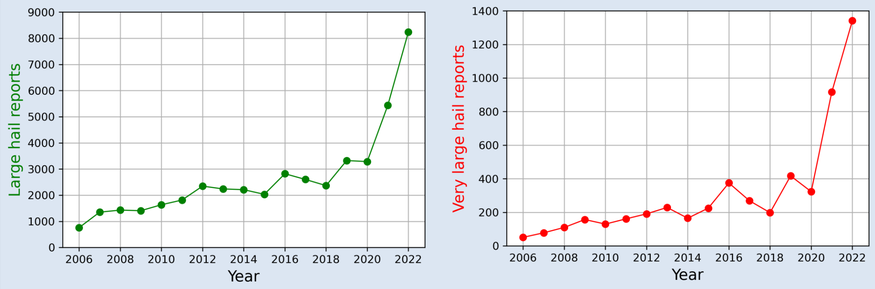
Pre-storm environments and storm-scale properties of the major hailstorms of 2021 and 2022 in Europe

Tomáš Púčik[1]*, Mateusz Taszarek[2], Pieter Groenemeijer[1], Francesco Battaglioli[1]
[1]European Severe Storms Laboratory, Austria/Germany; [2]Adam Mickiewicz University, Poland
*tomas.pucik@essl.org

1. INTRODUCTION

Both 2021 and 2022 were record breaking for hail in Europe.



What can we say about the environments and storm-scale characteristics of the major hailstorms in these years?

Is there a parameter that can help us forecasting the maximum hail diameter and hailstorm duration?

2. ERA-5 PROXIMITY PROFILES CHOICE METHODOLOGY

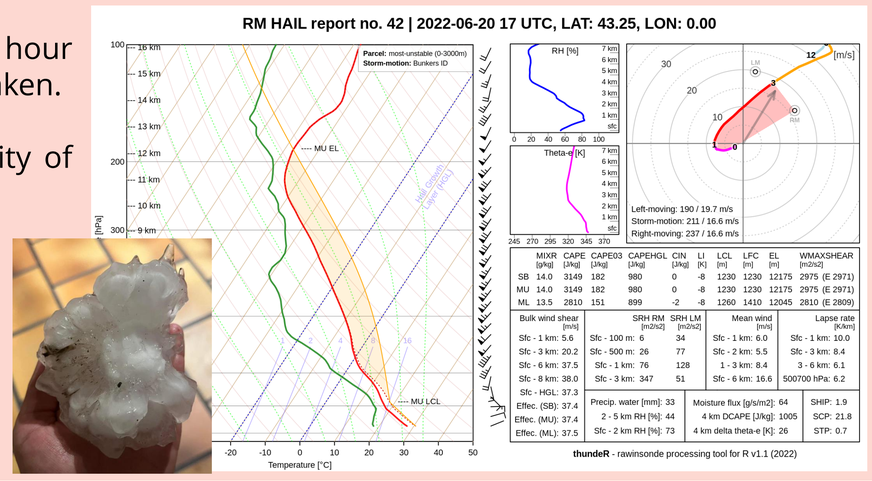
We looked at the environments of the hailstorms that produced hail ≥ 5 cm and substantial impact based on the ERA-5 reanalysis.

For each hailstorm case, ERA-5 grid point and an hour closest to the largest hailstone observation was taken.

Representative profile was searched in the vicinity of the grid point in the +4 to -4 h period.

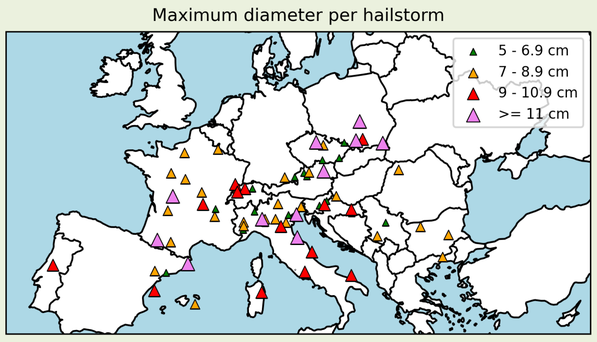
Profile was selected based on the best match with surface observations.

73 storms * 9 hourly periods * 9 grid points = 5913 profiles to consider!

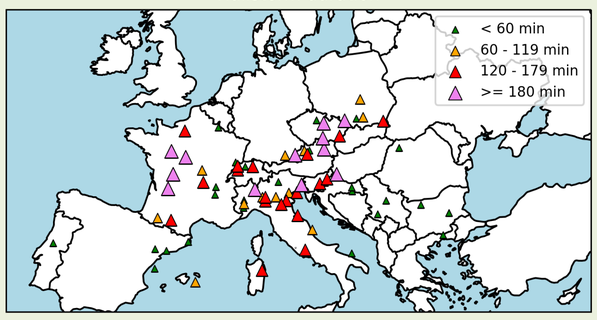


3. STORM-SCALE PROPERTIES

Maximum diameter per hailstorm



Hailstorm duration



73 cases

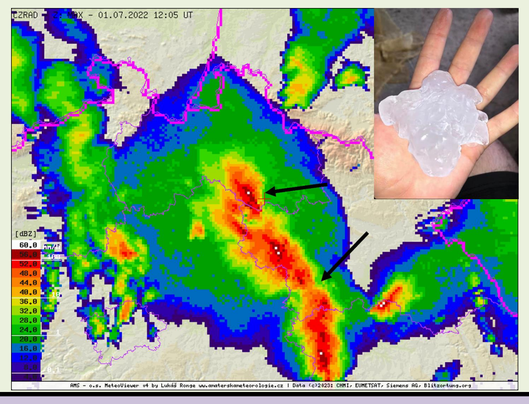
Min. hail diameter: 5 cm
Max. hail diameter: 14 cm

Min. duration: 10 minutes
Max. duration: 420 minutes

Duration defined as the time between the first and the last large hail report.

Cell mergers

- Present in 23/73 cases (31.5%).
- In 8 cases the largest hail fell after the merger.
- In 5 cases the cell interaction resulted in the dissipation of the storm.
- Could play decisive role in marginal environments.

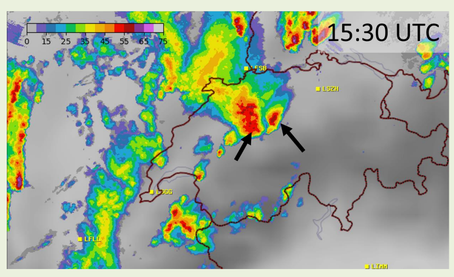


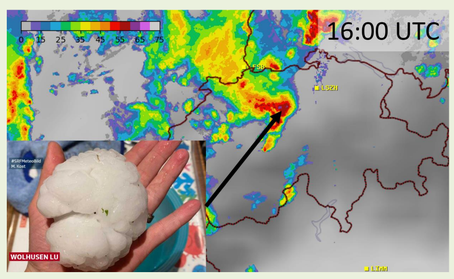
All cases were supercells

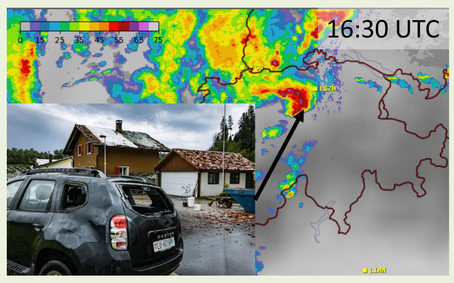
9 of the supercells were left-movers

Largest hailstone (14 cm) in our sample fell from a left-mover!

Hailstorm typically ended with cell dissipation or due to upscale growth.



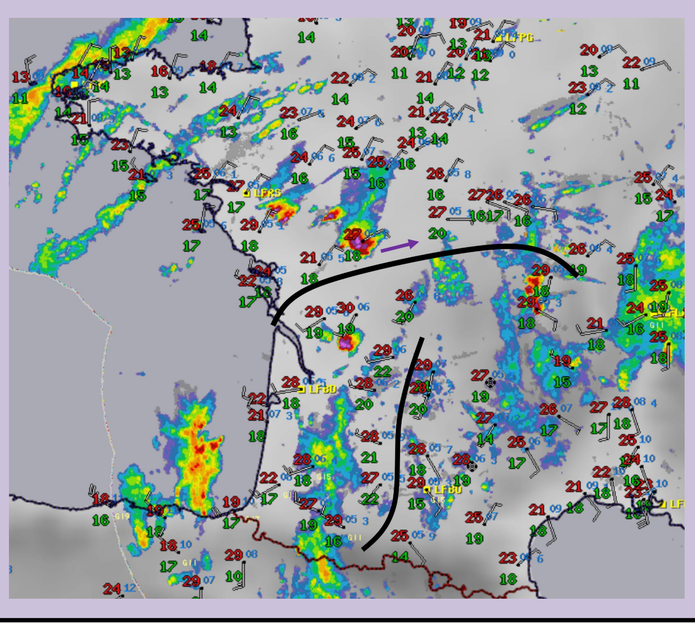




4. BOUNDARIES

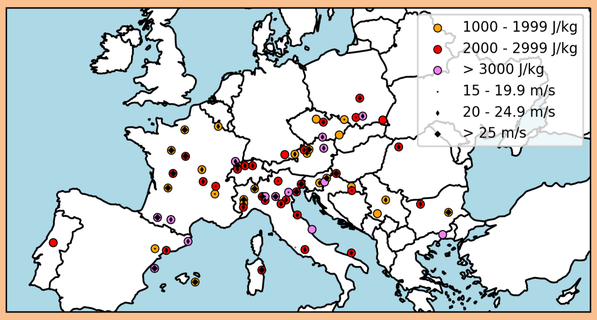
Median duration of hailstorms traveling **close** to the boundary: 130 minutes
Median duration of hailstorms traveling **outside** of the boundary: 55 minutes

Presence of a boundary had no impact on the maximum hail diameter



5. STORM ENVIRONMENTS

Hailstorms MUCAPE and 0-6 km bulk shear



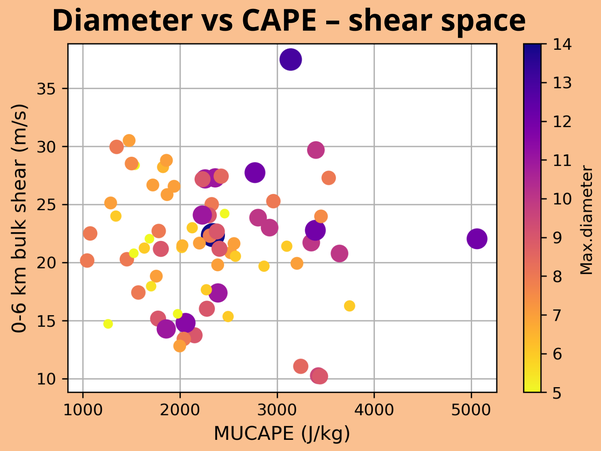
All cases had MUCAPE > 1000 J/kg

Highest MUCAPE: 5059 J/kg
Lowest MUCAPE: 1044 J/kg

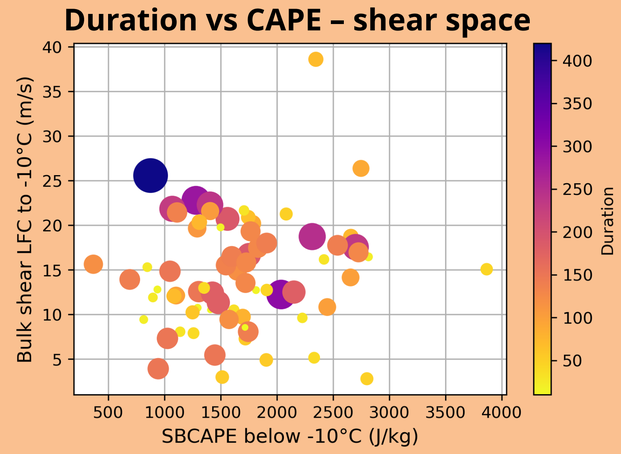
9 cases had 0-6 km shear < 15 m/s

Highest 0-6 km shear: 37.5 m/s
Lowest 0-6 km shear: 10.2 m/s

Diameter vs CAPE – shear space



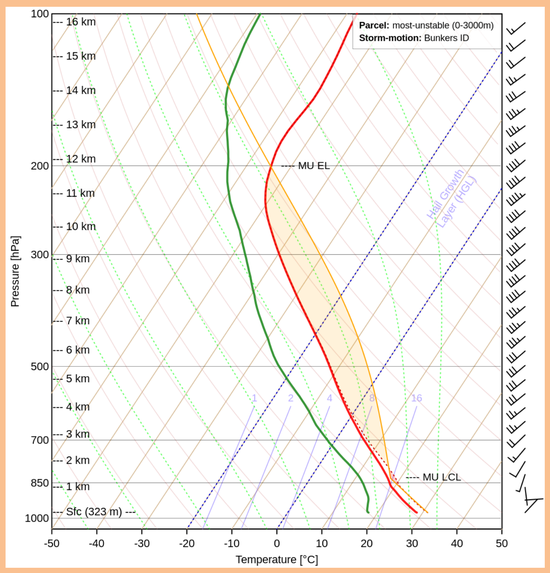
Duration vs CAPE – shear space



Sounding-derived parameters poorly correlated with the maximum diameter or with hailstorm duration.

Parameters describing buoyancy had the strongest relation to the diameter.
SBCAPE in the temperature zone below -10°C: correlation coefficient 0.42

Parameters describing the wind profile had the strongest relation to the duration.
Bulk shear LFC to -10°C: correlation coefficient 0.3

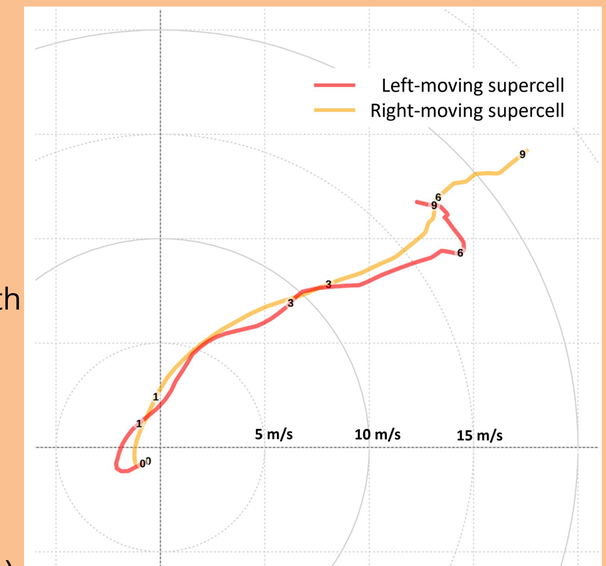


Thermodynamic profiles

- **At least 65% of CAPE** confined to the temperature zone below -10°C.
- Median mixing ratio for ML parcel 12.9 g/kg
- Median lapse rates 1-6 km -6.7°C/km
  Lapse rates do not need to be very steep!
- Median LCL for ML parcel 1145 m
- Median LFC for ML parcel 1725 m

Hodographs

- Hodographs **straight**, most shear in 2/3 cases in the **1-3 km layer**
- Median 0-500 m inflow: 14.3 m/s
- Median storm-relative wind in the hail growth zone: 10.4 m/s
- Fraction of streamwise vorticity **increasing with height** (0.29 -› 0.62)
- SRH 3-6 km > SRH 0-3 km (Gensini et al 2021)



The work on this poster was funded by the Austrian Science Funds (FWF) project no. 33113 "Prediction of Convective Hazards Across Spatial and Temporal Scales", by the Polish National Science Centre grant no. 2020/39/D/ST10/00768 and by the German Ministry of Education and Research for project 01LP1902G "CHECC", part of the Research Programme "ClimXtreme".