POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Single vs. consecutive extreme events:

Economic resonance of weather extremes increases impact on societal welfare loss

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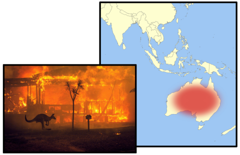
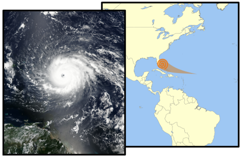
Weather extreme events and economic impact

- Increase in intensity and frequency of local weather extremes
  - heat waves (Australia 2012/13: 0.33 to 0.47 % GDP loss)
  - river floods (Europe 2002: USD 18 bn property loss)
  - tropical cyclones (Hurricane Irma 2017 in USA: USD 50 bn property loss)





IPCC (2013). ; Zander (2015). ; Helmer (2006). ; NOAA-1; Econews-1; S. Malsch; NASA-1

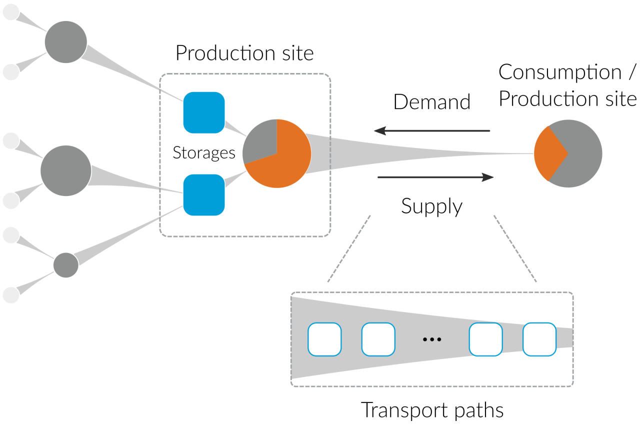
Research on consecutive events

- Overlap of impacts of two or more disasters
- Independent & dependet consecutive events
- Spatial dynamics
  - Spatial overlap of different hazard types
  - Mostly local-scale case studies
- Temporal dynamics
  - Second disaster in the aftermath of first extreme event
  - Rarely studied: crucial time resolution, state of rebuilding
  - Increase vs. decrease of damage
- Our approach of consecutive events
  - Independent disasters
  - Spatial dynamics: overlay of two or three regional extreme events
  - Temporal dynamics: overlay of regional aftermath due to different (local or non-local) disasters

deRuiter et al. (2020).

Loss-propagation model Acclimate

- Complex network of heterogeneous economic agents:
  - Firms and regional consumer
- Decision rationale:
  - Demand driven economy
  - High temporal resolution
  - Explicit modeling of inventories
  - Transport delays for commodity supply
  - Recursive dynamic modeling
  - Myopic, locally optimizing agents



Otto (2017).

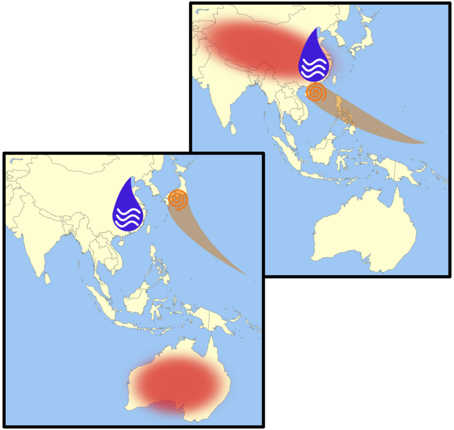
Simulation setup

- Economic setup:
  - Baseline: EORA MRIO table 2012
  - Regions: 184 countries + dissagregated USA (51 states) and China (32 provinces)
  - 26 economic sector + final demand sector (consumer)
  - Resulting $7,236$ economic agents
- Time range: 2000-2039
- Physical direct production reduction driver
  - Heat stress
  - River floods
  - Tropical cyclones
- Daily calculation of direct production losses, local optimization, demand shift for each firm

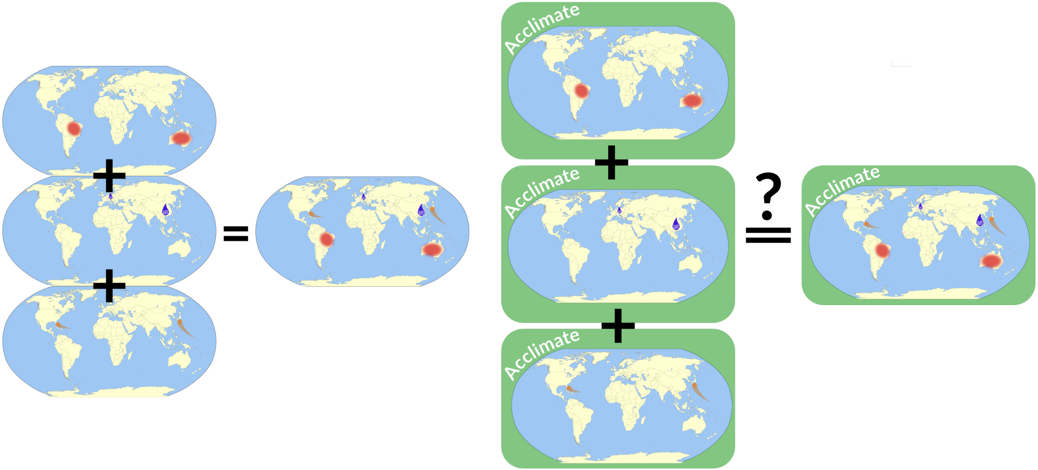
Hsiang (2010). ; Taylor (2012). ; Frieler´ (2017). ; Willner et al. (2018).

Simulation setup: consecutive extreme events scenario

- Independent natural disasters
- Overlap of time series of damage function of heat stress, river floods, tropical cyclones
- Spatial and/or temporal consecutive disaster
- $D_{\mathrm{total}}(r, s, t) = D_{\mathrm{HS}}(r, s, t) + D_{\mathrm{RF}}(r, s, t) + D_{\mathrm{TC}}(r, s, t)$

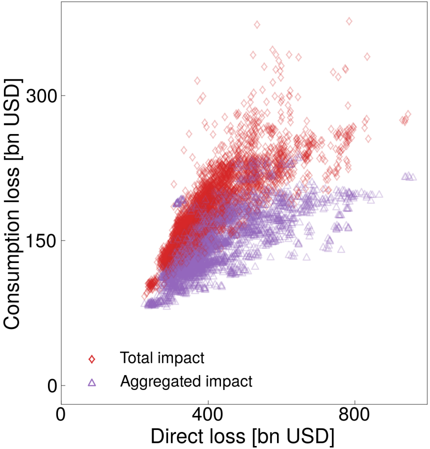


Direct losses vs. indirect effects



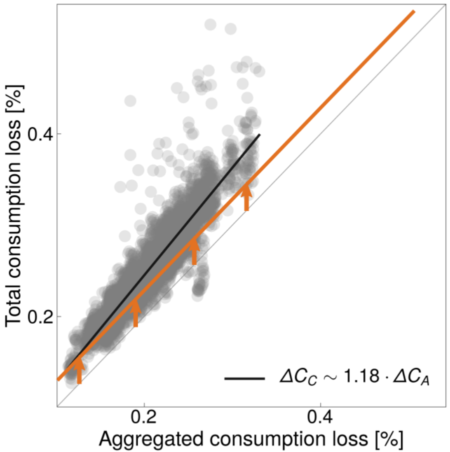
Results: worldwide losses per year

- Annual global consumption loss vs. annual global direct production loss
- Equal direct loss
- Increase of consumption losses for consecutive disaster scenarios



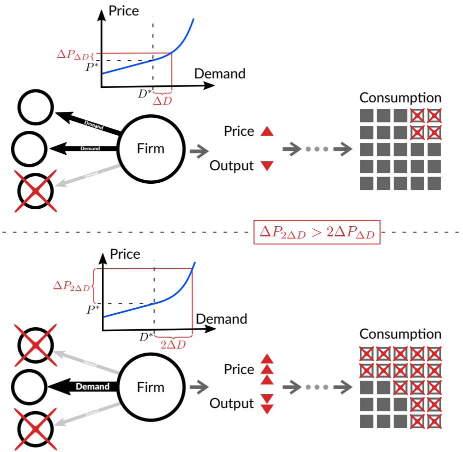
Results: global consumption losses

- Annual total global consumption losses vs. annual aggregated global consumption losses
- Consumption loss offset
- Increasing aggregated loss: amplified total consumption loss increase
  $\Rightarrow$ Loss amplification $= 18\%$



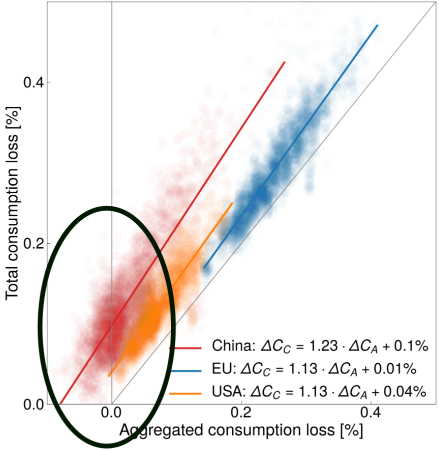
Explanation: nonlinear price response

- Single supplier outage
  - Increased demand among non-disturbed suppliers due to supplier
  - Higher prices & less output $\rightarrow$ consumption loss
- Overlapping supploer outage
  - Double rise in demand
  - Non-linear (> twofold) increase in production price
  - At the end of supply chain: Less goods/services for significantly higher prices for consumer
    $\Rightarrow$ Collapse in consumption



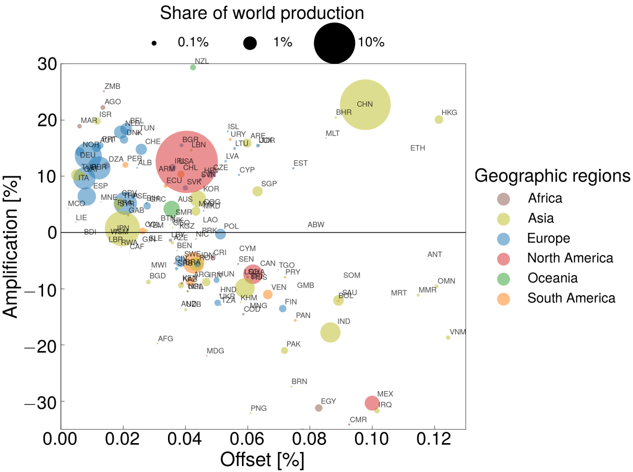
Results: regional amplification & offset I

- Regional amplification rates
  - $A(\text{USA}) = A(\text{EU})$ even if $D(\text{USA}) \approx 4D(\text{EU})$
- China:
  - $A(\text{CHN}) = 23\%$
  - Aggregated Events: consumption gain possible
  - Change from consumption gain to consumption loss $\Rightarrow$ Qualitative response shift
  - Non-zero total consumption loss for vanishing aggregated consumption loss



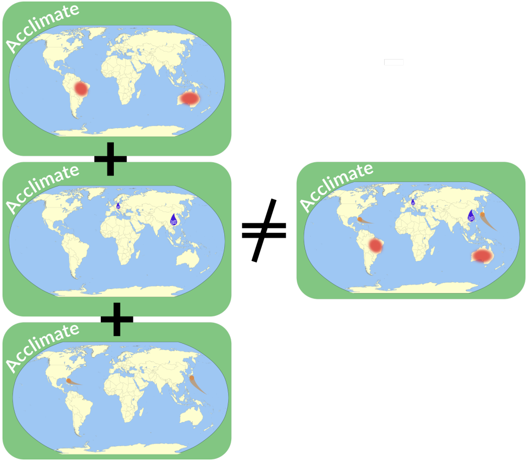
Results: regional amplification & offset II

- Negative amplification (≙ Mitigation)
  - Biggest Economies: Brazil, Canada, Russia, Sweden, India, Mexico
- 79% of world production: positive amplification



Take-home messages

- Increase of global consumption losses for consecutive disaster scenarios ⇒ loss offset
- Loss amplification globally and regionally
- Regional response shift possible
- Consecutive disasters: significant impact on welfare loss and risk analysis



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NOAA-1 https://www.nhc.noaa.gov/news/UpdatedCostliest.pdf

Econews-1 http://econews.com.au/37395/climate-council-says-its-been-an-angry-summer/

NASA-1 https://go.nasa.gov/2ylxIL6