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2. DO NOT DISCUSS COMPETITIVELY SENSITIVE MATTERS. Members should not discuss with each other competitively sensitive issues concerning products currently or that may be offered, such as pricing or premiums, underwriting or coverage terms and standards, loss experience, rate-related information, reserves, IBNR, volume of business, customers, or specific elements of profitability. If such information is not otherwise publicly available or properly disseminated by the ISCM itself, it should not be discussed.

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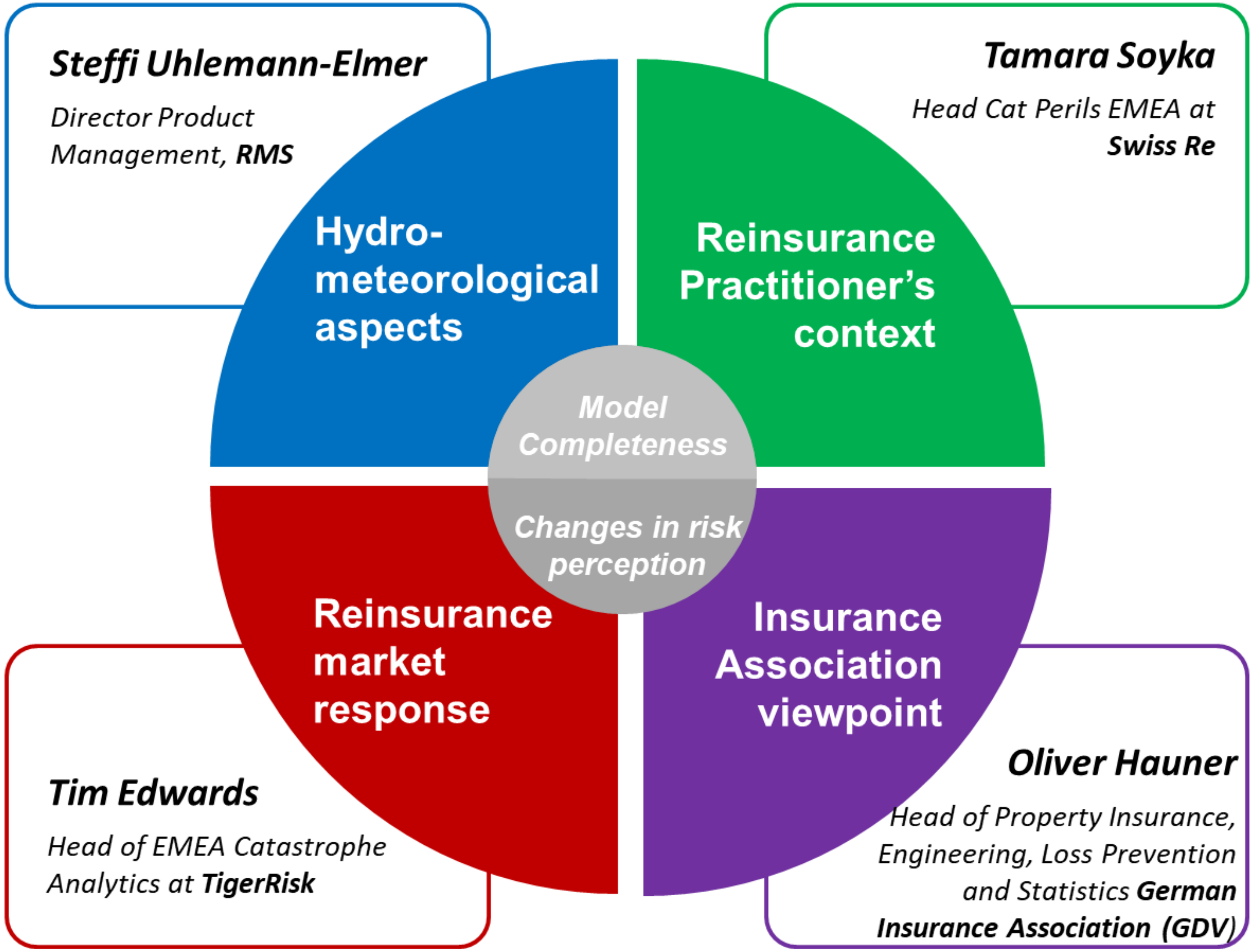
Lessons learnt from the July 2021 European ‘Bernd’ floods



ISCM
INTERNATIONAL SOCIETY OF CATASTROPHE MANAGERS

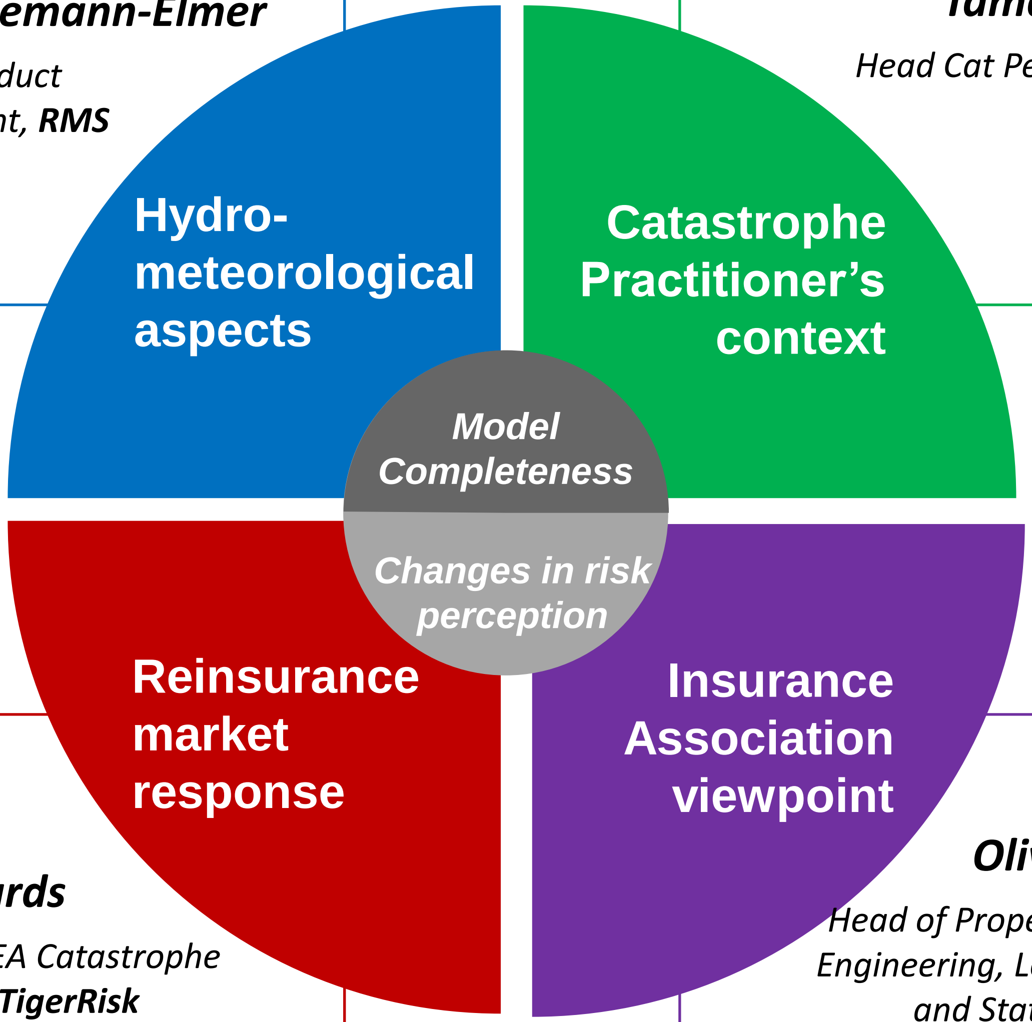
Lessons learnt from the July 2021 European ‘Bernd’ floods

Steffi Uhlemann-Elmer

*Director Product Management, **RMS***

Tamara Soyka

*Head Cat Perils EMEA at **Swiss Re***



Tim Edwards

*Head of EMEA Catastrophe Analytics at **TigerRisk***

Oliver Hauner

*Head of Property Insurance, Engineering, Loss Prevention and Statistics **German Insurance Association (GDV)***

RMS A Moody's Analytics Company

ISCM INTERNATIONAL SOCIETY OF CATASTROPHE MANAGERS

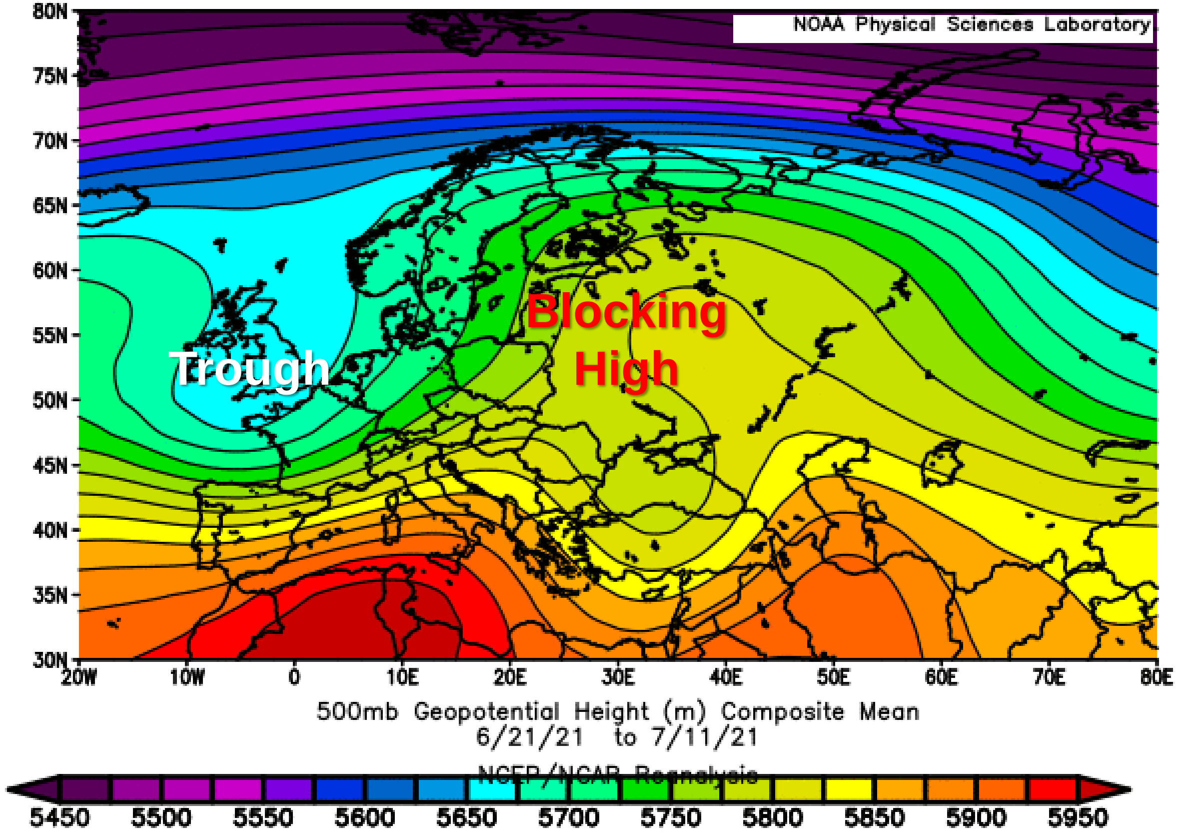
ISCM Lessons Learnt from European Flood 'Bernd'

Bernd Flood 2021: Hydrometeorological Overview

SUE | April 2022

The Season in review

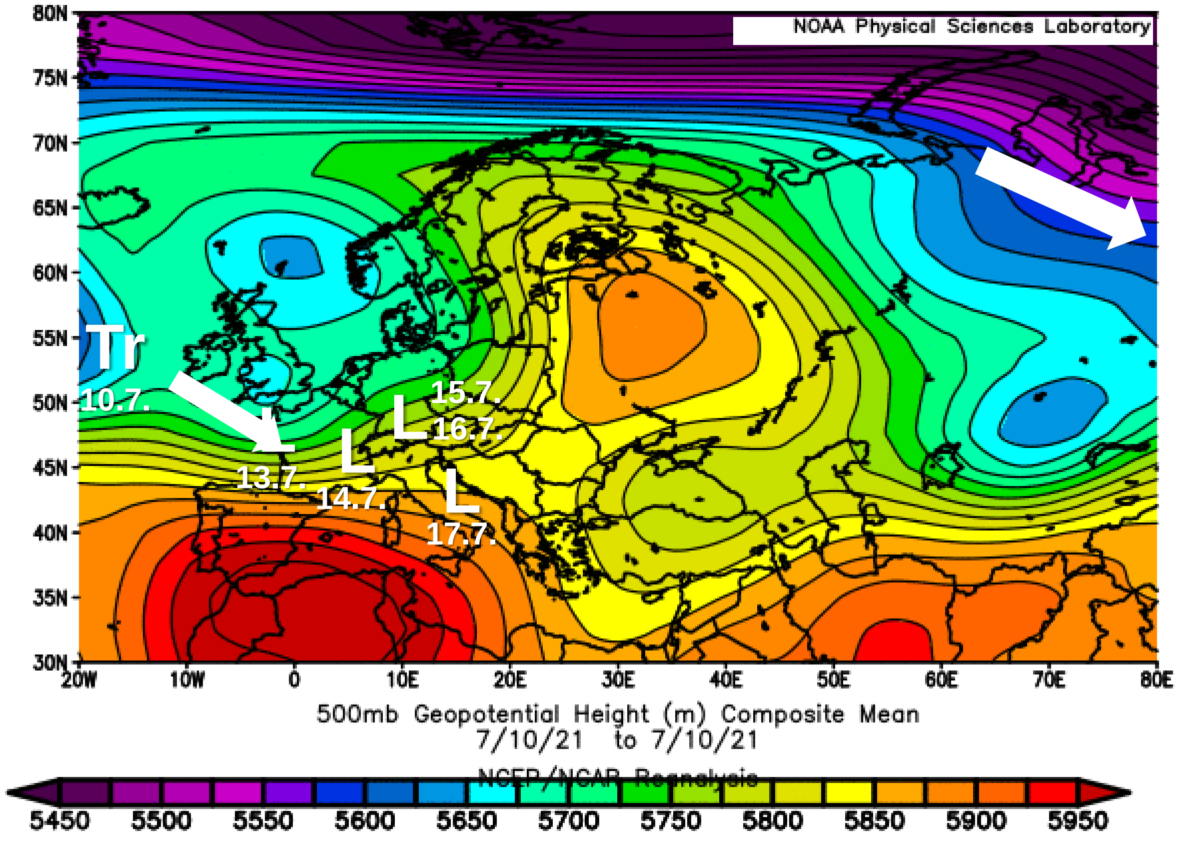
- **Mild winter** with above average precipitation, i.e. high snow accumulation in the Alps
- Cool and regionally **very wet spring** in West & Central Europe (CH: coldest since 30yrs, wettest May since 100yrs)
- Distinct change of synoptic scale weather since **mid June** with strongly meandering jet stream:
  - Trough over Western Europe
    - meteorologically well known as one of the strongest thunderstorm situations in CE
  - Blocking High over Western Russia and eastern Europe
    - high air pressure near the ground and hot weather all the way to Scandinavia
- the "pair" of the precipitation trough and the high-pressure area to the east remained more or less stationary for weeks
- **June characterised by a sequence of severe weather events, incl. hailstorms and tornadoes (F3 in CZ)**



Meteorologic Overview of Low “Bernd”

- Start of July distinct Trough forms south of Greenland and quickly moves southeast
- Cut-off area of low-pressure (named “Bernd”) remained stationary over western Europe for several days

10.7. – 19.7.



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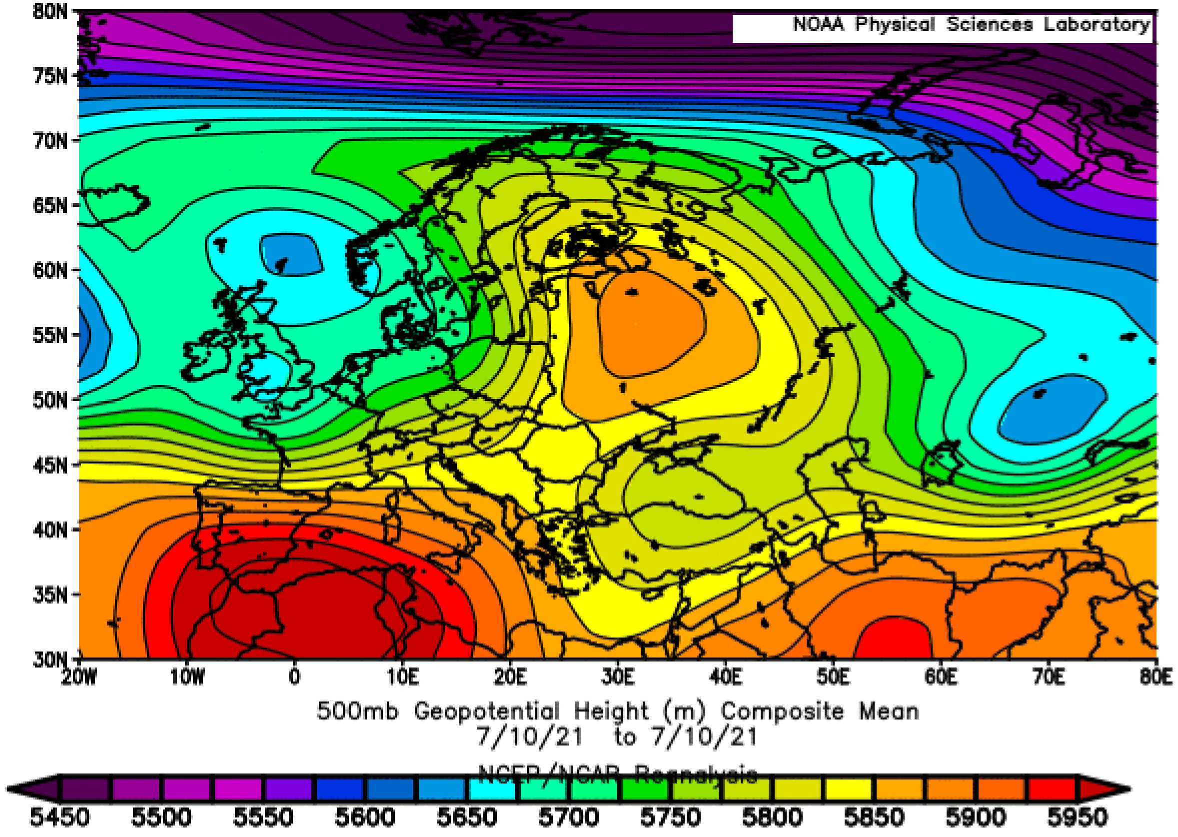
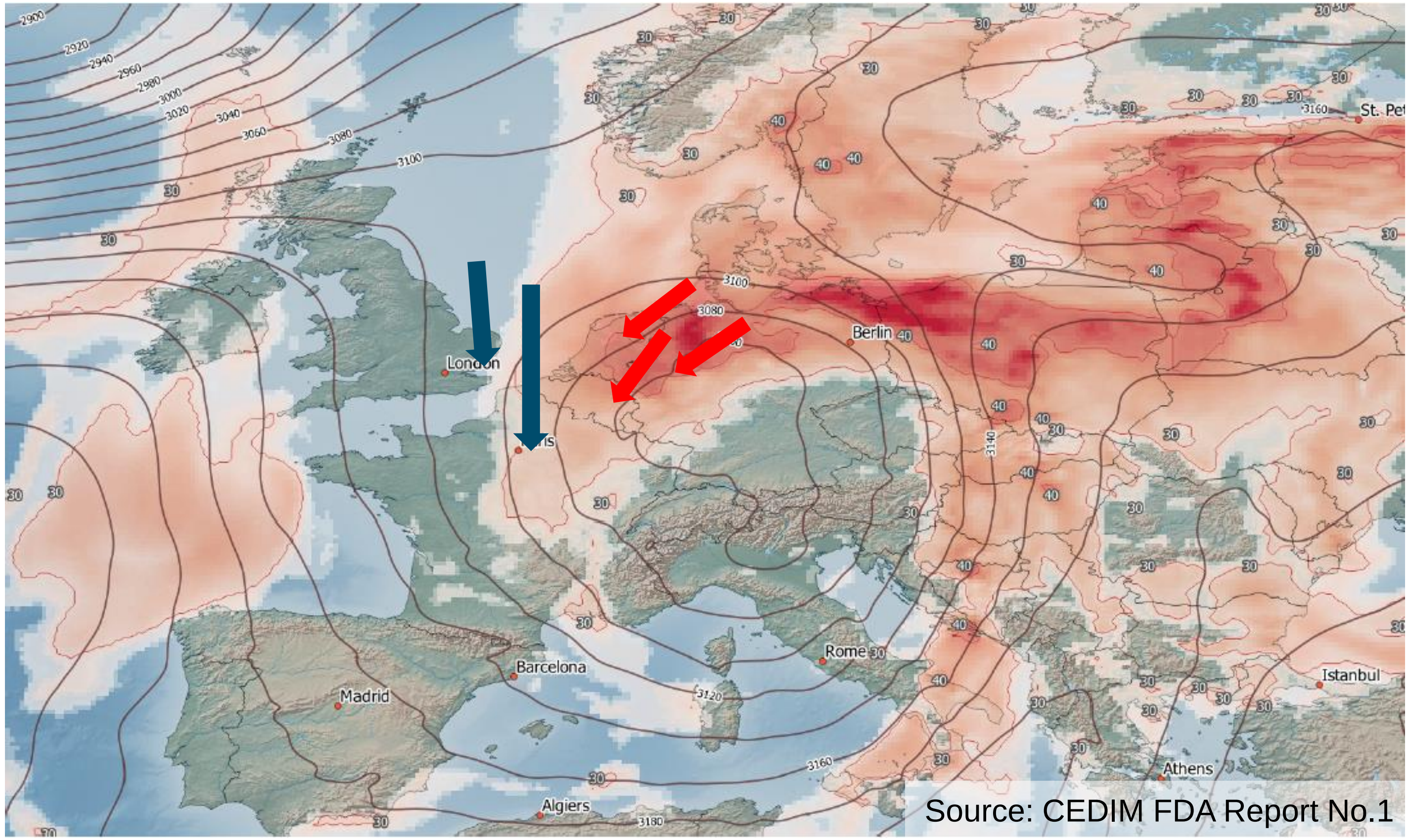


Meteorologic Overview

- Start of July distinct trough forms south of Greenland and quickly moves south east
- Cut-off area of low-pressure (named “Bernd”) remained stationary over western Europe for several days
- Counterclockwise rotation transporting moist air from the Mediterranean in a wide arc north
- This airmass interacted with the cooler airmass being drawn in from the north and produced intense and prolonged rainfall across Western and Central Europe (northeastern France, western Germany, eastern Belgium, the Netherlands, and Luxembourg)

Precipitable Water in the Atmosphere (14. July)



Source: CEDIM FDA Report No.1

Meteorologischer Überblick

- Start of July distinct trough forms south of Greenland and quickly moves south east
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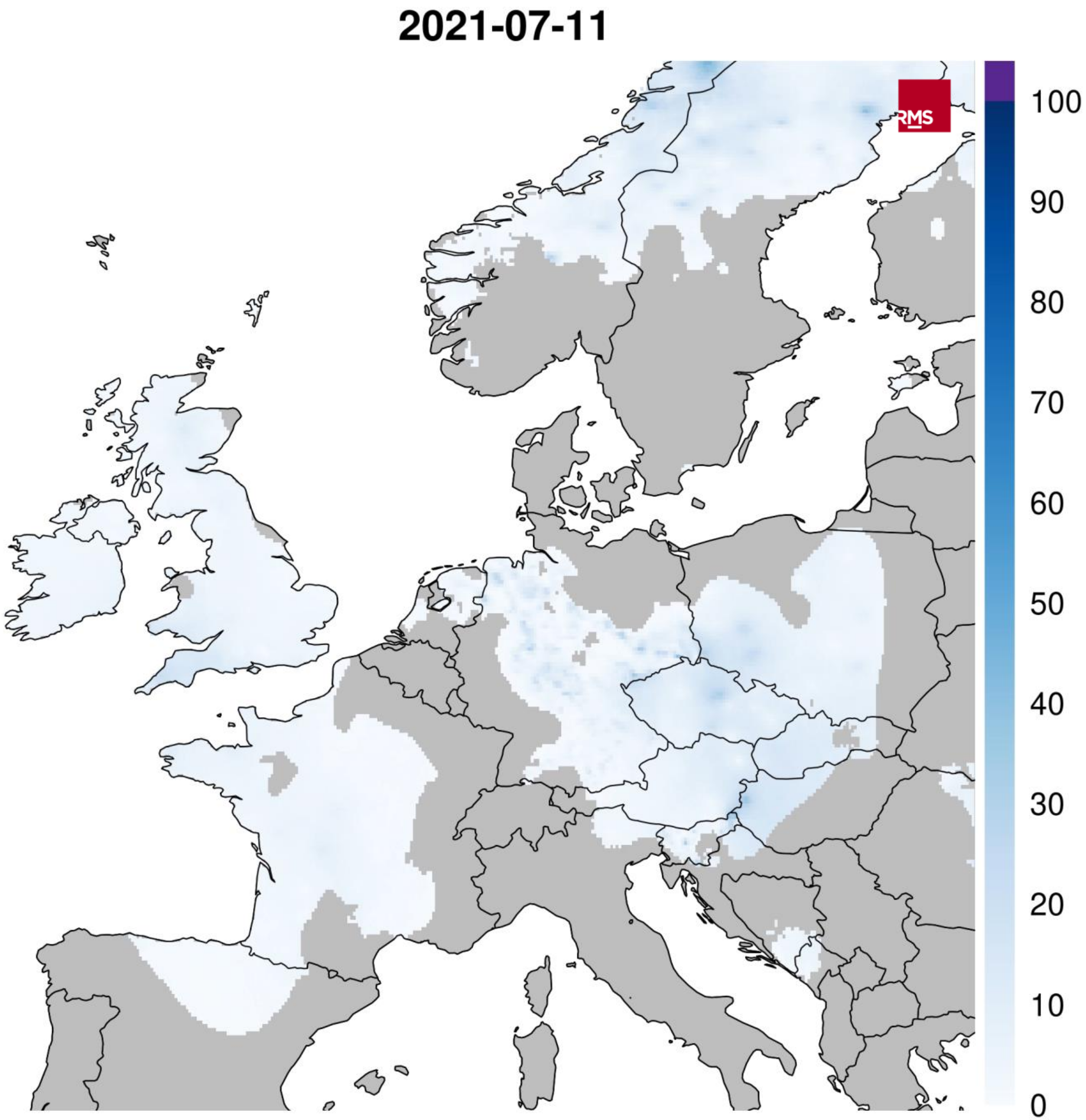


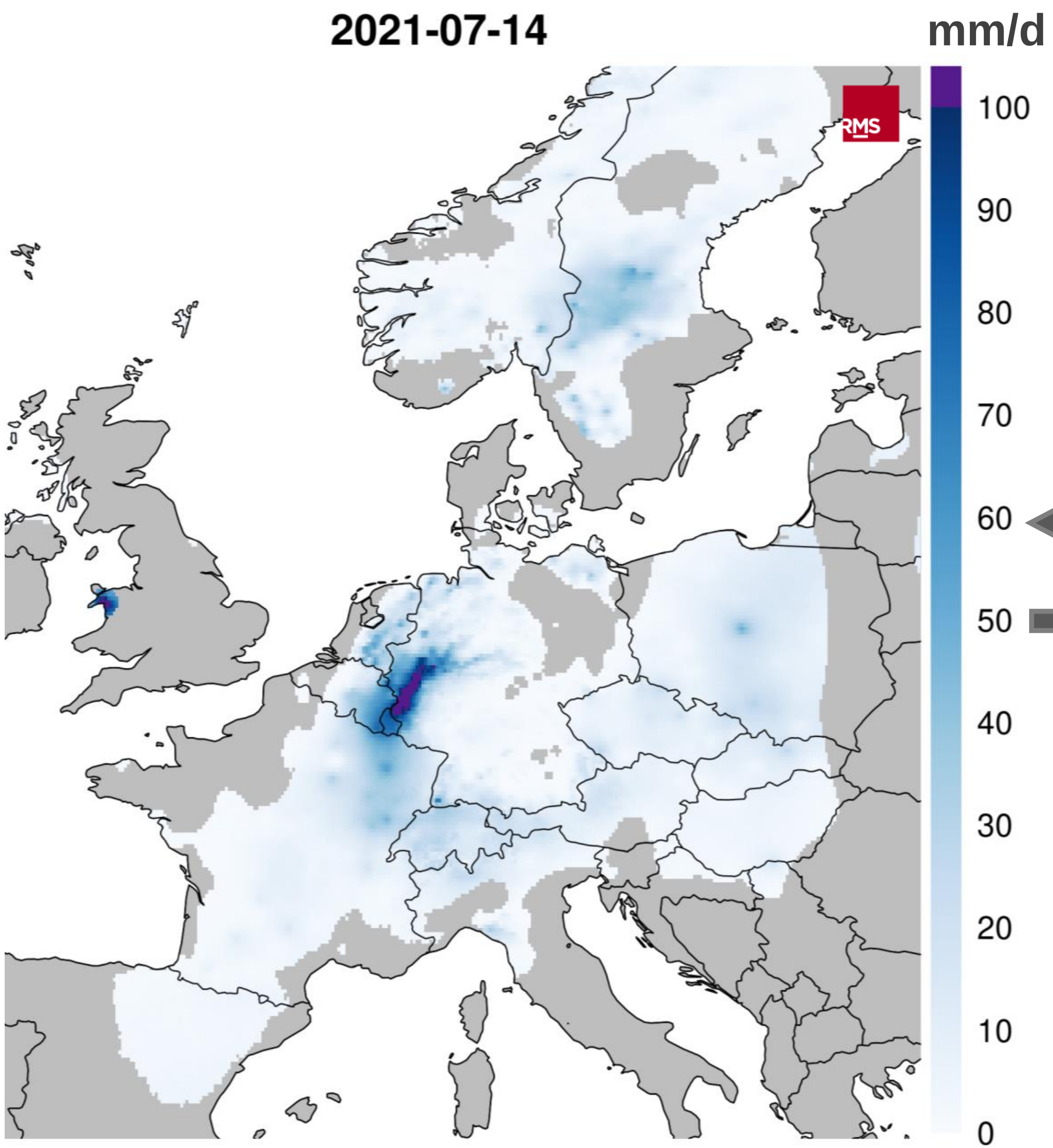
Data Source: EOBs daily, 0.1x0.1°

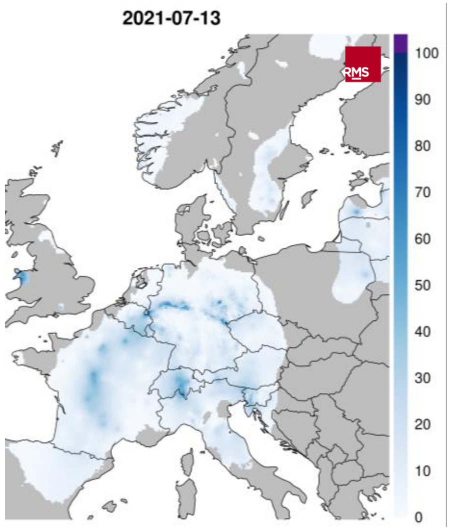
How much and when did it rain?

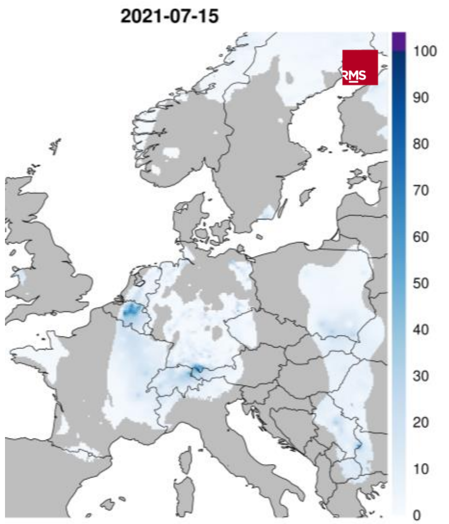
*Source: DWD**

	14. Juli (mm/Tag)	Monat Juli (Mittelwert)	Faktor
Kyll	145,7	73,1	**1,99**
Erft	169,1	67,9	**2,49**
Ahr	147,5	69,4	**2,13**
Rur	154,1	74,4	**2,07**
Mosel	145,7	71,6	**2,03**
Wupper	151,4	100,7	**1,50**

**T. Junghänel, et al. (2021) Hydro-klimatologische Einordnung der Stark- und Dauerniederschläge in Teilen Deutschlands im Zusammenhang mit dem Tiefdruckgebiet „Bernd" vom 12. bis 19. Juli 2021, DWD Geschäftsbereich Klima und Umwelt, https://www.dwd.de/DE/leistungen/besondereereignisse/niederschlag/20210721_bericht_starkniederschlaege_tief_bernd.pdf*

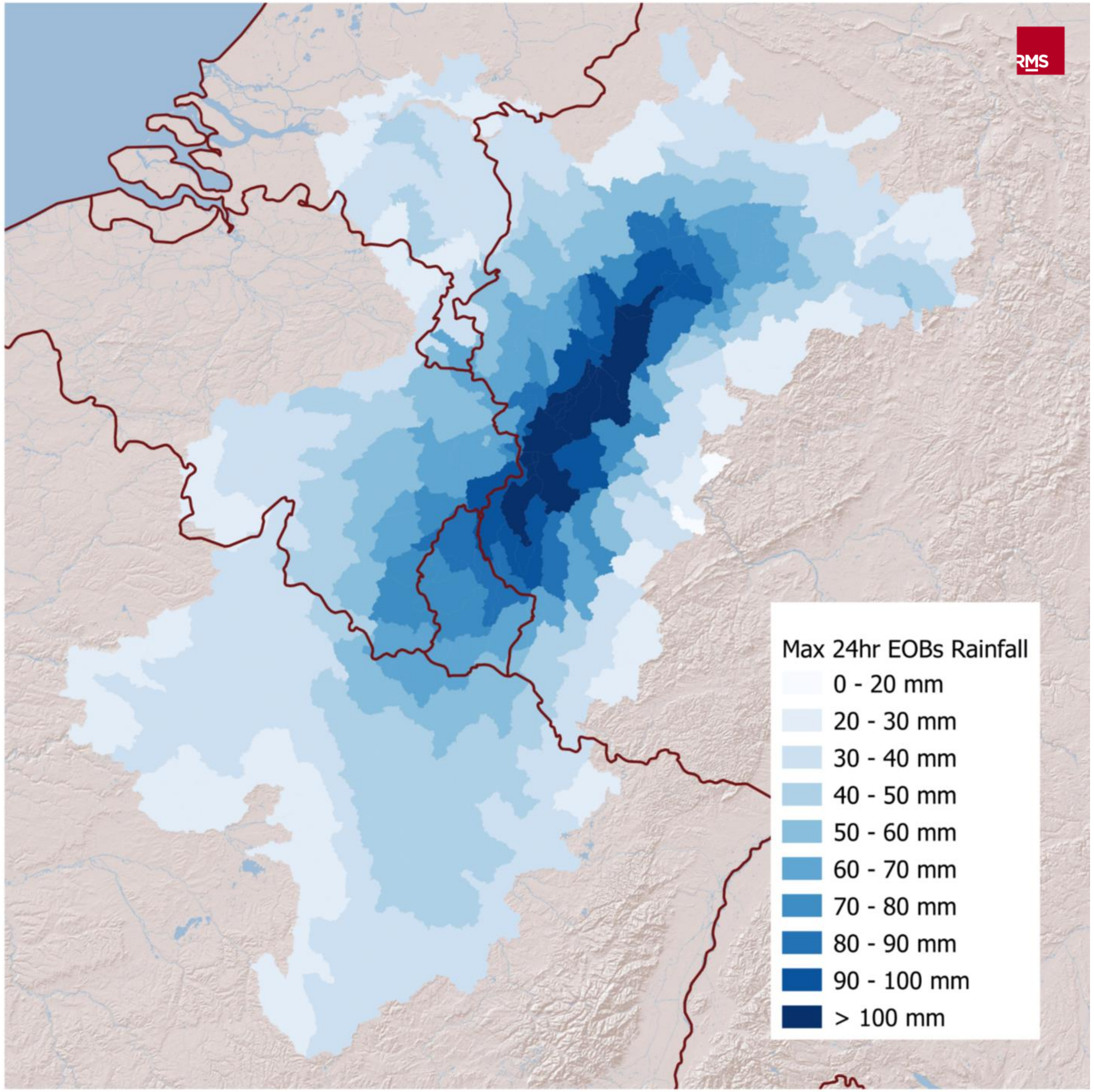






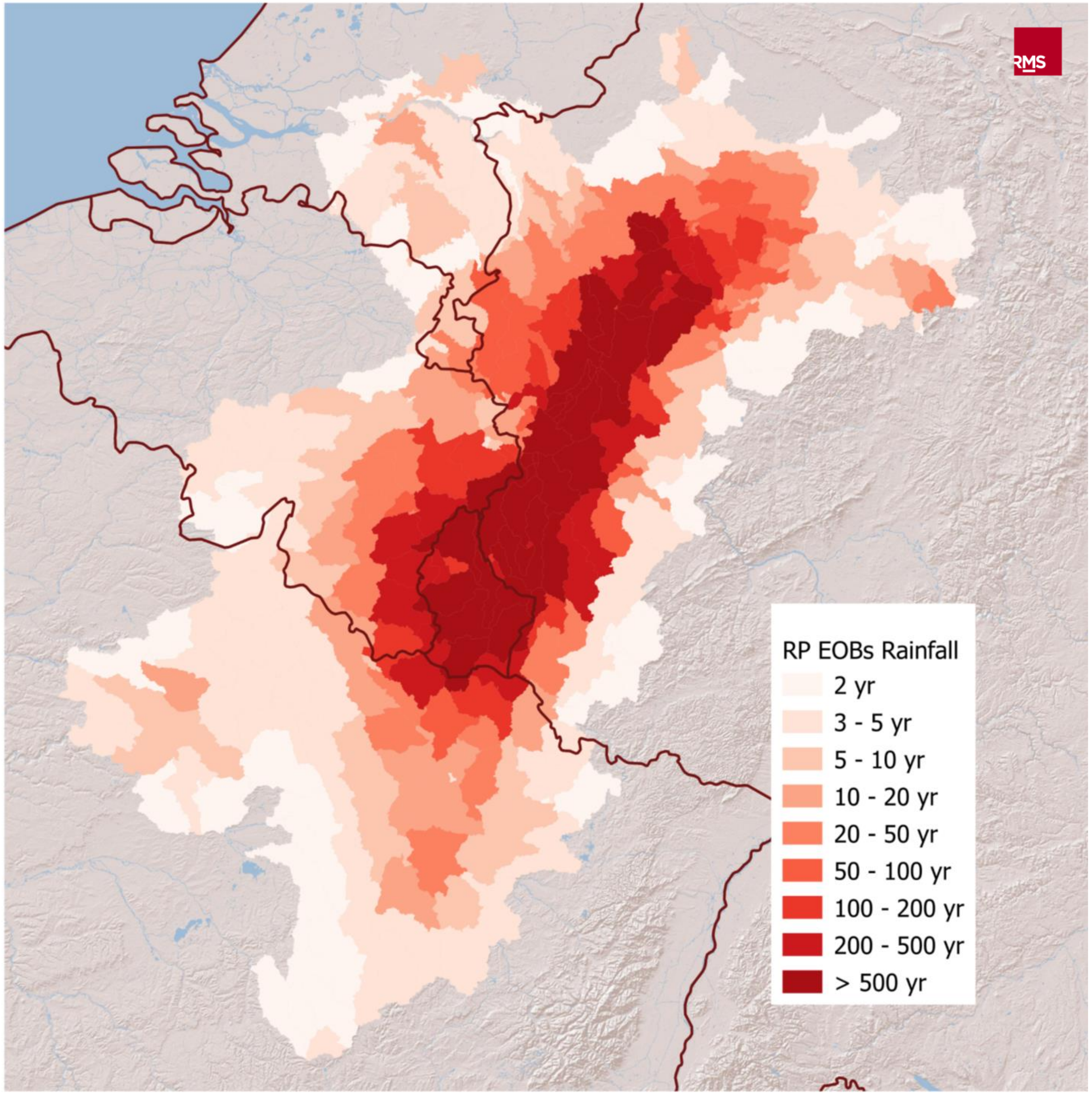
Catchment Precipitation

- E-OBS Precipitation sums aggregate at ***catchment level***
- Maximum daily precipitation between ***13. – 15. July***
- Used as input into RMS EUFL Model for event reconstruction



Catchment Precipitation Return Period

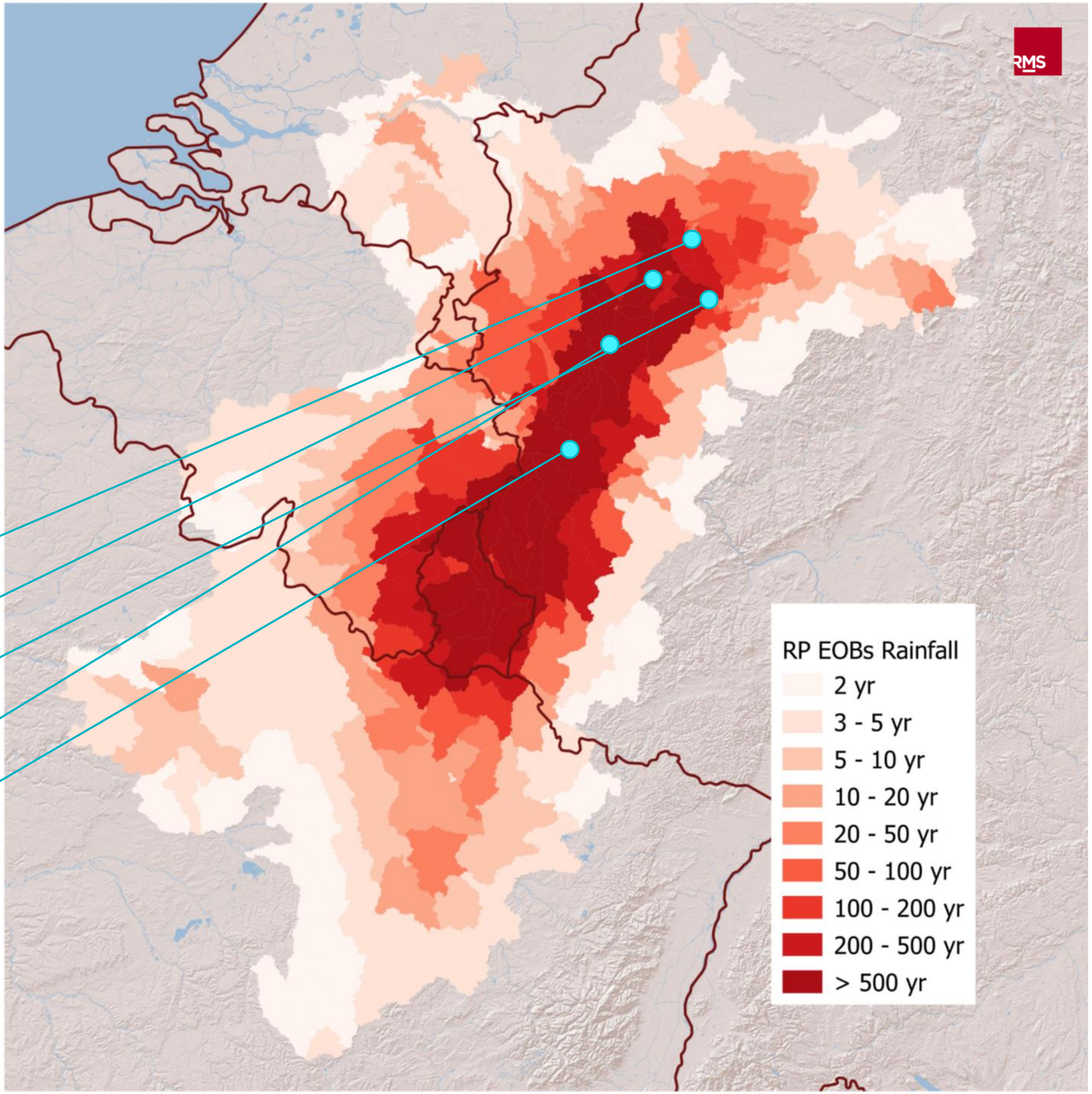
- Return period of catchment precipitation based on stochastic event catalogue of RMS HD Europe Inland Flood Model



Catchment Precipitation Return Period

- Return period of catchment precipitation based on stochastic event catalogue of RMS HD Europe Inland Flood Model
- ***Empirical RP estimate*** according to DWD*

Precipitation intensity (duration)	Empirical RP [a]	Station
241,3 *mm* (22 *h*)	**> 100 a**	**Hagen**
151,0 *mm* (24 *h*)	**> 100 a**	**Wuppertal**
162,4 *mm* (24 *h*)	**> 100 a**	**Wipperfurth**
159,8 *mm* (24 *h*)	**> 100 a**	**Köln**
129,3 *mm* (24 *h*)	**> 100 a**	**Dahlem**



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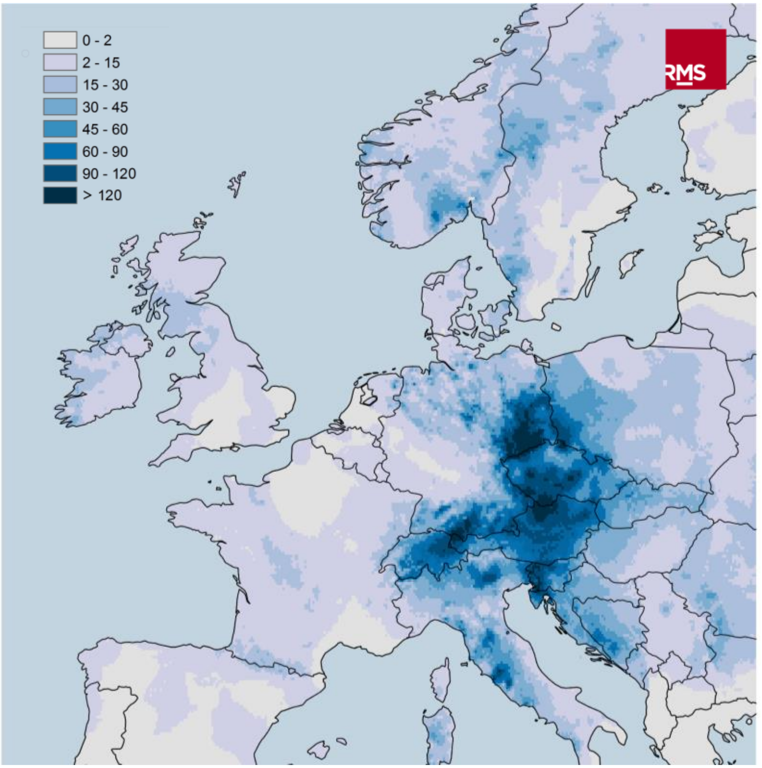
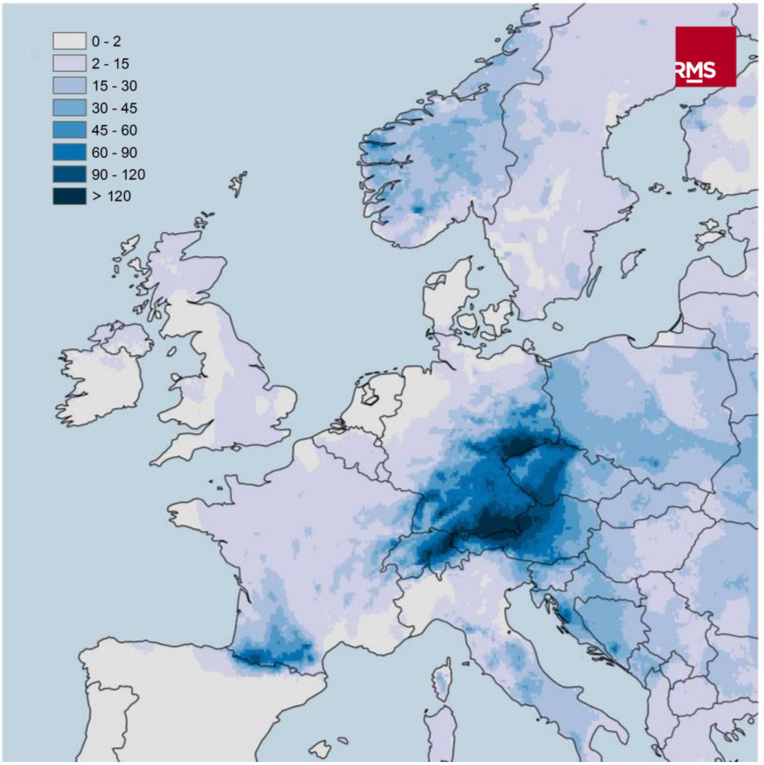
Bernd in perspective:
4day precipitation totals for 2002, 2013, and 2021 floods

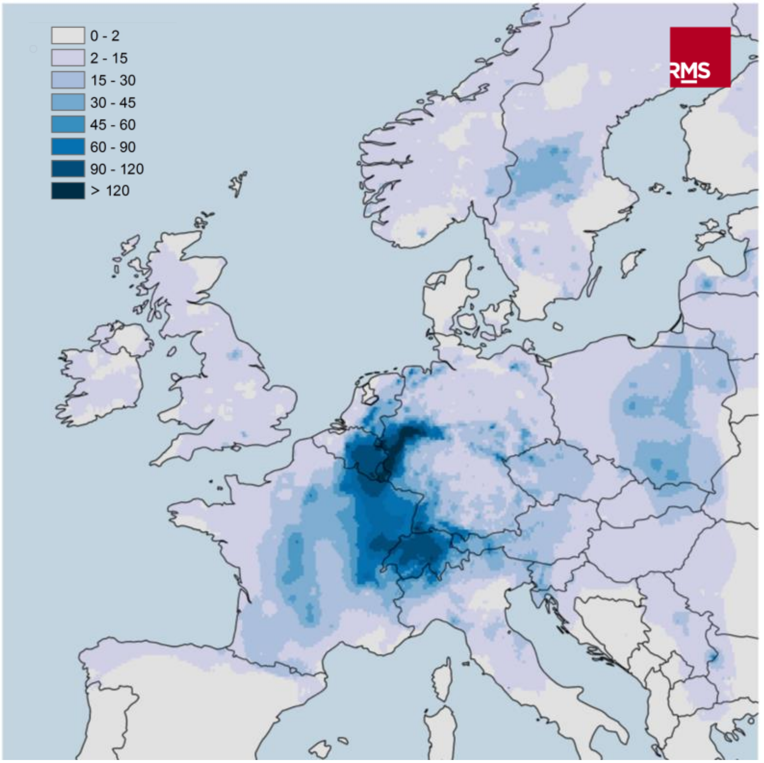
10.-13. August 2002



30. May – 2. June 2013

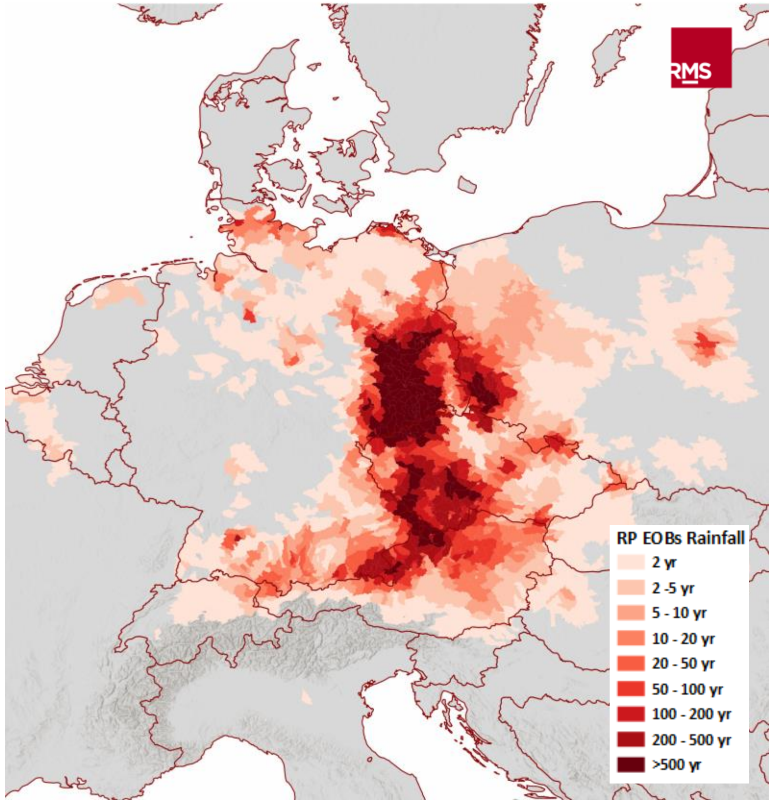


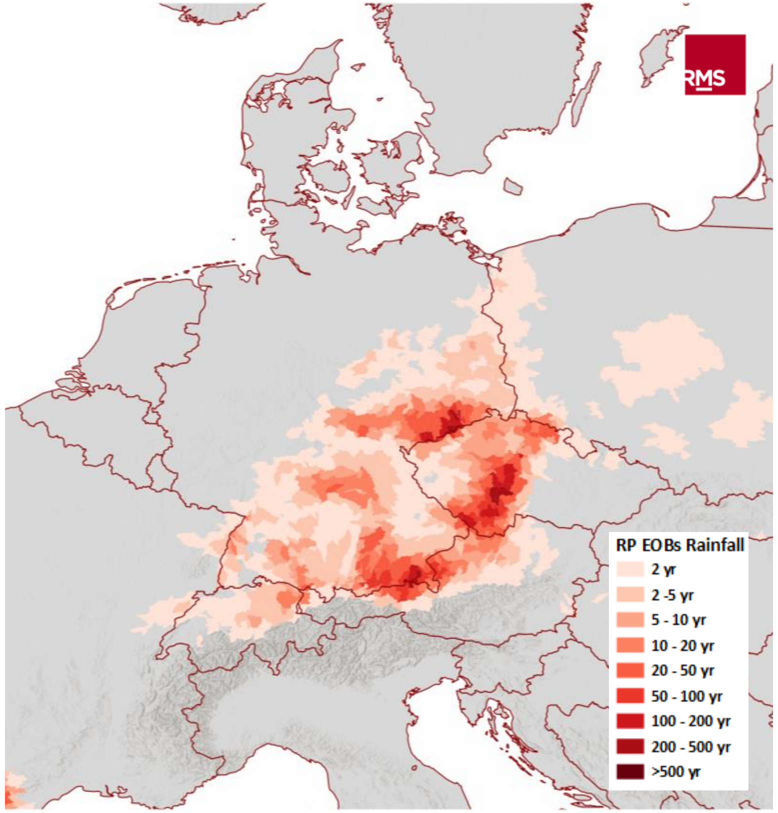
12. – 15.July 2021

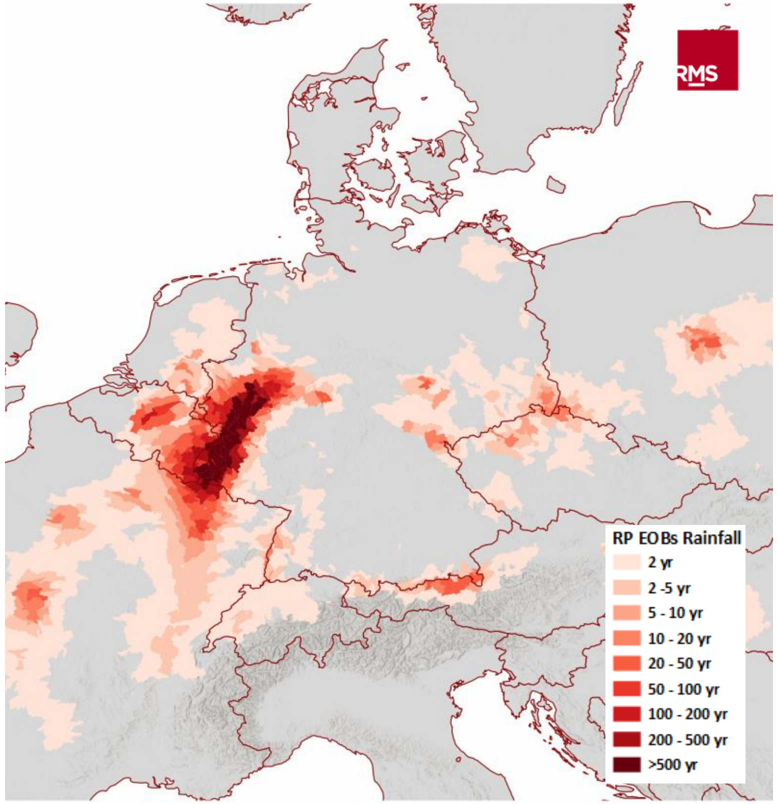


Bernd in perspective:
24h max precipitation RPs for 2002, 2013, and 2021 floods

10.-13. August 2002	30. May – 2. June 2013	12. – 15.July 2021

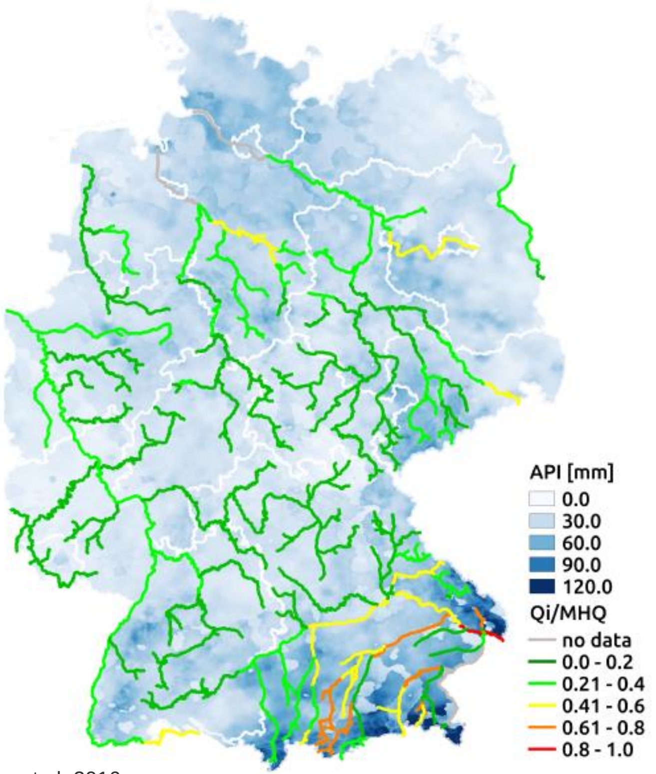






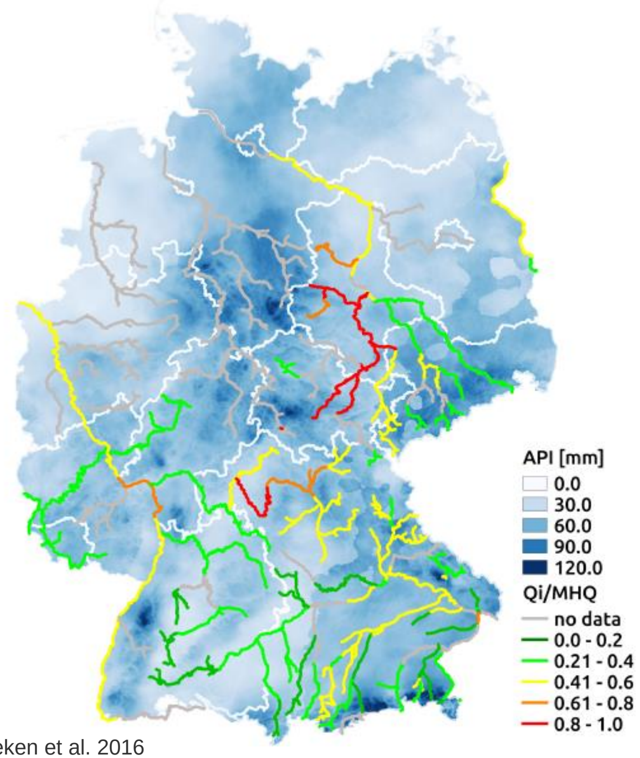
Bernd in perspective:
Antecedent conditions for 2002, 2013, and 2021 floods

August 2002



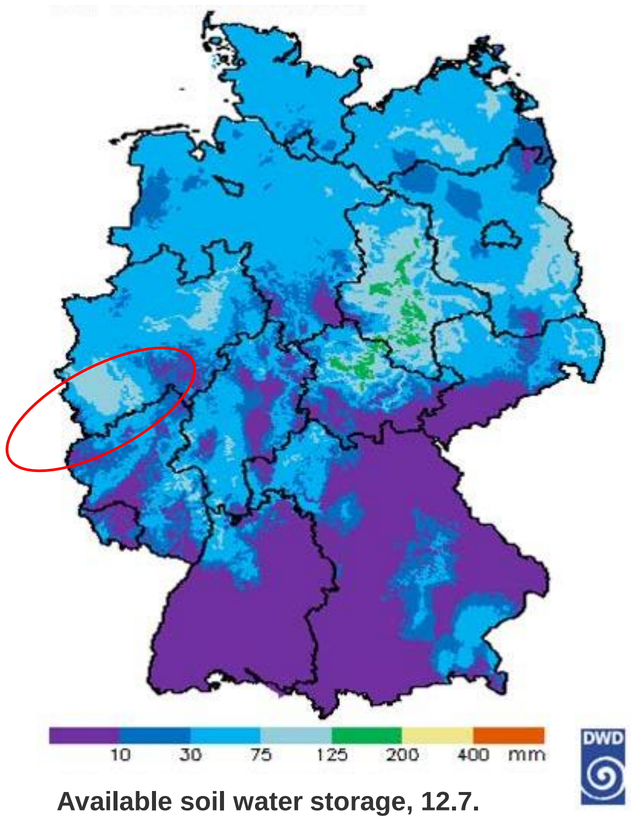
Thieken et al. 2016

June 2013



Thieken et al. 2016

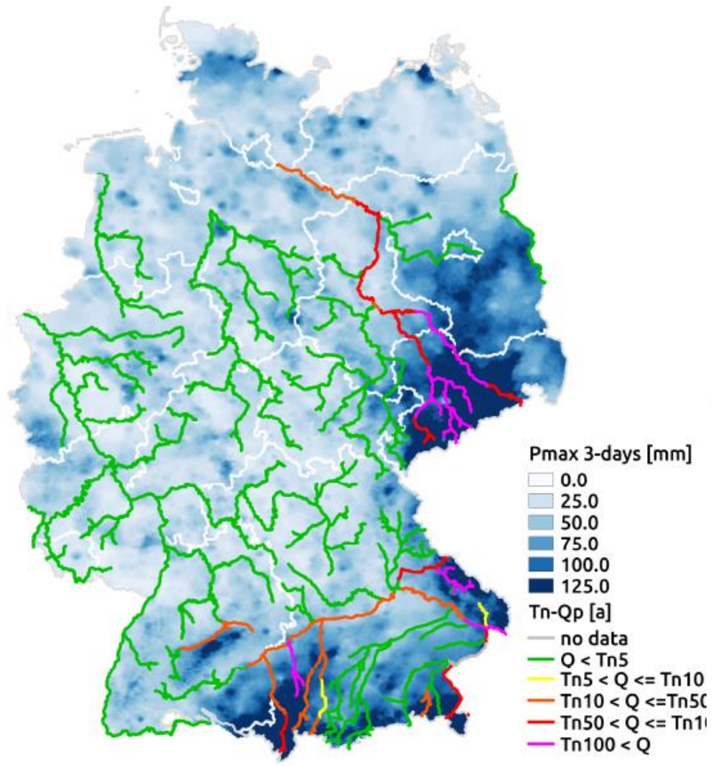
July 2021



Available soil water storage, 12.7.

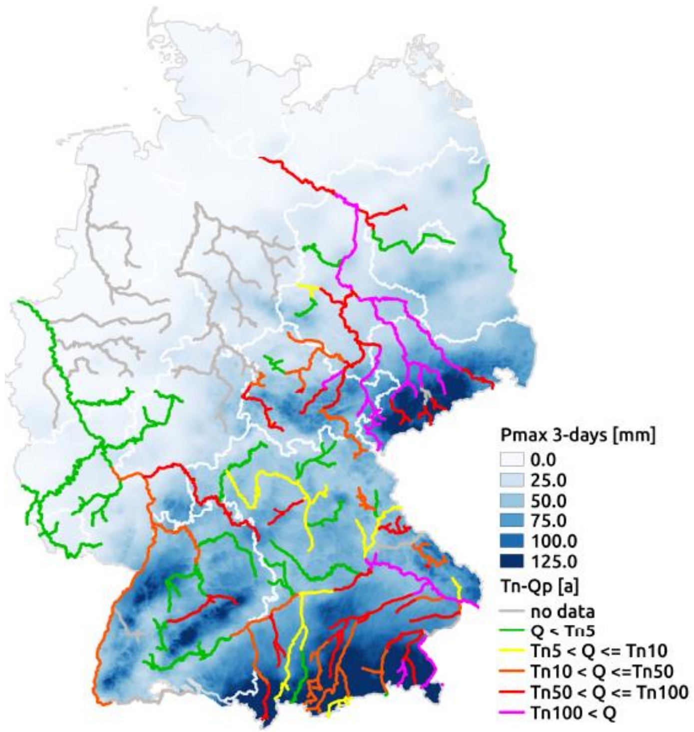
Bernd in perspective:
Peak discharge for 2002, 2013, and 2021 floods

August 2002



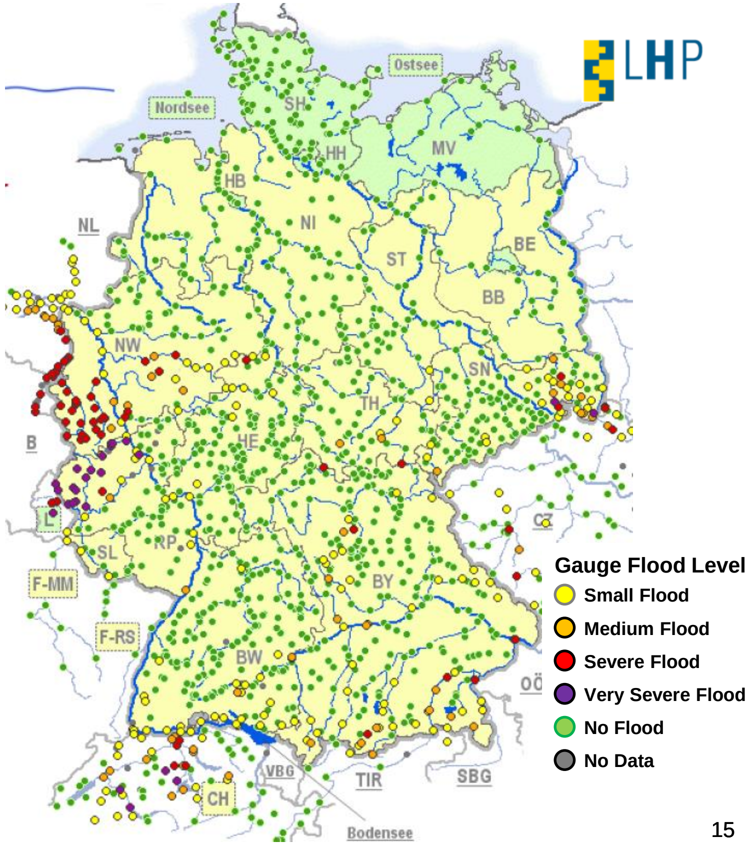
Thieken et al. 2016

June 2013

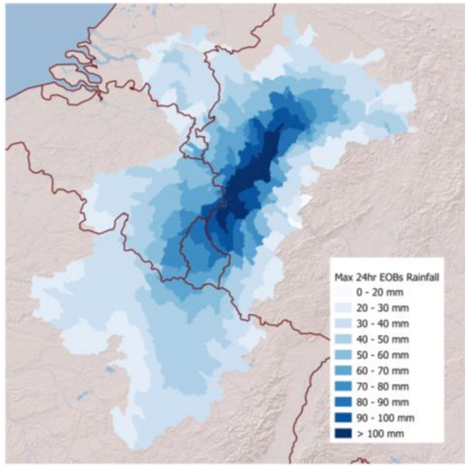


Thieken et al. 2016

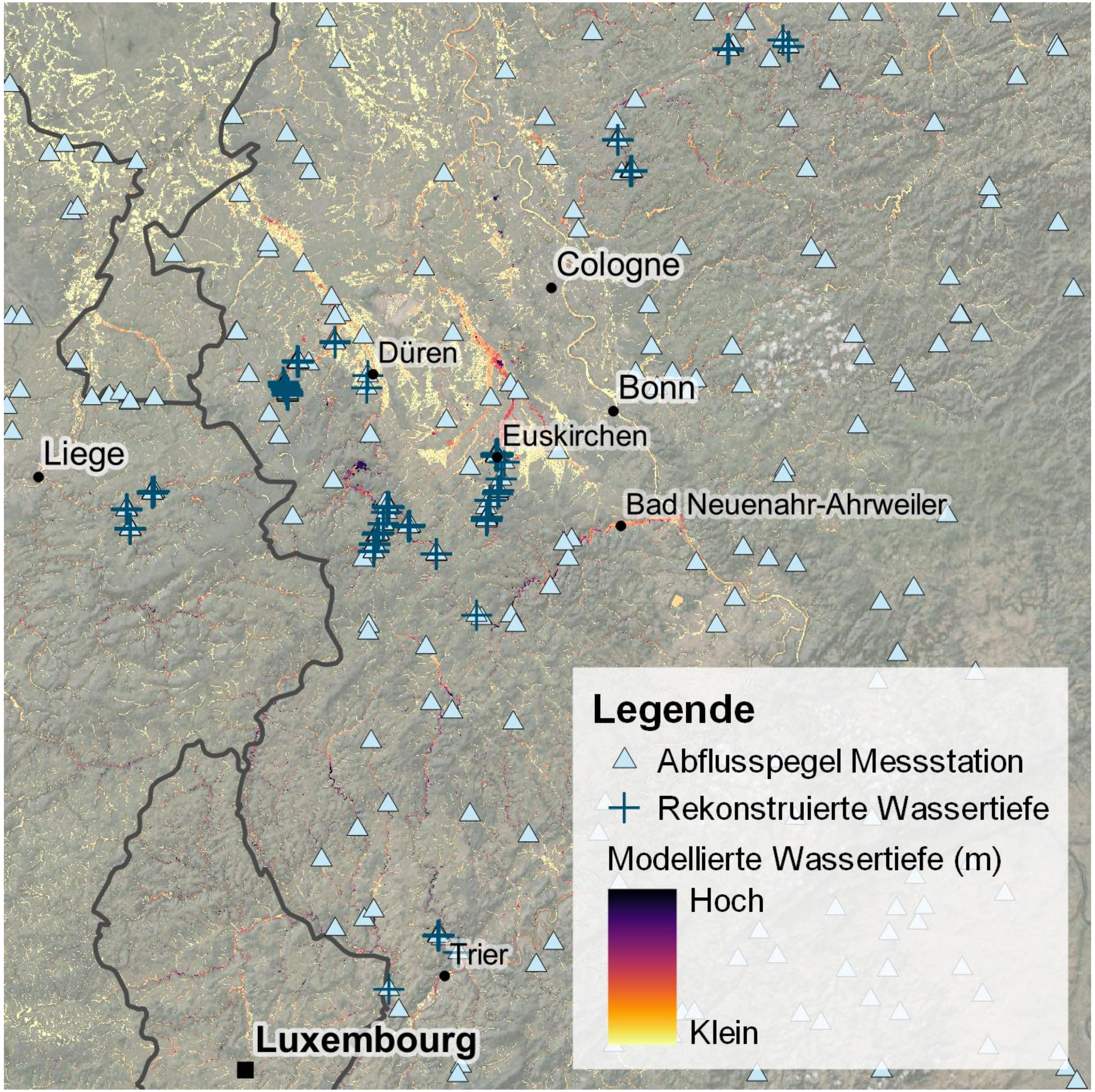
July 2021



Event Footprint Reconstruction



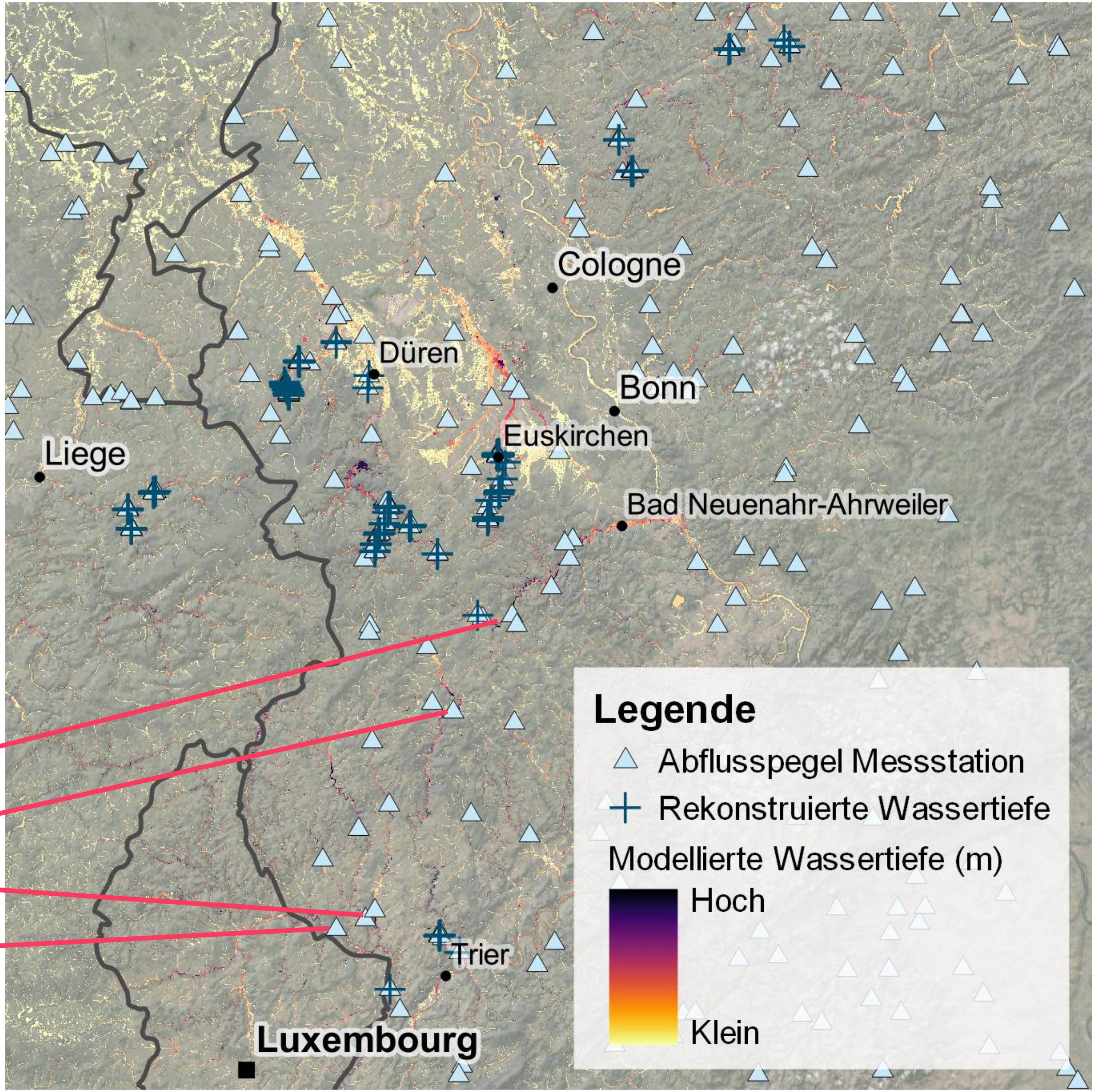
- Precipitation based reconstructed footprint of July 2021 Floods
- Water level records of 700 river gauges (predom smaller and medium sized rivers)
- Collection of water depth measurements during reconnaisance trip at appr. 200 locations



River Discharge Return Period

- Event peak discharges 2021 exceeding previous records in many cases
- Kyll, Ahr HQ100 exceeded by a factor of 2 to 2.4, Erft at 1.6 *
- **Table:** Return period of matching gauges based on stochastic event catalogue of RMS HD Europe Inland Flood Model

Peak Discharge	Mapped RP [a]	River
164 m³/s	**> 500 a**	**Ahr**
151 m³/s	**175 a**	**Kyll**
275 m³/s	**175 a**	**Prüm**
800 m³/s	**250 a**	**Our**



**Schäfer, A., et al., Center for Disaster Management and Risk Reduction Technology, 2021: Hochwas-ser Mitteleuropa, Juli 2021 (Deutschland). 21.Juli 2021 – Bericht Nr. 1*
https://www.cedim.kit.edu/download/FDA_HochwasserJuli2021_Bericht1.pdf

Event Summary

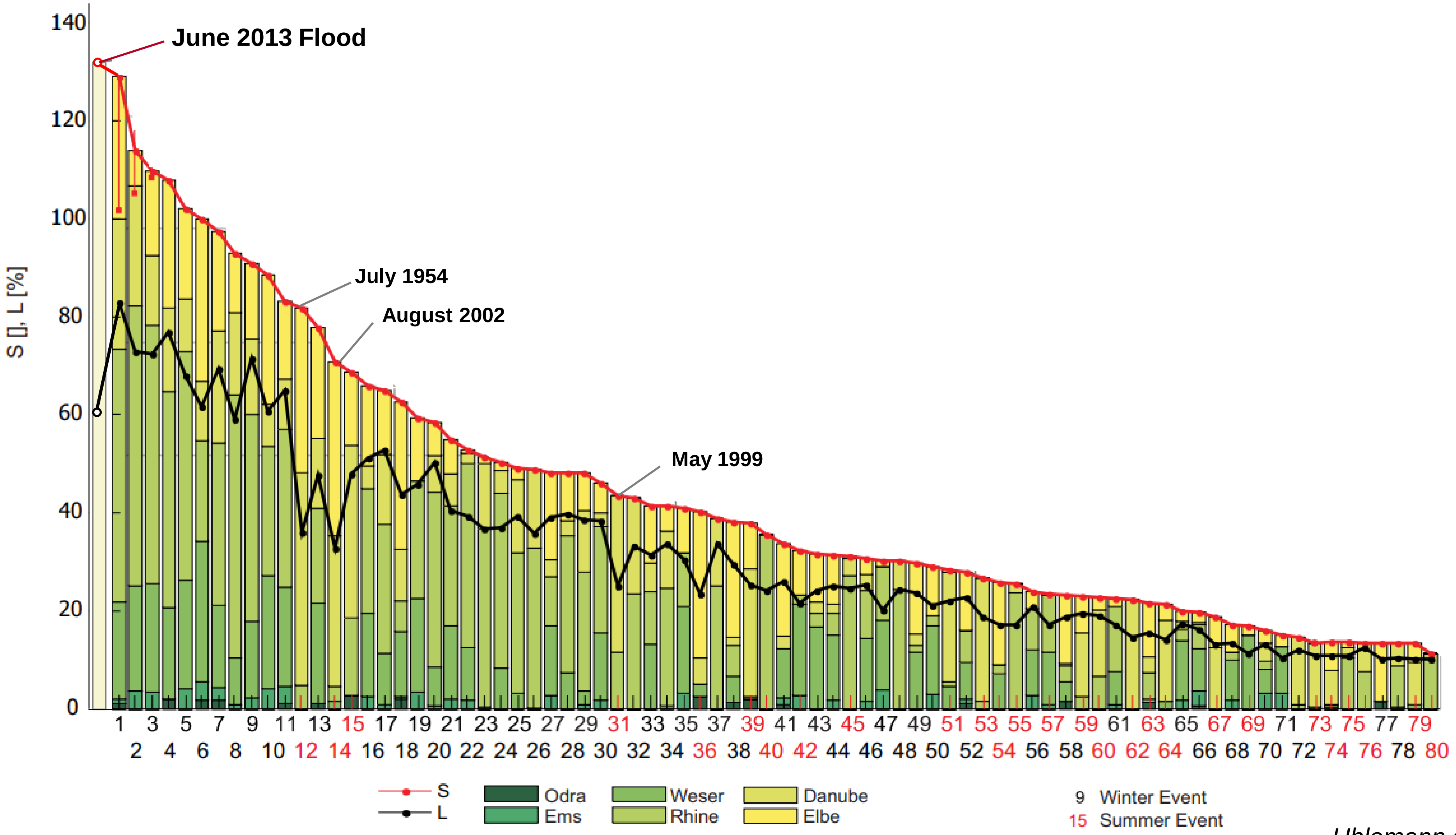
- The July Floods in Central Europe were caused by widespread intense and prolonged, locally extreme rainfall
  - Rainfall events of this magnitude are rare, but not unlikely
- Flooding caused strong surface water flooding and flood waves in smaller rivers, i.e. tributaries to the Rhine and Meuse (No flood wave in the Rhine!)
- The flood event has affected a relatively densely populated region with a high value concentration
- Majority of the worst affected rivers with no recent flood history
  - Authority maps did not account for historic floods of 1804 and 1910
  - Very limited structural flood defense in place, design levels of infrastructure exceeded
  - Crisis response not trained; warning chains failed
- Highest death toll from river flooding in Europe since 1970

Event Summary and Key Findings

- Event characterized by numerous loss amplifying factors
  - Inundation depths very relatively deep
  - High flow velocity, high debris load, undercutting and damage to the foundations occurred
  - Short warning times or lack of response to warning increased the damage
  - Widely used oil heating systems increased risk of contamination
  - Destroyed roads, bridges and infrastructure, as well as the large volume of repairs have slowed damage recovery and are the reason for long business interruption (BI) and post-event loss amplification (PLA)
  - Very high demand surge compounded by covid induced (global) cost inflation and regional labor shortage

Appendix

A consistent set of trans-basin floods in Germany between 1952–2002



Uhlemann et al., 2010; Merz et al. 2014

A consistent set of trans-basin floods in Germany between 1952–2002

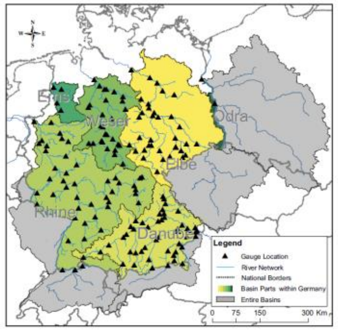
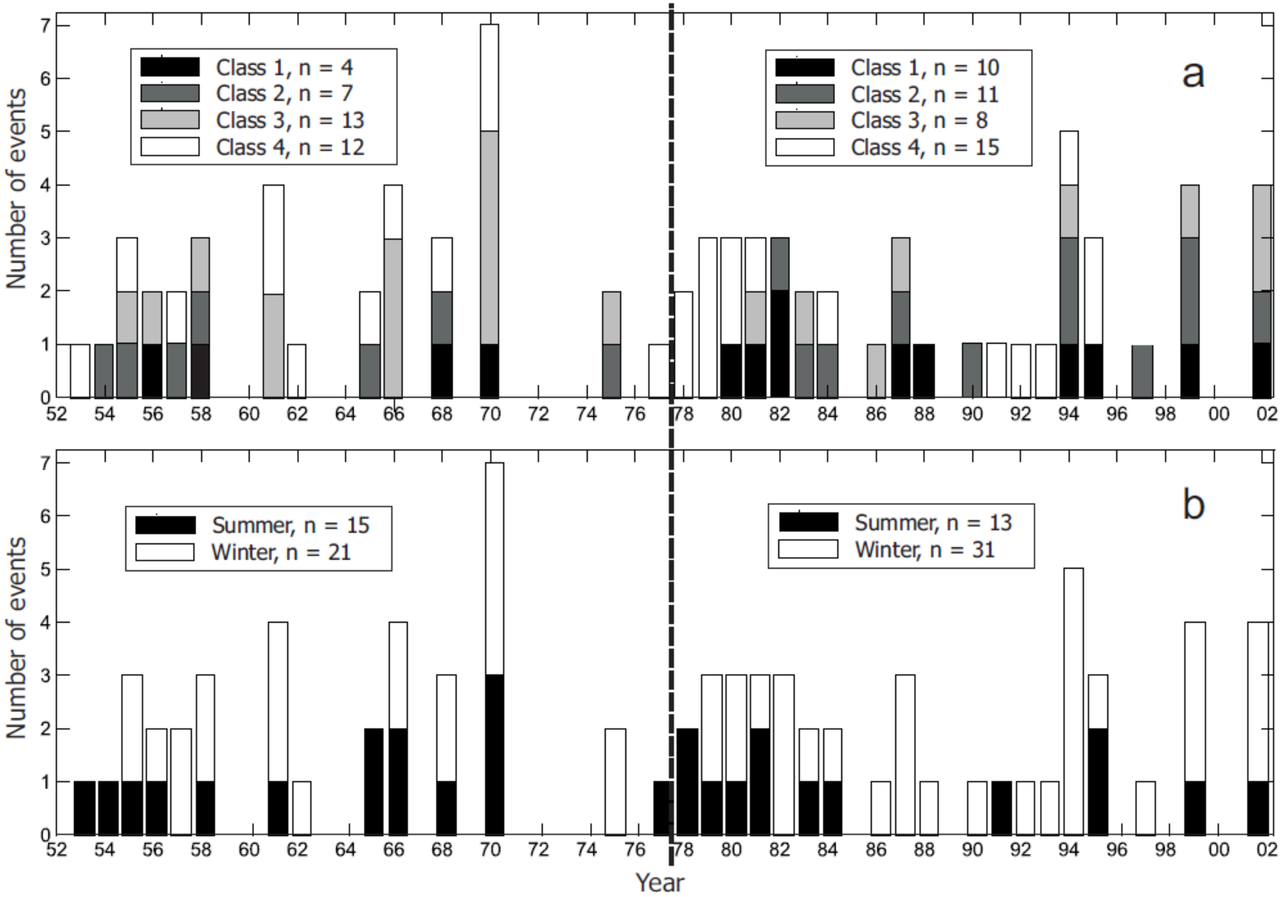


Fig. 1. Basins, locations of gauges, and river network used in the study.

Rank	Start	End	Rank	Start	End	Rank	Start	End
1	15 3 1988	11 4 1988	29	28 2 1987	7 3 1987	57	30 5 1984	7 6 1984
2	22 2 1970	4 3 1970	30	5 12 1981	12 12 1981	58	17 3 1979	19 4 1979
3	23 1 1995	7 2 1995	31	11 5 1999	27 5 1999	59	19 5 1965	30 5 1965
4	31 12 1981	18 1 1982	32	20 3 2002	26 3 2002	60	28 5 1995	5 6 1995
5	29 10 1998	11 11 1998	33	26 1 2002	2 2 2002	61	12 1 1993	20 1 1993
6	9 3 1981	26 3 1981	34	7 2 1958	22 2 1958	62	8 8 1970	15 8 1970
7	3 3 1956	17 3 1956	35	18 12 1965	28 12 1965	63	21 7 1980	28 7 1980
8	20 12 1993	31 12 1993	36	28 6 1958	18 7 1958	64	5 7 1955	20 7 1955
9	4 2 1980	14 2 1980	37	22 2 1957	4 3 1957	65	8 2 1961	15 2 1961
10	30 12 1986	10 1 1987	38	11 4 1970	3 5 1970	66	5 3 1979	12 3 1979
11	15 1 1968	25 1 1968	39	19 7 1981	30 7 1981	67	28 8 1995	6 9 1995
12	2 7 1954	31 7 1954	40	25 5 1983	31 5 1983	68	17 3 1957	8 4 1957
13	10 4 1994	27 4 1994	41	29 12 1974	7 1 1975	69	4 6 1981	12 6 1981
14	9 8 2002	24 8 2002	42	13 7 1956	31 7 1956	70	5 12 1961	17 12 1961
15	1 6 1965	20 6 1965	43	25 3 1987	1 4 1987	71	24 1 1994	4 2 1994
16	25 2 2002	4 3 2002	44	25 12 1954	8 1 1955	72	17 6 1991	25 6 1991
17	23 1 1982	8 2 1982	45	11 5 1970	18 5 1970	73	30 7 1977	8 8 1977
18	8 12 1974	21 12 1974	46	19 1 1986	23 1 1986	74	22 8 1970	30 8 1970
19	31 12 1993	9 1 1994	47	4 12 1960	13 12 1960	75	25 6 1953	7 7 1953
20	24 2 1958	3 3 1958	48	9 2 1970	13 2 1970	76	8 8 1978	13 8 1978
21	24 12 1967	3 1 1968	49	18 3 1970	2 4 1970	77	30 4 1980	8 5 1980
22	6 2 1984	11 2 1984	50	16 3 1994	27 3 1994	78	21 12 1991	29 12 1991
23	10 1 1955	27 1 1955	51	22 7 1966	31 7 1966	79	28 6 1966	7 7 1966
24	9 4 1983	20 4 1983	52	13 2 1966	2 3 1966	80	22 9 1968	28 9 1968
25	20 2 1999	26 2 1999	53	17 6 1979	28 6 1979			
26	15 2 1990	20 2 1990	54	1 6 1961	20 6 1961			
27	2 3 1999	7 3 1999	55	22 5 1978	31 5 1978			
28	22 2 1997	3 3 1997	56	31 1 1961	5 2 1961			



Swiss Re Institute

July 2021 European flood Bernd
The Reinsurance practitioner´s context

Tamara Soyka, Cat Perils EMEA

Table of Contents

Natural catastrophes in 2021: the floodgates are open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No 1/2022

sigma

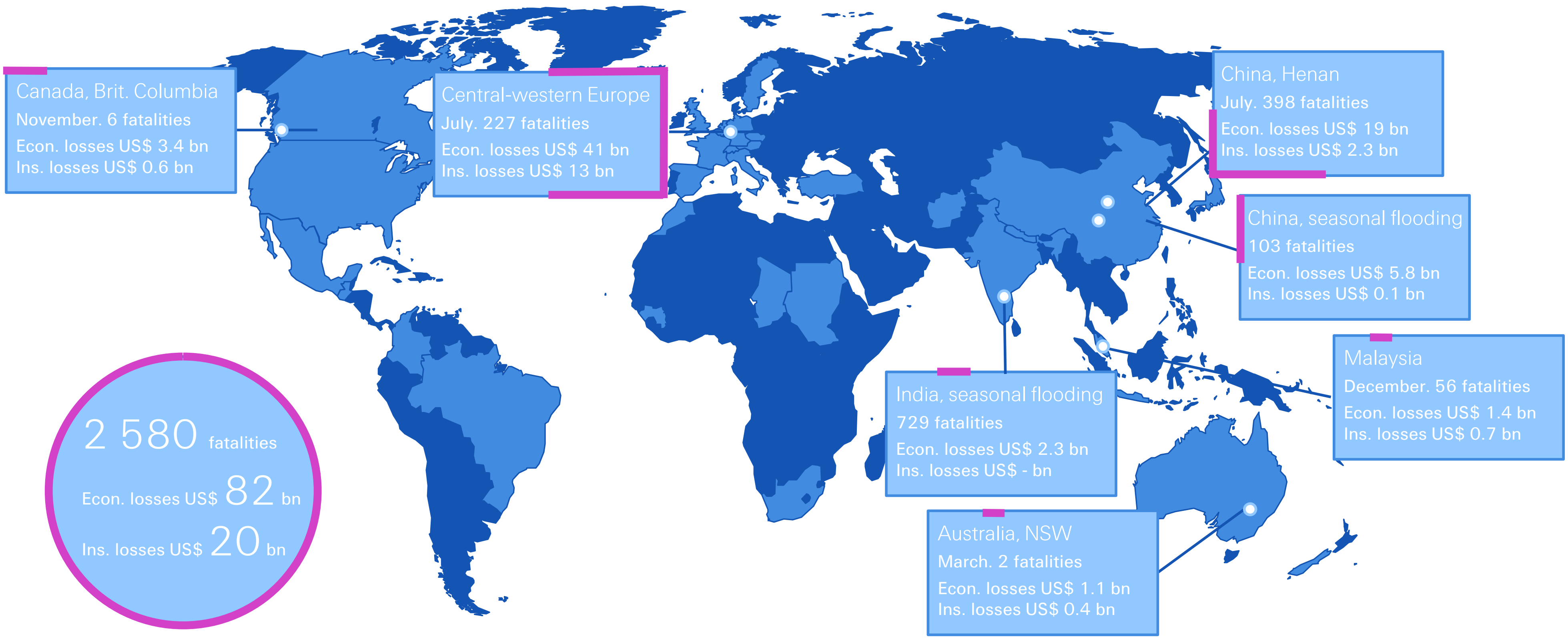
Natural catastrophes in 2021: the floodgates are open

Go to Publication

Bernd in the global context

01

In 2021, there were more than 50 severe flood events globally, with flash fluvial and pluvial floods in urban environments causing the largest damages



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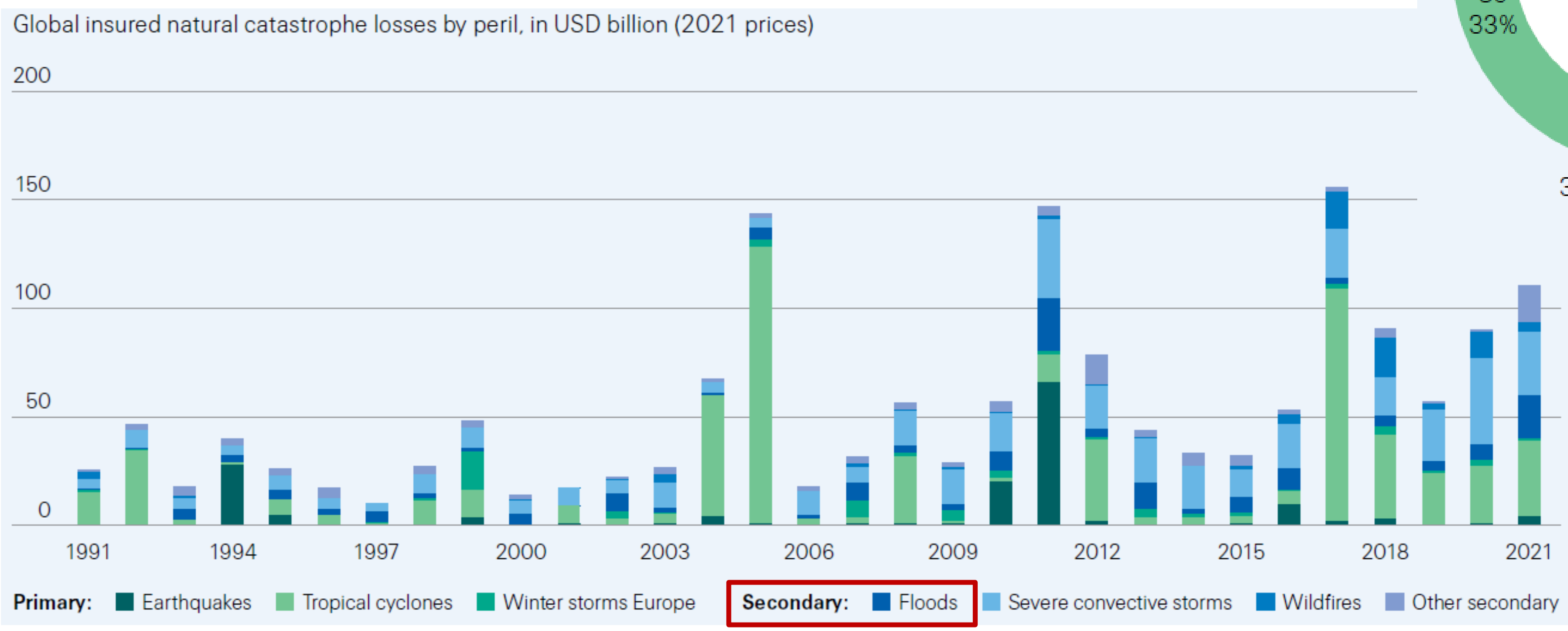
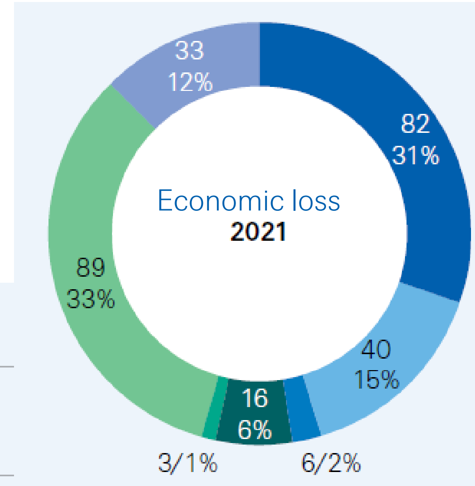
Bernd accounts for USD 13 bn (**65%**) out of total USD 20 bn **global insured inland flood losses in 2021**

Data from sigma 01/2022

Significant protection gap in flood risk - only 25% of global flood losses were insured in 2021, and only 15% in last decade

Insured flood losses in 2021: USD 20 bn
Economic flood losses in 2021: USD 82 bn

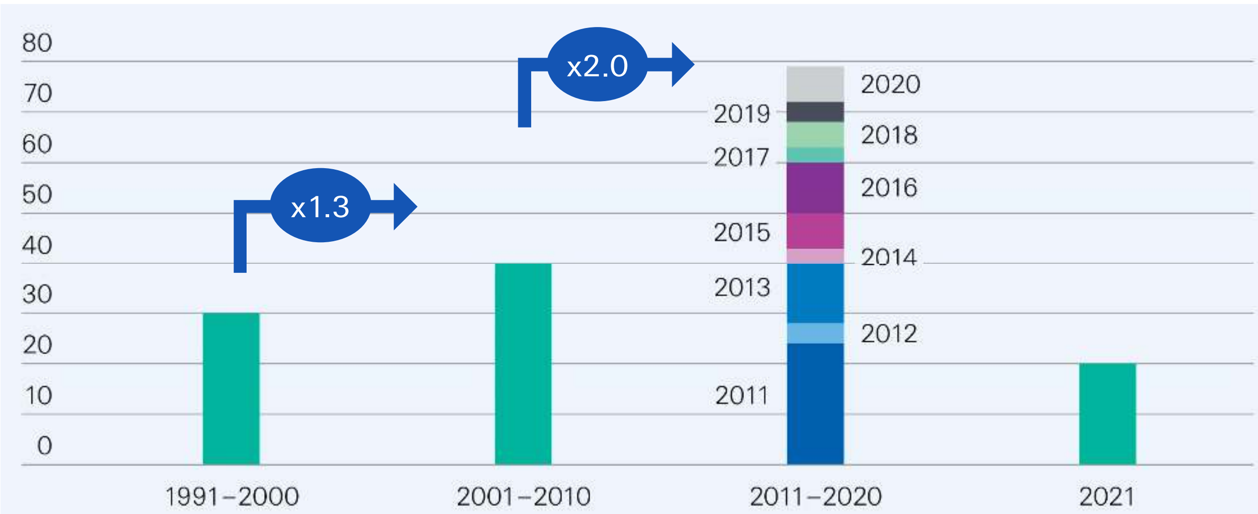




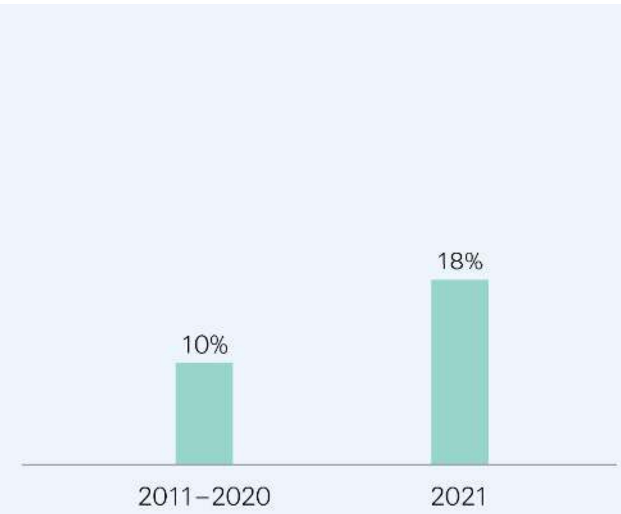
Data from sigma 01/2022

Insured flood losses are increasing and represent a significant share of 18% of all nat cat insured losses in 2021

Global insured losses from flooding since 1991



Floods as % of all nat cat insured losses



Swiss Re Institute

Data from sigma 01/2022

Drivers of flood risk globally

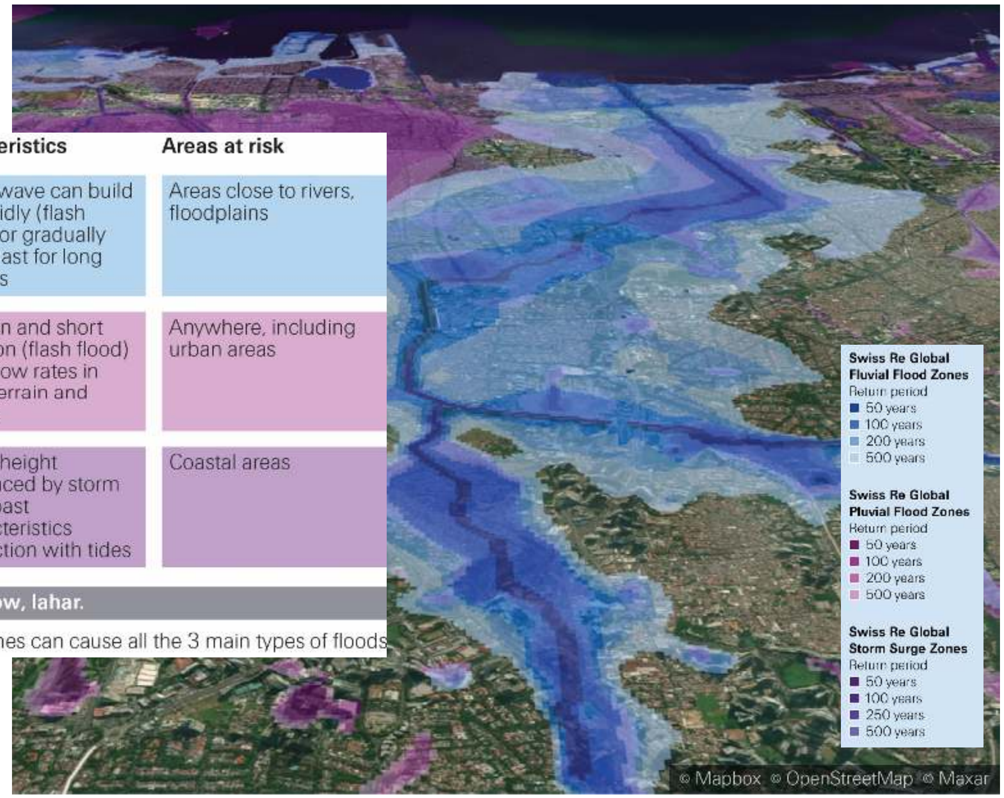
02

Understanding the drivers of flood risk: fluvial flood, pluvial flood and storm surge have different causes and loss factors

		Sources	Typical causes*	Characteristics	Areas at risk
Inland	**Fluvial flood**	Major and moder-ate-sized rivers, lakes	Heavy rainfall over days or weeks, but also snow melt, ice jams	▪ Flood wave can build up rapidly (flash flood) or gradually ▪ Often last for long periods	Areas close to rivers, floodplains
Inland	**Pluvial flood**	Surfaces not able to drain and minor rivers	Extreme rainfall in short time. Soil infiltration excess and overwhelmed drainage systems	▪ Sudden and short duration (flash flood) ▪ High flow rates in steepterrain and debris	Anywhere, including urban areas
Coastal	**Storm surge**	Seawater	Storm-force onshore winds pushing water against a coast over hours.	▪ Surge height influenced by storm and coast characteristics ▪ Interaction with tides	Coastal areas

+ Tsunami, reservoir or dam failure, ground-water flooding. sewer flooding, mudflow, lahar.

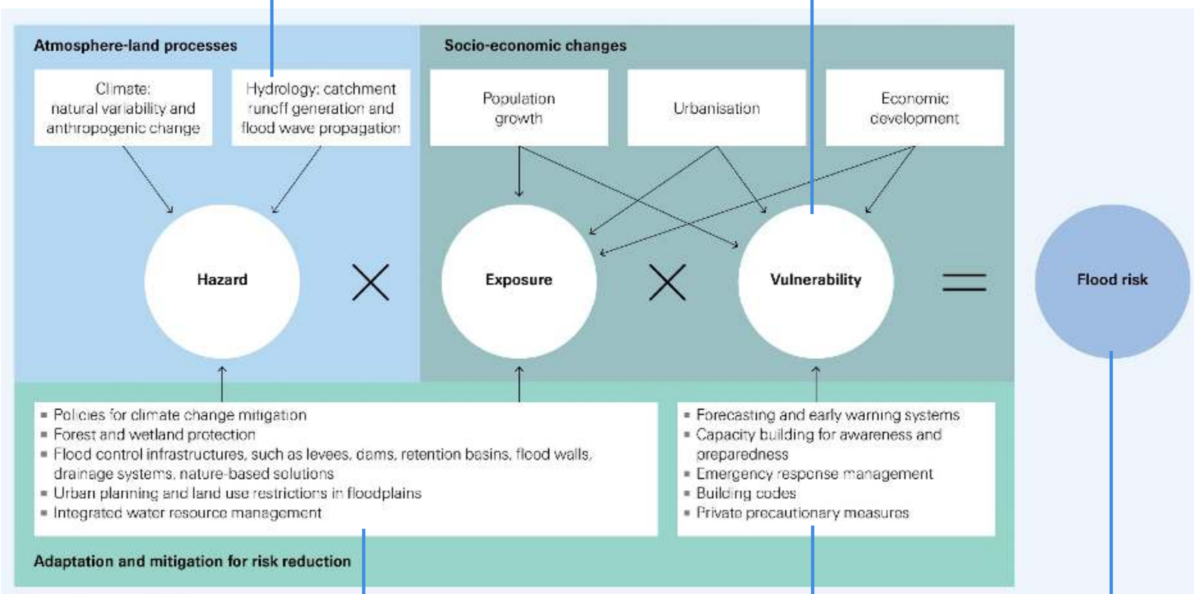
*Tropical cyclones can cause all the 3 main types of floods



Flood risk is determined by a combination of climate and land processes, and influenced by socio-economic factors

How is land topography and drainage capacity?

E.g., electrical equipment in basements?



Any flood defence in place?

Any emergency response?

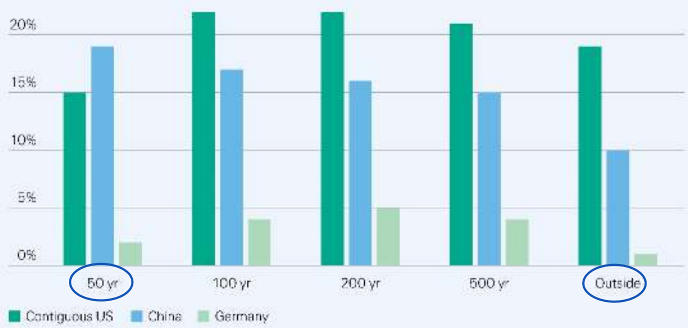
Insurance for protection against residual flood risk?

Multiple drivers behind rising insurance losses, with economic growth, the accumulation of exposed asset values, and insurance penetration on top

Shanghai, 1990

Shanghai, today

Growth rate of population exposed to inland flooding at different return periods between 2000 and 2020



Source: Swiss Re CatNet®, GHS population grid multitemporal, World Pop

Economic development
Increasing values in line with GDP growth

Concentration in exposed areas
Urbanisation, population growth

Insurance penetration
Take-up rates, broader coverage, social inflation, regulatory changes

Changing vulnerability
Sealing of surfaces, overbuilding in flood-prone areas

Changing hazard
Natural climate variability, climate change

Loss drivers of the Bernd event

03

Swiss Re Institute

A complex interplay of many factors resulted in record losses from “Bernd”

Extreme precipitation over days. **Climate change** likely one driver for the increase of these events

Severe convective storms with heavy rain a month earlier had left the **soils close to saturation**

The topography with **steep river valleys** exacerbated the **flash intensity** of the event

Soil erosion and debris flow due to the heavy flows and fewer trees after 2018 drought

In some areas, the rapid onset of flooding undermined **alert and emergency systems**

Supply chain disruptions, inflation, increased material costs and labour shortages

The Bernd flood event emphasized the industry need of advanced Nat Cat models able to properly capture today risk and helping us closing the protection gap

Frequency increase

Germany was affected by 3 catastrophic floods in the last 20 years (2002, 2013 and 2021) and smaller flood and storm surge events every year.

Severity increase

The increase in precipitation rates brings more flash floods. These are characterized by high and fast water and debris flows that cause relevant damages.
On top of this, we are experiencing pandemic-related demand surge, supply chain disruption, and high inflation.

Cross-country correlation

Models need to cover more countries simultaneously to assure the cross-country event correlation is properly simulated, e.g. Germany with Belgium, Austria, CEE.

Flood protection measures

Proper considerations of available flood defences, their maintenance status, and design standards should be included. As an industry, we should support effective mitigation plans and building/maintaining flood infrastructures.

The underinsurance issue

More than half of Germany population is not covered against flood events. Innovative products based on a sound understanding of the risk should be offered aiming at closing the protection gap.
Discussion on mandatory flood insurance ongoing.

Additional challenge: reinsurance contract and wording

- **No standardized wording and unified market clauses** in Germany
- Different event definitons
  - Examples: jet stream, atmospheric perturbation, weather pattern, named pressure area
  - Often, independent decision instance is not defined (for example, national weather services)
- Particularity of Bernd: **Combination of pluvial and fluvial flooding**
- Usually, **different event duration definitions and sublimits** for inundation stemming from rain or river flood
  - Clarification lacking if combination of hazards occurs

Call for action to collaborate on data and insights

04

"We believe flood risk is insurable. Flood should be afforded the same attention as primary perils regarding quality of exposure and claims data."

Re/insurers are instrumental for building flood resilience by acting in 3 directions

Assess flood risk rigorously

- Use actively **existing technology and model** capabilities
- Quantify and de-bias for today and future **macro trends**
- Push for **data** quality, transparency, and flow, as for primary perils

Close flood infrastructure gap

- Flood defences are **aging** and could not be adequate for today climate
- **Green infrastructure** required for new and more sustainable defences
- By **underwriting risks** of green infrastructures, insurers can support the **sustainability agenda** and gain access to new risk pools

Close flood protection gap

- Since 2012, **85% flood losses uninsured** (95% in emerging markets and 66% in advanced economies)
- Incumbent to increase risk awareness and develop **risk transfer solutions**: private insurance covers and national pool schemes

Call for action for the re/insurance industry

Make flood risk assessment more rigorous and develop risk transfer solutions.

	Call for action for the industry	The positive trajectory
1	**Data quality, transparency, and flow:** collect and include in submission data accurate flood-related exposure, claims, policy information	Detailed exposure available on building level, including correct coverage coding for flood
2	**Expand model capabilities:** probabilistic models for the different types of flooding and markets	Pluvial and tropical cyclone-induced floods represented along side fluvial and storm surge risk for major markets
3	**Ensure representation of present-day risk:** frequent recalibration and debiasing of models from macro trends	Underwriting using flood models with near-future perspective, instead of experience costing
4	**Ensure representation of future risk:** scenario simulations projecting to 2050–2100 horizons	Regulatory requests for climate change scenarios to inform business strategy
5	**Increase risk awareness and transfer solutions:** private insurance covers and national pool schemes	Flood insurance products available for privates and successful examples of national schemes

Any questions?

Swiss Re Institute

Swiss Re Institute

Thank you!

Contact us

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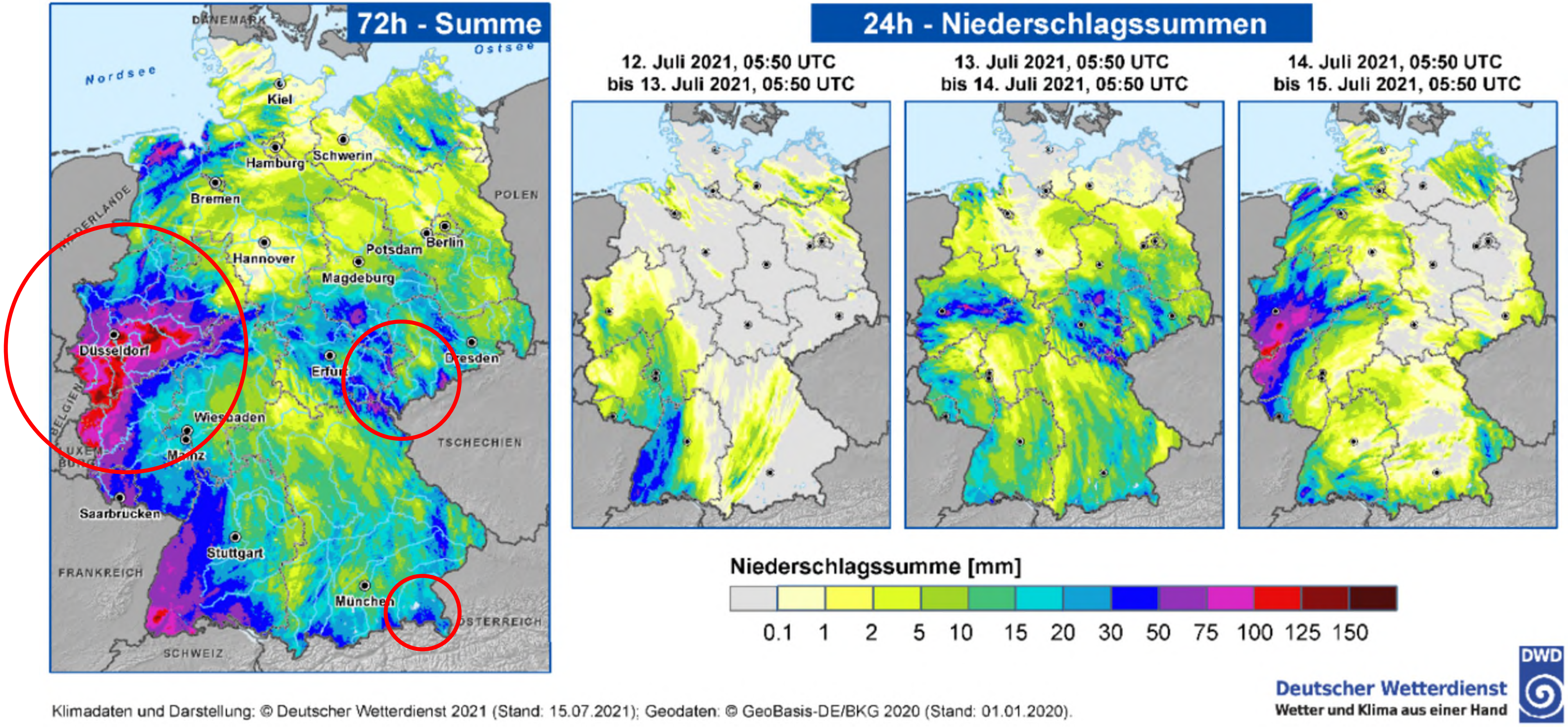
Lessons Learned from European Flood „Bernd“

An Insurance Association Viewpoint - German Market

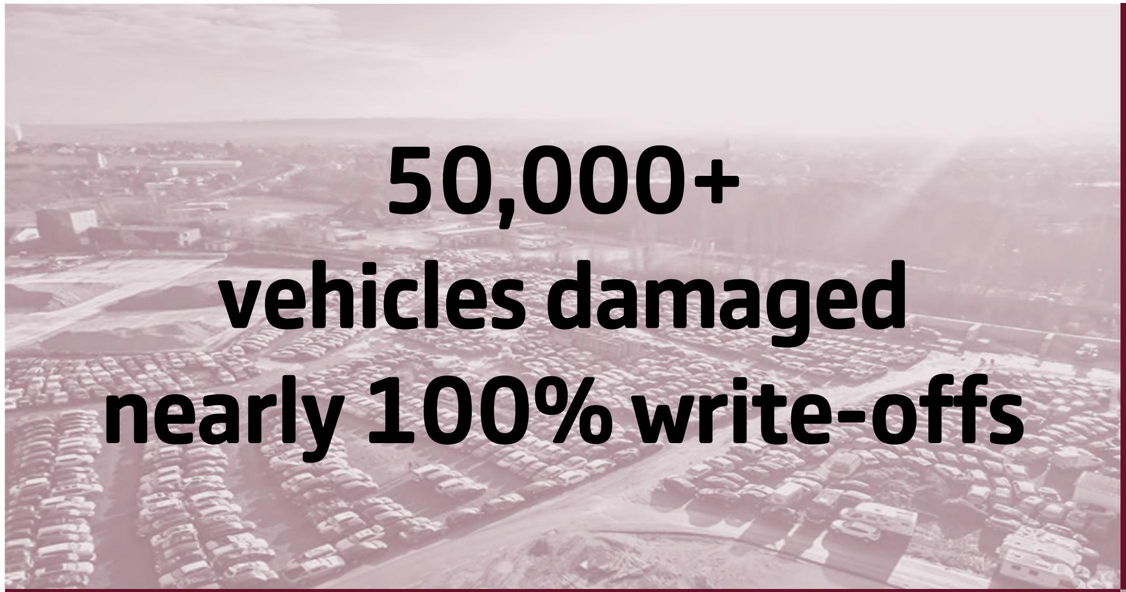
April 12, 2022

Oliver Hauner, GDV

Preface: Who is Bernd?



Source: DWD German Weather Service,
https://www.dwd.de/DE/leistungen/besondereereignisse/niederschlag/20210721_bericht_starkniederschlaege_tief_bernd.pdf?__blob=publicationFile&v=6



Key Takeaway No. 1

expect the unexpected

Key Takeaway No. 2

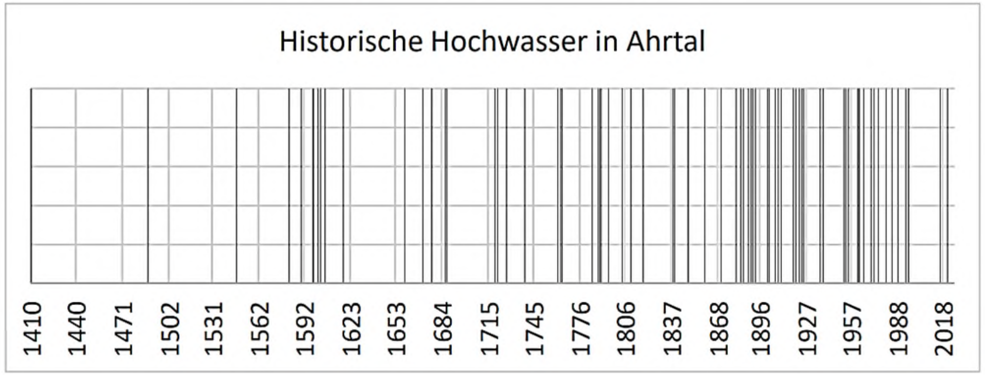


Abbildung 14: Historische Hochwasser in Ahrtal (Quelle: Adaptiert von Frick (1955), Seel (1983), RLP Daten, Pegelstände); mindestens 70 Hochwasser seit 1410.

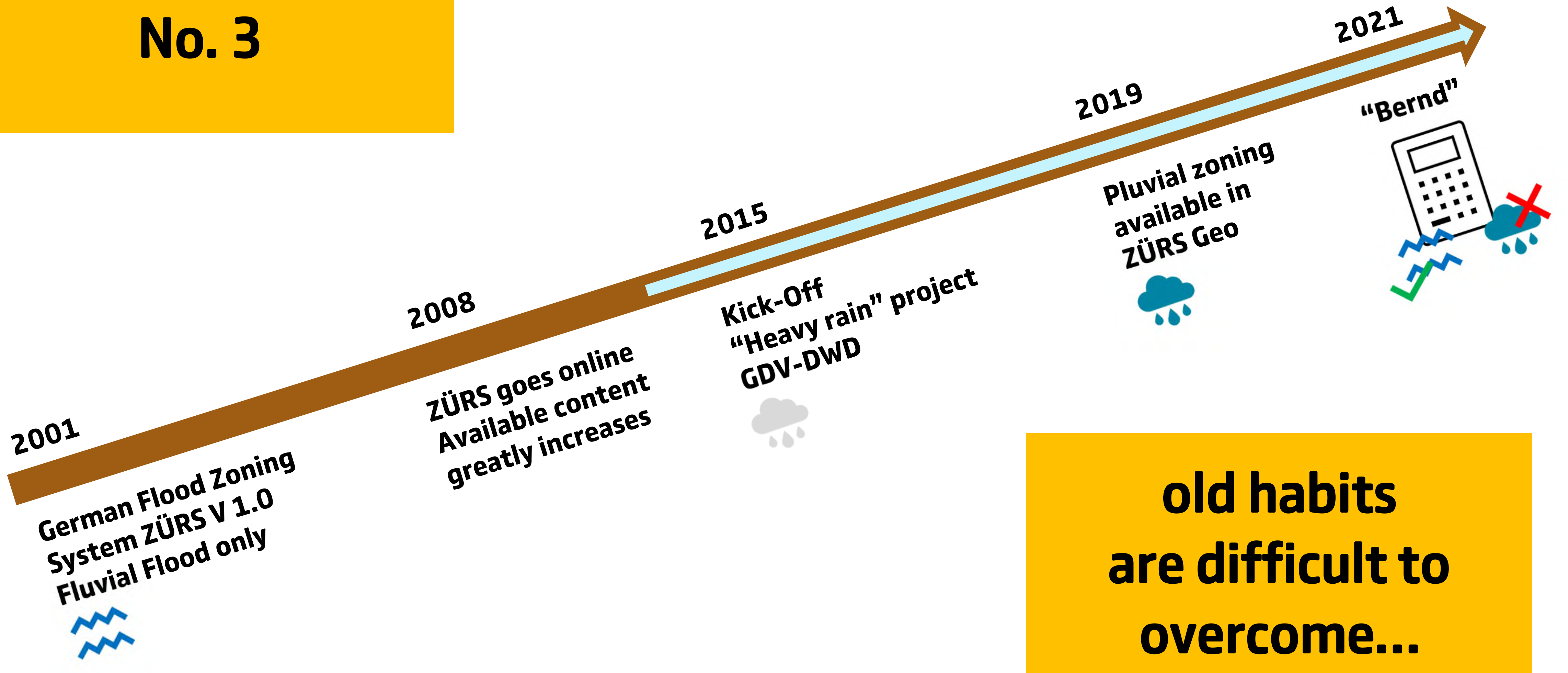
remodel the past to enhance your view of the future

The flood of 1910 may have been of a similar magnitude as 2021...

However, science assumes that the flood event of 1804 on the river Ahr was **more severe** than the flood event of 2021.

Since there is not only one "Ahr Valley" in Germany,
events of the 2021 magnitude can be expected nationwide several times in a century
(GDV Flood-Model HQ Kumul 2.1 = 40y to 60y).

Key Takeaway No. 3



old habits are difficult to overcome…

...insured perils are fire, escape of water, windstorm, hailstorm and ***inundation (including pluvial flooding, heavy rain and sewer backwater)****...*

...inundation caused by storm surge is not insured...

...insured perils are fire, escape of water, windstorm, hailstorm and ***heavy rain****...*

...inundation caused by ***pluvial flooding****, sewer backwater or storm surge is not insured...*

Key Takeaway No. 4

loss experience vs. marketing: and the winner is...

Key Takeaway No. 5

enhance your situational awareness

Key Takeaway No. 6 - shareholder value is the least problem...

loss adjuster capacity

unstable infrastructure

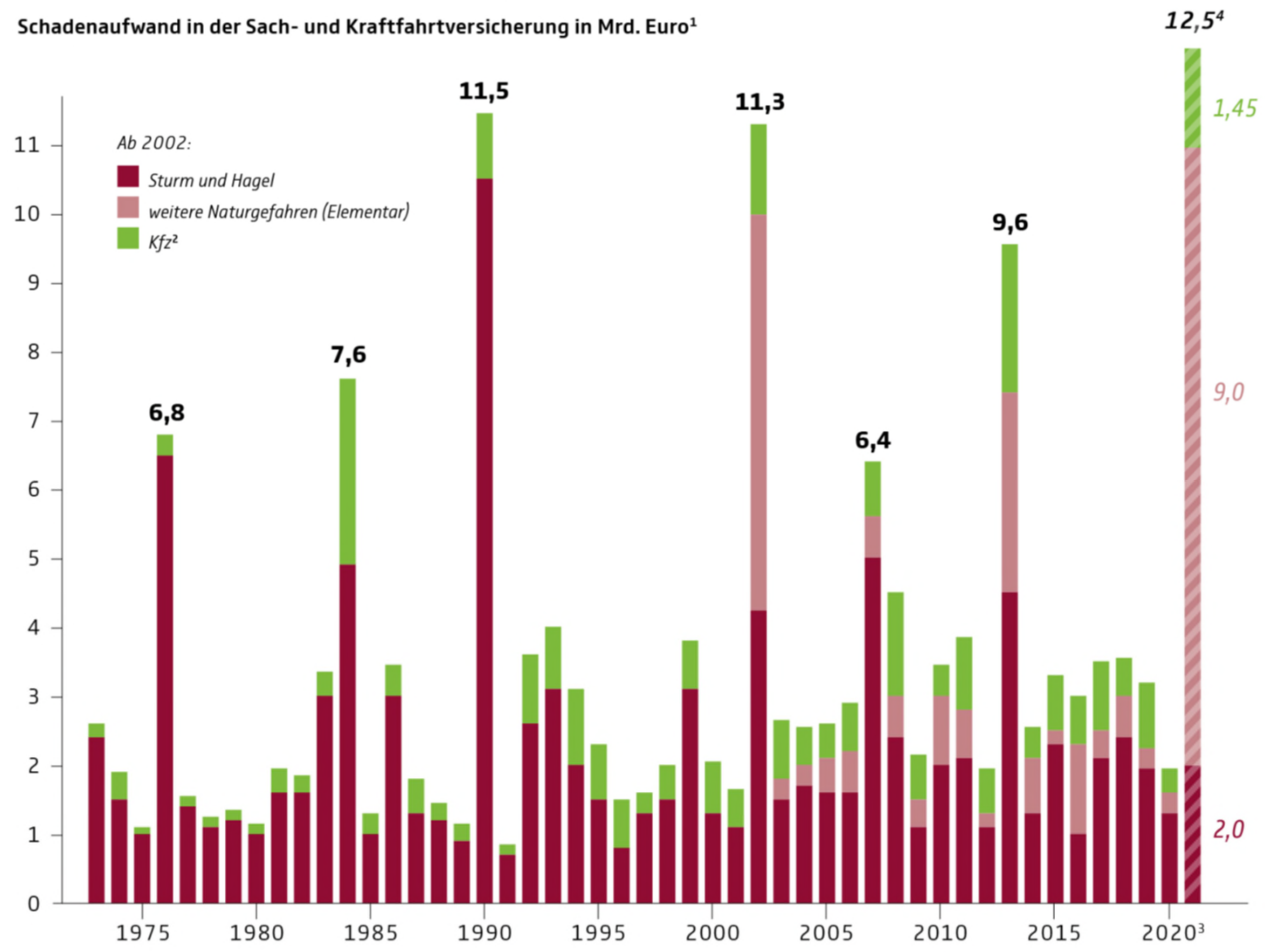
craftsmen capacity

permissions by the authorities

supply chain trouble & inflation

fake news

2021 was the most expensive natural hazard year so far, but we are still a long way from hitting the Solvency II "thresholds*"



Key Takeaway No. 7

comprehensive analytical statistics are essential for media coverage and political discussion

ISCM Bernd

*SCR 99,5 % quantile ⇨ 200y return period

Key Takeaway No. 8 - make natcat insurance future-proof

Politicians

Extreme weather events? We need a mandatory natcat-insurance (only)!

(aka the insurance industry & the policyholders will pay for the consequences of climate change)

Insurers

Coverage for private homeowners

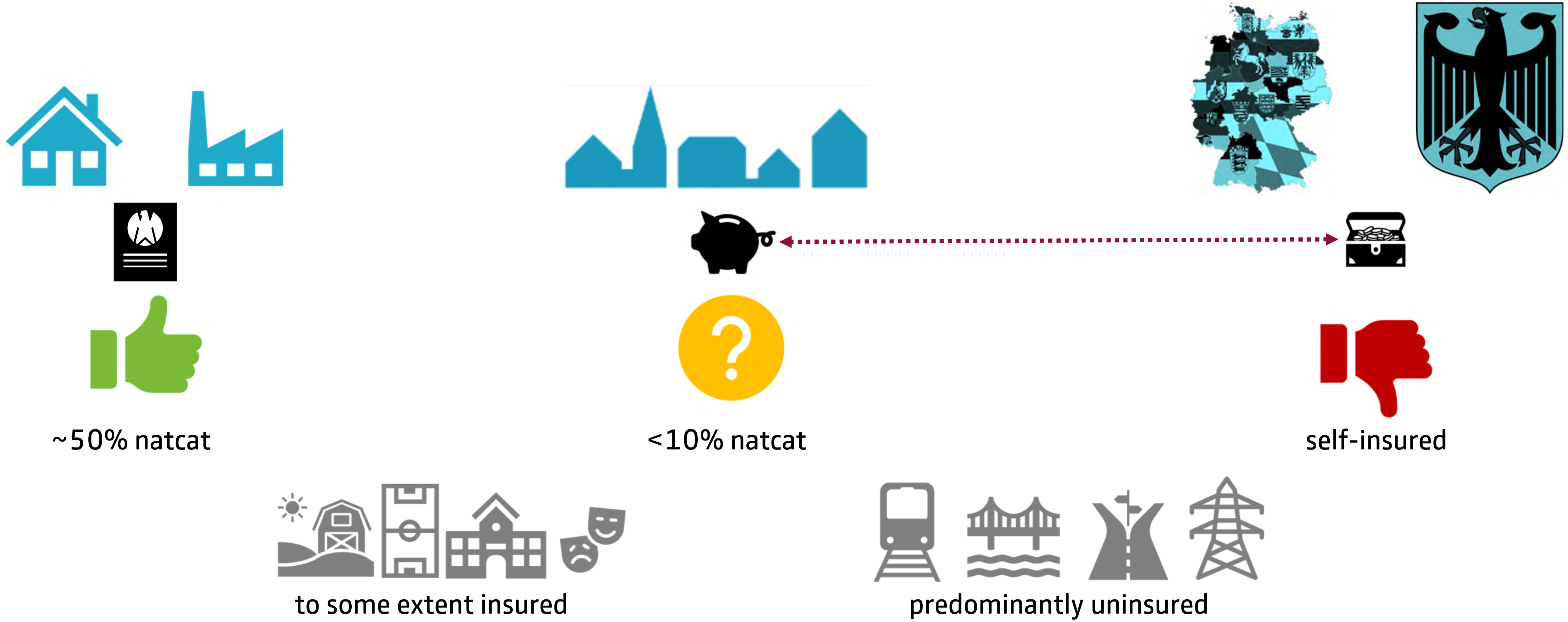
Binding steps for climate adaptation measures / prevention

Provision for the catastrophic accumulation loss event

A new system for Germany

⇨ these elements not only build on each other, but are directly dependent on each other

Epilogue: 30bn € total economic loss / 8bn € insured loss - will things change?



ISCM Bernd

Source: Wikimedia Commons

Thank you.
Questions?

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Head of
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DIE DEUTSCHEN VERSICHERER

Backup

year	name of event	insured losses in €	# of claims	average loss in €	# of major losses (> 100.000 €)
2002	European Floods in August (Germany)	1.800.000.000	107.000	**13.500**	63
2010	Event “Viola”	260.000.000	13.000	**13.800**	15
2013	European Floods in June (Germany)	1.650.000.000	120.000	**19.500**	270

zip code	district	incidence of loss in ‰	average loss in €
05366	LK Euskirchen	280,1	62.353
07131	LK Ahrweiler	210,8	**209.543**
05914	SK Hagen	123,8	28.614
05316	SK Leverkusen	107,5	36.563
05362	LK Rhein-Erft-Kreis	100,3	23.582

INTERNATIONAL SOCIETY OF CATASTROPHE MANAGERS

July 2021 European Floods, ‘Bernd’

April 12th 2022

Tim Edwards, Head of EMEA Catastrophe Analytics

TIGERRISK | THE NEW BREED IN RISK MANAGEMENT & CAPITAL SOLUTIONS

Lessons learnt from the July 2021 European 'Bernd' floods

Steffi Uhlemann-Elmer

*Director Product Management, **RMS***

Hydro-meteorological aspects

Tamara Soyka

*Head Cat Perils EMEA at **Swiss Re***

Reinsurance Practitioner's context

Model Completeness

Changes in risk perception

Reinsurance market response

Tim Edwards

*Head of EMEA Catastrophe Analytics at **TigerRisk***

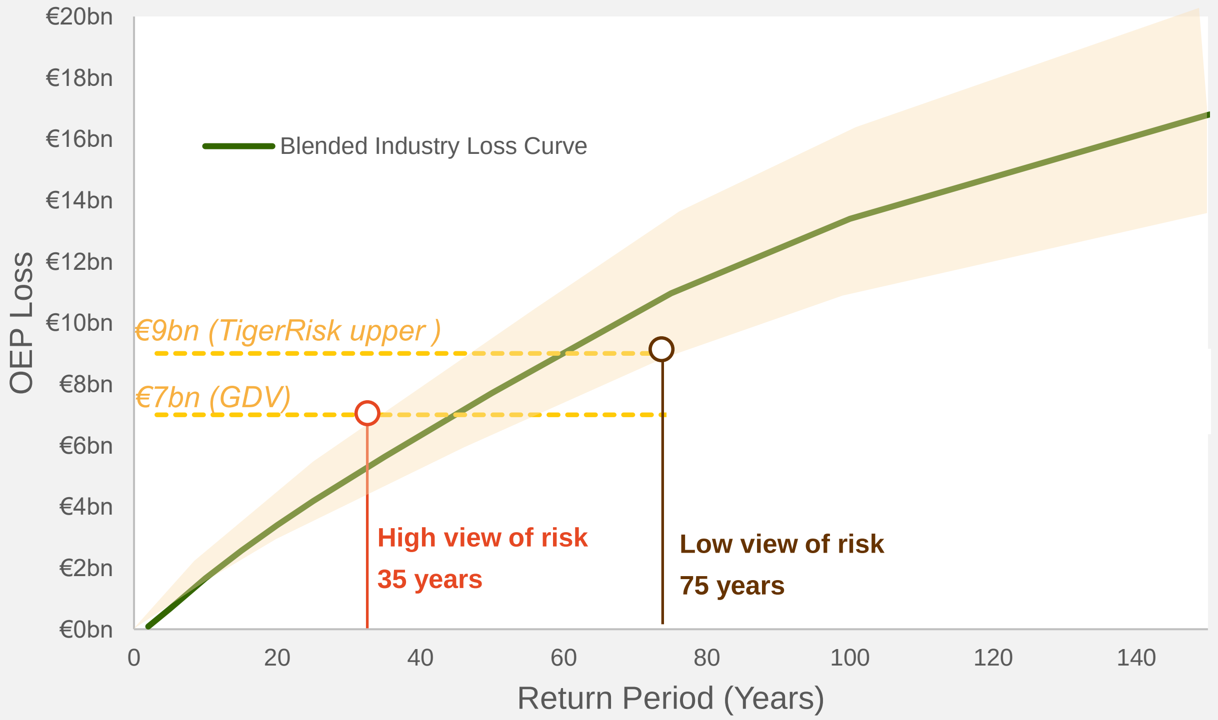
Insurance Association viewpoint

Oliver Hauner

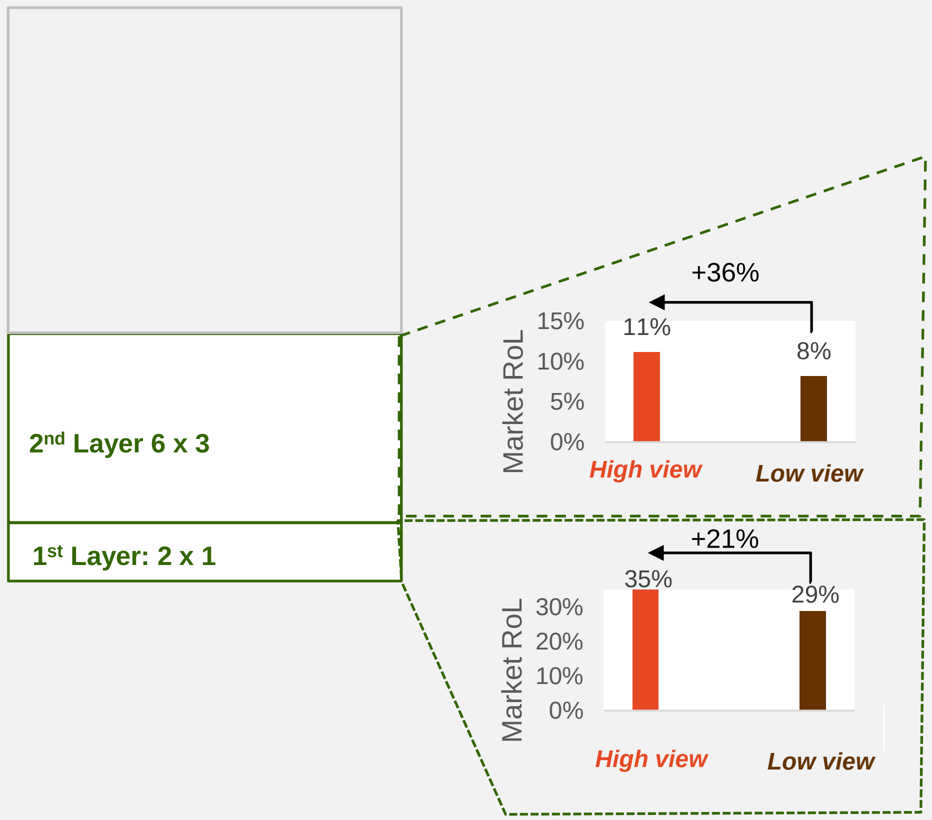
*Head of Property Insurance, Engineering, Loss Prevention and Statistics **German Insurance Association (GDV)***

The challenge in estimating loss return periods – *its importance in pricing*

Loss into second or third layers – 35 to 75 years is a potential loss return period for the industry



That the risk is being re-assessed impacts pricing – changes to the technical view could have a material change in pricing



A wide range of loss return periods are being discussed in the market – there is a significant price impact from adopting the upper or lower range of these.

2021 'Bernd' insured losses in Germany between a 35 and 75 loss return period.

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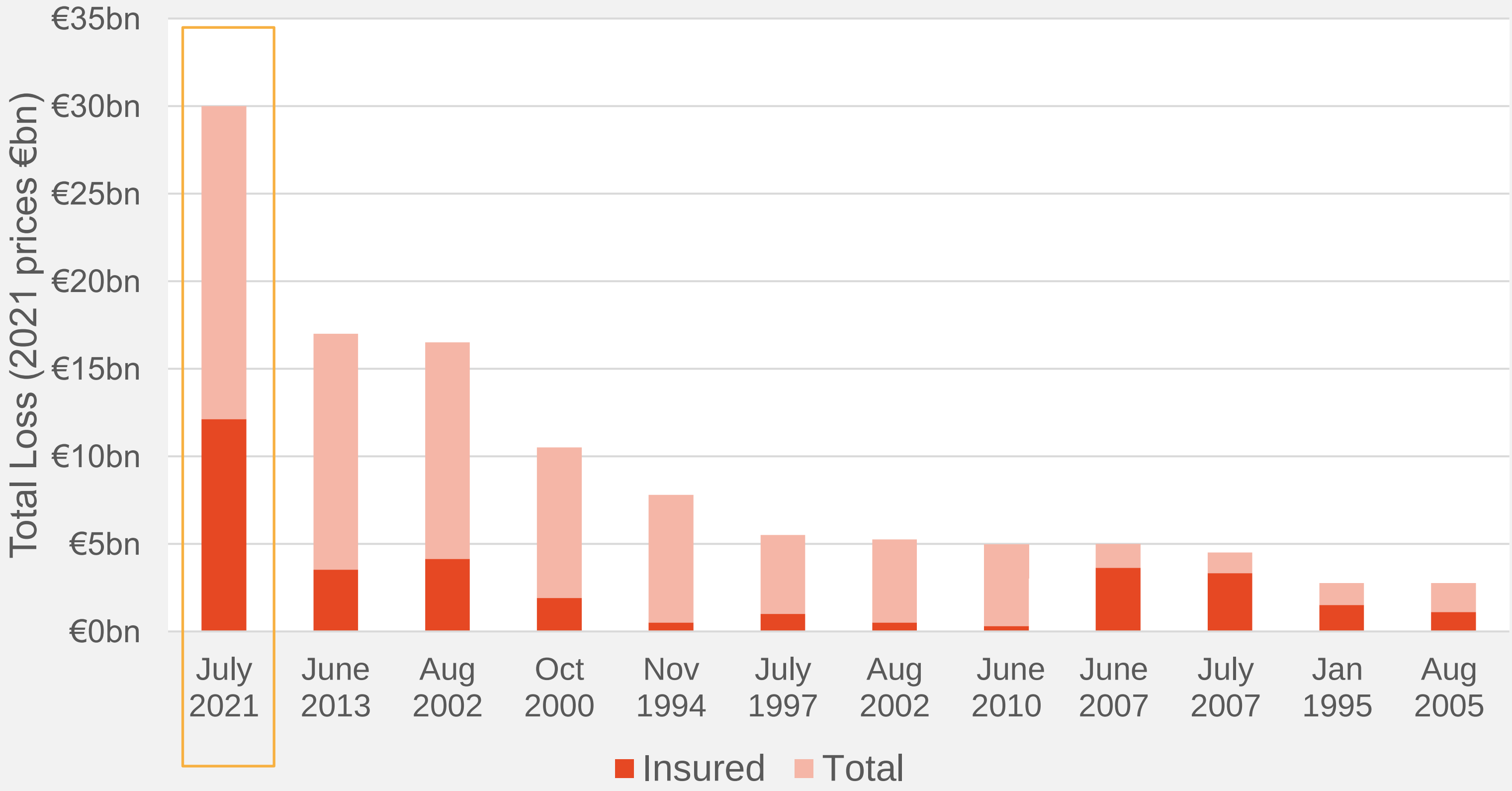
The challenge in estimating loss return periods – *a lack of consistent loss data over time*



2021 'Bernd' floods were the largest European flood event in 30+ years:

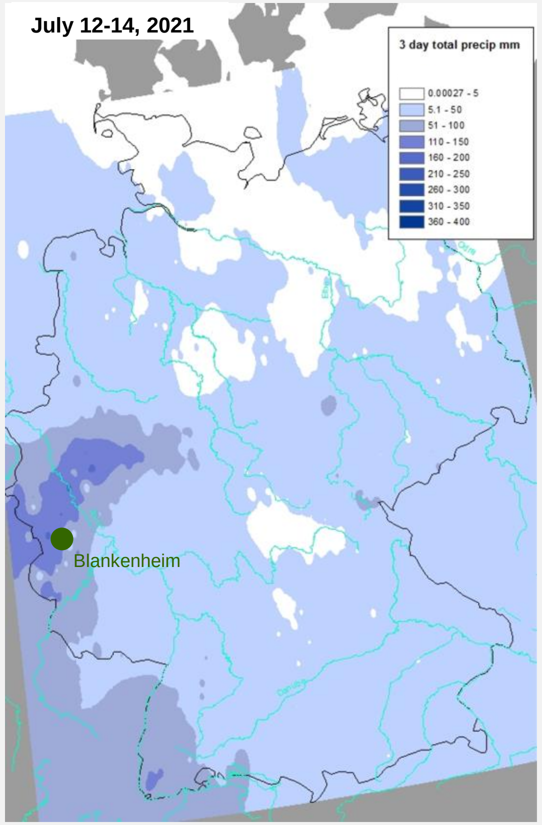
Insured and total losses, source: Swiss Re, CRESTA Clix, Munich Re Nat Cat Service

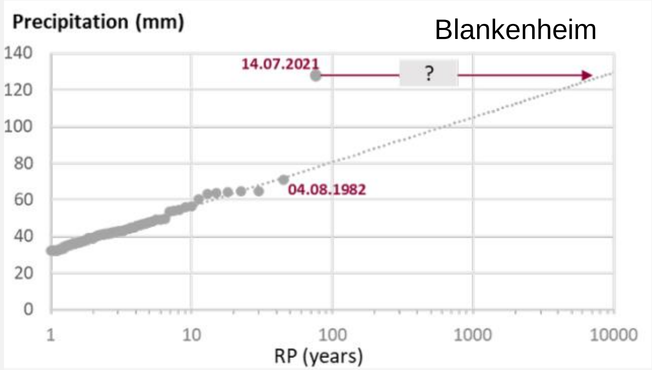
An empirical analysis framework

- July 2021 'Bernd' is the largest insured flood event since the 1990's, when expressed in terms of 2021 prices.
- There are just 3 significant reference events for Germany since 2002 but others back to the 1800's if you use the hazard information
- Significant non-stationary impacts to consider when referring to historical events: exposure change, insurance market terms and changes to flood hydrology and run-off conditions all need to be taken into account when indexing losses.

The challenge in estimating return periods – *looking at precipitation levels over time*

Extreme local rainfall not seen in history, for that region, 1.8 times higher than previous levels seen in 1982 at Blankenheim weather station highlighting the 'futility' in modelling this return period.

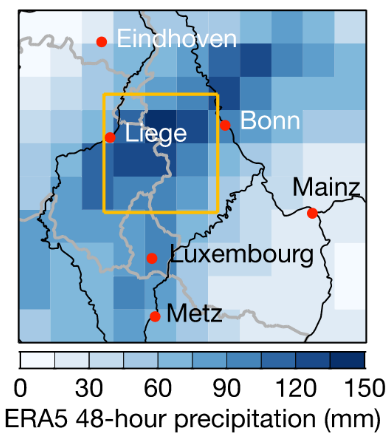


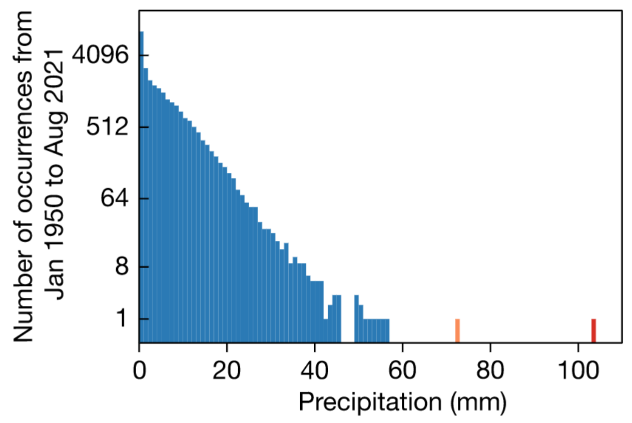


Date	Precip	Empirical RP
14/07/2021	129.2	?
04/08/1982	70.8	45
06/10/1988	64.5	30
04/11/1940	64.4	22.5
04/07/1937	64.1	18
27/09/2007	63.7	15
01/07/1942	63	12.9
24/07/1947	60	11.3
29/05/1956	56.5	10

***2021 'Bernd' floods peak rainfall:** 3 day total precipitation in mm (data:https://cdc.dwd.de/portal/202204011005/mapview).*

Across the surrounding region this was also record level of rainfall, the 2 day period from 13th-14th July has not been observed over the 72 year ERA 5 rainfall record





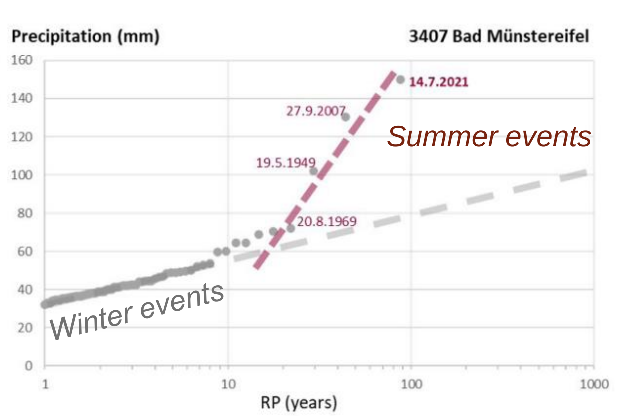
'Bernd' a regional precipitation record. The left-hand chart shows 48-hour precipitation from the ERA5 reanalysis for 13 July 06 UTC to 15 July 06 UTC. The yellow box highlights the area of 50–51°N and 5.5–7°E. The right-hand chart shows the distribution of 48-hour ERA5 precipitation for all days from January 1950 to August 2021 in that area. The period 13 July 06 UTC to 15 July 06 UTC 2021 is denoted by the red bar and 14 July 06 UTC to 16 July 06 UTC by the orange bar

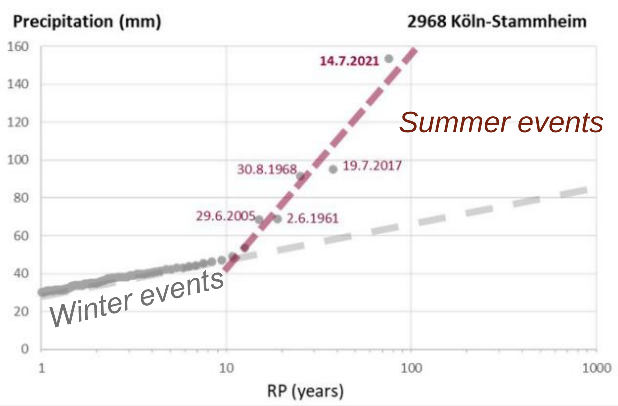
https://www.ecmwf.int/en/newsletter/169/news/extreme-rain-germany-and-belgium-july-2021.

A truly extreme event – <u>for that region</u>

The challenge in estimating return periods – *comparing precipitation across events*

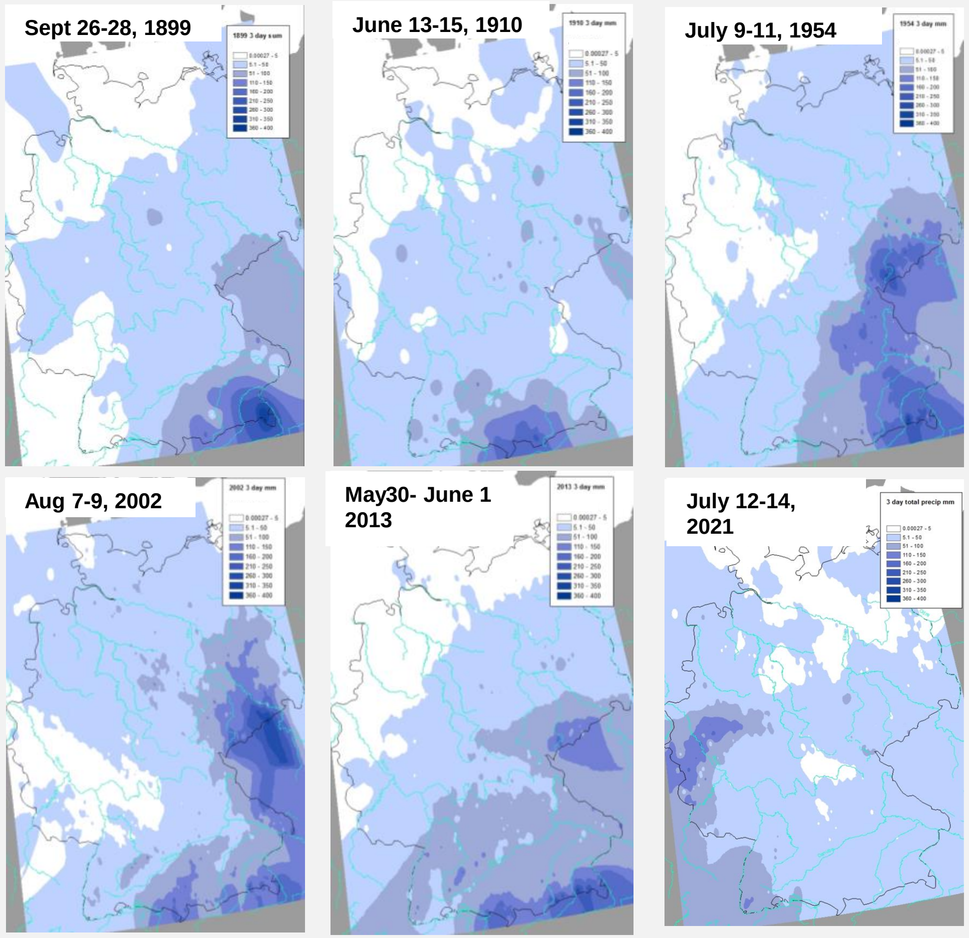
2 separate flood perils? - Summer vs Winter rainfall climatology, evidence suggests summer events may be more intense. Mann, M., Rahmstorf, S., Kornhuber, K. et al. Influence of Anthropogenic Climate Change on Planetary Wave Resonance and Extreme Weather Events. Sci Rep 7, 45242 (2017).





Historical rainfall return periods using empirical frequencies (ie not modelled): Frequency analyses of daily precipitation at the stations Bad Münstereifel and Köln-Stammheim (DWD data). Source: KA Köln.Assekuranz Agentur, 2021

A comparison to historical events shows these summer rainfall events have occurred in the past across Germany, albeit not in the Ruhr



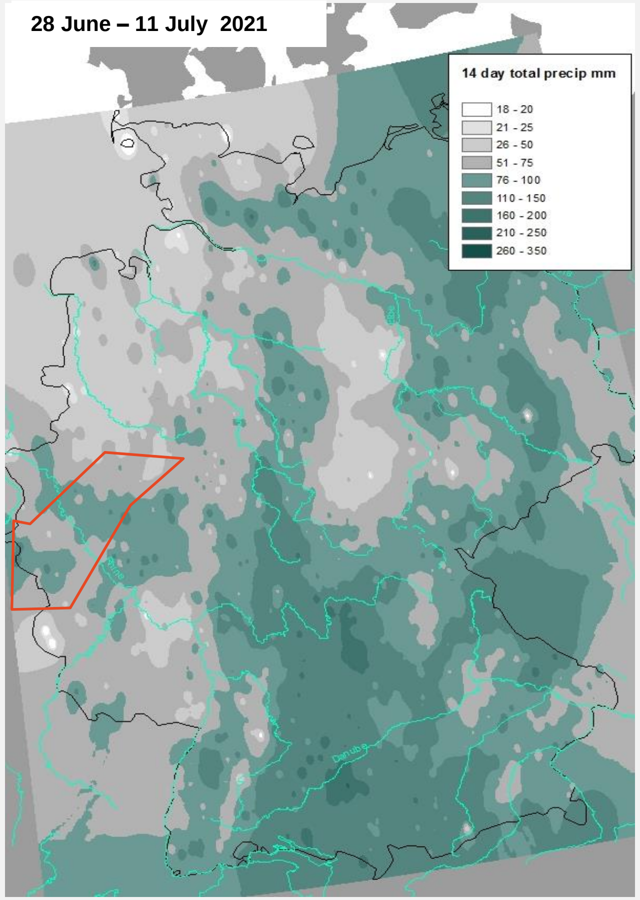
Source data: https://cdc.dwd.de/portal/202204011005/mapview

A truly extreme event – <u>for that region</u>

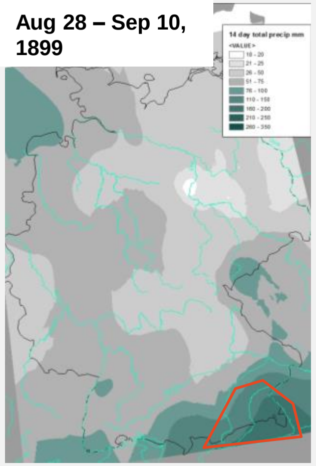
The challenge in estimating return periods – *comparing the antecedent conditions*

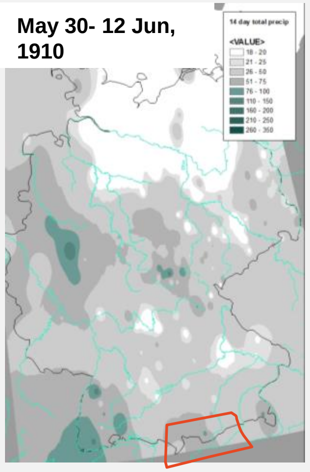
Extreme local rainfall that was accompanied by ‘medium’ level of groundwater saturation from the 14 day’s prior rainfall

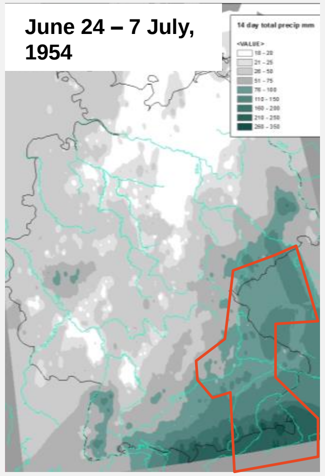
Area of most intense rainfall for the peak period of the event

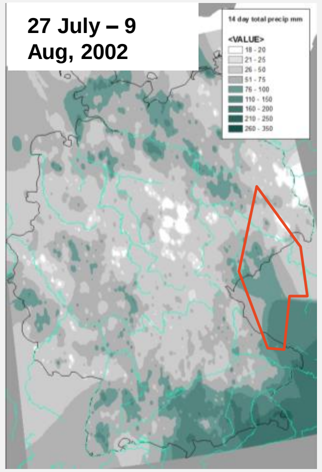


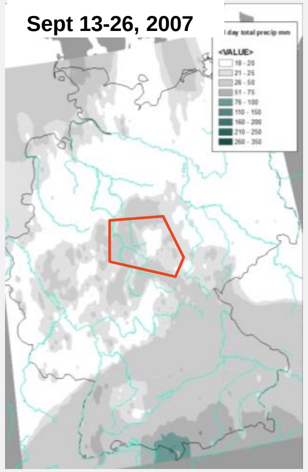
A comparison to antecedent conditions from other events

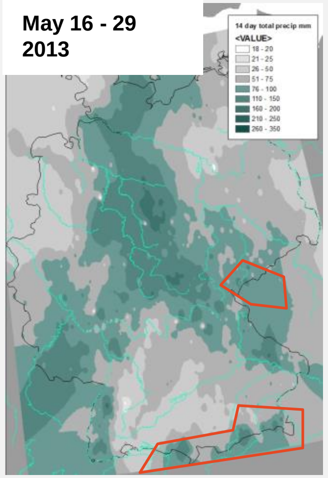












2021 ‘Bernd’ flood antecedent conditions: *14 day total precipitation in mm prior to max 3 day period (Source data: https://cdc.dwd.de/portal/202204011005/mapview).*

Building the extreme rainfall index – considering both 3 day peak rainfall and antecedent conditions

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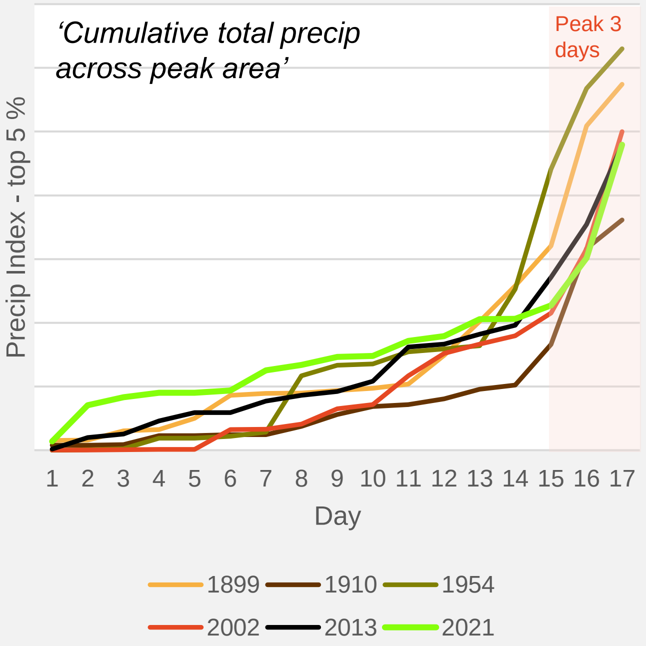
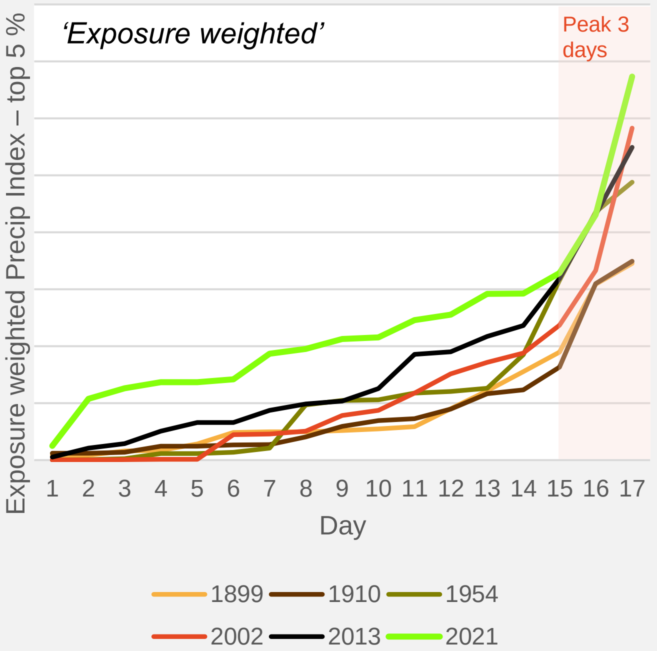
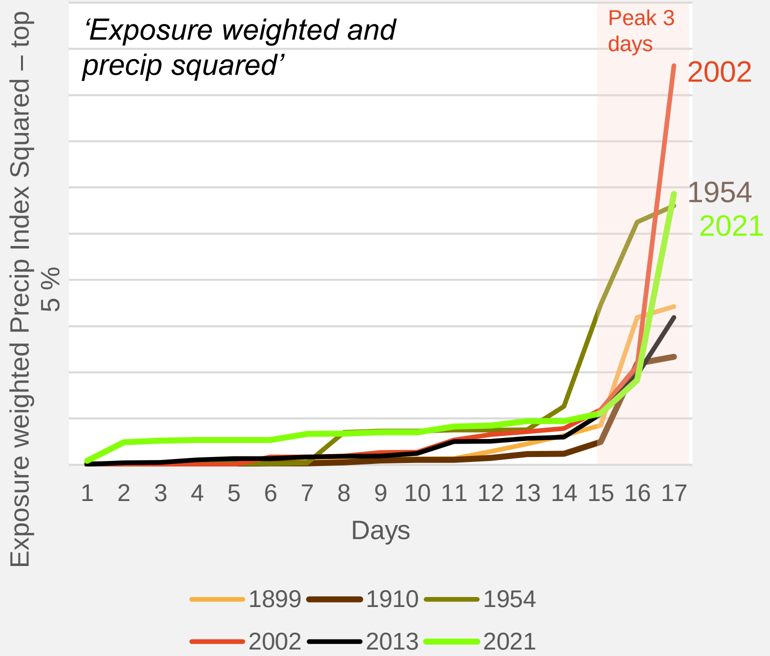
The challenge in estimating return periods – *designing an extreme rainfall index*

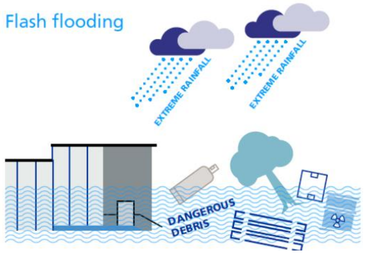
Hazard parameters → **Loss proxy**





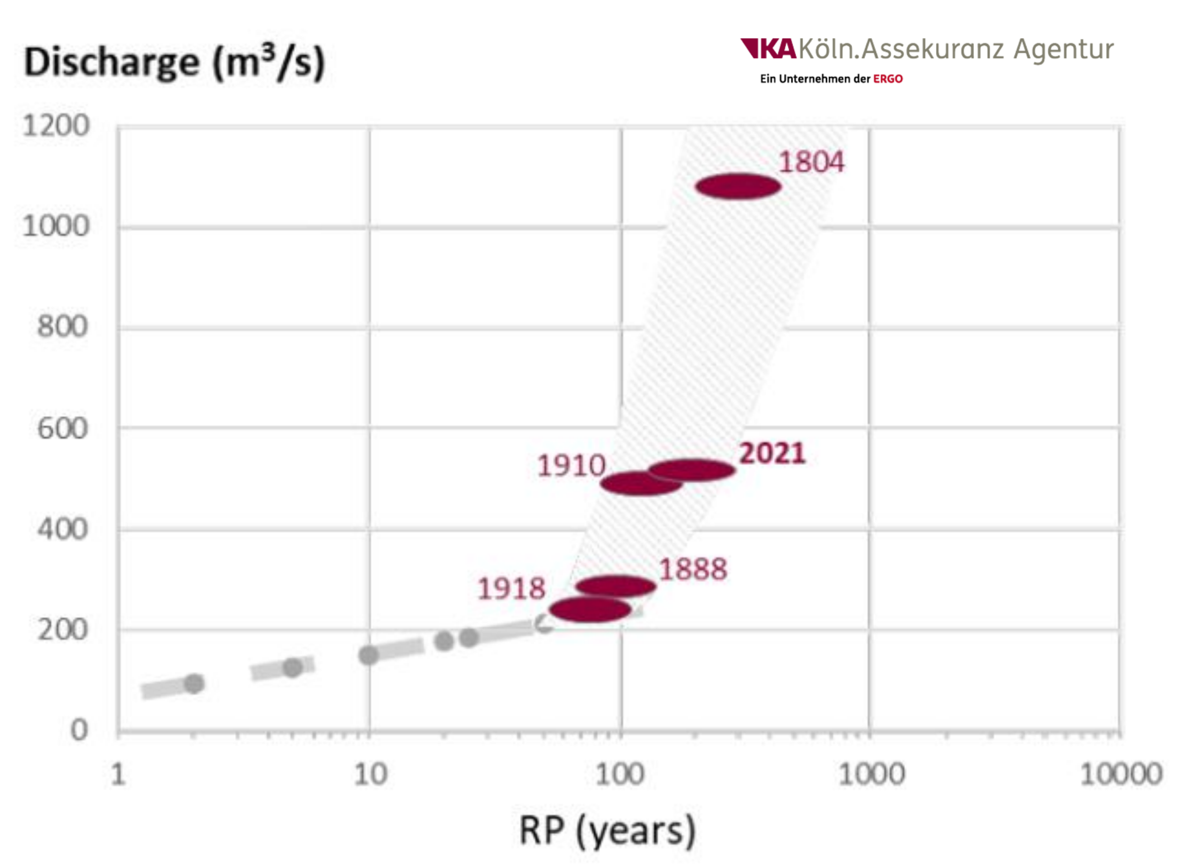


***Extreme rainfall index:** a.) cumulative total precipitation index in mm across top 5% of postcodes (left), b.) exposure weighted version of a.), c.) exposure weighted version of a.) squared. (data:https://cdc.dwd.de/portal/202204011005/mapview).*



The extreme rainfall index suggests the 2021 Bernd flood was the second or third largest 'flash flood' loss event in 120+ years

The challenge in estimating return periods – *river discharge comparison for one gauge*



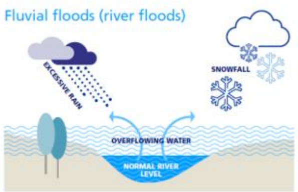
2021 'Bernd' river flows in the Ahr likely a 1 in 100-250 year event. *Frequency analysis of the discharges of the river Ahr at the gauge Altenahr (data: Landesamt für Umwelt Rheinland-Pfalz, HERGET & ROGGENKAMP 2015).*

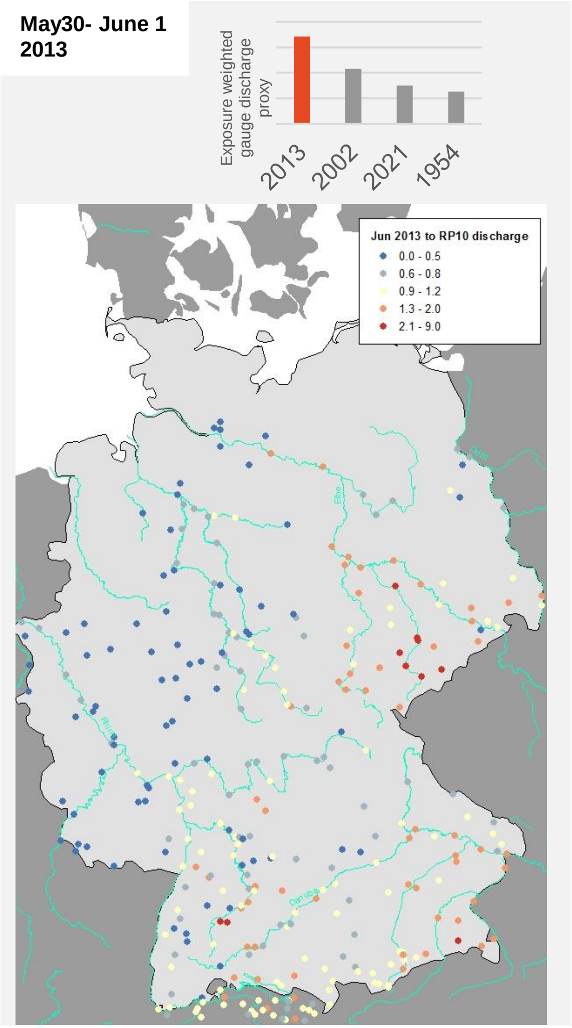
- Fluvial flood risk - extreme rainfall considers the risk from flash-flooding but what about periods of prolonged rainfall across the broader river network?
- The extreme catastrophe of 1804 is likely to have been a 300- to 500-year event, although an uncertainty range of up to a return period of 1,000 years is appropriate.
- According to KAA's evaluation, **the flood of July 2021 can thus be classified as a 100- to 250-year event, just like the flood of 1910, <u>for the region.</u>**

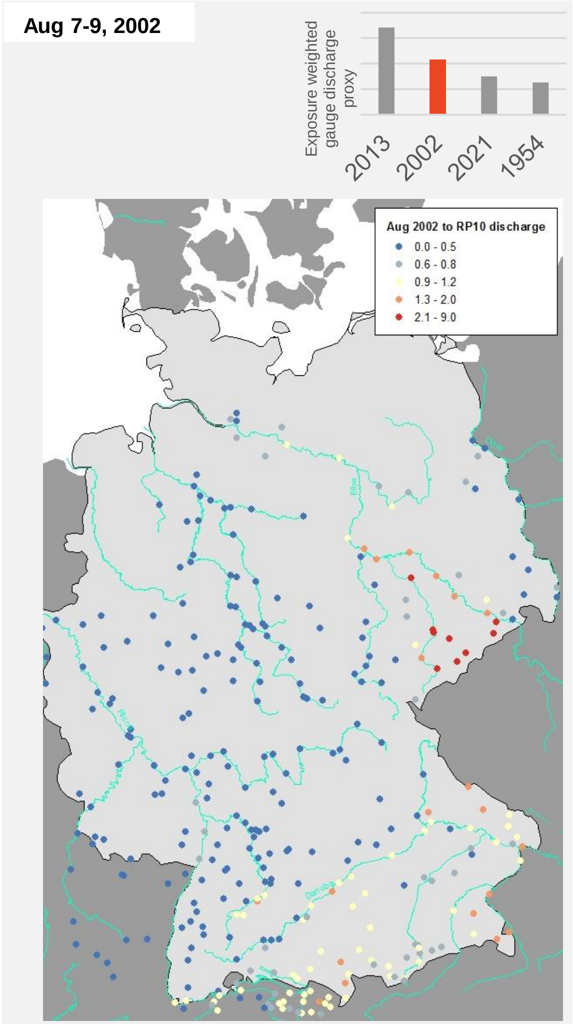
However a need to also consider all gauges in combination

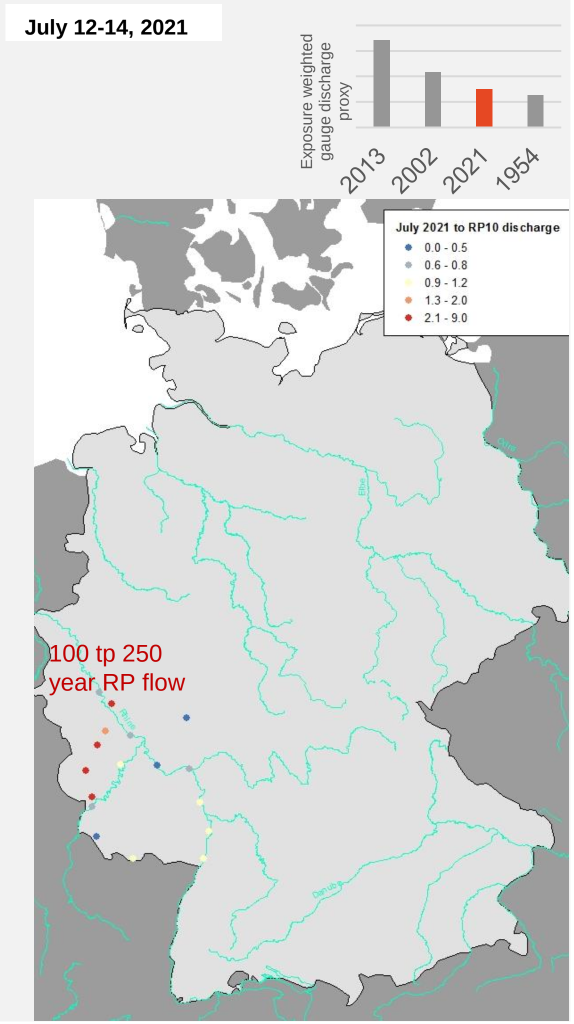
A truly extreme event – for that region, though with historical precedent

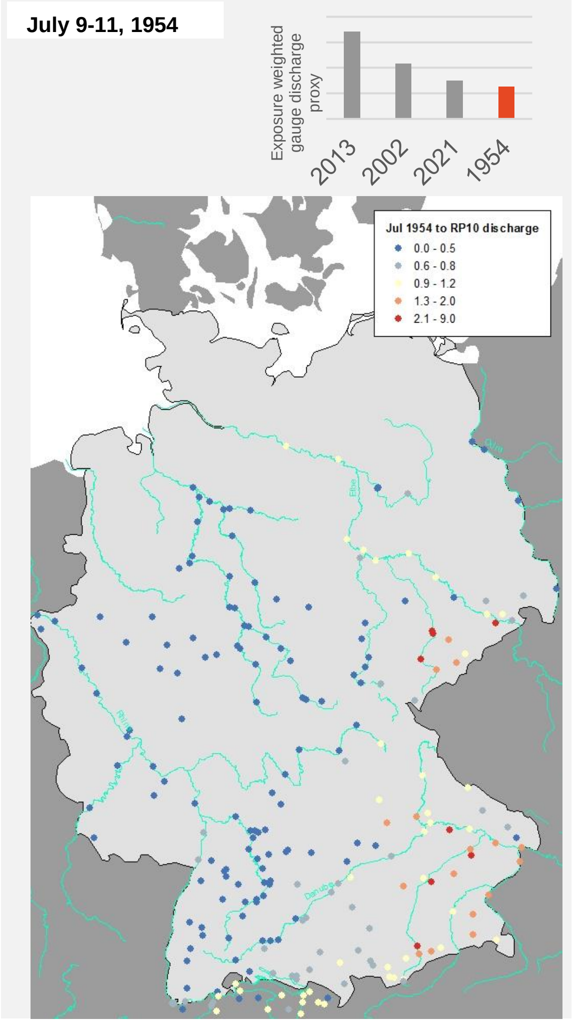
The challenge in estimating return periods – *river discharge index*









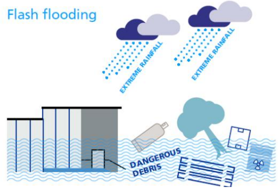


Exposure weighted river discharge index: *peak monthly discharge relative to 10 year RP discharge (above), this ratio squared weighted by exposure shown (top). (Source data: German Federal Waterways and Shipping Administration (WSV), German Federal Institute of Hydrology (BfG))*

Largest loss proxy

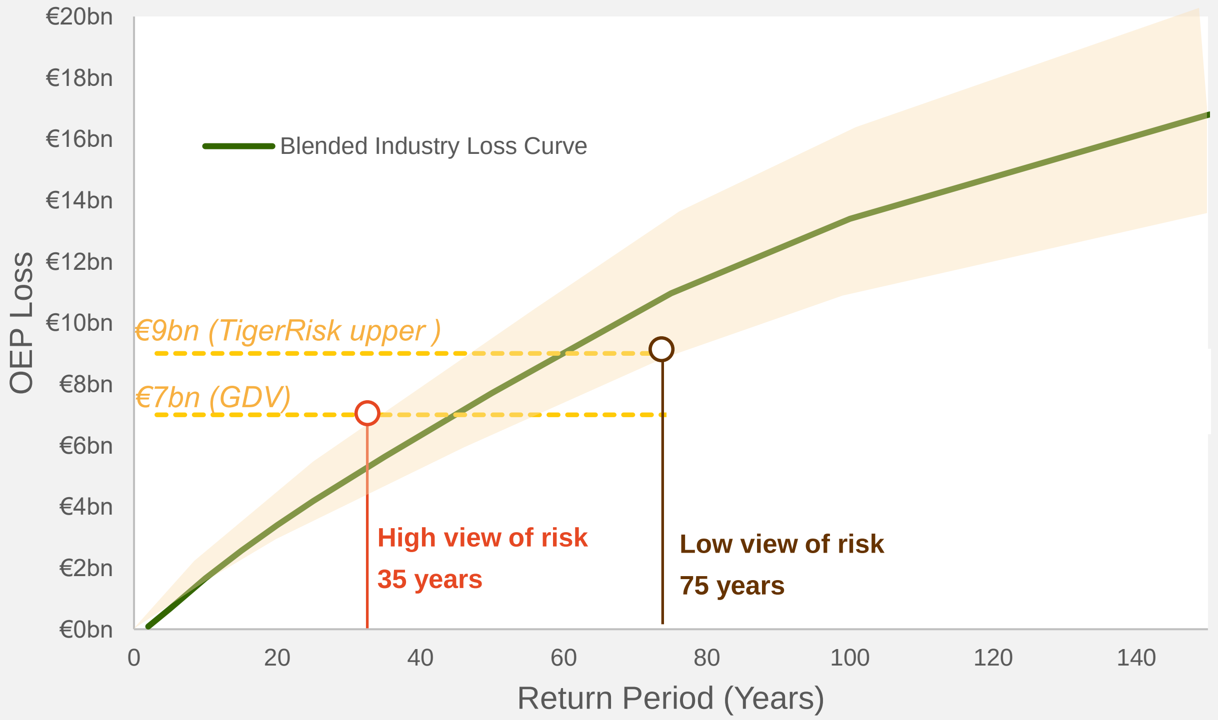
The river discharge index suggests the 2021 Bernd flood was the third largest 'river flood' loss event in 70+ years

Smallest loss proxy



The challenge in estimating return periods

Loss into second or third layers – 35 to 75 years is a potential loss return period for the industry

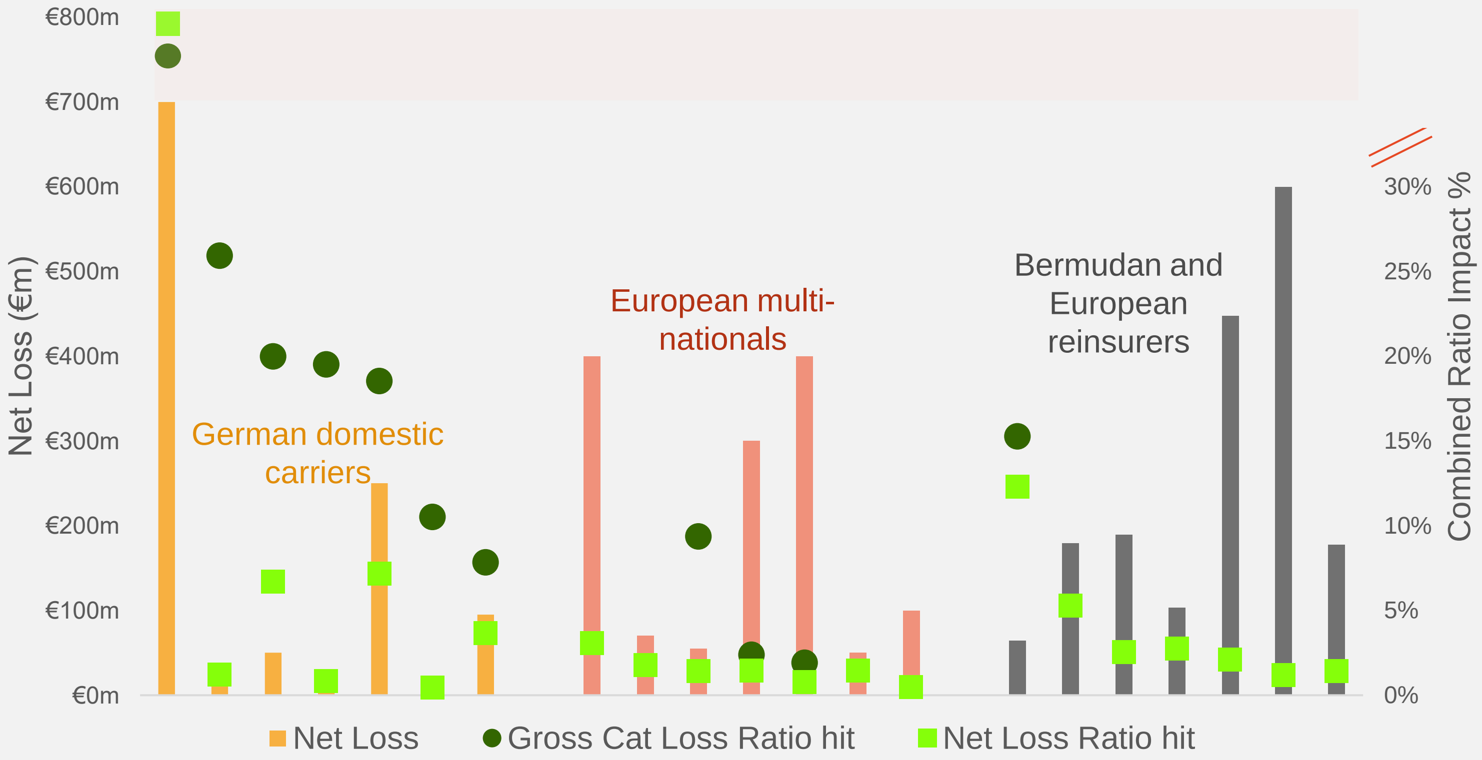


2021 'Bernd' insured losses in Germany between a 35 and 75 loss return period.

Conclusions on the return period analysis

- **35 to 75 year return period appears reasonable** – the 2021 extreme rainfall and discharge event characteristics have occurred more frequently than a 1 in 100 year probability, albeit less frequently than a 1 in 25 year probability would suggest. Is summer flood its own peril?
- **Climate impacts**: whilst the extreme rainfall and discharge event characteristics have occurred in history should summer floods be considered a separate peril to winter floods? It may be important to stress-test the impact of more 'Vb' summer extreme rainfall events occurring.
- **A new peak peril:** given the likely increase in insurance penetration is flood the most significant cat peril for short and long periods?

How were cedants and reinsurers impacted by the event?



The German insurance market is regionally fragmented. The loss impact therefore is unevenly distributed.

Most European multi-national insurers have a net combined ratio impact of less than 5% (1.5% is the average).

The event was largely reinsured. Reinsurers net combined ratios were, in some cases, significantly impacted with an average of 4% NCR points.

Net Loss size and combined ratio impact as at December 2021. *Ordered left to right by gross combined ratio impact, if available. Source: publicly available data and TigerRisk analysis*

How did the event impact the reinsurance market?

- Local cedants' experience varied significantly given the fragmented nature of the market. The multi-nationals were less impacted, relatively speaking. **The event was largely reinsured.**
- European Flood is a known modelled peril but certain **amplifying non-modelled factors** increased the severity of the event.
- Predominantly a reinsured event it has led to some **restructuring of programs and repricing for the risk.**
- Inclusive of the infrastructure losses, **this was a €30bn + event**, this has ramifications for how international flood risk is perceived

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