

Supplemental Material

**The GGCMI phase II emulators: global gridded crop model
responses to changes in CO₂, temperature, water, and nitrogen
(version 1.0)**

James Franke¹, et al.

1. Department of the Geophysical Sciences, University of Chicago, Chicago, IL, USA

1 Experiment Simulation Sampling in Variable Space

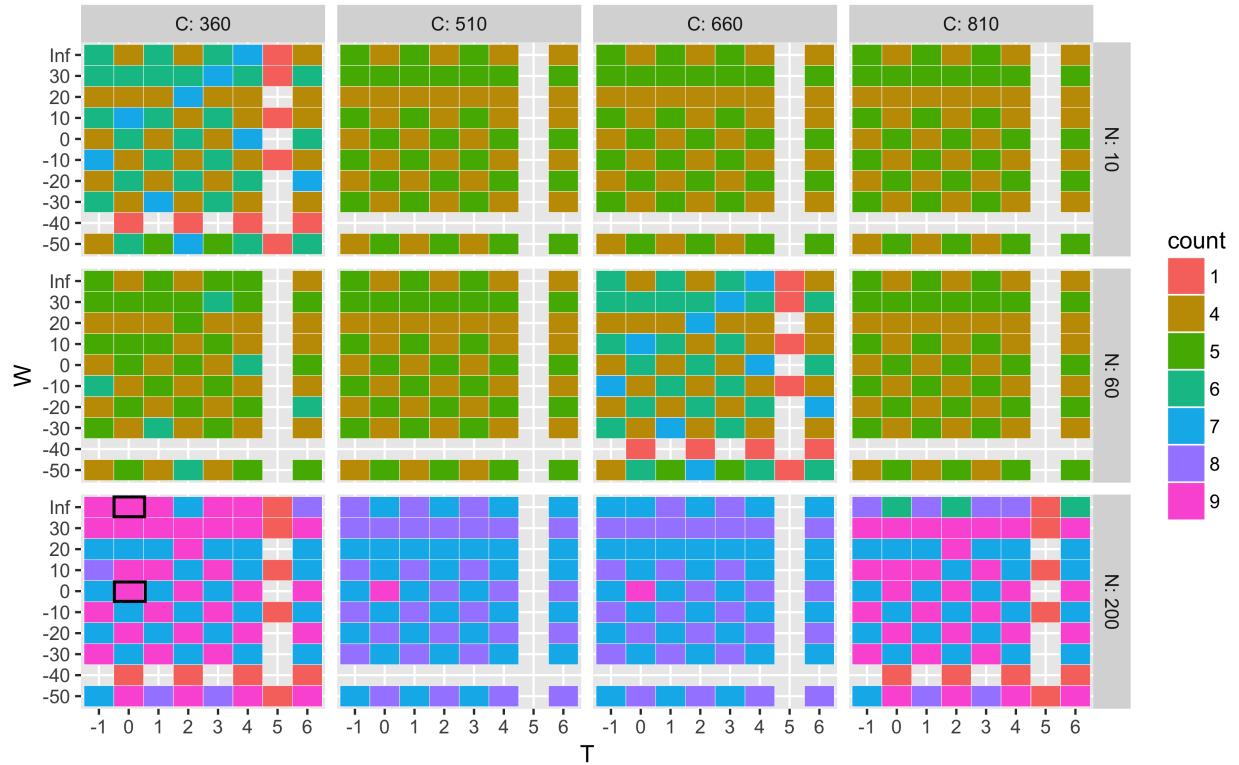


Figure S1: Heatmap illustrates number of model simulations provided for each of the scenarios in the variable space. The max number is 9, the number of models included in the emulator analysis (excluding three models not included in the emulator analysis). Normalized error calculations are run over scenarios with max number of models.

2 Cultivation Areas

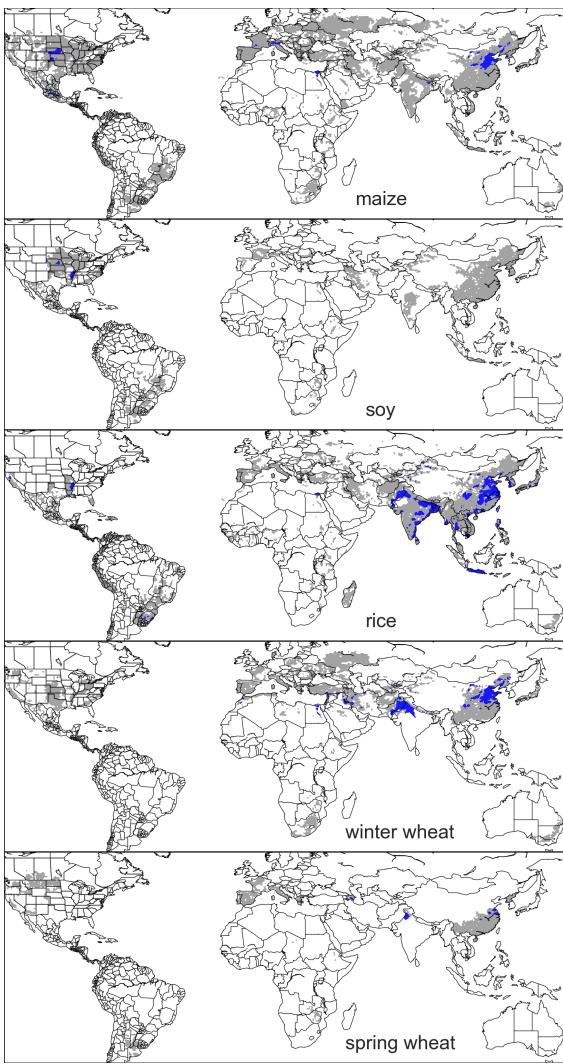


Figure S2: Presently cultivated area for irrigated crops in the real world. The blue contour area indicates grid-cells with more than 20,000 hectares of crop cultivated. The gray contour shows area with more than 10 hectares cultivated. Data from the MIRCA2000 data set for maize, rice, and soy. Winter and spring wheat areas are adapted from MIRCA2000 data and sorted by growing season

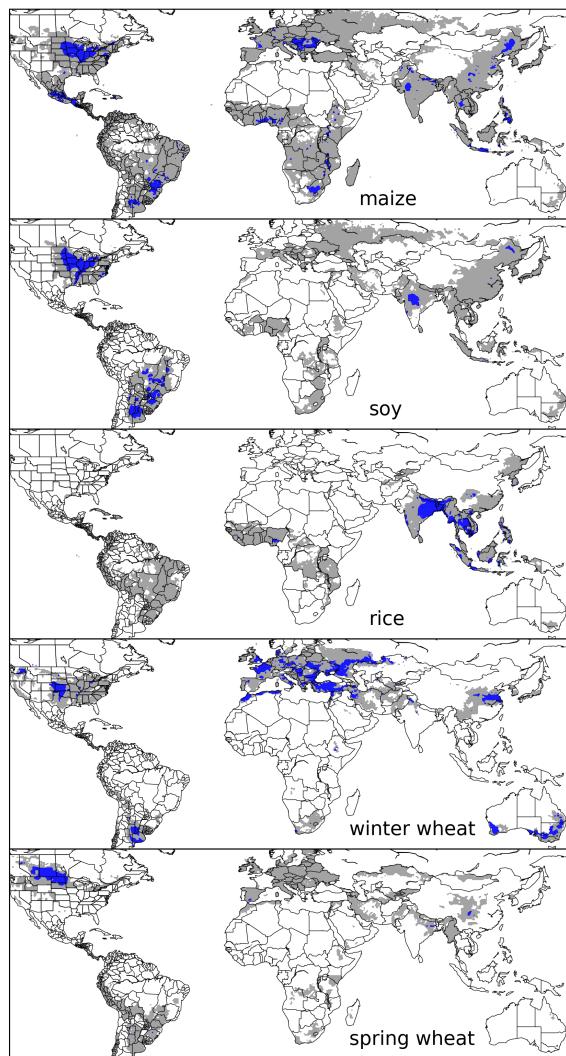


Figure S3: Presently cultivated area for rain fed crops in the real world. Conventions as in Figure S1.

3 Yield Response for A1 Simulations

4 Normalized Error

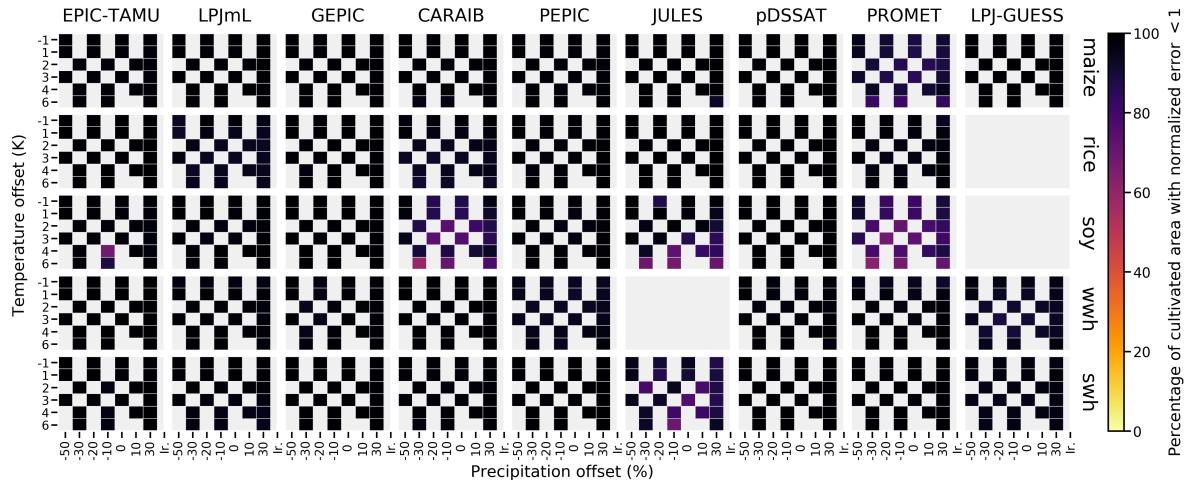


Figure S4: The fraction of currently cultivated hectares with normalized emulation error less than 1 (blue colors contours in Figure A2) for the $\text{CO}_2=810 \text{ ppm}$ and $200 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ case for the temperature and precipitation perturbations scenarios provided by all 9 models included in the emulator analysis. See Equations A1 and A2 for normalized error calculation. The yield response is generally easy to emulate over currently cultivated areas (dark blue and light blue).

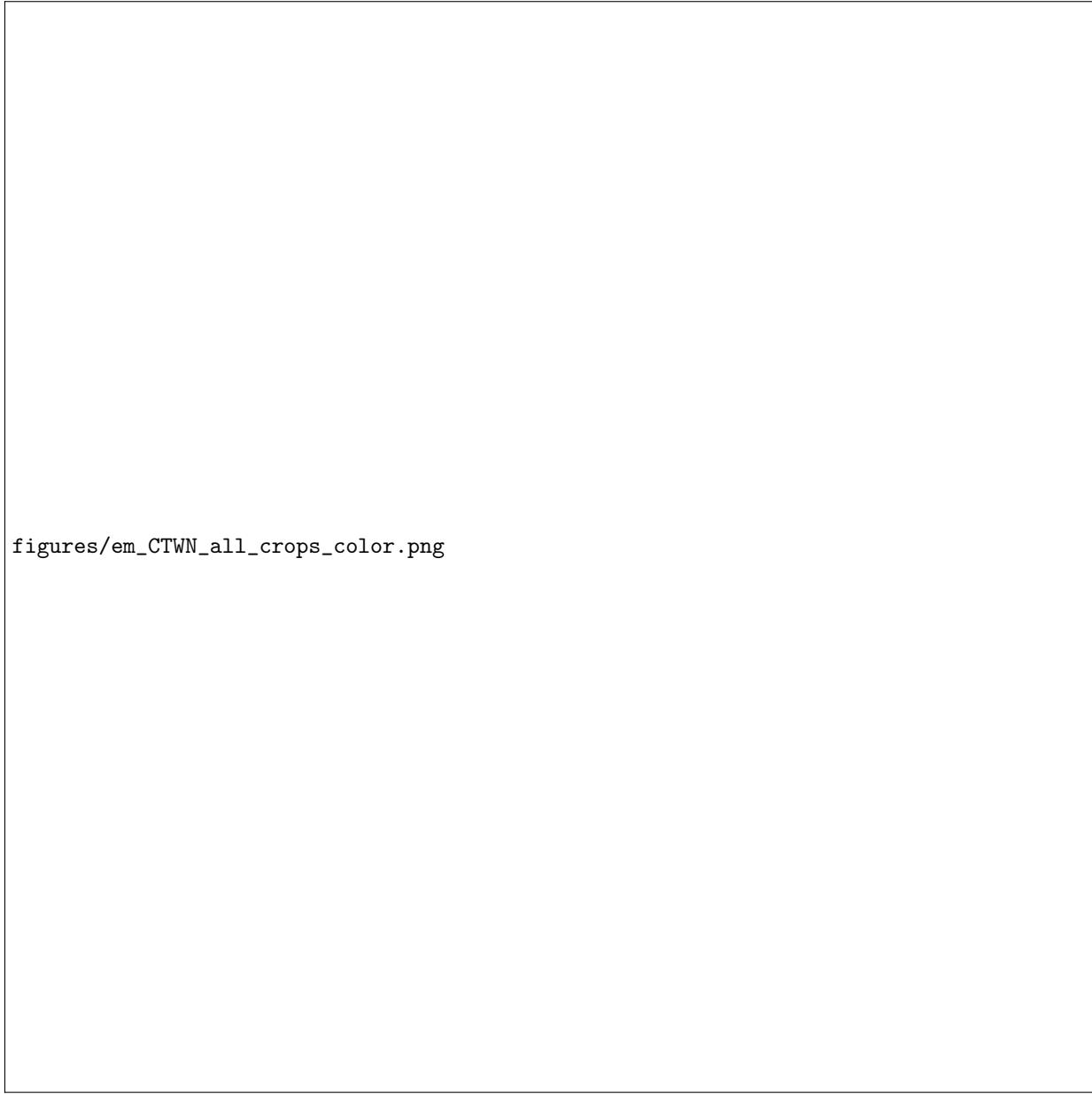
5 Comparison to transient climate run simulation



figures/LPJMLRCP85comp_30N.png

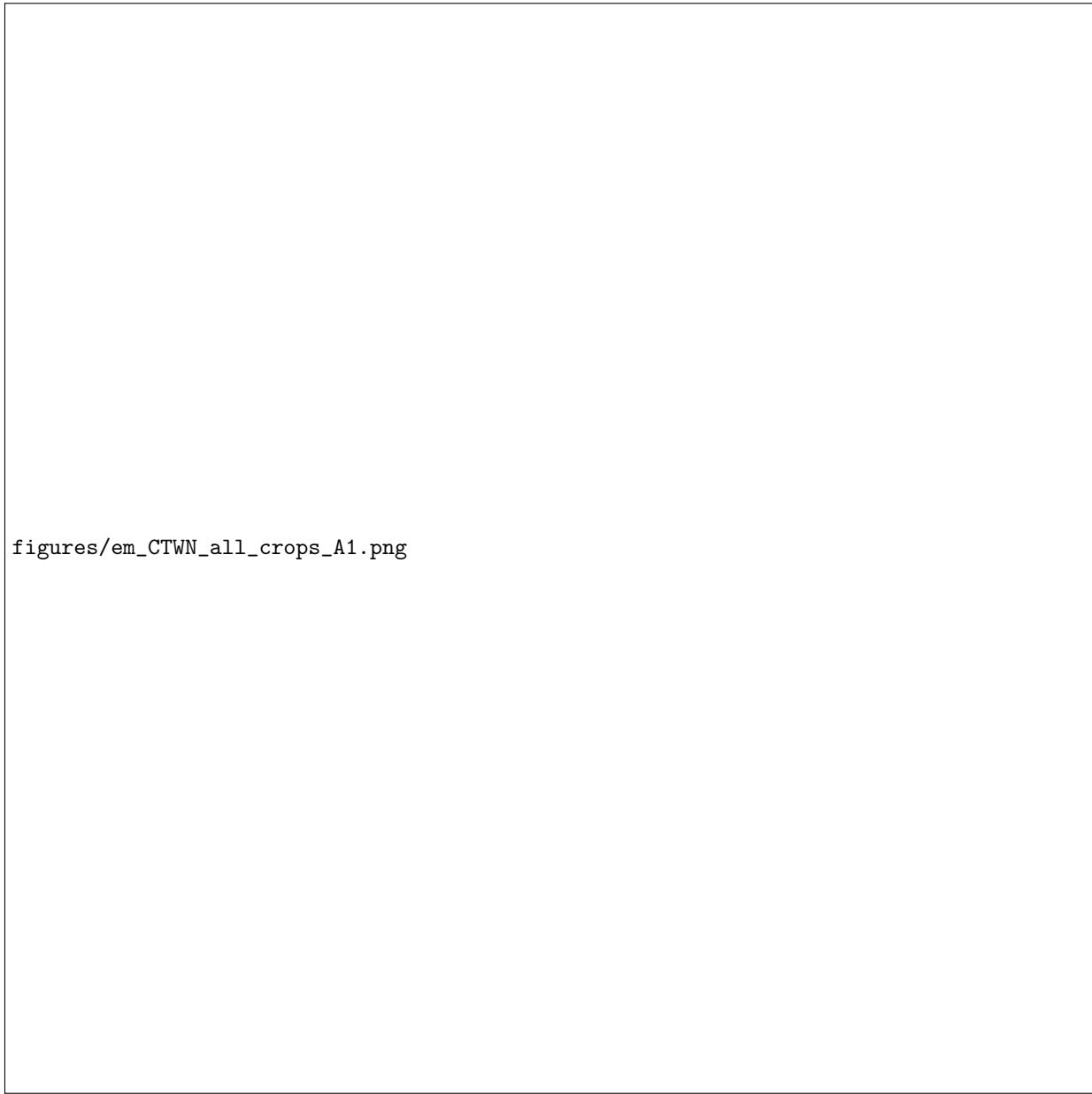
Figure S5: Same as main text Figure 9 except now only for crops north of 30N latitude.

6 Emulator products



figures/em_CTN_all_crops_color.png

Figure S6: Same as main text Figure 10 except now each model is shown in color.



figures/em_CTN_all_crops_A1.png

Figure S7: Same as main text Figure 10 except now for A1 simulations. Note: JULES does not provide A1 simulations.

7 Reduced specification emulator details

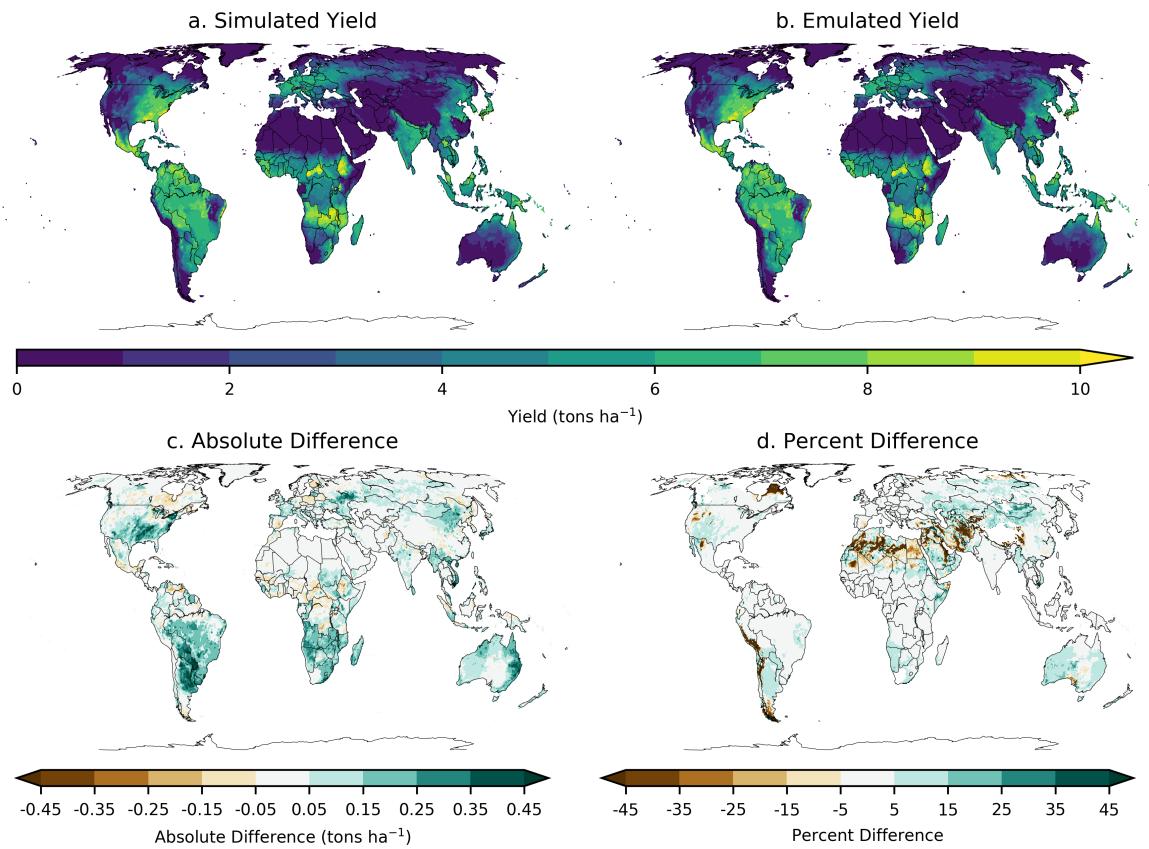


Figure S8: Same convention as Figure 4 in the main text except now with the reduced (23-term) emulator specification.

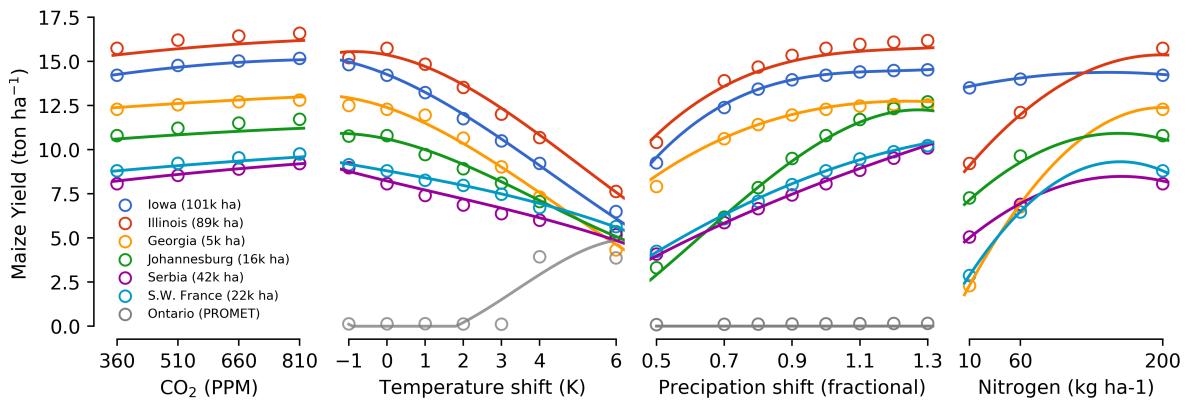


Figure S9: Same convention as Figure 5 in the main text except now with the reduced (23-term) emulator specification.

8 Yield Responses for other crops and models

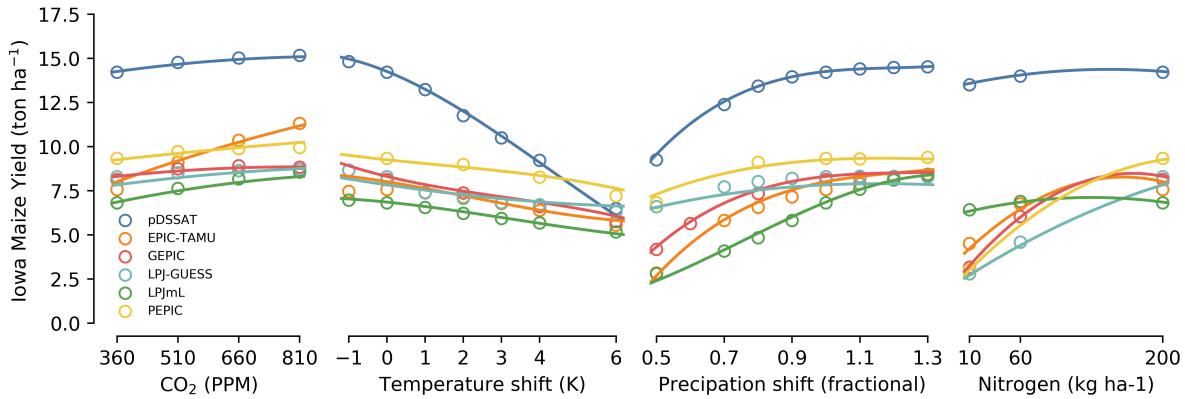


Figure S10: Same convention as Figure 6 in the main text except now with the reduced (23-term) emulator specification.

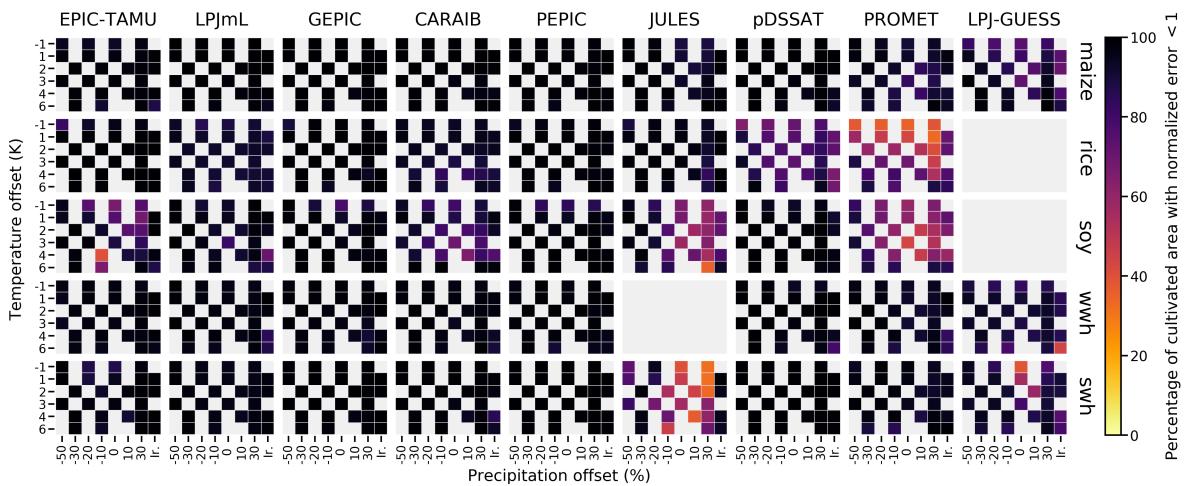


Figure S11: Same convention as Figure 7 in the main text except now with the reduced (23-term) emulator specification.

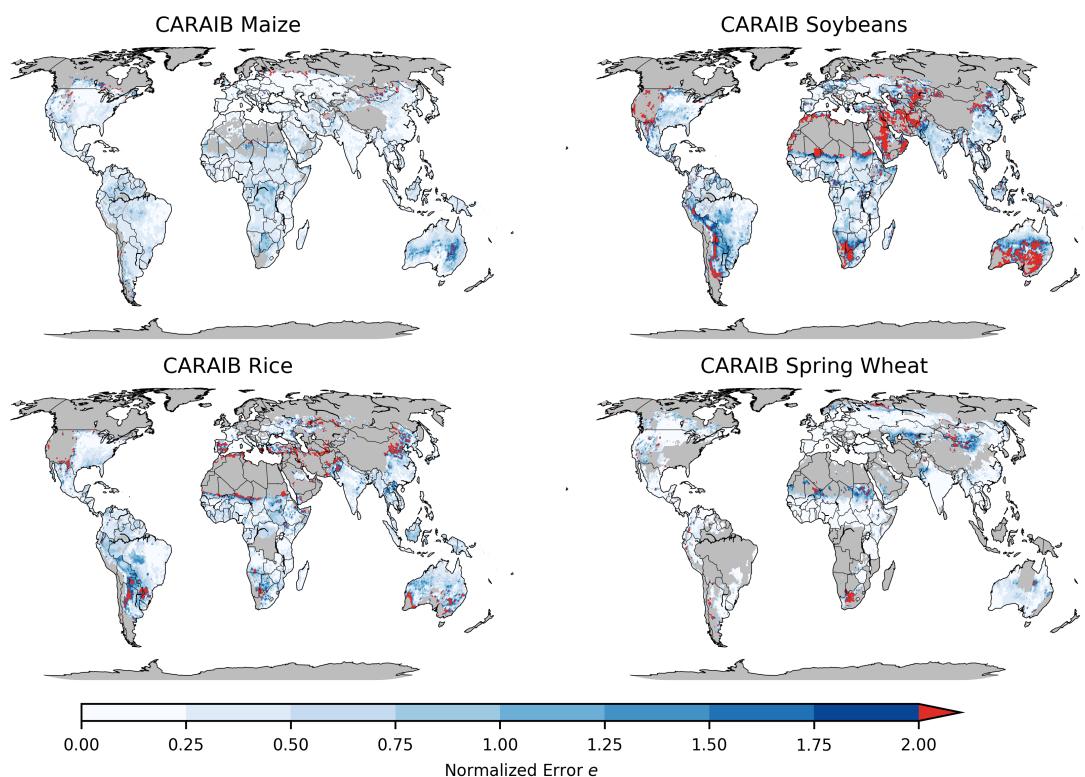


Figure S12: Same convention as Figure 8 in the main text except now with the reduced (23-term) emulator specification.

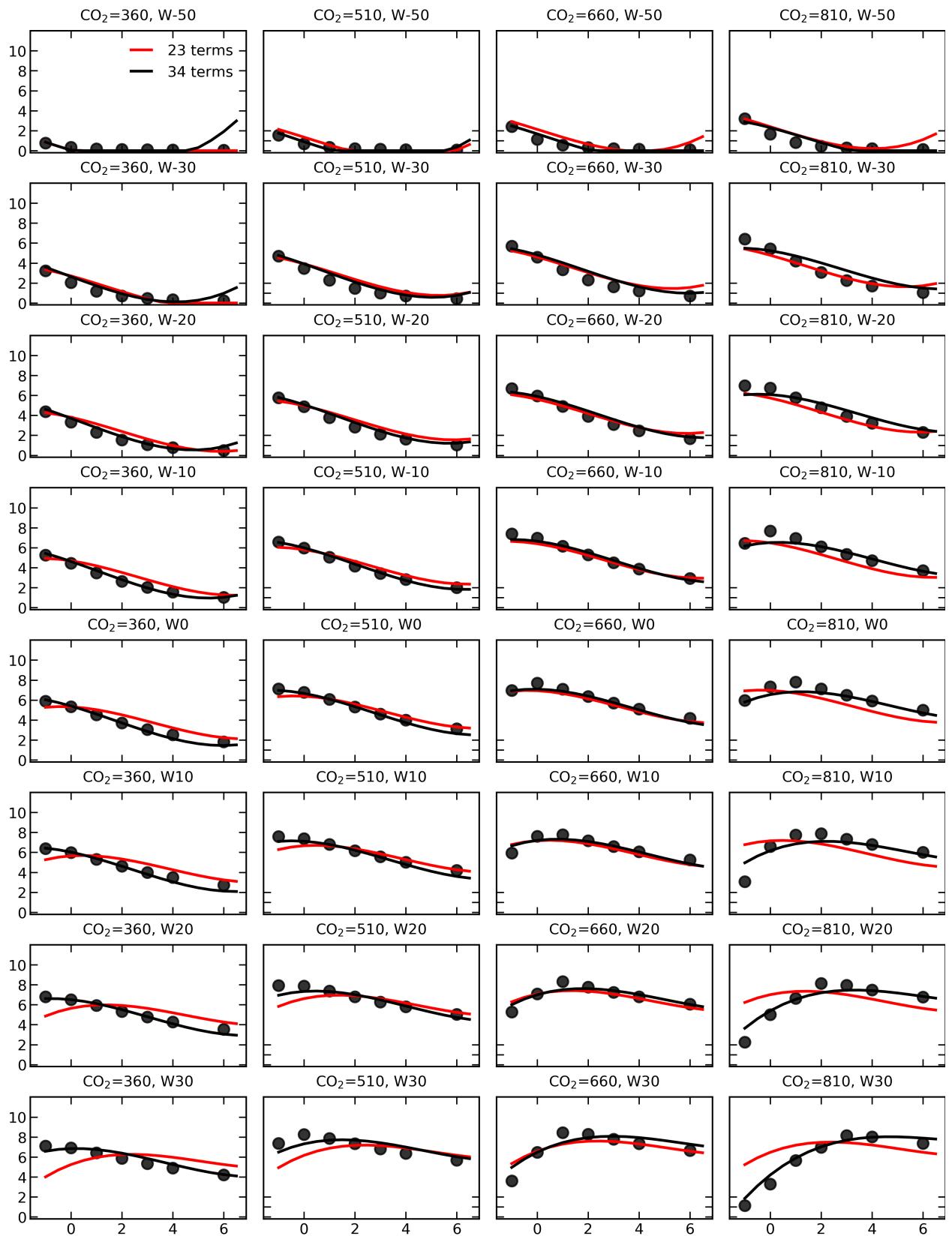


Figure S13: Example of emulator failure. Simulated and emulated values for JULES soybean in Southern Germany. RMSE = 41% of baseline yield.

`promet_rice_bad_arun.png`

Figure S14: Example of emulator failure. Simulated and emulated values for PROMET rice in Arunachal Pradesh. RMSE = 132% of baseline yield.

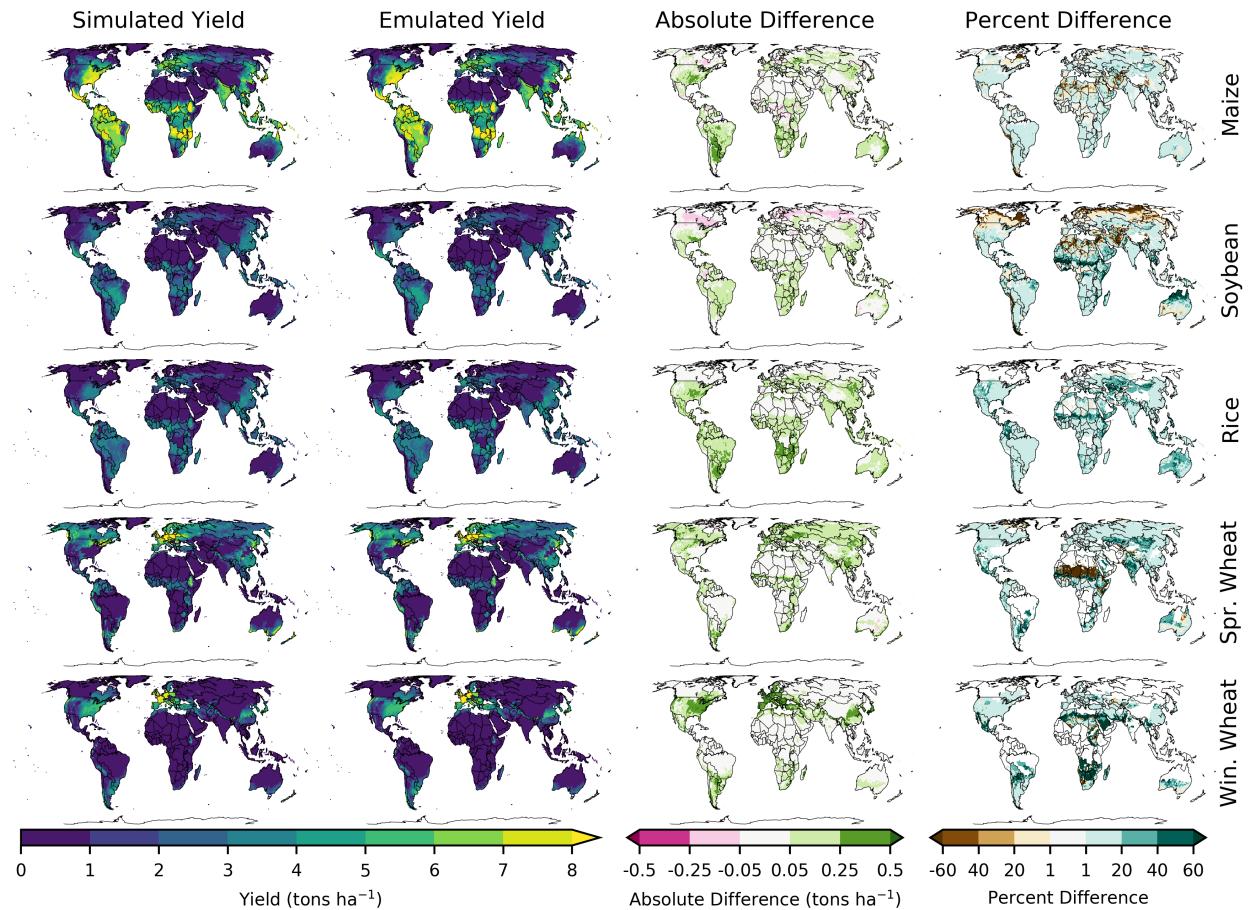


Figure S15: Same convention as Figure 4 in the main text except now for all crops.

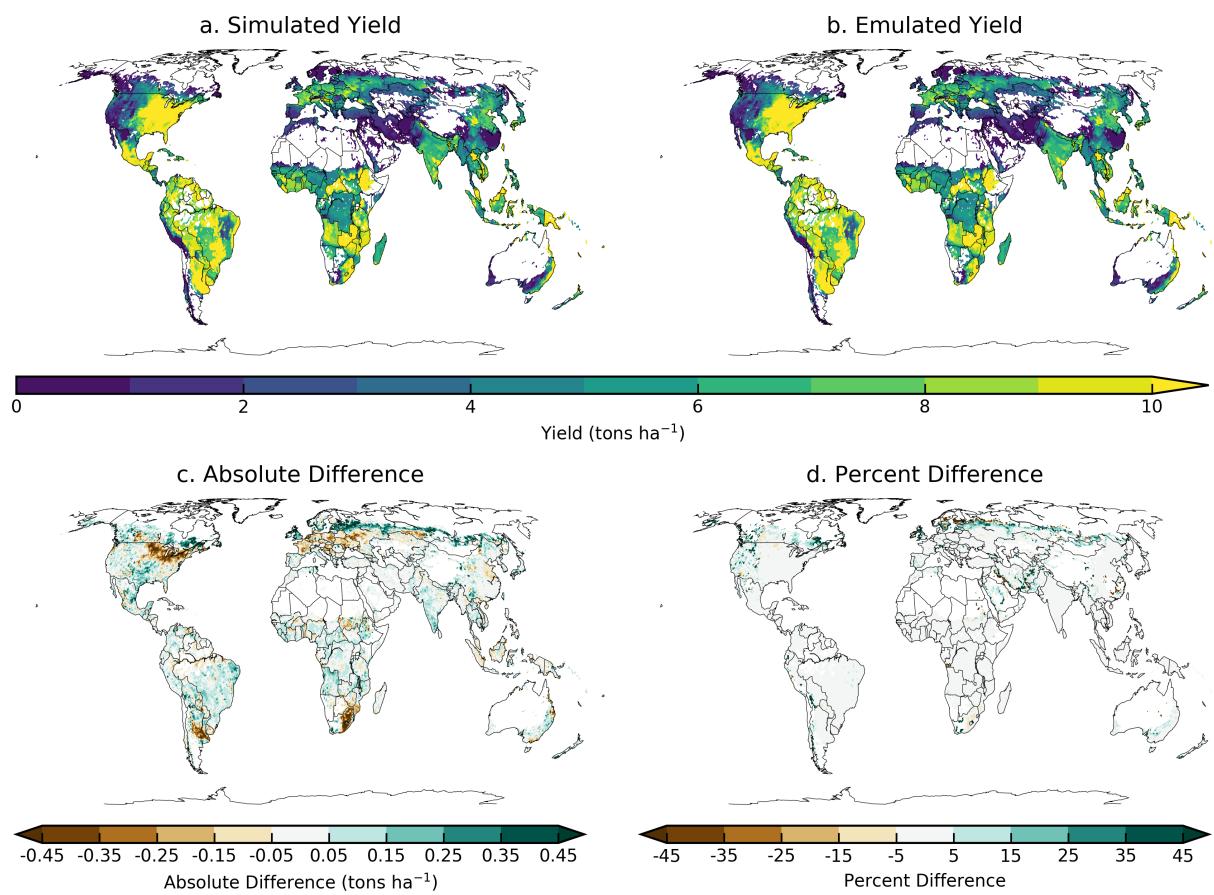


Figure S16: Same convention as Figure 4 in the main text except now pDSSAT maize.

9 Normalized Error for all models

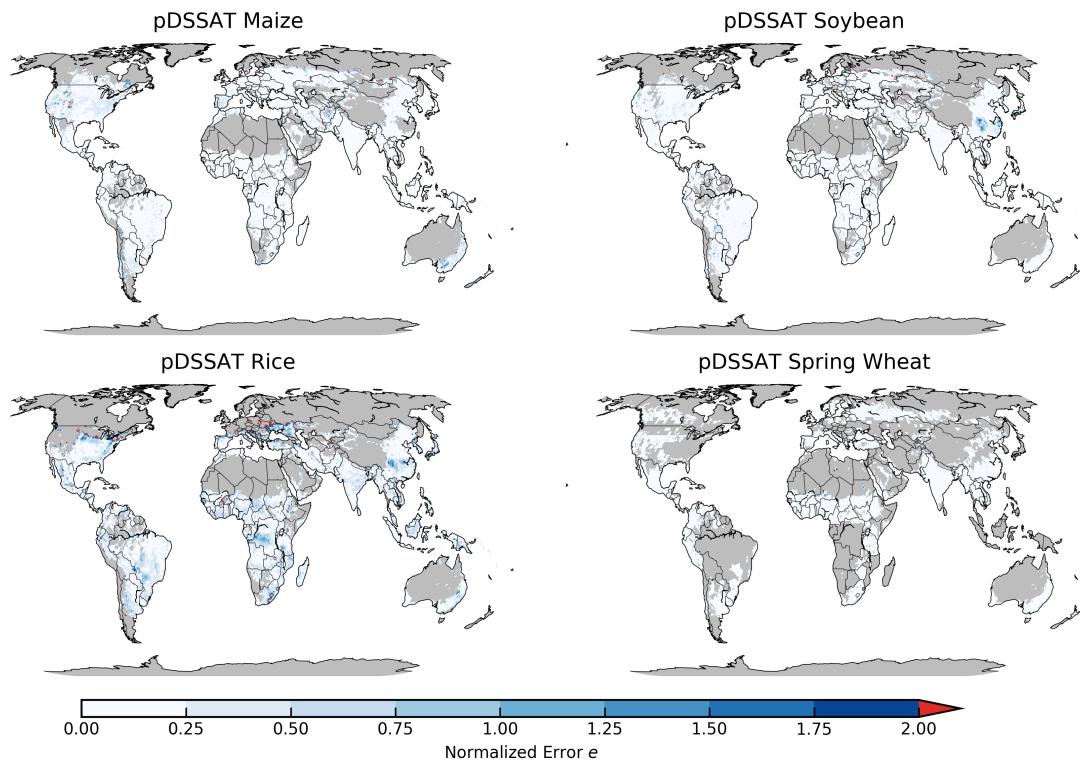


Figure S17: Same convention as main text Figure 8 except now for pDSSAT.

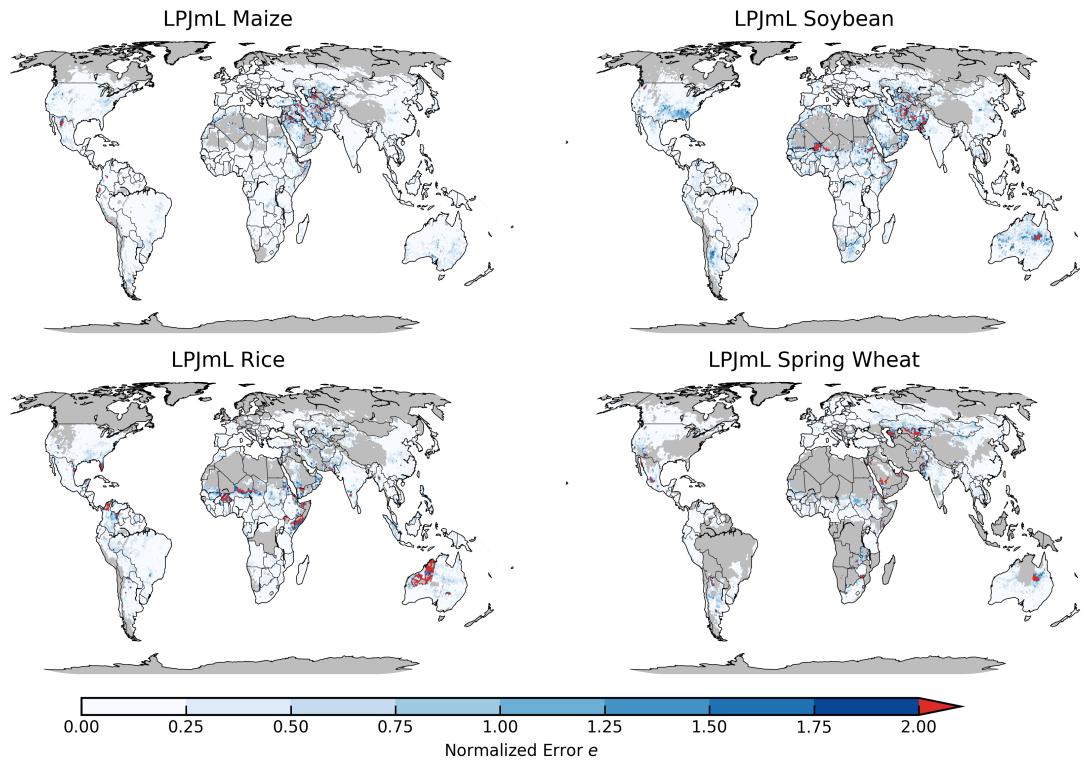


Figure S18: Same convention as main text Figure 8 except now for LPJmL.

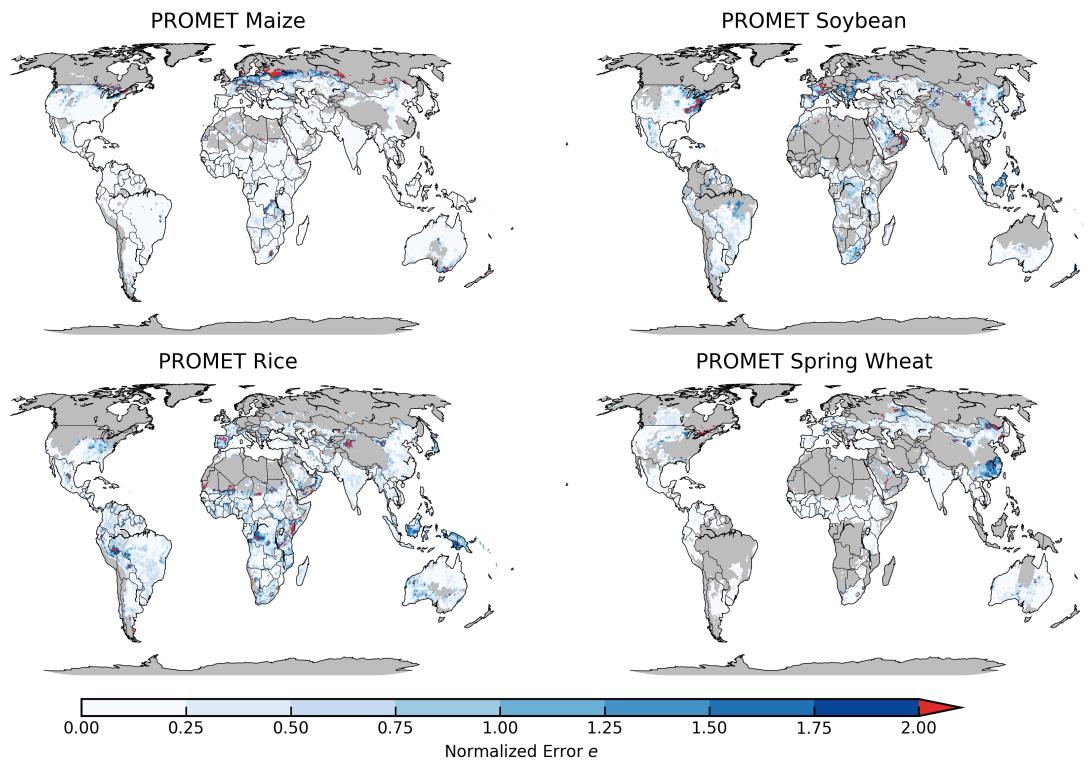


Figure S19: Same convention as main text Figure 8 except now for PROMET.

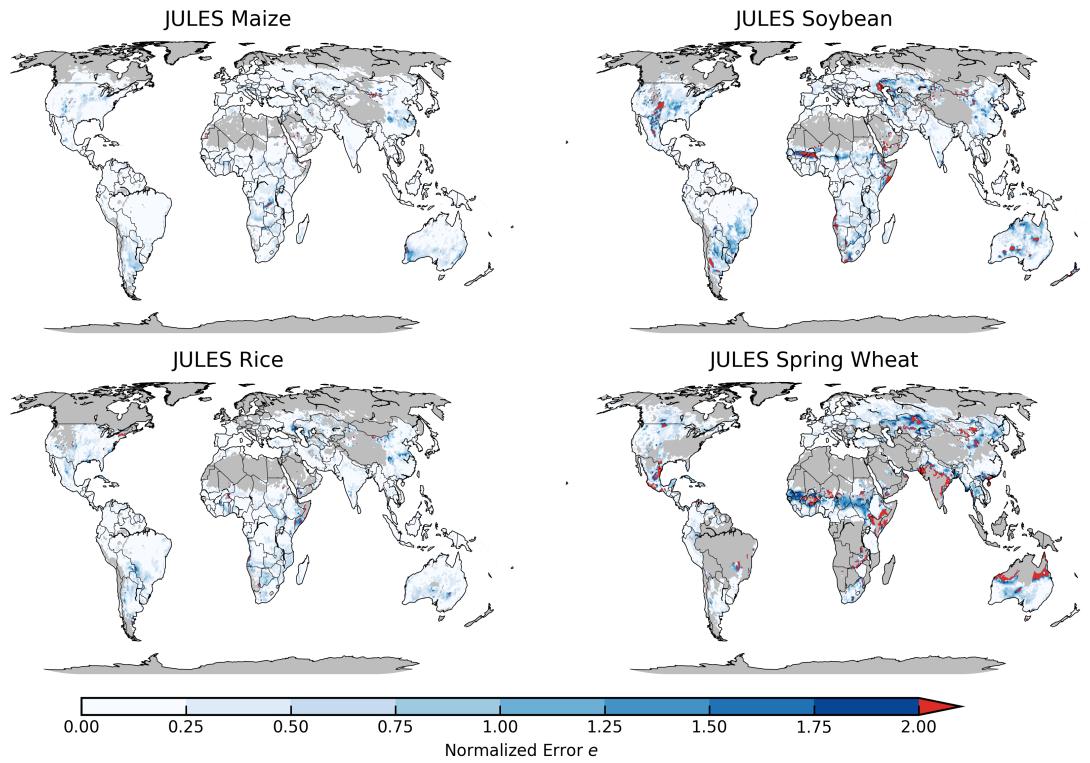


Figure S20: Same convention as main text Figure 8 except now for JULES.

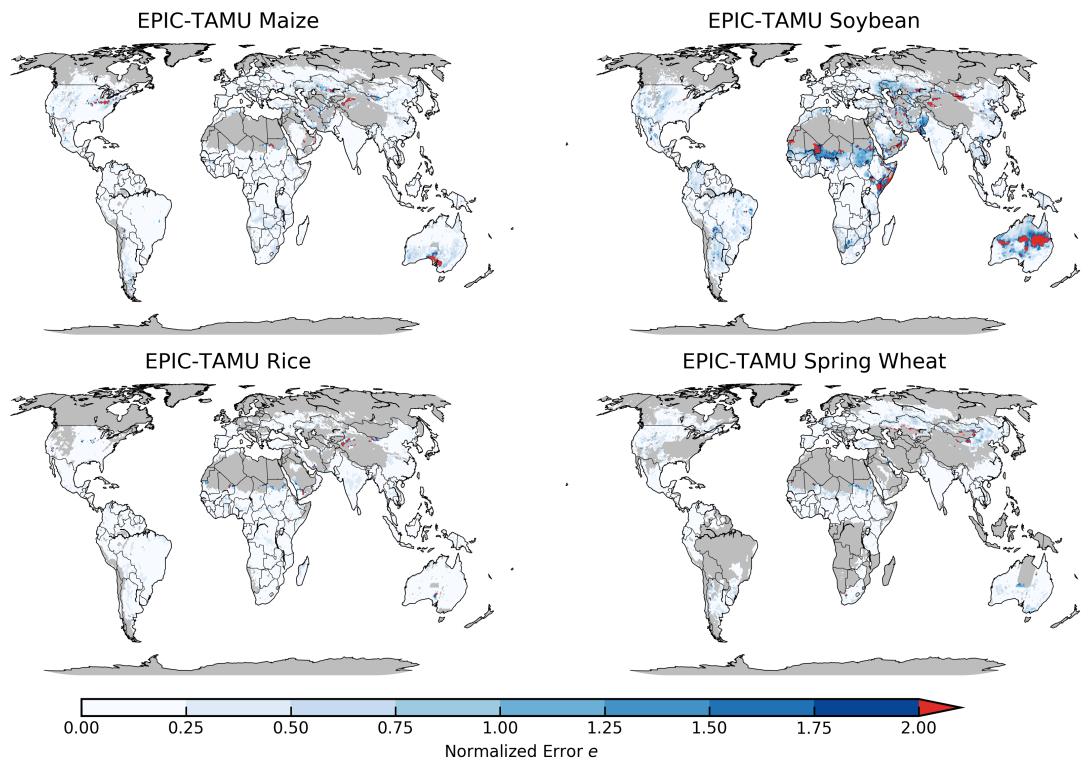


Figure S21: Same convention as main text Figure 8 except now for EPIC-TAMU.

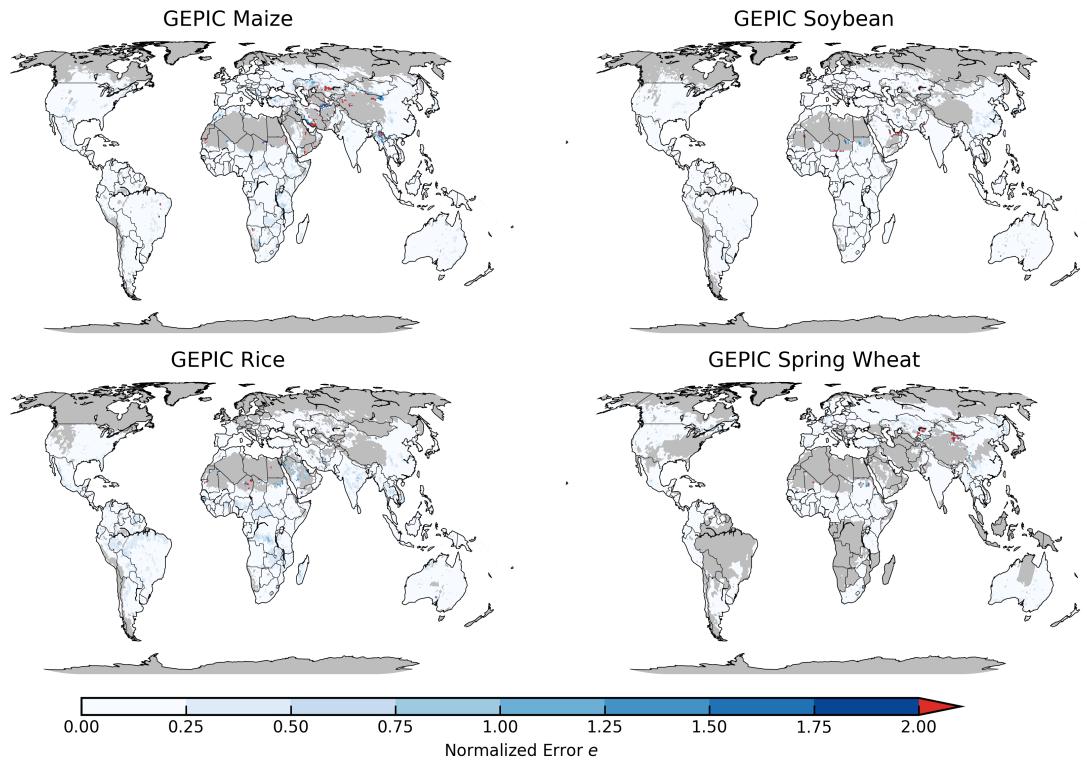


Figure S22: Same convention as main text Figure 8 except now for GEPIC.

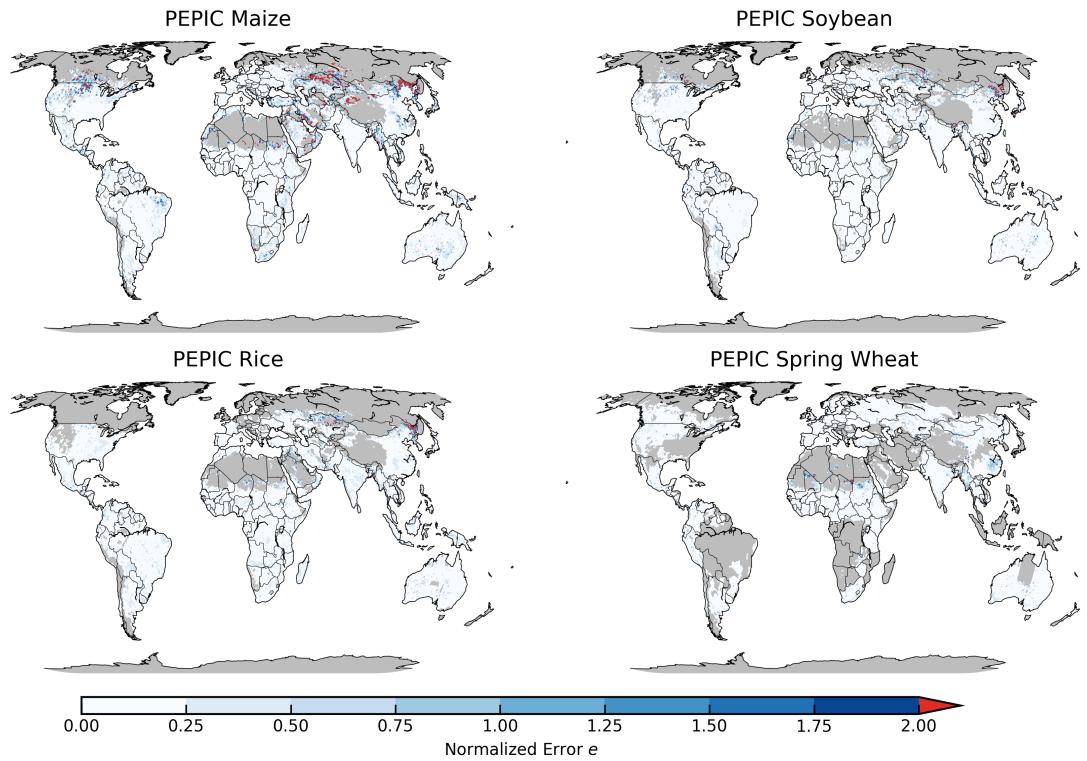


Figure S23: Same convention as main text Figure 8 except now for PEPIC.

10 Cross validation error for all models

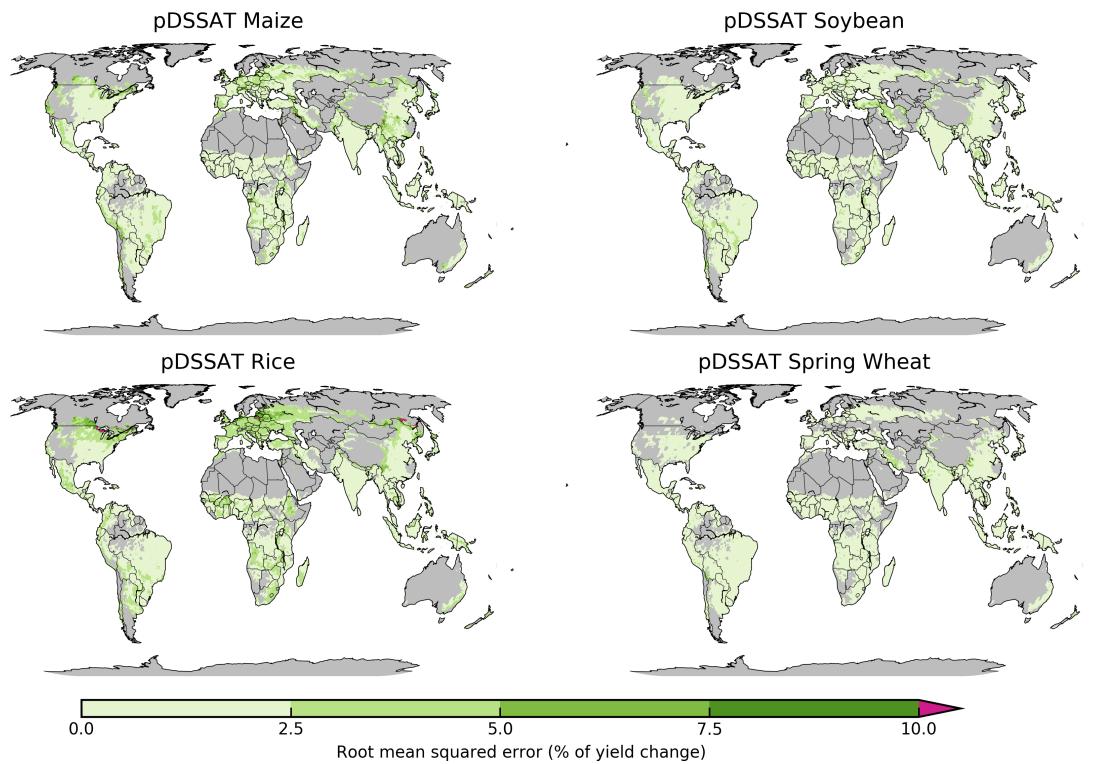


Figure S24: Root mean squared error for three-fold cross validation for the pDSSAT model for rainfed crops.

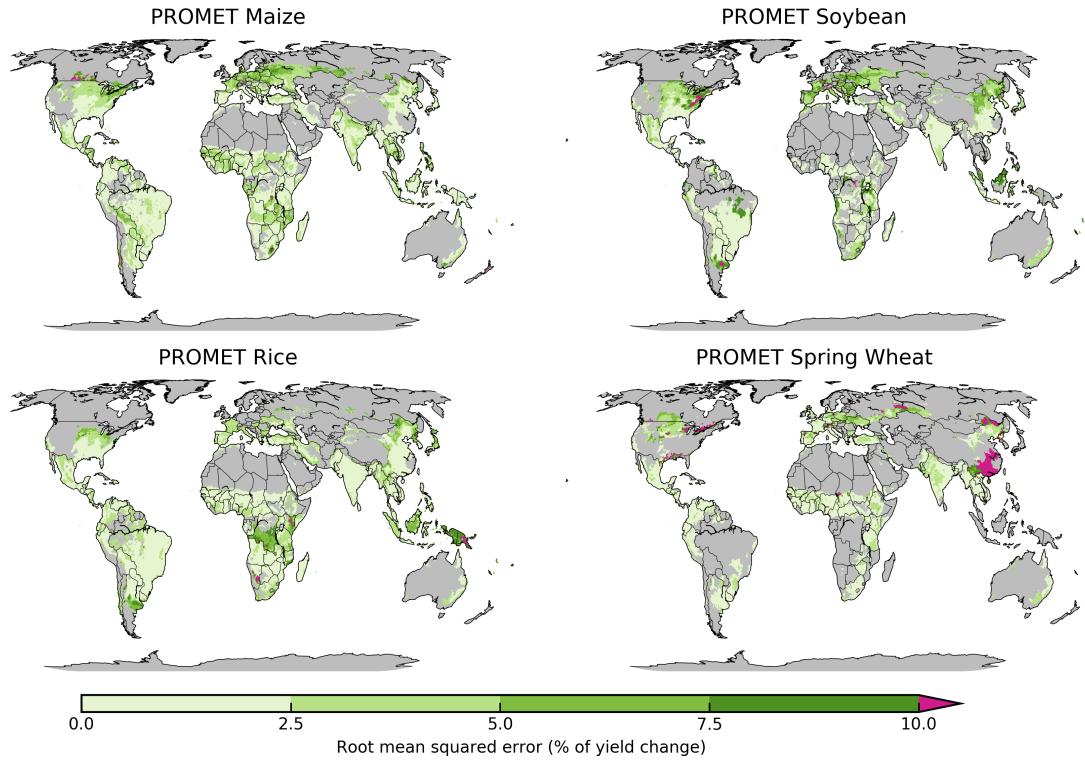


Figure S25: Map of root mean squared error for three fold cross validation process for the PROMET model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

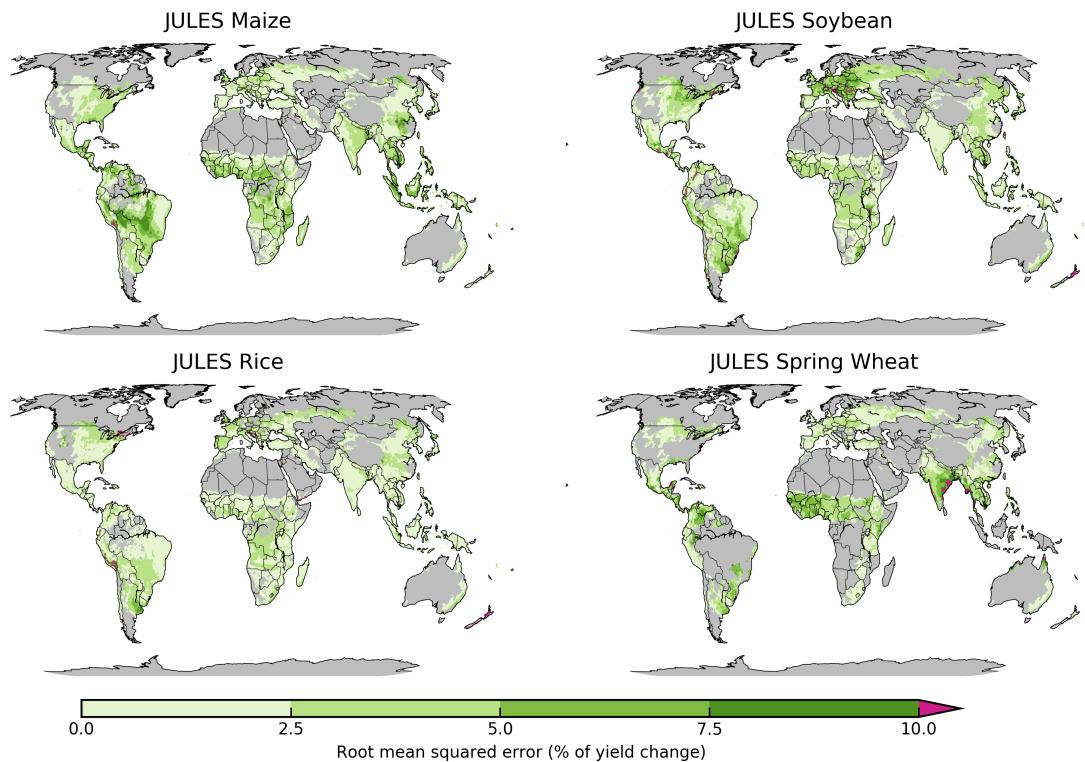


Figure S26: Map of root mean squared error for three fold cross validation process for the JULES model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

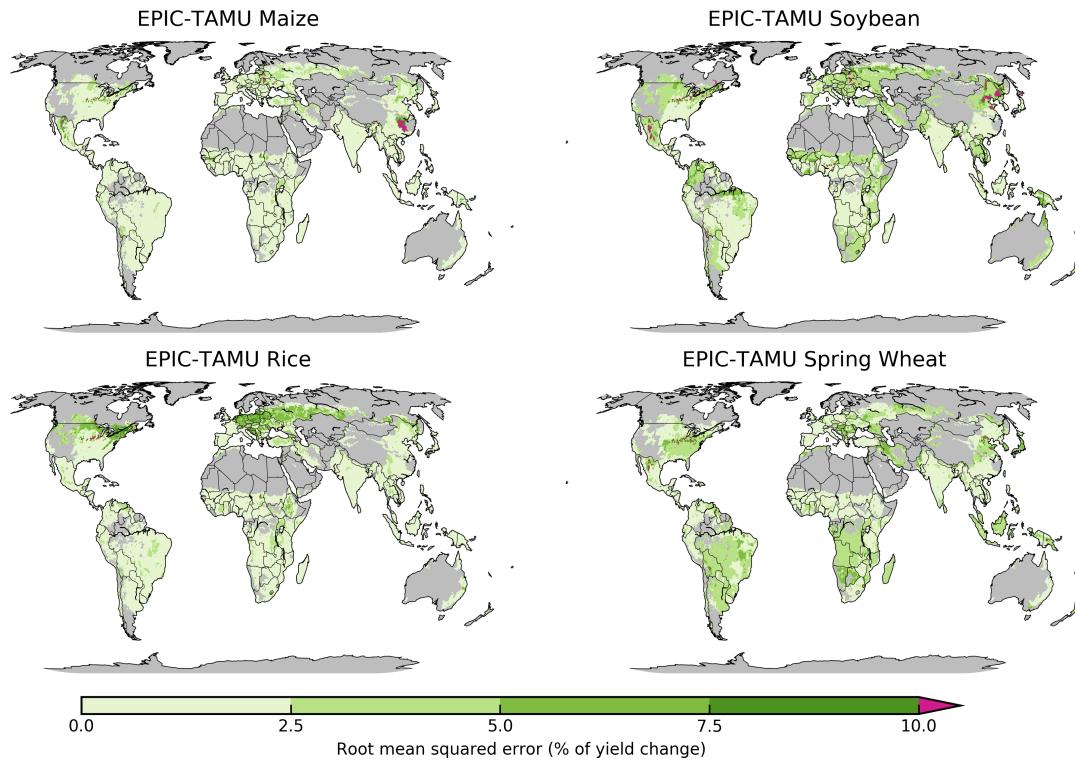


Figure S27: Map of root mean squared error for three fold cross validation process for the EPIC-TAMU model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

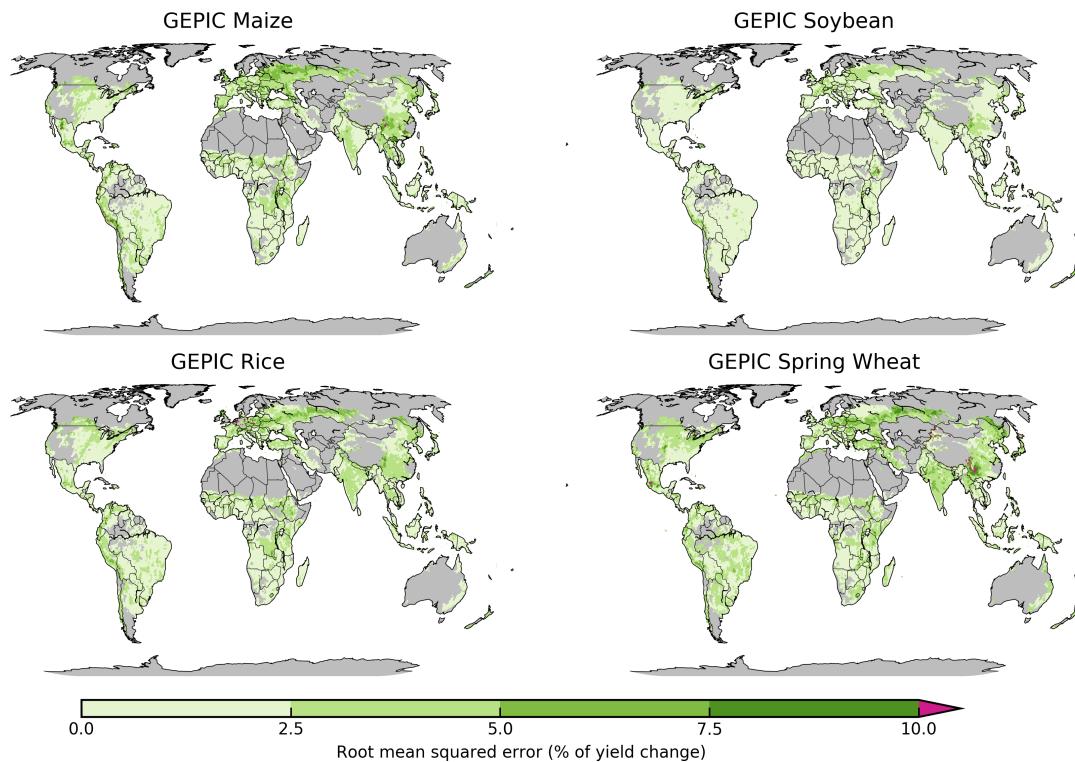


Figure S28: Map of root mean squared error for three fold cross validation process for the GEPIC model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

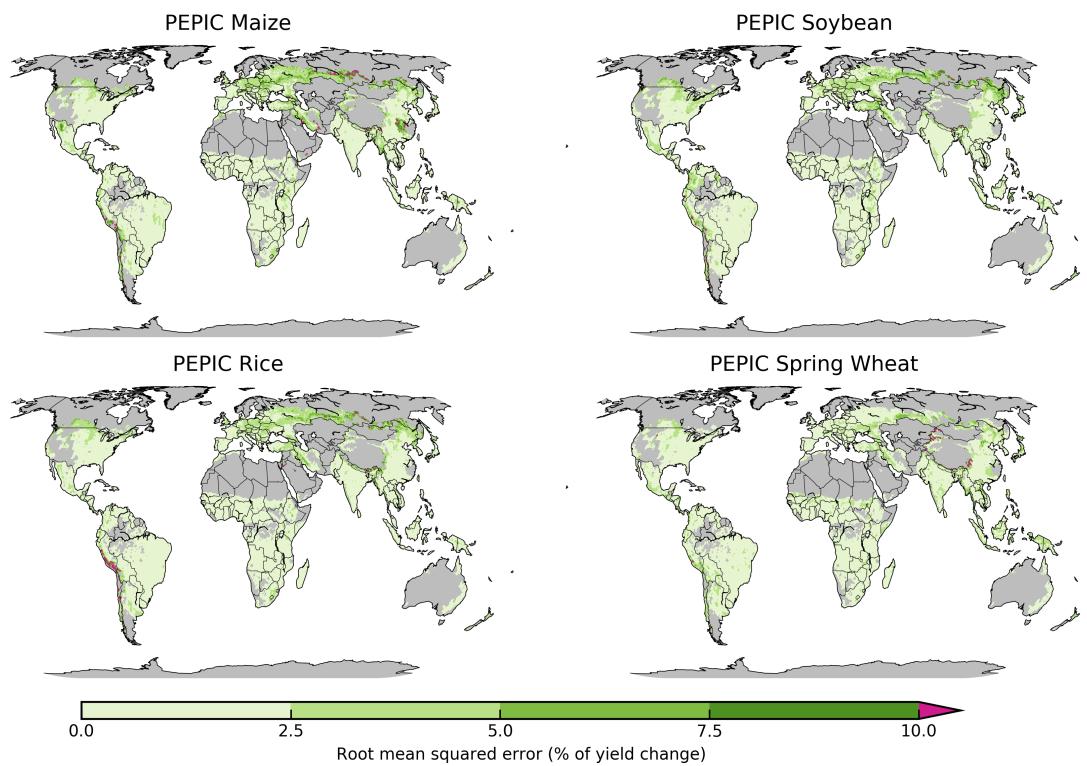


Figure S29: Map of root mean squared error for three fold cross validation process for the PEPIC model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.