Time of Emergence (ToE) Analysis for Extreme Temperature-Related Mortality

This study introduces the concept of Time of Emergence (ToE) to identify when climate-induced mortality exceeds natural variability, offering insights into the timing and severity of extreme-temperature impacts. It suggests that in warmer regions, climate change may counteract or reverse development-driven reductions in temperature-related mortality, highlighting the need for targeted adaptation and policy interventions to mitigate health risks.

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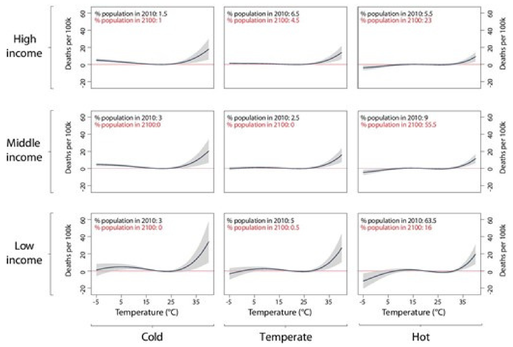
1 Introduction

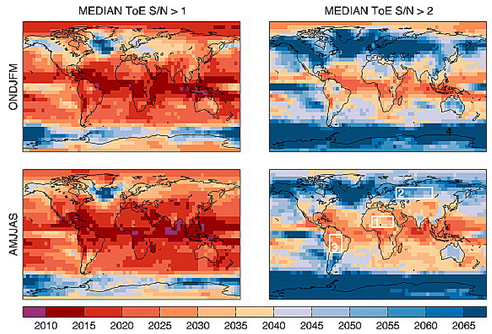
Global climate shifts and extreme events, intensified by long-term climate change, increasingly impact human health, particularly through rising extreme heat, leading to heat-related illnesses and mortality (IPCC, 2022). Empirical analyses highlight income and past climate experience as key factors in adapting to heat exposure, with low-income communities and countries—despite contributing less to climate change—bearing the brunt of these impacts (Carleton et al., 2022; Stuckler et al., 2009).



Heterogeneity in the Mortality-Temperature Relationship (Age > 64 Mortality Rate) Carleton, T. et al. (2022)

2 Time of Emergence (ToE)

Time of Emergence (ToE) in climate science identifies when climate change impacts surpass natural variability, helping to gauge their timing and scale. ToE marks the first year when the signal-to-noise ratio (S/N) exceeds a defined threshold, with natural climate variability as the primary source of noise (Hawkins & Sutton, 2012).



Median ToE for surface air temperatures for (top) Oct-Mar and (bottom) Apr-Sep. First year when temp. has expected (left) S/N > 1 and (right) S/N > 2 (Hawkins, E., & Sutton, R., 2012).

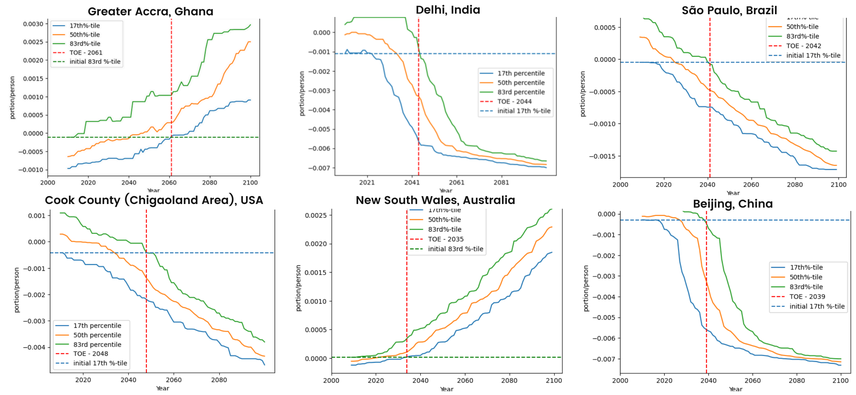
3 Methodology

- Use Carleton et al. (2022) future mortality impact projections and socioeconomic data:
  - Surface temperatures, climate adaptation, and income growth.
  - Mortality data from 40 countries, covering 38% of the global population.
  - Utilizes 21 high-resolution models from NASA Earth Exchange (NEX) combined with SSPs.
  - Focusing on CCSM4/SSP3/RCP8.5 combination in this analysis
  - Shows a U-shaped relationship between extreme temperatures and age.
  - Incorporates adaptation via income growth and mitigation strategies.
- Focus on Vulnerable Groups:
  - We emphasize mortality rates for individuals aged 64+, as they are more vulnerable to heat-related illnesses.
- Time of Emergence (ToE) Analysis:
  - Apply 20-year rolling percentiles to raw mortality data.
  - Identify ToE for mortality benefits or damages from extreme temperatures
  - **Threshold**: When the 17th percentile crosses the initial 83rd percentile (benefits) or vice versa (damages).
  - Find acceleration or delay of benefits relative to the histroical climate projection.

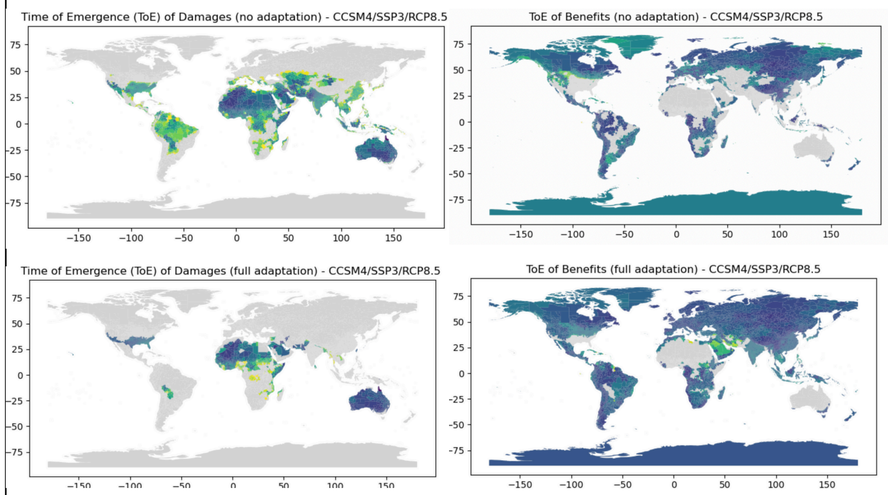
4 ToE Benefits and Damages for Extreme Temperature Mortality

These plots, based on Carleton et al. (2022) and Hawkins and Sutton (2012), project mortality trends under extreme temperatures through 2100. Using a 30-year rolling average, SSP3-RCP8.5, and CCSM4 simulations, they highlight Time of Emergence (ToE) across regions, marking critical points of benefit or harm. Regions with early ToE harm require immediate adaptation, while regions with later ToE may initially benefit but face rising risks without proactive measures. The interaction between climate impacts and economic pathways emphasizes the need for adaptive strategies to balance resilience and growth, as regions may experience both benefits and harms over time.

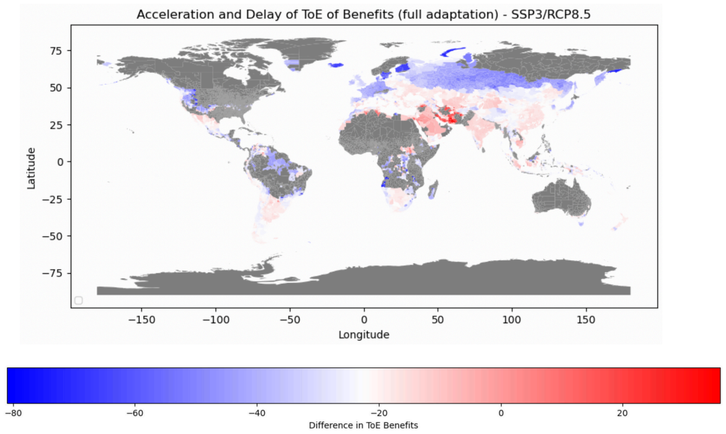
ToE of Human Mortality (64+) from Extreme Temperatures to 2100 under SSP3-RCP8.5-CCSM4



Global Maps of ToE for Extreme Temperature Mortality (64+) under SSP3-RCP8.5-CCSM4: Adaptation vs. No Adaptation



5 Acceleration and Delay of ToE of Benefits



6 Summary and Next Steps

- Time of Emergence (ToE) indicates when regions face benefits or harms from extreme temperatures, shown on global maps.
- Early ToE harm regions need immediate adaptation to reduce rising mortality risks.
- Later ToE regions initially benefit but require proactive measures to prevent escalating risks.
- Some regions may experience both benefits and harms simultaneously.

- Use Carleton et al.'s mortality dataset with 21 GCMs and 999 simulations.
- Account for Urban Heat Island (UHI) and wet bulb temperature effects.
- Translate findings into policy recommendations for targeted adaptation strategies.

Sources:

(1.) Dodman, D., et al. (2022). Cities, Settlements and Key Infrastructure. In H.-O. Pörtner, et al. (Eds.), Climate Change 2022: Impacts, Adaptation and Vulnerability (pp. 907–1040). Cambridge University Press. My apologies for the oversight. Here's the revised bibliography: (2.) Carleton, T. A., & Hsiang, S. M. (2016). Social and economic impacts of climate. *Science*, 353(6304), aad9837. doi:10.1126/science.aad9837 (3.) Stuckler, D., Basu, S., Suhrcke, M., Coutts, A., & McKee, M. (2009). The public health effect of economic crises and alternative policy responses in Europe: An empirical analysis. *The Lancet*, 374(9686), 315–323. doi:10.1016/S0140-6736(09)61124-7 (4.) Time of emergence of climate signals. (2012). *Geophysical Research Letters*, 39*(1). doi:10.1029/2011gl050087

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