Climatological aspects of quasi-linear convective systems across Europe

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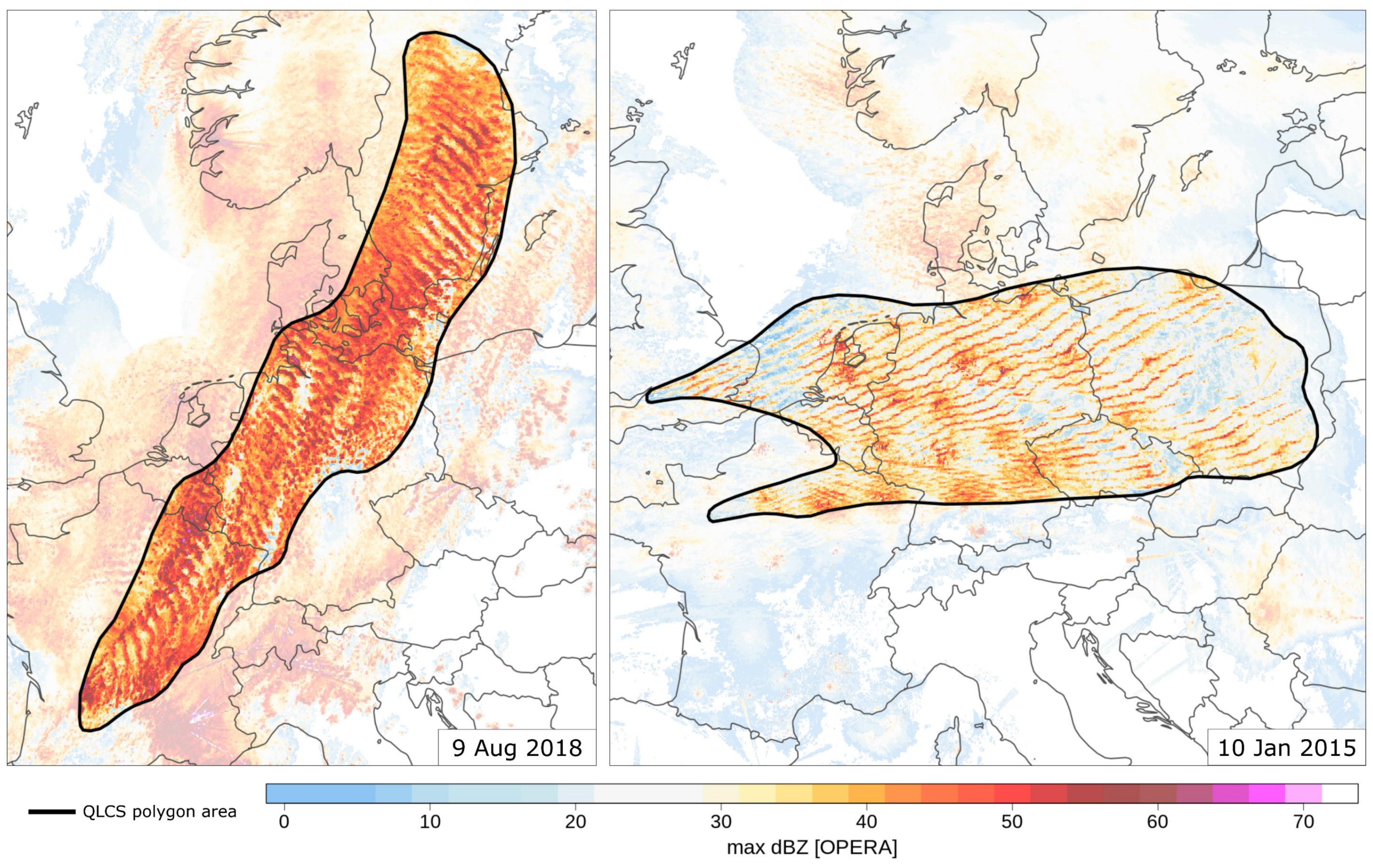
Introduction and motivation

Available European analyses of quasi-linear convective systems (QLCS) consist of mostly regional or case studies. However, recent availability of 8-years (2014–2021) of pan-European OPERA radar datasets along with ATDnet lightning detection data and ESWD severe weather reports made it possible to construct QLCS climatology, including their lifecycle, severity, morphological features and social impacts, which is the goal of this work.

Results

- In total, we manually identified 2201 QLCS cases in the OPERA domain, among which 1844 were classified as marginal, 304 as moderate and 53 as derecho.
- At least 240 QLCS cases occur every year in the analyzed domain.
- QLCSs are the most frequent during warm season in Central Europe, while in southern Europe the season of their occurrence is extended to late autumn.
- QLCSs are less frequent during winter when they appear mostly in northwestern Europe in the form of narrow cold frontal rainbands (NCFR).
- Duration, width, length, area and the speed of QLCSs increase with their intensity. The longest classified QLCS had a length of 2200 km while the widest 1635 km.
- Dominant propagation component of QLCS is S/SW for warm season and W/NW during cold.
- Marginal and moderate cases tend to initiate at 12–18 UTC and fade in the late afternoon hours. Derechos typically initiate earlier (06–15 UTC) but last till nighttime (21–00 UTC).
- Fastest moving QLCS were found over W Europe (coinciding with derecho occurrence) while the slowest were found over S France.
- Warm-season derecho events had the largest relative frequency of injuries, fatalities, storm reports and lightning activity, and they were associated with the largest social impacts.
- Derecho of 18 Aug 2017 was found to be the most impactful event in the evaluated period.

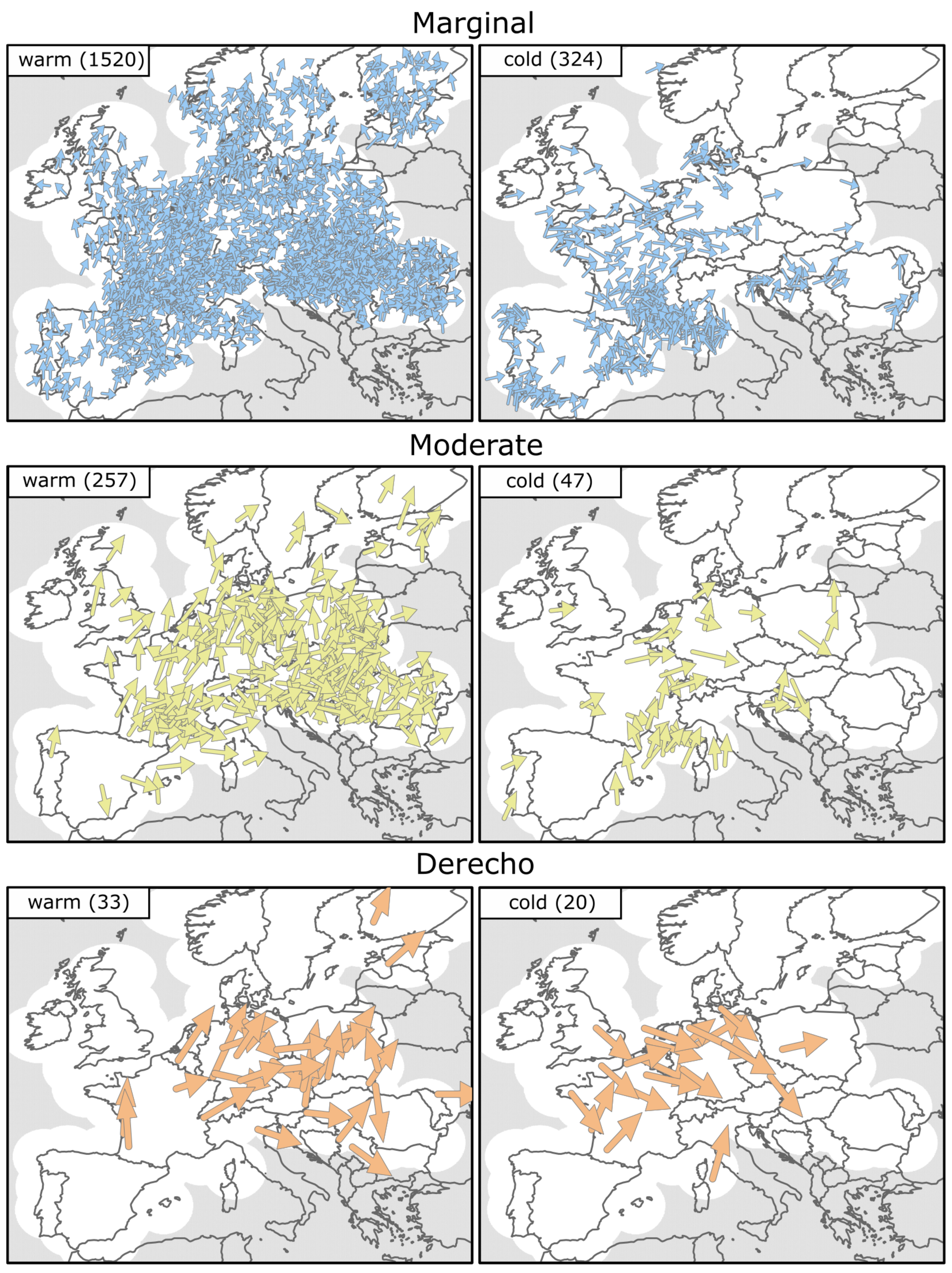
Example of QLCS manual polygonization technique



Definition of QLCS intensity categories

Intensity	Explanation	Number of cases
Marginal	Weakly organized QLCS which produce at most several ESWD reports during its lifespan.	1844
Moderate	QLCS which produce at least a cluster of severe weather events (several ESWD reports in a relatively short distance) or long-lived QLCS producing bowing segments or long lasting continuous line of high radar reflectivity (more than 50 dBZ).	304
Derecho	QLCS which fulfill derecho criteria provided by Johns and Hirt (1987).	53

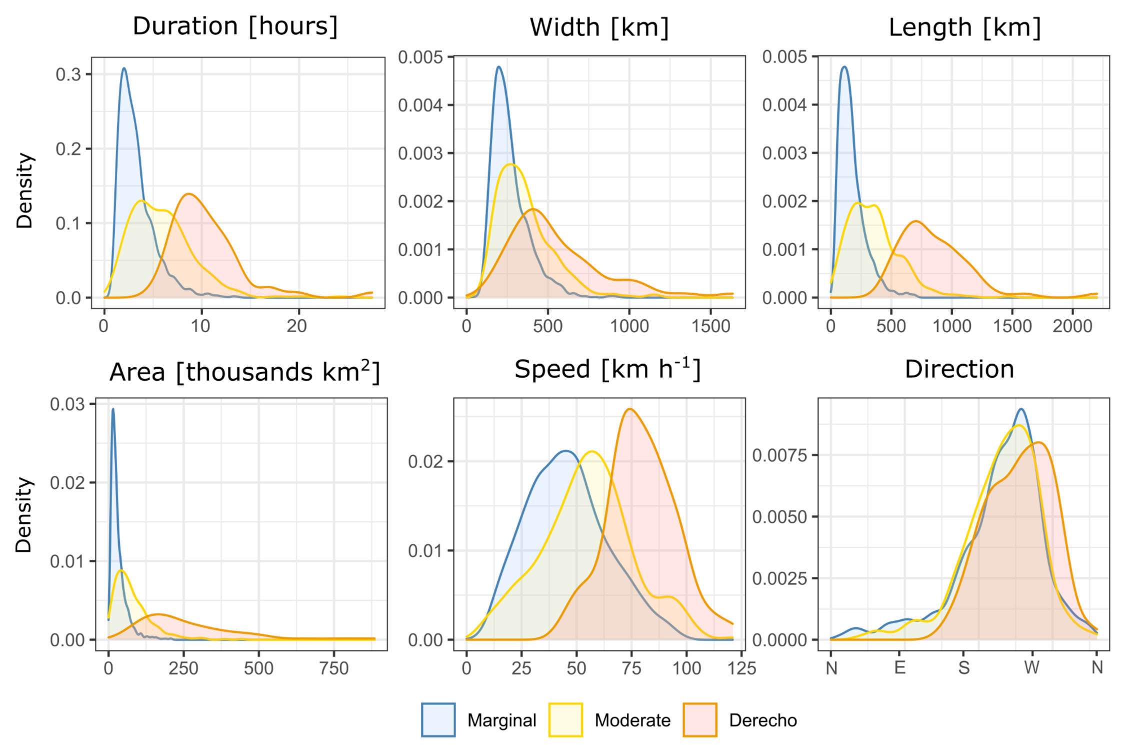
Trajectories of QLCS systems



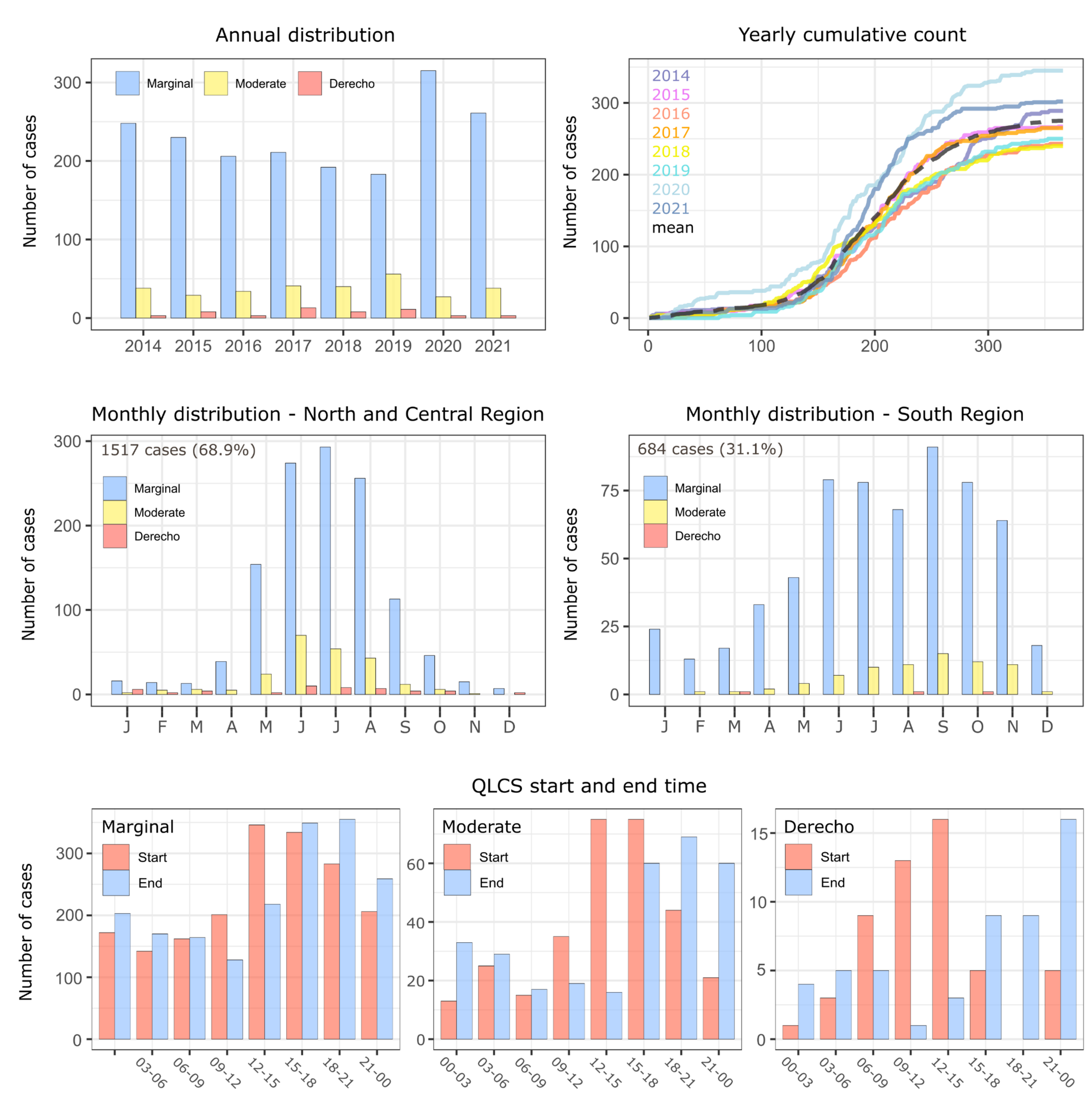
Five most impactful QLCS in the period 2014–2021

No.	QLCS date	Length [km]	Width [km]	Speed [km h^{-1}]	Area [1000 km^2]	Storm reports [1000 km^2]	Injured [no.]	Killed [no.]
1.	2017-08-18	1000	435	97	194	116	142	2
2.	2017-09-17	915	405	87	183	76	89	8
3.	2017-08-11	1140	340	68	202	126	54	6
4.	2020-02-09	1335	1340	67	774	613	17	1
5.	2014-06-09	665	200	68	106	49	40	4

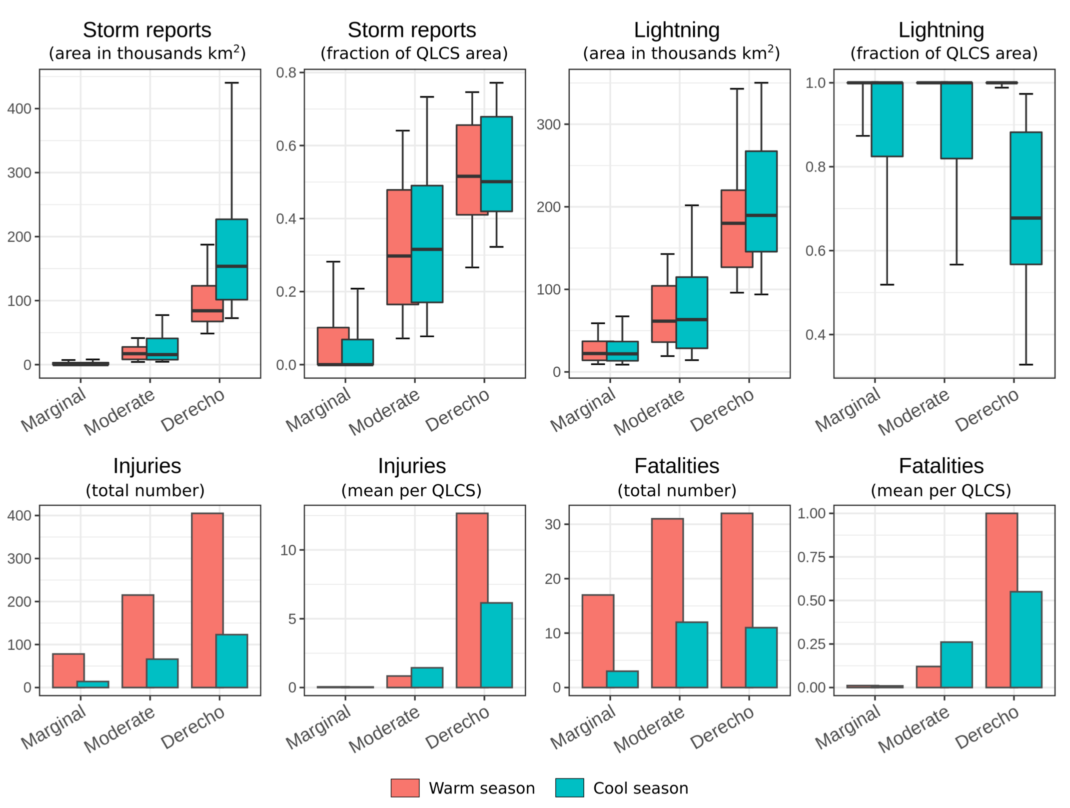
QLCS characteristics



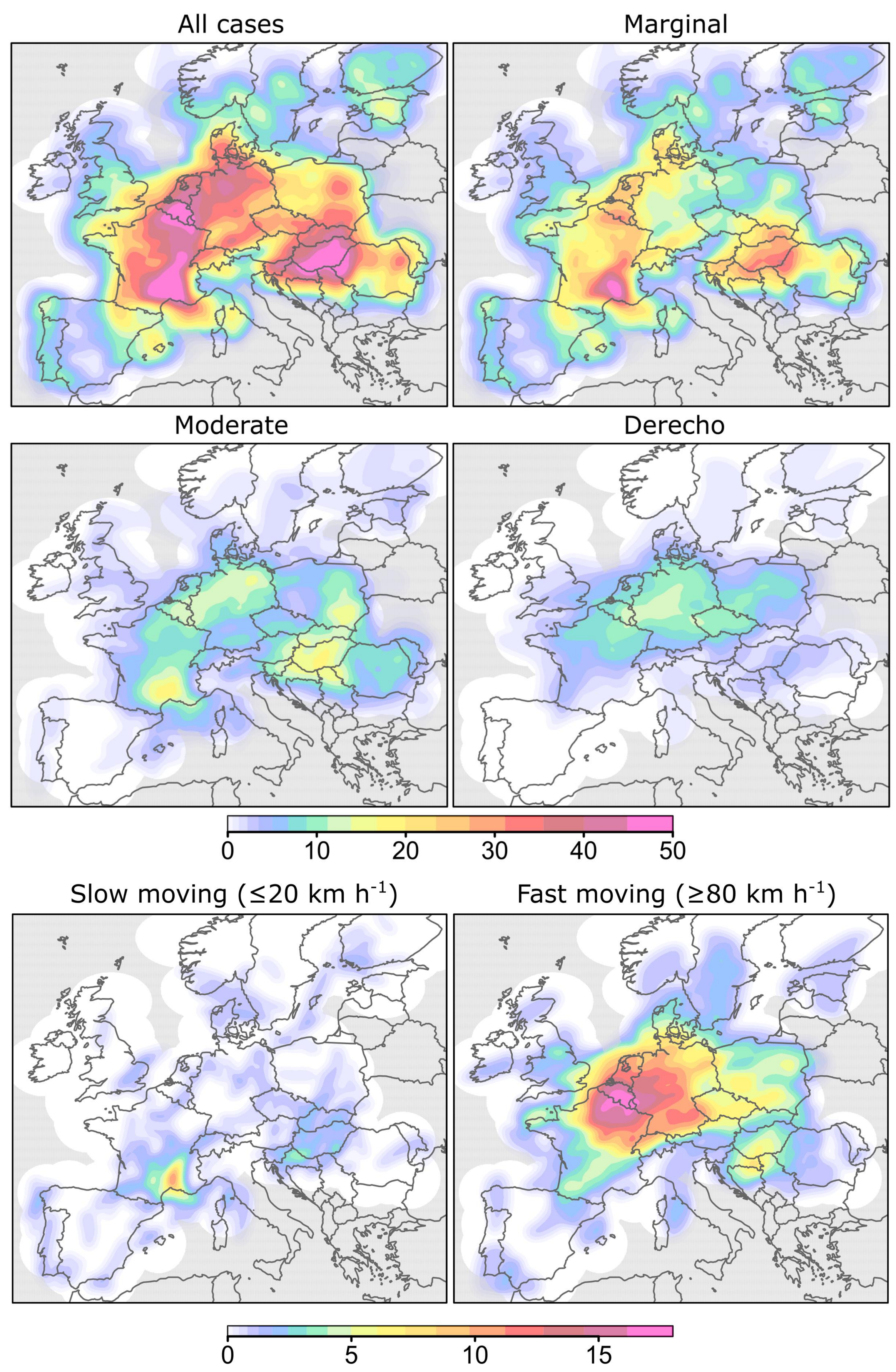
Temporal variability of QLCS occurrence



QLCS social impacts



Spatial variability of QLCS events (frequency)



Dataset and methodology

For manual QLCS determination and its intensity we used 15-min animations covering a period of 2014–2021 including following datasets:

- OPERA radar composite maximum reflectivity product (EUMETSAT),
- ESWD severe weather reports of tornado, large hail, severe wind and excessive precipitation (ESSL),
- ATDnet lighting data (Met Office).

Polygons which cover QLCS track were defined based on MCS definition (Parker and Johnson 2000), which means storm developed as a result of a deep moist convection extending on a minimum distance of 100 km and lasting at least 3 h. We consider the beginning of each QLCS, when a linear storm structure with reflectivity >40 dBZ was observed. When the linear structure disintegrated or the storm got significantly weaker (e.g. absence of lighting), the end of the system was noted. To ensure homogenity of the database, polygonization procedure of QLCS events was performed by one person.

Acknowledgements
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