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Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Research policies, see Authors & Referees and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	No software was used to collect data in this study. All climate data were from publicly available sources, which were downloaded directly. The sources have been described in the manuscript.
Data analysis	Eight crop models described in the manuscript have been used to simulate wheat yield for four study sites. R version 3.5.2 was used by authors for aggregating and analyzing the modeling results and plotting.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors/reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

Historical climate data (1961-2000) were obtained from the Scientific Information for Land Owners (SILO) (https://legacy.longpaddock.qld.gov.au/silo/about.html) for two Australian sites and from China's Meteorological Administration (CMA) (http://www.cma.gov.cn/en2014/) for two Chinese sites. All monthly raw GCM climate data were downloaded from public sources (https://esgf-node.llnl.gov/search/cmip5/). We used two downscaling methods (SD and CF) to generate daily climate data to drive eight wheat crop models. The adjusted genetic parameters of wheat crop for each model can be found in the supplementary. Simulated results including wheat yield from each model and all other processed data for making figures and tables are available from the corresponding author on request.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Uncertainty in modelling crop response to climate change is contingent on many factors, including Global Climate Models (GCMs), climate scenarios, downscaling methods and the crop models used. Previous uncertainty assessment studies have concluded that the primary source of uncertainty in projected yield change arises from the crop models. Here, we tested this conclusion using two downscaling methods at four locations of rain-fed wheat growing regions, two each in south-eastern Australia and northern China. For each location, eight crop models were forced by 32 GCMs under RCP4.5 and RCP8.5 for the time slices 2021-2060 and 2061-2100. We analysed ensemble projections of yield changes for study locations, and presented a methodology to separate uncertainties from three components (GCMs, crop models and climate scenarios) for two downscaling methods.
Research sample	The observed climate data were used to simulate wheat yield for baseline period (1961-2000). The GCM data under RCP4.5 and RCP8.5 for future years (2021-2100) were split into two parts (2021-2060 and 2061-2100) for wheat yield simulations, which was a standard practice in the field of climate change studies. Other datasets including soil, crop calendar and management practices, were in agreed with local observations, which was described in the method.
Sampling strategy	No sampling procedure was involved in our study.
Data collection	B. Wang downloaded crop data for two Australian sites (https://www.nvtonline.com.au/) and D. Xiao and T. Jiang provided observed crop data including soil properties for two Chinese sites. P. Feng downscaled raw GCM data to daily scale using a CF method and D. Liu used a statistical downscaling (SD) method to generate future daily climate data.
Timing and spatial scale	The timing of the historical analysis sample and the future projection sample ranged over 1961-2000, 2021-2060 and 2061-2100, respectively. Our work was conducted at site scale.
Data exclusions	No data were excluded from the analyses.
Reproducibility	Our results can be reproduced through rerunning the eight crop models with the exact model version, wheat crop genetic parameters, soil parameters, agronomic management options and climate datasets. We can provide technical help if readers are interested.
Randomization	Our work was based on climate-crop modeling simulations, so randomizatioin is not relevant.
Blinding	This is a climate-crop modeling study, so no need to use blinding.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study	
☒	☐	Antibodies
☒	☐	Eukaryotic cell lines
☒	☐	Palaeontology
☒	☐	Animals and other organisms
☒	☐	Human research participants
☒	☐	Clinical data

Methods

n/a	Involved in the study	
☒	☐	ChIP-seq
☒	☐	Flow cytometry
☒	☐	MRI-based neuroimaging