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Supplement of

Droughts in Germany: performance of regional climate models in reproducing observed characteristics

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Supplementary material

Additional tables and figures that were omitted in the manuscript for brevity.
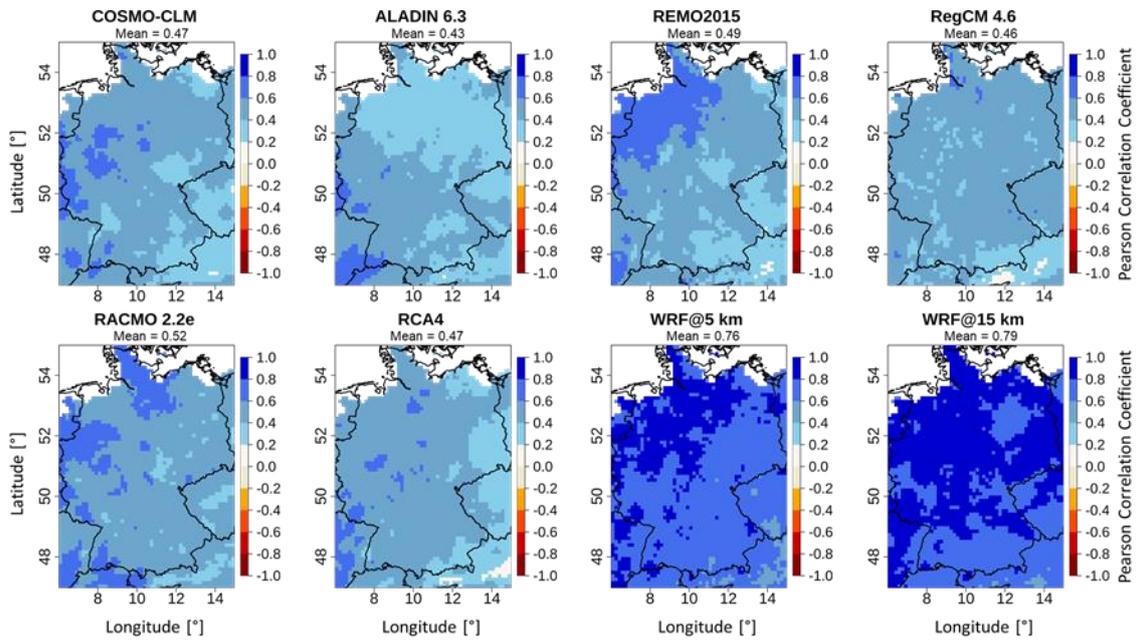
Figure S1. Grid cell based Pearson correlation coefficients of the SPEI-6 time series for 1980–2009 between each RCM and E-OBS.
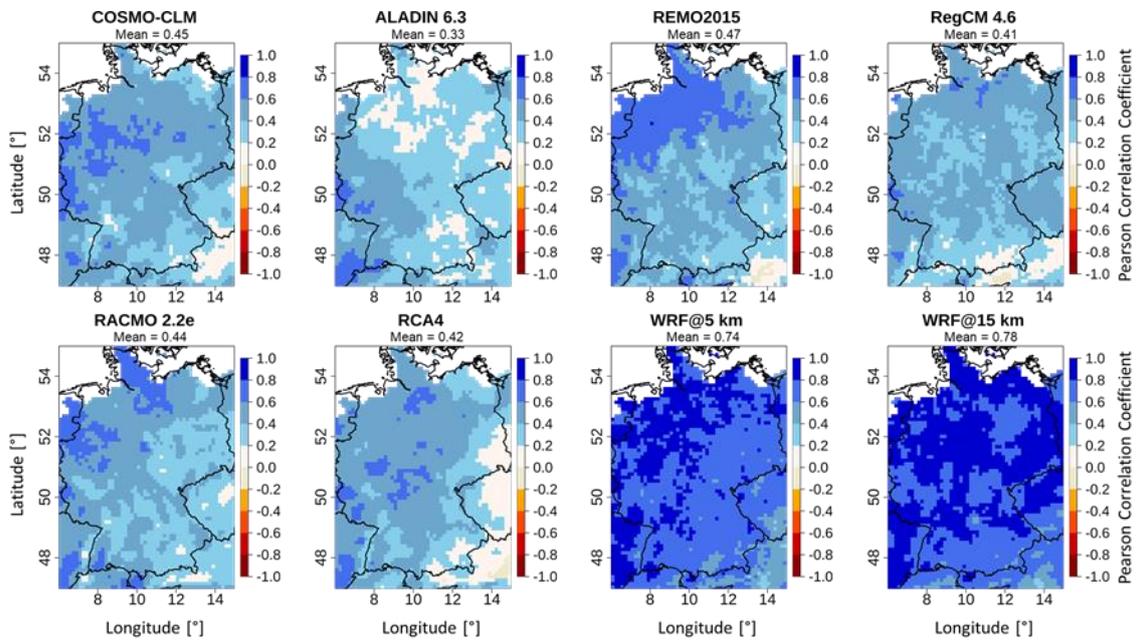
Figure S2. Grid cell based Pearson correlation coefficients of the SPEI-12 time series for 1980–2009 between each RCM and E-OBS.
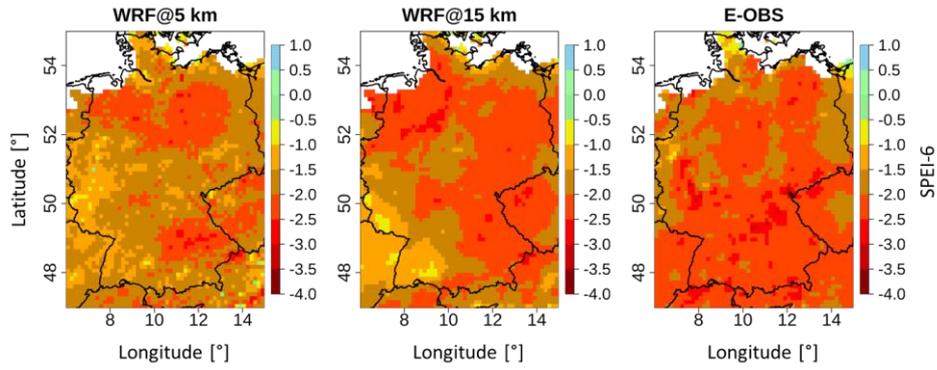
Figure S3. SPEI-6 values for August 2003 from the two WRF domains and E-OBS.
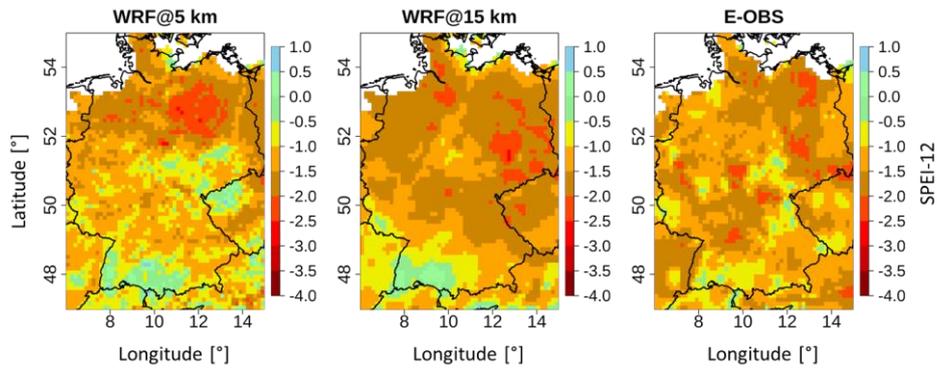
Figure S4. SPEI-12 values for August 2003 from the two WRF domains and E-OBS.

Table S1. Drought event August 2003 - SPEI-6 metrics including the spatial efficiency (SPAEF) scores for the spatial agreement between each RCM and E-OBS as reference.

Model	Mean SPEI-6	Area under Drought [%]	Mean Bias [SPEI units]	SPAEF
COSMO-CLM	-1.44	82.1	-0.67	0.27
ALADIN 6.3	-1.64	84.7	-0.45	0.51
REMO2015	-1.40	69.2	-0.71	-0.72
RegCM 4.6	-1.65	86.0	-0.45	0.11
RACMO 2.2e	-1.57	82.9	-0.54	0.13
RCA4	-1.98	86.8	-0.12	0.13
WRF@5 km	-1.78	85.5	-0.32	0.17
WRF@15 km	-1.94	85.6	-0.15	0.04
E-OBS	-2.11	84.7		

Table S2. Drought event August 2003 - SPEI-12 metrics including the spatial efficiency (SPAEF) scores for the spatial agreement between each RCM and E-OBS as reference.

Model	Mean SPEI-12	Area under Drought [%]	Mean Bias [SPEI units]	SPAEF
COSMO-CLM	-0.96	50.0	-0.43	-0.33
ALADIN 6.3	-1.24	67.0	-0.14	0.11
REMO2015	-0.87	38.4	-0.53	-0.92
RegCM 4.6	-1.31	67.8	-0.08	0.10
RACMO 2.2e	-1.15	57.9	-0.25	-0.17
RCA4	-1.61	82.0	0.22	0.18
WRF@5 km	-1.19	58.3	-0.19	0.13
WRF@15 km	-1.42	70.7	0.04	0.25
E-OBS	-1.39	71.3		
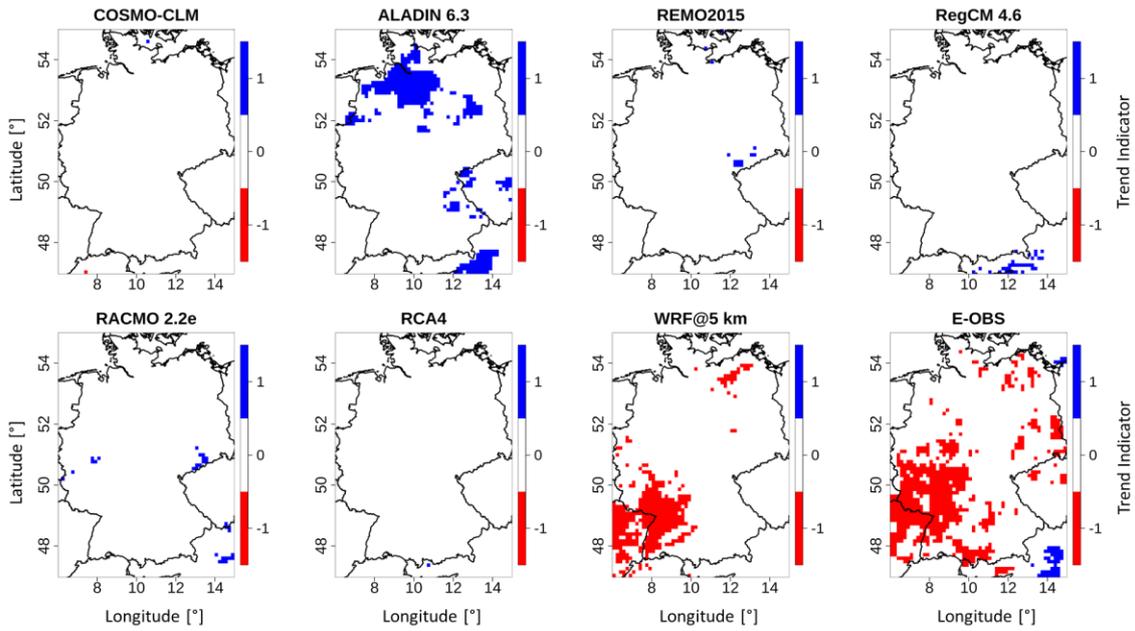
Figure S5. Grid cell based SPEI-6 trends for 1980–2009 based on the Mann-Kendall test for each RCM and E-OBS.
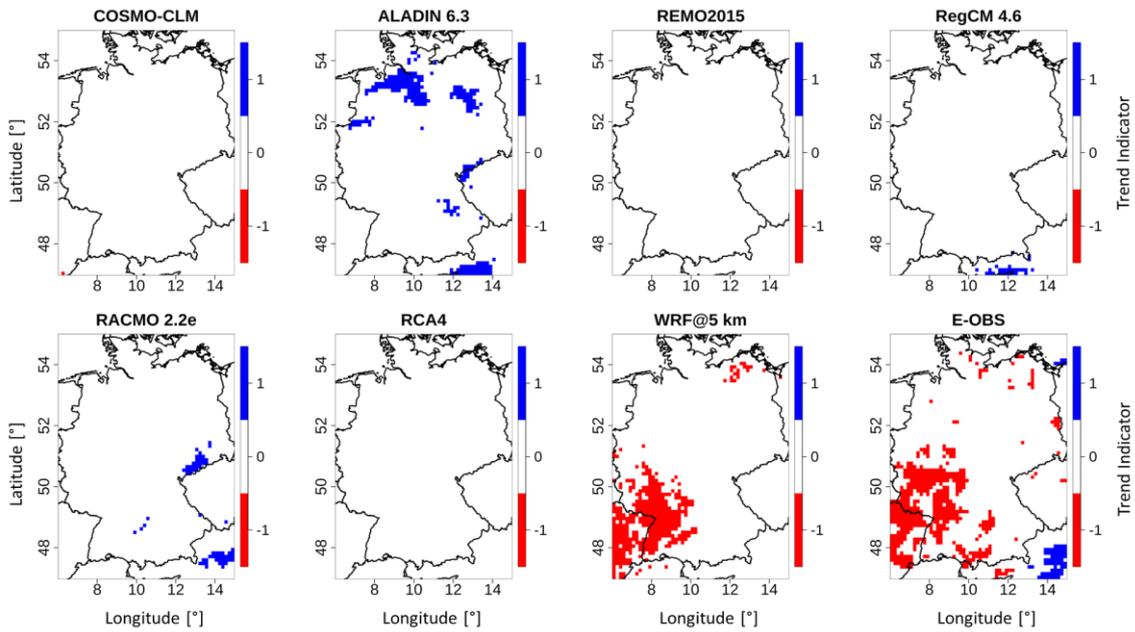
Figure S6. Grid cell based SPEI-12 trends for 1980–2009 based on the Mann-Kendall test for each RCM and E-OBS.
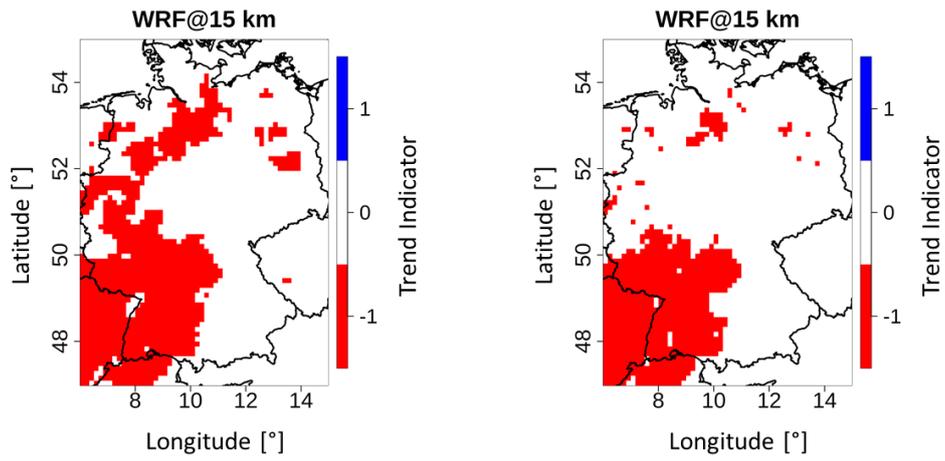
Figure S7. Grid cell based SPEI-6 and SPEI-12 trends for 1980–2009 based on the Mann-Kendall test for WRF@15 km.

Table S3. SPEI-6 trends overall metrics.

Model	negative [%]	neutral [%]	positive [%]
COSMO-CLM	0.03	99.94	0.03
ALADIN 6.3	0	90.3	9.7
REMO2015	0	99.7	0.3
RegCM 4.6	0	99.2	0.8
RACMO 2.2e	0	99.2	0.8
RCA4	0	99.97	0.03
WRF@5 km	9.7	90.3	0
E-OBS	17.6	81.2	1.2
WRF@15 km	28.3	71.7	0

Table S4. SPEI-12 trends overall metrics.

Model	negative [%]	neutral [%]	positive [%]
COSMO-CLM	0.03	99.97	0
ALADIN 6.3	0	94	6
REMO2015	0	100	0
RegCM 4.6	0	99.3	0.7
RACMO 2.2e	0	98.3	1.7
RCA4	0	100	0
WRF@5 km	10.1	89.9	0
E-OBS	12.6	85.7	1.7
WRF@15 km	20.2	79.8	0
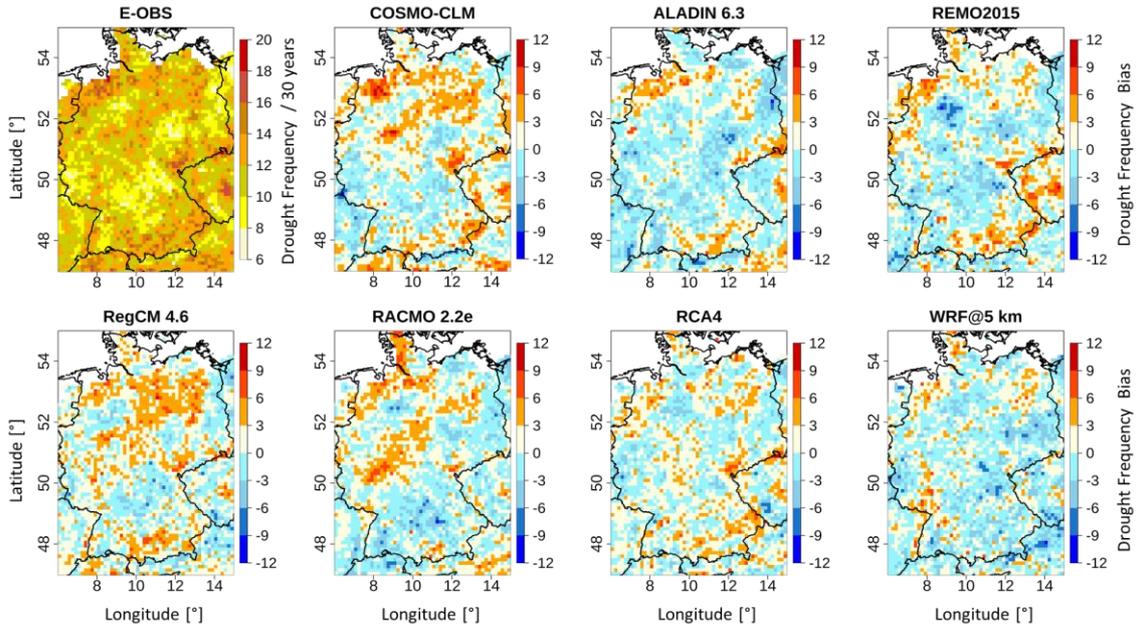
Figure S8. Grid cell based E-OBS drought frequency pattern based on the SPEI-6 between 1980–2009 and differences between each RCM and E-OBS.
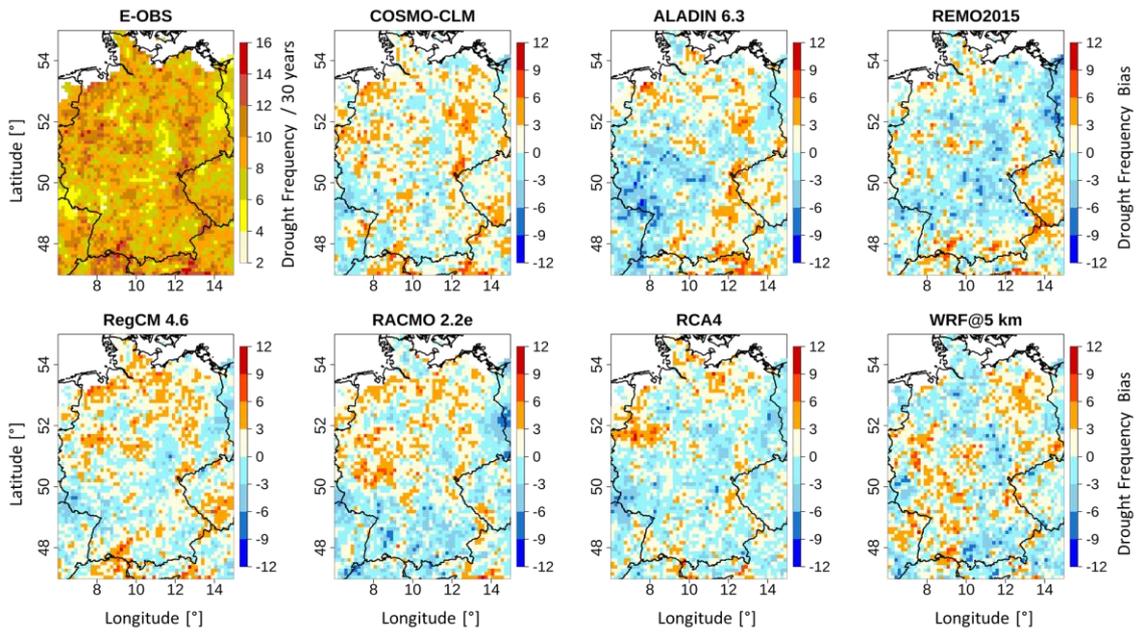
Figure S9. Grid cell based E-OBS drought frequency pattern based on the SPEI-12 between 1980–2009 and differences between each RCM and E-OBS.

Table S5. Drought frequency SPEI-6 metrics.

Model	Mean [n Events / 30 years]	Mean Bias [n Events]	SPAEF
COSMO-CLM	10.4	2.53	-0.30
ALADIN 6.3	11.9	2.06	-0.34
REMO2015	11.4	2.31	-0.44
RegCM 4.6	10.5	2.43	-0.36
RACMO 2.2e	11.2	2.24	-0.01
RCA4	10.9	2.07	-0.16
WRF@5 km	12.1	2.06	0.14
WRF@15 km	11.4	2.14	-0.24
E-OBS	12.1		

Table S6. Drought frequency SPEI-12 metrics.

Model	Mean [n Events / 30 years]	Mean Bias [n Events]	SPAEF
COSMO-CLM	7.6	2.33	-0.34
ALADIN 6.3	8.6	2.36	-0.30
REMO2015	8.8	2.27	-0.43
RegCM 4.6	7.7	2.30	-0.35
RACMO 2.2e	8.5	2.27	-0.38
RCA4	8.6	1.98	-0.30
WRF@5 km	8.4	2.37	-0.22
WRF@15 km	8.1	2.26	-0.06
E-OBS	9.2		
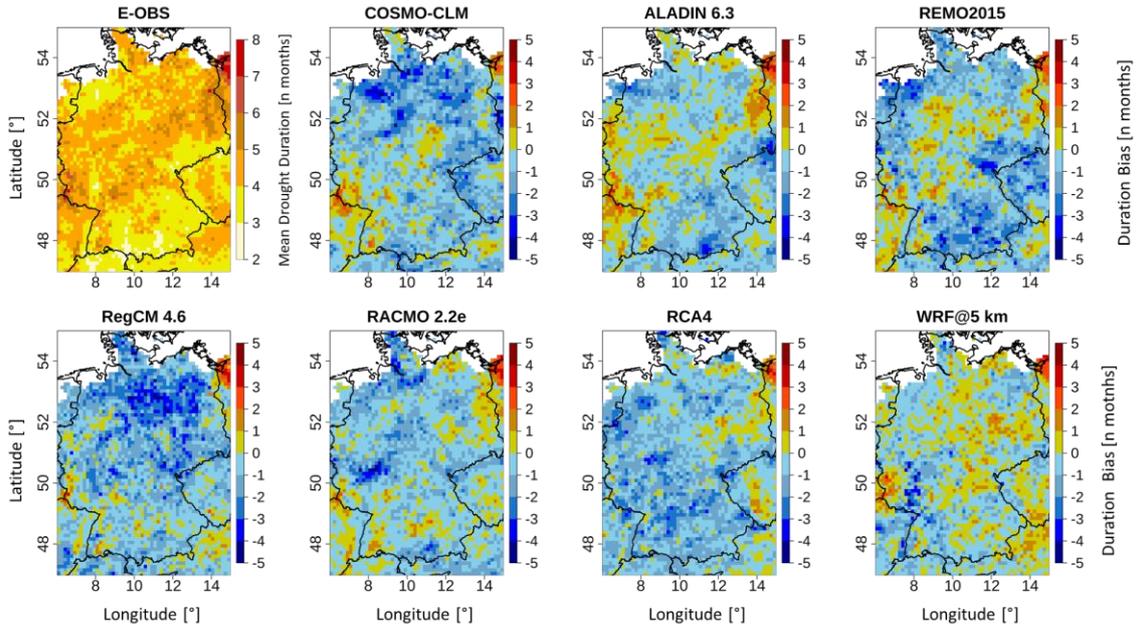
Figure S10. Grid cell based E-OBS mean drought duration pattern based on the SPEI-6 between 1980–2009 and differences between each RCM and E-OBS.
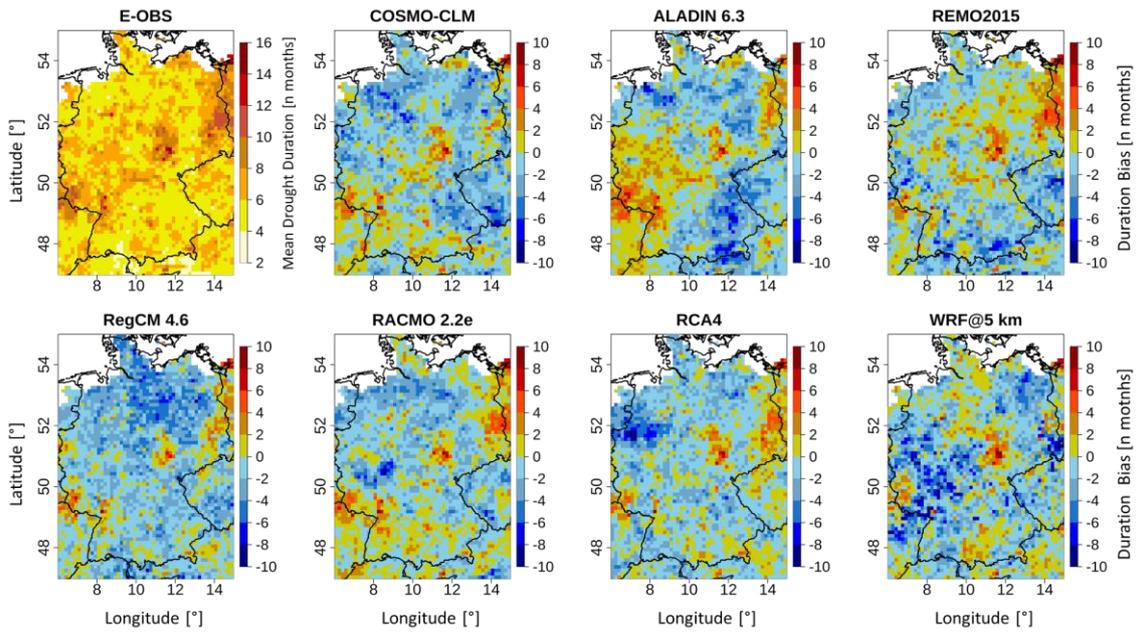
Figure S11. Grid cell based E-OBS mean drought duration pattern based on the SPEI-12 between 1980–2009 and differences between each RCM and E-OBS.

Table S7. Mean drought duration SPEI-6 metrics.

Model	Mean [n months]	Mean Bias [n months]	SPAEF
COSMO-CLM	5.1	1.09	0.19
ALADIN 6.3	4.6	0.81	-0.06
REMO2015	5.0	1.07	-0.02
RegCM 4.6	5.2	1.23	0.18
RACMO 2.2e	4.8	0.86	0.19
RCA4	5.0	1.03	0.23
WRF@5 km	4.4	0.71	0.24
WRF@15 km	4.6	0.79	0.26
E-OBS	4.2		

Table S8. Mean drought duration SPEI-12 metrics.

Model	Mean [n months]	Mean Bias [n months]	SPAEF
COSMO-CLM	7.2	1.82	0.15
ALADIN 6.3	6.9	1.91	-0.02
REMO2015	6.9	1.77	-0.02
RegCM 4.6	7.6	2.06	0.02
RACMO 2.2e	6.8	1.66	0.03
RCA4	7.1	1.70	0.06
WRF@5 km	7.5	2.09	0.17
WRF@15 km	7.6	2.13	0.13
E-OBS	6.2		
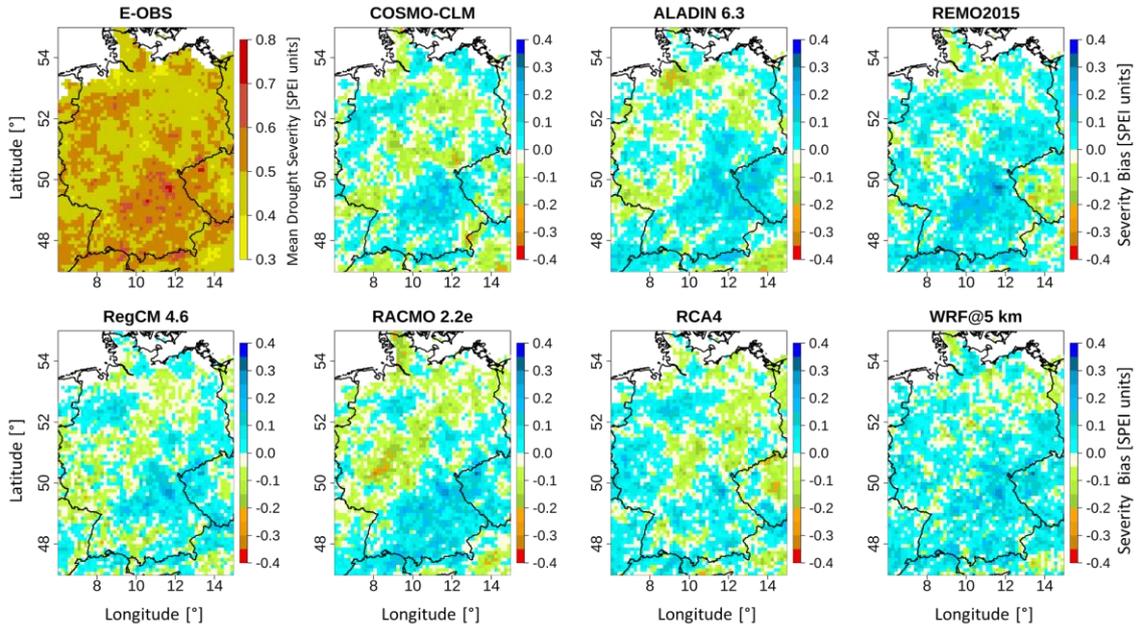
Figure S12. Grid cell based E-OBS mean drought severity pattern based on the SPEI-6 between 1980–2009 and differences between each RCM and E-OBS.
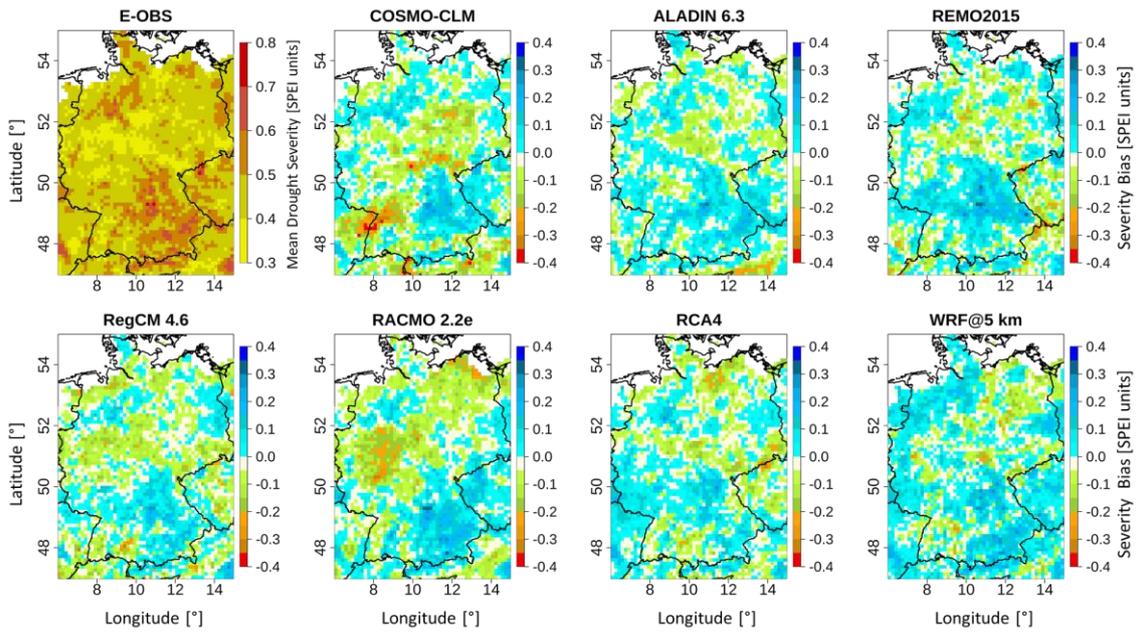
Figure S13. Grid cell based E-OBS mean drought severity pattern based on the SPEI-12 between 1980–2009 and differences between each RCM and E-OBS.

Table S9. Mean drought severity SPEI-6 metrics.

Model	Mean [SPEI units]	Mean Bias [SPEI units]	SPAEF
COSMO-CLM	0.51	0.06	-0.04
ALADIN 6.3	0.49	0.06	-0.15
REMO2015	0.47	0.06	0.02
RegCM 4.6	0.50	0.05	0.01
RACMO 2.2e	0.50	0.07	-0.21
RCA4	0.50	0.06	0.08
WRF@5 km	0.47	0.06	0.08
WRF@15 km	0.48	0.06	0.04
E-OBS	0.50		

Table S10. Mean drought severity SPEI-12 metrics.

Model	Mean [SPEI units]	Mean Bias [SPEI units]	SPAEF
COSMO-CLM	0.49	0.08	0.05
ALADIN 6.3	0.46	0.06	0.09
REMO2015	0.46	0.07	0.12
RegCM 4.6	0.49	0.07	-0.06
RACMO 2.2e	0.48	0.08	-0.20
RCA4	0.47	0.06	0.18
WRF@5 km	0.44	0.07	0.07
WRF@15 km	0.45	0.06	0.21
E-OBS	0.46		