Statistically bias-corrected and downscaled climate models underestimate the adverse effects of extreme heat on US maize yields

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Motivation

Efforts to understand and quantify how a changing climate can impact agriculture often rely on bias-corrected and downscaled climate information, making it important to quantify potential biases of this approach.
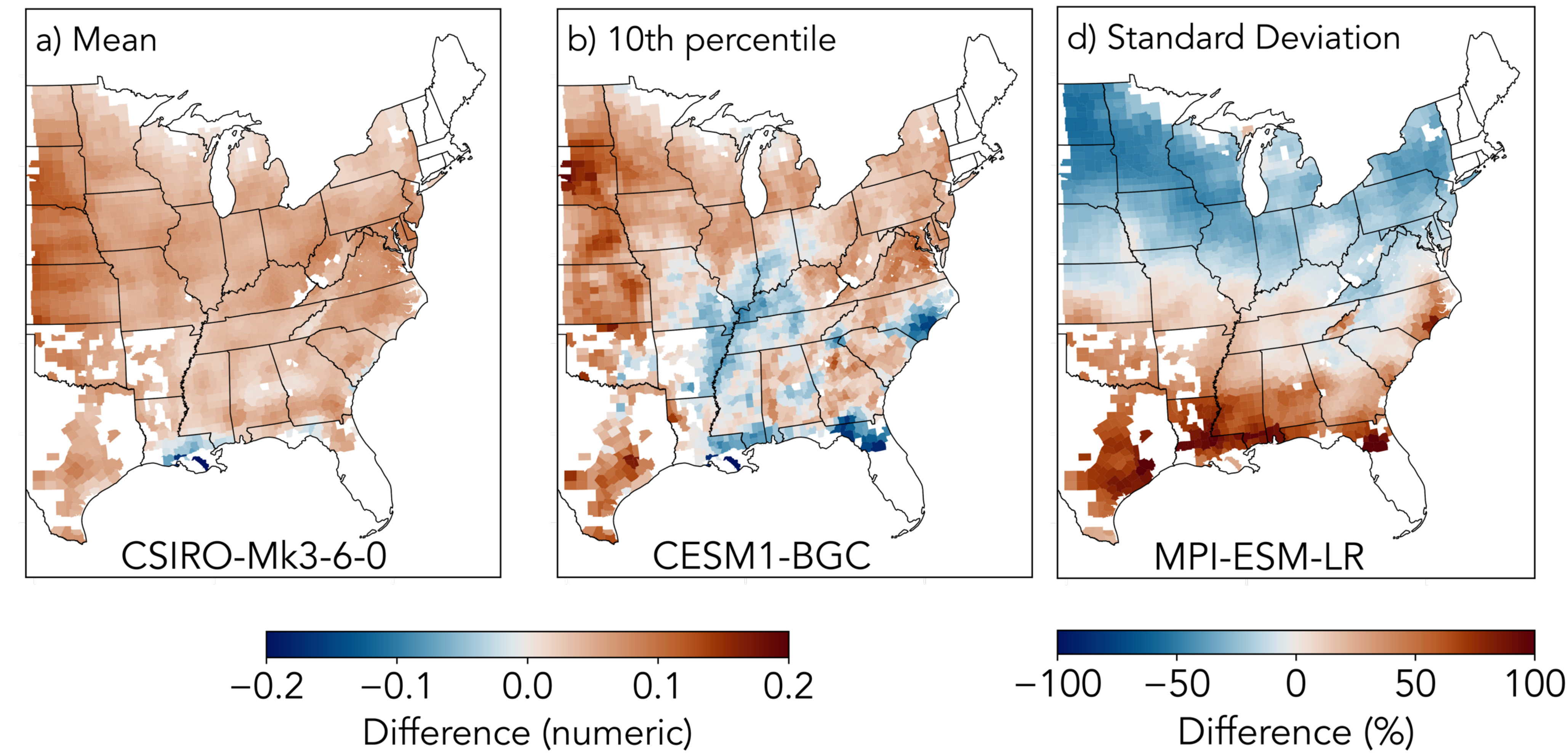
Methods

We use an ensemble of statistically bias-corrected and downscaled climate models (NEX-GDDP), as well as the corresponding parent models (CMIP5), to drive a statistical panel model of U.S. maize yields and analyze uncertainty in hindcasts and projections.

We employ a well-established yield model from Schlenker & Roberts (2009) that incorporates season-wide measures of temperature and precipitation.
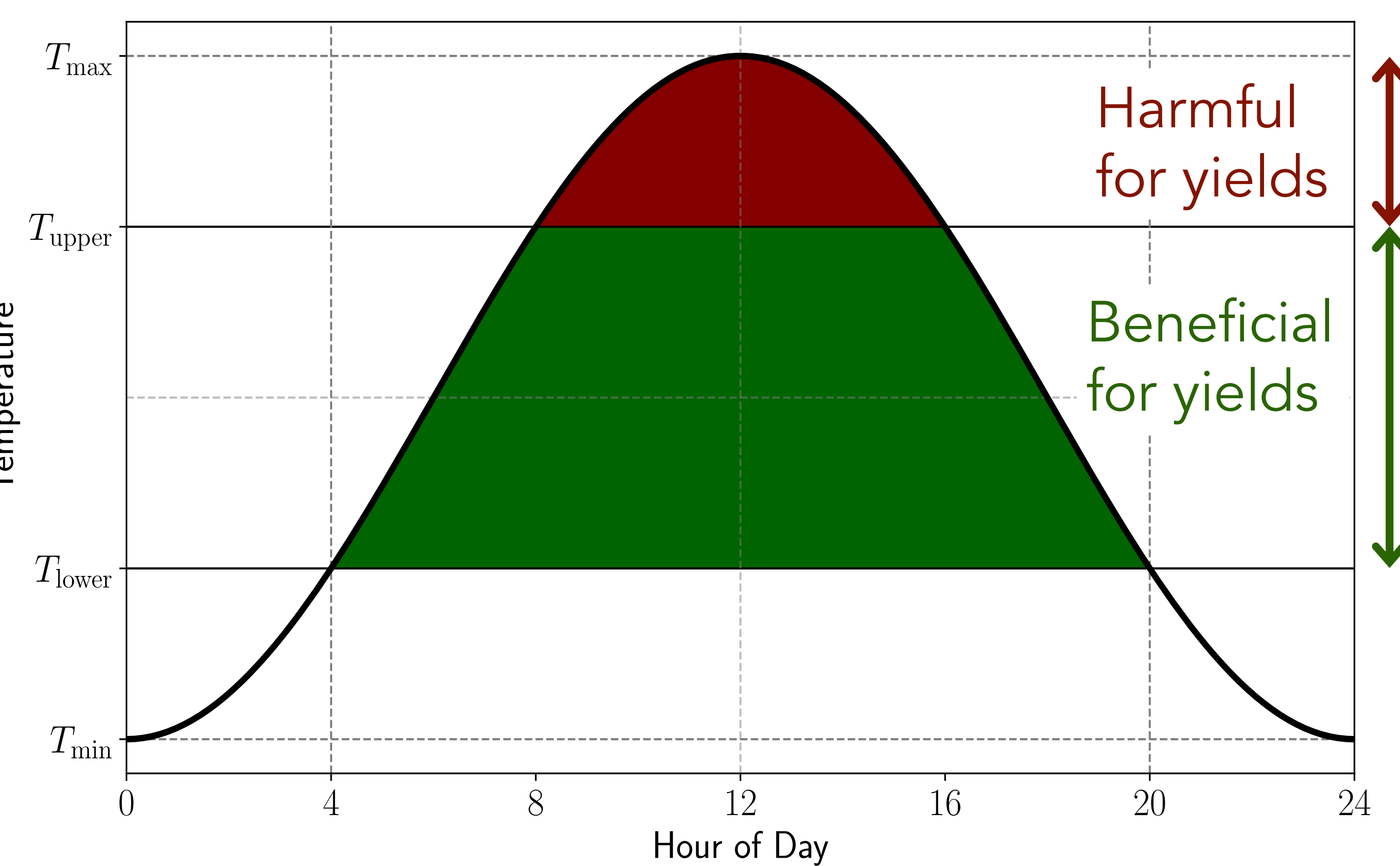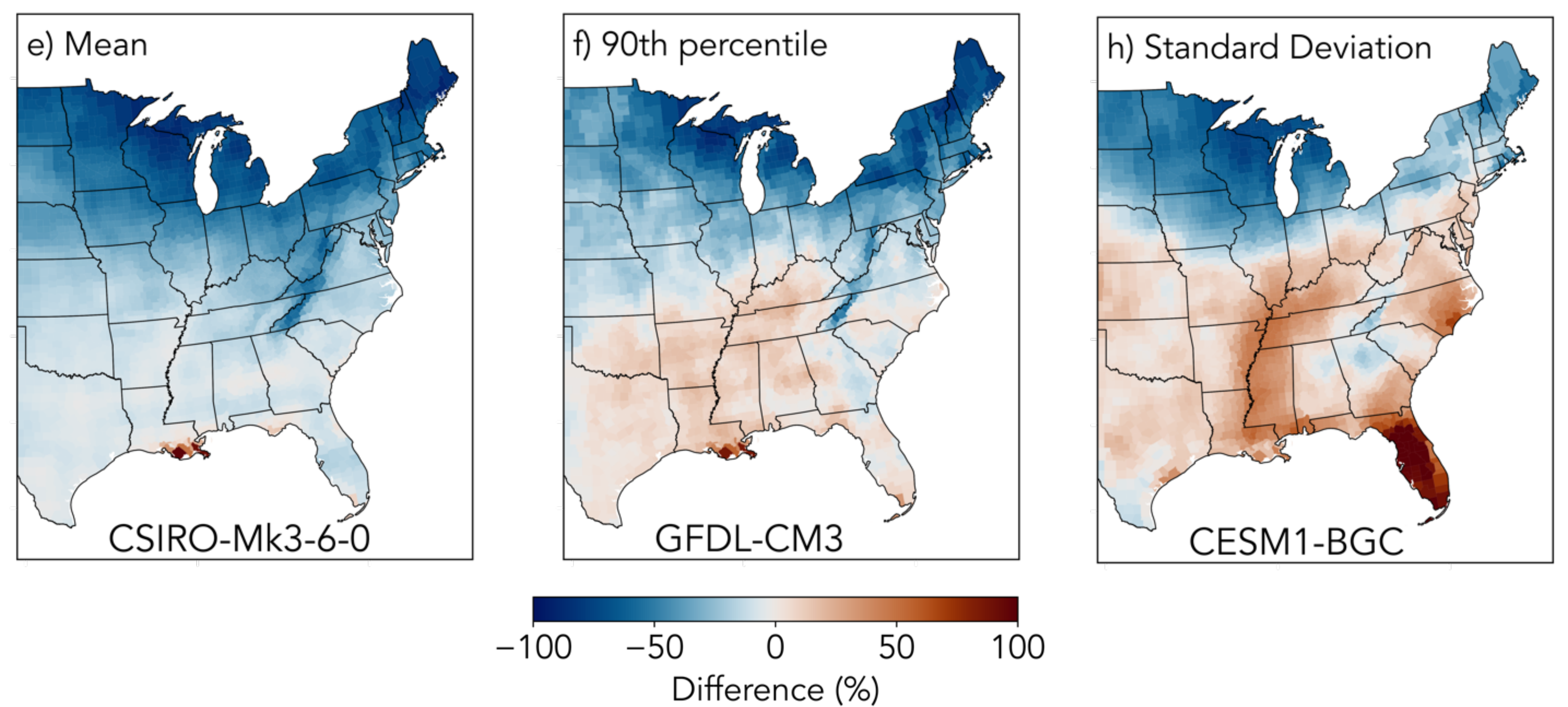

Results

1) NEX-GDDP models are typically overconfident; average yields are too high and yield variability is too low:

a) Mean — CSIRO-Mk3-6-0
b) 10th percentile — CESM1-BGC
d) Standard Deviation — MPI-ESM-LR

Difference (numeric): −0.2 −0.1 0.0 0.1 0.2
Difference (%): −100 −50 0 50 100

2) These biases are driven by how downscaling and bias-correction affect the underlying representation of temperature extremes (>29°C):

e) Mean — CSIRO-Mk3-6-0
f) 90th percentile — GFDL-CM3
h) Standard Deviation — CESM1-BGC

Difference (%): −100 −50 0 50 100

3) We find large differences in projected national-level yields under RCP8.5, leaving stakeholders with modeling choices that require navigating trade-offs in resolution, historical accuracy, and projection confidence.
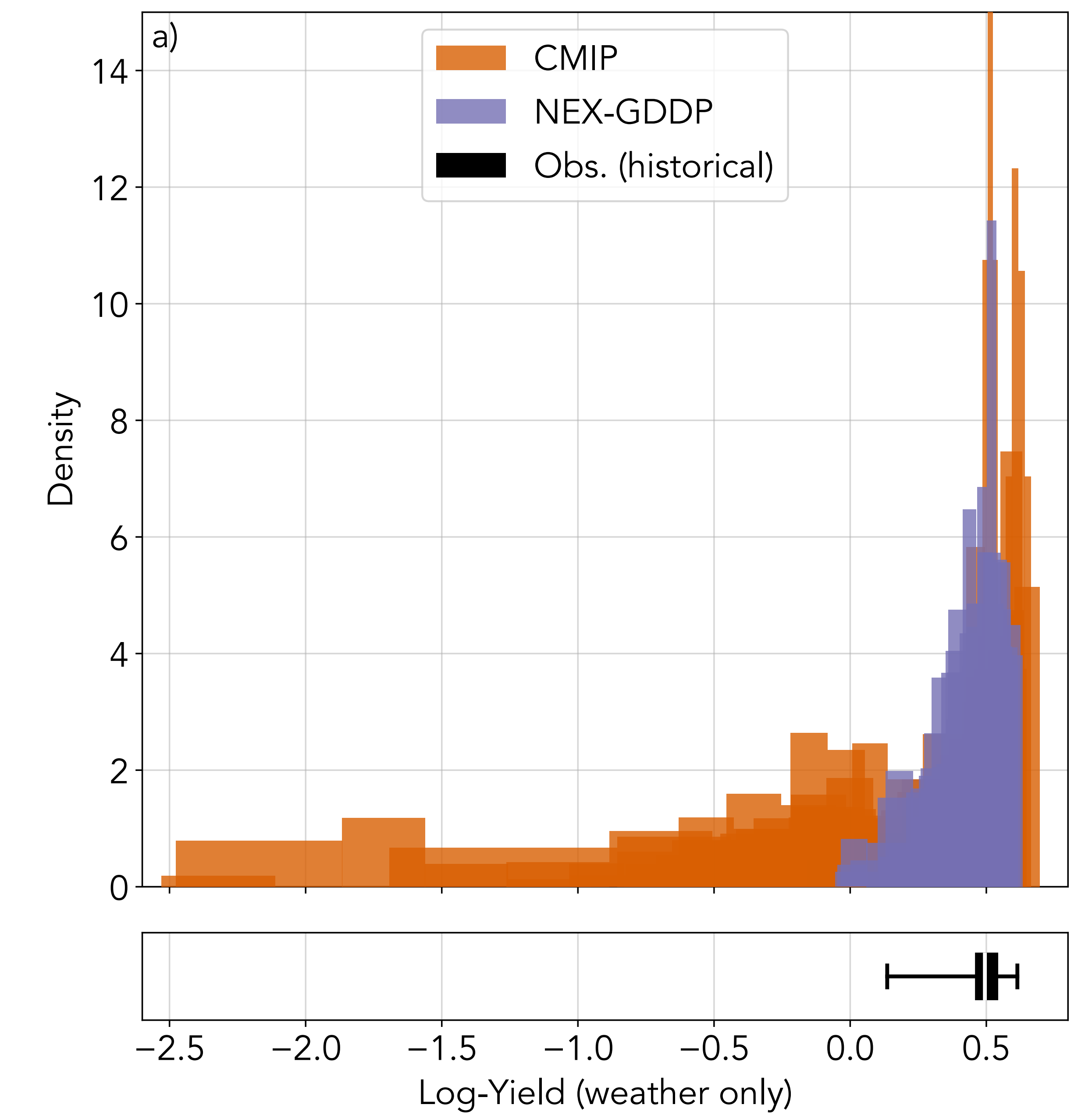
Future Work

How do these uncertainties, associated with temperature extremes, interact with other external factors to influence farm-level decisions, including crop-switching strategies or irrigation techniques?