

Reporting Summary

Nature Portfolio 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 Portfolio policies, see our [Editorial Policies](#) 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 (<i>n</i>) 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 <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ 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 <i>d</i> , Pearson's <i>r</i>), 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	The GEOS-Chem v13.2.0 model code is available at https://doi.org/10.5281/zenodo.5500536 . The other analysis codes used in this study are available at https://doi.org/10.5281/zenodo.16927100 .
Data analysis	Python version 3.10 (https://www.python.org/downloads/release/python-3100/) was used to analysis the data. The other analysis codes used in this study are available at https://doi.org/10.5281/zenodo.16927100 .

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 and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [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 description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

CMIP6 model output is publicly available through the ESGF at <https://esgf-node.llnl.gov/projects/cmip6>. The European Centre for Medium-Range Weather Forecast Reanalysis version 5 data can be accessed via the Copernicus Climate Data Store: <https://cds.climate.copernicus.eu>. GCAP2.0 meteorological data are available at

<http://atmos.earth.rochester.edu/input/gc/ExtData/>. LUH2 land-use data can be found at <https://aims2.llnl.gov/search/input4mips>. The 2021 GBD air pollution exposure estimates at $0.1^\circ \times 0.1^\circ$ resolution are available from <https://ghdx.healthdata.org/record/ihme-data/gbd-2021-air-pollution-exposure-estimates-1990-2021>. The projected fire emissions constructed in this study can be obtained from <https://doi.org/10.5281/zenodo.16926891>. Additional datasets supporting the main findings of this study are described in the main text, the Methods section, and the Supplement.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	For this study, sex and gender information has not been collected. Consequently, no sex- or gender-based analysis was performed.
Reporting on race, ethnicity, or other socially relevant groupings	The study design includes GDP data from various countries worldwide, sourced from the SSP Public Database Version 2.0 (available at https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=30).
Population characteristics	Population data for different age groups were obtained from the Gridded Population of the World version 4 (GPWv4) dataset (http://sedac.ciesin.columbia.edu/data/collection/gpw-v4/sets/browse).
Recruitment	No human participants were involved in this study. All analyses were based on publicly available datasets and model simulations; therefore, issues of recruitment, self-selection bias, or related participant-level biases are not applicable.
Ethics oversight	This study did not involve human participants, animal experiments, or field sampling that requires institutional approval. All analyses were conducted using publicly available datasets and established modeling frameworks; therefore, no study protocol approval was required.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

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](https://www.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	we developed an interpretable machine learning framework to project global wildfire emissions through the end of this century and quantify the premature deaths and direct radiative forcing associated with fire-induced PM2.5 pollution.
Research sample	All data needed to evaluate the conclusions in the paper are accessible to the public and already present in the paper and/or the Supplementary Materials.
Sampling strategy	All data can be directly downloaded from the provided data source.
Data collection	All data can be directly downloaded from the provided data source.
Timing and spatial scale	The time range for input data related to historical and future scenario simulations is 2010-2014 and 2095-2099, respectively. The time range for validation data related to wildfire emissions is 2000-2014. The time range for the data used in predictions is 2015-2099, and the spatial range for all data is global.
Data exclusions	No data were excluded.
Reproducibility	All attempts to repeat the experiment were successful.
Randomization	No samples/organisms/participants relevant data used.
Blinding	Blinding was not relevant for this study because all data were directly downloaded from the provided data source.

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 and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

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

Plants

Seed stocks

N/A

Novel plant genotypes

N/A

Authentication

N/A