Escalating risk and pronounced inter-regional differences in exposure to natural hazards due to development patterns in the United States

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Combined, earthquakes, fires, floods, tornados and hurricanes are the most prominent natural disturbances in the United States that endanger human lives and result in substantial costs to society. Between 2006 and 2016, property and crop damage due to these hazards increased from ~5.4 to ~ 14.6 billion USD, with the record number of billion-dollar losses set in 2017. Unprecedented impacts and escalating costs highlight the imperative for better understanding of risk, which emerges from the coupling of disturbance probability and the exposure and adaptive capabilities of local communities. This study harmonizes earthquake, fire, flood, tornado and hurricane hazard data with fine-resolution annual settlement information to assess how risk due to changes in exposure has varied over the past 40 years across the contiguous U.S. Natural hazard risk assessments have been historically hindered by scale mismatches, poor characterization of property exposure and spatially-variable accuracy of the built environment. To overcome these limitations, we combined hazard occurrence data to create an integrated hazard map and employed gridded settlement layers from the Historical Settlement Data Compilation for the U.S. (HISDAC-US) derived from cadastral and housing data compiled in the Zillow Transaction and Assessment Dataset (ZTRAX) to map exposure. HISDAC-US describes the built environment of most of the country back to 1810 at fine temporal and spatial granularity. Trends in density of structures and built-up land were estimated for hazardous and non-hazardous areas (i.e., top and bottom 10% highest and lowest probabilities of a given hazard, respectively) as well temporal dynamics of risk at the subregional-, regional- and continental-scales. Results suggest a monotonic increase in risk to all hazards as well as pronounced and rising spatial variability in exposure, pointing to long-standing institutional issues around equity and social justice. By assessing exposure at fine spatial resolution, with high temporal accuracy, and over long periods, we reliably identified populations at risk, and evaluated the development trajectories that lead to higher vulnerability to natural hazards.
