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Economic ripple resonance from consecutive weather extremes amplifies consumption losses

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Weather extremes such as heat waves, tropical cyclones, and river floods are likely to intensify with increasing global mean temperature. In a globally connected supply and trade network such extreme weather events cause economic shocks that may interfere with each other potentially amplifying their overall economic impact.

Here we analyze the economic resonance of consecutive extreme events, that is the overlapping of economic response dynamics of more than one extreme event category both spatially and temporally. In our analysis we focus on the event categories heat stress, river floods, and tropical cyclones. We simulate, via an agent-based anomaly model with more than 7,000 economic agents and 1.8 million connections, the regional (direct) and inter-regional (indirect via supply chains) economic losses and gains for each extreme event category individually as well as for their concurrent occurrence for the next two decades (2020-2039). Thus we compare the outcome of the sum of the three single simulations to the outcome of the concurrent simulation. We show that the global welfare losses due to concurrent weather extremes are increased by more than 18% due to market effects compared to the summation of the losses of each single event category. Overall, this economic resonance yields a non-linearly enhanced price effect, which leads to a stronger economic impact. As well as a highly heterogeneous distribution of the amplification of regional welfare losses among countries.

Our analysis is based on the climate models of the CMIP5 ensemble which have been bias-corrected within the ISIMIP2b project towards an observation-based data set using a trend-preserving method. From these we use RCP2.6 and 6.0 for future climate projections. Thus we compute for each of the three extreme weather event category regional, and sectoral production failure on a daily time scale. Our agent-based dynamic economic loss-propagation model *Acclimate* then uses these local production failures to compute the immediate response dynamics within the global supply chain as well as the subsequent trade adjustments. The Acclimate model thereby depicts a highly interconnected network of firms and consumers, which maximize their profits by choosing the optimal production level and corresponding upstream demand as well as the optimal distribution of this demand among its suppliers; transport and storage inventories act

as buffers for supply shocks. The model accounts for local price changes; supply and demand mismatches are resolved explicitly over time.

Our results suggest that economic impacts of weather extremes are larger than can be derived from conventional single event analysis. Consequently the societal cost of climate change are likely to be underestimated in studies focusing on single extreme categories.