Hail frequency in central Europe estimated from radar data - and the relation to orographic / atmospheric characteristics

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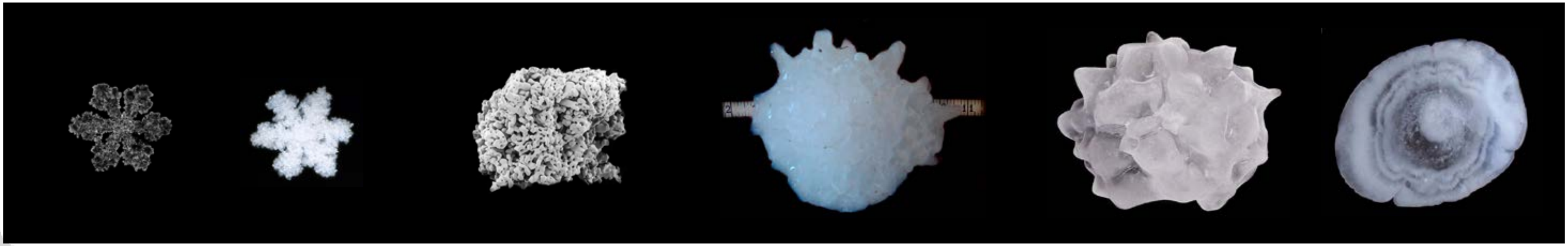
Key questions…

Assessment of the hail hazard**?**

Pre-convective conditions**?**

Frontal vs. non-frontal hail**?**



Methods: hail estimation from radar

2D/3D radar reflectivity: FRANCE, GER, BELUX

Mason (1971) criterion

$$Z > X \text{ dBZ}$$

Waldvogel (1979) criterion

$$HK = Z_{46} - Z_{0°C}$$

Lightning data (CG strokes) Siemens BLIDS

strokes YES/NO → correction of clutter

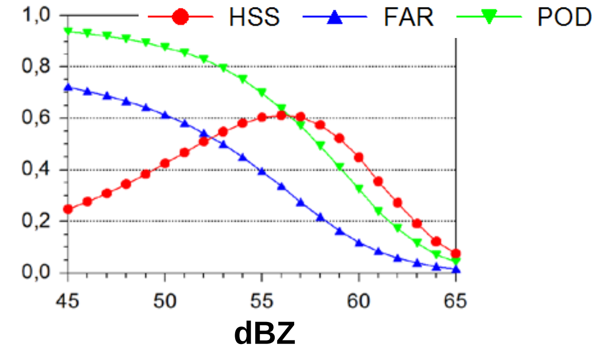
Tracking conv. structures TRACE3D/METAR

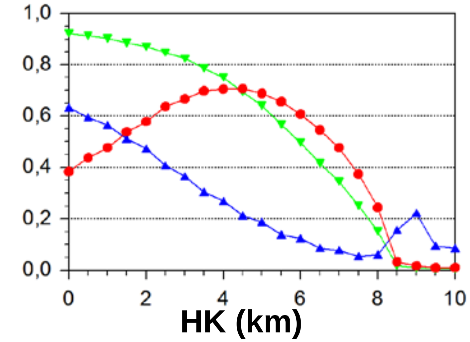
reconstruction of hailstreaks; advection correction

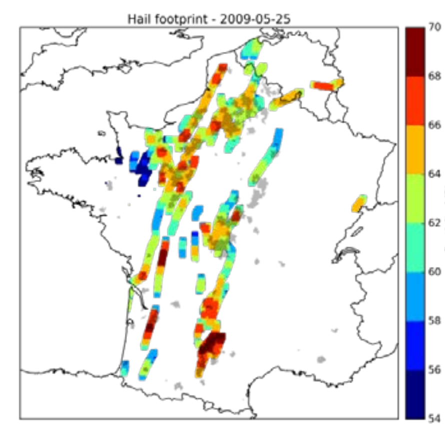
Calibration using insurance loss data

determination of thresholds + tracking parameters

Event set: Hailstreaks, frequency

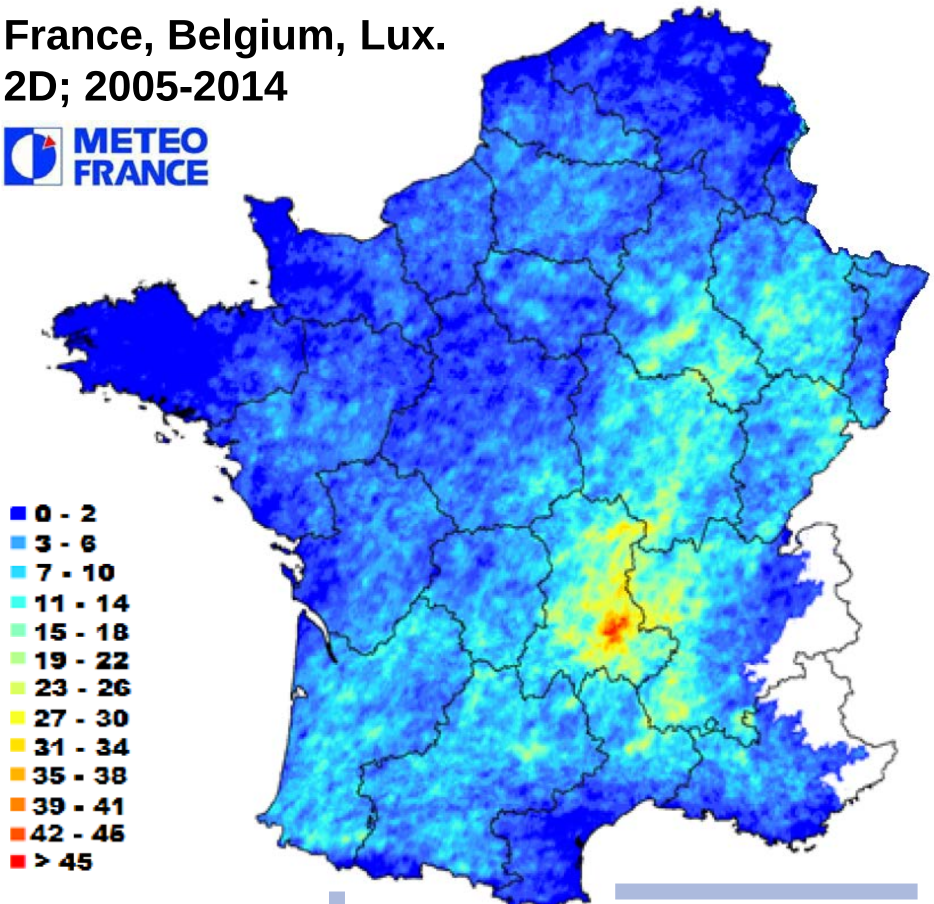




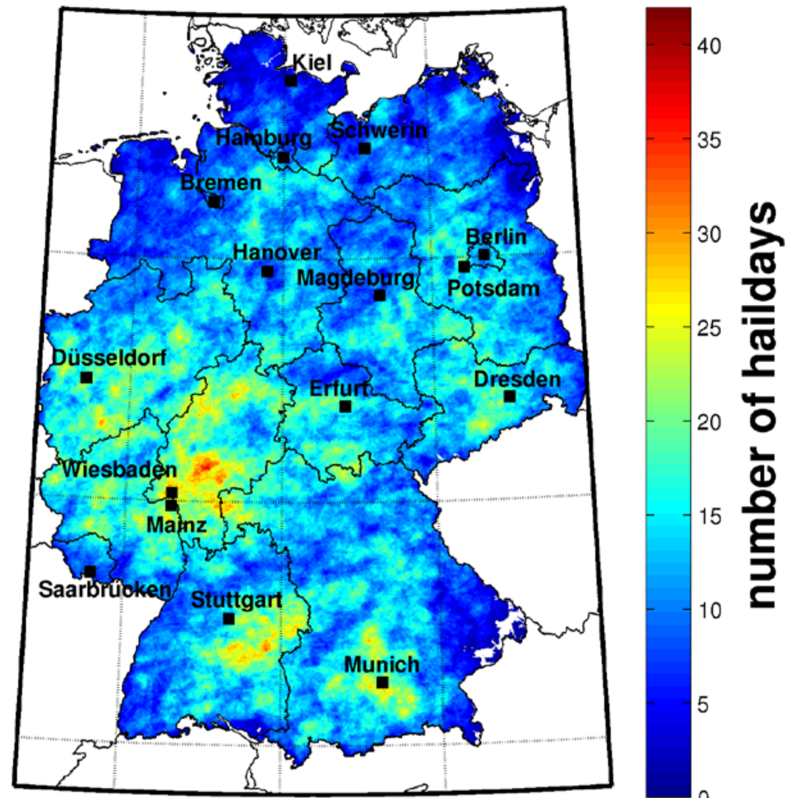


Radar-based hail*climatologies*

France, Belgium, Lux.
2D; 2005-2014



Germany
3D; 2005-2015



Days with hail signals
(2D/3D radar reflectivity)

(Fluck, 2017;
Schmidberger, 2017)

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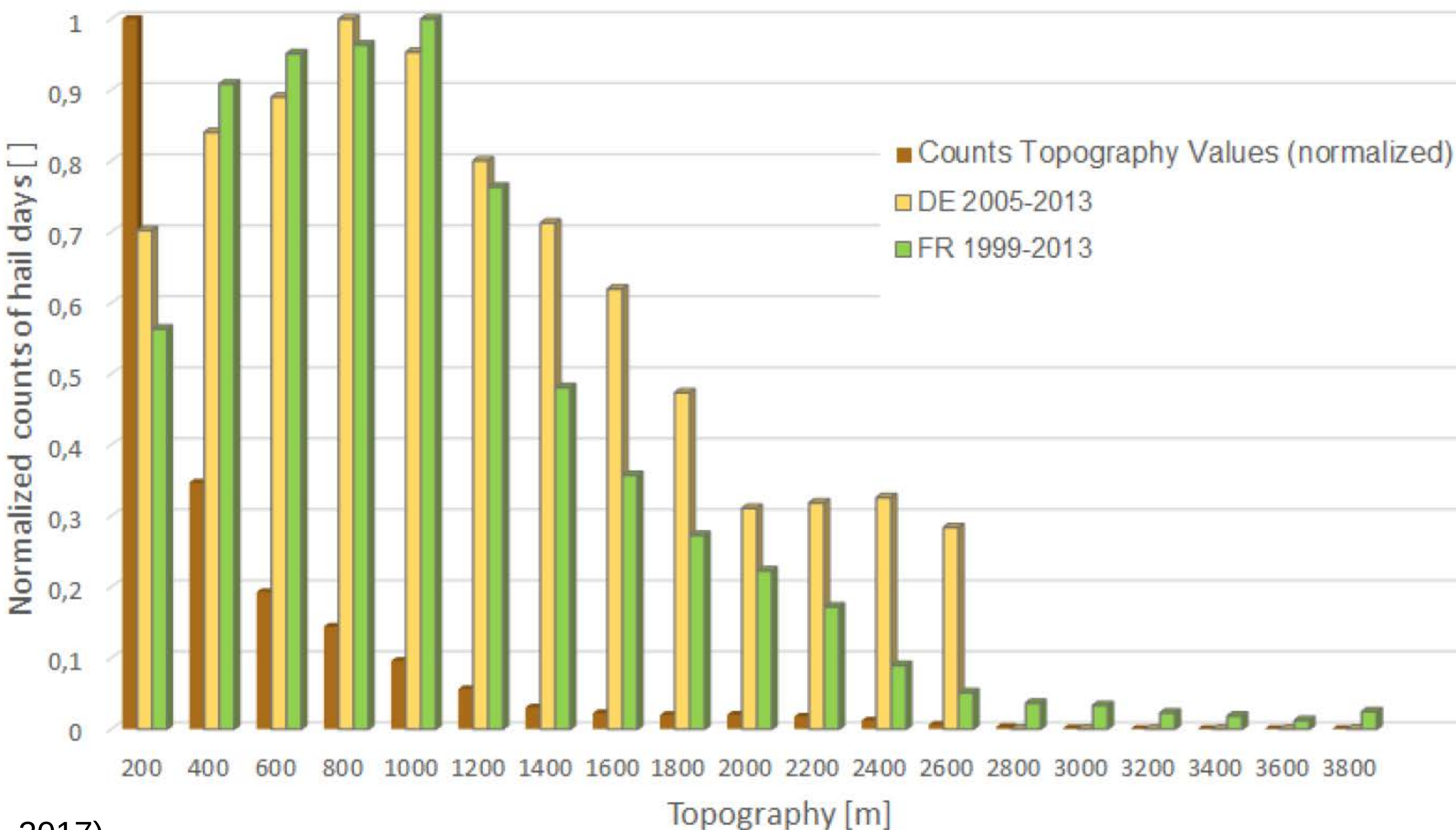
Hail signals vs orography

- Most hail hotspots over/downstream of mountain ranges

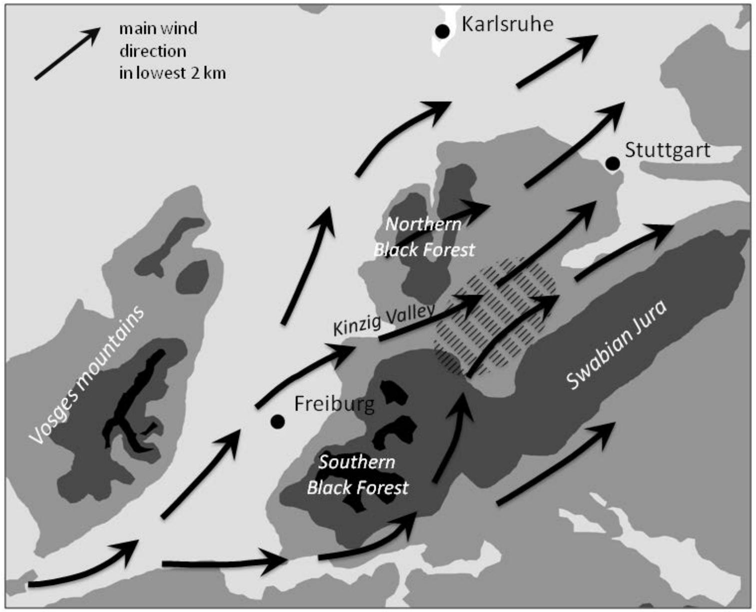


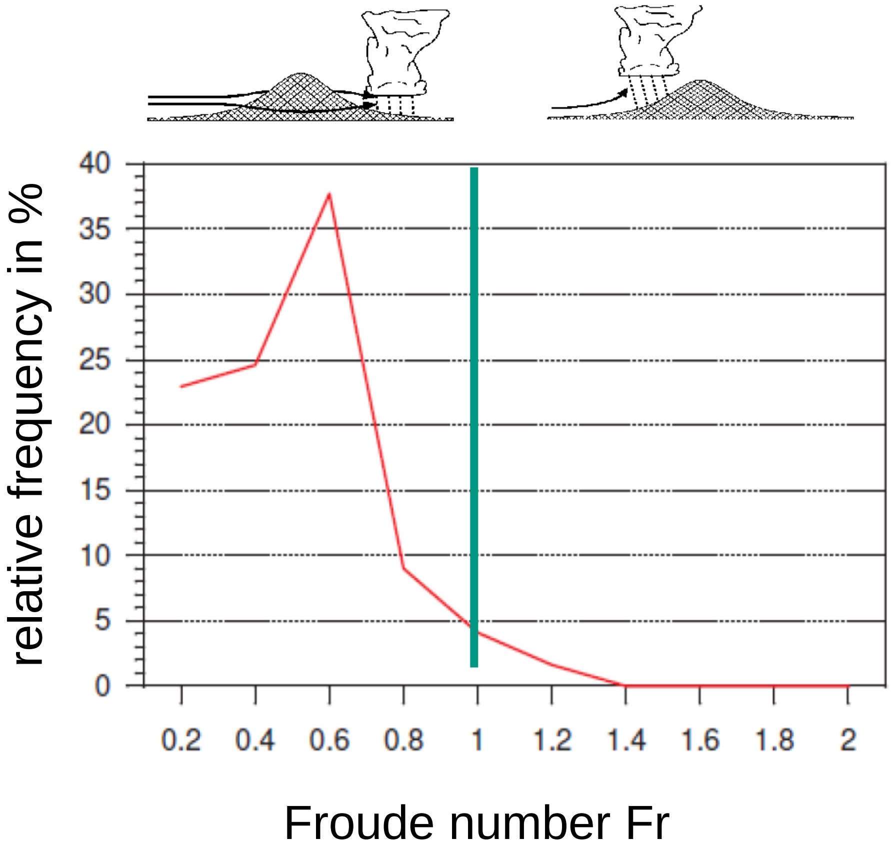
(Fluck, 2017)

Hail signals vs orography

- Hypothesis: pre-convective flow around regime creates in SW Germany

$$Fr = \frac{U}{N\,H}$$





(Kunz and Puskeiler, MZ, 2010)

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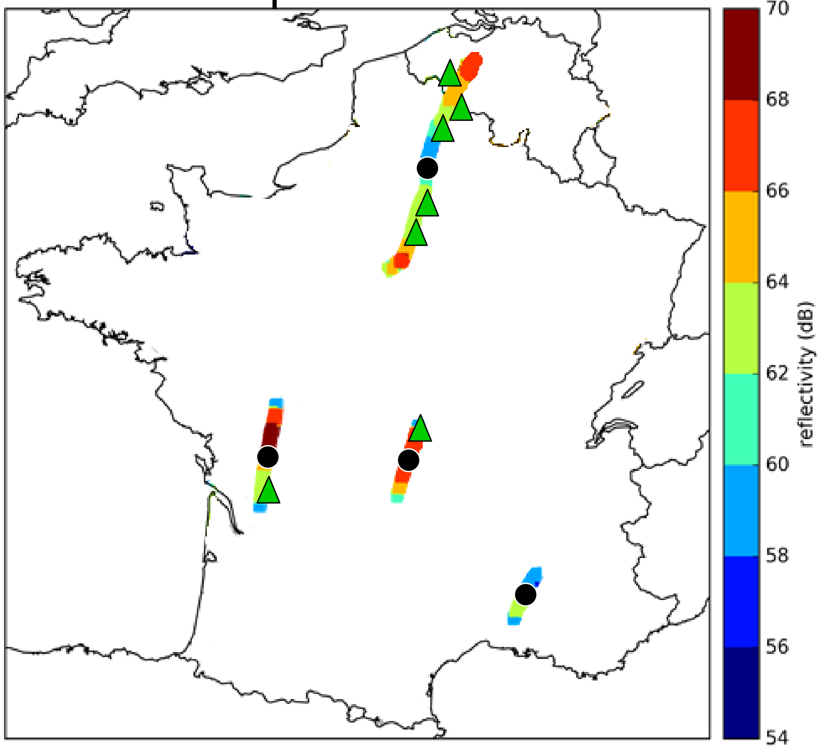
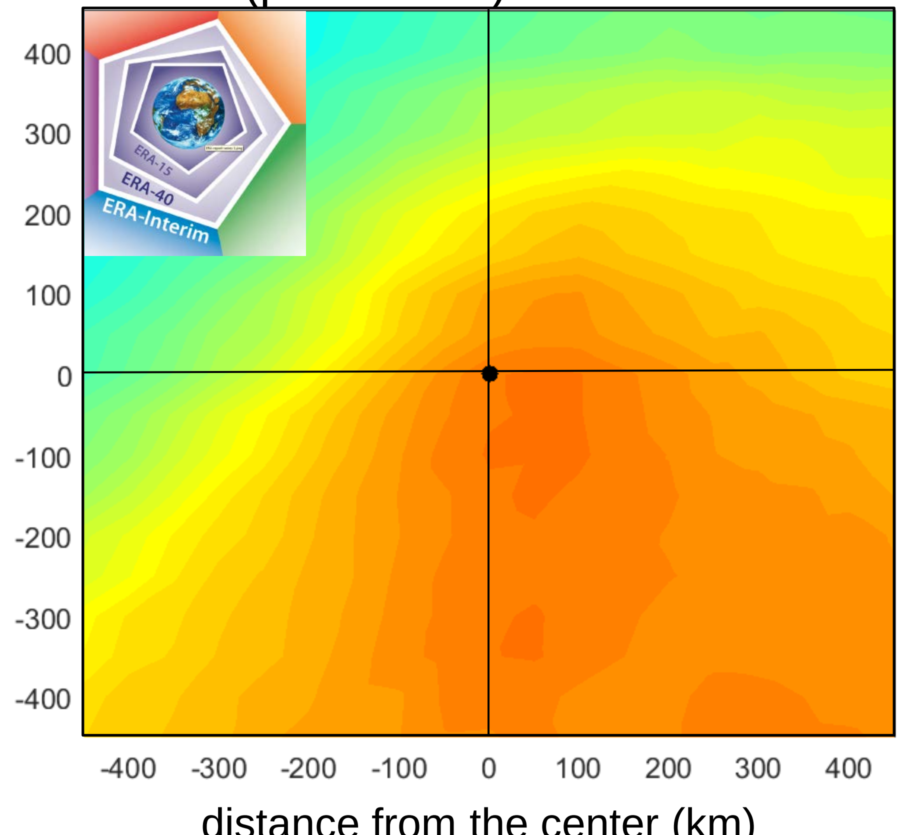
Pre-convective conditions

- Combination hailstreaks with ESWD data (D_max)
- Composite of ambient conditions (12 UTC ERA-Interim) around hailstreaks centered in the middle of the domain

Hail footprints from radar



Mean (percentiles) of all events



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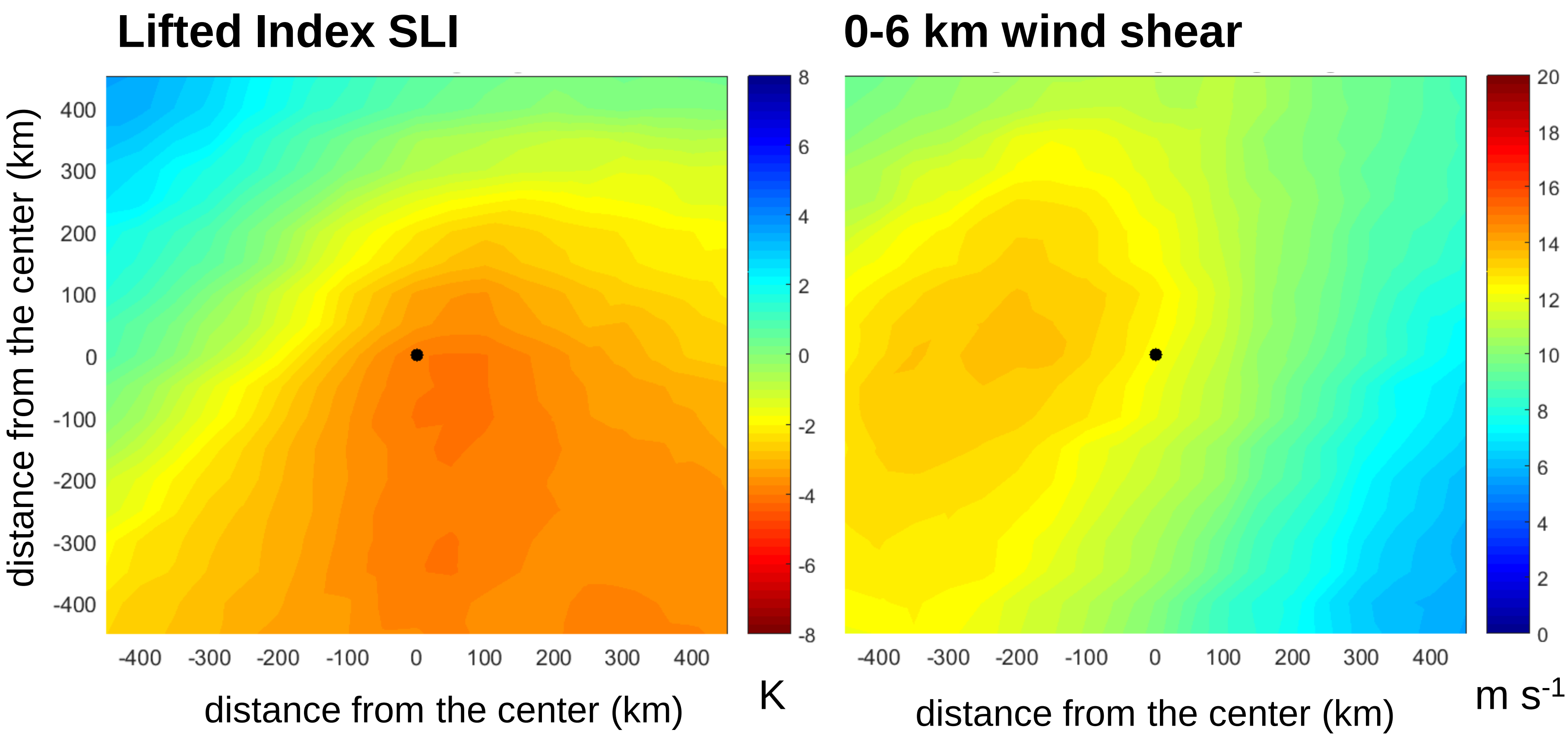
Pre-convective conditions

- Mean fields around hailstreaks



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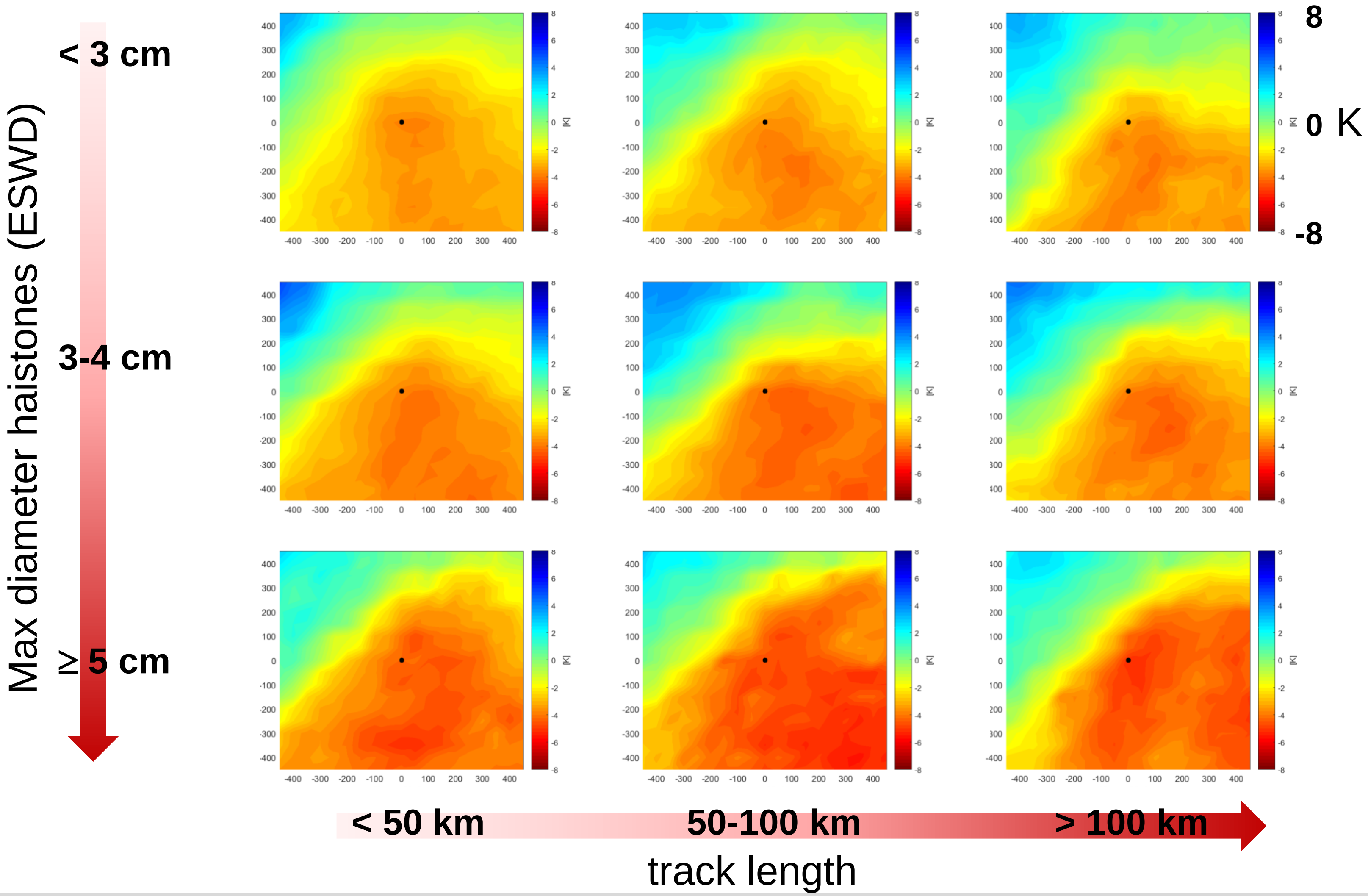
Pre-convective conditions

- Composite **Lifted Index** fct(L, D)



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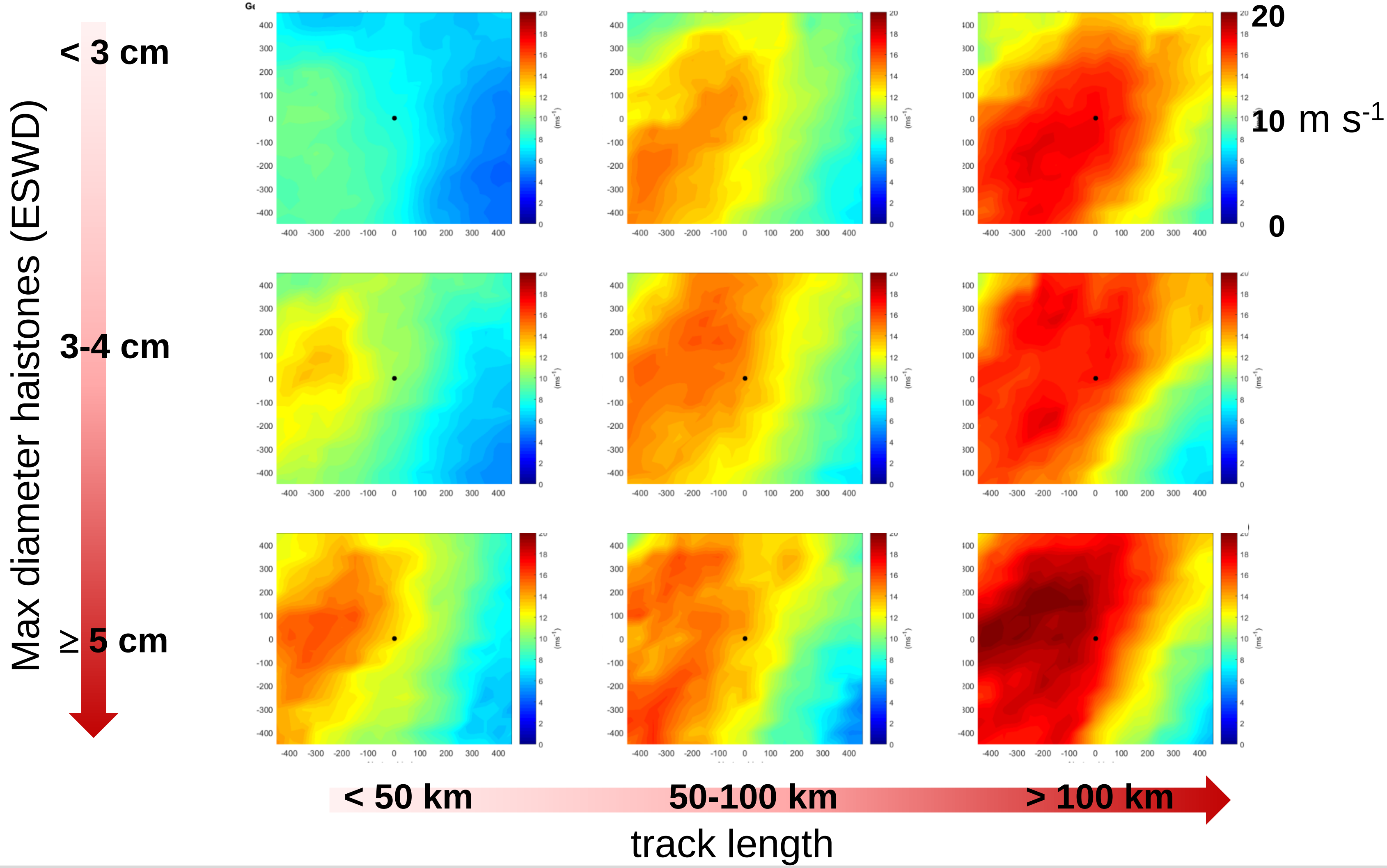
Pre-convective conditions

- Composite **0-6 km wind shear** fct(L, D)



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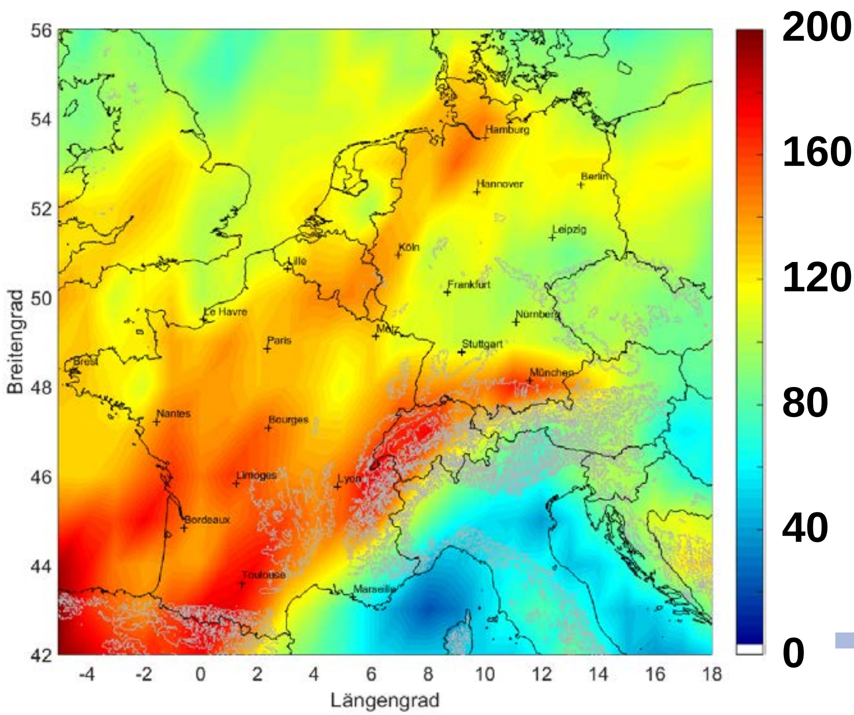
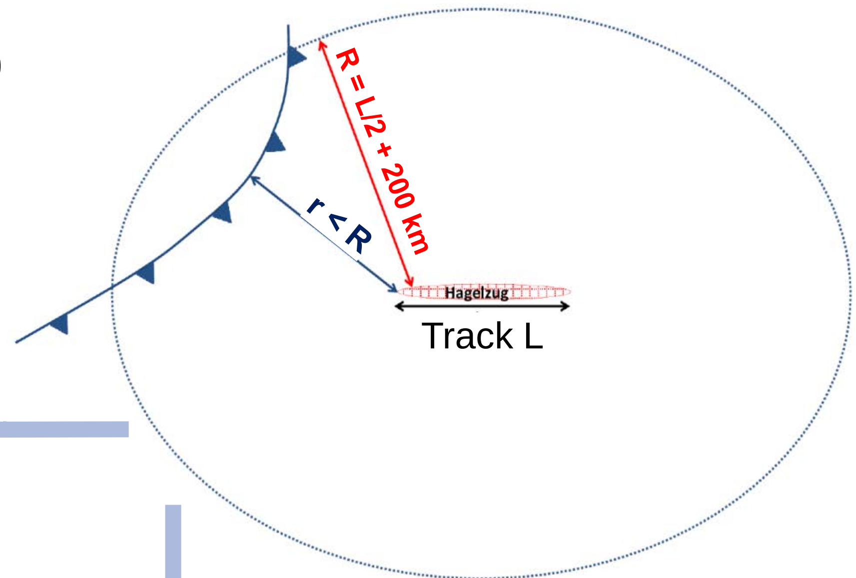
Ambient conditions: Fronts

- Hailstreaks vs cold fronts?





Cold fronts 1° × 1°; 6-hourly; 2005-2014
ERA-Interim-Reanalysis (Schemm et al., 2015)

thermal frontal parameter $$TFP = -\nabla|\nabla\theta_e| \cdot \frac{\nabla\theta_e}{|\nabla\theta_e|}$$

(Baumstark, 2017)

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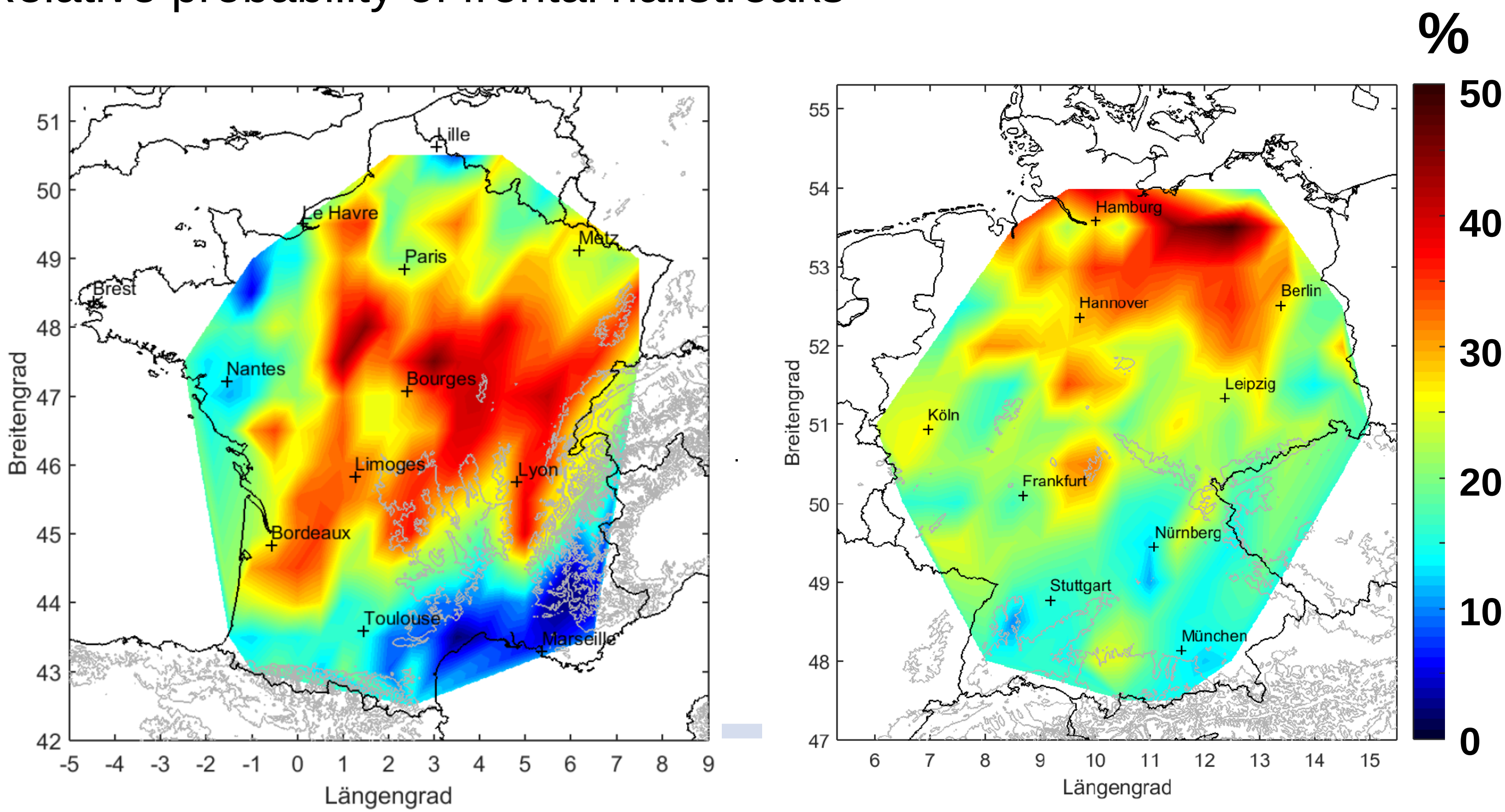
Ambient conditions: Fronts

- Relative probability of frontal hailstreaks



0.5° x 0.5°; ERA-Interim / Radar-based streaks
SHJ 2005-2014

(Baumstark, 2017)

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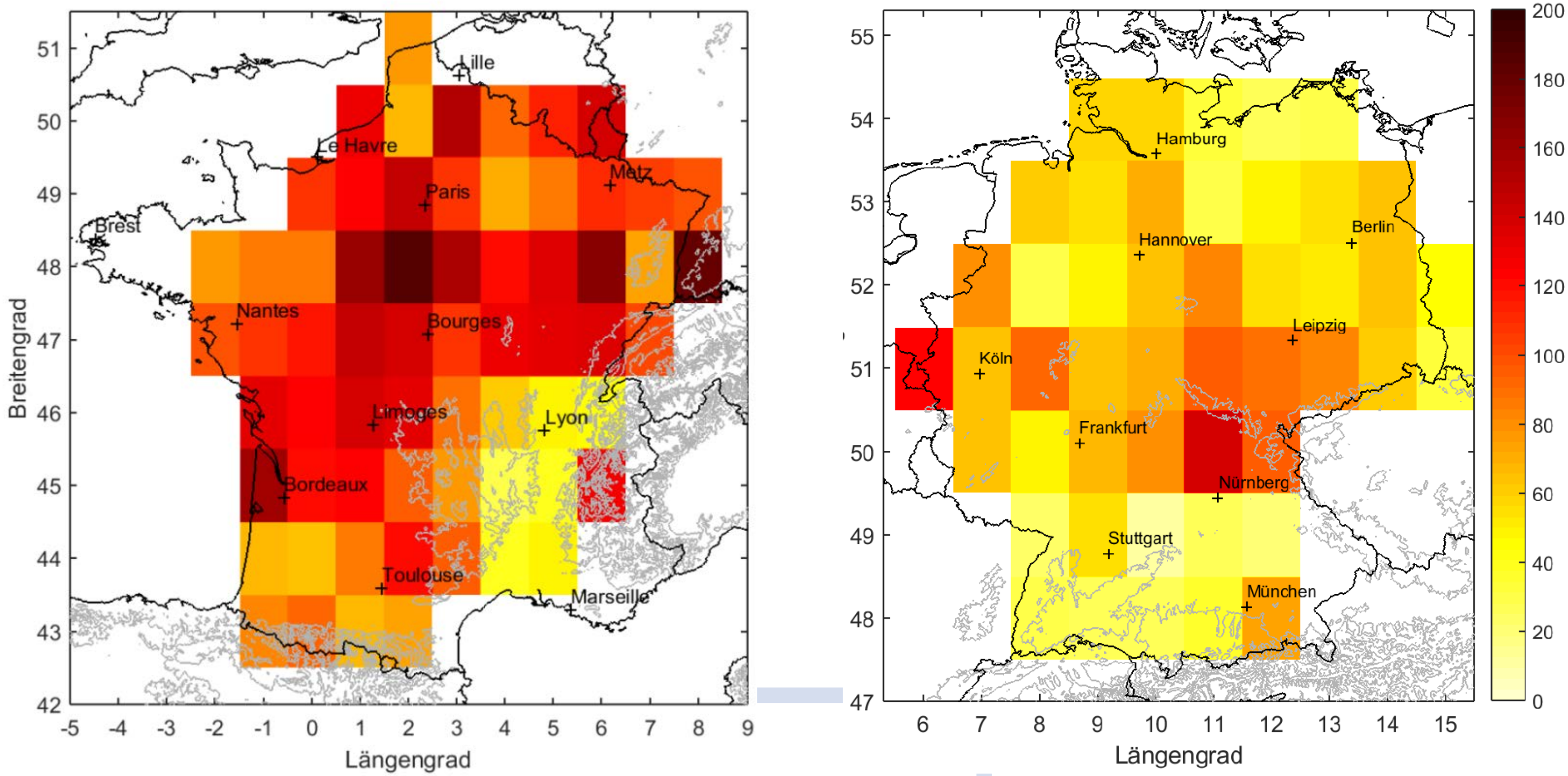
Hailtracks: frontal vs non-frontal

- Track length: $L_{frontal} - L_{non\text{-}frontal}$ (90% percentiles)



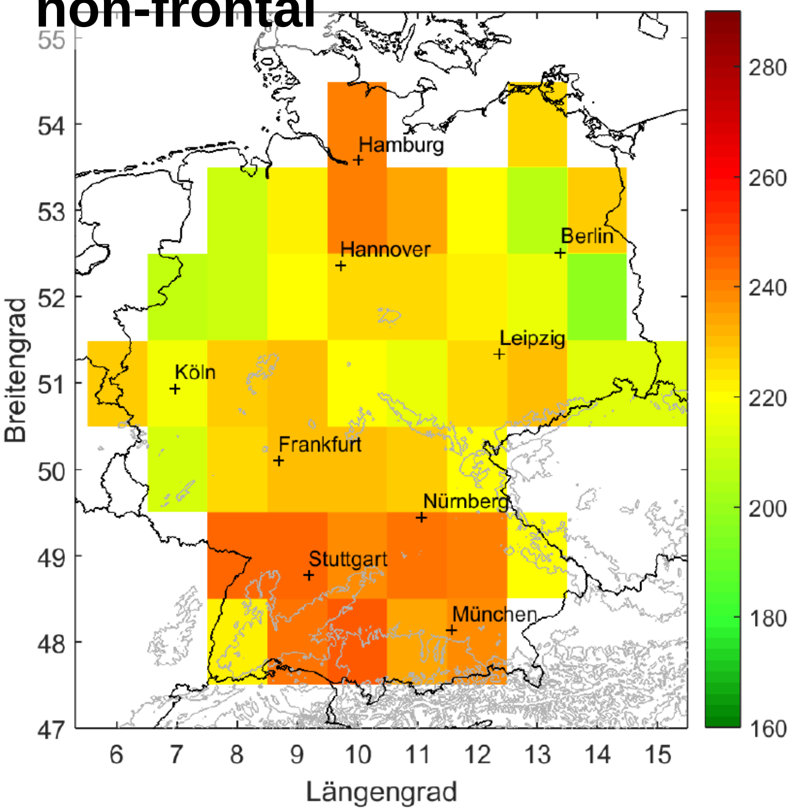
0.5° x 0.5°; ERA-Interim / Radar-based streaks
SHJ 2005-2014

(Baumstark, 2017)

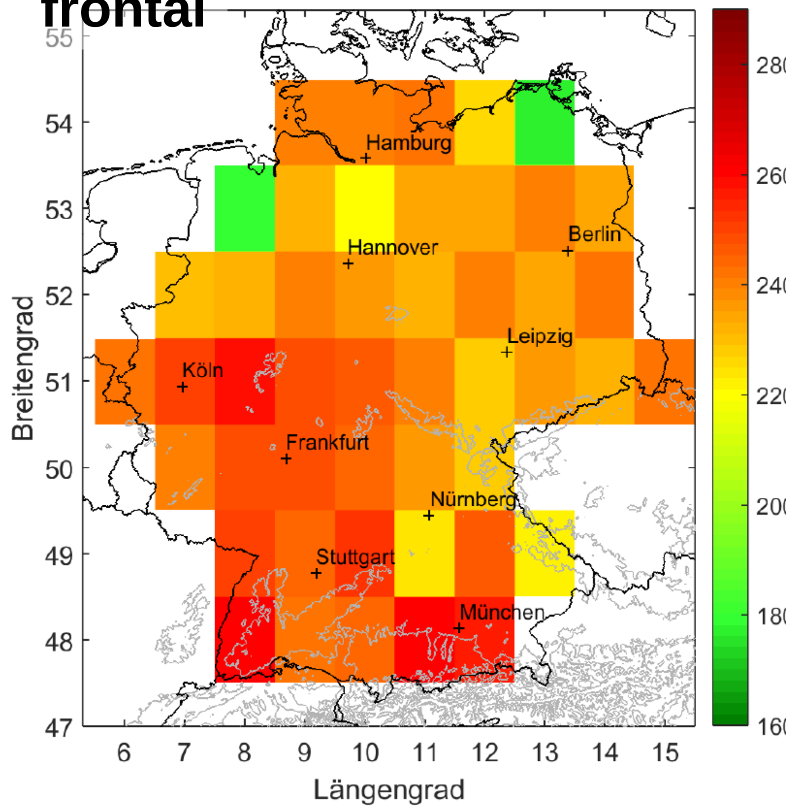
Hailtracks: frontal vs non-frontal

- Orientation (median)

non-frontal



frontal



0.5° x 0.5°; ERA-Interim / Radar-based streaks
SHJ 2005-2014

Conclusions

- **Hail hazard assessment** from radar is robust and physically plausible
- High spatial variability of **radar-derived hail signals**:
  - large-scale: increase from north-to-south due to climate
  - local-scale: hot spots mostly downstream of the mountains
- **Pre-convective conditions**
  - LI < -2.5K (center N of the LI minimum); ~ insensitive to diameter / length
  - 0-6 km wind shear; both diameter and track length decisive
- **Streaks vs Fronts**
  - 15-50% of all streaks are related to a cold front; large spatial differences
  - Frontal streaks exhibit different characteristics: longer, direct. to the west,…