Challenges in Evaluating the Costs of Climate Change

Oren Cass

Senior Fellow, Manhattan Institute for Policy Research

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All Analyses Are Preliminary, for Discussion Purposes Only

Summary

- Most climate science is rigorously conducted and subject to careful scrutiny; consensus statements tend to be framed conservatively and should be taken seriously by policymakers as they anticipate and prepare for future challenges

- By contrast, climate economics has become overrun by poorly constructed studies that rely on unreasonable assumptions to generate large cost estimates
    - Early "Integrated Assessment Models" made good-faith efforts to forecast costs, but their estimates are not large
    - More recently, abstract "temperature studies" have sought to establish statistical correlations between higher temperatures and outcomes like higher mortality or slower growth, and then extrapolate these forward; this produces strange results:
        - A forecast that Pittsburgh's heat-related mortality rate in 2100 will be 75 times higher than Phoenix's is today
        - A forecast that Iceland and Mongolia will be the leading economies of the twenty-first century
- Studies like these, which accounted for more than 80% of the costs identified in the recent GAO report on climate cost, are ripe for scrutiny
- The Environmental Protection Agency could play a central role in strengthening climate research by endorsing high-quality scientific evidence while setting clear standards for the economic and policy studies built atop that foundation

Studies discussed in this presentation

Syntheses of Individual Studies

Robert Kopp, Solomon Hsiang, et al., "American Climate Prospectus: Economic Risks in the United States," Rhodium Group, Oct. 2014.

U.S. Environmental Protection Agency, "Climate Change in the United States: Benefits of Global Action," June 2015.

U.S. Government Accountability Office, "Climate Change: Information on Potential Economic Effects Could Help Guide Federal Efforts to Reduce Fiscal Exposure," Sept. 2017.

Individual Temperature Studies

Olivier Deschênes and Michael Greenstone, "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US," *Applied Economics* 3, no. 4 (Oct. 2011): 152-85.

Joshua Graff Zivin and Matthew Neidell, "Temperature and the Allocation of Time: Implications for Climate Change," *Journal of Labor Economics* 32, no. 1 (Jan. 2014): 1-26.

Fernando Garcia-Menendez et al., "U.S. Air Quality and Health Benefits from Avoided Climate Change under Greenhouse Gas Mitigation," *Environmental Science & Technology* 49 (June 2015): 7580-33.

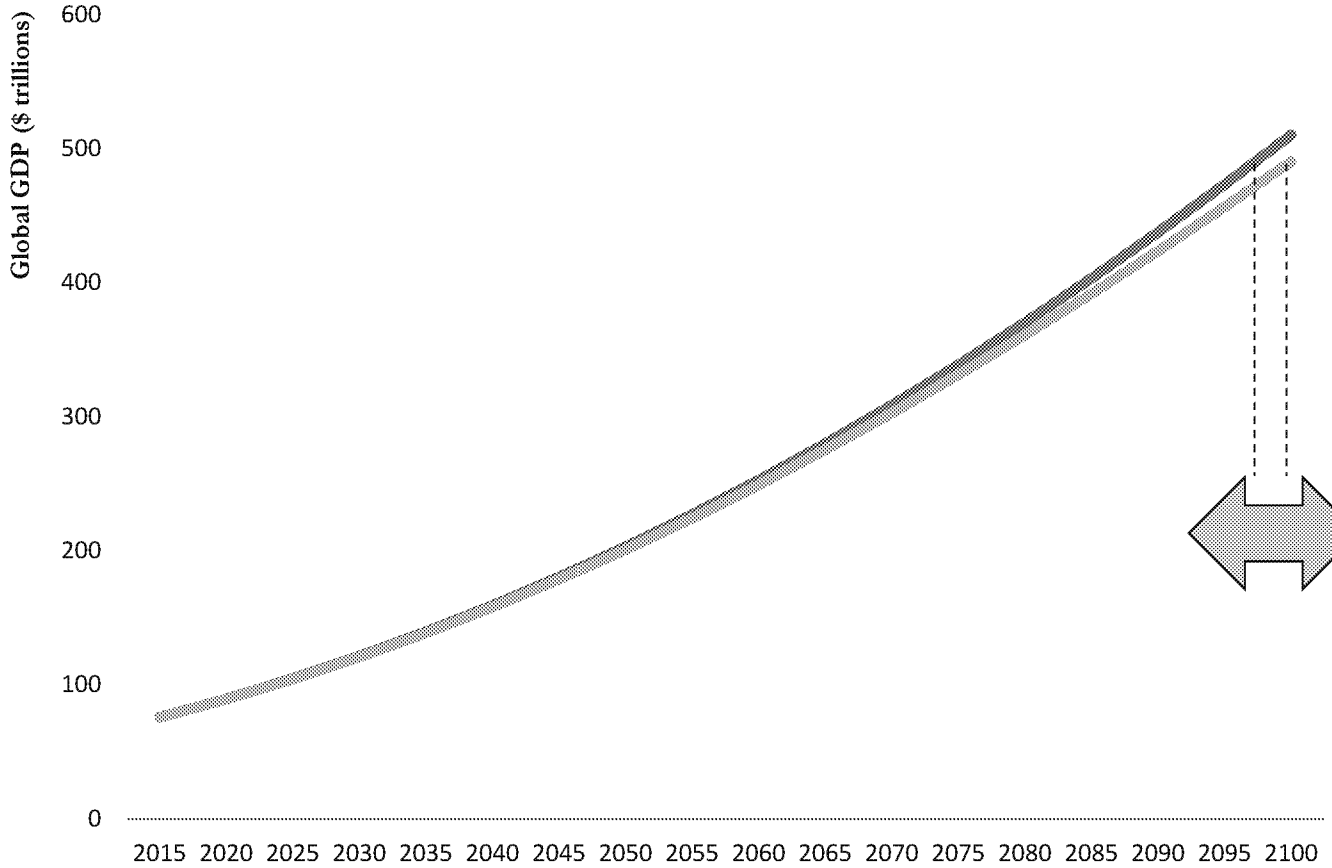
David Mills et al., "Climate Change Impacts on Extreme Temperature Mortality in Select Metropolitan Areas in the United States," *Climatic Change* 131, no. 1 (July 2015): 83-95.

Marshall Burke, Solomon Hsiang, and Edward Miguel, "Global Non-Linear Effect of Temperature on Economic Production," *Nature* 527 (Nov. 2015): 235-39.

Alan Barreca et al., "Adapting to Climate Change: The Remarkable Decline in the US Temperature-Mortality Relationship over the Twentieth Century," *Journal of Political Economy* 124, no. 1 (Feb. 2016): 105-59.

Solomon Hsiang et al., "Estimating Economic Damage from Climate Change in the United States," *Science* 356, no. 6345 (June 30, 2017): 1362-69.

The high-end cost estimate in Obama "Social Cost of Carbon" analysis amounts to slowing growth by ~2 years over a century

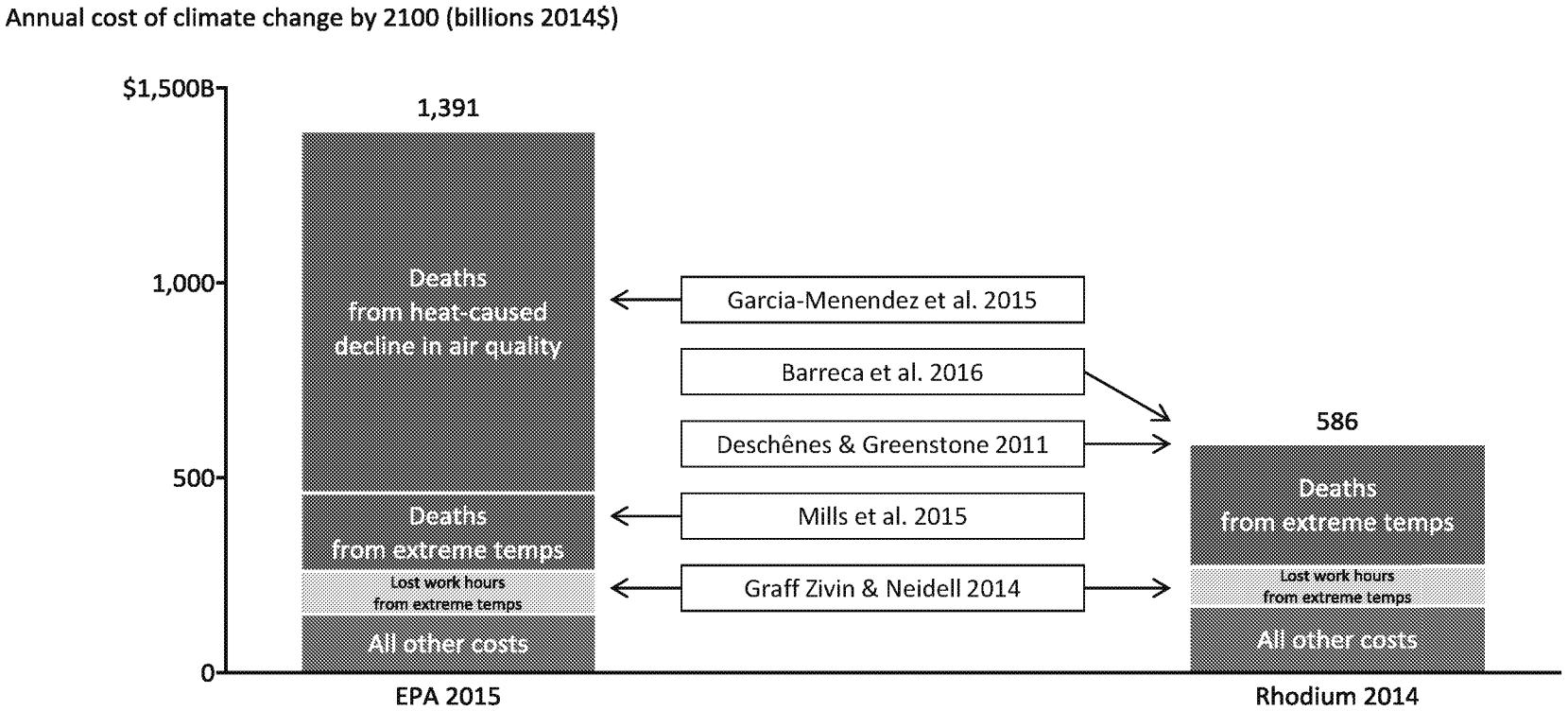


- $20 trillion annual cost by 2100, but…
- Postpones prosperity by less than five years
- World still 6.5X wealthier than 2015 (instead of 6.7X)
- Annualized growth rate shifts from 2.27% to 2.22% over the century

Source

William Nordhaus, DICE-2013 integrated assessment model.

84% of climate-change costs identified by recent GAO survey come from a group of five "temperature studies" cited in two synthesis reports



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U.S. Environmental Protection Agency, "Climate Change in the United States: Benefits of Global Action," June 2015.

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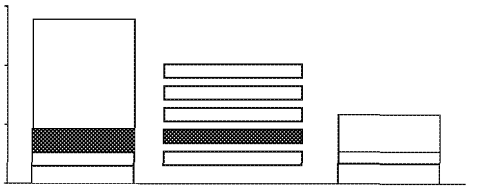
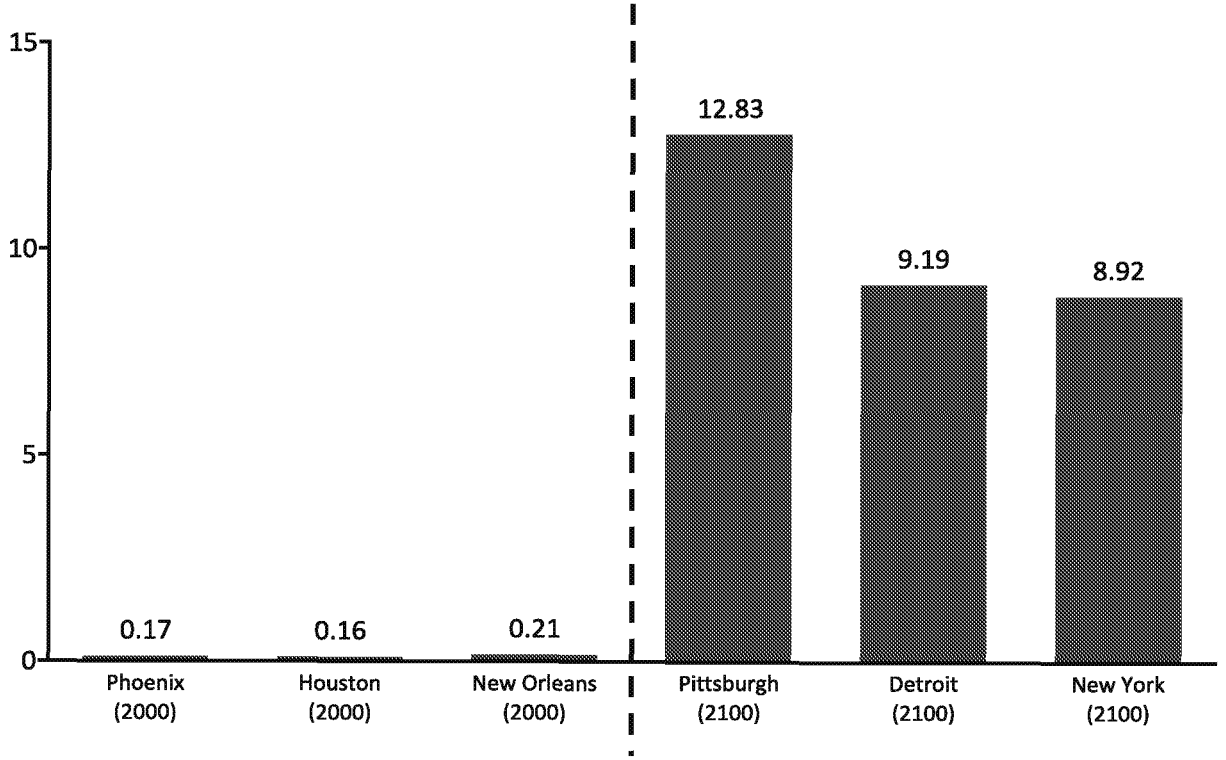
Heat-death estimates require absurd assumptions about failure to adapt to rising temperatures over time



Estimated net mortality from extremely hot and cold days
(deaths per 100,000 residents)



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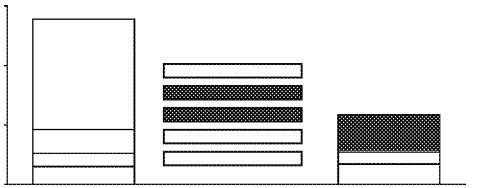
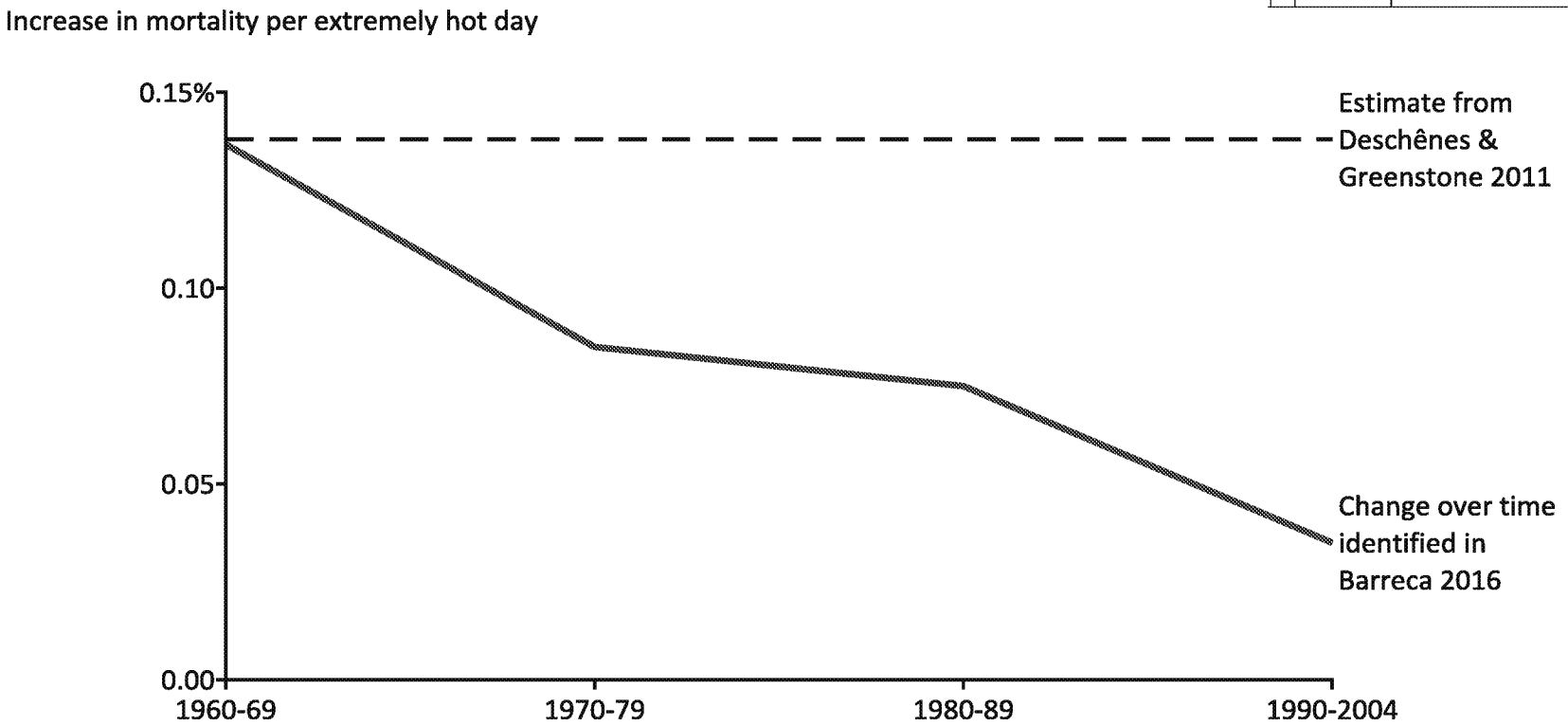
Rhodium cites two studies in support of its temp-deaths claim, but only uses the higher, no-adaptation estimate





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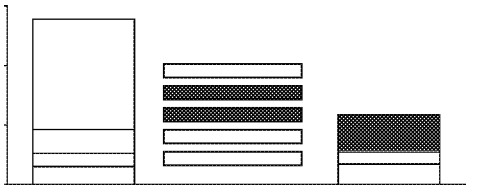
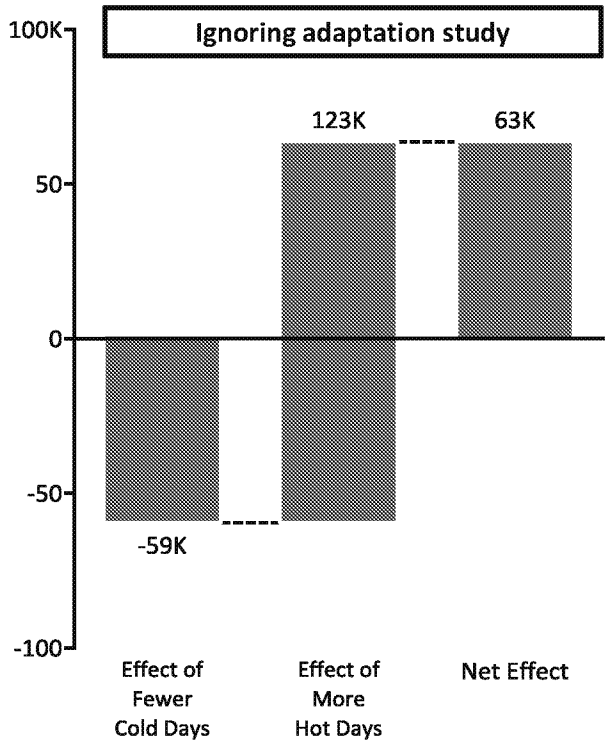
Just accounting for already-observed adaptation switches the net effect of extreme temp deaths to a reduction in mortality



Increase in annual deaths from extreme temperatures by 2100



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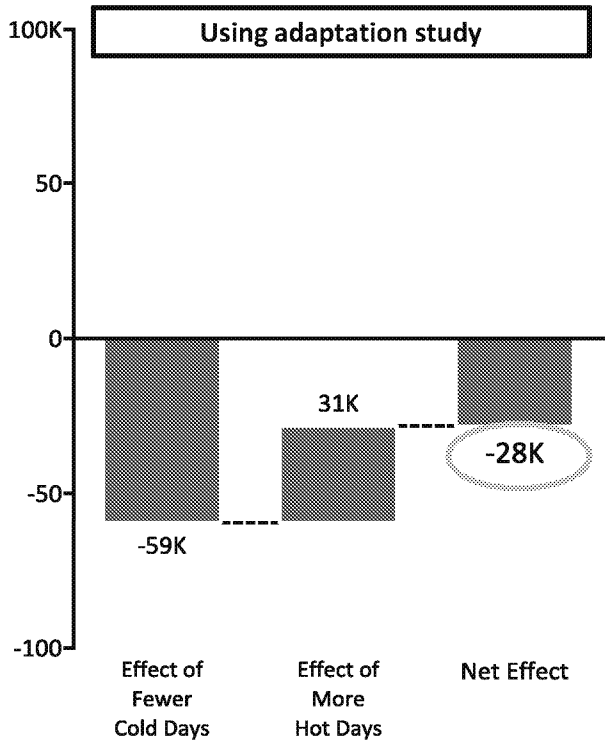

Accounting for air conditioning, climate change is estimated to save tens of thousands of lives annually, eliminating 2/3 of Rhodium cost estimate

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Robert Kopp, Solomon Hsiang, et al., "American Climate Prospectus: Economic Risks in the United States," Rhodium Group, Oct. 2014.

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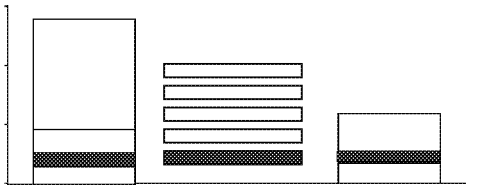
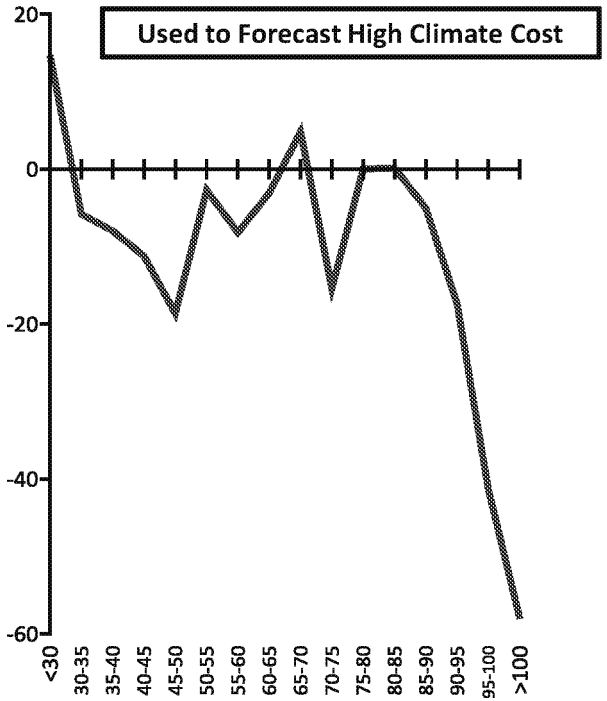
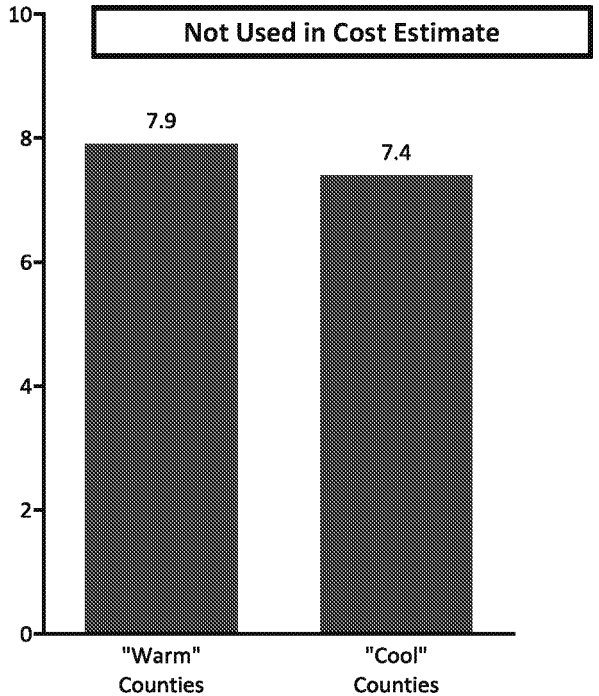
The study finding that higher temperatures reduce labor output also finds higher labor output in hotter states



Change in minutes worked by daily temp
(degrees Fahrenheit, high-risk industries)



Hous worked per day in July-August
(high-risk industries)



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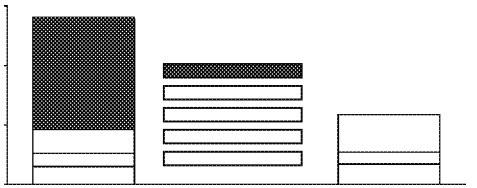
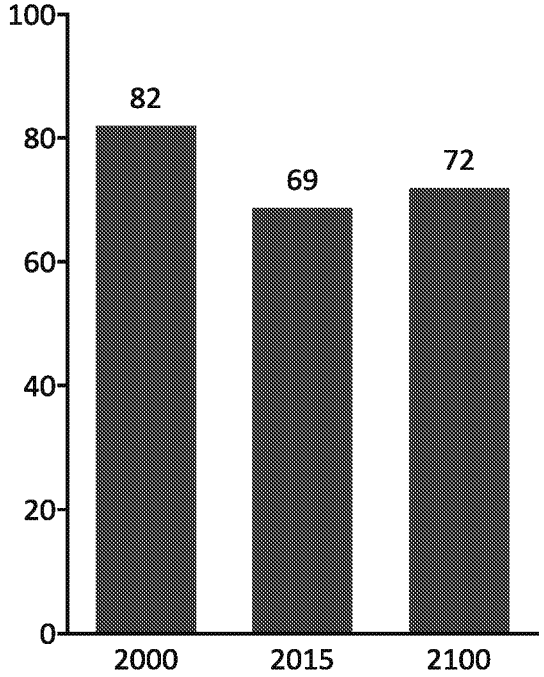
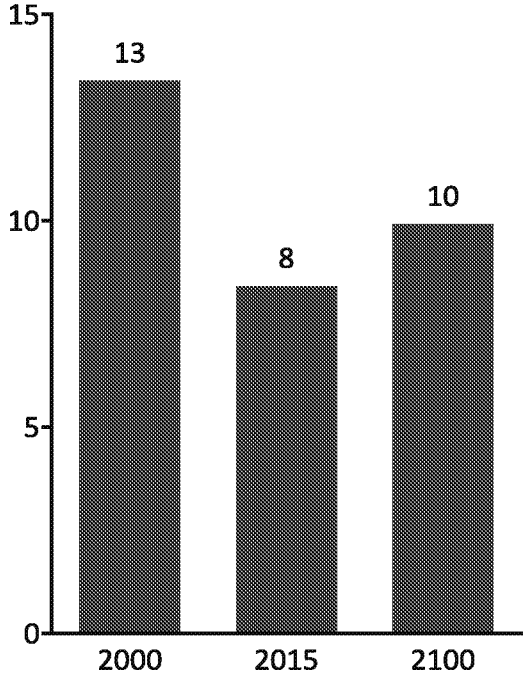
EPA analysis attributes 59,000 deaths and $930B of cost annually by 2100 to minute air-quality changes



Ozone, ppb
(ground-level 8-hr max)



PM2.5, micrograms per cubic meter



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Fernando Garcia-Menendez et al., "U.S. Air Quality and Health Benefits from Avoided Climate Change under Greenhouse Gas Mitigation," *Environmental Science & Technology* 49, (June 2015): 7580-33.

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Another study, based on Rhodium and published in *Science*, claims to provide county-level cost estimates

As the United States confronts global warming in the decades ahead, not all states will suffer equally. Maine may benefit from milder winters. Florida, by contrast, could face major losses, as deadly heat waves flare up in the summer and rising sea levels eat away at valuable coastal properties.

In a new study in the journal Science, researchers analyzed the economic harm that climate change could inflict on the United States in the coming century. They found that the impacts could prove highly unequal: states in the Northeast and West would fare relatively well, while parts of the Midwest and Southeast would be especially hard hit.

In all, the researchers estimate that the nation could face damages worth 0.7 percent of gross domestic product per year by the 2080s for every 1 degree Fahrenheit rise in global temperature. But that overall number obscures wide variations: The worst-hit counties — mainly in states that already have warm climates, like Arizona or Texas — could see losses worth 10 to 20 percent of G.D.P. or more if emissions continue to rise unchecked.

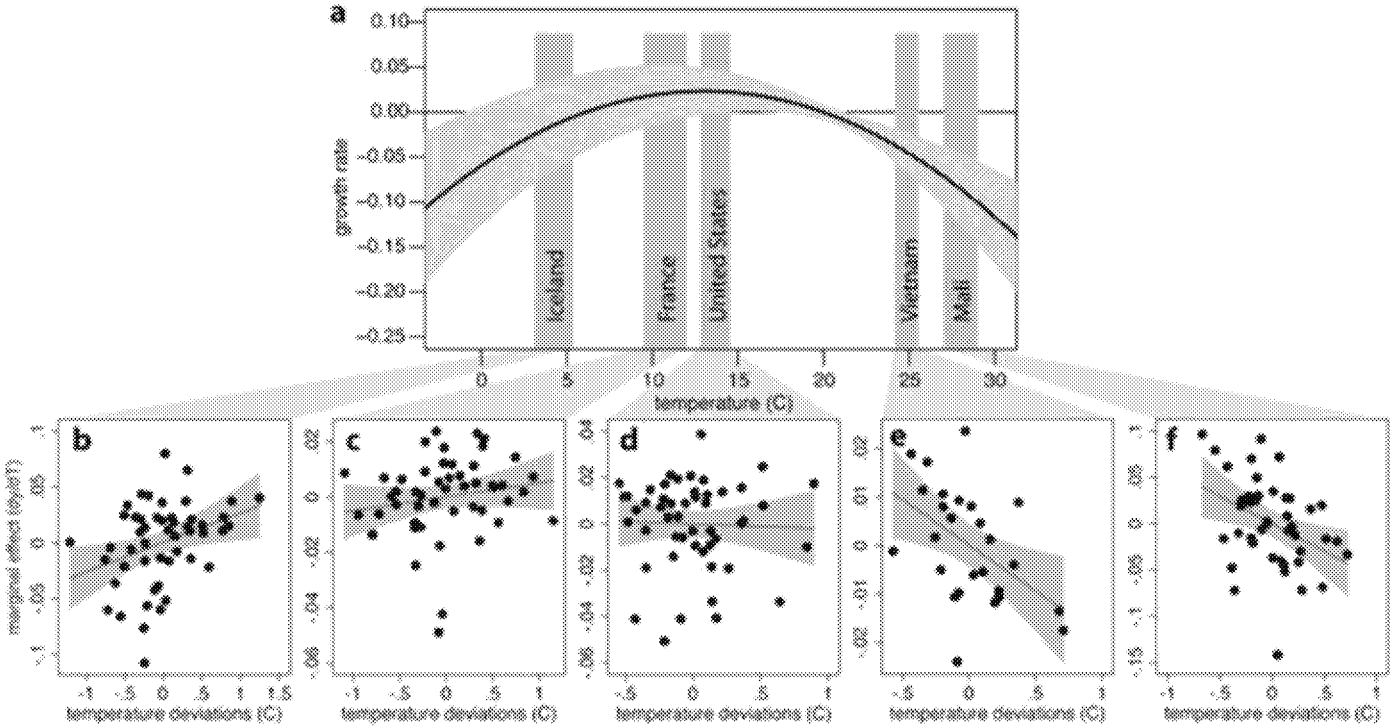
The map shows median estimates of economic damage per year in 2080 to 2099 under a high-emissions scenario (RCP8.5). Damage is calculated as a percentage of county G.D.P., factoring in agriculture, mortality, crime, labor productivity, coastal impacts and energy demand. Counties with negative damage (green) are projected to see economic benefits. In the chart, the ranges labeled "likely" refer to outcomes with a two-thirds chance of occurring.

Sources

Solomon Hsiang et al., "Estimating Economic Damage from Climate Change in the United States," *Science* 356, no. 6345 (June 30, 2017): 1362-69.

Brad Plumer and Nadja Popovich, "As Climate Changes, Southern States Will Suffer More Than Others," *New York Times* (interactive), June 29, 2017.

A different study, published in *Nature*, attempts to use annual changes in growth rates to identify climate's affect on growth

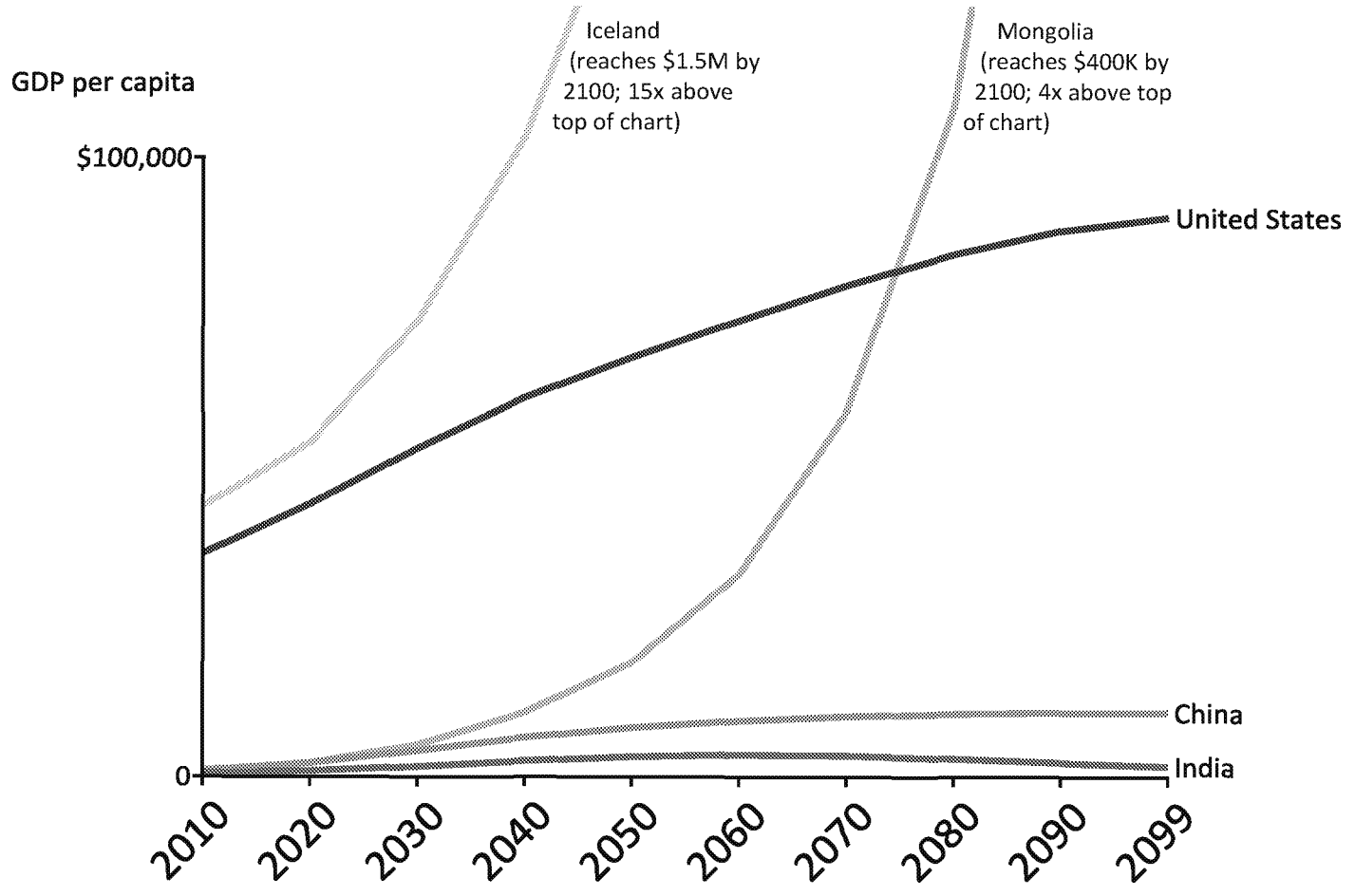


Washington Post: "Sweeping study claims that rising temperatures will sharply cut economic productivity"
Bloomberg: "Climate Change Slams Global Economy in a New Study From Stanford and Berkeley"

Source

Marshall Burke, Solomon Hsiang, and Edward Miguel, "Global Non-Linear Effect of Temperature on Economic Production," *Nature* 527 (Nov. 2015): 235-39.

The GDP growth study relies upon absurd projections for future economic growth based on a country's climate

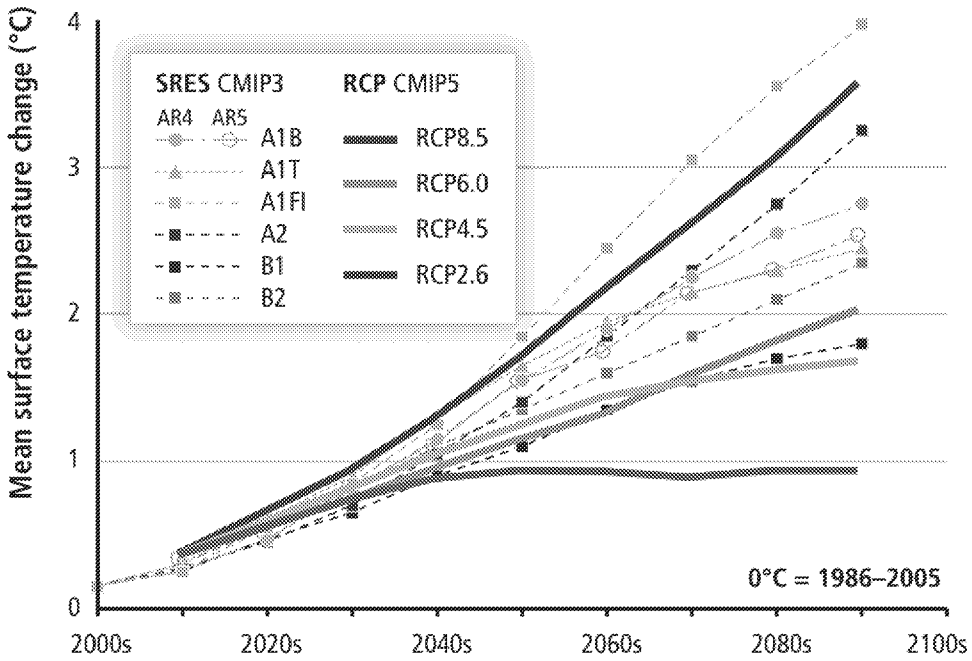


Source

Marshall Burke, Solomon Hsiang, and Edward Miguel, "Global Non-Linear Effect of Temperature on Economic Production," *Nature* 527 (Nov. 2015): 235-39.

Appendix: Baselines

IPCC Fifth Assessment Report, WG2 Fig 1-4



Justin Richie and Hadi Dowlatabadi, "Why Do Climate Change Scenarios Return to Coal?," *Energy* 140, no. 1 (December 2017): 1276-91.

"This paper finds climate change scenarios anticipate a transition toward coal because of systematic errors in fossil production outlooks based on total geologic assessments like the LBE model. Such blind spots have distorted uncertainty ranges for long-run primary energy since the 1970s and continue to influence the levels of future climate change selected for the SSP-RCP scenario framework. Accounting for this bias indicates RCP8.5 and other 'business-as-usual scenarios' consistent with high CO2 forcing from vast future coal combustion are exceptionally unlikely. Therefore, SSP5-RCP8.5 should not be a priority for future scientific research or a benchmark for policy studies."

Analyses still using RCP8.5: Third and Fourth National Climate Assessments, EPA CIRA, Climate Impact Lab, *New York Times* assessments of Paris, etc.

Notes

Pg 5: Midpoints shown where analyses provide both high and low estimates. Rhodium 2014 reports estimates in 2011$, updated here to 2014$ using BEA GDP deflator. GAO overview of Rhodium 2014 reports duplicative totals for "lost lifetime labor supply" and "storm losses," excluded here. EPA 2015 provides no 2100 estimate for power-systems savings; 2050 value used here. EPA estimate understates sea-level impact by comparing it to mitigation case in which sea levels still rise.

Pg 6: Estimates for both 2000 and 2100 use modeled forecasts of temperature.

Pg 7: Deschênes & Greenstone 2011 estimates increased mortality for all days with temperatures >80°F whereas Barreca 2016 estimates the impact of temperatures >90°F. However, Barreca's estimates for the effect of temperatures between 80-89°F are extremely low and the study reports that, "the impact of days with a mean temperature exceeding 80°F has declined by about 75 percent over the course of the twentieth century in the United States, with almost the entire decline occurring after 1960." The Deschênes & Greenstone 2011 estimate in terms of mortality per day is calculated as 5.8% increase in hot-day mortality divided by 42.3 additional days with temperature >90°F. The Barreca 2016 estimate is converted from data reported in its Figure 3 by dividing by 6 to annualize from the two-month window used in its analysis.

Pg 8: See prior note; change in "Effect of More Hot Days" results from changing the increase in mortality on such days from 5.81% to 1.48%.

Pg 9: The study only reports hours worked in warm versus cool states on an aggregate basis, including for individuals who were not working at all. Figures here are scaled up to work-hours per person working using the ratio reported for the overall population. "Warm" counties are the 1/3 of U.S. counties in the top third of the 1980-89 July-August temperature distribution; "Cool" counties represent the bottom 1/3 of the distribution.

Pg 10: The study uses population-weighted pollution concentrations whereas EPA data reports nationwide levels. Thus, the 2000 and 2015 data points show the nationwide concentrations reported by EPA, whereas the 2100 data points are calculated as the 2015 values plus the changes in population-weighted concentrations forecasted by the study.