

Supplemental Material

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

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1 Experiment Simulation Sampling in Variable Space

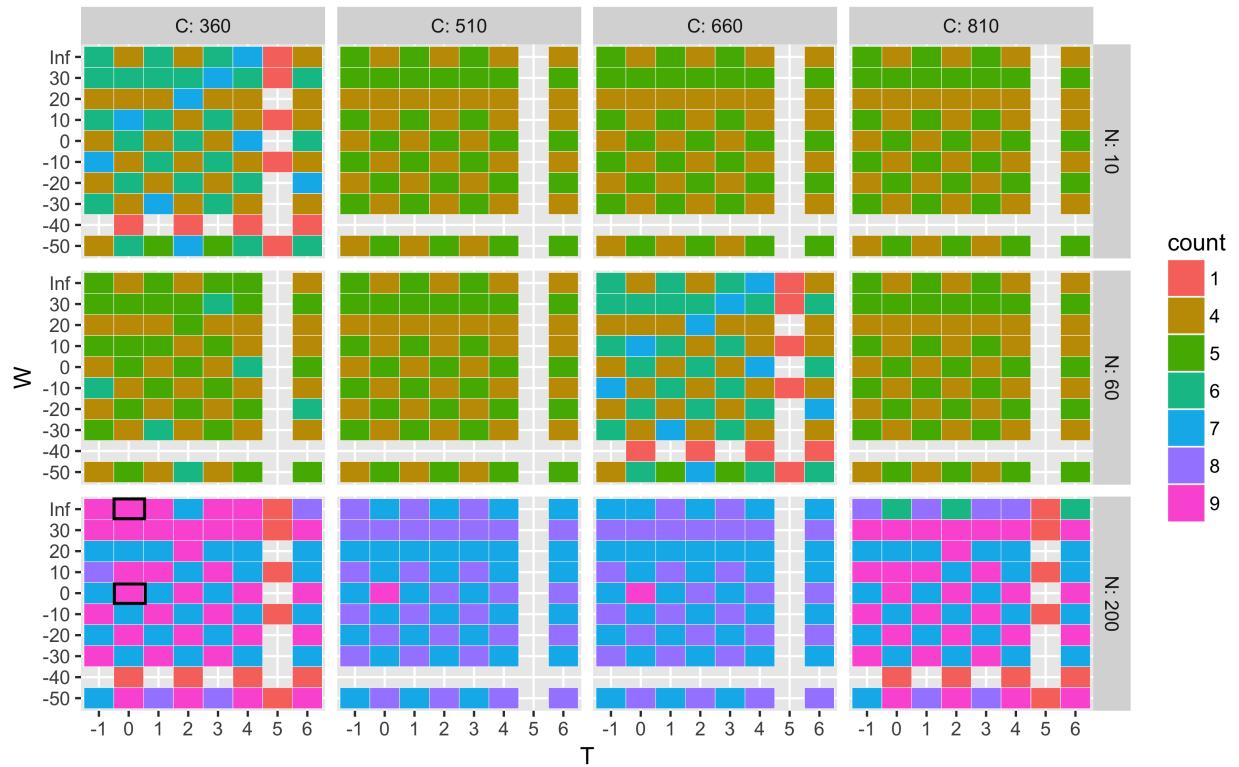


Figure S1: Tile heatmap illustrates number of model simulations provided for each of the scenarios in the variable space. The max number is 9, the number of models included in the emulator analysis (excluding three models not included in the emulator analysis). Normalized rrror calculations are run over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

2 Cultivation Areas

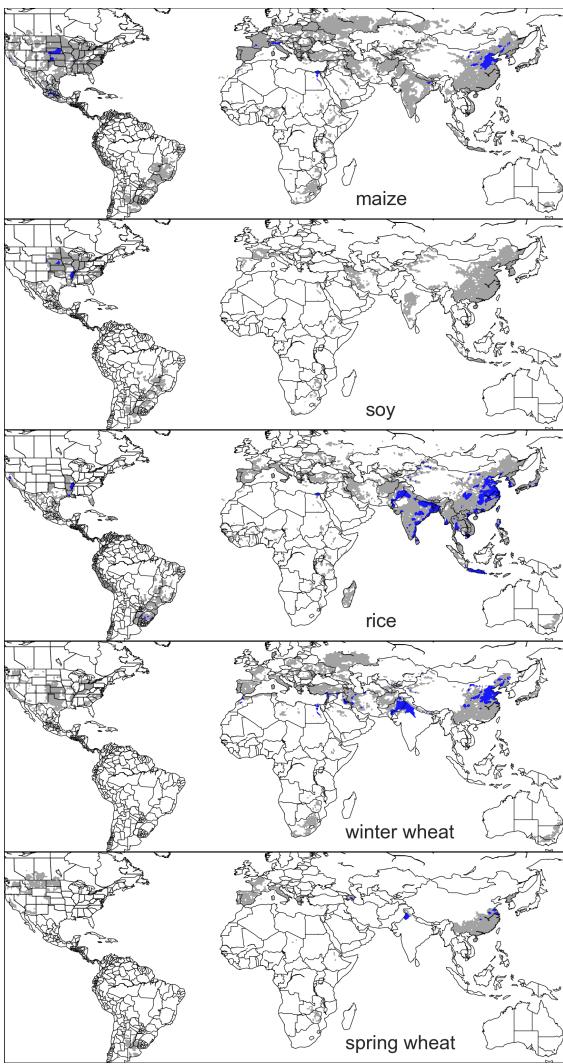


Figure S2: Presently cultivated area for irrigated crops in the real world. The blue contour area indicates grid-cells with more than 20,000 hectares of crop cultivated. The gray contour shows area with more than 10 hectares cultivated. Data from the MIRCA2000 data set for maize, rice, and soy. Winter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

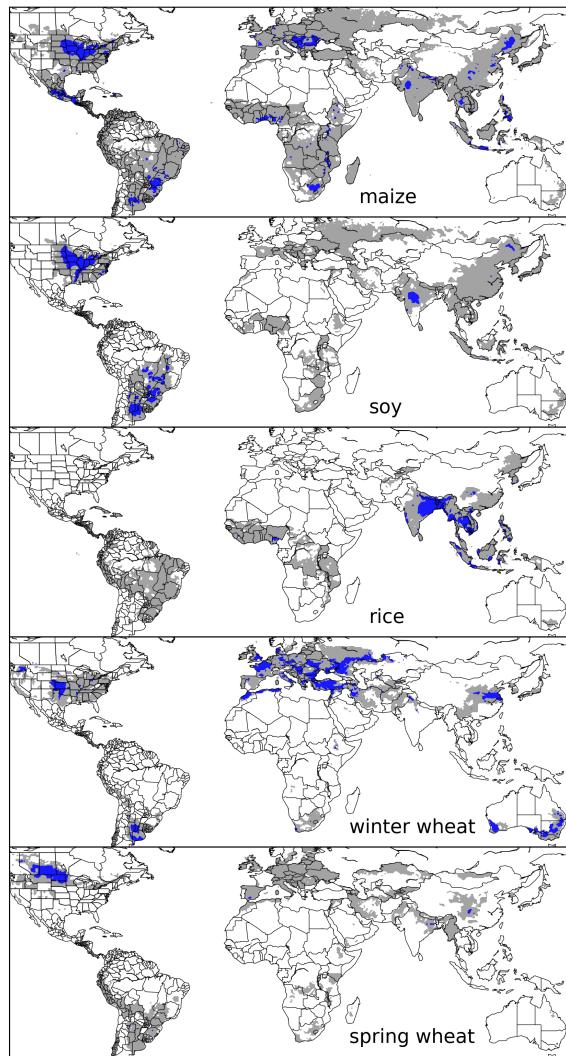


Figure S3: Presently cultivated area for rain fed crops in the real world. Conventions as in Figure S1.

2.1 Year-to-year vs climatological mean

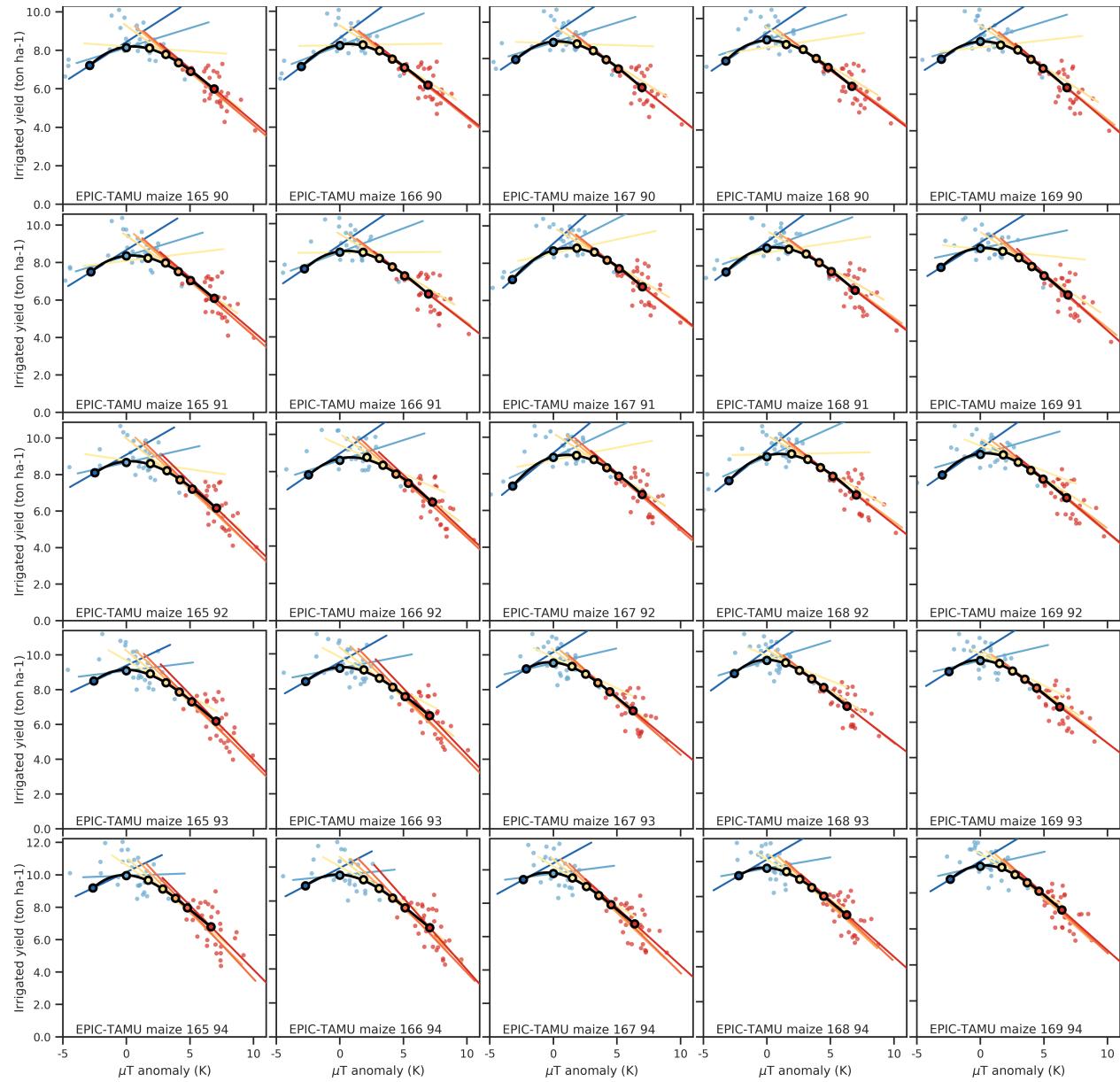


Figure S4: Same convention as main text Figure 1 except for multiple gricells in iowa for maize for the EPIC-TAMU model.

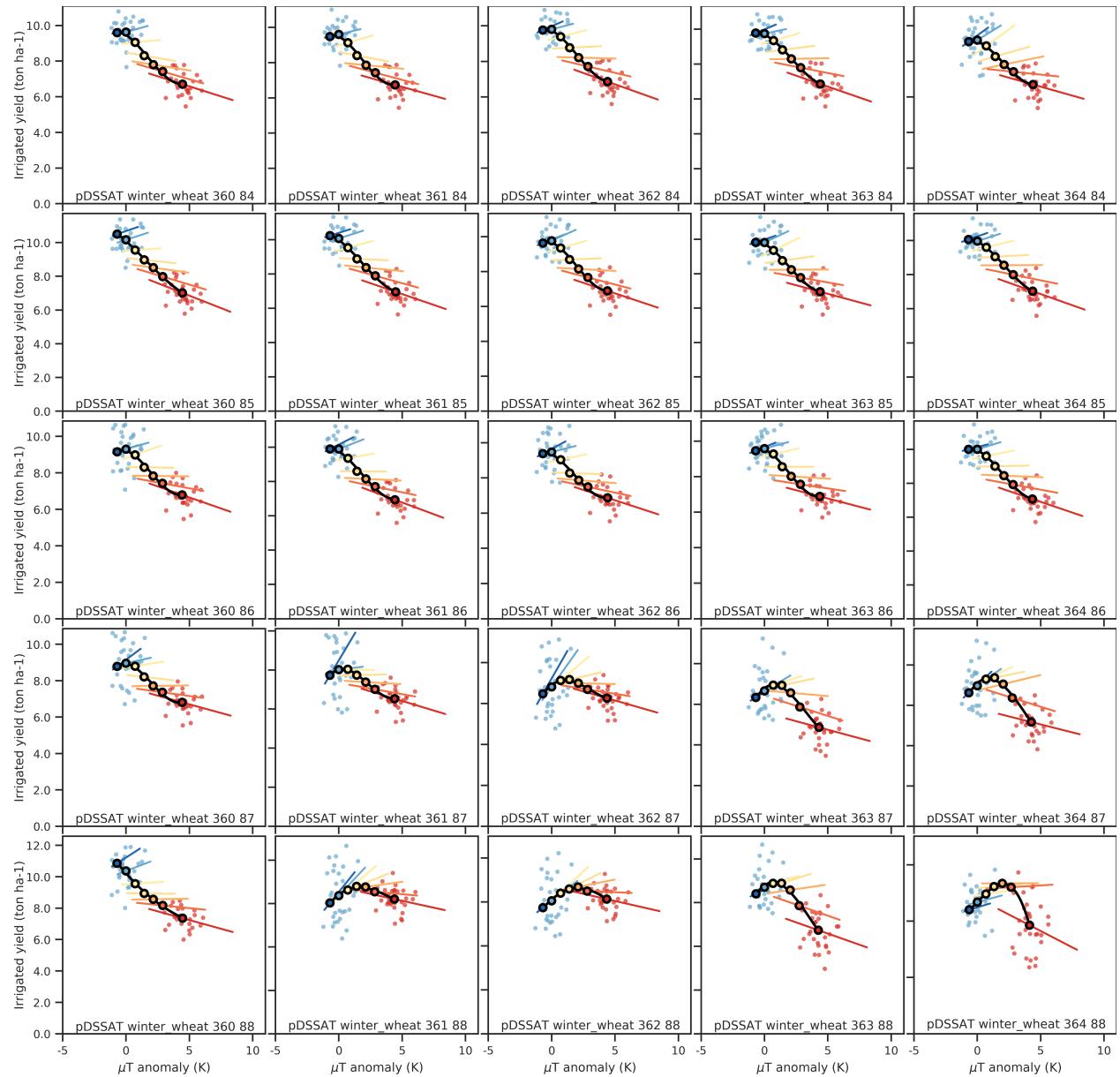


Figure S5: Same convention as above except for winter wheat in France for the pDSSAT model.

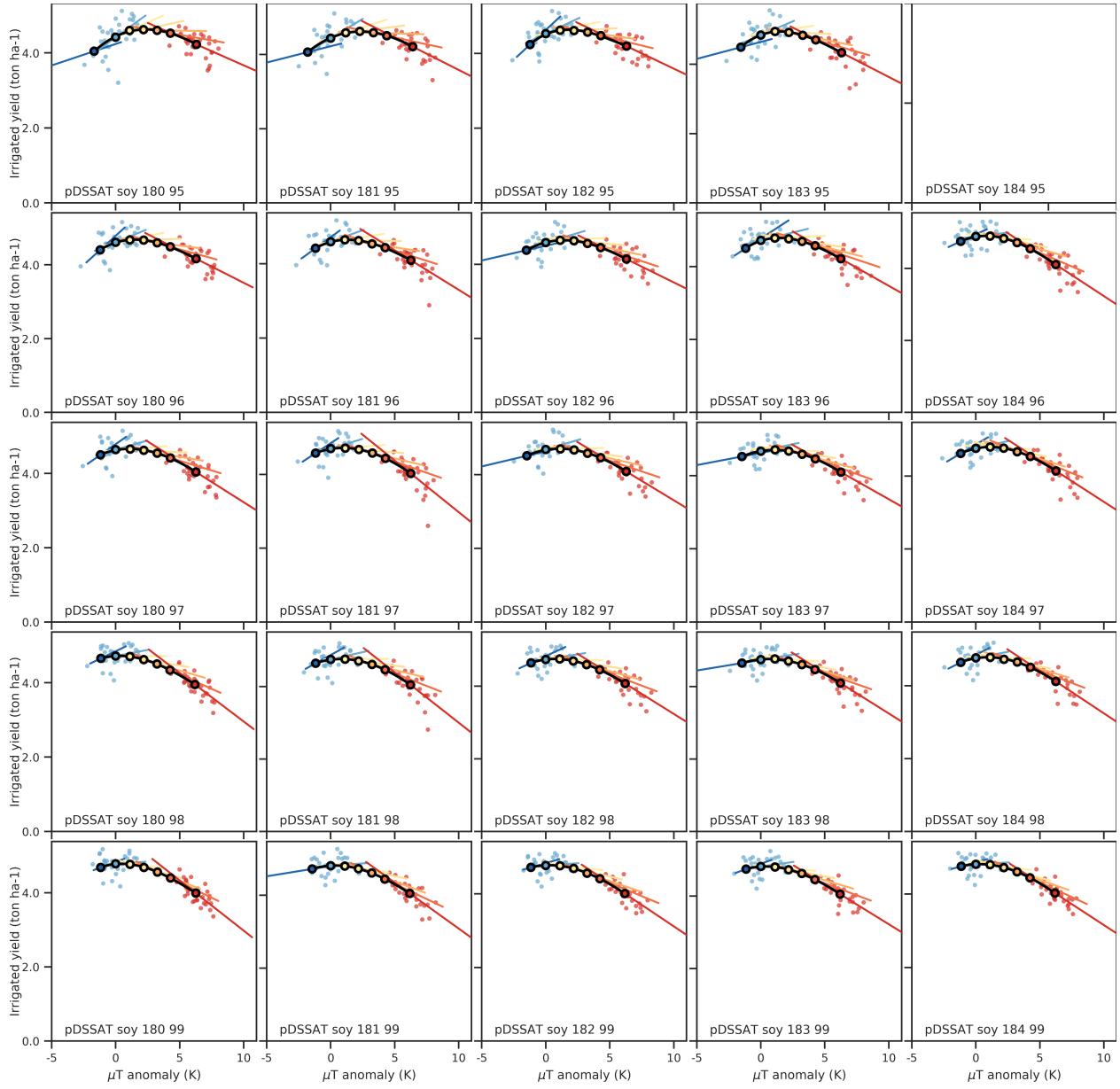


Figure S6: Same convention as above except for soy in Illinois for the pDSSAT model.

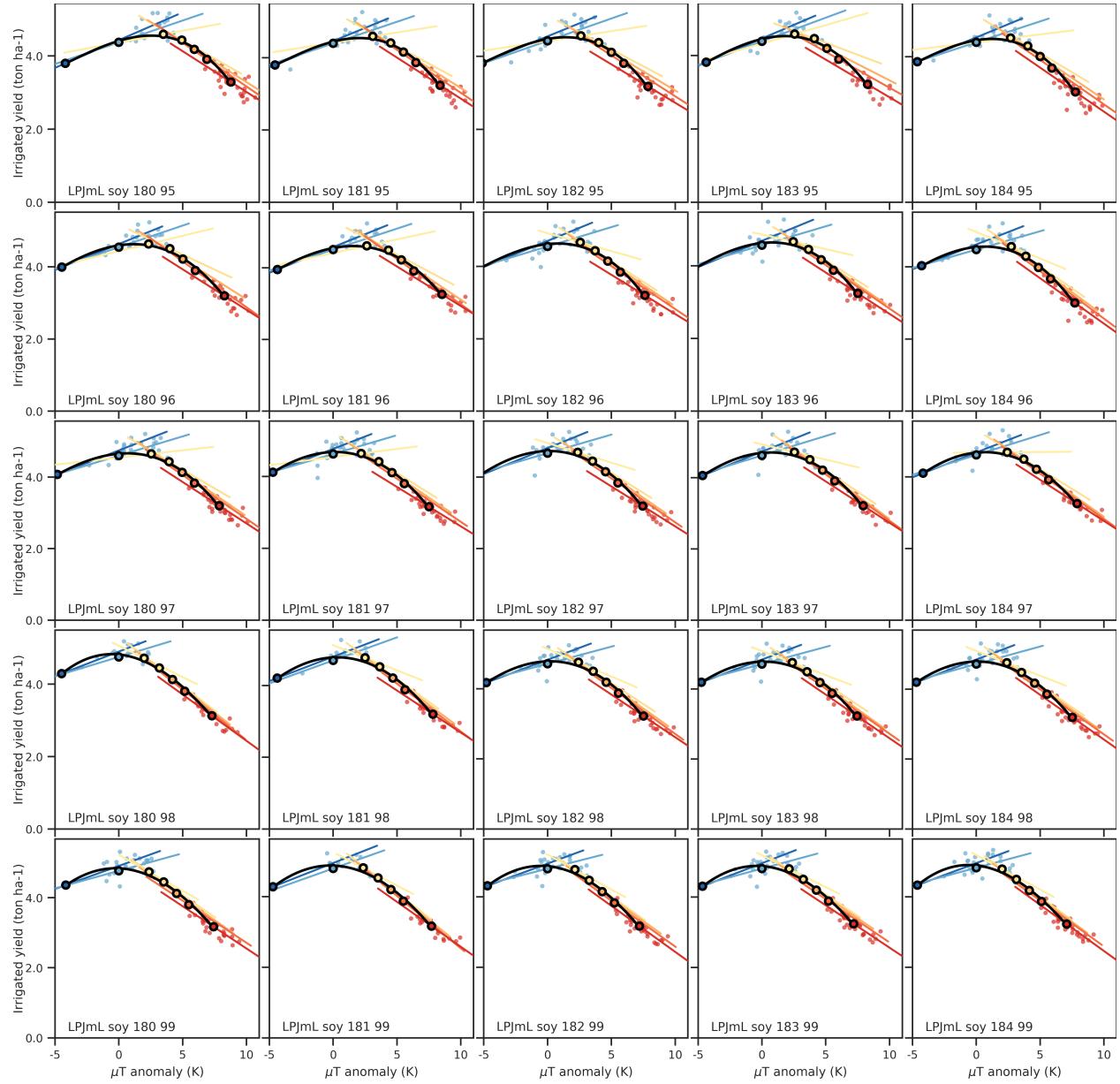


Figure S7: Same convention as above except for soy in Illinois for the LPJmL model.

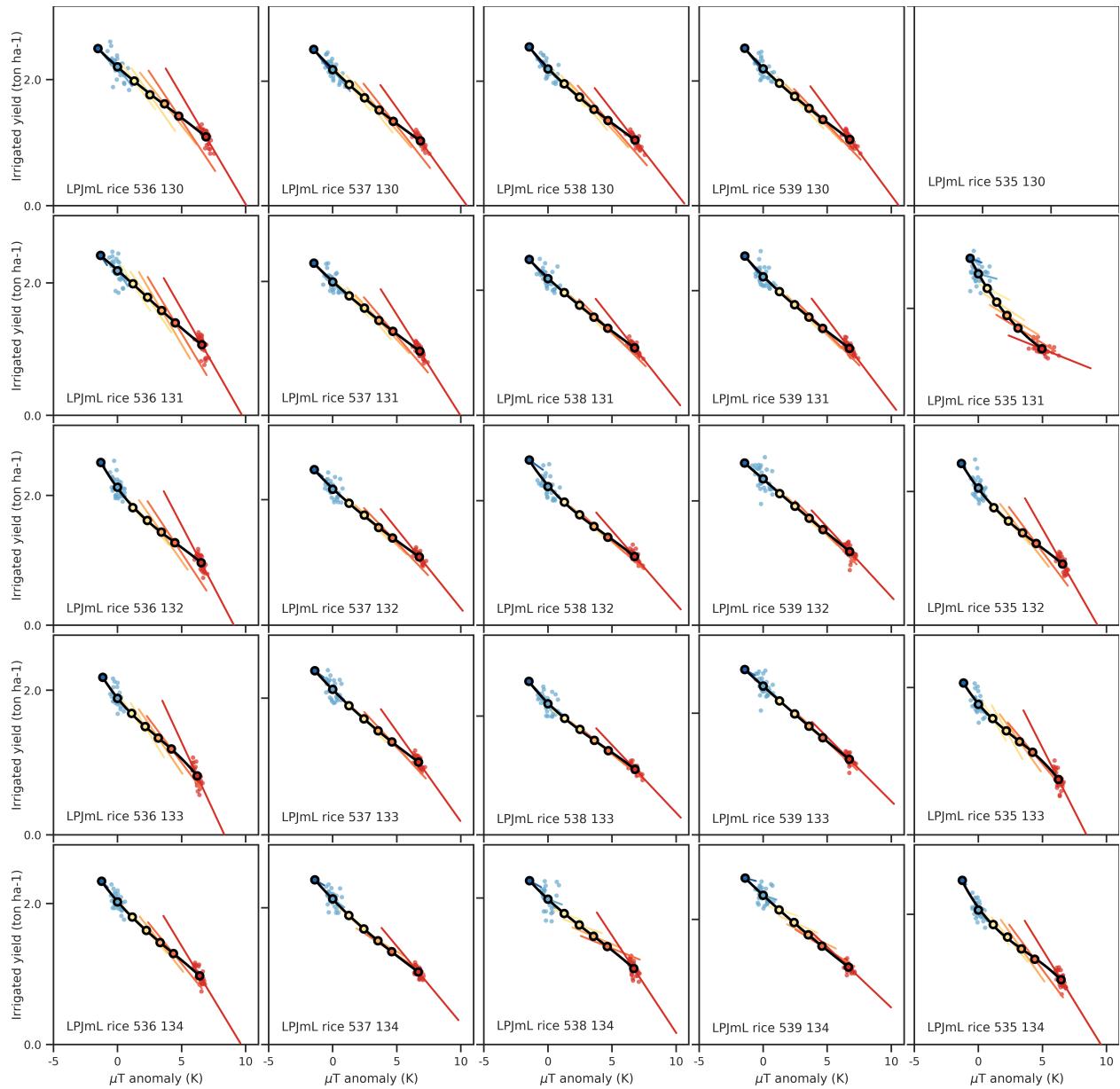


Figure S8: Same convention as above except for rice in India/Bangladesh for the LPJmL model.

2.2 Yield Response

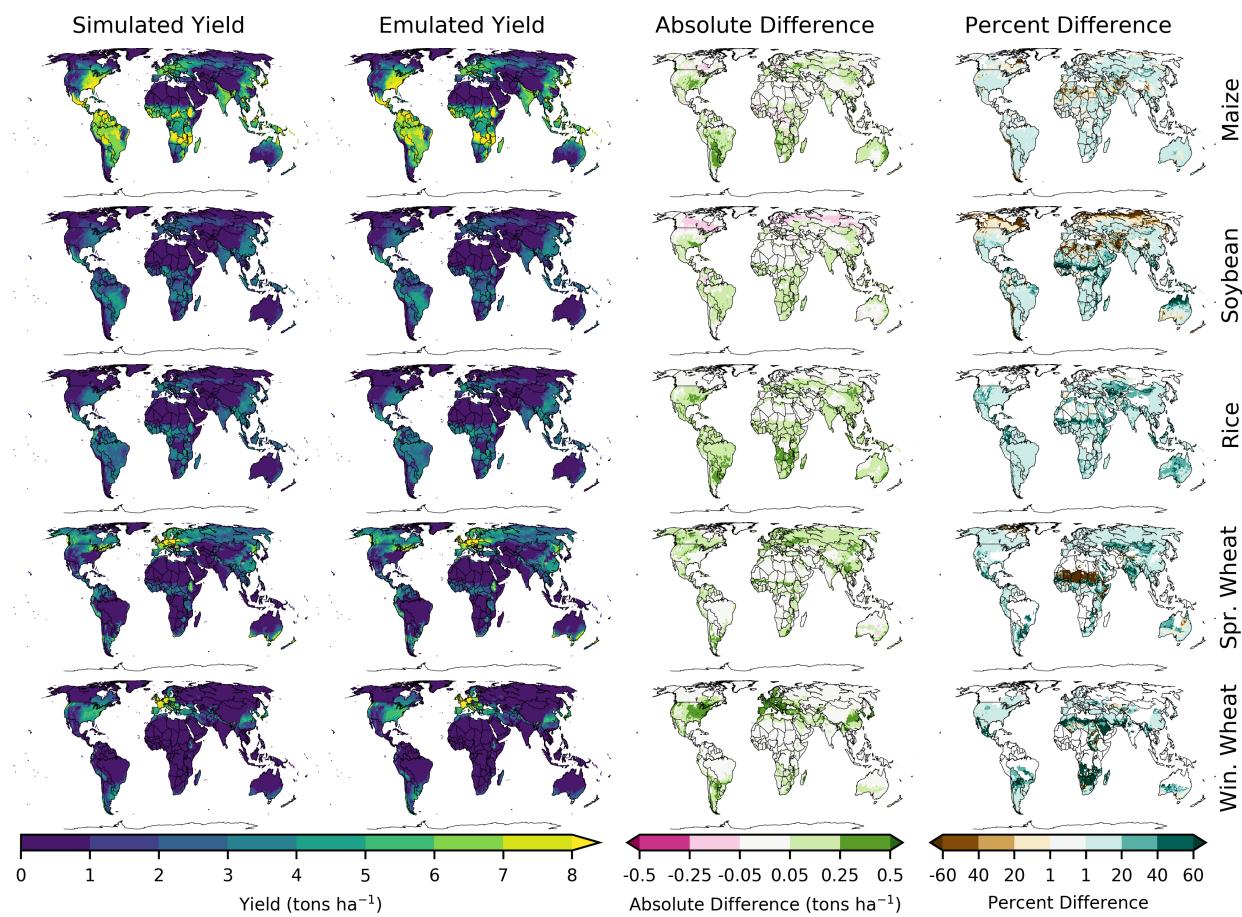


Figure S9: Same convention as Figure 4 in the main text except now for all crops.

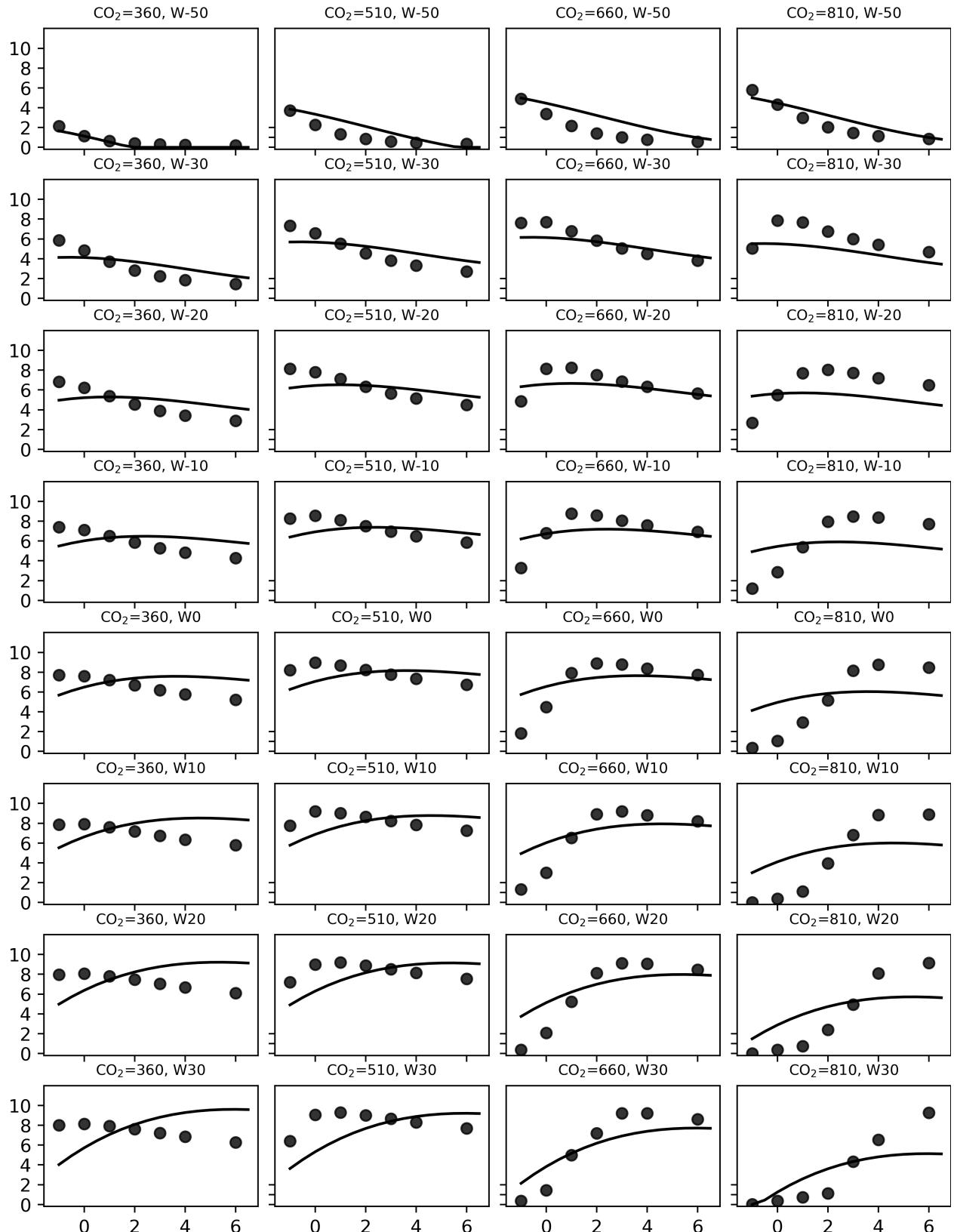


Figure S10: Example of emulator failure. Simulated and emulated values for JULES soybean in Southern Germany. RMSE = 41% of baseline yield.

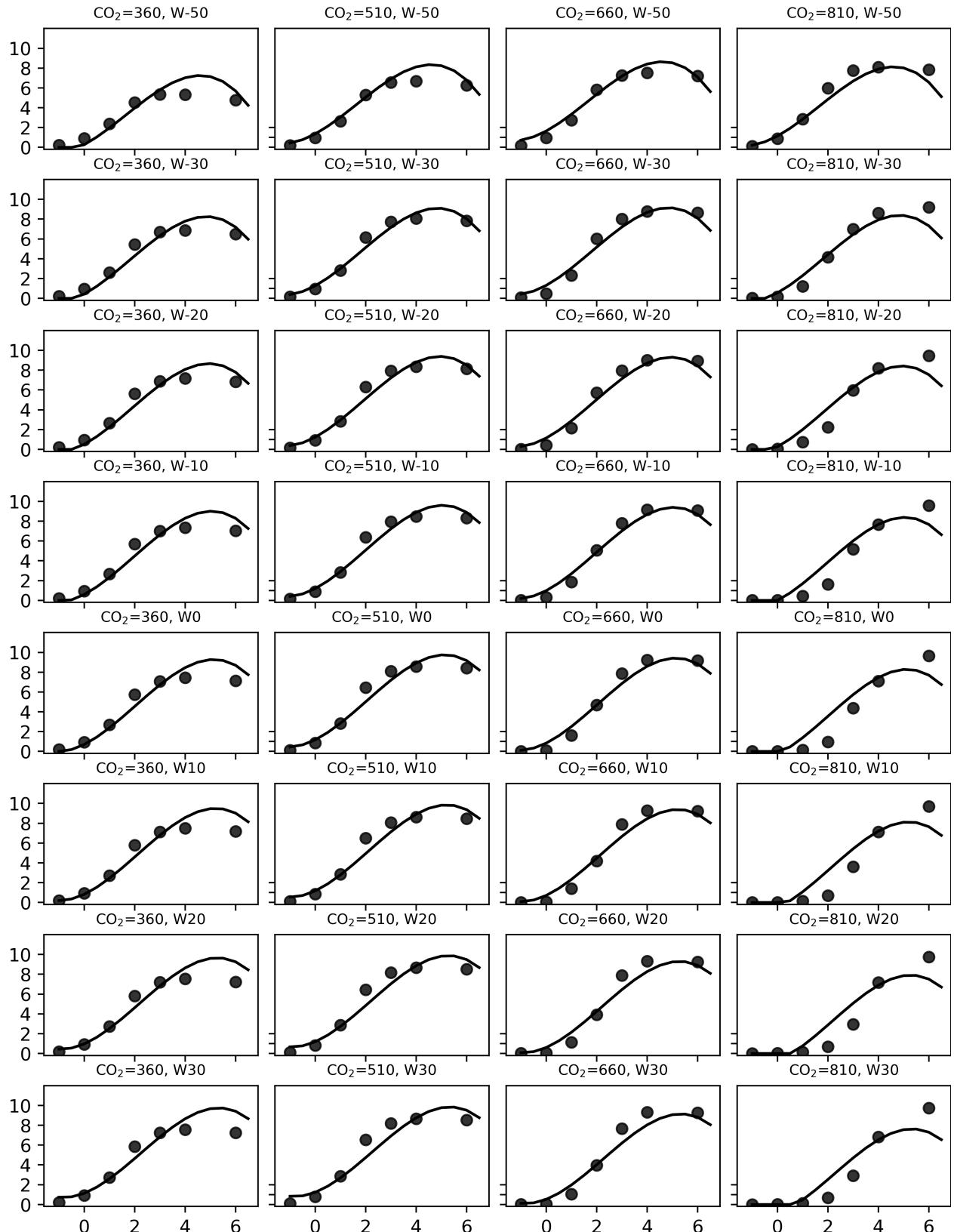


Figure S11: Example of emulator failure. Simulated and emulated values for JULES soybean in Southern Germany (one grid-cell south of Figure S10). RMSE = 10% of baseline yield.

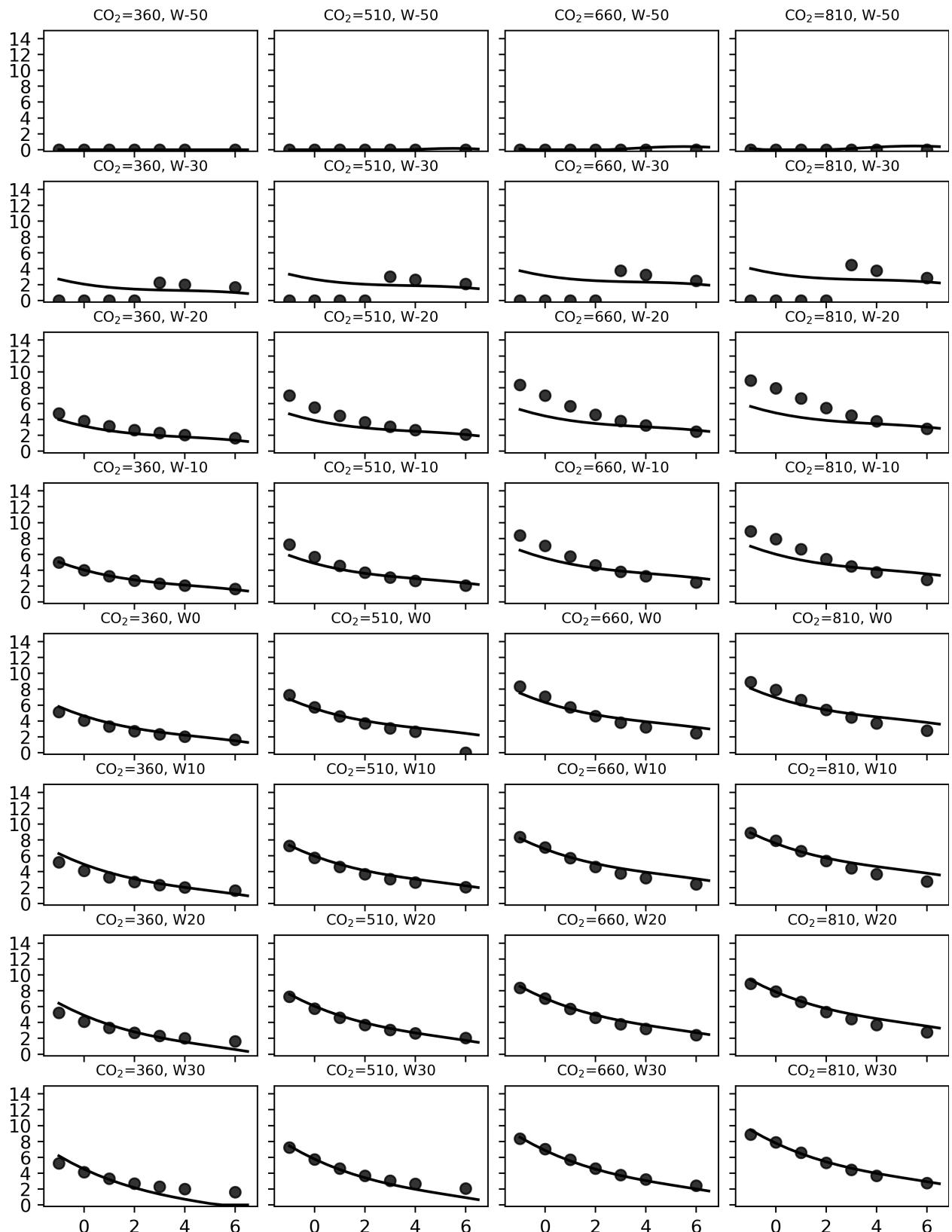


Figure S12: Example of emulator failure. Simulated and emulated values for PROMET rice in Papua New Guinea. RMSE = 67% of baseline yield.

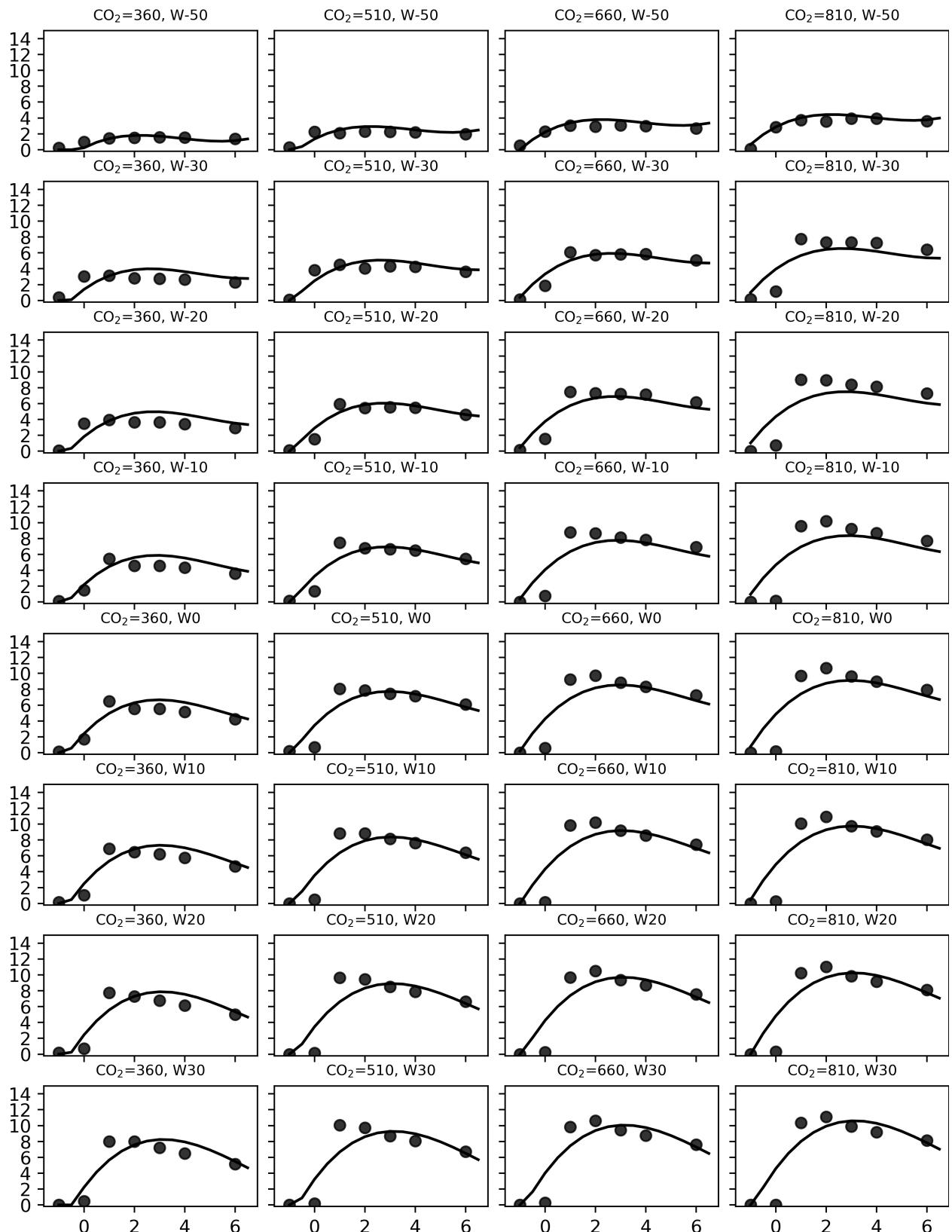


Figure S13: Example of emulator failure. Simulated and emulated values for PROMET rice in Arunachal Pradesh. RMSE = 132% of baseline yield.

2.3 Normalized Error

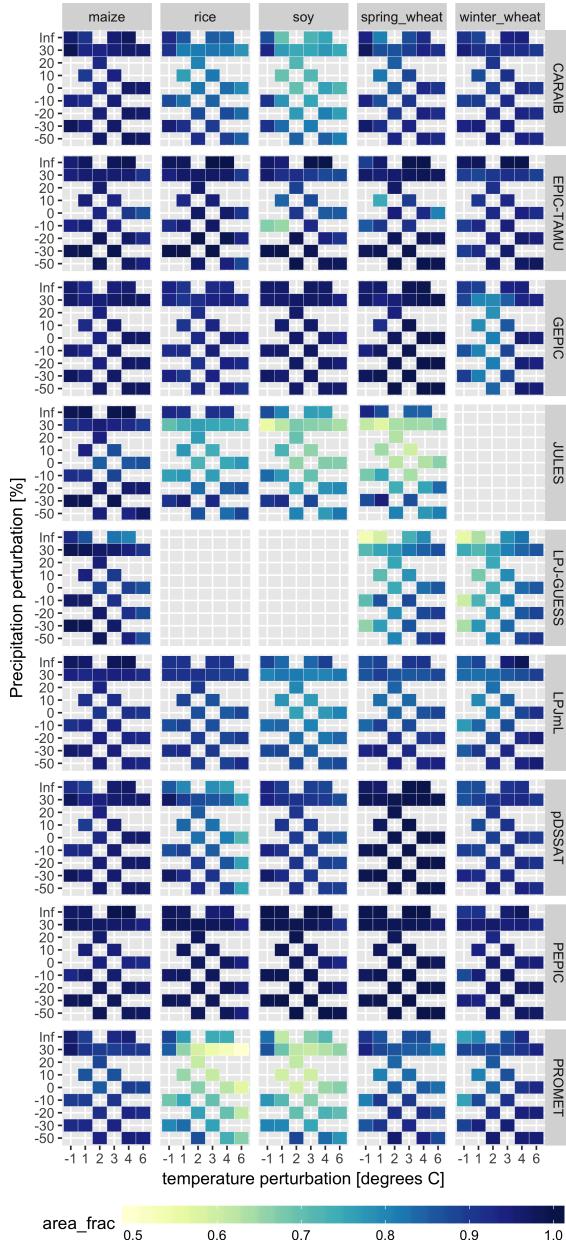


Figure S14: The fraction of grid cells (across all grid cells) with normalized emulation error less than 1 for the CO₂=360 ppm and 200 kg N ha⁻¹ yr⁻¹ case for the temperature and precipitation perturbations scenarios provided by all 9 models included in the emulator analysis. This is in contrast to the fraction of currently cultivated hectares shown in the C360 case in the manuscript and for the C810 case show in the supplemental material. The emulator is marginally more successful over currently cultivated areas than over all grid cells in general.

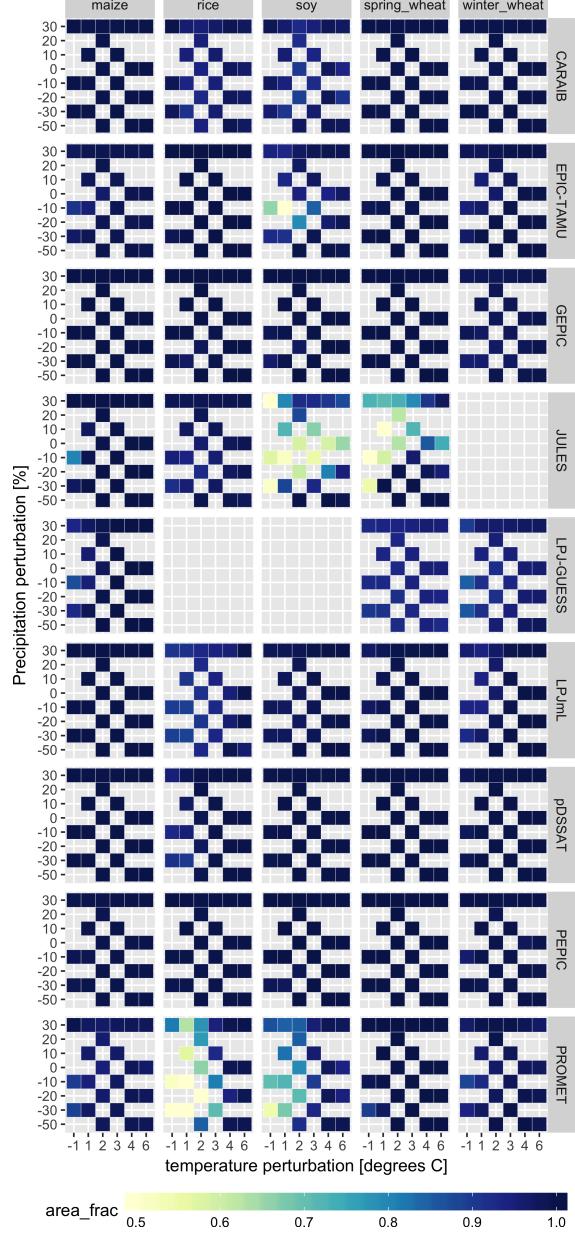


Figure S15: The fraction of currently cultivated hectares with normalized emulation error less than 1 (blue colors contours in Figure A2) for the CO₂=810 ppm and 200 kg N ha⁻¹ yr⁻¹ case for the temperature and precipitation perturbations scenarios provided by all 9 models included in the emulator analysis. 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).

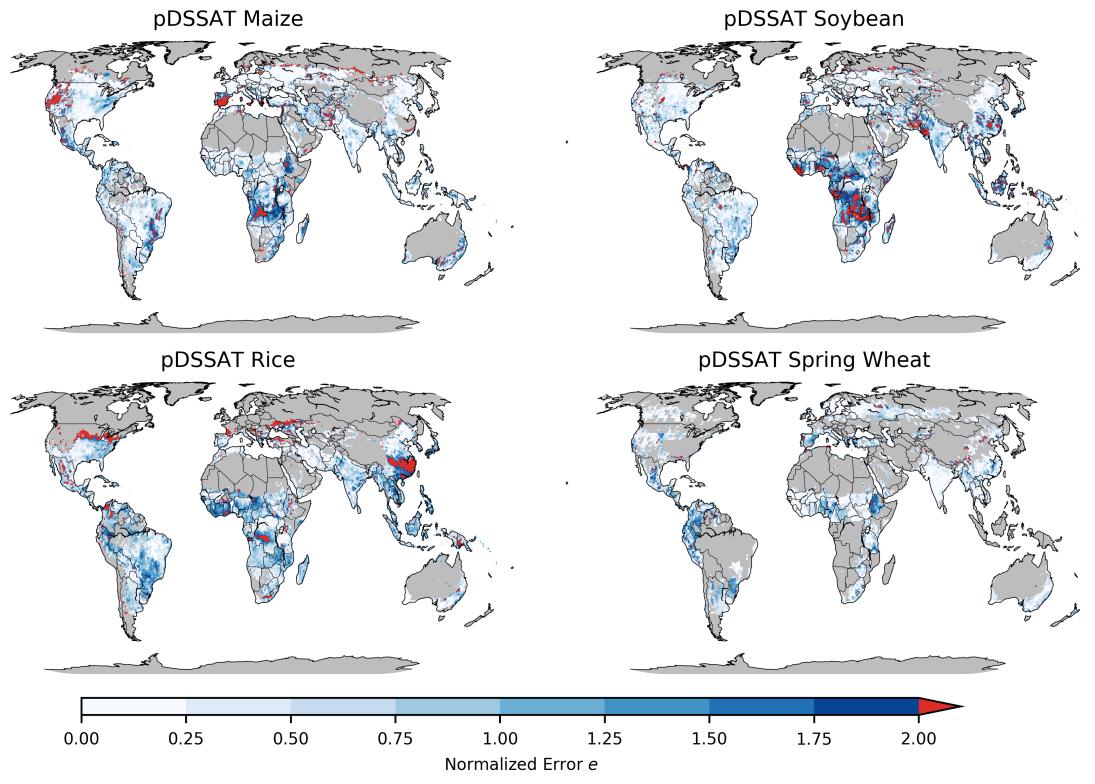


Figure S16: Same convention as main text Figure 8 except now for pDSSAT.

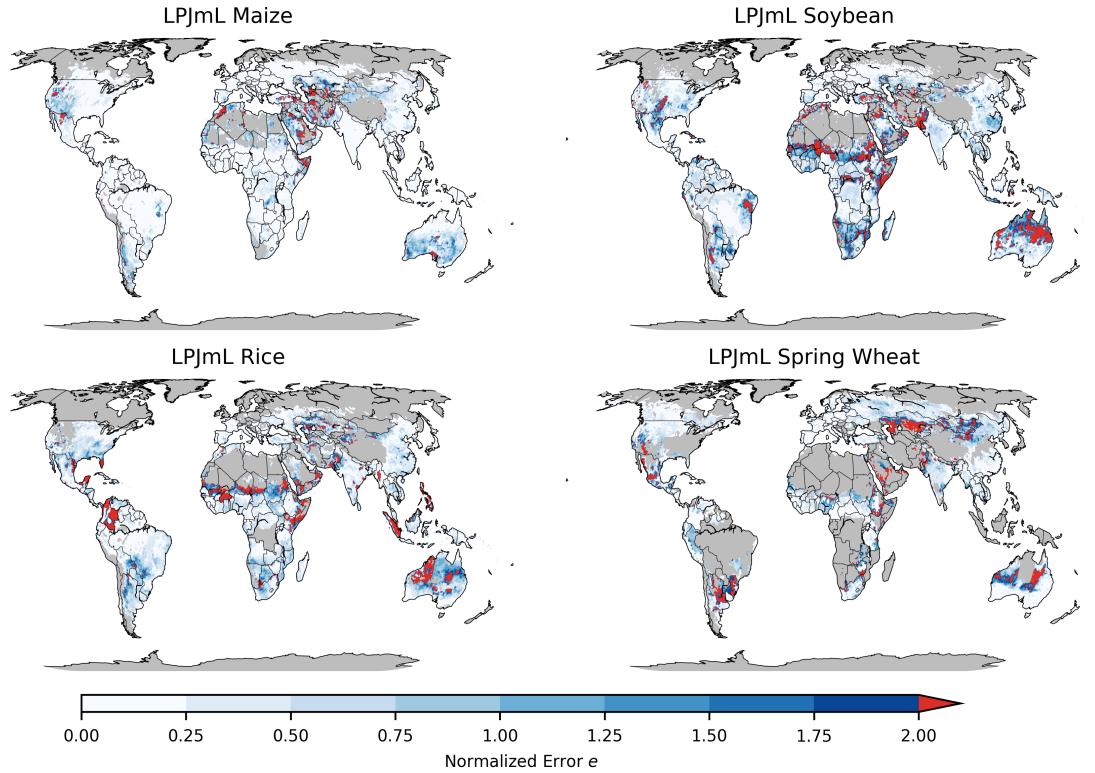


Figure S17: Same convention as main text Figure 8 except now for LPJmL.

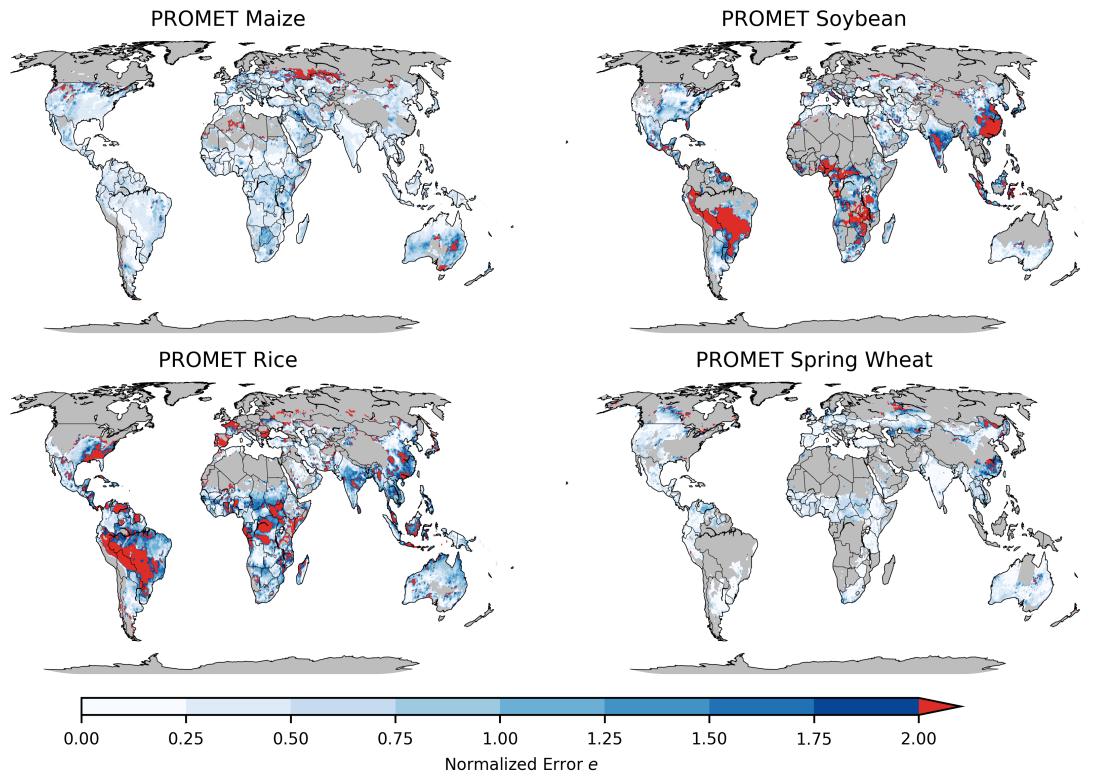


Figure S18: Same convention as main text Figure 8 except now for PROMET.

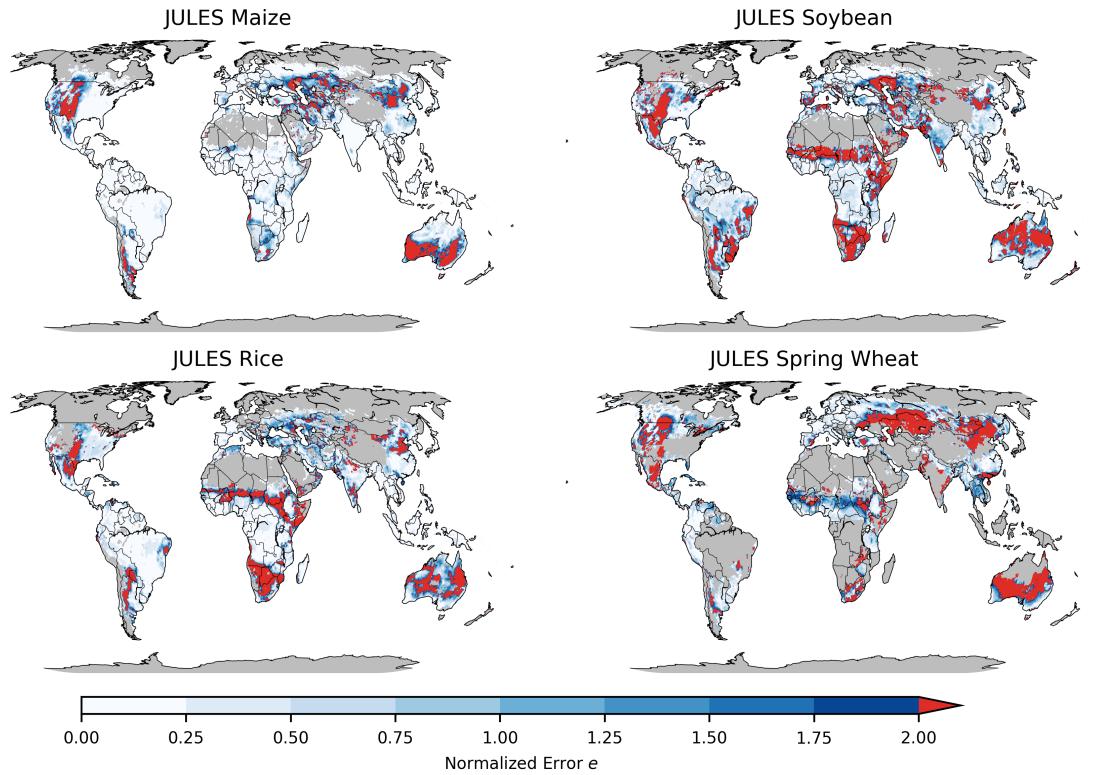


Figure S19: Same convention as main text Figure 8 except now for JULES.

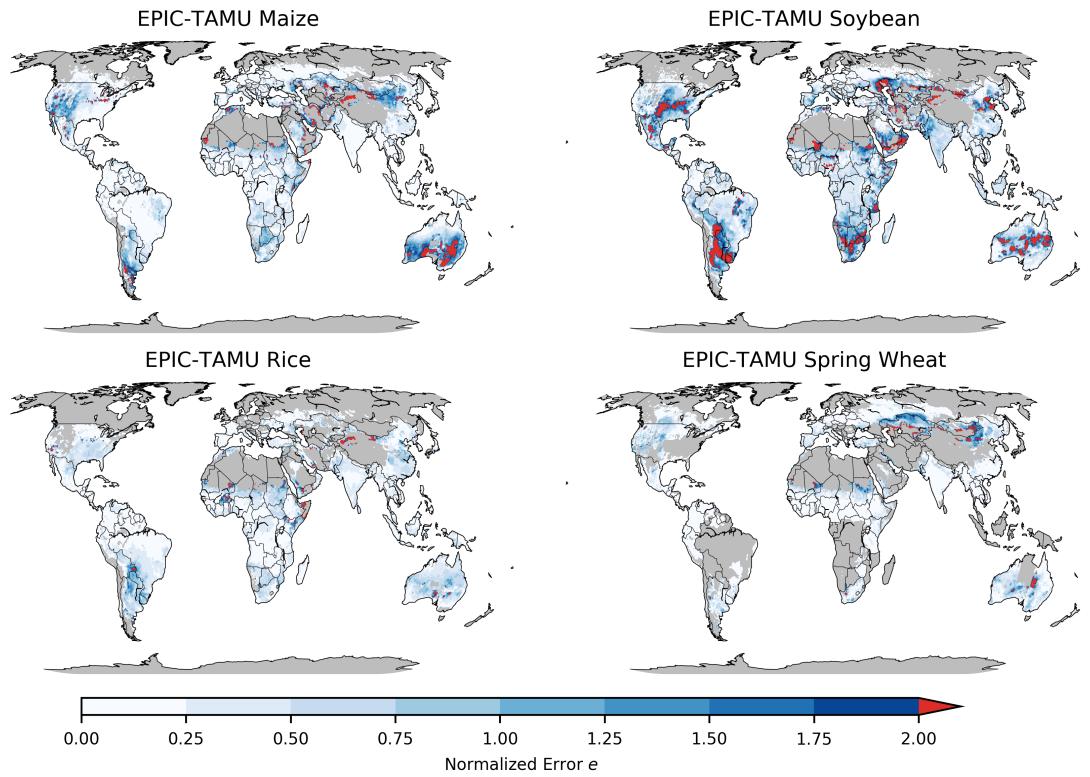


Figure S20: Same convention as main text Figure 8 except now for EPIC-TAMU.

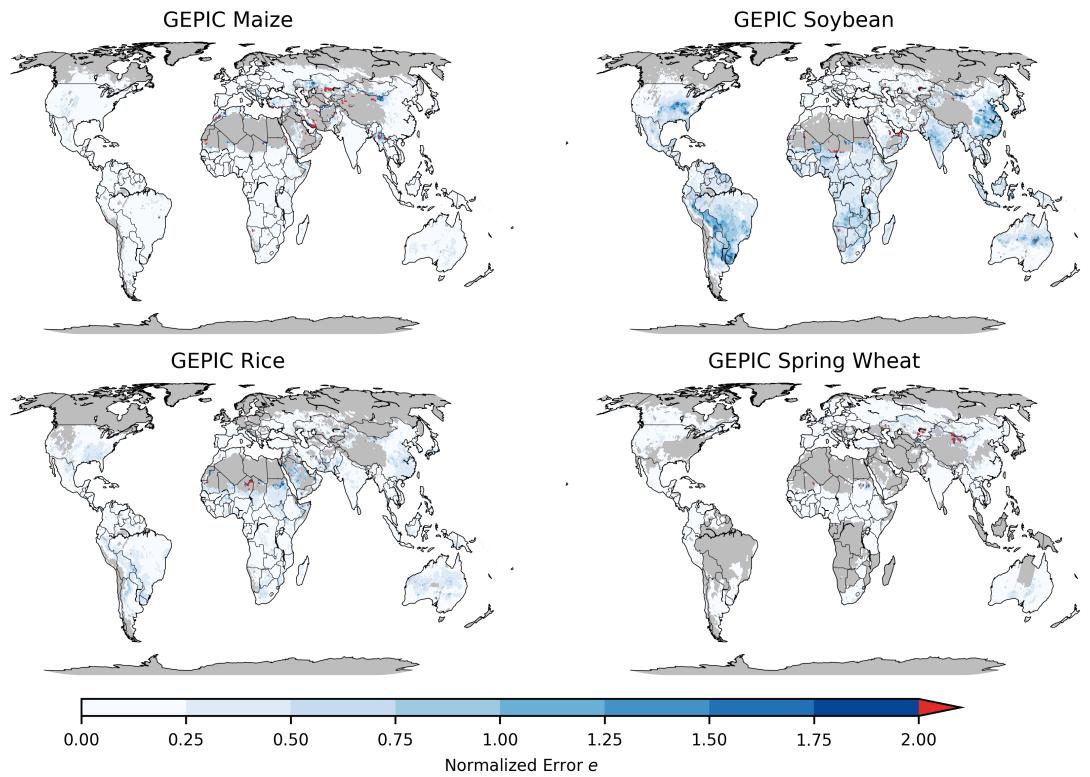


Figure S21: Same convention as main text Figure 8 except now for GEPIC.

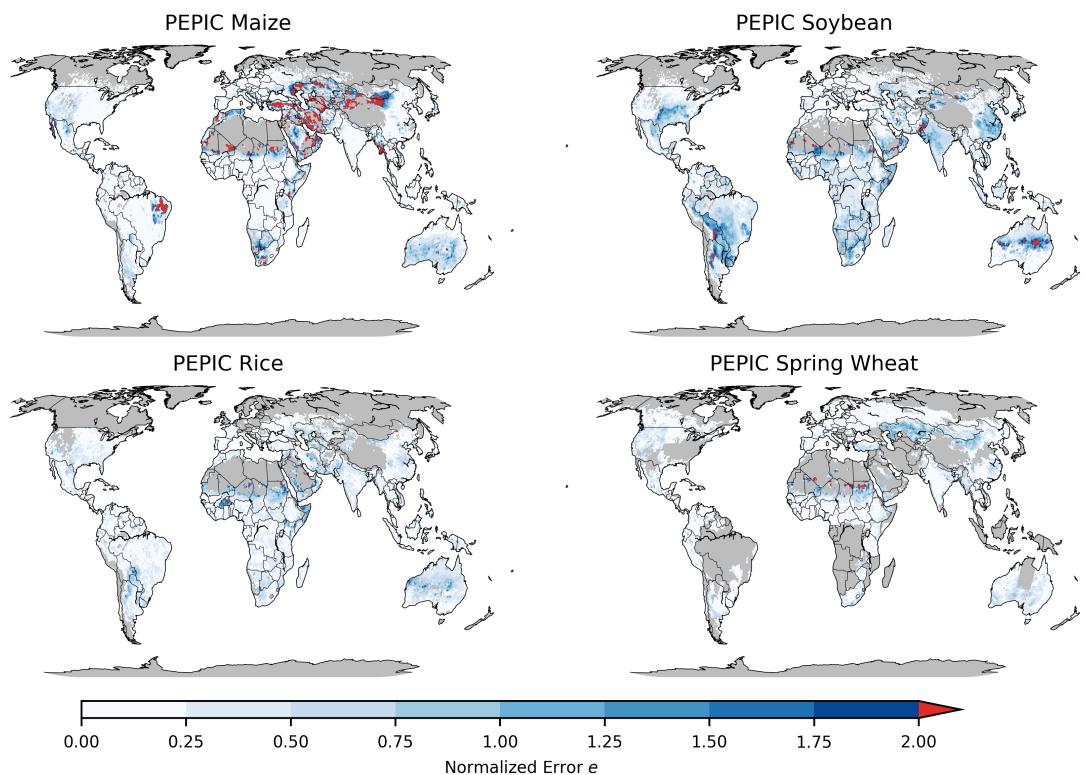


Figure S22: Same convention as main text Figure 8 except now for PEPIC.

2.4 Cross Validation

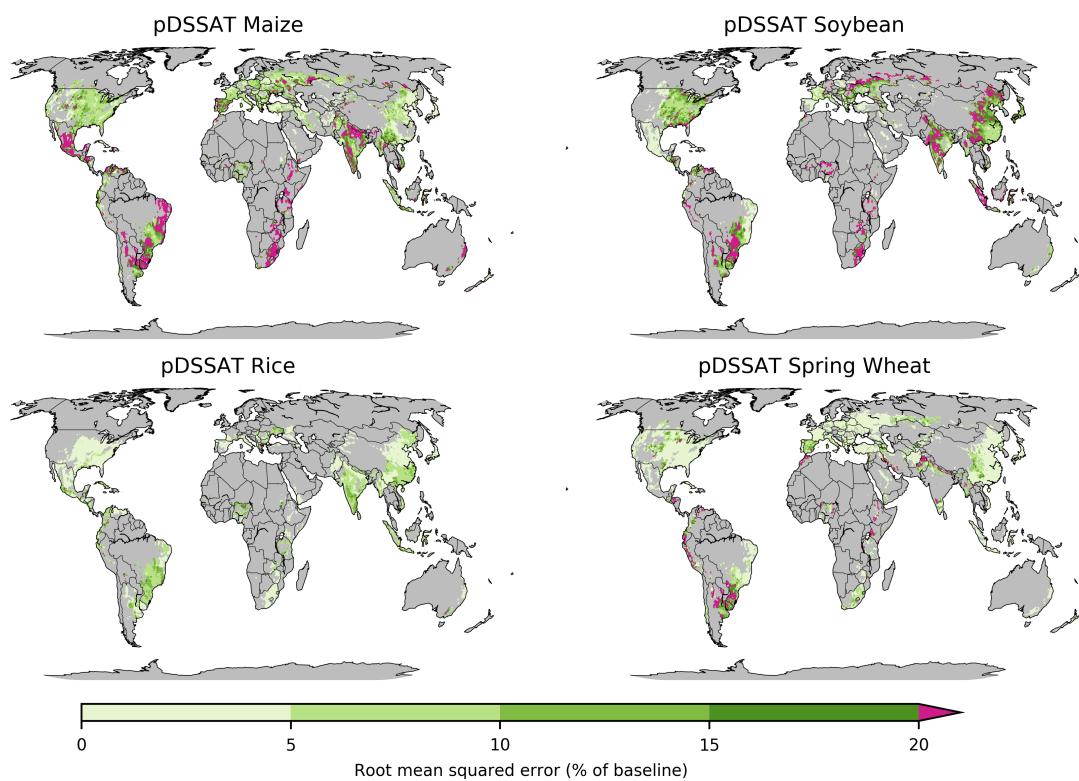


Figure S23: Root mean squared error for three-fold cross validation for the pDSSAT model for rainfed crops.

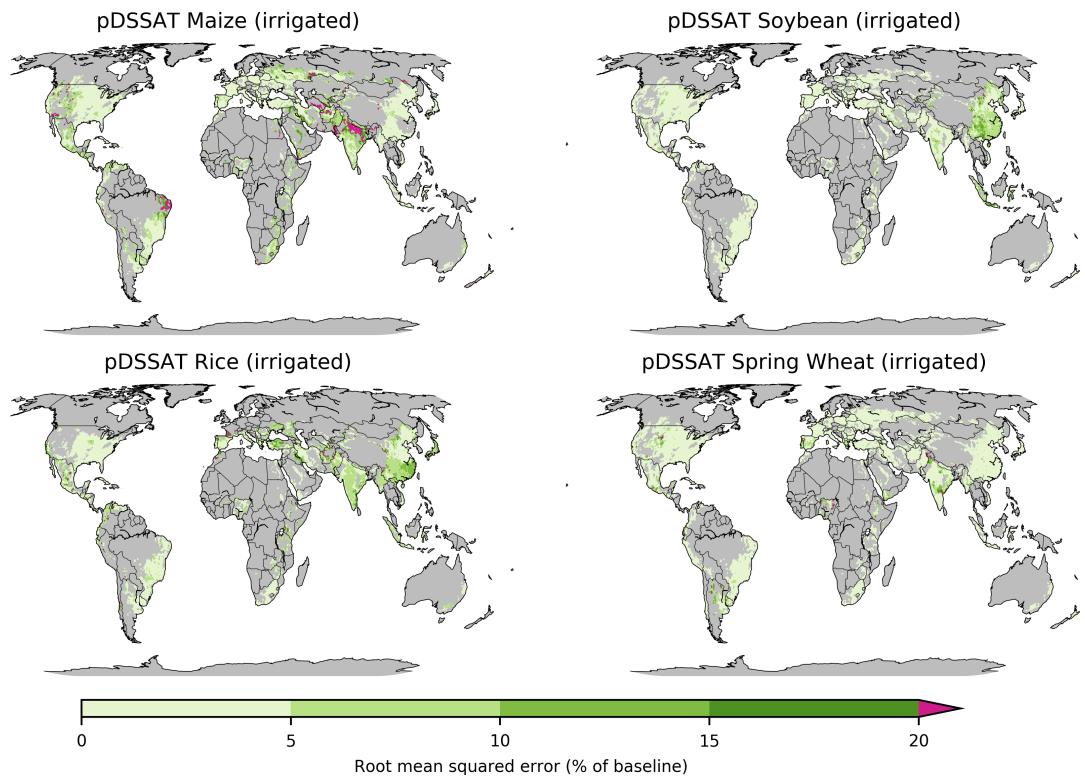


Figure S24: Same as above for irrigated simulations.

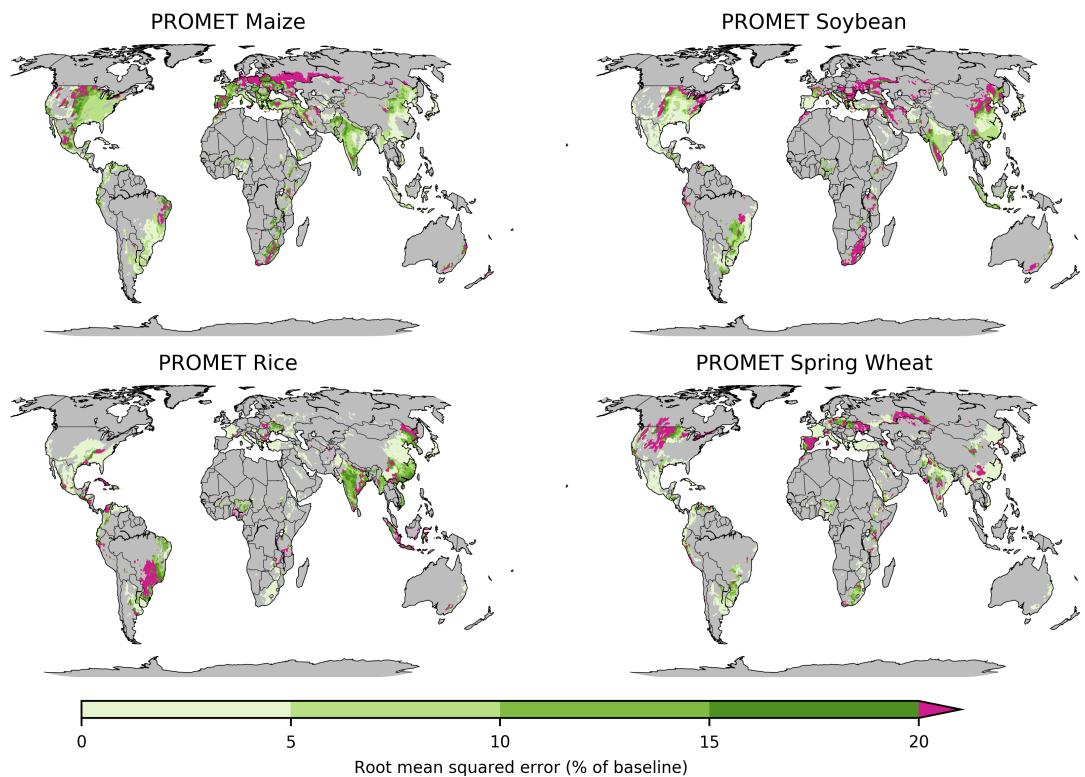


Figure S25: Map of root mean squared error for three fold cross validation process for the PROMET model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

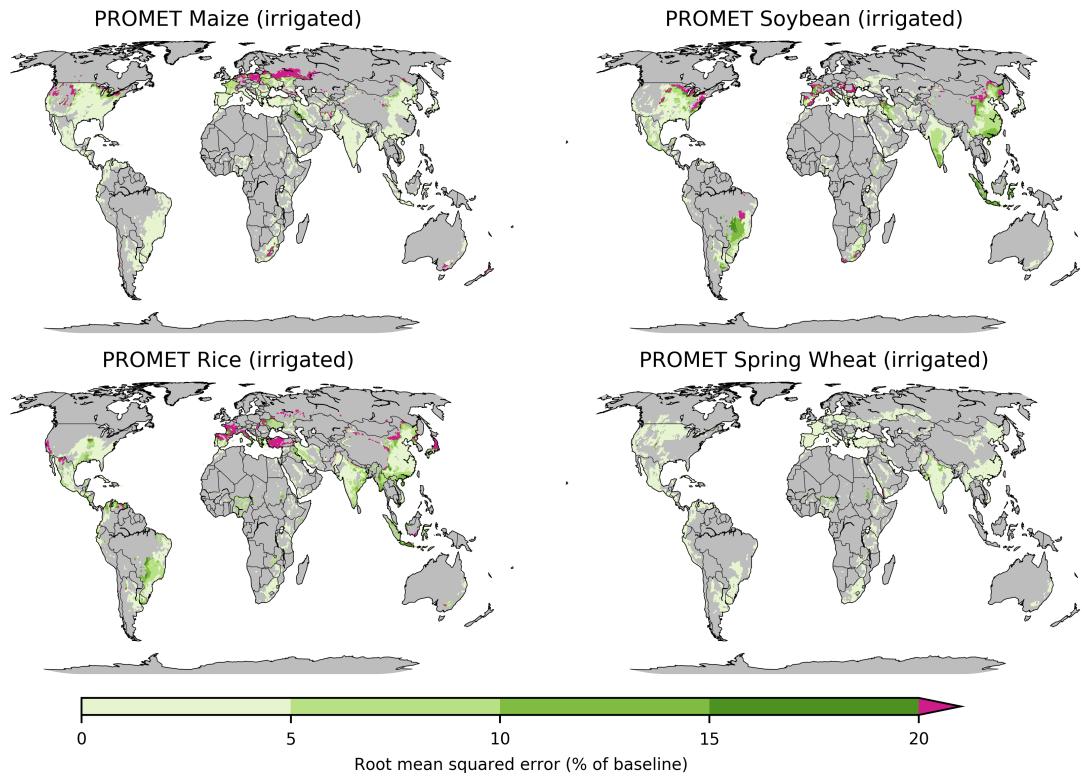


Figure S26: Same as above for irrigated simulations.

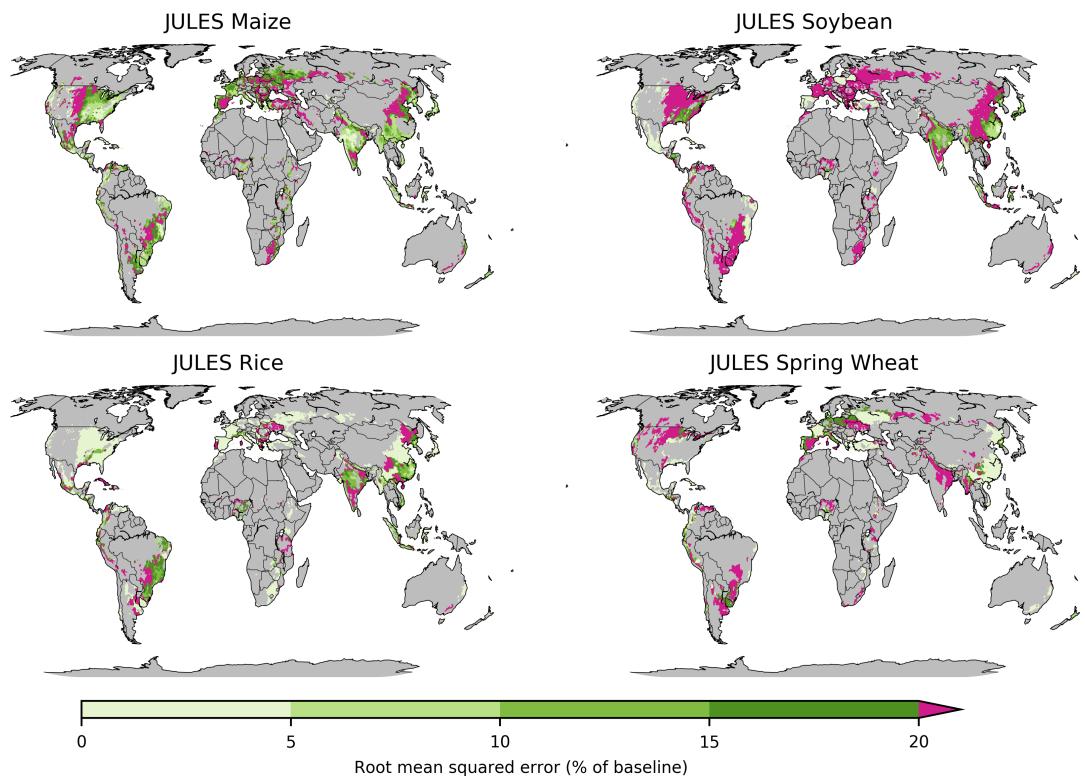


Figure S27: Map of root mean squared error for three fold cross validation process for the JULES model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

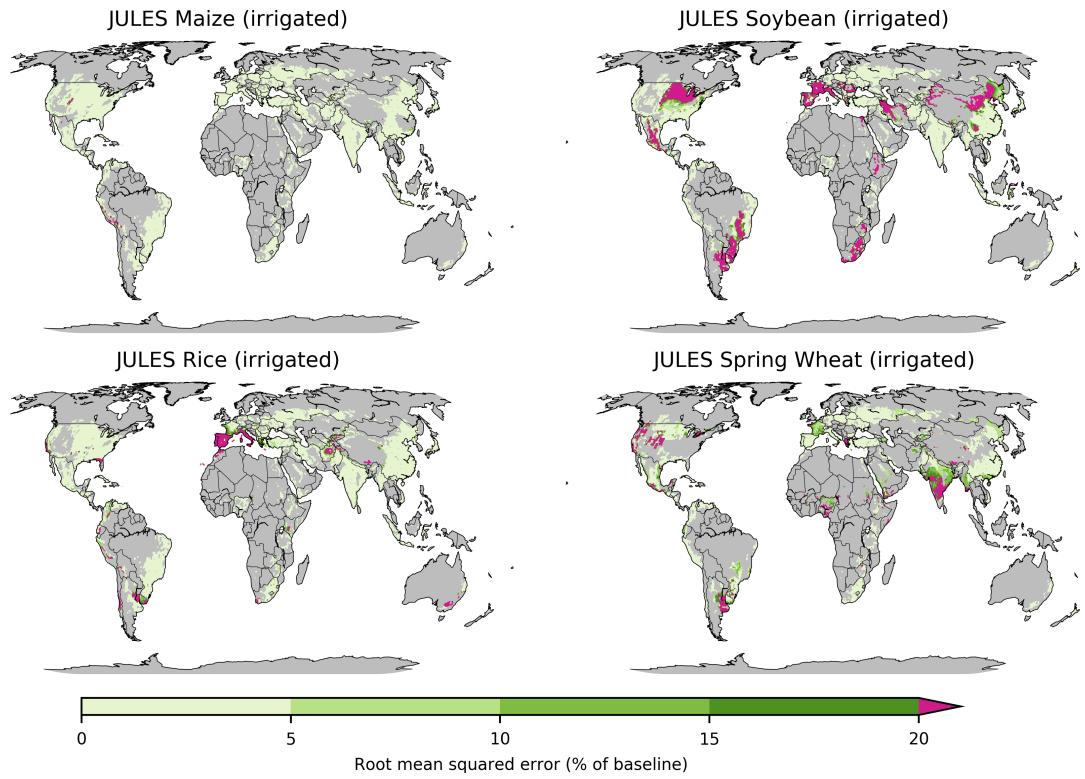


Figure S28: Same as above for irrigated simulations.

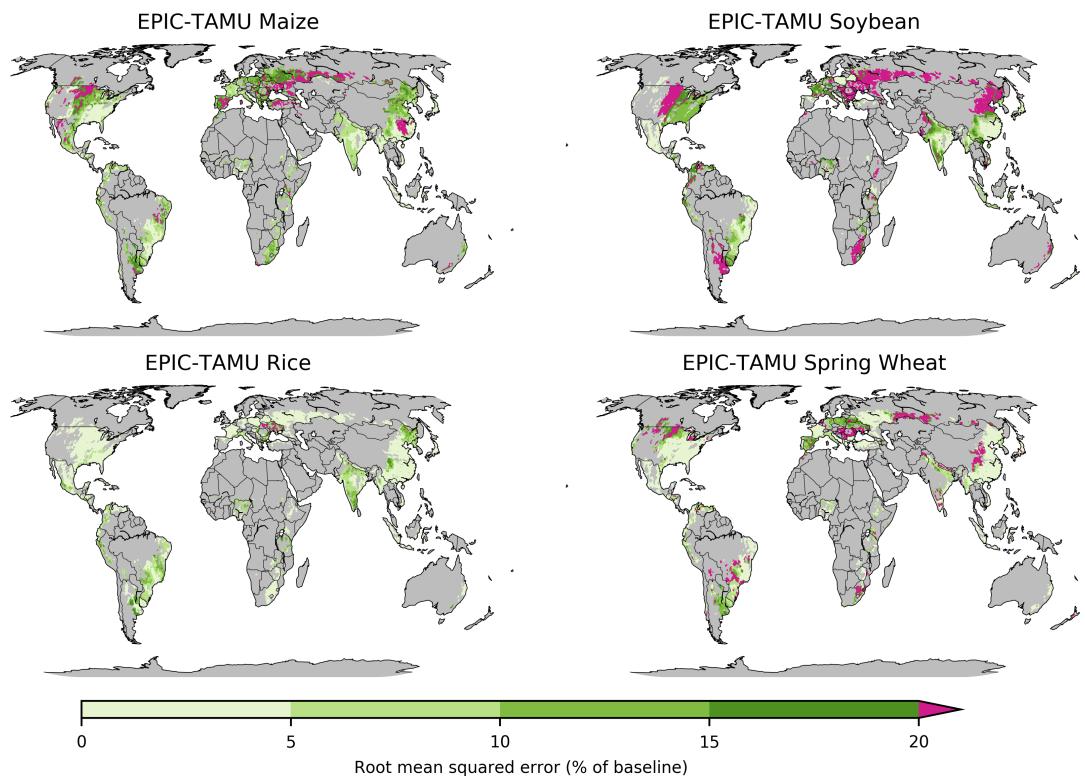


Figure S29: Map of root mean squared error for three fold cross validation process for the EPIC-TAMU model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

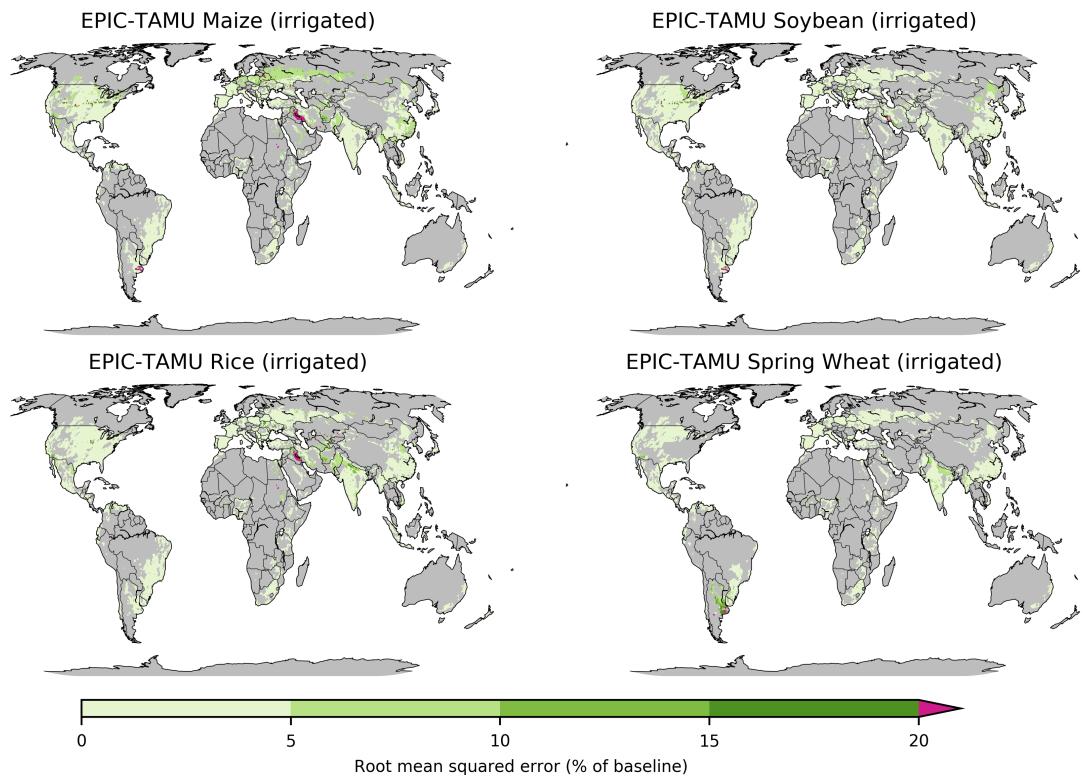


Figure S30: Same as above for irrigated simulations.

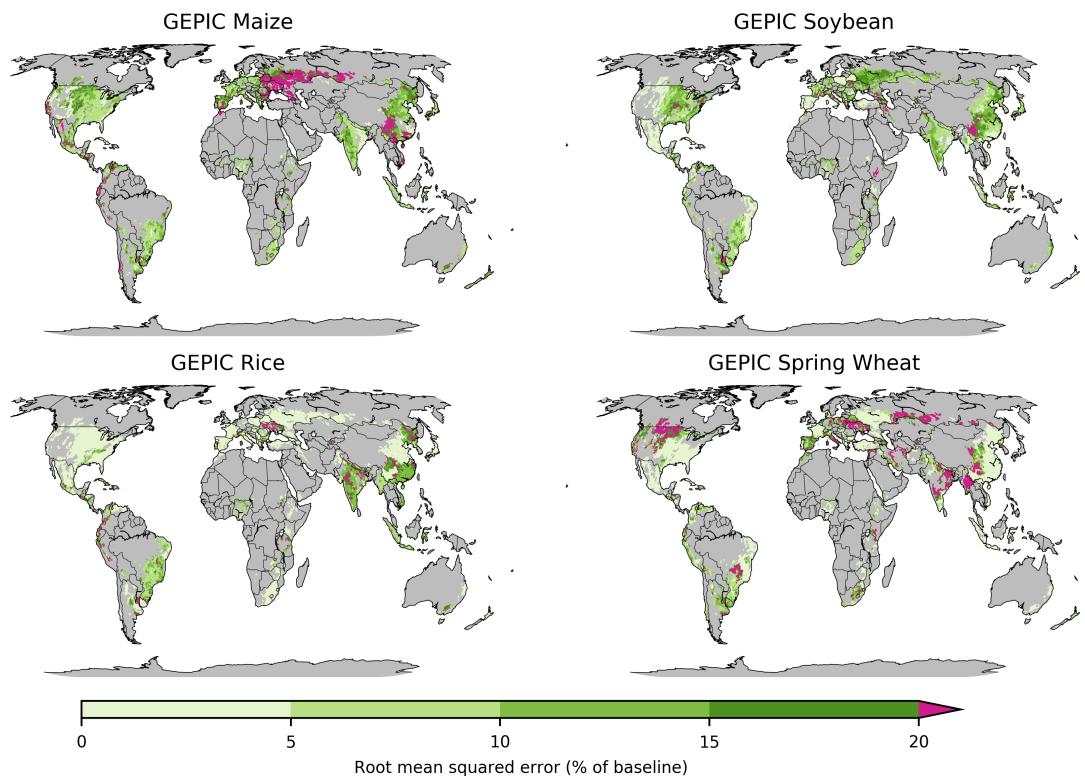


Figure S31: Map of root mean squared error for three fold cross validation process for the GEPIC model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

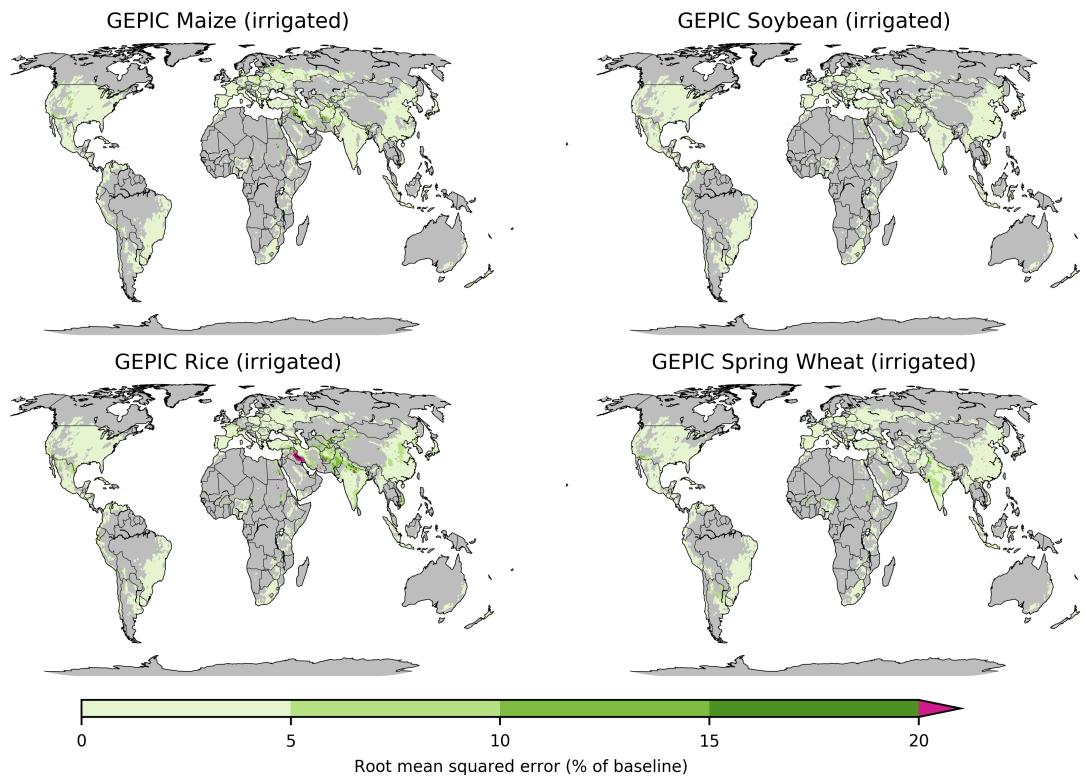


Figure S32: Same as above for irrigated simulations.

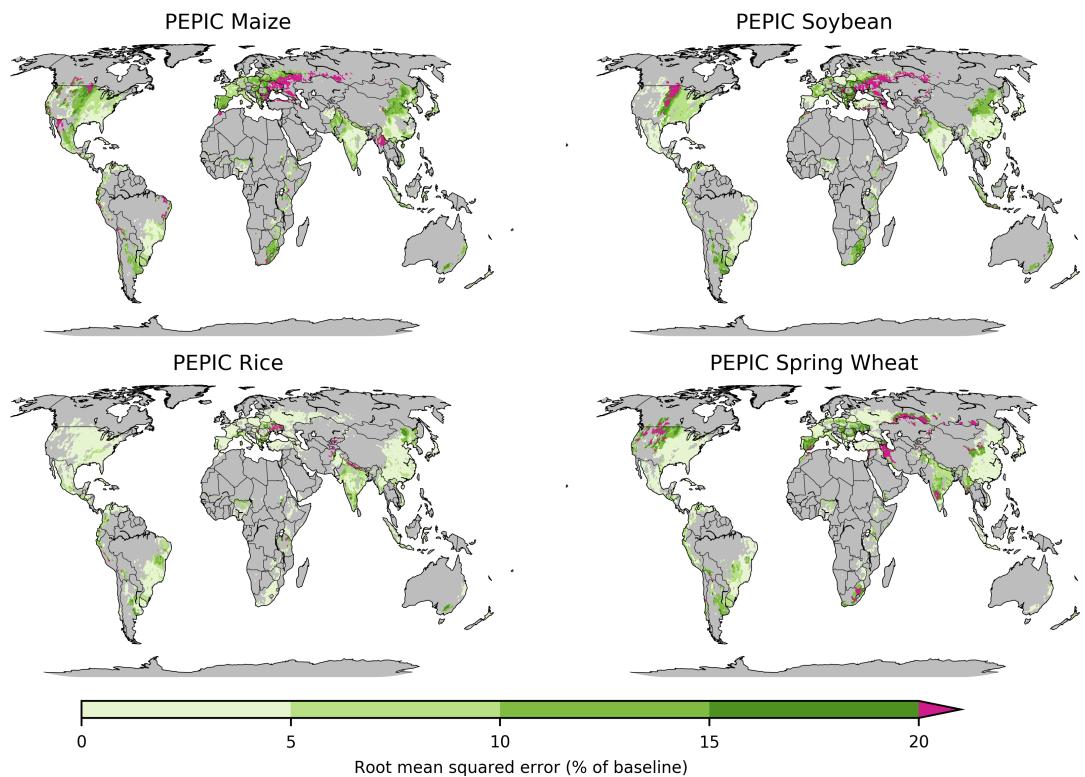


Figure S33: Map of root mean squared error for three fold cross validation process for the PEPIC model for rainfed crops. Values shown as a percentage of baseline yield in each gridcell.

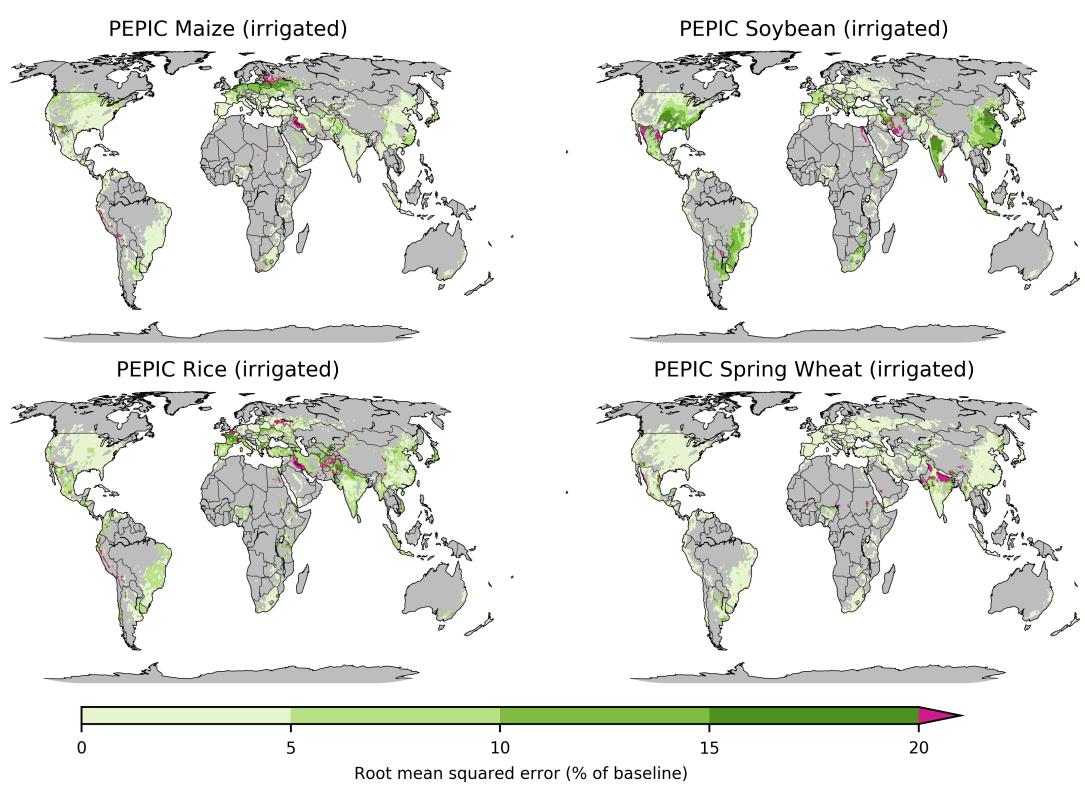


Figure S34: Same as above for irrigated simulations.