POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Deriving empirically based damage functions for integrated assessment models

Tobias Geiger and Katja Frieler

Potsdam Institute for Climate Impacts Research

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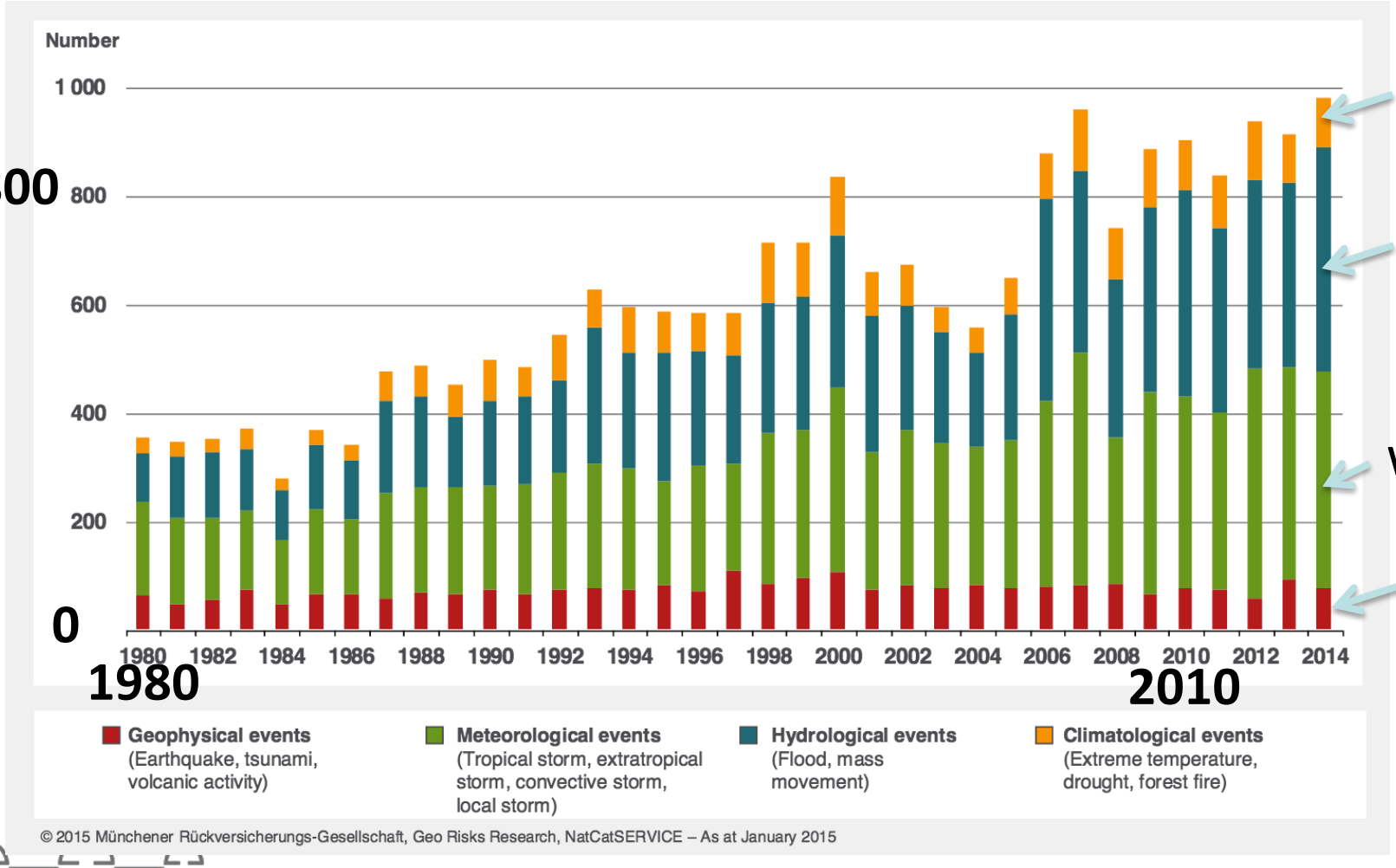
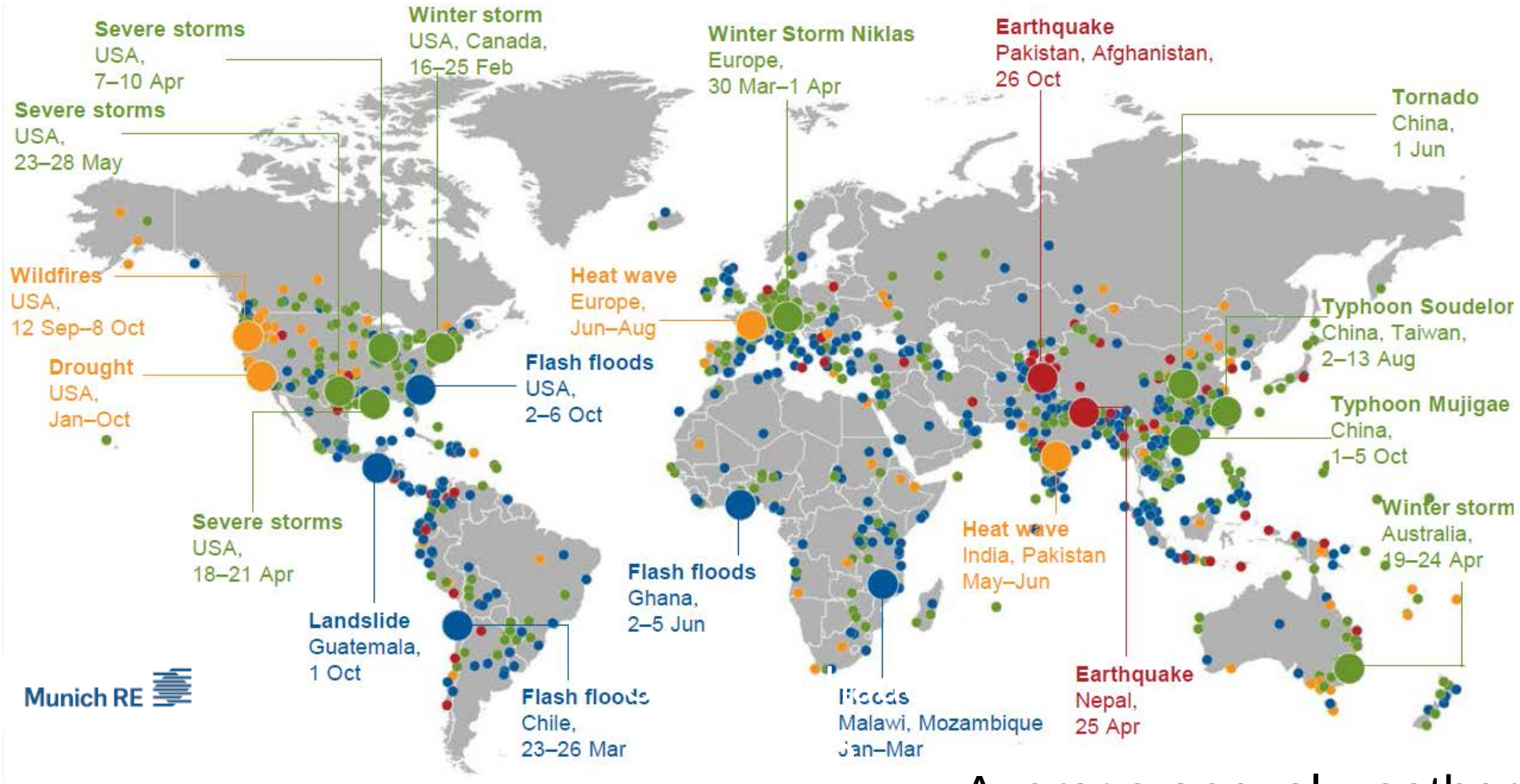
Leibniz Gemeinschaft

Extreme events are rising



Munich Re (2015)

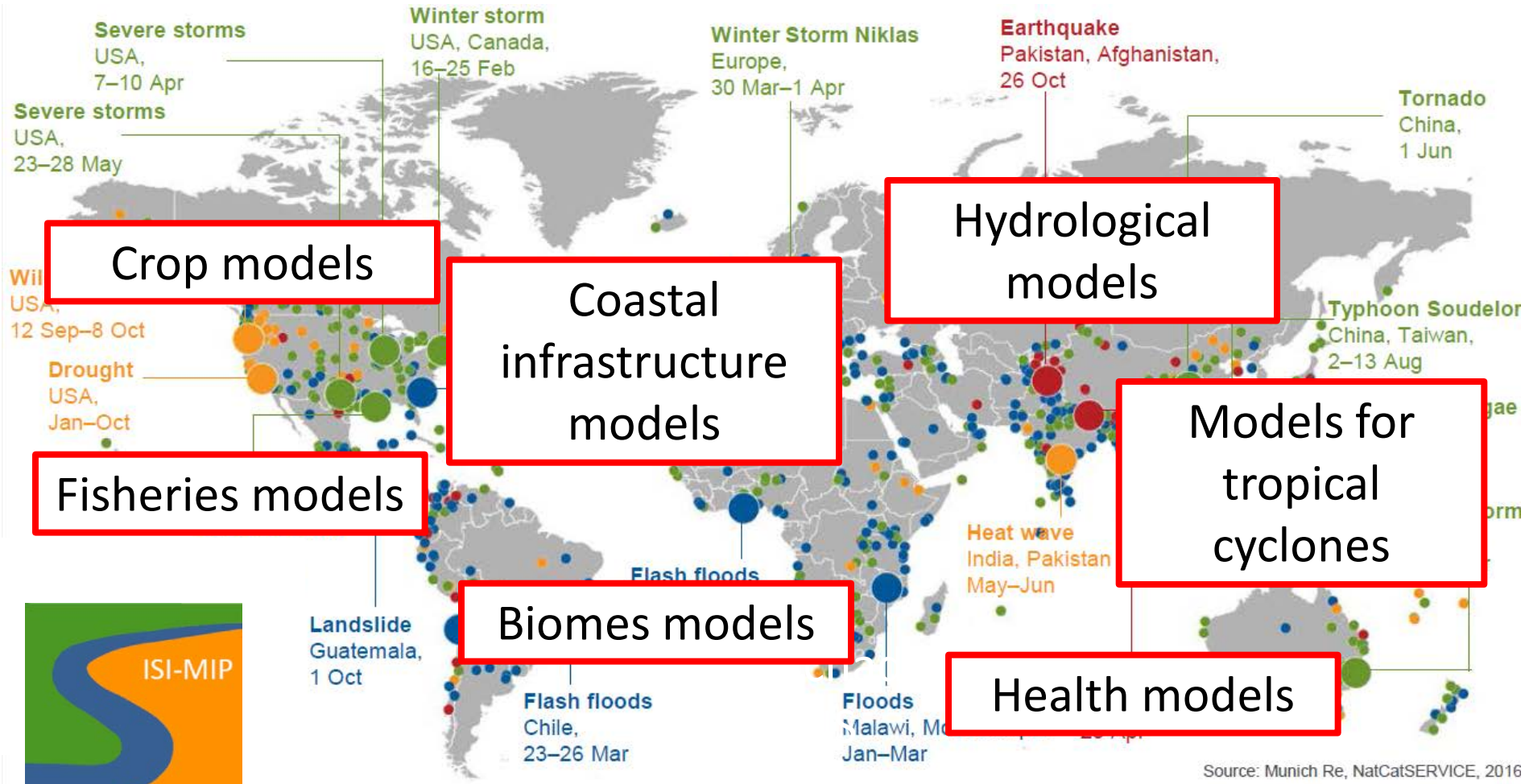
Natural disasters 2015



- **Geophysical events** (Earthquake, tsunami, volcanic activity)
- **Hydrological events** (Flood, mass movement)
- **Meteorological events** (Tropical storm, extratropical storm, convective storm, local storm)
- **Climatological events** (Extreme temperature, drought, wildfire)

Average annual weather losses 100 billion $US

Extreme events in a 2°C-world?

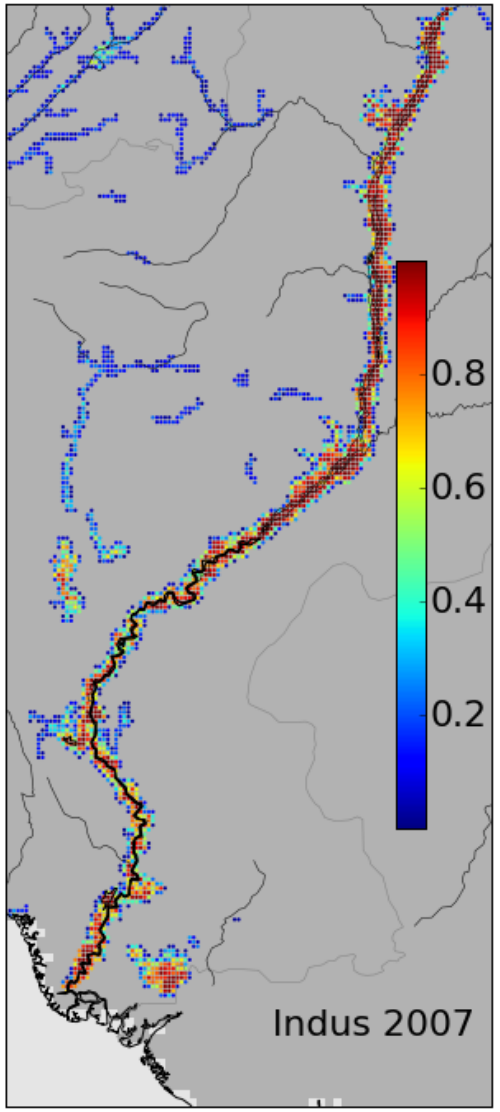


ISI-MIP

PIK

Global river flood modeling

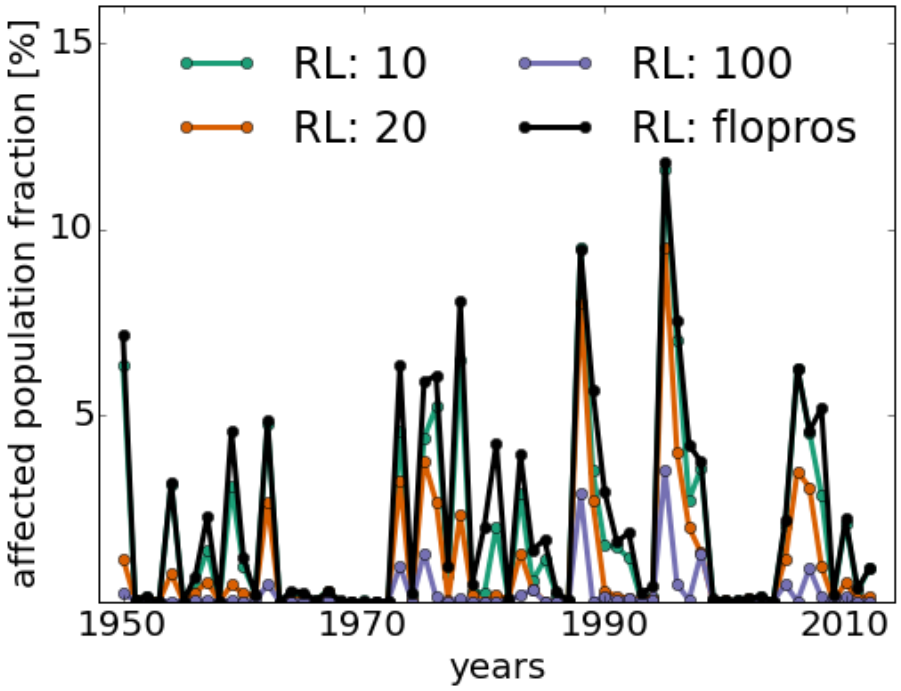
- **Daily Run-off simulation by 10 models from ISI-MIP**
  - **1970-2012 driven by observed weather**
  - **present-2100 driven by 5 GCMs, all RCPs**
- **Floodplain flow scheme -> CaMaFlood [1]**
  - **Gridded flood protection FLOPROS [2]**
  - **Inundation areas & depth @ 0.01˚ resolutio**
- **Validation in progress!**



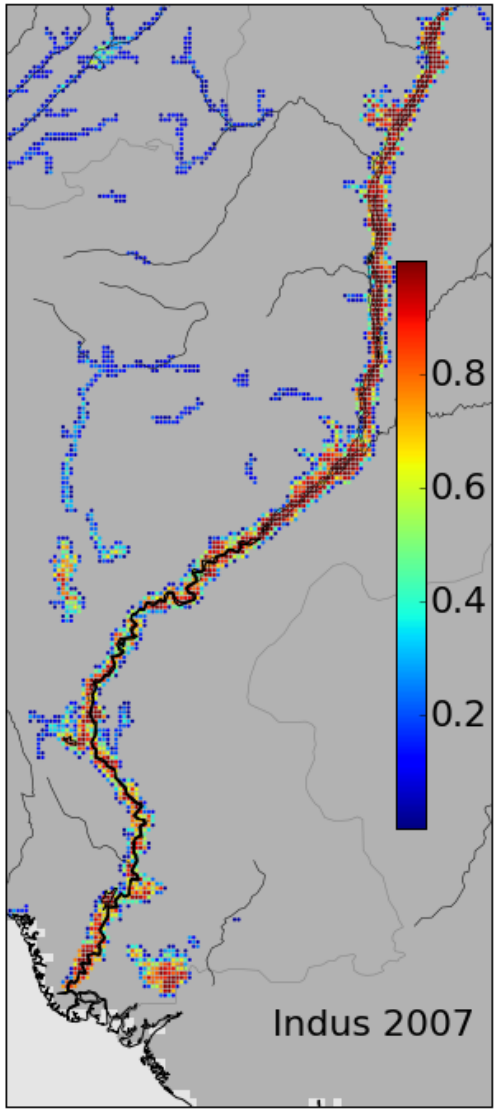
[1] D. Yamazaki et al. (2011), [2] P. Scussolini et al.,(2016)

Global river flood impacts

- **Exposed people (e.g. Pakistan)**



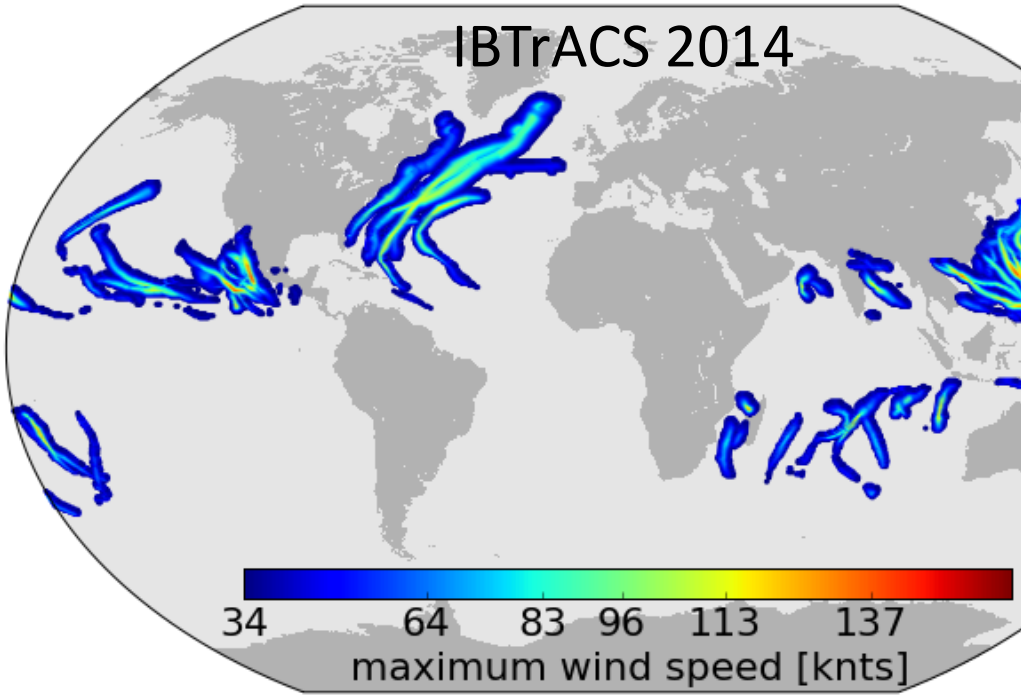
- **Stock losses**
  - **Damage functions by Juan Carlos [1]**



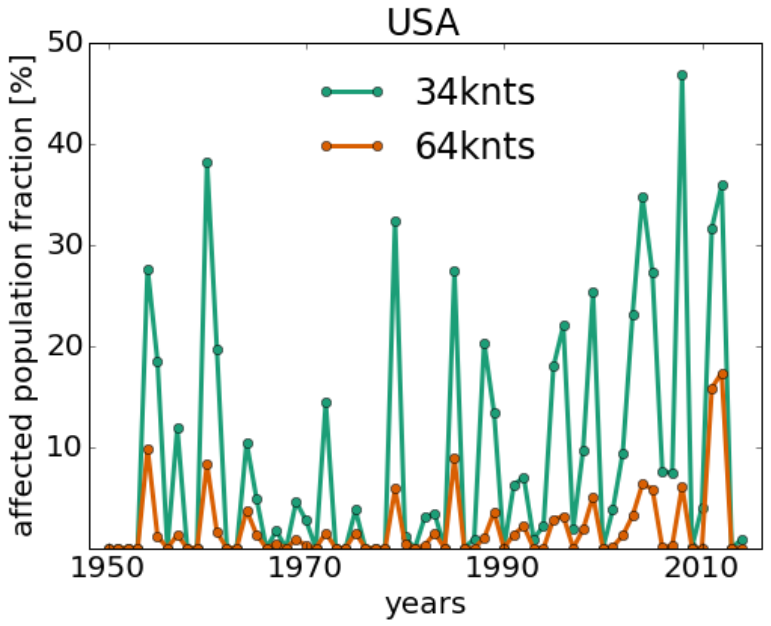
[1] J. Carlos et al. (submitted 2016)

Global tropical cyclone impacts

- **Global best track archive IBTrACS**
- **540k cyclone tracks from dynamical downscaling [1]**
  - **6 GCMs: 1950-2005 & 2006-2100 (RCP 8.5)**
- **TC extension via wind field model [2]**



Exposed people: USA



[1] K. Emanuel (2013), [2] G. Holland (2008)

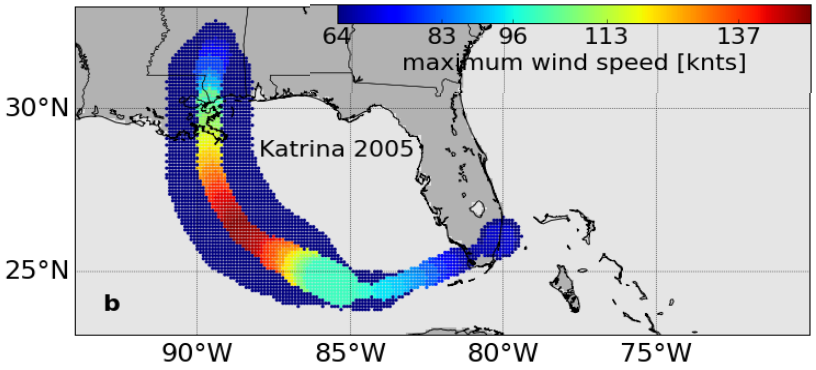
Tropical cyclone impacts for USA

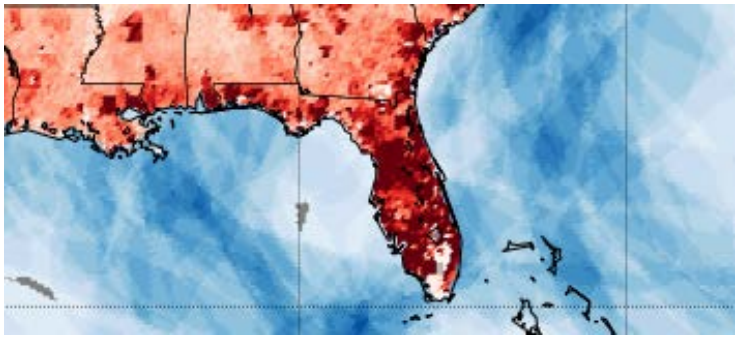
$$Loss = \alpha \times f_1(Hazard) \times f_2(Socio - Econ.)$$

Empirical losses
e.g. Munich Re

Wind-speed /
Storm size

GDP per capita /
Population





Different socio-economic scaling of losses

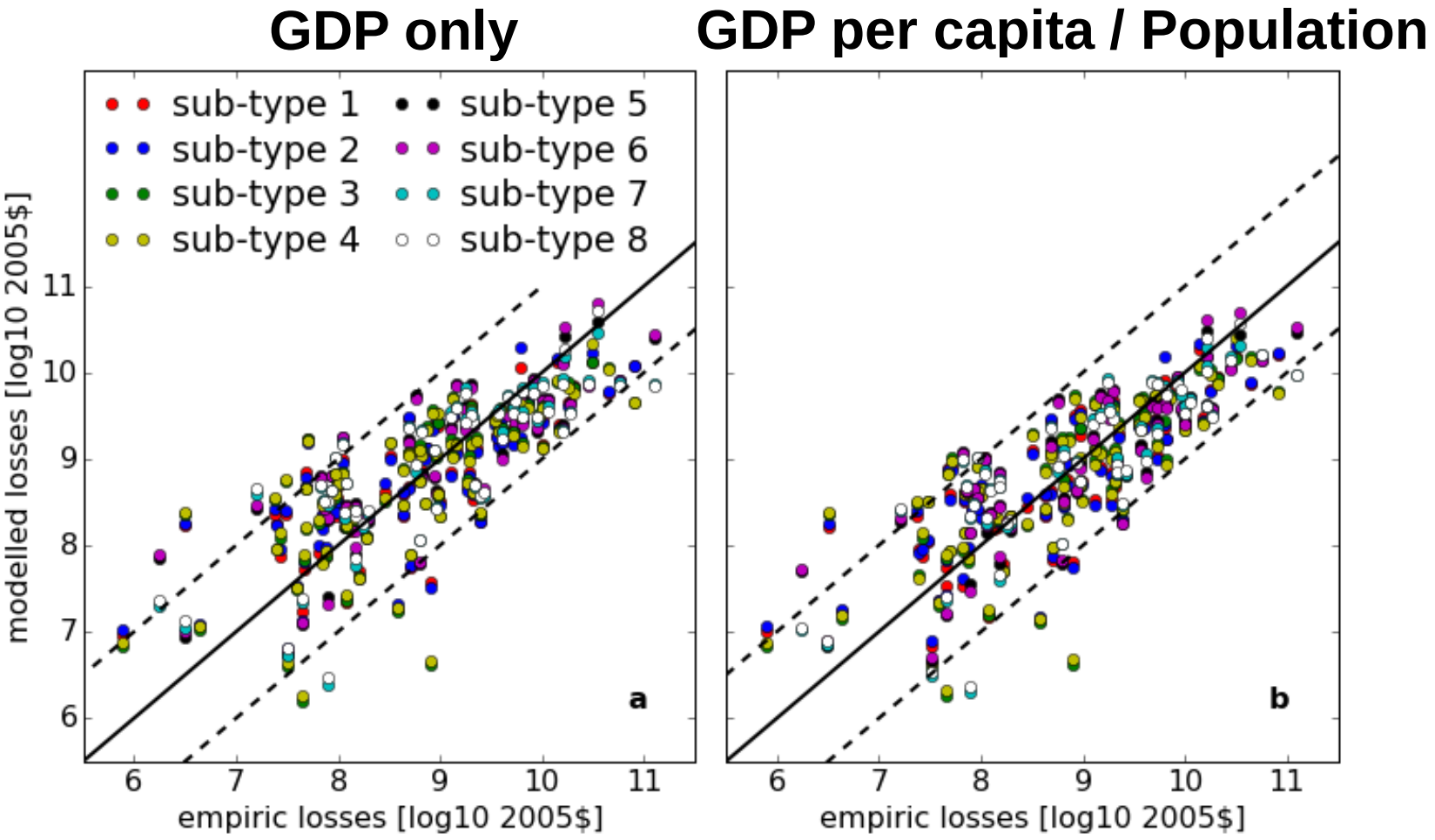
$$Loss \propto GDP^{\beta_{GDP}} \times f_1(v_{wind})$$

	8 model-mean	8 model-median	8 model-range	
β_{GDP}	0.50	0.57	0.20 - 0.67	< 1
β_{GDPpc}	2.29	2.26	1.48 - 3.13	> 1
β_{Pop}	0.41	0.47	0.12 - 0.59	< 1

$$Loss \propto GDPpc^{\beta_{GDPpc}} \times Pop^{\beta_{Pop}} \times f_1(v_{wind})$$

T. Geiger et al. (in review, 2016)

Skill of damage function ensemble

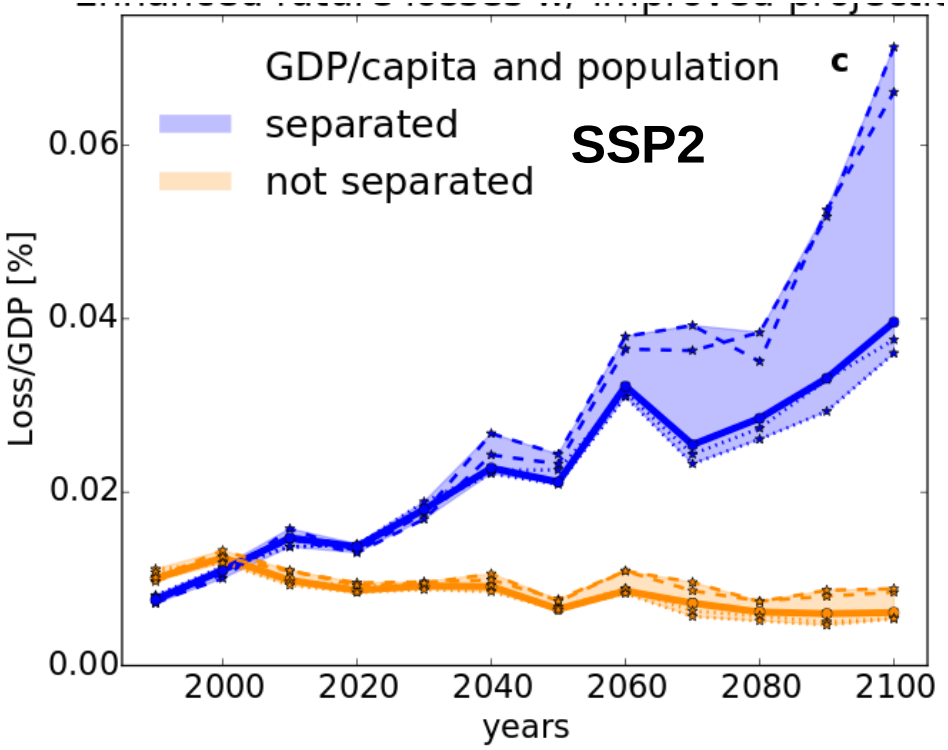


T. Geiger et al. (in review, 2016)

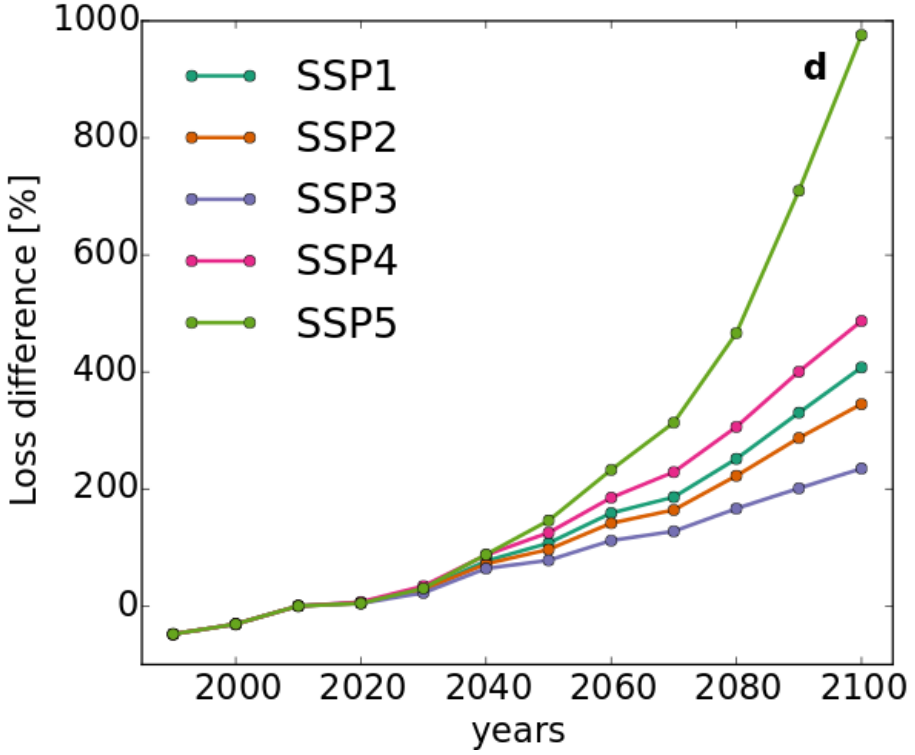
Projecting future losses for USA

- **Simulated TC tracks (Emanuel, 2013)**
- **Socio-economic vulnerability becomes strongest loss driver!**

Loss/storm as median over 8 models & 6 GCMs



Loss difference for different development scenarios



T. Geiger et al. (in review, 2016)

From impacts to economic models

We have

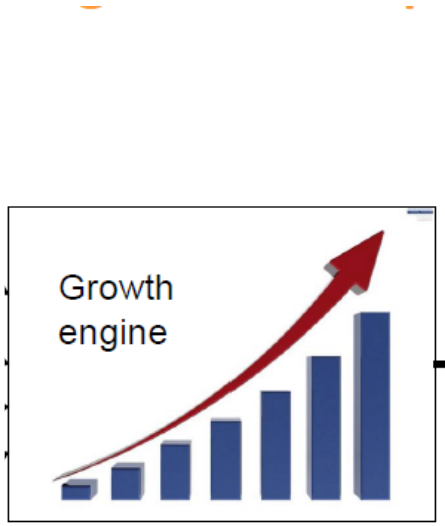
climate change impacts:

- **Exposed population**
- **Stock damage**

spatio-temporal aggregation

We have

economic growth models:



Climate damage

α

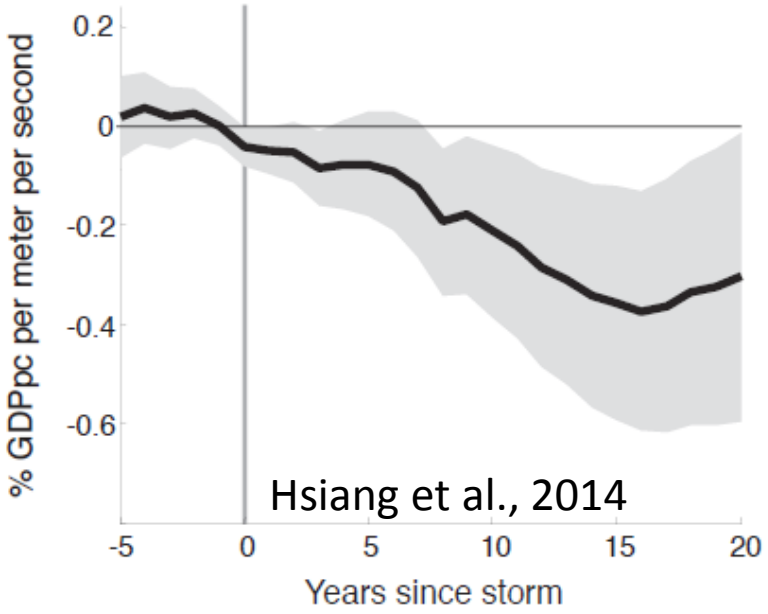
Output (Y)
(food, consumption, health)

(1-α)Y

How will the output then change?

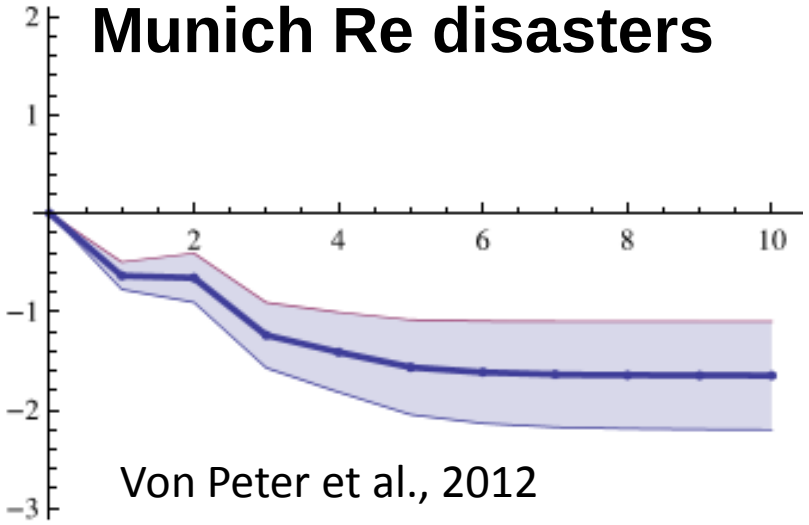
Extreme impacts have long-term effects

Growth impact of TCs



Hsiang et al., 2014

Growth impact of all Munich Re disasters



Von Peter et al., 2012

Effect depends on disaster type, resolution, and methodology

See also Felbermayer et al (2013), Strobl (2008), and others

Long term growth effects across impacts

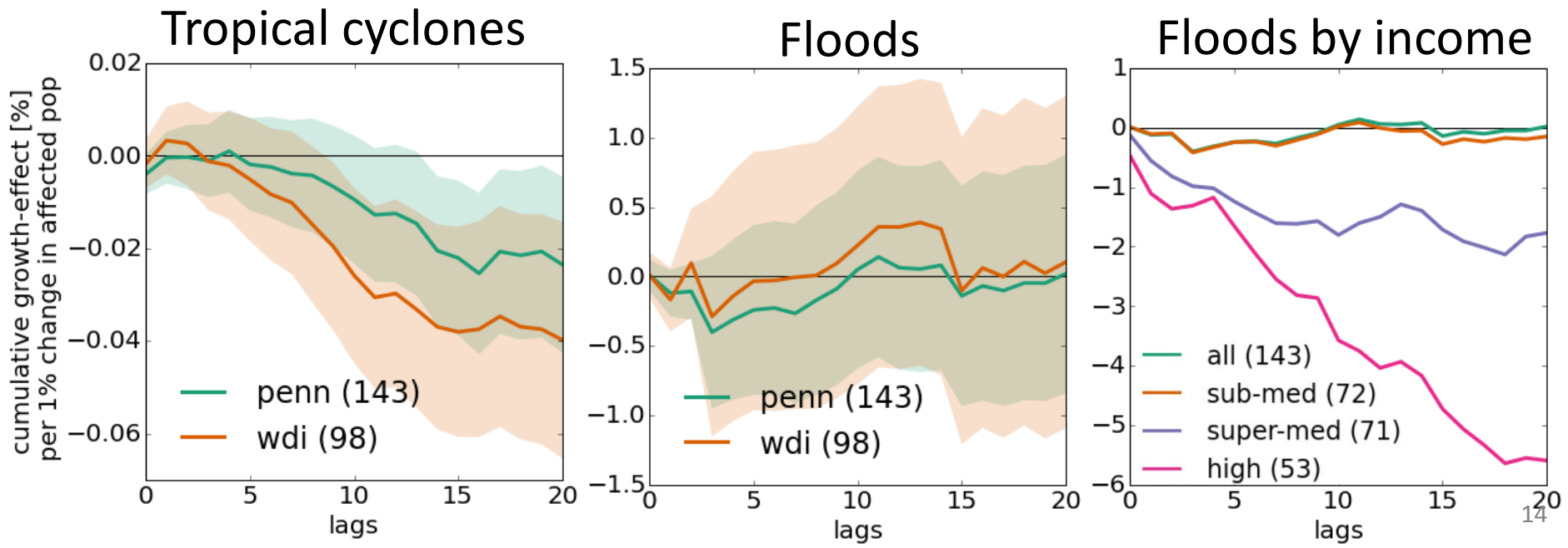
- **Unified predictor across impacts: Exposed population**

lags

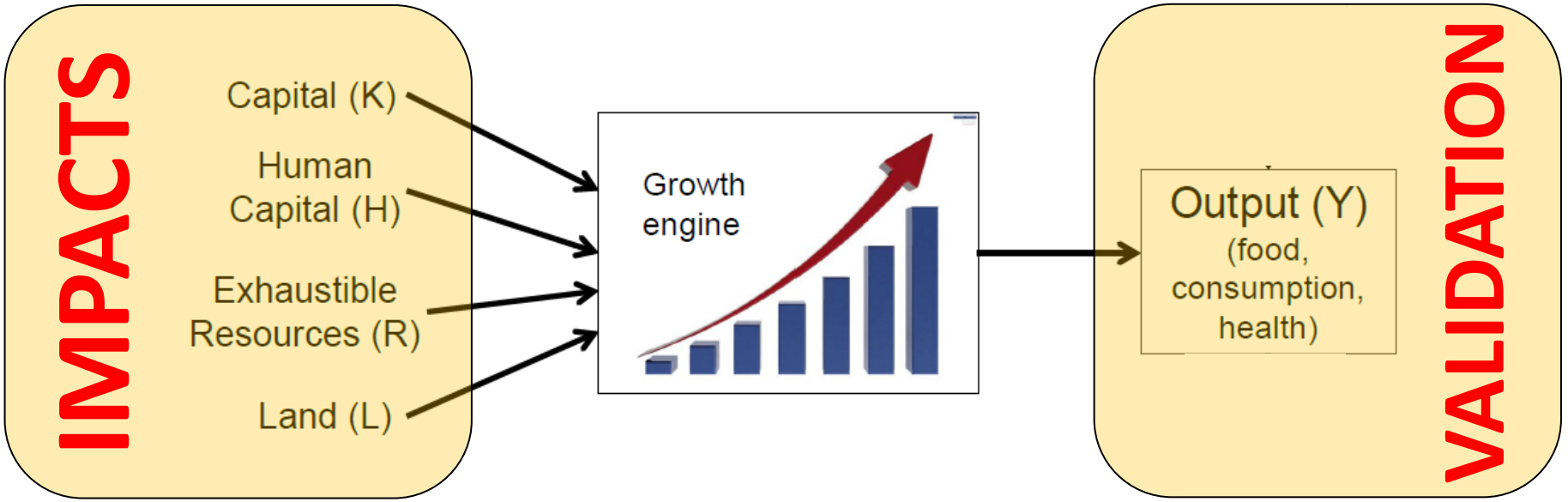
various controls

$$\Delta GDP_{i,t} = \sum_{L=0}^{k} [\beta_L \times D_{i,t-L}] + C_{i,t} + \varepsilon_{i,t}$$

exposed population



Will economic models be able to reproduce the observed long-term growth reduction?



Thank you!

Slide courtesy: Franziska Piontek