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Updraft width in severe thunderstorms – observations of significant-hail producing thunderstorms in Finland

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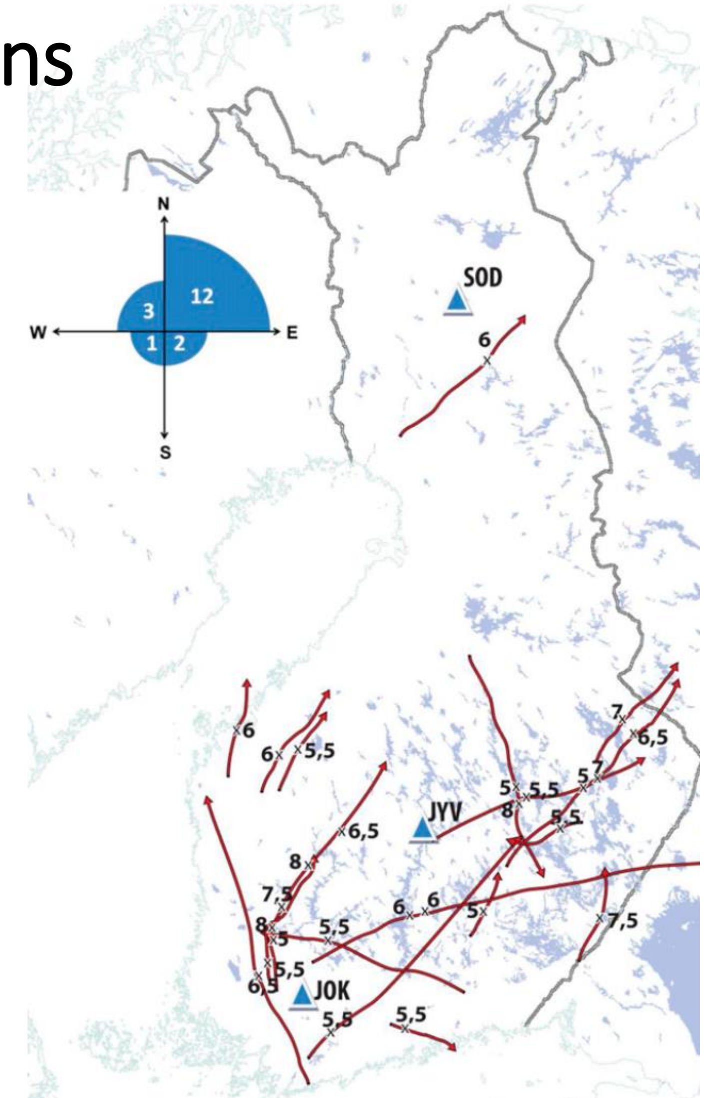
Significant-hail (≥5 cm) observations

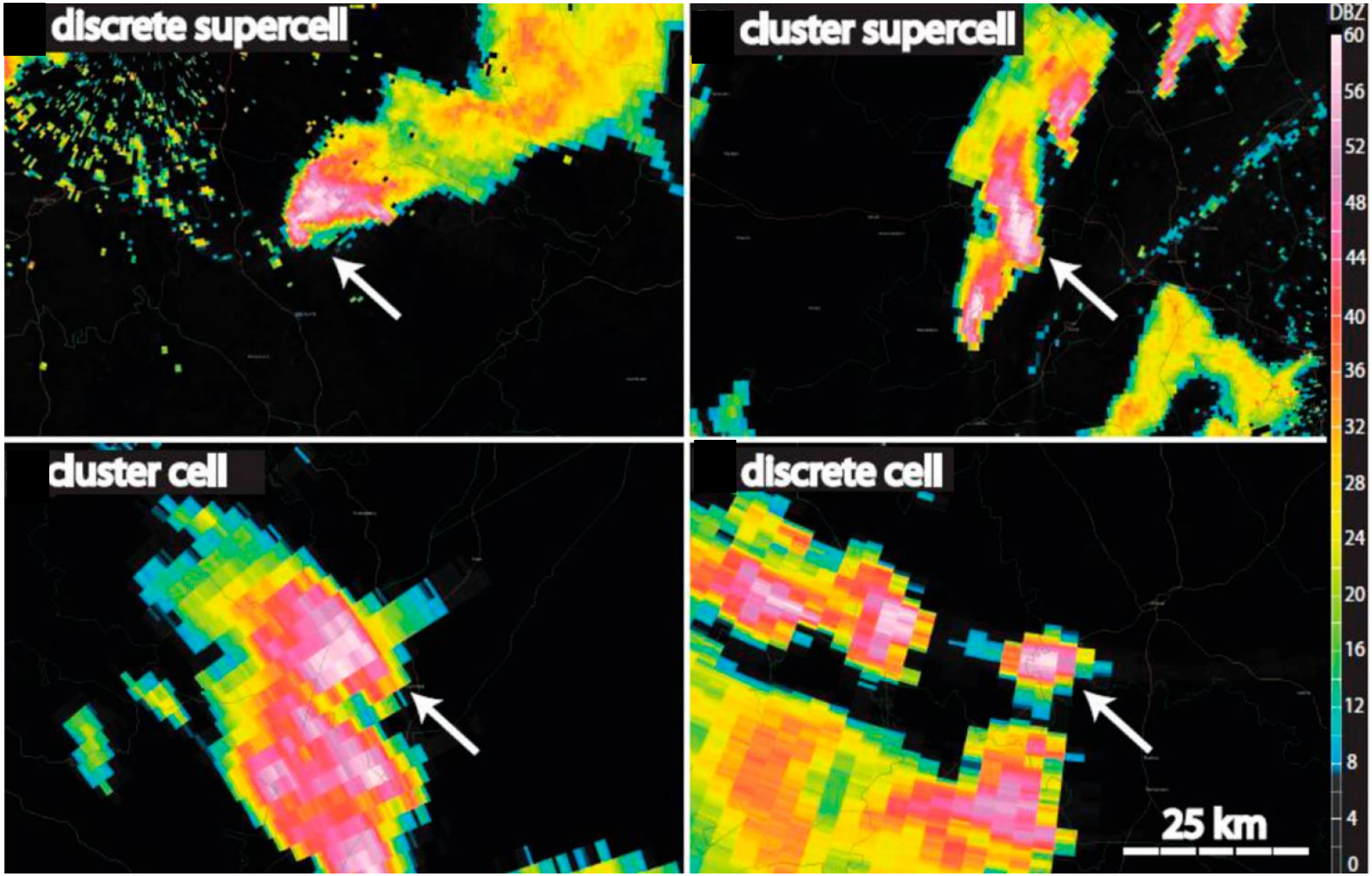
- 25 significant-hail reports 1999–2011
- caused by 18 separate storms
- All significant hail produced by cellular convection

Goal was to study storm characteristics of these 18 significant-hail producing storms



All significant-hail observations during 1999–2011 with hail diameter (cm) and their 18 parent-storm tracks (Tuovinen et al. 2015)

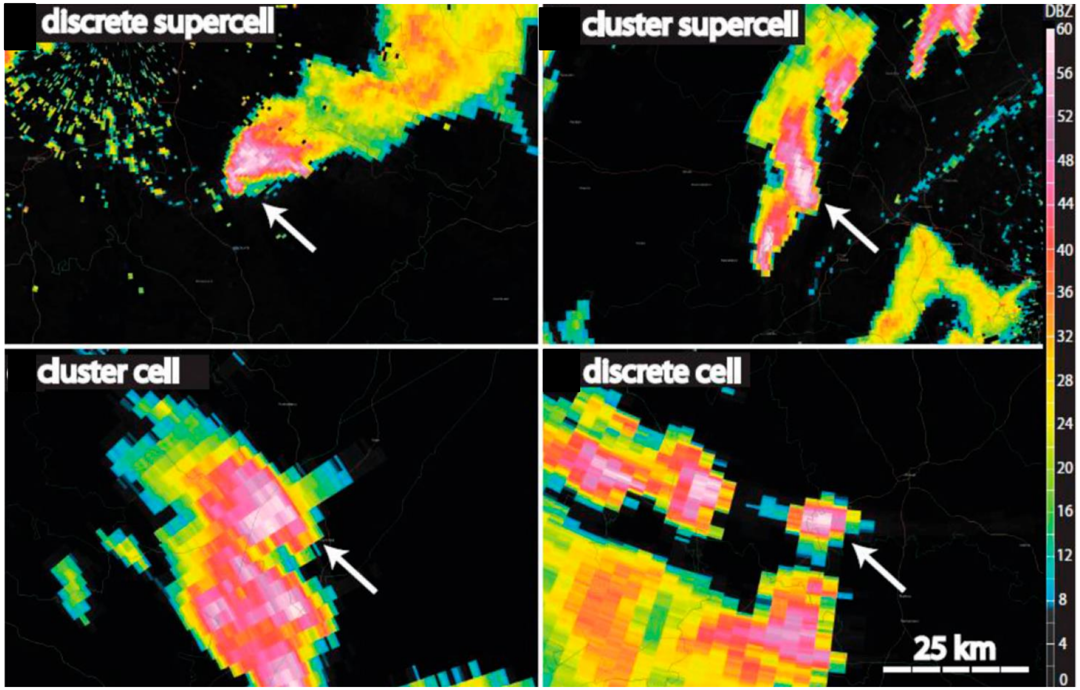
Storm modes used in the classification



Storm type was defined based on the mode just prior to the first significant-hail report

Most storms (14/18) were supercell storms

- Right-moving cluster supercells (8)
- Right-moving discrete supercells (5)
- A left-moving discrete supercell (1)
- Cluster cells (2) and discrete cells (2)



Mean values of parameters by storm modes

Parameter	Cluster supercell	Discrete supercell	Ordinary cells
MUCAPE	1787	1080	2150
0–6-km deep-layer shear	15.2	23	9.3
Storm lifetime	254	310	180
Storm-track length	186	257	87
5-cm hail onset time	80	165	64
Speed of motion	11	13	8
Direction of motion	214	240	163

(Tuovinen et al. 2015)

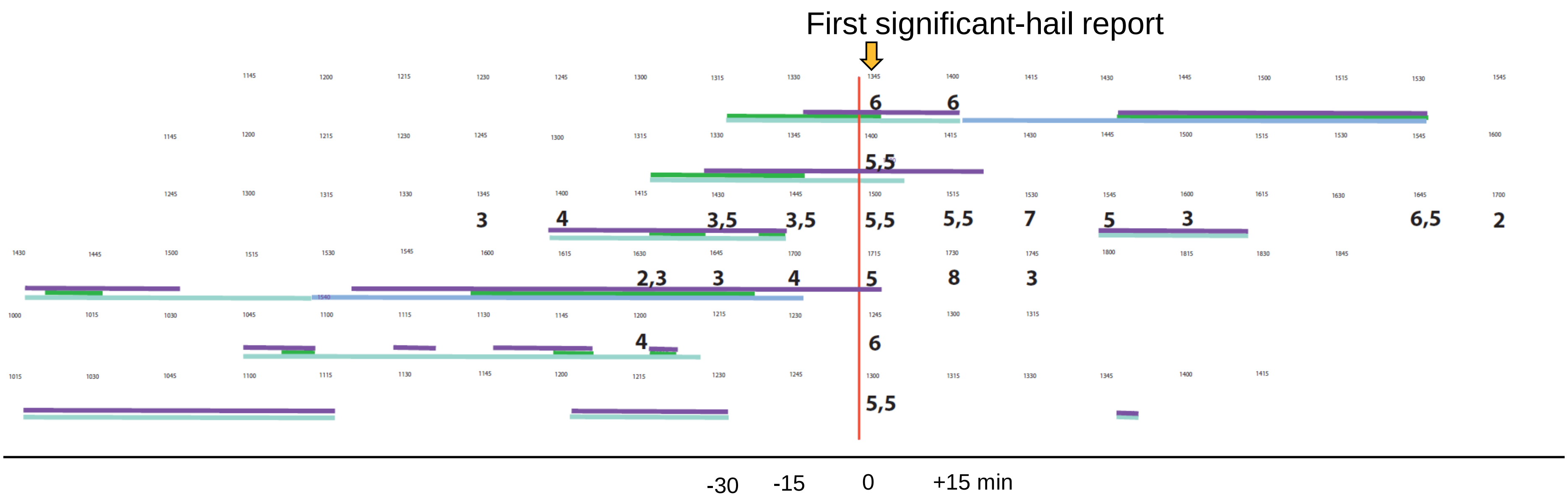
Storm lifetime

- 78% had a lifetime of more than 3 h
- 30% had a lifetime of more than 5 h
- Discrete significant-hail producing supercells had longer lifetimes than cluster supercells

Storm-track length

- Nonsupercells shorter storm-track lengths (a mean 87 km)
- Cluster supercells longer (186 km)
- Discrete supercells the longest (257 km)

Discrete supercell evolution and hail reports



Severe thunderstorm features

hook echo

BWER

rotating updraft

In discrete supercells, the significant hail was observed later in the storm's lifetime

5/6 BWER before significant hail observation

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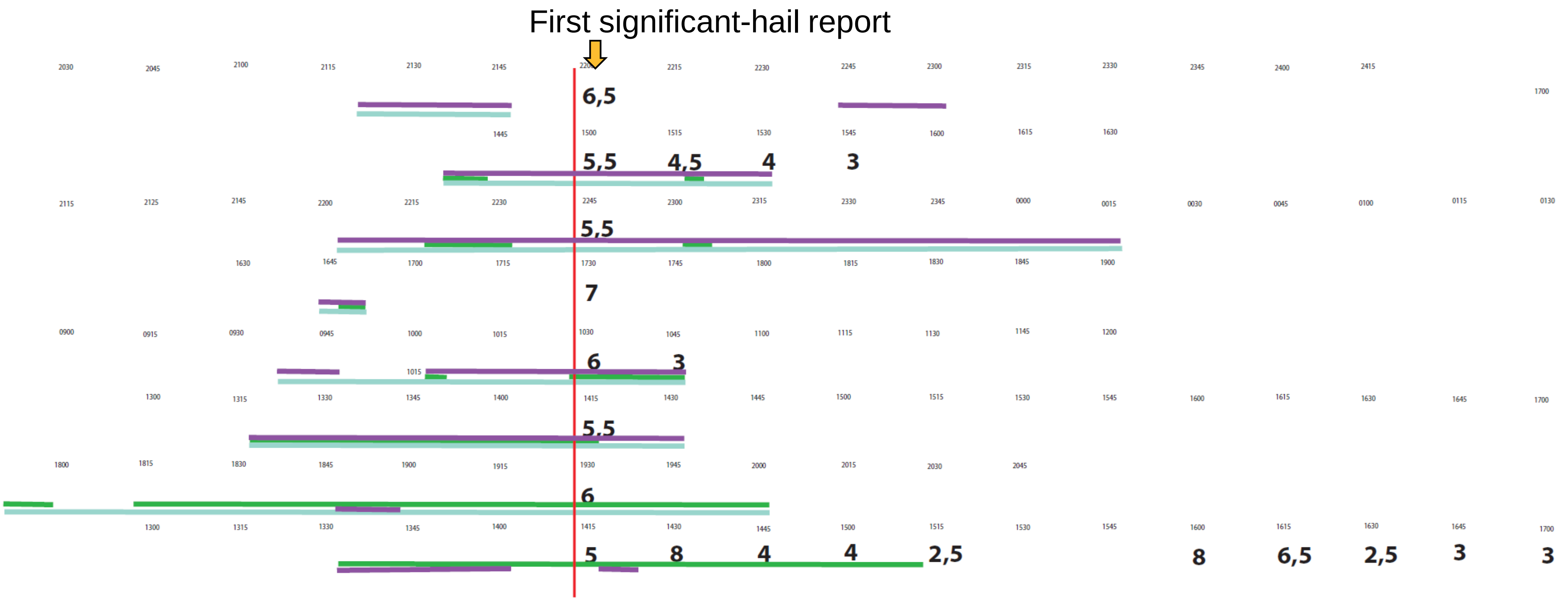
Cluster supercell evolution and hail reports



Severe thunderstorm features

hook echo

BWER

rotating updraft

In cluster supercells significant-hail was observed within 2 h of the storm onset

7/8 BWER before significant hail observation

Features of 14 significant-hail producing supercells

- All had a persistent hook echo
- Most (11/14) BWER observed before the first significant-hail occurrence
- The storm lost both BWER and hook echo close to the onset of

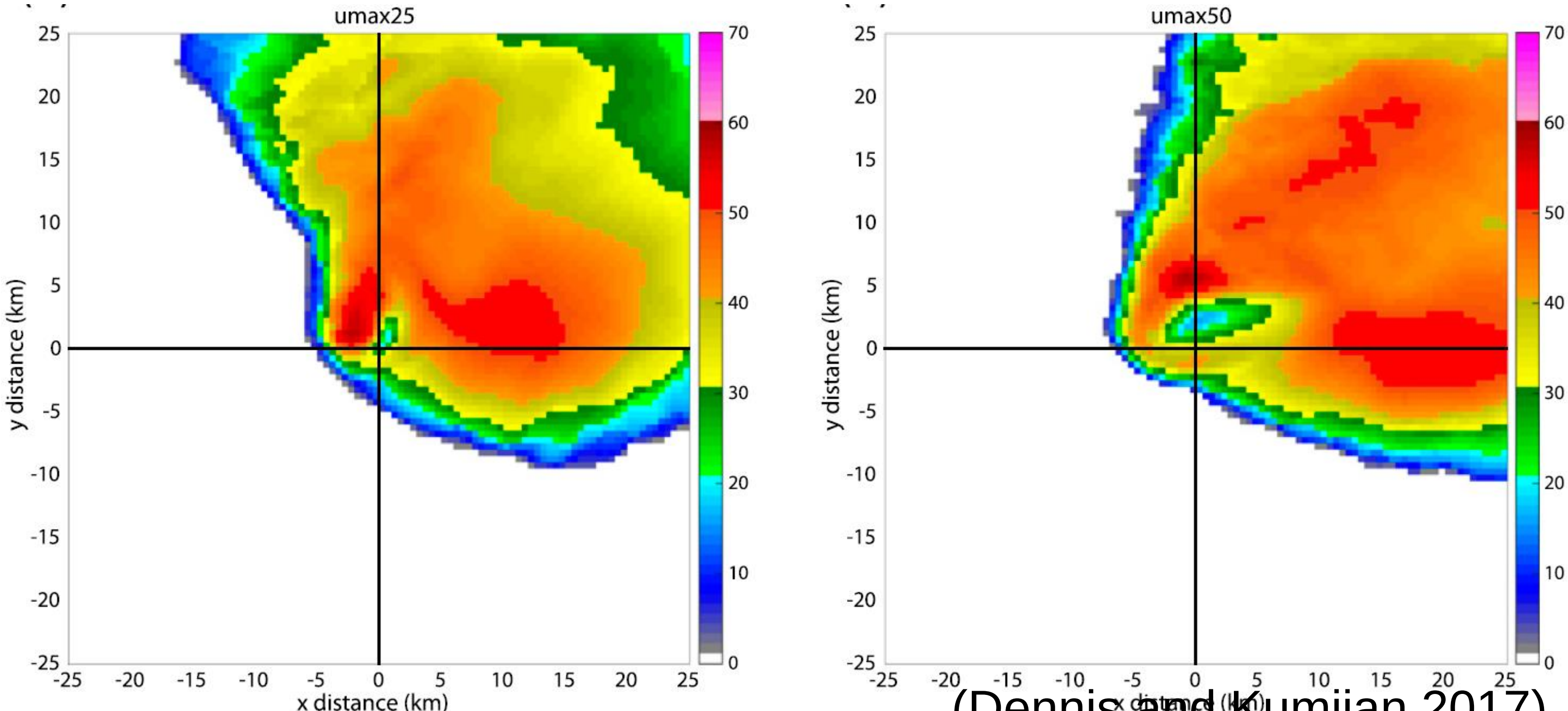
the significant-hail fall in 6 cases

- All supercells began as ordinary cells or as multicells before they developed into supercells
- Each storm had a different evolution - no common storm-development structure was present before the significant-hail fall

Are there other signs in the storm structure that indicate significant severe weather?

Updraft width as a sign of storm intensity?

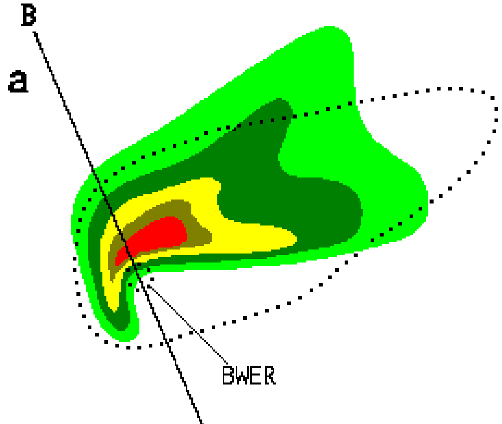
- In simulated supercells (Trapp et al. 2017) the most intense updrafts were generally the widest updrafts
- Updraft area controls the hail growth (Dennis and Kumjian 2017)
- Substantial difference of BWER size in simulated hail producing supercells with different updraft strength (Dennis and Kumjian 2017)



(Dennis and Kumjian 2017)

The challenge: How can we observe severe thunderstorms better?

- Specially in situation when the large scale environment does is not so obvious for significant severe weather (Relatively low CAPE and low shear)
- In same environment not all storms produce significant hail

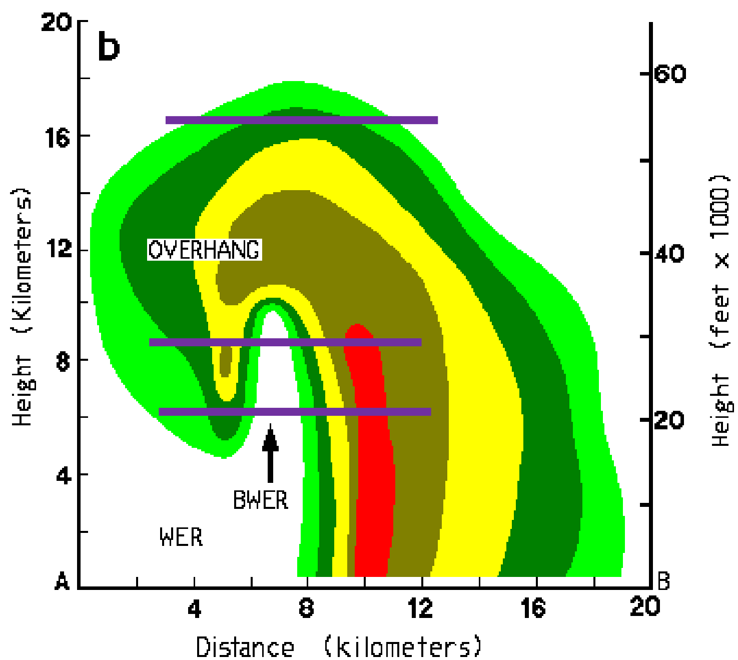


How can we estimate updraft area in a supercell storm radar data?

BWER

bounded weak echo region

”The BWER, sometimes called a vault, is related to the strong updraft in a severe convective storm that carries newly formed hydrometeors to high levels before they can grow to radar- detectable sizes. BWERs are typically found at midlevels of convective storms, 3–10 km above the ground, and are a few kilometers in horizontal diameter.“(Glossary of meteorology)



Algorithms to observe updraft width with radar, or measure overshooting top area?

References

- Dennis, E. J., and M. R. Kumjian, 2017: The impact of vertical wind shear on hail growth in simulated supercells. *Journal of the Atmospheric Sciences*., **74**, 641–663.
- Trapp, R. J., G. R. Marion and S. W. Nesbitt, 2017: The regulation of tornado intensity by updraft width. *Journal of the Atmospheric Sciences*., **74**, 4199–4211.
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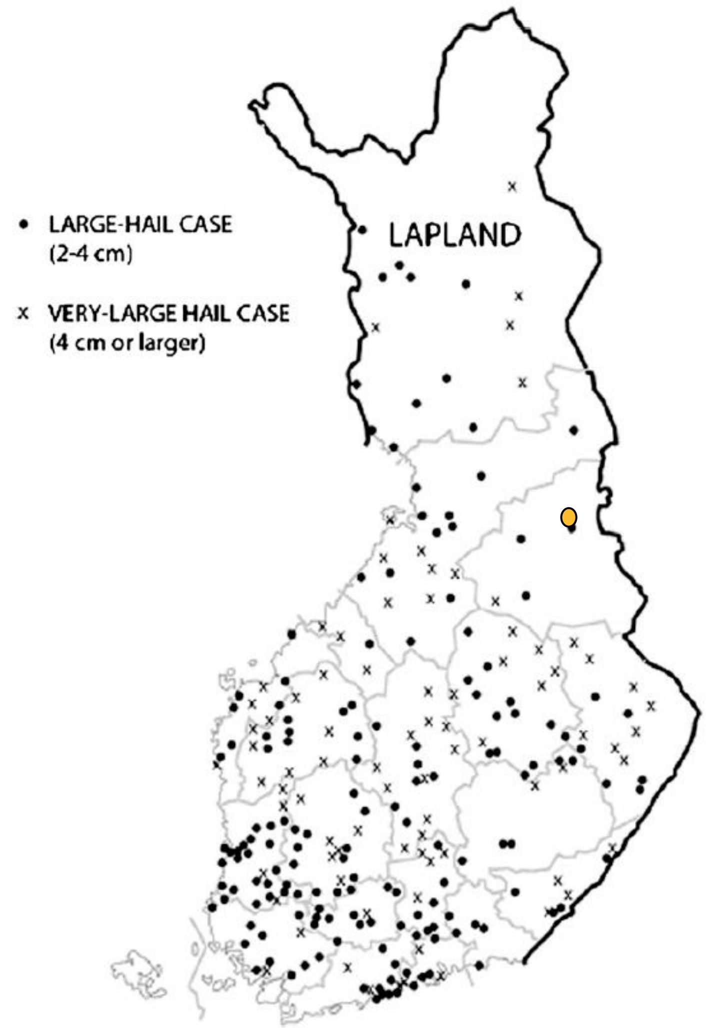
- Tuovinen, J.-P., A.-J. Punkka, J. Rauhala, H. Hohti, and D. M. Schultz, 2009: Climatology of severe hail in Finland: 1930–2006. Mon. Wea. Rev., **137**, 2238–2249.

Severe hail in Finland

- Systematic collecting hail reports started in FMI in 2006
- *Climatology of severe hail in Finland: 1930–2006* (Tuovinen et al. 2009)
  - 240 severe-hail cases (2 cm or larger)
  - Occur mostly between June and August, maximum in July
  - Most cases occur in southern and western Finland, generally decreasing north

- Annual average of 17 severe-hail days (2008-12) (Tuovinen et al. 2015)
- The largest hail diameter 9 cm (31 July 2014)



Geographical distribution of severe-hail cases in Finland during 1930–2006 (Tuovinen et al. 2009)

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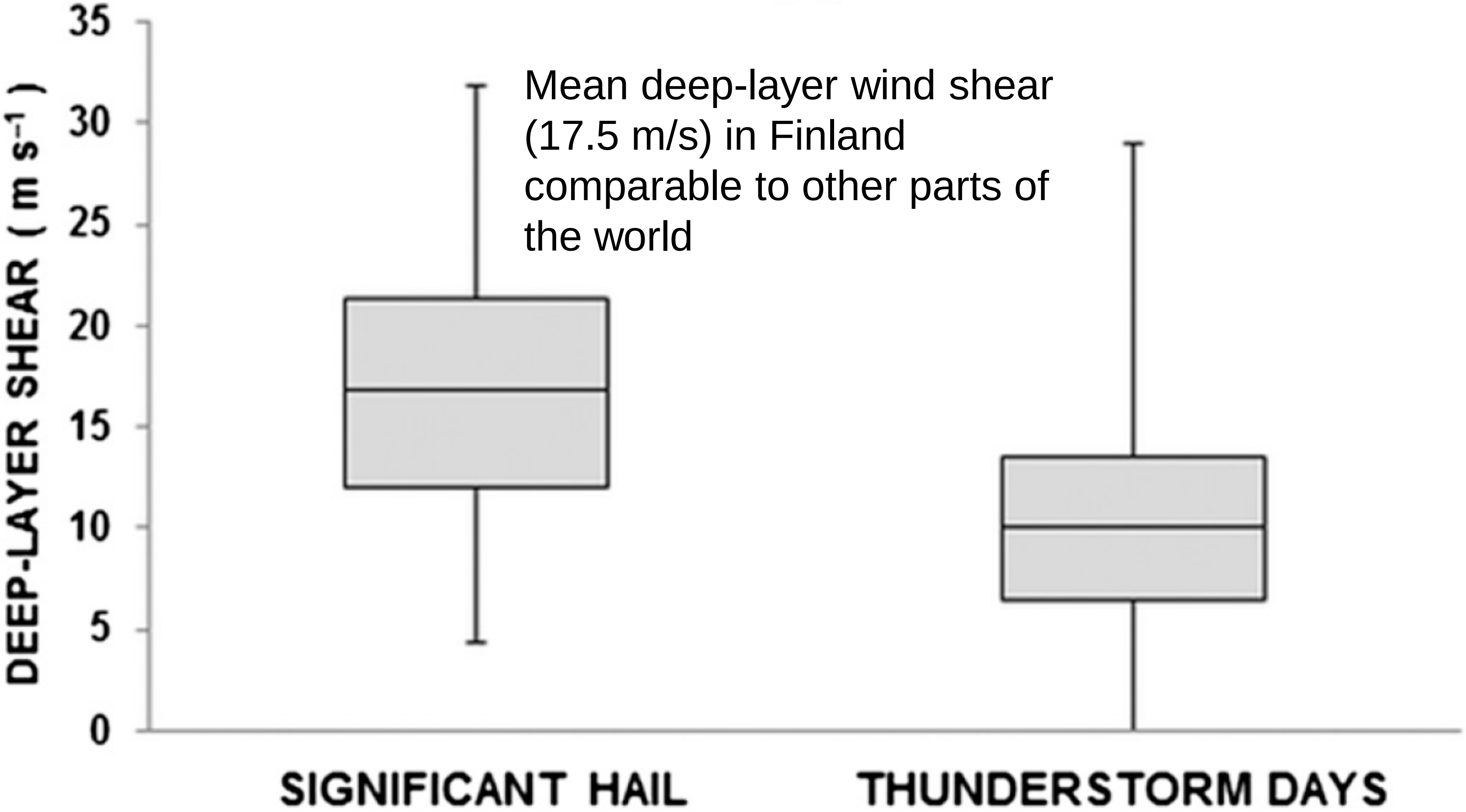
0-6 km shear for significant-hail and thunderstorm days in Finland



Tuovinen et al. 2015

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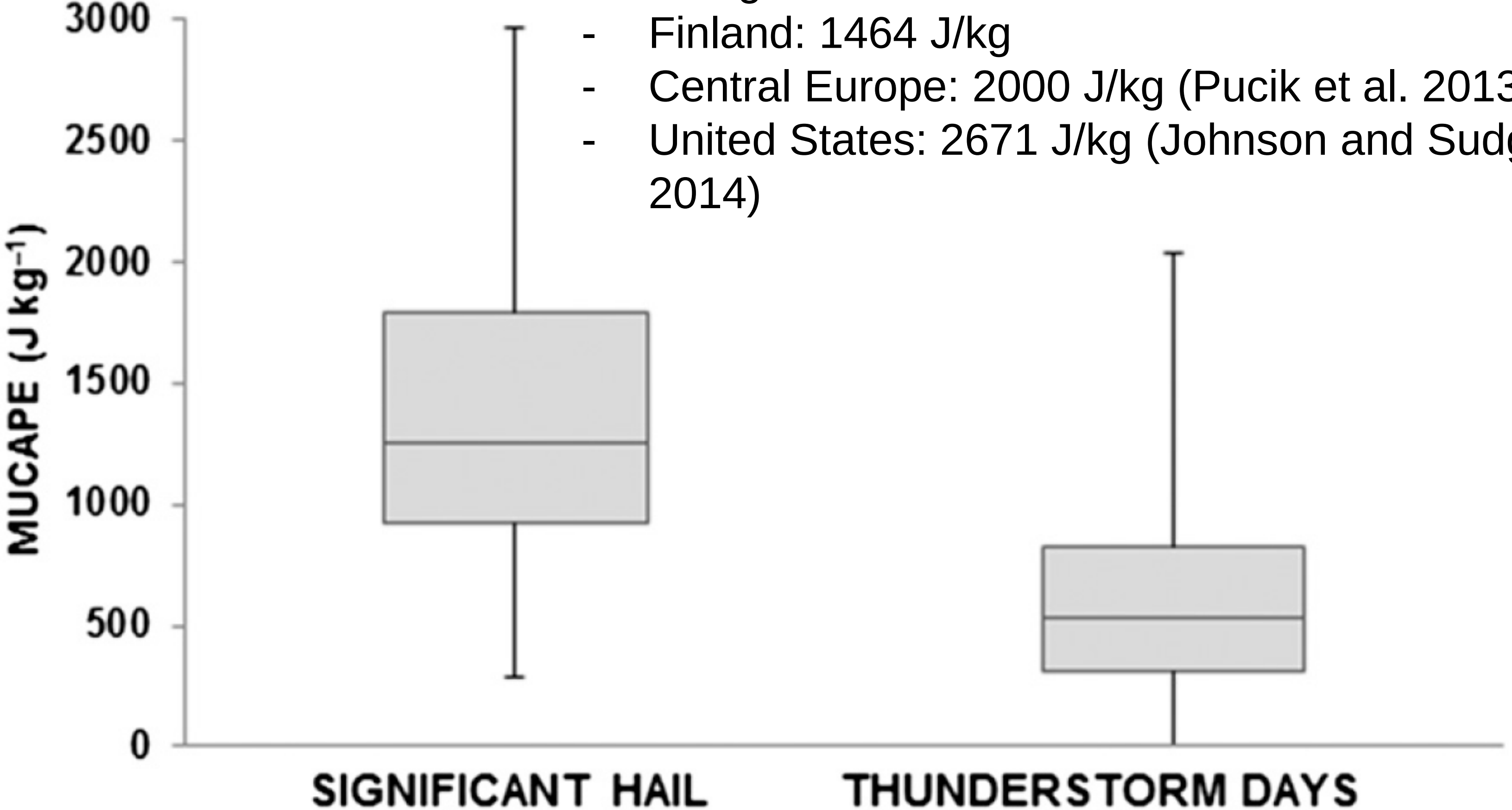
MUCAPE for significant-hail and thunderstorm days in Finland

Mean significant-hail MUCAPE lower in Finland

- Finland: 1464 J/kg
- Central Europe: 2000 J/kg (Pucik et al. 2013)
- United States: 2671 J/kg (Johnson and Sudgen 2014)



Tuovinen et al. 2015