

From radar-based heavy rainfall event monitoring to impact assessment *(an example from Germany)*

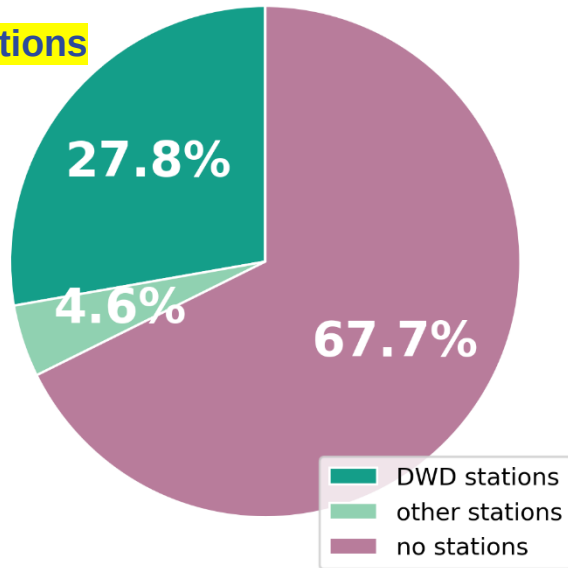


Ewelina Walawender, Dr. Katharina Lengfeld, Dr. Tanja Winterrath, Elmar Weigl

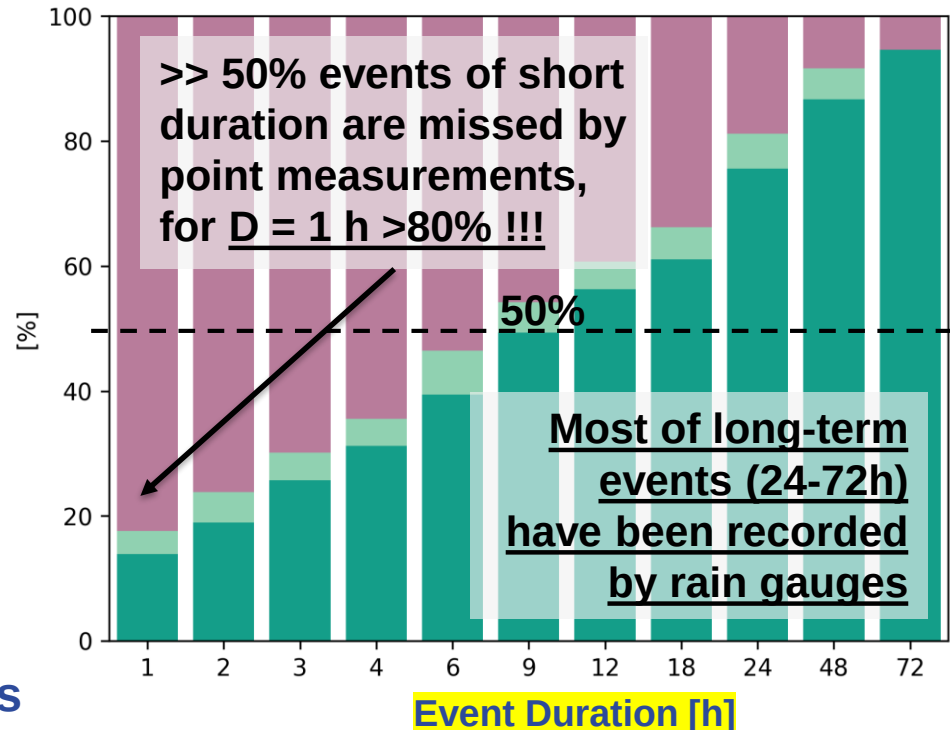
Deutscher Wetterdienst, Hydrometeorology, Offenbach am Main, Germany

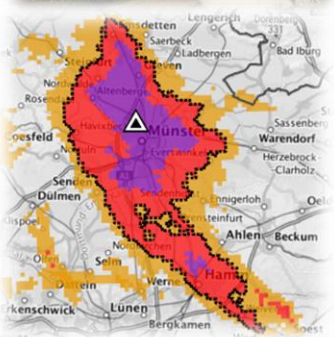
Percentage of extreme events (2001-2021, D: 1-72h) that were **measured** or **missed** by the precipitation stations

All Durations



→ percentage of detected events decreases with shorter durations





From radar-based heavy rainfall event monitoring to impact assessment (an example from Germany)

1

Radar - derived Datasets

2

Operational Event Monitoring

3

Impact Assessment

4

Outcome

1 Radar-derived Rainfall - Datasets for Germany

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



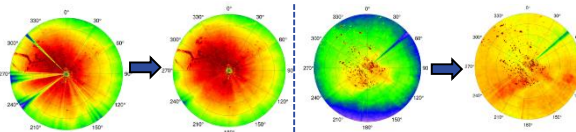
- **RADOLAN**: radar-based reflectivity measurements adjusted to station-based precipitation totals (operational)
- **RADKLIM**: re-processed RADOLAN (extended and corrected for typical measurement errors), **21 years (2001 - 2021)** of radar data for **Germany** with **1 km** spatial and **1 hour** temporal resolution

RADOLAN (real-time)

RADKLIM (annually updated)

→ Additional weather stations
(Better quantitative data)

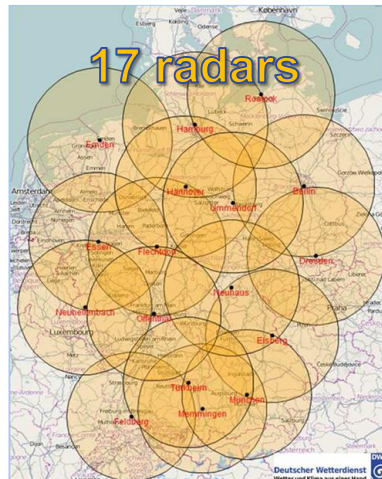
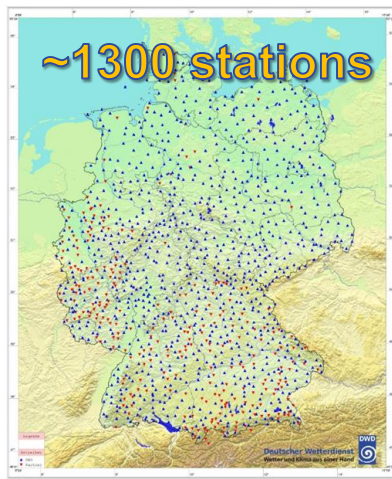
→ Correction procedures
(Spoke, Distance, Clutter. . .)



Download: opendata.dwd.de

DOI: [10.5676/DWD/RADKLIM_RW_V2017.002](https://doi.org/10.5676/DWD/RADKLIM_RW_V2017.002)

http

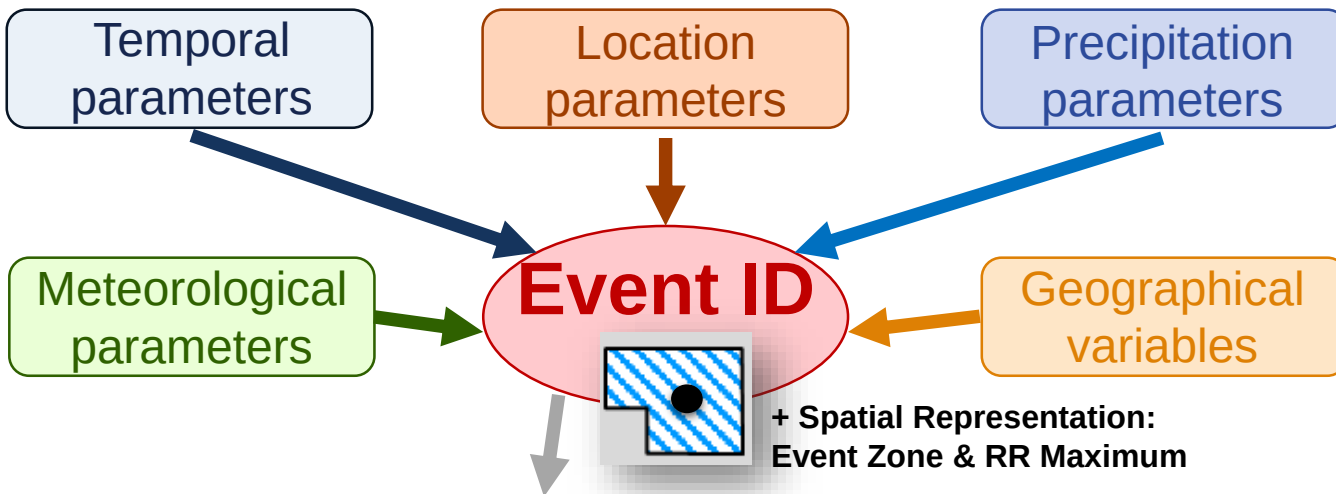


“CatRaRE” → Catalogue of Radar-based heavy Rainfall Events

- Contains all short-term and long-term heavy rain events in Germany from 2001 to 2021 (annual update)
- Two variants: **W3**: Events with **Precipitation Sum $\geq$ Warning Level 3 (Severe Weather)**
T5: Events with **Return Period $\geq$ 5 Years**
- Event identification for various durations:
1, 2, 3, 4, 6, 9, 12, 18, 24, 48 and 72h
- No overlap in space and time
- Based on Radar Climatology Dataset **RADKLIM**
- BUT** Operational monitoring based on **RADOLAN Data**
(Radar Online Calibration)

Event choice based on the
highest **Extremity***

* **EXTREMITY ($E_{T,A}$)** - combination of Event Area and its Return Period based on concept of Weather Extremity Index (WEI) by Müller and Kaspar (➔ [Source Paper](#))



+ extension with other attributes is possible (e.g. for our projects: fire brigades operations, insurance data, air temperature and wind parameters...)



Download:

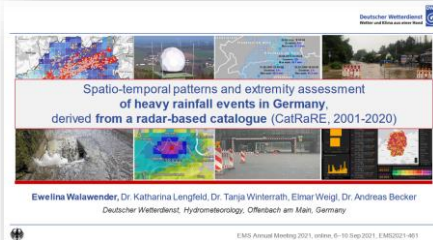
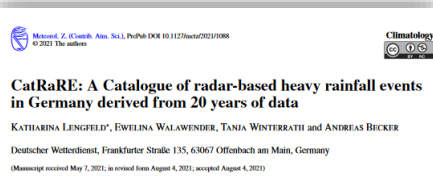
opendata.dwd.de/climate_environment/CDC/event_catalogues/



Learn more about CatRaRE

INTERESTED? → DISPLAY MATERIAL

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



CatRaRE PAPER:

Lengfeld, K., Walawender, E., Winterrath, T., Becker, A., 2021, *CatRaRE: A Catalogue of radar-based heavy rainfall events in Germany derived from 20 years of data*, Meteorologische Zeitschrift, DOI: [10.1127/metz/2021/1088](https://doi.org/10.1127/metz/2021/1088).

EMS2021 TALK:

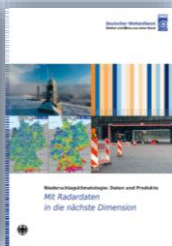
Walawender, E., Lengfeld, K., Winterrath, T., Weigl, E., and Becker, A.: *Spatio-temporal patterns and extremity assessment of heavy rainfall events in Germany, derived from a radar-based catalogue (CatRaRE, 2001-2020)*, EMS Annual Meeting 2021, online, 6–10 Sep 2021, EMS2021-461, <https://doi.org/10.5194/ems2021-461>, 2021

https://presentations.copernicus.org/EMS2021/EMS2021-461_presentation.pdf

In German?

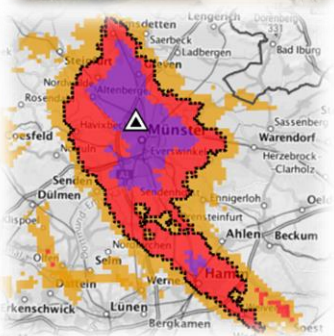


click on the
miniature to open
the publication



Or simply... → [**dwd.de/catrare**](https://dwd.de/catrare)





From radar-based heavy rainfall event monitoring to impact assessment (an example from Germany)

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Radar - derived Datasets

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Impact Assessment

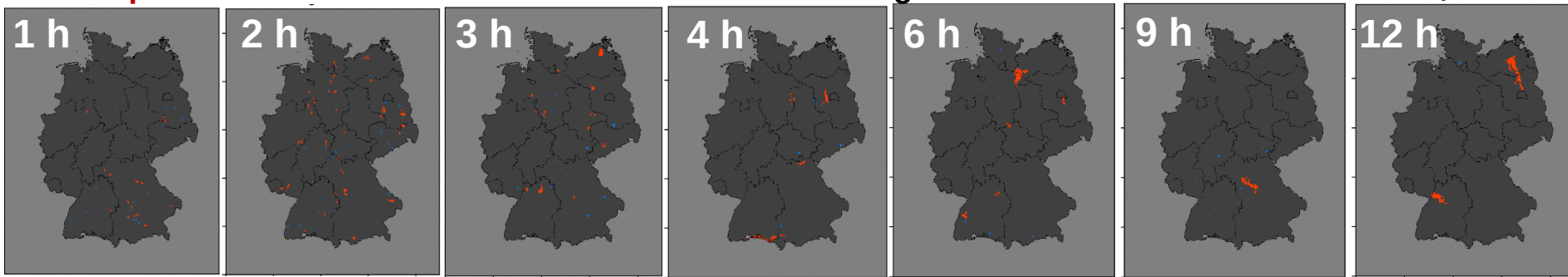
4

Outcome

2 Operational Event Monitoring (“ExRain”)

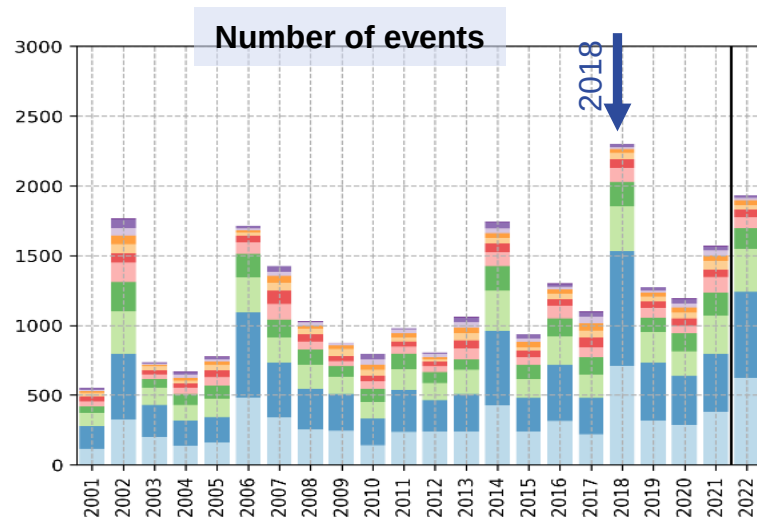
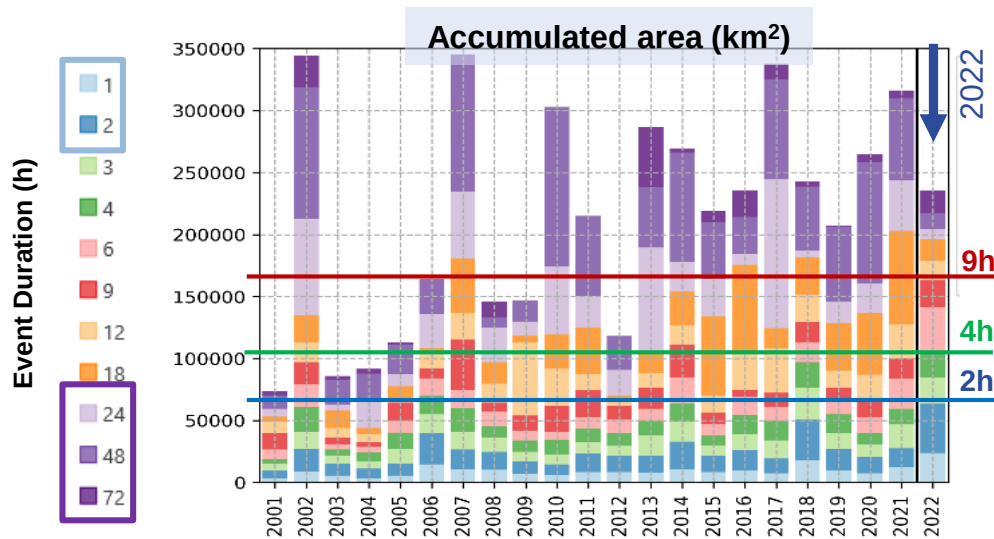
- **Event-monitoring** based on CatRaRE methodology and software
- Databasis - realtime **RADOLAN-data**
- **Fully operational, hourly updated**
- Events detection **iterative** for each of **11 CatRaRE- Durations (1 to 72h)**
- **Basic attributes + spatial representation**
- ...since 2020 (allows for an **overall statistics for the current year**)

Example: Events detected for variuos durations on 27. Aug 2022 05:50 UTC



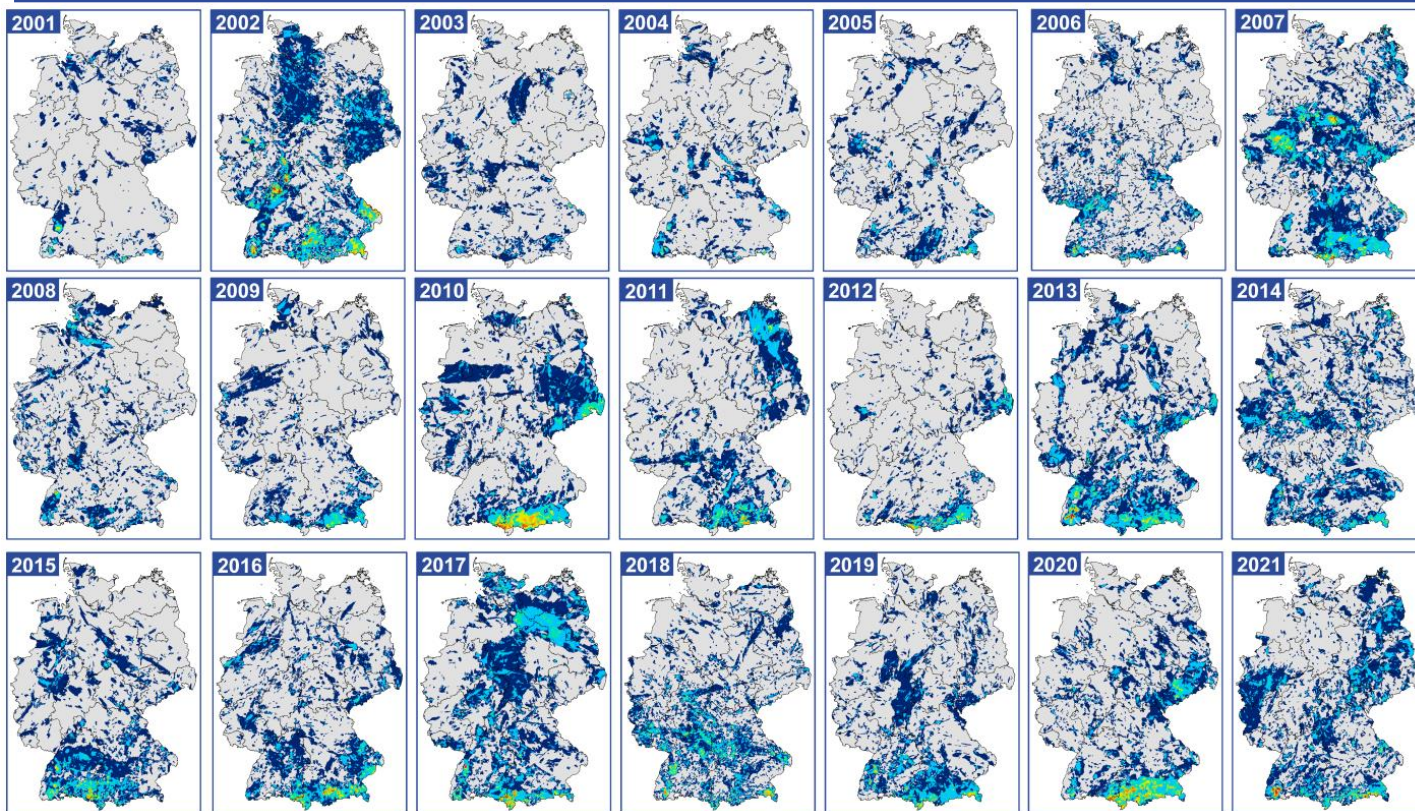
2 Current statistic for Germany (CatRaRE 2001-2021 + ExRain 2022)

- Large **Areas** mainly caused by events with **long durations** (*violet colours*)
- **Number** of extreme events dominated by **short durations** (*blue colours*)
- Despite being a very **dry year** on average, **most events** occurred in **2018**; 2nd : 2022 (!)
- **Year 2022 (Jan-Aug)** already with the **biggest area** affected by short-term events (1-9 h)

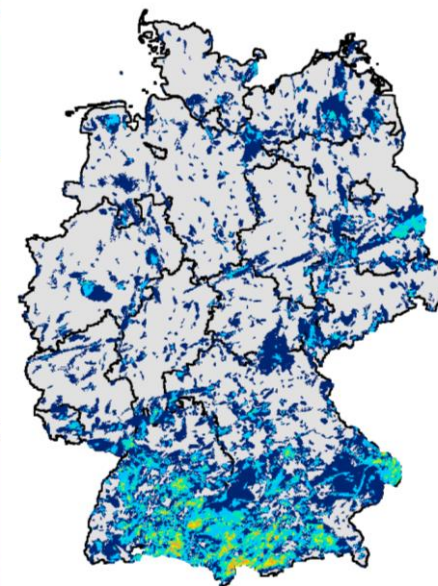


2 Current statistic for Germany (CatRaRE 2001-2021 + ExRain 2022)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

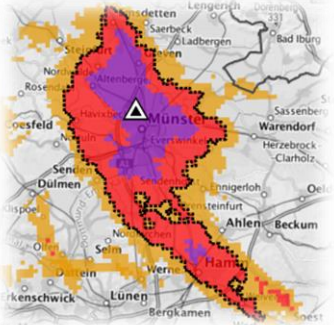


Jan-Aug 2022



Event Count





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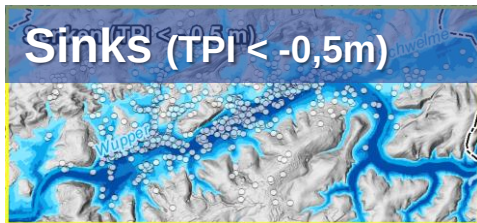
Impact Assessment

4

Outcome

Topographic Position Index [m]

≤ -50 ≤ -25 ≤ -10 ≤ -5 ≤ -0.5 > -0.5



~ Endangering

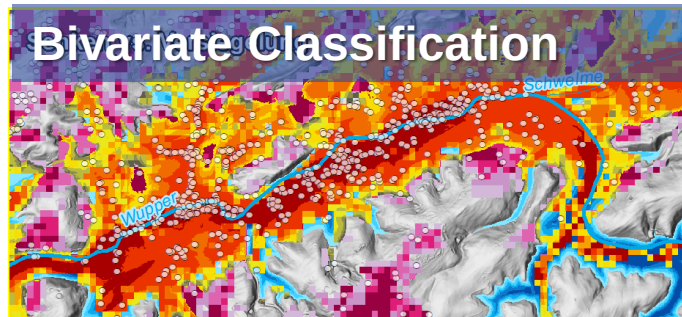
Sealing Degree [%]

< 10 ≥ 10 ≥ 20 ≥ 30 ≥ 40 ≥ 50

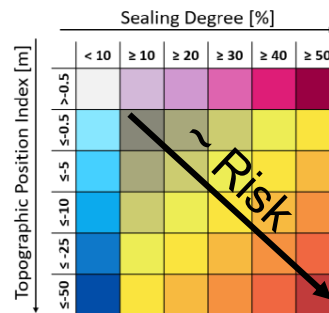


~ Damage potential

=



○ Fire brigade operations



“GeoRisk”

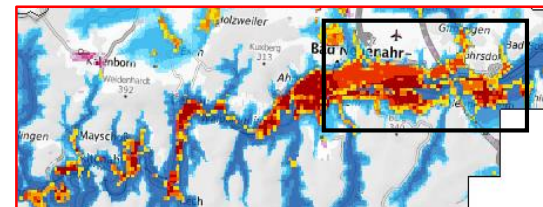
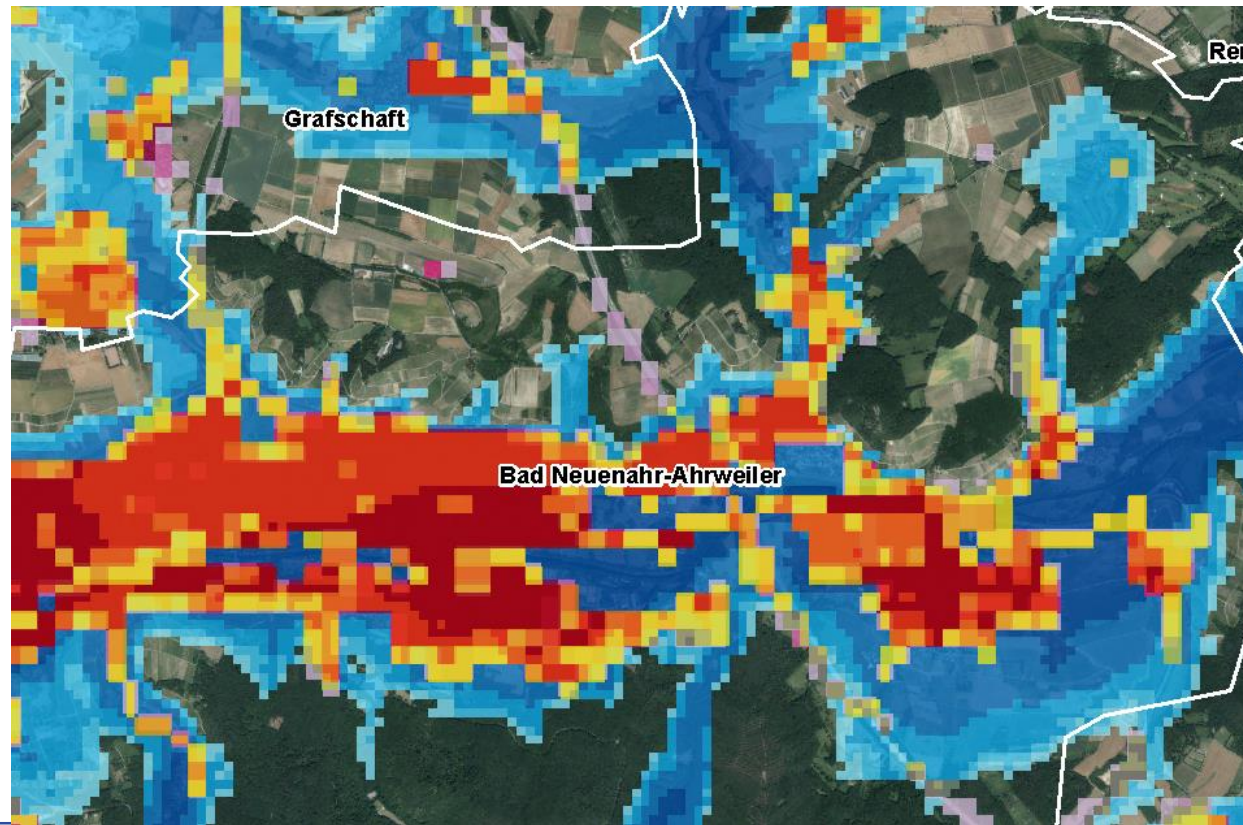
		Sealing Degree [%]					
		< 10	≥ 10	≥ 20	≥ 30	≥ 40	≥ 50
Topographic Position Index [m]	> -0.5						
	≤ -0.5		1	2	4	7	11
	≤ -5		2	4	7	11	16
	≤ -10		4	7	11	16	20
	≤ -25		7	11	16	20	23
	≤ -50		11	16	20	23	25

GeoRisk Values

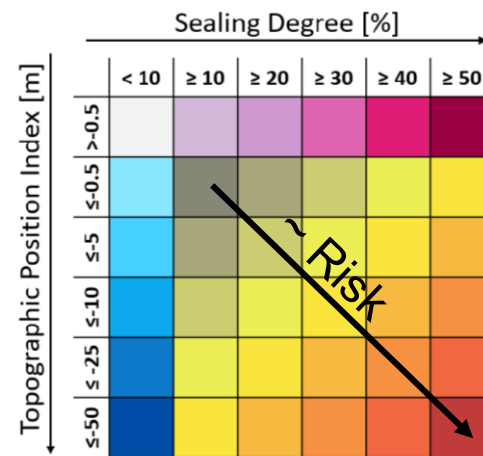
GeoRisk Sum – Sum of GeoRisk Values within a zone

GeoRisk Index - % of maximal possible GeoRisk Sum within a zone

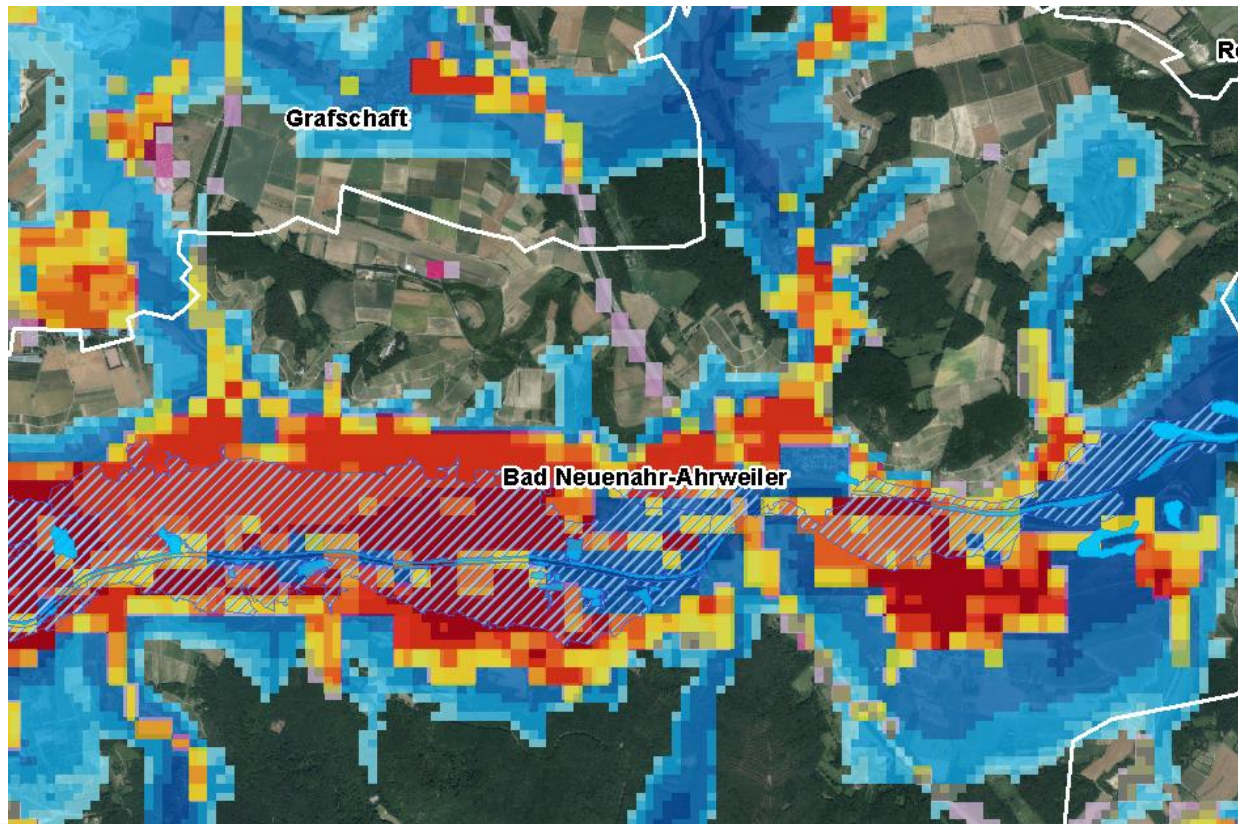
3 Impact Assessment – “GeoRisk”



Ahr Valley (flooded in July 2021)



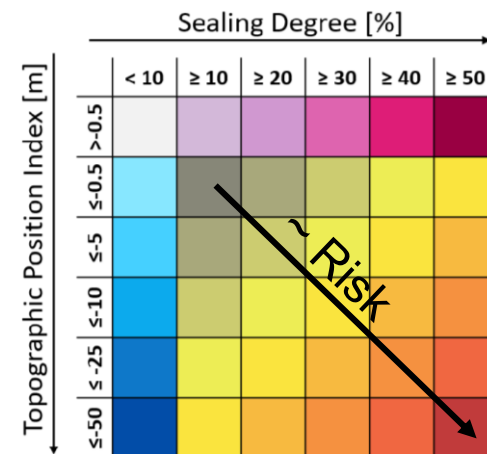
3 Impact Assessment – “GeoRisk”



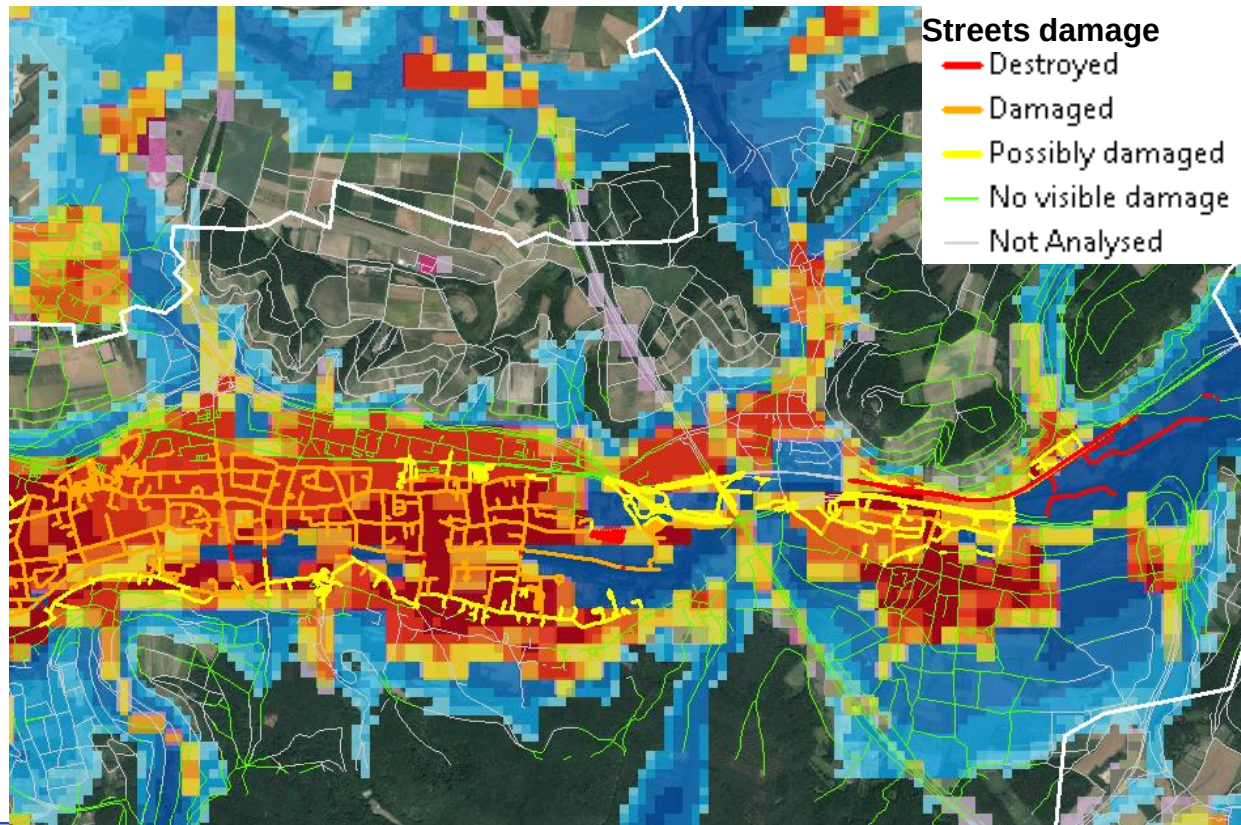
July 2021 Flood

CEMS (Copernicus
Emergency Management
Service) **Rapid Mapping**

→ Flooded area



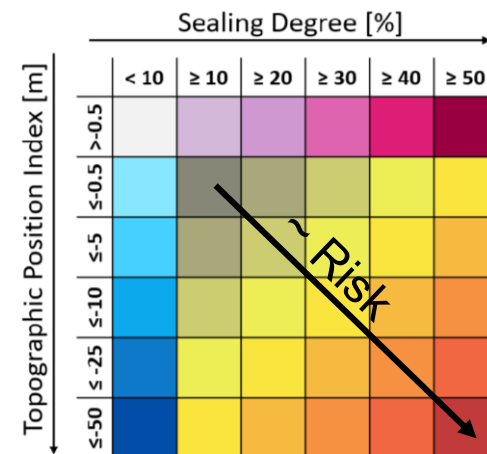
3 Impact Assessment – “GeoRisk”



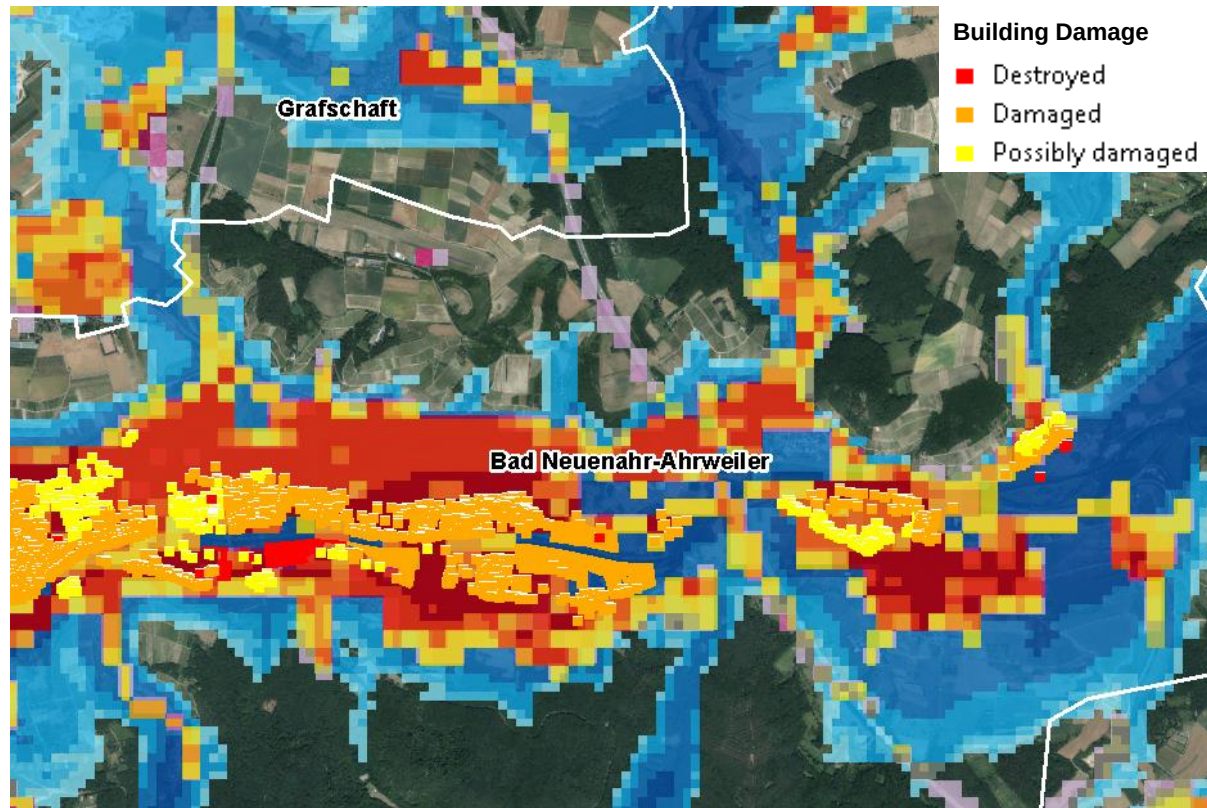
July 2021 Flood

CEMS Rapid Mapping

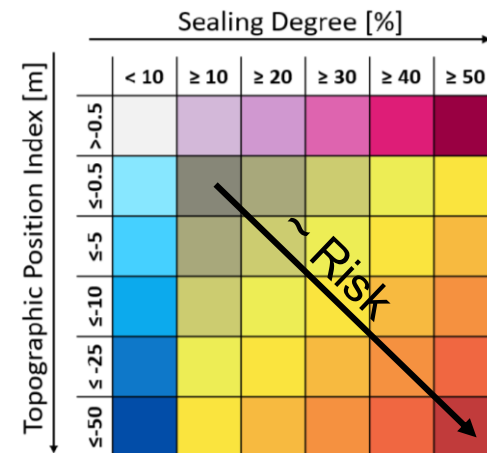
→ Damage monitor



3 Impact Assessment – “GeoRisk”



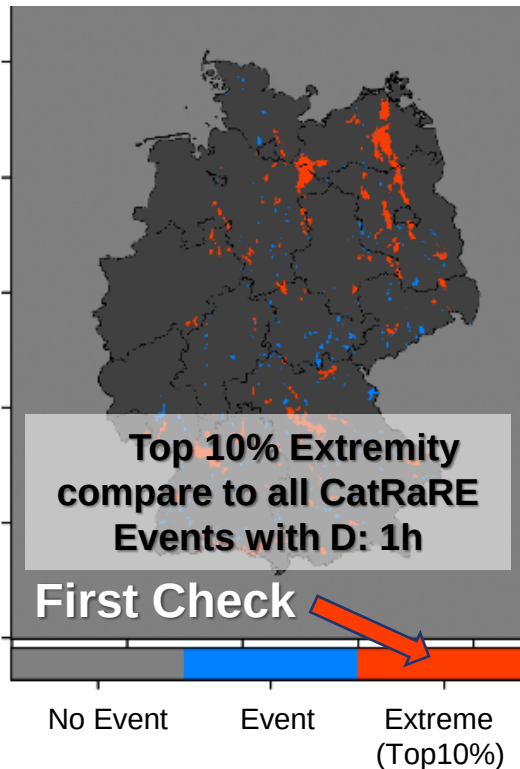
July 2021 Flood CEMS Rapid Mapping → Damage monitor



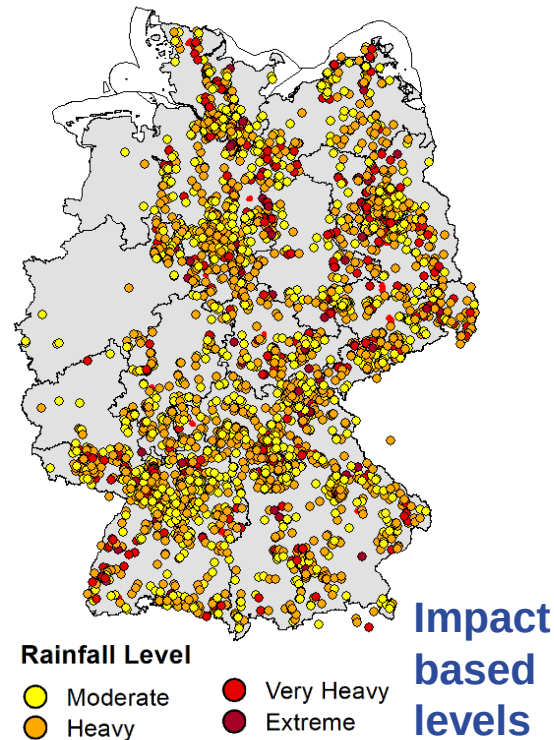
How to assess the impact for a single event from ExRain Monitoring?

Case Study

- 26. August 2022
- „Record Day“ > 300 detected Events in ExRain Monitoring !
- 26 hourly events only in 1h : 12:50 UTC - 13:50 UTC



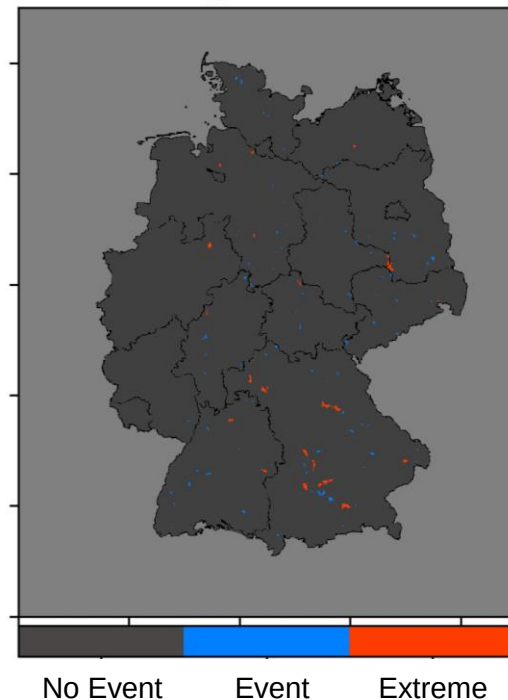
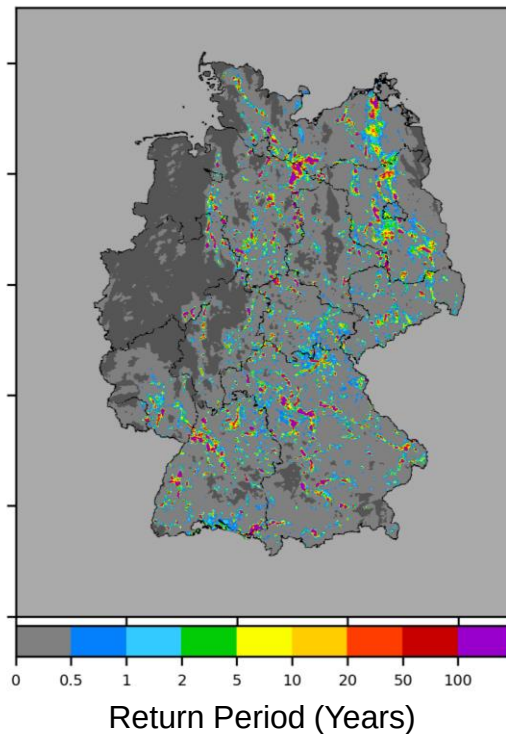
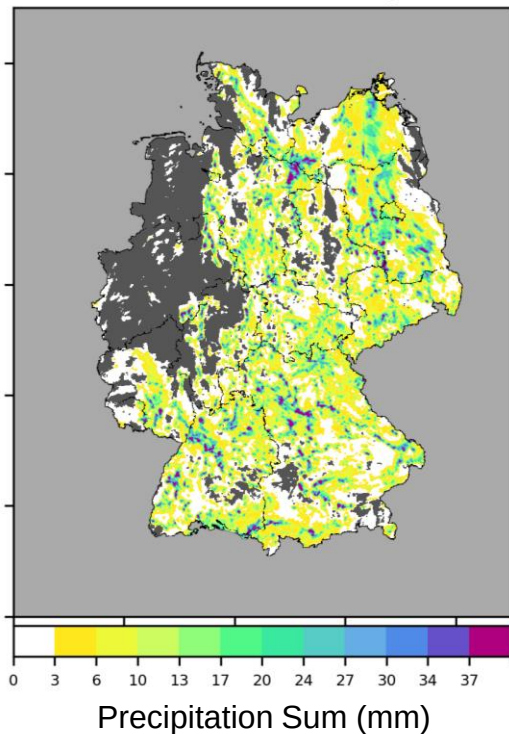
Crowd Data from WarnWetter App

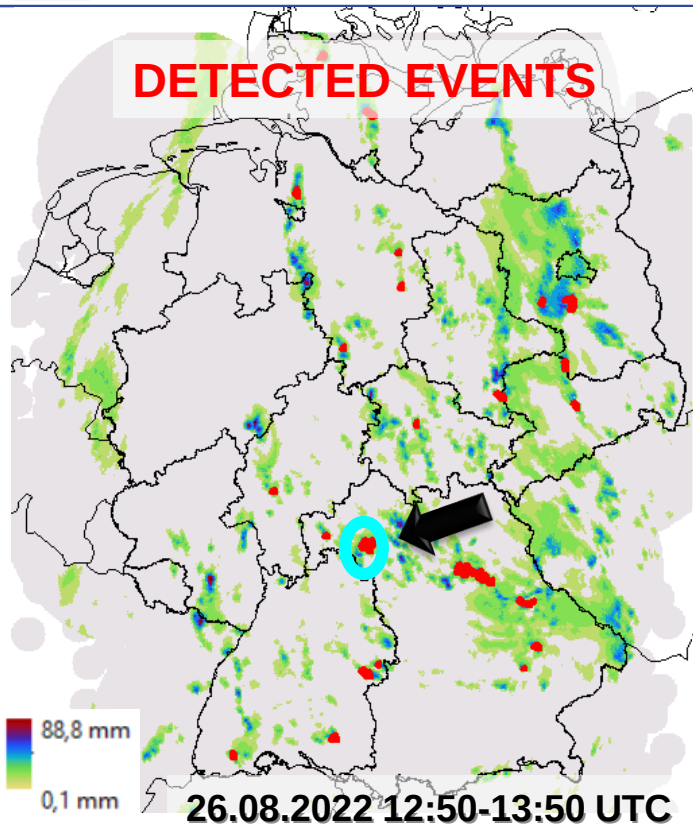


2 Operational Event Monitoring (“ExRain”)

Hourly Events (D: 1h) detected by ExRain on 26.08.2022 05:50 UTC – 27.08.2022 05:50 UTC

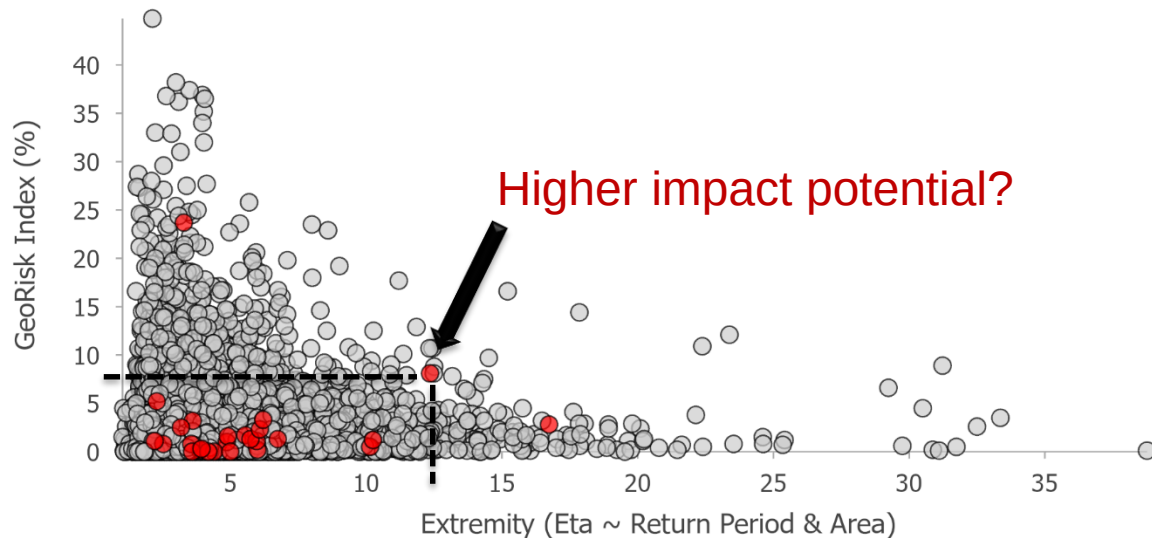
→ „Event“ if:
**Precipitation
Sum $\geq$ Warning
Level 3**
&
**No overlap in
time and space**
(Object with a
bigger
Extremity “Eta”
always wins)

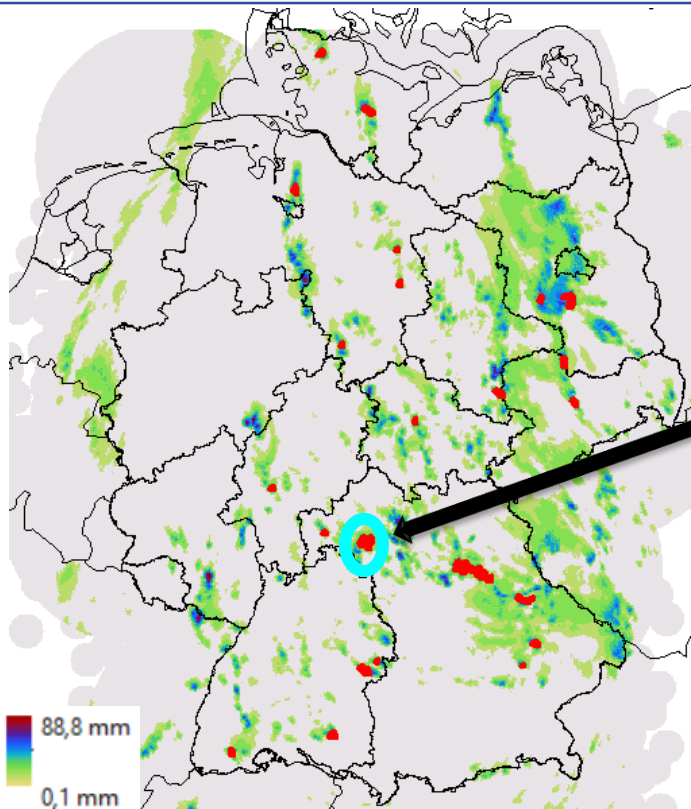




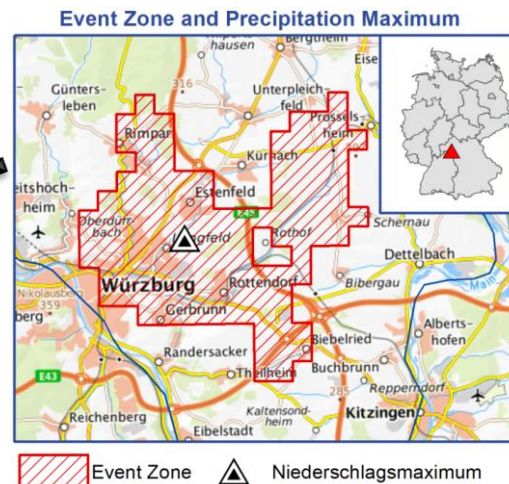
Step 1. Compare event attributes with CatRaRE looking for a possible impactful events

Events detected by ExRain vs. CatRaRE (D: 1h, 2001-2021)





Step 2. Look closer on the event basic characteristics (all derived from ExRain)



Start Time: 26.08.2022 12:50:00
Duration: 1 h
Area (only DE): 116 km²
RRmax / RRmean: 88.8 mm / 39.29 mm
SRImax / SRImean: 11 / 6
Tmax / Tmean: >> 100 Years / > 100 Years
Eta: 12.35

Location of the Maximum:

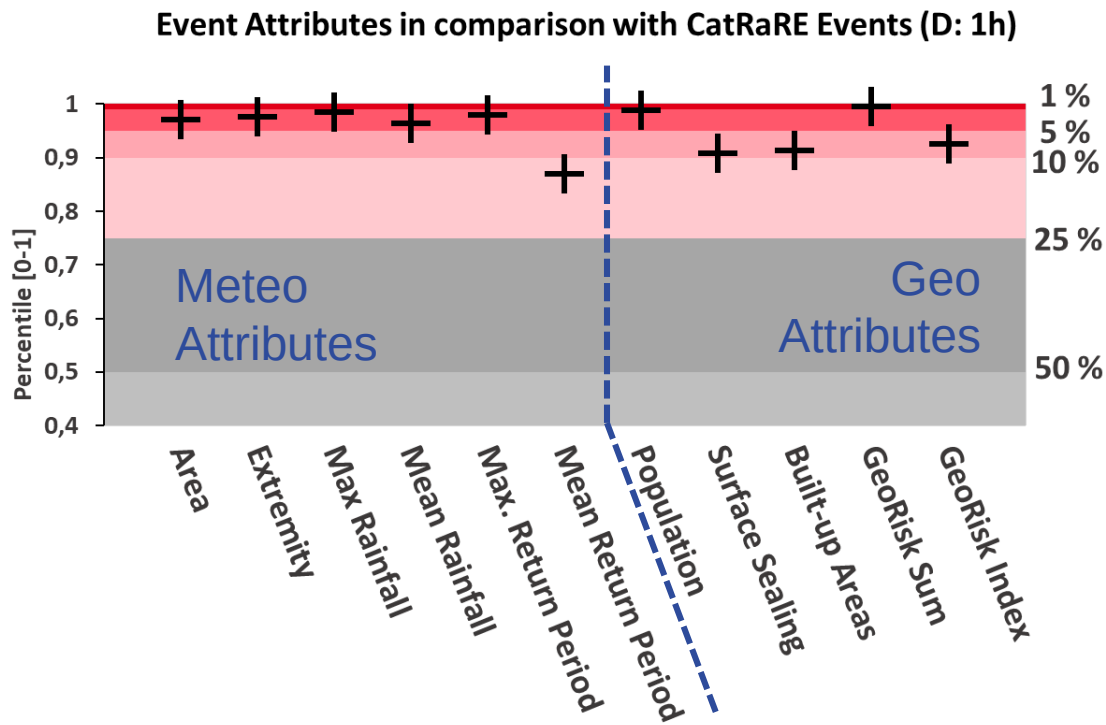
Bundesland: Freistaat Bayern
Landkreis: Kreisfreie Stadt Würzburg
County/City: Kreisfreie Stadt Würzburg

Step 3. Add additional “Geo-Variables”

- Population
- Built-up Areas Density
- Degree of Surface Sealing
- GeoRisk Sum & Index

and compare attributes with the CatRaRE past events of the same duration

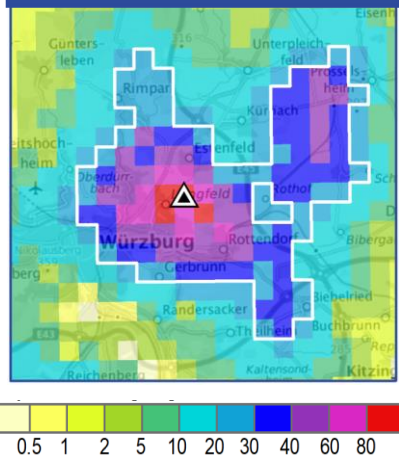
→ Check percentile (= Top %) of each attribute value



3 Impact Assessment

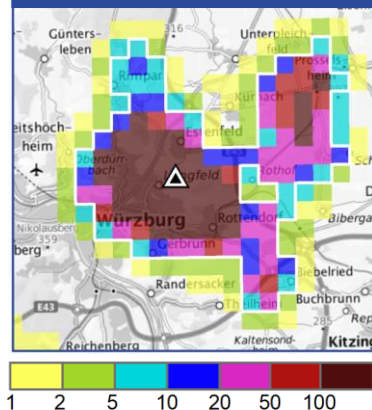
Step 4. Look closer on the spatial variability within the event zone

Precipitation Sum (mm)

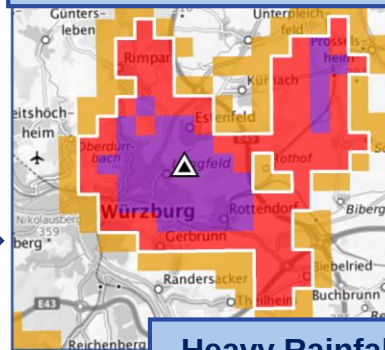


„Translated“ to user-friendly representation

Return Period (Years)

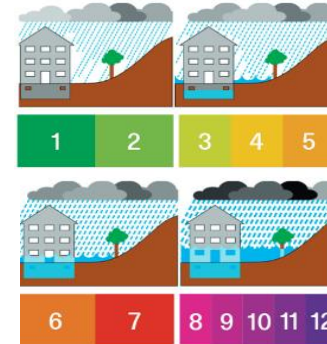
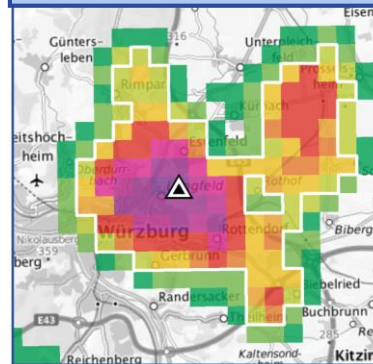


Level of Weather Warning (DWD Criteria for Rainfall)



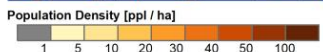
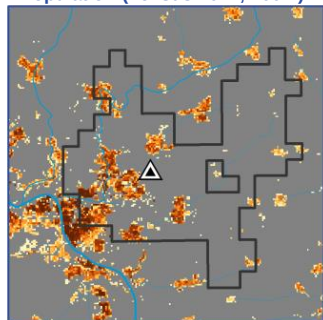
- Warnings of extreme weather (Level 4)
- Warnings of severe weather (Level 3)
- Warning of significant weather (Level 2)

Heavy Rainfall Index (SRI, based on [Schmitt](#))

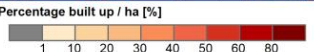
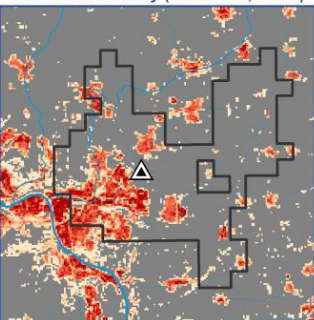


3 Impact Assessment

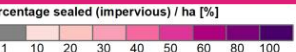
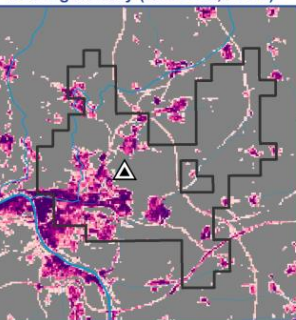
Population (Zensus 2011, 100m)



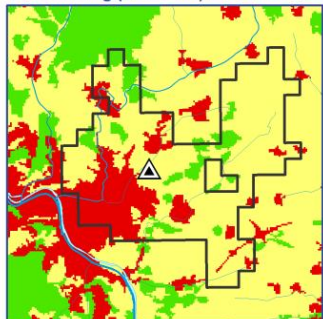
Settlement Density (ESM 2016, 100m)



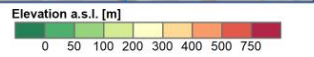
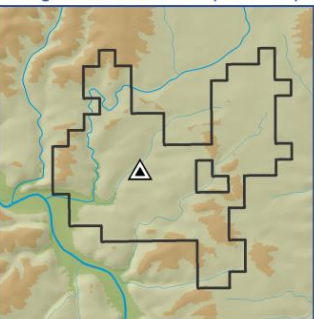
Sealing Density (IMD 2015, 100m)



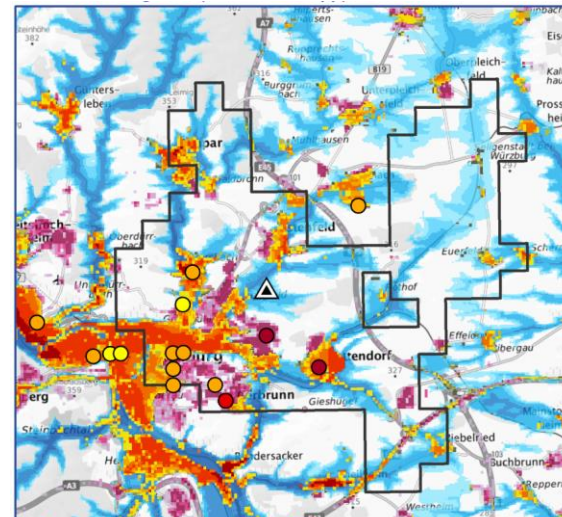
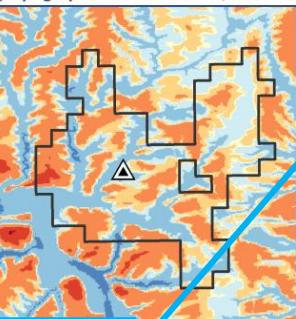
Landnutzung (CLC 2018) und Gewässer



Digital Elevation Model (DGM 50m)



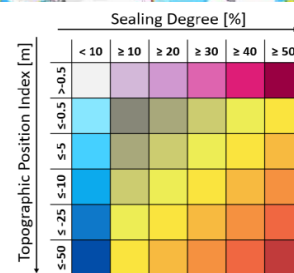
TPI (topographic position index, DGM 50m)



Crowd Data
(WarnWetter App)

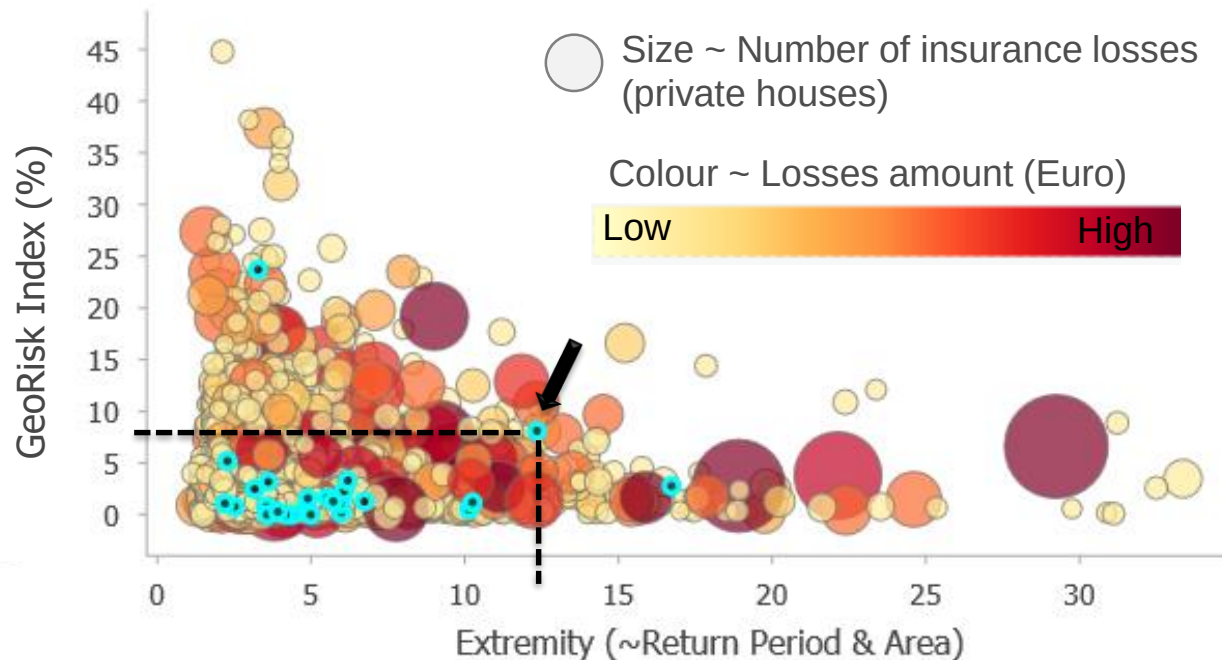
Rainfall Level

- Moderate
- Heavy
- Very Heavy
- Extreme



3 Impact Assessment – Possible Losses?

Events from ExRain Monitoring vs. CatRaRE (W3Eta 2001-2021)

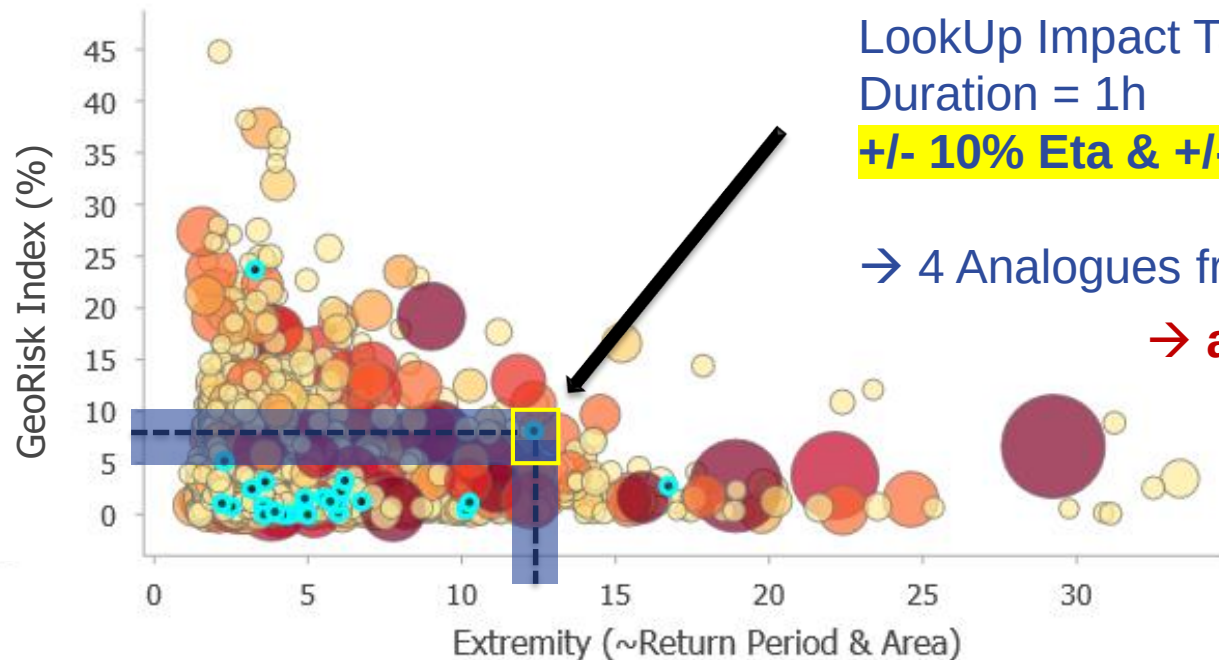


derived from GDV Data
(German Insurance
Association)

**Step 5. Assess possible
losses using CatRaRE
LookUp Table**

3 Impact Assessment – Possible Losses?

Events from ExRain Monitoring vs. CatRaRE (W3Eta 2001-2021)

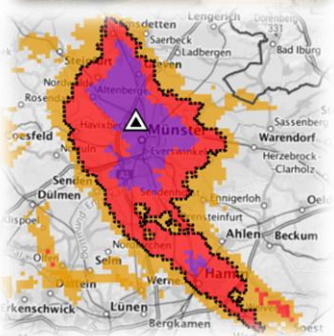


LookUp Impact Table:
Duration = 1h

+/- 10% Eta & +/- 10% GeoRisk Index

→ 4 Analogues from CatRaRE were found:

→ all 4 caused losses
(7 to 68 in amount of 3000
– 6400 EUR per loss)



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Outlook

- RADKLIM & CatRaRE annual Update (1st half of 2023)
- ExRain Monitoring based on hourly RADOLAN-online data for the current year
 - Extension of the event attributes with non-meteorological variables
 - Use of the CatRaRE for **Rankings + Analogues**
- Validation and further tests of combination of high-resolution risk variables for determination of **potential risk/impact of future events** (e.g in combination with **nowcasting tools**)
 - + validation of the “Analogues” approach
- Future Applications:
 - Implementation of the operational Impact Assessment in the hourly ExRain Monitoring and (???) Nowcasting/Forecast (e.g. RADVOR +6h, SINFONY +12h horizon)



Thank You for your attention!

- CatRaRE Event Catalogues : <https://www.dwd.de/catrare>
- Radar Climatology Dataset - RADKLIM: <https://www.dwd.de/radklm>

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