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# Comprehensive assessment of hazard, exposure, and vulnerability using a new database of climate impact indicators to identify hotspots for adaptation needs

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In the 21st century, an increasing global population will be exposed to various risks caused by climate change. The impact depends not only on the geophysical climate change hazards, but also on the population's vulnerability, its spatial distribution, and its capacity to adapt. Here we present a new database of climate impact indicators at various global warming levels (1.2 - 3.5°C) using global climate and hydrological model data from the latest Coupled Model Intercomparison Project (CMIP6) and Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b) simulation rounds.

Indicators include a variety of temperature and precipitation extremes, heatwaves, drought intensity, hydrological variability, and water stress. Building on previous work (Byers et al. 2018), the first novel aspect of this work is the development of a bi-variate hazard index that includes statistics on the absolute hazard level (e.g. low or high precipitation) and the relative change under global warming compared to the historical baseline (e.g. a large change from low to high precipitation).

We combine this new index with gridded projections of population from the Shared Socioeconomic Pathways (SSPs) and land area to calculate temporal and spatial exposure. Finally, to allow for risk assessment, we introduce the layer of vulnerability measured through various socio-economic indicators, such as income, inequality, or the Notre-Dame Global Adaptation Index (ND-GAIN).

In aggregate, we find that impacts manifest substantially even in the near-term at lower global warming levels. For example, even at 1.5°C 93% of the population of South Asia will face a medium exposure to heatwave events. Countries predominantly in the low latitudes and global south are comparatively more severely affected by multiple climate impacts. The window for reducing the risk burden is rapidly closing while there is substantial unavoidable risk even at 1.5C, thus adaptation actions will be key. By analysing impact and vulnerability hotspots, our work can help identify these adaptation needs, i.e. for financial assessments or loss and damage, down to high spatial resolution but also at the country level. With further categorisation, we can assess populations at the highest risk, such as those with high impacts, high vulnerability and lowest institutional governance capacities.