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Past, present and future rainfall erosivity in central Europe based on convection-permitting climate simulations

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Supplement

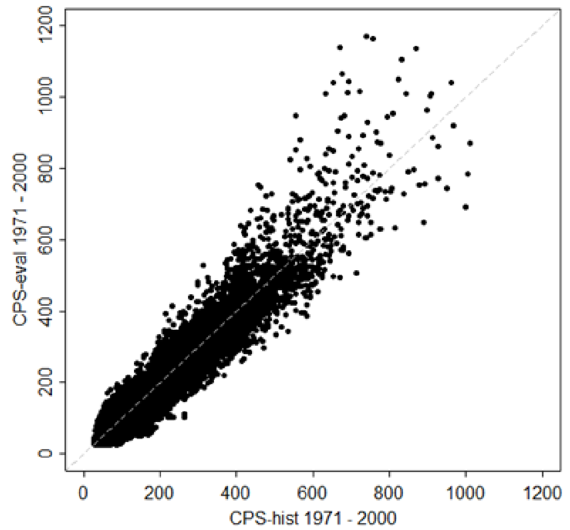

Figure S1: Comparison of average annual rainfall erosivity from 1971 - 2000 calculated from the evaluation simulation (CPS-eval) and with the historical projection simulations (CPS-hist). Each point in the scatter plot represents a grid point.

Table S1: Comparison of past and future changes in rainfall erosivity reported in the literature and calculated here (data from the projection run unless stated otherwise). The values from the other studies were either given in the text or tables, estimated from figures or extracted from reported data (see description of methodology below). For ease of comparison, we give the changes per decade and always assume linear trends. Note that while the spatial extent always matches, the temporal coverage can differ due to data availability. References: (1) Verstraeten et al., 2006; (2) Fiener et al., 2013 ;(3) Hanel et al., 2016; (4) Auerswald et al., 2019; (5) Auerswald et al., 2019b; (6) Wurbs and Steininger, 2011; (7) Gericke et al., 2019; (8) Panagos et al., 2017; (9) Panagos et al., 2022; (10) Köhn et al., 2022.

Study				Change per decade [%]	
Ref.	Location	Precipitation data	Temporal coverage	Other study	This study
Past trends in rainfall erosivity					
1	Ukkel, Belgium	1 rain gauge (10 min resolution)	1971-2002	13.9	34.2
2	Ruhr area, Germany	10 rain gauges (5 min)	1973-2007	21.0	23.2
3	Czech Republic	17 rain gauges (30 min)	1962-2011	3.9	16.5
4	Germany	contiguous radar data (60 min)	2001-2017	12.0	1.2
5	Germany	≥ 50 rain gauges	1962-2017	14.0	17.1
Future trends in rainfall erosivity					

6	Germany	ECHAM5-WETTREG (SRES A1B)	1985-2055	-0.4	3.9
6	Germany	ECHAM5-WETTREG (SRES A1B)	1985-2085	0.8	6.3
7	Brandenburg, Germany	EURO-CORDEX ensemble (RCP 8.5)	2008-2038	5.0-11.0	5.3
7	Brandenburg, Germany	EURO-CORDEX ensemble (RCP 8.5)	2008-2078	2.0-8.0	8.4
8	Germany	HadGem2 (RCP 4.5)	2010-2050	16.5	3.9
8	Denmark	HadGem2 (RCP 4.5)	2010-2050	19.6	9.6
8	Netherlands	HadGem2 (RCP 4.5)	2010-2050	19.4	1.8
8	Switzerland	HadGem2 (RCP 4.5)	2010-2050	6.1	3
8	Czech Republic	HadGem2 (RCP 4.5)	2010-2050	17.2	4.5
9	Germany	CMIP5 ensemble (RCP 8.5)	2010-2050	36.0	3.9
9	Denmark	CMIP5 ensemble (RCP 8.5)	2010-2050	24.9	9.6
9	Netherlands	CMIP5 ensemble (RCP 8.5)	2010-2050	39.6	1.8
9	Switzerland	CMIP5 ensemble (RCP 8.5)	2010-2050	21.5	3
9	Czech Republic	CMIP5 ensemble (RCP 8.5)	2010-2050	23.5	4.5
10	Mansfeld Südharz, Germany	EURO-CORDEX ensemble (RCP 8.5)	1995-2035	4.3	2.3
10	Mansfeld Südharz, Germany	EURO-CORDEX ensemble (RCP 8.5)	1995-2085	2.4	8.4

Methods for obtaining the values in Table S1:

Ref. 1) Ukkel, Belgium: Annual R-factor values for the period 1971-2002 were extracted from Fig. 2 in Verstraeten et al., (2006) using WebPlotDigitizer (https://automeris.io/WebPlotDigitizer/, accessed 09/02/2023). A linear regression model was fitted to the data and the slope of the best fit was 1.2865 MJ mm ha-1 h-1 a-1 per year. This corresponds to 1.39 % of the mean value during the same period per year and 13.9 % change per decade. From this study, annual R-factor values were extracted for the period 1971-2000 from the CPS-hist simulation run at the 9 grid cells surrounding Ukkel, Belgium. The 9 grid cells were averaged and the change rate per decade was calculated as for the data extracted from Verstraeten et al. (2006).

Ref. 2) Ruhr area, Germany: Fiener et al. (2013) state an increase of 21% change per decade between 1973 and 2007 in the abstract. From this study, annual R-factors were extracted for the period 1971-2000 from the CPS-hist simulation run at a rectangle which includes the locations of the raingauges shown in Fig. 1 of Fiener et al. (2013). The annual values were averaged over all grid cells included in this rectangle and a linear change rate per decade was calculated as described above. It has to be noted that Fiener et al. (2013) consider summer erosivity while we consider annual erosivity.

Ref. 3) Czech Republic: In Table 2 by Hanel et al. (2016), the authors give a mean change of 3.87 % per decade for annual rainfall erosivity (called EI30 by the authors) averaged over 17 rain gauges in the Czech Republic in the period 1962-2011. From this study, annual R-factor values were extracted for the period 1971-2000 from the CPS-hist simulation run at all grid cells in the Czech Republic. The spatial mean was calculated and the linear change rate per decade was calculated as described above.

Ref. 4) Germany: Annual R-factor values for the period 2001-2017 were extracted from Fig. 7 in Auerswald et al. (2019) using WebPlotDigitizer (https://automeris.io/WebPlotDigitizer/, accessed 09/02/2023). A linear change rate was calculated as described above. From this study, annual R-factor values were extracted for the period 2001 - 2017 from the CPS-eval evaluation run at all grid cells in Germany. Note that the change rate in the evaluation run was smaller than in the simulation run which was not available for the period 2001-2017.

Ref. 5) Germany: Auerswald et al. (2019b) state that the R-factor doubled between 1962 and 2017. 100% change in 5.5 decades corresponds to 18.2% change per decade, but this is with respect to the initial value of 1962, not with respect to the mean of the annual time series. Using the values of spatially averaged R-factors given in the text, we estimated a change rate of approx. 12 % per decade. From this study, annual R-factor values were extracted for the period 1971-2000 from the CPS-hist simulation run at all grid cells in the Germany.

Ref. 6) Germany: Wurbs and Steininger (2011) give an R-factor that is spatially averaged over Germany of 57.3 for the reference period 1971-2000 (central year 1985), an R-factor of 55.8 N h-1 a-1 for the near future 2041-2070 (central year 2055) and an R-factor of 62.0 for the far future 2071-2100 (central year 2085). This corresponds to a decrease of -0.4% of the value of the reference period for the near future and an increase of 0.8% for the far future. From this study, all grid cells in Germany were extracted from the R-factor maps for the historical period (CPS-hist), the near future (CPS-scen-nf) and the far future (CPS-scen-ff). All grid cells were spatially averaged and change rates per decade were calculated in percent of the mean value in the historical period.

Ref. 7) Brandenburg, Germany: The range of values given in the lower left subfigure of Fig. 6 in Gericke et al. (2019) was extracted with WebPlotDigitizer (https://automeris.io/WebPlotDigitizer/, accessed 09/02/2023) for the start years of 15-year intervals 2030 and 2070 (corresponding to central years 2038 and 2078). From this study, all grid cells in the German federal state of Brandenburg were extracted from the R-factor maps for the historical period (CPS-hist), the near future (CPS-scen-nf) and the far future (CPS-scen-ff) and rates of change per decade were calculated as described above. It has to be noted that the reference period differs considerably between this study (1971-2000) and the study by Gericke et al. (2019) (2000-2015).

Ref. 8) Germany, Denmark, Czech Republic, Netherlands, Switzerland: The values of change in R-factor given in Table 2 by Panagos et al. (2017) for the respective countries were transformed to changes per decade through division by the number of decades (four). From this study, all grid cells in the respective countries were extracted from the R-factor maps for the historical period (CPS-hist) and the near future (CPS-scen-nf) and rates of change per decade were calculated as described above. It has to be noted that the central year for the near future is similar in our study (2055) and the one of Panagos et al. (2017) (central year 2050) but the reference period differs considerably between the studies (central year 1985 in our study and 2010 in Panagos et al. (2017)).

Ref. 9) Germany, Denmark, Czech Republic, Netherlands, Switzerland: Change rates between 2010 and 2050 or 2070 are provided by Panagos et al. (2022) at https://esdac.jrc.ec.europa.eu/content/global-rainfall-erosivity-projections-2050-and-2070 (accessed 09/02/2023). The values from the file 2010-2050-rcp8.5.tif were extracted for the respective countries, spatially averaged and divided by the number of decades. Change rates for this study are the same as for reference 8.

Ref. 10) District of Mansfeld Südharz, Germany: Köhn et al. (2022) state in the text of the paper that mean changes from the present (reference period 1971-2000) to the near future (2021-2050) and the far future are 17 % and 22 % respectively. Divided by the number of decades these values correspond to 4.3 % change per decade for the near future and 2.4 % for the far future. From this study, all grid cells in the German district of Mansfeld Südhrz were extracted from the R-factor maps for the historical period (CPS-hist), the near future (CPS-scen-nf) and the far future (CPS-scen-ff) and rates of change per decade were calculated as described above.

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