Climate Hazards, Co-Exposure, and Inequality in U.S. School Districts

Priyanka deSouza,[1,2,*] Colleen E. Reid,[3] Lisa Frueh,[4] Shin Bin Tan,[5] Carrie Makarewicz,[1] Rockli Kim,[6,7] SV Subramanian,[8,9] Jaime Madrigano,[10] Yang Liu.[11]
1: Department of Urban and Regional Planning, University of Colorado Denver
2: CU Population Center, University of Colorado Boulder
3: Department of Geography, University of Colorado Boulder, Boulder, CO, United States of America
4: Department of Environmental and Occupational Health, Drexel University Dornsife School of Public Health, Philadelphia, PA, United States of America
5: Lee Kuan Yew School of Public Policy, National University of Singapore
6: Division of Health Policy and Management, College of Health Sciences, Korea University, Seoul, South Korea
7: Interdisciplinary Program in Precision Public Health, Department of Public Health Sciences, Graduate School of Korea University, Seoul, South Korea
8: Department of Social and Behavioural Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, USA
9: Harvard Center for Population and Development Studies, Cambridge, Massachusetts
10: Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe Street, Baltimore, MD, 21205, USA
11: Gangarosa Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA 30322, USA

*: priyanka.desouza@ucdenver.edu

Abstract

Children spend substantial time in school, yet little is known about how multiple climate-related hazards jointly shape exposure in these settings. We constructed a national panel (2013-2022) of extreme heat, ozone, wildfire smoke, wildfire burn, and tropical cyclone exposure across U.S. public school districts. Districts with multi-hazard exposure increased sharply over the study period, rising from 1.6% to 27.4%. Exposure was systematically unequal, with districts serving larger non-White student populations experiencing greater individual and multi-hazard exposures. Climate hazard risk differed by district fiscal contexts.

Introduction

Children spend a substantial share of their waking hours at school, making school environments an important but underexamined site of environmental exposure. Because children are especially susceptible to environmental hazards, school conditions may influence health, attendance, cognitive development, and academic performance (Sadrizadeh et al. 2022; Toyinbo 2023). Public schools also represent one of the nation's largest public infrastructure systems, serving approximately 56 million students and adults each day across an estimated 8.3 billion square feet of facilities (Filardo et al. 2025).

Much of this infrastructure is aging and underinvested. The average main instructional building is approximately 40 years old, roughly 40% of public schools were built before 1980, and 41% of districts report needing HVAC updates or replacement (Filardo 2021). Many school buildings were therefore constructed before contemporary expectations for ventilation, cooling, energy efficiency, accessibility, and climate resilience. The *2025 State of Our Schools* report estimated more than $540 billion in unmet facilities needs, including approximately $285 billion related to HVAC systems (Filardo et al. 2025). These conditions matter because school buildings can either buffer or amplify exposure to extreme heat, wildfire smoke, poor air quality, and other climate-related hazards.

Climate hazards increasingly affect student health and learning. Extreme heat, wildfire smoke, ozone, tropical cyclones, and wildfire exposure have been linked to absenteeism, respiratory illness, school closures, cognitive performance, and academic outcomes (de Oliveira et al. 2026; Meltzer et al. 2025; Schulze et al. 2020; Venegas Marin et al. 2024; Wen and Burke 2022). At the same time, investments in ventilation, air filtration, cooling, and building modernization can improve indoor environmental quality and educational outcomes (Hinkley and Vincent, 2026; Biasi et al. 2024). School infrastructure is therefore an important component of climate adaptation (Patel et al., 2022).

Environmental justice research has long demonstrated that environmental risks are disproportionately concentrated among historically marginalized populations. However, most school-based studies focus on individual hazards rather than the multiple hazards districts may experience simultaneously (Cheeseman et al. 2022; Jones et al. 2024). School districts can face combinations of extreme heat, ozone exceedances, wildfire smoke, wildfire burn exposure, and tropical cyclones within the same year, creating cumulative burdens that may exceed the effects of any single hazard alone (Zscheischler et al. 2020). Despite growing attention to compound hazards, little research has examined these patterns across U.S. public school districts or evaluated how they intersect with school finance and facility conditions.

Climate vulnerability reflects both hazard exposure and adaptive capacity (Brooks, 2003). In school districts, adaptive capacity depends partly on the resources available to maintain, modernize, and adapt facilities. Recent work links school facility quality to local fiscal capacity and capital investment, while evidence from New York State documents substantial racial disparities in school building conditions associated with differences in local property-tax revenues (Ambali, Sodiq et al., 2025). These findings suggest that school finance and infrastructure are important dimensions of climate vulnerability for children.

In this study, we construct a national longitudinal panel of climate-related hazards across U.S. public school districts from 2013 to 2022. We evaluate exposure to extreme heat, ozone exceedances, wildfire smoke, wildfire burn exposure, and tropical cyclones, and develop measures of multi-hazard co-exposure. We then examine whether these burdens differ by district racial and ethnic composition, fiscal context, and school facility conditions. At the national level, we analyze school finance indicators, including revenues, capital outlays, construction expenditures, and debt. Where facility-condition data are available, we also evaluate direct measures of infrastructure age, condition, maintenance, and adequacy.

We hypothesize that (1) climate-related hazards and multi-hazard co-exposures increased between 2013 and 2022; (2) these increases disproportionately affected districts serving larger shares of historically marginalized students; (3) hazard exposure is associated with systematic differences in district fiscal context and infrastructure investment; and (4) districts experiencing greater hazard burdens differ in observed facility conditions. By linking climate hazards with student demographics, school finance, and school infrastructure, this study provides one of the first national assessments of how climate-related risks intersect with educational inequality and adaptive capacity across U.S. public school systems.

Data and Methods

School Districts

We assembled a longitudinal panel of U.S. public school district environmental exposures from 2013-2022, using the district-year as the unit of analysis. District identifiers were obtained from the NCES Common Core of Data (CCD) and harmonized across years. Student demographic composition was measured using race-specific enrollment counts and shares from the Urban Institute's educationdata package in R (Tyagi et al. 2025) (**Figure S1**).

School districts were selected because they are the primary administrative entities responsible for school facilities, transportation, and environmental management. In several states, however, some CCD identifiers correspond to supervisory unions or other administrative entities without unique geographic boundaries and therefore could not be linked to spatial boundary files. These entities were excluded from spatial analyses.

The final analytic sample included 131,810 district-year observations representing 13,582 unique districts, with annual district counts ranging from 13,071 to 13,432. Mean district area was 630.0 km^2 (median: 279.2 km^2), ranging from 0.17 to 47,134.1 km^2. Only 3.9% of district-year observations were smaller than 10 km^2, approximately corresponding to the resolution of the coarsest exposure datasets, and just 0.1% were smaller than 1 km^2.

Exposure Measures

We constructed annual district-year exposure metrics by overlaying environmental datasets with school district boundaries. Hazards included extreme heat, ozone exceedances, wildfire smoke, wildfire burn exposure, and tropical cyclones. We additionally developed multi-hazard metrics capturing both the number of distinct hazards experienced (extensive margin) and the frequency of overlapping exposures (intensive margin). All metrics were calculated using the full calendar year to capture climate-related infrastructure and adaptation burdens beyond the academic calendar. Annual exposure metrics were calculated as the number of exposure days per district-year.

Ozone

Ground-level ozone concentrations were derived from a daily 0.1° × 0.1° (~10 km) MDA8 ozone dataset for 2013-2022 (Wang et al. 2025). Concentrations were aggregated to school district boundaries using area-weighted means. Ozone exposure was defined as days with MDA8 ozone ≥140 μg/m^3 (approximately 70 ppb), consistent with the current U.S. EPA National Ambient Air Quality Standard (US EPA 2020).

Wildfire Smoke

Wildfire smoke exposure was based on the daily 10 km wildfire-attributable $PM_{2.5}$ dataset of Childs et al. (2022), which integrates monitoring, satellite, and atmospheric modeling data. Following prior work (Hu et al. 2025), smoke exposure was defined as days with wildfire-attributable $PM_{2.5}$ >0 μg/m^3. Sensitivity analyses evaluated a >5 μg/m^3 threshold.

Wildfire Burned Area

Direct wildfire exposure was measured using the national wildfire burn-zone dataset developed by Wilner et al. (2025). Following Hu et al. (2025), districts were classified as exposed when wildfire perimeters intersected district boundaries between ignition and containment dates. Because disruptions may persist beyond containment, this metric may underestimate longer-term impacts (Reid 2025).

Extreme Heat Exposure

Extreme heat exposure was derived from PRISM 4 km daily temperature data aggregated to district boundaries. Extreme heat days were defined as days exceeding both the district-specific 95th percentile of warm-season (May-September) temperatures during 2010-2014 and an absolute threshold of 90°F, consistent with Hu et al. (2025).

Tropical Cyclones

Tropical cyclone exposure was derived from IBTrACS using the StormR package (Delaporte et al. 2024), which models spatially explicit cyclone wind fields. Districts were classified as exposed when modeled wind speeds exceeded 18 m/s (39 mph), consistent with prior work (Jiang et al. 2026). Sensitivity analyses additionally evaluated hurricane-force exposure (≥33 m/s; 74 mph).

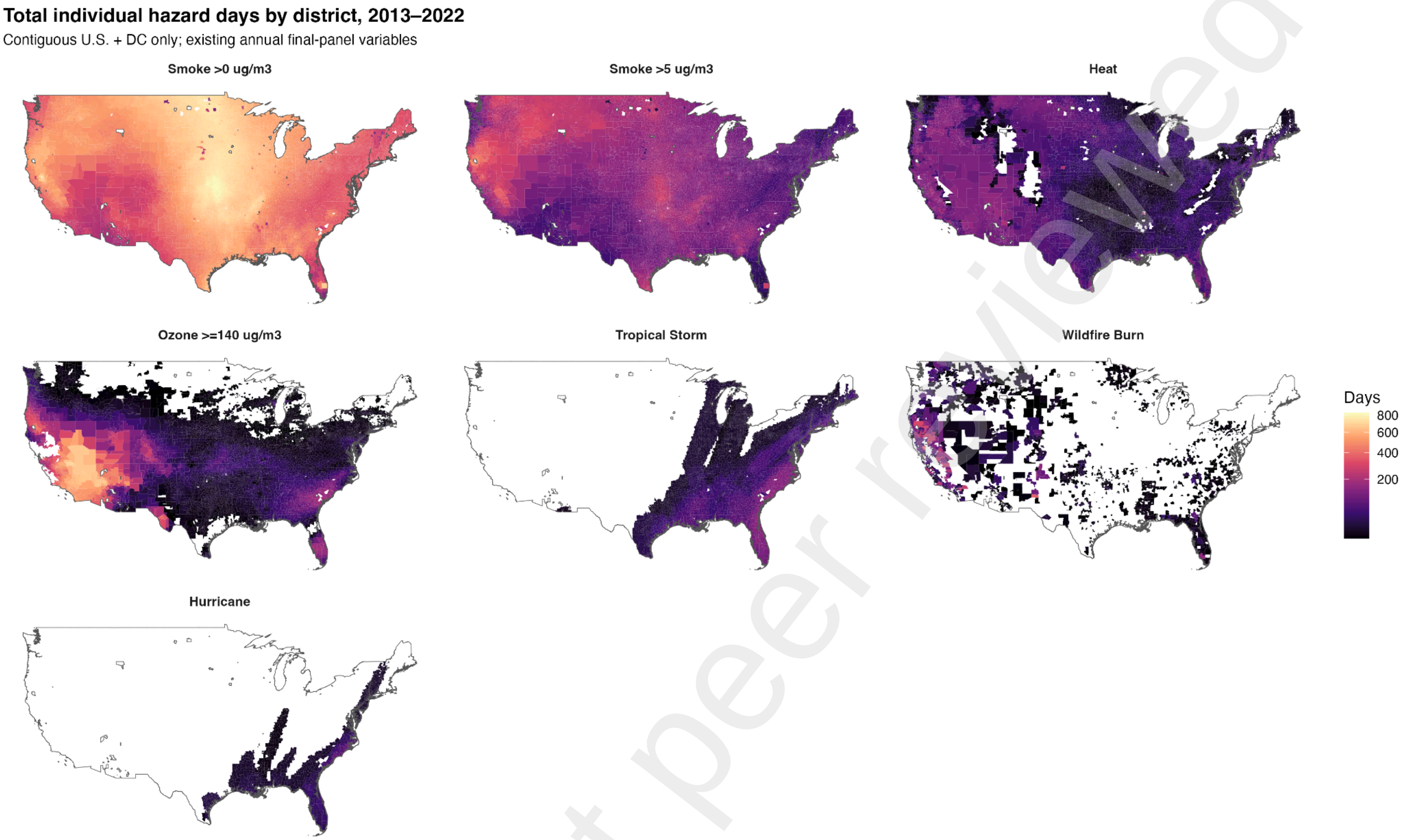

Figure 1: ***S****patial distribution of cumulative climate hazard exposure across U.S. public school districts during 2013-2022. Maps show total district-days of exposure to extreme heat, ozone exceedances (MDA8 ozone ≥140 µg/m^3), wildfire smoke (wildfire-attributable $PM_{2.5}$ >0 µg/m^3), wildfire burn exposure, and tropical storms. Supplementary analyses evaluate alternative thresholds including hurricane-force winds (≥33 m/s) and wildfire smoke $PM_{2.5}$ >5 µg/m^3.*

School Finance

District-level fiscal measures were downloaded via the *educationdata* package (Tyagi et al. 2025). For each district-year with available data (2010-2020), we extracted total revenue per pupil; federal, state, and local revenue components; and local property-tax revenue per pupil where reported. Distinguishing among funding sources is important because local revenues, particularly property taxes, are closely tied to local wealth and tax bases, whereas state and federal funding may partially offset local fiscal disparities.

To characterize infrastructure investment, we also extracted capital outlay per pupil, construction capital outlay per pupil, the share of revenue devoted to capital spending, debt-service expenditures, and long-term debt issuance. Although these measures do not directly capture facility quality, they reflect the fiscal resources and investment patterns through which districts maintain, modernize, and expand school infrastructure.

Because school finance systems vary substantially across states and property-tax revenues are not consistently reported or directly comparable, finance measures are interpreted as indicators of district fiscal context and infrastructure investment rather than direct measures of facility conditions. All finance analyses were restricted to 2010-2020 because of data availability (**Figure S2**).

Urbanicity and Population Density

Urbanicity was measured using the NCES locale classification (City, Suburb, Town, and Rural). Because both climate hazard exposure and district resources vary systematically across urban and rural contexts, urbanicity was included as a covariate in regression models and examined as a potential effect modifier in heterogeneity analyses.

Population density was calculated by dividing annual district population estimates from the U.S. Census Bureau's Small Area Income and Poverty Estimates (SAIPE) program by district land area. Density was log-transformed (log(density + 1)) for regression analyses to reduce skewness and the influence of extreme values. Descriptive distributions are shown in **Figure S1**.

Statistical Analysis

We constructed a longitudinal panel of U.S. public school districts from 2013 to 2022, with the district-year as the primary unit of analysis. Daily hazard indicators generated at the district level were aggregated to derive annual exposure measures. Analyses combined descriptive summaries with regression models to characterize temporal trends, spatial patterns, disparities, and associations with fiscal and infrastructural dimensions of climate vulnerability.

Descriptive Analysis

We summarized exposure distributions using district-day and student-day metrics and evaluated temporal trends through descriptive comparisons (2013-2017 vs. 2018-2022) and panel regression models. Regional analyses compared exposures across U.S. Census regions and NCES urbanicity categories, while seasonal analyses examined monthly hazard frequencies and co-exposure metrics, including the proportion of districts experiencing ≥2 and ≥3 concurrent hazards.

Analysis of Exposure Trends

To estimate temporal trends in environmental exposures, we fit district-level panel regression models separately for each hazard and multi-hazard co-exposure metric, including measures capturing days with ≥2, ≥3, or ≥4 simultaneous hazards. Models included district fixed effects and state-by-year fixed effects, allowing estimates to reflect within-district changes over time while accounting for shared state-level shocks, policies, climatic variation, and temporal trends. Standard errors were clustered at the district level.

Disparities in Exposure to Climate Hazards by Race and Ethnicity

To evaluate Hypothesis 2, we examined whether climate hazards were disproportionately concentrated in districts serving larger shares of historically marginalized racial and ethnic groups. As an initial descriptive assessment, districts were grouped into quartiles based on the shares of non-Hispanic White, Hispanic, non-Hispanic Black, non-Hispanic Asian, and non-Hispanic American Indian/Alaska Native (AIAN) students. Hazard-specific and multi-hazard exposures were compared across quartiles using Kruskal-Wallis and pairwise Wilcoxon rank-sum tests.

Regression analyses used annual hazard-specific and multi-hazard exposure measures as continuous outcomes. Because racial composition variables are compositional, non-Hispanic White student share was omitted as the reference category. Models included state-by-year fixed effects, with additional specifications controlling for log(population density + 1) and NCES urbanicity.

To evaluate whether disparities changed over time (Hypothesis 4), we estimated interactions between district racial composition and year. Positive interaction coefficients indicate that exposure burdens increased more rapidly in districts serving larger shares of historically marginalized students. We additionally estimated district fixed-effects models to examine whether within-district changes in racial composition were associated with changes in hazard exposure. To assess geographic heterogeneity, analyses were stratified by region and NCES urbanicity category. Standard errors were clustered at the district level.

Adaptive Capacity: Finance and Infrastructure

To evaluate whether climate hazard exposure is associated with adaptive capacity, we examined two complementary dimensions: district fiscal context and observed school facility conditions. National analyses assessed financial resources and infrastructure investment patterns, while state-level analyses examined facility age, condition, maintenance, and adequacy.

National Finance Analysis

We estimated district-year panel models relating hazard-specific and multi-hazard exposure measures to district financial indicators, including total, local, state, federal, and property-tax revenues per pupil; debt measures; capital outlays; construction expenditures; and the share of revenue devoted to capital investment:

$$Finance_{it} = \beta Exposure_{it} + \gamma X_{it} + \alpha_s + \lambda_t + \varepsilon_{it}$$

where $Finance_{it}$ represents district financial outcomes, $Exposure_{it}$ represents hazard-specific or multi-hazard exposure measures, (X_{it}) includes NCES urbanicity and log(population density + 1), and (α_s) and (λ_t) denote state and year fixed effects. Standard errors were clustered at the district level.

To assess heterogeneity, models were stratified by region and urbanicity and supplemented with interaction models between hazard exposure and district racial composition. These analyses evaluated whether relationships between climate hazards and district fiscal outcomes differed across geographic, urban-rural, and demographic contexts.

State Infrastructure Analysis

To complement the national finance analysis, we evaluated whether districts experiencing greater climate hazard burdens also differed in observed school facility conditions. We assembled publicly available school facility datasets from Colorado (https://api.vfafacility.com/CDOEDashboard/, last accessed 2 May 2026), Maryland (https://www.devmdschoolconstruction.org/web/facilities/list, last accessed 2 May 2026), and Florida (https://www.fldoe.org/finance/edual-facilities/fl-inventory-of-school-houses-fish.stml, last accessed 2 May 2026), which provide information on facility age, condition, maintenance, adequacy, and facility inventories. Because these datasets represent cross-sectional assessments rather than annual observations, analyses were cross-sectional rather than longitudinal.

Facility measures varied by state. Colorado data included facility age, Facility Condition Index (FCI), adequacy measures, and campus-level condition assessments; Maryland data included facility age, maintenance ratings, and facility-condition classifications; and Florida data included facility age. Facility-level observations were averaged to the district level to align with district-level hazard metrics.

To improve comparability with these cross-sectional assessments, climate hazard exposures were averaged over 2013-2020 to create long-term district exposure indicators. We then estimated state-specific regression models relating facility-condition measures to average hazard exposure while controlling for NCES urbanicity and log(population density + 1). Models were estimated separately because facility measures differed substantially in definition, scale, and assessment methodology across states.

Together, the national finance and state infrastructure analyses evaluate complementary dimensions of adaptive capacity: fiscal resources and infrastructure investment patterns at the national level, and observed facility conditions at the state level. All results are reported as point estimates with standard errors (SE), emphasizing effect sizes, uncertainty, and consistency across specifications rather than binary significance thresholds.

Results

Climate hazard exposure increased along both extensive and intensive margins

Climate hazard exposure increased substantially across U.S. school districts between 2013 and 2022 (**Figure 2; Tables S1-S4**). The distribution of exposures shifted toward more complex multi-hazard environments, with the share of districts experiencing three or more hazards increasing from 1.6% (221 districts) in 2013 to 27.4% (3,585 districts) in 2022 (**Table S1**). Correspondingly, the share of districts experiencing only a single hazard declined from 39.9% to 5.0%.

Co-exposure intensity also increased sharply. Mean annual exposure to at least two simultaneous hazards increased from 1.85 to 9.68 district-days, while exposure to at least three simultaneous hazards increased from 0.02 to 0.57 district-days (**Table S2**). The percentage of districts experiencing at least one day with two or more simultaneous hazards increased from 60.1% to 95.0%, and the percentage experiencing at least one day with three or more hazards increased from 1.6% to 27.4%.

District fixed-effects models confirmed significant upward trends in multi-hazard exposure over time (**Table S3**). Exposure to at least two hazards increased by 0.86 district-days per year, while exposure to at least three hazards increased by 0.06 district-days per year (both $p < 0.001$). These results indicate a marked shift toward more frequent and more complex climate hazard exposure across U.S. school districts.

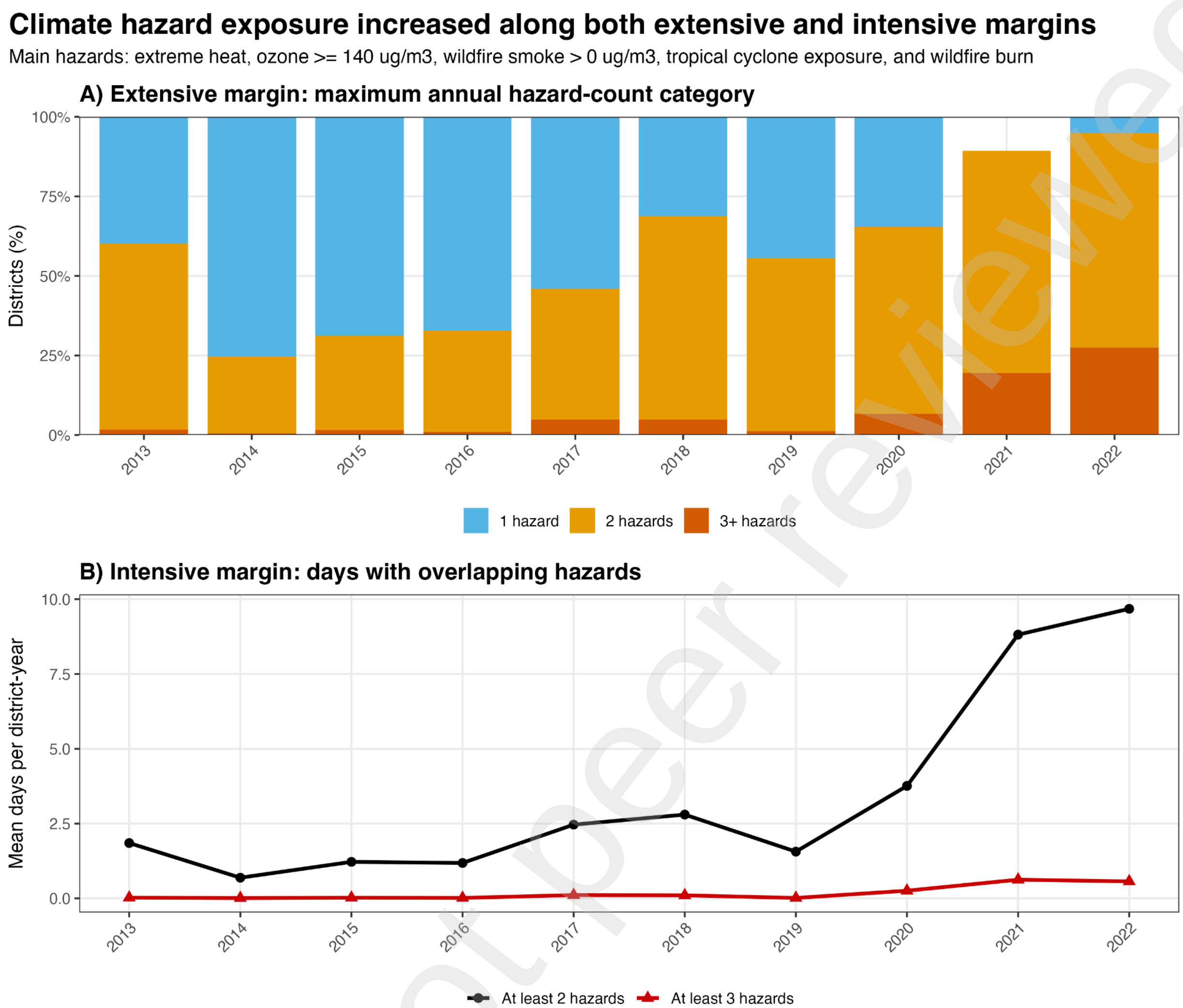

Figure 2*: Extensive and intensive margins of school district climate co-exposure, 2013-2022. Main hazards include extreme heat, ozone exceedances (≥140 μg/m^3), wildfire smoke exposure (>0 μg/m^3), tropical cyclone exposure, and wildfire burn exposure. Panel A shows the percentage of districts classified according to the maximum number of hazards experienced within a district-year, categorized as one hazard, two hazards, or three or more hazards. Thus, districts in the 3+ hazards category experienced at least one day during the year with three or more simultaneous hazards. Panel B shows the mean annual number of district-days with at least two simultaneous hazards and at least three simultaneous hazards.*

Exposure days increased substantially across individual hazards

The increase in multi-hazard exposure coincided with increases across all major hazards (**Table S2**). Mean district exposure to extreme heat increased from 4.07 to 7.64 days per year, while ozone exceedance exposure increased from 1.27 to 8.48 days. Wildfire smoke remained the most widespread hazard, increasing from 38.1 to 113.8 exposure days annually and affecting nearly all districts throughout the study period. Wildfire burn exposure increased modestly, while tropical cyclone exposure exhibited substantial interannual variability driven by major storm years.

Panel fixed-effects models confirmed significant upward trends across all hazards (**Table S3**), including increases of 0.41 heat-exposure days, 0.81 ozone exceedance days, 7.49 wildfire smoke days, 0.04 wildfire burn days, and 0.26 tropical cyclone exposure days per year (all $p < 0.001$).

Population-weighted burdens increased even more sharply. Mean exposure to at least two simultaneous hazards increased from 6,126 to 41,378 student-days per district-year, while exposure to at least three hazards increased from 54 to 3,070 student-days (**Table S2**), indicating that growing climate burdens affected not only more districts but also larger student populations. Supplementary analyses using alternative hazard definitions, including wildfire smoke >5 μg/m^3 and hurricane-force winds, produced similar patterns (**Table S5**), indicating that increasing multi-hazard exposure was robust to hazard definitions.

Regional patterns reveal distinct hazard exposures

Regional analyses revealed distinct hazard regimes that help explain the national increase in multi-hazard exposure (**Figures S4-S7; Section S3; Tables S5-S6**). The West consistently experienced the highest extreme heat and ozone exposure, while tropical cyclone exposure was concentrated in the South. Wildfire smoke increased substantially across all regions and became an increasingly important driver of multi-hazard exposure nationwide.

Across all regions, wildfire smoke was the dominant contributor to co-exposure. The most common pairwise combination was extreme heat and wildfire smoke, while combinations involving heat, ozone, and wildfire smoke were particularly concentrated in the West. In contrast, southern districts more commonly experienced co-exposures involving heat, smoke, ozone, and tropical cyclones. Together, these findings indicate that western multi-hazard exposure was driven largely by overlapping heat, ozone, and wildfire smoke, whereas southern multi-hazard exposure more often reflected interactions among heat, smoke, ozone, and tropical cyclones.

Climate hazard exposure varies systematically across NCES urbanicity categories

Cities and suburbs generally experienced the highest exposure to extreme heat and ozone exceedances (**Figure S8; Table S7**). By 2022, city districts averaged 9.6 extreme heat days and 15.9 ozone exceedance days per year, compared with 8.2 and 8.8 days, respectively, in suburban districts, 7.3 and 8.9 days in towns, and 7.3 and 7.4 days in rural districts. Ozone exposure increased across all urbanicity categories over time but remained consistently highest in cities and lowest in rural districts.

Wildfire-related hazards exhibited a different pattern. Wildfire smoke exposure increased dramatically across all urbanicity categories and affected all districts throughout the study period. By 2022, towns and rural districts experienced the highest wildfire smoke exposure, averaging 119.3 and 120.0 smoke days per year, respectively, compared with 99.8 days in cities and 99.1 days in suburbs. Wildfire burn exposure was also highest in towns and rural districts, while cities and suburbs generally experienced lower burn exposure.

Tropical cyclone exposure occurred across all urbanicity categories but generally produced the largest population-weighted burdens in cities and suburbs because of their larger enrollments. Major storm years such as 2017, 2020, and 2021 produced substantial exposure across all urbanicity categories, but cities and suburbs generally experienced higher population-weighted storm burdens because of their larger enrollments.

These differences produced distinct multi-hazard profiles. Cities and suburbs were more likely to experience co-exposures involving extreme heat and ozone exceedances, whereas towns and rural districts experienced co-exposures more strongly influenced by wildfire smoke and wildfire burn. Nevertheless, multi-hazard exposure increased substantially across all urbanicity categories, indicating that climate-related hazards have become a growing concern for school districts regardless of settlement type.

Racial and Ethnic Disparities in Climate Hazard Exposure

Consistent with Hypothesis 2, both descriptive and regression-based analyses revealed substantial racial and ethnic disparities in climate hazard exposure across U.S. school districts (**Figure 3; Tables S8-S15**). Descriptive analyses showed strong exposure gradients across district racial composition (all Kruskal-Wallis $p < 0.001$). The largest disparities were observed for Hispanic student share. Districts in the highest Hispanic-share quartile experienced substantially greater exposure to extreme heat, ozone exceedances, and multi-hazard co-exposure than districts in the lowest quartile. For example, mean annual heat exposure increased from 2.81 to 6.69 days, ozone exposure increased from 0.95 to 9.89 days, and exposure to at least two simultaneous hazards increased from 1.92 to 5.36 days across Hispanic-share quartiles (**Table S8**). White-share quartiles exhibited the opposite pattern.

Regression analyses confirmed that several disparities persisted after controlling for geography and population density (**Figure 3A; Tables S10-S11**). In state-year fixed-effects models, Hispanic student share was consistently associated with greater exposure to extreme heat (+3.36 days, SE = 0.19), ozone exceedances (+7.39 days, SE = 0.66), exposure to at least two hazards (+1.51 days, SE = 0.16), and exposure to at least three hazards (+0.24 days, SE = 0.03), relative to districts serving larger White student populations. Hispanic-associated disparities remained evident in district fixed-effects models, indicating that districts experiencing increases in Hispanic enrollment also tended to experience increasing climate hazard exposure over time. In contrast, many Black-share coefficients became statistically insignificant after inclusion of district fixed effects, suggesting that some Black-exposure associations reflect broader geographic sorting of populations and hazards rather than within-district demographic change. Overall, Hispanic-associated disparities were the most consistent across model specifications.

Consistent with Hypothesis 4, race-by-year interaction models indicated widening disparities over time (**Figure 3B; Table S12**). Hispanic student share was associated with faster annual increases in heat exposure (+0.40 days per year), ozone exposure (+2.73 days per year), wildfire smoke exposure (+0.50 days per year), and exposure to at least two hazards (+0.98 days per year). Positive interaction coefficients were also observed for Black, Asian, and AIAN student shares for ozone and multi-hazard exposure, indicating that higher-order co-exposure became increasingly concentrated among historically marginalized student populations.

Regional and urbanicity analyses revealed substantial geographic heterogeneity (**Tables S13-S15**). In the South and West, Hispanic student share was strongly associated with heat, ozone, and multi-hazard exposure, with particularly large ozone disparities observed in the West (+16.96 days, SE = 1.58). Race-by-urbanicity analyses showed that Hispanic-associated heat and multi-hazard disparities were strongest in cities and suburbs, whereas ozone disparities were largest in rural districts.

These findings indicate that districts serving larger shares of Hispanic students consistently experienced greater exposure to extreme heat, ozone, and multi-hazard climate risks and experienced faster growth in these exposures over time. Disparities involving Black, Asian, and AIAN student populations were more sensitive to geographic controls and varied substantially across regions and urbanicity categories, suggesting that both demographic composition and the spatial distribution of climate hazards contribute to observed exposure inequalities.

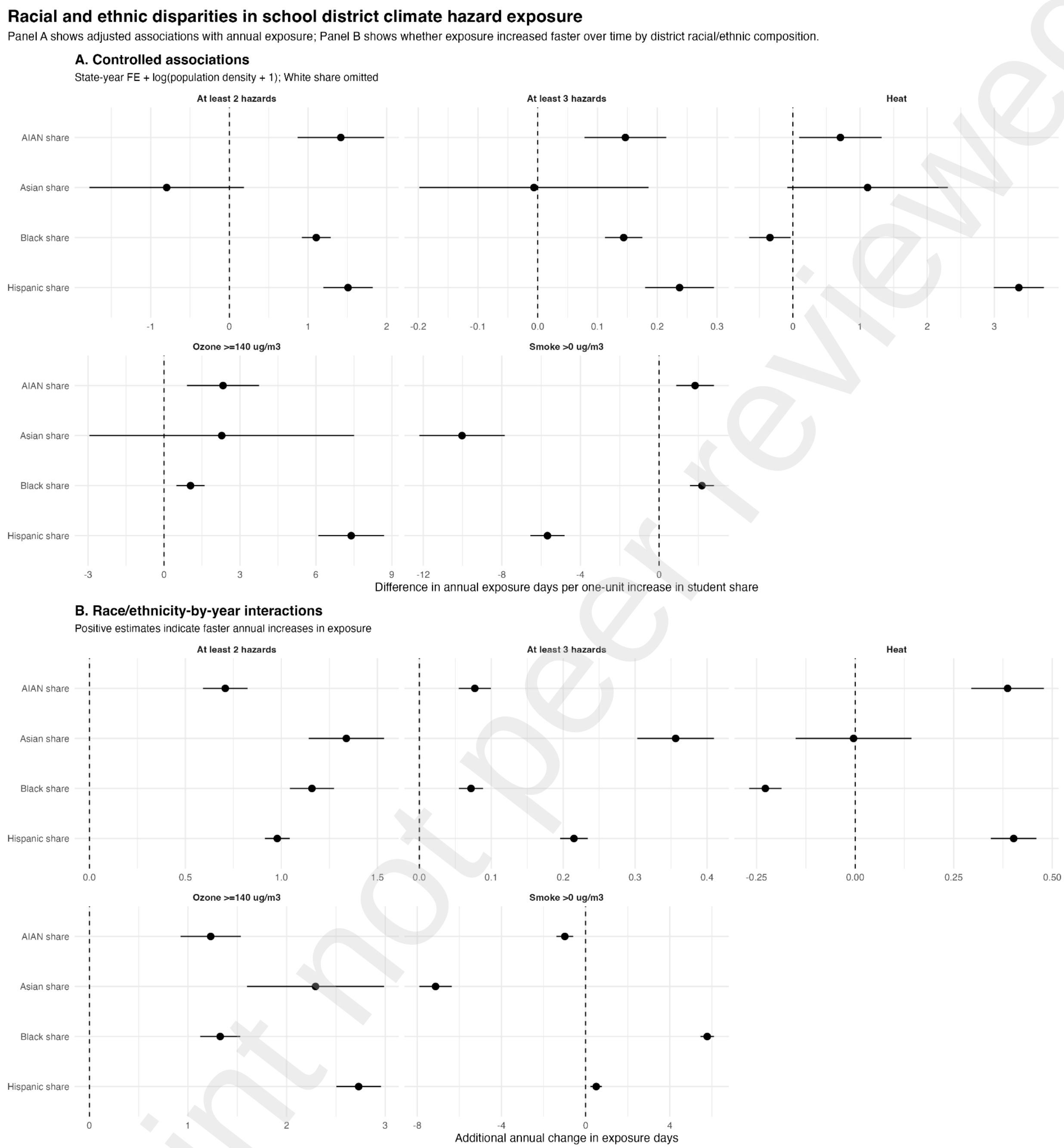

Figure 3*: Racial and ethnic disparities in climate hazard exposure. Panel A shows coefficient estimates from state-year fixed-effects models controlling for log(population density + 1), with White student share omitted as the reference category. Panel B shows race/ethnicity-by-year interaction coefficients, where positive estimates indicate faster annual increases in exposure over time. Outcomes include extreme heat, ozone exceedances (≥140 μg/m^3), wildfire smoke exposure (>0 μg/m^3), exposure to at least two hazards (≥2 hazards), and exposure to at least three hazards (≥3 hazards). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals; standard errors are clustered at the district level.*

Adaptive Capacity: Finance and Infrastructure

National Associations Between Climate Hazards and School District Finances

Across 102,995 district-year observations representing 13,264 school districts, climate hazard exposure was more strongly associated with school finance composition than with capital investment or debt financing (**Figures 4, S9-S10; Table S16**). Unless otherwise noted, all outcomes are reported on a per-pupil basis. These results should be interpreted as associations with the fiscal contexts of hazard-exposed districts rather than evidence that hazards directly altered district finances.

Several hazards were associated with distinct revenue profiles (**Figure 4**; **Table S16**). Tropical-storm exposure was associated with higher total (+$34.4, SE = 6.3), local (+$66.5, SE = 12.7), and property-tax revenues (+$79.2, SE = 7.6), but lower state (-$27.5, SE = 2.5) and federal revenues (-$4.6, SE = 1.1). In contrast, wildfire smoke exposure was associated with lower total (-$7.7, SE = 3.4), local (-$21.2, SE = 3.1), and property-tax revenues (-$18.4, SE = 3.4), alongside higher state (+$12.2, SE = 1.6) and federal revenues (+$1.3, SE = 0.6). Ozone exposure showed a similar pattern.

Multi-hazard exposure was likewise associated with differences in revenue composition. Districts experiencing at least two hazards exhibited higher total (+$36.4, SE = 12.2), state (+$26.1, SE = 7.0), and federal revenues (+$18.6, SE = 2.6), while districts experiencing at least three hazards exhibited even larger positive associations with total (+$144.8, SE = 58.6), state (+$102.2, SE = 27.0), and federal revenues (+$76.6, SE = 20.6).

In contrast, capital investment and debt outcomes showed weaker and less consistent relationships with hazard exposure (**Figures S9-S10; Table S16**). Most hazards were not strongly associated with capital outlays, construction expenditures, debt-service expenditures, or long-term debt issuance. The clearest exceptions were lower capital-outlay shares among districts experiencing at least two hazards (-0.147 percentage points, SE = 0.073) and lower long-term debt issuance among districts experiencing at least three hazards (-$48.8, SE = 15.5). Overall, hazard exposure was associated more strongly with revenue composition than with observed investment or borrowing behavior.

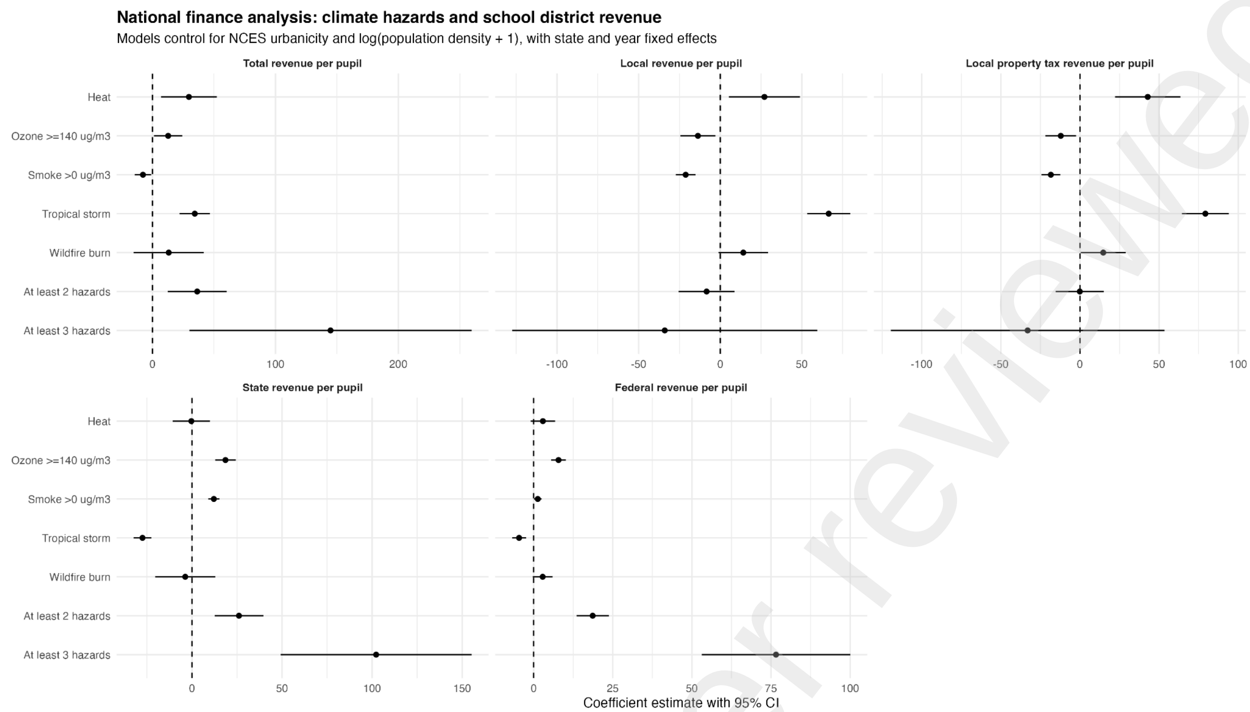

***Figure 4**: Associations between climate hazard exposure and school district revenue composition. Coefficient estimates from district-year regression models relating climate hazard exposure to total revenue per pupil, local revenue per pupil, local property-tax revenue per pupil, state revenue per pupil, and federal revenue per pupil. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals; standard errors are clustered at the district level.*

Regional and Urbanicity Heterogeneity

Associations between climate hazards and school district finances varied substantially across Census regions and NCES urbanicity categories (**Figures S11-S16; Table S17**), indicating that national averages mask considerable geographic heterogeneity.

Regional revenue patterns differed sharply. In the Northeast, ozone exposure was associated with substantially higher total (+$513.7, SE = 130.8), local (+$589.7, SE = 150.2), and property-tax revenues (+$528.0, SE = 163.6). In contrast, western heat and wildfire smoke exposure were generally associated with lower local revenues but higher state revenues. In the South, wildfire smoke exposure was associated with lower total (-$55.0, SE = 11.4), local (-$56.0, SE = 11.6), and property-tax revenues (-$58.5, SE = 12.6), whereas heat exposure was associated with higher local and total revenues.

Regional heterogeneity was also evident for infrastructure investment. In the Midwest, heat exposure was associated with higher capital outlays (+$29.5, SE = 7.4), construction expenditures (+$24.8, SE = 7.1), and capital-outlay shares (+0.118 percentage points, SE = 0.037), whereas wildfire-burn exposure was associated with lower infrastructure investment.

Urbanicity-stratified models showed similarly divergent patterns. Rural heat exposure was associated with higher capital outlays (+$12.9, SE = 5.4), property-tax revenues (+$59.9, SE = 20.7), and total revenues (+$59.6, SE = 22.8). In contrast, suburban ozone exposure was associated with lower local (-$41.9, SE = 7.4) and property-tax revenues (-$34.7, SE = 6.0), higher state revenues (+$26.8, SE = 3.6), and lower capital outlays (-$7.0, SE = 2.8). Suburban districts experiencing at least three hazards exhibited a similar pattern of lower local revenues but greater state and federal support.

In sum, hazard exposure was associated with markedly different fiscal contexts across regions and urbanicity categories, highlighting the importance of local institutional and policy environments in shaping adaptive capacity.

Environmental Justice Heterogeneity

Associations between climate hazards and school district finances also varied by student racial and ethnic composition (**Figures S17-S19; Tables S18-S20**). The strongest and most consistent patterns involved revenue outcomes.

Several positive hazard-revenue associations became substantially weaker in districts serving larger shares of Hispanic, Black, and Asian students. For example, the positive association between heat exposure and total revenue was significantly weaker in districts with larger Hispanic (-$209.3, SE = 35.4) and Asian student shares (-$676.0, SE = 135.9). Ozone exposure similarly exhibited weaker total, local, and property-tax revenue associations in districts serving larger shares of Hispanic, Black, and Asian students. For local property-tax revenue, heat exposure was associated with interaction coefficients of -$232.1 (SE = 33.7) for Hispanic students, -$88.7 (SE = 40.3) for Black students, and -$900.1 (SE = 126.2) for Asian students. Districts experiencing at least three hazards likewise exhibited weaker local-revenue and property-tax revenue associations among these student populations. Many of these same interactions were associated with larger state-revenue coefficients, suggesting greater reliance on state funding.

Capital-investment and debt interactions were more heterogeneous. Heat exposure was associated with lower capital outlays in districts serving larger shares of Hispanic students (-$27.2, SE = 9.4), while ozone exposure was associated with lower capital outlays among districts serving larger shares of Hispanic (-$12.4, SE = 5.4) and Asian students (-$31.9, SE = 10.6). Several of the strongest debt interactions involved Asian student share, including higher debt-interest expenditures (+$14.8, SE = 2.6) and long-term debt issuance (+$44.1, SE = 15.4) associated with wildfire smoke exposure.

Overall, these findings suggest that climate hazards intersect with existing racialized patterns of fiscal structure and institutional capacity. Districts serving larger shares of Hispanic, Black, and Asian students often exhibited weaker local-revenue and property-tax revenue associations and greater reliance on state funding under comparable levels of hazard exposure.

State Infrastructure Analyses

The national finance analyses suggested that climate hazard exposure was associated more strongly with differences in district fiscal context than with capital investment. To evaluate whether these patterns corresponded to observed facility conditions, we analyzed publicly available facility datasets from Colorado (177 districts), Maryland (24 districts), and Florida (67 districts) (**Figures S20-S28; Tables S21-S28**).

Facility conditions varied substantially across districts within all three states. However, adjusted models provided limited evidence that climate hazard exposure was consistently associated with observed infrastructure quality. In Colorado, greater ozone exposure was associated with lower Facility Condition Index scores (-0.008, SE = 0.003) and fewer facilities classified as poor condition (-1.685 percentage points, SE = 0.619), while greater wildfire smoke exposure was associated with lower facility adequacy scores (-0.003, SE = 0.001). In Maryland, wildfire smoke exposure was associated with older facilities (+5.56 years, SE = 2.43). In Florida, climate hazard exposures showed little consistent association with facility age after adjustment for urbanicity and population density.

Across all three states, facility-condition measures exhibited substantial variation, but associations between climate hazard exposure and infrastructure quality were generally weak and inconsistent. Although several state-specific relationships emerged, particularly involving wildfire smoke exposure in Colorado and Maryland, these patterns were not replicated across states or infrastructure metrics. Taken together, the results suggest that districts experiencing greater climate hazard exposure do not systematically exhibit older or poorer-condition facilities despite substantial geographic variation in both hazard burdens and infrastructure conditions.

Discussion

This study provides the first national multi-hazard assessment of climate exposure across U.S. public school districts and examines how these exposures intersect with student demographics, district fiscal context, and school facility conditions. Three findings stand out. First, climate hazard exposure increased substantially between 2013 and 2022, with the share of districts experiencing three or more hazards increasing from 1.6% to 27.4%, driven by increases in both individual hazards and multi-hazard co-exposure. Second, exposure was not evenly distributed across districts. Districts serving larger shares of Hispanic students consistently experienced greater exposure to extreme heat, ozone exceedances, and multi-hazard conditions, and these disparities widened over time. Third, climate hazard exposure was associated more strongly with differences in school finance composition than with capital investment, debt financing, or facility conditions. Together, these findings suggest that climate hazards are becoming an increasingly important dimension of educational inequality (Sheffield et al. 2017).

A central contribution of this study is demonstrating that climate hazard exposure follows clear and persistent gradients of inequality. Consistent with prior environmental justice research (Cheeseman et al. 2022; Jones et al. 2024), districts serving larger shares of Hispanic students experienced greater exposure to extreme heat, ozone exceedances, and multi-hazard conditions, even after controlling for state, year, urbanicity, and population density. We also found evidence that these disparities widened over time, with districts experiencing increases in Hispanic student enrollment tending to experience larger increases in climate hazard exposure. Regional analyses showed that these disparities were particularly pronounced in the South and West, where heat, ozone, and multi-hazard exposures increased most rapidly during the study period. Together, these findings suggest that climate-related risks are becoming increasingly concentrated in Hispanic-serving districts (Zanocco et al. 2022). More broadly, they extend environmental justice research by demonstrating that inequalities increasingly emerge through exposure to multiple overlapping hazards rather than individual hazards considered in isolation (Sanchez et al. 2025).

Co-exposure emerged as a particularly important dimension of climate risk. Wildfire smoke was the dominant contributor to multi-hazard exposure nationally and frequently co-occurred with extreme heat and ozone exceedances. The most common combinations involved heat and wildfire smoke, while higher-order co-exposures often included heat, ozone, and wildfire smoke, particularly in the West. In the South, multi-hazard exposure more commonly reflected combinations of heat, ozone, wildfire smoke, and tropical cyclones. The rapid increase in districts experiencing three or more hazards indicates that climate risks to schools are becoming increasingly interconnected and that adaptation efforts will need to address compound hazards rather than individual risks in isolation (Haer and Ruiter 2024).

The finance analyses revealed a more nuanced pattern than originally hypothesized. Climate hazard exposure was associated with differences in district fiscal context, particularly the balance between local and state revenues, but showed limited and inconsistent associations with capital investment, debt financing, or observed facility conditions. These relationships should not be interpreted as evidence that climate hazards directly influence school revenues. Rather, they likely reflect the geographic coincidence of climate hazards with existing patterns of local wealth, housing markets, property-tax bases, state aid systems, and socioeconomic inequality.

Regional and demographic heterogeneity analyses support this interpretation. Hazard-finance relationships varied substantially across regions and student populations, indicating that climate-exposed districts operate within different fiscal environments. For example, ozone exposure in the Northeast was associated with higher local and property-tax revenues, whereas heat and wildfire smoke exposure in parts of the West were associated with lower local revenues but higher state revenues. Districts serving larger shares of Hispanic, Black, and Asian students often exhibited weaker local-revenue associations and stronger state-revenue associations under comparable levels of hazard exposure. Although this study did not directly evaluate district wealth, property values, or funding formulas, these patterns are consistent with broader inequalities in school finance systems (Baker 2021). Consequently, districts facing similar climate burdens may possess very different capacities to finance facility improvements, implement adaptation measures, and respond to climate-related risks. Revenue composition may therefore be as important as total revenue for understanding adaptive capacity, since local property-tax revenues are closely tied to local wealth and often provide greater discretion for long-term infrastructure investment than state funding formulas.

These findings challenge the common assumption that districts facing greater climate hazards necessarily possess fewer resources and poorer facilities (Lewis et al. 2023). Instead, our results suggest a more complex relationship between exposure and adaptive capacity. Some highly exposed districts appear to possess substantial fiscal resources, whereas others rely more heavily on state support, implying that districts with similar overall revenues may face very different constraints when financing facility improvements, issuing debt, responding to emergencies, or implementing adaptation measures.

The state infrastructure analyses likewise revealed substantial variation in facility conditions but limited evidence of a consistent relationship between climate hazard exposure and poorer infrastructure. Although some state-specific associations emerged, including older facilities in higher-smoke districts in Maryland and lower facility adequacy in Colorado, these patterns were not consistently replicated across states or infrastructure measures. Together, the finance and infrastructure analyses suggest that climate exposure, fiscal context, and facility quality are related but distinct dimensions of vulnerability.

Taken together, the results suggest that districts facing greater climate hazard exposure do not uniformly possess fewer resources or poorer facilities. Instead, climate vulnerability reflects the intersection of hazard exposure, fiscal capacity, and infrastructure conditions. Districts facing high exposure but possessing substantial resources may benefit primarily from planning and targeted investments, whereas districts facing both high exposure and limited local fiscal capacity may require additional state or federal support. Existing evidence supports the notion that school infrastructure quality is associated with poor childhood health and educational outcomes and that infrastructure improvements can improve indoor air quality in schools (Wu et al. 2023). Thus, school resources and ability to improve infrastructure quality could be an important lever to protect children from climate-related hazards. Existing school finance systems rarely account for climate risk explicitly, yet our findings suggest that climate hazards are becoming an increasingly important dimension of educational inequality.

Several limitations should be considered. The observational design limits causal interpretation, and district-level analyses may obscure substantial within-district variation in exposure, infrastructure quality, and adaptive resources. National finance measures capture fiscal context rather than direct facility quality, and school finance systems differ substantially across states. Because local wealth, housing markets, land-use patterns, and other determinants of school finance were not directly modeled, hazard-finance associations should be interpreted as differences in fiscal context rather than causal effects of climate hazards on district revenues. This modeling choice reflects the study’s objective of characterizing the financial environments in which climate hazards occur rather than identifying the independent causal contribution of hazards after conditioning on factors that help shape district fiscal capacity. Direct facility-condition data were available for only three states and were not nationally representative.

Finally, additional unmeasured factors may influence both climate hazard exposure and district adaptive capacity.

Future research should examine how climate hazards influence school operations, attendance, academic performance, and long-term infrastructure planning. Additional work is needed to evaluate how adaptation investments, including cooling systems, air filtration, building modernization, and resilience planning, modify the effects of increasing climate hazards on students and schools. Because school districts and local governments often conduct climate planning separately, stronger coordination between school systems, municipalities, and regional planning agencies may help identify shared vulnerabilities and prioritize resilience investments in districts facing the greatest climate burdens.

Acknowledgements

Thank you to Sara Hinkley and Jeffrey M Vincent for comments on an early draft

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Supplementary Information

Climate Hazards, Co-Exposure, and Inequality in U.S. School Districts

Priyanka deSouza,[1,2,*] Colleen E. Reid,[3] Lisa Frueh,[4] Shin Bin Tan,[5] Carrie Makarewicz,[1] Rockli Kim,[6,7] SV Subramanian,[8,9] Jaime Madrigano,[10] Yang Liu.[11]
1: Department of Urban and Regional Planning, University of Colorado Denver
2: CU Population Center, University of Colorado Boulder
3: Department of Geography, University of Colorado Boulder, Boulder, CO, United States of America
4: Department of Environmental and Occupational Health, Drexel University Dornsife School of Public Health, Philadelphia, PA, United States of America
5: Lee Kuan Yew School of Public Policy, National University of Singapore
6: Division of Health Policy and Management, College of Health Sciences, Korea University, Seoul, South Korea
7: Interdisciplinary Program in Precision Public Health, Department of Public Health Sciences, Graduate School of Korea University, Seoul, South Korea
8: Department of Social and Behavioural Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, USA
9: Harvard Center for Population and Development Studies, Cambridge, Massachusetts
10: Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe Street, Baltimore, MD, 21205, USA
11: Gangarosa Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA 30322, USA

*: priyanka.desouza@ucdenver.edu

S1 Figures

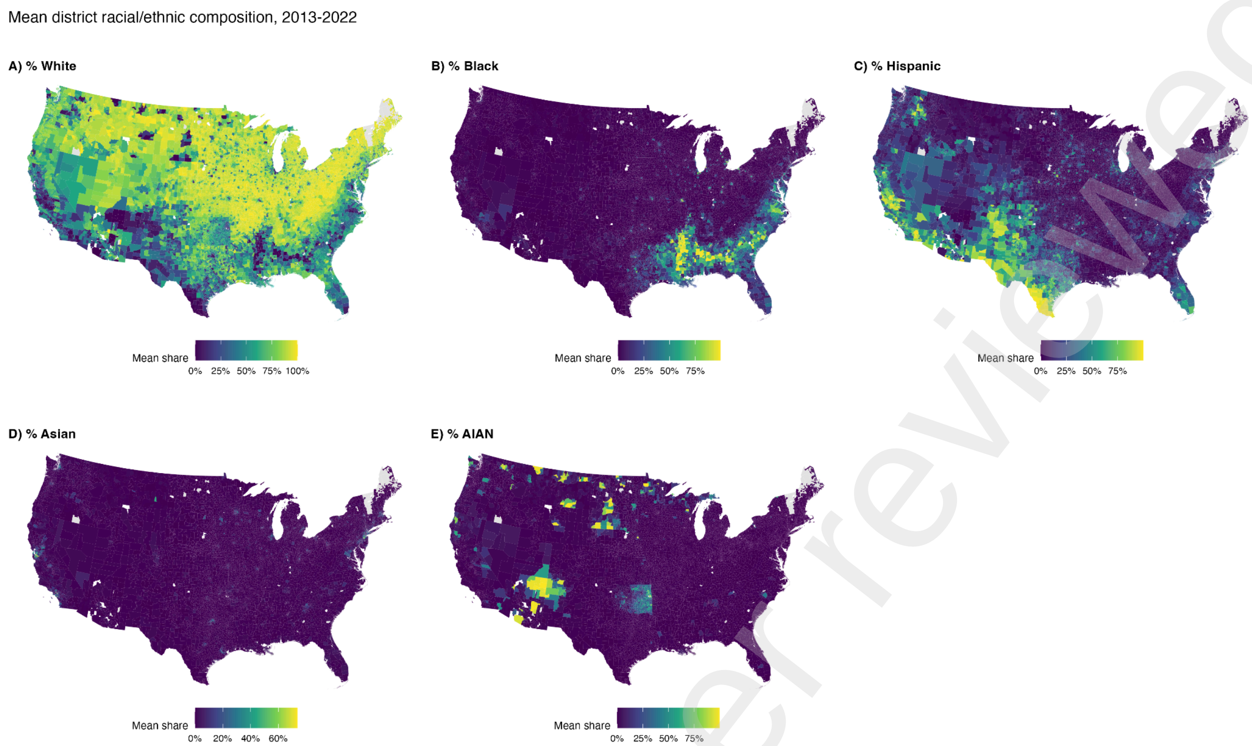

***Figure S1**: Average student racial composition across U.S. school districts, 2013-2022. Maps show district-level average shares of students by race: White, Black, Hispanic, Asian, and American Indian/Alaska Native (AIAN) over the 2013-2022 period. Persistent regional patterns are evident, including higher shares of Black students in the Southeast, Hispanic students in the Southwest and parts of the West, and AIAN students in the Mountain West and Northern Plains. White student shares are highest in much of the Midwest and Northeast, while Asian student shares are concentrated in coastal metropolitan regions. Values represent the mean percentage of enrolled students in each racial group across years at the district level.*

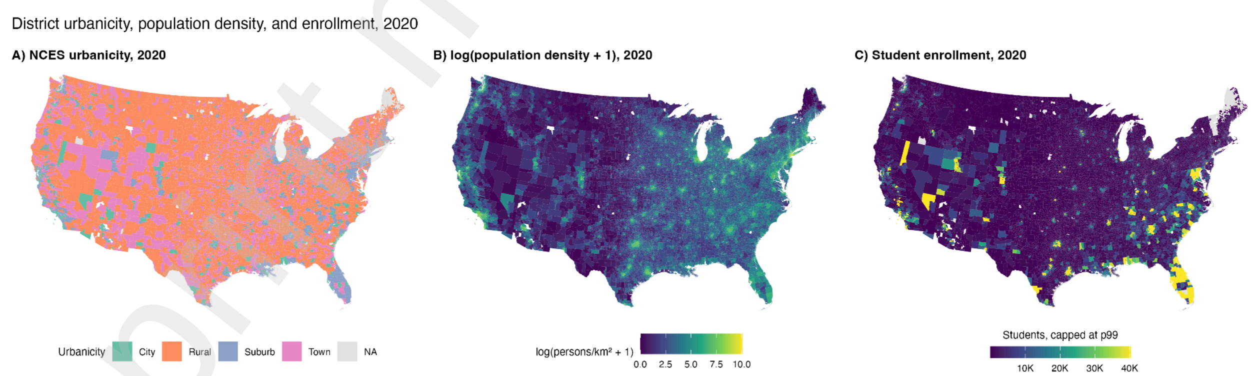

***Figure S2**: Contextual school district characteristics, 2020. Maps show district-level variation in (top left) urban-rural status, (top right) log population density (log-transformed), and (bottom) student enrollment.*

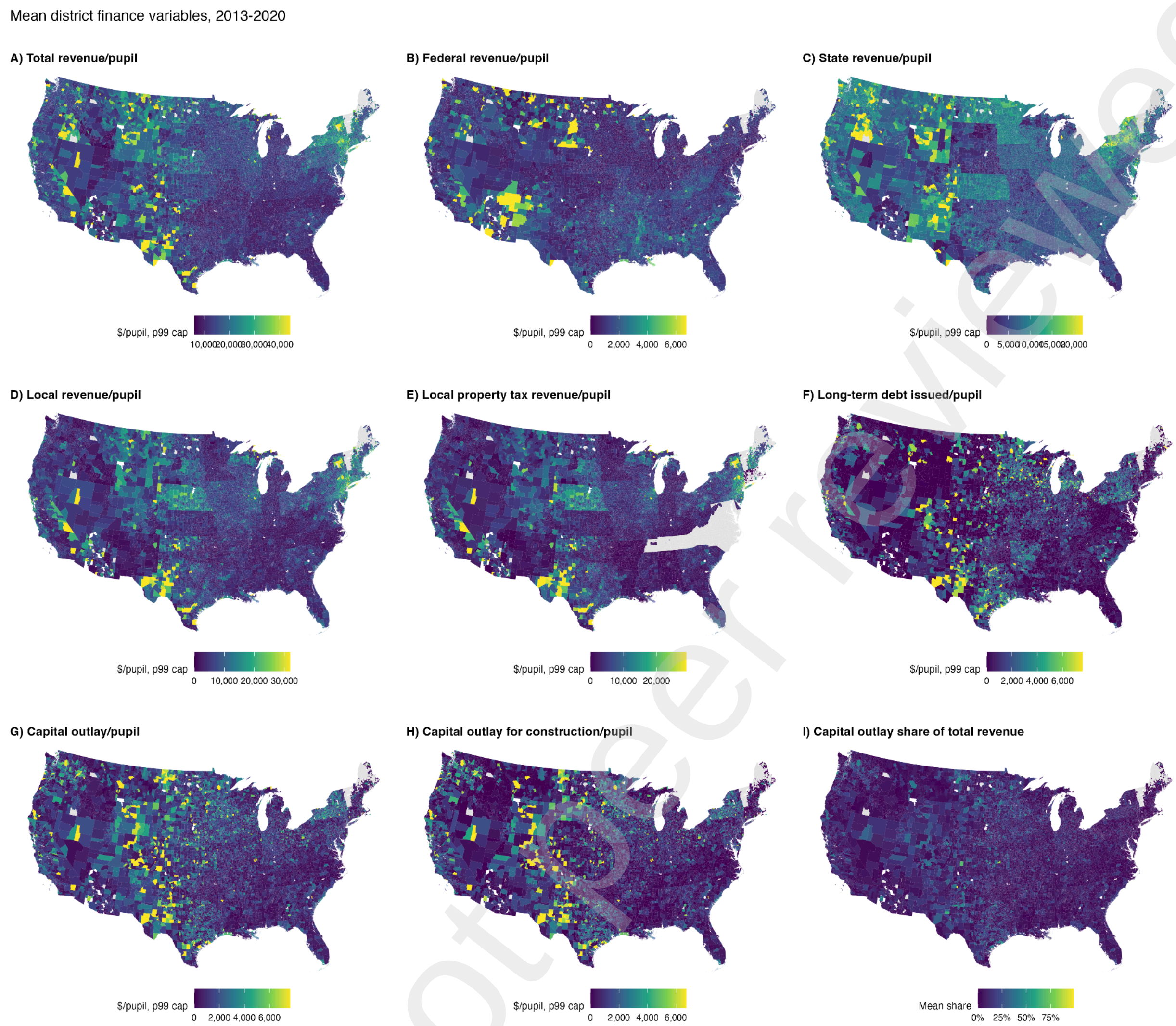

***Figure S3**: Maps display district-level averages of key school finance variables, including total, federal, state, and local revenue per pupil; local property tax revenue per pupil; long-term debt issuance per pupil; total capital outlay and construction-specific capital outlay per pupil; and the share of total revenue devoted to capital outlays. Substantial spatial heterogeneity is evident across revenue sources and investment patterns. State funding dominates in many regions, while local and property tax revenues are higher in parts of the Northeast and Midwest. Capital investment and debt issuance show strong regional clustering, particularly in the West and selected metropolitan areas. Values represent averages over the 2013-2020 period.*

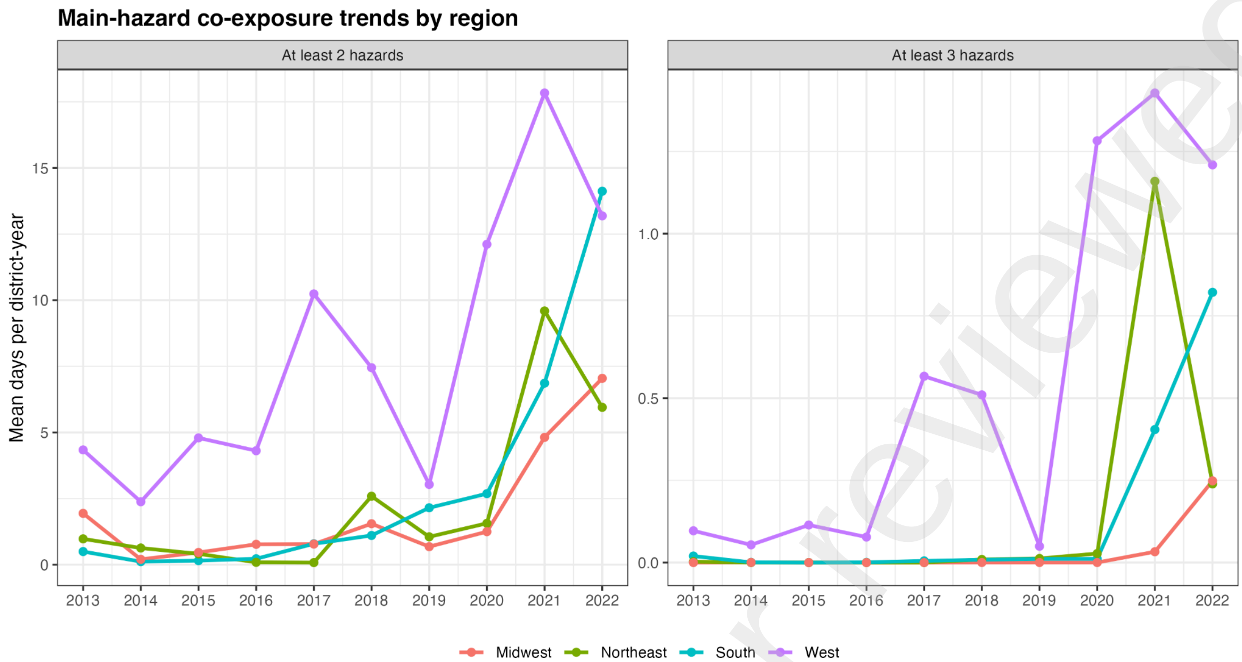

Figure S4: *Mean annual district-days with at least two (left) and at least three (right) main hazards: heat, ozone ≥ 140 μg/m^3, wildfire-PM$_{2.5}$ > 0 μg/m^3, tropical storm, and wildfire burn, by U.S. Census region. Co-exposure intensity increases over time across all regions, with particularly sharp rises after 2020. The West consistently experiences the highest levels of co-exposure, followed by notable increases in the South and Northeast, while the Midwest shows more moderate but rising trends. Three-hazard exposures remain relatively rare prior to 2020 but increase markedly in recent years, especially in the West and South.*

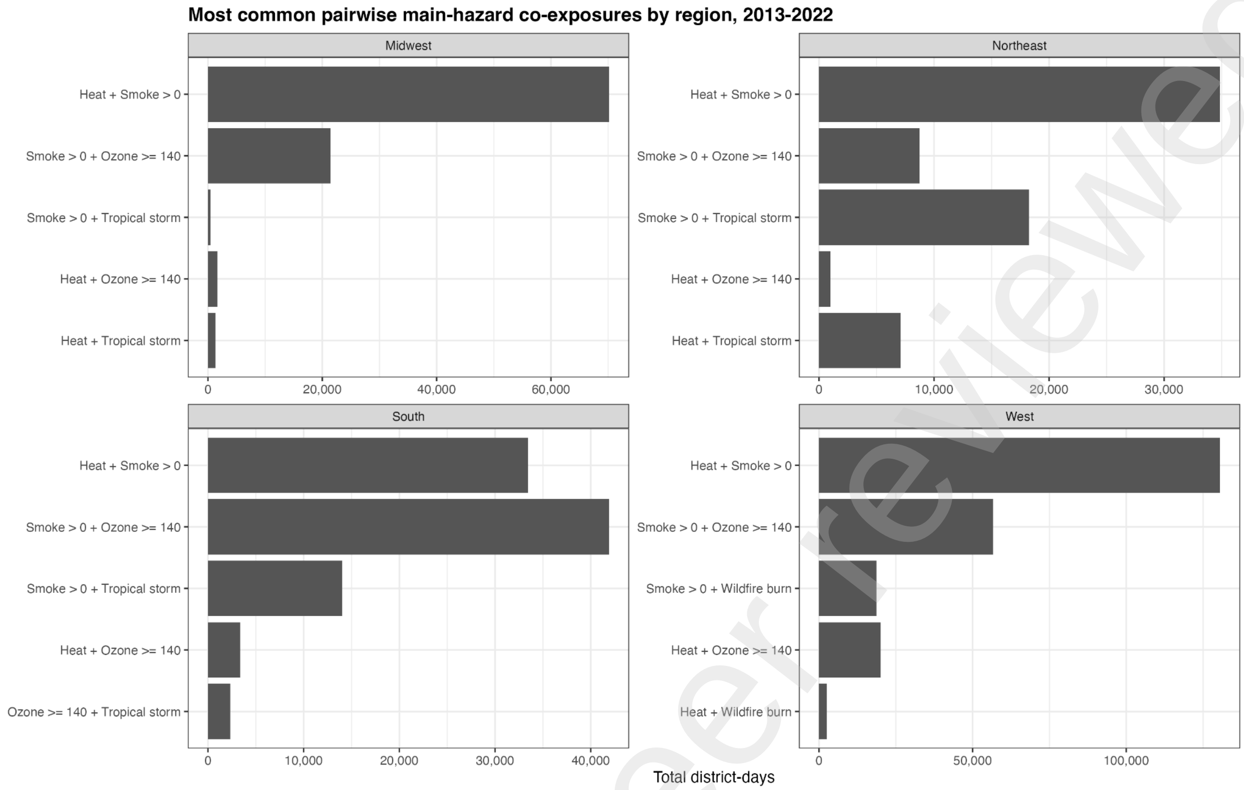

***Figure S5**: Most common pairwise climate hazard co-exposures by region, 2013-2022. Bar charts show the top pairwise combinations of main hazards: heat, ozone ≥ 140 µg/m^3, wildfire smoke (wildfire-PM$_{2.5}$ > 0 µg/m^3), tropical storm, and wildfire burn, measured as total district-days across U.S. Census regions. Across all regions, the most frequent co-exposure is heat combined with wildfire smoke, followed by smoke and ozone exceedances. The West exhibits the highest total co-exposure burden, with substantial contributions from heat-smoke and smoke-ozone combinations, while the South shows notable overlap between smoke and ozone. Co-exposures involving wildfire burn are less common but present in regions with active fire regimes. Values represent cumulative district-days over the 2013-2022 period.*

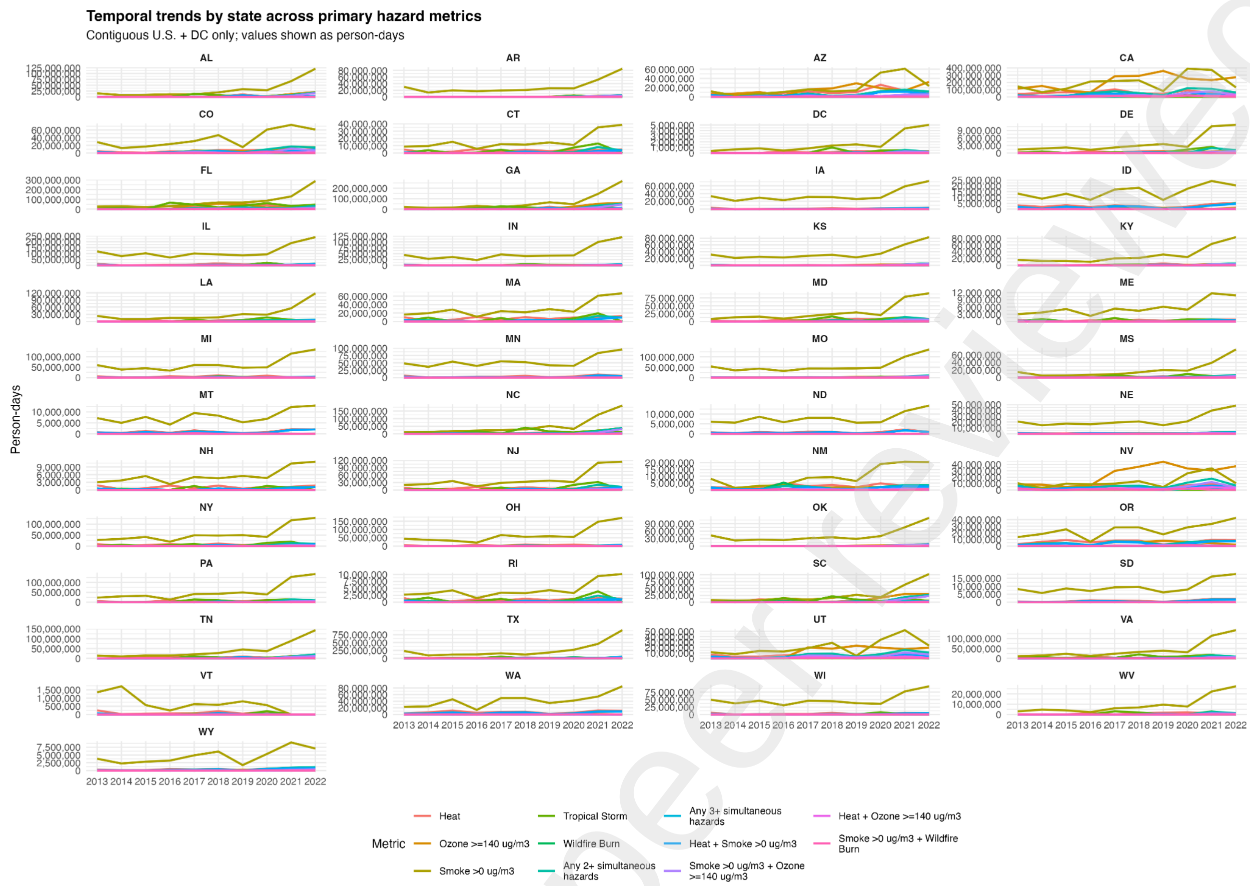

Figure S6: *State-level temporal trends in climate hazard exposure, 2013-2022. Small-multiple panels show annual district-days of primary climate hazards for each state, including heat, ozone exceedances, wildfire smoke (wildfire-$PM_{2.5}$ > 0 μg/m^3), tropical storms, and wildfire burn, along with selected co-exposure combinations. Values represent the total number of district-days in which each hazard occurred within a state-year. Substantial heterogeneity is evident across states and hazards, with wildfire smoke and heat driving large increases in exposure in many western and midwestern states, while tropical storm-related exposures are concentrated in coastal states. Co-exposure metrics remain relatively low in most states but have increased in recent years, reflecting the growing overlap of multiple hazards.*

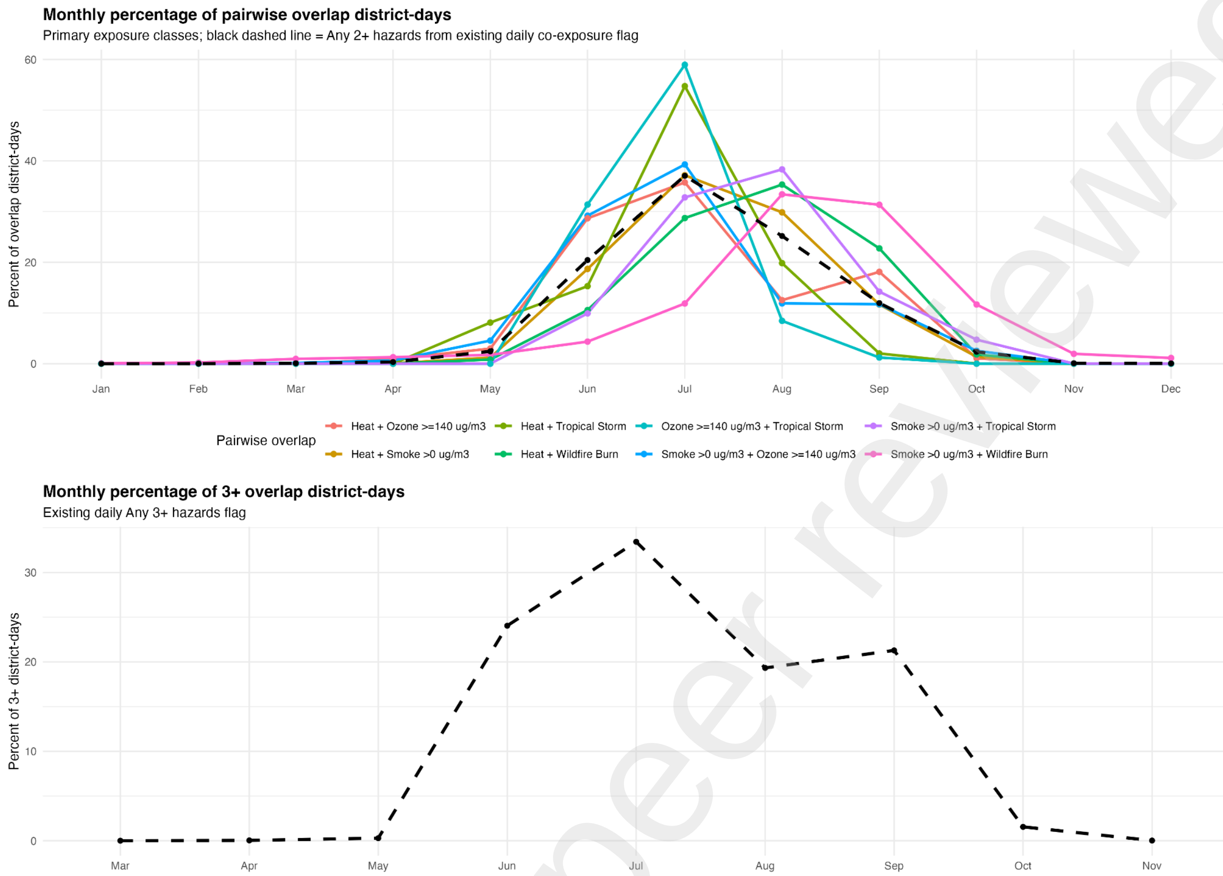

Figure S7: *Seasonal distribution of pairwise and higher-order climate hazard co-exposures, 2013-2022. Panel A shows the monthly percentage distribution of district-days associated with the most common pairwise hazard co-exposures, including combinations of extreme heat, ozone exceedances (≥140 μg/m³), wildfire smoke (>0 μg/m³), tropical storms, and wildfire burn exposure. Values represent the percentage of annual overlap district-days occurring in each month for a given co-exposure combination. The black dashed line indicates the monthly distribution of all district-days experiencing at least two simultaneous hazards. Panel B shows the monthly distribution of district-days experiencing at least three simultaneous hazards. Multi-hazard exposures were strongly seasonal, with pairwise and higher-order co-exposures concentrated during summer months. Most combinations peaked in June-August, reflecting the coincident occurrence of extreme heat, ozone exceedances, and wildfire smoke, while tropical storm-related overlaps extended into late summer and early autumn. The distribution of 3+ hazard co-exposure days peaked in July and remained elevated through September, indicating that the most complex multi-hazard environments occur primarily during the summer and early fall hazard season.*

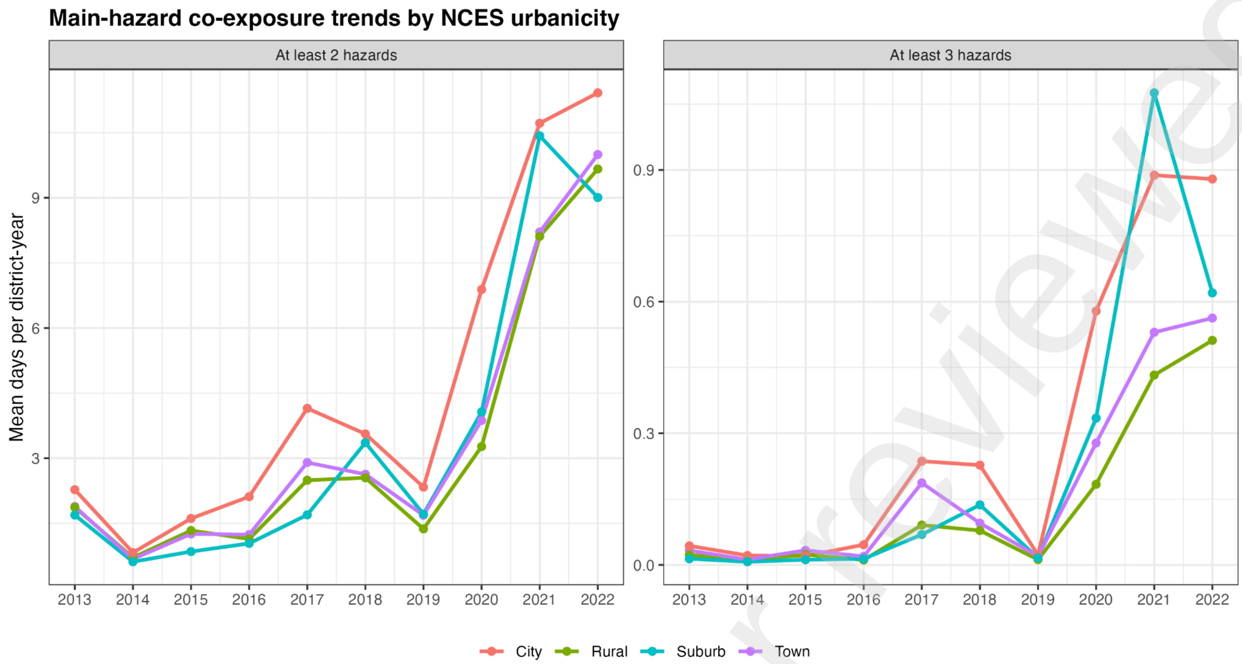

Figure S8: *Urban-rural differences in climate hazard co-exposure, 2013-2022. The figure shows mean annual district-days with at least two (left) and at least three (right) main climate hazards: heat, ozone ≥ 140 μg/m³, wildfire smoke > 0 μg/m³, tropical storm, and wildfire burn, by urban and rural status. Both urban and rural districts experience increasing co-exposure over time, with sharp increases after 2020. Urban districts exhibit slightly higher levels of high-intensity (three-hazard) co-exposure, particularly during peak years, while rural districts experience comparable or higher levels of two-hazard exposure in earlier periods. These patterns indicate broadly shared exposure dynamics, with modest differences in intensity rather than fundamentally distinct exposure regimes.*

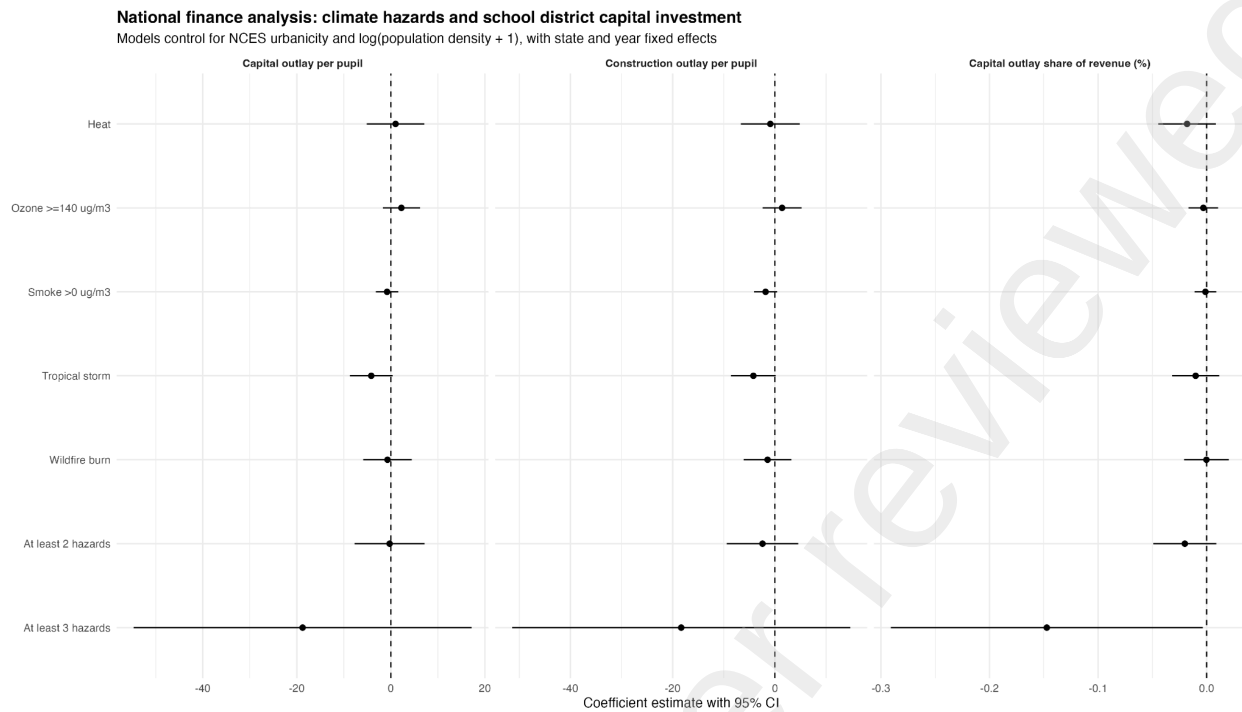

***Figure S9**: National associations between climate hazards and school district capital investment. Coefficient estimates from district-year regression models relating climate hazard exposure to capital outlay expenditures per pupil, construction expenditures per pupil, and capital outlay share of total revenue. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals; standard errors are clustered at the district level. Most hazard measures exhibit limited associations with capital investment outcomes, suggesting that districts experiencing greater climate hazard exposure do not consistently invest more or less in school infrastructure.*

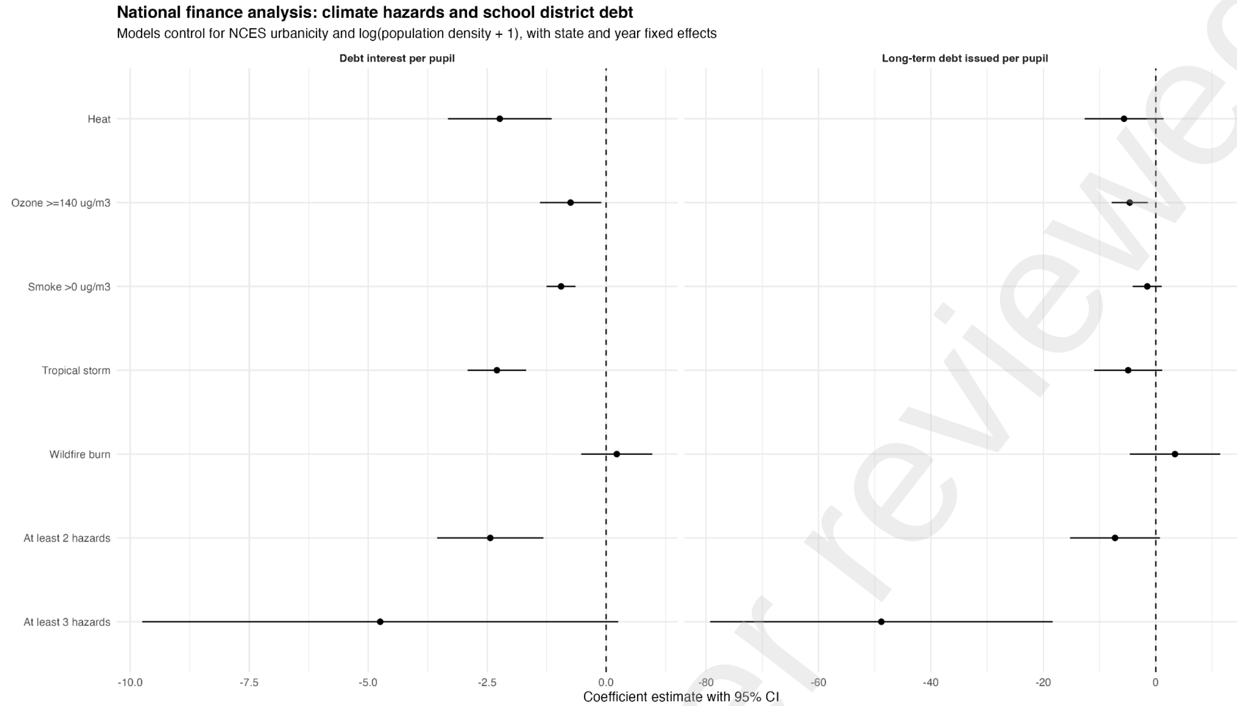

Figure S10: *National associations between climate hazards and school district debt. Coefficient estimates from district-year regression models relating climate hazard exposure to debt interest expenditures per pupil and long-term debt issuance per pupil. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals; standard errors are clustered at the district level. Results provide limited evidence that hazard-exposed districts systematically rely more heavily on debt financing, although districts experiencing multiple hazards exhibit lower long-term debt issuance.*

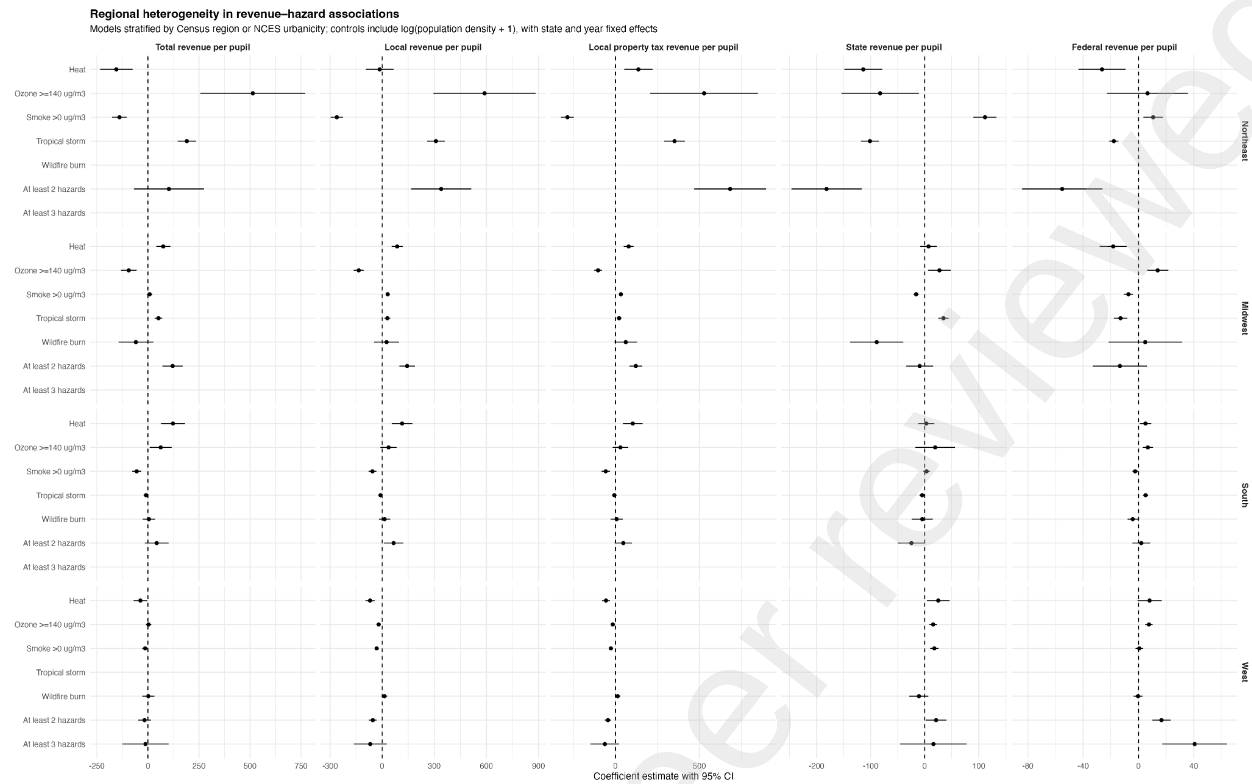

Figure S11: *Regional heterogeneity in revenue-hazard associations. Coefficient estimates from region-stratified regression models relating climate hazard exposure to school district revenues, including total, local, property-tax, state, and federal revenue per pupil. Models include year fixed effects and controls for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Results demonstrate substantial regional variation in the relationship between climate hazards and district revenue composition.*

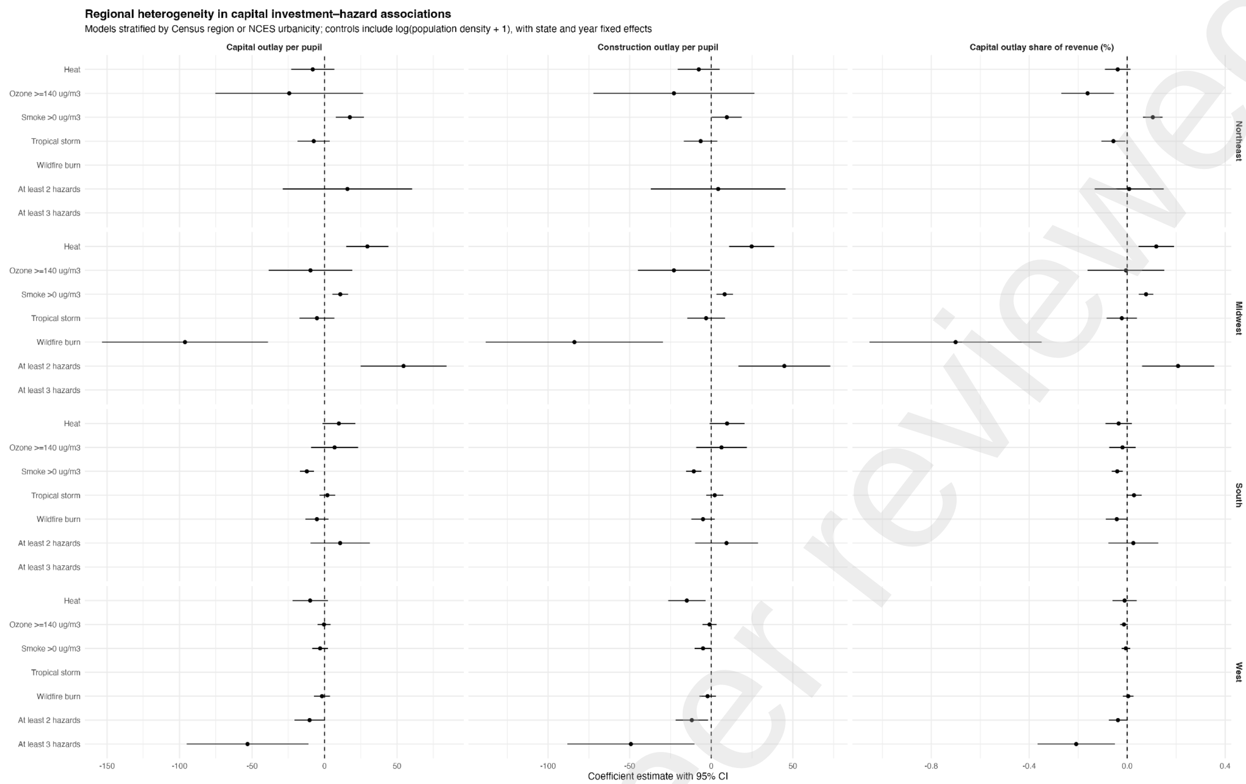

***Figure S12**: Regional heterogeneity in capital investment-hazard associations. Coefficient estimates from region-stratified regression models relating climate hazard exposure to capital outlay expenditures per pupil, construction expenditures per pupil, and capital outlay share of revenue. Models include year fixed effects and controls for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Associations between hazards and infrastructure investment vary considerably across regions, indicating that national averages mask important geographic differences.*

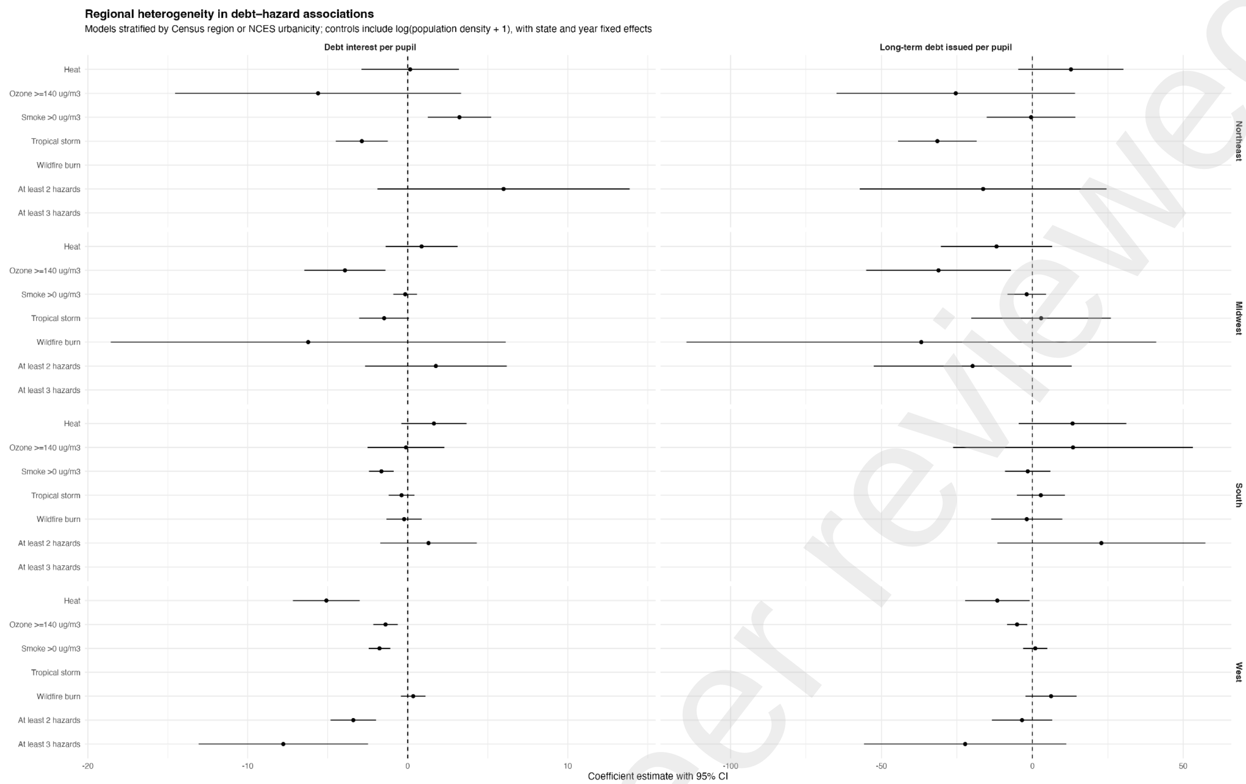

***Figure S13**: Regional heterogeneity in debt-hazard associations. Coefficient estimates from region-stratified regression models relating climate hazard exposure to debt interest expenditures and long-term debt issuance per pupil. Models include year fixed effects and controls for NCES urbanicity and log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Debt-financing patterns associated with climate hazards differ substantially across Census regions.*

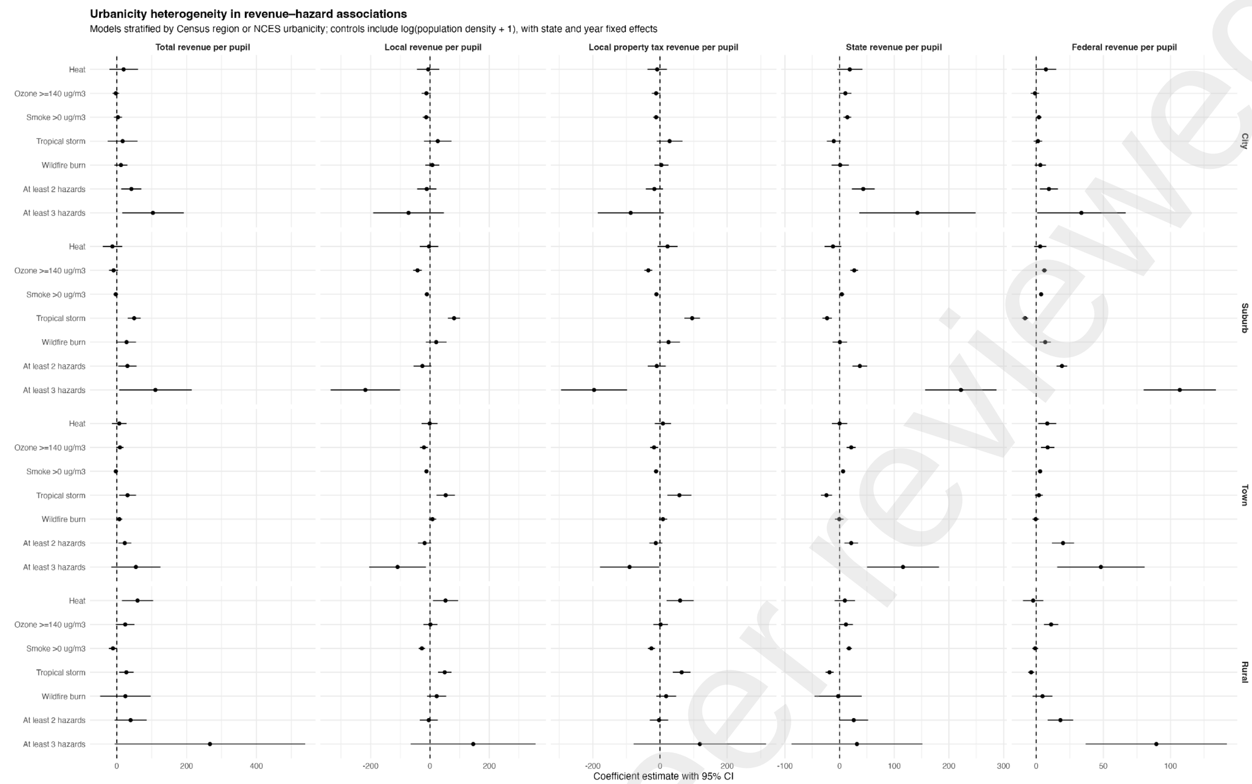

Figure S14*: Urbanicity heterogeneity in revenue-hazard associations. Coefficient estimates from NCES urbanicity-stratified regression models relating climate hazard exposure to district revenue composition. Models include state and year fixed effects and control for log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Results illustrate how hazard-finance relationships differ among city, suburban, town, and rural districts.*

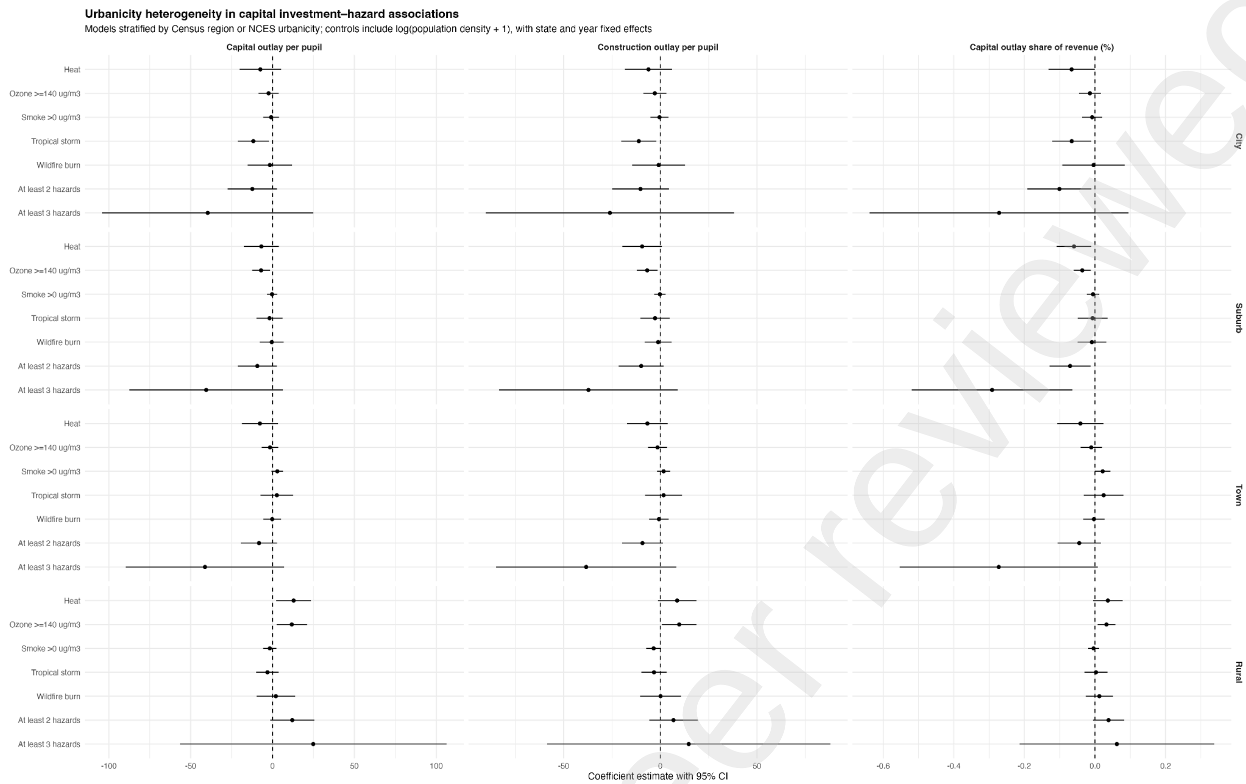

***Figure S15**: Urbanicity heterogeneity in capital investment-hazard associations. Coefficient estimates from NCES urbanicity-stratified regression models relating climate hazard exposure to capital outlay expenditures, construction expenditures, and capital outlay shares of revenue. Models include state and year fixed effects and control for log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Capital-investment responses associated with climate hazards vary across settlement contexts.*

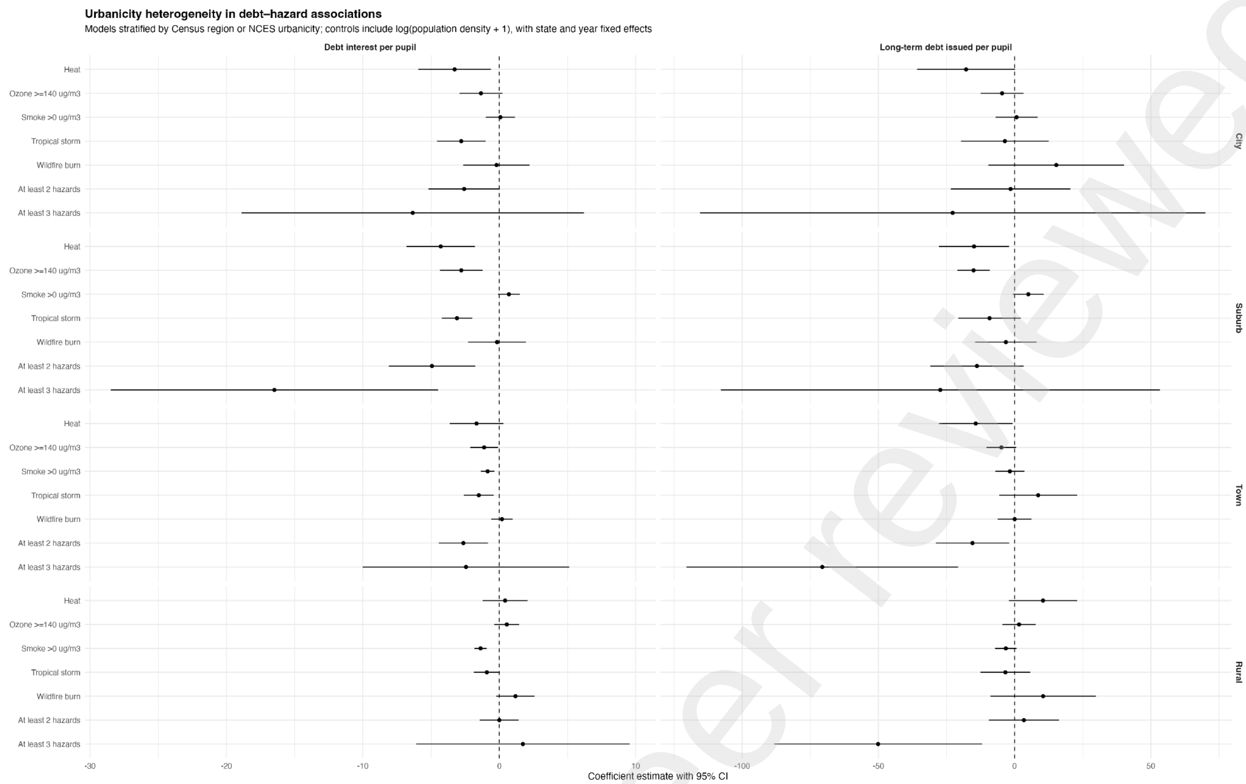

***Figure S16**: Urbanicity heterogeneity in debt-hazard associations. Coefficient estimates from NCES urbanicity-stratified regression models relating climate hazard exposure to debt interest expenditures and long-term debt issuance. Models include state and year fixed effects and control for log(population density + 1). Points indicate coefficient estimates and horizontal bars indicate 95% confidence intervals. Associations between hazards and debt financing differ across city, suburban, town, and rural districts.*

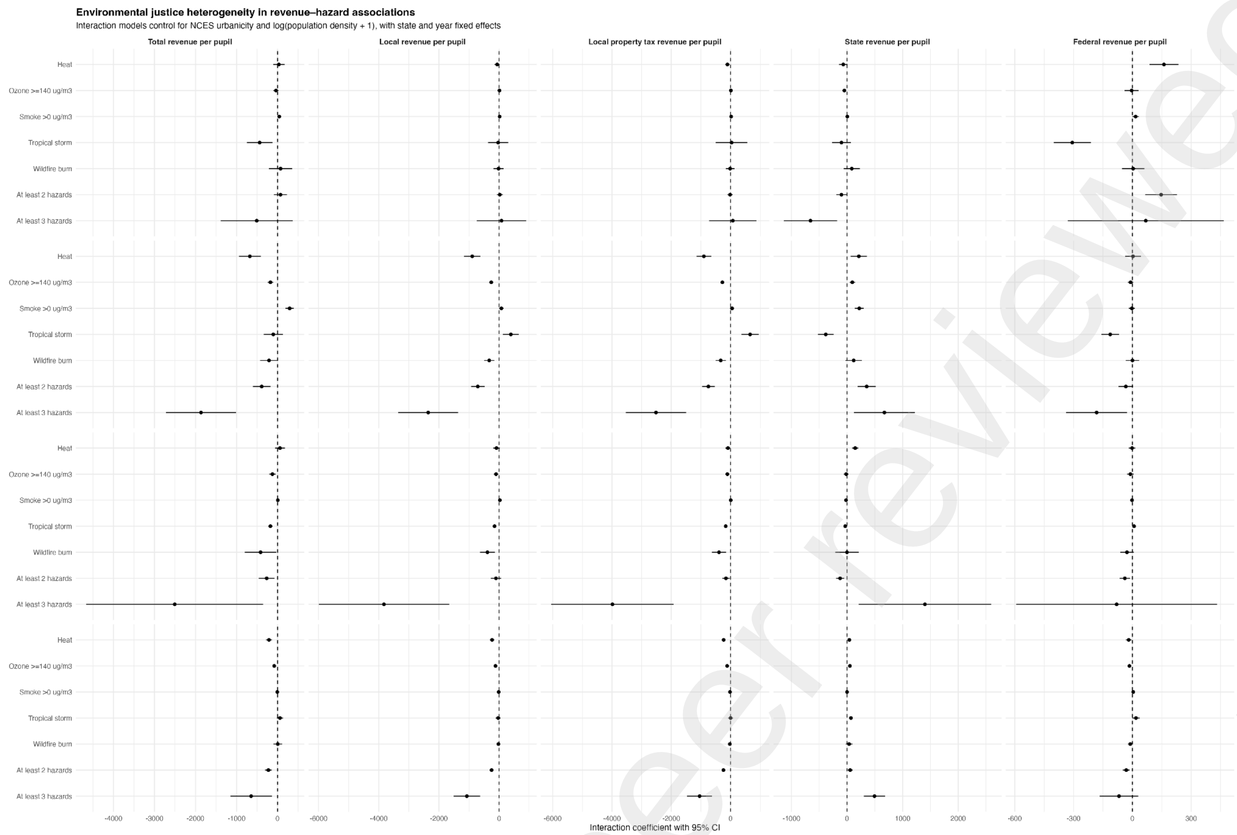

Figure S17: *Environmental justice heterogeneity in revenue-hazard associations. Interaction coefficients from district-year regression models evaluating whether associations between climate hazard exposure and school district revenue composition vary by student racial and ethnic composition. Interaction models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Panels display interaction estimates for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares. Positive coefficients indicate stronger hazard–revenue associations in districts serving larger shares of the specified student group, while negative coefficients indicate weaker associations.*

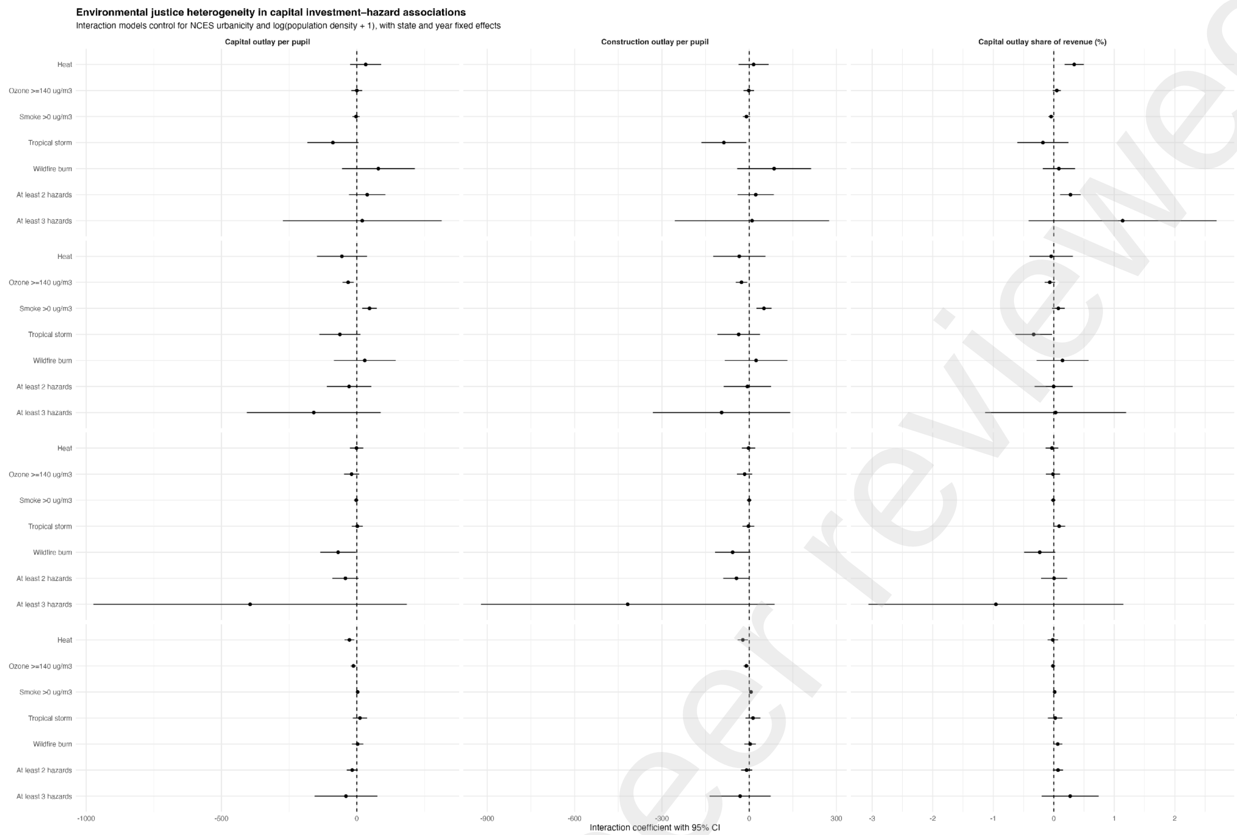

Figure S18*: Environmental justice heterogeneity in capital investment-hazard associations. Interaction coefficients from district-year regression models evaluating whether associations between climate hazard exposure and capital investment outcomes vary by student racial and ethnic composition. Outcomes include capital outlay expenditures per pupil, construction expenditures per pupil, and capital outlay share of revenue. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Results illustrate how climate hazard-infrastructure investment relationships differ across districts serving different student populations.*

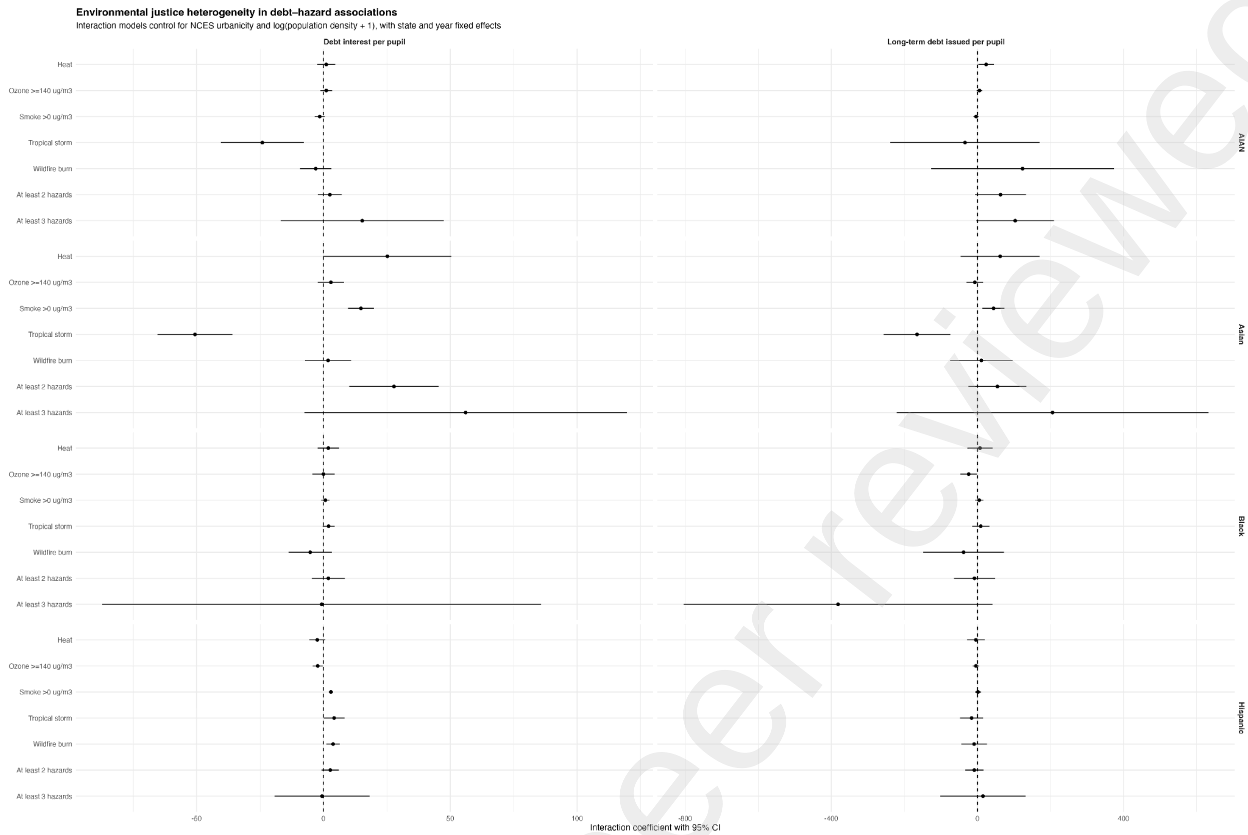

Figure S19*: Environmental justice heterogeneity in debt-hazard associations. Interaction coefficients from district-year regression models evaluating whether associations between climate hazard exposure and debt financing outcomes vary by student racial and ethnic composition. Outcomes include debt interest expenditures per pupil and long-term debt issuance per pupil. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Positive coefficients indicate stronger hazard–debt associations in districts serving larger shares of the specified student group, while negative coefficients indicate weaker associations.*

Figure S20: *Colorado district-level school facility conditions. District-level facility metrics derived from the Colorado facilities assessment dataset and matched to analytic-panel school district geometries. Panel A shows mean facility age, Panel B shows mean Facility Condition Index (FCI), Panel C shows mean facility adequacy index, and Panel D shows the number of matched facilities per district. Higher FCI values indicate poorer facility condition, while higher adequacy values indicate better facility adequacy.*

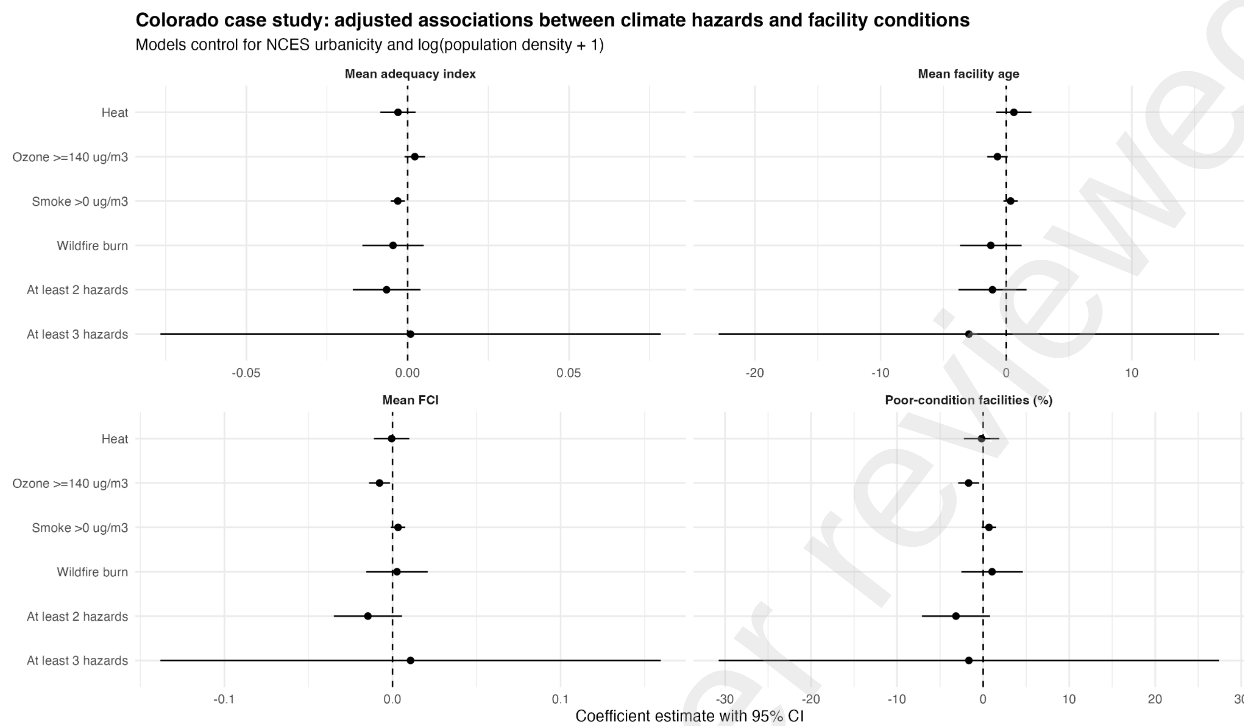

Figure S21*: Colorado case study: adjusted associations between climate hazards and facility conditions. Coefficient estimates and 95% confidence intervals from district-level linear regression models relating climate hazard exposure to facility conditions in Colorado. Outcomes include mean facility age, mean FCI, mean adequacy index, and percentage of poor-condition facilities. Models control for NCES urbanicity and log(population density + 1). Hazard metrics represent average annual exposure between 2013 and 2020. Vertical dashed lines indicate null associations.*

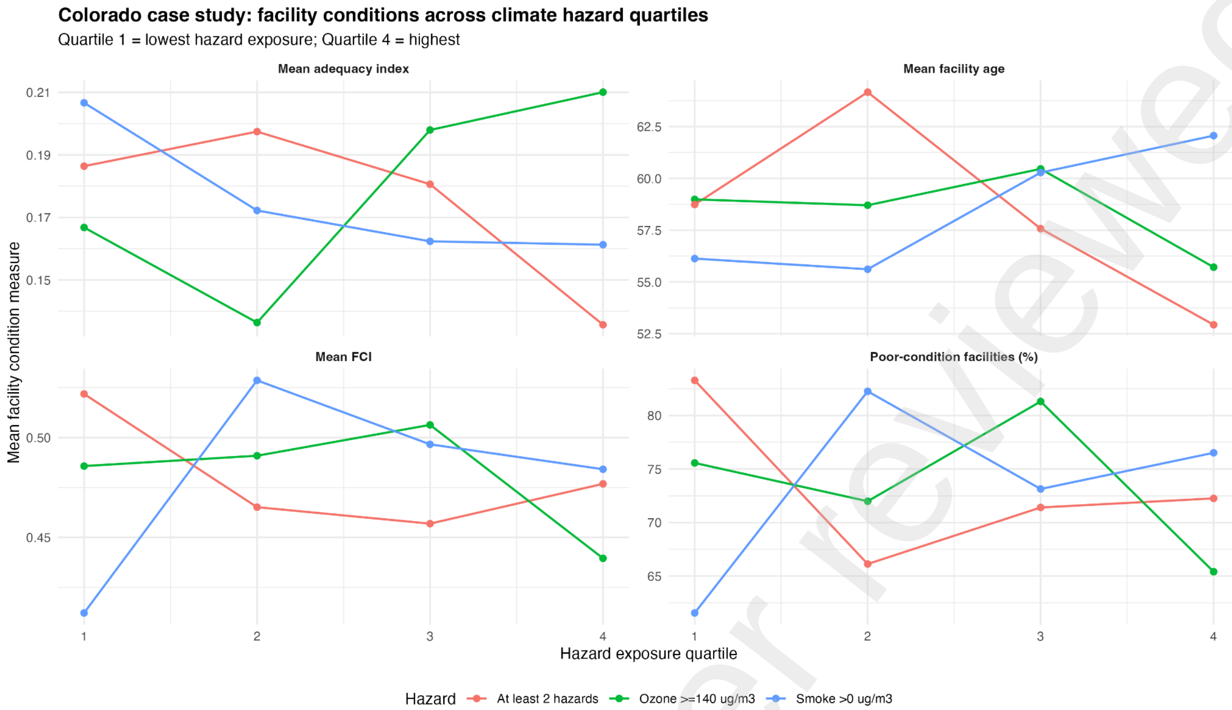

Figure S22: *Colorado case study: facility conditions across climate hazard quartiles. Mean facility condition measures across quartiles of climate hazard exposure in Colorado school districts. Quartile 1 represents the lowest hazard exposure and Quartile 4 the highest. Panels show mean adequacy index, mean facility age, mean FCI, and percentage of poor-condition facilities. Lines illustrate descriptive gradients in facility conditions across exposure quartiles for selected hazards and are intended to complement the adjusted regression results.*

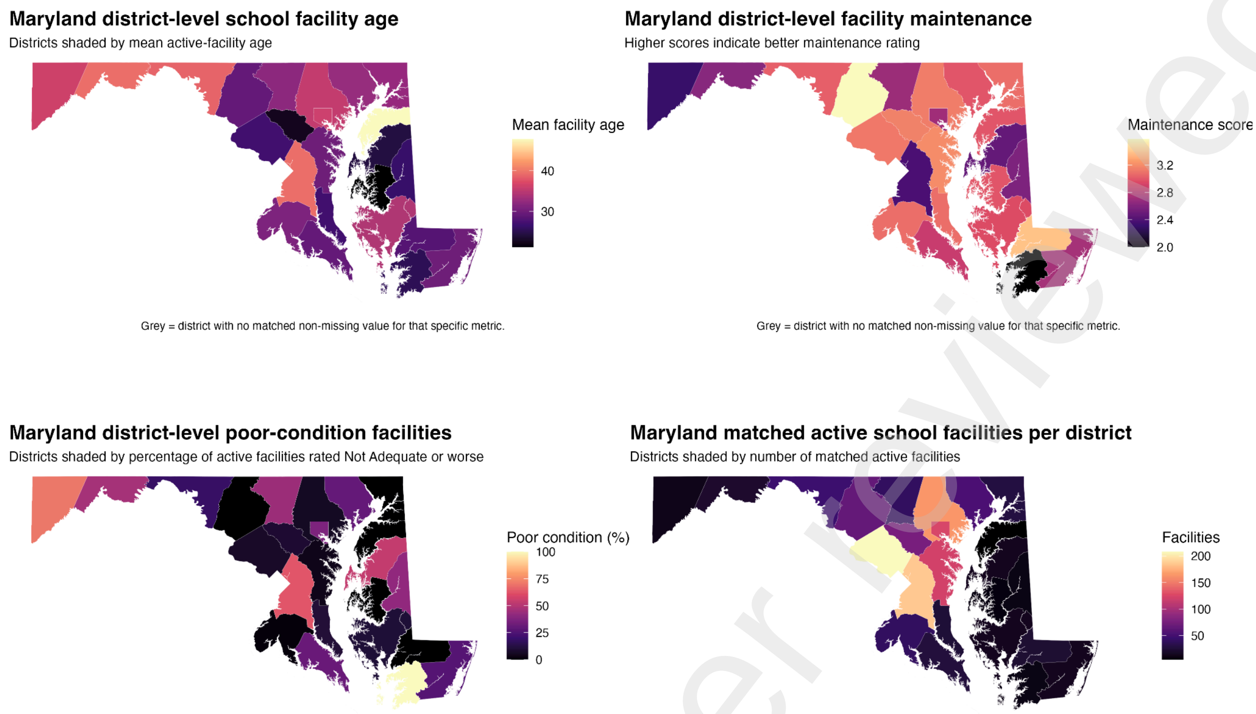

Figure S23*: Maryland district-level school facility conditions. District-level facility metrics derived from the Maryland school facilities inventory and matched to analytic-panel school district geometries. Panel A shows mean active-facility age, Panel B shows mean maintenance score, Panel C shows the percentage of facilities rated Not Adequate or worse, and Panel D shows the number of matched active facilities per district. Higher maintenance scores indicate better facility conditions.*

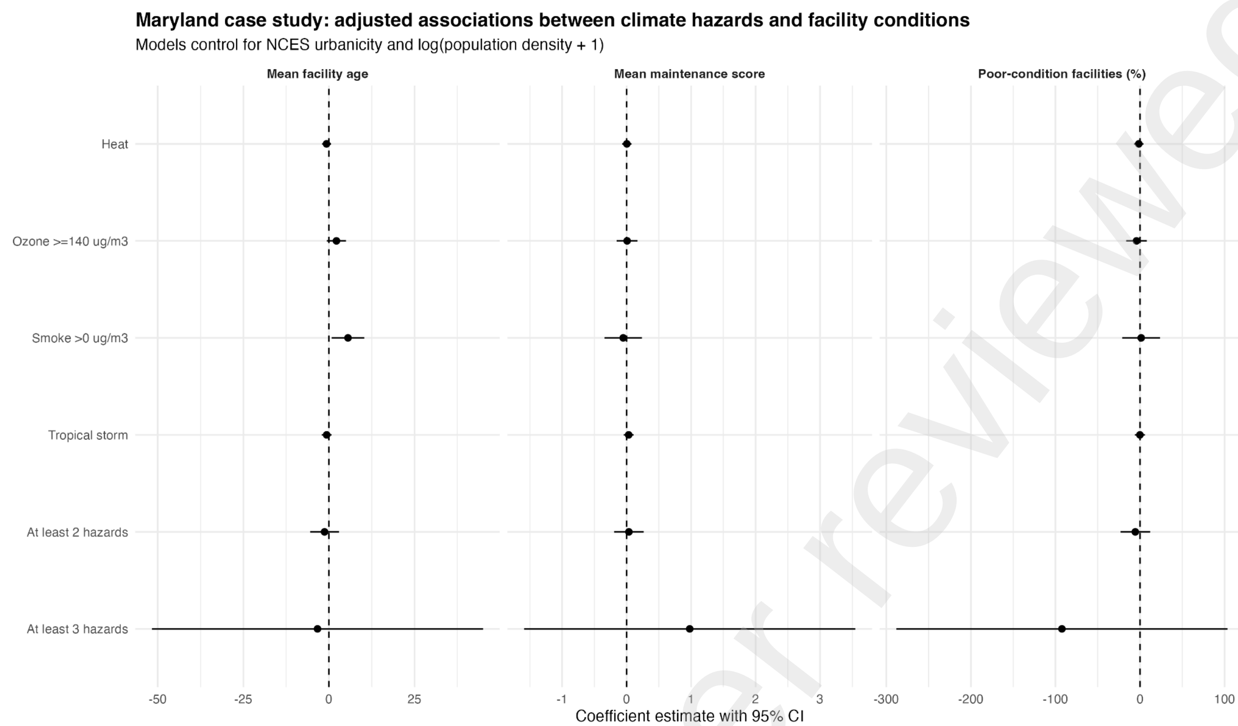

***Figure S24**: Maryland case study: adjusted associations between climate hazards and facility conditions. Coefficient estimates and 95% confidence intervals from district-level linear regression models relating climate hazard exposure to facility conditions in Maryland. Outcomes include mean facility age, mean maintenance score, and percentage of poor-condition facilities. Models control for NCES urbanicity and log(population density + 1). Hazard metrics represent average annual exposure between 2013 and 2020. Vertical dashed lines indicate null associations.*

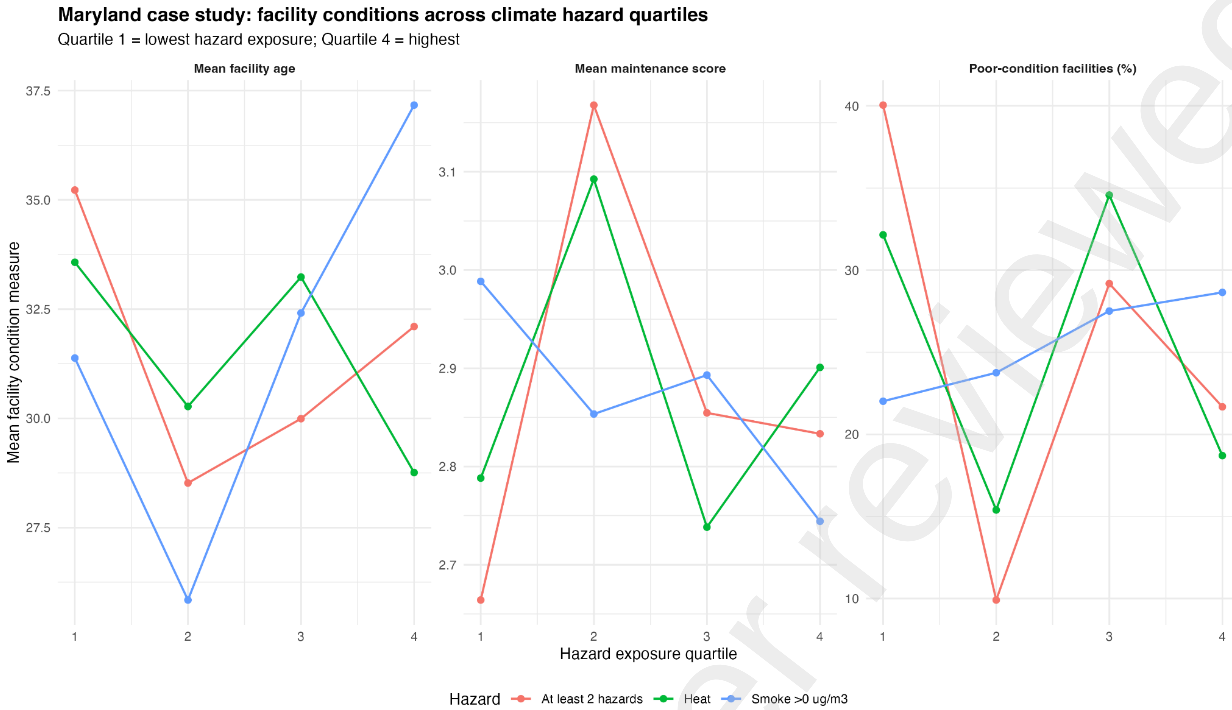

Figure S25*: Maryland case study: facility conditions across climate hazard quartiles. Mean facility condition measures across quartiles of climate hazard exposure in Maryland school districts. Quartile 1 represents the lowest hazard exposure and Quartile 4 the highest. Panels show mean facility age, mean maintenance score, and percentage of poor-condition facilities. Lines illustrate descriptive gradients across hazard exposure quartiles and provide a visual comparison to the adjusted regression results.*

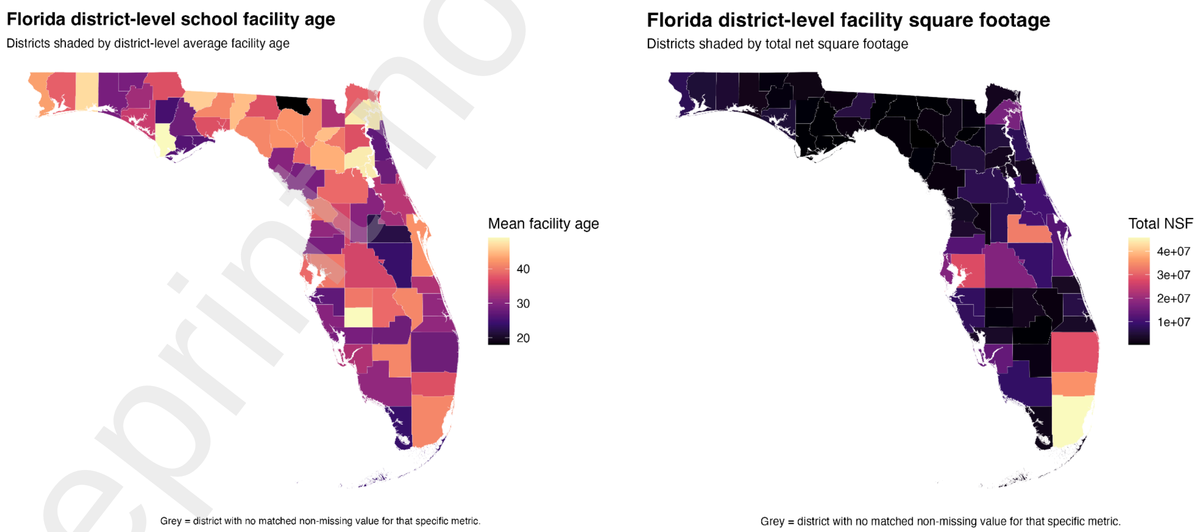

Figure S26*: Florida district-level school facility characteristics. District-level facility metrics derived from the Florida age-of-facilities inventory and matched to analytic-panel school district geometries. The left panel shows mean facility age and the right panel shows total net square* *footage (NSF) of school facilities. Grey areas indicate districts with no matched non-missing value for the corresponding metric.*

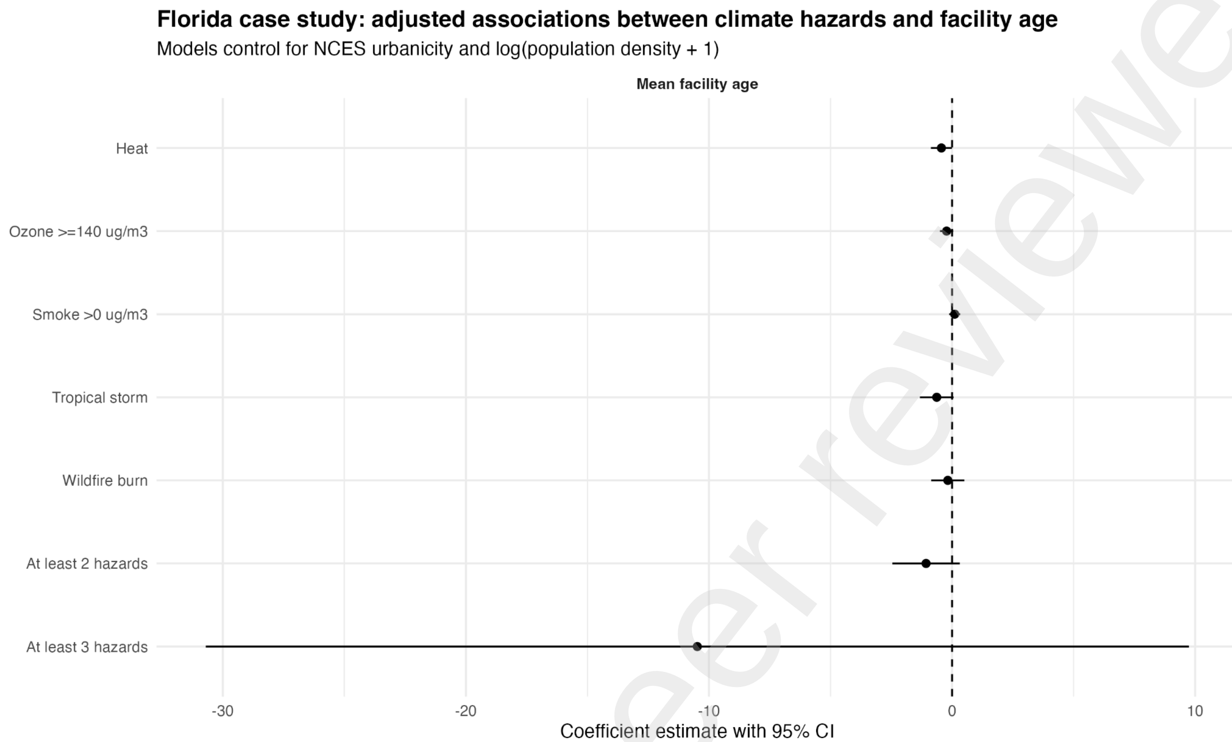

***Figure S27**: Florida case study: adjusted associations between climate hazards and facility age. Coefficient estimates and 95% confidence intervals from district-level linear regression models relating climate hazard exposure to mean facility age in Florida school districts. Models control for NCES urbanicity and log(population density + 1). Hazard metrics represent average annual exposure between 2013 and 2020. The vertical dashed line indicates the null association.*

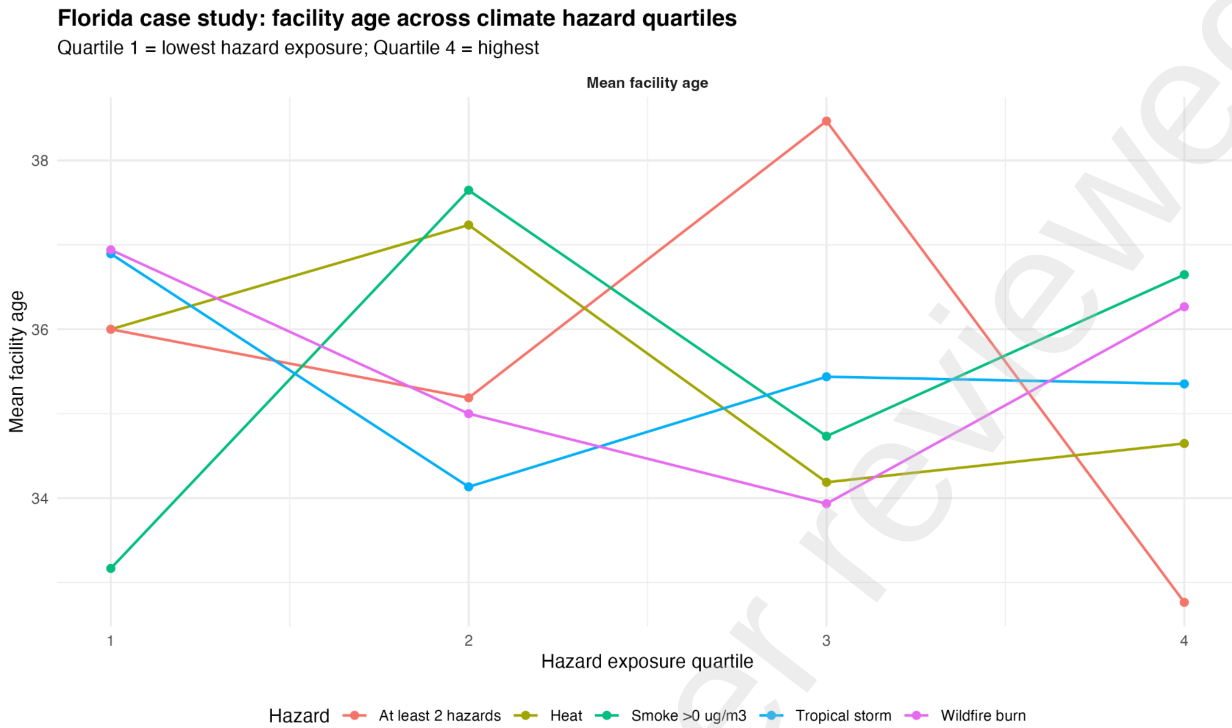

Figure S28: *Florida case study: facility age across climate hazard quartiles.*
Mean facility age across quartiles of climate hazard exposure in Florida school districts. Quartile 1 represents the lowest hazard exposure and Quartile 4 the highest. Lines show descriptive relationships between facility age and exposure to heat, smoke, tropical storms, wildfire burn, and multi-hazard conditions. These descriptive trends are intended to complement the adjusted regression analyses.

S2 Tables

Table S1: *Extensive margin: distribution of districts by number of main hazards, 2013-2022*
Values are the number of districts and the percentage of districts.

Year	0 hazards	1 hazard	2 hazards	3+ hazards
2013	0 (0.0%)	5,347 (39.9%)	7,832 (58.4%)	221 (1.6%)
2014	0 (0.0%)	10,110 (75.3%)	3,249 (24.2%)	73 (0.5%)
2015	0 (0.0%)	9,015 (68.8%)	3,882 (29.6%)	206 (1.6%)
2016	0 (0.0%)	8,859 (67.2%)	4,209 (31.9%)	123 (0.9%)
2017	0 (0.0%)	7,117 (54.1%)	5,400 (41.1%)	631 (4.8%)
2018	0 (0.0%)	4,104 (31.2%)	8,410 (64.0%)	627 (4.8%)
2019	0 (0.0%)	5,824 (44.4%)	7,136 (54.4%)	164 (1.2%)

2020	0 (0.0%)	4,535 (34.6%)	7,703 (58.8%)	869 (6.6%)
2021	0 (0.0%)	1,397 (10.7%)	9,146 (69.9%)	2,550 (19.5%)
2022	0 (0.0%)	653 (5.0%)	8,833 (67.6%)	3,585 (27.4%)

***Table S2**: Hazard Exposure Intensity and Population-Weighted Exposure, 2013 and 2022 District-days are the mean days per district-year. Person-days are the mean student-days per district-year. 'Impacted' here refers to the percentage of districts with any exposure.*

Exposure	District-days 2013	District-days 2022	Impacted 2013	Impacted 2022	Person-days 2013	Person-days 2022
Heat	4.07	7.64	76.00%	93.00%	13,919	30,220
Ozone ≥ 140 μg/m^3	1.27	8.48	16.10%	58.50%	10,594	51,223
Tropical Storm	0.16	0.19	4.00%	1.90%	1,114	5,119
Wildfire Burn	0.12	0.22	1.70%	2.10%	1,103	469
Smoke > 0 μg/m^3	38.13	113.8	100.00%	100.00%	103,460	383,851
≥2 hazards	1.85	9.68	60.10%	95.00%	6,126	41,378
≥3 hazards	0.02	0.57	1.60%	27.40%	205	3,070

***Table S3**: Time-trend tests for main exposures. District-days are the mean days per district-year. Fixed-effects trend coefficients represent the annual change in days per district-year. All listed estimates are significant at $p < 0.001$.*

Exposure	2013-2017 mean	2018-2022 mean	Difference	% change	FE annual trend
Heat	3.41	5.36	1.95	57.10%	0.41
Ozone ≥ 140 μg/m^3	1.72	5.94	4.22	245.10%	0.81
Tropical Storm	0.95	2.21	1.26	132.50%	0.26
Wildfire Burn	0.18	0.36	0.19	105.60%	0.04
Smoke > 0 μg/m^3	33.23	66.4	33.17	99.80%	7.49
At Least 2 Hazards	1.48	5.32	3.84	259.20%	0.86
At Least 3 Hazards	0.04	0.31	0.28	762.50%	0.06

***Table S4**: Most common pairwise main-hazard co-exposures, 2013-2022. Ranked by total district-days.*

Rank	Co-exposure	District-days	Mean days	P95 days	% district-years	Districts affected
1	Heat + Smoke > 0 μg/m^3	269,017	2.04	10	46.90%	12,814

2	Smoke > 0 μg/m³ + Ozone ≥ 140 μg/m³	128,683	0.98	6	19.20%	9,516
3	Smoke > 0 μg/m³ + Tropical Storm	32,722	0.25	0	5.00%	4,052
4	Heat + Ozone ≥ 140 μg/m³	26,042	0.2	1	7.20%	4,390
5	Smoke > 0 μg/m³ + Wildfire Burn	19,578	0.15	0	1.20%	1,055
6	Heat + Tropical Storm	9,371	0.07	0	3.50%	3,155
7	Ozone ≥ 140 μg/m³ + Tropical Storm	3,196	0.02	0	0.60%	722
8	Heat + Wildfire Burn	2,678	0.02	0	0.50%	492
9	Ozone ≥ 140 μg/m³ + Wildfire Burn	1,906	0.01	0	0.30%	253
1-	Tropical Storm + Wildfire Burn	23	0	0	0.00%	8

***Table S5**: Supplementary pairwise co-exposures, 2013-2022. Ranked by total district-days. Supplementary definitions include Smoke > 5 μg/m³ and Hurricane.*

Rank	Co-exposure	District-days	Mean days	P95 days	% district-years	Districts affected
1	Heat + Smoke > 5 μg/m³	117,389	0.89	5	29.30%	11,997
2	Smoke > 5 μg/m³ + Ozone ≥ 140 μg/m³	50,138	0.38	3	11.80%	7,973
3	Heat + Ozone ≥ 140 μg/m³	26,042	0.2	1	7.20%	4,390
4	Smoke > 5 μg/m³ + Wildfire Burn	16,073	0.12	0	0.90%	824
5	Heat + Wildfire Burn	2,678	0.02	0	0.50%	492
6	Ozone ,≥ 140 μg/m³ + Wildfire Burn	1,906	0.01	0	0.30%	253
7	Heat + Hurricane	1,654	0.01	0	0.70%	948
8	Smoke > 5 μg/m³ + Hurricane	379	0	0	0.10%	180
9	Ozone ≥ 140 μg/m³ + Hurricane	249	0	0	0.10%	70
10	Hurricane + Wildfire Burn	16	0	0	0.00%	2

***Table S6**: Top five pairwise main-hazard co-exposures by region, 2013-2022*

Region	Rank	Co-exposure	District-days	% district-years	Districts affected
Midwest	1	Heat + Smoke > 0 μg/m³	70,162	48.20%	4,769
Midwest	2	Smoke > 0 μg/m³ + Ozone ≥ 140 μg/m³	21,433	12.80%	3,335
Midwest	3	Heat + Ozone ≥ 140 μg/m³	1,662	2.20%	984
Midwest	4	Heat + Tropical Storm	1,323	2.20%	1,045
Midwest	5	Smoke > 0 μg/m³ + Tropical Storm	433	0.70%	337
Northeast	1	Heat + Smoke > 0 μg/m³	34,865	36.20%	2,550
Northeast	2	Smoke > 0 μg/m³ + Tropical Storm	18,243	10.80%	1,919
Northeast	3	Smoke > 0 μg/m³ + Ozone ≥ 140 μg/m³	8,740	11.80%	1,719
Northeast	4	Heat + Tropical Storm	7,098	11.00%	1,771
Northeast	5	Heat + Ozone ≥ 140 μg/m³	975	2.30%	543
South	1	Smoke > 0 μg/m³ + Ozone ≥ 140 μg/m³	41,912	21.10%	2,815
South	2	Heat + Smoke > 0 μg/m³	33,433	30.00%	3,041
South	3	Smoke > 0 μg/m³ + Tropical Storm	14,046	10.40%	1,796
South	4	Heat + Ozone ≥ 140 μg/m³	3,346	5.70%	1,599
South	5	Ozone ≥ 140 μg/m³ + Tropical Storm	2,345	1.40%	383
West	1	Heat + Smoke > 0 μg/m³	130,557	76.90%	2,454
West	2	Smoke > 0 μg/m³ + Ozone ≥ 140 μg/m³	56,598	37.20%	1,647
West	3	Heat + Ozone ≥ 140 μg/m³	20,059	24.00%	1,264
West	4	Smoke > 0 μg/m³ + Wildfire Burn	18,750	4.70%	712
West	5	Heat + Wildfire Burn	2,622	2.50%	453

***Table S7**: Mean annual hazard exposure by NCES urbanicity status, 2018-2022.*

Hazard	City	Suburb	Town	Rural
Heat (days)	7.37	6.45	5.03	4.8
Ozone ≥ 140 μg/m³ (days)	12.12	6.76	6.23	4.84
Tropical storm (days)	2.29	3.9	1.73	1.61

Wildfire burn (days)	0.41	0.2	0.57	0.36
Wildfire smoke > 0 μg/m^3 (days)	61.16	58.48	68.77	69.7
≥2 hazards (days)	6.99	5.71	5.27	4.99
≥3 hazards (days)	0.52	0.44	0.3	0.24

***Table S8**: Descriptive exposure gradients across quartiles of district racial/ethnic composition, 2013-2022. Values show mean annual exposure days [median; P90; percentage with any exposure].*

Race group	**Outcome**	**Q1**	**Q2**	**Q3**	**Q4**
AIAN	Heat	3.95 [median 2.00; P90 10.00; any 67.8%]	4.13 [median 3.00; P90 10.00; any 71.1%]	4.42 [median 3.00; P90 12.00; any 70.0%]	5.11 [median 3.00; P90 14.00; any 66.7%]
AIAN	Ozone ≥ 140 μg/m^3	2.59 [median 0.00; P90 5.00; any 23.8%]	3.56 [median 0.00; P90 6.00; any 25.4%]	4.02 [median 0.00; P90 9.00; any 27.1%]	5.20 [median 0.00; P90 16.00; any 31.9%]
AIAN	Smoke > 0 μg/m^3	50.50 [median 42.00; P90 100.00; any 100.0%]	45.66 [median 34.00; P90 98.00; any 100.0%]	49.22 [median 41.00; P90 97.00; any 100.0%]	53.92 [median 48.00; P90 96.00; any 100.0%]
AIAN	Tropical storm	1.52 [median 0.00; P90 8.00; any 12.6%]	2.53 [median 0.00; P90 10.00; any 20.4%]	1.70 [median 0.00; P90 8.00; any 13.8%]	0.51 [median 0.00; P90 0.00; any 4.0%]
AIAN	Wildfire burn	0.12 [median 0.00; P90 0.00; any 1.0%]	0.11 [median 0.00; P90 0.00; any 1.4%]	0.22 [median 0.00; P90 0.00; any 2.0%]	0.63 [median 0.00; P90 0.00; any 3.7%]
AIAN	At least 2 hazards	2.92 [median 1.00; P90 9.00; any 54.2%]	2.92 [median 1.00; P90 9.00; any 53.1%]	3.26 [median 1.00; P90 10.00; any 57.2%]	4.51 [median 2.00; P90 13.00; any 63.5%]
AIAN	At least 3 hazards	0.13 [median 0.00; P90 0.00; any 5.6%]	0.17 [median 0.00; P90 0.00; any 6.8%]	0.17 [median 0.00; P90 0.00; any 6.8%]	0.23 [median 0.00; P90 0.00; any 8.4%]
AIAN	Exactly 2 hazards	2.79 [median 1.00; P90 8.00; any 54.2%]	2.75 [median 1.00; P90 8.00; any 53.1%]	3.08 [median 1.00; P90 10.00; any 57.2%]	4.29 [median 2.00; P90 13.00; any 63.5%]
AIAN	Exactly 3 hazards	0.13 [median 0.00; P90 0.00; any 5.5%]	0.17 [median 0.00; P90 0.00; any 6.8%]	0.17 [median 0.00; P90 0.00; any 6.8%]	0.22 [median 0.00; P90 0.00; any 8.4%]
Asian	Heat	4.05 [median 2.00; P90 11.00; any 64.7%]	3.50 [median 2.00; P90 10.00; any 63.1%]	4.27 [median 2.00; P90 11.00; any 67.8%]	5.78 [median 5.00; P90 13.00; any 80.1%]
Asian	Ozone ≥ 140 μg/m^3	2.94 [median 0.00; P90 7.00; any 25.8%]	2.57 [median 0.00; P90 6.00; any 24.8%]	3.68 [median 0.00; P90 9.00; any 26.5%]	6.18 [median 0.00; P90 20.00; any 31.0%]
Asian	Smoke > 0 μg/m^3	55.18 [median 48.00; P90 106.00; any 100.0%]	52.11 [median 44.00; P90 104.00; any 100.0%]	48.71 [median 41.00; P90 96.00; any 100.0%]	43.31 [median 33.00; P90 87.00; any 100.0%]
Asian	Tropical storm	0.83 [median 0.00; P90 0.00; any 7.3%]	1.36 [median 0.00; P90 5.00; any 12.0%]	1.71 [median 0.00; P90 9.00; any 14.1%]	2.36 [median 0.00; P90 10.00; any 17.6%]
Asian	Wildfire burn	0.22 [median 0.00; P90 0.00; any 1.9%]	0.16 [median 0.00; P90 0.00; any 1.9%]	0.32 [median 0.00; P90 0.00; any 2.3%]	0.37 [median 0.00; P90 0.00; any 1.9%]

Asian	At least 2 hazards	3.39 [median 1.00; P90 10.00; any 57.1%]	2.77 [median 1.00; P90 8.00; any 51.6%]	3.37 [median 1.00; P90 10.00; any 55.8%]	4.08 [median 1.00; P90 12.00; any 63.6%]
Asian	At least 3 hazards	0.12 [median 0.00; P90 0.00; any 5.5%]	0.11 [median 0.00; P90 0.00; any 4.9%]	0.18 [median 0.00; P90 0.00; any 6.6%]	0.28 [median 0.00; P90 1.00; any 10.5%]
Asian	Exactly 2 hazards	3.26 [median 1.00; P90 10.00; any 57.1%]	2.66 [median 1.00; P90 8.00; any 51.6%]	3.19 [median 1.00; P90 10.00; any 55.8%]	3.80 [median 1.00; P90 11.00; any 63.5%]
Asian	Exactly 3 hazards	0.12 [median 0.00; P90 0.00; any 5.5%]	0.11 [median 0.00; P90 0.00; any 4.9%]	0.18 [median 0.00; P90 0.00; any 6.6%]	0.28 [median 0.00; P90 1.00; any 10.5%]
Black	Heat	4.89 [median 3.00; P90 13.00; any 68.7%]	4.22 [median 2.00; P90 11.00; any 68.2%]	4.45 [median 3.00; P90 11.00; any 71.0%]	4.04 [median 2.00; P90 10.00; any 67.7%]
Black	Ozone ≥ 140 μg/m^3	4.13 [median 0.00; P90 10.00; any 27.6%]	3.55 [median 0.00; P90 8.00; any 25.6%]	3.83 [median 0.00; P90 8.00; any 26.1%]	3.85 [median 0.00; P90 9.00; any 28.9%]
Black	Smoke > 0 μg/m^3	52.97 [median 47.00; P90 98.00; any 100.0%]	51.36 [median 44.00; P90 99.00; any 100.0%]	48.58 [median 41.00; P90 95.00; any 100.0%]	46.38 [median 34.00; P90 98.00; any 100.0%]
Black	Tropical storm	0.57 [median 0.00; P90 0.00; any 5.5%]	0.90 [median 0.00; P90 0.00; any 8.3%]	1.57 [median 0.00; P90 9.00; any 12.7%]	3.21 [median 0.00; P90 12.00; any 24.4%]
Black	Wildfire burn	0.39 [median 0.00; P90 0.00; any 2.2%]	0.35 [median 0.00; P90 0.00; any 2.2%]	0.21 [median 0.00; P90 0.00; any 1.5%]	0.14 [median 0.00; P90 0.00; any 2.1%]
Black	At least 2 hazards	3.93 [median 1.00; P90 12.00; any 60.8%]	3.17 [median 1.00; P90 10.00; any 56.3%]	3.16 [median 1.00; P90 10.00; any 56.8%]	3.34 [median 1.00; P90 10.00; any 54.1%]
Black	At least 3 hazards	0.17 [median 0.00; P90 0.00; any 6.7%]	0.15 [median 0.00; P90 0.00; any 6.0%]	0.18 [median 0.00; P90 0.00; any 7.1%]	0.20 [median 0.00; P90 0.00; any 7.8%]
Black	Exactly 2 hazards	3.76 [median 1.00; P90 11.00; any 60.8%]	3.02 [median 1.00; P90 9.00; any 56.3%]	2.98 [median 1.00; P90 9.00; any 56.8%]	3.15 [median 1.00; P90 10.00; any 54.1%]
Black	Exactly 3 hazards	0.17 [median 0.00; P90 0.00; any 6.7%]	0.15 [median 0.00; P90 0.00; any 6.0%]	0.18 [median 0.00; P90 0.00; any 7.1%]	0.19 [median 0.00; P90 0.00; any 7.8%]
Hispanic	Heat	2.81 [median 1.00; P90 8.00; any 57.2%]	3.54 [median 2.00; P90 10.00; any 66.0%]	4.56 [median 3.00; P90 12.00; any 71.5%]	6.69 [median 5.00; P90 15.00; any 81.0%]
Hispanic	Ozone ≥ 140 μg/m^3	0.95 [median 0.00; P90 2.00; any 15.3%]	1.31 [median 0.00; P90 3.00; any 19.4%]	3.22 [median 0.00; P90 9.00; any 29.6%]	9.89 [median 0.00; P90 38.00; any 43.8%]
Hispanic	Smoke > 0 μg/m^3	47.63 [median 41.00; P90 93.00; any 100.0%]	53.17 [median 45.00; P90 105.00; any 100.0%]	51.59 [median 43.00; P90 100.00; any 100.0%]	46.91 [median 37.00; P90 92.00; any 100.0%]
Hispanic	Tropical storm	1.14 [median 0.00; P90 3.00; any 10.4%]	1.43 [median 0.00; P90 7.00; any 13.0%]	2.12 [median 0.00; P90 9.00; any 16.2%]	1.57 [median 0.00; P90 6.00; any 11.4%]
Hispanic	Wildfire burn	0.04 [median 0.00; P90 0.00; any 1.3%]	0.06 [median 0.00; P90 0.00; any 1.4%]	0.35 [median 0.00; P90 0.00; any 2.2%]	0.63 [median 0.00; P90 0.00; any 3.1%]
Hispanic	At least 2 hazards	1.92 [median 0.00; P90 6.00; any 42.9%]	2.54 [median 1.00; P90 7.00; any 52.5%]	3.79 [median 1.00; P90 11.00; any 61.1%]	5.36 [median 2.00; P90 15.00; any 71.5%]

Hispanic	At least 3 hazards	0.05 [median 0.00; P90 0.00; any 2.4%]	0.07 [median 0.00; P90 0.00; any 3.5%]	0.18 [median 0.00; P90 0.00; any 7.6%]	0.40 [median 0.00; P90 1.00; any 14.1%]
Hispanic	Exactly 2 hazards	1.87 [median 0.00; P90 6.00; any 42.9%]	2.47 [median 1.00; P90 7.00; any 52.5%]	3.61 [median 1.00; P90 11.00; any 61.1%]	4.96 [median 2.00; P90 14.00; any 71.4%]
Hispanic	Exactly 3 hazards	0.05 [median 0.00; P90 0.00; any 2.4%]	0.07 [median 0.00; P90 0.00; any 3.5%]	0.18 [median 0.00; P90 0.00; any 7.6%]	0.40 [median 0.00; P90 1.00; any 14.1%]
White	Heat	6.02 [median 4.00; P90 15.00; any 75.3%]	4.79 [median 3.00; P90 12.00; any 70.2%]	4.02 [median 2.00; P90 11.00; any 70.4%]	2.77 [median 1.00; P90 8.00; any 59.7%]
White	Ozone ≥ 140 μg/m^3	9.41 [median 0.00; P90 36.00; any 41.2%]	3.89 [median 0.00; P90 10.00; any 31.9%]	1.38 [median 0.00; P90 3.00; any 20.5%]	0.68 [median 0.00; P90 2.00; any 14.5%]
White	Smoke > 0 μg/m^3	47.63 [median 37.00; P90 96.00; any 100.0%]	49.90 [median 41.00; P90 97.00; any 100.0%]	52.11 [median 45.00; P90 101.00; any 100.0%]	49.67 [median 44.00; P90 97.00; any 100.0%]
White	Tropical storm	2.16 [median 0.00; P90 10.00; any 15.7%]	1.91 [median 0.00; P90 9.00; any 14.6%]	1.34 [median 0.00; P90 6.00; any 12.0%]	0.86 [median 0.00; P90 0.00; any 8.6%]
White	Wildfire burn	0.48 [median 0.00; P90 0.00; any 2.9%]	0.46 [median 0.00; P90 0.00; any 2.9%]	0.11 [median 0.00; P90 0.00; any 1.5%]	0.02 [median 0.00; P90 0.00; any 0.8%]
White	At least 2 hazards	5.12 [median 2.00; P90 15.00; any 66.6%]	3.94 [median 1.00; P90 12.00; any 60.5%]	2.79 [median 1.00; P90 8.00; any 56.5%]	1.77 [median 0.00; P90 5.00; any 44.5%]
White	At least 3 hazards	0.39 [median 0.00; P90 1.00; any 13.5%]	0.20 [median 0.00; P90 0.00; any 8.2%]	0.07 [median 0.00; P90 0.00; any 3.7%]	0.04 [median 0.00; P90 0.00; any 2.2%]
White	Exactly 2 hazards	4.73 [median 2.00; P90 14.00; any 66.6%]	3.73 [median 1.00; P90 11.00; any 60.4%]	2.71 [median 1.00; P90 8.00; any 56.5%]	1.73 [median 0.00; P90 5.00; any 44.5%]
White	Exactly 3 hazards	0.38 [median 0.00; P90 1.00; any 13.5%]	0.20 [median 0.00; P90 0.00; any 8.2%]	0.07 [median 0.00; P90 0.00; any 3.7%]	0.04 [median 0.00; P90 0.00; any 2.2%]

***Table S9**: Kruskal-Wallis and pairwise Wilcoxon tests for differences in exposure distributions across racial/ethnic composition quartiles. Pairwise p-values are Benjamini-Hochberg adjusted.*

Race group	**Outcome**	**Kruskal-Wallis statistic**	**Kruskal-Wallis p-value**
AIAN	Heat	228.79	<0.001
AIAN	Ozone ≥ 140 μg/m^3	868.21	<0.001
AIAN	Smoke >0 ug/m3	2696.34	<0.001
AIAN	Tropical storm	3946.15	<0.001
AIAN	Wildfire burn	684.89	<0.001
AIAN	At least 2 hazards	1529.97	<0.001
AIAN	At least 3 hazards	207.64	<0.001

AIAN	Exactly 2 hazards	1552.4	<0.001
AIAN	Exactly 3 hazards	208.17	<0.001
Asian	Heat	4476.68	<0.001
Asian	Ozone ≥ 140 μg/m^3	566.27	<0.001
Asian	Smoke > 0 μg/m^3	3150.72	<0.001
Asian	Tropical storm	1689.58	<0.001
Asian	Wildfire burn	17	<0.001
Asian	At least 2 hazards	1285.52	<0.001
Asian	At least 3 hazards	976.14	<0.001
Asian	Exactly 2 hazards	1251.05	<0.001
Asian	Exactly 3 hazards	973.45	<0.001
Black	Heat	200.11	<0.001
Black	Ozone ≥ 140 μg/m^3	113.36	<0.001
Black	Smoke > 0 μg/m^3	2601.77	<0.001
Black	Tropical storm	6192.73	<0.001
Black	Wildfire burn	52.6	<0.001
Black	At least 2 hazards	467.15	<0.001
Black	At least 3 hazards	82.97	<0.001
Black	Exactly 2 hazards	479.44	<0.001
Black	Exactly 3 hazards	82.53	<0.001
Hispanic	Heat	9458.63	<0.001
Hispanic	Ozone ≥ 140 μg/m^3	9571.37	<0.001
Hispanic	Smoke > 0 μg/m^3	1198.84	<0.001
Hispanic	Tropical storm	587.68	<0.001

Hispanic	Wildfire burn	363.94	<0.001
Hispanic	At least 2 hazards	8085.08	<0.001
Hispanic	At least 3 hazards	4346.58	<0.001
Hispanic	Exactly 2 hazards	7940.41	<0.001
Hispanic	Exactly 3 hazards	4347.53	<0.001
White	Heat	5383.58	<0.001
White	Ozone ≥ 140 μg/m^3	8644.37	<0.001
White	Smoke > 0 μg/m^3	1020.57	<0.001
White	Tropical storm	962.62	<0.001
White	Wildfire burn	545.13	<0.001
White	At least 2 hazards	5684.93	<0.001
White	At least 3 hazards	4018.12	<0.001
White	Exactly 2 hazards	5584.34	<0.001
White	Exactly 3 hazards	4017.68	<0.001

Table S10*: State-year fixed effects models of racial/ethnic composition and hazard exposure White student share is the omitted reference category. Models include state-by-year fixed effects and log(population density + 1). Coefficients represent differences in annual hazard exposure associated with larger racial/ethnic group shares relative to White share. Standard errors clustered at the district level.*

Outcome	**Hispanic**	**Black**	**Asian**	**AIAN**
Heat	3.364 (0.190)***	-0.341 (0.157)*	1.113 (0.610)†	0.708 (0.313)*
Ozone ≥ 140 μg/m^3	7.394 (0.661)***	1.046 (0.284)***	2.279 (2.667)	2.330 (0.726)**
Smoke > 0 μg/m^3	-5.680 (0.442)***	2.179 (0.312)***	-10.026 (1.109)***	1.831 (0.490)***
Tropical storm	0.753 (0.072)***	1.346 (0.136)***	1.913 (0.264)***	0.235 (0.040)***
Wildfire burn	-0.574 (0.161)***	0.264 (0.050)***	-1.377 (0.384)***	0.215 (0.154)
At least 2 hazards	1.508 (0.160)***	1.104 (0.093)***	-0.797 (0.501)	1.417 (0.280)***

At least 3 hazards	0.237 (0.029)***	0.144 (0.016)***	-0.006 (0.098)	0.147 (0.035)***
Exactly 2 hazards	1.271 (0.139)***	0.960 (0.084)***	-0.791 (0.431)†	1.270 (0.262)***
Exactly 3 hazards	0.239 (0.029)***	0.141 (0.016)***	-0.004 (0.094)	0.147 (0.035)***

*Notes: N = 129,942 district-years. Significance: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.*

***Table S11**: District fixed-effects models of racial/ethnic composition and hazard exposure White student share is the omitted reference category. Models include district fixed effects, state-by-year fixed effects, and log(population density + 1). Coefficients represent within-district associations between changes in racial composition and changes in hazard exposure over time. Standard errors clustered at the district level.*

Outcome	**Hispanic**	**Black**	**Asian**	**AIAN**
Heat	2.187 (0.503)***	2.104 (0.728)**	0.317 (1.002)	-1.724 (0.759)*
Ozone ≥ 140 μg/m^3	3.649 (1.702)*	-2.096 (1.961)	-4.790 (3.911)	-5.583 (2.592)*
Smoke > 0 μg/m^3	-3.110 (0.943)***	0.399 (1.558)	-3.586 (1.577)*	-0.717 (1.635)
Tropical storm	2.338 (0.291)***	-1.367 (0.790)†	4.808 (1.033)***	0.504 (0.193)**
Wildfire burn	0.081 (1.032)	-0.726 (0.859)	-0.696 (1.749)	-4.449 (1.881)*
At least 2 hazards	3.402 (0.681)***	-1.389 (0.923)	3.242 (1.533)*	-4.298 (1.459)**
At least 3 hazards	0.449 (0.165)**	-0.050 (0.213)	0.294 (0.426)	-0.438 (0.214)*
Exactly 2 hazards	2.953 (0.583)***	-1.339 (0.811)†	2.948 (1.270)*	-3.860 (1.338)**
Exactly 3 hazards	0.435 (0.163)**	-0.038 (0.211)	0.337 (0.419)	-0.431 (0.212)*

*Notes:. N = 129,888 district-years. Significance: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.*

***Table S12**: Race × Year interaction models of climate hazard exposure. White student share is the omitted reference category. Positive coefficients indicate that exposure increased more rapidly over time in districts serving larger shares of that racial/ethnic group relative to districts serving larger White student shares. Models include state fixed effects, race share, year, race share × year interactions, and log(population density + 1). Standard errors clustered at the district level.*

Outcome	**Hispanic**	**Black**	**Asian**	**AIAN**
Heat	0.402 (0.029)***	-0.228 (0.021)***	-0.004 (0.075)	0.387 (0.047)***
Ozone ≥ 140 μg/m^3	2.731 (0.116)***	1.326 (0.104)***	2.293 (0.354)***	1.230 (0.156)***

Smoke > 0 μg/m³	0.503 (0.138)***	5.776 (0.163)***	-7.130 (0.393)***	-0.989 (0.204)***
Tropical storm	-0.161 (0.015)***	0.956 (0.032)***	1.508 (0.122)***	-0.367 (0.014)***
Wildfire burn	0.142 (0.026)***	-0.081 (0.009)***	0.144 (0.074)†	0.112 (0.041)**
At least 2 hazards	0.978 (0.033)***	1.159 (0.058)***	1.338 (0.100)***	0.708 (0.059)***
At least 3 hazards	0.215 (0.010)***	0.072 (0.009)***	0.356 (0.027)***	0.077 (0.011)***
Exactly 2 hazards	0.763 (0.027)***	1.087 (0.052)***	0.982 (0.082)***	0.631 (0.053)***
Exactly 3 hazards	0.213 (0.010)***	0.072 (0.008)***	0.351 (0.026)***	0.076 (0.011)***

*Notes: Values are interaction coefficients with district-clustered standard errors in parentheses. White student share is the omitted reference category. Significance: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.*

***Table S13**: Region-stratified associations between district racial/ethnic composition and climate hazard exposure, 2013-2022. State-year fixed-effects models estimating associations between district racial/ethnic composition and annual exposure to extreme heat, ozone exceedances (≥140 μg/m³), wildfire smoke (>0 μg/m³), tropical storm exposure, wildfire burn exposure, exposure to at least two hazards (≥2 hazards), and exposure to at least three hazards (≥3 hazards), stratified by U.S. Census region (South, West, Northeast, and Midwest). White student share is omitted as the reference category; coefficients for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares therefore represent differences in exposure relative to districts with larger White student shares. Models include state-year fixed effects and log(population density + 1), with standard errors clustered at the district level. Positive coefficients indicate greater exposure among districts serving larger shares of the specified racial/ethnic group after accounting for shared state-year climatic conditions, policy environments, and population density. Results demonstrate substantial geographic heterogeneity in racial and ethnic disparities, indicating that national disparities reflect both regional concentration of hazards and within-region environmental inequalities.Coefficients are reported as estimates with clustered standard errors in parentheses.*

Outcome	**Hispanic**	**Black**	**Asian**	**AIAN**
South				
Heat	4.738 (0.288)***	-0.690 (0.240)**	-2.036 (1.379)	0.449 (0.175)*
Ozone ≥140 μg/m³	2.658 (0.471)***	1.803 (0.235)***	5.397 (2.190)*	1.681 (0.456)***
Smoke >0 μg/m³	-10.122 (0.796)***	3.145 (0.485)***	-10.042 (3.637)**	6.360 (0.792)***
Tropical storm	0.500 (0.164)**	2.739 (0.236)***	-0.502 (1.742)	0.339 (0.153)*

Wildfire burn	-0.043 (0.057)	-0.135 (0.031)***	0.315 (0.187)†	-0.151 (0.064)*
≥2 hazards	1.052 (0.129)***	1.017 (0.132)***	1.647 (0.912)†	0.240 (0.213)
≥3 hazards	-0.031 (0.011)**	0.119 (0.020)***	0.157 (0.120)	0.126 (0.033)***
West				
Heat	2.926 (0.393)***	-1.371 (2.549)	-2.475 (1.308)†	1.645 (0.540)**
Ozone ≥140 μg/m^3	16.961 (1.583)***	24.896 (15.208)	8.627 (6.372)	6.440 (1.484)***
Smoke >0 μg/m^3	-5.403 (0.829)***	-17.052 (5.639)**	-10.831 (2.241)***	0.202 (0.822)
Tropical storm	0.005 (0.006)	-0.025 (0.029)	0.018 (0.007)*	-0.020 (0.005)***
Wildfire burn	-1.564 (0.399)***	1.805 (1.911)	-2.576 (0.868)**	-0.082 (0.290)
≥2 hazards	1.781 (0.376)***	3.132 (2.588)	-3.357 (1.078)**	2.407 (0.494)***
≥3 hazards	0.507 (0.070)***	1.509 (0.564)**	0.025 (0.223)	0.227 (0.066)***
Northeast				
Heat	-0.286 (0.307)	-1.795 (0.384)***	3.477 (0.600)***	-3.197 (3.271)
Ozone ≥140 μg/m^3	0.560 (0.213)**	0.362 (0.205)†	-0.028 (0.265)	-0.334 (0.646)
Smoke >0 μg/m^3	-3.205 (0.284)***	0.778 (0.429)†	-5.594 (0.556)***	6.175 (2.104)**
Tropical storm	3.556 (0.401)***	-2.204 (0.379)***	3.929 (0.534)***	-3.939 (1.351)**
Wildfire burn	0.007 (0.002)***	-0.008 (0.003)**	0.002 (0.002)	-0.002 (0.003)
≥2 hazards	0.972 (0.209)***	-0.644 (0.210)**	2.308 (0.315)***	-1.209 (0.903)
≥3 hazards	0.239 (0.042)***	-0.122 (0.041)**	0.313 (0.076)***	-0.129 (0.082)
Midwest				
Heat	2.950 (0.225)***	-0.078 (0.200)	2.481 (0.528)***	-1.487 (0.386)***
Ozone ≥140 μg/m^3	-1.044 (0.103)***	-0.156 (0.103)	-1.111 (0.318)***	-0.148 (0.039)***
Smoke >0 μg/m^3	-0.244 (0.686)	-1.055 (0.380)**	-4.723 (1.008)***	-0.945 (0.606)
Tropical storm	0.075 (0.046)	0.033 (0.049)	-0.122 (0.120)	0.052 (0.038)
Wildfire burn	-0.013 (0.007)†	0.006 (0.005)	0.004 (0.018)	0.004 (0.008)

≥2 hazards	0.845 (0.114)***	0.228 (0.083)**	0.588 (0.233)*	-0.541 (0.279)†
≥3 hazards	-0.041 (0.008)***	0.020 (0.012)†	-0.063 (0.021)**	-0.008 (0.003)*

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

***Table S14**: Race-by-NCES urbanicity interaction models of climate hazard exposure, 2013-2022. District fixed-effects models estimating associations between district racial/ethnic composition and annual exposure to extreme heat, ozone exceedances (≥140 μg/m^3), wildfire smoke (>0 μg/m^3), tropical storm exposure, wildfire burn exposure, exposure to at least two hazards (≥2 hazards), exposure to at least three hazards (≥3 hazards), exactly two hazards, and exactly three hazards. Models include district fixed effects, state-year fixed effects, and log(population density + 1), with standard errors clustered at the district level. White student share and NCES City districts are omitted as the reference categories. Main race coefficients therefore represent associations within City districts, while interaction terms indicate how those associations differ in Suburban, Town, and Rural districts relative to City districts. Positive coefficients indicate greater exposure among districts serving larger shares of the specified racial/ethnic group relative to districts serving larger White student shares. These models evaluate whether racial and ethnic disparities in climate hazard exposure vary across the urban-rural continuum and help distinguish disparities associated with district demographic composition from those associated with urbanicity and patterns of metropolitan development. Coefficients are reported as estimates with district-clustered standard errors in parentheses.*

Outcome	City (main effect)	Hispanic × Suburb	Hispanic × Town	Hispanic × Rural
Hispanic Share				
Heat	4.52 (1.46)**	0.01 (1.17)	-2.62 (1.49)†	-2.84 (1.42)*
Ozone ≥140 μg/m^3	-4.71 (4.69)	3.97 (4.71)	8.34 (5.04)†	9.61 (4.80)*
Smoke >0 μg/m^3	-4.38 (1.61)**	-2.72 (1.26)*	1.04 (2.54)	2.47 (1.53)
Tropical Storm	4.99 (0.82)***	1.77 (0.57)**	-3.83 (0.95)***	-3.70 (0.86)***
Wildfire Burn	-0.41 (1.22)	-0.25 (1.03)	0.50 (1.16)	0.66 (1.16)
≥2 Hazards	6.86 (1.46)***	0.49 (1.11)	-5.02 (1.55)**	-4.14 (1.48)**
≥3 Hazards	0.28 (0.44)	0.73 (0.39)†	-0.18 (0.45)	0.08 (0.45)
Exactly 2 Hazards	6.57 (1.17)***	-0.24 (0.87)	-4.83 (1.25)***	-4.22 (1.16)***
Exactly 3 Hazards	0.23 (0.44)	0.75 (0.39)†	-0.14 (0.45)	0.12 (0.45)
Outcome	**City**	**Black × Suburb**	**Black × Town**	**Black × Rural**
Black share				
Heat	-0.59 (1.72)	2.68 (1.93)	2.90 (1.78)	2.96 (1.73)†
Ozone ≥140 μg/m^3	2.96 (4.46)	-5.39 (4.31)	-4.55 (4.67)	-4.67 (4.47)

Smoke >0 μg/m³	0.01 (2.51)	1.74 (2.15)	-1.17 (2.90)	0.25 (2.62)
Tropical Storm	-0.24 (1.21)	-1.28 (1.21)	-2.28 (1.24)†	-1.50 (1.07)
Wildfire Burn	0.47 (1.01)	-0.29 (0.87)	-2.15 (1.07)*	-1.96 (1.07)†
≥2 Hazards	-0.55 (1.69)	0.05 (1.66)	-2.01 (1.78)	-1.28 (1.67)
≥3 Hazards	0.59 (0.37)	-0.63 (0.36)†	-0.85 (0.36)*	-0.67 (0.34)*
Exactly 2 Hazards	-1.13 (1.49)	0.69 (1.46)	-1.16 (1.59)	-0.61 (1.47)
Exactly 3 Hazards	0.55 (0.36)	-0.59 (0.35)†	-0.80 (0.35)*	-0.62 (0.33)†
Outcome	**City**	**Asian × Suburb**	**Asian × Town**	**Asian × Rural**
Asian share				
Heat	-1.37 (2.91)	1.75 (2.92)	0.51 (4.93)	1.81 (3.22)
Ozone ≥140 μg/m³	3.90 (16.14)	-7.31 (16.69)	23.95 (21.93)	-10.41 (16.93)
Smoke >0 μg/m³	2.77 (3.92)	-9.38 (3.70)*	-12.11 (8.97)	-3.96 (4.44)
Tropical Storm	3.95 (1.64)*	4.60 (1.51)**	-1.22 (2.63)	-2.58 (1.77)
Wildfire Burn	-5.13 (2.42)*	2.61 (2.40)	11.81 (7.55)	6.26 (3.86)
≥2 Hazards	3.79 (4.31)	0.98 (4.26)	7.87 (6.63)	-1.63 (4.70)
≥3 Hazards	0.85 (1.37)	-0.56 (1.39)	2.45 (1.88)	-0.60 (1.49)
Exactly 2 Hazards	2.95 (3.23)	1.54 (3.14)	5.43 (5.28)	-1.03 (3.61)
Exactly 3 Hazards	0.87 (1.35)	-0.57 (1.36)	2.44 (1.84)	-0.56 (1.47)
Outcome	**City**	**AIAN × Suburb**	**AIAN × Town**	**AIAN × Rural**
AIAN				
Heat	19.87 (18.10)	-17.87 (17.69)	-22.17 (18.10)	-21.66 (18.10)
Ozone ≥140 μg/m³	31.71 (53.57)	-49.48 (53.60)	-38.66 (53.61)	-37.04 (53.58)
Smoke >0 μg/m³	-30.52 (32.13)	33.95 (31.06)	35.66 (32.15)	29.36 (32.13)
Tropical Storm	6.91 (5.48)	-0.92 (5.64)	-6.81 (5.48)	-6.55 (5.48)
Wildfire Burn	0.67 (12.97)	-3.36 (12.65)	-3.84 (12.97)	-5.23 (12.99)
≥2 Hazards	24.63 (17.80)	-26.70 (17.30)	-28.86 (17.81)	-29.08 (17.80)
≥3 Hazards	-0.47 (4.22)	0.73 (4.19)	-0.14 (4.22)	0.03 (4.22)
Exactly 2 Hazards	25.10 (15.36)	-27.43 (14.89)†	-28.72 (15.37)†	-29.11 (15.36)†
Exactly 3 Hazards	-0.68 (4.19)	1.06 (4.17)	0.06 (4.19)	0.24 (4.19)

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Table S15. *NCES urbanicity-stratified associations between district racial/ethnic composition and climate hazard exposure, 2013-2022. State-year fixed-effects models estimating associations between district racial/ethnic composition and annual exposure to extreme heat, ozone exceedances (≥140 μg/m^3), wildfire smoke exposure (>0 μg/m^3), tropical storm exposure, wildfire burn exposure, exposure to at least two hazards (≥2 hazards), exposure to at least three hazards (≥3 hazards), exactly two hazards, and exactly three hazards. Analyses are stratified by NCES urbanicity category (City, Suburb, Town, and Rural) to evaluate whether racial and ethnic disparities in climate hazard exposure vary across the urban-rural continuum.*
White student share is omitted as the reference category. Coefficients for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares therefore represent differences in annual exposure relative to districts serving larger White student shares within the same urbanicity category. Positive coefficients indicate greater exposure among districts serving larger shares of the specified racial/ethnic group after accounting for shared state-year climatic conditions, policy environments, and population density. All models include state-year fixed effects and log(population density + 1), with standard errors clustered at the district level. Results are reported as coefficient estimates with district-clustered standard errors in parentheses.

NCES urbanicity	**Outcome**	**Hispanic**	**Black**	**Asian**	**AIAN**
City	Heat	2.568 (0.810)**	0.170 (0.858)	2.423 (1.792)	15.529 (4.154)***
City	Ozone ≥140 μg/m^3	5.346 (3.146)†	-0.040 (1.422)	-3.174 (7.641)	27.060 (32.458)
City	Smoke >0 μg/m^3	-4.103 (1.745)*	3.281 (1.167)**	-4.294 (3.187)	21.377 (17.957)
City	Tropical storm	0.213 (0.251)	0.836 (0.410)*	0.388 (0.316)	-0.209 (1.125)
City	Wildfire burn	-0.264 (0.408)	0.069 (0.175)	-0.639 (1.207)	6.132 (6.251)
City	At least 2 hazards	1.153 (0.650)†	1.062 (0.426)*	-0.127 (1.372)	27.500 (11.139)*
City	At least 3 hazards	0.217 (0.125)†	0.211 (0.073)**	0.335 (0.347)	4.764 (2.686)†
City	Exactly 2 hazards	0.936 (0.555)†	0.851 (0.380)*	-0.461 (1.113)	22.736 (8.558)**
City	Exactly 3 hazards	0.219 (0.121)†	0.207 (0.070)**	0.295 (0.324)	4.668 (2.598)†
Suburb	Heat	2.648 (0.354)***	-0.271 (0.226)	0.817 (0.620)	-3.635 (3.805)
Suburb	Ozone ≥140 μg/m^3	10.272 (1.357)***	-0.392 (0.546)	-3.022 (3.234)	0.630 (6.775)
Suburb	Smoke >0 μg/m^3	-1.999 (0.736)**	0.893 (0.327)**	-3.143 (1.029)**	27.446 (9.852)**
Suburb	Tropical storm	1.061 (0.156)***	0.087 (0.143)	1.438 (0.295)***	2.030 (2.863)

Suburb	Wildfire burn	0.203 (0.189)	0.209 (0.077)**	-0.258 (0.237)	3.031 (2.515)
Suburb	At least 2 hazards	2.216 (0.239)***	0.547 (0.123)***	-0.506 (0.440)	4.736 (3.762)
Suburb	At least 3 hazards	0.389 (0.050)***	0.089 (0.025)***	-0.034 (0.094)	0.810 (0.654)
Suburb	Exactly 2 hazards	1.827 (0.204)***	0.458 (0.107)***	-0.472 (0.371)	3.926 (3.226)
Suburb	Exactly 3 hazards	0.380 (0.048)***	0.084 (0.024)***	-0.028 (0.092)	0.763 (0.621)
Town	Heat	4.707 (0.465)***	-0.988 (0.319)**	4.164 (5.061)	3.599 (0.982)***
Town	Ozone ≥140 μg/m³	5.498 (1.450)***	3.676 (0.719)***	11.577 (12.125)	3.849 (3.265)
Town	Smoke >0 μg/m³	-4.262 (0.938)***	2.785 (0.877)**	25.464 (10.835)*	4.396 (1.464)**
Town	Tropical storm	0.614 (0.143)***	2.294 (0.378)***	-0.066 (1.101)	0.291 (0.151)†
Town	Wildfire burn	-0.876 (0.517)†	-0.112 (0.153)	15.488 (9.636)	-0.048 (0.569)
Town	At least 2 hazards	1.694 (0.433)***	1.183 (0.223)***	14.116 (6.828)*	3.781 (0.947)***
Town	At least 3 hazards	0.106 (0.077)	0.164 (0.040)***	2.766 (1.280)*	0.295 (0.137)*
Town	Exactly 2 hazards	1.588 (0.375)***	1.019 (0.202)***	11.349 (5.815)†	3.485 (0.872)***
Town	Exactly 3 hazards	0.113 (0.075)	0.163 (0.040)***	2.668 (1.224)*	0.298 (0.136)*
Rural	Heat	3.369 (0.286)***	-0.449 (0.213)*	6.976 (1.710)***	0.049 (0.332)
Rural	Ozone ≥140 μg/m³	7.519 (1.032)***	2.380 (0.376)***	-3.361 (6.329)	1.768 (0.670)**
Rural	Smoke >0 μg/m³	-8.959 (0.690)***	3.488 (0.629)***	2.241 (2.883)	0.564 (0.525)
Rural	Tropical storm	0.462 (0.100)***	3.181 (0.322)***	1.449 (0.715)*	0.084 (0.032)**
Rural	Wildfire burn	-1.441 (0.245)***	-0.179 (0.051)***	0.704 (2.132)	0.033 (0.152)
Rural	At least 2 hazards	0.871 (0.263)***	1.173 (0.172)***	4.206 (2.098)*	0.652 (0.280)*
Rural	At least 3 hazards	0.214 (0.048)***	0.145 (0.028)***	0.112 (0.378)	0.064 (0.034)†
Rural	Exactly 2 hazards	0.657 (0.229)**	1.027 (0.157)***	4.095 (1.857)*	0.587 (0.264)*
Rural	Exactly 3 hazards	0.220 (0.048)***	0.145 (0.028)***	0.142 (0.376)	0.065 (0.034)†

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

Table S16: *National associations between climate hazards and school district finances. Coefficient estimates (standard errors) from district-year regression models relating climate hazard exposure to school district revenue composition, capital investment, and debt outcomes. Outcomes include total, local, property-tax, state, and federal revenue per pupil; capital outlay expenditures per pupil; construction expenditures per pupil; capital outlay share of total revenue; debt interest expenditures per pupil; and long-term debt issuance per pupil. Models include state and year fixed effects and control for NCES urbanicity and log(population density + 1). Standard errors are clustered at the district level. Positive coefficients indicate higher revenues, investment, or debt among districts experiencing greater hazard exposure. Results show that climate hazards are associated more strongly with differences in revenue composition than with capital investment or borrowing behavior.*

Outcome	**At least 2 hazards**	**At least 3 hazards**	**Heat**	**Ozone ≥140 μg/m^3**	**Smoke >0 μg/m^3**	**Tropical storm**	**Wildfire burn**
Capital outlay per pupil	-0.270 (3.794)	-18.767 (18.335)	0.998 (3.124)	2.238 (2.020)	-0.808 (1.220)	-4.174 (2.318)†	-0.718 (2.632)
Capital outlay share of revenue (%)	-0.020 (0.015)	-0.147 (0.073)*	-0.018 (0.014)	-0.003 (0.007)	-0.001 (0.005)	-0.010 (0.011)	-0.000 (0.011)
Construction outlay per pupil	-2.428 (3.569)	-18.327 (16.865)	-0.899 (2.936)	1.400 (1.945)	-1.827 (1.159)	-4.211 (2.228)†	-1.432 (2.379)
Debt interest per pupil	-2.435 (0.570)***	-4.747 (2.552)†	-2.235 (0.556)***	-0.747 (0.329)*	-0.947 (0.156)***	-2.295 (0.314)***	0.223 (0.381)
Federal revenue per pupil	18.648 (2.605)***	76.574 (11.963)***	2.920 (1.969)	7.862 (1.185)***	1.301 (0.618)*	-4.595 (1.111)***	2.852 (1.598)†
Local property tax revenue per pupil	-0.114 (7.771)	-33.098 (44.115)	42.808 (10.533)***	-12.149 (4.945)*	-18.423 (3.043)***	79.233 (7.556)***	14.688 (7.231)*
Local revenue per pupil	-8.352 (8.739)	-33.989 (47.691)	27.074 (11.125)*	-13.671 (5.465)*	-21.172 (3.091)***	66.470 (6.721)***	14.126 (7.767)†
Long-term debt issued per pupil	-7.252 (4.086)†	-48.818 (15.541)**	-5.648 (3.578)	-4.635 (1.646)**	-1.523 (1.324)	-4.920 (3.083)	3.407 (4.105)
State revenue per pupil	26.103 (6.900)***	102.244 (27.041)***	-0.335 (5.279)	18.604 (2.925)***	12.156 (1.573)***	-27.452 (2.514)***	-3.715 (8.496)
Total revenue per pupil	36.399 (12.221)**	144.829 (58.533)*	29.659 (11.572)*	12.795 (5.860)*	-7.714 (3.415)*	34.423 (6.285)***	13.263 (14.575)

*Significance levels: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.*

Table S17: *Regional and urbanicity heterogeneity in climate hazard-finance associations. Stratified regression estimates examining whether associations between climate hazard exposure and school district finances vary across Census regions (Northeast, Midwest, South, West) and NCES urbanicity categories (City, Suburb, Town, Rural). Outcomes include revenue composition, capital investment, and debt measures. Models include year fixed effects and controls for log(population density + 1); urbanicity-stratified models additionally include state fixed effects. Coefficients are reported with standard errors in parentheses. Results demonstrate substantial heterogeneity in both the magnitude and direction of hazard-finance associations* *across geographic and settlement contexts, indicating that national averages mask important regional and institutional variation.*

Stratum type	Stratum	Hazard	Capital outlay per pupil	Capital outlay share of revenue (%)	Construction outlay per pupil	Debt interest per pupil	Federal revenue per pupil	Local property tax revenue per pupil	Local revenue per pupil	Long-term debt issued per pupil	State revenue per pupil	Total revenue per pupil
NCES urbanicity	City	At least 2 hazards	-12.350 (7.686)	-0.101 (0.046)*	-10.229 (7.508)	-2.579 (1.337)†	9.443 (3.409)**	-16.885 (13.054)	-10.915 (16.628)	-1.508 (11.185)	43.292 (10.666)***	41.819 (14.712)**
NCES urbanicity	City	At least 3 hazards	-39.612 (32.940)	-0.272 (0.187)	-26.060 (32.748)	-6.345 (6.404)	33.653 (16.839)*	-87.262 (50.253)†	-72.338 (60.763)	-22.758 (47.318)	142.284 (54.232)**	103.599 (45.017)*
NCES urbanicity	City	Heat	-7.452 (6.486)	-0.066 (0.033)*	-6.094 (6.217)	-3.277 (1.357)*	7.222 (3.949)†	-8.355 (14.776)	-6.102 (19.327)	-17.830 (9.155)†	18.642 (11.828)	19.762 (20.866)
NCES urbanicity	City	Ozone ≥140 μg/m^3	-2.427 (3.167)	-0.014 (0.016)	-2.852 (3.044)	-1.345 (0.807)†	-0.918 (1.621)	-11.613 (6.531)†	-12.270 (7.844)	-4.620 (4.014)	10.591 (5.610)†	-2.597 (4.942)
NCES urbanicity	City	Smoke >0 μg/m^3	-0.861 (2.459)	-0.008 (0.015)	-0.423 (2.389)	0.083 (0.545)	2.030 (1.000)*	-11.459 (4.594)*	-12.721 (6.062)*	0.706 (3.944)	14.183 (3.519)***	3.493 (5.889)
NCES urbanicity	City	Tropical storm	-11.743 (4.854)*	-0.066 (0.028)*	-11.128 (4.641)*	-2.792 (0.910)**	1.316 (1.629)	28.477 (19.510)	26.187 (23.859)	-3.592 (8.221)	-10.675 (6.527)	16.828 (21.829)
NCES urbanicity	City	Wildfire burn	-1.627 (6.895)	-0.004 (0.045)	-0.900 (6.973)	-0.206 (1.243)	3.082 (2.168)	4.097 (10.660)	7.830 (12.057)	15.271 (12.694)	1.061 (8.025)	11.973 (9.505)
NCES urbanicity	Rural	At least 2 hazards	12.045 (6.855)†	0.038 (0.023)†	6.811 (6.398)	-0.003 (0.726)	18.024 (4.824)***	-2.874 (13.907)	-4.173 (15.495)	3.391 (6.580)	25.860 (13.449),†	39.711 (23.298)†
NCES urbanicity	Rural	At least 3 hazards	24.870 (41.537)	0.062 (0.141)	14.691 (37.355)	1.729 (3.994)	89.454 (26.860)***	118.673 (100.638)	145.708 (107.385)	-50.116 (19.451)**	31.713 (61.059)	266.874 (139.180)†
NCES urbanicity	Rural	Heat	12.879 (5.403)*	0.037 (0.021)†	8.693 (5.067)†	0.424 (0.840)	-2.281 (3.860)	59.858 (20.658)**	52.257 (21.659)*	10.409 (6.390)	9.588 (9.519)	59.564 (22.764)**
NCES urbanicity	Rural	Ozone ≥140 μg/m^3	11.760 (4.747)*	0.033 (0.013)*	9.759 (4.589)*	0.548 (0.465)	11.080 (2.745)***	1.969 (10.994)	1.452 (11.946)	1.604 (3.104)	11.663 (6.467)†	24.195 (13.671)†
NCES urbanicity	Rural	Smoke >0 μg/m^3	-1.663 (2.067)	-0.004 (0.008)	-3.452 (1.958)†	-1.375 (0.227)***	-0.768 (1.112)	-25.564 (5.233)***	-27.386 (5.321)***	-3.241 (2.009)	17.273 (2.545)***	-10.881 (5.937)†
NCES urbanicity	Rural	Tropical storm	-3.125 (3.509)	0.003 (0.017)	-3.269 (3.333)	-0.914 (0.488)†	-3.778 (1.165)**	64.504 (13.440)***	49.561 (11.615)***	-3.404 (4.665)	-18.360 (3.726)***	27.423 (10.632)**
NCES urbanicity	Rural	Wildfire burn	2.032 (6.019)	0.012 (0.020)	0.120 (5.407)	1.183 (0.717)†	4.680 (3.751)	18.320 (15.150)	22.583 (16.457)	10.445 (9.872)	-2.520 (22.051)	24.744 (36.900)
NCES urbanicity	Suburb	At least 2 hazards	-9.302 (6.112)	-0.071 (0.030)*	-9.896 (5.930)†	-4.938 (1.615)**	19.158 (2.052)***	-9.639 (13.675)	-25.603 (15.370)†	-13.839 (8.748)	37.040 (6.941)***	30.594 (13.349)*

NCES urbanicity	Suburb	At least 3 hazards	-40.529 (23.904)†	-0.291 (0.116)*	-37.190 (23.577)	-16.490 (6.120)**	106.888 (13.710)***	-196.350 (50.108)***	-218.005 (59.716)***	-27.277 (41.113)	221.853 (33.299)***	110.736 (53.050)*
NCES urbanicity	Suburb	Heat	-6.847 (5.456)	-0.059 (0.025)*	-9.413 (5.209)†	-4.294 (1.281)***	2.936 (2.303)	22.504 (15.191)	-3.309 (15.975)	-14.908 (6.565)*	-12.102 (7.754)	-12.475 (14.174)
NCES urbanicity	Suburb	Ozone ≥140 μg/m^3	-7.002 (2.790)*	-0.036 (0.012)**	-6.785 (2.760)*	-2.790 (0.802)***	6.059 (0.941)***	-34.700 (6.021)***	-41.943 (7.380)***	-15.082 (3.037)***	26.794 (3.582)***	-9.090 (6.465)
NCES urbanicity	Suburb	Smoke >0 μg/m^3	-0.304 (1.591)	-0.006 (0.009)	-0.228 (1.516)	0.702 (0.408)†	3.657 (0.622)***	-10.607 (3.428)**	-10.517 (3.803)**	5.007 (2.904)†	4.070 (2.288)†	-2.790 (3.390)
NCES urbanicity	Suburb	Tropical storm	-1.841 (4.071)	-0.007 (0.022)	-2.719 (3.875)	-3.103 (0.573)***	-8.332 (1.168)***	95.686 (11.889)***	81.026 (10.421)***	-9.226 (5.854)	-22.916 (4.330)***	49.777 (9.566)***
NCES urbanicity	Suburb	Wildfire burn	-0.507 (3.738)	-0.009 (0.021)	-1.124 (3.578)	-0.172 (1.081)	6.685 (2.181)**	25.356 (17.366)	20.899 (17.984)	-3.227 (5.758)	0.513 (6.737)	28.096 (13.817)*
NCES urbanicity	Town	At least 2 hazards	-8.263 (5.618)	-0.045 (0.031)	-9.219 (5.394)†	-2.637 (0.921)**	19.977 (4.222)***	-12.514 (9.836)	-18.196 (11.150)	-15.482 (6.878)*	21.223 (6.364)***	23.003 (9.363)*
NCES urbanicity	Town	At least 3 hazards	-41.273 (24.671)†	-0.273 (0.143)†	-38.331 (23.773)	-2.443 (3.865)	48.158 (16.616)**	-90.602 (44.937)*	-109.266 (48.775)*	-70.603 (25.437)**	115.950 (33.597)***	54.842 (35.868)
NCES urbanicity	Town	Heat	-7.712 (5.624)	-0.041 (0.034)	-6.691 (5.346)	-1.672 (1.001)†	8.250 (3.448)*	8.662 (12.356)	-0.992 (13.722)	-14.291 (6.902)*	-0.004 (7.240)	7.254 (10.625)
NCES urbanicity	Town	Ozone ≥140 μg/m^3	-1.534 (2.569)	-0.010 (0.015)	-1.434 (2.498)	-1.112 (0.522)*	8.500 (2.592)**	-17.624 (6.032)**	-20.458 (6.655)**	-4.881 (2.769)†	21.184 (4.214)***	9.226 (5.367)†
NCES urbanicity	Town	Smoke >0 μg/m^3	2.907 (1.803)	0.022 (0.011)*	1.707 (1.722)	-0.857 (0.256)***	2.905 (0.850)***	-11.714 (3.479)***	-11.934 (3.644)**	-1.756 (2.725)	6.417 (1.759)***	-2.612 (3.142)
NCES urbanicity	Town	Tropical storm	2.630 (5.070)	0.025 (0.029)	1.684 (4.886)	-1.505 (0.561)**	1.990 (1.532)	57.707 (18.226)**	52.916 (15.836)***	8.635 (7.285)	-24.030 (5.242)***	30.876 (12.439)*
NCES urbanicity	Town	Wildfire burn	-0.200 (2.761)	-0.003 (0.016)	-0.736 (2.580)	0.193 (0.402)	-0.397 (1.223)	8.809 (6.375)	8.474 (6.563)	-0.009 (3.177)	-0.619 (3.905)	7.457 (4.276)†
Census region	Midwest	At least 2 hazards	54.485 (15.109)***	0.208 (0.075)**	44.782 (14.368)**	1.755 (2.261)	-13.424 (9.980)	120.858 (19.608)***	143.635 (22.968)***	-19.793 (16.741)	-9.241 (12.742)	120.970 (25.474)***
Census region	Midwest	Heat	29.534 (7.419)***	0.118 (0.037)**	24.751 (7.057)***	0.863 (1.147)	-18.272 (4.980)***	78.351 (15.028)***	86.282 (16.487)***	-11.874 (9.393)	7.132 (7.881)	75.142 (17.564)***
Census region	Midwest	Ozone ≥140 μg/m^3	-9.706 (14.705)	-0.005 (0.080)	-22.883 (11.279)*	-3.926 (1.293)**	13.916 (3.915)***	-103.786 (11.610)***	-135.020 (14.865)***	-31.088 (12.234)*	27.311 (10.693)*	-93.793 (19.601)***
Census region	Midwest	Smoke >0 μg/m^3	10.855 (2.759)***	0.077 (0.015)***	8.215 (2.596)**	-0.160 (0.377)	-7.239 (1.734)***	31.823 (5.523)***	31.591 (6.019)***	-1.875 (3.249)	-15.803 (2.411)***	8.549 (6.770)

Census region	Midwest	Tropical storm	-5.229 (6.127)	-0.022 (0.032)	-3.163 (5.901)	-1.476 (0.794)†	-12.957 (2.465)***	21.289 (7.282)**	29.996 (8.367)***	2.910 (11.801)	34.700 (4.865)***	51.740 (9.405)***
Census region	Midwest	Wildfire burn	-96.242 (29.189)***	-0.701 (0.179)***	-83.857 (27.690)**	-6.225 (6.297)	4.915 (13.606)	60.960 (34.370)†	25.212 (36.620)	-36.795 (39.712)	-88.791 (25.105)***	-58.664 (43.439)
Census region	Northeast	At least 2 hazards	15.780 (22.768)	0.008 (0.072)	4.229 (21.075)	5.991 (4.021)	-55.224 (14.837)***	683.054 (109.382)***	339.712 (88.438)***	-16.303 (20.868)	-181.545 (33.126)***	102.943 (87.092)
Census region	Northeast	Heat	-8.136 (7.607)	-0.039 (0.027)	-7.646 (6.566)	0.149 (1.553)	-26.390 (8.688)**	136.187 (42.822)**	-14.406 (40.466)	12.794 (8.901)	-113.622 (17.850)***	-154.418 (40.525)***
Census region	Northeast	Ozone ≥140 μg/m^3	-24.357 (25.975)	-0.162 (0.055)**	-22.879 (25.184)	-5.608 (4.560)	6.540 (14.958)	528.028 (163.637)**	589.658 (150.201)***	-25.383 (20.171)	-82.465 (36.505)*	513.732 (130.846)***
Census region	Northeast	Smoke >0 μg/m^3	17.453 (4.948)***	0.104 (0.020)***	9.554 (4.676)*	3.228 (1.008)**	10.641 (3.634)**	-286.382 (19.426)***	-261.419 (18.252)***	-0.417 (7.498)	111.568 (10.950)***	-139.209 (18.585)***
Census region	Northeast	Tropical storm	-7.470 (5.661)	-0.056 (0.025)*	-6.478 (5.239)	-2.872 (0.832)***	-17.828 (1.747)***	351.512 (31.489)***	309.440 (26.044)***	-31.469 (6.650)***	-101.302 (8.454)***	190.310 (23.040)***
Census region	South	At least 2 hazards	10.767 (10.431)	0.025 (0.052)	9.358 (9.855)	1.298 (1.540)	2.031 (3.304)	46.484 (26.245)†	65.512 (28.356)*	22.869 (17.587)	-24.568 (12.938),†	42.975 (29.781)
Census region	South	Heat	9.858 (5.805)†	-0.035 (0.027)	9.694 (5.467)†	1.635 (1.039)	5.089 (2.136)*	102.945 (29.817)***	114.662 (30.172)***	13.330 (9.091)	2.968 (7.606)	122.718 (29.815)***
Census region	South	Ozone ≥140 μg/m^3	6.921 (8.268)	-0.019 (0.028)	6.285 (7.912)	-0.108 (1.227)	6.797 (1.892)***	29.524 (23.521)	36.625 (23.868)	13.480 (20.262)	19.407 (18.685)	62.830 (27.452)*
Census region	South	Smoke >0 μg/m^3	-12.212 (2.475)***	-0.041 (0.012)***	-10.699 (2.401)***	-1.649 (0.395)***	-2.402 (0.996)*	-58.474 (12.621)***	-56.048 (11.613)***	-1.523 (3.849)	3.487 (3.013)	-54.963 (11.436)***
Census region	South	Tropical storm	1.968 (2.756)	0.028 (0.016)†	2.113 (2.640)	-0.390 (0.412)	5.139 (0.956)***	-6.889 (6.899)	-9.554 (6.263)	2.821 (4.054)	-4.646 (2.624)†	-9.061 (6.060)
Census region	South	Wildfire burn	-5.264 (4.063)	-0.043 (0.023)†	-5.047 (3.659)	-0.227 (0.564)	-4.149 (1.927)*	6.966 (18.380)	13.596 (16.686)	-1.849 (6.007)	-4.511 (9.904)	4.936 (15.432)
Census region	West	At least 2 hazards	-10.322 (5.383)†	-0.038 (0.019)*	-11.921 (5.089)*	-3.404 (0.726)***	16.649 (3.398)***	-44.887 (9.751)***	-54.280 (11.455)***	-3.423 (5.100)	21.078 (9.846)*	-16.554 (16.264)
Census region	West	At least 3 hazards	-53.099 (21.394)*	-0.208 (0.080)**	-49.237 (19.864)*	-7.781 (2.702)**	40.677 (11.951)***	-63.398 (43.442)	-68.934 (48.233)	-22.256 (17.102)	16.180 (31.282)	-12.078 (57.428)
Census region	West	Heat	-9.940 (6.230)	-0.011 (0.025)	-14.972 (5.829)*	-5.089 (1.067)***	8.034 (4.406)†	-56.860 (12.030)***	-69.966 (13.731)***	-11.603 (5.439)*	25.120 (10.758)*	-36.812 (17.018)*

Census region	West	Ozone ≥140 μg/m^3	-0.387 (2.314)	-0.014 (0.008)†	-1.038 (2.218)	-1.391 (0.389)***	7.597 (1.374)***	-16.275 (5.676)**	-20.062 (6.369)**	-5.055 (1.714)**	15.646 (3.590)***	3.181 (6.747)
Census region	West	Smoke >0 μg/m^3	-3.068 (2.752)	-0.006 (0.009)	-5.035 (2.603)†	-1.769 (0.346)***	0.593 (1.382)	-27.466 (5.191)***	-31.841 (5.831)***	0.974 (2.048)	17.828 (3.841)***	-13.421 (7.016)†
Census region	West	Wildfire burn	-1.753 (2.816)	0.004 (0.011)	-2.231 (2.569)	0.338 (0.395)	-0.306 (1.641)	12.952 (7.457)†	13.251 (8.061)	6.210 (4.313)	-10.736 (8.955)	2.209 (14.915)

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

***Table S18**: Environmental justice heterogeneity in climate hazard-revenue associations. Interaction-model estimates examining whether associations between climate hazard exposure and school district revenue composition vary by district racial and ethnic composition. Outcomes include total revenue, local revenue, local property-tax revenue, state revenue, and federal revenue per pupil. Interaction terms were estimated separately for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares. Models include state and year fixed effects and controls for NCES urbanicity and log(population density + 1). Coefficients represent the change in the hazard-revenue association associated with a one-unit increase in the corresponding racial/ethnic population share. Standard errors are reported in parentheses.*

Outcome	Hazard	AIAN	Asian	Black	Hispanic	White
Federal revenue per pupil	At least 2 hazards	146.743 (41.667)***	-33.576 (18.844)†	-38.513 (13.649)**	-31.269 (8.712)***	-50.014 (11.954)***
Federal revenue per pupil	At least 3 hazards	68.150 (202.995)	-182.570 (79.382)*	-80.357 (261.211)	-68.319 (50.039)	123.455 (64.033)†
Federal revenue per pupil	Heat	161.191 (37.654)***	3.209 (20.646)	-1.812 (8.295)	-18.825 (7.358)*	-14.930 (9.120)
Federal revenue per pupil	Ozone ≥140 μg/m^3	-3.806 (18.133)	-9.175 (7.131)	-10.292 (8.269)	-15.169 (3.981)***	17.476 (4.811)***
Federal revenue per pupil	Smoke >0 μg/m^3	16.464 (8.395)*	-2.776 (7.749)	-1.822 (2.081)	4.576 (1.892)*	-37.667 (3.848)***
Federal revenue per pupil	Tropical storm	-306.646 (48.349)***	-113.061 (22.748)***	8.556 (3.300)**	18.332 (9.558)†	54.718 (8.576)***
Federal revenue per pupil	Wildfire burn	3.727 (29.271)	0.312 (17.701)	-27.736 (17.877)	-10.838 (6.133)†	18.880 (6.138)**
Local property tax revenue per pupil	At least 2 hazards	-16.628 (44.372)	-747.760 (109.787)***	-155.959 (61.779)*	-239.723 (30.941)***	275.930 (30.509)***
Local property tax revenue per pupil	At least 3 hazards	77.299 (406.861)	-2515.617 (519.164)***	-3983.005 (1052.664)***	-1043.859 (215.399)***	1252.461 (290.397)***
Local property tax revenue per pupil	Heat	-106.052 (37.099)**	-900.135 (126.209)***	-88.668 (40.277)*	-232.100 (33.729)***	221.358 (29.134)***
Local property tax revenue per pupil	Ozone ≥140 μg/m^3	11.144 (24.991)	-276.437 (31.470)***	-108.345 (34.797)**	-116.029 (16.729)***	132.097 (21.762)***

Local property tax revenue per pupil	Smoke >0 μg/m³	20.405 (11.498)†	51.522 (35.981)	5.614 (10.952)	-18.789 (7.563)*	30.230 (6.938)***
Local property tax revenue per pupil	Tropical storm	34.801 (272.923)	659.157 (148.421)***	-163.919 (24.345)***	1.261 (40.944)	62.733 (23.650)**
Local property tax revenue per pupil	Wildfire burn	-13.946 (75.483)	-331.514 (86.790)***	-389.865 (123.319)**	-23.701 (24.495)	49.810 (19.949)*
Local revenue per pupil	At least 2 hazards	24.253 (49.423)	-707.678 (114.183)***	-102.525 (86.040)	-249.457 (32.912)***	283.329 (32.396)***
Local revenue per pupil	At least 3 hazards	80.679 (419.546)	-2356.072 (507.742)***	-3827.397 (1105.529)***	-1070.871 (225.148)***	1333.229 (300.132)***
Local revenue per pupil	Heat	-63.435 (41.994)	-891.650 (138.123)***	-87.016 (55.399)	-232.726 (36.620)***	221.436 (31.292)***
Local revenue per pupil	Ozone ≥140 μg/m³	12.448 (26.253)	-260.068 (34.718)***	-99.912 (37.577)**	-119.255 (17.665)***	141.070 (22.666)***
Local revenue per pupil	Smoke >0 μg/m³	18.798 (12.986)	76.256 (38.160)*	26.328 (12.178)*	-12.336 (8.078)	20.077 (7.430)**
Local revenue per pupil	Tropical storm	-30.671 (170.827)	391.378 (137.329)**	-150.233 (28.235)***	-30.281 (40.463)	71.428 (24.853)**
Local revenue per pupil	Wildfire burn	-16.275 (86.290)	-327.518 (85.298)***	-386.620 (125.358)**	-21.815 (26.333)	52.171 (23.152)*
State revenue per pupil	At least 2 hazards	-100.239 (46.343)*	353.813 (82.515)***	-124.008 (37.143)***	56.685 (21.892)**	-21.253 (20.864)
State revenue per pupil	At least 3 hazards	-656.982 (244.887)**	672.242 (279.364)*	1401.022 (608.325)*	494.351 (97.249)***	-467.909 (102.339)***
State revenue per pupil	Heat	-66.987 (38.755)†	212.489 (74.986)**	146.953 (29.492)***	42.223 (16.231)**	-36.046 (16.494)*
State revenue per pupil	Ozone ≥140 μg/m³	-47.468 (17.208)**	95.473 (24.213)***	-15.312 (21.077)	52.273 (8.040)***	-52.712 (9.378)***
State revenue per pupil	Smoke >0 μg/m³	6.233 (13.781)	220.698 (40.745)***	-18.275 (9.484)†	0.650 (4.597)	-0.926 (5.148)
State revenue per pupil	Tropical storm	-99.916 (87.417)	-382.670 (72.327)***	-32.986 (8.850)***	70.275 (18.046)***	-31.704 (10.062)**
State revenue per pupil	Wildfire burn	85.308 (73.594)	119.232 (75.845)	-0.345 (106.909)	37.915 (30.457)	-63.065 (18.825)***
Total revenue per pupil	At least 2 hazards	70.756 (80.556)	-387.442 (109.758)***	-265.046 (98.368)**	-224.041 (40.939)***	212.062 (40.927)***
Total revenue per pupil	At least 3 hazards	-508.153 (449.216)	-1866.400 (435.151)***	-2506.732 (1099.826)*	-644.839 (257.925)*	988.775 (350.921)**
Total revenue per pupil	Heat	30.769 (71.073)	-675.952 (135.862)***	58.125 (63.124)	-209.328 (35.443)***	170.460 (34.281)***
Total revenue per pupil	Ozone ≥140 μg/m³	-38.826 (30.671)	-173.770 (35.001)***	-125.516 (39.369)**	-82.151 (18.569)***	105.834 (25.792)***

Total revenue per pupil	Smoke >0 μg/m^3	41.495 (19.230)*	294.178 (50.720)***	6.231 (13.710)	-7.111 (8.337)	-18.515 (8.854)*
Total revenue per pupil	Tropical storm	-437.233 (159.061)**	-104.353 (118.775)	-174.663 (28.080)***	58.325 (39.817)	94.443 (27.222)***
Total revenue per pupil	Wildfire burn	72.759 (145.382)	-207.974 (110.656)†	-414.701 (195.850)*	5.262 (53.343)	7.987 (35.635)

*Significance levels: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.*

Table S19: *Environmental justice heterogeneity in climate hazard-capital investment associations. Interaction-model estimates examining whether associations between climate hazard exposure and school district capital investment vary by district racial and ethnic composition. Outcomes include capital outlay expenditures per pupil, construction expenditures per pupil, and capital outlay share of total revenue. Interaction terms were estimated separately for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares. Models include state and year fixed effects and controls for NCES urbanicity and log(population density + 1). Coefficients represent the change in the hazard-capital investment association associated with a one-unit increase in the corresponding racial/ethnic population share. Standard errors are reported in parentheses.*

Outcome	Hazard	AIAN	Asian	Black	Hispanic	White
Capital outlay per pupil	At least 2 hazards	38.689 (34.323)	-28.453 (42.218)	-41.960 (24.696)†	-16.818 (10.403)	6.205 (9.980)
Capital outlay per pupil	At least 3 hazards	20.183 (149.801)	-158.876 (126.289)	-394.130 (295.634)	-39.985 (59.233)	25.750 (67.199)
Capital outlay per pupil	Heat	33.074 (29.225)	-55.047 (47.112)	-0.895 (12.631)	-27.166 (9.372)**	10.816 (8.683)
Capital outlay per pupil	Ozone ≥140 μg/m^3	0.204 (10.163)	-31.872 (10.643)**	-19.153 (14.094)	-12.370 (5.374)*	14.217 (6.807)*
Capital outlay per pupil	Smoke >0 μg/m^3	-2.624 (6.762)	47.085 (13.665)***	-1.982 (4.191)	3.323 (2.954)	-3.906 (2.688)
Capital outlay per pupil	Tropical storm	-88.245 (48.167)†	-62.391 (38.850)	2.054 (10.585)	11.683 (13.507)	-1.063 (8.751)
Capital outlay per pupil	Wildfire burn	79.806 (68.783)	29.571 (58.207)	-68.978 (33.590)*	3.161 (10.660)	-18.045 (8.852)*
Capital outlay share of revenue (%)	At least 2 hazards	0.277 (0.087)**	-0.002 (0.160)	0.006 (0.110)	0.071 (0.043)†	-0.137 (0.040)***
Capital outlay share of revenue (%)	At least 3 hazards	1.138 (0.793)	0.031 (0.594)	-0.956 (1.075)	0.271 (0.240)	-0.559 (0.272)*
Capital outlay share of revenue (%)	Heat	0.338 (0.081)***	-0.043 (0.184)	-0.030 (0.054)	-0.016 (0.045)	-0.077 (0.039)*
Capital outlay share of revenue (%)	Ozone ≥140 μg/m^3	0.050 (0.033)	-0.066 (0.043)	-0.013 (0.060)	-0.013 (0.019)	0.000 (0.022)

Capital outlay share of revenue (%)	Smoke >0 μg/m³	-0.044 (0.023)†	0.076 (0.053)	-0.009 (0.019)	0.016 (0.013)	-0.001 (0.011)
Capital outlay share of revenue (%)	Tropical storm	-0.179 (0.215)	-0.332 (0.154)*	0.089 (0.051)†	0.025 (0.061)	-0.049 (0.038)
Capital outlay share of revenue (%)	Wildfire burn	0.084 (0.136)	0.145 (0.219)	-0.232 (0.131)†	0.066 (0.039)†	-0.102 (0.038)**
Construction outlay per pupil	At least 2 hazards	22.352 (31.705)	-6.333 (41.397)	-43.821 (23.173)†	-8.872 (9.918)	0.686 (9.312)
Construction outlay per pupil	At least 3 hazards	9.655 (135.260)	-94.804 (120.333)	-417.718 (257.438)	-31.322 (53.666)	12.760 (58.650)
Construction outlay per pupil	Heat	14.964 (26.388)	-34.272 (45.866)	-2.355 (11.797)	-22.031 (8.876)*	9.411 (7.986)
Construction outlay per pupil	Ozone ≥140 μg/m³	-1.608 (9.251)	-26.675 (9.975)**	-15.833 (13.324)	-9.957 (5.125)†	11.151 (6.430)†
Construction outlay per pupil	Smoke >0 μg/m³	-9.580 (6.351)	50.481 (13.246)***	-0.228 (4.028)	6.032 (2.795)*	-5.324 (2.509)*
Construction outlay per pupil	Tropical storm	-87.065 (39.446)*	-36.289 (37.278)	-2.662 (10.273)	12.928 (12.980)	1.214 (8.404)
Construction outlay per pupil	Wildfire burn	85.582 (64.692)	23.566 (54.862)	-56.957 (31.044)†	3.085 (10.121)	-18.426 (8.005)*

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

***Table S20**: Environmental justice heterogeneity in climate hazard–debt associations. Interaction-model estimates examining whether associations between climate hazard exposure and school district debt measures vary by district racial and ethnic composition. Outcomes include debt-interest expenditures per pupil and long-term debt issuance per pupil. Interaction terms were estimated separately for Hispanic, Black, Asian, and American Indian/Alaska Native (AIAN) student shares. Models include state and year fixed effects and controls for NCES urbanicity and log(population density + 1). Coefficients represent the change in the hazard–debt association associated with a one-unit increase in the corresponding racial/ethnic population share. Standard errors are reported in parentheses.*

Outcome	**Hazard**	**AIAN**	**Asian**	**Black**	**Hispanic**	**White**
Debt interest per pupil	At least 2 hazards	2.525 (2.406)	27.809 (9.000)**	1.937 (3.321)	2.685 (1.729)	-2.363 (1.870)
Debt interest per pupil	At least 3 hazards	15.287 (16.396)	56.053 (32.438)†	-0.707 (44.155)	-0.569 (9.552)	1.624 (11.393)
Debt interest per pupil	Heat	1.111 (1.800)	25.209 (12.850)*	1.913 (2.152)	-2.432 (1.606)	1.843 (1.571)
Debt interest per pupil	Ozone ≥140 μg/m³	1.116 (1.180)	2.932 (2.655)	-0.008 (2.249)	-2.272 (1.017)*	2.546 (1.260)*
Debt interest per pupil	Smoke >0 μg/m³	-1.475 (1.027)	14.780 (2.608)***	0.750 (0.852)	2.944 (0.419)***	-2.150 (0.420)***

Debt interest per pupil	Tropical storm	-24.091 (8.354)**	-50.661 (7.525)***	2.026 (1.209)†	4.203 (2.089)*	-2.954 (1.098)**
Debt interest per pupil	Wildfire burn	-3.061 (3.172)	1.814 (4.626)	-5.245 (4.355)	3.789 (1.333)**	-2.382 (1.545)
Long-term debt issued per pupil	At least 2 hazards	63.201 (35.545)†	54.869 (40.501)	-8.079 (28.609)	-8.525 (12.719)	-3.202 (10.392)
Long-term debt issued per pupil	At least 3 hazards	103.406 (54.194)†	205.583 (217.663)	-381.528 (215.643)†	15.178 (59.490)	-53.604 (53.702)
Long-term debt issued per pupil	Heat	23.843 (10.817)*	62.234 (55.194)	6.980 (17.595)	-4.203 (12.489)	-6.364 (9.763)
Long-term debt issued per pupil	Ozone ≥140 $\mu g/m^3$	5.496 (3.934)	-7.051 (11.588)	-23.892 (11.482)*	-4.032 (4.378)	5.315 (4.587)
Long-term debt issued per pupil	Smoke >0 $\mu g/m^3$	-3.603 (3.728)	44.055 (15.368)**	4.925 (5.735)	1.619 (4.014)	-0.419 (2.838)
Long-term debt issued per pupil	Tropical storm	-33.919 (104.155)	-165.269 (46.465)***	9.169 (11.998)	-15.941 (16.129)	-0.119 (9.705)
Long-term debt issued per pupil	Wildfire burn	123.575 (127.683)	10.716 (43.541)	-37.963 (56.443)	-8.977 (17.928)	-7.648 (13.496)

*Significance levels: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.*

***Table S21**: Colorado school district facility condition summary statistics. Descriptive statistics for district-level school facility condition measures derived from the Colorado facilities assessment dataset and matched to 177 analytic-panel school districts. Facility metrics include mean, 75th percentile (P75), and maximum facility age; mean and P75 Facility Condition Index (FCI); mean adequacy index; and the percentage of facilities classified as poor condition. P25 and P75 denote the 25th and 75th percentiles of the district-level distributions. Higher FCI values indicate poorer facility conditions.*

Outcome	**Districts**	**Mean**	**Median**	**P25**	**P75**	**Min**	**Max**
Mean facility age	177	58.45	56.63	43.47	73	2	143
P75 facility age	177	67.3	68	55	78	2	146
Maximum facility age	177	79.29	76	64	103	2	169
Mean FCI	177	0.48	0.5	0.36	0.62	0	0.83
P75 FCI	177	0.54	0.61	0.43	0.69	0	0.88
Mean adequacy index	177	0.18	0.16	0.1	0.23	0	0.49
Poor-condition facilities (%)	177	72.9	98.27	56.77	100	0	100

Table S22: *Adjusted associations between climate hazard exposure and school facility conditions in Colorado. Coefficient estimates (standard errors) from district-level linear regression models relating facility condition measures to average annual climate hazard exposure between 2013 and 2020. Outcomes include facility age, Facility Condition Index (FCI), adequacy index, and the percentage of poor-condition facilities. Models control for NCES urbanicity and log(population density + 1). Hazard metrics include extreme heat days, ozone exceedance days (≥140 μg/m³), smoke days, wildfire burn exposure, and multi-hazard exposure metrics.*

Outcome	At least 2 hazards	At least 3 hazards	Heat	Ozone ≥140 μg/m³	Smoke >0 μg/m³	Wildfire burn
Maximum facility age	-0.988 (1.687)	-0.200 (12.426)	-0.472 (0.874)	-0.374 (0.509)	-0.324 (0.356)	0.583 (1.528)
Mean FCI	-0.015 (0.010)	0.011 (0.076)	-0.001 (0.005)	-0.008 (0.003)*	0.003 (0.002)	0.003 (0.009)
Mean adequacy index	-0.007 (0.005)	0.001 (0.040)	-0.003 (0.003)	0.002 (0.002)	-0.003 (0.001)**	-0.005 (0.005)
Mean facility age	-1.091 (1.379)	-2.972 (10.162)	0.611 (0.714)	-0.697 (0.414)†	0.353 (0.291)	-1.226 (1.247)
P75 FCI	-0.015 (0.011)	-0.036 (0.080)	-0.004 (0.006)	-0.005 (0.003)	0.003 (0.002)	0.004 (0.010)
P75 facility age	-0.849 (1.507)	-2.423 (11.102)	0.527 (0.781)	-0.458 (0.455)	0.141 (0.319)	-0.956 (1.364)
Poor-condition facilities (%)	-3.157 (2.015)	-1.654 (14.836)	-0.177 (1.047)	-1.685 (0.619)**	0.682 (0.426)	1.041 (1.823)

*Statistical significance is indicated as † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.*

Table S23: *Colorado school facility conditions across climate hazard exposure quartiles. District-level facility condition measures summarized across quartiles of climate hazard exposure. Quartile 1 (Q1) represents districts with the lowest hazard exposure, and Quartile 4 (Q4) represents districts with the highest exposure. Values are reported as means with interquartile ranges [P25, P75]. Hazard metrics include exposure to at least two hazards, ozone exceedance days (≥140 μg/m³), and smoke days. The table provides descriptive comparisons of facility conditions across exposure gradients and complements the adjusted regression analyses presented in Table S22.*

Hazard	Outcome	Q1	Q2	Q3	Q4
At least 2 hazards	Maximum facility age	81.98 [63.50, 101.00]	72.34 [59.25, 97.25]	79.78 [62.00, 106.00]	83.12 [72.00, 106.00]
At least 2 hazards	Mean FCI	0.52 [0.39, 0.66]	0.47 [0.27, 0.64]	0.46 [0.35, 0.57]	0.48 [0.36, 0.60]
At least 2 hazards	Mean adequacy index	0.19 [0.12, 0.23]	0.20 [0.12, 0.26]	0.18 [0.11, 0.23]	0.14 [0.08, 0.18]
At least 2 hazards	Mean facility age	58.74 [43.98, 71.11]	64.16 [49.27, 86.29]	57.57 [44.64, 72.00]	52.93 [42.94, 63.43]

At least 2 hazards	P75 FCI	0.58 [0.45, 0.71]	0.51 [0.27, 0.66]	0.53 [0.44, 0.67]	0.57 [0.52, 0.70]
At least 2 hazards	P75 facility age	66.85 [51.50, 73.50]	69.66 [59.25, 89.00]	68.67 [58.00, 84.00]	63.78 [52.00, 77.00]
At least 2 hazards	Poor-condition facilities (%)	83.29 [75.11, 100.00]	66.13 [0.00, 100.00]	71.41 [57.77, 100.00]	72.26 [60.53, 100.00]
Ozone ≥140 μg/m^3	Maximum facility age	70.36 [60.00, 88.00]	84.92 [71.00, 100.00]	87.70 [66.75, 108.25]	74.40 [57.50, 103.50]
Ozone ≥140 μg/m^3	Mean FCI	0.49 [0.34, 0.64]	0.49 [0.37, 0.64]	0.51 [0.41, 0.60]	0.44 [0.32, 0.57]
Ozone ≥140 μg/m^3	Mean adequacy index	0.17 [0.10, 0.21]	0.14 [0.07, 0.18]	0.20 [0.14, 0.25]	0.21 [0.13, 0.28]
Ozone ≥140 μg/m^3	Mean facility age	58.99 [46.36, 72.10]	58.70 [45.91, 72.00]	60.46 [45.18, 67.30]	55.71 [34.30, 77.87]
Ozone ≥140 μg/m^3	P75 FCI	0.53 [0.44, 0.68]	0.57 [0.46, 0.70]	0.58 [0.45, 0.69]	0.51 [0.34, 0.70]
Ozone ≥140 μg/m^3	P75 facility age	65.36 [57.00, 77.00]	67.39 [56.00, 76.00]	70.40 [53.00, 77.50]	66.35 [53.00, 88.50]
Ozone ≥140 μg/m^3	Poor-condition facilities (%)	75.57 [57.77, 100.00]	71.99 [61.98, 100.00]	81.31 [71.55, 100.00]	65.41 [35.41, 100.00]
Smoke >0 μg/m^3	Maximum facility age	77.73 [62.00, 106.00]	88.52 [70.00, 105.50]	79.42 [67.50, 98.50]	70.91 [57.00, 89.00]
Smoke >0 μg/m^3	Mean FCI	0.41 [0.24, 0.57]	0.53 [0.42, 0.62]	0.50 [0.41, 0.62]	0.48 [0.35, 0.64]
Smoke >0 μg/m^3	Mean adequacy index	0.21 [0.13, 0.28]	0.17 [0.11, 0.23]	0.16 [0.09, 0.22]	0.16 [0.09, 0.19]
Smoke >0 μg/m^3	Mean facility age	56.13 [36.44, 73.00]	55.61 [44.24, 63.19]	60.28 [47.33, 72.50]	62.06 [47.15, 75.00]
Smoke >0 μg/m^3	P75 FCI	0.48 [0.24, 0.68]	0.62 [0.57, 0.70]	0.56 [0.43, 0.69]	0.53 [0.43, 0.68]
Smoke >0 μg/m^3	P75 facility age	66.78 [45.00, 85.00]	66.15 [50.75, 74.75]	69.91 [61.50, 77.50]	66.47 [57.00, 84.00]
Smoke >0 μg/m^3	Poor-condition facilities (%)	61.55 [0.00, 100.00]	82.26 [68.27, 100.00]	73.14 [60.01, 100.00]	76.52 [50.01, 100.00]

***Table S24**: Maryland school district facility condition summary statistics. Descriptive statistics for district-level facility condition measures derived from the Maryland school facilities inventory and matched to 24 analytic-panel school districts. Facility metrics include mean, 75th percentile (P75), and maximum facility age; mean maintenance score; and the percentage of active facilities classified as poor condition. P25 and P75 denote the 25th and 75th percentiles of the district-level distributions. Higher maintenance scores indicate better facility conditions.*

Outcome	**Districts**	**Mean**	**Median**	**P25**	**P75**	**Min**	**Max**

Mean facility age	24	31.46	30.46	27.08	35.48	21.18	47.78
P75 facility age	24	43.71	44	39.75	50	28	62
Maximum facility age	24	64.88	62	55.25	72	32	139
Mean maintenance score	24	2.88	3	2.68	3.1	2	3.58
Poor-condition facilities (%)	24	25.2	14.29	2.73	41.99	0	100

***Table S20**: Adjusted associations between climate hazard exposure and school facility conditions in Maryland. Coefficient estimates (standard errors) from district-level linear regression models relating facility condition measures to average annual climate hazard exposure between 2013 and 2020. Outcomes include mean facility age, P75 facility age, maximum facility age, mean maintenance score, and the percentage of poor-condition facilities. Models control for NCES urbanicity and log(population density + 1). Hazard metrics include extreme heat days, ozone exceedance days (≥140 μg/m^3), smoke days, tropical storm exposure, and multi-hazard exposure metrics.*

Outcome	**At least 2 hazards**	**At least 3 hazards**	**Heat**	**Ozone ≥140 μg/m^3**	**Smoke >0 μg/m^3**	**Tropical storm**
Maximum facility age	2.042 (4.420)	44.323 (49.402)	-0.112 (1.390)	4.354 (2.926)	7.938 (5.327)	-0.249 (1.519)
Mean facility age	-1.282 (2.153)	-3.339 (24.676)	-0.705 (0.659)	2.189 (1.425)	5.564 (2.429)*	-0.662 (0.727)
Mean maintenance score	0.036 (0.117)	0.979 (1.310)	0.004 (0.037)	0.008 (0.082)	-0.053 (0.148)	0.032 (0.039)
P75 facility age	-1.421 (3.108)	-3.232 (35.492)	-0.899 (0.954)	2.731 (2.082)	5.414 (3.759)	-0.188 (1.068)
Poor-condition facilities (%)	-5.595 (8.904)	-92.359 (99.881)	-1.492 (2.793)	-4.198 (6.198)	1.355 (11.427)	-0.161 (3.077)

*Significance is indicated as † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.*

***Table S25**: Maryland school facility conditions across climate hazard exposure quartiles. District-level facility condition measures summarized across quartiles of climate hazard exposure. Quartile 1 (Q1) represents districts with the lowest hazard exposure, and Quartile 4 (Q4) represents districts with the highest exposure. Values are reported as means with interquartile ranges [P25, P75]. Hazard metrics include exposure to at least two hazards, extreme heat, and smoke. Outcomes include facility age, maintenance score, and the percentage of poor-condition facilities. The table provides descriptive comparisons of facility conditions across exposure gradients and complements the adjusted regression analyses presented in Table S24.*

Hazard	**Outcome**	**Q1**	**Q2**	**Q3**	**Q4**

At least 2 hazards	Maximum facility age	63.50 [55.00, 72.00]	64.33 [62.25, 68.50]	64.67 [56.00, 73.00]	67.00 [49.25, 65.00]
At least 2 hazards	Mean facility age	35.22 [32.26, 39.30]	28.52 [27.34, 31.27]	29.99 [27.72, 31.92]	32.10 [25.50, 35.54]
At least 2 hazards	Mean maintenance score	2.66 [2.43, 2.92]	3.17 [3.08, 3.32]	2.85 [2.80, 3.12]	2.83 [2.75, 2.99]
At least 2 hazards	P75 facility age	48.00 [44.25, 51.50]	39.67 [37.25, 43.50]	43.83 [42.00, 47.75]	43.33 [30.00, 56.00]
At least 2 hazards	Poor-condition facilities (%)	40.05 [24.13, 58.71]	9.91 [0.00, 8.30]	29.18 [6.55, 28.88]	21.67 [2.36, 34.79]
Heat	Maximum facility age	65.33 [57.00, 72.00]	62.17 [61.00, 65.75]	61.67 [56.00, 62.75]	70.33 [48.25, 81.00]
Heat	Mean facility age	33.57 [29.14, 38.21]	30.27 [27.62, 32.16]	33.23 [29.32, 34.48]	28.76 [24.99, 33.15]
Heat	Mean maintenance score	2.79 [2.43, 3.06]	3.09 [3.02, 3.14]	2.74 [2.71, 2.97]	2.90 [2.77, 3.06]
Heat	P75 facility age	46.17 [42.50, 48.50]	42.67 [38.25, 47.25]	45.83 [41.25, 49.25]	40.17 [30.25, 48.00]
Heat	Poor-condition facilities (%)	32.15 [4.60, 57.48]	15.39 [2.52, 24.44]	34.57 [10.69, 40.90]	18.70 [4.78, 29.53]
Smoke >0 μg/m^3	Maximum facility age	68.29 [62.00, 74.50]	50.83 [48.00, 55.00]	76.00 [61.25, 70.50]	63.60 [56.00, 72.00]
Smoke >0 μg/m^3	Mean facility age	31.38 [28.93, 33.94]	25.84 [24.81, 27.08]	32.41 [29.62, 35.54]	37.17 [32.42, 39.44]
Smoke >0 μg/m^3	Mean maintenance score	2.99 [2.85, 3.17]	2.85 [2.66, 3.06]	2.89 [2.77, 3.07]	2.74 [2.62, 3.00]
Smoke >0 μg/m^3	P75 facility age	44.14 [41.50, 49.00]	34.00 [30.00, 35.50]	48.33 [45.00, 50.00]	49.20 [44.00, 52.00]
Smoke >0 μg/m^3	Poor-condition facilities (%)	22.02 [4.28, 36.86]	23.75 [7.35, 38.77]	27.51 [3.28, 31.58]	28.64 [0.00, 46.19]

***Table S26**: Florida school district facility age summary statistics. Descriptive statistics for district-level facility age derived from the Florida school facilities inventory and matched to 67 county-based public school districts. Values represent district-level average facility age. P25 and P75 denote the 25th and 75th percentiles of the district-level distribution.*

Outcome	**Districts**	**Mean**	**Median**	**P25**	**P75**	**Min**	**Max**
Mean facility age	67	35.54	37	29.5	41	18	49

Table S27: Adjusted associations between climate hazard exposure and school facility age in Florida. Coefficient estimates (standard errors) from district-level linear regression models relating mean facility age to average annual climate hazard exposure between 2013 and 2020.

Models control for NCES urbanicity and log(population density + 1). Hazard metrics include extreme heat days, ozone exceedance days (≥140 μg/m^3), smoke days, tropical storm exposure, wildfire burn exposure, and multi-hazard exposure metrics.

Outcome	At least 2 hazards	At least 3 hazards	Heat	Ozone ≥140 μg/m^3	Smoke >0 μg/m^3	Tropical storm	Wildfire burn
Mean facility age	-1.069 (0.708)	-10.480 (10.317)	-0.438 (0.221)†	-0.224 (0.139)	0.109 (0.115)	-0.630 (0.354)†	-0.174 (0.347)

Significance is indicated as † p < 0.10, * p < 0.05, ** p < 0.01.

Table S28*: Florida school facility age across climate hazard exposure quartiles. District-level mean facility age summarized across quartiles of climate hazard exposure. Quartile 1 (Q1) represents districts with the lowest hazard exposure, and Quartile 4 (Q4) represents districts with the highest exposure. Values are reported as means with interquartile ranges [P25, P75]. Hazard metrics include exposure to at least two hazards. The table provides descriptive comparisons of facility age across hazard exposure gradients and complements the adjusted regression analyses presented in Table S27.*

Hazard	Outcome	Q1	Q2	Q3	Q4
At least 2 hazards	Mean facility age	36.00 [30.50, 41.50]	35.19 [28.00, 40.25]	38.47 [35.00, 41.50]	32.76 [28.00, 36.00]
Heat	Mean facility age	36.00 [29.00, 42.00]	37.24 [34.00, 41.00]	34.19 [28.00, 40.00]	34.65 [29.00, 40.00]
Smoke >0 μg/m^3	Mean facility age	33.17 [29.25, 39.00]	37.65 [33.00, 42.00]	34.73 [30.00, 40.50]	36.65 [28.00, 43.00]
Tropical storm	Mean facility age	36.89 [29.50, 42.50]	34.13 [29.50, 39.00]	35.44 [30.25, 41.00]	35.35 [30.00, 40.00]
Wildfire burn	Mean facility age	36.94 [30.00, 42.00]	35.00 [27.75, 41.00]	33.93 [29.00, 40.00]	36.27 [33.00, 40.00]

S3 Maps of Co-Exposures

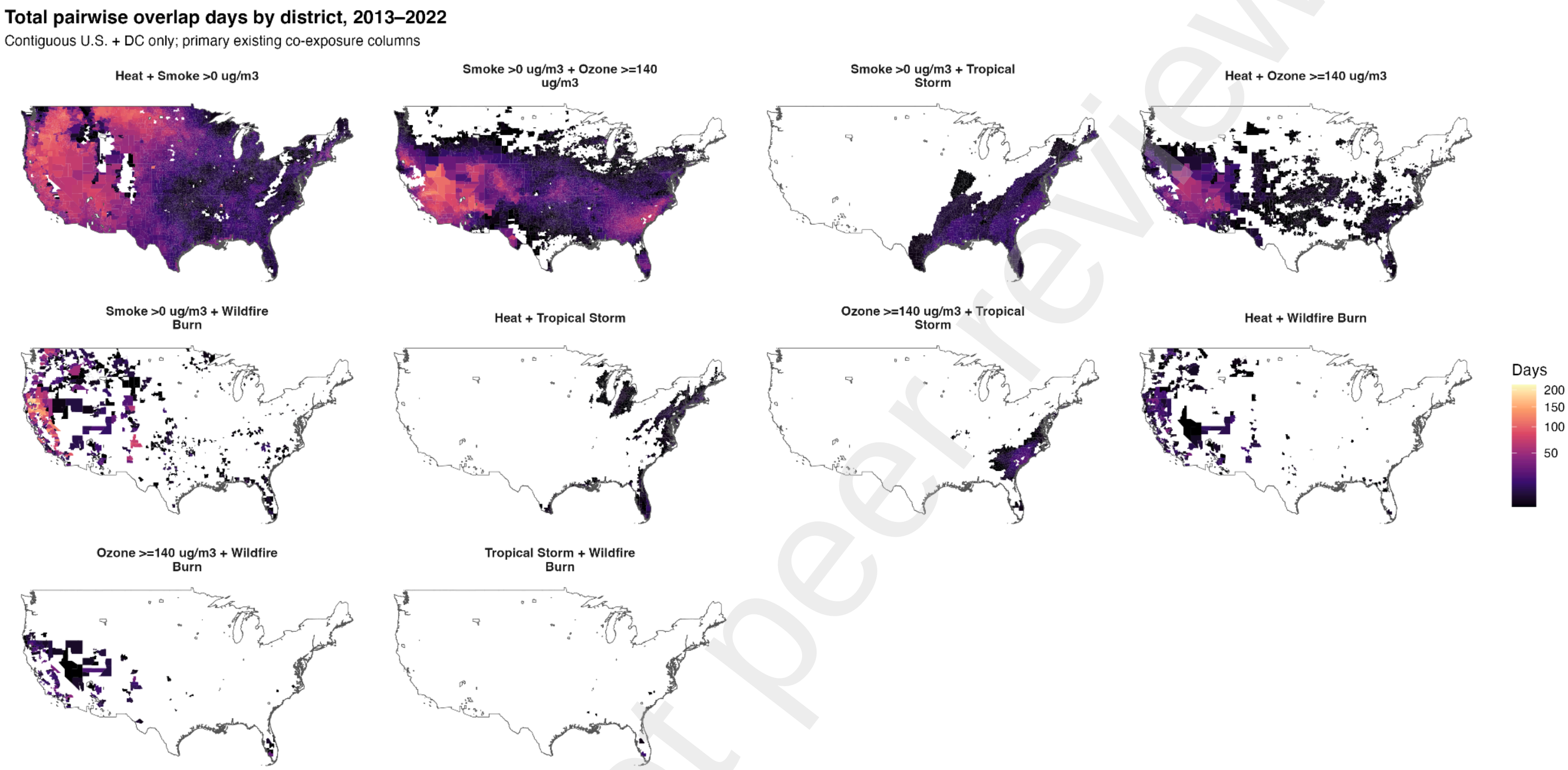

Figure S4.1*: National distribution of pairwise climate hazard co-exposure days by district, 2013-2022. This figure maps the total number of district-days experiencing pairwise combinations of climate hazards across U.S. school districts from 2013 to 2022. Each panel represents a specific two-hazard combination, including interactions between tropical storms, extreme heat, wildfire smoke, wildfire burn, and ozone exceedances. Color intensity indicates the cumulative number of co-exposure days, with darker colors representing higher levels of overlap. The figure highlights strong spatial clustering of co-exposures: tropical storm-related combinations are concentrated along the Gulf Coast and southeastern United States, while wildfire smoke and heat co-exposures dominate in the western and southwestern regions. Ozone-related co-exposures are most prominent in California and parts of the Mountain West. These patterns illustrate that multi-hazard exposure is highly regionalized, with different combinations of risks shaping the environmental conditions experienced by school districts across the country.*

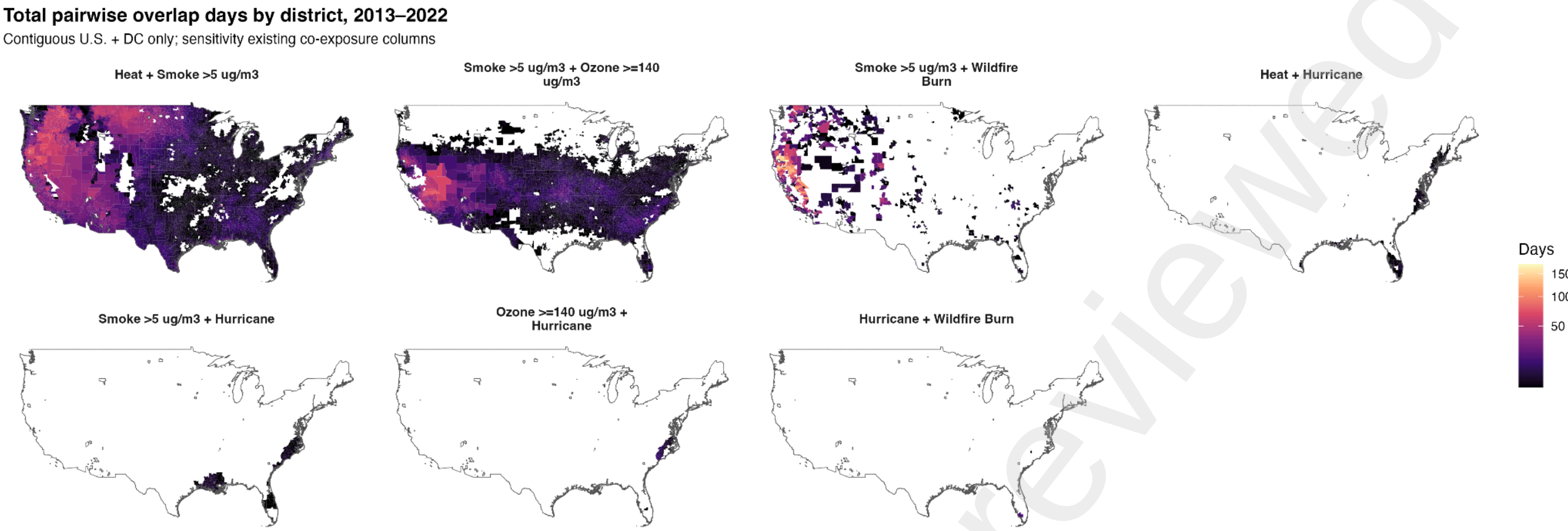

Figure S4.2: *National distribution of pairwise climate hazard co-exposure days by district (sensitivity definitions), 2013-2022. This figure presents the total number of district-days experiencing pairwise combinations of climate hazards across U.S. school districts from 2013 to 2022 using alternative (sensitivity) exposure definitions. In this specification, tropical cyclone exposure is restricted to hurricane-force events, and wildfire smoke exposure is defined using a higher threshold (smoke > 5 μg/m^3). Each panel shows a specific two-hazard combination, including interactions among hurricanes, extreme heat, wildfire smoke, wildfire burn, and ozone exceedances. Color intensity indicates the cumulative number of co-exposure days, with darker colors representing higher levels of overlap. Compared to the primary specification, co-exposure patterns are more spatially concentrated, reflecting the greater rarity and severity of these thresholds. Hurricane-related co-exposures are localized along coastal regions, particularly the Gulf Coast and southeastern United States, while high-intensity smoke co-exposures remain concentrated in the western United States. Ozone-related co-exposures continue to be most prominent in California and parts of the Mountain West. Overall, the figure demonstrates that the spatial structure of multi-hazard exposure is robust to alternative hazard definitions, though more extreme thresholds yield more geographically concentrated patterns of co-exposure.*

Total specific 3+ hazard overlap days by district, 2013–2022

Contiguous U.S. + DC only; each panel shows district-days for a specific 3+ hazard combination. Zero-day combinations are shown as blank maps.

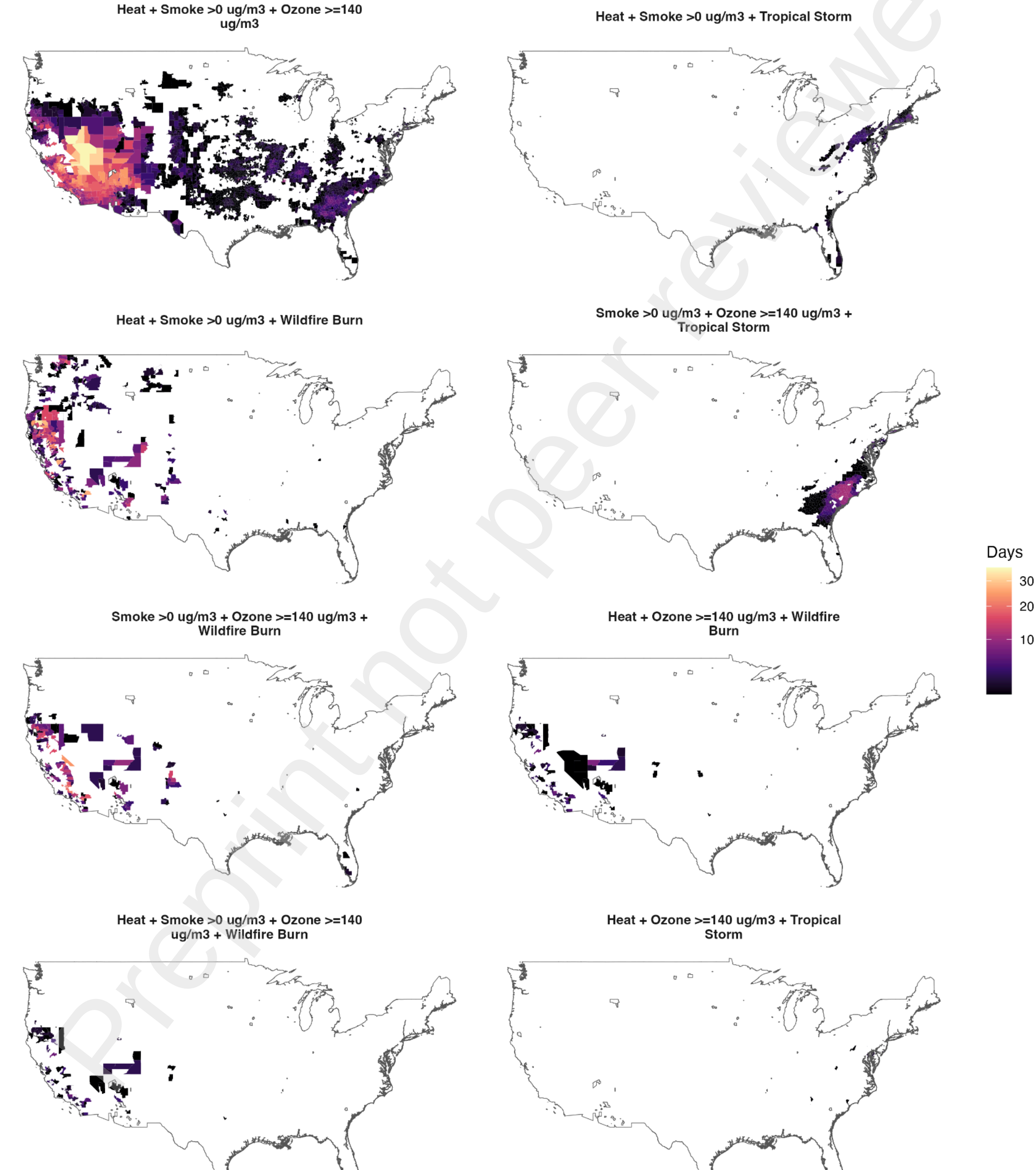

Figure S4.3: *National distribution of specific 3+ hazard co-exposure days by district, 2013-2022. This figure maps cumulative district-days with simultaneous exposure to specific combinations of three or more primary climate hazards across contiguous U.S. school districts and DC. Primary hazards include extreme heat, ozone exceedances ≥140 μg/m³, wildfire smoke >0 μg/m³, tropical storm exposure, and wildfire burn exposure. Each panel shows one specific high-order co-exposure combination; districts with zero days are shown in white. Color intensity indicates the cumulative number of co-exposure days. Specific 3+ co-exposures are geographically concentrated, with the most prominent clustering in the western U.S. for combinations involving heat, wildfire smoke, and ozone. Smaller clusters appear along the eastern seaboard for combinations involving tropical storms. Overall, the figure shows that higher-order co-exposures are less widespread than pairwise overlaps but are concentrated in regions where multiple hazard regimes intersect.*