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Climate damage projections beyond annual temperature

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Projections of economic damages from climate change are key for evaluating the benefits of climate mitigation and informing discussions around adaptation needs. So far, global and country-level top-down assessments of GDP damages have focused on annual mean temperature changes and annual precipitation. Recent backward-looking studies have identified further impacts of variability and extremes in precipitation and temperatures on income growth.

Here, we examine GDP impacts and uncertainties under different global warming levels by combining empirical dose-response functions for temperature variability, rainfall deviations, and extreme precipitation with climate projections of 33 CMIP6 models. The main contribution of this work is to understand the projected relative contributions of multiple climate variables under many possible future climates.

We find that at a +3°C global warming level, global average losses reach 10% of GDP, with worst effects (up to 17%) in poorer, low-latitude countries. Relative to annual temperature damages, which find to seemingly capture heat wave impacts, the additional GDP impacts of projecting variability and extremes are relatively small and dominated by inter-annual variability, especially in lower latitudes. However, accounting for variability and extremes when estimating the temperature dose-response function still raises global GDP losses by nearly 2%-pts and exacerbates tail risks for economic growth.

Our results call for region-specific risk assessments and complementary research into climatic extremes not considered here, including their indirect effects on temperature dose-response functions. Additionally, it will be very important to further the work on understanding historical and future persistence and adaptive capacities for these different impact channels.