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Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C

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S1 Spatial aggregation of extreme event and climate impact projections

As described in Section 2 of the main manuscript, the projections for extreme events, water availability and crop yields presented in Section 3 and 4 of the main manuscript are based on multi-model ensembles from the CMIP5 and ISI-MIP archive (Taylor et al., 2011; Warszawski et al., 2013) and aggregated over distinct world regions. For each individual model m from the model ensemble M and respective realizations $e_m \in E_m$, the aggregated distributions $D^{R,W}_{m,e_m}$ for world region R and warming level W are derived as

$$D^{R,W}_{m,e_m} = \left\{ \frac{1}{20} \sum_{t \in T^W_{m,e_m}} x_{m,e_m,t,i} - \bar{x}_{m,e_m,ref,i} \text{ , for all } \; i \in R \right\} \tag{1}$$

with x denoting individual grid cells, $\bar{x}_{ref}$ the grid-cell average over the reference period 1986-2005 and T^W_{m,e_m} indicating the model dependent time-slice for the respective warming level W.

S1.1 Regional cumulative density functions for 1.5 °C and 2 °C

To ensure equal weighting of individual models independent of the number of realizations E_m available, further analysis is performed on the multi-realization mean $\bar{D}^{R,W}_m$. Probability density functions ($PDF^{R,W}_m$) are fitted using a Gaussian kernel density estimator and integrated to the cumulative density functions ($CDF^{R,W}_m$). For each world region R, the two warming levels $W \in [1.5°C, 2°C]$ and respective climate indices, the ensemble median and the 17 % and 83 % quantile are derived and given in Tables S2-8.

S1.2 Derivation of regional cumulative density functions for natural variability

Multiple realizations E_m for individual models allow to estimate cumulative density functions as they would arise from natural variability alone. To this end, pair-wise differences between the individual members are derived for the respective models

$$D^{R,ref}_{m,e_{j,k}} = \left\{ \bar{x}_{m,e_j,ref,i} - \bar{x}_{m,e_k,ref,i} \text{ , for all } i \in R \text{ and } e_j, e_k \in E_m \right\} \tag{2}$$

Respective CDFs are derived as described above and the ensemble median and the 17 % and 83 % quantile are derived over the full ensemble $D^{R,ref}$. Multiple realizations are only available for the CMIP5 and not the ISI-MIP archive, which is why estimates natural variability CDFs for water availability and crop yield impacts cannot be provided.

Table S1. Overview of models of the CMIP5 model ensemble used in these projections, the respective 20-year time slices for a 1.5°C and 2°C warming (see Section 2) and their representation in the Temperature and Precitipation as well as ISI-MIP ensemble. Please note that the 5 GCMs used in the ISI-MIP projections have been bias-corrected (Hempel et al., 2013).

Model	1.5	2	Temperature	Precipitation	ISIMIP
bcc-csm1-1-m	[2016,2035]	[2034,2053]		x	
CanESM2	[2009,2028]	[2022,2041]	x	x	
CCSM4	[2020,2039]	[2035,2054]	x		
CESM1-BGC	[2018,2037]	[2032,2051]		x	
CMCC-CM	[2028,2047]	[2040,2059]		x	
CMCC-CMS	[2017,2036]	[2029,2048]	x	x	
CSIRO-Mk3-6-0	[2017,2036]	[2032,2051]	x	x	
EC-EARTH	[2019,2038]	[2034,2053]	x	x	
GFDL-ESM2M	[2028,2047]	[2044,2063]			x
HadGEM2-ES	[2010,2029]	[2022,2041]			x
inmcm4	[2034,2053]	[2048,2067]		x	
IPSL-CM5A-LR	[2016,2035]	[2029,2048]	x		x
MIROC-ESM	[2014,2033]	[2023,2042]	x	x	
MIROC-ESM-CHEM	[2010,2029]	[2022,2041]	x	x	x
MIROC5	[2023,2042]	[2036,2055]	x	x	
MPI-ESM-LR	[2019,2038]	[2032,2051]	x	x	
MPI-ESM-MR	[2022,2041]	[2036,2055]		x	
MRI-CGCM3	[2026,2045]	[2039,2058]	x		
NorESM1-M	[2022,2041]	[2038,2057]		x	x

Table S2. Median projections and KS test results for changes in temperature related extremes resolved for different world regions and a 1.5 °C and 2 °C warming level. The likely range over the model ensemble (66 % likelihood) is indicated in square brackets. The KS test gives the share of models from the model ensemble for which the null hypothesis that the regional aggregated distribution for 1.5 °C and 2 °C are drawn from the same underlying probability distribution is rejected at the 95 % significance level.

	TXX [σ]			WSDI [days]		
	1.5° C	2° C	KS [%]	1.5° C	2° C	KS [%]
ALA	0.6 [0.3,0.9]	0.9 [0.5,1.3]	100	33.9 [23.3,40.9]	46.2 [38.3,54.1]	100
AMZ	1.5 [1.4,2.0]	2.3 [2.0,2.8]	100	58.5 [37.4,75.2]	90.2 [63.8,120.2]	100
CAM	1.6 [1.3,2.2]	2.2 [1.7,3.1]	100	58.5 [47.1,75.2]	81.4 [70.0,94.6]	100
CAS	1.1 [0.7,1.2]	1.7 [1.2,2.0]	92	25.9 [23.3,35.6]	41.8 [32.1,55.0]	100
CEU	1.0 [0.8,1.2]	1.4 [1.1,1.7]	92	27.7 [20.6,34.7]	37.4 [26.8,47.9]	100
CGI	0.7 [0.6,0.9]	1.2 [0.9,1.5]	100	24.2 [20.6,30.3]	33.9 [28.6,49.7]	100
CNA	0.9 [0.6,1.3]	1.4 [1.1,1.6]	100	24.2 [20.6,28.6]	37.4 [33.0,43.5]	100
EAF	1.7 [1.3,2.2]	2.6 [1.9,3.0]	85	56.8 [36.5,77.9]	90.2 [55.9,118.4]	100
EAS	1.0 [0.8,1.2]	1.6 [1.3,1.7]	100	22.4 [17.1,27.7]	35.6 [25.9,40.9]	100
ENA	1.1 [0.9,1.5]	1.7 [1.4,2.3]	100	22.4 [17.1,30.3]	34.7 [28.6,55.0]	100
MED	1.3 [1.0,1.6]	1.8 [1.5,2.2]	100	33.0 [26.8,45.3]	50.6 [44.4,68.2]	100
NAS	0.8 [0.4,0.9]	1.0 [0.6,1.4]	100	24.2 [18.0,32.1]	33.9 [25.9,48.8]	100
NAU	1.1 [0.6,1.5]	1.5 [1.0,2.1]	92	36.5 [27.7,44.4]	52.3 [40.0,62.0]	93
NEB	1.7 [1.1,2.0]	2.6 [1.5,2.9]	85	55.0 [43.5,67.3]	84.1 [70.0,94.6]	93
NEU	0.8 [0.5,1.2]	1.1 [0.8,1.4]	100	30.3 [23.3,51.5]	39.1 [33.0,67.3]	100
SAF	1.5 [0.9,1.8]	2.2 [1.7,2.5]	100	43.5 [32.1,53.2]	70.0 [50.6,80.5]	100
SAH	1.8 [1.2,2.4]	2.7 [1.8,3.5]	100	46.2 [32.1,58.5]	80.5 [50.6,87.6]	100
SAS	1.2 [0.8,1.5]	1.9 [1.2,2.0]	100	48.8 [36.5,65.6]	76.1 [53.2,97.3]	100
SAU	0.7 [0.6,1.0]	1.1 [0.9,1.4]	92	12.7 [8.3,15.4]	19.8 [13.6,25.9]	100
SEA	1.9 [1.4,2.5]	2.8 [2.0,3.6]	100	70.0 [58.5,92.9]	88.5 [71.7,114.9]	100
SSA	1.0 [0.5,1.1]	1.3 [0.9,1.6]	100	15.4 [12.7,19.8]	22.4 [18.0,31.2]	100
TIB	1.0 [0.8,1.3]	1.5 [1.2,2.0]	100	24.2 [19.8,32.1]	37.4 [32.1,50.6]	100
WAF	1.9 [1.3,2.2]	2.6 [2.0,3.3]	100	46.2 [34.7,64.7]	79.6 [59.4,107.8]	100
WAS	1.4 [1.1,2.2]	2.3 [1.7,2.7]	100	41.8 [28.6,56.8]	66.4 [48.8,85.8]	100
WNA	1.0 [0.7,1.2]	1.6 [1.0,1.8]	100	31.2 [27.7,38.3]	49.7 [41.8,56.8]	100
WSA	1.4 [1.0,2.1]	2.0 [1.5,2.5]	92	43.5 [26.8,51.5]	54.1 [28.6,72.6]	86
Global	1.2 [1.0,1.4]	1.8 [1.5,2.0]	100	33.0 [29.5,40.9]	47.9 [43.5,55.0]	100

Table S3. Same as Tab. S2, but for precipitation related extremes.

	RX5Day [%]			CDD [%]		
	1.5° C	2° C	KS [%]	1.5° C	2° C	KS [%]
ALA	7 [5,9]	11 [7,12]	94	-3 [-4,-1]	-5 [-7,-2]	81
AMZ	6 [0,7]	6 [0,12]	59	6 [0,9]	8 [1,16]	88
CAM	3 [0,8]	4 [-3,9]	65	5 [1,7]	7 [4,12]	62
CAS	5 [1,11]	7 [1,11]	35	0 [-4,7]	4 [-6,9]	62
CEU	7 [3,8]	7 [5,11]	59	1 [-1,8]	4 [0,11]	56
CGI	7 [4,8]	10 [8,12]	94	-3 [-6,-1]	-5 [-7,-3]	69
CNA	5 [3,7]	7 [3,9]	59	1 [-4,5]	2 [-1,4]	38
EAF	5 [2,11]	8 [5,14]	71	1 [-3,4]	3 [-3,5]	50
EAS	5 [2,7]	8 [5,11]	76	1 [-4,4]	-1 [-4,5]	38
ENA	6 [3,7]	7 [5,9]	35	2 [0,5]	2 [0,5]	50
MED	1 [-1,4]	3 [0,5]	24	7 [4,10]	11 [6,15]	88
NAS	6 [5,7]	10 [7,11]	100	-4 [-6,-1]	-5 [-7,-2]	69
NAU	4 [0,7]	5 [1,10]	35	7 [-1,11]	8 [1,15]	62
NEB	7 [0,10]	7 [1,14]	47	4 [0,10]	7 [4,14]	62
NEU	6 [4,7]	8 [6,11]	71	2 [-3,4]	0 [-1,4]	62
SAF	3 [0,6]	4 [0,7]	41	5 [0,7]	7 [4,11]	81
SAH	4 [-8,11]	4 [-9,18]	53	1 [-2,6]	3 [-2,7]	56
SAS	7 [4,8]	10 [7,14]	53	4 [-1,7]	5 [-1,9]	69
SAU	2 [-2,5]	3 [-1,7]	59	4 [0,8]	6 [1,13]	31
SEA	5 [3,6]	7 [4,11]	76	6 [0,10]	6 [0,9]	62
SSA	3 [0,7]	5 [2,7]	41	3 [-1,5]	4 [0,9]	62
TIB	6 [4,8]	8 [5,11]	53	-3 [-5,1]	-4 [-9,2]	50
WAF	6 [1,8]	7 [3,12]	71	1 [-1,4]	2 [0,5]	69
WAS	6 [0,11]	5 [2,14]	53	0 [-5,6]	3 [-4,8]	69
WNA	5 [3,7]	5 [4,8]	65	1 [-2,4]	1 [0,7]	62
WSA	3 [0,5]	4 [0,7]	35	4 [1,6]	7 [0,8]	38
Global	5 [4,6]	7 [5,7]	100	2 [0,4]	2 [1,6]	100

Table S4. Same as Tab. S2, but for projected changes in annual mean runoff.

	Runoff [%]				Runoff [%]		
	1.5° C	2° C	KS [%]		1.5° C	2° C	KS [%]
ALA	8.4 [3.3,14.3]	12.3 [7.6,16.6]	100	NEB	-6.5 [-19.4,3.7]	-3.3 [-23.3,30.7]	100
AMZ	-5.7 [-14.7,-1.0]	-5.7 [-11.5,-1.8]	95	NEU	1.4 [-4.1,5.7]	1.8 [-6.1,9.2]	100
CAM	-7.2 [-20.9,-0.6]	-2.5 [-33.5,8.8]	98	SAF	-5.7 [-17.0,2.2]	-8.4 [-17.8,-0.6]	87
CAS	-1.4 [-9.6,4.9]	-3.7 [-17.0,1.8]	100	SAH	-4.9 [-25.6,10.0]	-6.5 [-37.4,15.1]	91
CEU	-2.5 [-9.6,1.0]	-3.7 [-12.3,5.7]	100	SAS	7.6 [0.2,11.9]	11.5 [1.0,17.4]	100
CGI	6.1 [3.7,9.2]	10.0 [6.8,13.9]	100	SAU	-7.2 [-33.9,-1.4]	-12.7 [-44.4,6.8]	100
CNA	4.1 [-3.3,11.2]	2.2 [-8.0,7.2]	100	SEA	1.4 [-2.2,8.0]	-0.6 [-6.8,12.7]	100
EAF	4.9 [-5.3,18.6]	5.3 [-4.5,27.2]	98	SSA	-5.3 [-15.9,5.3]	-7.2 [-15.9,5.7]	96
EAS	-1.8 [-5.3,2.2]	1.4 [-9.2,5.7]	100	TIB	5.3 [-2.9,11.2]	5.7 [-2.5,13.5]	96
ENA	2.2 [-0.6,8.4]	1.8 [-3.3,6.8]	100	WAF	-0.2 [-2.2,3.3]	-1.0 [-6.8,4.1]	100
MED	-8.8 [-15.5,-4.5]	-17.0 [-28.0,-8.0]	100	WAS	-1.8 [-10.0,11.9]	-7.6 [-13.5,1.8]	100
NAS	8.4 [2.9,11.2]	11.2 [5.3,14.7]	100	WNA	1.8 [-8.0,5.7]	2.2 [-8.4,8.8]	100
NAU	-10.4 [-36.2,-2.5]	-6.8 [-40.5,7.6]	98	WSA	-1.4 [-8.4,2.2]	-6.1 [-11.9,1.8]	69
Global	0.6 [-2.5,3.3]	0.6 [-2.5,3.7]	100				

Table S5. Same as Tab. S2, but for projected changes in wheat yields. Projections including and excluding CO_2-fertilization are assessed seperatly. Accounting for the specific vulnerability in tropical regions, these are included as a separate region (between $30°$S and $30°$N)

	Wheat CO_2 [%]			Wheat noCO$_2$ [%]		
	$1.5°$ C	$2°$ C	KS [%]	$1.5°$ C	$2°$ C	KS [%]
AMZ	-26.0 [-47.2,19.8]	-33.1 [-57.7,20.9]	90	-35.4 [-57.7,-1.4]	-62.4 [-70.6,-15.5]	95
CAM	-3.7 [-27.2,10.4]	-13.1 [-42.5,11.5]	90	-22.5 [-44.8,-11.9]	-19.0 [-40.1,-9.6]	100
CAS	4.5 [-11.9,16.2]	3.3 [-16.6,18.6]	93	-10.8 [-24.9,5.7]	-10.8 [-31.9,18.6]	95
CEU	16.2 [4.5,32.7]	17.4 [4.5,38.6]	97	-2.5 [-10.8,8.0]	-6.1 [-13.1,5.7]	100
CGI	25.6 [-6.1,40.9]	25.6 [-11.9,45.6]	87	2.2 [-7.2,9.2]	-1.4 [-20.2,5.7]	95
CNA	4.5 [-24.9,13.9]	3.3 [-33.1,17.4]	100	-8.4 [-42.5,4.5]	-14.3 [-55.4,16.2]	100
EAF	-6.1 [-27.2,17.4]	-6.1 [-34.2,20.9]	87	-15.5 [-31.9,16.2]	-19.0 [-43.6,13.9]	100
EAS	11.5 [-0.2,22.1]	13.9 [-0.2,25.6]	97	-1.4 [-13.1,4.5]	-6.1 [-19.0,4.5]	95
ENA	9.2 [-6.1,25.6]	8.0 [-9.6,29.2]	100	-8.4 [-36.6,-0.2]	-11.9 [-44.8,-2.5]	100
MED	5.7 [-3.7,19.8]	5.7 [-4.9,22.1]	83	-9.6 [-20.2,11.5]	-10.8 [-24.9,11.5]	95
NAS	-1.4 [-15.5,31.5]	-4.9 [-21.3,39.7]	100	-8.4 [-21.3,8.0]	-7.2 [-22.5,4.5]	95
NAU	4.5 [-16.6,26.8]	3.3 [-20.2,32.7]	87	-10.8 [-40.1,17.4]	-22.5 [-47.2,-0.2]	100
NEB	-8.4 [-27.2,23.3]	-8.4 [-42.5,20.9]	87	-28.4 [-46.0,-13.1]	-34.2 [-55.4,-16.6]	95
NEU	15.1 [5.7,40.9]	16.2 [4.5,47.9]	83	5.7 [-7.2,20.9]	3.3 [-10.8,20.9]	91
SAF	1.0 [-16.6,18.6]	-0.2 [-20.2,20.9]	97	-22.5 [-34.2,16.2]	-24.9 [-50.7,16.2]	100
SAH	-1.4 [-29.5,19.8]	-2.5 [-34.2,19.8]	70	-22.5 [-73.0,4.5]	-33.1 [-83.6,-14.3]	91
SAS	1.0 [-24.9,18.6]	-2.5 [-36.6,19.8]	100	-15.5 [-49.5,-7.2]	-22.5 [-58.9,-9.6]	100
SAU	10.4 [-1.4,19.8]	11.5 [-1.4,20.9]	80	-10.8 [-24.9,12.7]	-11.9 [-30.7,11.5]	86
SEA	-8.4 [-53.0,30.3]	-11.9 [-65.9,38.6]	90	-30.7 [-63.6,-4.9]	-41.3 [-75.3,10.4]	95
SSA	-0.2 [-10.8,13.9]	1.0 [-11.9,17.4]	90	-13.1 [-31.9,1.0]	-17.8 [-50.7,-6.1]	100
TIB	6.8 [1.0,19.8]	8.0 [1.0,23.3]	77	-11.9 [-21.3,-4.9]	-13.1 [-21.3,-6.1]	77
WAF	-13.1 [-47.2,18.6]	-19.0 [-58.9,22.1]	100	-46.0 [-55.4,-21.3]	-56.6 [-68.3,-27.2]	100
WAS	6.8 [-1.4,25.6]	5.7 [-3.7,35.0]	87	-11.9 [-26.0,-2.5]	-15.5 [-34.2,-1.4]	100
WNA	12.7 [4.5,23.3]	11.5 [2.2,29.2]	93	-3.7 [-11.9,3.3]	-7.2 [-17.8,3.3]	100
WSA	8.0 [-1.4,22.1]	4.5 [-8.4,24.5]	47	-1.4 [-9.6,13.9]	-1.4 [-21.3,13.9]	64
Tropical	-9.0 [-25.4,12.7]	-15.5 [-41.9,13.9]	100	-27.8 [-47.7,-15.5]	-35.4 [-56.6,-20.2]	100
Global	2.2 [-6.1,17.4]	-0.2 [-8.4,20.9]	100	-14.3 [-20.2,-4.9]	-19.0 [-36.6,-6.1]	100

Table S6. Same as Tab. S4, but for projected changes in maize yields.

	Maize CO_2 [%]			Maize noCO$_2$ [%]		
	1.5° C	2° C	KS [%]	1.5° C	2° C	KS [%]
AMZ	-7.2 [-35.4,2.2]	-13.1 [-40.1,-0.2]	93	-10.8 [-35.4,5.7]	-16.6 [-38.9,3.3]	100
CAM	-6.1 [-13.1,4.5]	-10.8 [-36.6,5.7]	100	-14.3 [-43.6,-9.6]	-19.0 [-47.2,-11.9]	100
CAS	-7.2 [-16.6,9.2]	-9.6 [-23.7,11.5]	77	-11.9 [-27.2,4.5]	-11.9 [-29.5,-0.2]	86
CEU	10.4 [4.5,50.3]	9.2 [-2.5,55.0]	93	3.3 [-4.9,31.5]	1.0 [-7.2,25.6]	77
CGI	53.8 [25.6,120.7]	52.6 [11.5,148.9]	43	47.9 [11.5,109.0]	40.9 [16.2,141.9]	41
CNA	-2.5 [-15.5,4.5]	-6.1 [-36.6,1.0]	93	-7.2 [-17.8,-0.2]	-10.8 [-21.3,4.5]	100
EAF	-2.5 [-15.5,2.2]	-4.9 [-19.0,2.2]	97	-10.8 [-37.8,-0.2]	-14.3 [-30.7,-0.2]	91
EAS	1.0 [-3.7,22.1]	1.0 [-4.9,25.6]	90	-6.1 [-9.6,4.5]	-3.7 [-9.6,2.2]	91
ENA	-0.2 [-10.8,9.2]	-2.5 [-13.1,9.2]	86	-1.4 [-7.2,4.5]	-7.2 [-11.9,3.3]	77
MED	-2.5 [-9.6,16.2]	-1.4 [-11.9,17.4]	97	-6.1 [-11.9,1.0]	-10.8 [-16.6,-3.7]	86
NAS	46.8 [2.2,76.1]	42.1 [-9.6,75.0]	83	25.6 [-10.8,56.2]	20.9 [-8.4,71.4]	86
NAU	-4.9 [-30.7,10.4]	-13.1 [-38.9,8.0]	83	-11.9 [-31.9,4.5]	-19.0 [-36.6,-0.2]	82
NEB	-4.9 [-33.1,3.3]	-6.1 [-43.6,2.2]	93	-16.6 [-37.8,-2.5]	-19.0 [-43.6,-4.9]	100
NEU	69.1 [19.8,133.7]	69.1 [18.6,123.1]	38	76.1 [29.2,139.5]	69.1 [23.3,121.9]	41
SAF	-1.4 [-33.1,3.3]	-0.2 [-38.9,3.3]	97	-4.9 [-14.3,4.5]	-7.2 [-40.1,-1.4]	95
SAH	-9.6 [-36.6,8.0]	-14.3 [-43.6,6.8]	77	-22.5 [-44.8,-8.4]	-31.9 [-47.2,-13.1]	86
SAS	-7.2 [-11.9,2.2]	-10.8 [-16.6,2.2]	97	-11.9 [-35.4,-4.9]	-15.5 [-37.8,-6.1]	100
SAU	10.4 [-6.1,20.9]	9.2 [-8.4,22.1]	73	-4.9 [-9.6,4.5]	-10.8 [-26.0,1.0]	77
SEA	-4.9 [-13.1,-0.2]	-7.2 [-19.0,-1.4]	97	-10.8 [-37.8,-6.1]	-15.5 [-43.6,-9.6]	100
SSA	2.2 [-19.0,6.8]	-0.2 [-23.7,5.7]	83	-1.4 [-13.1,4.5]	-4.9 [-17.8,3.3]	95
TIB	1.0 [-8.4,16.2]	-0.2 [-8.4,24.5]	62	-7.2 [-13.1,-1.4]	-6.1 [-14.3,6.8]	64
WAF	-10.8 [-37.8,-0.2]	-8.4 [-34.2,-1.4]	96	-15.5 [-40.1,-4.9]	-20.2 [-42.5,-8.4]	100
WAS	-2.5 [-13.1,11.5]	-2.5 [-16.6,13.9]	87	-10.8 [-19.0,1.0]	-13.1 [-22.5,1.0]	86
WNA	5.7 [-3.7,25.6]	3.3 [-3.7,24.5]	83	10.4 [-3.7,22.1]	5.7 [-10.8,17.4]	82
WSA	9.2 [-10.8,22.1]	8.0 [-15.5,23.3]	47	-0.2 [-29.5,4.5]	-2.5 [-41.3,4.5]	44
Tropical	-3.1 [-15.5,1.6]	-5.5 [-19.0,1.6]	100	-11.4 [-37.2,-6.7]	-16.0 [-44.2,-9.6]	100
Global	-1.4 [-26.0,8.0]	-6.1 [-37.8,2.2]	100	-8.4 [-26.0,4.5]	-11.9 [-33.1,-7.2]	100

Table S7. Same as Tab. S4, but for projected changes in soy yields.

	Soy CO_2 [%]			Soy noCO_2		
	1.5° C	2° C	KS [%]	1.5° C	2° C	KS [%]
AMZ	4.5 [-30.7,25.6]	3.3 [-27.2,38.6]	100	-15.5 [-47.2,1.0]	-20.2 [-55.4,-4.9]	100
CAM	-0.2 [-29.5,9.2]	-1.4 [-30.7,17.4]	100	-17.8 [-42.5,-11.9]	-24.9 [-50.7,-15.5]	100
CAS	-0.2 [-17.8,24.5]	-2.5 [-30.7,28.0]	90	-29.5 [-41.3,15.1]	-40.1 [-47.2,10.4]	95
CEU	20.9 [4.5,38.6]	18.6 [3.3,67.9]	83	-0.2 [-6.1,19.8]	-2.5 [-8.4,19.8]	73
CNA	4.5 [-21.3,26.8]	5.7 [-24.9,30.3]	97	-9.6 [-31.9,1.0]	-13.1 [-40.1,9.2]	86
EAF	8.0 [-8.4,26.8]	6.8 [-8.4,30.3]	93	-3.7 [-17.8,15.1]	-4.9 [-21.3,19.8]	100
EAS	9.2 [-15.5,30.3]	11.5 [-9.6,39.7]	97	-6.1 [-22.5,-1.4]	-8.4 [-28.4,-2.5]	100
ENA	-1.4 [-13.1,16.2]	-4.9 [-16.6,19.8]	63	-13.1 [-26.0,1.0]	-16.6 [-34.2,-7.2]	82
MED	9.2 [-0.2,25.6]	12.7 [4.5,30.3]	73	-2.5 [-8.4,66.7]	-4.9 [-9.6,89.0]	91
NAS	28.0 [-24.9,147.7]	32.7 [-20.2,138.4]	59	24.5 [8.0,140.7]	11.5 [-0.2,152.4]	55
NAU	9.2 [-9.6,22.1]	10.4 [-4.9,26.8]	38	-11.9 [-20.2,6.8]	-10.8 [-23.7,8.0]	50
NEB	3.3 [-26.0,28.0]	2.2 [-23.7,22.1]	97	-10.8 [-38.9,9.2]	-16.6 [-48.3,2.2]	100
NEU	79.6 [55.0,293.3]	82.0 [44.4,320.4]	9	52.6 [32.7,345.0]	47.9 [29.2,275.7]	19
SAF	15.1 [-4.9,26.8]	15.1 [-3.7,31.5]	90	6.8 [-19.0,13.9]	3.3 [-38.9,12.7]	100
SAH	4.5 [-21.3,35.0]	-8.4 [-27.2,36.2]	72	-21.3 [-46.0,11.5]	-29.5 [-58.9,9.2]	82
SAS	5.7 [-30.7,30.3]	-1.4 [-37.8,35.0]	100	-15.5 [-43.6,-10.8]	-21.3 [-55.4,4.5]	100
SAU	11.5 [-8.4,25.6]	13.9 [-4.9,31.5]	64	1.0 [-14.3,12.7]	-0.2 [-20.2,11.5]	59
SEA	8.0 [-26.0,33.9]	1.0 [-37.8,40.9]	93	-13.1 [-43.6,-2.5]	-16.6 [-51.9,-4.9]	100
SSA	11.5 [-15.5,23.3]	6.8 [-20.2,22.1]	100	-11.9 [-31.9,8.0]	-14.3 [-40.1,9.2]	100
TIB	9.2 [-16.6,35.0]	5.7 [-23.7,20.9]	76	-13.1 [-23.7,-3.7]	-13.1 [-31.9,5.7]	77
WAF	3.3 [-17.8,25.6]	-2.5 [-38.9,30.3]	100	-17.8 [-53.0,-7.2]	-22.5 [-62.4,-4.9]	100
WAS	1.0 [-21.3,22.1]	1.0 [-23.7,13.9]	86	-1.4 [-26.0,32.7]	15.1 [-31.9,43.2]	95
WNA	12.7 [-26.0,31.5]	15.1 [-30.7,37.4]	44	-10.8 [-20.2,-4.9]	-10.8 [-24.9,-7.2]	50
WSA	16.2 [-14.3,35.0]	12.7 [-16.6,38.6]	47	4.5 [-34.2,17.4]	1.0 [-35.4,15.1]	77
Tropical	6.3 [-3.1,23.3]	6.8 [-4.9,26.8]	100	-10.2 [-45.4,-7.2]	-15.5 [-52.4,-10.2]	100
Global	6.8 [-2.5,28.0]	1.0 [-11.9,33.9]	100	-9.6 [-37.8,-6.1]	-11.9 [-24.9,-6.1]	100

Table S8. Same as Tab. S4, but for projected changes in rice yields.

	Rice CO_2 [%]			Rice noCO$_2$ [%]		
	1.5° C	2° C	KS [%]	1.5° C	2° C	KS [%]
AMZ	4.5 [-3.7,26.8]	4.5 [-4.9,32.7]	96	-16.6 [-23.7,-6.1]	-21.3 [-26.0,-9.6]	88
CAM	3.3 [-22.5,18.6]	1.0 [-9.6,23.3]	79	-14.3 [-21.3,-9.6]	-19.0 [-27.2,-13.1]	100
CAS	16.2 [-8.4,50.3]	16.2 [-19.0,58.5]	76	-17.8 [-40.1,-1.4]	-24.9 [-44.8,-6.1]	88
CEU	39.7 [4.5,112.5]	44.4 [3.3,107.8]	76	29.2 [-0.2,63.2]	23.3 [-9.6,56.2]	88
CNA	6.8 [-7.2,53.8]	8.0 [-9.6,63.2]	100	-6.1 [-27.2,6.8]	-8.4 [-37.8,1.0]	94
EAF	2.2 [-22.5,18.6]	5.7 [-17.8,18.6]	73	-13.1 [-16.6,3.3]	-14.3 [-20.2,39.7]	81
EAS	11.5 [-0.2,29.2]	12.7 [5.7,45.6]	100	-9.6 [-11.9,4.5]	-13.1 [-16.6,3.3]	71
ENA	5.7 [-2.5,56.2]	6.8 [-9.6,64.4]	84	-4.9 [-15.5,5.7]	-8.4 [-21.3,3.3]	94
MED	9.2 [-9.6,29.2]	9.2 [-28.4,52.6]	65	-11.9 [-17.8,9.2]	-17.8 [-20.2,8.0]	76
NAS	40.9 [-8.4,141.9]	40.9 [-14.3,231.1]	83	33.9 [9.2,229.9]	19.8 [-6.1,219.4]	82
NAU	2.2 [-17.8,57.3]	1.0 [-11.9,75.0]	100	-15.5 [-30.7,-0.2]	-20.2 [-44.8,-1.4]	82
NEB	3.3 [-21.3,22.1]	2.2 [-24.9,23.3]	78	-14.3 [-20.2,-1.4]	-19.0 [-22.5,-3.7]	94
NEU	47.9 [-11.9,323.9]	57.3 [-14.3,275.7]	30	26.8 [2.2,152.4]	25.6 [9.2,93.7]	57
SAF	6.8 [-2.5,23.3]	8.0 [-1.4,30.3]	80	-4.9 [-19.0,5.7]	-15.5 [-24.9,6.8]	76
SAH	15.1 [-15.5,60.9]	16.2 [-14.3,60.9]	50	-13.1 [-24.9,1.0]	-19.0 [-33.1,-6.1]	59
SAS	5.7 [-2.5,33.9]	3.3 [-4.9,40.9]	92	-13.1 [-22.5,58.5]	-22.5 [-29.5,3.3]	100
SAU	11.5 [-17.8,35.0]	10.4 [-16.6,43.2]	61	-8.4 [-35.4,18.6]	-0.2 [-37.8,22.1]	65
SEA	6.8 [-0.2,28.0]	6.8 [-1.4,35.0]	96	-11.9 [-16.6,-0.2]	-13.1 [-20.2,-0.2]	100
SSA	8.0 [-0.2,24.5]	8.0 [-0.2,22.1]	75	-4.9 [-15.5,9.2]	-8.4 [-20.2,4.5]	94
TIB	4.5 [-13.1,46.8]	8.0 [-16.6,52.6]	61	-10.8 [-21.3,1.0]	-20.2 [-29.5,-1.4]	69
WAF	8.0 [-1.4,29.2]	13.9 [-1.4,42.1]	75	-3.7 [-21.3,57.3]	-10.8 [-28.4,19.8]	69
WAS	11.5 [-9.6,26.8]	11.5 [-7.2,32.7]	71	-17.8 [-26.0,10.4]	-23.7 [-30.7,9.2]	88
WNA	29.2 [9.2,89.0]	30.3 [8.0,99.6]	56	15.1 [-9.6,55.0]	-0.2 [-11.9,46.8]	65
WSA	9.2 [-19.0,26.8]	4.5 [-16.6,25.6]	33	-2.5 [-11.9,3.3]	-8.4 [-17.8,-0.2]	41
Tropical	5.7 [0.4,20.4]	6.3 [-0.2,23.9]	100	-14.9 [-19.6,-4.3]	-19.6 [-24.9,-6.7]	100
Global	6.8 [-16.6,24.5]	6.8 [-14.3,26.8]	100	-8.4 [-16.6,4.5]	-15.5 [-21.3,13.9]	100

Table S9. Regional share of global production in percent of wheat, rice, soy and maize in the year 2000 based on Monfreda et al. (2008)

Region	Maize	Rice	Soy	Wheat
ALA	0	0	0	0
AMZ	3.9	7.4	7.7	1.2
CAM	1.9	3.4	2.7	2.4
CAS	1.8	2.8	1.5	1.8
CEU	7.6	2.2	5.6	8.9
CGI	0.6	0	0.3	1.4
CNA	9.7	1.2	7.8	6.2
EAF	2.0	4.1	4.4	2.5
EAS	9.3	21.1	11.9	10.1
ENA	5.0	0.03	4.0	4.1
MED	5.8	5.3	3.9	4.3
NAS	5.3	1.2	7.1	4.8
NAU	1.7	0.02	1.3	1.1
NEB	1.4	2.0	2.4	0.7
NEU	0.6	0	0.5	4.5
SAF	2.4	4.3	4.0	8.1
SAH	0.4	0.9	0.3	0.7
SAS	2.4	6.4	4.2	4.2
SAU	2.8	1.6	1.4	2.3
SEA	3.2	6.3	3.2	0.3
SSA	5.0	5.4	7.2	3.2
TIB	4.3	6.0	6.5	6.3
WAF	2.0	5.1	2.1	2.7
WAS	4.1	3.5	3.1	3.7
WNA	8.0	0.5	2.2	8.4

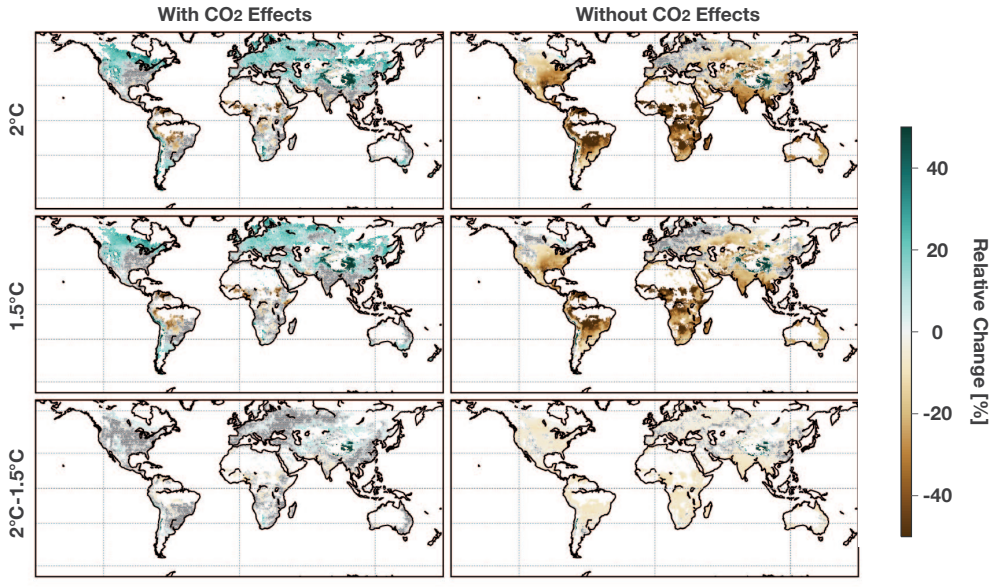

Figure S1. Same as Fig. 1 but for wheat yields and with the effect of CO_2 -fertilization explicitly resolved. The left panel shows projections including CO_2 -fertilization, whereas this effect is deactivated for the projections shown in the right panel. Changes are given relative to the 1986-2005 reference period.

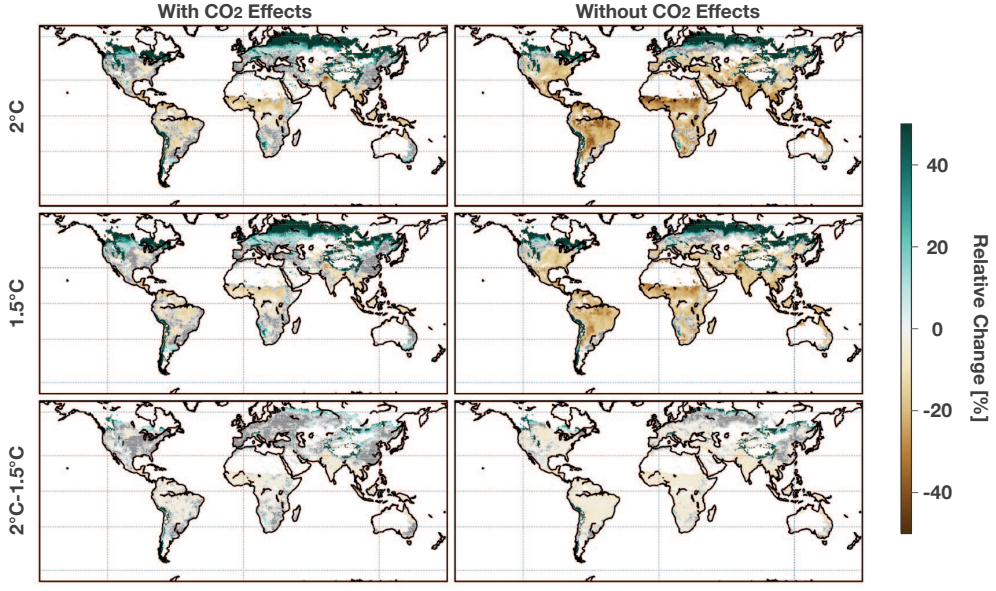

Figure S2. Same as Fig. S1 but for maize yields.

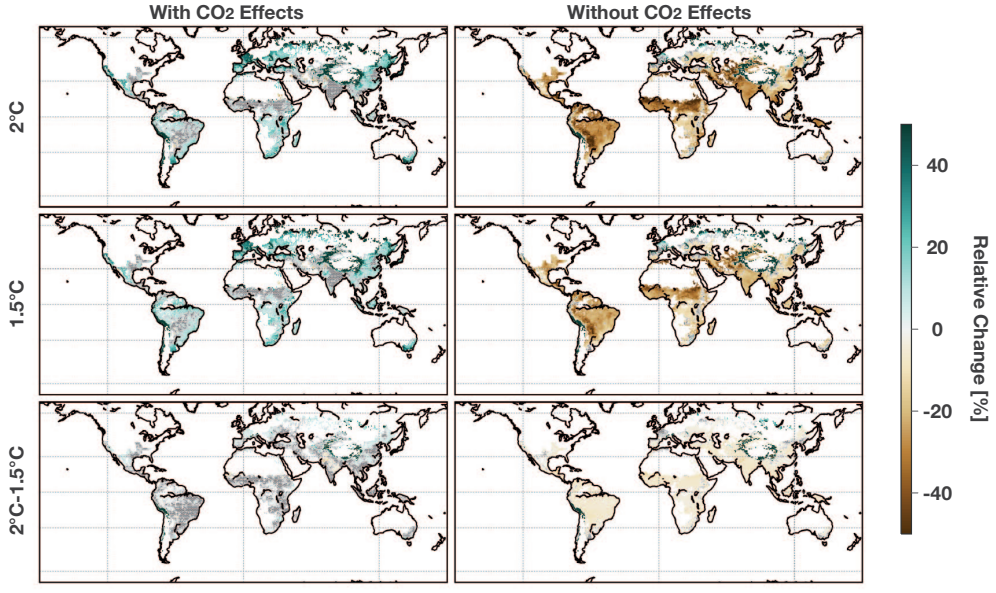

Figure S3. Same as Fig. S1 but for soy yields.

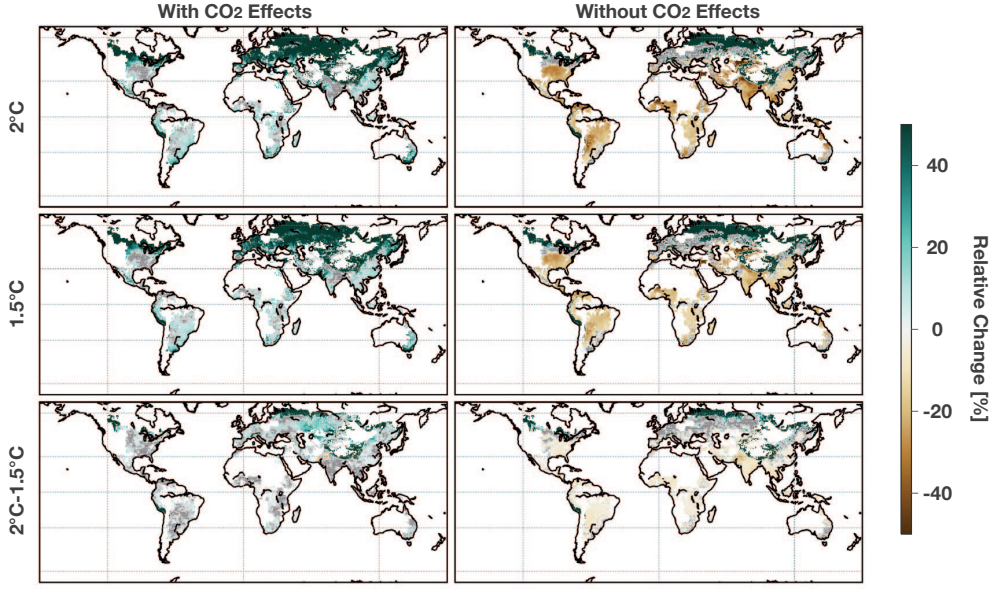

Figure S4. Same as Fig. S1 but for rice yields.

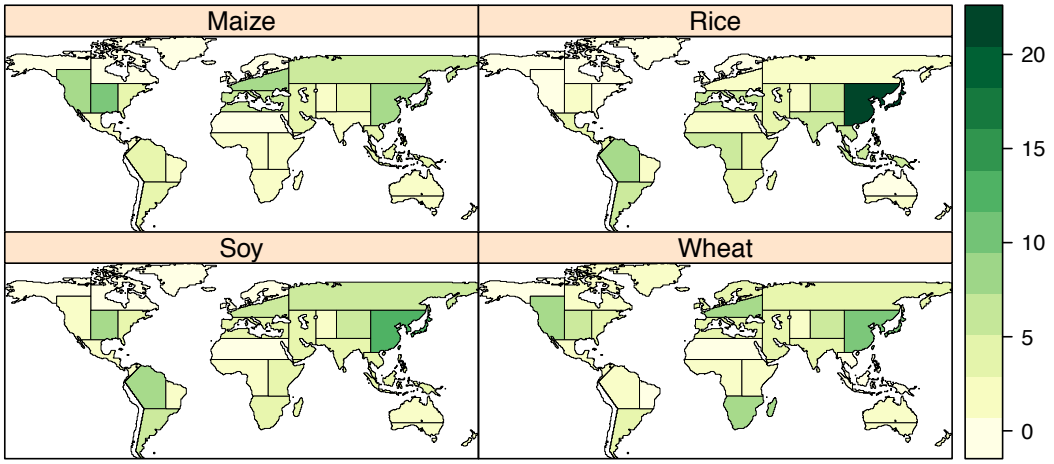

Figure S5. Regional share of global production of Maize, Rice, Soy and Wheat in the year 2000, based on data from Monfreda et al. 2008.

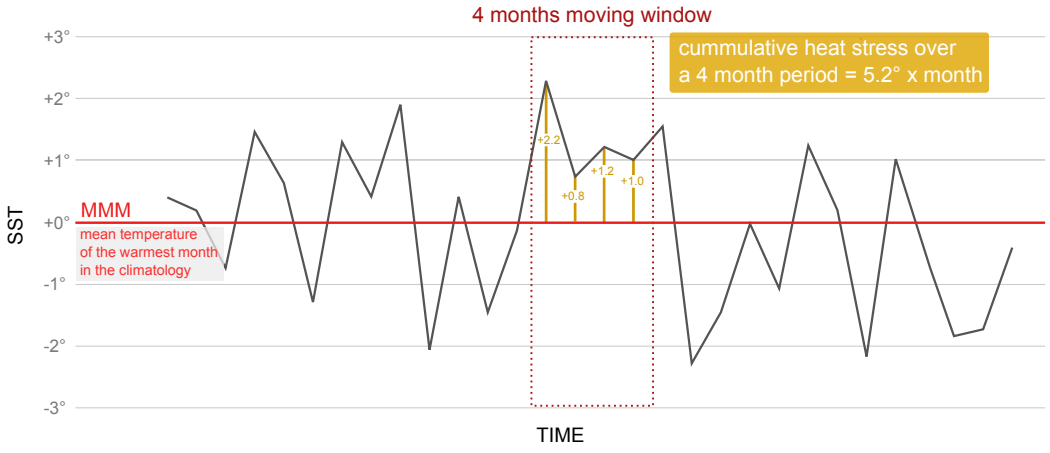

Figure S6. The calculation of the degree heating months (DHM) in a four months moving window of a sea surface temperature pathway.

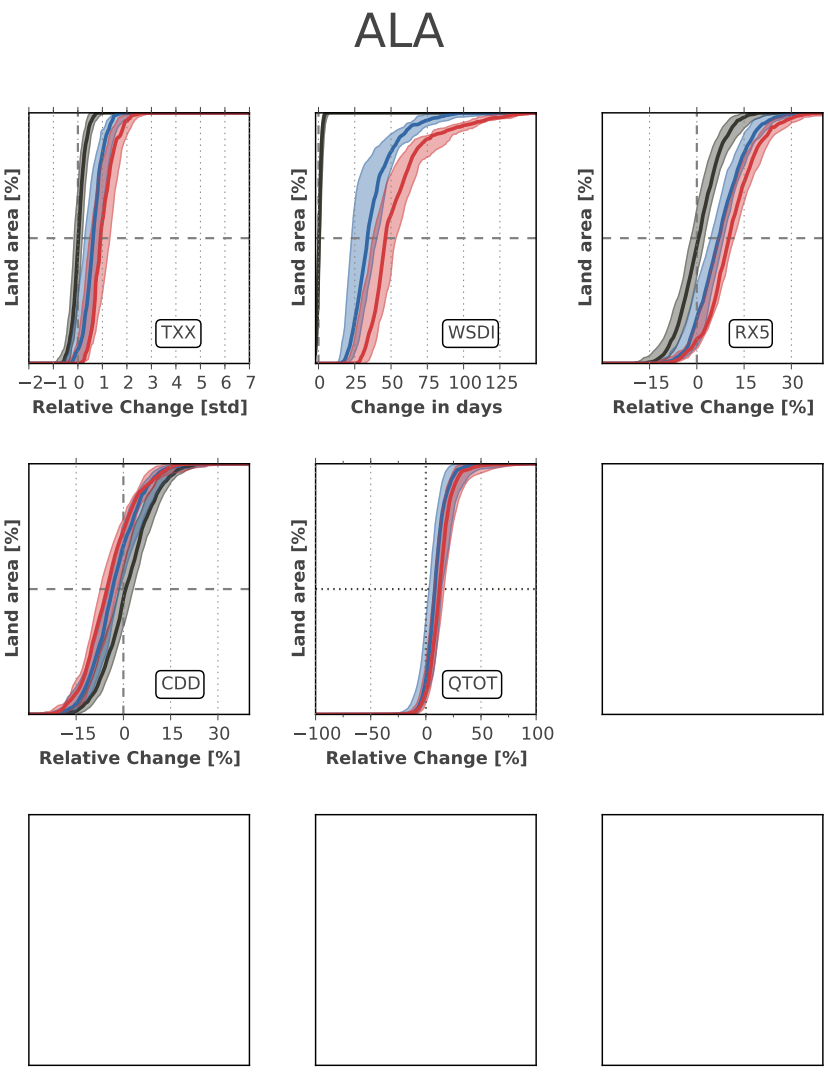

Figure S7. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Alaska, North-West Canada.

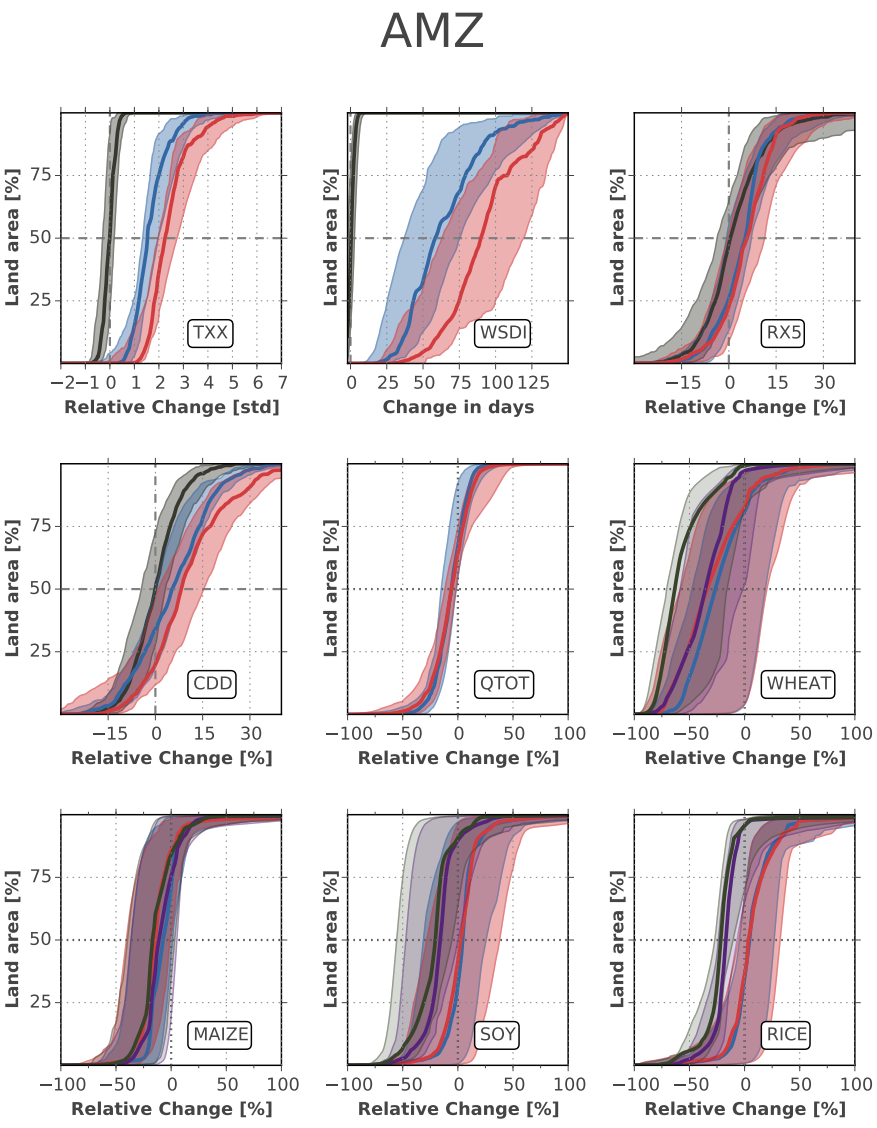

Figure S8. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Amazon.

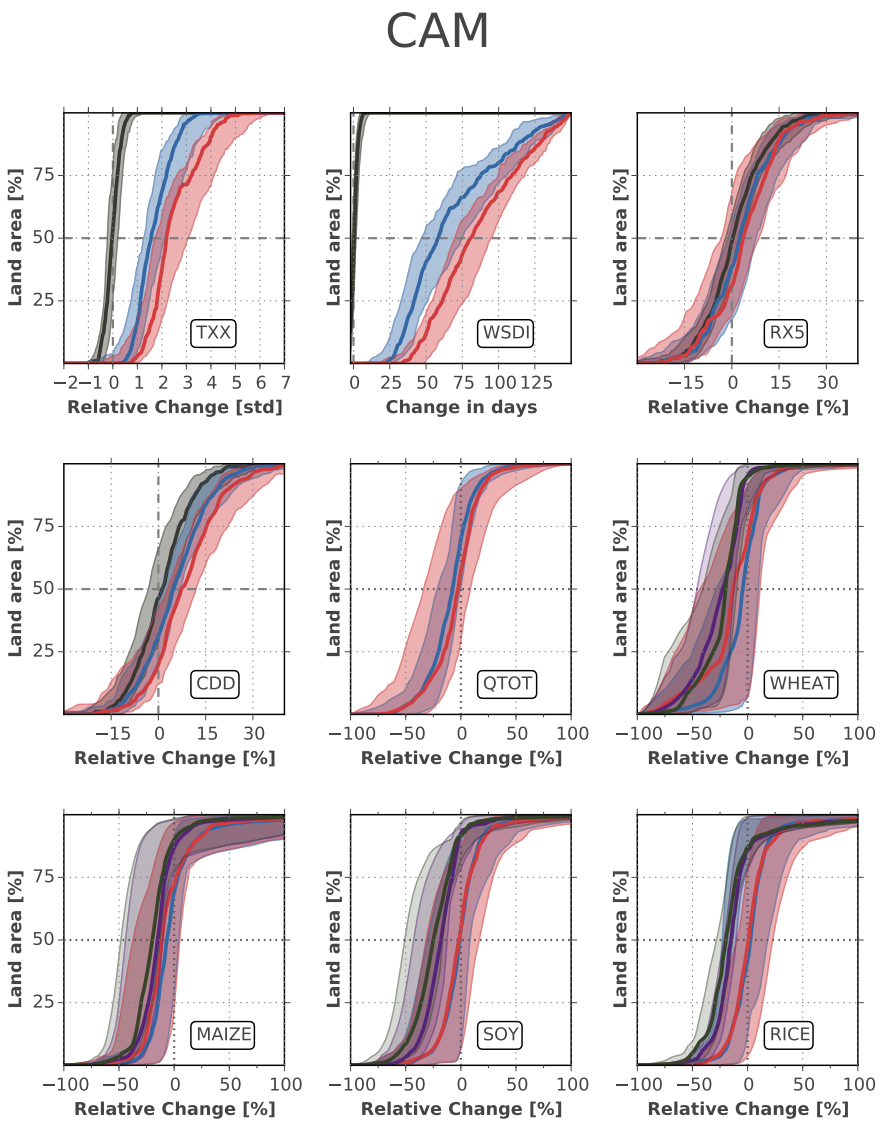

Figure S9. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Central America, Mexico, Caribbean.

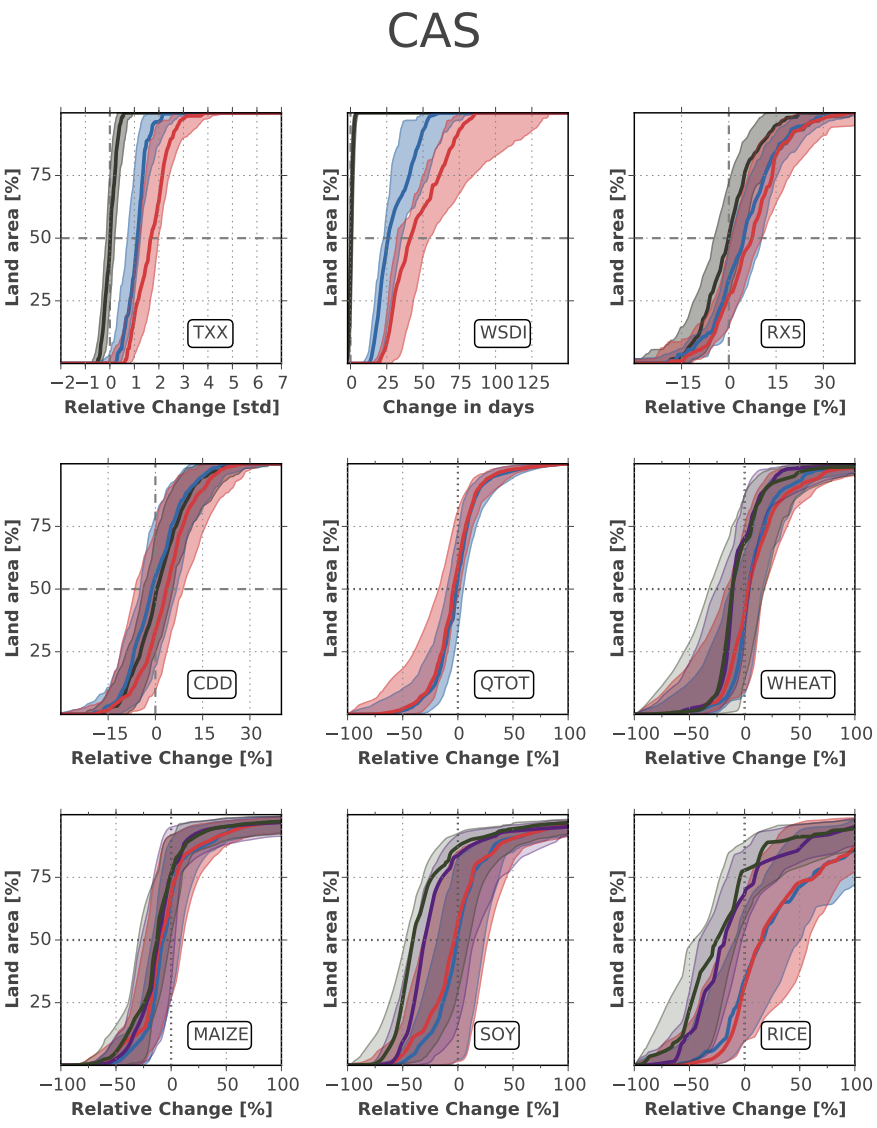

Figure S10. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Central Asia.

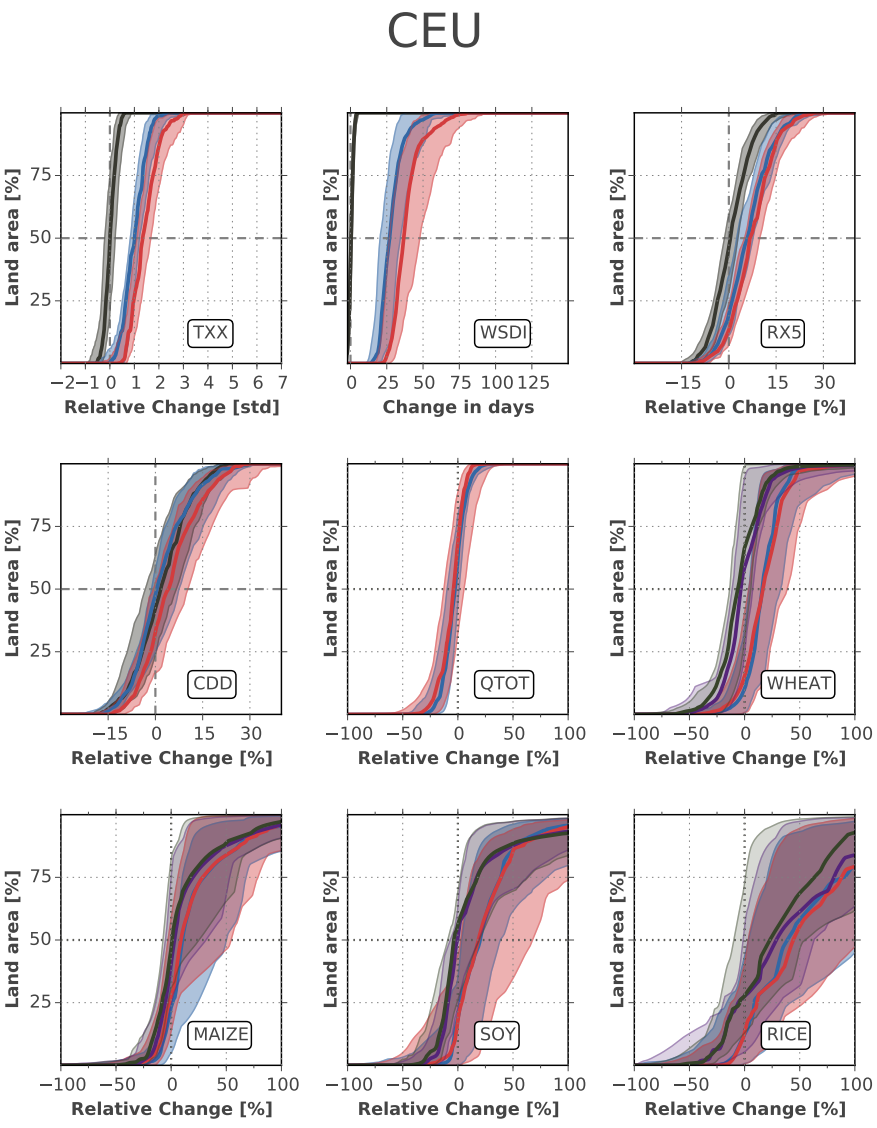

Figure S11. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Central Europe.

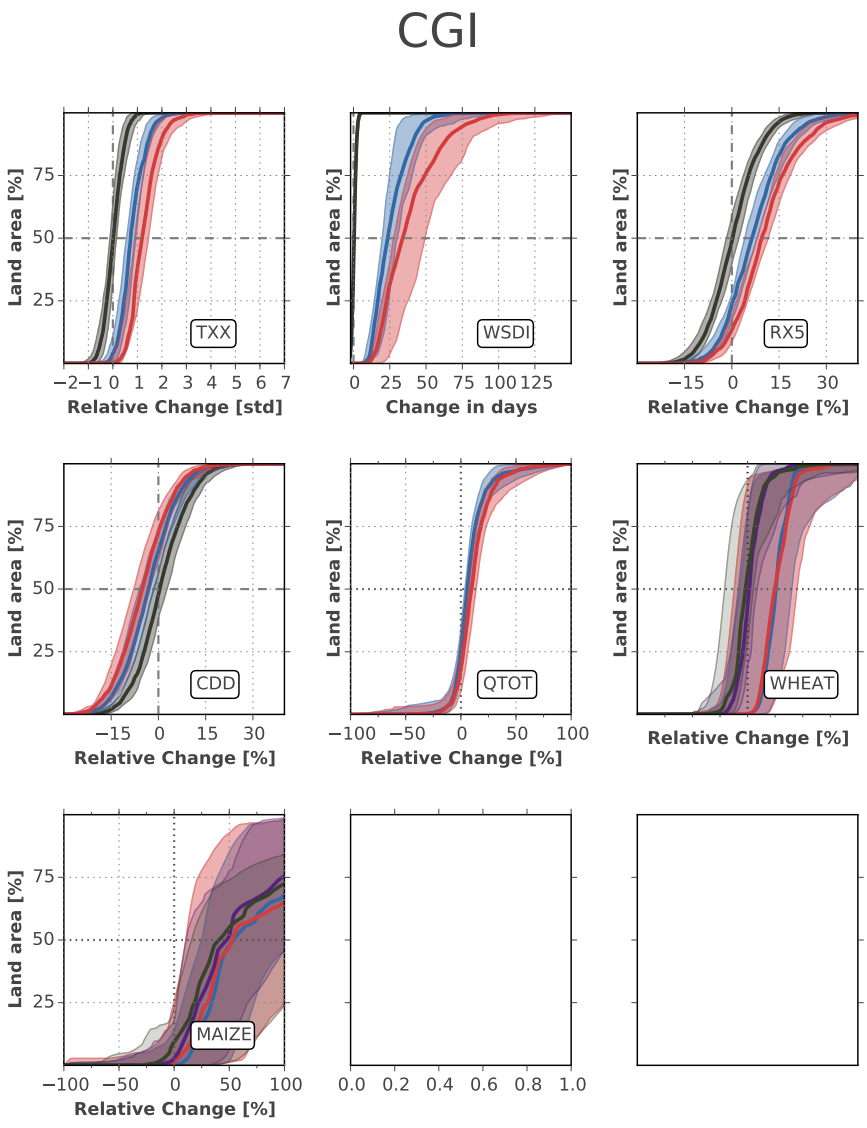

Figure S12. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for East Canada, Greenland, Iceland.

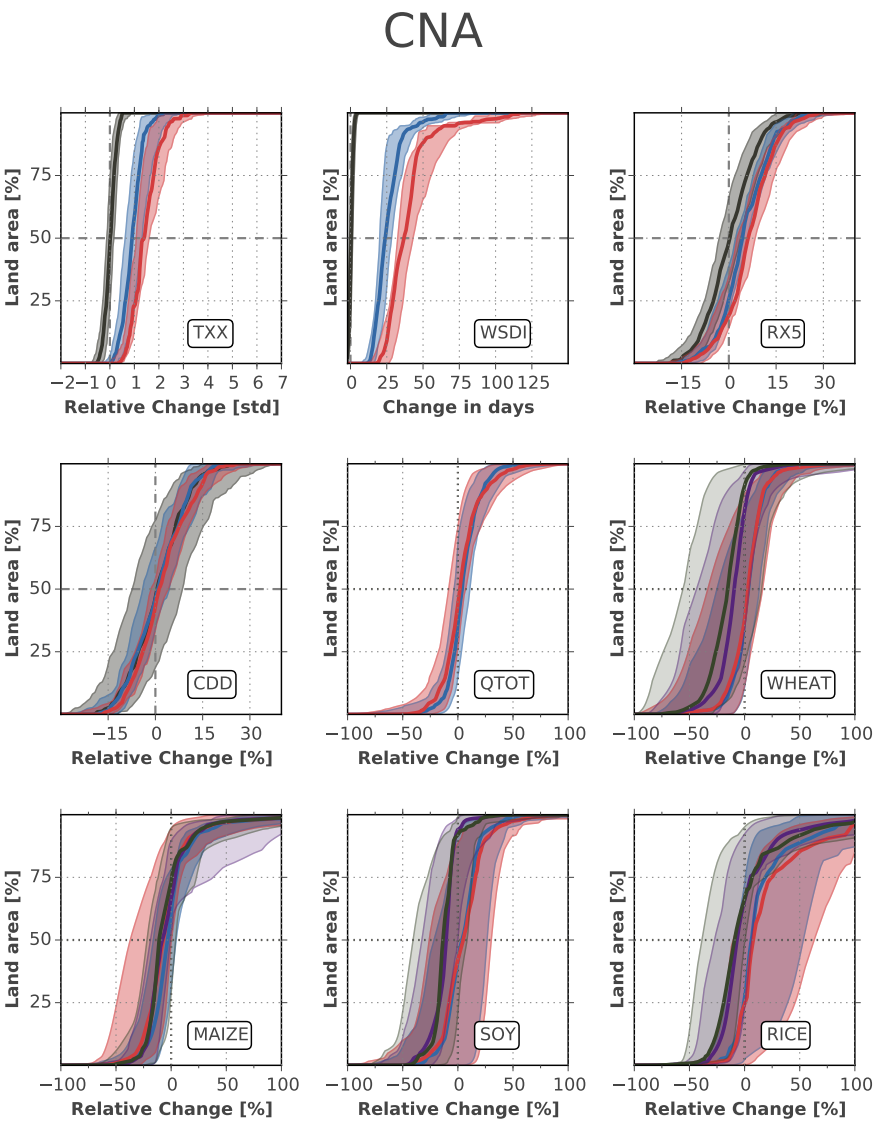

Figure S13. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Central North America.

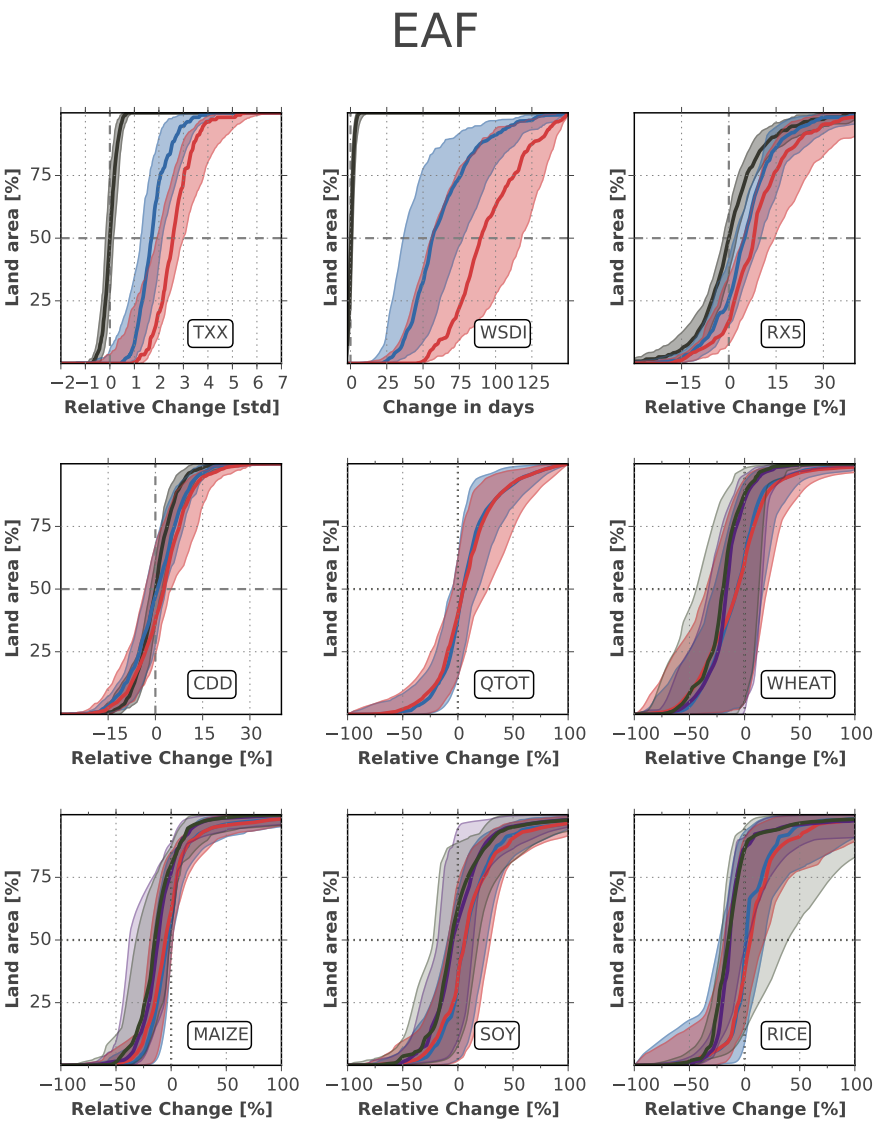

Figure S14. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for East Africa.

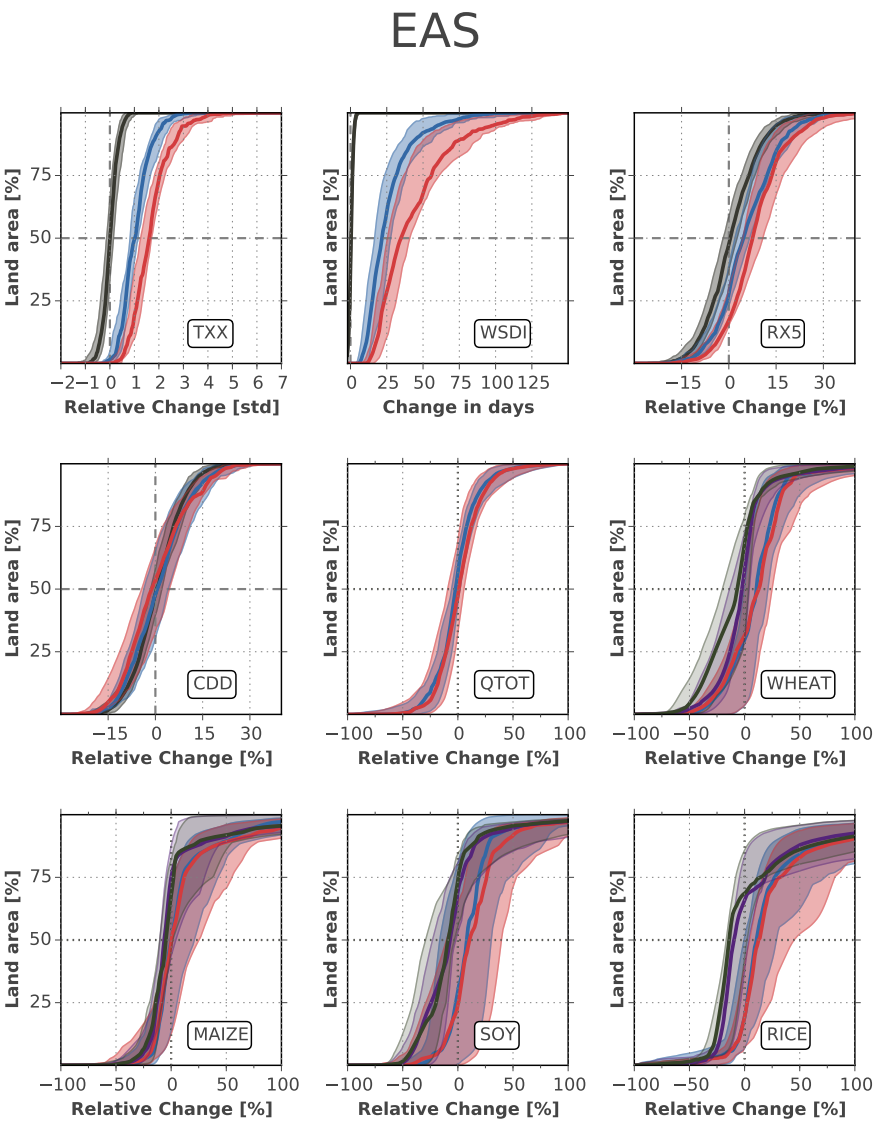

Figure S15. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for East Asia.

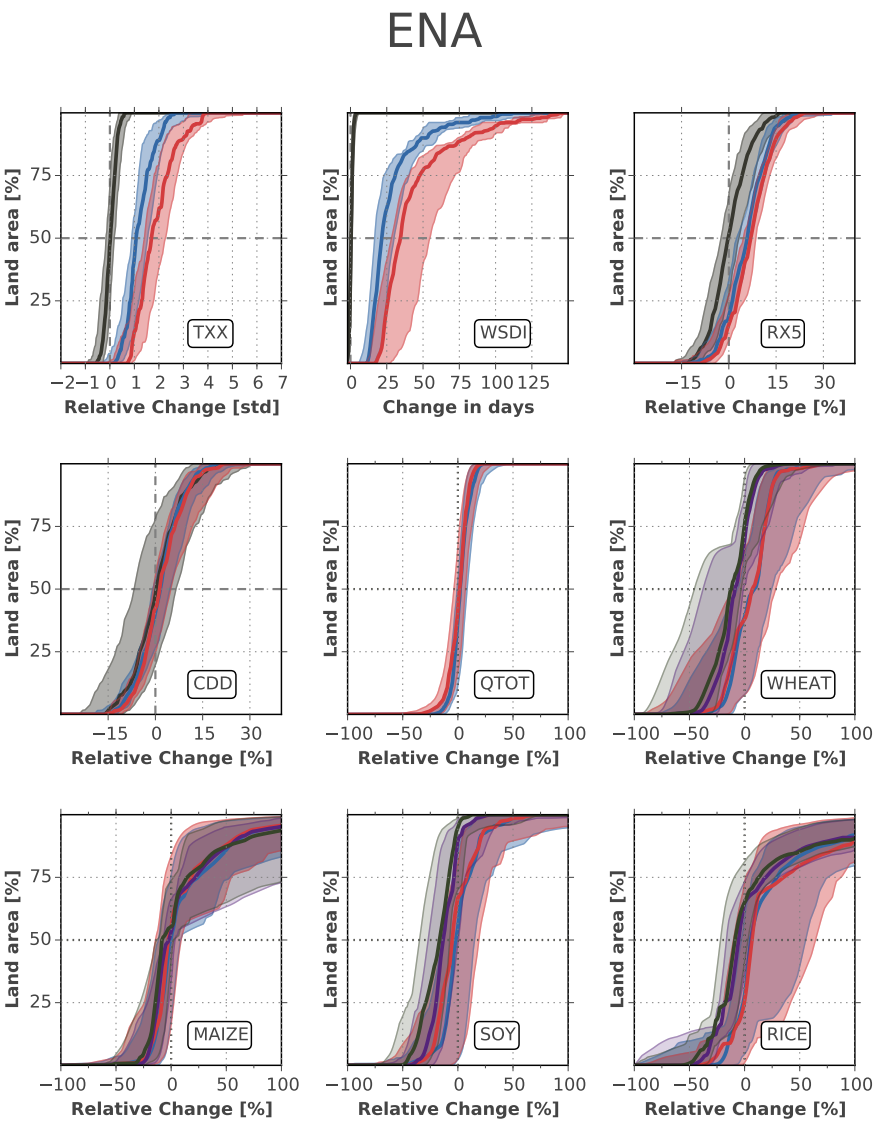

Figure S16. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for East North America.

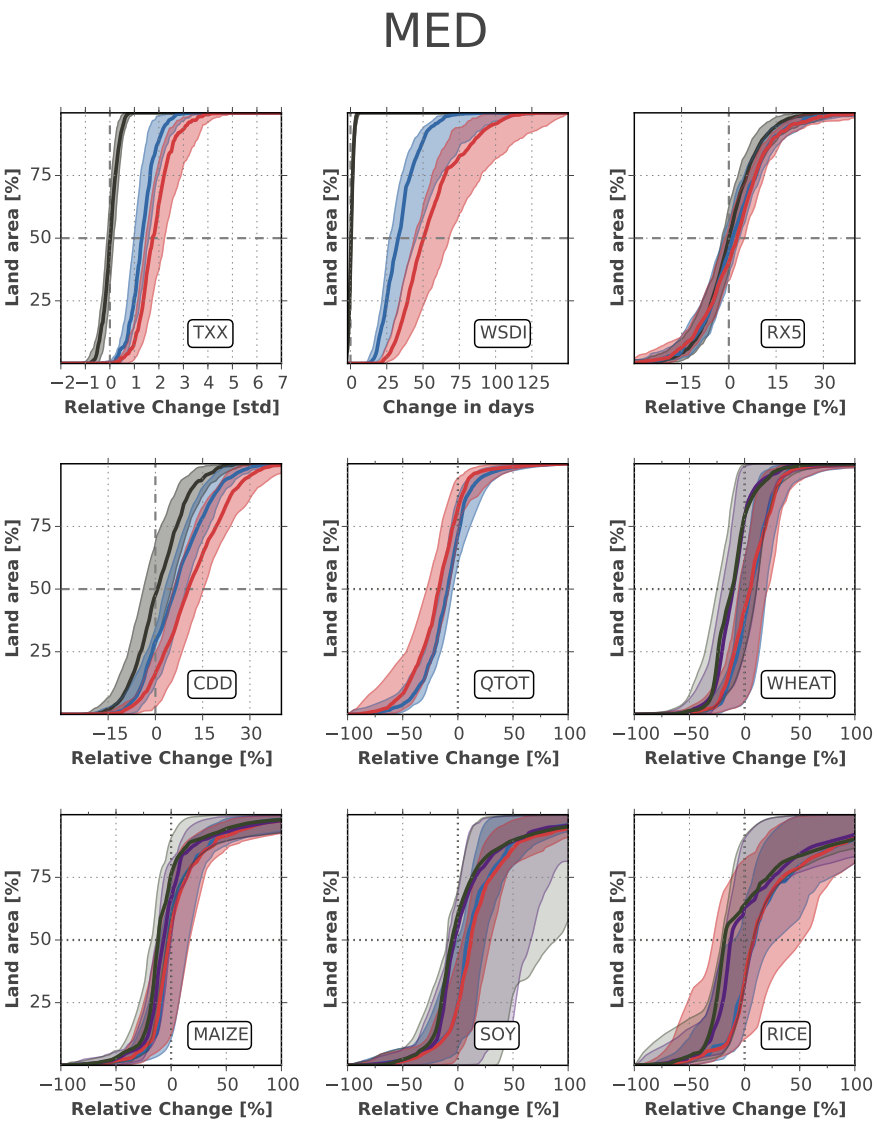

Figure S17. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Mediterranean.

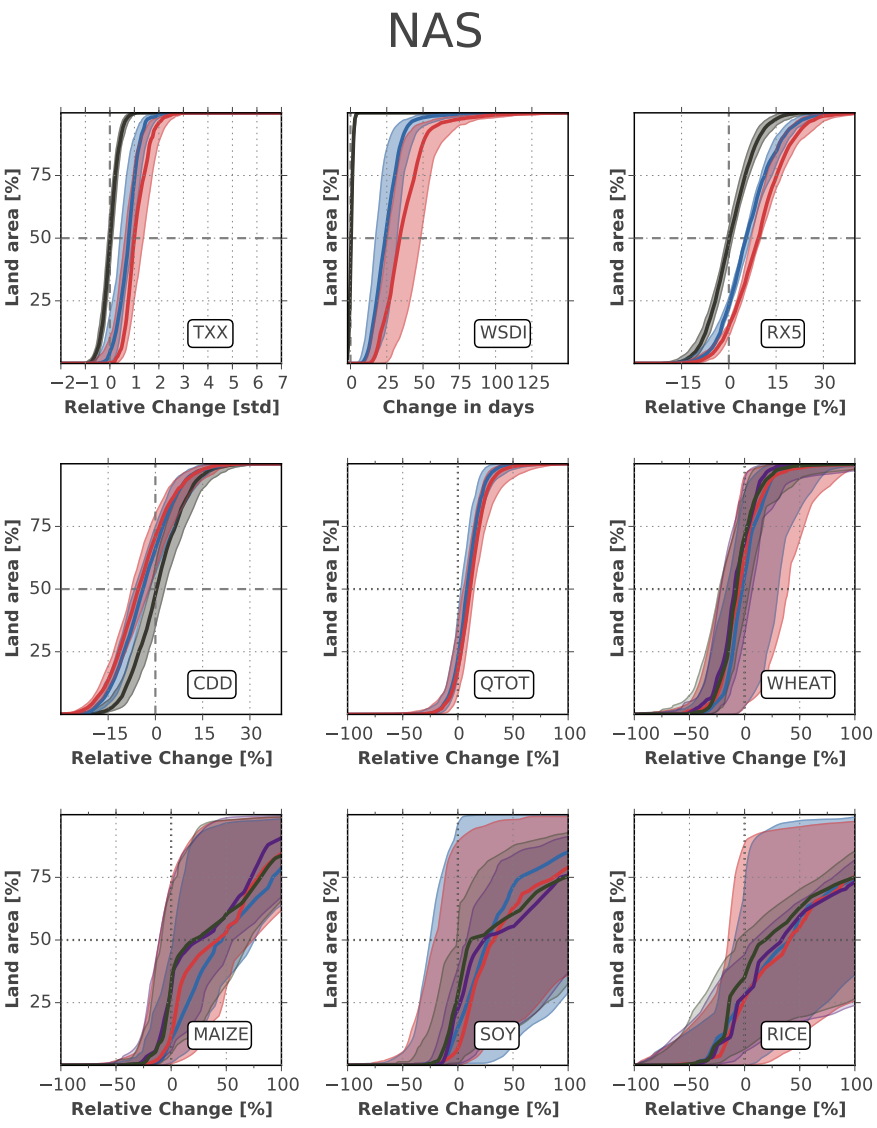

Figure S18. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for North Asia.

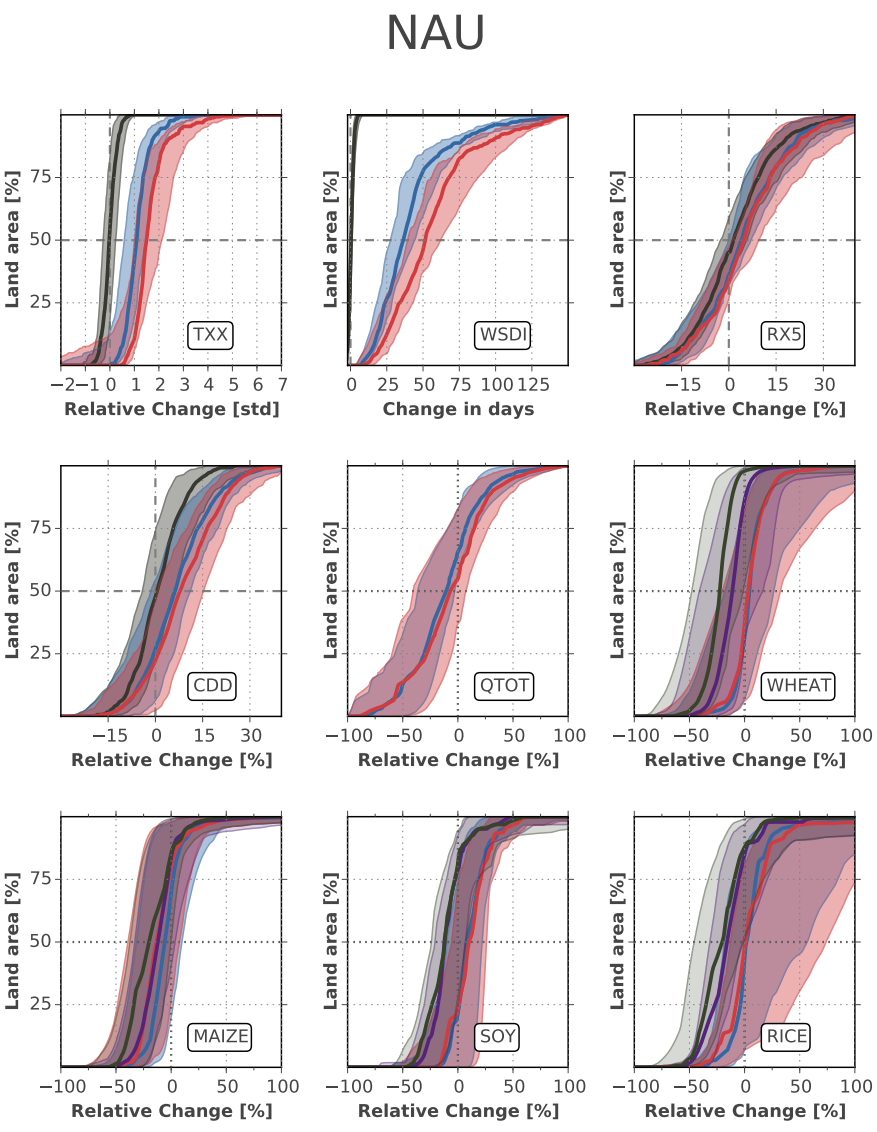

Figure S19. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for North Australia.

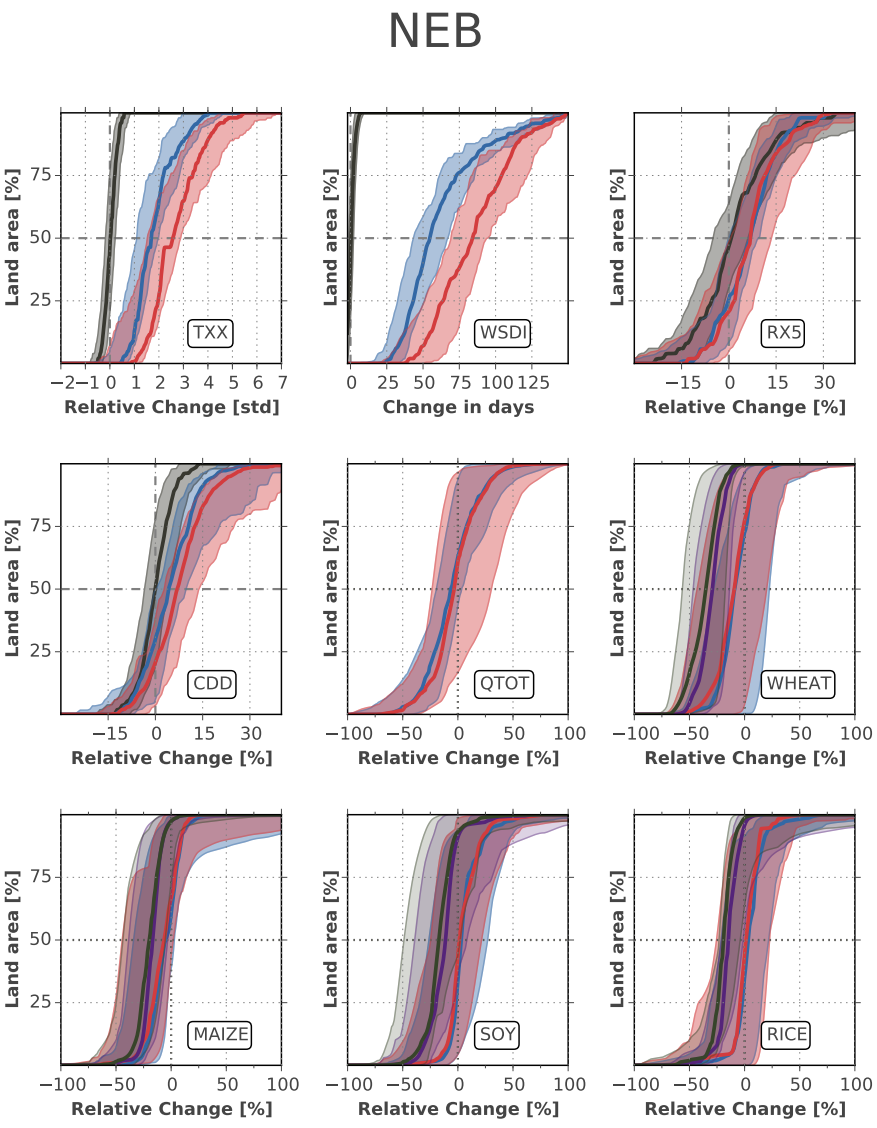

Figure S20. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for North East Brazil.

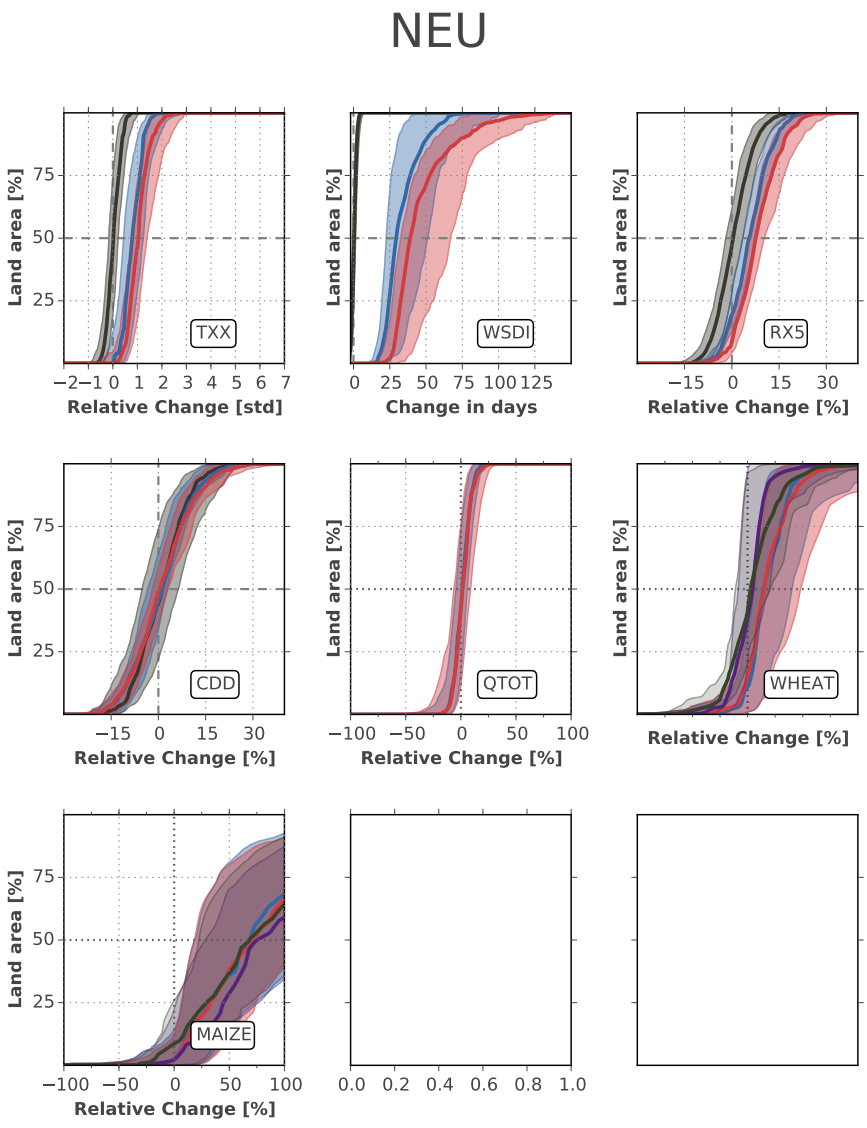

Figure S21. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for North Europe.

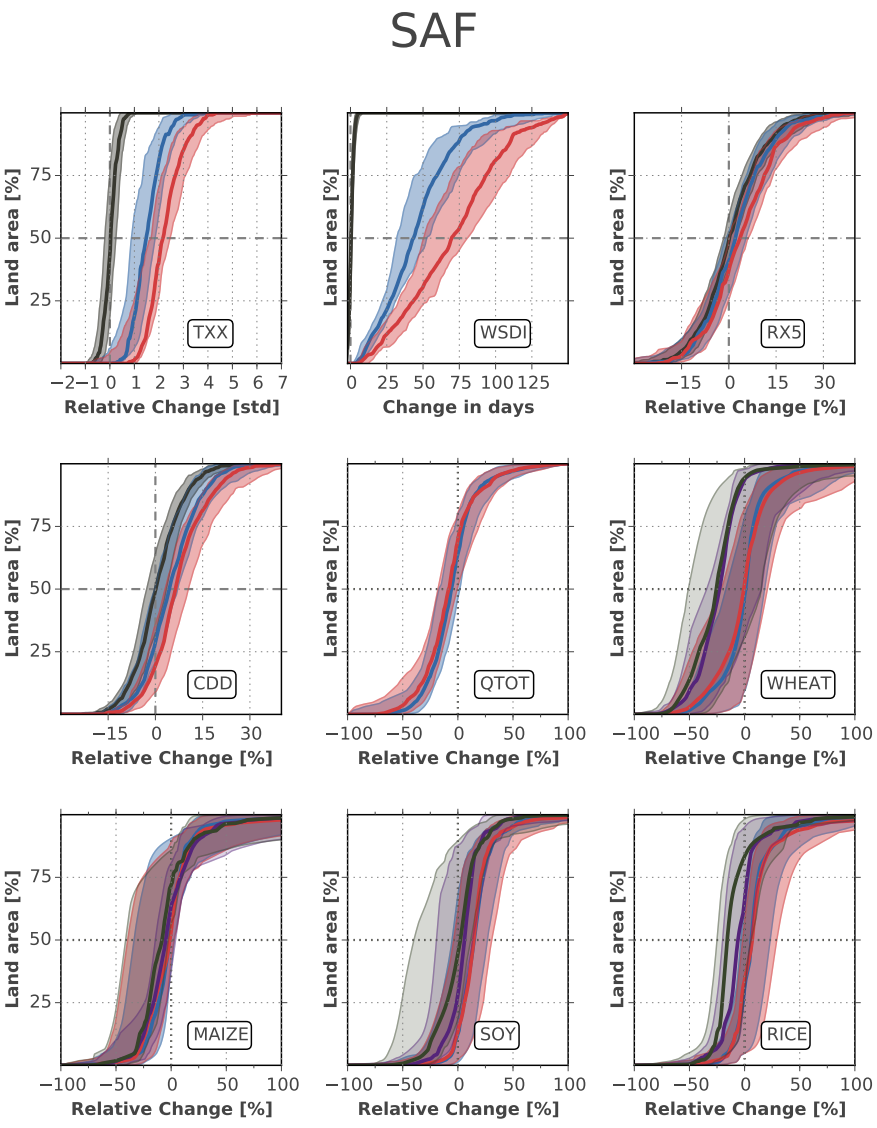

Figure S22. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for South Africa.

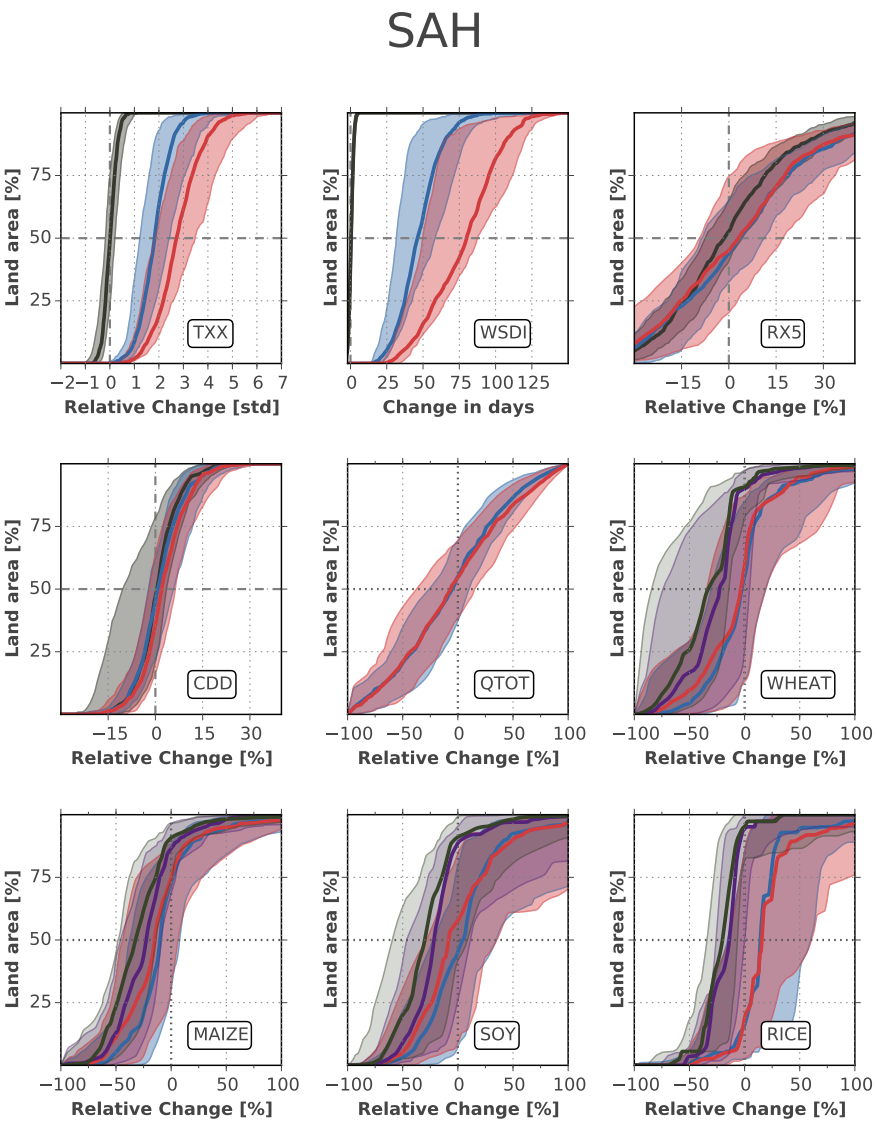

Figure S23. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for Sahara.

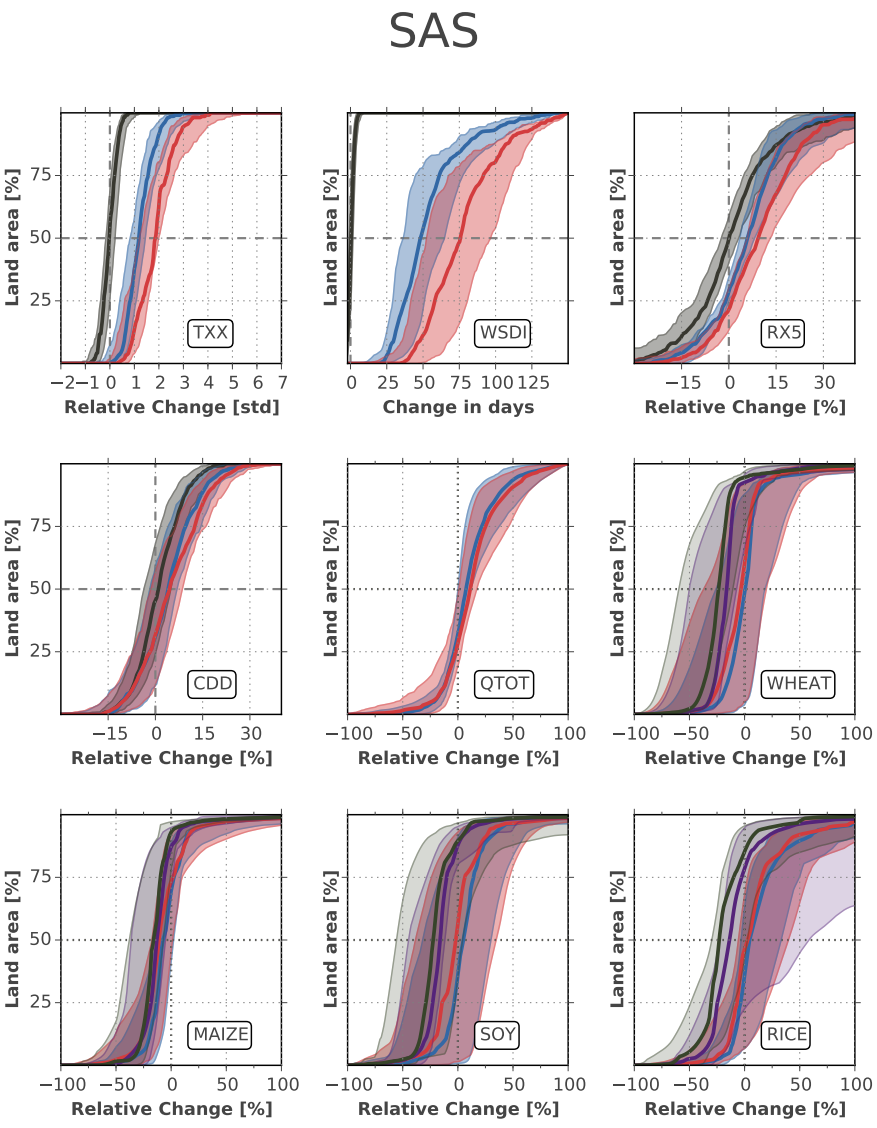

Figure S24. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for South Asia.

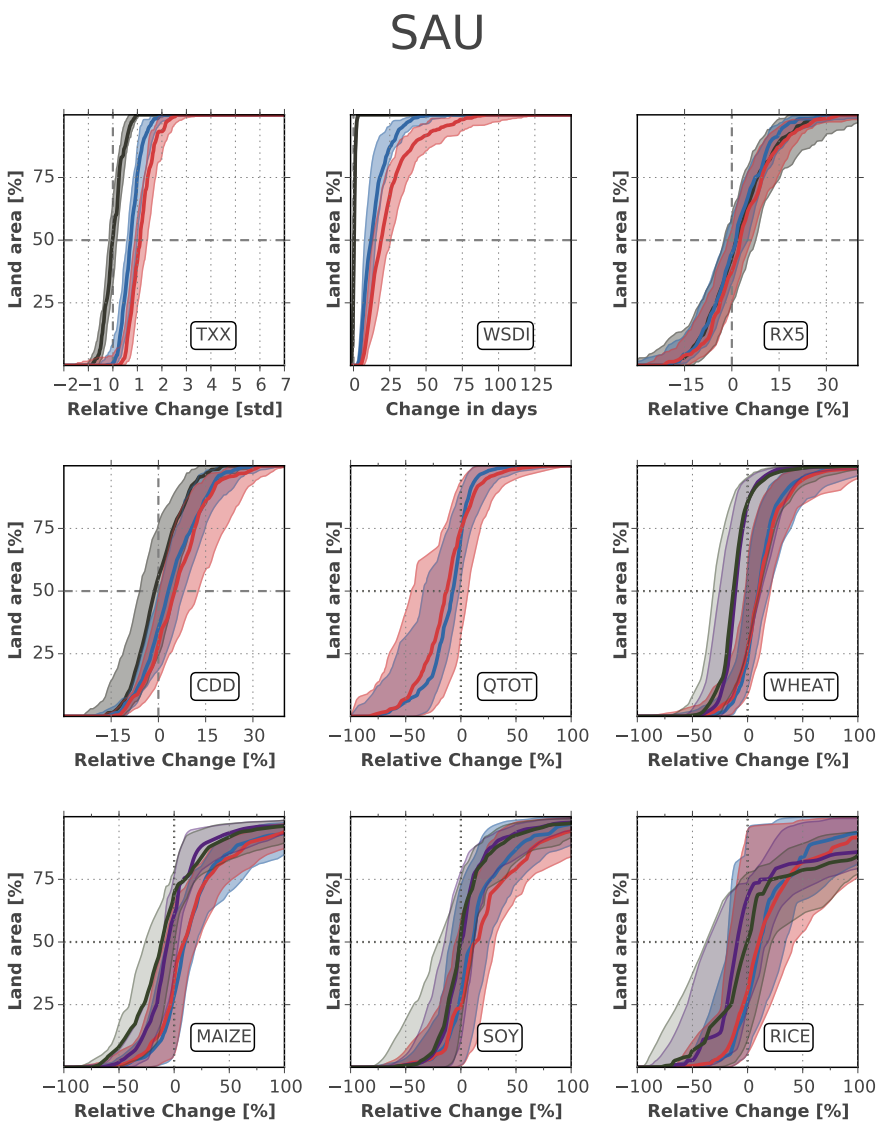

Figure S25. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for South Australia, New Zealand.

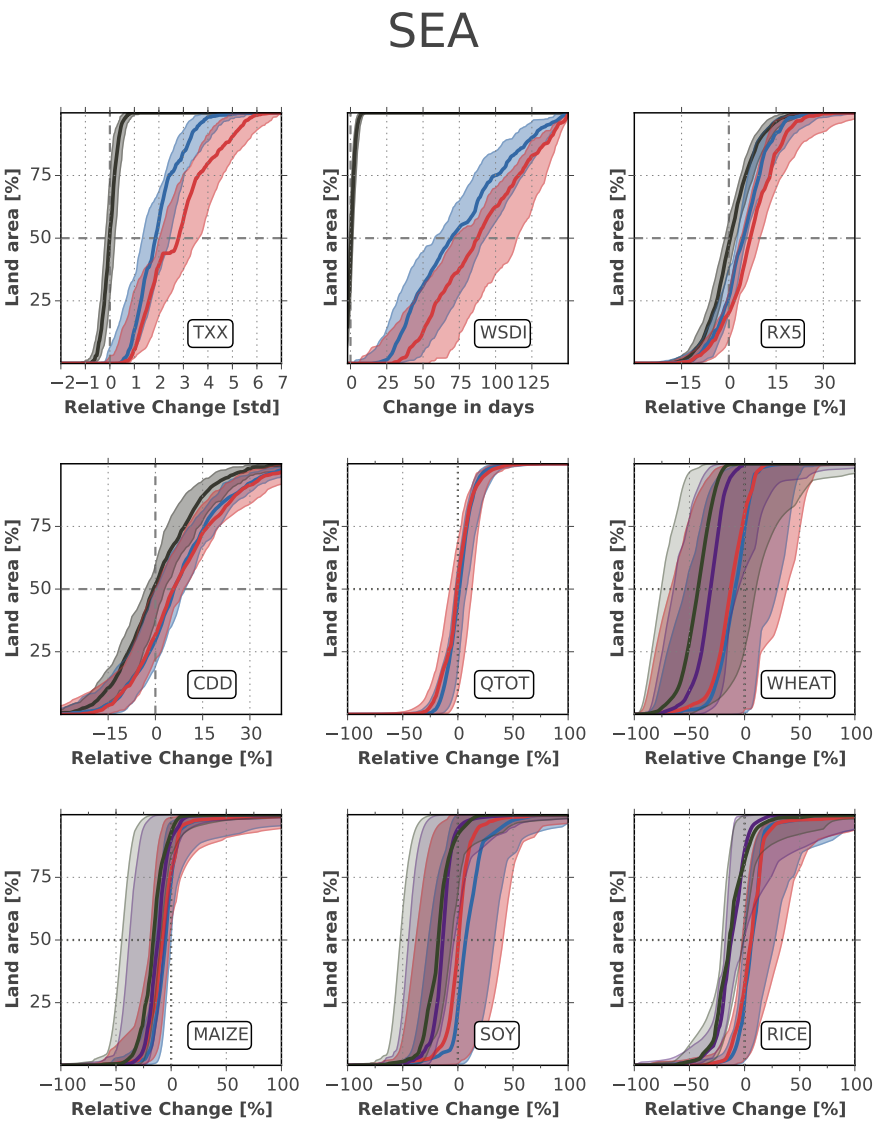

Figure S26. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for South-East Asia.

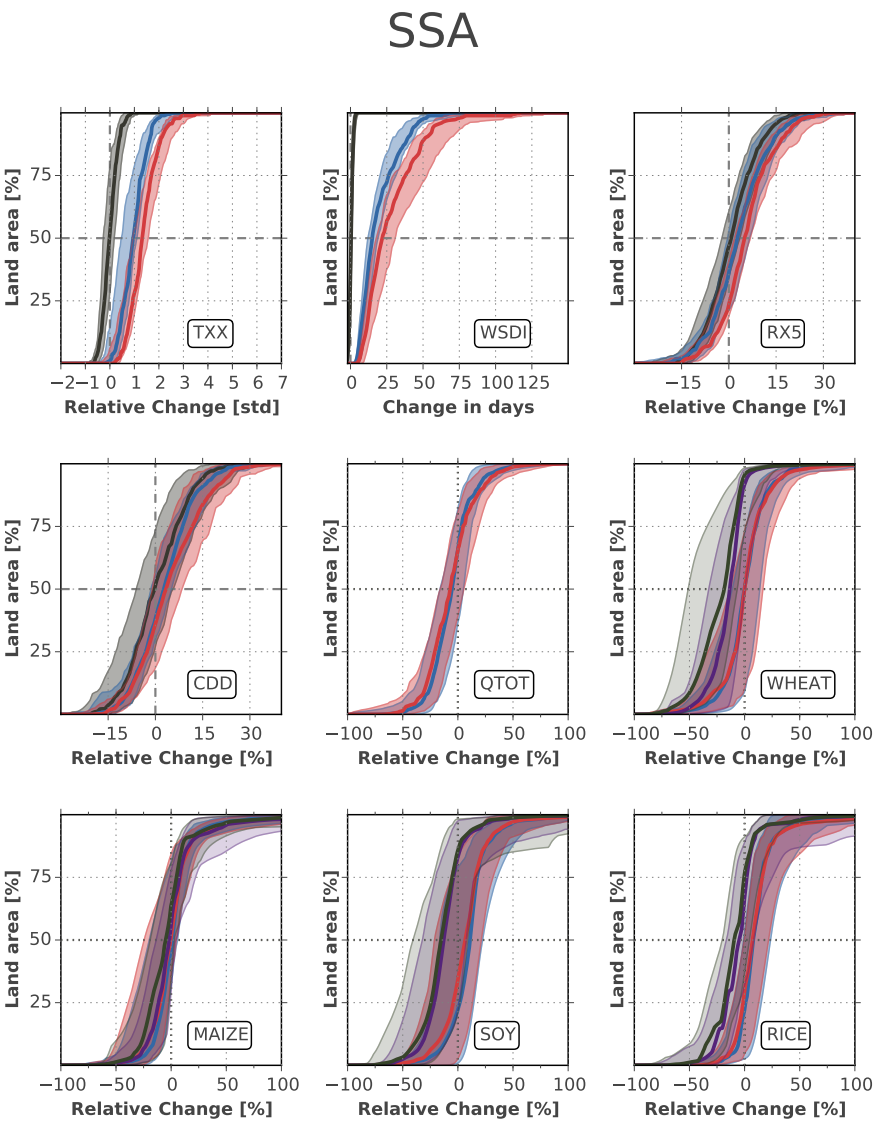

Figure S27. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for South-East South America.

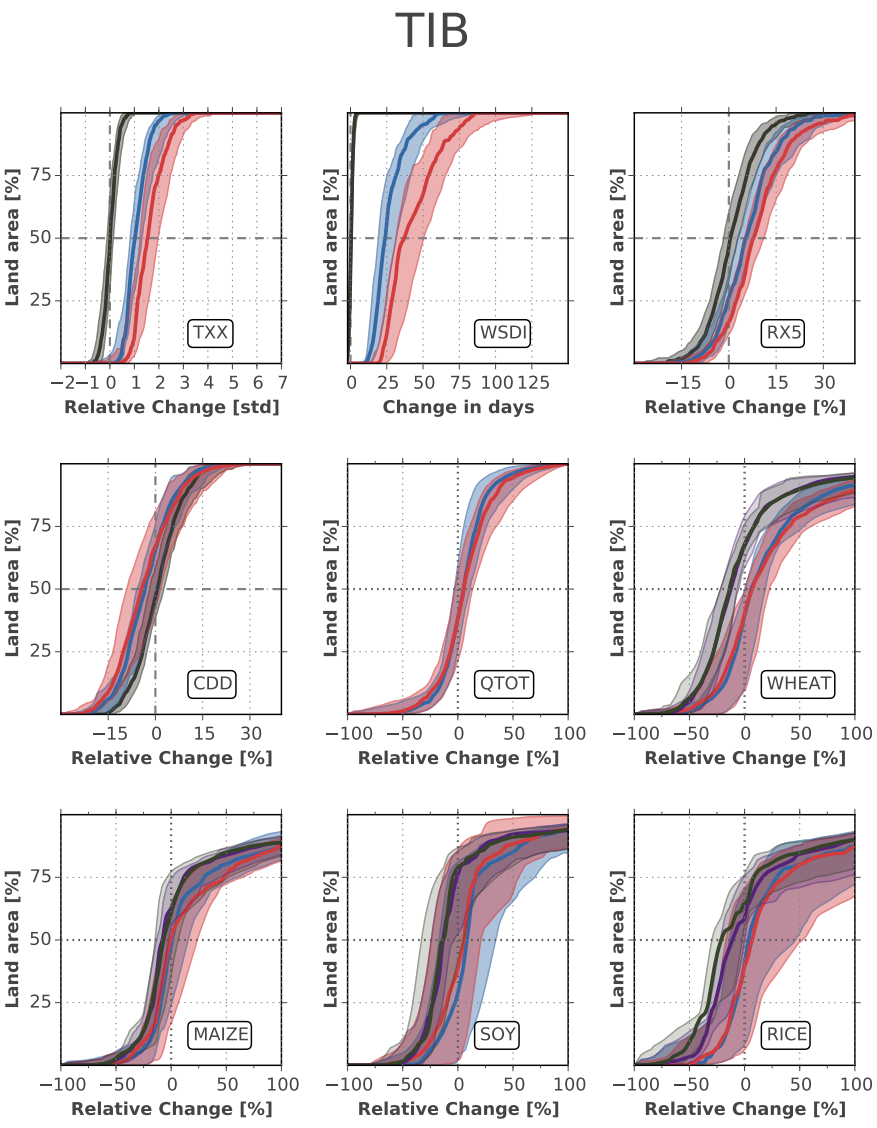

Figure S28. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for the Tibetan Plateau.

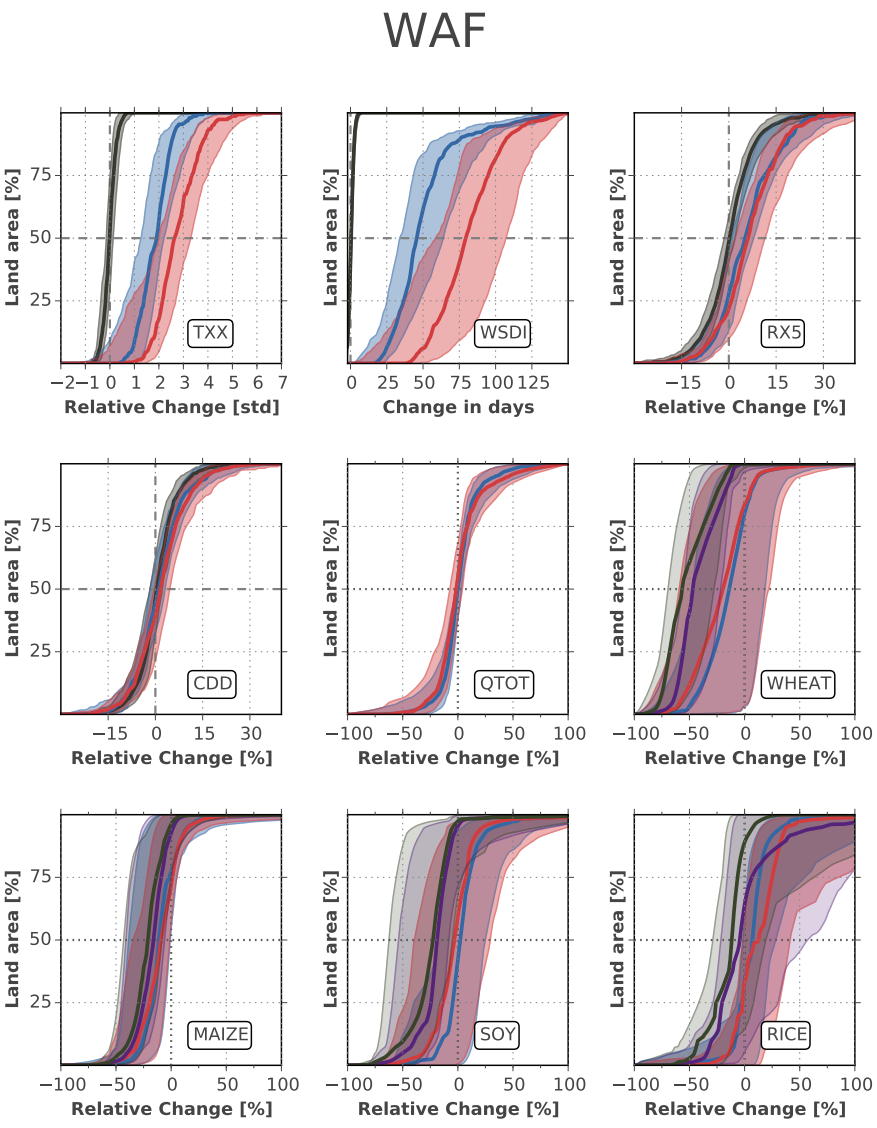

Figure S29. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for West Africa.

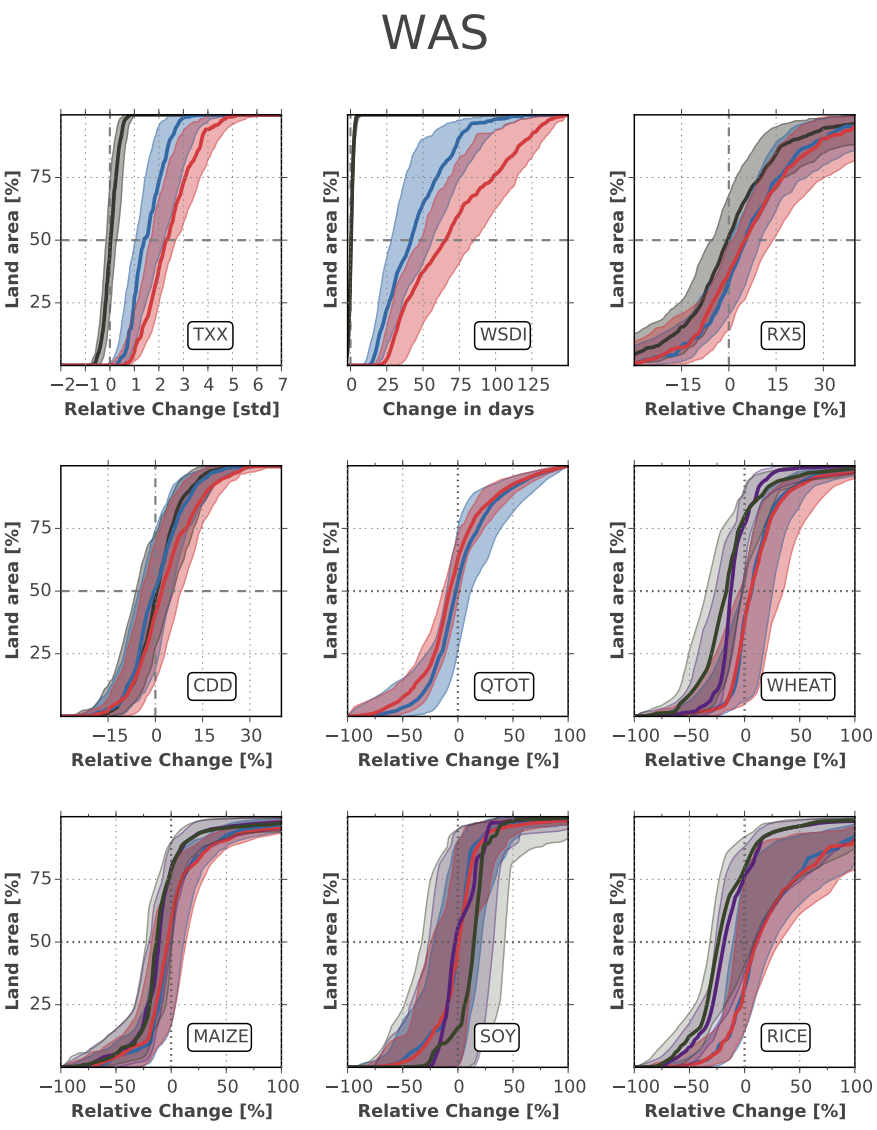

Figure S30. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for West Asia.

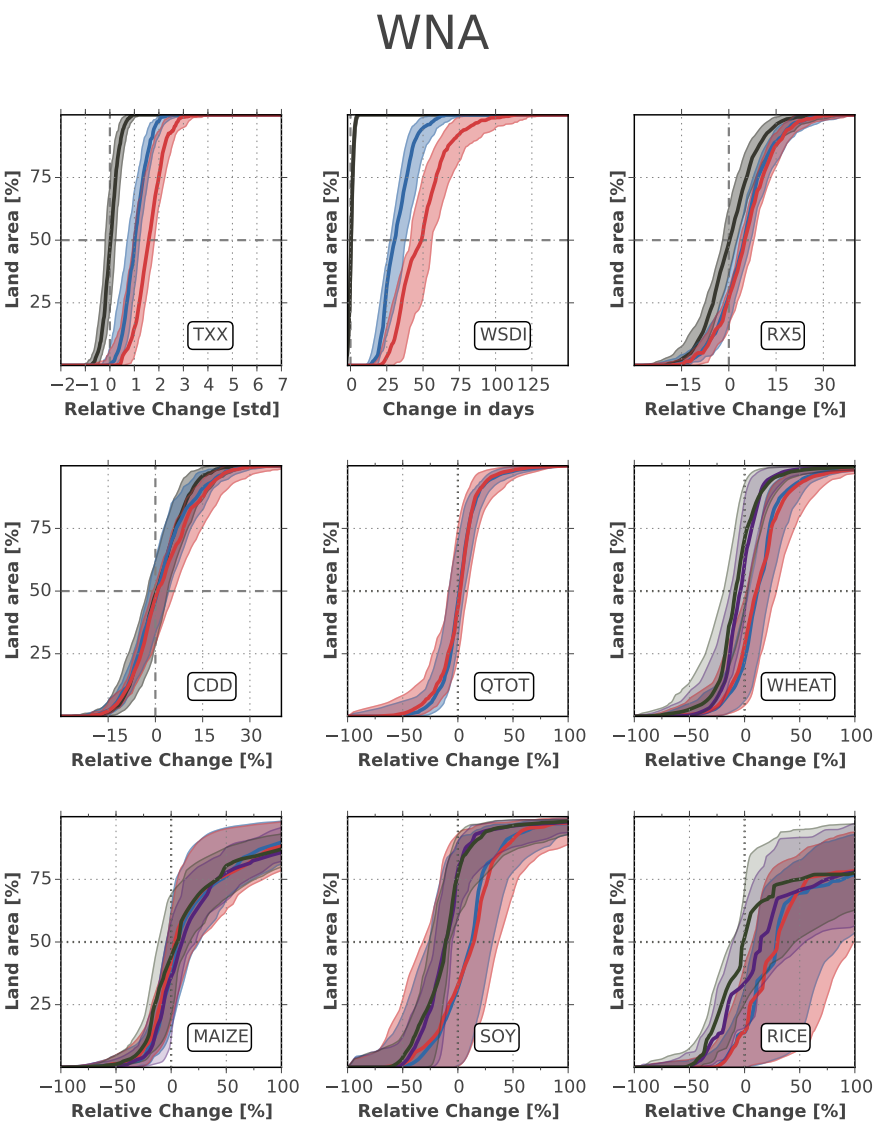

Figure S31. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for West North America.

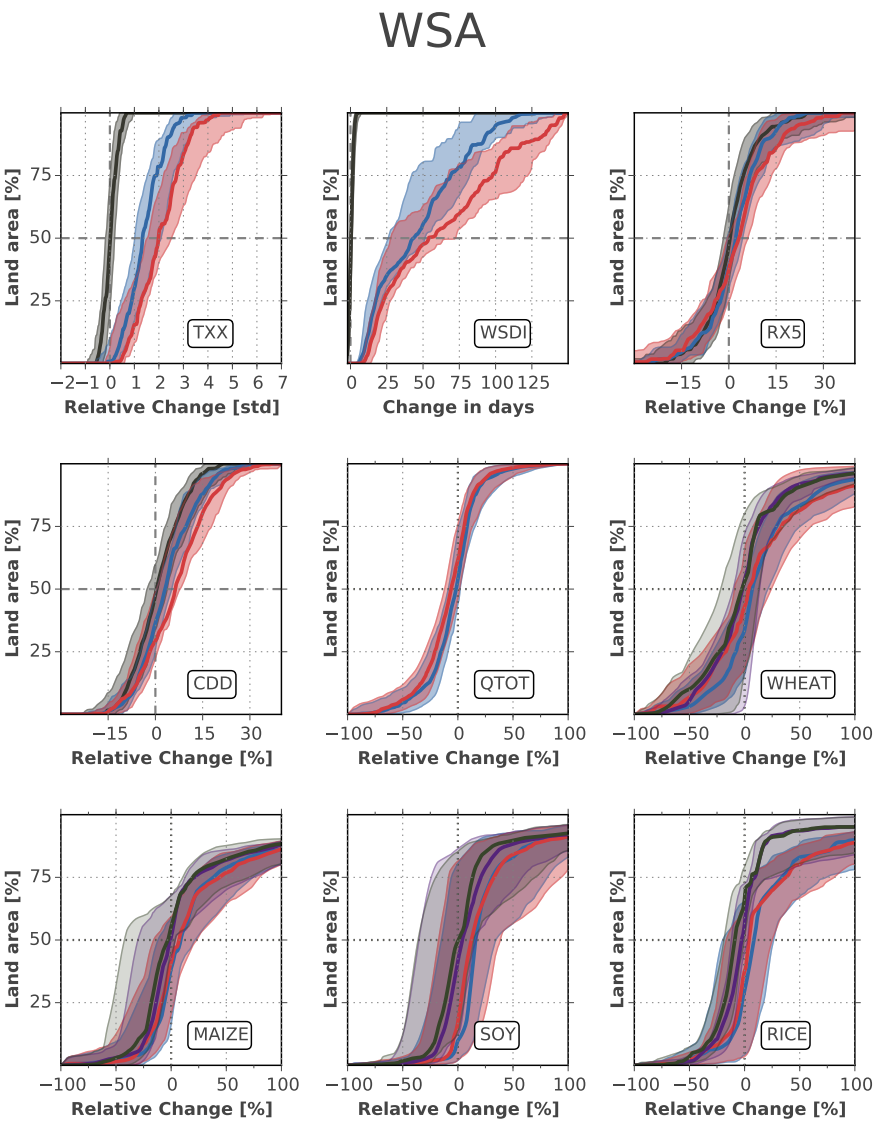

Figure S32. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for West Coast South America.

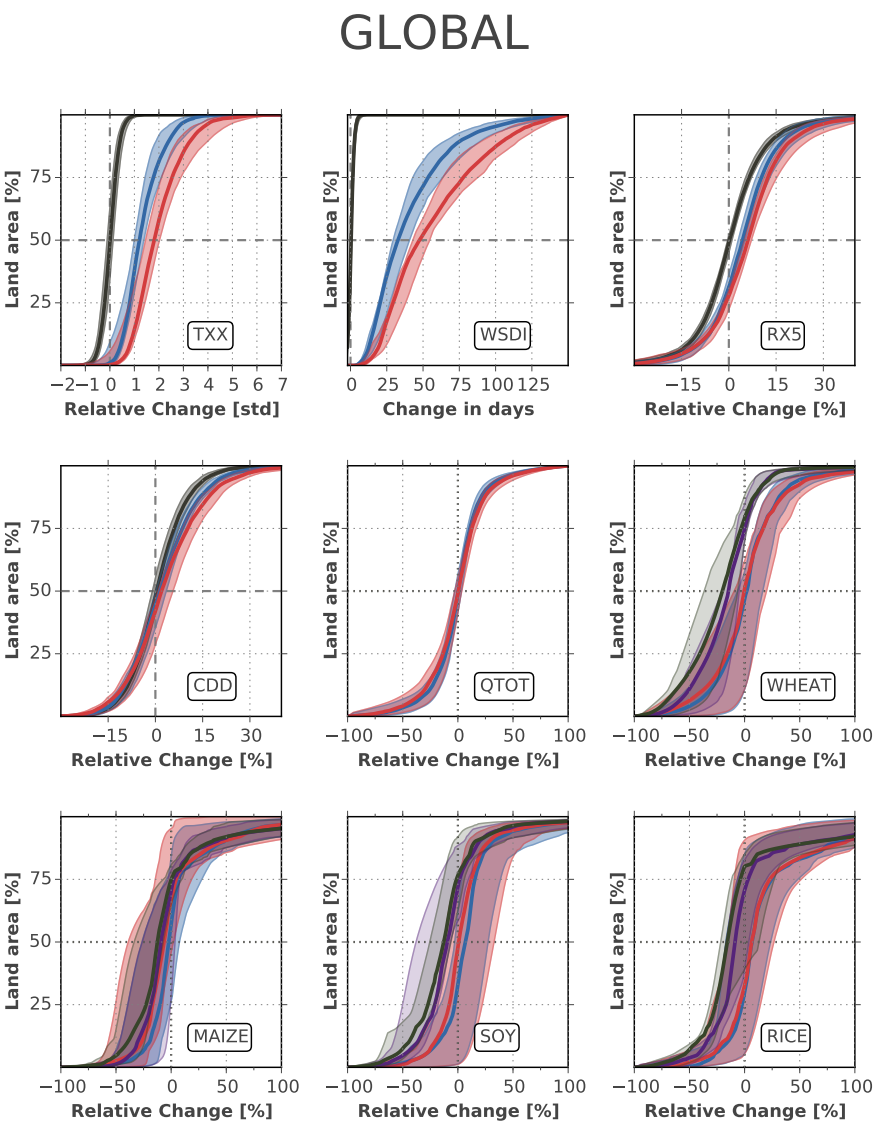

Figure S33. CDFs for projected regional aggregated changes as in Figs. 2,3,5,6,8-12 of the main manuscript for the global land area between 66 °N and 66 °S.

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