Supplementary Material
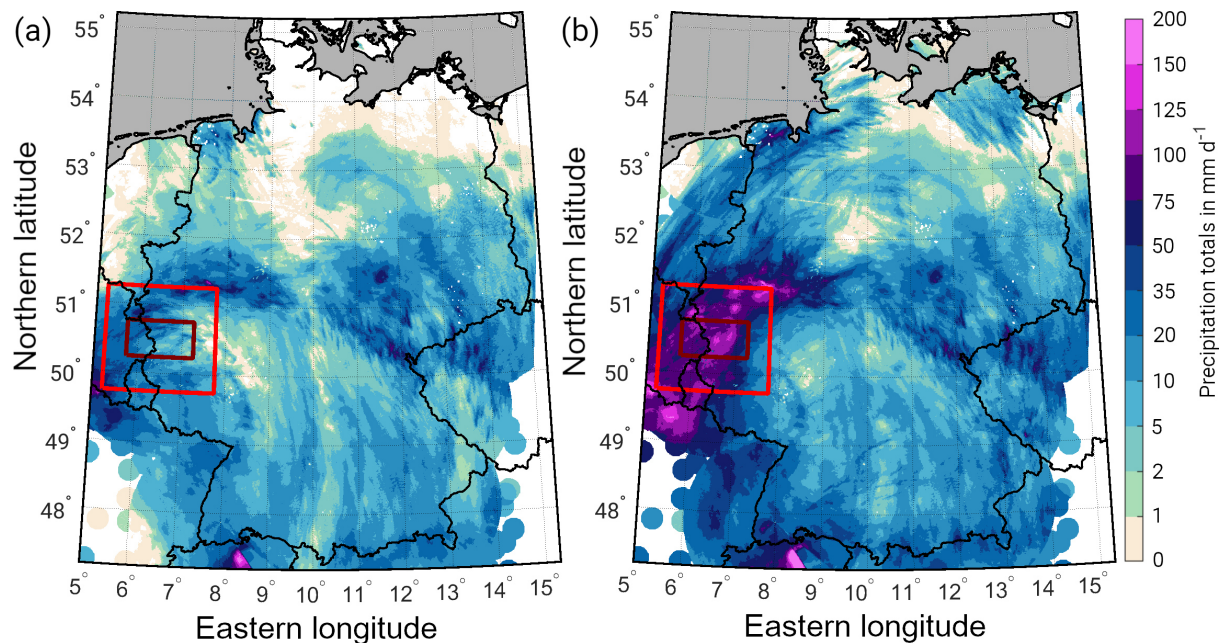
Figure S1. Precipitation totals based on RADOLAN data for (a) the 24 h period from 13 July 2021 05:50 UTC to 14 July 2021 05:50 UTC, and (b) the 48 h period from 13 July 2021 05:50 UTC to 15 July 2021 05:50 UTC. The larger light red rectangle indicates the region named LReg, the smaller dark red rectangle the region named SReg (cf. also PART2).
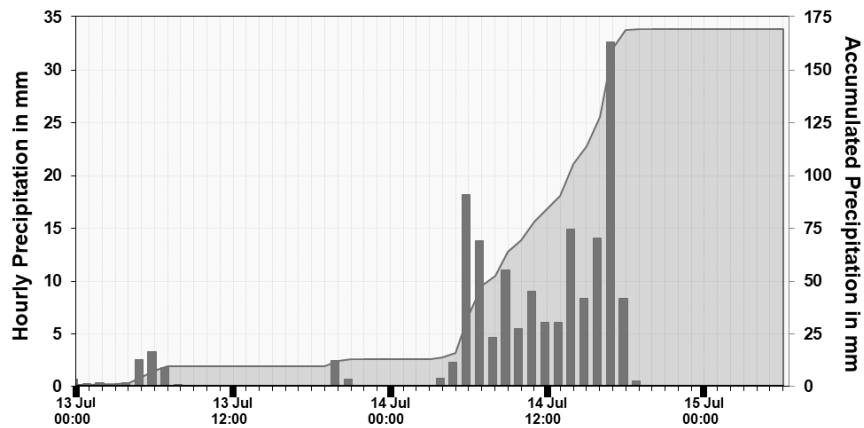
Figure S2. Time series of hourly precipitation (bars) in mm (y-axis left) and accumulative precipitation (line) in mm (y-axis right) at the DWD station Cologne-Stammheim from 13 July 2021 00:00 UTC to 15 July 2021 06:00 UTC.

Table S1. 24 h precipitation totals above 100 mm on 14 July 2021 (14 July 2021 05:50 UTC to 15 July 2021 05:50 UTC) based on DWD stations in the federal states North Rhine-Westphalia (NRW) and Rhineland-Palatinate (RP). Msl means meters above mean sea level.

Station	Measuring height in msl	Fed. state	Prec. totals in mm
Cologne-Stammheim	43	NRW	153.5
Kall-Sistig	505	NRW	144.8
Dahlem-Schmidtheim	573	NRW	129.2
Schneifelforsthaus	649	RP	124.1
Lissendorf	407	RP	119.4
Gerolstein	530	RP	116.6
Alfter-Volmershoven	160	NRW	114.6
Lüdenscheid	387	NRW	114.4
Weilerswist-Lommersum	147	NRW	113.9
Wipperfürth-Gardeweg	360	NRW	111.8
Blankenheim-Ahrhütte	402	NRW	111.2
Wermelskirchen	244	NRW	107.0
Cologne-Bonn	92	NRW	106.9

Heavy rain catalog: KOSTRA-DWD-2010R

1200 With KOSTRA-DWD-2010R data (*Koordinierte Starkniederschlagsregionalisierung und -auswertung*; Malitz and Ertel, 2015; Junghänel et al., 2017), the DWD provides a tool that allows statements about the intensity and occurrence probabilities of heavy precipitation events at any location in Germany. KOSTRA-DWD-2010R is a gridded data set of precipitation statistics with a grid resolution of about $8{\times}8\,\mathrm{km}^2$. For each grid cell, precipitation statistics for different duration levels from 5 minutes to 72 hours and return periods ranging from 1 year to 100 years are included. KOSTRA-DWD-2010R is based on interpolated

1205 station data for duration levels below 24 hours and on HYRAS-DE above. It is commonly used in Germany as a calculation basis for precipitation runoff and the dimensioning of facilities. Figure S3 shows the return periods of 24 h precipitation totals on 14 July 2021 based on this catalog.
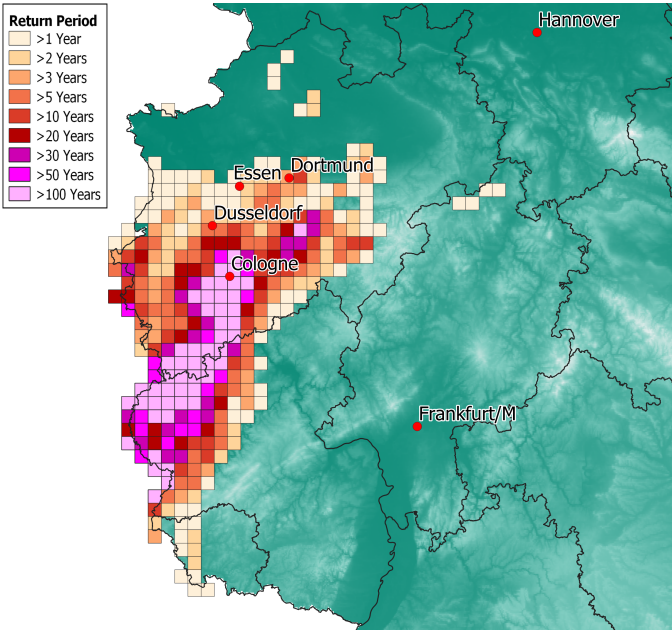
Figure S3. Return periods of 24 h precipitation totals based on KOSTRA-DWD-2010R (14 July 2021 05:50 UTC to 15 July 2021 05:50 UTC).
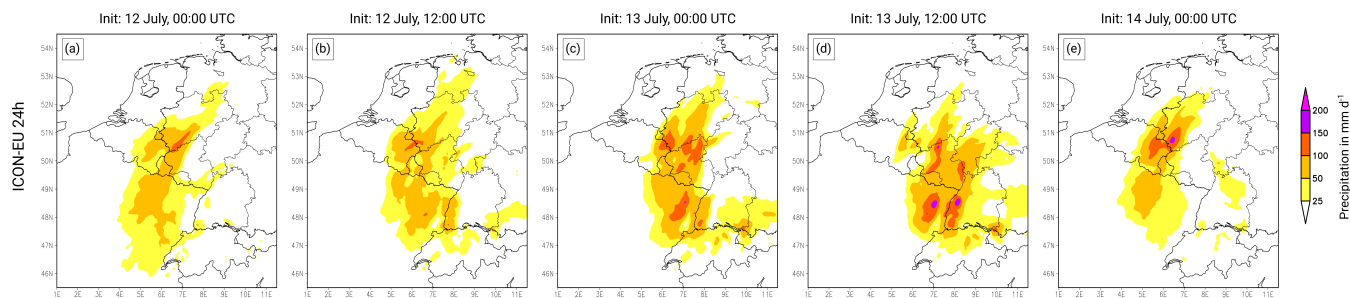
Figure S4. 24 h precipitation forecasts (14 July 2021 06:00 UTC to 15 July 2021 06:00 UTC) for ICON-EU for different initialization times (a: 12 July 2021 00:00 UTC; b: 12 July 2021 12:00 UTC; c: 13 July 2021 00:00 UTC; d: 13 July 2021 12:00 UTC; e: 14 July 2021 00:00 UTC).
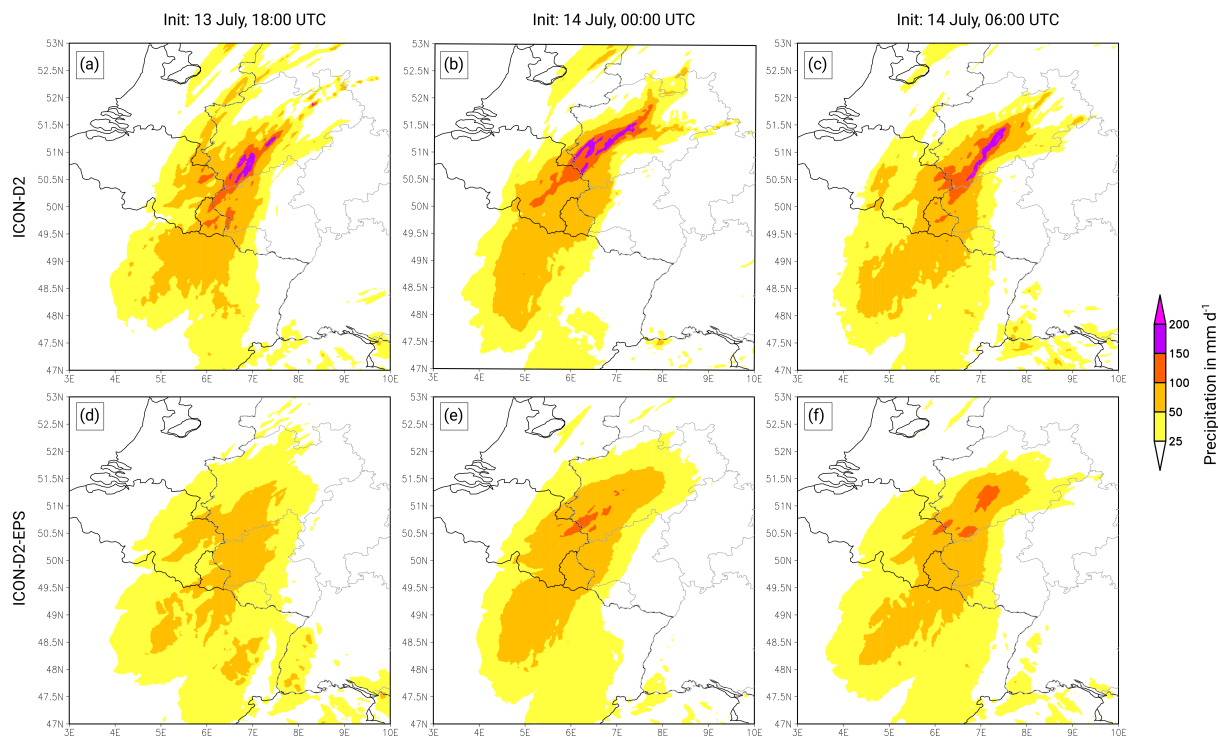
Figure S5. 24 h precipitation forecasts (14 July 2021 06:00 UTC to 15 July 2021 06:00 UTC) for ICON-D2 (a)-(c) and ICON-D2-EPS (d)-(f) for different initialization times (a, d: 13 July 2021 18:00 UTC; b, e: 14 July 2021 00:00 UTC; c, f: 14 July 2021 06:00 UTC).

Table S2. Fatalities, total estimated losses, and insured damage including references with release date. The abbreviation Gov. stands for the German government. Note that all damage estimations for Germany (unless otherwise stated) also include damage from the federal states of Bavaria and Saxony, which were also associated with the low-pressure system *Bernd*.

Entity	Fatalities	Total Damage	Insured Damage	Reference	Release date
CEDIM FDA	194	EUR 11–29 bn[3]	EUR 5–10 bn	Schäfer et al. (2021)	20.07.2021
GDV Vers. 2			EUR 8.2 bn	GDV (2021b)	29.12.2021
			EUR 7.7 bn (property)		
GDV Vers. 1			EUR 6.95 bn	GDV (2021a)	06.10.2021
			EUR 6.5 bn (buildings)		
Gov.: Total Vers. 2	183	EUR 32.05 bn		BMI (2022)	03.2022
Gov.: Total Vers. 1		EUR 30 bn		BMI (2021)	28.09.2021
MunichRe		EUR 33 bn[1]	EUR 8.2 bn[1]	Munich Re (2022)	01.2022
		EUR 46 bn[2]	EUR 11 bn[2]		
Aon	197	EUR 31.5 bn		Podlaha et al. (2022)	01.2022
CATDAT		EUR 33.6 bn	EUR 8 bn	EEA (2022)	31.12.2021
SwissRe		USD 40+ bn[2]		Swiss Re (2021)	14.12.2021
Deutsche Rück		EUR 40–50 bn	EUR 8.2 bn[1]	Deutsche Rück (2021)	04.08.2021
			EUR 11 bn[2]		

[1]Germany; [2]All countries: [3]Incl. buildings, infrastructure, production