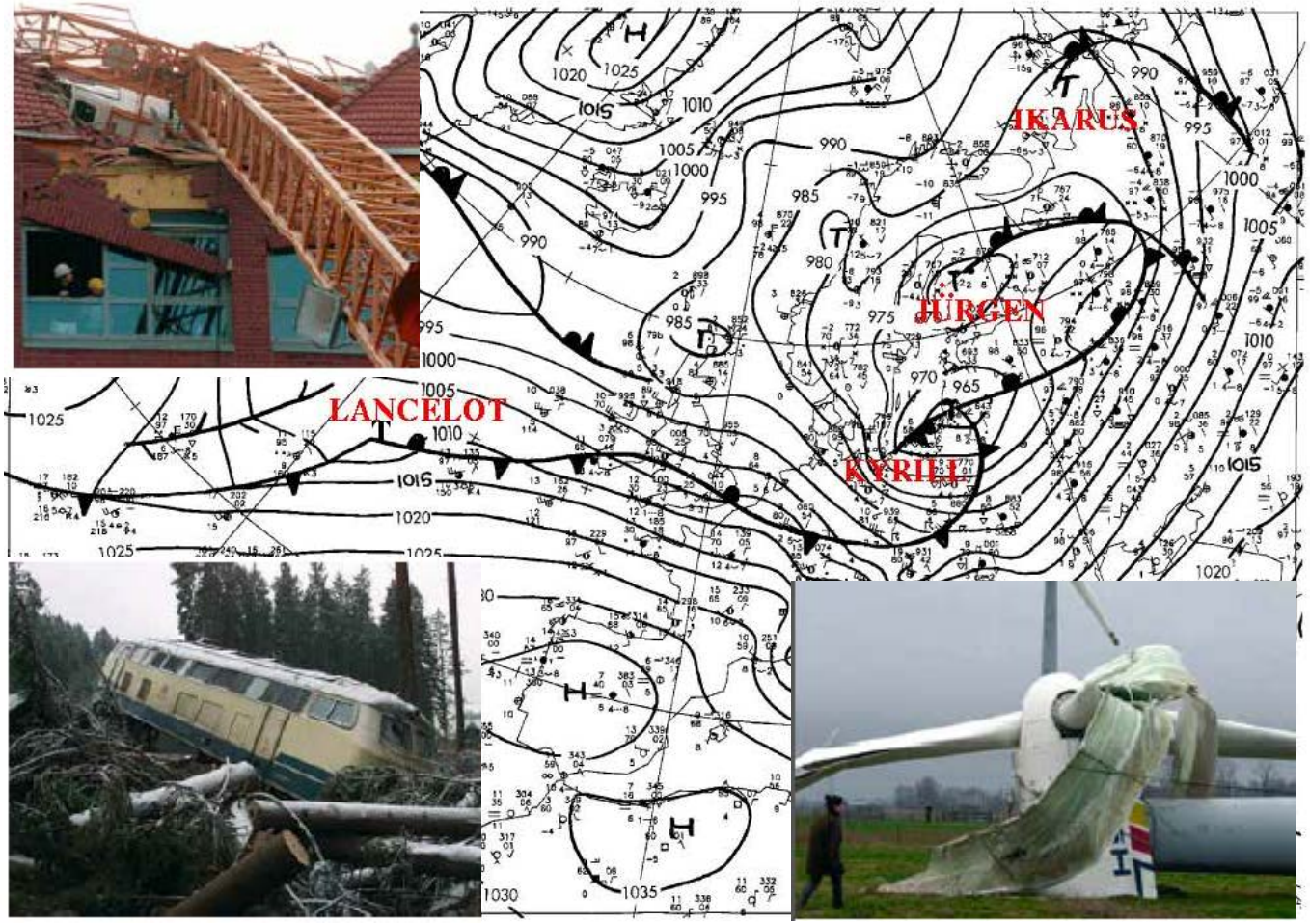
Return periods of losses associated with European windstorm series in a changing climate

J.G. Pinto (a,b)

M.K. Karremann (b)

M. Reyers (b)

M. Klawa (c)



(a) Univ. Reading, UK
(b) Univ. Cologne, Germany
(c) Deutsche Rück, Germany

Contact: j.g.pinto@reading.ac.uk

Motivation - European Storm Climatology, Top 15 Events

Storm rank	Storm Year	Storm Name	Fatalities	Economic Damage Actual (USD)
1	1999	Lothar	137	11,350,000,000
2	2007	Kyrill	47	10,000,000,000
3	1990	Daria	97	7,000,000,000
4	2010	Xynthia	64	6,100,000,000
5	1999	Martin	90	6,000,000,000
6	2009	Klaus	28	6,000,000,000
7	2005	Erwin	18	5,505,000,000
8	1976	Capella	0	5,000,000,000
9	1987	Great Storm of 1987	23	4,000,000,000
10	1990	Vivian	50	3,500,000,000
11	1999	Anatol	27	3,000,000,000
12	2002	Jeanett	38	2,531,000,000
13	1995	Thalia	28	2,310,000,000
14	1990	Wiebke	67	2,260,000,000
15	1990	Herta	30	1,960,000,000

1990 season

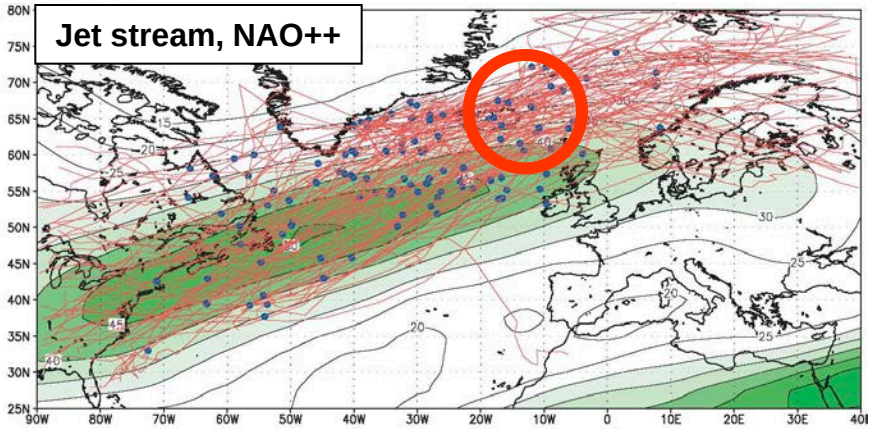
1999 season

Multiple occurrences per year may be critical for contractual reasons

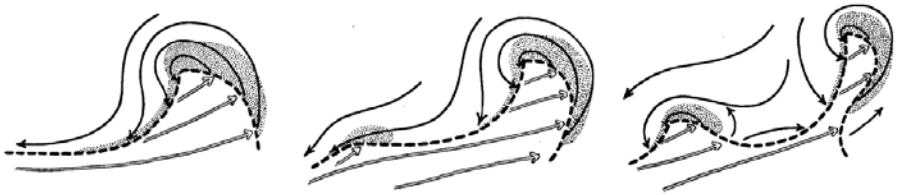
Source: Perils

Serial clustering of cyclones over North Atlantic / Europe

Physical processes: a) Steering by large-scale patterns



b) Secondary cyclogenesis (cyclone families)



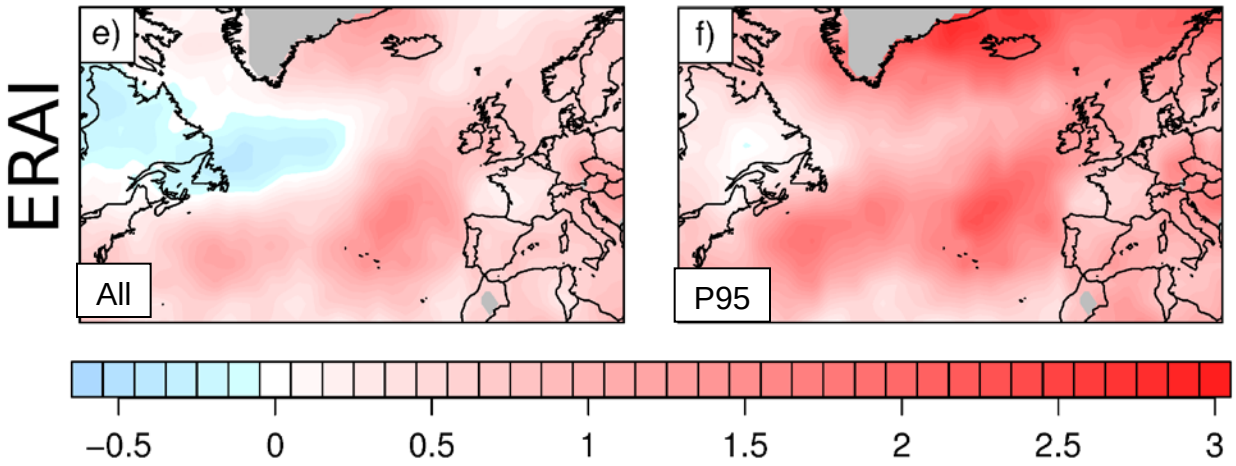
Dispersion $\Phi = \frac{VAR(N)}{E(N)}$

Dispersion statistics $\Psi = \Phi - 1$

Ψ <0: serial regularity

Ψ =0: serial randomness

Ψ >0: serial clustering



Sources: Pinto et al., 2009, Clim. Dyn.; Bjerkness & Solberg, 1922, Geophys. Publ.; Mailier et al., 2006, MWR; Pinto et al., 2013, JGR-A

Data and Methods

Data

- NCEP [1958-2010], ERA40 [1958-2002], ERA-Interim [1979-2010]
- ECHAM5/MPI-OM1 20C [1960-2000] + SRES A1B [2060-2100]

Validation: 4092 years; Climate change: 800 years vs 800 years

Loss estimation (after Klawa and Ulbrich, 2003; Pinto et al., 2012)

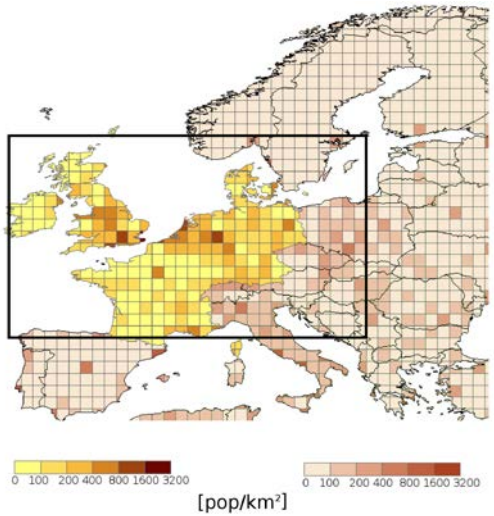
Based on exceedance of the 98th local percentile of wind / wind gusts

$$LI = \sum_{ij} \left[max_{3D} \left(\frac{v_{ij}}{v_{ij}^{98}} \right) - 1 \right]^3 * pop_{ij}$$

for grid points *ij* with max. winds (v_{ij}) > critical wind speed (v_{ij}^{98});

$max_{3D}(v_{ij}/v_{ij}^{98})$: *max* of gliding 3-day time window;

pop_{ij}: proxy for insured property values

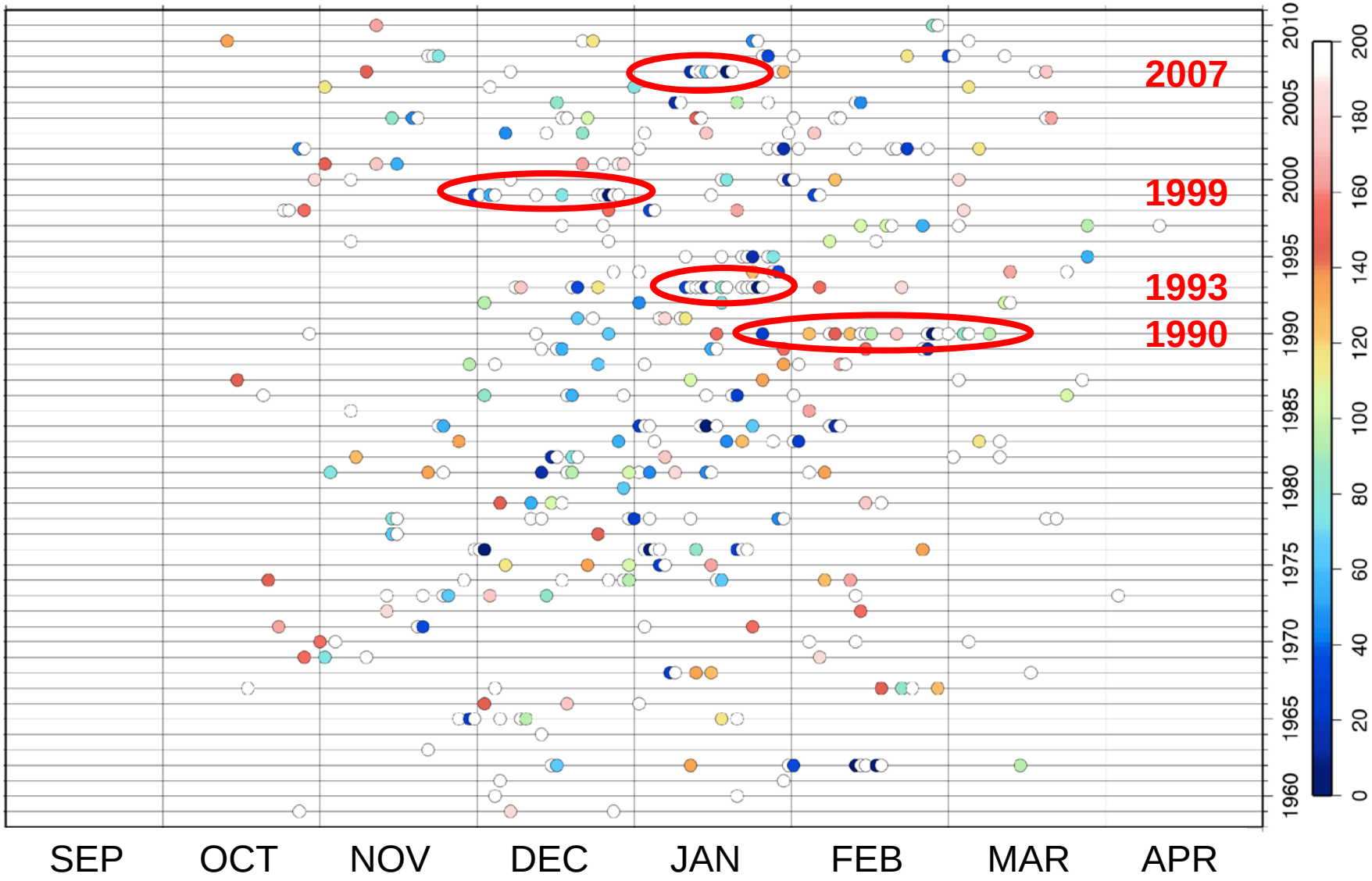


Estimation of Return Periods (RP)

Comparison of empirical estimates (eRP) with Negative Binominal distribution (nRP) and Poisson distribution (pRP)

Source: Klawa and Ulbrich (2003) NHESS; Pinto et al. (2012) Clim. Res.

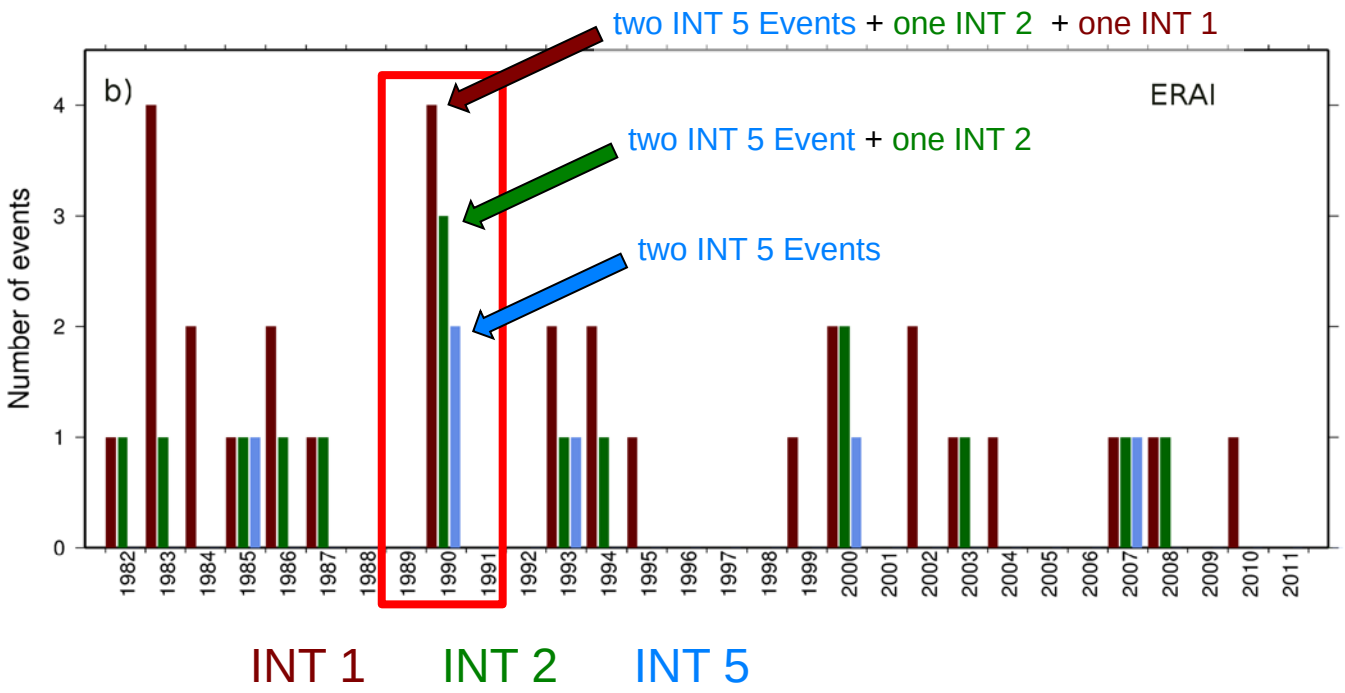
Serial clustering of windstorm related losses for Europe



Source: M.K. Karremann, PhD Thesis, adapted

Serial clustering windstorm losses

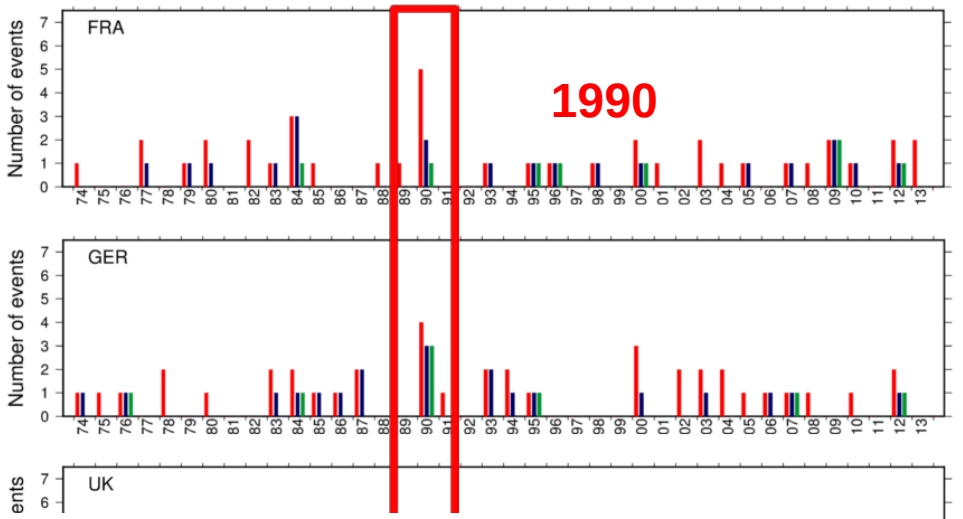
- Consider lists of top events for single countries (e.g. Germany)
- Series with 1-, 2-, 5-yearly loss intensity (INT)
- In 30 years of data: 30x INT 1; 15x INT 2; 6x INT 5
- Events separated per winter (1990: Oct 1989 - Mar 1990)

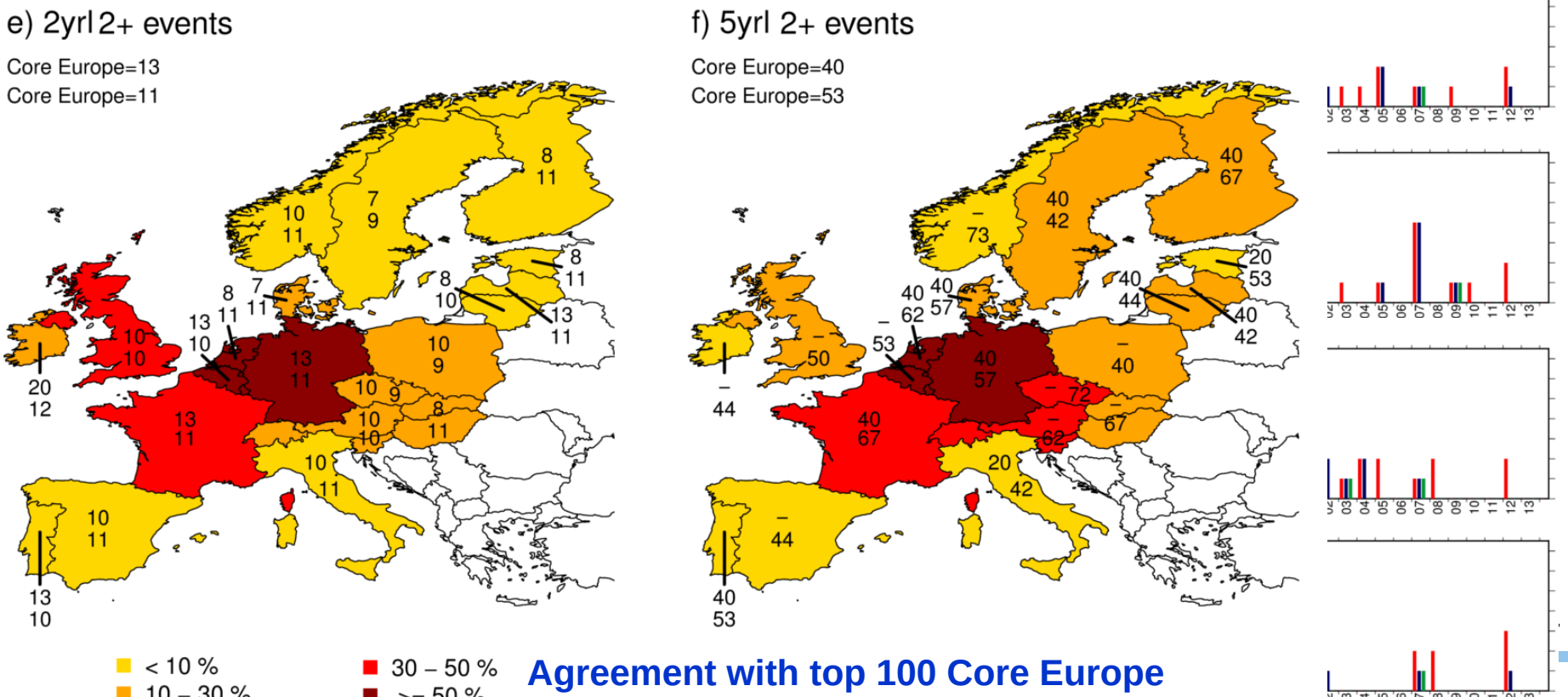


Rank	Date	INT
1	20070118	5
2	19841124	5
3	19900226	5
4	19991226	5
5	19900301	5
6	19930124	5
7	20021028	2
8	19991203	2
9	19830201	2
10	19811124	2
11	19861219	2
12	19900125	2
13	19860120	2
14	20080301	2
15	19940128	2
16	20020226	1
17	19930114	1
18	19851206	1
19	19840115	1
20	19821216	1
21	20100228	1
22	19931209	1
23	19950123	1
24	20040321	1
25	19981028	1
26	19830118	1
27	19830104	1
28	19900208	1
29	19840113	1
30	20020129	1

Return Periods of storm series

- Comparison of storm series e.g. 1989/1990
- Comparison of RP of storm series e.g. NCEP vs GCM (2+ events)





Agreement with top 100 Core Europe

Estimates of return periods based on different distributions

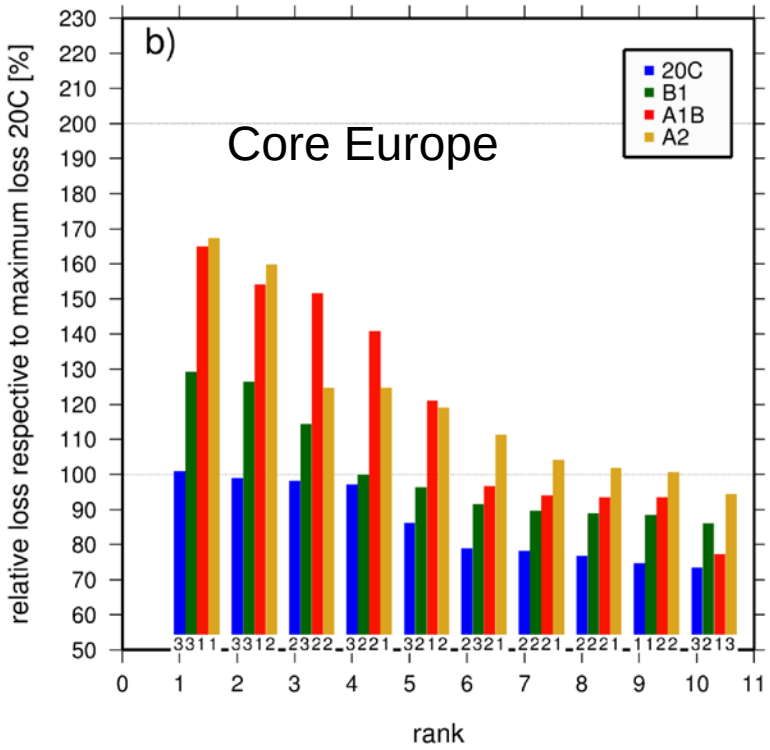
Example: return period of storm series of INT 2 events, Germany

Events per year		NCEP (30 Y)	GCM (4092 Y)	NCEP (30 Y)	GCM (4092 Y)
	pRP	eRP	eRP	nRP	nRP
0	1.65	1.58	1.54	1.58±0.09	1.57±0.03
1	3.3	3.75	4.07	3.78±0.22	3.81±0.07
2	13	15	13	13±2.25	13±0.7
3	**79**	**30**	**51**	**52±15**	**51±5**
4	633	-	-	229±93	221±28

- Poisson (pRP) overestimates empirical RP (eRP), Negative Binomial estimate (nRP) much closer to empirical
- GCM estimates similar to NCEP, but much smaller uncertainties

Climate change signal: top losses

Increase on average potential losses, larger top losses, larger internannual variability



ECHAM5 GCM; Periods: 1960-2000 vs 2060-2100
Core Europe: UK, Ireland, Netherlands, Belgium, Germany, Denmark, France

Two possibilities:

- Fixed number of events for 20C and A1B (e.g. 40; 40)
- Fixed 20C LI, enabling different numbers for 20C and A1B, e.g. (40; 51)

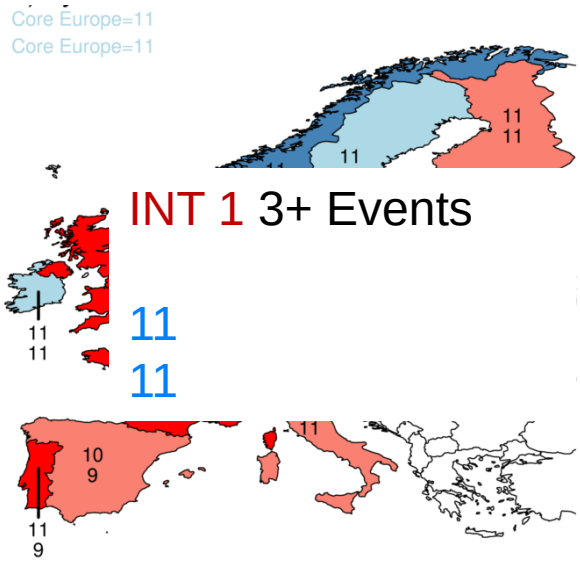
The latter permits the quantification of the combined effect of changes in clustering and changes in intensity

Source: Pinto et al. (2012) Clim. Res.

Climate change signal: fixed number of events

Selected return periods for storm series

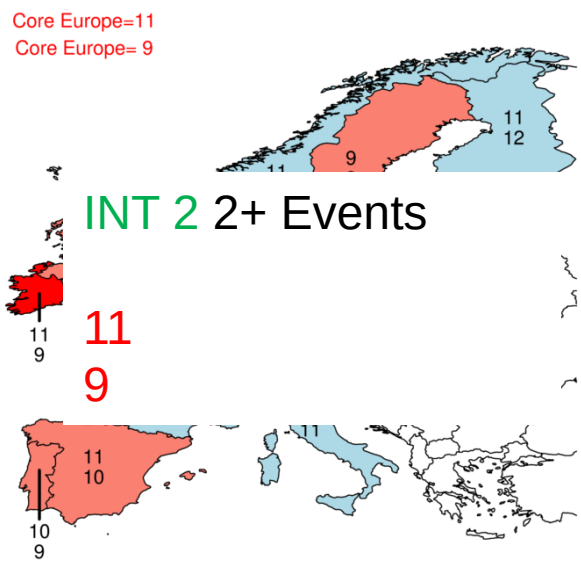
INT 1 3+ Event



INT 1 3+ Events

11
11

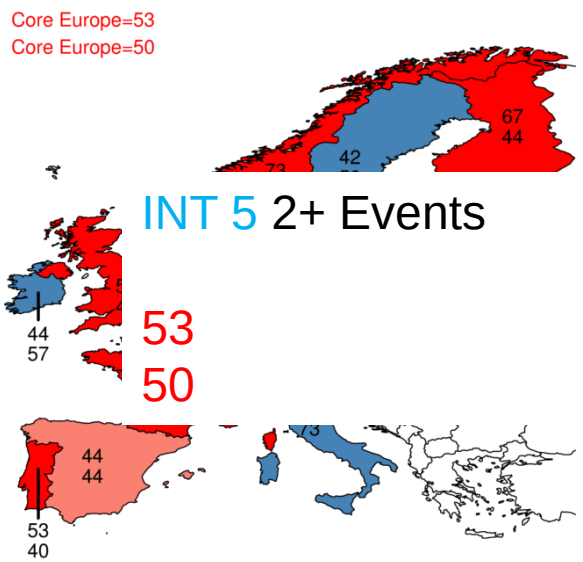
INT 2 2+ Events



INT 2 2+ Events

11
9

INT 5 2+ Events



INT 5 2+ Events

53
50

red: shorter return periods (light: less than one year)

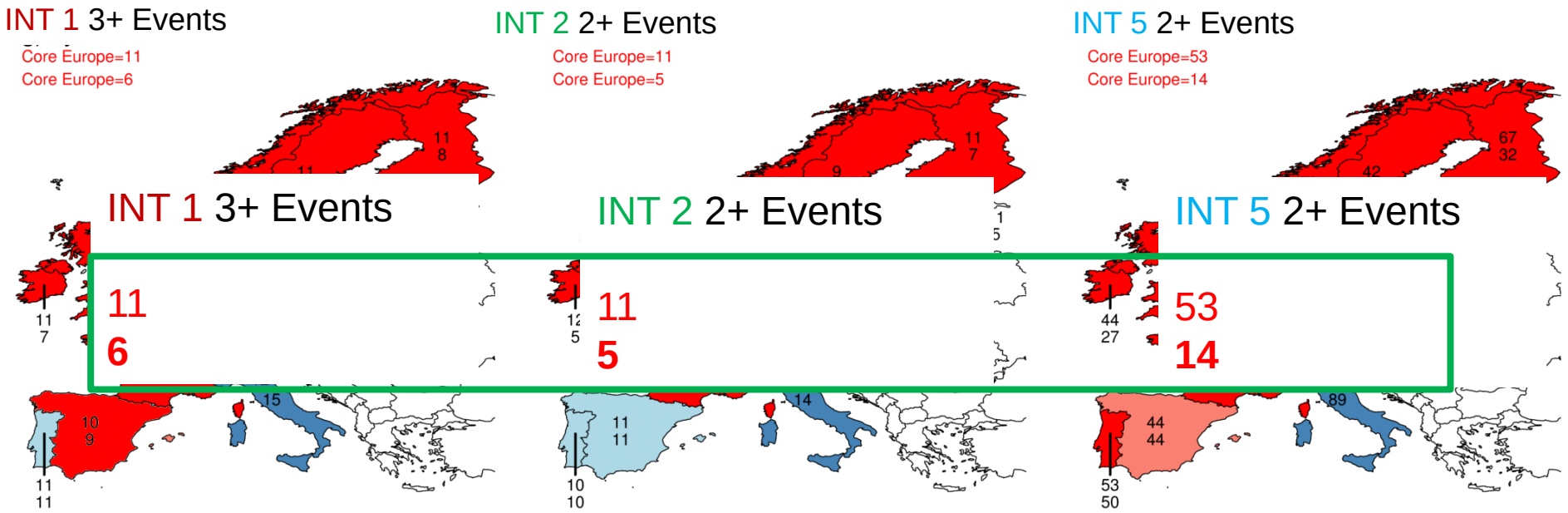
blue: longer return periods (light: less than one year)

upper value: RP 20C; lower value: RP A1B

Hardly any changes are statistically significant

Climate change signal: fixed 20C LI

Selected return periods for storm series



red: shorter return periods (light: less than one year)

blue: longer return periods (light: less than one year)

upper value: RP 20C; lower value: RP A1B

RP differences often outside the range of natural climate variability (505y control run)

Take-away messages

- Similar RP of windstorm losses associated with storm series based on NCEP and GCM for most countries and INTs. nRP closer to eRP than pRP
- Top events: More intense under future climate conditions for most of Europe
- Storm series: RP changes small and heterogeneous for fixed number of events. Very few changes statistical significant at 95% confidence level
- RP changes for fixed 20C LI clearly indicate shorter RPs for almost whole Europe (minus S. Europe), changes mostly beyond the range of natural climate variability
- This quantification of losses associated with storm series permits a more adequate windstorm risk assessment in a changing climate

Published as: **Karremann et al. (2014a) *Nat Hazards Earth Syst Sci*, 14, 2041-2052.**

Karremann et al. (2014b) *Environ Res Let*, 9, 124016.