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science for global insight

Exposure and Vulnerability to Energy, Water, and Land Hotspots under Different Climate Futures

A Spatially-Explicit, Global Assessment of Vulnerable Populations and Hydroclimatic Impacts

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10th Integrated Assessment Modelling Consortium Meeting

December 6, 2017

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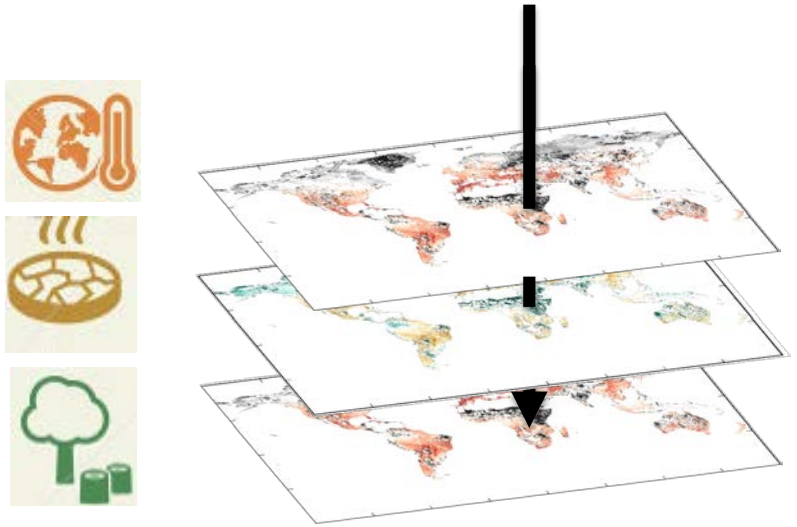
Multi-sectoral risk

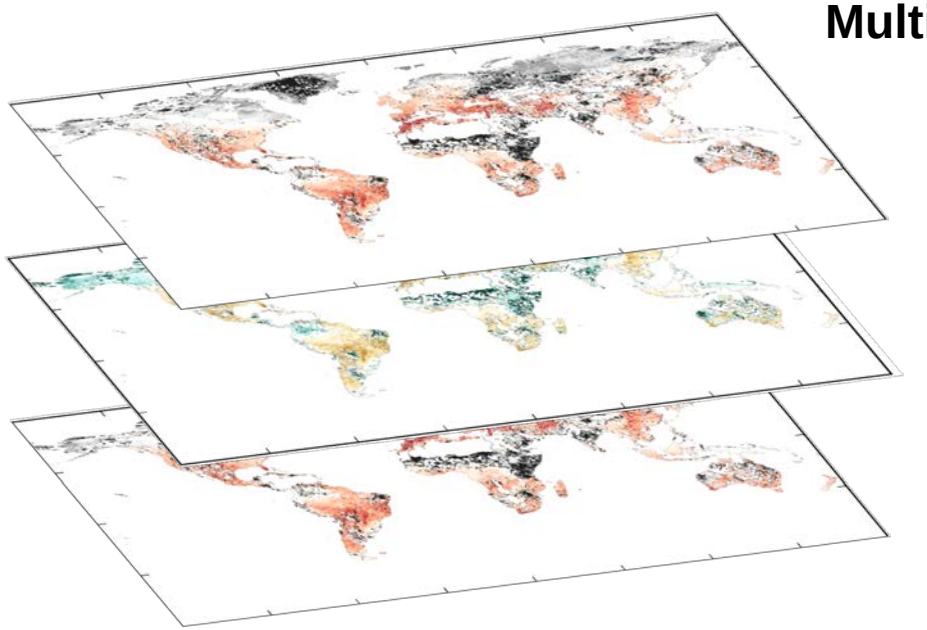
- Many studies on climate impacts
- Increased attention on multiple sectors



Risk aggregation in climate impacts research

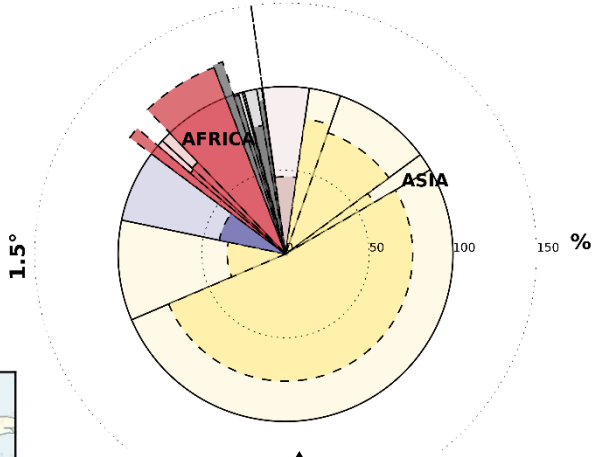
1. Temporal: *"compound events"* … two or more simultaneous events, e.g. drought + heatwave, with impacts often more severe than their sum
2. Spatial: *"hotspots"*… locations exposed to risks in multiple sectors, although not necessarily at the same time

Global mapping of multi-sector climate and vulnerability hotspots



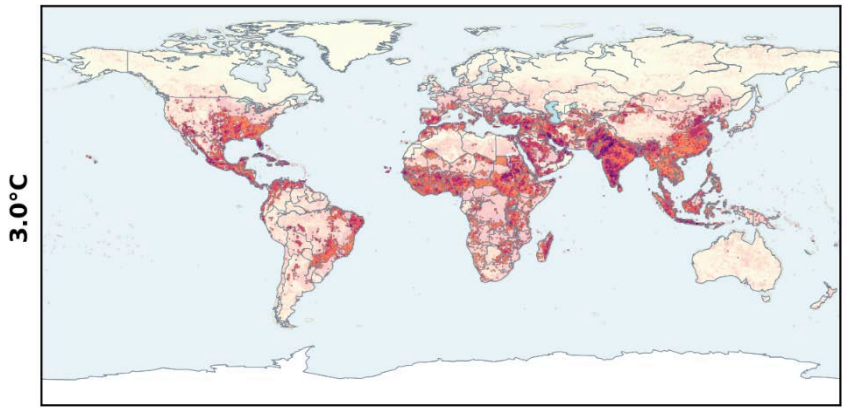
Multiple indicators (14) across 3 sectors

Hotspots of significant nexus vulnerabilities and impacts

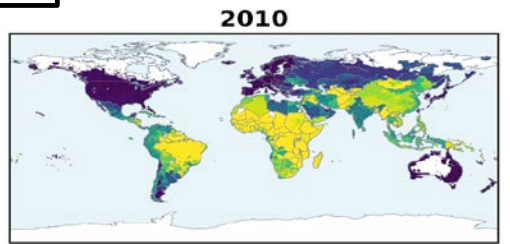


3.0 °C

combined indicators



SSP1-3



Byers et al. (2017, in review)

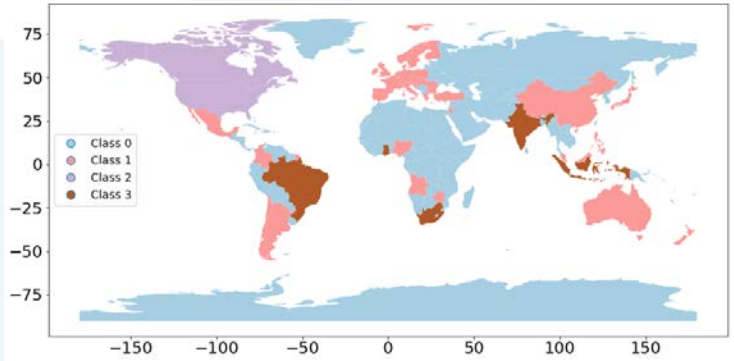
Projecting Subnational Income and Inequality

EUROPEAN STATISTICAL SYSTEM

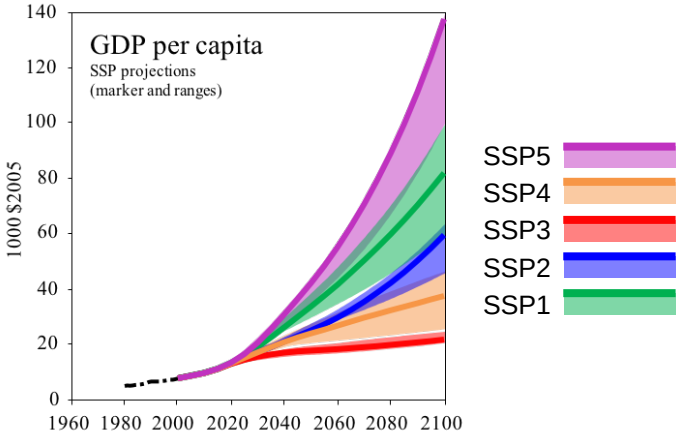
IHDS

IBGE
Instituto Brasileiro de Geografia e Estatística

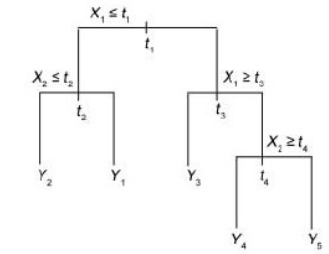
United States Census Bureau

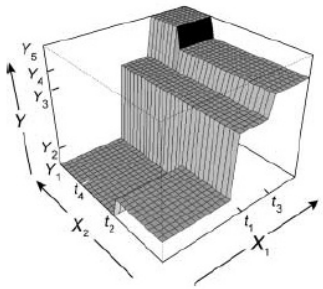


70% of Global Population



BRT Machine Learning





NLP Projection

$$\min_{i^\tau, t^\tau} \left(N^\tau \Omega(\frac{1}{4} I^\tau, I^\tau, T^\tau) - \sum_{j \in J} n_j^\tau \Omega(\frac{1}{4} I^\tau, i_j^\tau, t_j^\tau) \right)^2 \quad (6a)$$

$$\text{s.t.} \quad \sum_{j \in J} n_j^\tau i_j^\tau = N^\tau I^\tau \quad (6b)$$

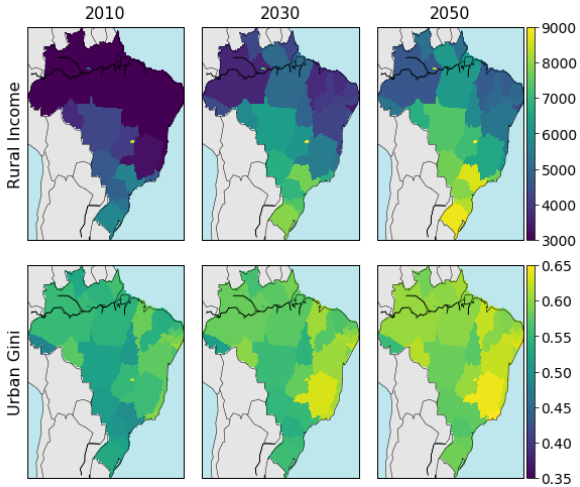
$$\frac{i_j^\tau - i_j^{\tau-1}}{\Delta\tau} \leq 1.65 \frac{I^\tau - I^{\tau-1}}{\Delta\tau} \qquad \forall\ j \in J \quad (6c)$$

$$\left| 1 - \frac{t_j^\tau}{t_j^{\tau-1}} \right| \leq 0.05 \Delta\tau \qquad \forall\ j \in J \quad (6d)$$

$$\left| 1 - \frac{\sum_{j \in J} n_j^\tau i_j^\tau t_j^\tau - \sum_{j \in J} n_j^\tau i_j^\tau \ln \frac{t_j^\tau}{I^\tau}}{N^\tau I^\tau T^\tau} \right| \leq 0.05 \qquad \forall\ j \in J \quad (6e)$$

$$t_j^\tau \in [t_{\min}, t_{\max}] \qquad \forall\ j \in J \quad (6f)$$

$$i_j^\tau \in [0, \infty) \qquad \forall\ j \in J \quad (6g)$$



Indicators	Urban and Rural Income and Inequality
Scenarios	All 5 SSPs
Resolution	Global, States, 0.125 Grids

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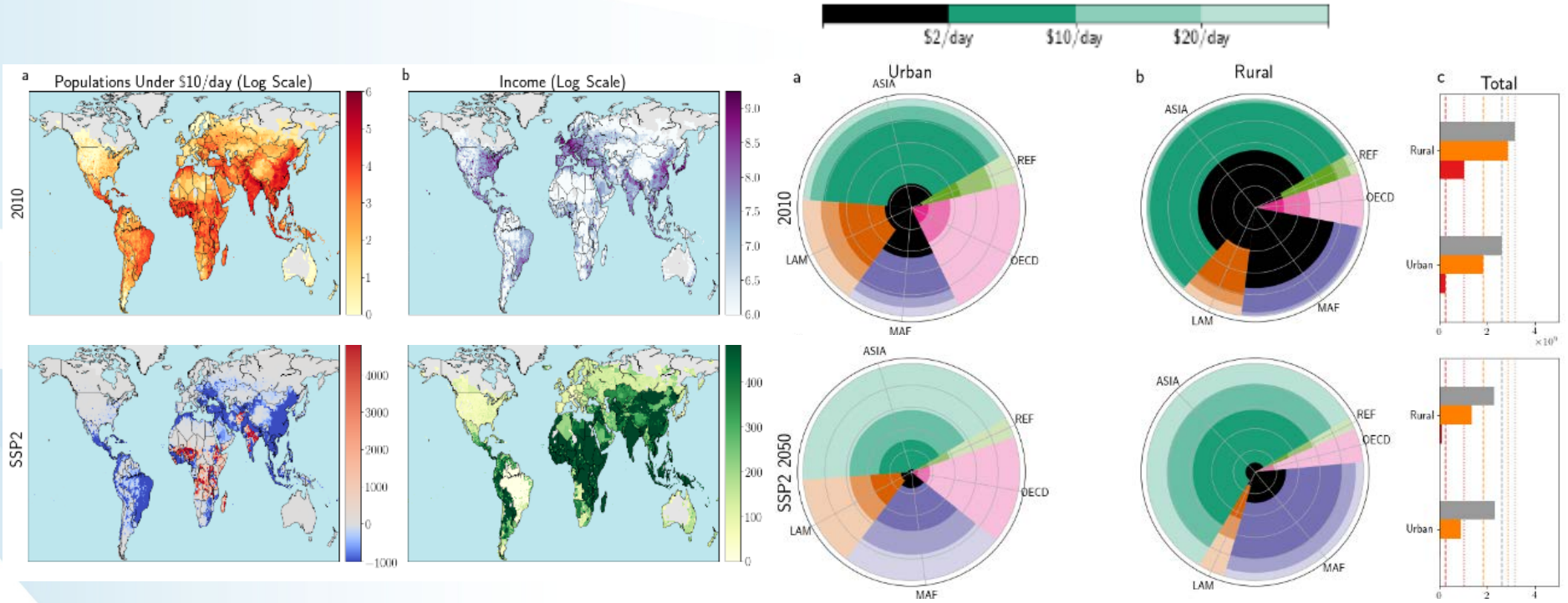
Gidden et al. (2017, in review)

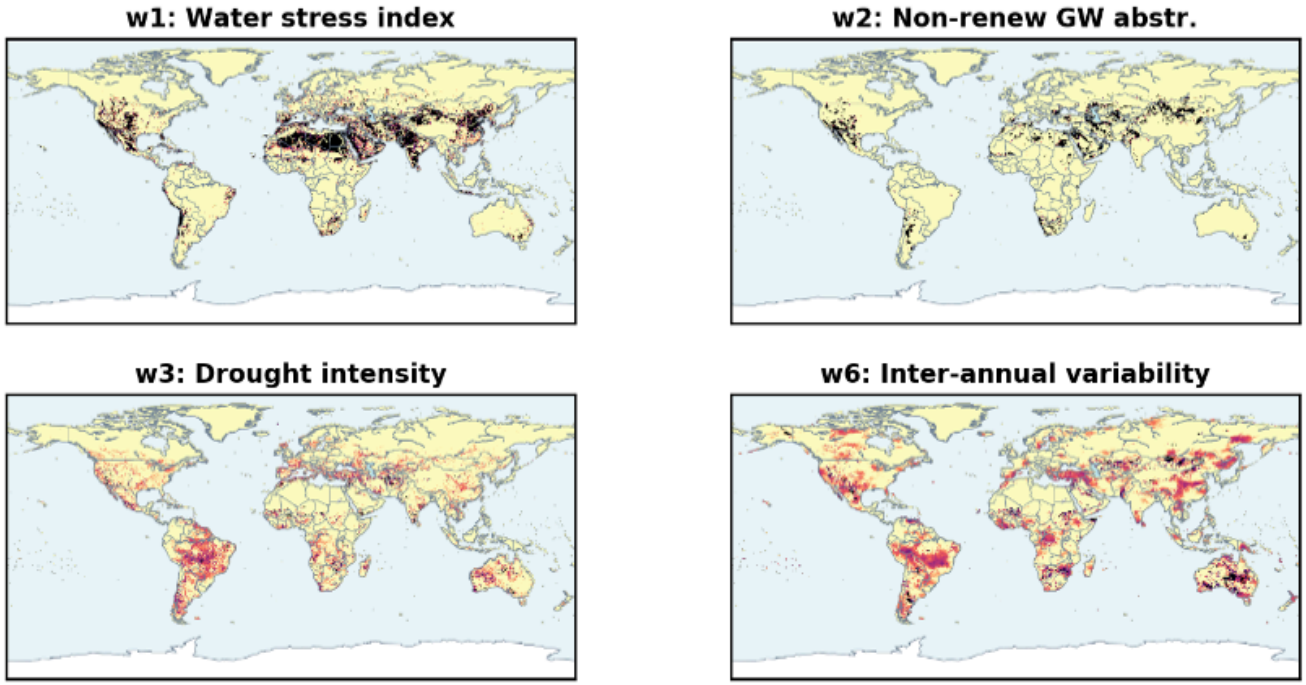
Populations Vulnerable to Poverty



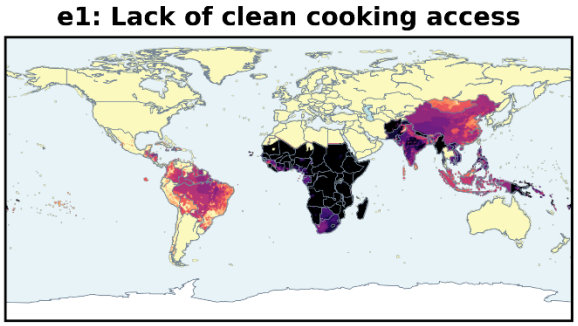
Gidden et al. (2017, in review)

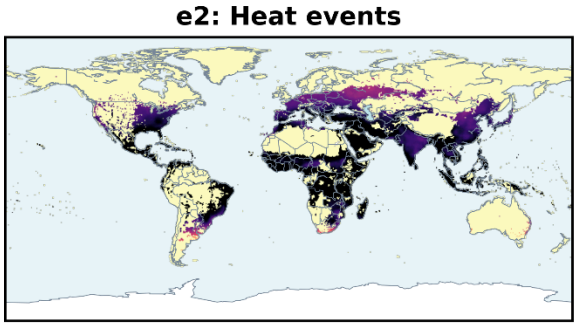
Multi-sector risk indicators

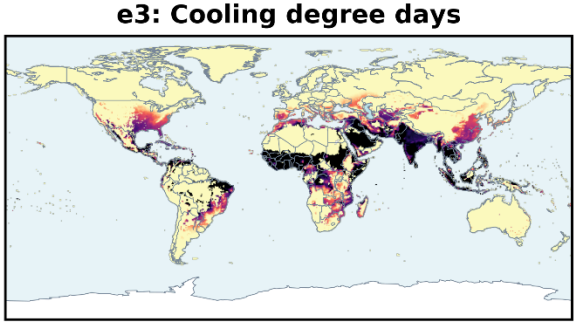
Indicator	Description	Models
Water		
Water stress index	Water stress index: as a proportion of human demands divided by renewable surface water resources	5 GCMs, 3 GHMs
Non-renewable GW abstraction index	Fraction of groundwater abstraction that is non-renewable	HadGEM2-ES + PCR-GLOBWB
Drought intensity	% change in drought intensity (deficit / duration)	5 GCMs, 4 GHMs
Peak flows risk	Substantial change in flood risk (doubling) is expected	5 GCMs, 4 GHMs
Seasonality	% change for the index of mean seasonality	5 GCMs, 4 GHMs
Inter-annual variability	% change for the index of mean inter-annual variability	5 GCMs, 4 GHMs

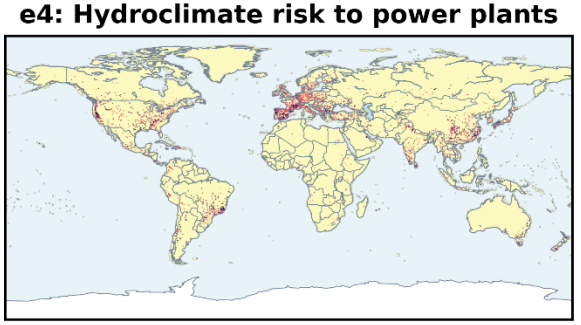


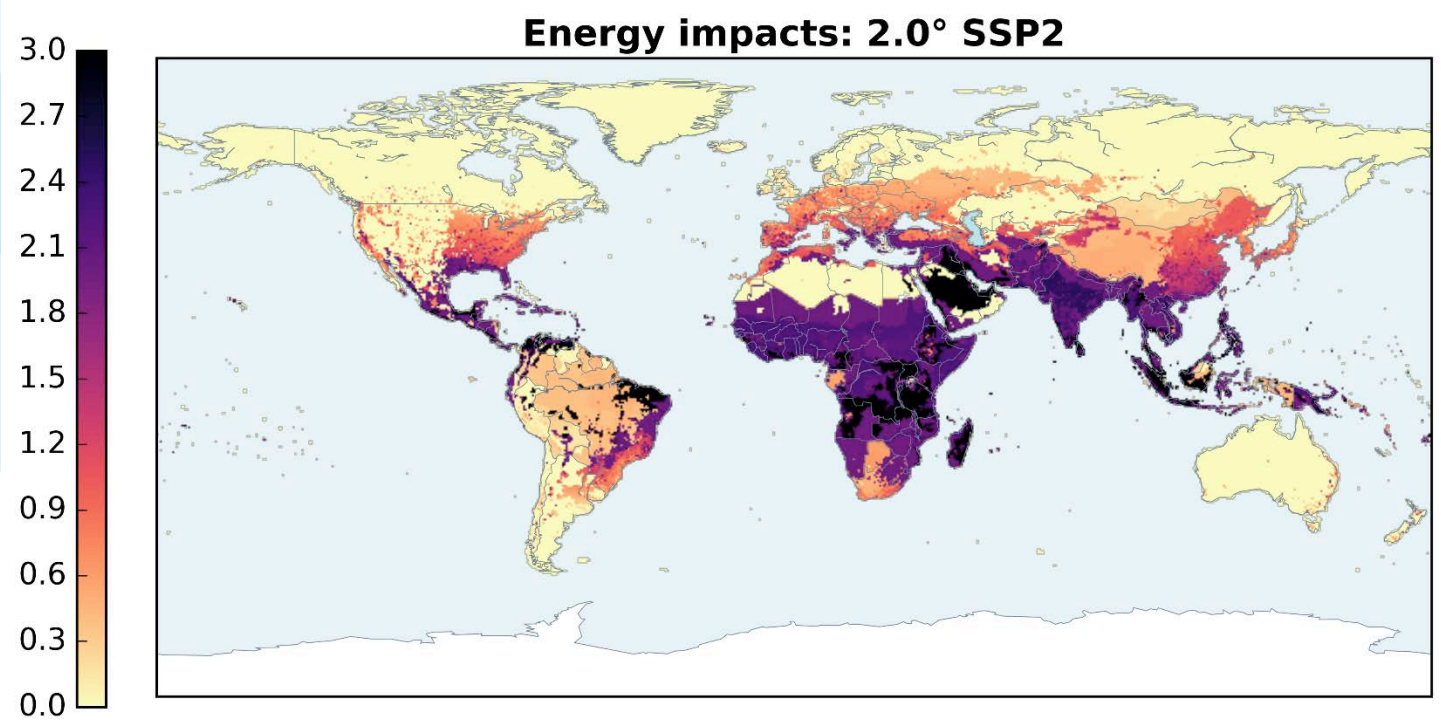
Byers et al. (2017, in review)











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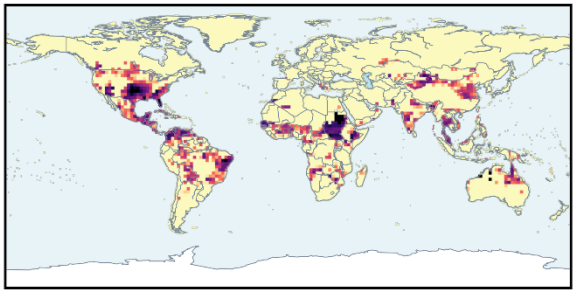
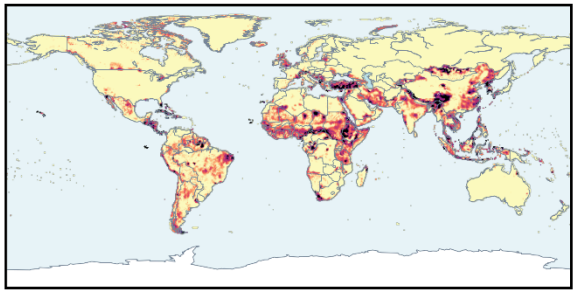
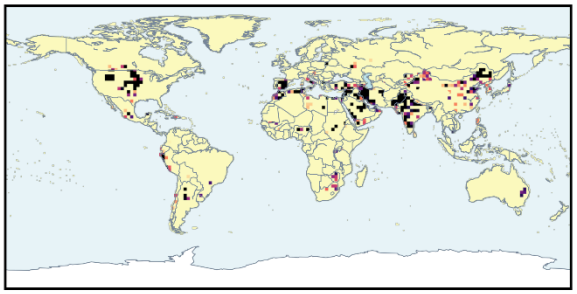
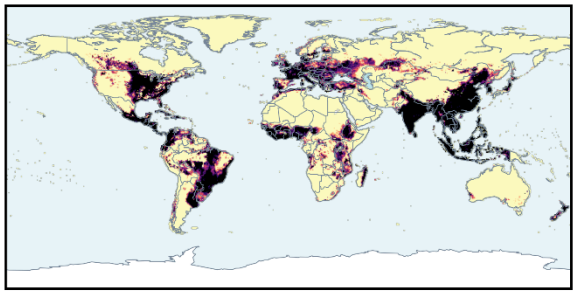
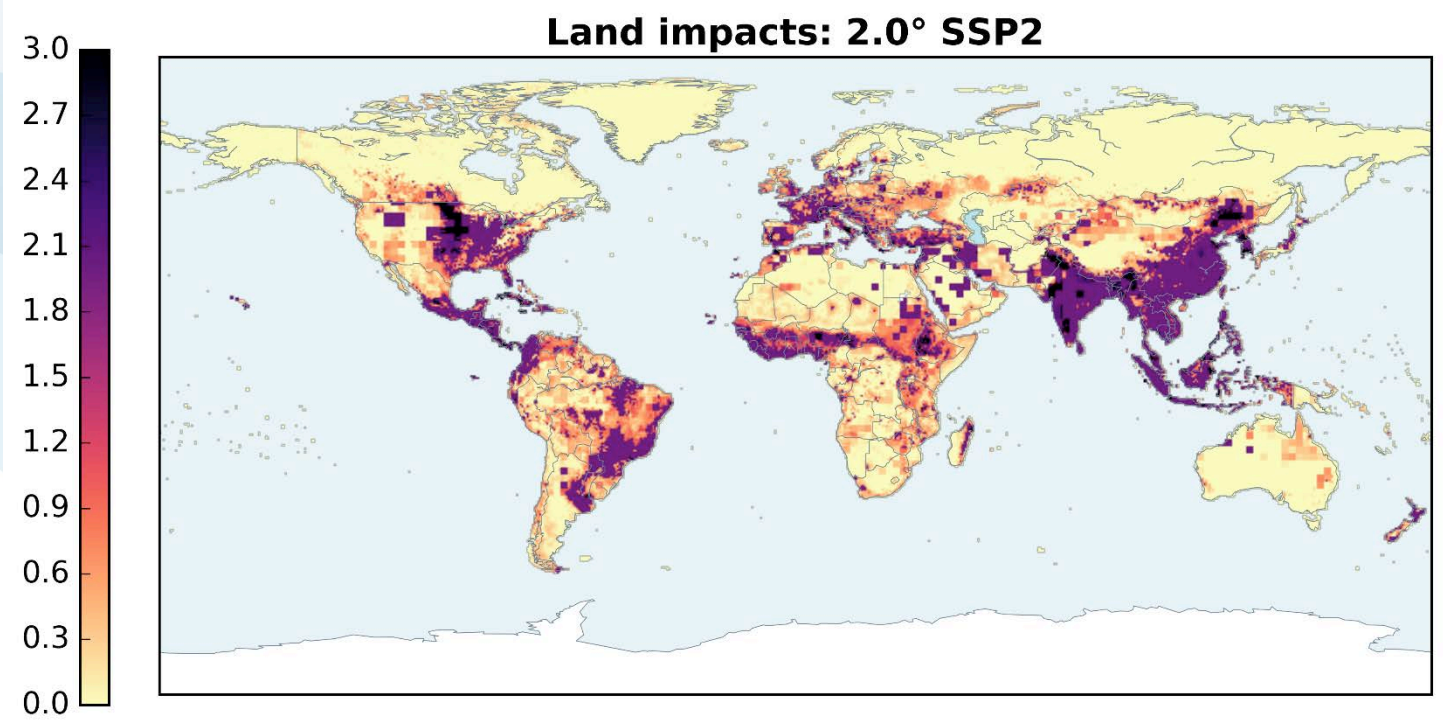






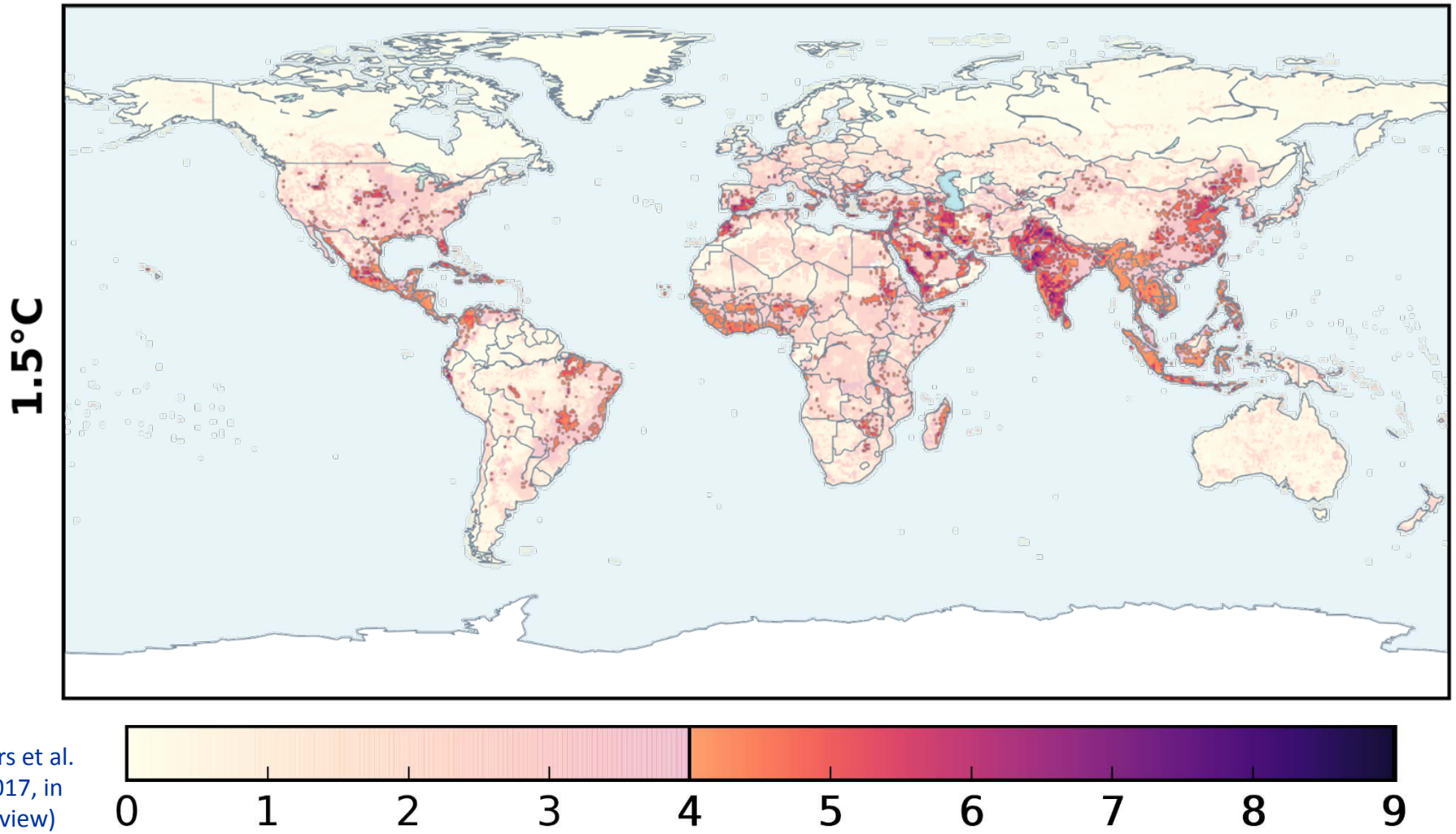




Byers et al. (2017, in review)

Global hotspot exposure

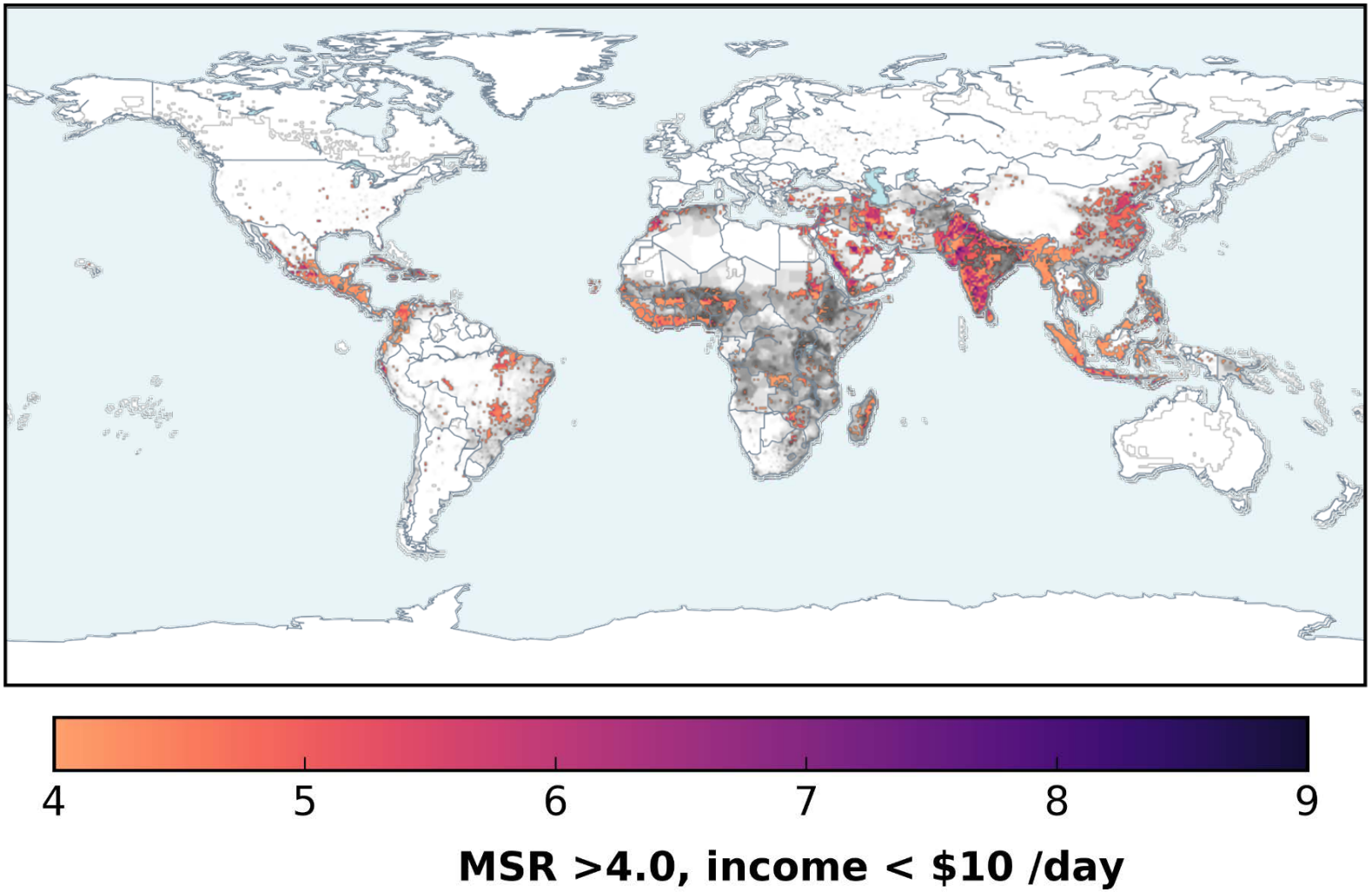
3.0 °C



Byers et al. (2017, in review)

Hot and vulnerable

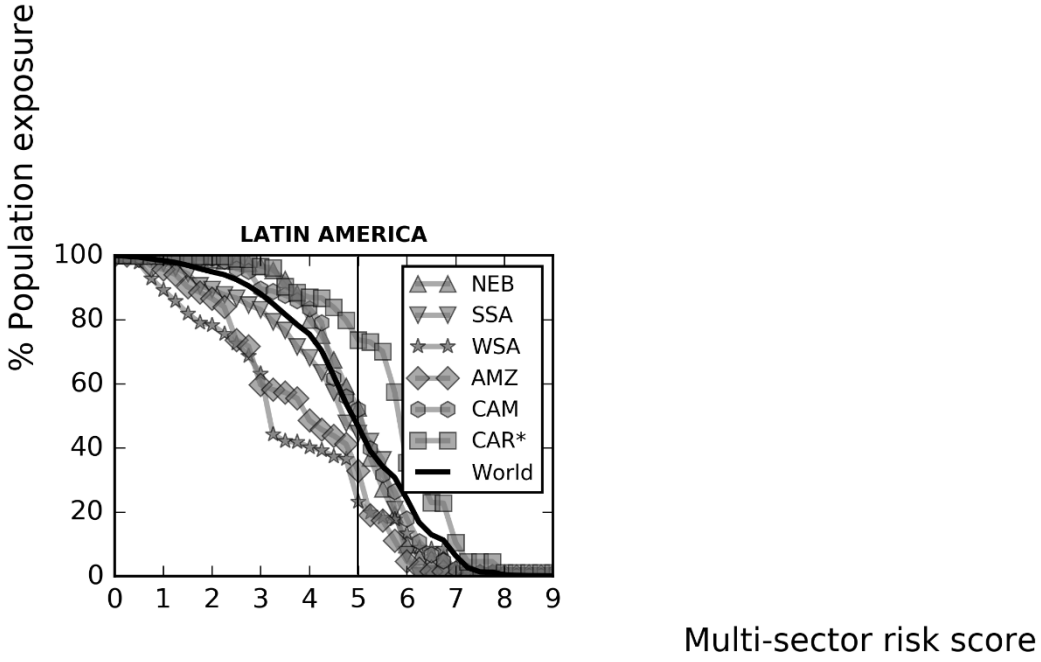
3.0 °C



Byers et al. (2017, in review)

Regionalised impacts – SSP2, 2050

3.0 °C



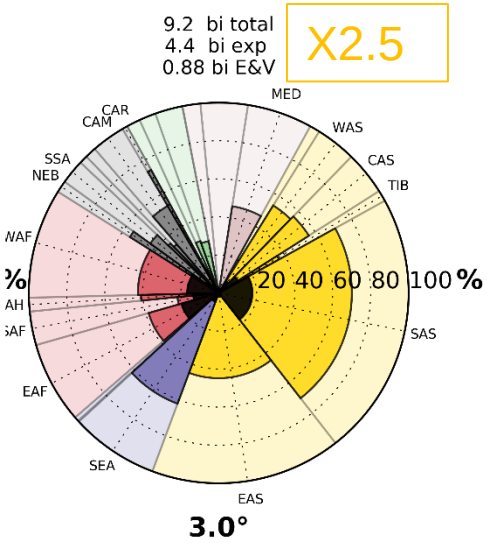
Byers et al. (2017, in review)

- Northern hemisphere regions have better than average impacts
- Most Asian and southern regions are on/worse than average

Impacted Populations

Exposed

x2

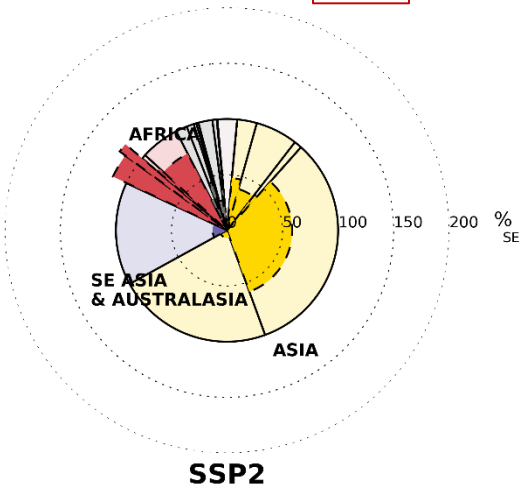


X2.5

Exposed & Vulnerable

x5

x15



Byers et al. (2017, in review)

Sustainability | **Middle of the road** | **Rocky road**

Conclusions and findings

- More than double exposure between 1.5-3.0°C
- Asia already faces severe exposure and vulnerability at 1.5°C
- African exposure emerges intensely at 2-3°C
- As many E&V in SSP3 as today, but more concentrated in Asia and Africa
- Difference in SSPs results in order of magnitude reductions in E&V

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Thank you very much for your attention!

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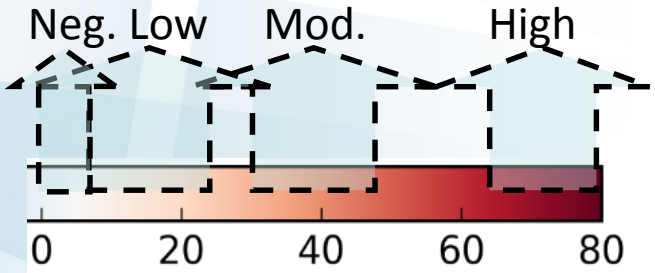
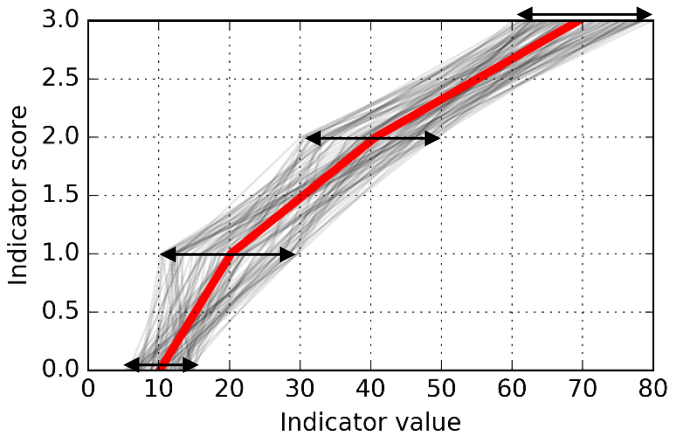
Backup Slides

Climate change index scoring under uncertainty

Continuous scale (0 to 3) with intermediate ranges determined

0. Negligible risk
1. Low risk
2. Moderate risk
3. High risk





2.0°C climate example: Drought intensity change