Environments of non-severe and severe thunderstorms in central Europe

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How can we find out about the thunderstorm environment?

- Model data
- Real observations : soundings
- Which is more important: Reality or higher resolution?
- **MOTIVATION:** Study and compare environments of different types of severe weather (hail, wind, tornado, rain)

Finding proximity soundings in central Europe

- Lightning / severe weather report within 150 km and 0-3 h after the sounding

- December 2007 till December 2013 – 16 421 proximity soundings

Severe weather reports

- Severe weather data obtained from ESWD
- Difficulty defining threshold for rain
- Tornadoes least common type of event

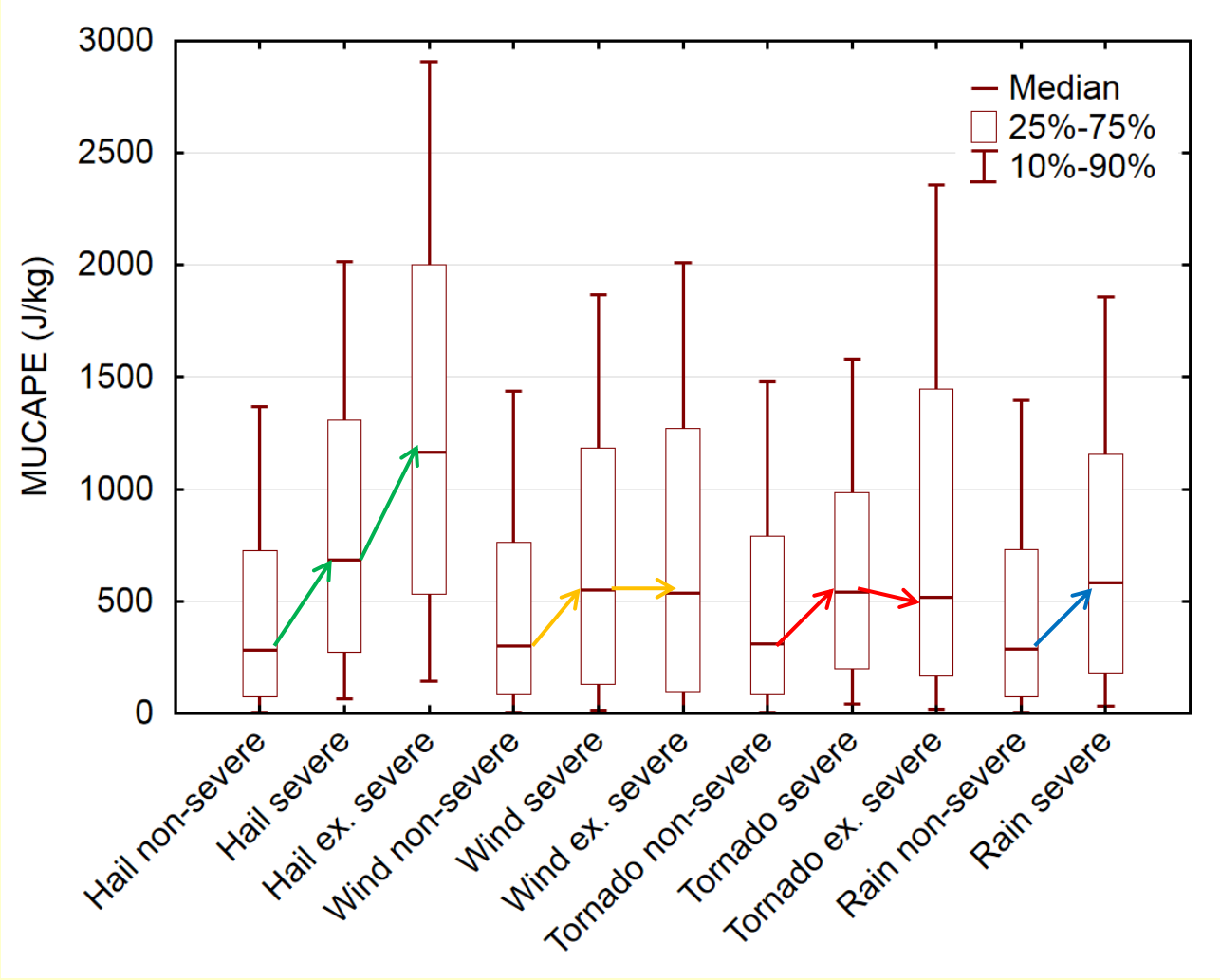
Intensity	Event type			
	Hail	Wind	Tornado	Rain
Non – severe	D < 2 cm	G < 25 m/s	No tornado	No flooding
Severe	2 cm =< D < 5 cm	25 =< G < 32, F0	F0 – F1	Flooding
Ex. severe	D >= 5 cm	G >= 32, F1+	F2+	-

Intensity	Event type			
	Hail	Wind	Tornado	Rain
Severe	1373	1089	482	2255
Ex. severe	262	220	54	-
Total severe	1635	1309	536	2255

Most Unstable CAPE

- Intensity generally increases with increasing MUCAPE, especially in case of hail

- Not the case between severe and extremely severe wind and tornado categories

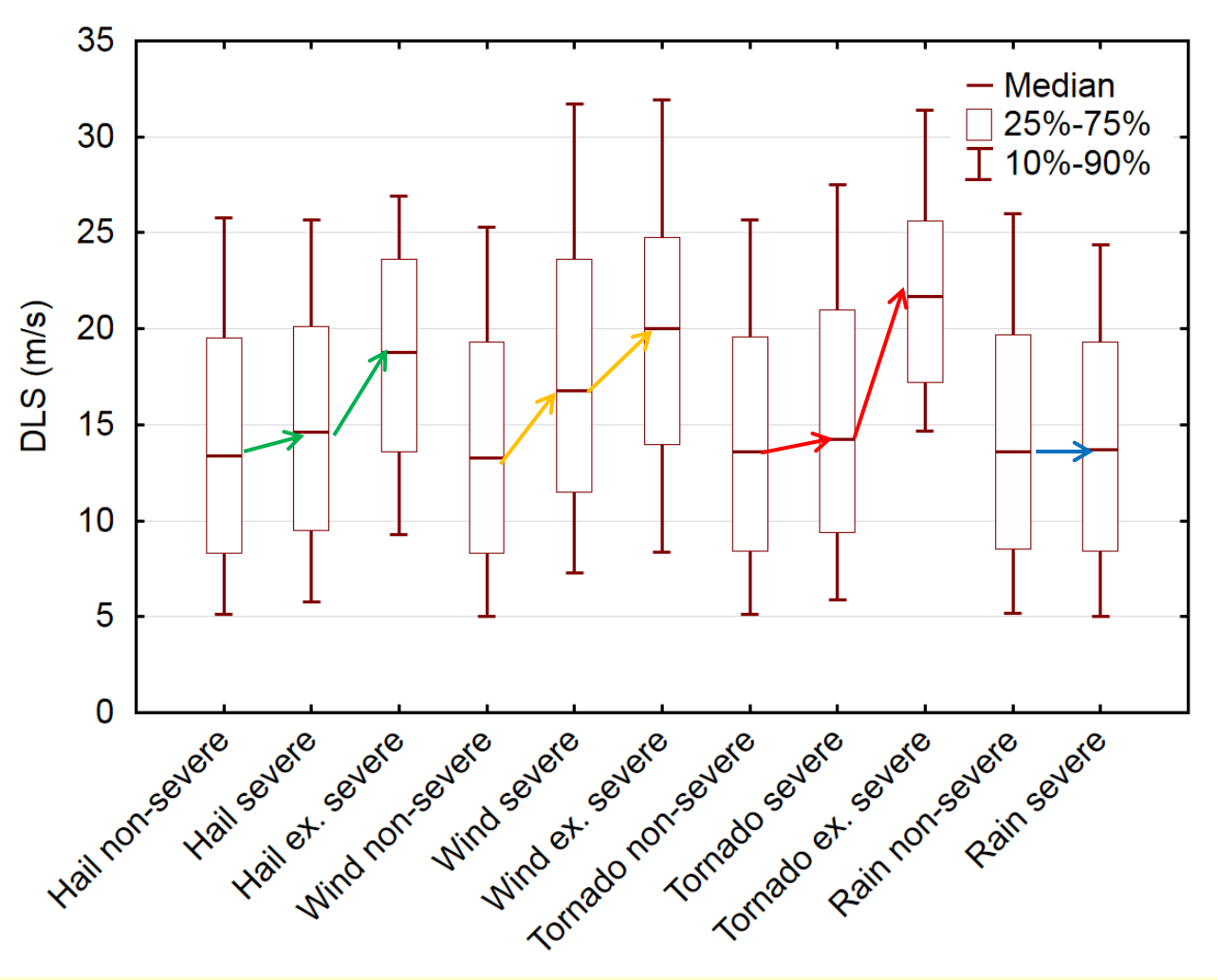


0-6 km bulk shear

- Increase for hail, wind, tornado intensity; NOT for rain

- Extremely severe categories of hail, wind, tornado with values conducive to supercells

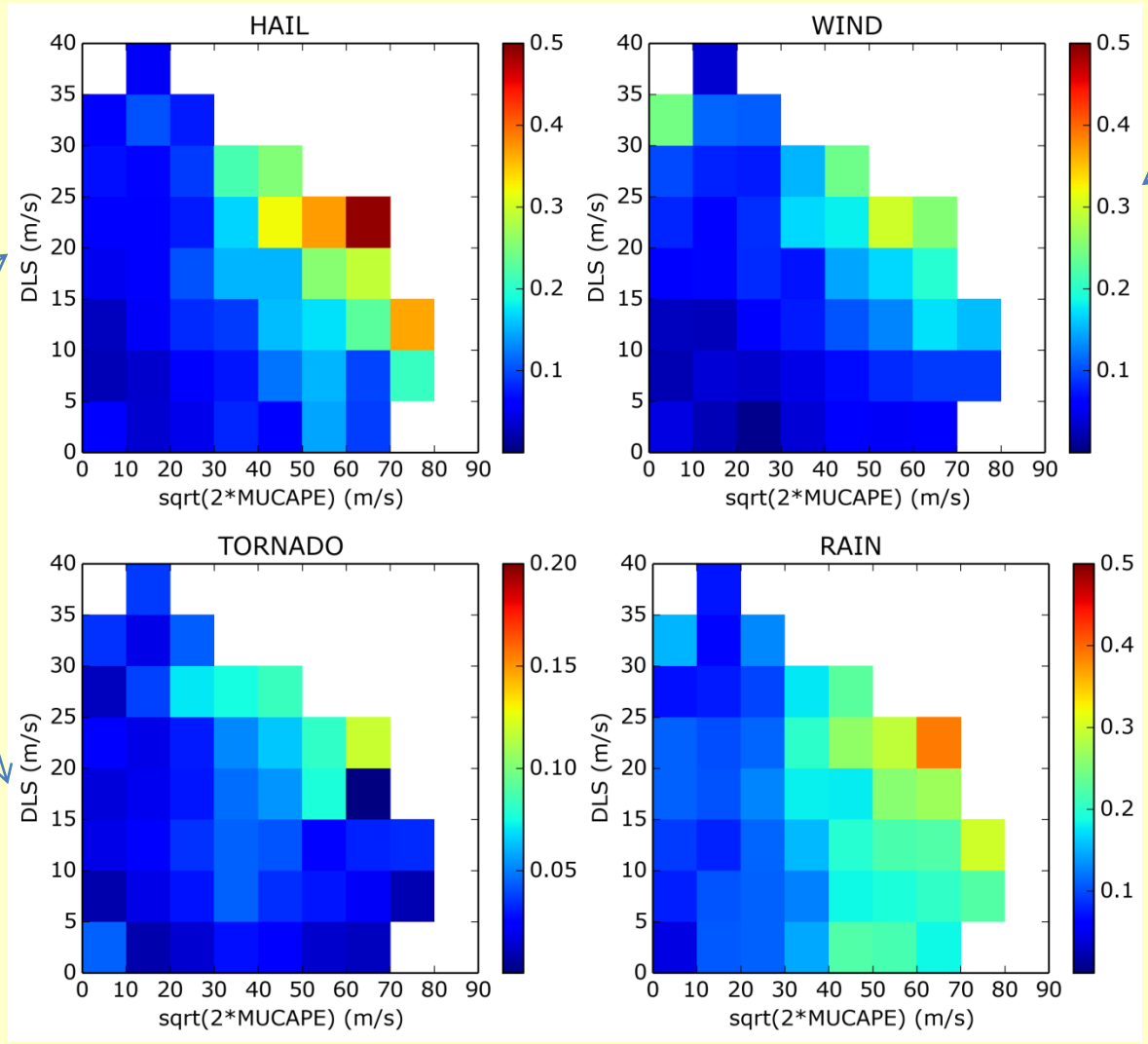
0-6 km shear



CAPE – shear parameter space: probability of severe

- Probability increasing towards the better „overlap“ of CAPE and shear

- Wind has second max in low CAPE, very high shear

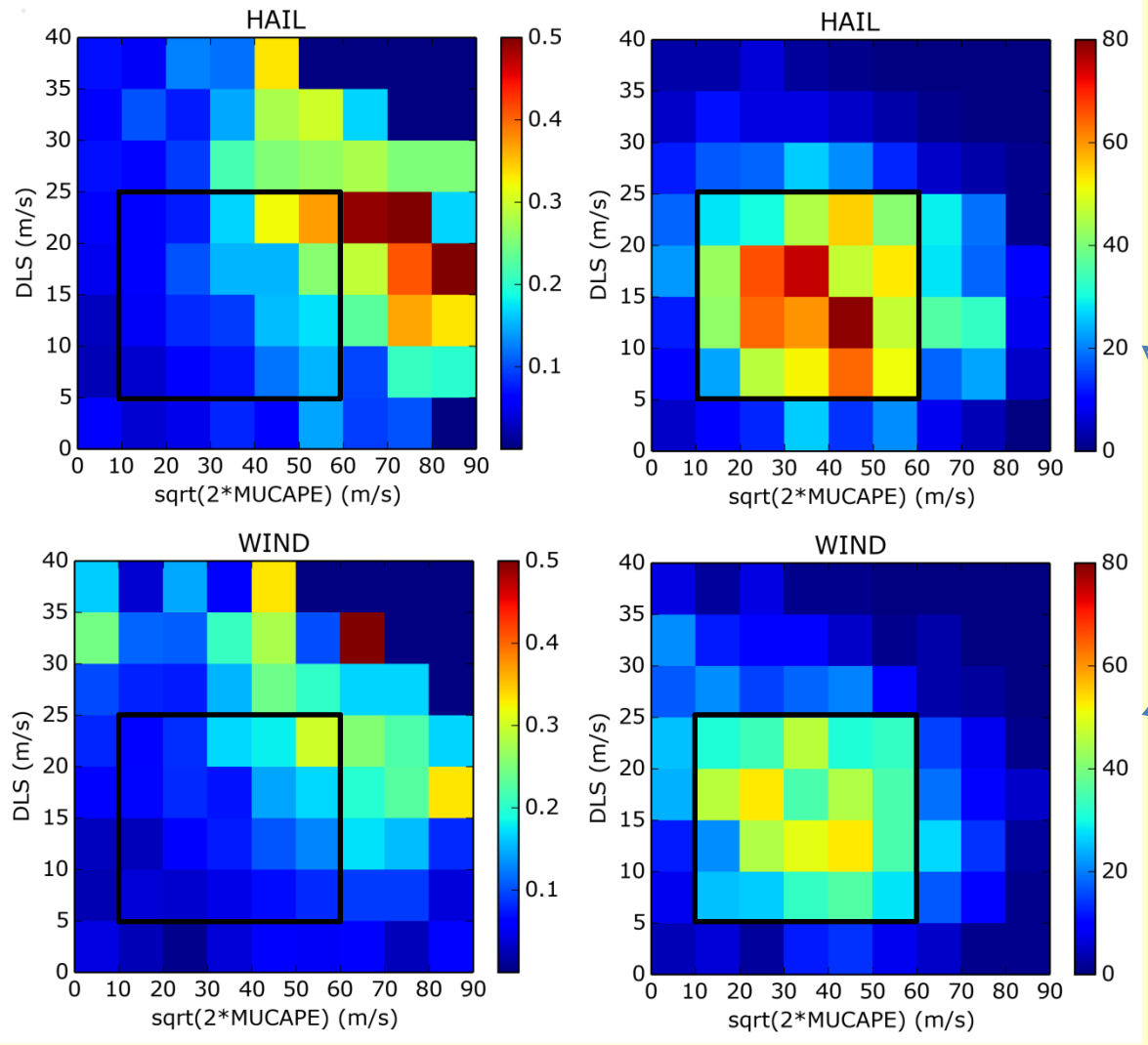


Is the highest probability collocated with the highest frequency?

- High CAPE / shear regime features high probability BUT not a lot of events

- More severe events actually occur with less favourable conditions

Probability

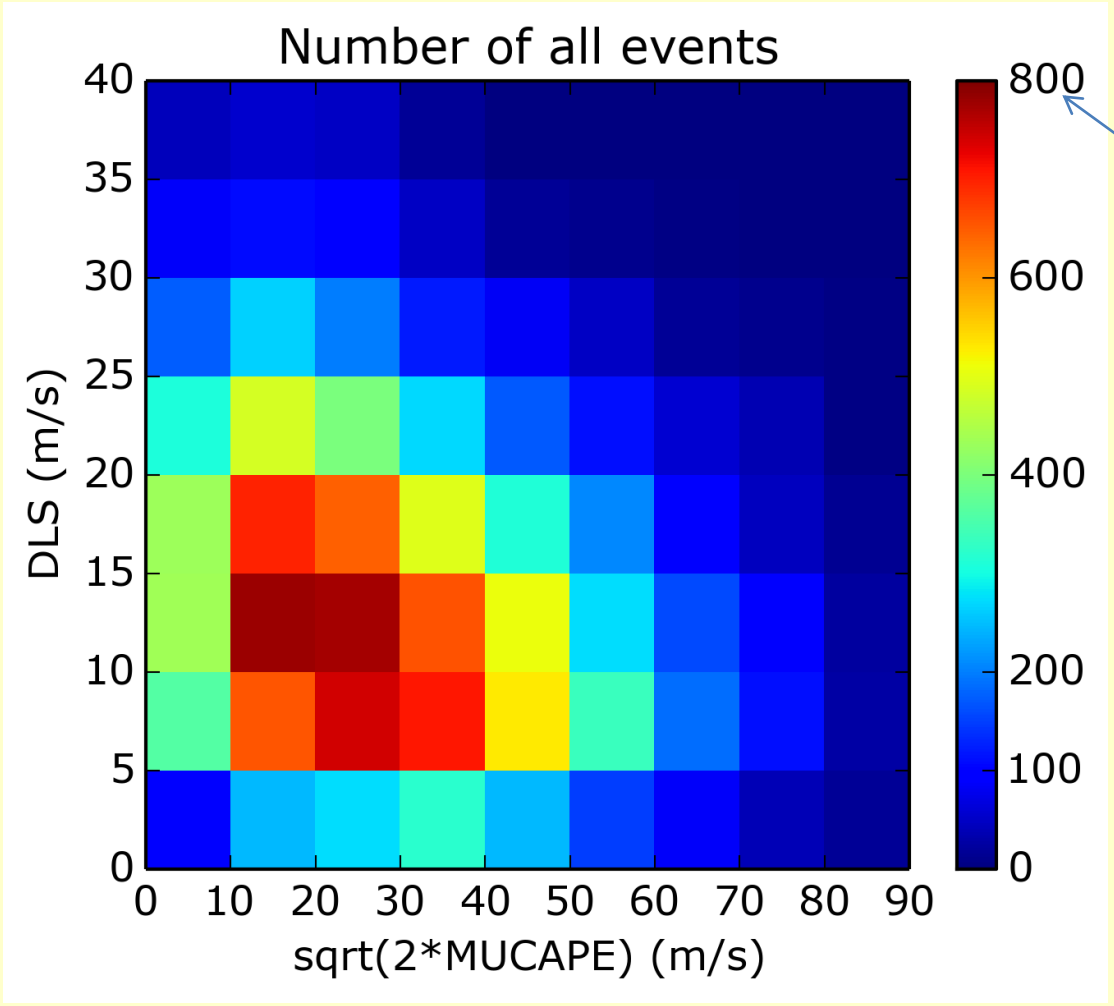


Number of severe events in each box

What causes this?

- Most of thunderstorm environments have low to moderate CAPE and moderate shear

- High CAPE / high shear regime is rare!



0-6 km shear

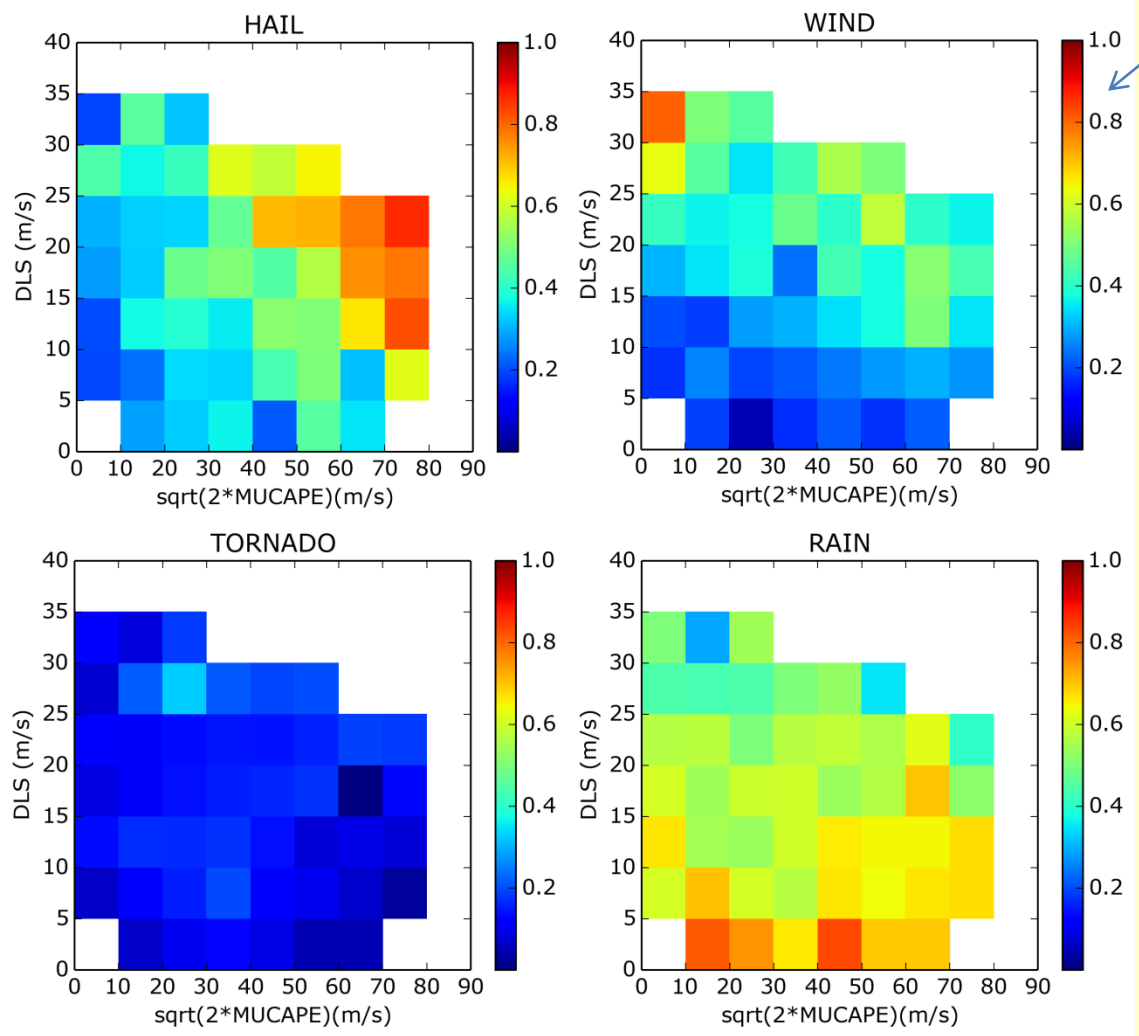
Number of ALL events in each box

Where are particular threats dominant?

- Hail dominant in high CAPE / high shear regime, wind in low CAPE / high shear regime

- Rain dominant in low shear environments

0-6 km shear

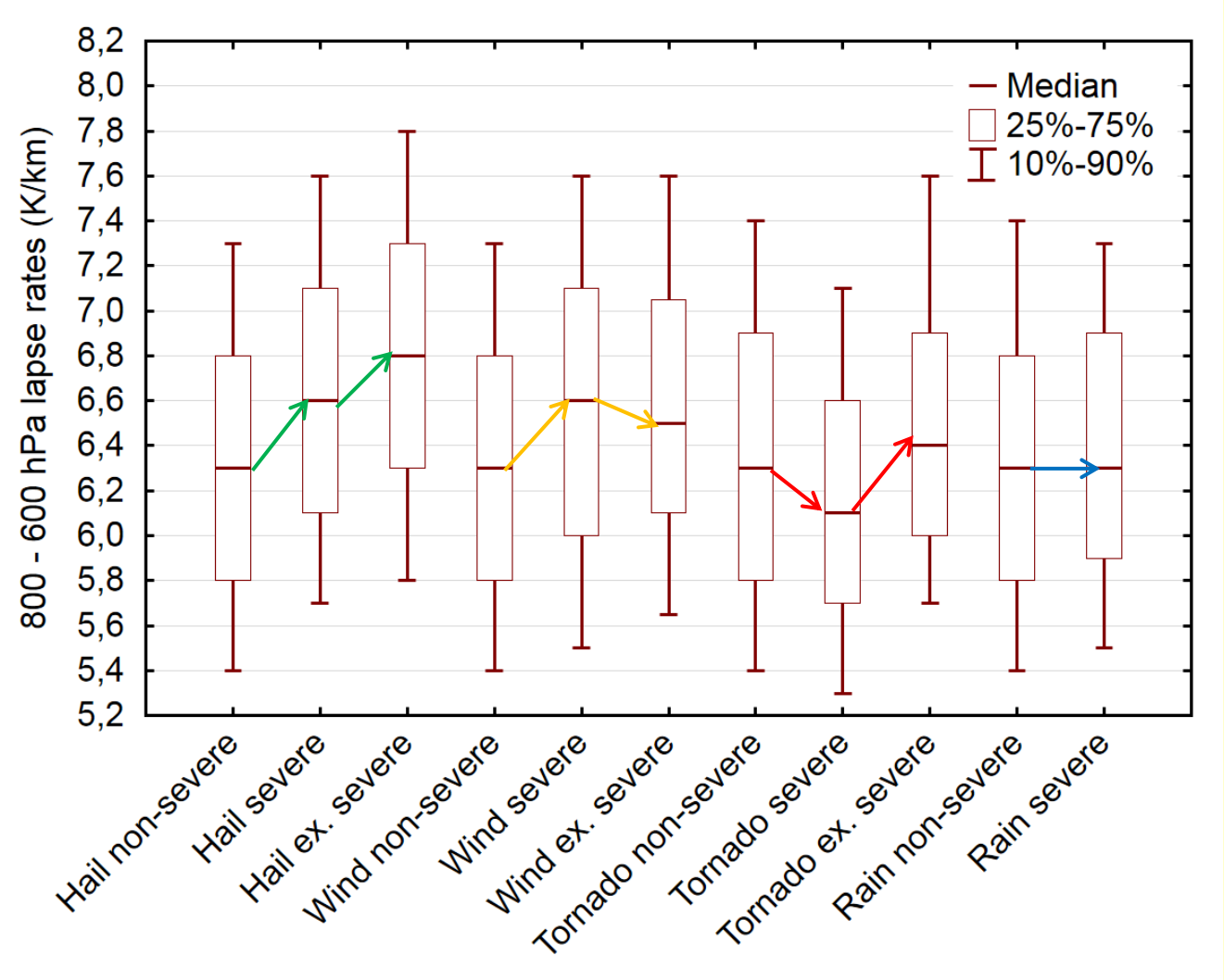


Fraction:
Severe of particular type/
All severe

Lapse rates 800 to 600 hPa

- Constant increase only in case of hail

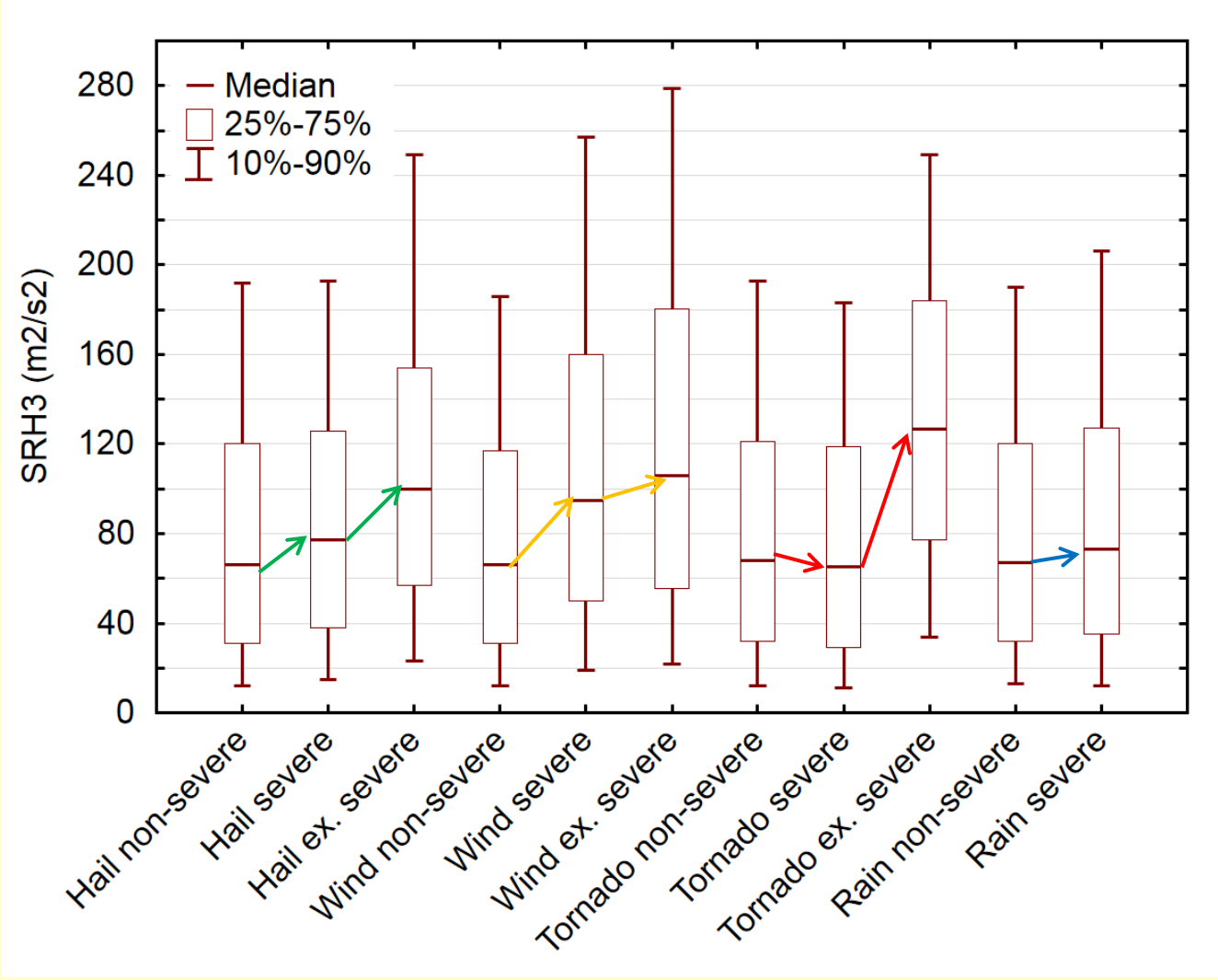
- Peculiar behaviour for wind and tornadoes



Storm relative helicity 0-3 km

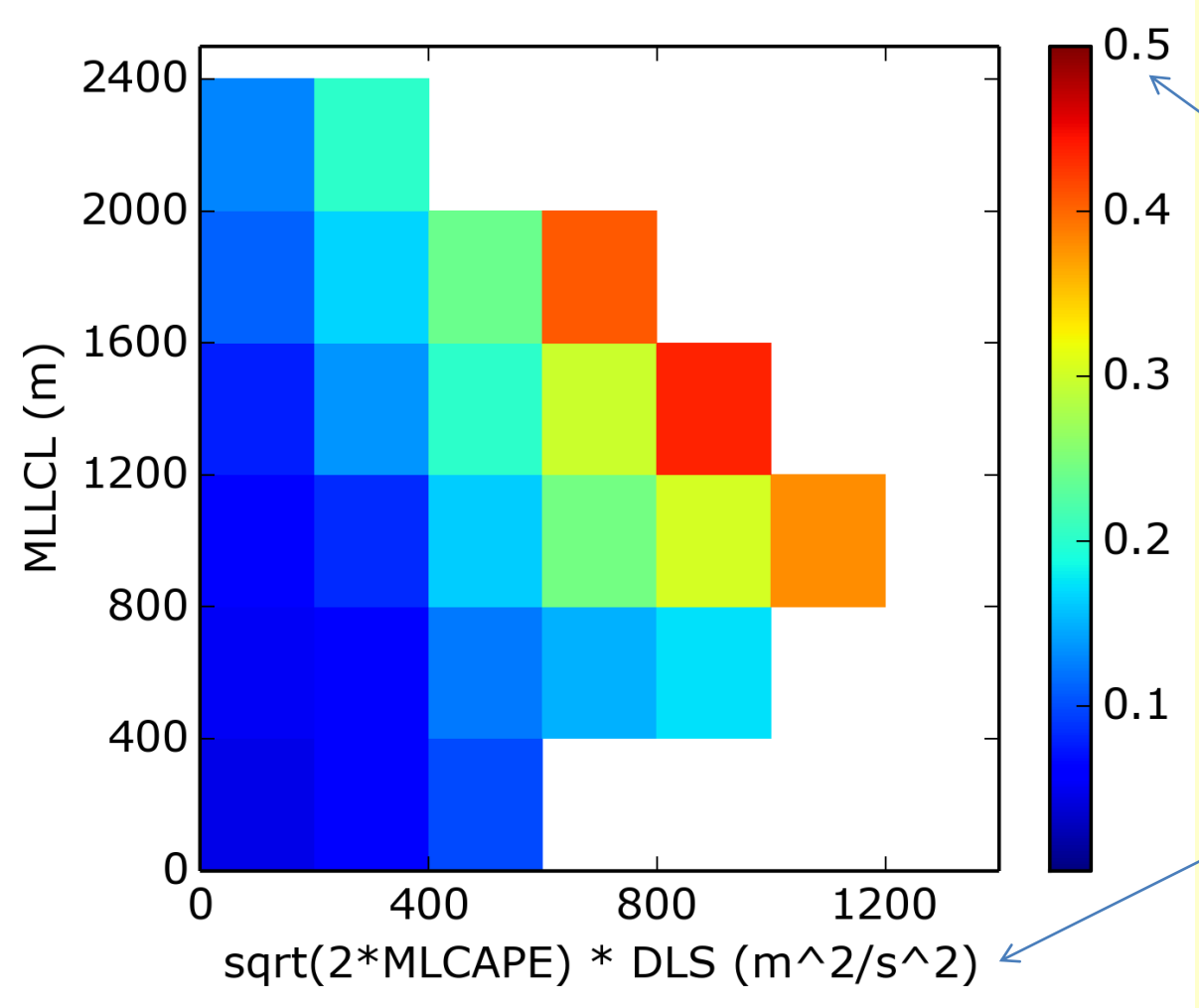
- Very similar pattern to 0-6 km shear but more overlap

- Note that high SREH values are rare



LCL vs CAPE-shear for hail forecasting

- Probability of severe hail increases with increasing LCL for given product of CAPE and shear



50 hPa mixed-layer lifted condensation level

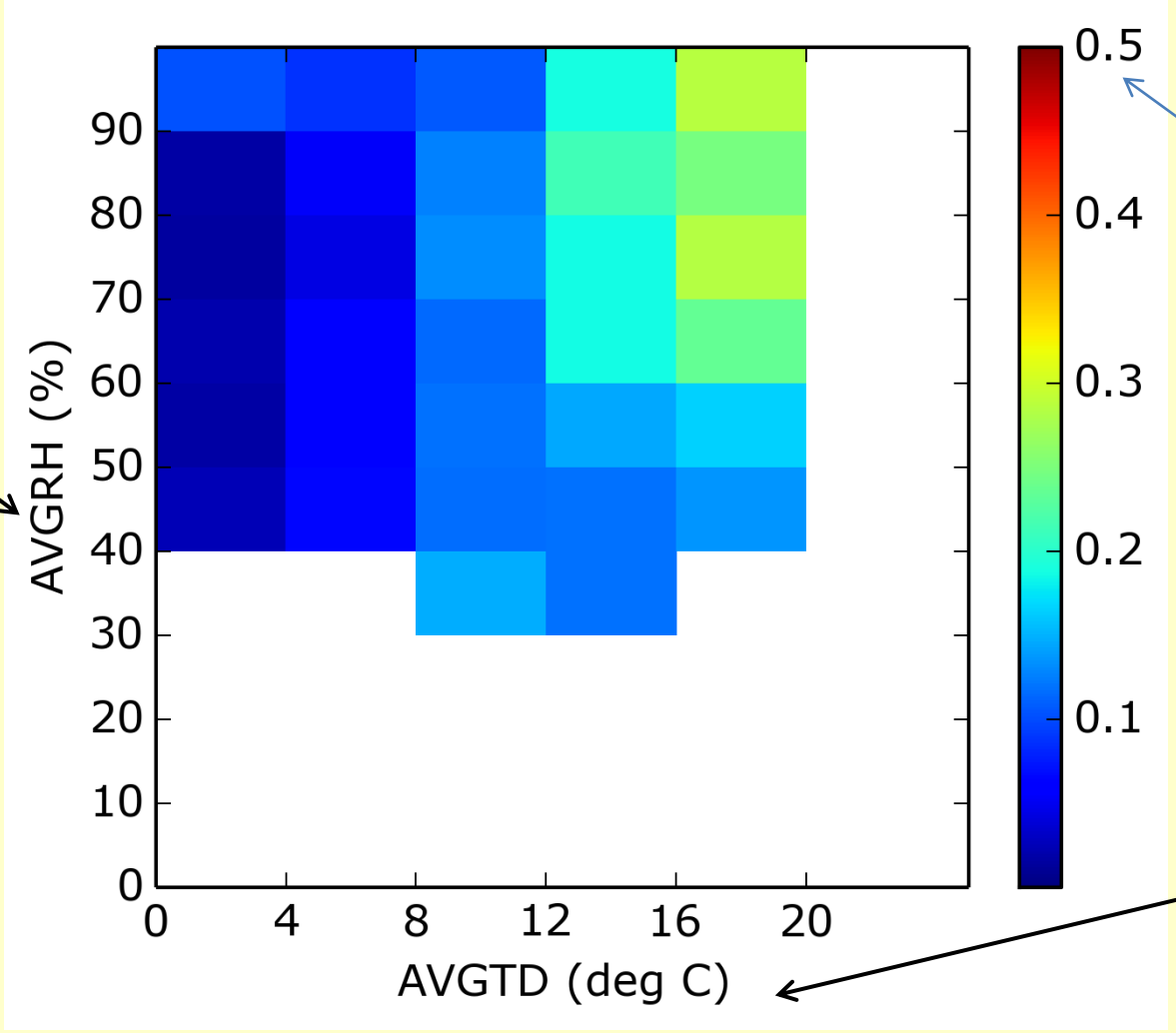
Probability

product of CAPE and shear

What about the rain events?

- Heavy rain so far dependent only on CAPE

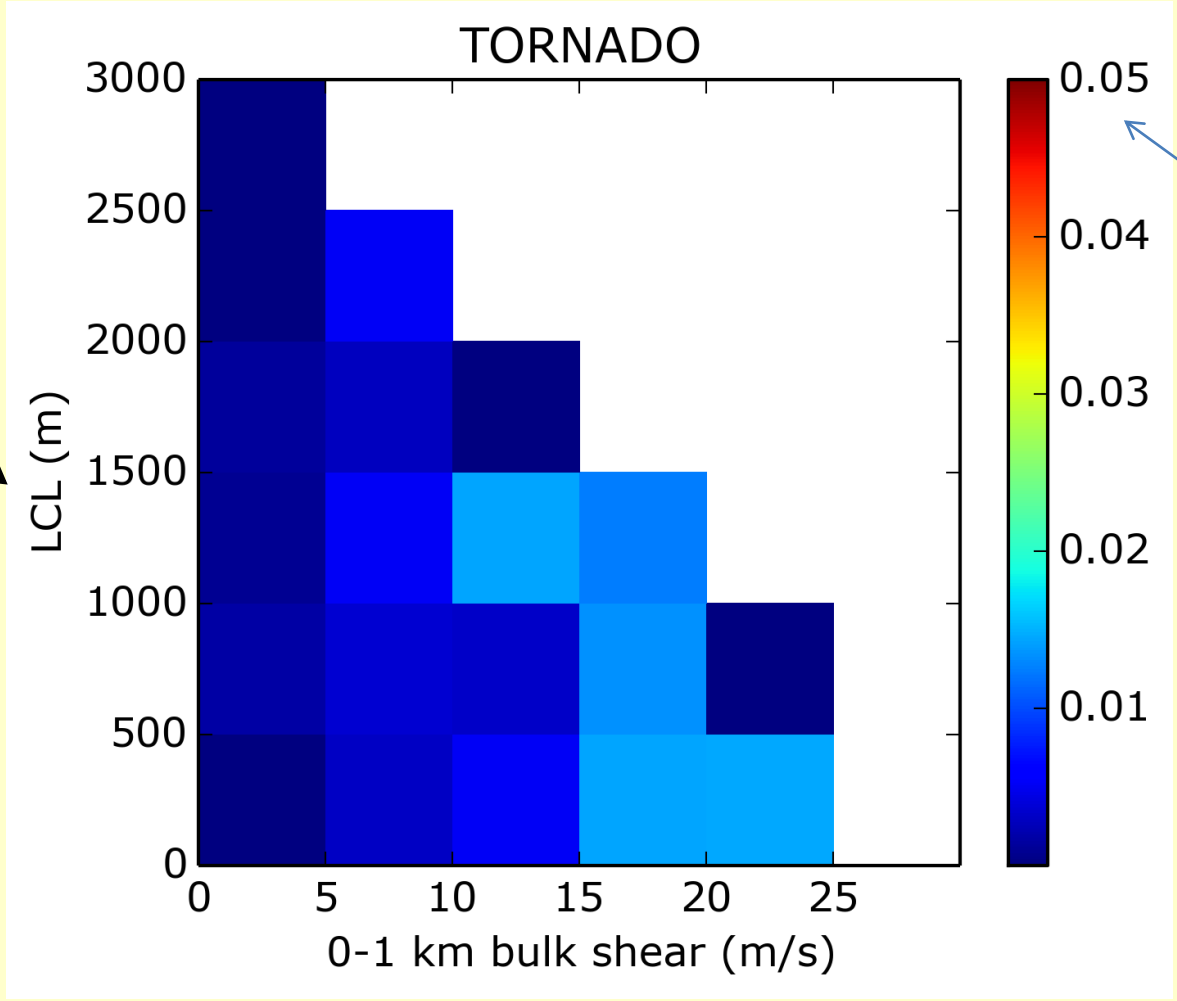
- Probability of severe rain higher with high absolute moisture and high relative humidity



What about strong tornadoes?

- Probability higher with lower LCLs and strong 0-1 km shear

- Probability very low even in favourable conditions!



But is that all?

- There are other things that matter, but we were unable to describe them:

- **Storm coverage and storm mode:**

Will storms exist as isolated, discrete cells or a big convective system?

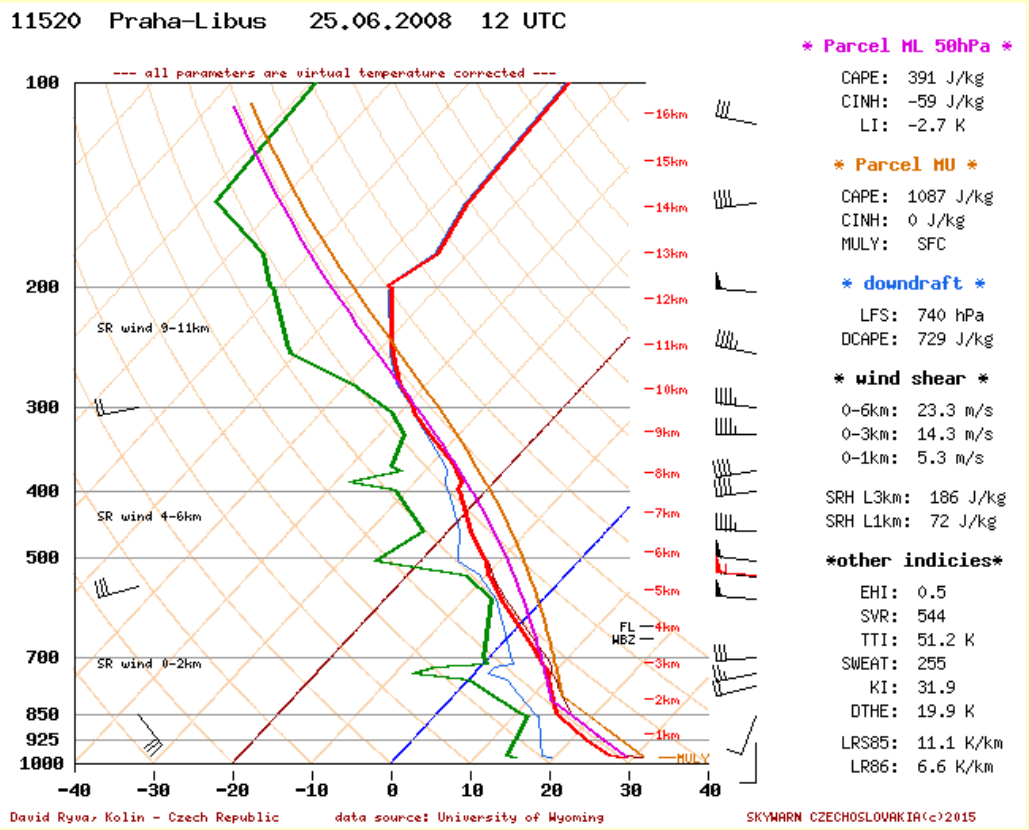
- **Orientation of the flow with respect to the storm system or the gust front**

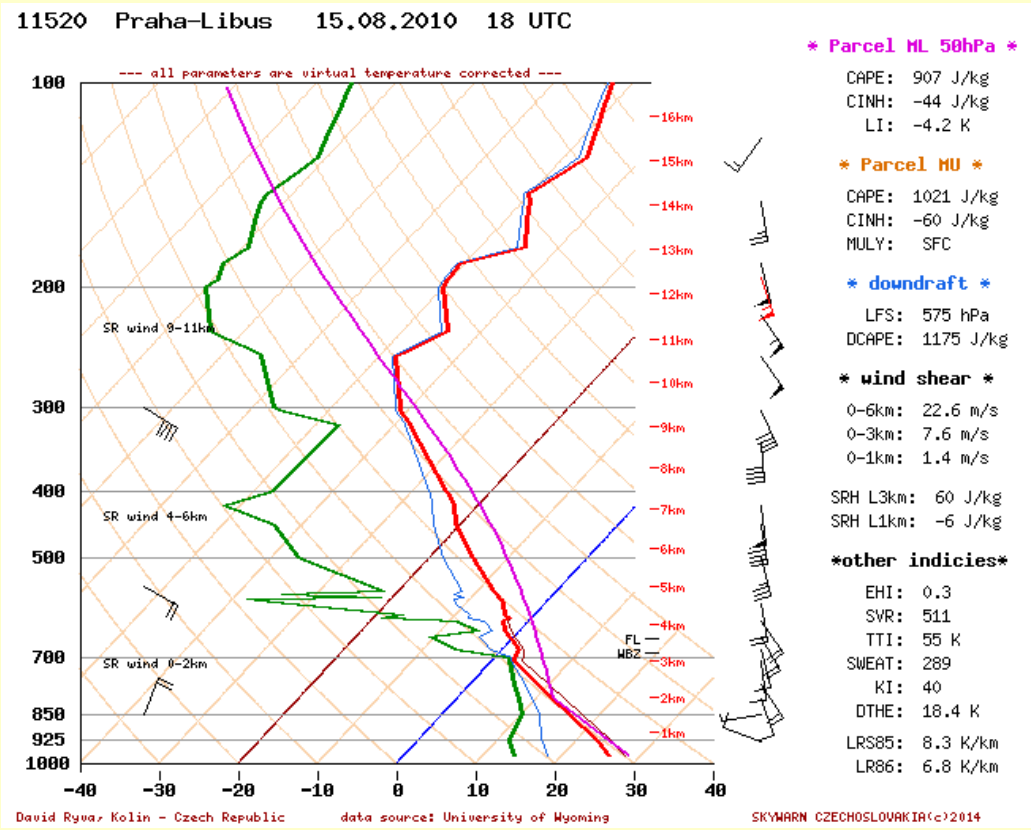
Are storms moving quickly forward (wind) or are they training over the same area (rain)

These factors are important and they are impossible to forecast using just sounding-derived parameters.

Storm mode example

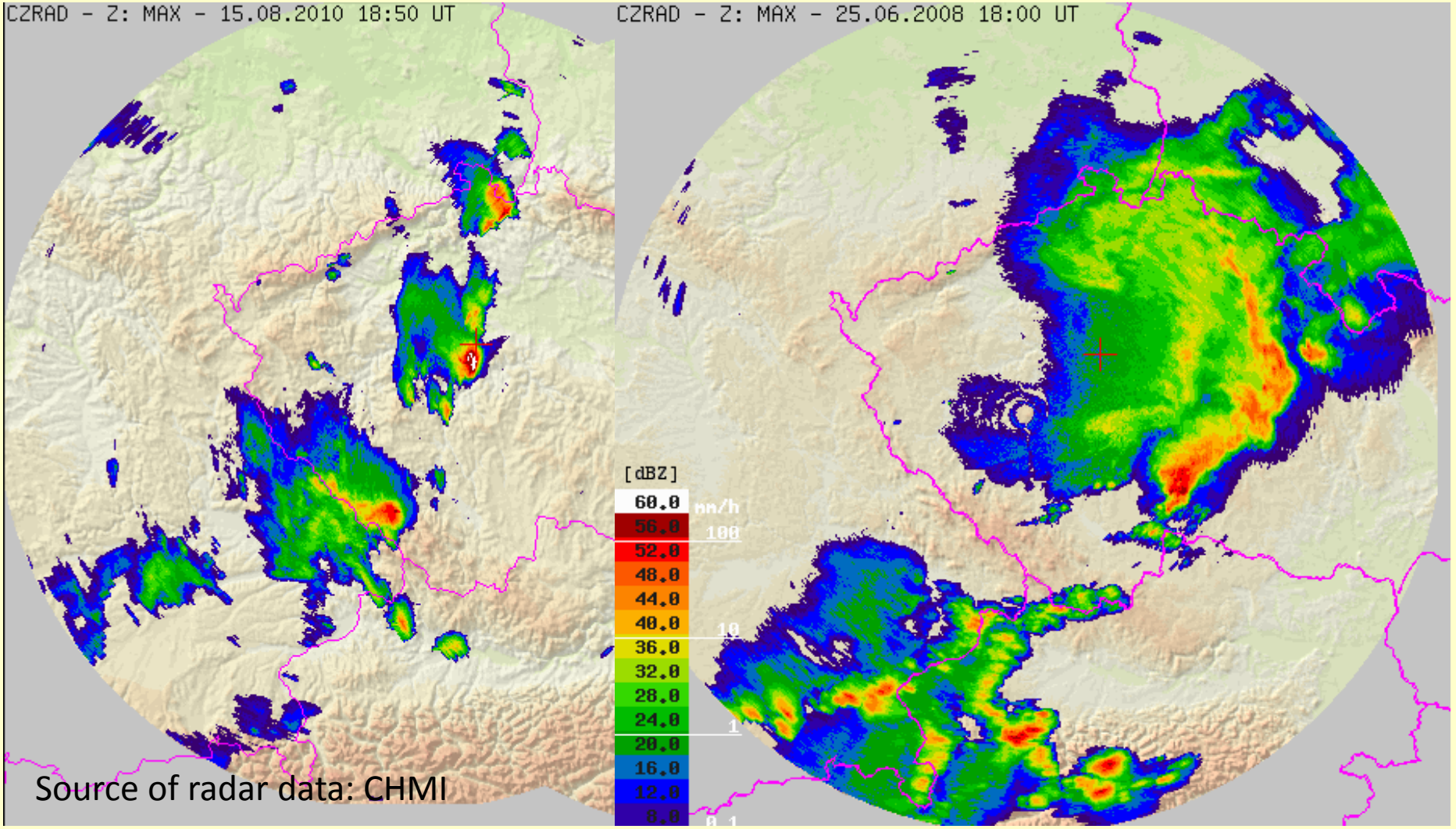
- Look at these two soundings. What do they show? What kind of severe would you expect?





Storm mode example

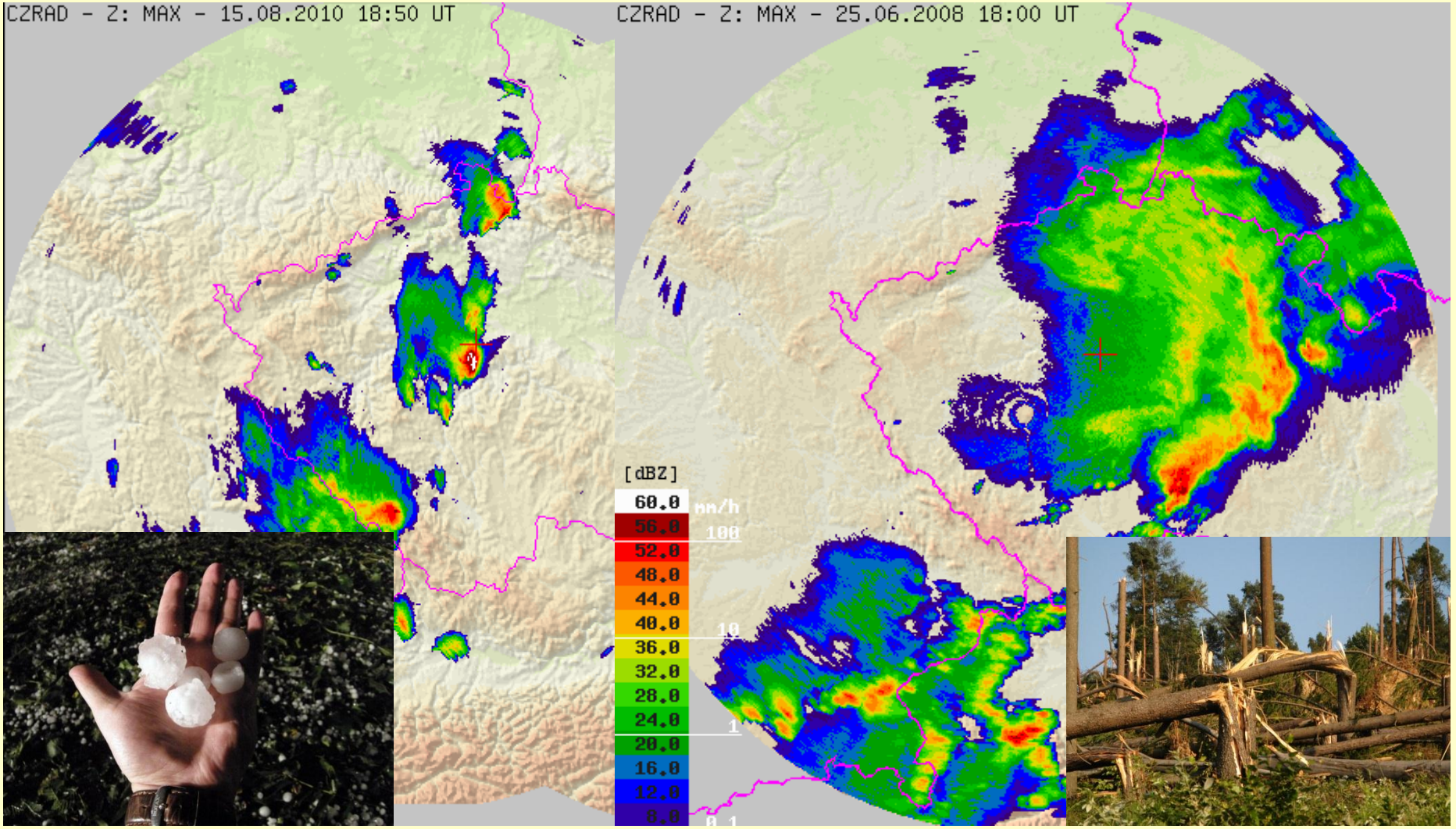
- Radar from these situations
- Which one is more likely to produce large hail? Which severe wind gusts?



Source of radar data: CHMI

Storm mode example

- RESULT: Discrete convection favours large hail, clustered favours stronger cold pools and severe wind gusts.



Conclusions (aimed at forecasters)

- Sounding derived parameters can help identifying thunderstorm related threats.

- Threats should be covered separately, different conditions favour different types of severe weather.

- Severe weather does often occur outside the perfect high CAPE – high shear conditions.

- And most importantly: There are no clear thresholds or magic values that clearly separate non-severe and severe events.