



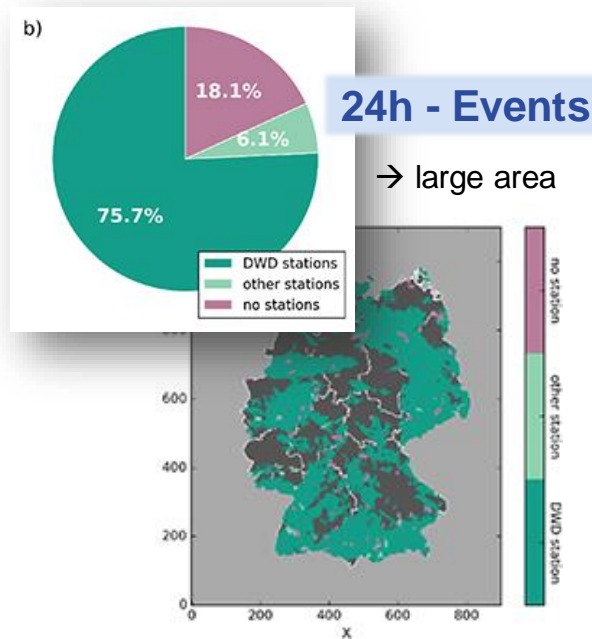
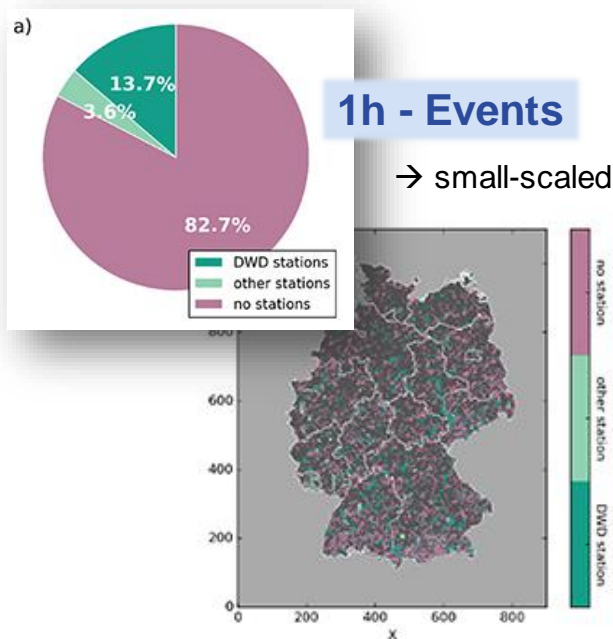
# Spatio-temporal patterns and extremity assessment of heavy rainfall events in Germany, derived from a radar-based catalogue (CatRaRE, 2001-2020)



**Ewelina Walawender, Dr. Katharina Lengfeld, Dr. Tanja Winterrath, Elmar Weigl, Dr. Andreas Becker**

*Deutscher Wetterdienst, Hydrometeorology, Offenbach am Main, Germany*

## Percentage of extreme events (2001-2018) that were measured or missed by the DWD precipitation stations



→ percentage of detected events decreases with shorter durations

→ only **33% of all events have been recorded** by rain gauges (more than **75% observed for D = 24h**)

→ the **events of short duration are rarely recorded** by the point measurements (**82.7% missed for D = 1 h**)

**MORE:** Katharina Lengfeld et al, 2020  
Environ. Res. Lett. 15 08500,  
<https://doi.org/10.1088/1748-9326/ab98b4>



*Spatio-temporal patterns and extremity assessment  
of heavy rainfall events in Germany,  
derived from a radar-based catalogue (CatRaRE, 2001-2020)*

**1**

**Radar Climatology**

**2**

**Catalogue of extreme precipitation events**

**3**

**Spatio-temporal patterns**

**4**

**Applications of the CatRaRE Catalogue**



# 1 Radar climatology (RADKLIM)

Deutscher Wetterdienst  
Wetter und Klima aus einer Hand



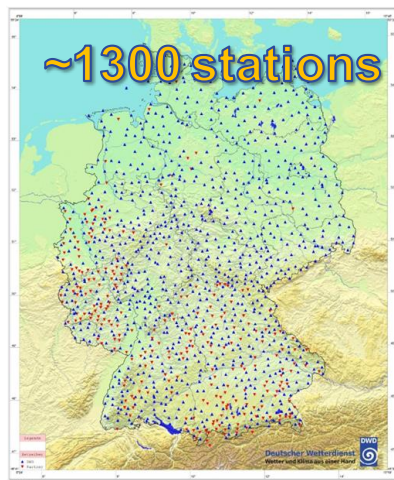
- 20 years (2001 - 2020) of re-processed radar data for Germany
- with 1 km spatial and 1 hour temporal resolution
- radar-based reflectivity measurements adjusted to hourly station-based precipitation totals and corrected for typical measurement errors applying specific climatological correction methods

## RADOLAN (real-time)

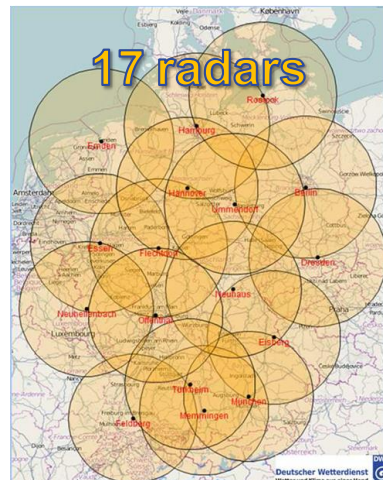
## RADKLIM (annual updated)

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

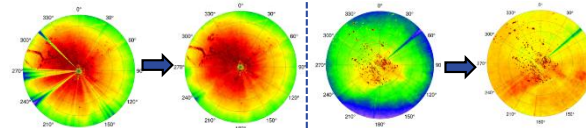
→ Additional weather stations  
(Better quantitative data)



+



+



Download: [opendata.dwd.de](https://opendata.dwd.de)

DOI: [10.5676/DWD/RADKLIM\\_RW\\_V2017.002](https://doi.org/10.5676/DWD/RADKLIM_RW_V2017.002)







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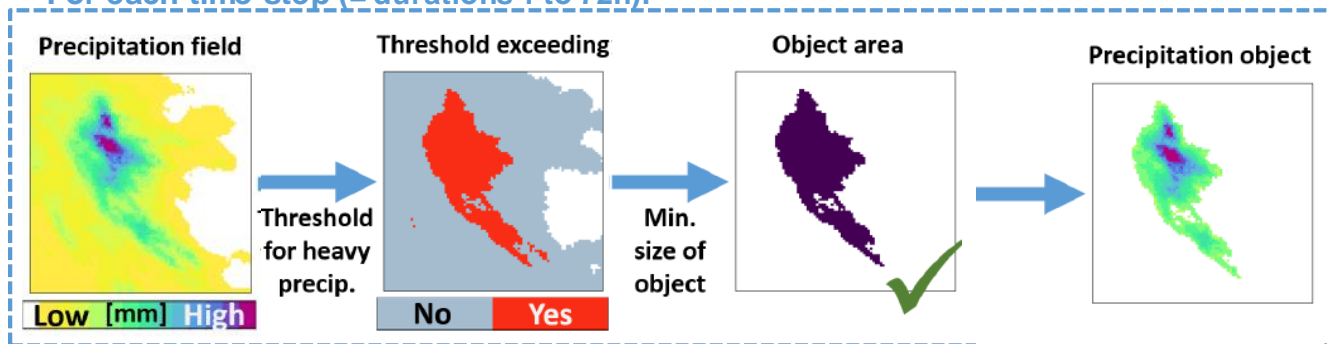
**Applications of the CatRaRE Catalogue**

## How to define an extreme event?

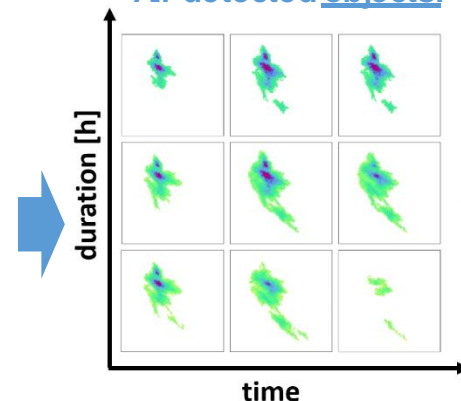
### → What is extreme?

- Precipitation rates (pixel) with **return periods** of at least **5 years (=T5 Catalogue)** *or*
  - Precipitation rates (pixel) exceeding the **DWD warning level 3 (=W3 Catalogue)**
  - **11 durations** between 1 and 72 hours (1, 2, 3, 4, 6, 9, 12, 18, 24, 48 and 72 hours)
  - Duration-dependent **minimal size** of a contiguous area
- } **objects** for each analyzed duration and time step

For each time step (= durations 1 to 72h):



All detected objects:

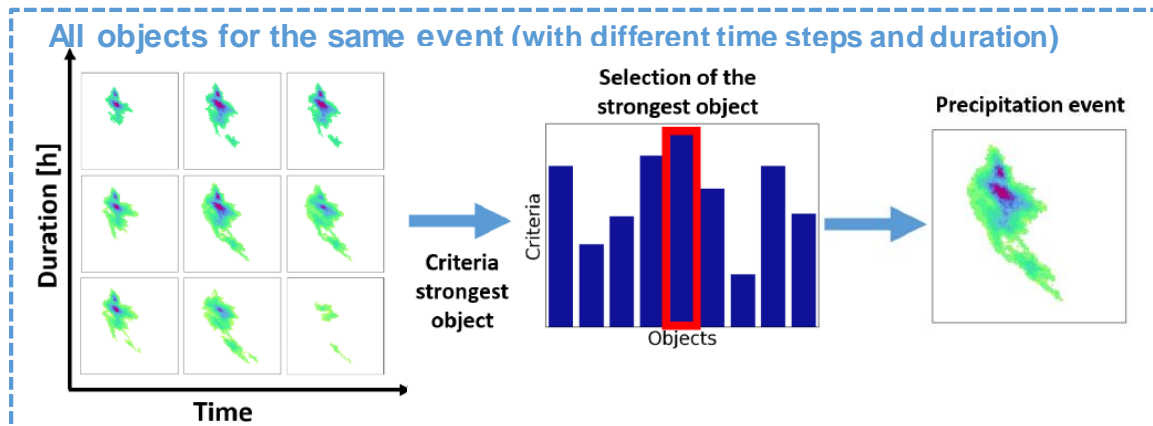


# From objects to an extreme event?

## → How to define an independent event ?

- Selection of the objects with **highest extremity\***: combination of mean **return period** and **area**
- **No spatial overlapping** of the detected objects of different durations
- **Temporal minimum distance** referring to the lower duration (but at least 4h)

**events**  
with  
characteristic  
duration



### \* EXTREMITY ( $E_{T,A}$ )

based on concept of Weather Extremity Index (WEI) by Müller and Kaspar

**Source:** Müller, M. and Kaspar, M.: Event-adjusted evaluation of weather and climate extremes, Nat. Hazards Earth Syst. Sci., 14, 473-483, doi:10.5194/nhess-14-473-2014, 2014




For all detected **events** the following **ATTRIBUTES** are determined:

- catalogue type, event ID
- **temporal parameters**: start and end time, duration
- **spatial parameters**: affected area, coordinates, state, county and district of the grid cell with maximum precipitation, proportion of the event area [%] in Germany
- **precipitation statistics**: mean and maximum precipitation, return period, heavy precipitation index (SRI) and extremity ( $E_{ta}$ ) within the event area
- **meteorological parameters**: weather type at start and end time of the event according to DWD's objective weather classification, 21- and 30-days antecedent precipitation index
- **additional geographical variables**: population, degree of settlement, degree of sealing, land use, elevation a.s.l. and topographic position index (TPI)

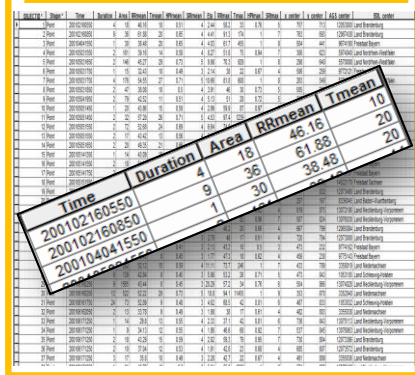
**+ extension with other attributes is possible** (e.g. for our projects: fire brigades operations, insurance data, air temperature and wind parameters... )

## CatRaRE Catalogues

- \* CatRaRE\_W3\_Eta
- \* CatRaRE\_T5\_Eta

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

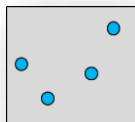
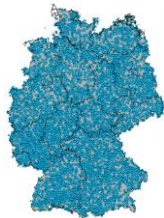
### Tabular form (.csv File)



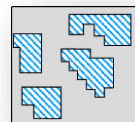
Time	Duration	Area	RRmean	Tmean
200102160550	4	18	48.16	10
200102160850	9	36	61.88	20
200104041550	1	30	38.48	20

### File Geodatabase (.gdb)

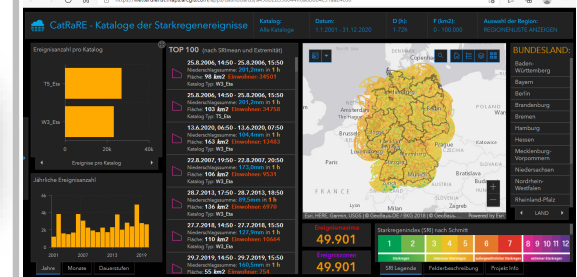
#### Event maxima (Point Feature Class)



#### Event zones (Polygone Feature Class)

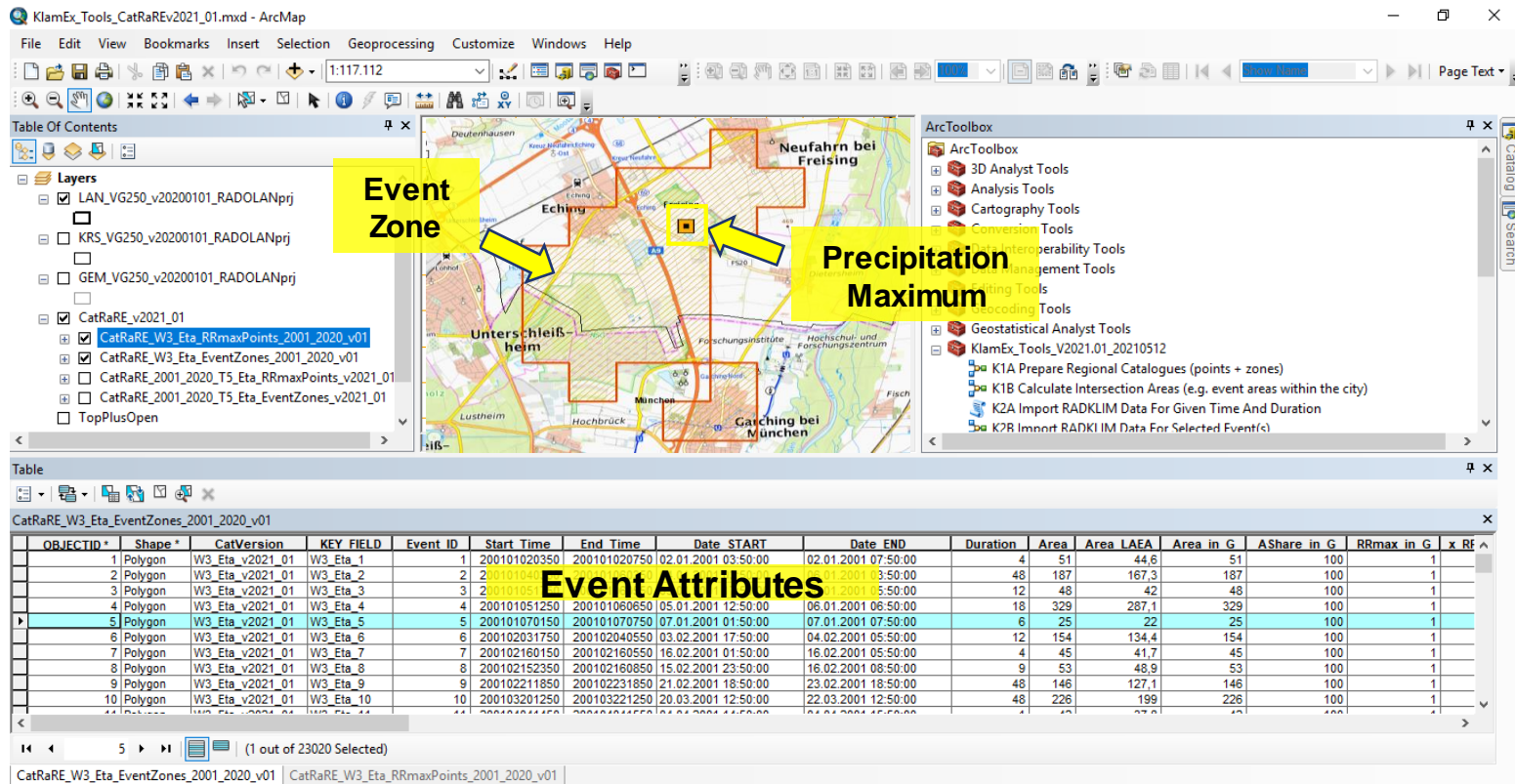


### Dashboard (online)



Download:

[opendata.dwd.de/climate\\_environment/CDC/event\\_catalogues/](https://opendata.dwd.de/climate_environment/CDC/event_catalogues/)



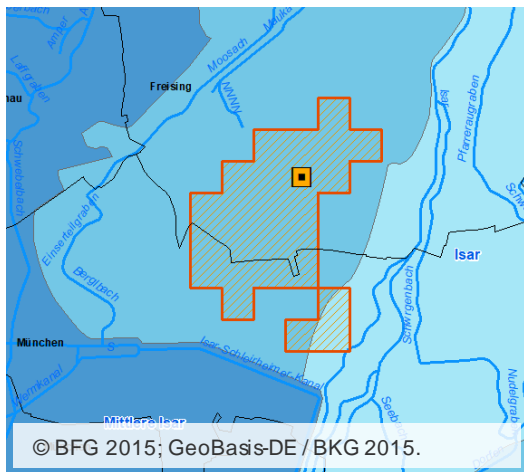
Working with  
.gdb format:





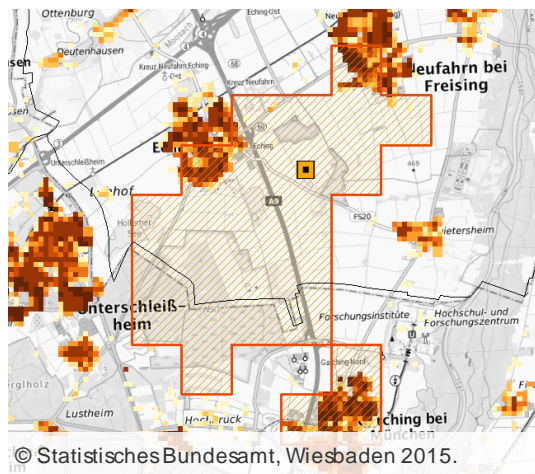
**Advantage:** Possibility of integration with other geospatial data of various formats and resolutions

**River Basins and Water bodies**  
(Polygon and Lines - **Vector data**)



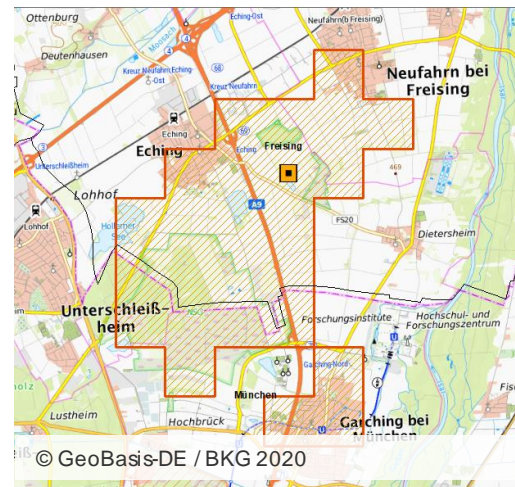
Isar Mittlere Isar

**Population density**  
(100 m **Raster**)



1 5 10 20 30 40 50 100

**Topographic map - TopPlus Open**  
(WMTS - **Web Map Tile Service**)



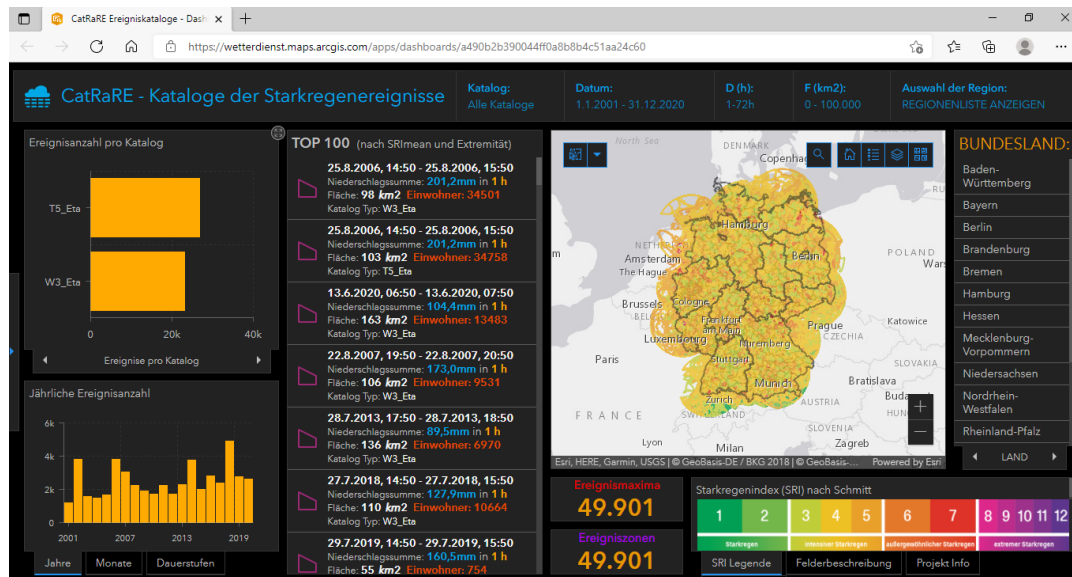
<https://arcg.is/1HDqH5>

oder:

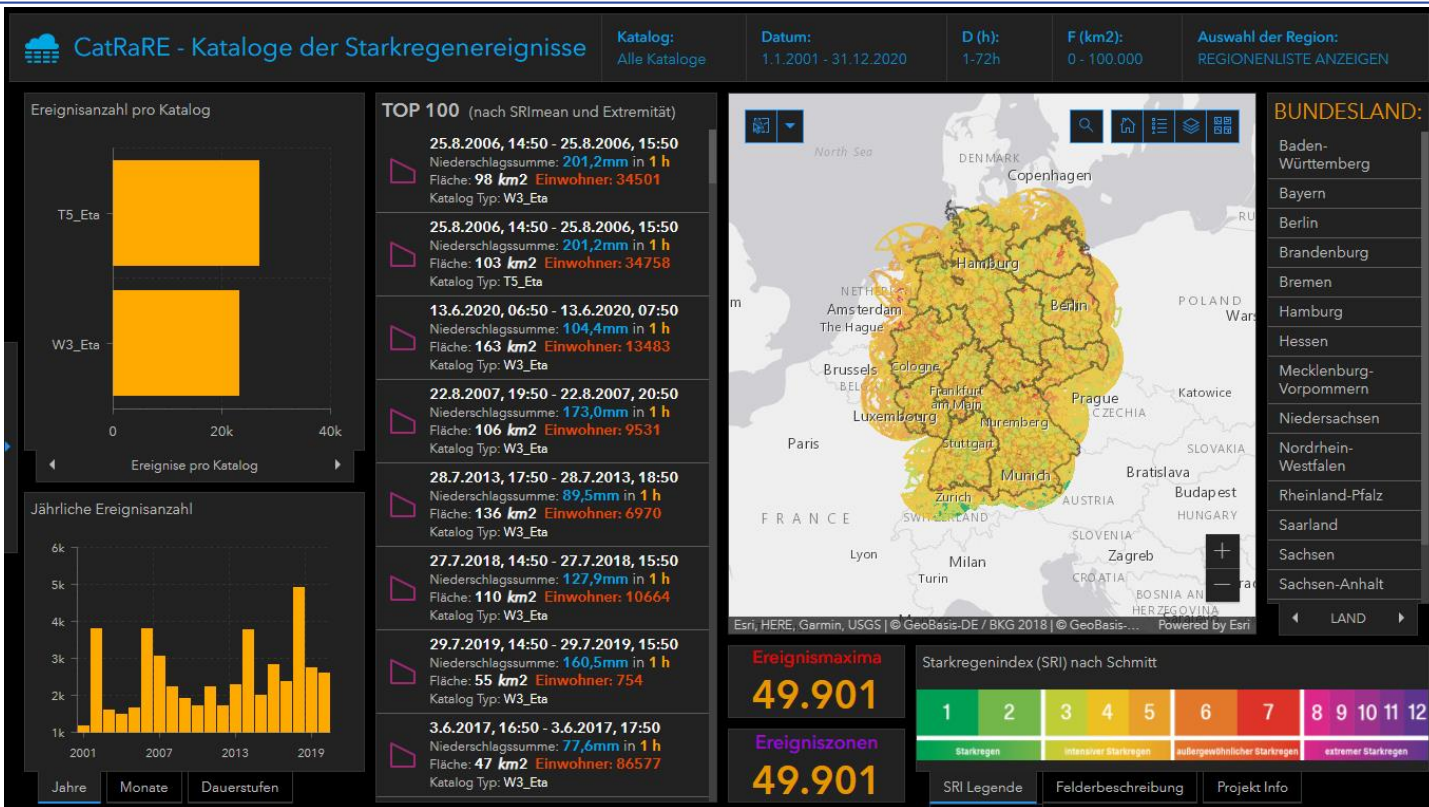
<https://wetterdienst.maps.arcgis.com/apps/dashboards/a490b2b390044ff0a8b8b4c51aa24c60>

Or go to:

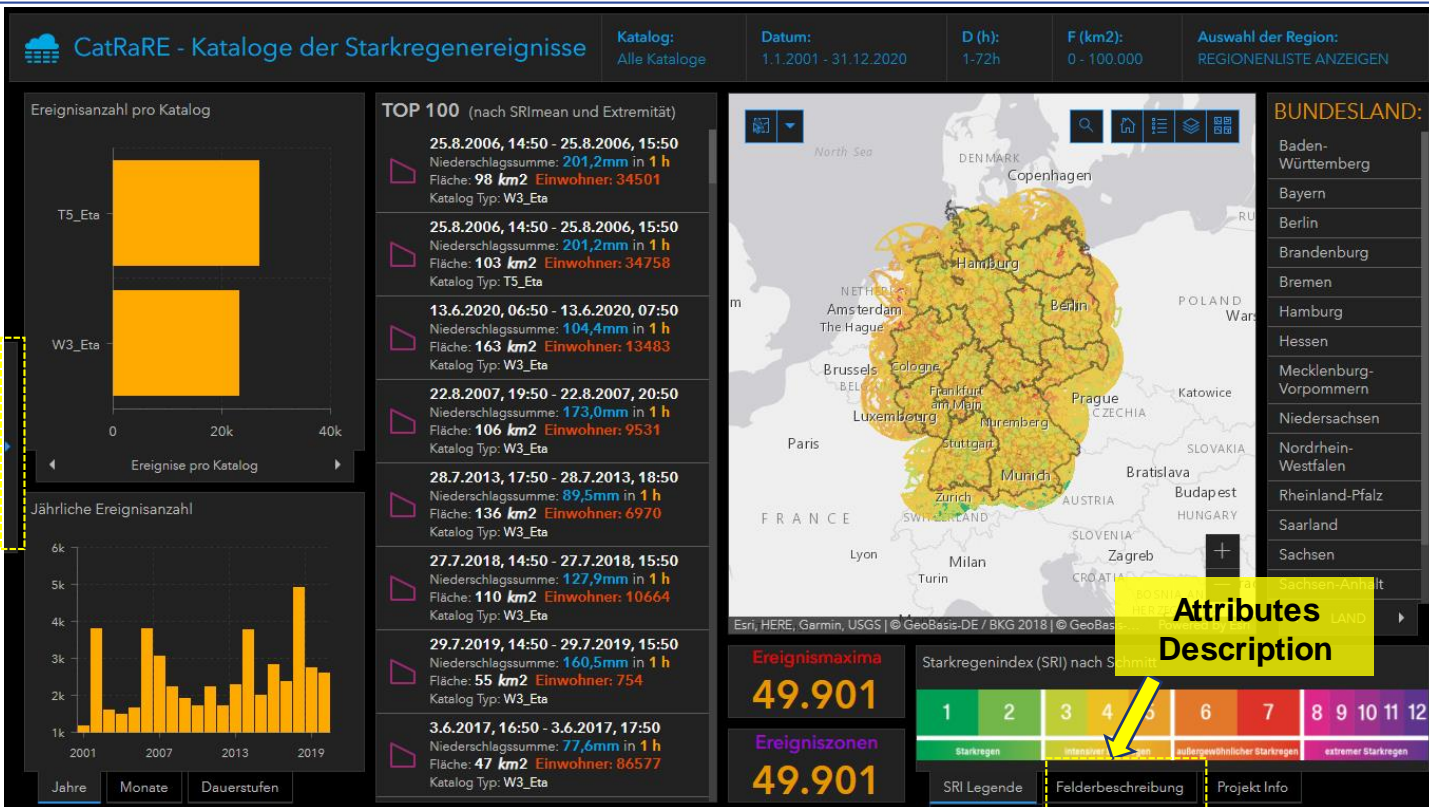
[dwd.de/klamex](https://dwd.de/klamex)



***Hint:** open the Dashboard-Link in a new Browser's Window (Internet Explorer)*







CatRaRE - Kataloge der Starkregenereignisse
Katalog: Alle Kataloge
Datum: 1.1.2001 - 31.12.2020
D (h): 1-72h
F (km2): 0 - 100.000
Auswahl der Region: REGIONLISTE ANZEIGEN

### CatRaRE (v. 2021.01)

#### Kataloge der Starkregenereignisse

basierend auf RADKLIM-RW Version 2017.002

#### Kurzbeschreibung

Die Kataloge der räumlich und zeitlich unabhängigen Starkregenereignisse basieren auf den RADKLIM-RW Daten der Version 2017.002. Die stündlichen Niederschlagsstundensummen (RW) resultieren aus den radarbasierten Niederschlagsabschätzungen, die mit den Niederschlagsmessungen an den Bodenstationen angeeicht sind und auf einem 1 km x 1 km Gitter für ganz Deutschland vorliegen.

Aus diesen Daten werden stündlich Niederschläge mit 11 verschiedenen Dauerstufen (1, 2, 3, 4, 6, 9, 12, 18, 24, 48 und 72 Stunden) summiert.

Für jede Dauerstufe und Stunde werden Niederschlagsobjekte aus zusammenhängenden Gitterzellen identifiziert, die einen gewählten Schwellwert (DWD Warnstufe 3 für Unwetter (W3) oder 5 Jährlichkeit berechnet aus den RADKLIM-RW Daten (T5)) überschritten haben.

Aus allen Objekten, die zu ein und demselben Niederschlagsereignis gehören, es kann beispielsweise für ein Event der gewählte Schwellwert für mehrere

#### TOP 100 (nach SRImean und Extremität)

25.8.2006, 14:50 - 25.8.2006, 15:50  
Niederschlagssumme: **201,2mm** in 1 h  
Fläche: **98 km2** Einwohner: **34501**  
Katalog Typ: W3\_Eta

25.8.2006, 14:50 - 25.8.2006, 15:50  
Niederschlagssumme: **201,2mm** in 1 h  
Fläche: **103 km2** Einwohner: **34758**  
Katalog Typ: T5\_Eta

13.6.2020, 06:50 - 13.6.2020, 07:50  
Niederschlagssumme: **104,4mm** in 1 h  
Fläche: **163 km2** Einwohner: **13483**  
Katalog Typ: W3\_Eta

22.8.2007, 19:50 - 22.8.2007, 20:50  
Niederschlagssumme: **104,4mm** in 1 h  
Fläche: **163 km2** Einwohner: **13483**  
Katalog Typ: W3\_Eta

28.7.2013, 17:50 - 28.7.2013, 18:50  
Niederschlagssumme: **89,5mm** in 1 h  
Fläche: **136 km2** Einwohner: **6970**  
Katalog Typ: W3\_Eta

27.7.2018, 14:50 - 27.7.2018, 15:50  
Niederschlagssumme: **127,9mm** in 1 h  
Fläche: **110 km2** Einwohner: **10664**  
Katalog Typ: W3\_Eta

29.7.2019, 14:50 - 29.7.2019, 15:50  
Niederschlagssumme: **160,5mm** in 1 h  
Fläche: **55 km2** Einwohner: **754**  
Katalog Typ: W3\_Eta

3.6.2017, 16:50 - 3.6.2017, 17:50  
Niederschlagssumme: **77,6mm** in 1 h  
Fläche: **47 km2** Einwohner: **86577**  
Katalog Typ: W3\_Eta

#### BUNDESLAND:

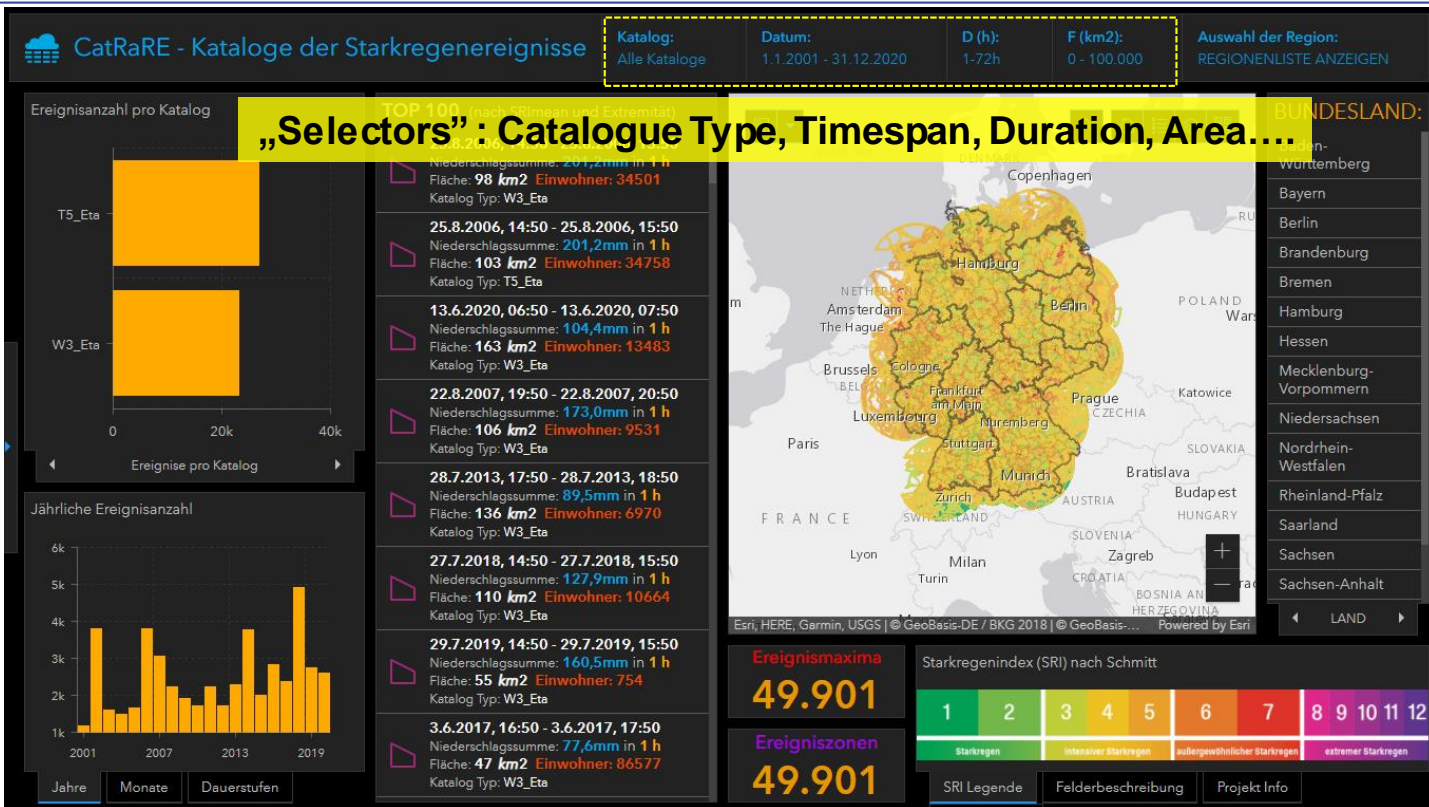
- Baden-Württemberg
- Bayern
- Berlin
- Brandenburg
- Bremen
- Hamburg
- Hessen
- Mecklenburg-Vorpommern
- Niedersachsen
- Nordrhein-Westfalen
- Rheinland-Pfalz
- Saarland
- Sachsen
- Sachsen-Anhalt

**Only in German...**

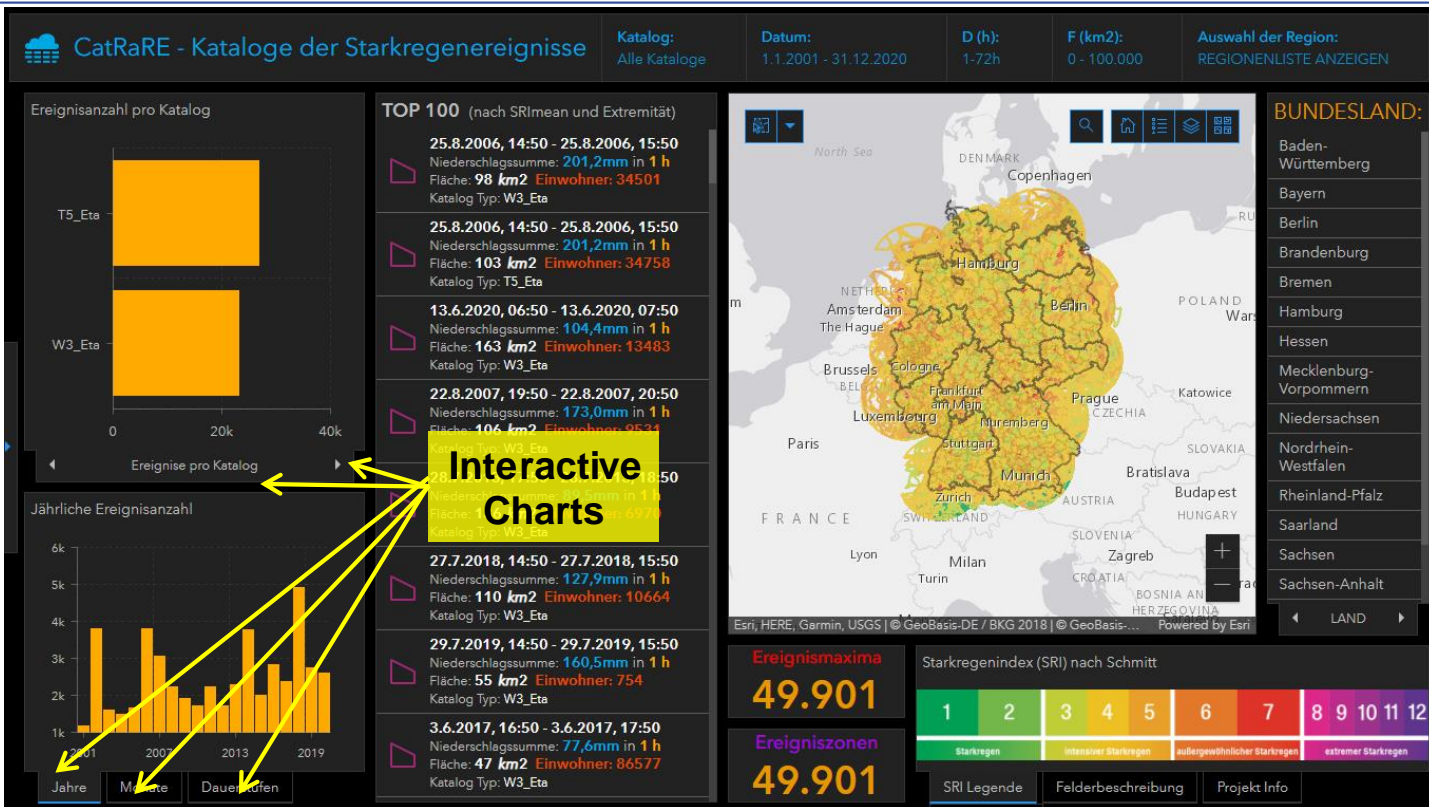
**Ereignismaxima**  
**49.901**

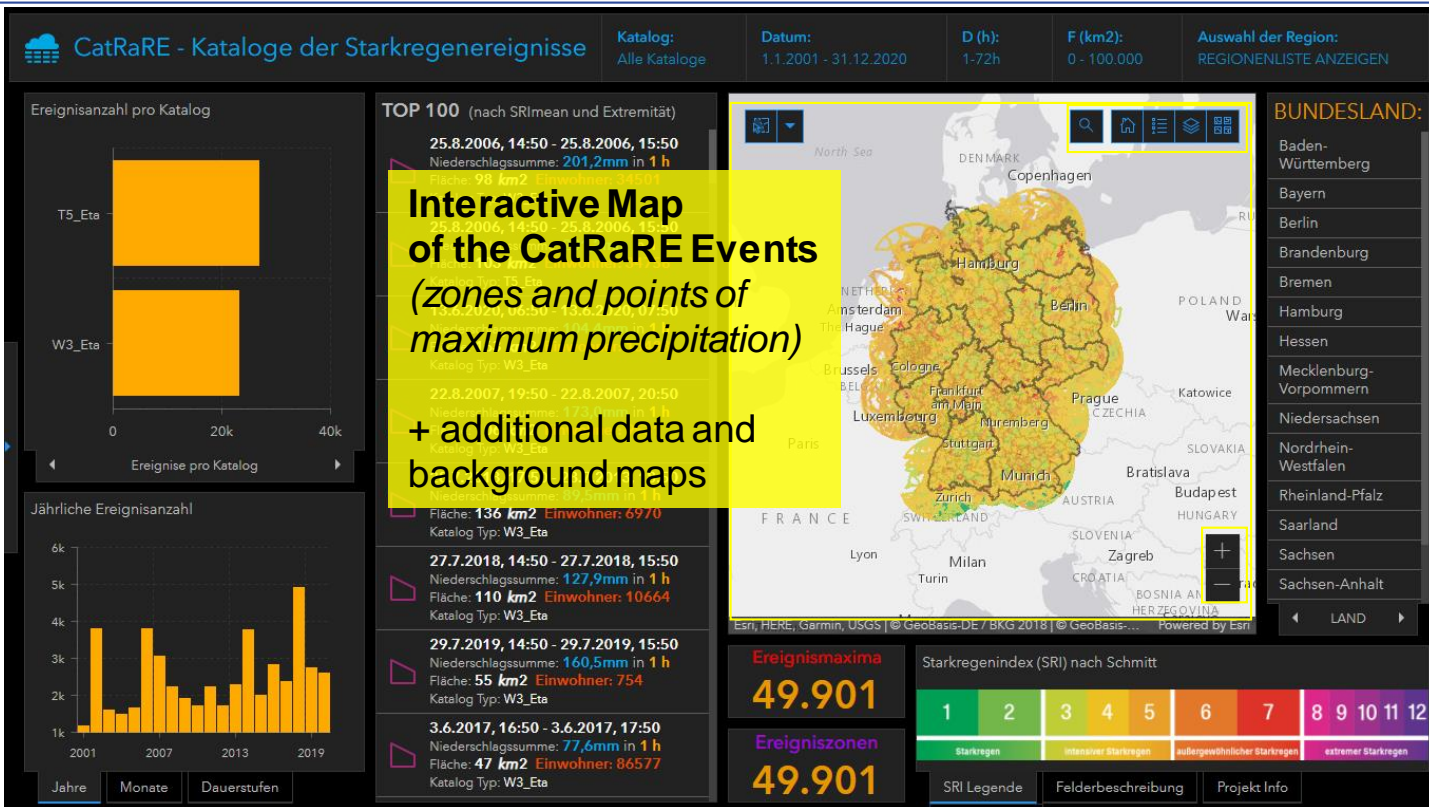
**Ereigniszonen**  
**49.901**

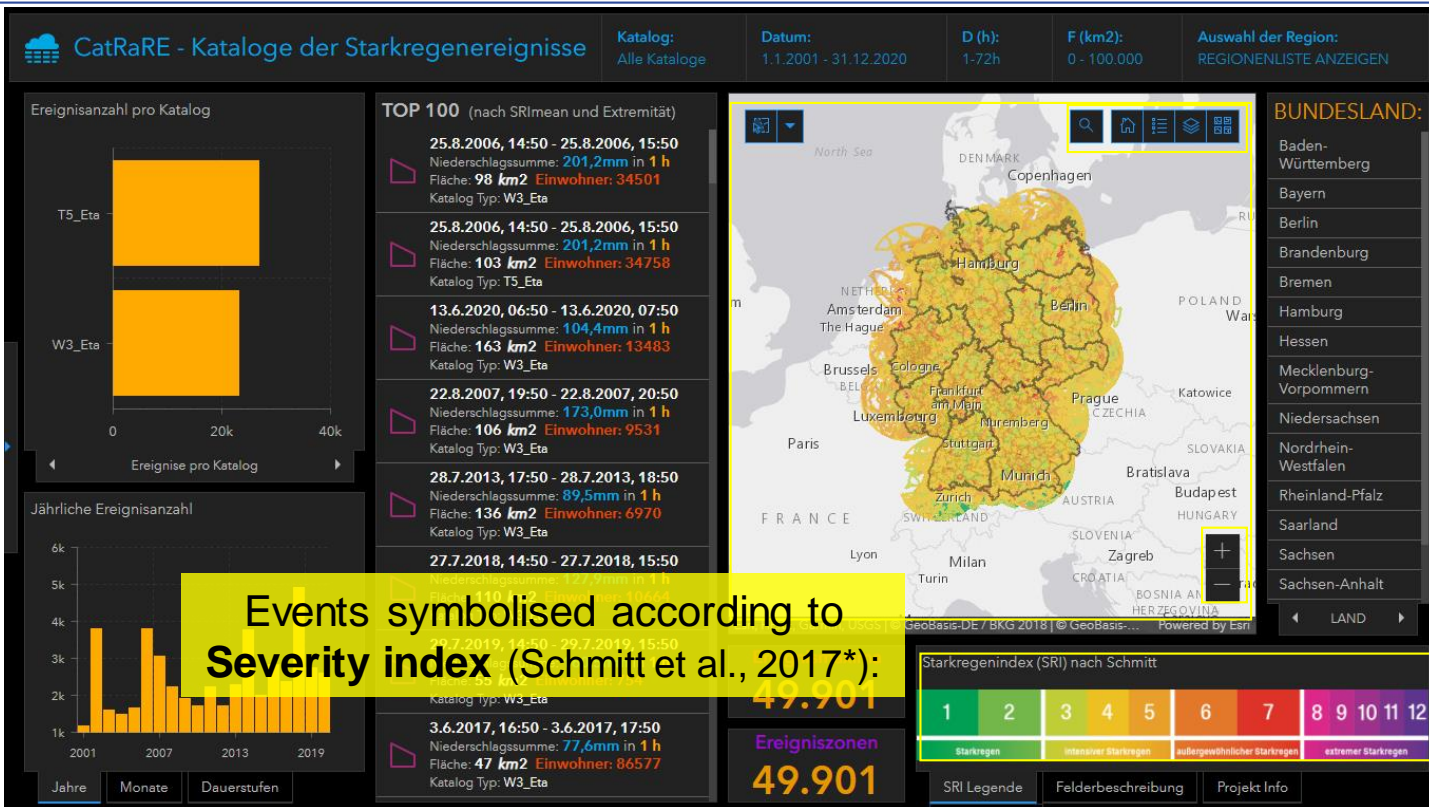
Feld Name	Beschreibung
CatVersion	Version des Katalogs
KEY_FIELD	Katalogvariante und Ereignis ID
Event_ID	Ereignis ID
Start_Time	Startzeitpunkt des Ereignisses in UTC (JJJJMMTHhmm).
End_Time	Endzeitpunkt des Ereignisses in UTC (JJJJMMTHhmm).





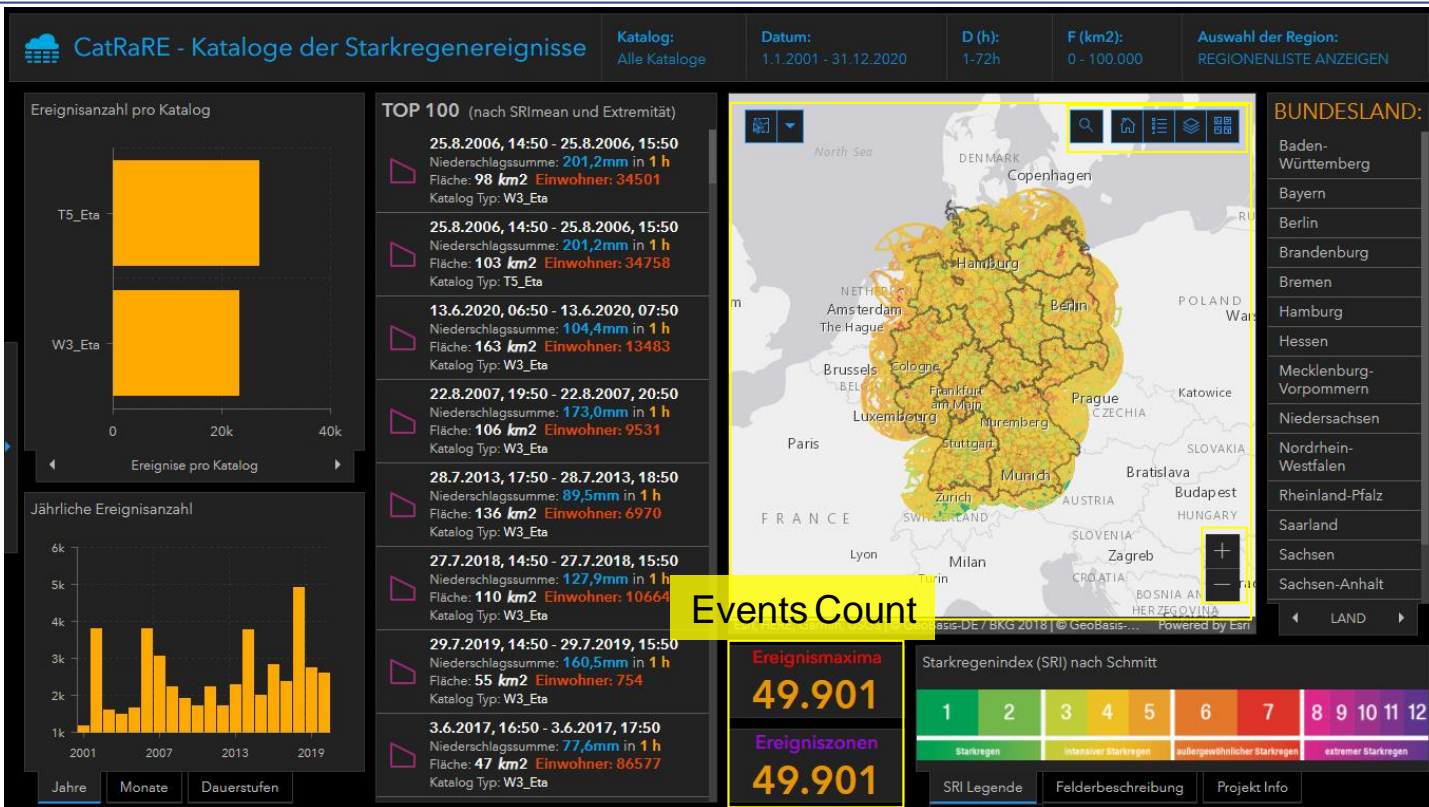






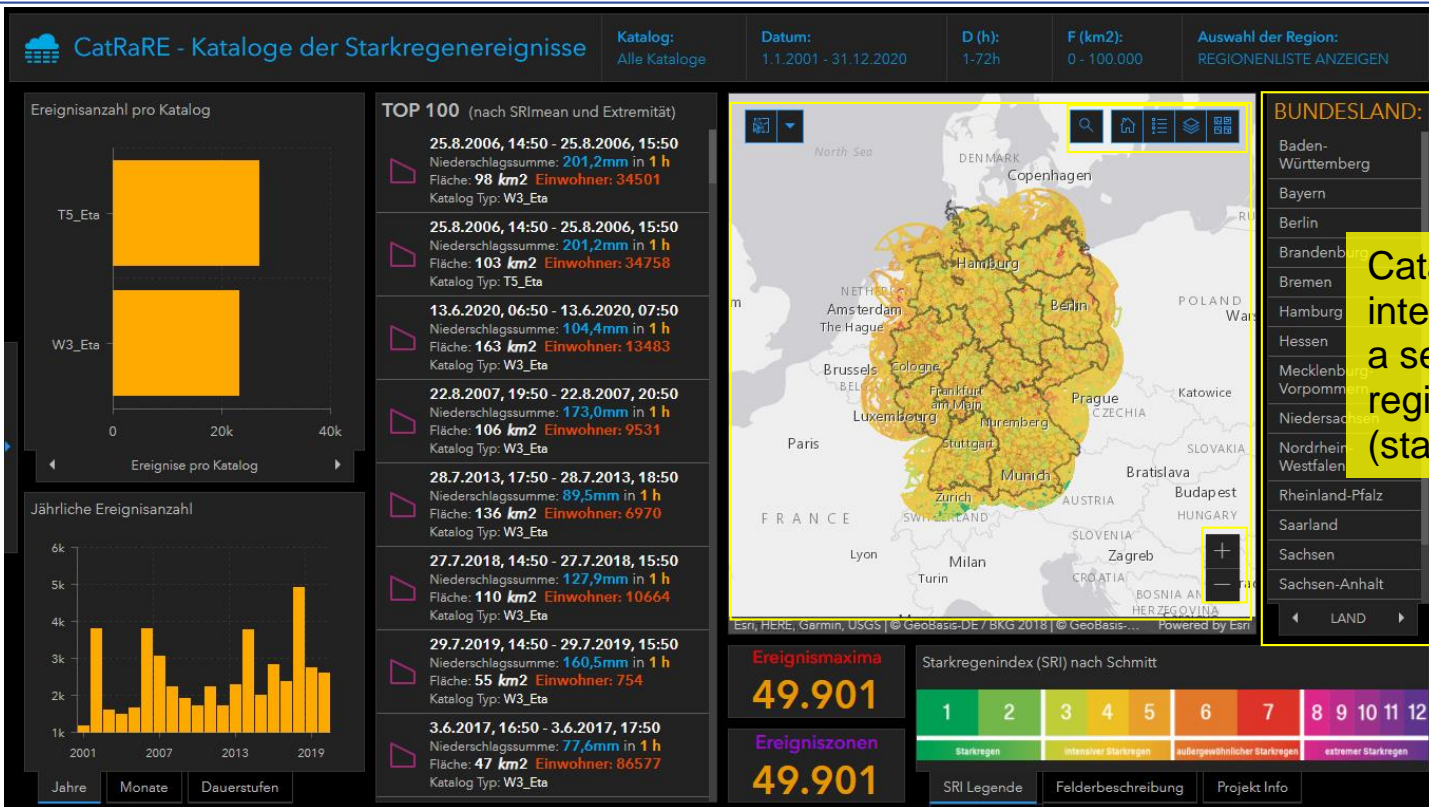
\*Schmitt, T.G.: Ortsbezogene Regenhöhen im Starkregenindexkonzept SRI12 zur Risikokommunikation in der kommunalen Überflutungsvorsorge, Korrespondenz Abwasser, Abfall, 2017 (64), Nr.4



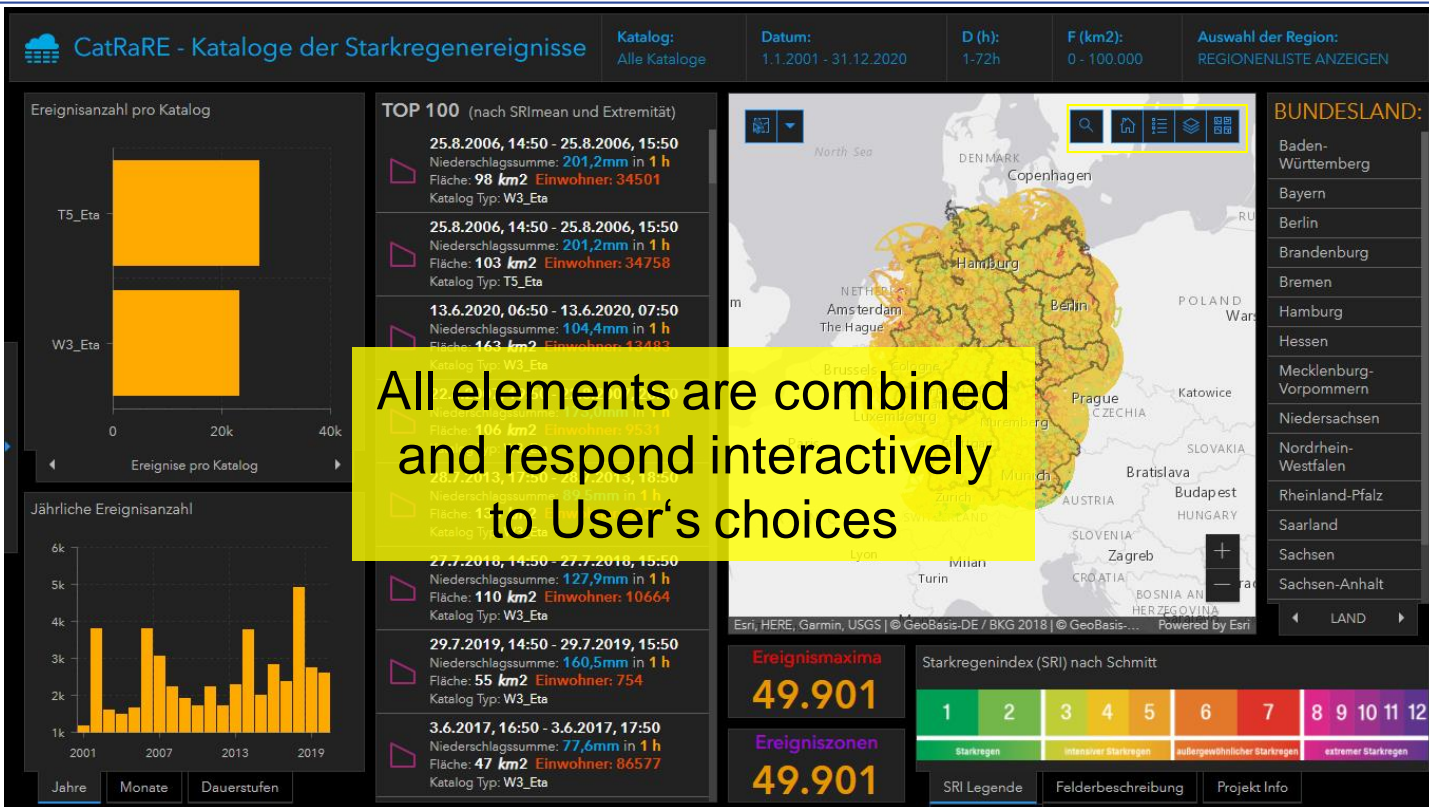






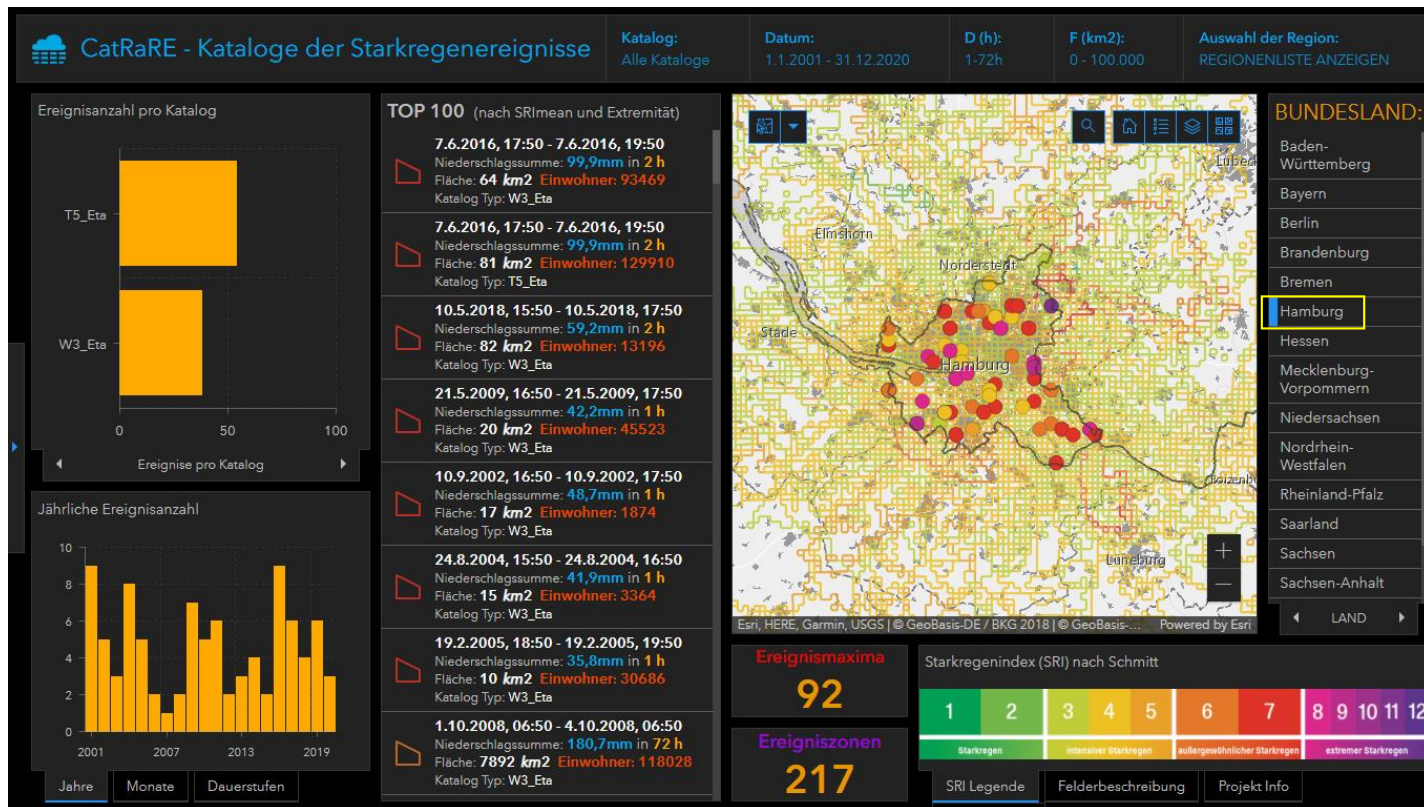


Catalogues intersection with a selected region (state, county)

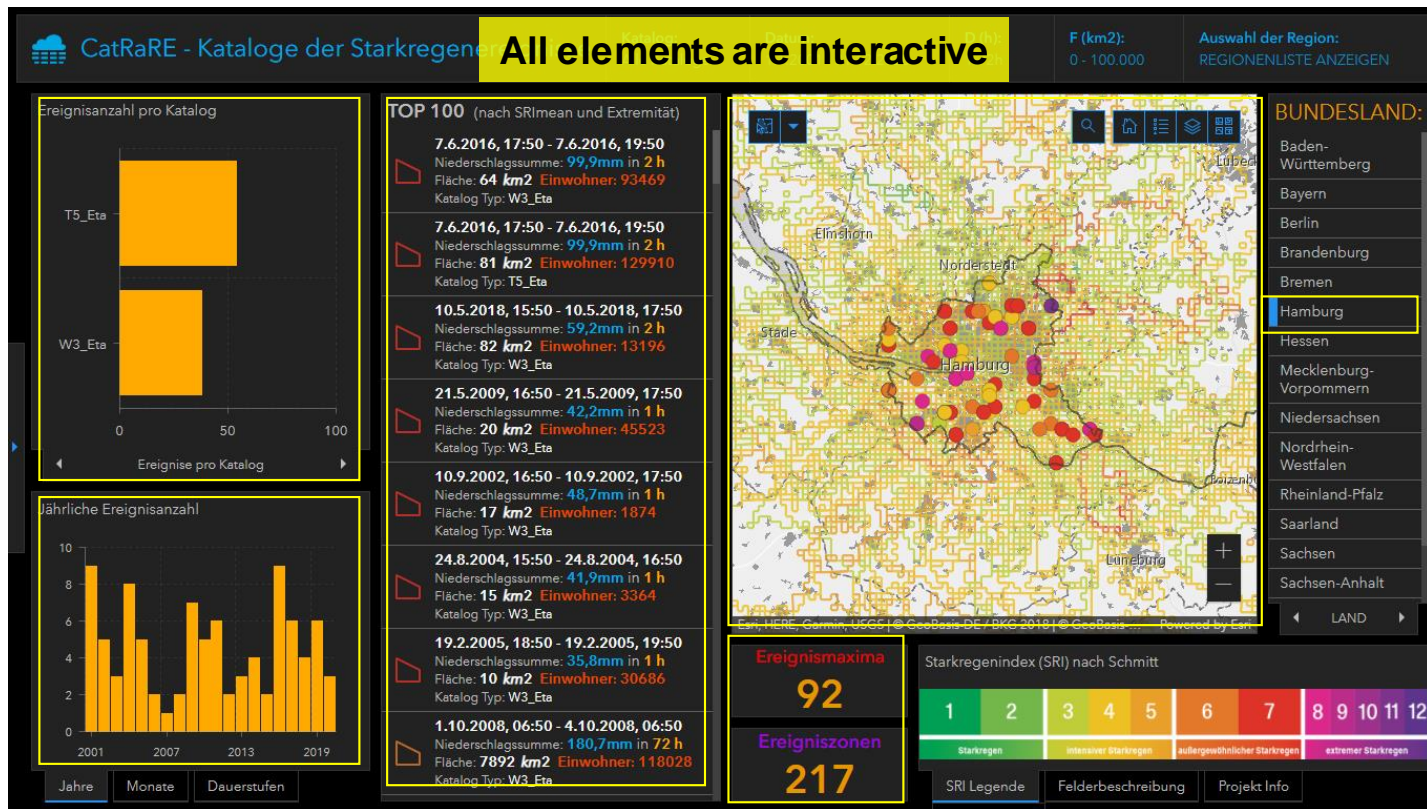


All elements are combined  
and respond interactively  
to User's choices











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**3**

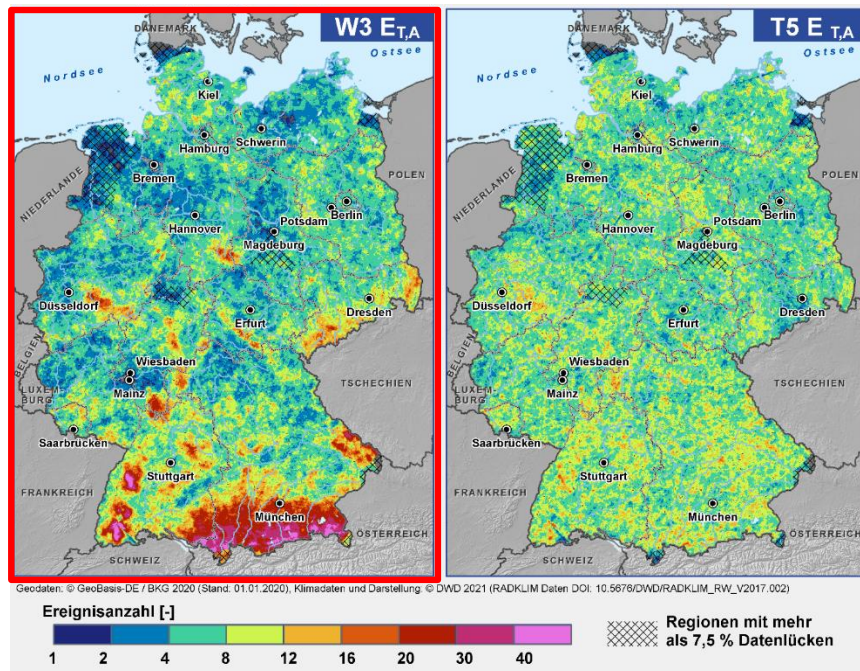
**Spatio-temporal patterns**

**4**

**Applications of the CatRaRE Catalogue**



## Comparison between W3\_E<sub>T,A</sub> and T5\_E<sub>T,A</sub> catalogues



- The distribution of events according to Warning Level 3 threshold (**W3\_E<sub>T,A</sub>**) reflects the **orographic amplification** and can be treated more as a “**climatology pattern**”
- The events classified on the basis of the 5a-return period (**T5\_ET,A**) are as expected more **evenly distributed**

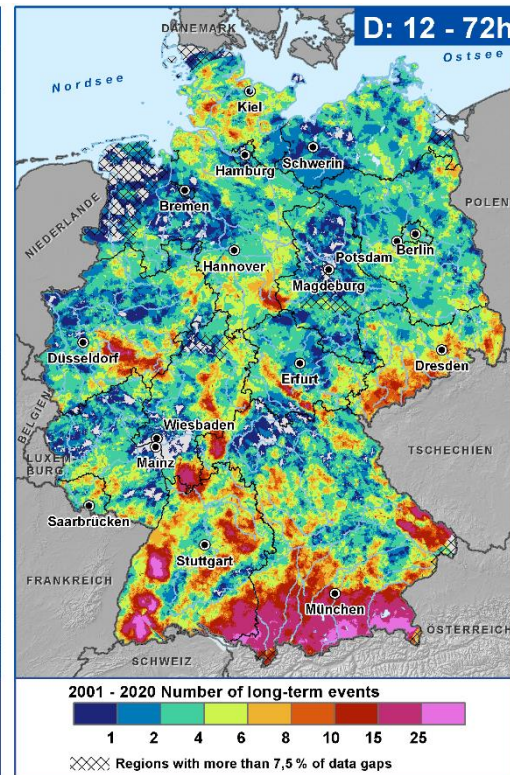
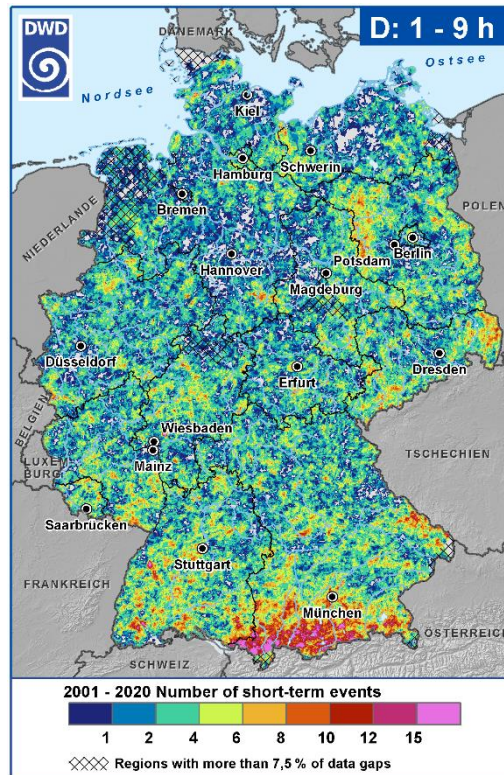
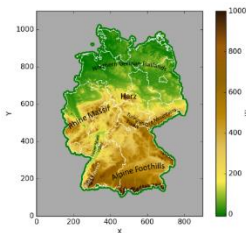
Both catalogues have their users and applications.

On the following slides we present results based on the **CatRaRE W3\_E<sub>T,A</sub>**

# 3 Spatio-temporal patterns

Spatial distribution shows clear differences between long-lasting and short-term heavy precipitation events

- **Short-term** events ( $D = 1$  to  $9$  h) are more **randomly distributed** over Germany
- Mostly **long-lasting** events ( $D = 12$  to  $72$  h) are bound to **orography**



Data source and credits: © DWD 2021 (CatRaRE: 10.5676/DWD/CatRaRE\_W3\_Eta\_v2021.01); Geodata: © GeoBasis-DE/BKG 2020 (Stand: 01.01.2020).

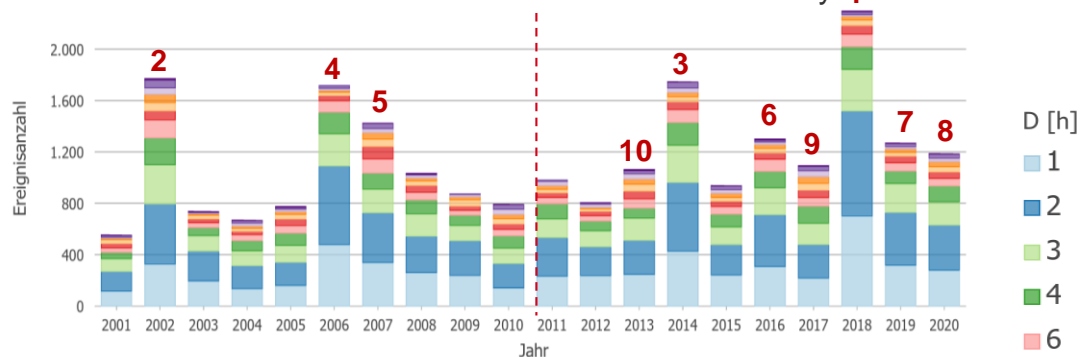


## Annual statistics of heavy-rainfall events:

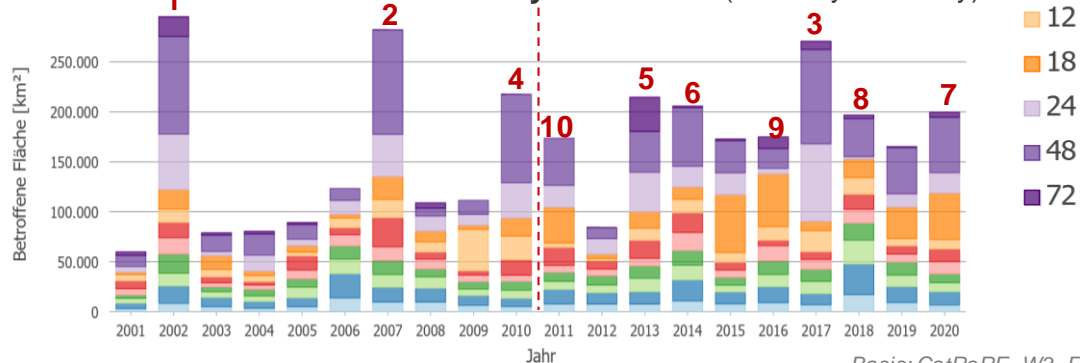
- Large **interannual variability** of extreme precipitation events in Germany
- Large **areas** are mainly hit by events of **long durations** (*violett colors*)
- **Number** of extreme events is dominated by **short durations** (*blue colors*)
- Extremely dry year 2018 with largest number of extreme events (???)

More events and larger affected area in 2011-2020...but still **not enough data for trend-analysis**

Annual number of the events in Germany



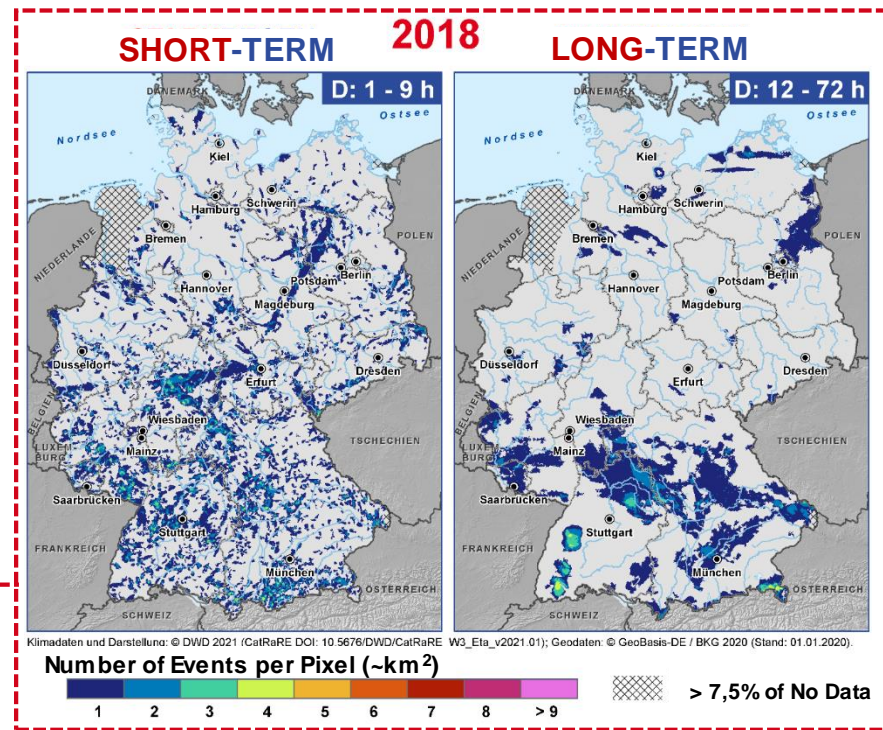
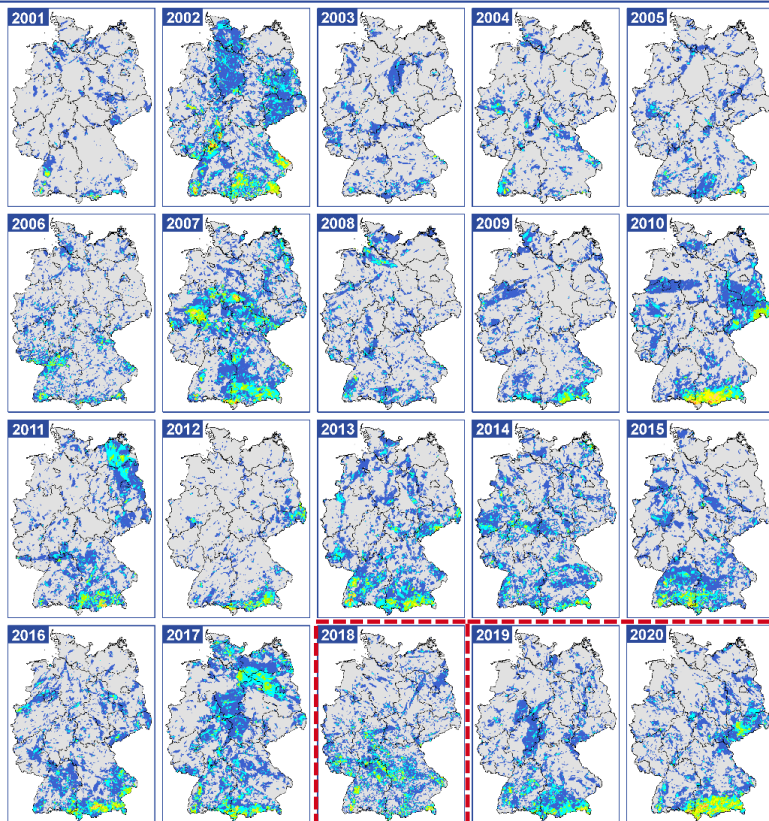
Annual area affected by the events (Germany area only)



Basis: CatRaRE\_W3\_Eta



Annual Number of heavy precipitation events



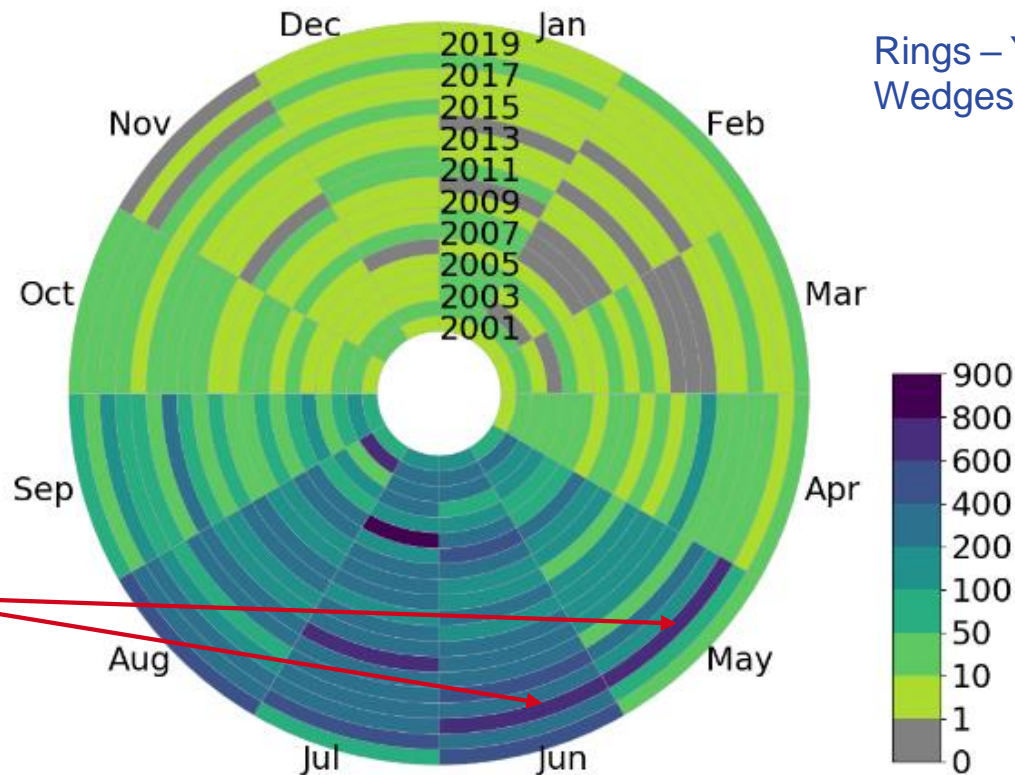
Basis: CatRaRE\_W3\_Eta

## Monthly Number of Events $\geq$ Warning Level 3

(D: 1-72h, CatRaRE W3ETA)

Rings – Years  
Wedges - Months

**2018:  
May – June**



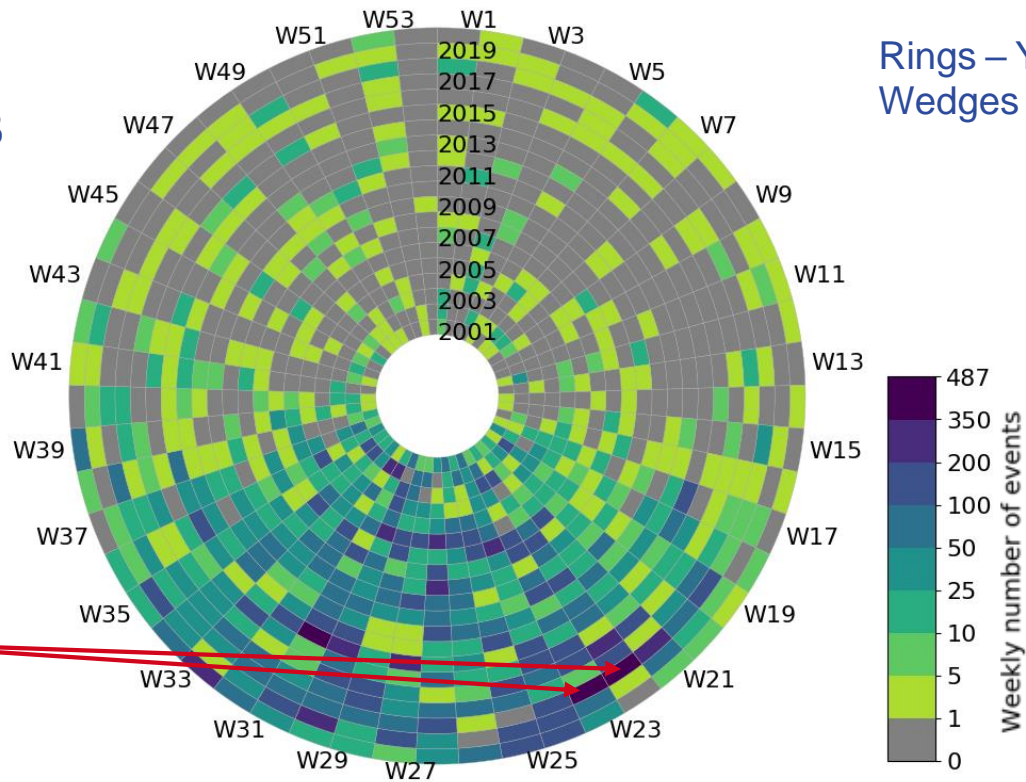
Basis: CatRaRE\_W3\_Eta

## Weekly Number of Events $\geq$ Warning Level 3

(D: 1-72h, CatRaRE W3ETA)

Rings – Years  
Wedges - Weeks

Two weeks:  
28.05.2018  
- 11.06.2018



Basis: CatRaRE\_W3\_Eta



## Daily Number of Events $\geq$ Warning Level 3

(D: 1-72h, CatRaRE W3ETA)

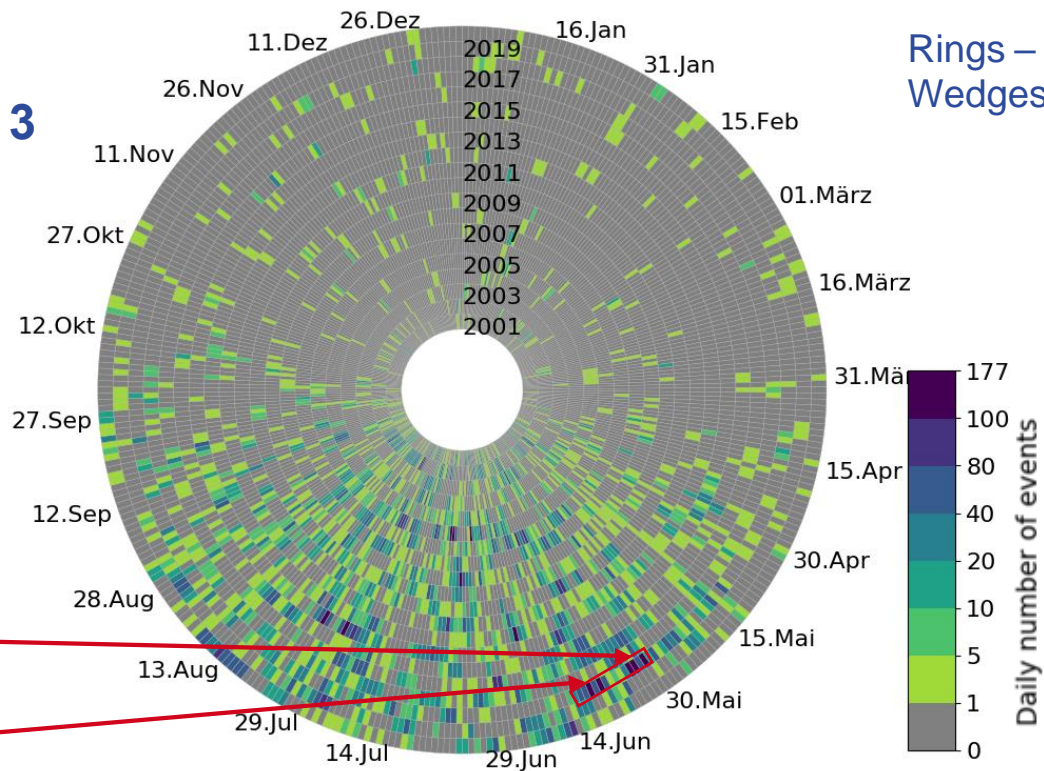
### Single “record days”:

29.05.2018: 117

31.05.2018: 136

01.06.2018: 119

09.06.2018: 177

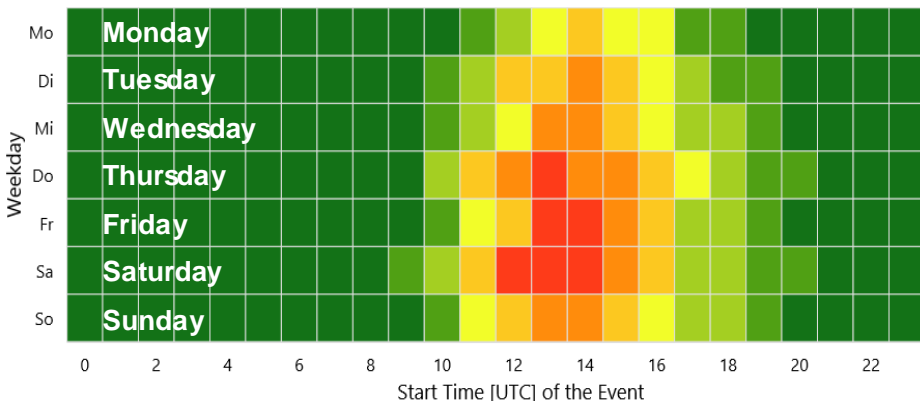


Basis: CatRaRE\_W3\_Eta

## Variation during the day and the week (based on the Start-time of the Event)

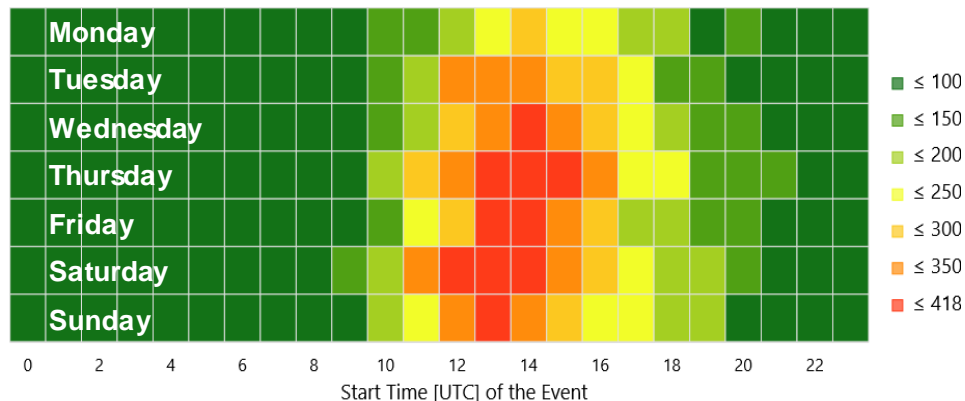
### Short-term Events

Number of Events (D: 1 - 9 h) (W3\_ETA, 2001 - 2020)



### All Events

Number of Events (D: 1 - 72 h) (W3\_ETA, 2001 - 2020)



- ➔ accumulation of events in the **afternoon and early evening** when typically **summer convection** occurs
- ➔ **smaller number of events at the beginning of the week** and delayed convection beginning on Monday
  - ➔ **coincidental finding or – derived from the weekly cycle of ozone pollution = traffic volume?**
  - more detailed analysis is needed...**



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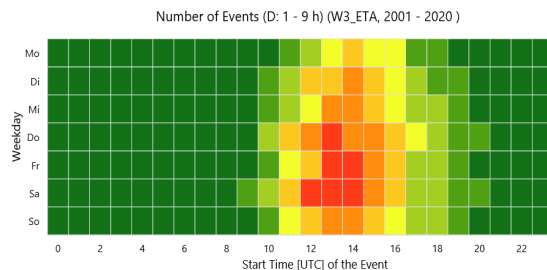
**Spatio-temporal patterns**

**4**

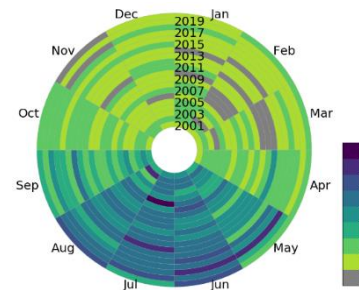
**Applications of the CatRaRE Catalogue**

# 4 Applications of the CatRaRE Catalogue

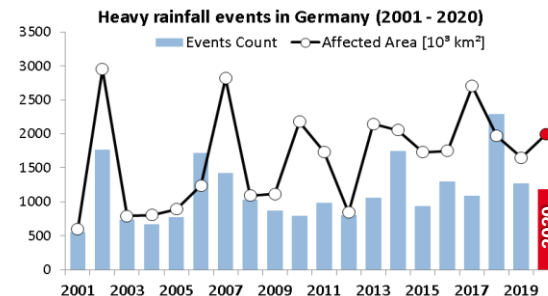
TIME



Hour, Day

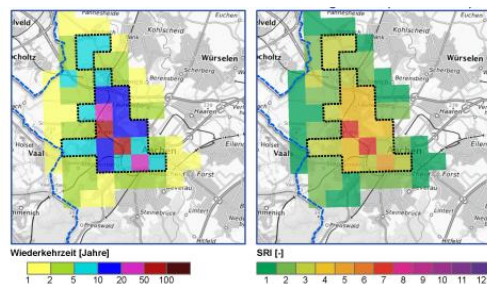


Weeks, Months

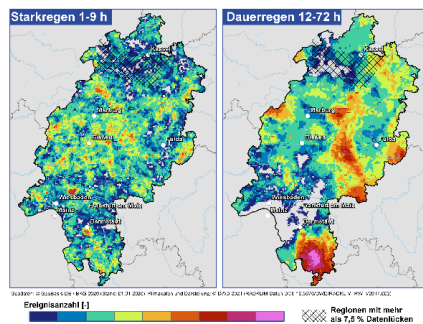


Year, Years

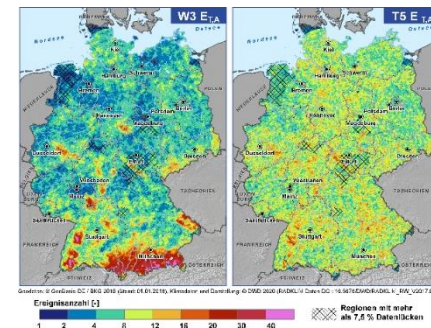
Single events



Regional variability



Country-wide

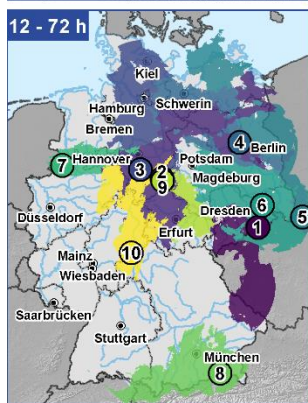
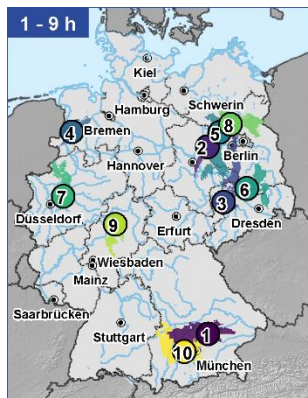


SPACE





## Ranking of extreme precipitation events



## EXAMPLE:

Top10 short-term (*upper*) and long-term (*bottom*) events in 2001-2020



## Starkregenereignisse (1 - 9 Std.)

RANK	Date_START	D_Std	Area	Eta	RRmax	RRmean	SRImax	SRImean	BDL/LKS/GMD_RRmax
1	21.07.2014 15:50	6	5360	53.2	74.2	45.61	8	4	BY /Freising /Wang
2	01.08.2018 21:50	9	2649	51.2	155.3	63.65	11	5	ST /Jerichower Land /Genthin
3	11.06.2019 17:50	4	3231	49.4	216.1	46.74	12	5	SN /Leipzig /Parthenstein
4	23.06.2016 17:50	6	1501	47.7	166	61.83	11	6	NI /Emsland /Groß Berßen
5	21.07.2007 23:50	9	5289	45.9	105.4	48.58	8	4	BB /Havelland /Wiesenaue
6	05.07.2012 13:50	6	2775	44.6	140.6	50.18	10	5	BB /Elbe-Elster /Bad Liebenwerda
7	20.06.2013 10:50	3	2460	44.1	99.6	41.38	10	5	NW /Bochum /Bochum
8	13.06.2020 10:50	9	2937	43.8	150.8	53.88	11	5	BB /Ostprignitz-Ruppin /Rüthnick
9	30.05.2008 16:50	2	2154	41.5	97.6	42.38	10	5	HE /Marburg-Biedenkopf /Kirchhain
10	18.05.2002 16:50	9	6159	41.2	184.3	50.28	11	3	BY /Fürstenfeldbruck /Landsberied

## Dauerregenereignisse (12 - 72 Std.)

RANK	Date_START	D_Std	Area	Eta	RRmax	RRmean	SRImax	SRImean	BDL/LKS/GMD_RRmax
1	12.08.2002 02:50	24	48420	208	283.1	86.89	11	5	SN /Sächsische Schweiz-Osterzgebirge /Altenberg
2	24.07.2017 07:50	48	54898	189	255.8	85.04	9	5	NI /Goslar /Bad Harzburg
3	17.07.2002 01:50	48	45053	176	187.2	85.26	10	5	NI /Hildesheim /Sibbesse
4	29.06.2017 10:50	24	33927	166	161.9	71.62	9	5	BE /Berlin /Berlin
5	21.07.2011 05:50	48	37879	145	187.2	82.44	8	5	Tschechien
6	25.09.2010 21:50	48	45655	133	154.5	79.38	8	4	SN /Bautzen /Wachau
7	26.08.2010 04:50	24	14519	132	163.9	86.16	10	6	NW /Borken /Schöppingen
8	30.05.2013 17:50	72	32937	127	319.5	131.95	8	4	BY /Rosenheim /Aschau i. Chiemgau
9	27.09.2007 12:50	48	26330	114	189.5	78.56	8	4	ST /Harz /Wernigerode
10	20.05.2019 12:50	18	22325	110	106.7	60.21	9	5	HE /Main-Kinzig-Kreis /Steinau an der Straße

Basis: CatRaRE\_W3\_Eta

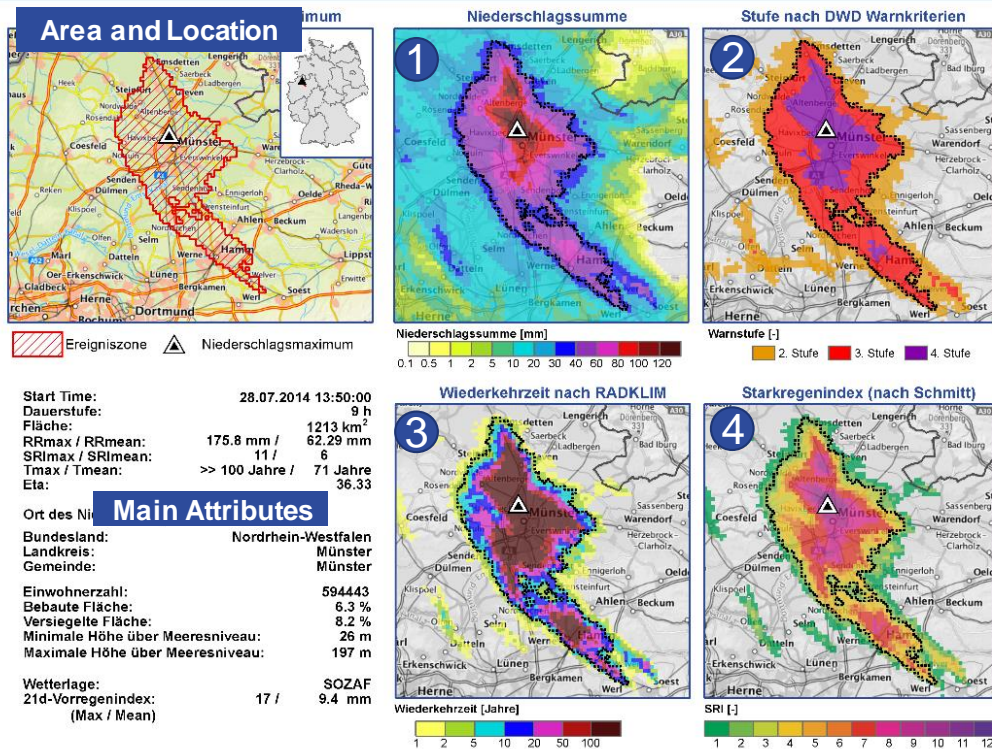
## Event Case Studies

### EXAMPLE:

Extremely heavy rainfall event over the city of Münster on 28<sup>th</sup> July 2014



## Starkregen in Münster am 28. Juli 2014 - Ereignisfallstudium



1. Precipitation sum
2. Areas where DWD's Warning Levels are exceeded,
3. Return period
4. Heavy Precipitation Index (SRI) according Schmitt

→ Data basis for all four elements is the RADKLIM Dataset (v. 2017.002)

Basis: CatRaRE\_W3\_Eta

EMS Annual Meeting  
2021, online, 6–10 Sep  
2021, EMS2021-461



FELDERBESCHREIBUNG:

Start Time - Anfangszeitpunkt des Ereignisses in UTC (TT.MM.JJJJ hh:mm); Duration - Signifikante Dauerstufe [h] des Ereignisses; Area - Gesamtfläche [km<sup>2</sup>] des Ereignisses (nach RADOLAN Projektion); RRmax/RRmean - Maximaler/Mittlerer Niederschlag [mm]; SRImax/SRImean - Maximaler/Mittlerer Starkregenindex nach Schmitt (Wertebereich [0,12]); Tmax/Tmean - Maximale/Mittlere Wiederkehrzeit nach RADKLIM Daten; Eta - Extremität.

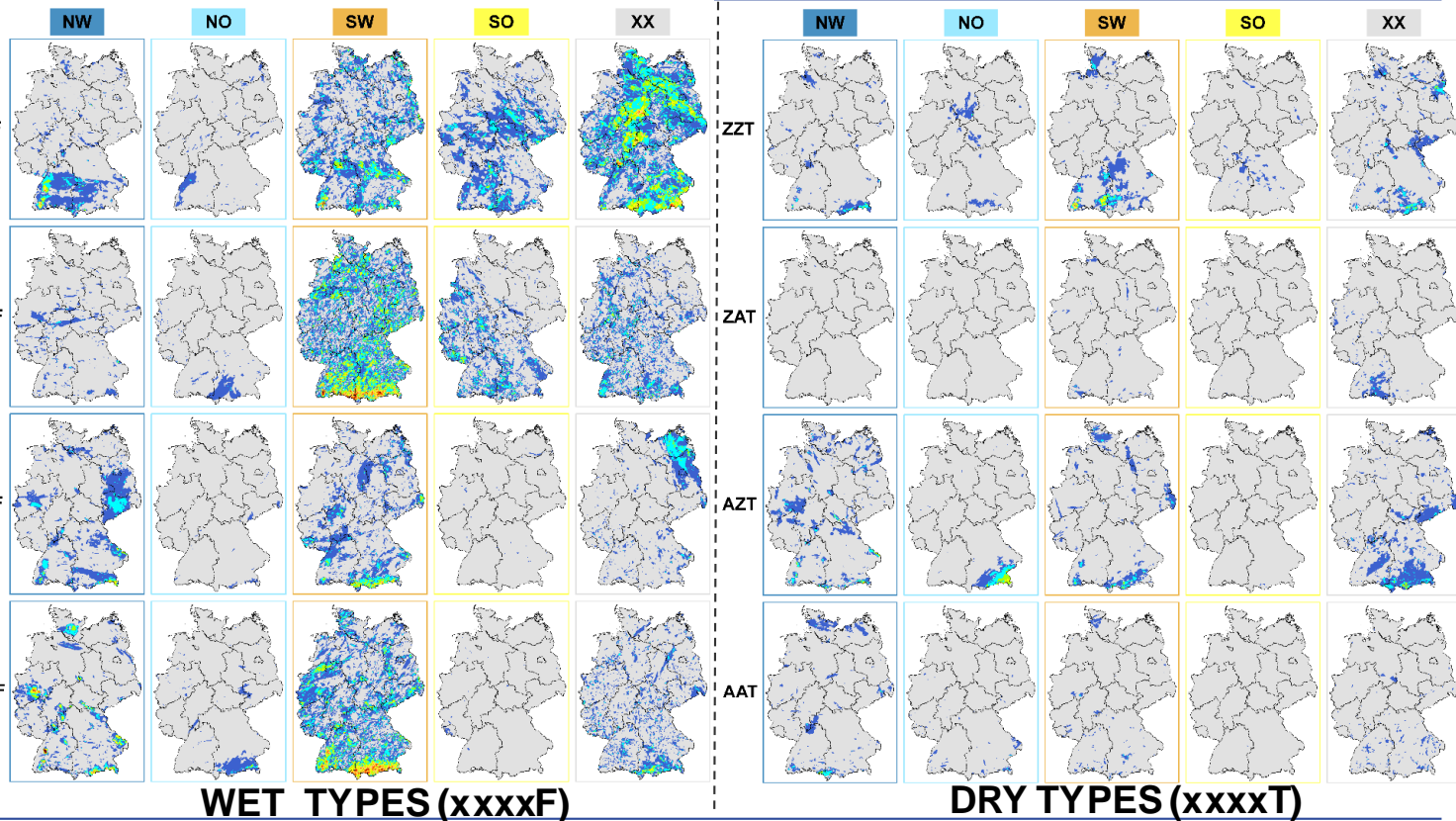
Klimadaten und Darstellung: © DWD 2021 (CatRaRE\_W3\_Eta v2021\_01; RADKLIM Daten DOI: 10.5676/DWD/RADKLIM\_RW\_V2017.002); Geodaten: © GeoBasis-DE / BKG 2020 (Stand: 01.01.2020); Hintergrundkarte: © Bundesamt für Kartographie und Geodäsie 2017; Datenquellen: [http://sg.geodatenzentrum.de/web\\_public/Datenquellen\\_TopPlus\\_Open.pdf](http://sg.geodatenzentrum.de/web_public/Datenquellen_TopPlus_Open.pdf)

Combining  
CatRaRE W3\_E<sub>T,A</sub>  
with the DWD's  
Objective Weather  
Classification



2001-2020  
number of heavy  
rainfall events per  
RADKLIM Pixel  
depending on  
the weather type

Cyclonicity (high- or low pressure influence)



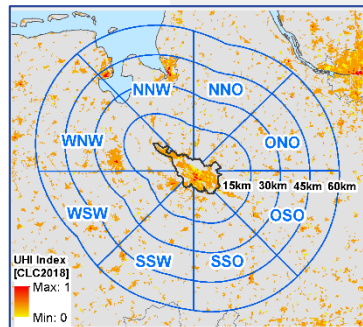
Basis: CatRaRE\_W3\_Eta





Combining  
CatRaRE W3\_E<sub>T,A</sub>  
with the DWD's  
Objective Weather  
Classification

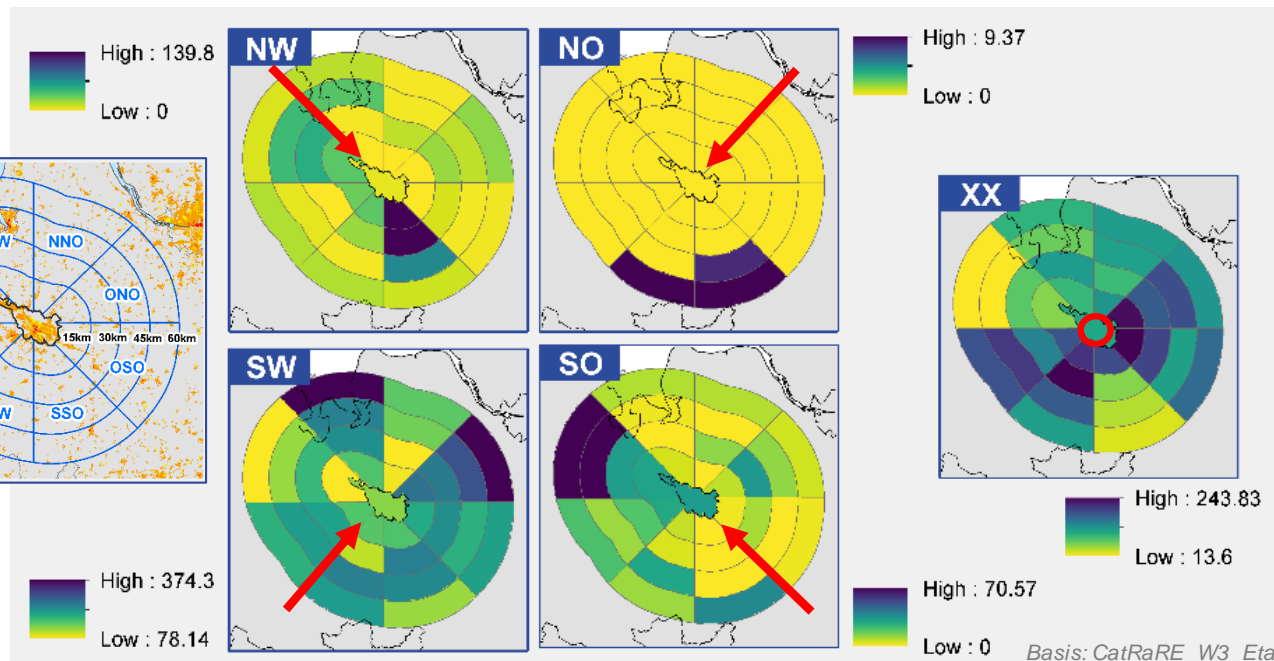
→ Does  
urbanization  
impact rainfall?  
**Hypothesis\*\*\*:**  
**rainfall increase**  
**in the downwind**  
**region of the city**  
**(up to 50 km)**



“City-effect” analysis  
for Bremen  
(lack of neighboring cities  
and orography influences  
but the North Sea...)



Relative area affected by heavy-rainfall events (1 - 9 h) depending on  
the **advection type** and the distance to the city of Bremen



\*\*\*Liu und Niyogi 2019, <https://doi.org/10.1038/s41598-019-42494-2>

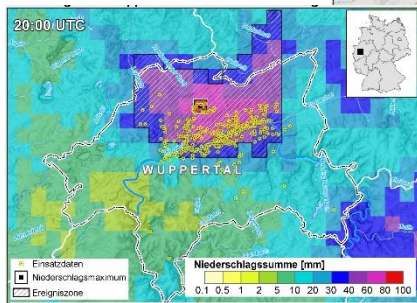
# 4 Applications of the CatRaRE Catalogue

Combining CatRaRE  
W3\_E<sub>TA</sub> with fire  
brigade reports

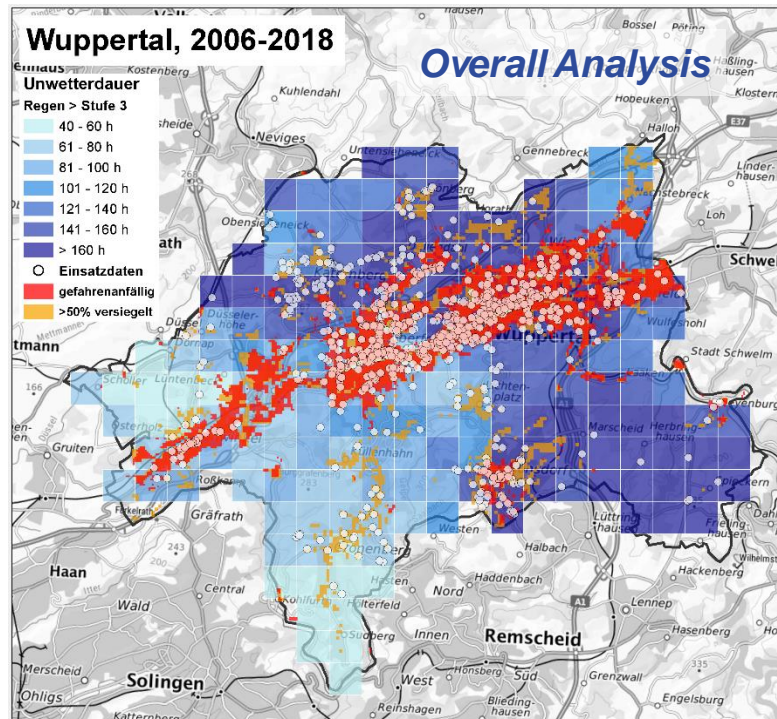
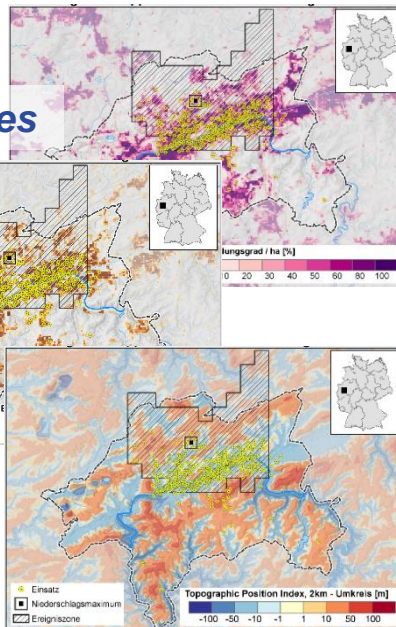
→ Projekt KlamEx

Hot-spot analysis: combination of rainfall  
parameters and geographical variables  
(sealing, settlement, topography...)

Case Studies



Example for the  
city of Wuppertal



Hot-Spots: The fire brigade's operations are significantly  
more often in strongly sealed and densely settled sinks...  
(RAINFALL ≠ RUNOFF)





*Spatio-temporal patterns and extremity assessment  
of heavy rainfall events in Germany,  
derived from a radar-based catalogue (CatRaRE, 2001-2020)*

# ► SUMMARY (+ References / Links)



- We have created an objective ***Catalogue of Radar-based heavy Rainfall Events “CatRaRE”***, which contains all heavy short-term and long-term rain events in Germany from 2001 onwards
- The CatRaRE Catalogues were published on the **DWD's Opendata server**
  - We **provide our data in user-friendly format (.csv , Geodatabase, Online Dashboard)**
  - Like RADKLIM Dataset, the CatRaRE Catalog will be **updated annually** by the DWD
- Due to the **large number of attributes** (met / geo) and **possibility of further extensions** there are many options for interesting applications and analysis - for us and other users...
- Already conducted analyses show:
  - **extreme events of short durations happen everywhere in Germany** and depend less on orography than precipitation of low intensity and long durations (**so everybody can be affected!**)
  - **large interannual variability** of extreme precipitation events **but not enough data for trend analysis**
  - **also an extremely hot and dry year (2018) can bring an enormous number of extreme events**

# Do you want to know more?

## CatRaRE PAPER (ENG):

“CatRaRE: A Catalogue of Radar-based Heavy Rainfall Events in Germany Derived from 20 Years of Data”

by Katharina Lengfeld, Ewelina Walawender, Tanja Winterrath and Andreas Becker, Meteorol. Z. (Contrib. Atm. Sci.)

PrePub Article, 2021 ([Link](#))



### CatRaRE: A Catalogue of radar-based heavy rainfall events in Germany derived from 20 years of data

KATHARINA LENGFELD\*, EWELINA WALAWENDER, TANJA WINTERATH and ANDREAS BECKER

Deutscher Wetterdienst, Frankfurter Straße 135, 63067 Offenbach am Main, Germany

(Manuscript received May 7, 2021, in revised form August 3, 2021, accepted August 6, 2021)

#### Abstract

In a warming climate, heavy rainfall is assumed to occur more frequently in the future. Extreme precipitation events are hard to observe and predict and can have devastating impact on infrastructure, housing and people. Rain gauge networks often cannot detect small-scale events, because the distances between stations are too large. In order to give a comprehensive overview on all heavy precipitation events, we will conduct observations with high spatial and temporal resolution, e.g. from radar networks, are reanalysed, allow a method to extract heavy precipitation events from 20 years of radar data in Germany and compile station precipitation (e.g. time, duration, location, onset and maximum precipitation, geographic position) as well as meteorological, geophysical and demographic information for each event in a database. In CatRaRE (Catalogue of Radar-based heavy Rainfall Events), rainfall events of 11 threshold classes (1 and 175 mm) are listed for the years 2001 to 2020. Two different thresholds for heavy precipitation will be the warning level for event severity in terms of precipitation rate from the German Weather Service (DWD) a series period of 5 years. The threshold determines their spatial distribution. While exceeding a given extent period of 5 years or other specific distances over Germany, events based on duration, height, maximum rain intensity related to geographic location, the distribution of events in the different regions of Germany is analysed. All over the country. Analyses reveal a large temporal variability. Regions and affected areas of events. Despite being a dry land average, the distribution of events is not uniform. Our studies of the spatial distribution of heavy rainfall events in the last 20 years illustrate the potential of CatRaRE to examine individual events in detail. CatRaRE will be updated on an annual basis, thereby available for development and can be a useful tool for hydrology, climatology, and risk management.

**Keywords:** radar meteorology, precipitation climatology, catalogue of rainfall events, rainfall statistics, extreme events

#### 1 Introduction

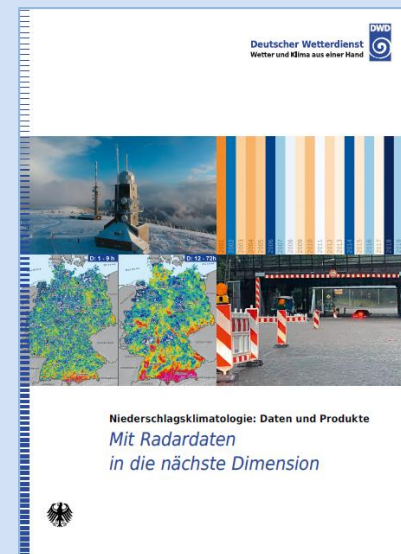
Precipitation is one of the most important parameters to observe and quantify in our climate system because of its high variability in space and time. Precipitation extremes can lead to severe damage due to intense rain, flash floods, and landslides and can occur in various forms. Moderately heavy rain lasting for more than 24 h can be harmful to infrastructure in intense short-term rainfall for several minutes up to a few hours (Schroeder and Tyt, 2018). According to Okeano (1975) long-lasting rainfall is mainly caused by strong systems and affects large regions of more than 100 km<sup>2</sup> whereas deep convection brings short-term heavy rain falls with spatial extent of only a few square kilometres. Lencz et al. (2019) found that the characteristic correlation length (spatial correlation function) dropped to 1/3 of its maximum for daily rainfall in Germany in 2015, while hourly precipitation is typically 5.5 times smaller with a characteristic length of only 30 km on average.

\*Corresponding author: Katharina Lengfeld, Deutscher Wetterdienst, Germany, e-mail: klangfeld@dwd.de

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Published by Deutscher Wetterdienst, Offenbach, Germany, www.dwd.de

DWD 10.1171/mz.2021.088





# Easy way to find the CatRaRE Data

## Catalogues of heavy precipitation events (CatRaRE) DE



Catalogues of radar-based heavy rainfall events as basis for the analysis of extreme precipitation and its potential impact in Germany since 2001

The catalogues of spatially and temporally independent heavy precipitation events are based on the climatological dataset derived from DWD's weather radar network (RADKLIM-RW). The hourly precipitation sums result from radar-based precipitation estimates on a 1 km x 1 km grid over Germany adjusted to station data. Based on this dataset precipitation sums with 11 different durations (1, 2, 3, 4, 6, 9, 12, 18, 24, 48 and 72 hours) were calculated for each hour.

**CatRaRE W3\_Eta\_2021.01:**

**DOI: [10.5676/DWD/CatRaRE\\_W3\\_Eta\\_v2021.01](https://doi.org/10.5676/DWD/CatRaRE_W3_Eta_v2021.01)**

**CatRaRE T5\_Eta\_2021.01 :**

**DOI: [10.5676/DWD/CatRaRE\\_T5\\_Eta\\_v2021.01](https://doi.org/10.5676/DWD/CatRaRE_T5_Eta_v2021.01)**

### Additional information

- [Latest data set of CatRaRE](#)
- [Information on event definition](#)
- [Description of the attributes in CatRaRE](#)
- [KlamEx](#)
- [RADKLIM](#)
- [Latest data set of RADKLIM](#)
- [Publications](#)
- [Heavy Precipitation \(Starkregen\)](#)

### Additional information

[Latest data set of CatRaRE](#)

[Information on event definition](#)

[Description of the attributes in CatRaRE](#)

[KlamEx](#)

[RADKLIM](#)

[Latest data set of RADKLIM](#)

[Publications](#)

[Heavy Precipitation \(Starkregen\)](#)

### Contact

[Contact](#)





# Easy way to find the CatRaRE Dashboard

Startseite > Fachnutzer > Wasserwirtschaft > Kooperationen und Projekte > KlamEx

Hydromet Gutachten

Radarniederschlag

Vorhersage Schneeschmelze

Hydromet Auswertungen

Hydromet Rasterwerte

Hydromet Zeitreihen

Kooperationen und Projekte

## KlamEx

Aktuelles

Projektvorhaben

Projektpartner

Projektdokumentation

Dashboard

## KlamEx

Klassifikation meteorologischer Ereignisse gegenüber Starkregen (KlamEx)

Mit einer Laufzeit vom 01.01.2011 bis heute wird das Projekt KlamEx durch die Behördenallianz „Anpassung Katastrophenhilfe (BBK), Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR), Deutscher Wetterdienst (DWD), Technisches Hilfswerk (THW) und Umweltbundesamt (UBA) das Projekt KlamEx durch.

Durch die statistische Auswertung der Starkregenereignisse und die Analyse von Einzeleignissen mittels Indizes sowie der Integration weiterer meteorologischer und nicht-meteorologischer Daten sollen die Kernfragen des Projekts angegangen werden,

- wie sich der Zusammenhang zwischen extremem Niederschlagsereignis und Einsatzgeschehen sowohl qualitativ als auch quantitativ beschreiben lässt,
- welche Quartiere und Siedlungstypen in den Jahren seit 2001 von Starkregen besonders betroffen waren,
- welche meteorologischen und nicht-meteorologischen Wirkkomponenten die räumlich unterschiedlichen Auswirkungen eines Starkregenereignisses bestimmen und
- welche Maßnahmen die Risikovorsorge gegenüber Starkregen im Bevölkerungsschutz und in der Stadtentwicklung unterstützen können

**GO TO:**  
→ [dwd.de/klamex](https://dwd.de/klamex)

## KlamEx

Aktuelles

Projektvorhaben

Projektpartner

Projektdokumentation

Dashboard

Publikationen

Kontakt

Extremereignisse (Berichte)



***Thank You for your attention!***



- CatRaRE Events Catalogues : <https://www.dwd.de/catrare>
- Radar Climatology Dataset - RADKLIM: <https://www.dwd.de/radklm>
- Project KlamEx (includes the Dashboard): <https://www.dwd.de/klamex>

**Ewelina Walawender**

E-Mail: [ewelina.walawender@dwd.de](mailto:ewelina.walawender@dwd.de)

Tel. : +49 (69) 8062-2976

**Deutscher Wetterdienst, Hydrometeorology**

Frankfurter Straße 135, 63067 Offenbach

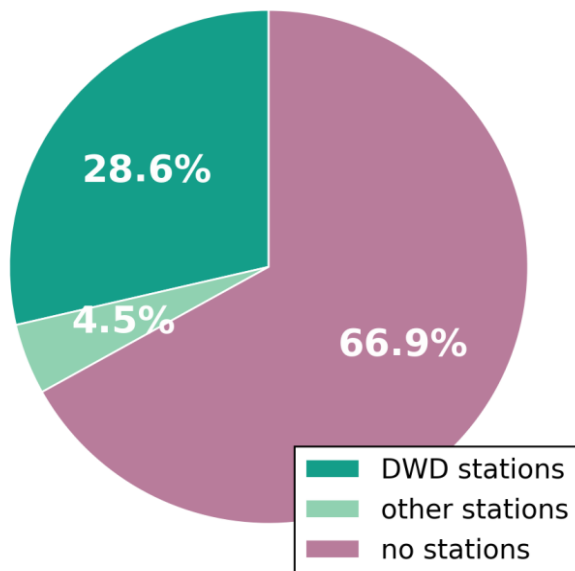
E-Mail: [hydromet@dwd.de](mailto:hydromet@dwd.de)

# ADDITIONAL MATERIALS

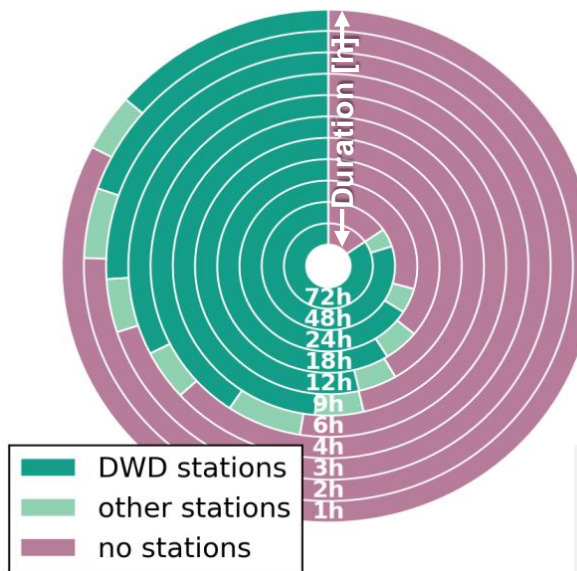


## Percentage of extreme events (2001-2018) that were measured or missed by the DWD precipitation stations

All Events (1 to 72h)



Events Duration's based



→ percentage of detected events decreases with shorter durations

→ only **33% of all events have been observed** by rain gauges (more than **75% observed for D = 24h**)

→ the **events of short duration are rarely recorded** by the point measurements (**82.7% missed for D = 1 h**)

**MORE:** Katharina Lengfeld et al, 2020  
Environ. Res. Lett. 15 08500,  
<https://doi.org/10.1088/1748-9326/ab98b4>

## Radar Online Adjustment - RADOLAN

- Hourly adjustment of the areal radar mosaic by combination with gauge-based point measurements of the hourly precipitation sum
- Retrieval of the **ratios/differences** between radar pixel and station values
- **Spatial interpolation** of the ratios and differences
- **Application** of the ratios and differences to the unadjusted radar mosaic
- Determination of the best adjustment procedure by **online verification**
- **Weighted combination** of the two gauge-adjusted products
- Application in flood prevention and flood protection since June 2005

Threshold applied for the detection of single precipitation objects:

Duration [h]	1	2	3	4	6	9	12	18	24	48	72
Minimum Area [# Pixel $\approx$ km <sup>2</sup> ]	9	9	9	12	18	27	36	54	72	144	216
Precipitation with a Return Period of 5 years ( $\geq 5a$ ) [mm] based on RADKLIM	14,8 to 28,8	18,9 to 36,5	21,4 to 42,8	22,4 to 53,0	26,1 to 56,0	29,2 to 65,7	31,6 to 73,5	35,2 to 87,3	37,8 to 99,6	44,4 to 137,8	48,7 to 167,6
DWD's Warning Level 3 [mm]	$\geq 25$	$\geq 27$	$\geq 29$	$\geq 31$	$\geq 35$	$\geq 37.5$	$\geq 40$	$\geq 45$	$\geq 50$	$\geq 60$	$\geq 90$

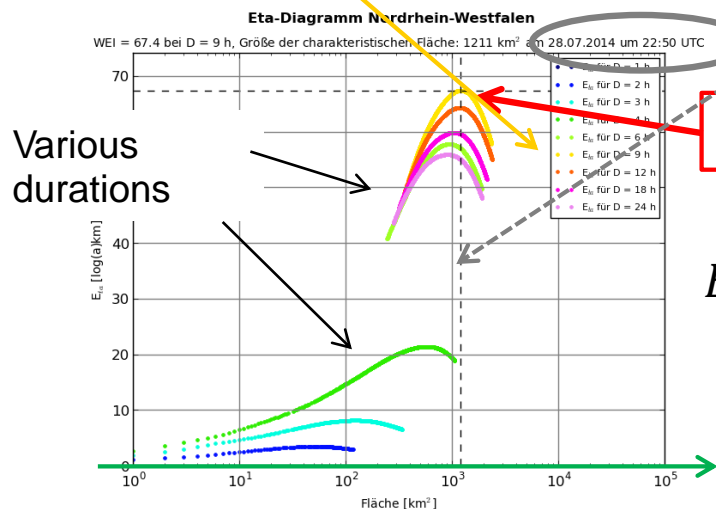


# Weather Extremity Index (Müller und Kašpar, 2014\*)

## Characteristic Durations

## Characteristic area

## Time step of the maximum extremity



$$WEI = \max(E_{ta})$$

$$E_{ta} = \frac{\sum_{i=1}^n \log(N_{ti})}{n} \frac{\sqrt{a}}{\sqrt{\pi}}$$

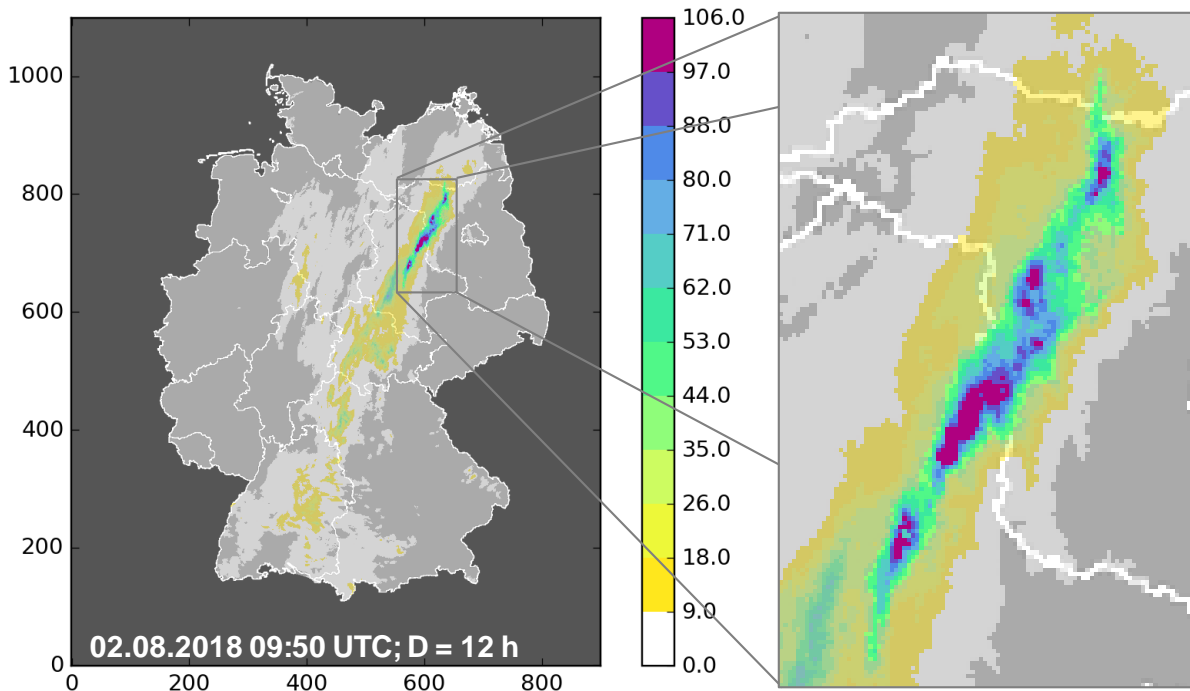
Mean log.  
Return Period

Area

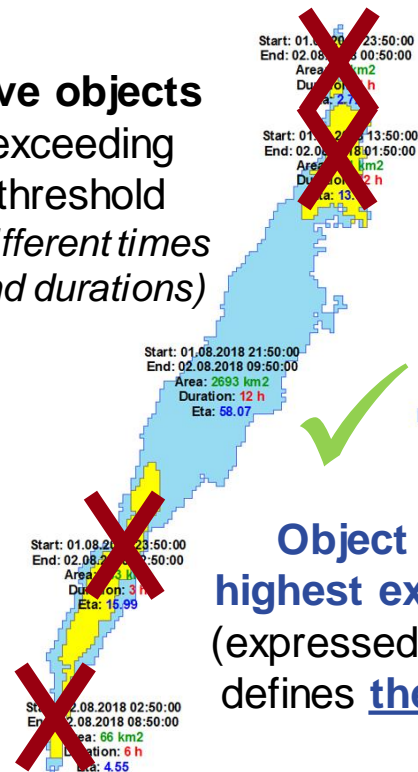
**Extremity ( $E_{ta}$ )  
of the Event =  
maximal combination of  
mean return period,  
area and duration**

\*Müller, M. and Kaspar, M.: Event-adjusted evaluation of weather and climate extremes, Nat. Hazards Earth Syst. Sci., 14, 473-483, doi:10.5194/nhess-14-473-2014, 2014

## How a spatially independent event is defined?

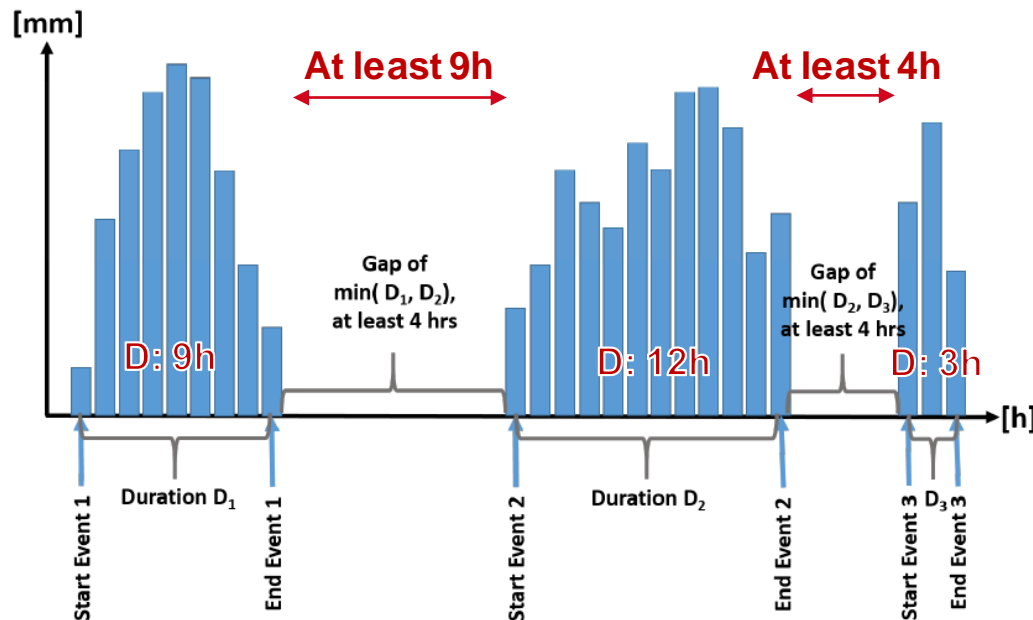


Five objects  
exceeding  
threshold  
(different times  
and durations)



Object with  
highest extremity  
(expressed by Eta)  
defines the event

## How temporally independent events are defined?



Between two events  
a temporal **gap of the  
shorter of their  
durations**, but in any  
case **at least 4 hours**  
must be given.

*Scheme of the temporal independence of precipitation events.*