SUPPLEMENTAL MATERIALS

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Climate Change and Rainfall Intensity–Duration–Frequency Curves: Overview of Science and Guidelines for Adaptation

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Table S1. Synthesis of 58 selected studies on rainfall extremes under climate change.

Reference	Location	Climate model simulations					GHG emission scenario					Extreme rainfall indicator	Return period	Future period	Studies that investigated[a]	
		GCM	RCM	CPM	Multiple models	Ensemble	RCP 8.5	RCP 6.0	RCP 4.5	RCP 2.6	Other				different frequencies[b]	the sub-daily scale[c]
Kharin et al., 2013	World	X			X		X		X	X		Rx1day	20-yr	2046-65; 2081-2100		
Fischer et al., 2014	World	X			X		X					Rx1day	N/A	2006-2100		X
Kendon et al., 2014	UK		X	X	X		X					R95p	N/A	2086-99		X
Srivastav et al., 2014	Canada	X					X	X	X	X		IDF curves	2- to 100-yr	2006-2100	X	
Arnbjerg-Nielsen et al., 2015	Denmark	X			X		X				X	Hourly and daily rainfall	2- to 1000-yr	2071-2100	X	X
Ban et al., 2015	Europe			X	X	X	X					R97.5p, R99p, R99.9p, R99.99p	N/A	2081-90		X
Chandra et al., 2015	India	X			X		X	X	X	X		IDF curves	N/A	2021-50, 2051-80, 2071-2100	X	X
Fischer and Knutti, 2015	World	X			X		X		X			R99p, R99.5p	N/A	30-yr		
Pendergrass et al., 2015	World	X			X		X	X	X	X		Rx1day	N/A	2071-2100		
Donat et al., 2016	World	X			X		X		X			RX1day	N/A	2070-99		
Lima et al., 2016	South Korea		X				X	X				IDF curves	2- to 100-yr	2011-2100	X	
Tabari et al., 2016	Belgium	X		X	X						X	IDF curves	1- and 10-yr	2060-69 2071-2100		X
Alexander and Arblaster, 2017	Australia	X			X		X		X			R95p, R99p, Rx1day, Rx5day	N/A	2046-65; 2081-2100		
Bao et al., 2017	Australia		X		X	X	X					R99p	N/A	2060-79		
Fadhel et al., 2017	England		X			X					X	IDF curves	5-yr	2069-98		
Kendon et al., 2017	UK			X	X		X					Rx1hr to Rx24hr	N/A	2087-2100	X	X
Mantegna et al., 2017	Australia			X	X						X	IDF curves	N/A	2070-99	X	X
Pfahl et al., 2017	World	X			X							Rx1day	N/A	1950-2100		
Prein et al., 2017	US	X			X		X					R97.5p, R99.95p	N/A	2071-2100	X	X
Rajczak and Schär, 2017	Europe		X		X	X	X		X	X		R99p, Rx1day, Rx5day	5- to 100-yr	2070-99		
Aalbers et al., 2018	Europe		X			X	X					Rx1day	10- and 20-yr	2071-2100	X	
Eekhout et al., 2018	Spain		X		X		X		X			R95p	N/A	2031-50; 2081-2100		

Forestieri et al., 2018	Italy		X		X		X				IDF curves	5- to 100-yr	2005-50; 2050-2100	X	
Kharin et al., 2018	World	X			X		X		X	X	Rx1day	20- and 50-yr	2005-2100		
Hosseinzadehtalaei et al., 2018	Belgium		X		X		X		X		IDF curves	1-month, 1-yr and 10-yr	2071-2100	X	
Nie et al., 2018	US	X			X	X	X				N/A	N/A	2090-99		
Pendergrass, 2018	World	N.A.									R95p	N/A	N.A.	X	
Ragno et al., 2018	US	X			X		X		X		IDF curves	2- to 100-yr	2050-99	X	
Berg et al., 2019	Europe		X		X		X		X		Rx1hr	5- to 100-yr	2011-40; 2041-70; 2071-2100		X
Butcher and Zi, 2019	US	X			X		X		X		IDF curves	2- to 1000-yr	2035-65; 2070-2100	X	
Cannon and Innocenti, 2019	North America			X			X				IDF curves	2- to 100-yr	2071-2100	X	
Fluixa-Sanmartin et al., 2019	Spain		X		X		X		X	X	IDF curves	2 to 100 000 yr	2010-39, 2040-69, 2070-99	X	
Ganguli and Coulibaly, 2019	Canada		X		X		X				IDF curves	5- to 25-yr	2030-70	X	
Hodnebrog et al., 2019	Europe	X	X	X	X		X				Rx10min, Rx1hr, Rx1day	N/A	2081-2100		X
Innocenti et al., 2019	North America		X			X	X				Rx1hr to Rx72hr	N/A	2006-2099	X	X
Kendon et al., 2019	Africa		X	X	X		X				R95p	N/A	2090-2100		
Morrison et al., 2019	World	X			X		X	X	X	X	Rx3hr, Rx1day	N/A	2026-45; 2081-2100		X
Myhre et al., 2019	Europe	X			X		X				R99p, Rx1day	N/A	2071-2100		
Schardong and Simonovic, 2019	Canada	X	X		X		X				IDF curves	2- to 100-yr	2020-2100	X	
Vanden Broucke et al., 2019	Europe		X	X	X		X				R95p, R99p	N/A	2069-99		X
Ban et al., 2020	Europe			X	X	X	X				Rx1hr, Rx1day, Rx5day	2- to 100-yr	2081-90	X	X
Donat et al., 2020	World	X			X		X				Rx1day	N/A	2081-2100		
Fosser et al., 2020	Europe		X	X	X	X	X				Rx1hr to Rx48hr	N/A	2060-80		X
Helsen et al., 2020	Europe		X	X	X		X				R95p to R99.995p	N/A	2070-2100	X	
Hosseinzadehtalaei et al., 2020	Europe	X	X		X		X		X		Rx3hour, Rx1day	2- to 100-yr	2041-70; 2071-2100	X	X
Huo et al., 2021	Europe	X			X		X			X	Rx1day, Rx5day, Rx15day	5- to 200-yr	2006-99	X	
Khazaei, 2021	Iran	X			X		X		X	X	IDF curves	2- and 15-yr	2036-65	X	
Kichmeier-Young and Zhang, 2020	North America	X	X		X	X	X				Rx1day, Rx5day	20- to 100-yr	1961-2100	X	

Knist et al., 2020	Europe		X	X	X			X		R95p, R99.9p, R99.99p	N/A	2038-50; 2088-2100		X
Li et al., 2020	World	X			X				X	Rx1day, Rx5day	2- to 50-yr	2071-2100	X	
Martel et al., 2020	World	X	X		X	X	X			Rx1hr to Rx5day	2- to 100-yr	2080-99	X	X
Tabari et al., 2020	World	X			X		X			N/A	30-yr	2070-2099		
Wood and Ludwig, 2020	Europe		X			X	X			Rx3hr, Rx1day, Rx5day	N/A	2070-99		X
Lenderink et al., 2021	Europe			X		X			X	R90P, R99p, R99.9p	N/A	2089-2099	X	X
Luu et al., 2021	France			X	X	X	X			Rx3hr, Rx1day	N/A	2001-2030	X	X
Moustakis et al., 2021	US			X			X			R90p,R95p, R98p, R99p, R99.5p	20-yr	2071-2100	X	X
Pichelli et al., 2021	Europe		X	X	X	X	X			R99p, R99.9p	N/A	2041-50; 2090-99	X	
Vergara-Temprado et al., 2021	Europe		X	X	X		X			R99p, R99.9p, R99.99p, R99.999p	N/A	2090-2100		X

Rx1(a)(b): maximum rainfall index where (a) is the time step and (b) the units.
R(c)p: rainfall percentile where (c) is the percentile value

[a]All studies referenced have shown an increase in extreme rainfall
[a]All studies that have investigated different frequencies have shown larger increases for longer return periods
[a]All studies that have investigated sub-daily time scale have shown larger increases for shorter durations

Table S2. List of the 26 CMIP5 models and simulations used.

#	Institution	Model name	Historical	RCP4.5	RCP8.5
1	CSIRO-BOM	ACCESS1.0	x	x	x
2	CSIRO-BOM	ACCESS1.3	x	x	x
3	BCC	BCC-CSM1.1	x	x	x
4	BCC	BCC-CSM1.1(m)	x	x	x
5	CCCMA	CanESM2	x	x	x
6	CMCC	CMCC-CESM	x		x
7	CMCC	CMCC-CM	x	x	x
8	CMCC	CMCC-CMS	x	x	x
9	CNRM-CERFACS	CNRM-CM5	x	x	x
10	CSIRO-QCCCE	CSIRO-Mk3.6.0	x	x	x
11	LASG-CESS	FGOALS-s2	x	x	x
12	NOAA-GFDL	GFDL-CM3	x	x	x
13	NOAA-GFDL	GFDL-ESM2G	x	x	x
14	NOAA-GFDL	GFDL-ESM2M	x	x	x
15	MOHC	HadGEM2-CC	x	x	x
16	MOHC	HadGEM2-ES	x	x	x
17	INM	INM-CM4	x	x	x
18	IPSL	IPSL-CM5A-LR	x	x	x
19	IPSL	IPSL-CM5A-MR	x	x	x
20	IPSL	IPSL-CM5B-LR	x	x	x
21	MIROC	MIROC5	x	x	x
22	MIROC	MIROC-ESM	x	x	x
23	MIROC	MIROC-ESM-CHEM	x	x	x
24	MPI-M	MPI-ESM-LR	x	x	x
25	MPI-M	MPI-ESM-MR	x	x	x
26	NCC	NorESM1-M	x	x	x

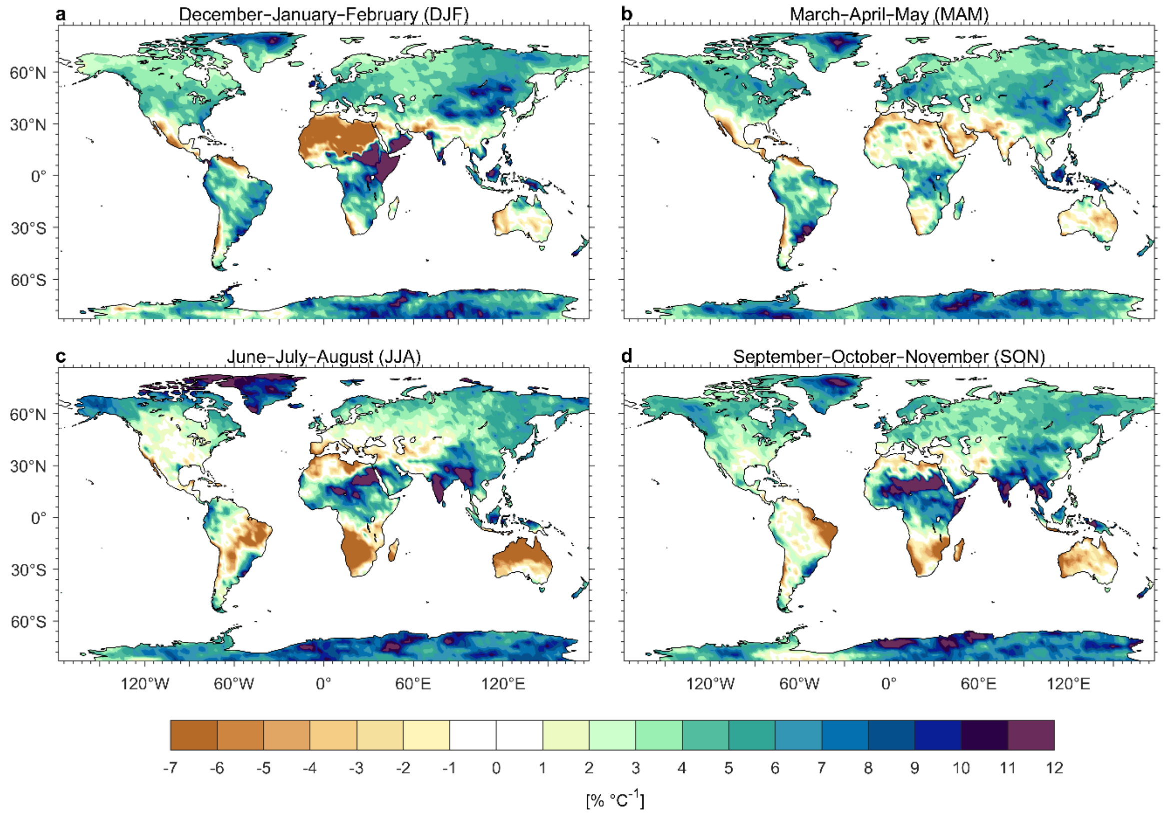

Fig. S1. Seasonal scaling rates (% $°C^{-1}$) of daily maximum rainfall (Rx1day) for DJF (a), MAM (b), JJA (c) and SON (d) with respect to global mean temperature changes for the RCP4.5 scenario.

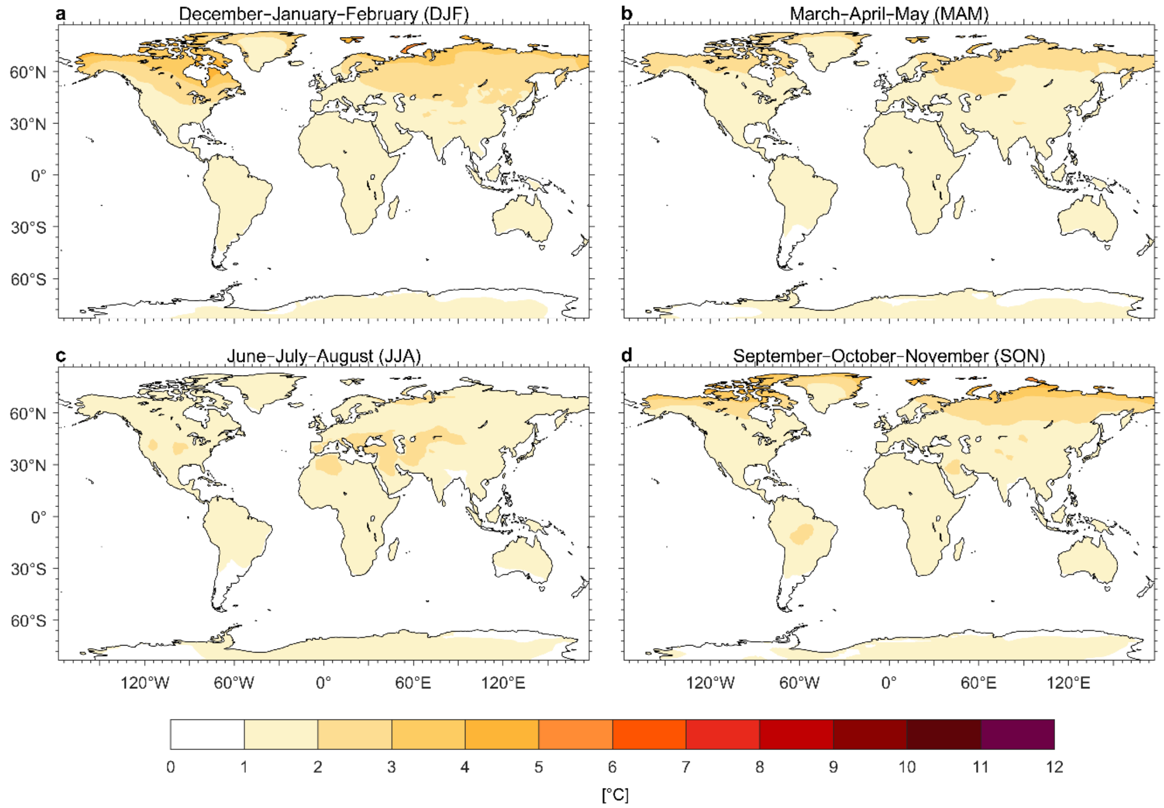

Fig. S2. Seasonal temperature change (°C) for DJF (a), MAM (b), JJA (c) and SON (d) between the future (2021-2040) and reference (1981-2000) periods for the RCP8.5 scenario.

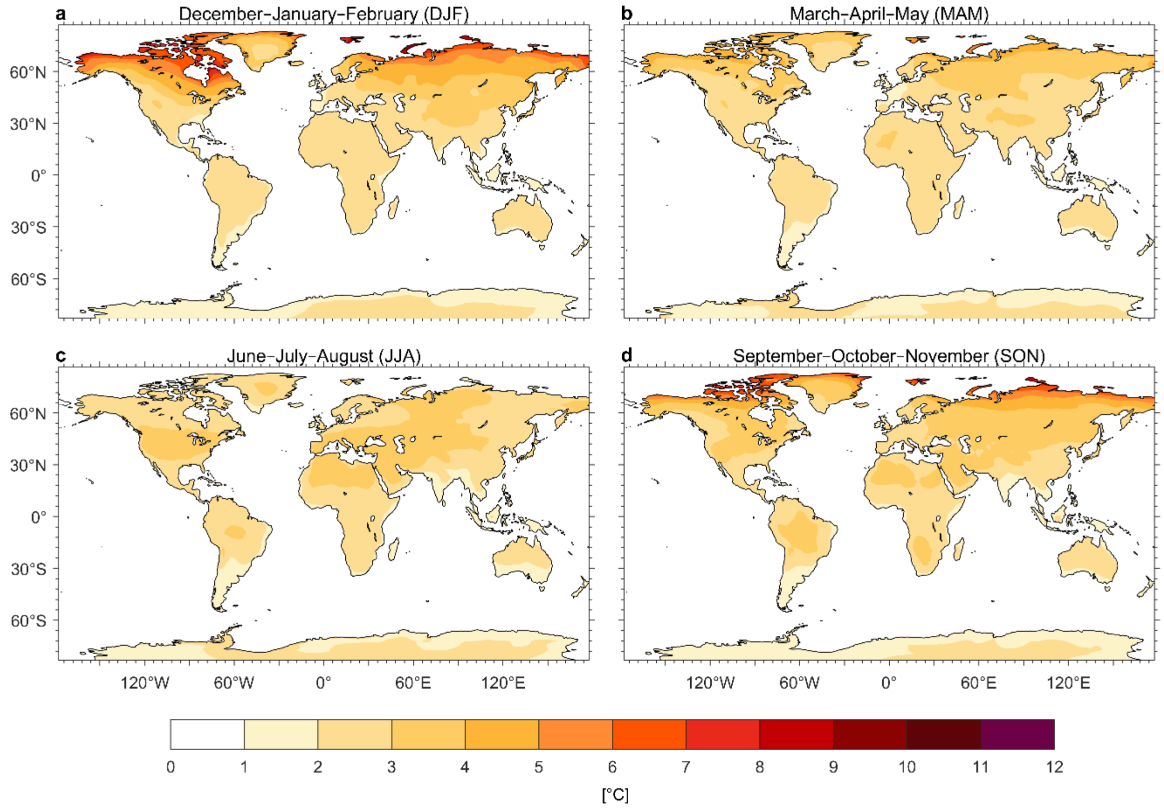

Fig. S3. Same as Fig. S2, but for the future (2041-2060) period.

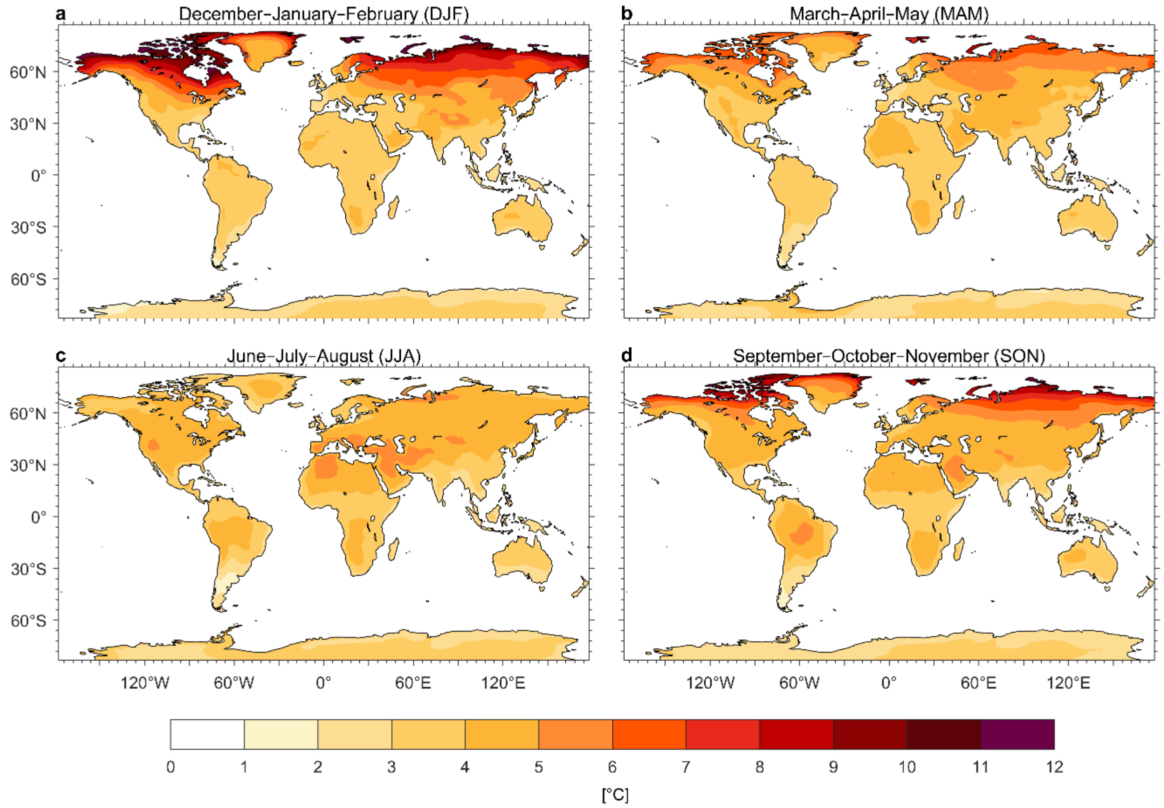

Fig. S4. Same as Fig. S2, but for the future (2061-2080) period.

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