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## 2 **Supplementary Information for**

### 3 **A regional nuclear conflict would compromise global food security**

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#### 9 **This PDF file includes:**

- 10     Supplementary text
- 11     Figs. S1 to S15
- 12     Tables S1 to S5
- 13     SI References

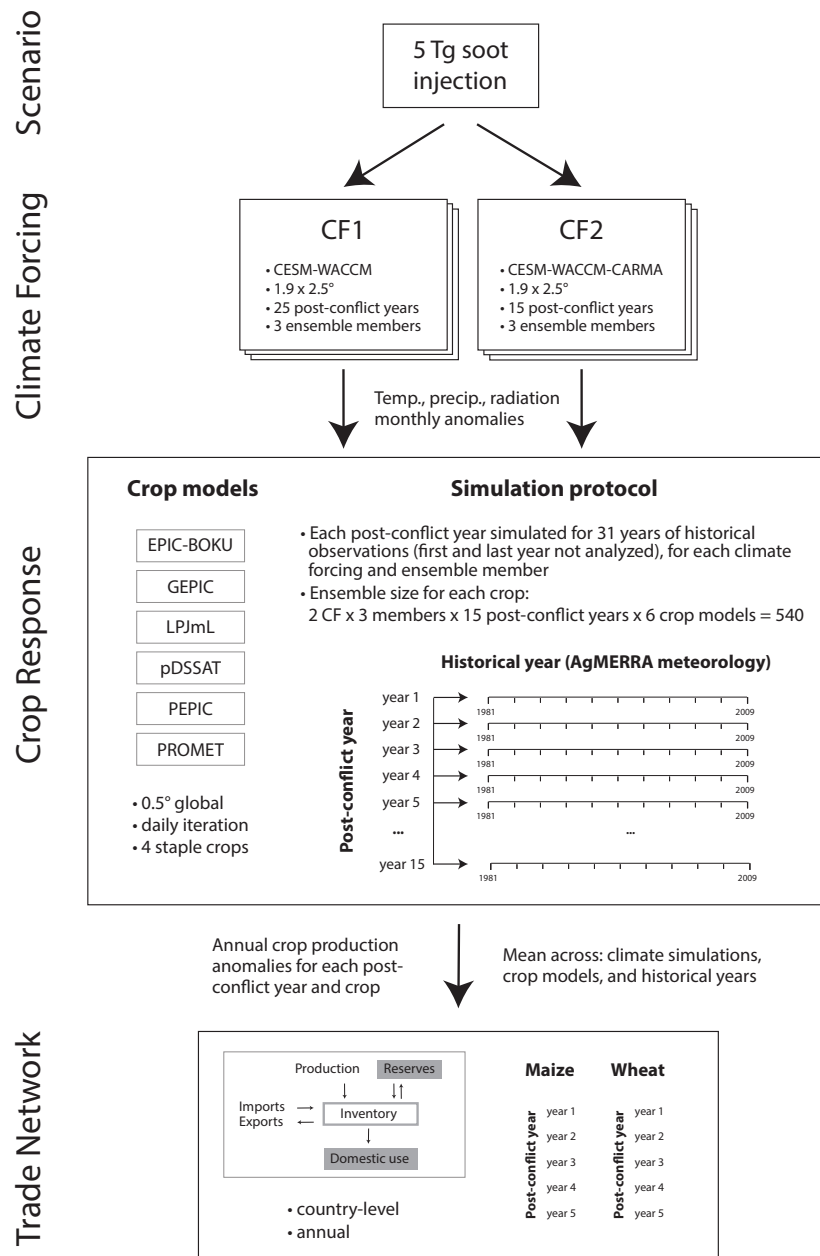
## 14 Supporting Information Text

15 **Decomposition of crop model responses.** The decomposition of yield responses to single climate drivers individually perturbed  
16 one at a time (filled-in with control AgMERRA climate) highlights that (using maize as an example) *SR* and *P* have spatially  
17 rather homogeneous responses, inducing regional yield decline by 5 to 20% in many world regions (Fig. 5 and S8). *T*, however,  
18 causes a strongly localized signal at latitudes  $>30^{\circ}\text{N}$ , with yield declines up to 50%. Cooler temperatures affect high-latitude  
19 temperature-limited agriculture primarily through slower accumulation of Growing Degree Days (GDD; daily mean temperature  
20 accumulation above a crop-specific base temperature, see Table S1) and therefore expanded growing period length, which  
21 can cause failure to reach physiological maturity, and enhance exposure to frost damage (see Table S1 and Fig. S9). In turn,  
22 slightly cooler temperatures in subtropical and tropical climates are shown to have beneficial effects as long as radiation and  
23 precipitation are not imposing additional stresses (Fig. S8). It was indeed recently confirmed that aerosol-induced cooling  
24 increases tropical rice yields (1). At the global level, perturbed *T*, *P*, *SR*, and *LR* cause maize production declines of 5, 2.5, 3.7,  
25 and 0.9%, respectively, which indicates that the individual effects are largely additive (combined perturbation -12.1%, Fig. 5).

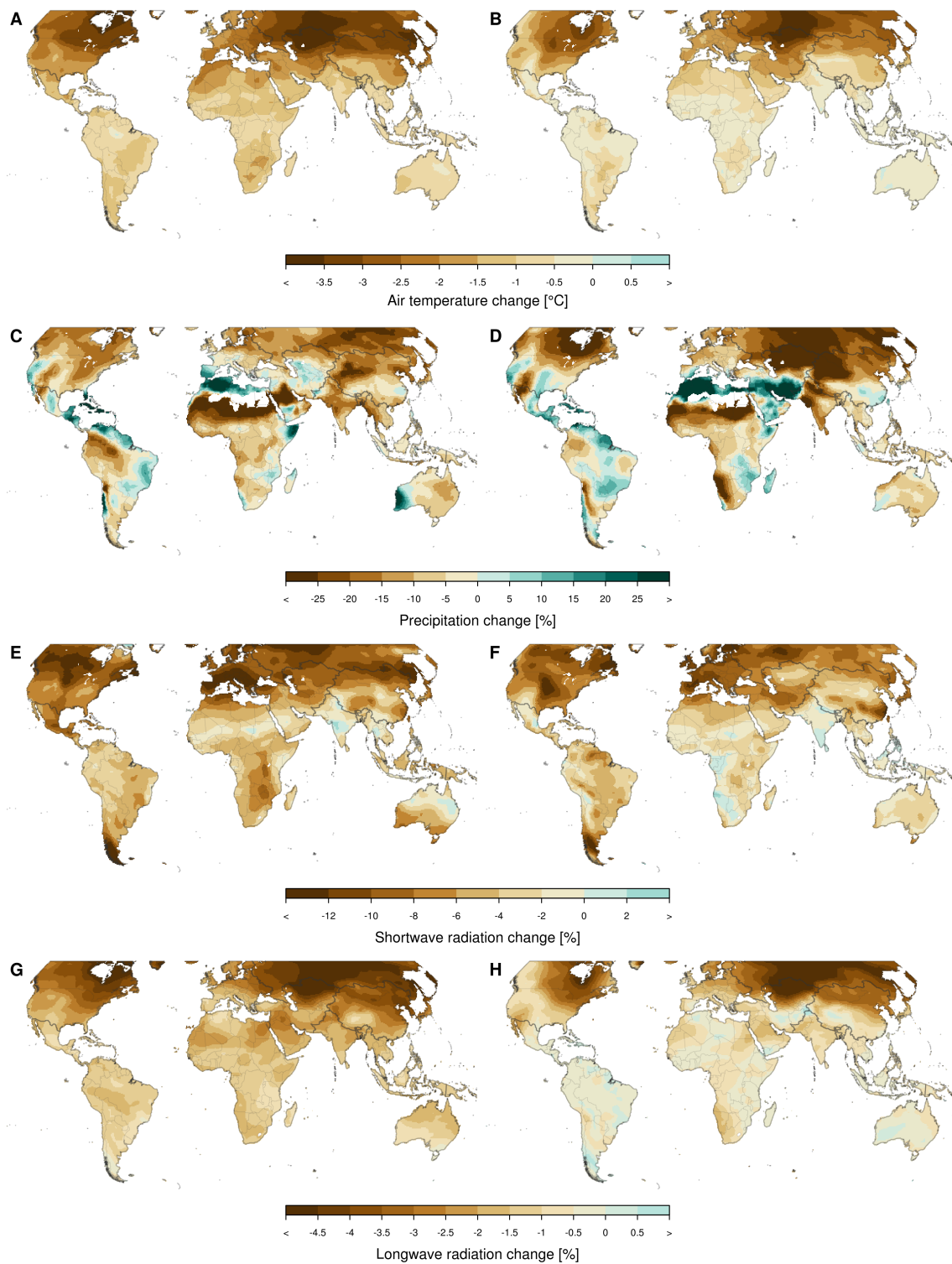
26 The representation of water stress is among the core capabilities of crop models (2), and we find a robust cross-model  
27 response to precipitation changes in water-limited rainfed systems (PEPIC uses a different potential evapotranspiration (PET)  
28 estimation method and is thus slightly less sensitive than other EPIC-based models). Yet, there are marked differences in  
29 the response to *T* and especially *SR* (Fig. S8). The global maize production response to  $\sim 1.8^{\circ}\text{C}$  decline in global mean *T*  
30 ranges from -1.8% (pDSSAT) to -9.6% (PEPIC), while the high-latitude losses are remarkably similar across models. It is the  
31 disagreement on the lower-latitude gains from cooler temperatures that causes global model differences (pDSSAT shows up to  
32  $\sim 20\%$  production gains in regions where PEPIC results remain unchanged). As for *SR*, maize production in LPJmL even  
33 gains 3% at the global level, while for pDSSAT and GEPIC it is the strongest negative driver (-4.2 and -7.8%, respectively). In  
34 all models, reduced solar radiation reduces Gross Primary Production (GPP). In LPJmL, however, radiation affects PET and  
35 thus determines atmospheric water demand. Lower *SR* therefore reduces crop water stress, which is beneficial for crop growth  
36 under unchanged temperature and outweighs reductions in GPP at global level. pDSSAT and GEPIC, on the other hand, use  
37 a radiation-use efficiency model in which GPP is more sensitive to lower radiation influx with immediate adverse responses.  
38 Longwave radiation is only considered in LPJmL. Despite differences in responses to individual climate drivers and varying  
39 cold damage implementations, the overall crop model response is largely similar, which adds confidence to the reliability of the  
40 analysis but also helps to better understand crop model response mechanisms under unprecedented climate anomalies than  
41 they were designed for (Fig. S8).

42 Schauburger et al. (3) show that the GGCM models reliably reproduce observed yield losses due to extreme heat. A similar  
43 observational response at global level for cold temperatures has not been established to our knowledge, but the results in this  
44 study suggest that there is a linear maize yield decline between -1 and  $-4^{\circ}\text{C}$  across currently cultivated areas (Fig. S10).

45 Largest post-conflict losses occur in different years for different crops. While maize and wheat show largest losses in year  
46 four, they occur for soybean in year one and for rice in year five (Fig. 2). This is explained by different regional patterns of the  
47 climate forcing (CF1 vs. CF2) and the different growing areas of each crop. The differences in crop responses between year one  
48 and four, however, are minor and do not indicate different physiological response pattern of the four crops.



**Fig. S1. Model workflow and simulation protocol.** Climate forcing CF1 (4) and CF2 (5) are published climate model simulations. The following ‘Materials and Methods’ sections in the main text provide more details: ‘Nuclear conflict scenario’; ‘Climate model simulations with 5 Tg soot emission’; ‘Climate perturbation protocol for crop model simulations’; ‘Crop yield simulations’; and ‘Food trade network’.



**Fig. S2. Spatial pattern of nuclear conflict-induced climate perturbations.** Year 1–5 post-conflict changes in surface air temperature [°C] (A, B), precipitation [%] (C, D), and incoming shortwave (E, F) and longwave (G, H) solar radiation [%] are shown for the CF1 (left column) and CF2 (right column) climate model simulations as averages across three ensemble members.



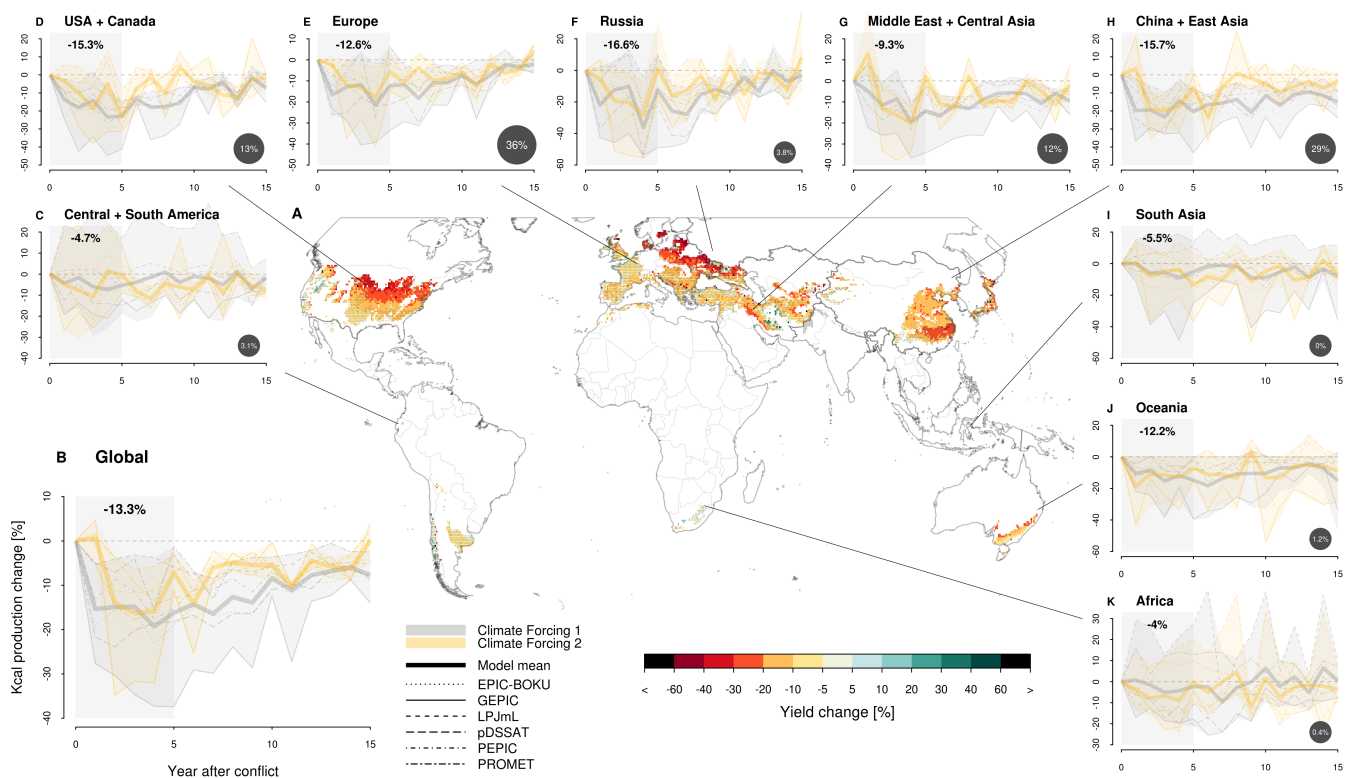
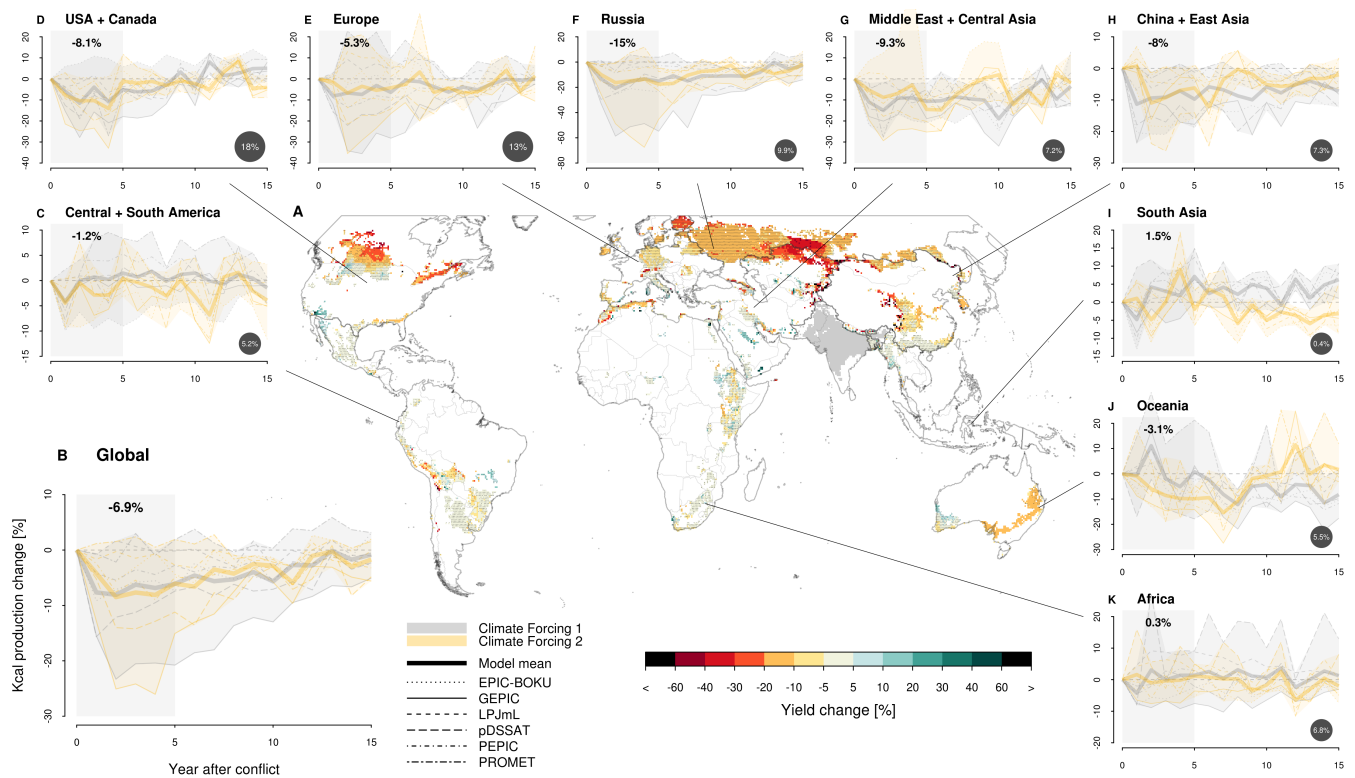
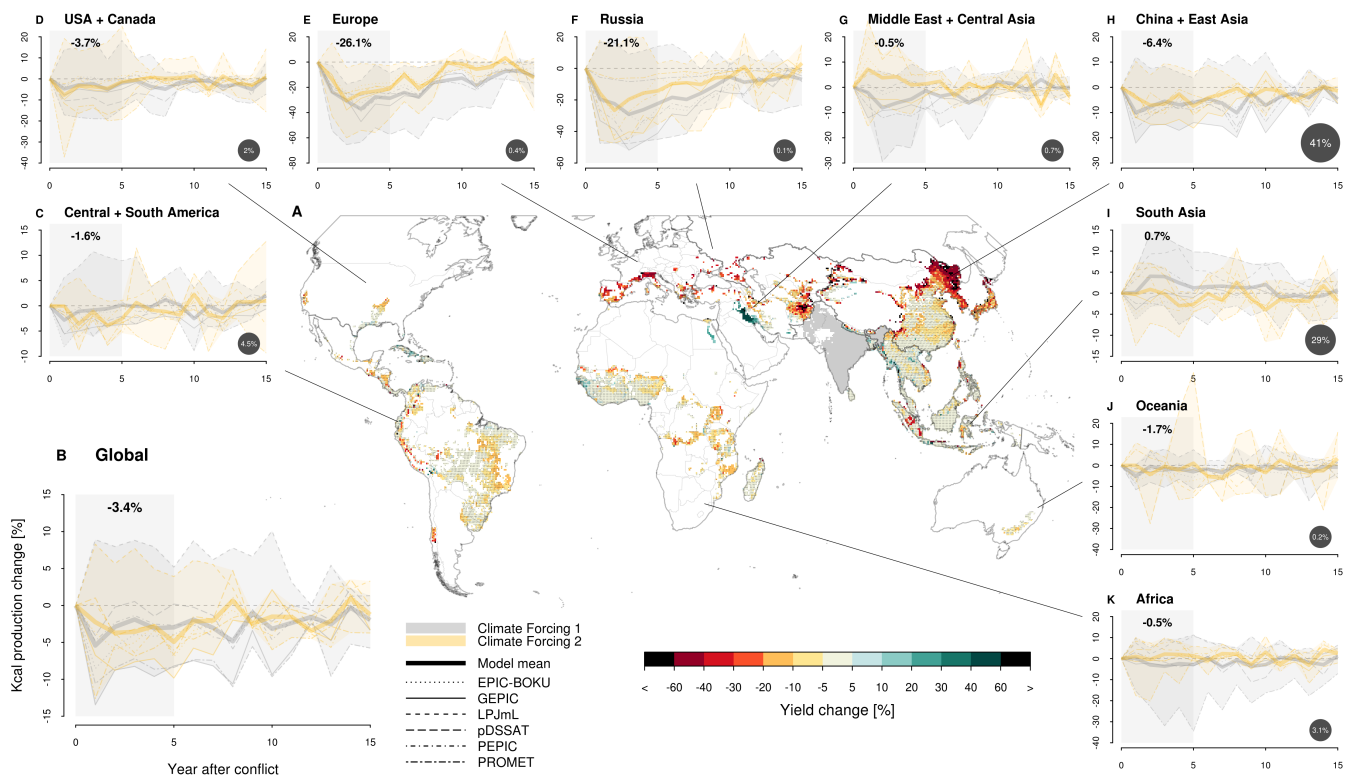


Fig. S3. Implications for winter wheat production. Same as Figure 3 but for winter wheat.



**Fig. S4. Implications for spring wheat production.** Same as Figure 3 but for spring wheat.



**Fig. S5. Implications for rice production.** Same as Figure 3 but for rice.

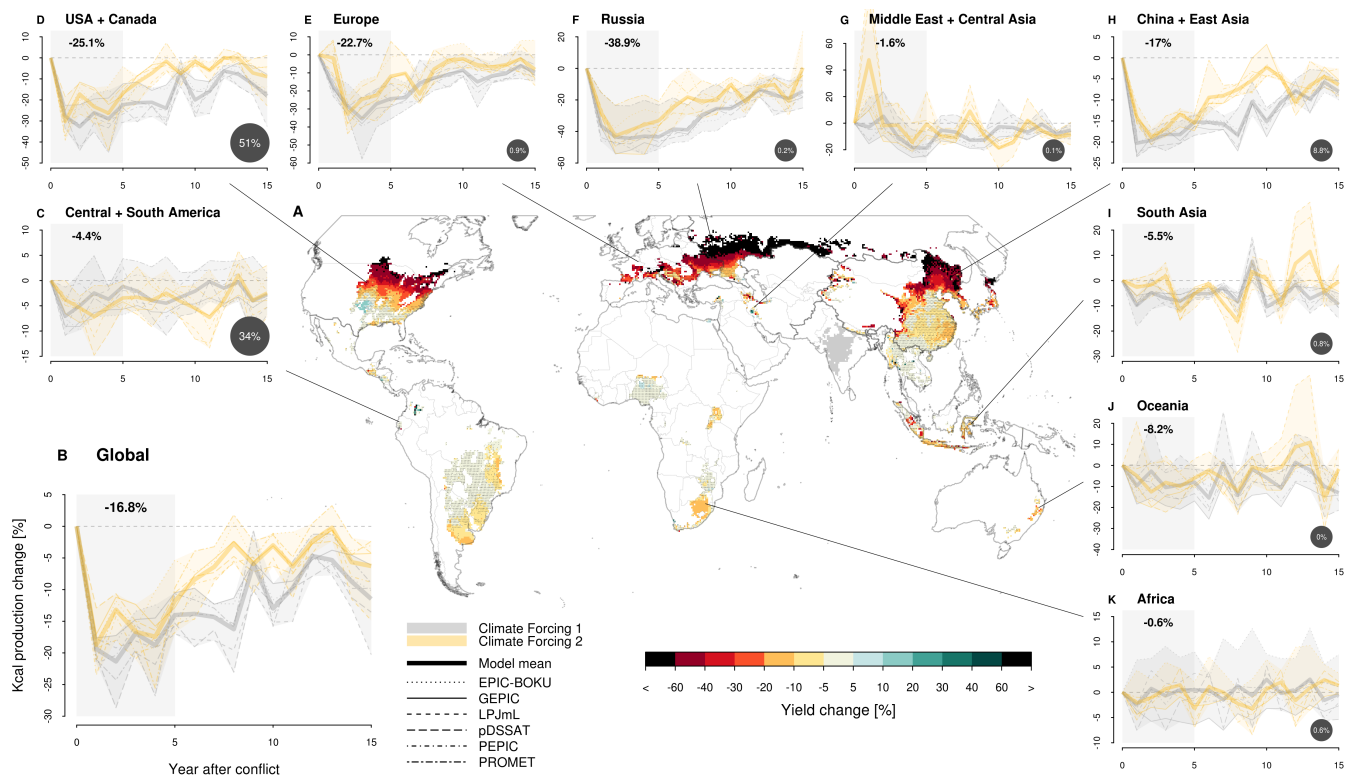
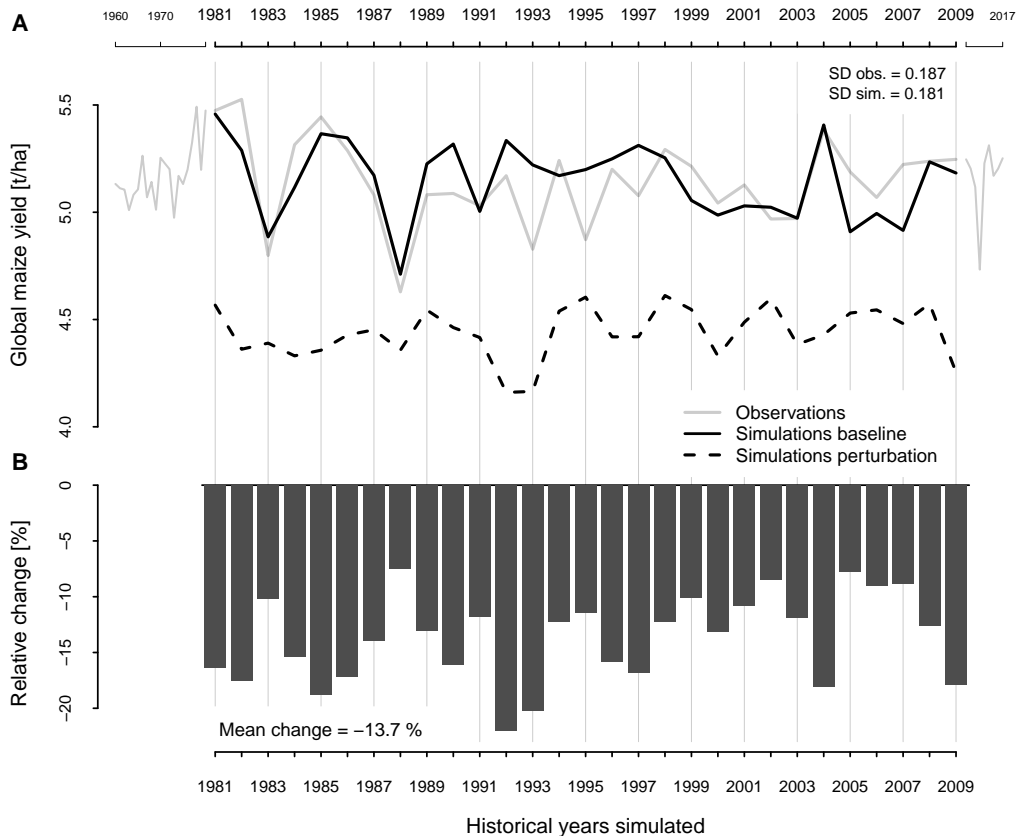
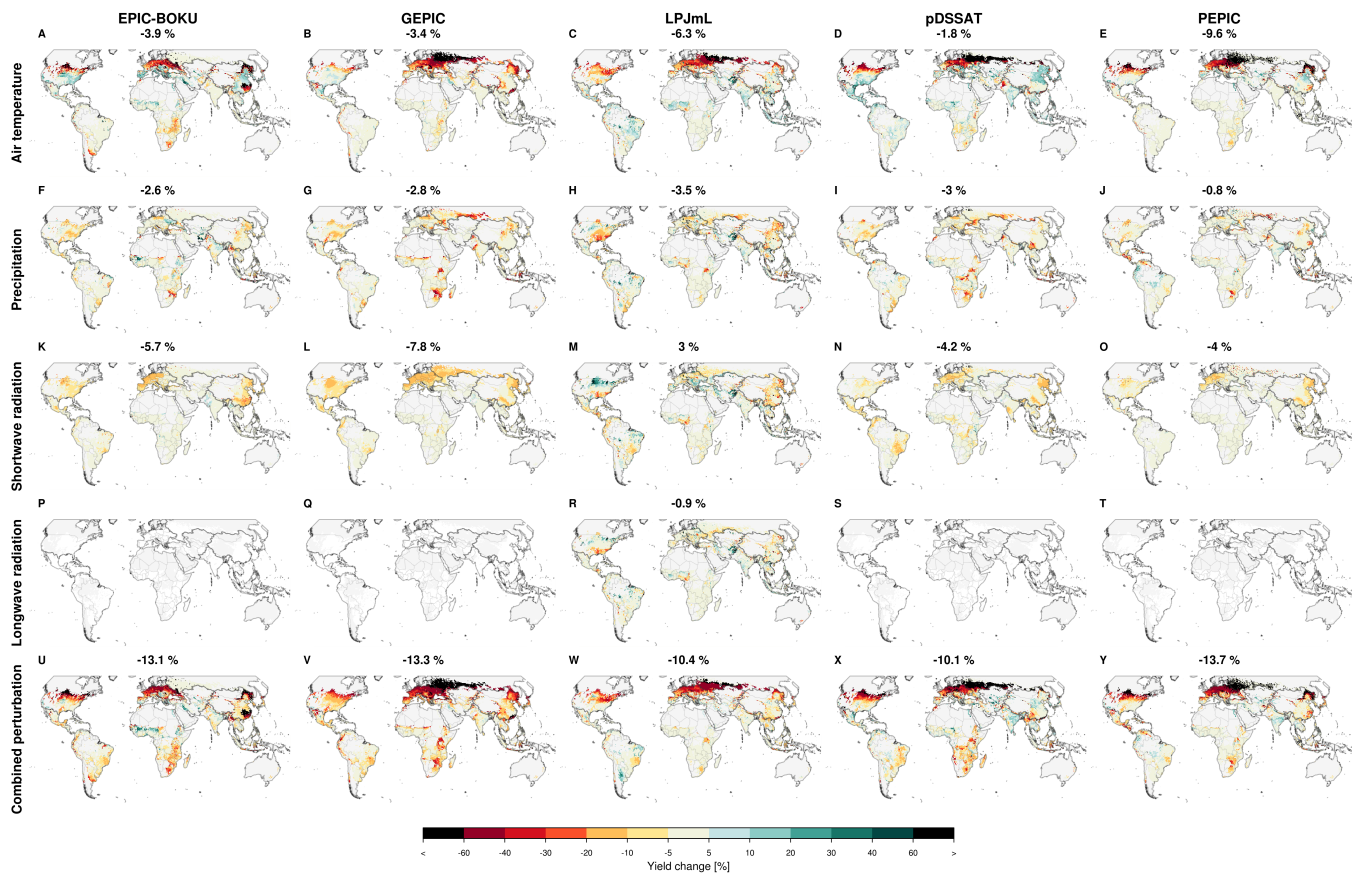


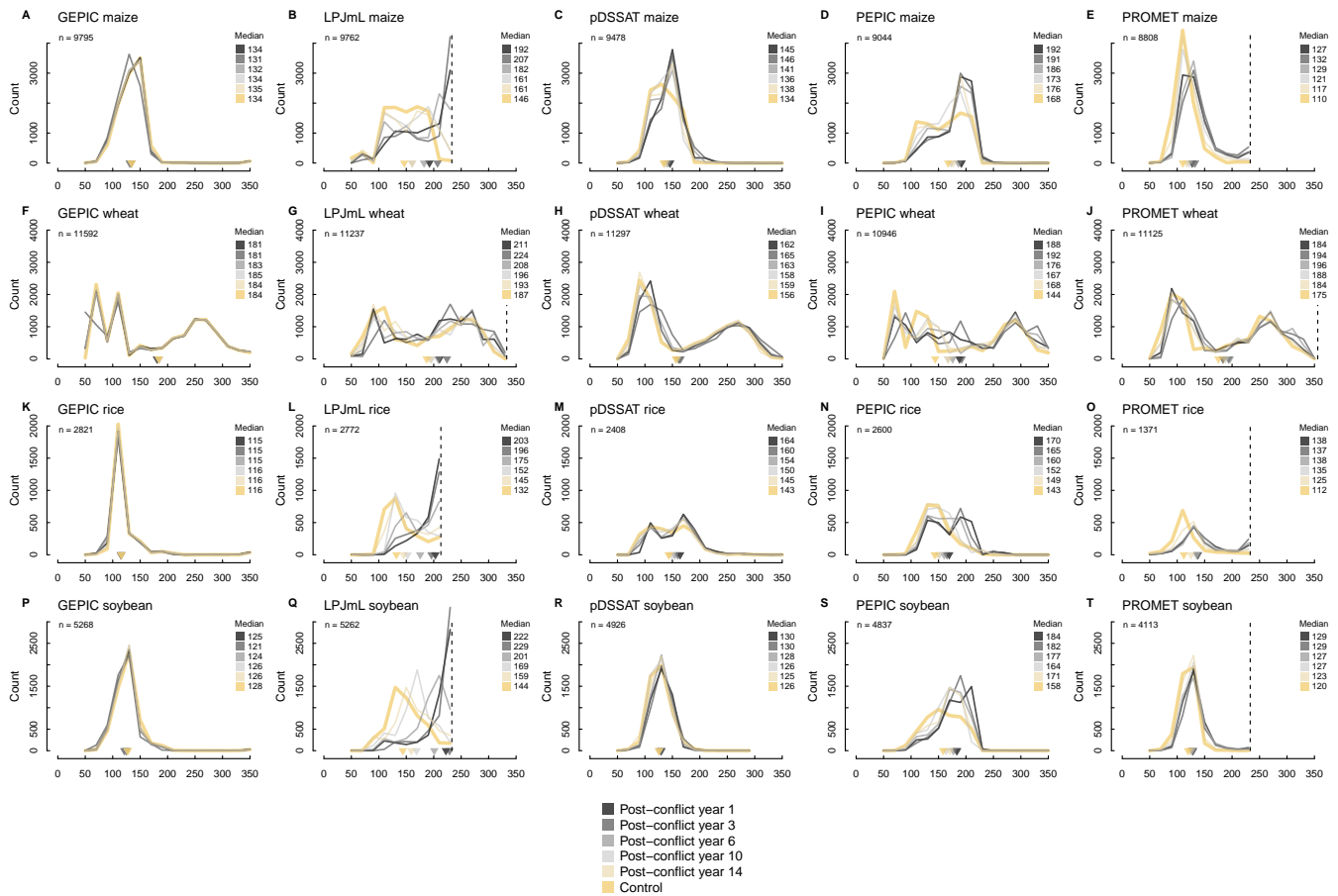
Fig. S6. Implications for soybean production. Same as Figure 3 but for soybean.



**Fig. S7. Baseline and perturbed historical maize yield variability.** To address interannual differences, each post-conflict year of climate anomalies is simulated for 29 years of historical weather observation. (A) The figure shows mean global maize yields for this historical time period from 1981 – 2009 for the post-conflict year four (dashed line; the post-conflict year with largest global maize losses), along with the baseline ensemble simulations (black solid line), as well as detrended FAOSTAT yield observations (gray solid line (6)). The standard deviation (SD) of observed and simulated historical baseline yields is indicated in the top right corner. Simulated yields are shown as the area-weighted mean across rainfed and irrigated systems and crop models (and climate models in the perturbed case). FAOSTAT yield observations are available from 1961 to 2017, shown on the compressed x-axes outside of the simulation period. Panel B highlights the relative change between the baseline and the perturbation shown in A. There is no statistically significant trend ( $p < 0.25$ ) in the impacts over the historical time period (neither in the absolute yields nor relative changes).

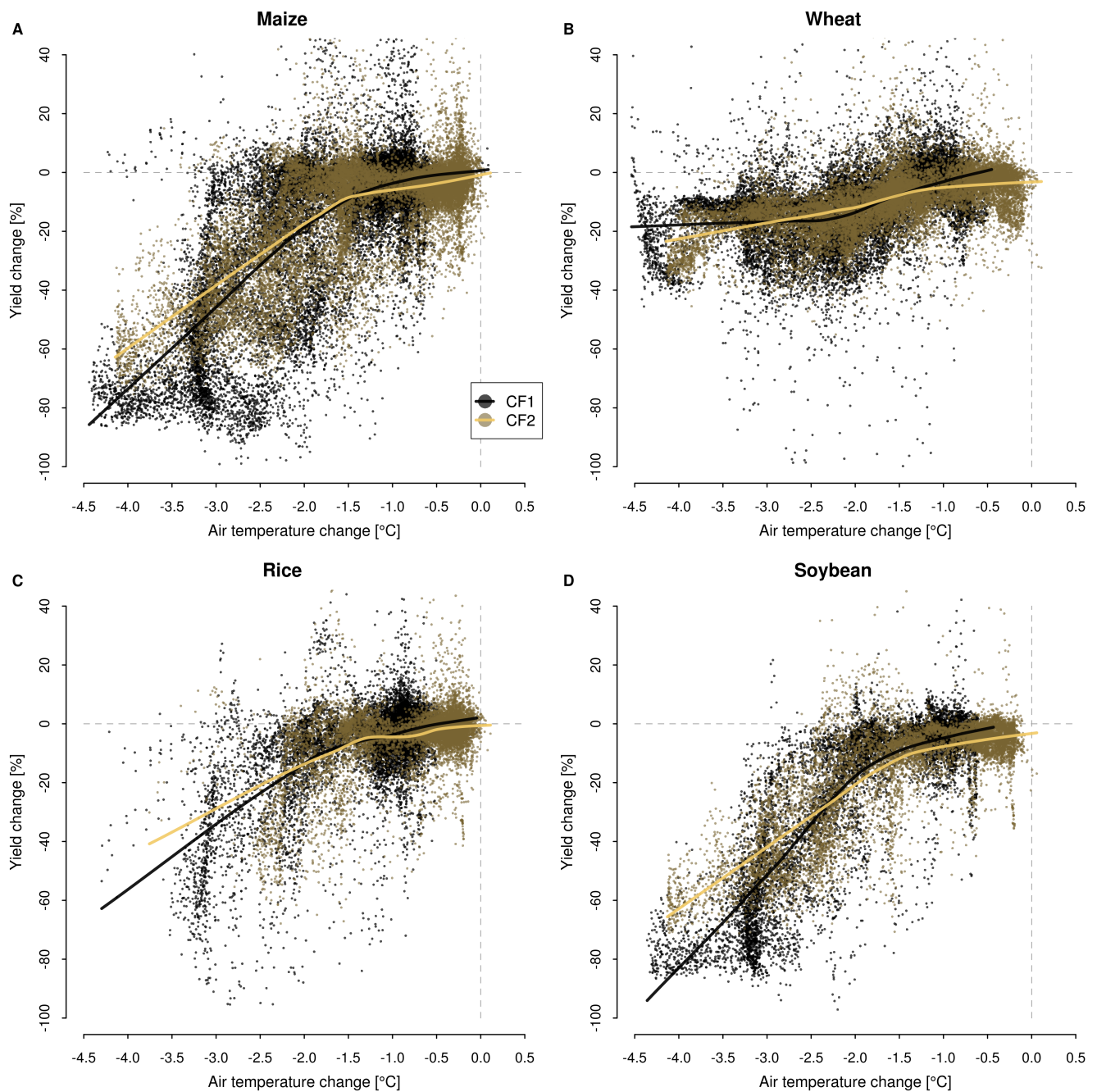


**Fig. S8. Maize yield and production sensitivity to individually perturbed climate drivers, shown by crop model.** (A–Y) Similar to Figure 5, yield and production changes for maize are shown for each climate driver perturbed one at a time (rows), but here separated for each crop model (columns). Percentage numbers in the title indicate the respective global caloric production change. This sensitivity test is only performed for climate model simulation CF1<sub>a</sub>, and by the crop models EPIC-BOKU, GEPIC, LPJmL, pDSSAT, and PEPIC.



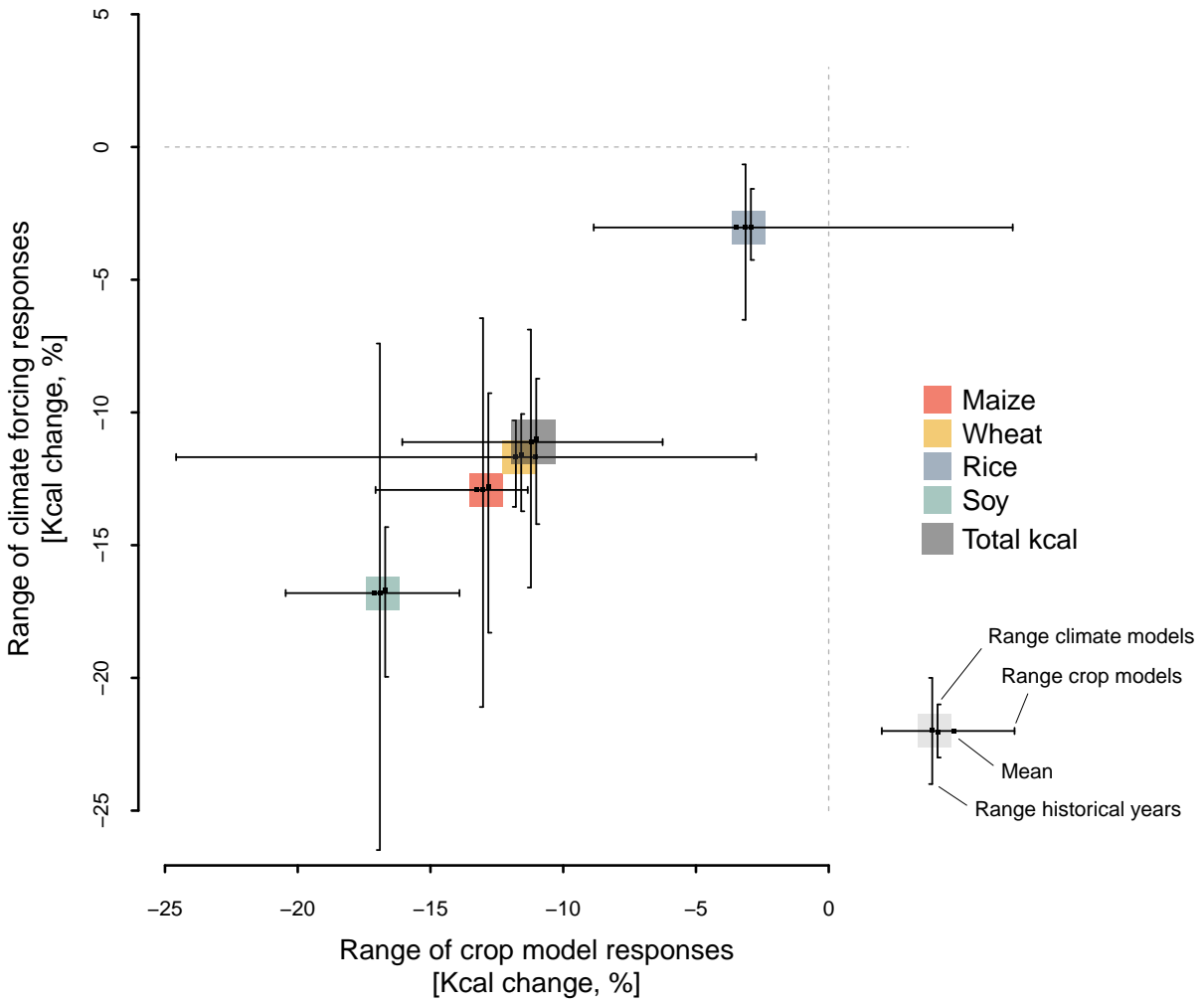
**Fig. S9. Climate perturbation effects on the growing season length.** (A–T) Histograms of the simulated growing season length are shown for maize, wheat, rice, and soybean (rows) and crop models (columns); for the control simulation and several post-conflict perturbation years (colors). Triangles along the x-axis and legend inserts indicate the respective median growing season length. The dashed vertical line illustrates the crop-specific maximal growing season length, if applicable. Data are shown for latitudes  $>30^{\circ}\text{N}$ . The number of grid cells behind each histogram is shown in the top corner (n, average across all 7 simulations). Rainfed and irrigated systems are combined as weighted averages based on current cropland extent. The crop model EPIC-BOKU is not shown as it cannot provide growing season outputs.





**Fig. S10. Temperature response function of crop yields.** Yield changes between post-conflict year 1 to 5 are plotted against the local annual mean temperature change for maize, wheat, rice, and soybean, separated for CF1 and CF2 climate anomalies. Lines illustrate the respective LOWESS curve (locally weighted scatterplot smoothing; with span = 0.7 and degree = 1). Data are shown for all grid cells with more than 10 ha cropland (7). Yield changes are based on perturbations of all climate inputs, not on isolated temperature perturbations such as shown in Figure S8.





**Fig. S11. Decomposition of crop model and climate input uncertainty.** Colored squares mark the overall mean perturbation response of global caloric production for the four crops and the total, shown as the 5-year post-conflict average (rainfed and irrigated combined). Both axes are identical, but the error bars separate the range of i) crop model responses (x-axis; as the mean across the climate model ensemble and historical years), ii) climate model ensemble (y-axis, error bars with right-hand whiskers; as the mean across crop models and historical years), iii) sensitivity of historical years (y-axis, error bars with left-hand whiskers; as the mean across crop model and climate model ensembles). See Figure S7 for the time series of historical years and the range of maize responses.

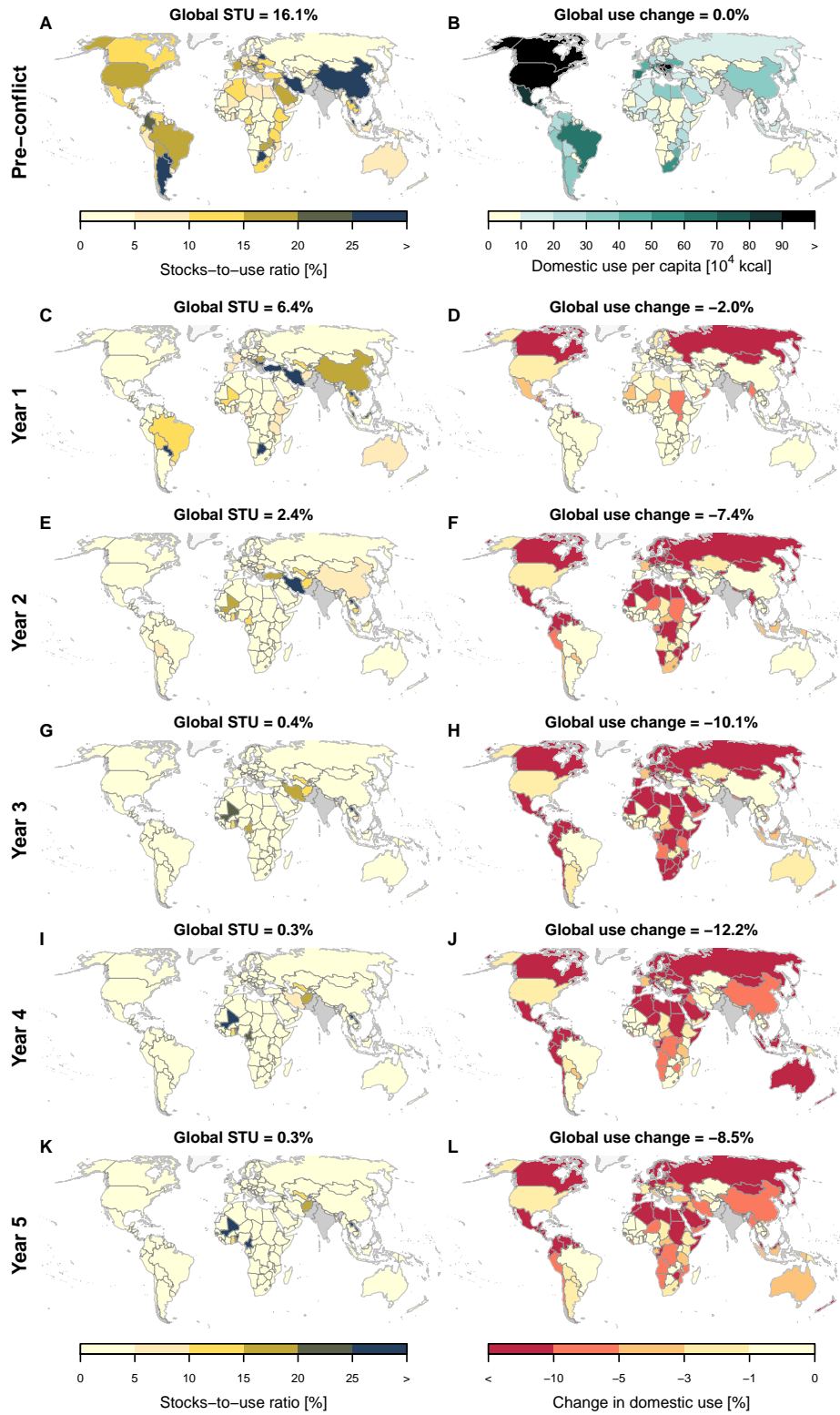


Fig. S12. Post-conflict changes in national maize reserves and domestic use. Same as Figure 6 but for maize only and for post-conflict years one to five.

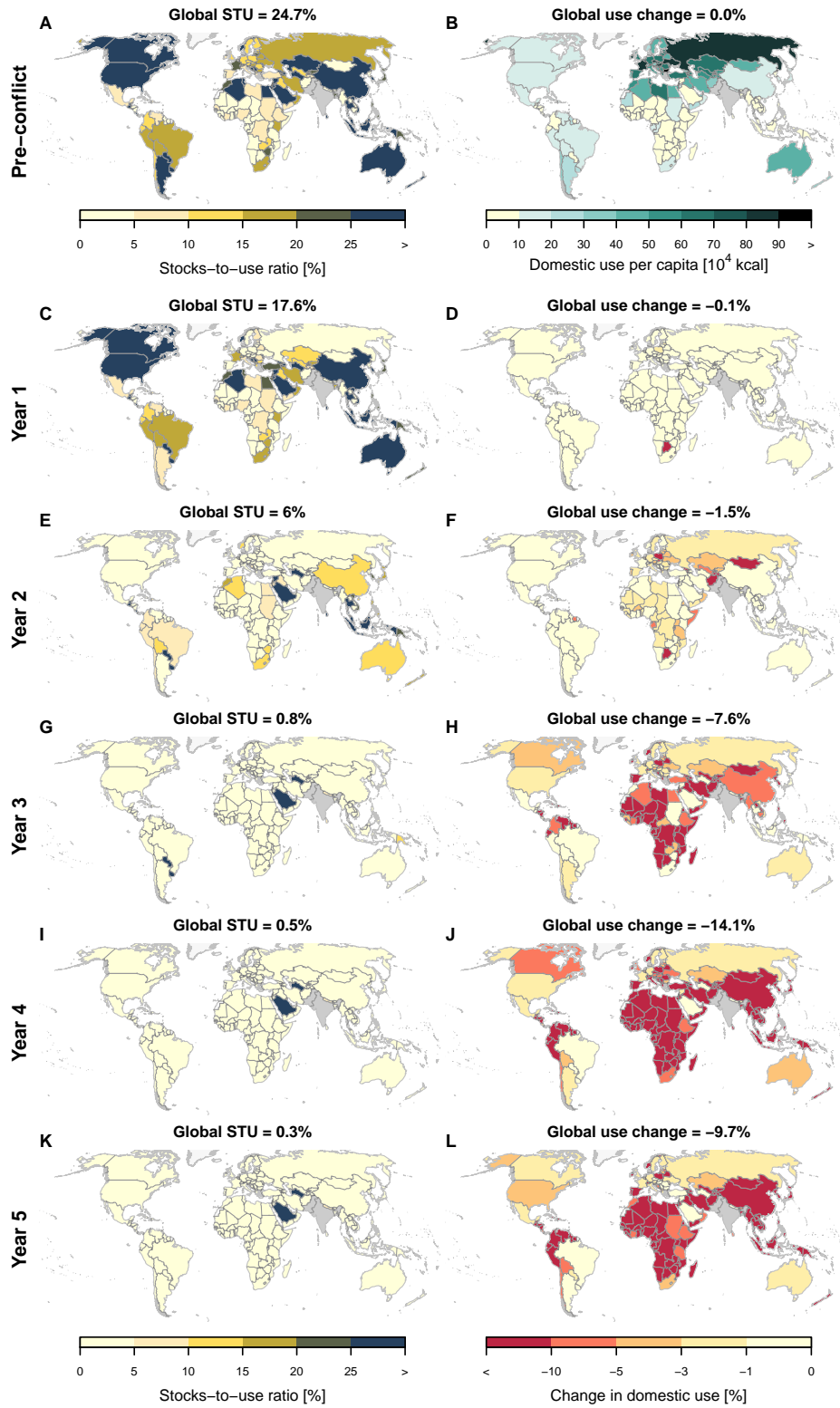
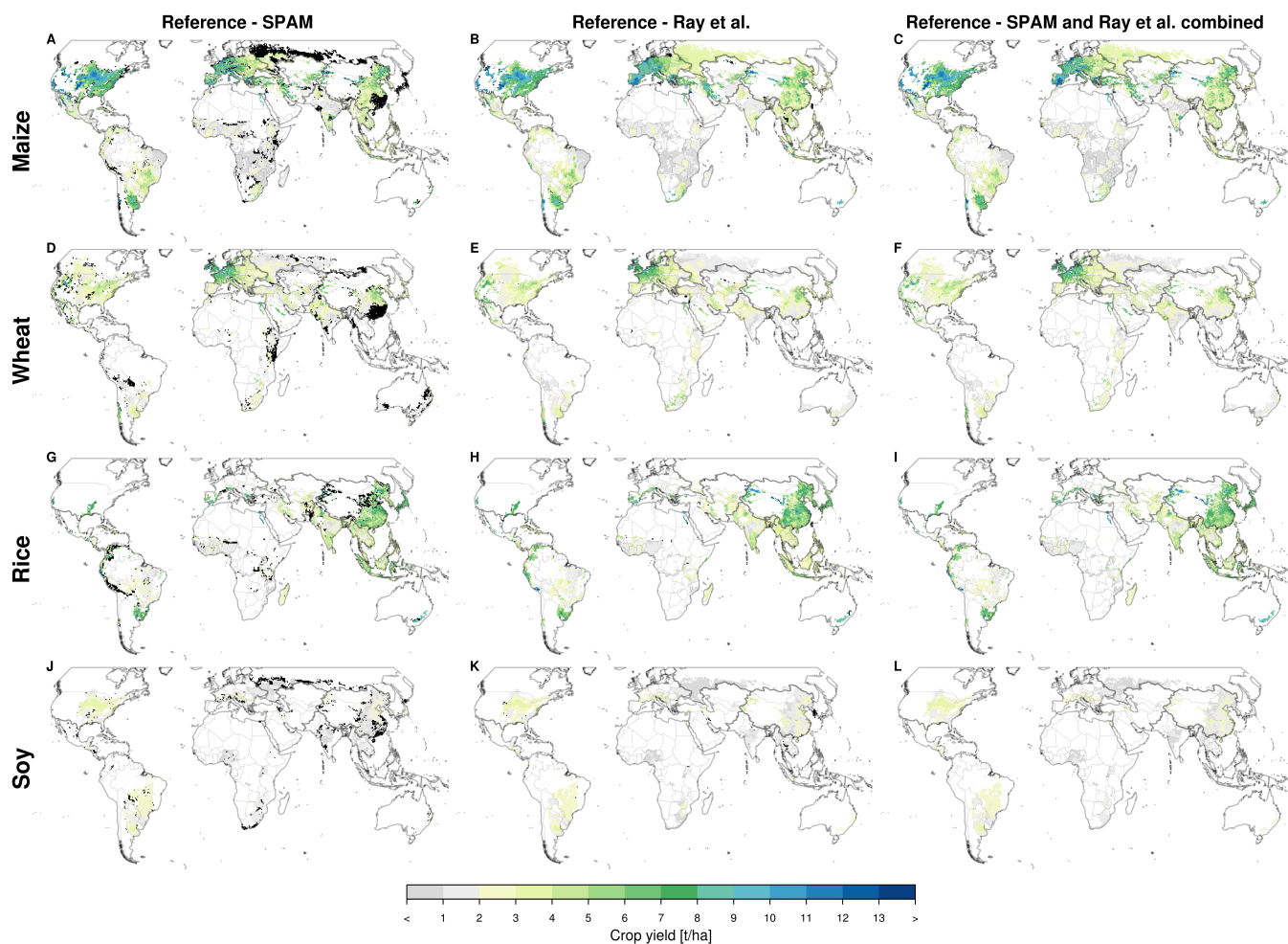
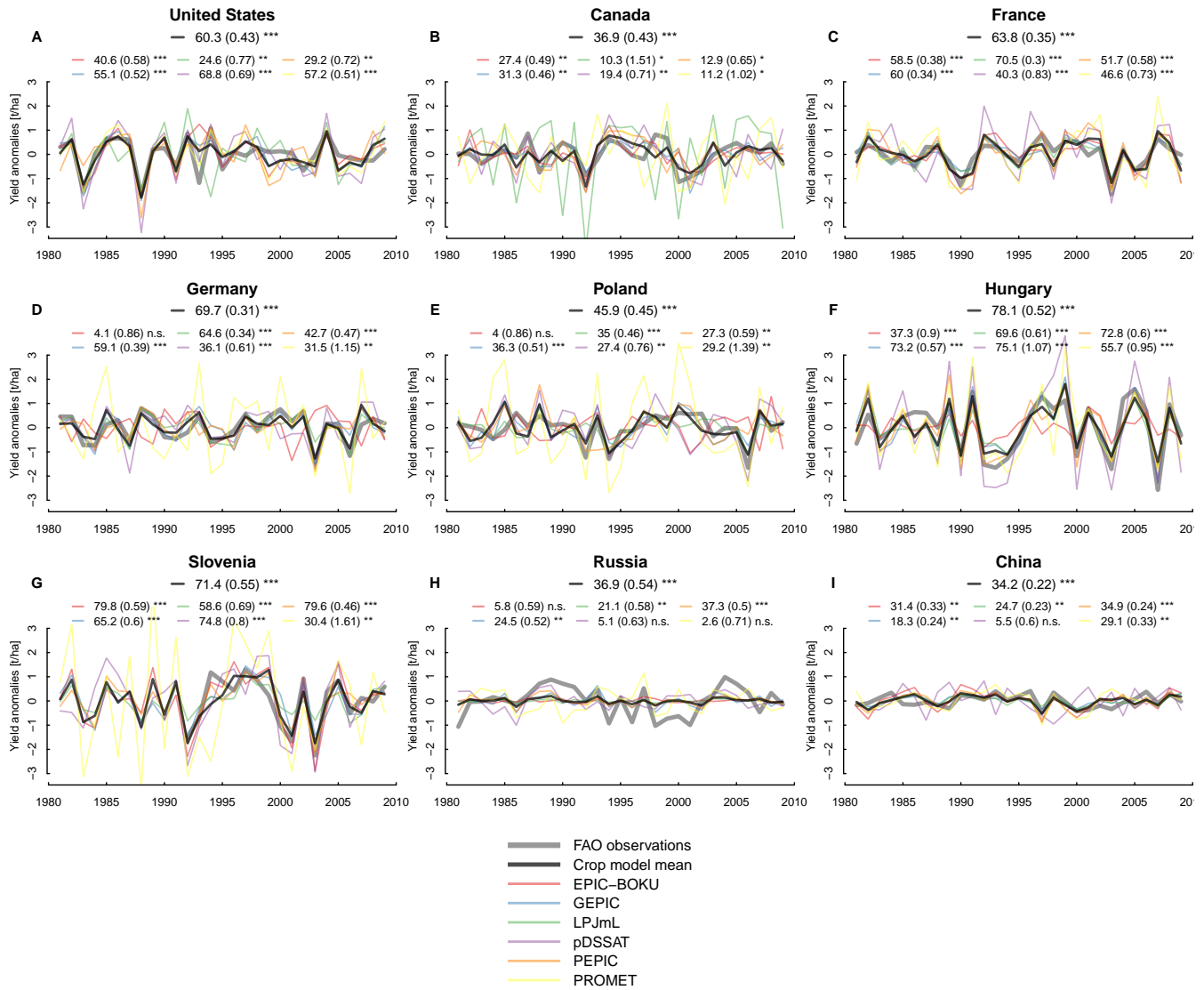


Fig. S13. Post-conflict changes in national wheat reserves and domestic use. Same as Figure 6 but for wheat only and for post-conflict years one to five.



**Fig. S14. Gridded yield reference data used in this study.** (A–L) Observational reference yield data are shown for each crop (row) and the reference data set SPAM2005 (8) (first column), Ray et al. (9) (second column), and a composite of both (third column), each representative for the time period 2003 – 2007, respectively. The composite yield product is primarily based on SPAM2005, gap-filled with Ray et al. data in case data are missing. Black areas indicate grid cells with missing values, but with more than 10 ha cropland area in the MIRCA2000 data set (7).



**Fig. S15. Evaluation of observed and simulated yield variability.** (A–I) Country-level time series of detrended maize yield anomalies from FAOSTAT reference data (6) are plotted against crop model simulations for selected countries (large producer countries at higher latitudes). Simulations are shown for each crop model individually and for the ensemble mean. Pearson’s correlation coefficients [%] are indicated at the top of each plot (significance: \*\*\*,  $p < 0.001$ ; \*\*,  $p < 0.05$ ; \*,  $p < 0.1$ ; n.s., not significant) and the root-mean-square error (RMSE) of absolute yield anomalies in parenthesis.

**Table S1. Overview of participating Global Gridded Crop Models.** The key references, simulations performed, phenological base temperatures, and response mechanisms to cold temperature exposure are detailed for each crop model. Codes for the simulations are: CF1 and CF2 climate forcing with ensemble members a–c (CF1<sub>a,b,c</sub> and CF2<sub>a,b,c</sub>) each for 15 post-conflict years and 31 historical years (see Fig. S1), climate sensitivity runs based on CF1<sub>a</sub> using only perturbed temperature, precipitation, shortwave, or longwave radiation, respectively (CF1<sub>a</sub>-T, CF1<sub>a</sub>-P, CF1<sub>a</sub>-SR, CF1<sub>a</sub>-LW), all models also provided the historical control simulation. Crop codes: maize (mai), winter wheat (wwh), spring wheat (swh), wheat (whe, if wwh and swh share the same parameter value), rice (ric), and soybean (soy). All temperatures are in °C. NH and SH refer to Northern and Southern Hemisphere, respectively.

Model name	Ref.	Simulations performed	Base temperature phenological development	Early harvest and response mechanisms to cold temperature
<b>EPIC-BOKU</b> (Environmental Policy Integrated Climate Universität für Bodenkultur Wien)	(10)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub> , CF1 <sub>a</sub> -T, CF1 <sub>a</sub> -P, CF1 <sub>a</sub> -SR	Mai 8, wwh 0, swh 5, ric 10, soy 10	Cold damage function, depending on snow cover and crop frost sensitivity, crop failures due to early harvest adapted from GEPIC and PEPIC, otherwise early harvest on 31 December NH and 31 June SH
<b>GEPIC</b> (GIS-based Environmental Policy Integrated Climate)	(11)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub> , CF1 <sub>a</sub> -T, CF1 <sub>a</sub> -P, CF1 <sub>a</sub> -SR	Mai 8, wwh 0, swh 5, ric 10, soy 10	Cold damage function, depending on snow cover and crop frost sensitivity, early harvest on 1 December NH and 1 June SH
<b>LPJmL</b> (Lund-Potsdam-Jena with managed Land)	(12)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub> , CF1 <sub>a</sub> -T, CF1 <sub>a</sub> -P, CF1 <sub>a</sub> -SR, CF1 <sub>a</sub> -LW	Mai 5–15 <sup>1</sup> , whe 0, ric 10, soy 10	Max. growing season length: 240 for mai, soy, swh, 330 for wwh, 220 for ric, which triggers early harvest
<b>pDSSAT</b> (pSIMS platform Decision Support System for Agrotechnology Transfer)	(13, 14)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub> , CF1 <sub>a</sub> -T, CF1 <sub>a</sub> -P, CF1 <sub>a</sub> -SR	Mai 8, whe 0, ric 9, soy -15–7 <sup>2</sup>	Early harvest if $T \leq T_{base}$ for $\geq 5$ days, leaf damage starts to occur if $T < 6$ (only maize), 50% of the plant is killed if $T < -6$ (unhardened seedling; only wheat), plant is killed when fully hardened if $T < -25$ (only wheat)
<b>PEPIC</b> (Python-based Environmental Policy Integrated Climate)	(15)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub> , CF1 <sub>a</sub> -T, CF1 <sub>a</sub> -P, CF1 <sub>a</sub> -SR	Mai 8, wwh 0, swh 5, ric 10, soy 10	Cold damage function, depending on snow cover and crop frost sensitivity, early harvest on 1 December NH and 1 June SH
<b>PROMET</b> (Processes of Mass and Energy Transfer)	(16, 17)	CF1 <sub>a,b,c</sub> , CF2 <sub>a,b,c</sub>	Mai 8, wwh 0–8 <sup>2</sup> , swh 0, ric 12–15 <sup>2</sup> , soy 15–17 <sup>3</sup>	Plant killing if $T < -8$ , except for wwh and not during germination or after maturity; crop failure if $T < T_b$ for $\geq 14$ consecutive days, max. growing season length: 240 all crops, except 360 for wwh, which triggers early harvest

<sup>1</sup>depending on local mean annual temperature; <sup>2</sup>depending on phenological stage; <sup>3</sup>depending on vegetative or reproductive stage

**Table S2. Global crop production changes under different assumptions for India and Pakistan.** As in Figure 2, relative changes [%] (five-year post-conflict average) in global caloric production from maize, wheat, rice, soybean, and their total are shown for combined, rainfed, and irrigated production, respectively. Here, changes are separated for three different assumptions regarding the contribution of India and Pakistan to the global sum, i) included in both control and perturbation (column "included"), ii) masked from both control and perturbation ("masked"; same as throughout the analyses in this study), and iii) included under the assumption that their production falls to zero after the war ("failure"). Data are shown for the crop and climate model ensemble mean. The column "share" lists the crops' respective fraction of total global caloric production of cereals, including soybean.

Crop	Share	Combined			Rainfed			Irrigated		
		included	masked	failure	included	masked	failure	included	masked	failure
Maize	35	-12	-13	-14	-15	-15	-16	-5	-6	-9
Wheat	24	-10	-11	-22	-11	-11	-12	-7	-10	-42
Rice	21	-3	-3	-22	-4	-3	-27	-3	-3	-20
Soybean	10	-16	-17	-20	-17	-17	-21	-13	-13	-14
Total	90	-10	-11	-19	-13	-13	-16	-5	-6	-23



**Table S3. Country-level changes in maize and wheat production, reserves, and use.** In declining order of production change, the table lists for maize and wheat in each country: the post-conflict year in which maximum changes occur, mean changes in caloric crop production (%), largest post-conflict change), maximum changes in any individual historical years (%), stocks-to-use ratios (STU) for the initial and post-conflict year one and four, the initial domestic use ( $10^4$  kcal/cap, sum of maize and wheat), changes in domestic use in post-conflict year one and four (%), mean changes in domestic use between year 1–5, and the population (2017 level). The cumulative population of countries with production declines exceeding 10, 20, and 30%, zero STU levels, and domestic use declines exceeding 10, 20, and 30%, respectively, are presented at the end of the table. India and Pakistan are excluded.

Country	year	Kcal change		STU initial	STU year 1	STU year 4	Use initial ( $10^4$ kcal/cap)	Use year 1 (%)	Use year 4 (%)	Use year 1–5 mean (%)	Population current (million)
		mean	max.								
		(%)	(%)	(%)	(%)	(%)					
Belarus	2	-59.5	-79.8	22.0	8.6	0.0	63.5	0.0	-27.0	-19.9	10
Netherlands	2	-54.5	-75.4	1.8	0.0	0.0	173.2	-0.3	-37.2	-20.8	17
Germany	2	-48.8	-73.7	12.9	0.4	0.0	88.4	-0.2	-9.1	-5.9	81
Poland	4	-44.5	-56.5	10.7	0.0	0.0	83.0	-1.4	-35.2	-20.2	38
Switzerland	2	-38.0	-58.7	17.8	12.2	0.0	56.2	-0.5	-44.9	-22.1	8
Belgium	2	-37.7	-56.7	6.9	2.1	0.0	109.5	-0.1	-8.3	-5.3	11
Mauritania	3	-36.6	-51.7	0.0	0.0	0.1	27.5	-0.4	-38.0	-19.0	4
Slovenia	2	-36.1	-61.3	7.1	1.2	0.0	112.8	0.0	-22.6	-11.5	2
Czech Republic	4	-34.0	-47.4	14.5	0.0	0.0	102.8	-0.6	-20.2	-6.1	11
Ukraine	4	-32.5	-47.9	14.8	0.0	0.0	133.6	-1.0	-10.8	-6.3	44
Austria	2	-32.3	-50.3	12.4	0.0	0.0	109.5	-0.3	-8.7	-8.0	9
Canada	4	-29.3	-50.4	35.9	16.2	0.0	127.1	-12.3	-31.8	-24.4	36
Russia	2	-29.2	-36.9	14.1	1.7	0.0	96.4	-3.6	-7.9	-6.7	142
Latvia	3	-28.9	-54.1	17.9	0.0	0.0	73.8	-1.9	-10.0	-8.3	2
Denmark	3	-26.1	-41.3	11.7	0.0	0.0	252.3	-1.4	-11.2	-8.2	6
Slovakia	2	-25.4	-46.1	13.6	0.0	0.0	109.9	-0.7	-20.9	-7.6	5
Moldova	2	-23.5	-52.8	26.6	15.4	0.0	155.1	0.0	-16.9	-10.0	3
Bosnia and Herzegovina	2	-22.0	-48.3	17.9	22.5	0.0	131.0	0.0	-29.8	-13.3	4
Kazakhstan	2	-20.2	-32.8	49.3	12.4	0.0	74.5	0.0	-3.2	-3.0	19
Macedonia	2	-19.6	-29.0	9.9	16.2	0.0	98.0	0.0	-41.2	-17.6	2
Turkey	4	-19.6	-23.0	10.5	25.6	0.0	86.2	0.0	-18.7	-4.9	81
Tunisia	4	-18.6	-26.7	22.5	16.9	0.0	87.9	-0.5	-49.3	-24.6	11
United States	1	-18.6	-37.0	18.5	3.0	0.0	244.7	-1.0	-2.3	-1.8	327
Botswana	1	-18.5	-26.2	102.9	73.0	0.0	0.0	0.0	-1.1	-5.6	2
Eritrea	4	-18.1	-29.0	0.0	0.0	0.0	7.6	-0.2	-64.8	-33.1	6
Lithuania	3	-18.0	-28.5	19.3	0.0	0.0	77.3	-0.4	-9.1	-7.2	3
Uganda	3	-17.9	-26.2	1.8	0.0	0.0	14.8	-6.2	-12.9	-8.4	40
Kyrgyzstan	2	-17.3	-29.7	19.1	11.8	0.0	76.0	-3.9	-21.1	-14.2	6
Namibia	2	-17.2	-23.9	2.6	0.8	0.0	16.2	0.0	-13.8	-11.3	2
Serbia	2	-17.1	-42.6	19.9	32.3	0.0	253.0	0.0	-3.3	-1.5	7
Armenia	2	-17.0	-24.0	5.6	1.4	0.0	53.4	-2.4	-56.8	-38.6	3
Japan	4	-17.0	-21.4	10.8	5.4	0.0	55.4	-21.3	-70.0	-49.9	126
Georgia	3	-16.4	-29.5	23.5	17.6	0.0	59.9	-0.1	-54.8	-31.1	5
France	4	-16.1	-28.7	19.4	13.3	0.0	121.0	0.0	-3.2	-1.9	67
Greece	4	-16.1	-20.4	8.8	10.7	0.0	162.1	0.0	-18.8	-8.2	11
Iran	4	-15.4	-18.4	27.1	23.8	1.9	59.0	0.0	-14.6	-7.3	82
Laos	2	-14.9	-21.0	30.2	30.2	30.1	26.4	0.0	-1.0	-0.4	7
Tajikistan	3	-14.9	-19.0	5.7	5.7	0.0	59.1	-0.1	-20.2	-16.3	8
United Kingdom	4	-14.6	-21.9	11.2	0.0	0.0	72.2	-0.1	-9.5	-4.4	65
Bulgaria	4	-13.9	-28.5	15.1	20.1	0.0	149.7	0.0	-2.8	-1.3	7
South Africa	3	-13.8	-18.0	15.2	4.6	0.0	67.3	-0.1	-1.8	-2.9	55
Myanmar (Burma)	2	-13.7	-20.9	2.4	0.2	0.0	8.4	-7.8	-8.4	-8.3	55
Chad	1	-13.6	-20.5	0.0	0.0	0.0	8.0	0.0	-10.4	-5.6	12
North Korea	4	-13.1	-20.7	0.0	0.0	0.0	28.9	-0.1	-11.2	-6.2	25
Afghanistan	3	-13.0	-17.5	0.0	0.8	1.3	43.3	-0.5	-16.7	-12.6	34
El Salvador	2	-12.8	-17.2	16.5	3.9	0.0	65.0	-4.5	-35.7	-25.8	6
Uzbekistan	5	-12.8	-16.3	12.0	10.4	0.5	71.7	0.0	-16.6	-11.3	30
Australia	4	-12.6	-17.2	50.3	26.2	0.0	52.6	0.0	-4.0	-1.6	23
Mongolia	1	-12.5	-19.5	0.0	0.0	0.0	43.8	-0.6	-48.9	-29.6	3
Sweden	2	-12.3	-34.1	14.2	0.0	0.0	50.5	-0.5	-3.6	-3.2	10
China	3	-12.1	-15.4	30.2	22.9	0.0	47.0	0.0	-10.1	-4.5	1379
Niger	1	-12.0	-31.9	0.0	0.7	0.0	1.2	-1.3	-49.4	-26.1	19
Turkmenistan	4	-11.9	-19.4	54.8	54.8	41.3	56.5	0.0	0.0	0.0	5
Rwanda	3	-11.7	-18.5	2.7	0.0	0.0	6.1	-3.6	-34.9	-24.4	12
Montenegro	2	-11.6	-36.3	0.0	12.9	0.0	9.7	-0.2	-63.8	-28.1	1
Hungary	4	-11.4	-30.4	20.0	4.5	0.0	187.8	-0.2	-2.8	-1.8	10
Lesotho	3	-11.4	-23.1	0.0	0.0	0.0	15.2	-2.6	-6.0	-4.7	2
New Zealand	4	-11.3	-14.2	23.6	20.6	0.0	50.4	0.0	-12.1	-5.1	5
Syria	4	-11.0	-16.7	76.7	68.6	0.0	21.2	-0.4	-28.7	-17.6	18
Zimbabwe	2	-10.9	-15.0	1.8	1.6	0.0	52.3	-0.6	-6.9	-15.9	14
Ecuador	3	-10.6	-13.2	11.4	3.7	0.0	33.3	-0.6	-27.5	-17.4	16
Mozambique	2	-10.6	-16.8	4.3	0.0	0.0	22.5	-0.5	-7.5	-9.1	27
Italy	3	-10.5	-26.5	8.3	8.3	0.0	119.5	0.0	-14.3	-5.7	62
Lebanon	2	-10.2	-14.7	2.8	0.0	0.0	36.2	-4.1	-63.9	-36.9	6
Burkina Faso	1	-10.0	-15.9	3.7	0.0	0.4	15.4	-2.2	-5.2	-3.4	20
Guatemala	2	-10.0	-13.8	14.5	5.4	0.0	56.3	-4.4	-29.4	-20.8	15
Croatia	3	-9.7	-41.9	11.6	19.0	0.0	198.5	0.0	-1.9	-0.8	4
Indonesia	4	-9.6	-12.2	13.2	6.8	0.0	22.8	-0.1	-16.7	-6.4	261
Kenya	3	-9.6	-17.5	15.7	8.4	0.0	24.7	0.0	-8.6	-6.4	48
Romania	4	-9.4	-19.5	11.6	13.0	0.0	171.8	0.0	-6.8	-1.7	22



Peru	4	-9.3	-11.3	10.4	6.7	0.0	44.7	0.0	-15.8	-8.0	31
Burundi	1	-9.0	-15.3	0.0	0.0	0.0	5.1	-21.1	-25.5	-23.6	11
Portugal	3	-9.0	-21.4	2.6	1.5	0.0	106.3	0.0	-31.7	-17.5	11
Zambia	2	-9.0	-13.3	14.9	1.7	0.0	25.7	0.0	-2.1	-1.4	16
Spain	3	-8.9	-18.8	5.9	5.6	0.0	123.5	0.0	-22.6	-12.0	49
Albania	4	-8.8	-19.2	2.4	2.2	0.0	97.1	0.0	-43.0	-21.1	3
Malawi	2	-7.8	-14.6	22.2	11.1	0.0	40.2	0.0	-2.0	-1.4	19
Paraguay	4	-6.9	-13.6	104.1	80.0	0.0	-1.8	0.0	-2.1	-1.2	7
Algeria	3	-6.8	-19.9	26.2	21.0	0.0	59.4	-0.1	-33.2	-16.2	41
South Korea	5	-6.7	-12.1	21.7	7.5	0.0	63.6	-0.8	-73.2	-41.2	51
Tanzania, U.R. of	3	-6.6	-10.1	12.1	6.3	0.0	26.9	0.0	-6.2	-4.1	54
Costa Rica	2	-6.5	-9.1	16.2	7.4	0.0	49.8	-22.7	-71.3	-53.7	5
Mexico	1	-6.2	-11.3	10.7	1.3	0.0	94.8	-4.1	-22.7	-17.0	125
Vietnam	1	-6.0	-9.7	11.8	6.1	0.0	18.3	0.0	-11.4	-4.9	96
Jordan	4	-5.8	-13.3	44.0	35.9	0.0	22.0	-0.5	-74.2	-32.2	10
D.R. Congo	4	-5.7	-11.2	3.3	2.0	0.0	6.7	-0.3	-16.7	-10.6	83
Argentina	3	-5.5	-8.4	27.9	3.7	0.0	59.5	0.0	-0.8	-0.8	44
Sri Lanka	1	-5.5	-9.0	30.4	30.0	0.0	11.2	0.0	-13.1	-4.4	22
Swaziland	1	-5.4	-14.9	0.0	0.0	0.0	13.0	-0.6	-1.1	-4.0	1
Cambodia	4	-5.0	-8.4	9.7	10.2	1.8	10.7	0.0	-2.6	-1.1	16
Ethiopia	1	-4.8	-10.0	8.2	4.0	0.0	19.6	0.0	-4.8	-2.5	105
Nicaragua	2	-4.8	-8.8	6.6	0.0	0.0	40.6	-3.1	-26.1	-17.7	6
Brazil	1	-4.8	-6.8	17.6	11.0	0.0	78.0	0.0	-0.3	-0.3	207
Bhutan	3	-4.5	-10.6	0.0	0.2	0.0	3.5	0.0	-2.1	-2.5	1
Malaysia	5	-4.3	-12.5	28.6	26.1	0.0	23.9	0.0	-24.8	-10.5	31
Uruguay	1	-4.3	-13.3	42.4	36.0	2.1	91.8	0.0	-1.9	-0.6	3
Chile	3	-4.2	-8.9	11.6	6.2	0.0	87.2	0.0	-8.2	-5.0	18
Nepal	1	-3.9	-10.6	4.1	0.9	3.2	37.3	-1.2	-2.8	-3.4	29
Bolivia	5	-3.7	-6.3	16.7	14.7	0.0	33.7	0.0	-3.1	-1.1	11
Saudi Arabia	4	-3.5	-6.0	53.8	48.9	34.8	25.3	0.0	-18.2	-11.6	29
Thailand	4	-3.3	-12.3	20.5	20.8	0.0	18.5	0.0	-5.7	-2.2	68
Cuba	2	-3.1	-4.6	3.5	0.0	0.0	54.5	-9.0	-50.3	-33.0	11
Senegal	3	-3.0	-9.6	6.0	6.0	0.0	15.3	0.0	-14.5	-6.3	15
Colombia	2	-2.8	-8.2	20.5	2.2	0.0	36.6	-0.3	-46.8	-31.2	48
Iraq	4	-2.6	-8.6	10.6	10.5	0.0	43.5	0.0	-25.4	-10.7	39
Panama	5	-2.3	-3.7	15.6	0.0	0.0	48.6	-10.1	-65.4	-46.5	4
Venezuela	5	-2.3	-4.8	10.6	5.0	0.0	47.9	0.0	-19.8	-12.2	31
Bangladesh	1	-2.2	-4.7	14.7	15.1	2.4	6.2	0.0	-29.4	-14.5	158
Honduras	5	-2.2	-4.8	13.1	0.0	0.0	40.9	-5.6	-38.4	-27.1	9
Libya	1	-1.9	-10.1	8.2	4.7	0.0	100.6	-0.6	-66.5	-35.1	7
Azerbaijan	5	-1.7	-5.8	25.0	28.1	0.0	74.6	-0.3	-28.8	-15.3	10
Haiti	5	-1.7	-5.8	0.0	0.0	0.0	15.8	-0.9	-21.8	-13.5	11
Nigeria	1	-1.6	-3.4	3.3	2.2	2.6	18.4	0.0	-6.9	-4.2	191
Dominican Republic	5	-1.5	-4.2	9.9	2.1	0.0	47.1	-21.9	-71.9	-52.9	11
Angola	5	-1.2	-4.0	1.6	1.3	0.0	14.7	0.0	-23.8	-13.1	29
Cyprus	3	-1.0	-4.1	0.2	0.0	0.0	106.7	-0.7	-66.6	-29.8	1
Philippines	2	-1.0	-3.6	13.0	12.5	3.3	27.3	0.0	-10.5	-5.1	104
Ghana	5	-0.3	-7.8	6.3	6.4	10.8	19.5	0.0	-6.8	-3.1	27
Cameroon	1	0.2	-2.3	8.2	7.8	17.6	21.6	0.0	-6.0	-2.7	25
Morocco	1	0.3	-17.9	20.7	18.5	0.0	68.3	-0.2	-17.8	-9.6	34
Somalia	3	0.6	-1.8	0.0	0.0	0.0	12.2	-0.1	-48.6	-32.9	8
Egypt	1	1.6	-1.5	18.7	14.8	0.0	78.0	0.0	-26.3	-13.3	97
Benin	4	1.8	-5.4	2.7	9.0	22.2	30.8	0.0	-3.2	-1.5	11
Gambia, The	1	1.9	-8.7	0.0	3.1	13.9	14.8	0.0	-53.3	-20.2	2
Yemen	1	1.9	-1.3	9.0	7.9	0.0	28.7	0.0	-32.1	-16.4	28
Mali	2	4.0	-6.5	4.5	11.6	23.8	15.8	0.0	-8.2	-4.1	18
Sudan	4	4.7	-2.4	5.6	9.0	0.0	17.6	-0.4	-17.5	-5.8	37
Israel	3	5.1	-10.4	10.6	5.8	0.0	109.3	-1.3	-66.6	-39.4	8
Central African Republic	0	0.0	0.0	0.0	0.0	0.0	11.1	-0.1	-10.5	-5.4	6
Congo-Brazzaville	0	0.0	0.0	0.0	0.0	0.0	11.4	-0.1	-32.4	-18.2	5
Djibouti	0	0.0	0.0	0.0	0.0	0.0	71.1	-0.2	-61.6	-29.6	1
Equatorial Guinea	0	0.0	0.0	0.0	0.0	0.0	7.6	0.0	-51.6	-27.7	1
Estonia	0	0.0	0.0	11.7	9.0	0.0	71.6	-0.2	-6.8	-5.2	1
Finland	0	0.0	0.0	11.3	9.7	0.0	42.0	0.0	-1.6	-1.1	5
Gabon	0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	-24.7	-11.9	2
Guinea	0	0.0	0.0	0.0	0.0	0.0	21.1	-0.1	-10.1	-4.0	12
Guinea-Bissau	0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	-22.2	-10.9	2
Guyana	0	0.0	0.0	0.0	0.0	0.0	38.6	-11.0	-49.2	-32.7	1
Ireland	0	0.0	0.0	5.0	3.9	0.0	123.9	-0.2	-38.8	-23.1	5
Ivory Coast	0	0.0	0.0	3.4	3.0	0.0	13.3	0.0	-7.4	-2.7	24
Jamaica	0	0.0	0.0	8.7	5.1	0.0	66.1	-14.8	-53.0	-36.5	3
Kuwait	0	0.0	0.0	2.2	0.0	0.0	61.5	-0.1	-27.6	-13.8	3
Liberia	0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	-54.3	-21.5	5
Luxembourg	0	0.0	0.0	9.3	7.8	0.0	53.9	0.0	-8.7	-5.8	1
Madagascar	0	0.0	0.0	3.2	3.2	2.1	7.4	0.0	-7.9	-4.1	25
Norway	0	0.0	0.0	43.5	38.4	0.0	31.1	0.0	-31.1	-16.9	5
Oman	0	0.0	0.0	16.0	13.8	0.0	20.0	-0.8	-20.8	-8.4	3
Papua New Guinea	0	0.0	0.0	16.1	16.1	0.0	8.0	0.0	-10.2	-5.0	7
Sierra Leone	0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	-30.1	-16.8	6
Suriname	0	0.0	0.0	0.0	0.0	0.0	17.1	-18.8	-83.9	-57.8	1
Togo	0	0.0	0.0	5.8	5.7	5.1	27.2	0.0	-5.1	-2.2	8
Trinidad and Tobago	0	0.0	0.0	15.0	2.6	0.0	61.7	-5.9	-51.6	-36.1	1
United Arab Emirates	0	0.0	0.0	7.2	6.5	0.0	60.8	-0.4	-26.5	-11.3	6

Global	4	-13.4	-20.7	19.6	10.9	0.4	61.8	-1.2	-13.0	-7.5	5835
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Population in countries with:

>30% kcal change	235
>20% kcal change	452
>10% kcal change	3,184
STU <sub>init</sub> = 0	182
STU <sub>year1</sub> = 0	474
STU <sub>year4</sub> = 0	5,007
Use <sub>year1</sub> < -10%	198
Use <sub>year4</sub> < -10%	3,858
Use <sub>year4</sub> < -20%	1,272
Use <sub>year4</sub> < -30%	595

Table S4. Country-level changes in maize production, reserves, and use. Same as Table S3, but for maize only.

Country	year	Kcal change		STU initial	STU year 1	STU year 4	Use initial (10 <sup>4</sup> kcal/cap)	Use year 1 (%)	Use year 4 (%)	Use year 1–5 mean (%)	Population current (million)
		mean	max.								
		(%)	(%)								
Belarus	2	-61.7	-83.5	37.9	6.1	0.0	13.6	0.0	-68.7	-51.9	10
Poland	2	-58.5	-74.6	8.4	0.0	0.0	17.0	-1.6	-44.3	-32.2	38
Russia	2	-57.8	-72.3	2.5	0.0	0.0	11.9	-33.0	-52.3	-49.2	142
Netherlands	2	-55.2	-77.3	0.7	0.0	0.0	64.8	-0.4	-43.5	-29.5	17
Germany	2	-52.2	-77.4	8.4	0.0	0.0	20.5	-1.0	-33.7	-21.1	81
Belgium	2	-48.3	-73.1	6.5	0.0	0.0	33.2	-0.4	-14.2	-9.5	11
Canada	4	-43.3	-65.9	12.5	0.0	0.0	107.8	-19.9	-47.8	-37.9	36
Switzerland	2	-43.2	-66.6	4.2	0.0	0.0	21.8	-1.5	-54.4	-32.7	8
Czech Republic	2	-41.6	-67.7	14.0	0.0	0.0	16.0	-0.6	-4.2	-6.6	11
Austria	2	-38.9	-61.9	11.3	0.0	0.0	69.5	-0.5	-10.7	-10.9	9
Ukraine	2	-38.3	-61.9	12.4	0.0	0.0	46.9	-1.4	-16.0	-11.2	44
Mauritania	3	-36.6	-51.7	0.0	0.0	1.6	1.9	-3.4	0.0	-8.0	4
Slovenia	2	-36.1	-61.3	7.9	0.0	0.0	67.3	0.0	-12.6	-9.0	2
Slovakia	2	-26.9	-57.1	14.8	0.0	0.0	36.5	-0.7	-2.3	-2.4	5
France	2	-26.2	-53.2	16.6	6.7	0.0	41.0	0.0	-3.8	-2.8	67
Macedonia	2	-25.9	-53.2	7.2	25.4	0.0	36.5	0.0	-26.4	-16.7	2
Eritrea	4	-25.8	-39.4	0.0	0.0	0.0	1.0	0.0	-4.0	-3.0	6
Moldova	2	-25.3	-58.3	18.1	8.6	0.0	112.3	0.0	-13.9	-11.1	3
Kyrgyzstan	1	-23.4	-44.9	11.8	0.0	0.0	24.7	-13.0	-19.9	-16.2	6
Bosnia and Herzegovina	2	-22.0	-48.3	11.0	19.5	0.0	90.2	0.0	-15.3	-10.7	4
United States	1	-20.8	-41.4	15.9	0.0	0.0	224.8	-1.1	-2.3	-1.8	327
Botswana	1	-20.6	-29.3	70.4	50.0	0.0	0.5	0.0	-0.7	-3.8	2
Armenia	5	-20.5	-32.2	0.0	0.0	0.0	7.7	-17.6	-66.6	-57.5	3
Georgia	3	-19.0	-36.7	13.4	0.0	0.0	21.0	-0.3	-16.7	-13.4	5
Uganda	3	-17.9	-26.2	1.9	0.0	0.0	13.5	-6.8	-8.7	-6.4	40
Namibia	2	-17.2	-23.9	4.6	1.4	0.0	8.9	0.0	-7.4	-11.0	2
Serbia	2	-17.1	-43.6	15.5	31.5	0.0	199.9	0.0	-0.6	-1.2	7
Niger	1	-16.5	-40.9	0.0	0.0	0.0	0.3	-4.6	-15.1	-9.0	19
South Africa	3	-16.3	-22.4	14.2	0.0	0.0	50.6	-0.1	-0.2	-3.1	55
Myanmar (Burma)	2	-15.4	-23.1	2.9	0.0	0.0	7.0	-9.4	-7.1	-8.6	55
New Zealand	4	-15.1	-34.8	9.1	9.2	0.0	15.5	0.0	-14.4	-6.9	5
Laos	2	-14.9	-21.1	30.5	30.5	30.4	26.0	0.0	0.0	0.0	7
Lesotho	3	-14.5	-26.6	0.0	0.0	0.0	14.4	-2.7	-6.3	-4.9	2
Zimbabwe	2	-13.7	-19.2	0.0	0.0	0.0	48.6	-0.7	-5.6	-16.6	14
Chad	1	-13.6	-20.5	0.0	0.0	0.0	6.2	0.0	-2.3	-1.7	12
North Korea	4	-13.4	-21.3	0.0	0.0	0.0	24.4	-0.1	-6.1	-3.3	25
El Salvador	2	-12.8	-17.2	13.6	0.0	0.0	62.1	-4.9	-37.9	-27.5	6
Italy	3	-12.8	-36.5	8.8	7.4	0.0	61.4	0.0	-12.0	-6.8	62
Bulgaria	4	-11.8	-30.7	12.0	36.9	0.0	53.0	0.0	-2.1	-1.1	7
Rwanda	3	-11.7	-18.5	4.4	0.0	0.0	3.7	-5.8	-10.7	-10.2	12
Nepal	2	-11.5	-22.5	7.3	0.0	0.0	20.3	-2.2	-4.9	-6.0	29
Saudi Arabia	5	-11.1	-25.7	17.9	0.0	0.0	20.1	-0.1	-40.6	-25.9	29
Greece	3	-10.9	-20.9	8.8	10.2	0.0	93.9	0.0	-13.2	-7.6	11
Ecuador	3	-10.7	-13.3	10.5	0.0	0.0	24.2	-0.9	-28.2	-19.8	16
Azerbaijan	5	-10.6	-17.3	4.9	0.0	0.0	6.4	-5.0	-19.8	-19.8	10
Mozambique	2	-10.6	-16.8	5.5	0.0	0.0	17.6	-0.7	-1.9	-7.5	27
Montenegro	2	-10.3	-45.7	0.0	60.0	0.0	2.1	0.0	-0.6	-0.7	1
Hungary	3	-10.2	-35.8	21.4	8.0	0.0	104.2	0.0	-1.1	-1.3	10
Japan	2	-10.1	-17.1	6.8	0.0	0.0	42.3	-29.2	-87.7	-65.1	126
Burkina Faso	1	-10.0	-15.9	4.0	0.0	0.4	13.9	-2.4	0.0	-0.8	20
Guatemala	2	-10.0	-13.8	11.3	0.0	0.0	47.3	-5.4	-30.8	-23.1	15
Australia	4	-9.9	-14.7	9.3	5.9	0.0	5.0	0.0	-12.9	-3.7	23
Croatia	3	-9.7	-43.9	11.1	23.6	0.0	149.3	0.0	-0.4	-0.3	4
Indonesia	4	-9.6	-12.2	8.3	0.0	0.0	18.2	-0.1	-12.4	-5.1	261
Kenya	3	-9.6	-17.5	15.0	5.9	0.0	19.0	0.0	-0.8	-3.0	48
Peru	4	-9.3	-11.3	7.7	2.4	0.0	30.4	0.0	-16.5	-9.4	31
Zambia	2	-9.3	-13.6	15.2	0.6	0.0	23.3	0.0	-0.8	-0.9	16
Burundi	1	-9.0	-15.3	0.0	0.0	0.0	4.7	-23.1	-24.2	-23.2	11
Portugal	3	-8.8	-22.2	3.5	2.6	0.0	60.1	0.0	-17.2	-10.4	11
Spain	3	-8.0	-26.2	4.3	7.7	0.0	61.1	0.0	-16.9	-9.9	49
Malawi	2	-7.8	-14.6	22.7	11.3	0.0	38.9	0.0	-1.2	-1.0	19
Morocco	4	-7.8	-25.4	8.9	0.0	0.0	17.2	-1.1	-44.0	-30.4	34
China	4	-7.4	-11.0	25.1	18.3	0.0	30.5	0.0	-8.4	-3.0	1379
Albania	3	-7.3	-22.6	0.0	4.4	0.0	33.5	0.0	-12.4	-8.2	3
Turkey	4	-7.1	-20.9	13.5	34.1	0.0	17.8	0.0	-18.4	-4.5	81
Mexico	1	-7.0	-12.4	11.3	0.0	0.0	80.2	-4.8	-26.4	-19.8	125
Paraguay	4	-6.9	-13.6	74.3	31.9	0.0	6.4	0.0	-3.8	-1.9	7
South Korea	5	-6.7	-12.3	18.6	0.0	0.0	49.6	-1.1	-84.0	-49.0	51
Tanzania, U.R. of	3	-6.6	-10.1	13.2	6.9	0.0	24.2	0.0	-4.0	-3.3	54
Costa Rica	2	-6.5	-9.1	10.8	0.0	0.0	43.1	-27.9	-86.6	-65.2	5
Vietnam	1	-6.0	-9.7	8.8	1.8	0.0	15.4	0.0	-5.3	-2.7	96
D.R. Congo	4	-5.7	-11.2	1.6	0.0	0.0	5.2	-0.4	-8.5	-7.2	83
Argentina	3	-5.5	-10.5	26.6	0.9	0.0	34.4	0.0	-0.4	-0.7	44
Sri Lanka	1	-5.5	-9.0	3.7	0.0	0.0	1.3	-0.2	-0.7	-0.2	22
Swaziland	1	-5.4	-14.9	0.0	0.0	0.0	13.0	-0.6	-1.1	-4.0	1
Cambodia	4	-5.0	-8.4	10.2	10.8	1.9	10.0	0.0	0.0	0.0	16

Bolivia	4	-4.8	-7.8	17.1	14.3	0.0	23.2	0.0	-2.6	-0.8	11
Nicaragua	2	-4.8	-8.8	8.0	0.0	0.0	32.9	-3.7	-23.0	-17.2	6
Romania	3	-4.7	-21.9	10.8	18.0	0.0	104.8	0.0	-1.7	-0.4	22
Brazil	1	-4.7	-6.8	17.6	10.1	0.0	63.8	0.0	-0.2	-0.2	207
Chile	3	-4.6	-9.5	10.9	3.3	0.0	49.9	0.0	-10.1	-6.5	18
Tajikistan	3	-4.4	-14.7	0.0	0.0	0.0	5.8	-0.8	-1.1	-1.0	8
Malaysia	5	-4.3	-12.5	26.9	23.3	0.0	16.5	0.0	-27.3	-12.5	31
Uruguay	1	-4.2	-13.5	9.6	7.5	0.0	69.8	0.0	-3.8	-1.1	3
Ethiopia	1	-4.0	-11.4	10.4	6.8	0.0	11.3	0.0	-1.2	-0.6	105
Kazakhstan	3	-4.0	-13.4	1.5	0.0	0.0	7.9	-0.2	-0.2	-0.7	19
Thailand	4	-3.3	-12.3	13.2	13.5	0.0	16.3	0.0	-0.6	-0.2	68
Cuba	2	-3.1	-4.6	6.1	0.0	0.0	30.1	-15.8	-55.9	-41.8	11
Senegal	3	-3.0	-9.6	4.2	4.3	0.0	7.5	0.0	-0.1	-0.6	15
Colombia	2	-2.8	-8.2	22.9	0.0	0.0	28.2	-0.4	-54.0	-36.7	48
Sudan	4	-2.7	-7.5	0.0	0.0	0.0	0.9	-7.0	-20.8	-14.8	37
Panama	5	-2.3	-3.7	20.5	0.0	0.0	34.8	-13.2	-73.9	-54.2	4
Venezuela	5	-2.3	-4.8	12.9	4.5	0.0	31.2	0.0	-17.1	-11.7	31
Honduras	5	-2.2	-4.8	16.1	0.0	0.0	32.0	-6.9	-39.1	-29.4	9
Bangladesh	5	-2.1	-6.2	0.0	7.1	8.5	2.1	0.0	0.0	0.0	158
Haiti	5	-1.7	-5.8	0.0	0.0	0.0	8.2	-1.6	-5.8	-4.2	11
Nigeria	1	-1.6	-3.4	2.5	1.0	3.6	13.1	0.0	0.0	0.0	191
Dominican Republic	5	-1.5	-4.2	10.3	0.0	0.0	35.3	-29.0	-86.0	-64.9	11
Angola	5	-1.2	-4.0	2.5	2.1	0.0	9.4	0.0	-6.6	-5.5	29
Lebanon	5	-1.1	-11.6	7.2	0.0	0.0	13.2	-10.3	-81.6	-56.5	6
Philippines	2	-1.0	-3.6	9.8	9.4	4.5	20.8	0.0	0.0	0.0	104
Yemen	4	-0.7	-4.3	8.9	6.8	0.0	4.1	0.0	-2.9	-4.0	28
Ghana	5	-0.3	-7.8	7.8	8.0	13.5	15.4	0.0	0.0	0.0	27
Cameroon	1	0.2	-2.3	10.1	9.6	21.6	17.2	0.0	0.0	0.0	25
Somalia	3	0.6	-1.8	0.0	0.0	0.0	6.8	-0.2	-14.4	-15.9	8
Afghanistan	3	0.7	-7.8	0.0	9.0	15.2	3.8	0.0	0.0	0.0	34
Jordan	3	1.0	-2.8	17.0	0.0	0.0	10.2	-1.6	-75.8	-48.4	10
Uzbekistan	5	1.0	-4.0	8.5	10.6	14.3	2.4	0.0	0.0	0.0	30
Benin	4	1.8	-5.4	2.8	9.5	23.5	29.0	0.0	0.0	0.0	11
Gambia, The	1	1.9	-8.7	0.0	7.5	33.8	6.1	0.0	0.0	0.0	2
Iran	2	2.3	-4.8	48.5	46.1	7.2	10.9	0.0	0.0	-2.0	82
Turkmenistan	5	2.5	-13.0	0.0	0.0	0.0	0.5	-0.1	-2.6	-1.4	5
Mali	2	4.0	-6.5	5.4	13.8	28.3	13.2	0.0	0.0	0.0	18
Syria	5	4.4	-10.4	17.4	0.0	0.0	29.5	-1.0	-69.6	-43.9	18
Egypt	3	6.0	1.0	9.4	1.4	0.0	36.7	0.0	-24.9	-16.3	97
Iraq	5	26.4	10.4	6.1	4.5	0.0	3.2	0.0	-5.4	-2.2	39
Algeria	0	0.0	0.0	14.6	0.0	0.0	16.0	-0.6	-43.9	-30.3	41
Bhutan	0	0.0	0.0	0.0	0.0	0.0	0.0	-100.0	-100.0	-100.0	1
Central African Republic	0	0.0	0.0	0.0	0.0	0.0	9.3	-0.1	-4.8	-3.6	6
Congo-Brazzaville	0	0.0	0.0	0.0	0.0	0.0	1.3	-0.8	-25.5	-19.5	5
Cyprus	0	0.0	0.0	0.0	0.0	0.0	49.1	-1.4	-63.1	-30.7	1
Denmark	0	0.0	0.0	0.0	0.0	0.0	11.8	-0.5	-40.8	-28.7	6
Djibouti	0	0.0	0.0	0.0	0.0	0.0	0.3	-0.7	-74.6	-36.8	1
Equatorial Guinea	0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-94.3	-73.0	1
Estonia	0	0.0	0.0	0.0	0.0	0.0	6.3	-2.8	-63.6	-52.0	1
Finland	0	0.0	0.0	0.0	0.0	0.0	0.2	-1.3	-82.9	-62.8	5
Gabon	0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	-6.1	-4.4	2
Guinea	0	0.0	0.0	0.0	0.0	0.0	17.3	0.0	-0.1	-0.4	12
Guinea-Bissau	0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	2
Guyana	0	0.0	0.0	0.0	0.0	0.0	15.6	-27.3	-72.9	-56.1	1
Ireland	0	0.0	0.0	0.0	0.0	0.0	36.0	-0.9	-52.2	-35.5	5
Israel	0	0.0	0.0	5.6	0.0	0.0	58.3	-2.5	-69.4	-45.2	8
Ivory Coast	0	0.0	0.0	1.3	0.8	0.0	9.5	0.0	-1.0	-0.6	24
Jamaica	0	0.0	0.0	8.1	0.0	0.0	29.3	-33.5	-88.1	-67.3	3
Kuwait	0	0.0	0.0	5.6	0.0	0.0	23.4	-0.2	-33.5	-19.9	3
Latvia	0	0.0	0.0	0.0	0.0	0.0	4.5	-18.5	-92.2	-77.4	2
Liberia	0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	-7.0	-5.8	5
Libya	0	0.0	0.0	6.5	0.0	0.0	32.6	-2.0	-61.3	-38.6	7
Lithuania	0	0.0	0.0	2.7	0.0	0.0	9.3	-3.6	-56.3	-46.2	3
Luxembourg	0	0.0	0.0	2.5	0.0	0.0	5.1	-0.1	-49.0	-36.4	1
Madagascar	0	0.0	0.0	4.1	4.1	2.7	5.7	0.0	0.0	0.0	25
Mongolia	0	0.0	0.0	0.0	0.0	0.0	0.0	-32.8	-98.1	-70.4	3
Norway	0	0.0	0.0	0.0	0.0	0.0	2.9	-0.1	-58.0	-40.4	5
Oman	0	0.0	0.0	0.0	0.0	0.0	2.4	-7.4	-24.7	-17.7	3
Papua New Guinea	0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	-1.7	-1.1	7
Sierra Leone	0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	-0.3	-0.2	6
Suriname	0	0.0	0.0	0.0	0.0	0.0	7.6	-42.1	-88.5	-69.6	1
Sweden	0	0.0	0.0	0.0	0.0	0.0	1.1	-1.0	-72.2	-52.7	10
Togo	0	0.0	0.0	6.6	6.6	5.9	23.5	0.0	0.0	0.0	8
Trinidad and Tobago	0	0.0	0.0	26.0	0.0	0.0	25.5	-12.4	-85.7	-61.2	1
Tunisia	0	0.0	0.0	11.4	0.0	0.0	20.9	-2.5	-67.4	-43.6	11
United Arab Emirates	0	0.0	0.0	0.0	0.0	0.0	19.6	-1.3	-32.7	-18.0	6
United Kingdom	0	0.0	0.0	0.0	0.0	0.0	6.1	-0.2	-43.6	-28.8	65
Global	4	-14.1	-24.9	16.1	6.6	0.3	38.6	-2.0	-12.2	-8.0	5835

Population in countries with:

>30% kcal change 413  
>20% kcal change 838

>10% kcal change	1,467
STU <sub>init</sub> = 0	526
STU <sub>year1</sub> = 0	2,311
STU <sub>year4</sub> = 0	5,073
Use <sub>year1</sub> < -10%	373
Use <sub>year4</sub> < -10%	1,962
Use <sub>year4</sub> < -20%	1,243
Use <sub>year4</sub> < -30%	910

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Table S5. Country-level changes in wheat production, reserves, and use. Same as Table S3, but for wheat only.

Country	year	Kcal change		STU initial	STU year 1	STU year 4	Use initial (10 <sup>4</sup> kcal/cap)	Use year 1 (%)	Use year 4 (%)	Use year 1-5 mean (%)	Population current (million)
		mean	max.								
		(%)	(%)								
Czech Republic	4	-38.6	-49.0	14.6	0.0	0.0	86.8	-0.6	-23.2	-6.0	11
Slovakia	4	-37.7	-47.6	13.0	0.0	0.0	73.4	-0.8	-30.3	-10.3	5
Poland	4	-35.3	-43.7	11.2	0.0	0.0	66.0	-1.3	-32.9	-17.3	38
Ukraine	4	-29.3	-39.9	16.0	0.0	0.0	86.7	-0.8	-8.2	-3.7	44
Hungary	4	-29.0	-36.4	18.3	0.0	0.0	83.6	-0.5	-5.1	-2.4	10
Latvia	3	-28.9	-54.1	18.9	0.0	0.0	69.3	-1.1	-5.6	-4.6	2
Kazakhstan	2	-28.0	-43.7	52.1	13.1	0.0	66.6	0.0	-3.3	-3.1	19
Denmark	3	-26.1	-41.3	12.2	0.0	0.0	240.6	-1.4	-9.9	-7.4	6
Moldova	4	-25.6	-47.9	42.2	28.0	0.0	42.9	0.0	-22.5	-8.1	3
Serbia	4	-24.1	-31.7	32.9	34.4	0.0	53.1	0.0	-11.1	-2.7	7
Albania	4	-22.8	-27.5	3.6	1.1	0.0	63.6	0.0	-58.5	-27.6	3
Romania	4	-22.3	-28.5	12.7	5.3	0.0	67.0	0.0	-14.5	-3.7	22
Turkey	4	-21.5	-24.5	9.7	23.3	0.0	68.4	0.0	-18.8	-5.0	81
Tajikistan	3	-21.0	-24.3	6.3	6.2	0.0	53.4	0.0	-22.1	-17.9	8
Bulgaria	4	-20.5	-27.1	16.6	11.4	0.0	96.7	0.0	-3.1	-1.5	7
China	3	-20.1	-22.3	38.0	30.0	0.0	16.5	0.0	-12.6	-6.6	1379
Croatia	4	-19.9	-29.3	13.3	5.3	0.0	49.2	0.0	-6.6	-2.1	4
Macedonia	4	-19.8	-28.5	11.4	10.9	0.0	61.5	0.0	-49.5	-18.2	2
Greece	4	-19.3	-24.2	8.9	11.3	0.0	68.2	0.0	-26.5	-9.0	11
Tunisia	4	-18.6	-26.7	25.4	21.3	0.0	67.0	0.0	-44.6	-19.6	11
Lithuania	3	-18.0	-28.5	21.1	0.0	0.0	68.0	0.0	-3.9	-2.9	3
Japan	4	-17.9	-23.1	21.6	20.2	0.0	13.1	0.0	-21.8	-8.7	126
Russia	4	-17.4	-23.6	15.5	1.9	0.0	84.5	0.0	-2.5	-1.5	142
Armenia	4	-17.2	-23.9	6.5	1.6	0.0	45.7	0.0	-55.2	-35.6	3
Austria	4	-17.2	-22.1	14.4	0.0	0.0	40.0	-0.1	-5.4	-3.2	9
Iran	4	-17.0	-20.1	19.4	15.8	0.0	48.1	0.0	-19.8	-9.1	82
Canada	4	-16.8	-41.5	74.3	42.7	0.0	19.3	0.0	-5.5	-2.4	36
Montenegro	4	-16.7	-25.8	0.0	0.0	0.0	7.6	-0.2	-81.2	-35.7	1
Switzerland	4	-16.4	-22.3	24.7	18.3	0.0	34.4	0.0	-40.2	-16.8	8
United States	5	-15.7	-20.3	39.8	27.4	0.0	19.9	0.0	-2.5	-1.6	327
Afghanistan	3	-15.5	-20.5	0.0	0.0	0.0	39.6	-0.6	-18.2	-13.8	34
Italy	4	-15.2	-20.3	7.8	9.3	0.0	58.1	0.0	-16.8	-4.6	62
Uzbekistan	5	-15.2	-18.9	12.1	10.4	0.0	69.3	0.0	-17.1	-11.7	30
United Kingdom	4	-14.6	-21.9	12.1	0.0	0.0	66.2	-0.1	-6.8	-2.4	65
Georgia	4	-14.5	-21.9	28.1	25.5	0.0	38.9	0.0	-71.9	-39.0	5
Kyrgyzstan	4	-13.6	-19.8	22.1	16.8	0.0	51.3	0.0	-21.5	-13.4	6
Laos	2	-12.8	-24.6	0.0	0.0	0.0	0.4	0.0	-100.0	-43.9	7
Australia	4	-12.7	-17.3	52.5	27.4	0.0	47.6	0.0	-3.5	-1.5	23
Mongolia	1	-12.5	-19.5	0.0	0.0	0.0	43.8	-0.5	-48.9	-29.6	3
Portugal	5	-12.4	-21.2	1.4	0.0	0.0	46.1	-0.1	-50.9	-26.9	11
Sweden	2	-12.3	-34.1	14.5	0.0	0.0	49.5	-0.5	-2.3	-2.3	10
Turkmenistan	4	-12.1	-19.6	55.1	55.0	41.5	56.0	0.0	0.0	0.0	5
Netherlands	5	-12.0	-25.5	2.5	0.0	0.0	108.4	-0.2	-33.4	-15.7	17
Syria	4	-11.7	-16.9	114.8	112.7	0.0	-8.2	0.0	-2.4	-0.8	18
Lebanon	2	-11.2	-16.0	0.0	0.0	0.0	23.0	-0.2	-53.0	-24.7	6
France	4	-11.0	-15.9	20.7	16.5	0.0	80.1	0.0	-2.9	-1.4	67
New Zealand	4	-11.0	-12.7	28.7	24.6	0.0	34.9	0.0	-11.2	-4.4	5
Eritrea	4	-10.5	-19.0	0.0	0.0	0.0	6.6	-0.2	-73.7	-37.5	6
Guatemala	2	-10.2	-16.2	28.2	28.2	0.0	9.0	0.0	-23.3	-10.8	15
Uruguay	1	-10.2	-15.6	73.2	62.9	4.1	22.0	0.0	0.0	-0.2	3
Spain	3	-9.5	-16.4	7.4	3.7	0.0	62.5	0.0	-28.1	-14.0	49
Belgium	4	-8.7	-13.7	7.1	2.9	0.0	76.3	0.0	-5.7	-3.4	11
South Korea	5	-8.3	-13.7	31.2	29.7	0.0	14.0	0.0	-40.8	-18.0	51
Jordan	4	-8.0	-17.1	56.2	52.2	0.0	11.8	0.0	-73.4	-24.9	10
North Korea	4	-7.6	-13.1	0.0	0.0	0.0	4.4	0.0	-39.1	-22.2	25
Belarus	5	-7.5	-14.7	16.1	9.5	0.0	49.9	0.0	-11.7	-8.1	10
Iraq	4	-7.5	-13.9	10.9	10.9	0.0	40.3	0.0	-27.0	-11.3	39
Algeria	3	-6.8	-19.9	29.7	27.4	0.0	43.4	0.0	-29.9	-11.9	41
Ethiopia	1	-6.4	-8.6	5.2	0.0	0.0	8.4	0.0	-9.8	-5.2	105
Germany	1	-6.4	-27.8	14.2	0.6	0.0	67.9	0.0	-2.2	-1.6	81
Brazil	1	-6.3	-10.8	18.0	15.3	0.0	14.2	0.0	-0.7	-0.3	207
Argentina	1	-5.7	-11.1	29.6	7.3	0.0	25.1	0.0	-1.3	-0.9	44
Bhutan	3	-4.5	-10.6	0.0	0.2	0.0	3.5	0.0	-2.1	-2.5	1
Chile	3	-3.9	-11.4	12.6	10.0	0.0	37.3	0.0	-5.6	-2.9	18
Saudi Arabia	4	-3.5	-6.0	82.8	88.4	63.0	5.2	0.0	0.0	0.0	29
Lesotho	3	-3.3	-16.1	0.0	0.0	0.0	0.8	0.0	0.0	0.0	2
Zimbabwe	1	-2.9	-4.7	20.4	18.2	0.0	3.7	0.0	-19.8	-8.6	14
Bangladesh	1	-2.3	-4.9	20.6	18.3	0.0	4.1	0.0	-41.3	-20.3	158
Vietnam	3	-2.0	-5.7	25.1	25.1	0.0	2.9	0.0	-38.1	-14.6	96
Botswana	1	-1.9	-7.7	0.0	0.0	0.0	-0.5	-100.0	-100.0	-100.0	2
Libya	1	-1.9	-10.1	9.0	6.9	0.0	68.0	0.0	-69.0	-33.4	7
Myanmar (Burma)	5	-1.8	-6.1	0.0	1.0	0.0	1.5	0.0	-14.8	-7.3	55
South Africa	2	-1.7	-7.8	18.3	17.8	0.0	16.6	0.0	-6.6	-2.3	55
Bolivia	1	-1.1	-3.5	16.0	15.5	0.0	10.4	0.0	-4.2	-1.9	11
Cyprus	3	-1.0	-4.1	0.4	0.0	0.0	57.6	-0.1	-69.6	-29.1	1
Azerbaijan	5	-0.9	-4.8	26.4	30.2	0.0	68.2	0.0	-29.5	-15.0	10

Nepal	5	-0.9	-2.4	0.0	2.0	7.4	17.0	0.0	0.0	0.0	29
Ecuador	3	-0.7	-3.8	13.5	13.2	0.0	9.1	0.0	-25.5	-11.3	16
Egypt	1	-0.2	-3.3	25.5	24.7	0.0	41.3	0.0	-27.3	-11.2	97
Morocco	1	0.3	-18.5	24.0	23.7	0.0	51.2	0.0	-10.5	-3.8	34
Zambia	1	0.9	-2.3	12.0	12.4	0.0	2.5	0.0	-14.9	-6.7	16
Nigeria	1	1.3	-1.8	5.3	5.1	0.0	5.3	0.0	-23.5	-14.3	191
Mexico	1	1.7	-1.6	7.2	8.4	0.0	14.6	0.0	-1.7	-0.9	125
Yemen	5	1.7	-3.9	9.0	8.1	0.0	24.6	0.0	-37.0	-18.5	28
Niger	2	4.6	0.5	0.0	1.0	0.0	0.9	0.0	-63.0	-32.9	19
Sudan	4	4.8	-2.4	5.9	9.5	0.0	16.7	0.0	-17.4	-5.4	37
Israel	3	5.1	-10.4	15.6	11.8	0.0	51.1	0.0	-63.6	-33.4	8
Angola	0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	-54.7	-26.9	29
Benin	0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	-56.1	-26.2	11
Bosnia and Herzegovina	0	0.0	0.0	30.0	27.8	0.0	40.8	0.0	-55.0	-17.8	4
Burkina Faso	0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	-56.7	-28.8	20
Burundi	0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	-39.2	-27.6	11
Cambodia	0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	-47.6	-19.4	16
Cameroon	0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	-32.3	-14.5	25
Central African Republic	0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	-39.6	-14.5	6
Chad	0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	-36.9	-18.5	12
Colombia	0	0.0	0.0	10.9	10.9	0.0	8.4	0.0	-19.0	-9.3	48
Congo-Brazzaville	0	0.0	0.0	0.0	0.0	0.0	10.1	0.0	-33.3	-18.0	5
Costa Rica	0	0.0	0.0	39.5	39.4	0.0	6.7	0.0	-4.6	-3.3	5
Cuba	0	0.0	0.0	0.0	0.0	0.0	24.4	-0.1	-42.8	-21.4	11
Djibouti	0	0.0	0.0	0.0	0.0	0.0	70.8	-0.2	-61.5	-29.6	1
Dominican Republic	0	0.0	0.0	8.7	8.7	0.0	11.8	0.0	-28.8	-16.3	11
El Salvador	0	0.0	0.0	51.1	51.0	0.0	2.9	0.0	-9.8	-6.1	6
Equatorial Guinea	0	0.0	0.0	0.0	0.0	0.0	7.6	0.0	-51.6	-27.7	1
Estonia	0	0.0	0.0	12.6	9.7	0.0	65.3	0.0	-2.0	-1.3	1
Finland	0	0.0	0.0	11.4	9.7	0.0	41.8	0.0	-1.3	-0.8	5
Gabon	0	0.0	0.0	0.0	0.0	0.0	16.3	0.0	-33.4	-15.4	2
Gambia, The	0	0.0	0.0	0.0	0.0	0.0	8.7	0.0	-90.3	-34.3	2
Ghana	0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	-34.2	-15.8	27
Guinea	0	0.0	0.0	0.0	0.0	0.0	3.8	-0.3	-56.3	-20.4	12
Guinea-Bissau	0	0.0	0.0	0.0	0.0	0.0	2.4	-0.1	-65.6	-32.3	2
Guyana	0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	-33.1	-16.9	1
Haiti	0	0.0	0.0	0.0	0.0	0.0	7.6	-0.2	-39.0	-23.4	11
Honduras	0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	-35.5	-17.6	9
Indonesia	0	0.0	0.0	28.5	28.4	0.0	4.5	0.0	-30.5	-10.6	261
Ireland	0	0.0	0.0	7.0	5.3	0.0	87.9	0.0	-33.7	-18.4	5
Ivory Coast	0	0.0	0.0	8.3	8.2	0.0	3.8	0.0	-22.2	-7.6	24
Jamaica	0	0.0	0.0	9.2	9.2	0.0	36.8	0.0	-25.4	-12.2	3
Kenya	0	0.0	0.0	18.2	16.2	0.0	5.7	0.0	-33.6	-17.1	48
Kuwait	0	0.0	0.0	0.0	0.0	0.0	38.0	0.0	-23.8	-9.7	3
Liberia	0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	-62.4	-24.2	5
Luxembourg	0	0.0	0.0	10.0	8.5	0.0	48.8	0.0	-4.8	-2.8	1
Madagascar	0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	-36.0	-18.5	25
Malawi	0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	-32.2	-16.1	19
Malaysia	0	0.0	0.0	32.1	32.1	0.0	7.3	0.0	-19.5	-6.4	31
Mali	0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	-51.6	-25.5	18
Mauritania	0	0.0	0.0	0.0	0.0	0.0	25.6	-0.1	-40.9	-19.8	4
Mozambique	0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	-28.5	-15.3	27
Namibia	0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	-22.1	-11.7	2
Nicaragua	0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	-40.6	-20.0	6
Norway	0	0.0	0.0	45.9	40.6	0.0	28.2	0.0	-29.6	-15.6	5
Oman	0	0.0	0.0	17.8	15.3	0.0	17.6	0.0	-20.3	-7.4	3
Panama	0	0.0	0.0	0.0	0.0	0.0	13.8	-0.1	-38.3	-22.3	4
Papua New Guinea	0	0.0	0.0	21.2	21.2	0.0	5.7	0.0	-12.9	-6.3	7
Paraguay	0	0.0	0.0	143.2	143.2	0.0	-8.2	0.0	0.0	-0.4	7
Peru	0	0.0	0.0	15.7	15.2	0.0	14.2	0.0	-14.5	-5.3	31
Philippines	0	0.0	0.0	21.9	21.2	0.0	6.5	0.0	-39.5	-19.3	104
Rwanda	0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	-75.2	-48.1	12
Senegal	0	0.0	0.0	7.7	7.7	0.0	7.7	0.0	-28.1	-11.6	15
Sierra Leone	0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	-57.3	-31.9	6
Slovenia	0	0.0	0.0	5.9	3.0	0.0	45.5	0.0	-37.7	-15.1	2
Somalia	0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	-91.8	-54.3	8
Sri Lanka	0	0.0	0.0	32.8	32.6	0.0	10.0	0.0	-14.2	-4.8	22
Suriname	0	0.0	0.0	0.0	0.0	0.0	9.5	-0.1	-80.2	-48.3	1
Swaziland	0	0.0	0.0	0.0	0.0	0.0	-0.1	-100.0	-100.0	-100.0	1
Tanzania, U.R. of	0	0.0	0.0	0.0	0.0	0.0	2.6	-0.1	-29.9	-12.9	54
Thailand	0	0.0	0.0	51.1	51.0	0.0	2.2	0.0	-26.9	-10.5	68
Togo	0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	-38.9	-16.6	8
Trinidad and Tobago	0	0.0	0.0	5.0	5.0	0.0	36.2	0.0	-20.8	-13.3	1
Uganda	0	0.0	0.0	0.0	0.0	0.0	1.3	-0.1	-56.1	-29.2	40
United Arab Emirates	0	0.0	0.0	10.2	9.3	0.0	41.2	0.0	-23.8	-8.4	6
Venezuela	0	0.0	0.0	6.0	6.0	0.0	16.6	0.0	-25.3	-13.2	31
D.R. Congo	0	0.0	0.0	8.7	8.6	0.0	1.5	0.0	-43.5	-22.0	83
Global	4	-12.1	-14.2	24.7	17.6	0.6	23.1	-0.1	-14.1	-6.6	5835

Population in countries with:

>30% kcal change 54  
>20% kcal change 1,645

>10% kcal change	2,808
STU <sub>init</sub> = 0	647
STU <sub>year1</sub> = 0	880
STU <sub>year4</sub> = 0	5,769
Use <sub>year1</sub> < -10%	3
Use <sub>year4</sub> < -10%	4,292
Use <sub>year4</sub> < -20%	2,285
Use <sub>year4</sub> < -30%	1,409

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