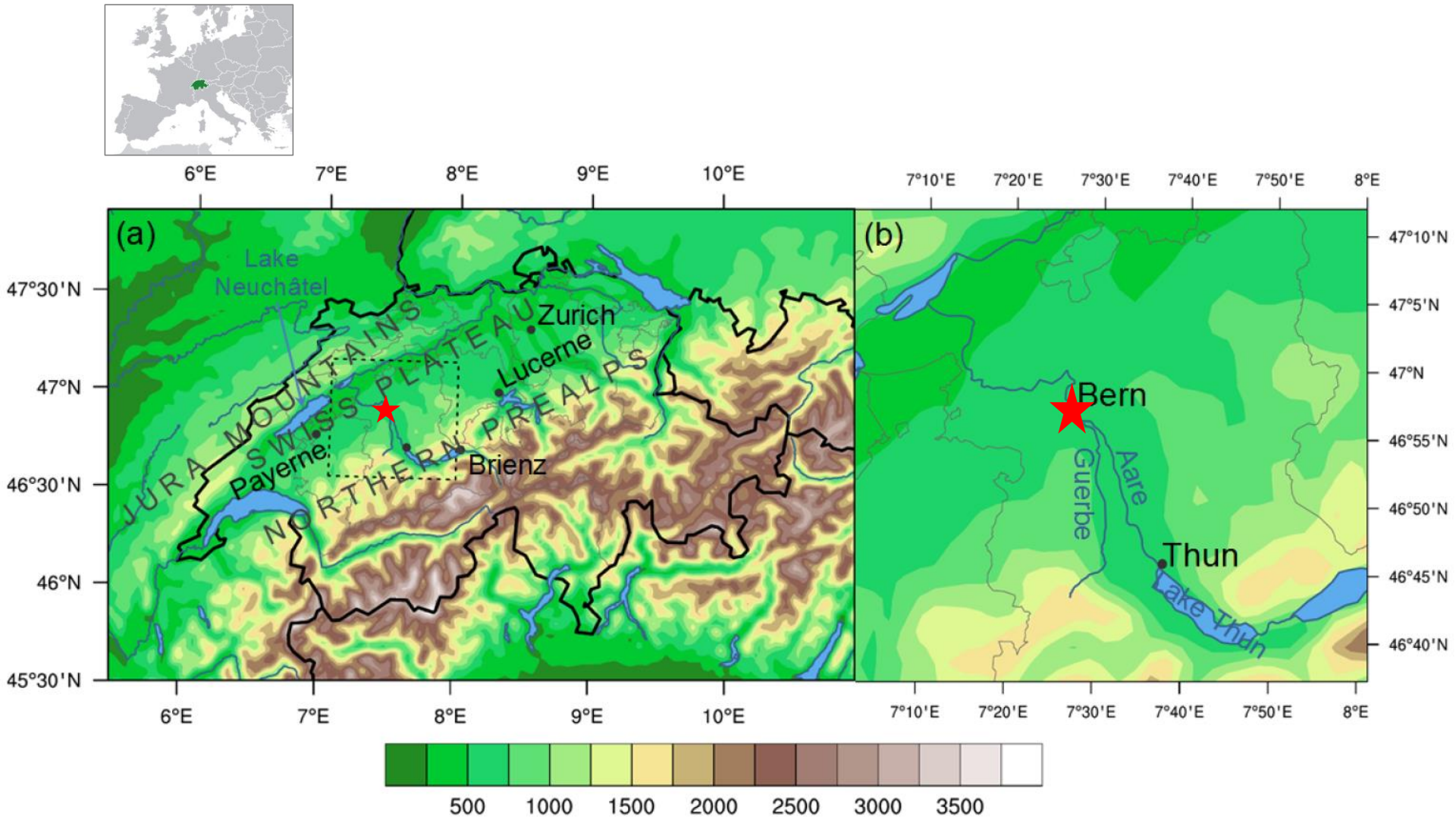
- **Hail observations**:
- **Radar**
  - Probability of hail (**POH**)
  - Maximum expected severe hail size (**MESHS)**
  - Hydrometeor classification
    talk J. Figueras i Ventura, today 11^{20}

Indirect

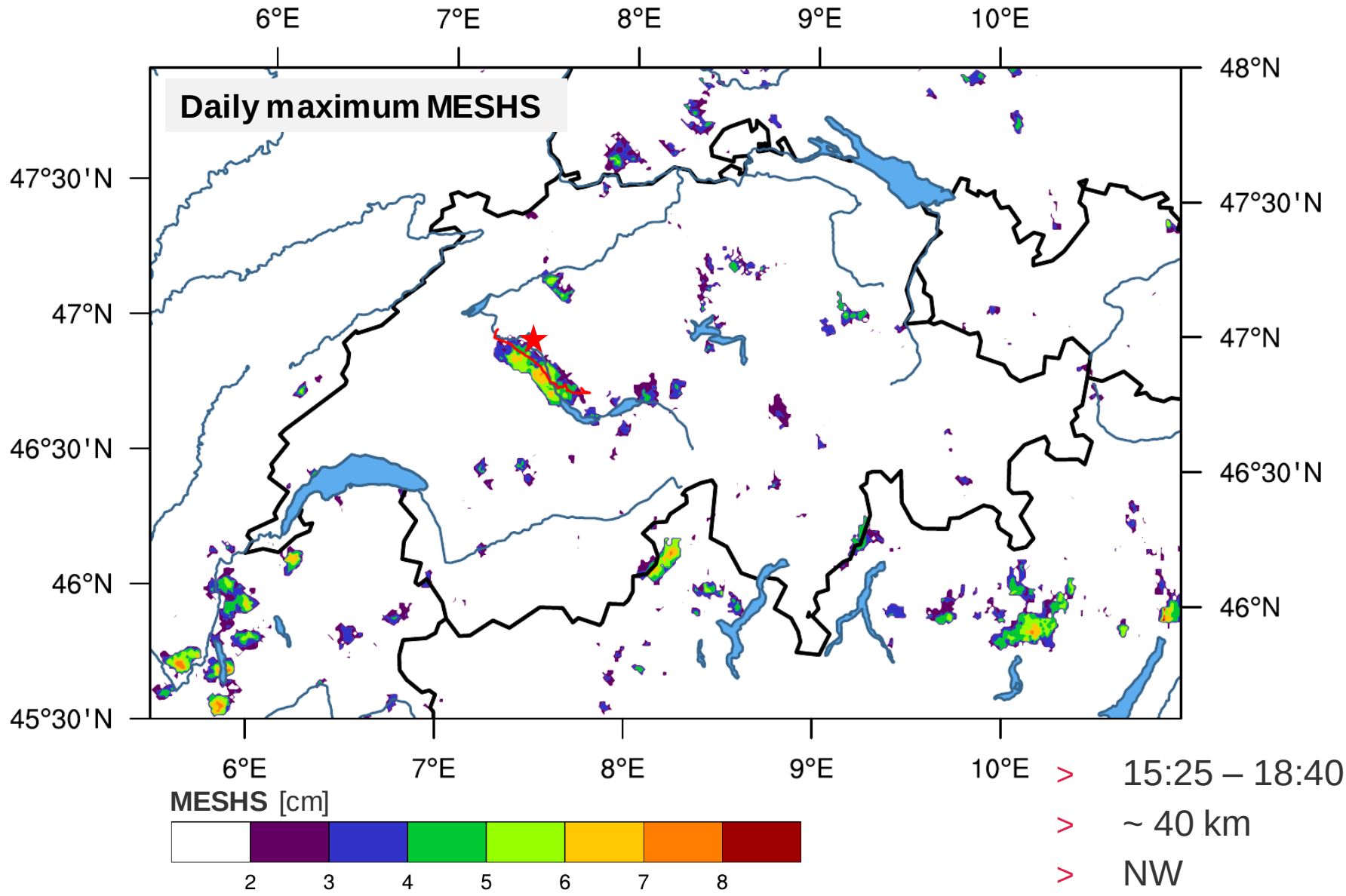
- **Insurance claims**
- **Crowd-sourced information**
  - MeteoSwiss App
    talk P. Noti, today 12^{20}
  - ESWD
  - Other photographic material

Direct

Orography

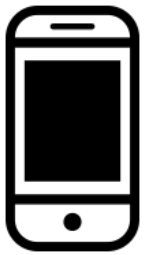

(a)
(b)
Lake Neuchâtel
JURA MOUNTAINS
SWISS PLATEAU
NORTHERN PREALPS
Zurich
Lucerne
Payerne
Brienz
Bern
Guerbe
Aare
Thun
Lake Thun
6°E
7°E
8°E
9°E
10°E
47°30'N
47°N
46°30'N
46°N
45°30'N
7°10'E
7°20'E
7°30'E
7°40'E
7°50'E
8°E
47°10'N
47°5'N
47°N
46°55'N
46°50'N
46°45'N
46°40'N
500
1000
1500
2000
2500
3000
3500

What happened on 6 June 2015?



- 15:25 – 18:40 UTC
- ~ 40 km
- NW

Hail observations on 6 June 2015



344 matched MeteoSwiss App reports
see talk P. Noti 12[20]

~1000 damage claims (>80% CH)

6 ESWD reports Photos

Geo-referenced hail (size) info

POH ✓

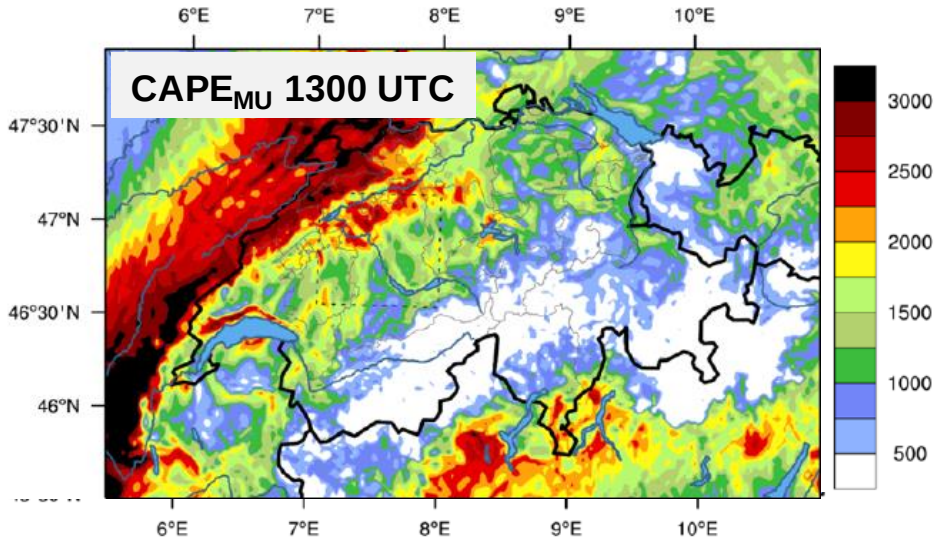
MESHS ✓

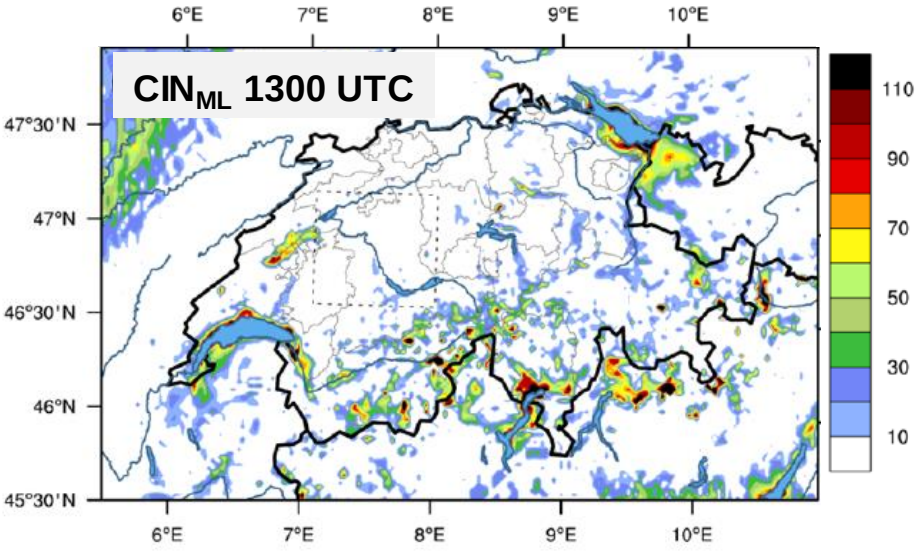
© Photos: K.C. Ewald, M. Imhof, E.A. Schenk

Local environment on 6 June 2015

- Very **unstable** atmosphere (CAPE 1000-1500 J/kg, sounding 99th perc.) near storm development area
- More unstable closer to cold front (Jura mountains)

- **No convective inhibition** (CIN ~0 J/kg)

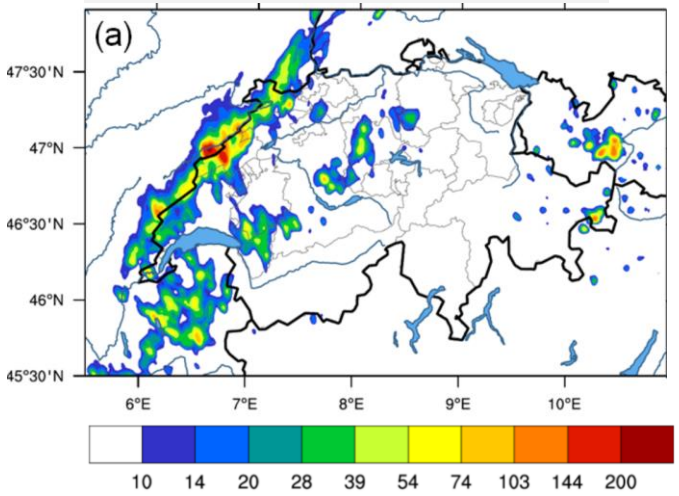




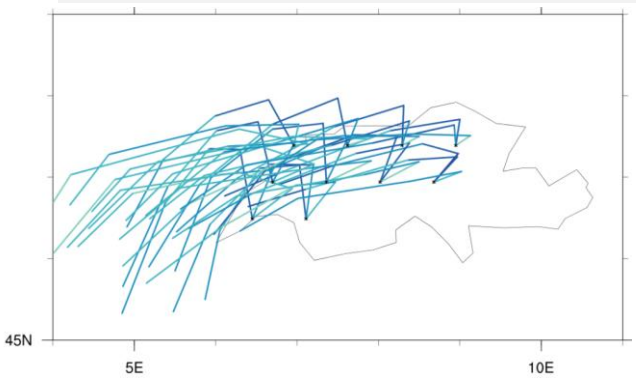
Local environment on 6 June 2015

- Very **moist** atmosphere above northern Switzerland, especially at **low-levels**
- Lagrangian **backwards-trajectories**:
  - ~ **2/3 advected** from the **Mediterranean** (Ligurian sea)
  - ~ **1/3** stemmed from **local recycling** of soil moisture in connection with precipitation on 5 June 2015

24h accu 5 June 2015 [mm]

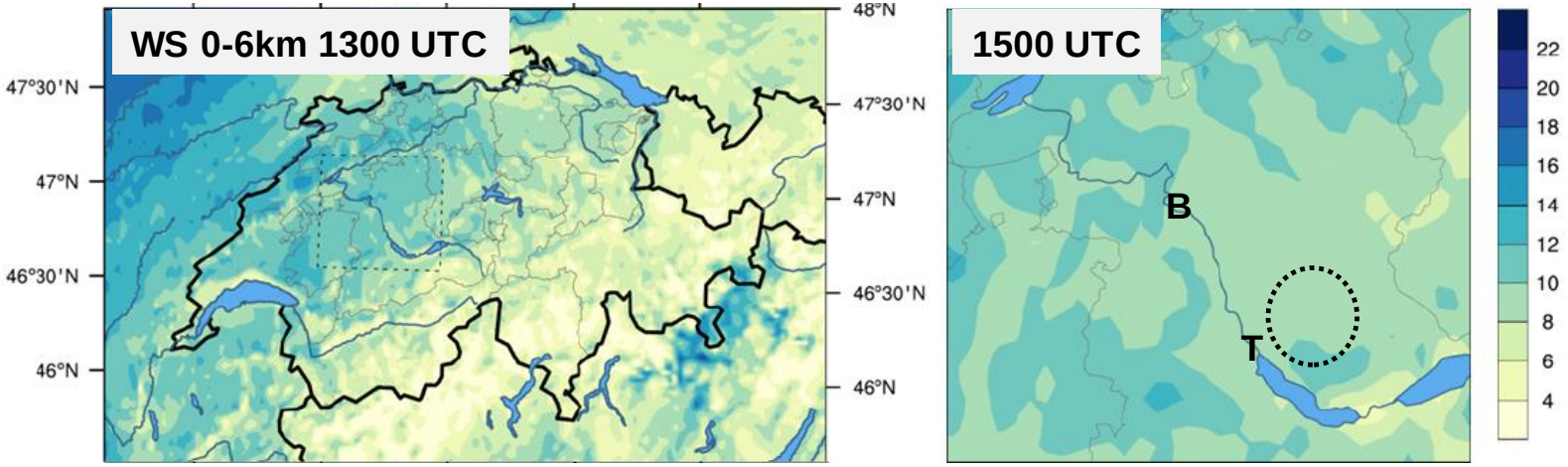


Low-level traj. 6 June 2015 -24h



Local environment on 6 June 2015

- Weak bulk deep-layer wind shear
- **BUT**…

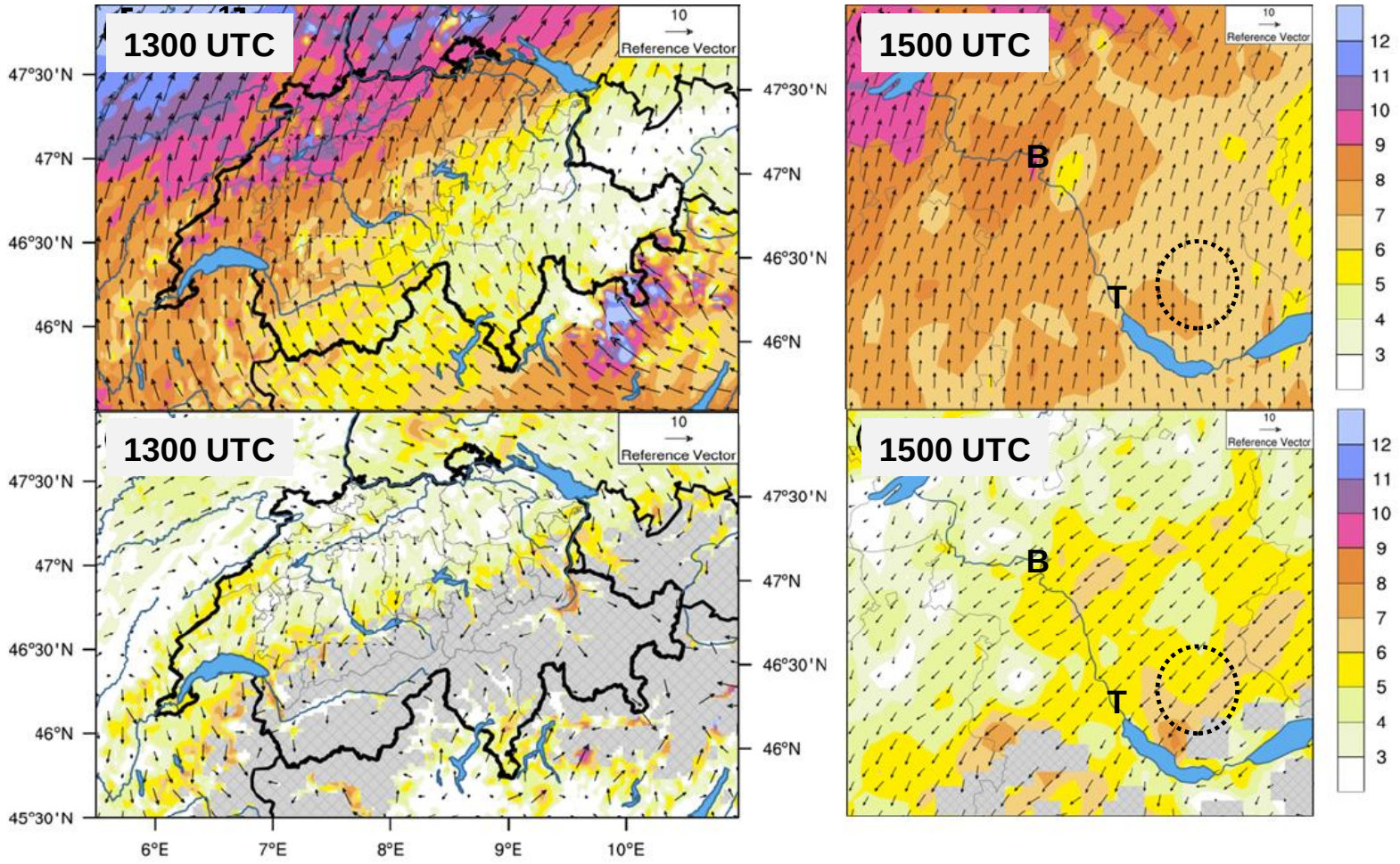


B Bern
T Thun

Environment on 6 June 2015

Wind 500 hPa (top) and 850 hPa (bottom)

B Bern
T Thun



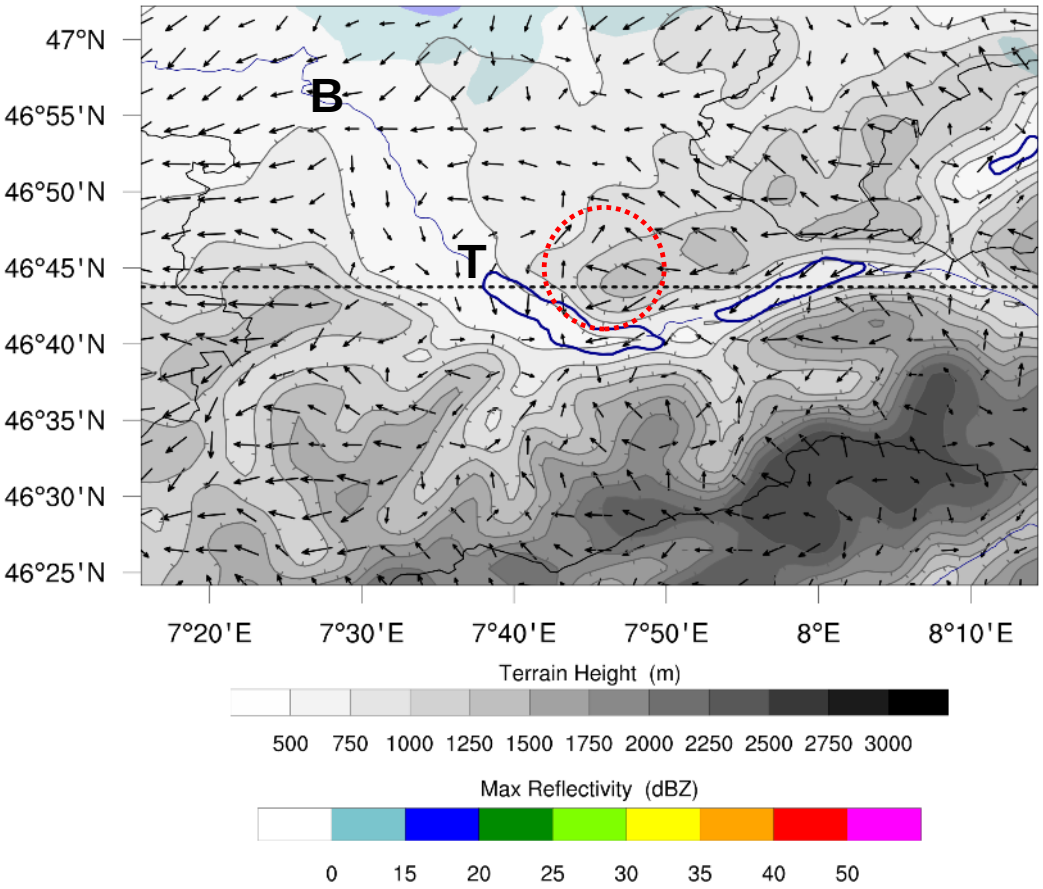
- **Strong directional wind shear**
- S/SW flow at mid-high levels and Alpine pumping at low-levels

Role of cold front

- **Inversion of the QG-omega-equation:**
  there was **no important contribution** to the vertical motion (lifting) by the **cold front** or large-scale

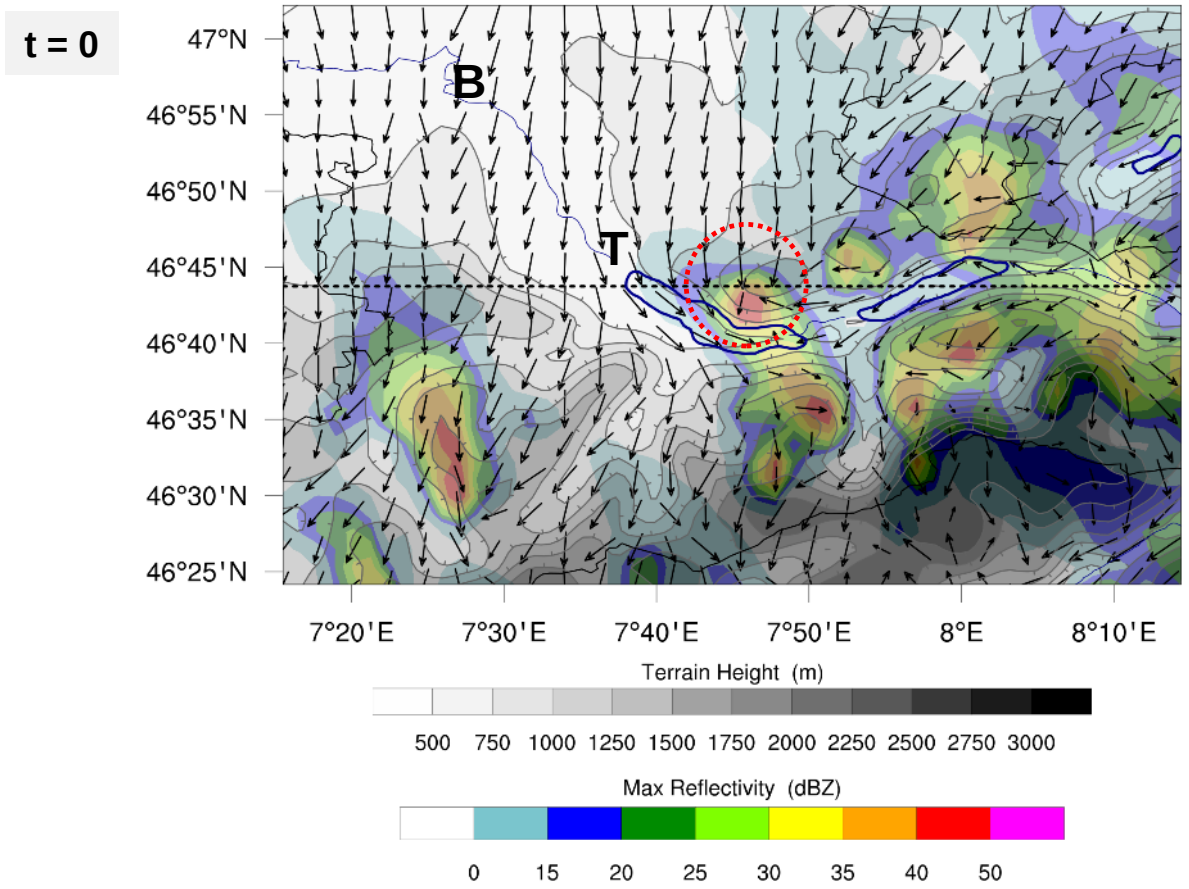
- Other possible mechanisms were investigated:
  - horizontal (moisture flux) convergence
  - gravity waves
  - orography

Triggering and propagation



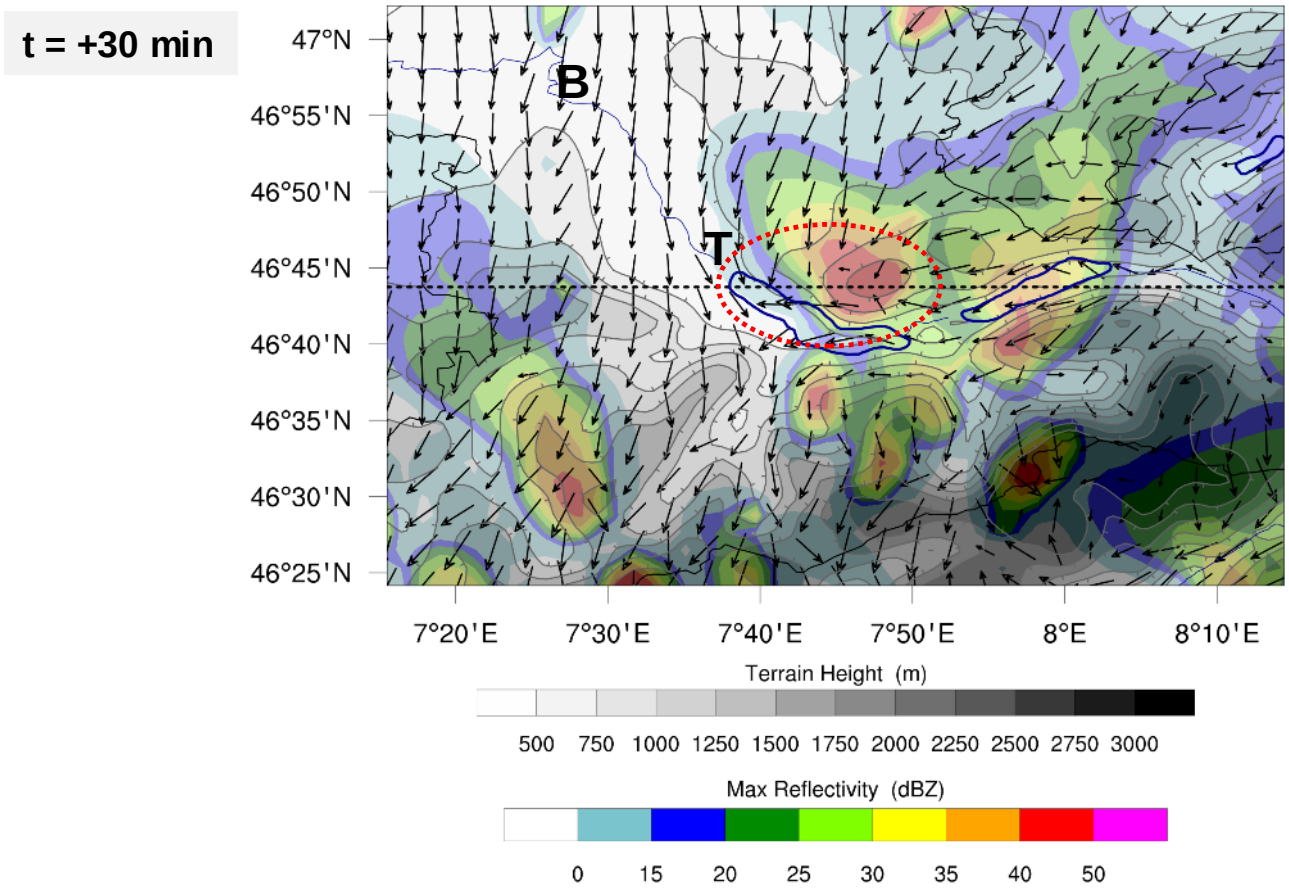
WRF simulation
No assimilation
ERA-I all 6h

Triggering and propagation



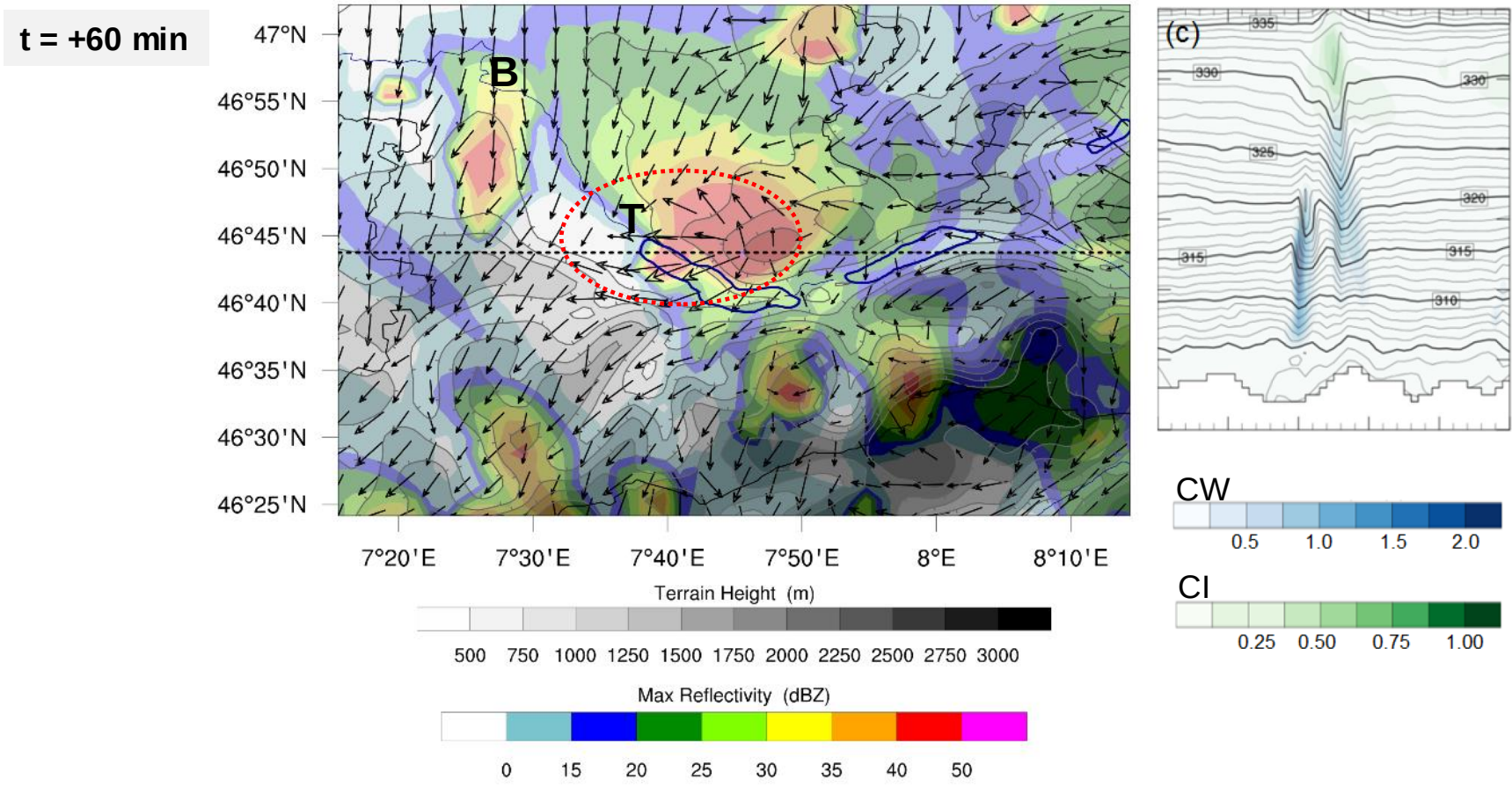
- Strong convergence at mountain top
- Cross section: mountain top +1°C than free atmosphere → thermo-topographic winds

Triggering and propagation



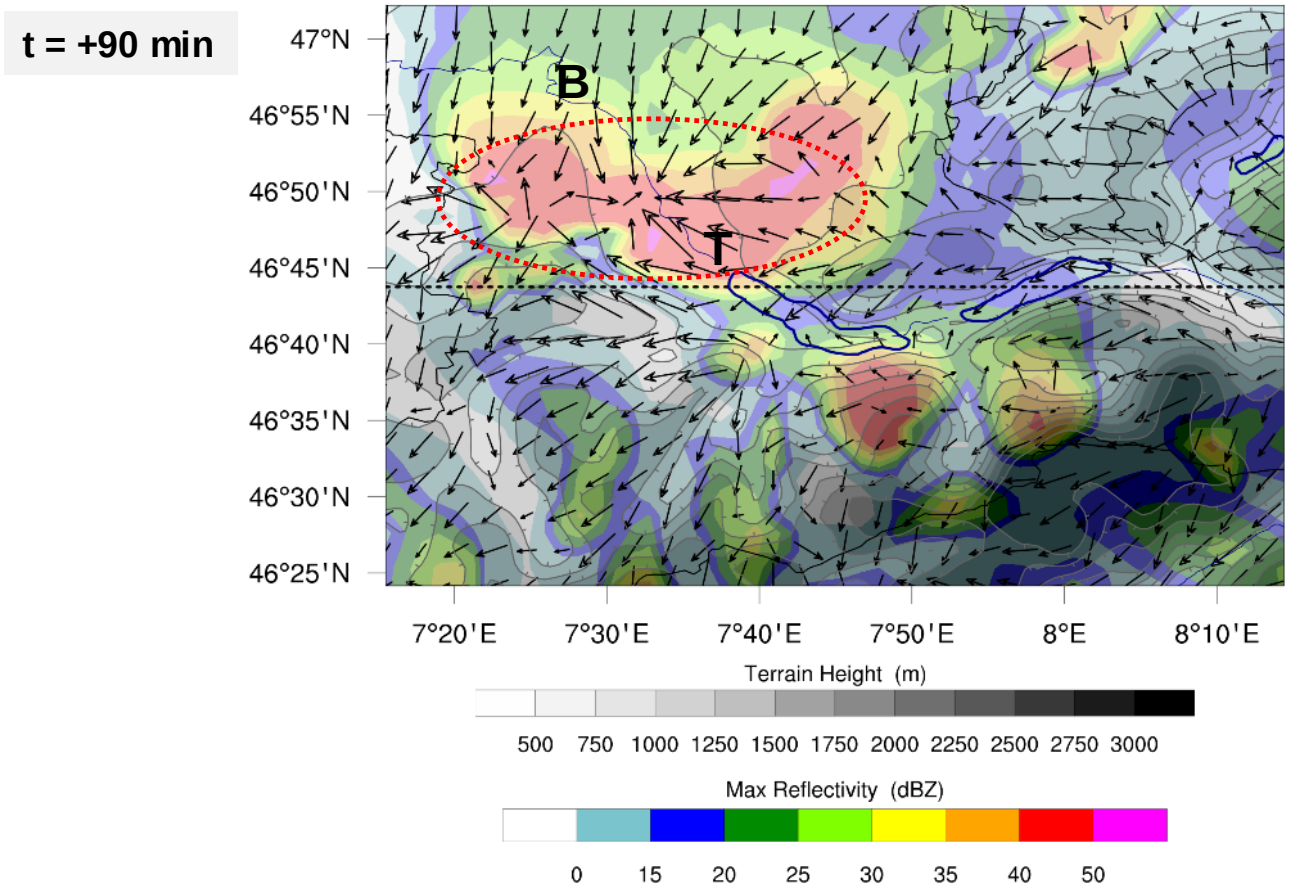
- Quasi-stationary
- Cross sections: cooled mountain top → cold pool

Triggering and propagation



- Downdraft / cooling of western flank of mountain → cold pool
- Updraft regeneration (auto-propagation mechanism)?

Triggering and propagation



- Because of steep topography, the cold air flows downhill
- Convergence at the centre of the valley!

Conclusions

- **Many direct** hail observations **confirm** large hail estimated by MESHS

- **Pre-convective environment:**
  - Elevated instability and low convective inhibition
  - Elevated low-level moisture, Mediterranean sea + local
  - Weak bulk deep layer wind shear

- **Roles of orography:**
  - Alpine pumping → directional wind shear → organisation
  - Thermo-topographic winds → convergence at top
  - Cold pool flow down steep flank → convergence at valley bottom → auto-propagation mechanism

- **No role of cold front** for lifting

Thank you for your attention!

Questions?

Trefalt S., Martynov A., Barras H., Besic N., Hering A.M., Lenggenhager S., Noti P., Röthlisberger M., Schemm S., Germann U. and Martius O.,
A multi-data process study of a severe hail storm in complex topography, submitted to *Weather and Forecasting,* 2017

Contact: S. Trefalt, simona.trefalt@meteoswiss.ch