Climate Change, Growth & Trade

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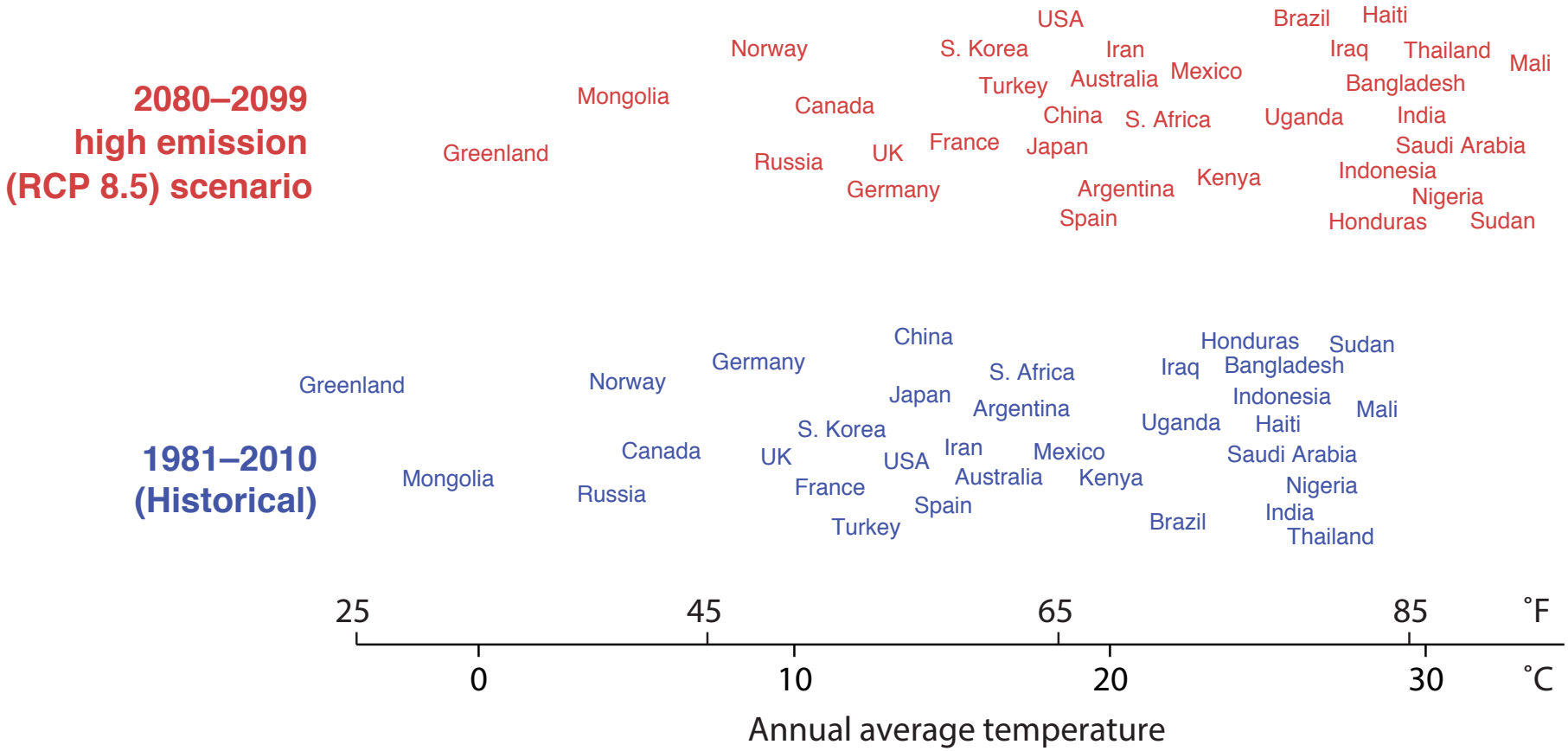
May 13, 2022

Climate change in context



Hsiang & Kopp (JEP, 2018)

Climate change in context

Moderate emissions scenario:

+1C over next 30 years

Climate change in context

Moderate emissions scenario:

$$+1\text{C over next 30 years}$$

$$= +0.033 \text{ C / yr}$$

$$= +\frac{1}{10{,}000} \text{ C / day}$$

Climate change in context

Moderate emissions scenario:

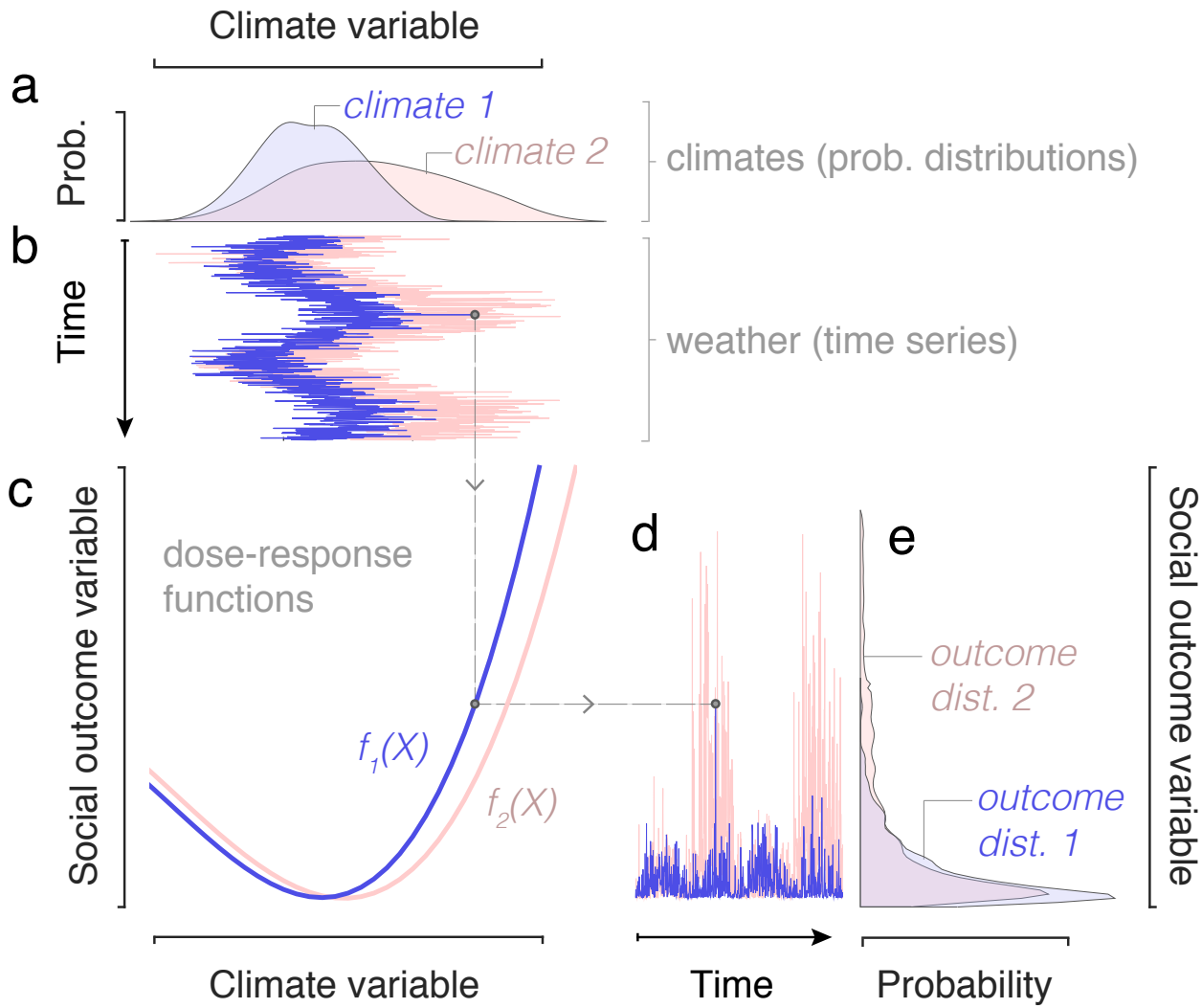
$$+1\text{C over next 30 years}$$

$$= +0.033 \text{ C / yr}$$

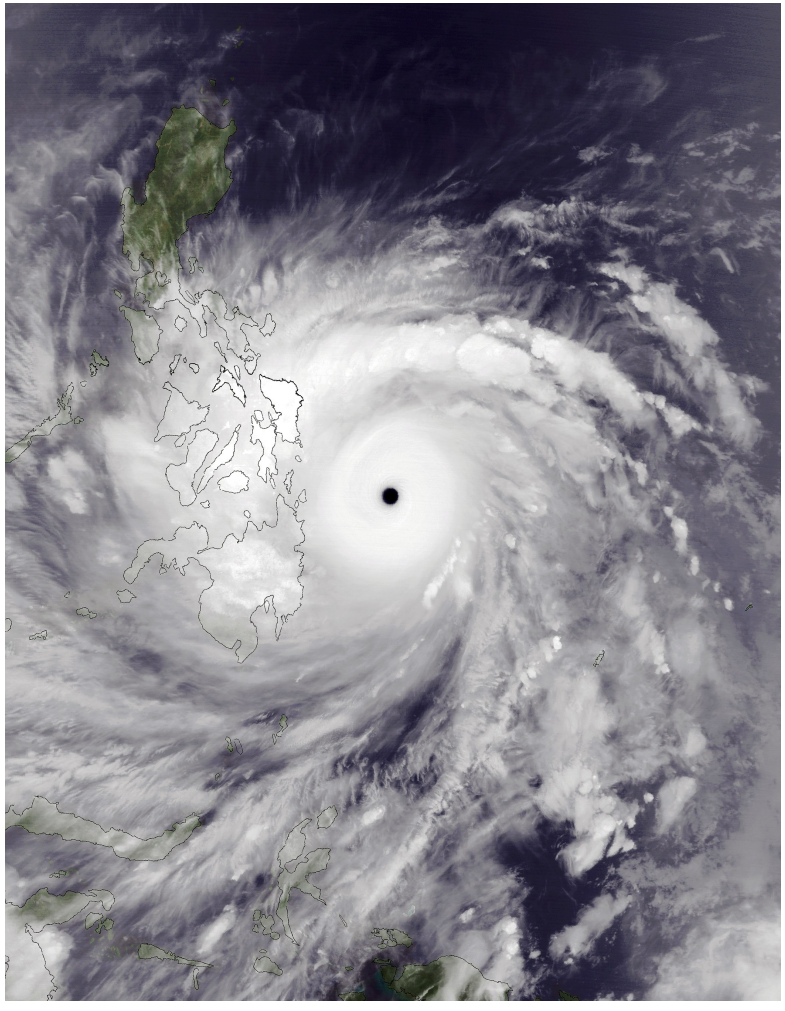
$$= +\frac{1}{10{,}000} \text{ C / day}$$

Climate change occurs incrementally, changing weather one day at a time.

The Empirical Approach



Carleton & Hsiang (Science 2016)



Typhoon Haiyan – how do you rebuild after such destruction?

The devastation caused in the Philippines will take years to repair. Previous efforts in Haiti, Japan and elsewhere point the way, but how can we build back better?

Vittorio Infante
The Guardian, Friday 15 November 2013 19.04 GMT

Jump to comments (25)

No quick fix … an entire neighbourhood is destroyed in Tacloban after Typhoon Haiyan. Photograph: Kevin Frayer/Getty Images AsiaPac

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Environment
Fukushima · Nuclear power · Climate change

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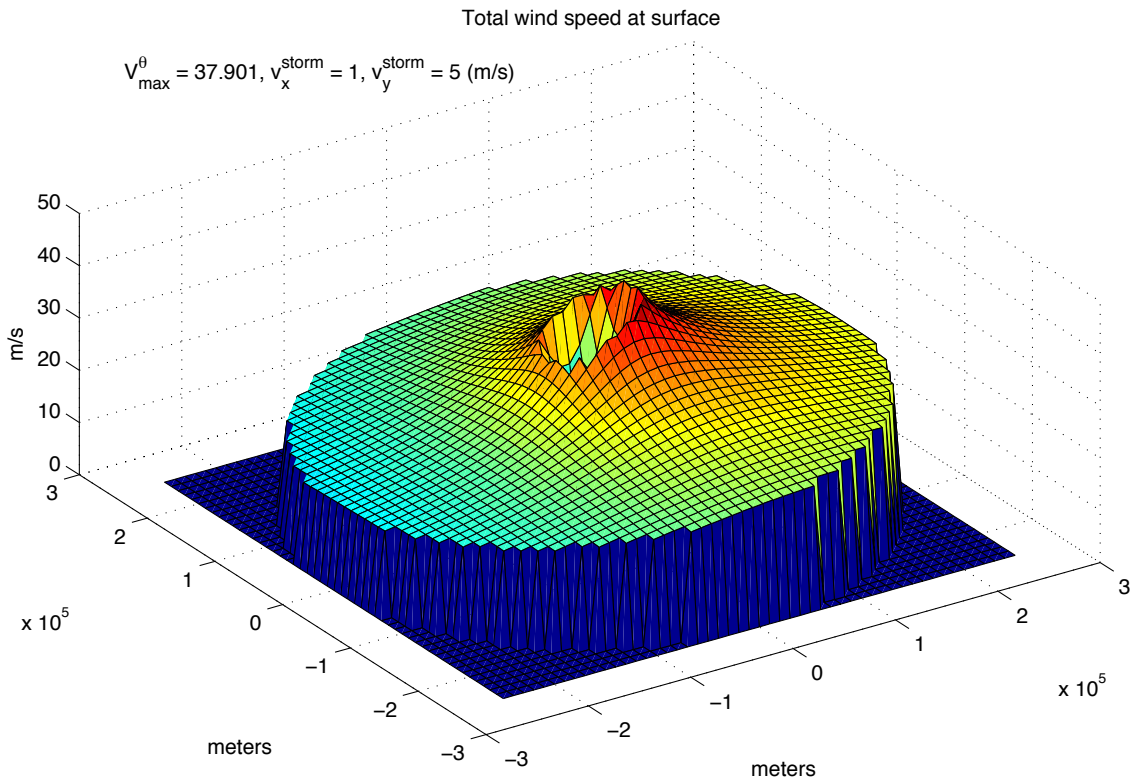
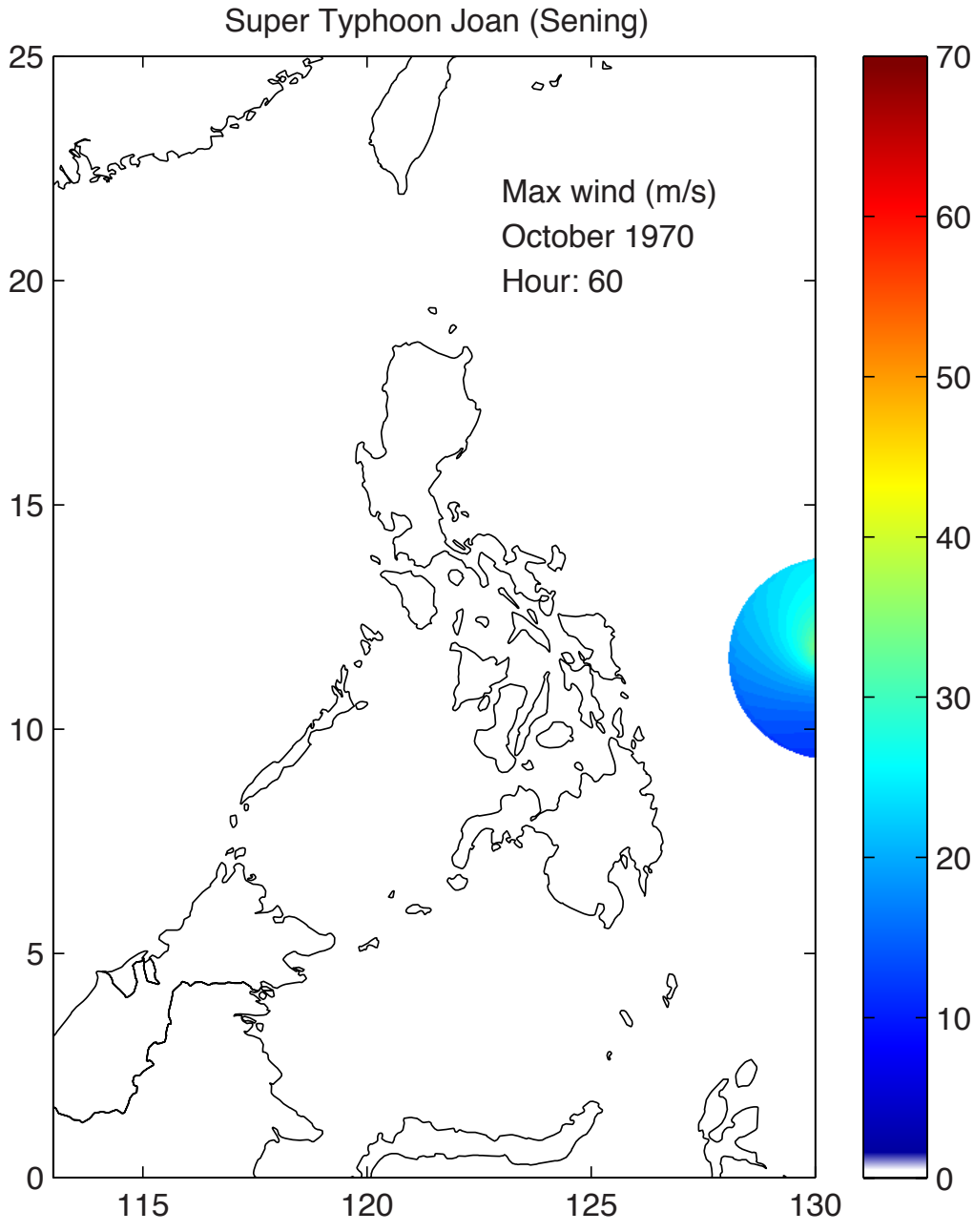
Typhoon Haiyan storm

Physical Cyclone Model (LICRICE)



Hsiang (PNAS, 2010)


Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 60
25
20
15
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115
120
125
130
70
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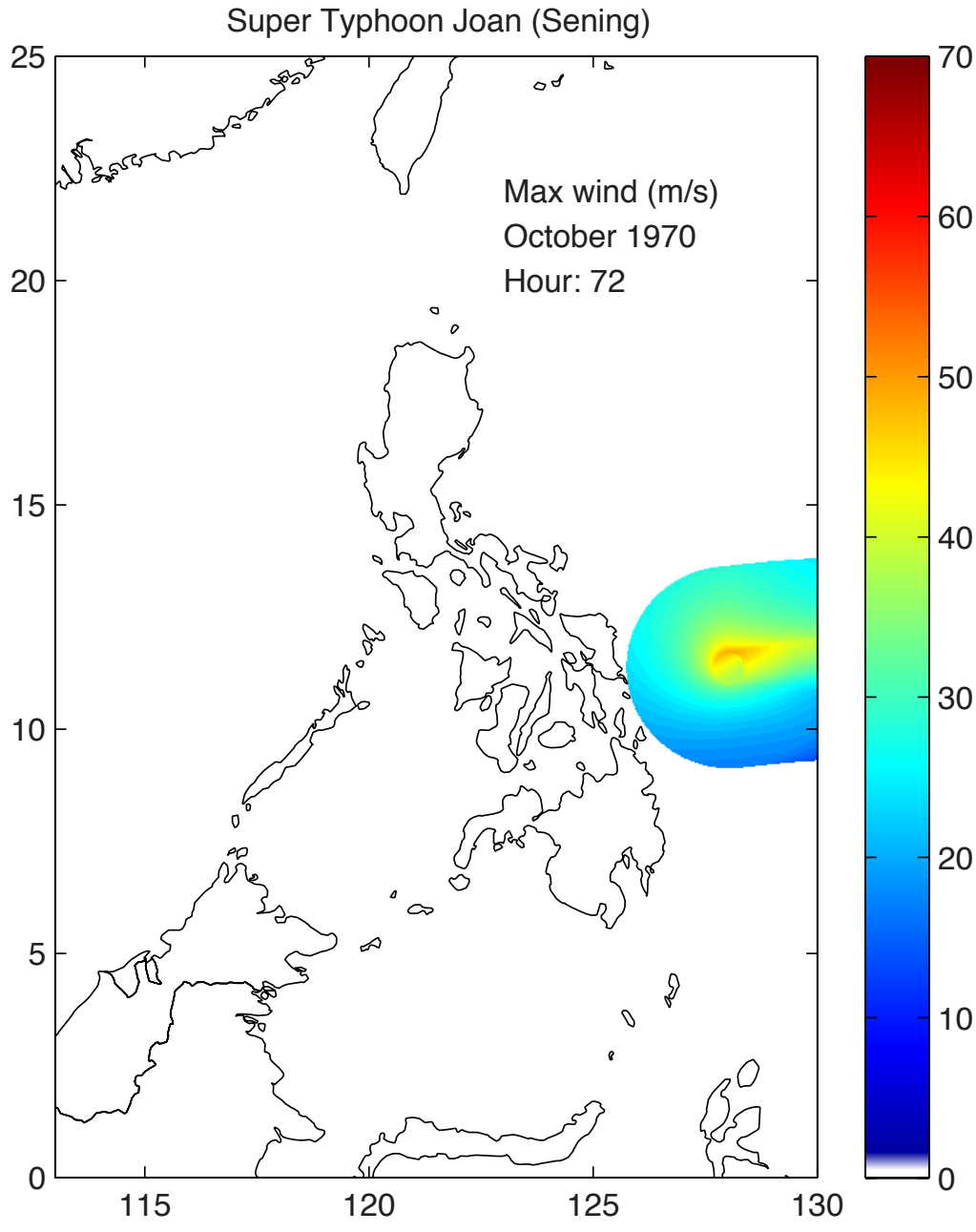
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 72
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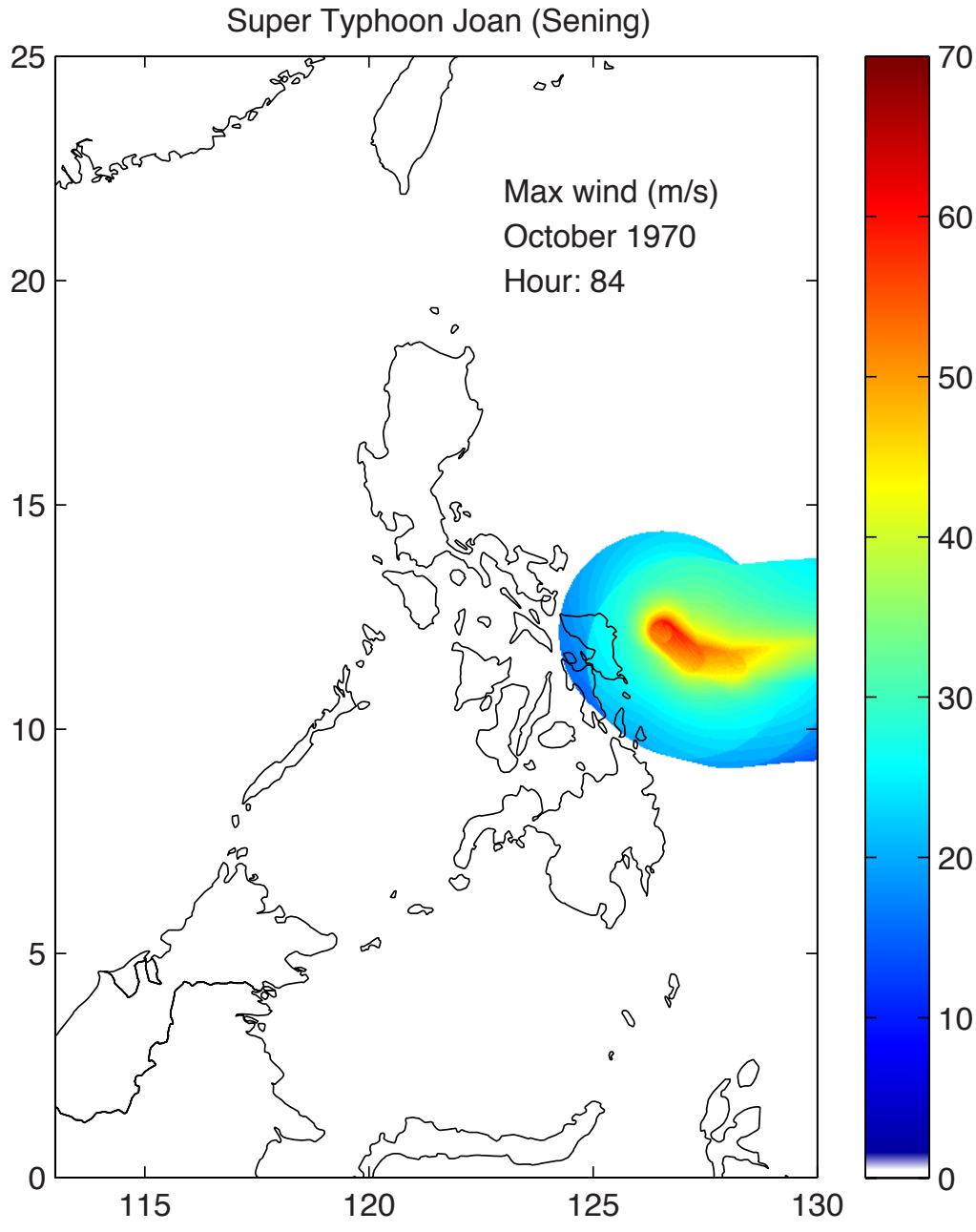
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 84
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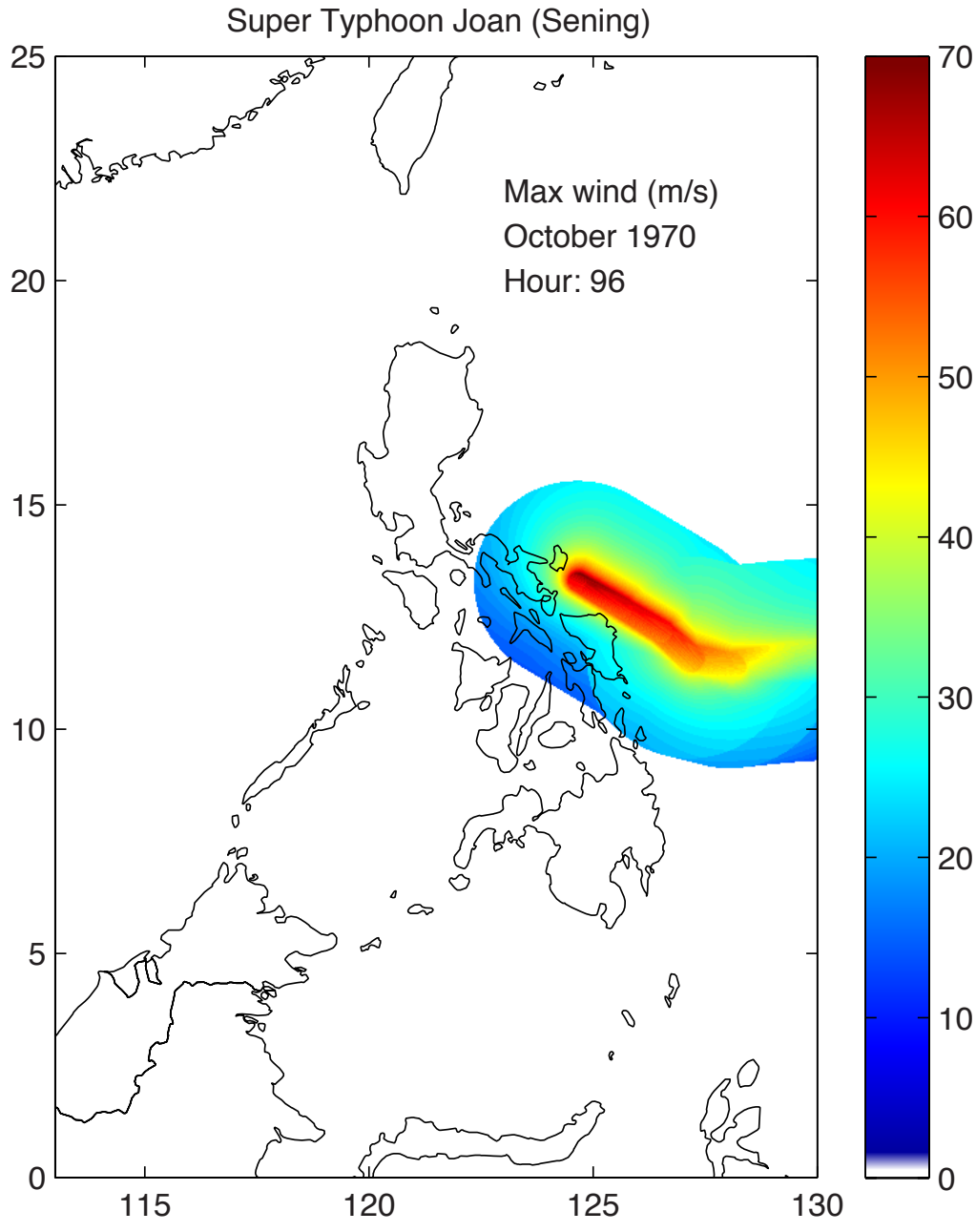
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 96
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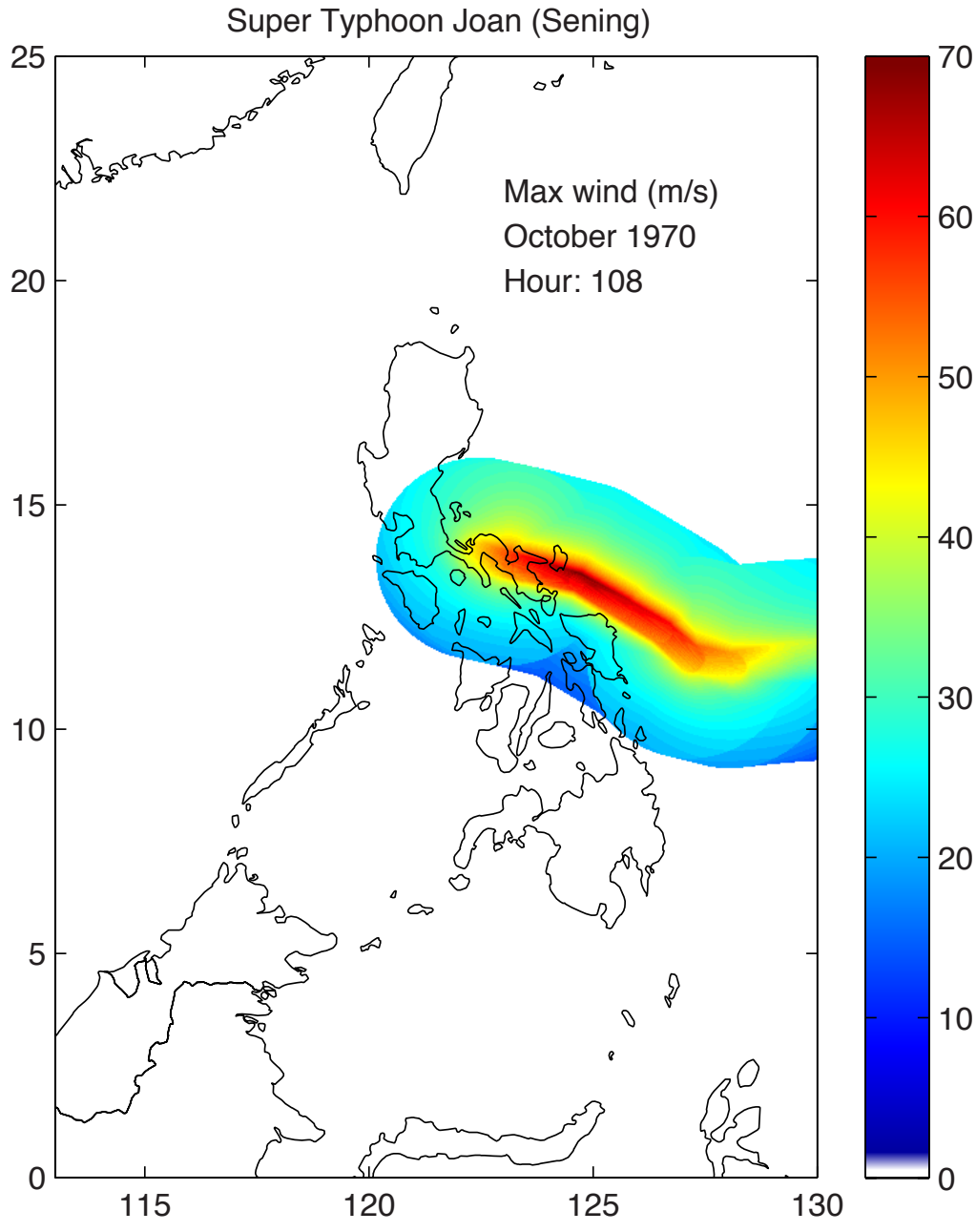
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 108
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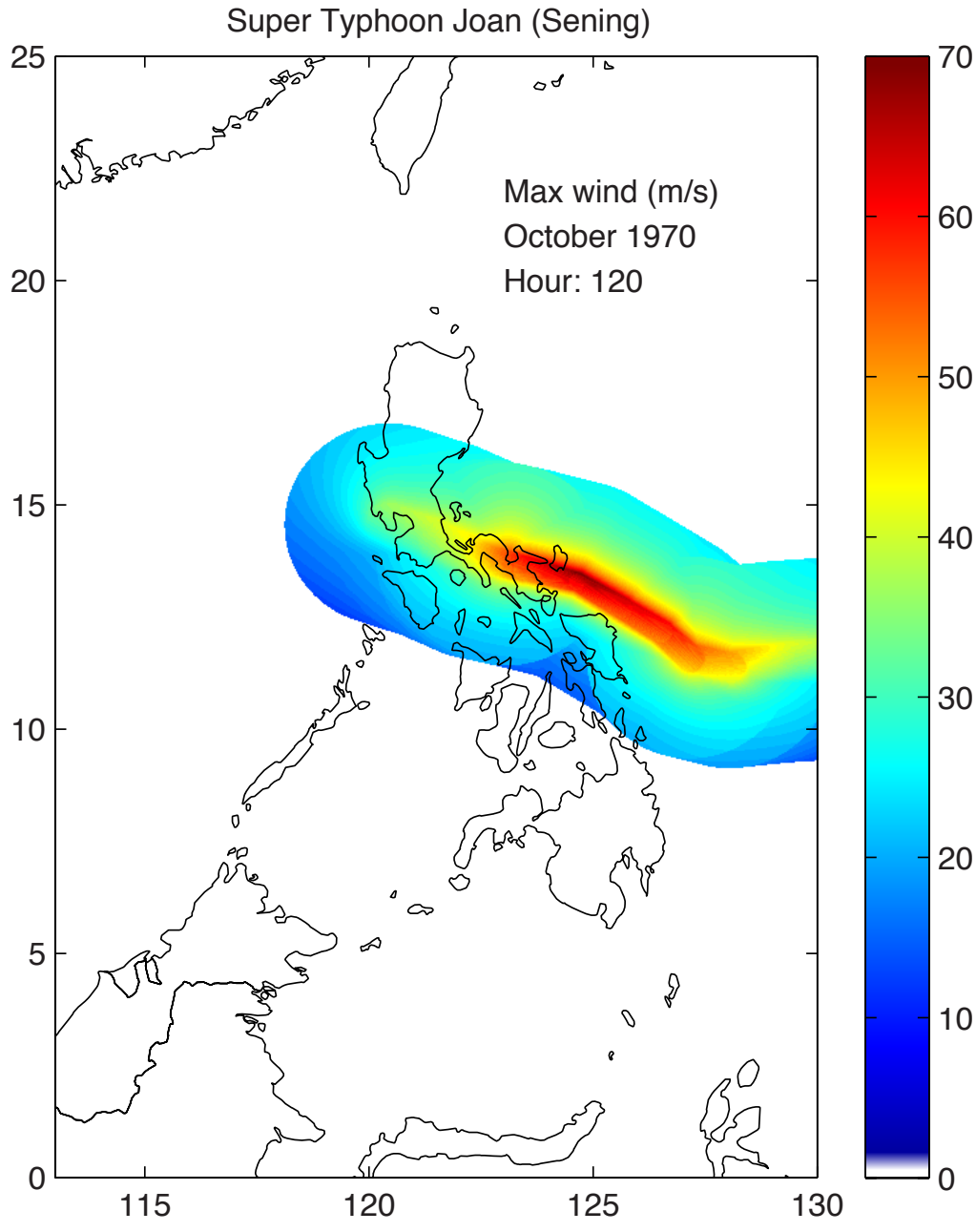
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 120
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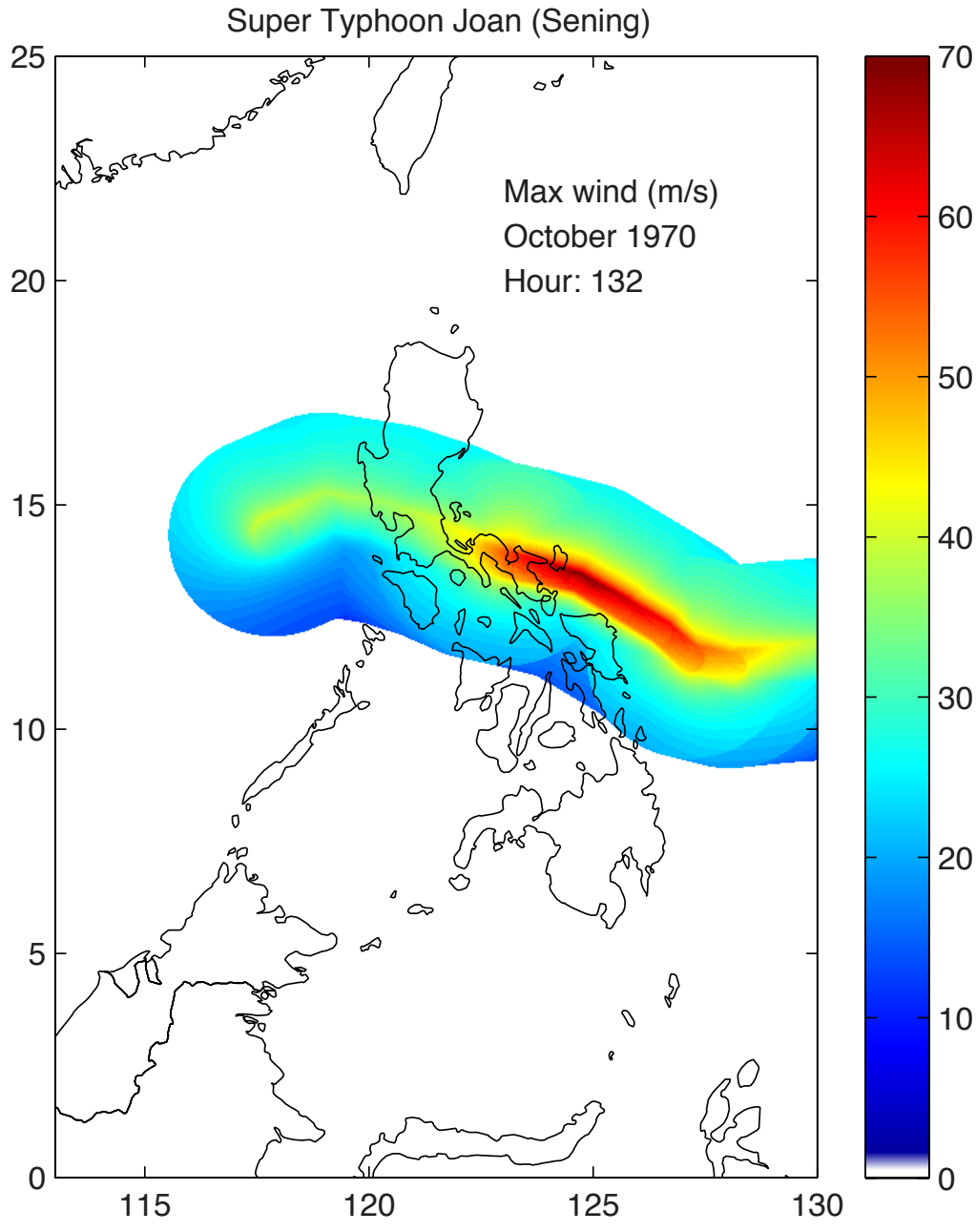
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 132
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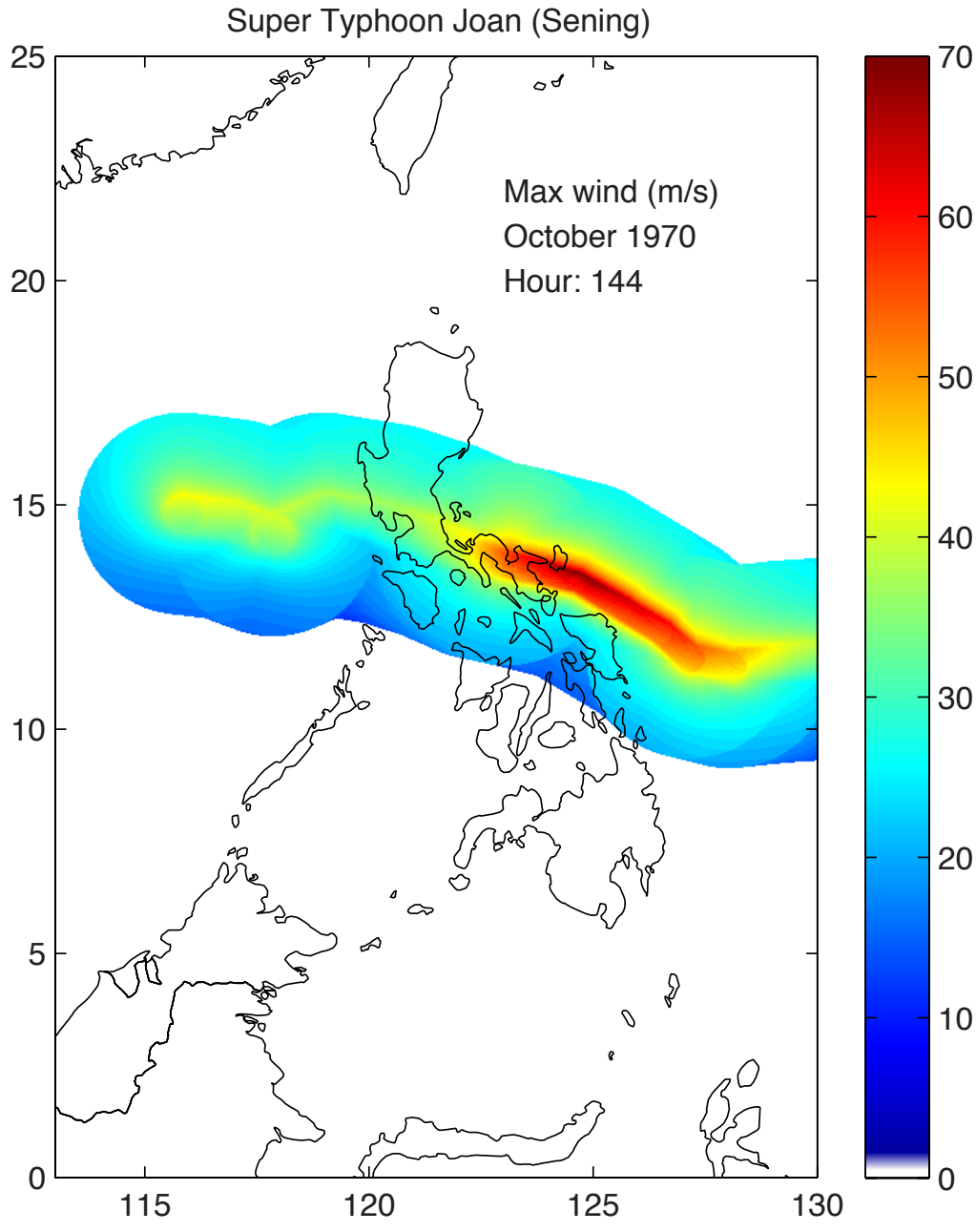
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 144
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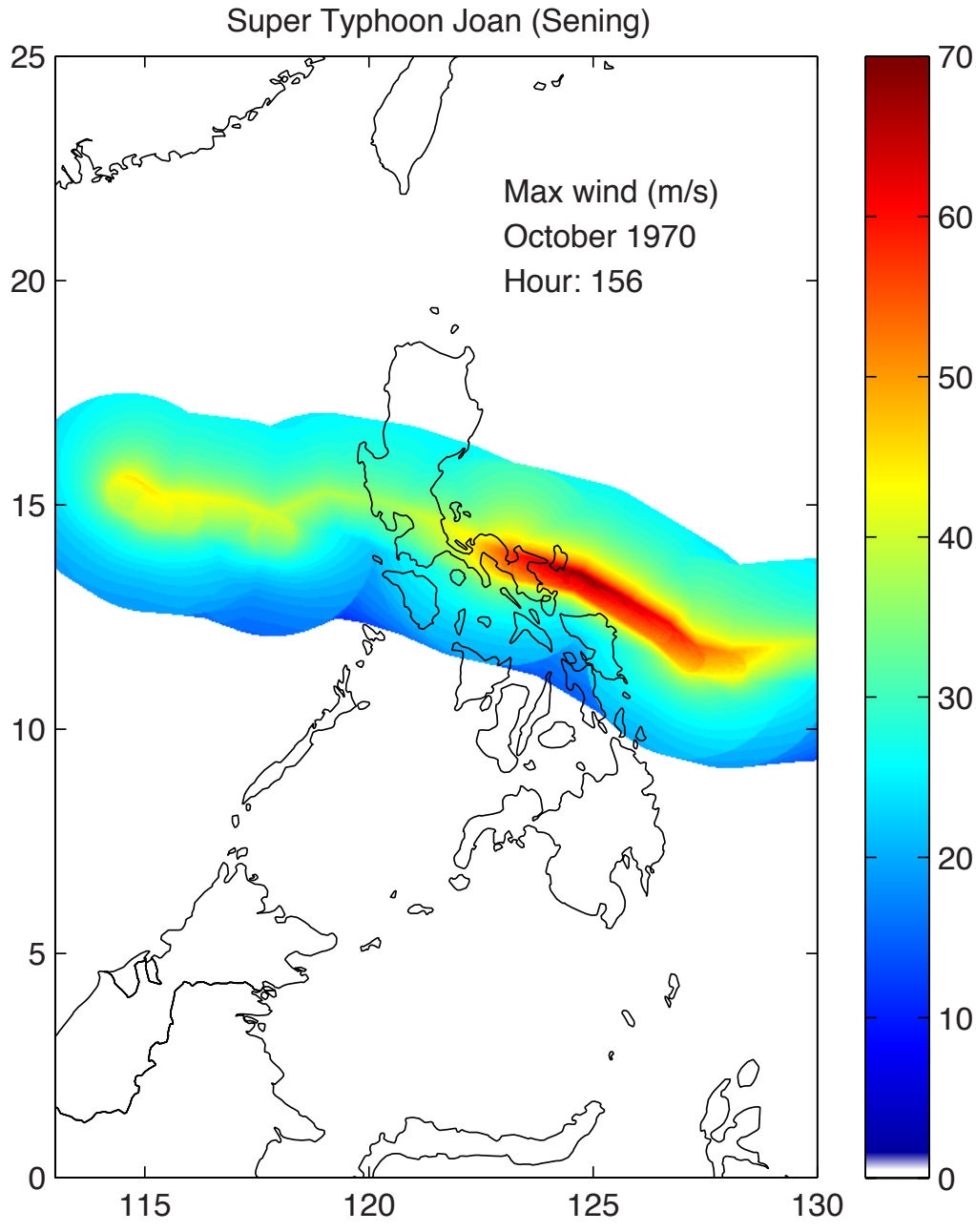
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 156
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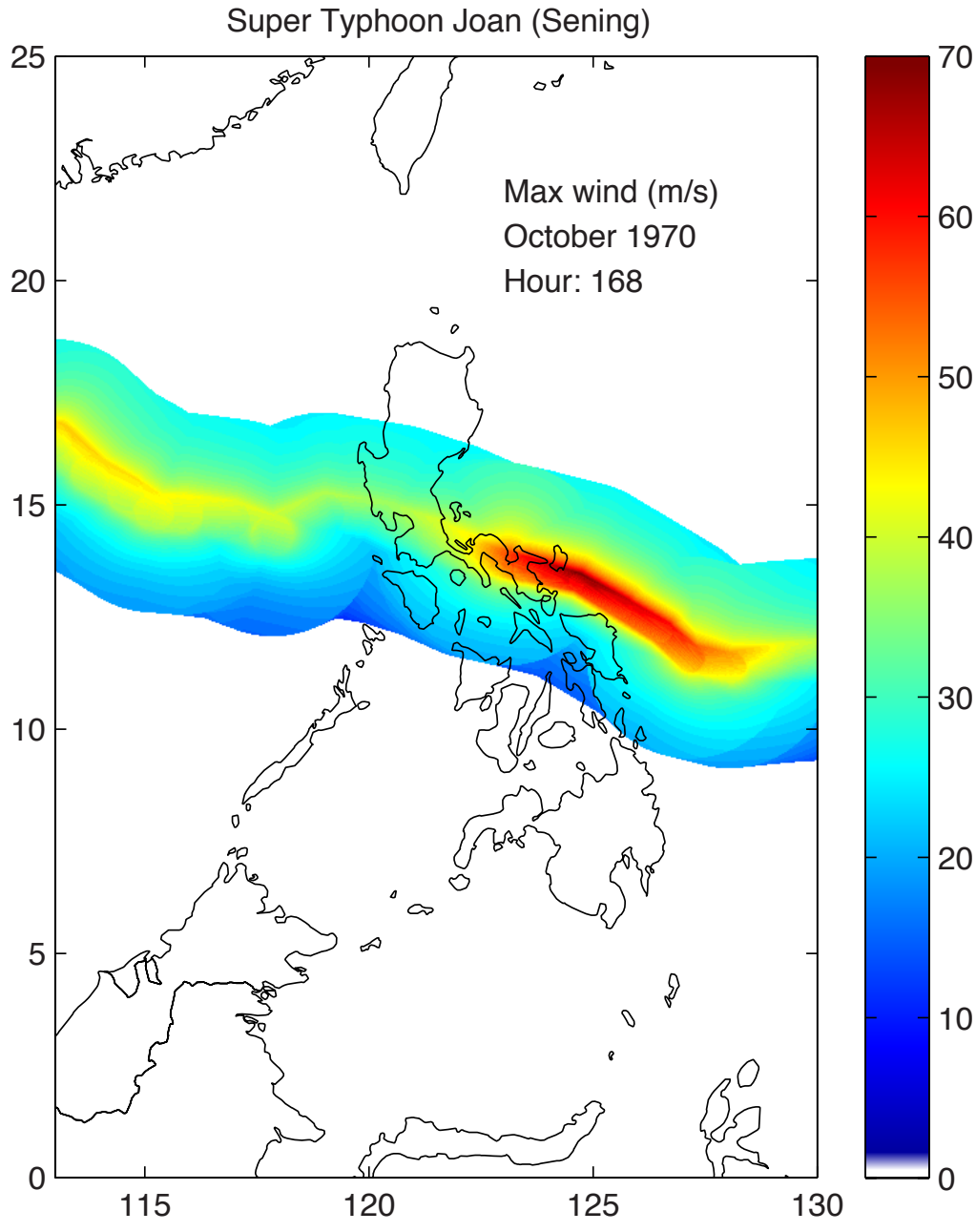
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 168
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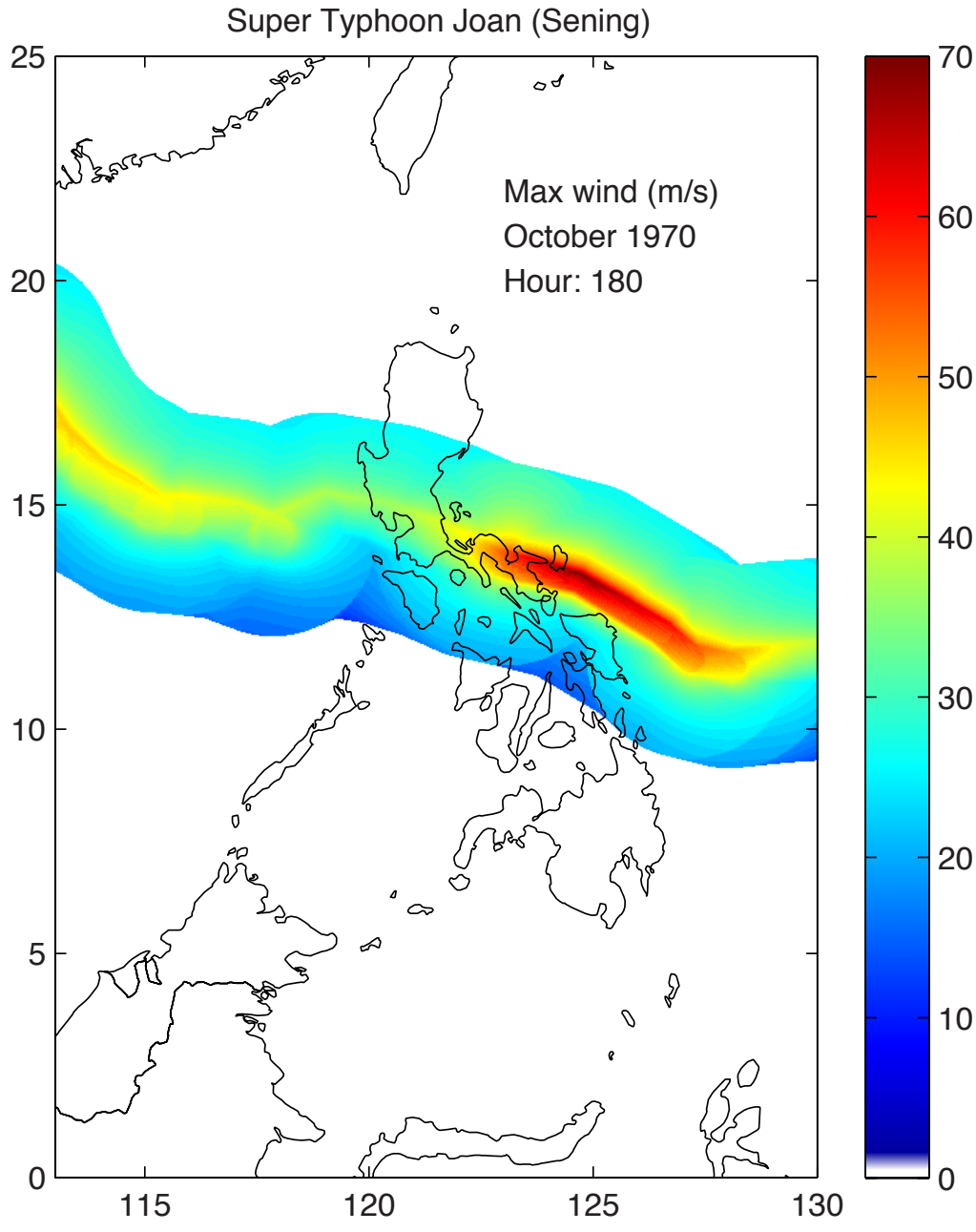
Super Typhoon Joan (Sening)
Max wind (m/s)
October 1970
Hour: 180
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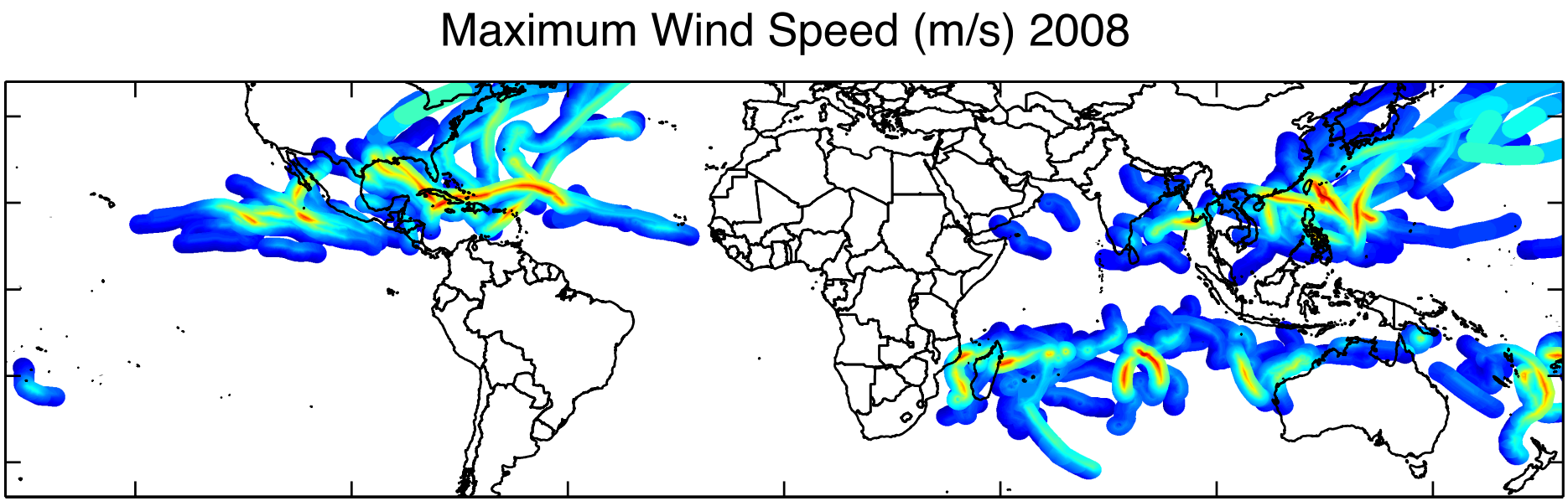
All storms within a year (LICRICE)

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2008
meters per second
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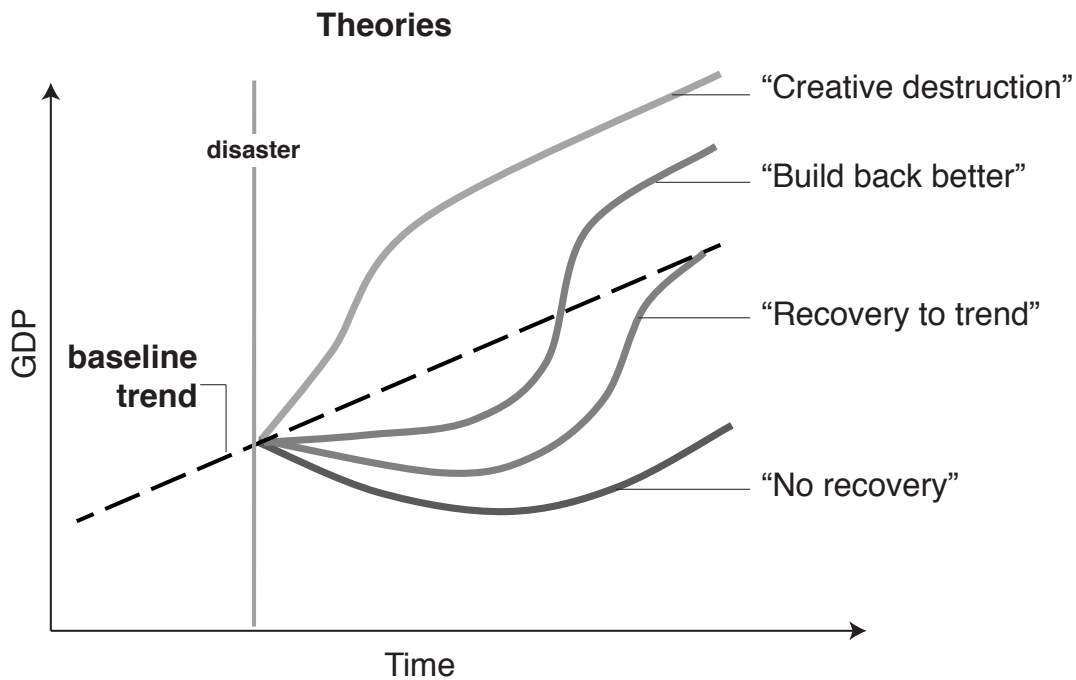
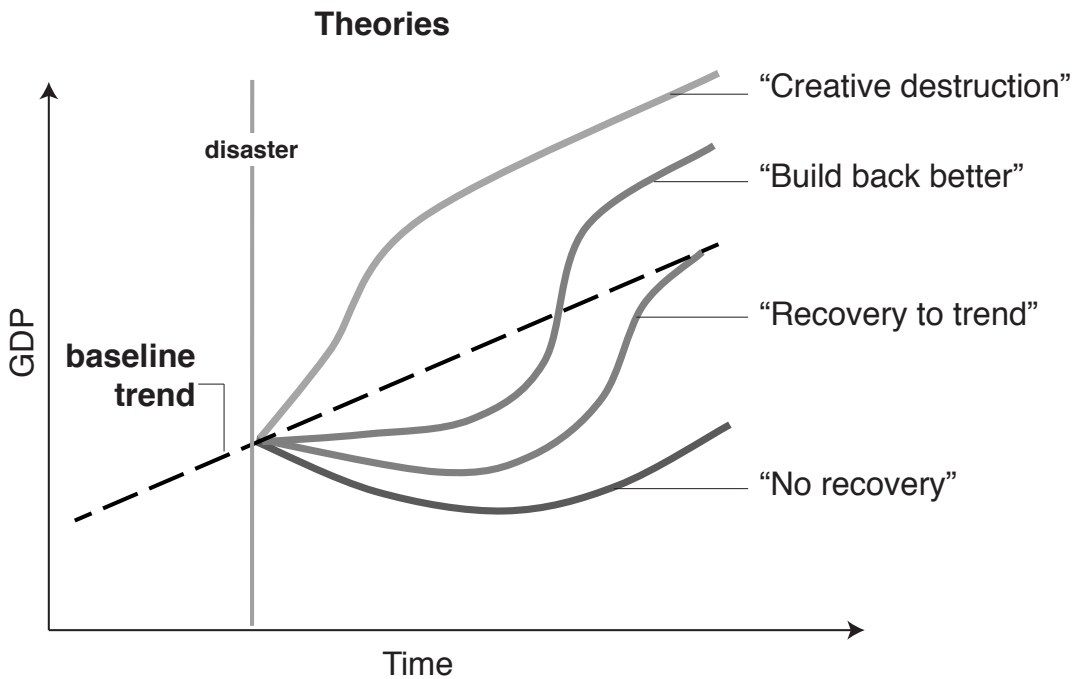
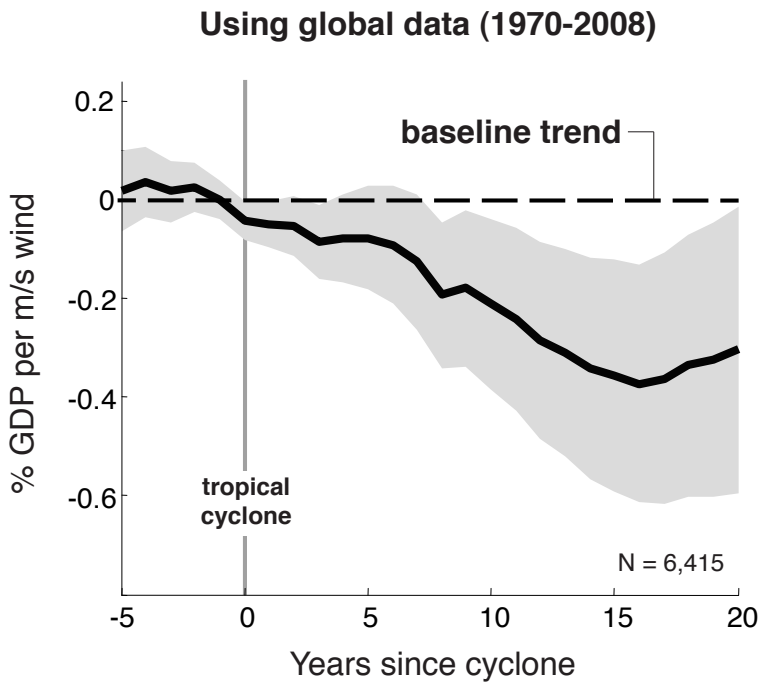
Growth: Theories vs. Evidence



(Hsiang & Jina, 2014)

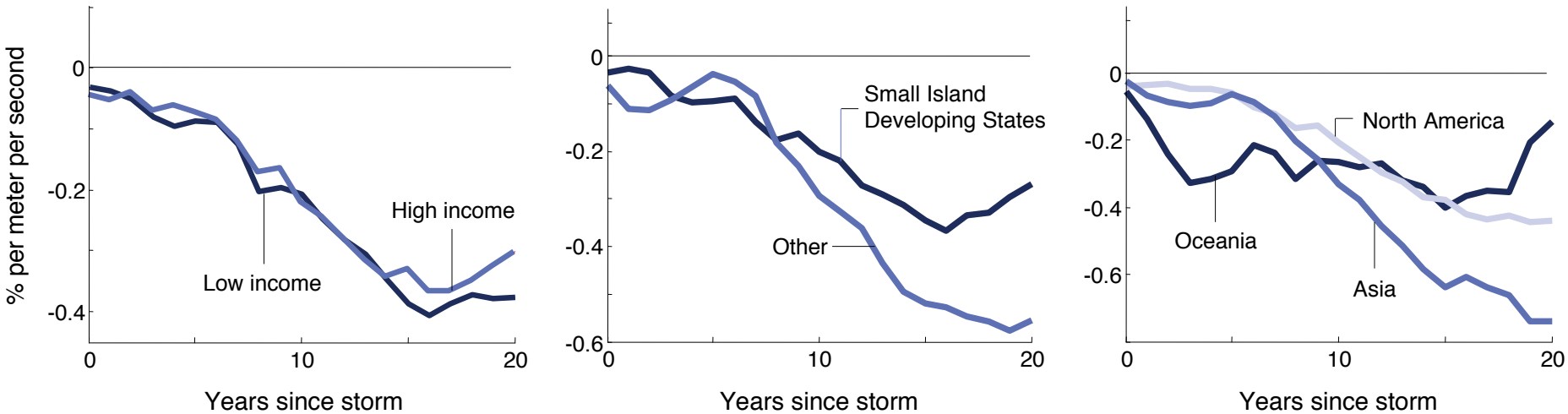
Growth: Theories vs. Evidence





(Hsiang & Jina, 2014)

Global generalizability



(Hsiang & Jina, 2014)

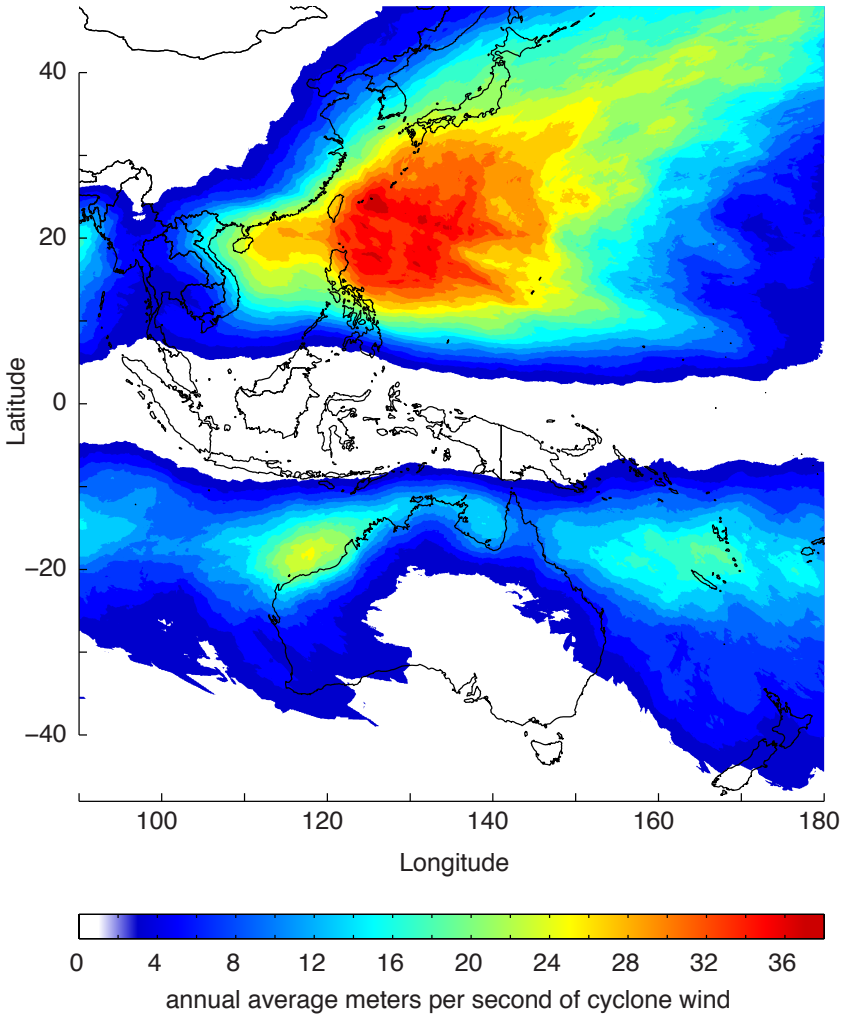
Repeated shocks slow growth

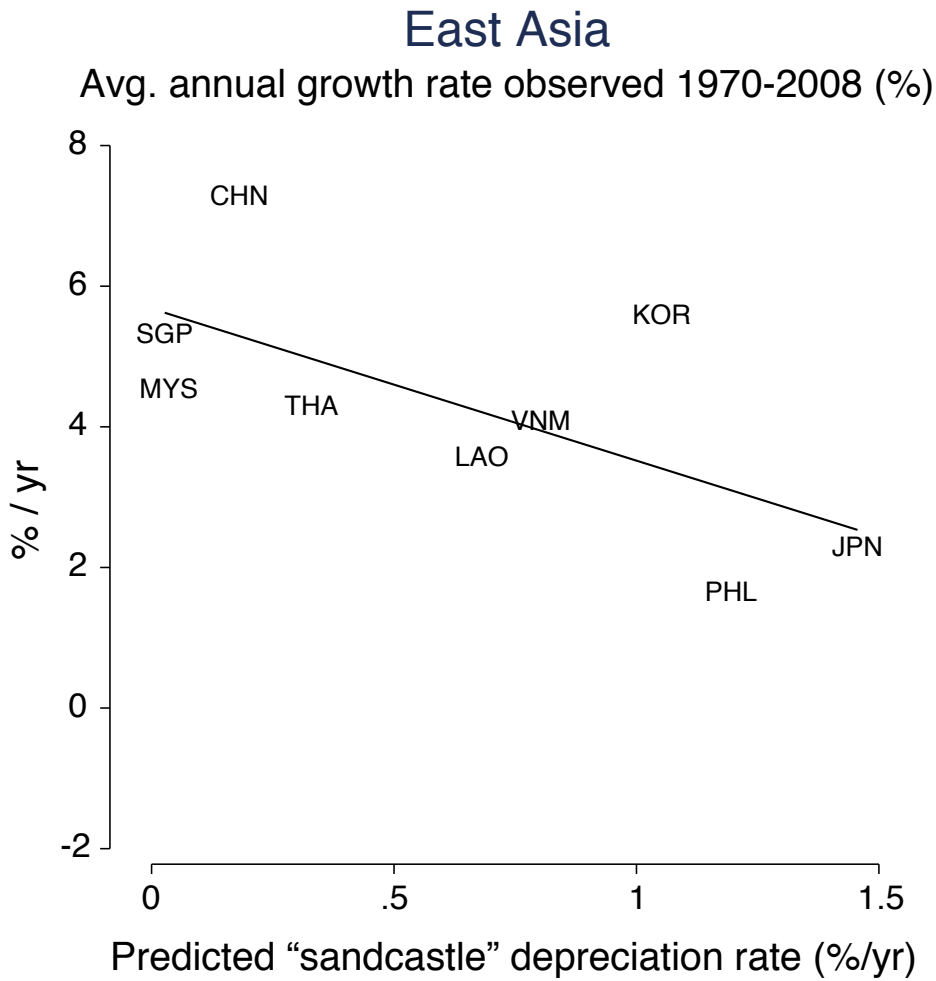
"Sandcastle depreciation": $\bar{\delta} \approx \frac{1}{s_2 - s_1} \int_{s_1}^{s_2} \delta(t) dt$

$$growth = investment - \bar{\delta} - pop\_growth - tech\_growth$$

Hsiang & Jina (AER, 2015)

Long run evidence consistent w/ "sandcastle depreciation"





Hsiang & Jina (AER, 2015)

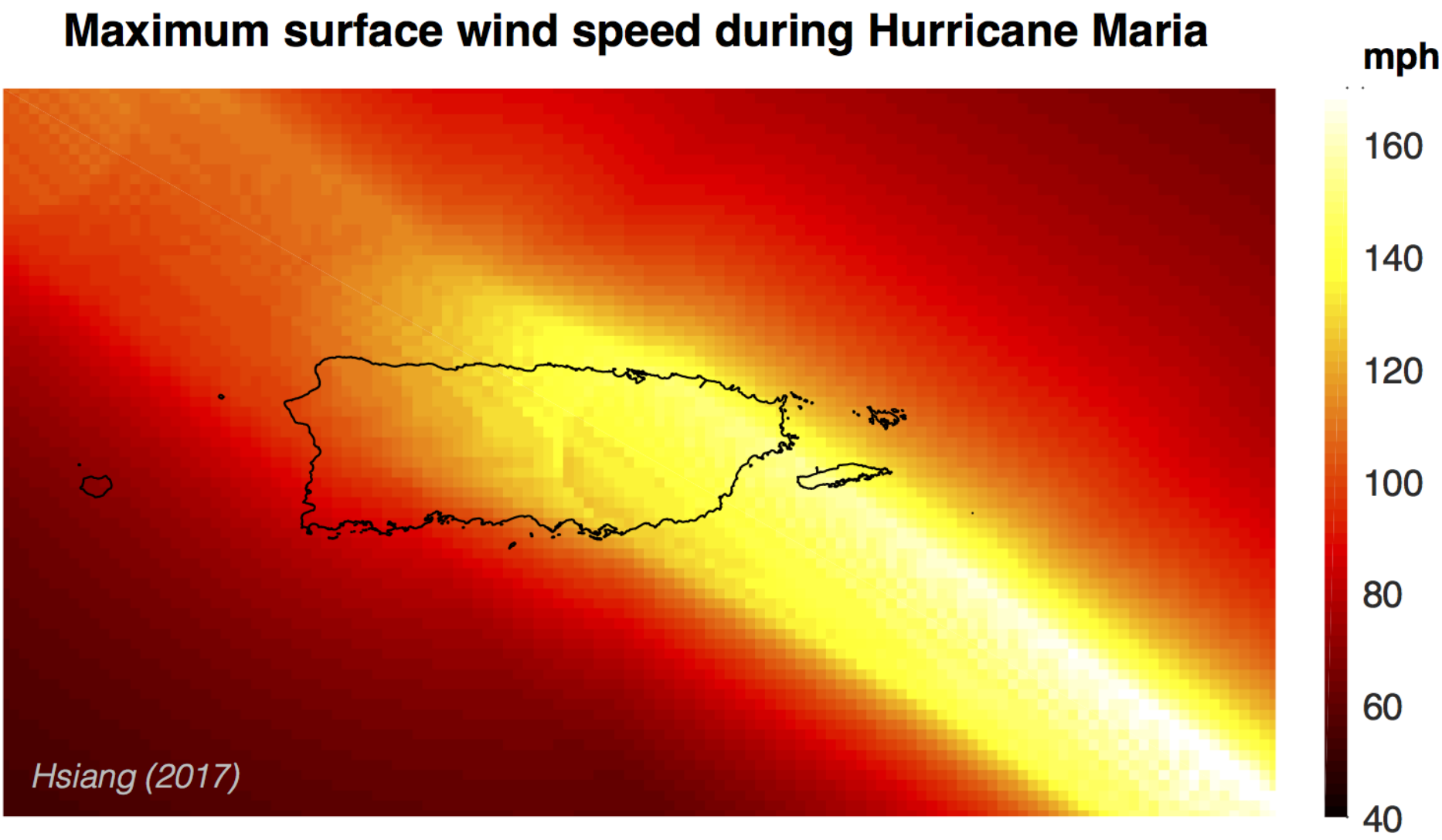
Comparing cyclones to other macroeconomic events

Event	Growth	Duration	Risk
Civil war[2]	−3.0%	10 yrs	6.3%
Taxes ↑ (+1% GDP)**[3]	−3.1%	4 yrs	†16.8%
1-σ cyclone	**−3.6%**	**20 yrs**	**14.4%**
Currency crisis[2]	−4.0%	10 yrs	34.7%
Executive constraints ↓[2]	−4.0%	10 yrs	3.7%
90-percentile cyclone	**−7.4%**	**20 yrs**	**5.8%**
Banking crisis[2]	−7.5%	10 yrs	15.7%
Financial crisis[4]	−9.0%	2 yrs	<0.1%
99-percentile cyclone	**−14.9%**	**20 yrs**	**0.6%**
Democratization[5]	+21.2%	30 yrs	1.4%

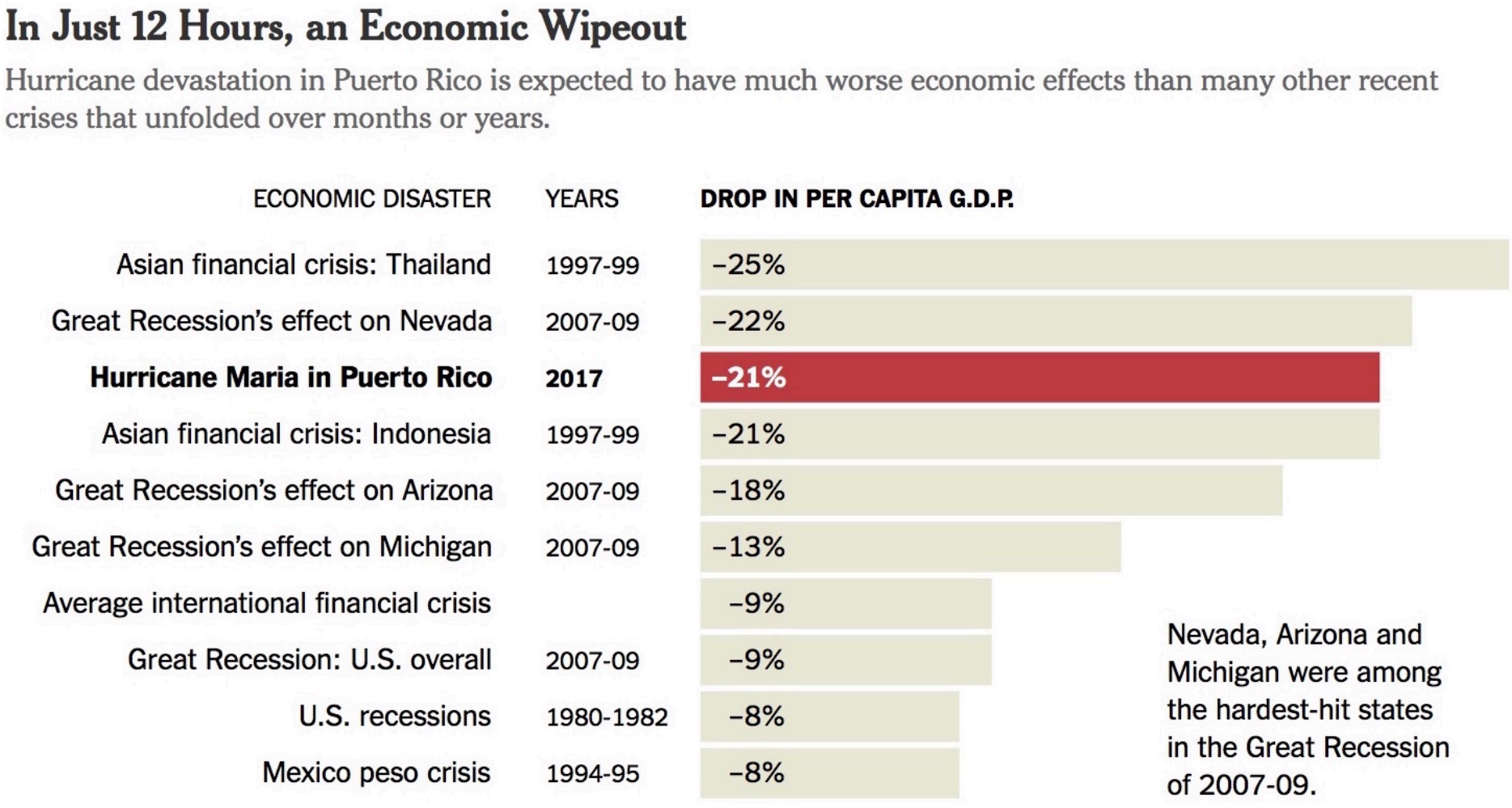
*Poor countries only. **USA only. †Number of quarters with any tax change.

[2]Cerra & Saxena (AER, 2008), [3]Romer & Romer (AER, 2010), [4]Reinhart & Rogoff (AER 2009), [5] Acemoglu, Naidu, Restrepo, Robinson (NBER, 2014)

A “new normal” ?


Maximum surface wind speed during Hurricane Maria
mph
160
140
120
100
80
60
40
Hsiang (2017)

Undoing 26 years of Puerto Rican growth in 12 hours



Hsiang & Houser (New York Times, 2017)

Climate Change $\rightarrow \Delta$ Hurricanes $\rightarrow \Delta$ Growth

NPV roughly $9.7 trillion (3% discount rate)

Climate Change $\rightarrow \Delta$ **Hurricanes** $\rightarrow \Delta$ **Growth**

NPV roughly $9.7 trillion (3% discount rate)

Climate Change $\rightarrow \Delta$ **Temperature** $\rightarrow \Delta$ **Growth**?

Why might temperature matter?

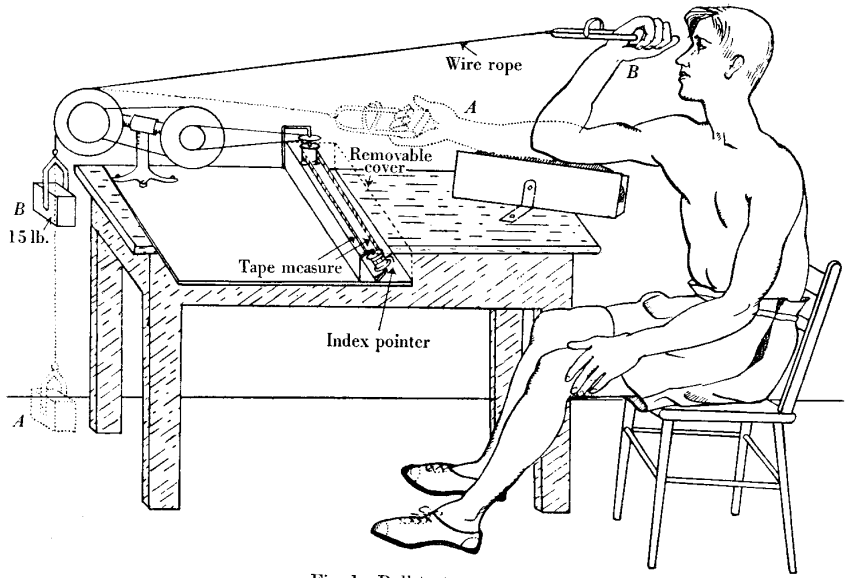


Fig. 1. Pull test apparatus.

British Naval Experiments
C. Mackworth (1947)
British Journal of Psychology

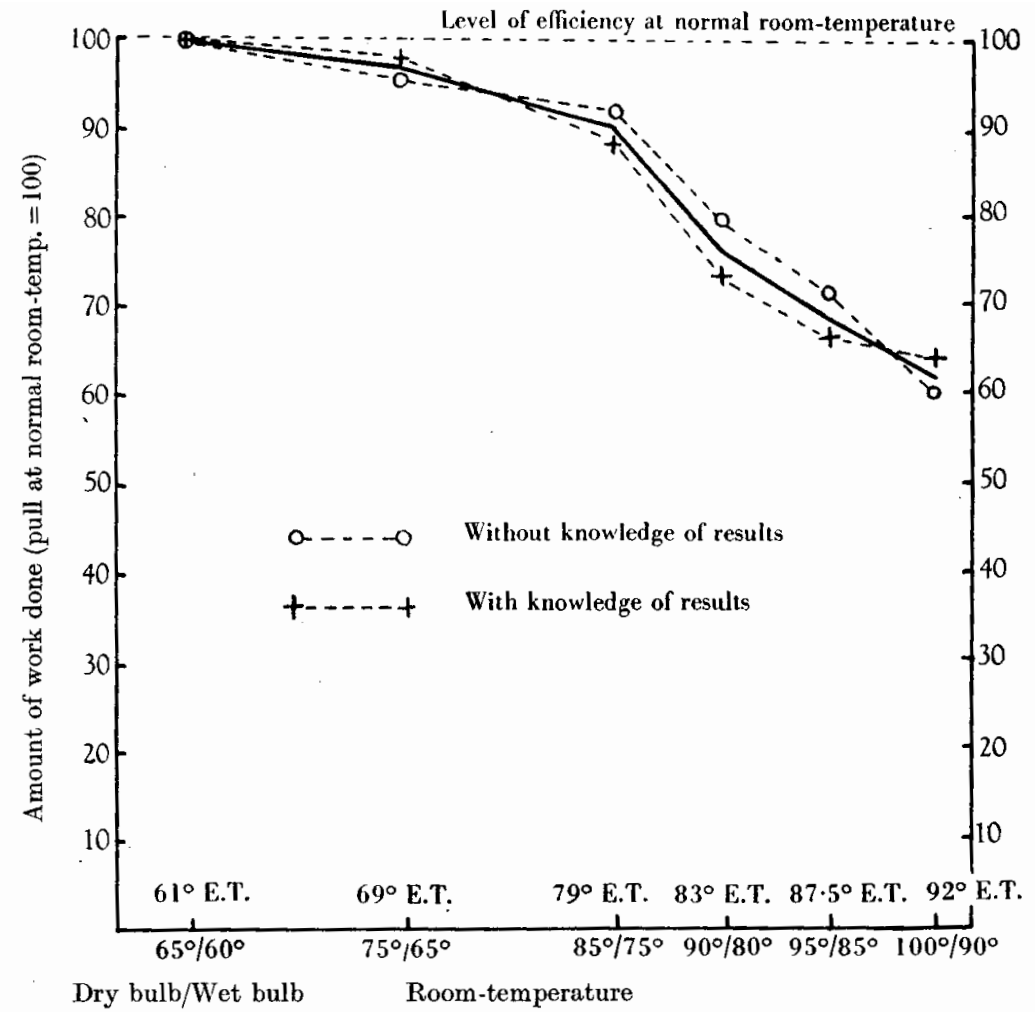
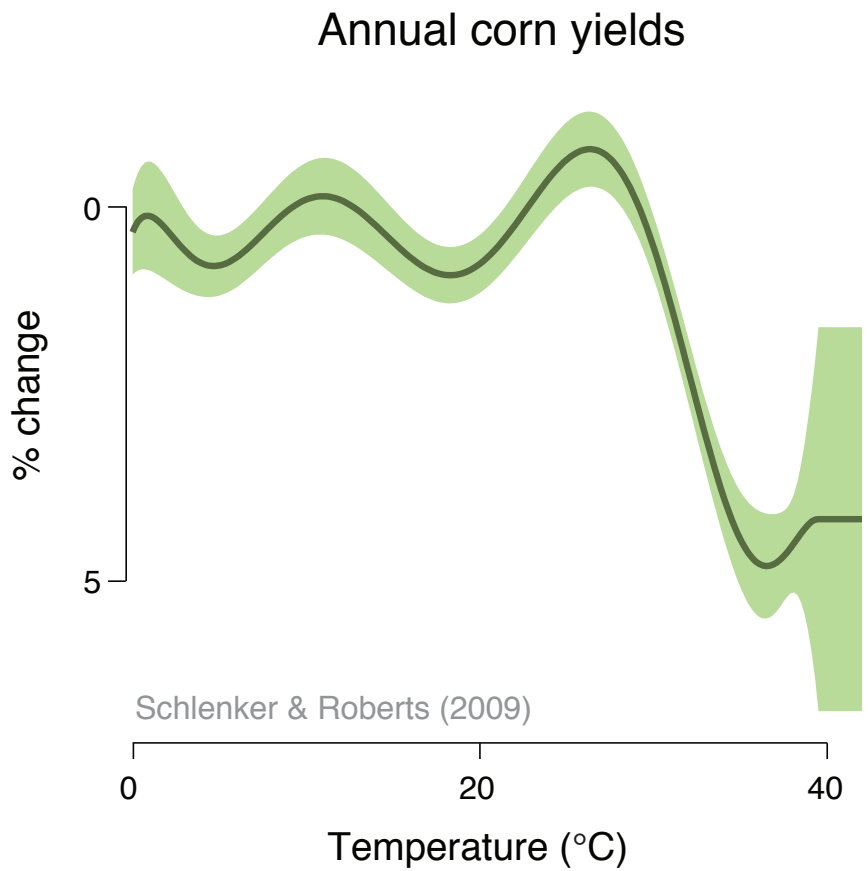
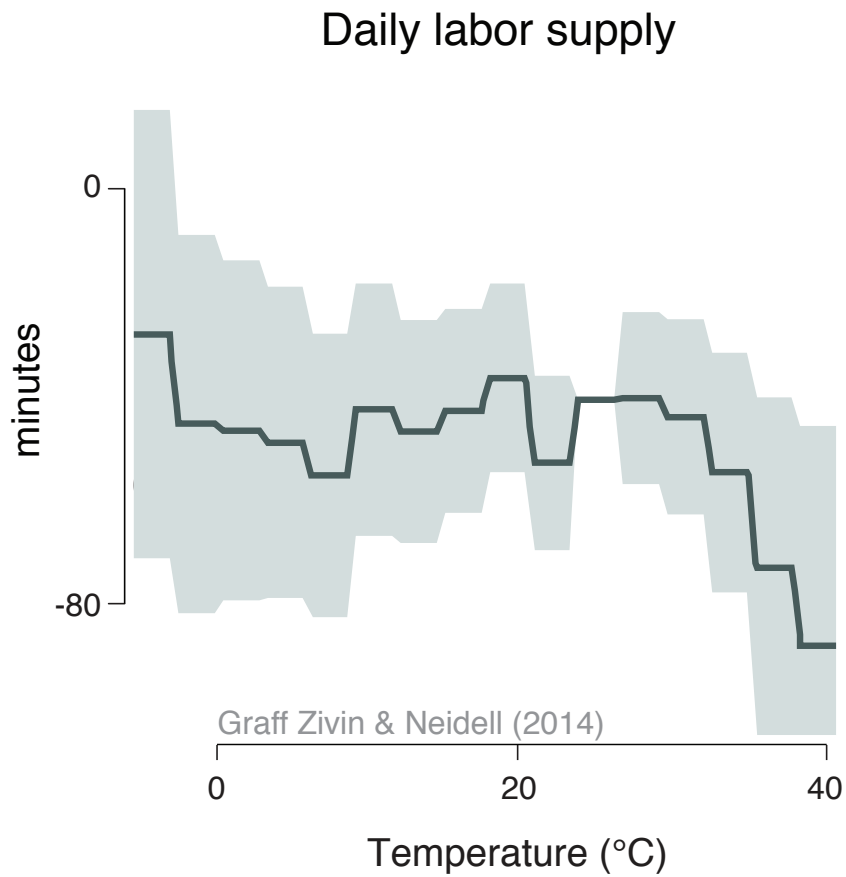


Fig. 3. The same *proportional* deterioration for high as for low incentive conditions when atmospheric temperature is raised.

Temperature affects productivity of labor & capital





Carleton & Hsiang (Science 2016)

An economy with temperature-sensitive units

T_d - temperature on day d of year t
K_j - capital in sector j with productivity A_j^K
L_j - labor is sector j with productivity A_j^L

Each day, based on temperature, capital and labor may be optimally reallocated between sectors:

$$q_j(T_d) = (A_j^K(T_d)K_j(T_d))^{\alpha}(A_j^L(T_d)L_j(T_d))^{1-\alpha}$$

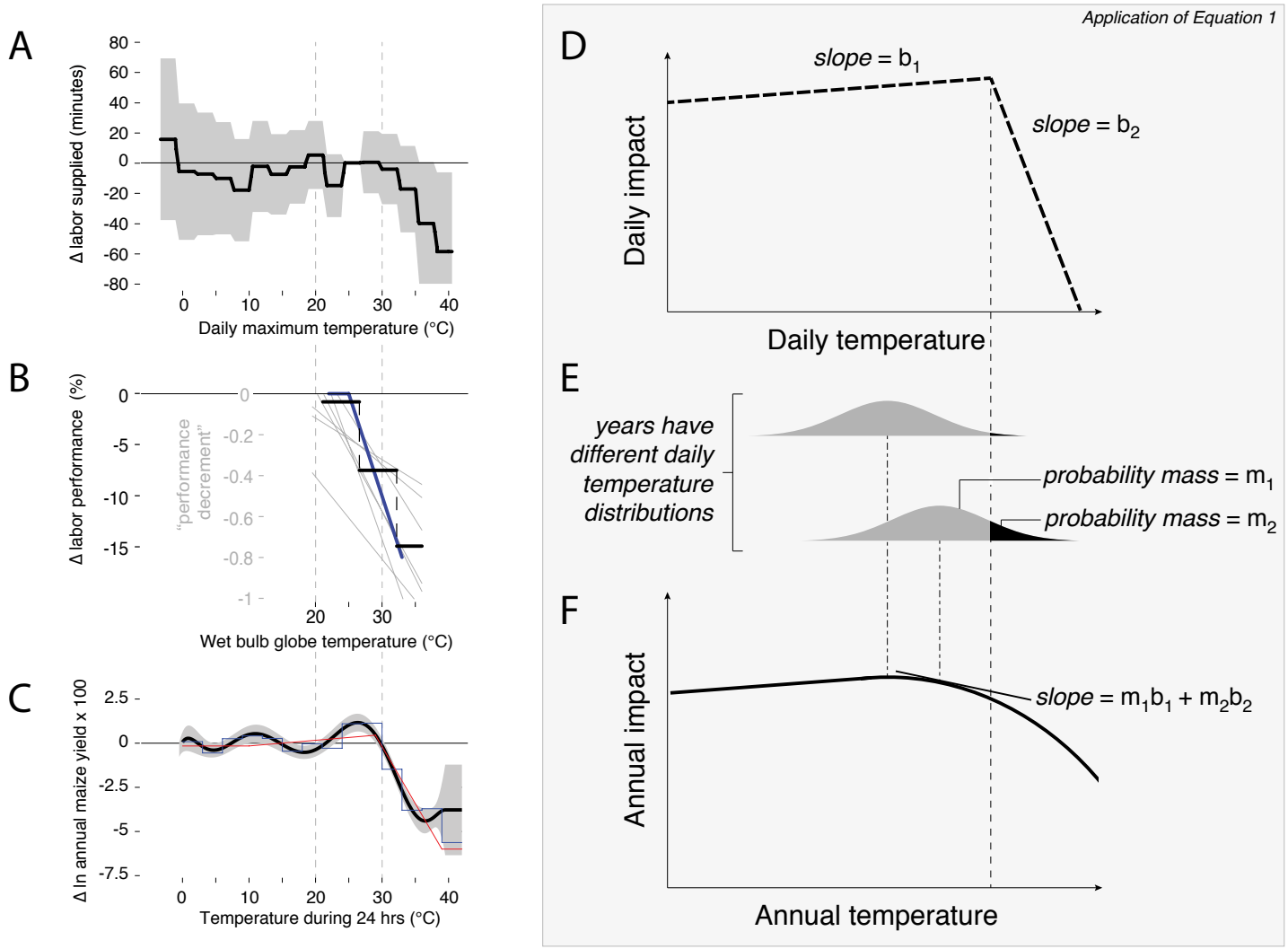
Optimal supply (q^*) and temperature-sensitive demand affects prices (p).

Repeated daily:

$$annual\_revenue_t = \sum_{d=1}^{365}\sum_{j} \underbrace{p_j(T_d) \cdot q_j^*(T_d)}_{\text{daily income sector } j}$$

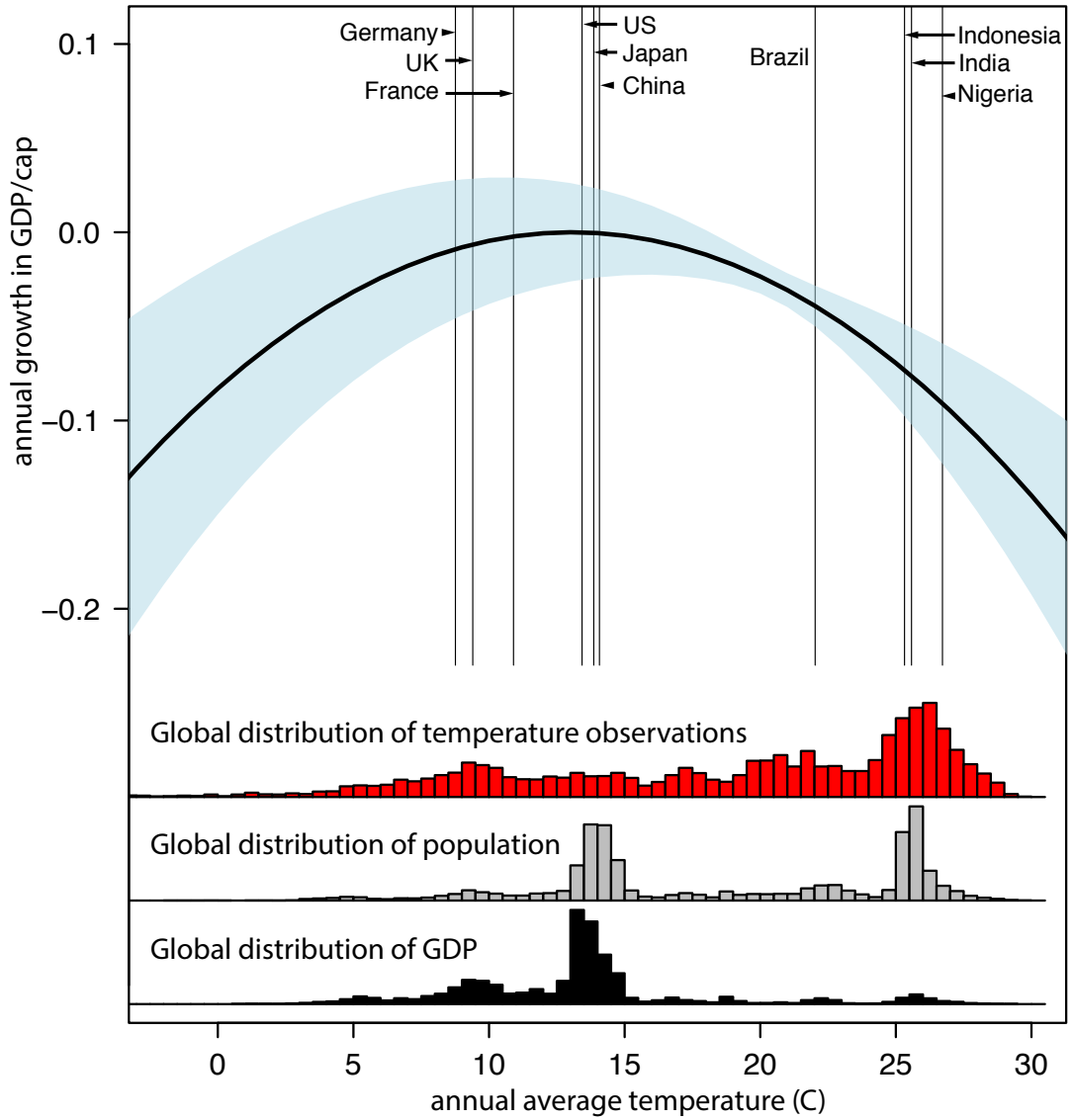
Dergugina & Hsiang (2014)

How should micro productivity map to macro?



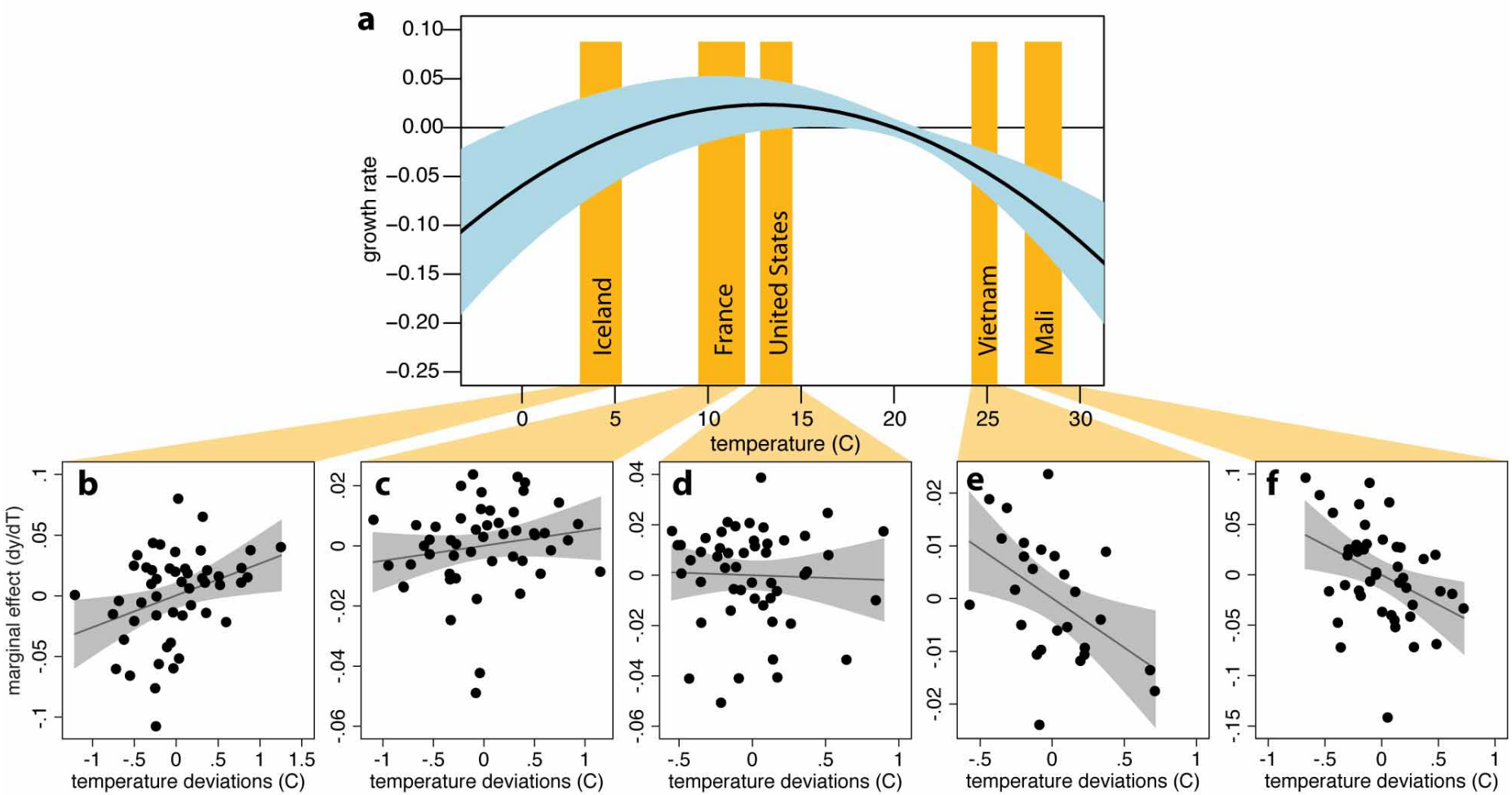
Burke, Hsiang, Miguel (Nature, 2015)

Global non-linear response of growth to temperature



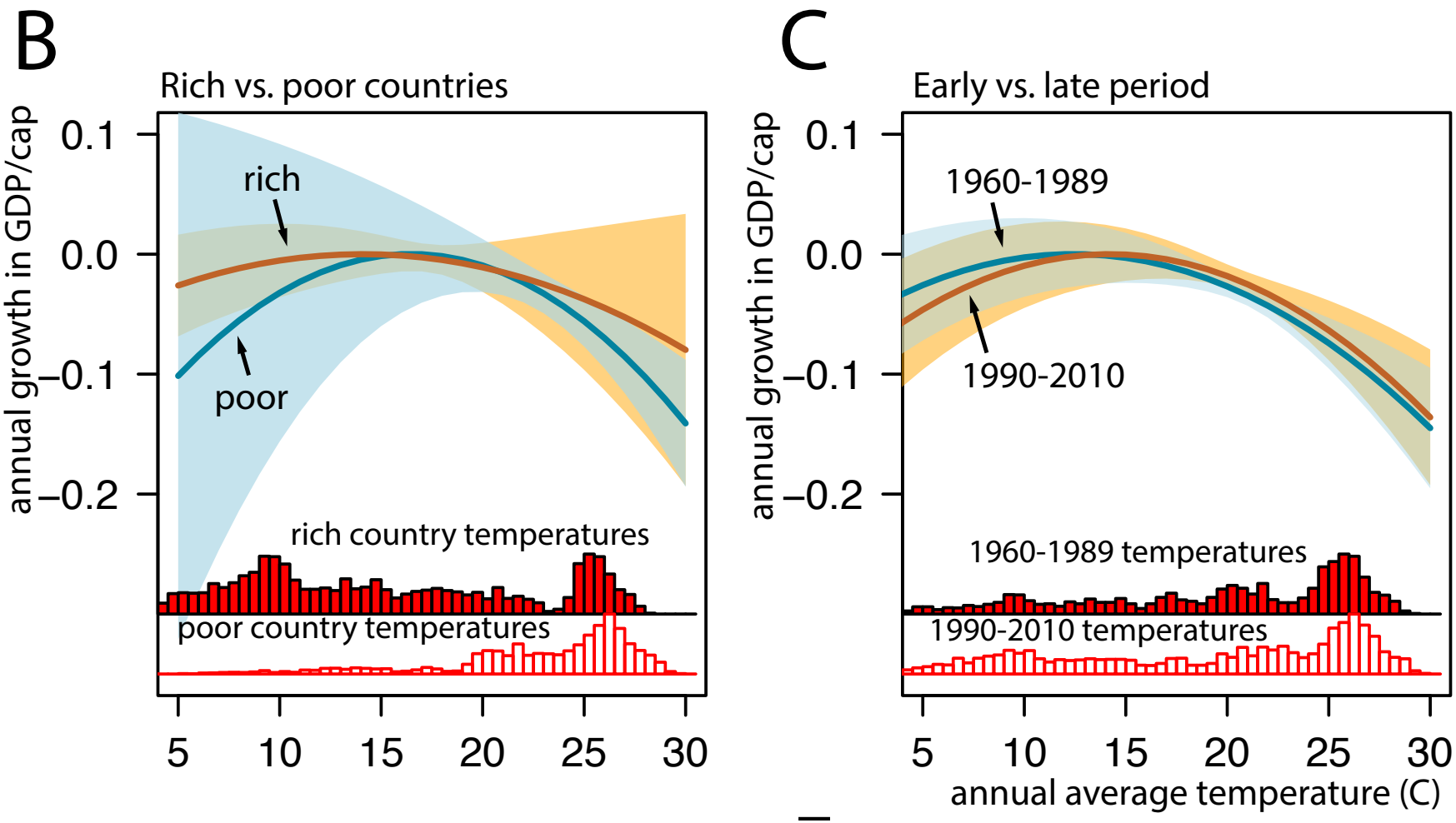
Burke, Hsiang, Miguel (Nature, 2015)

Using within-country variation to estimate a global function



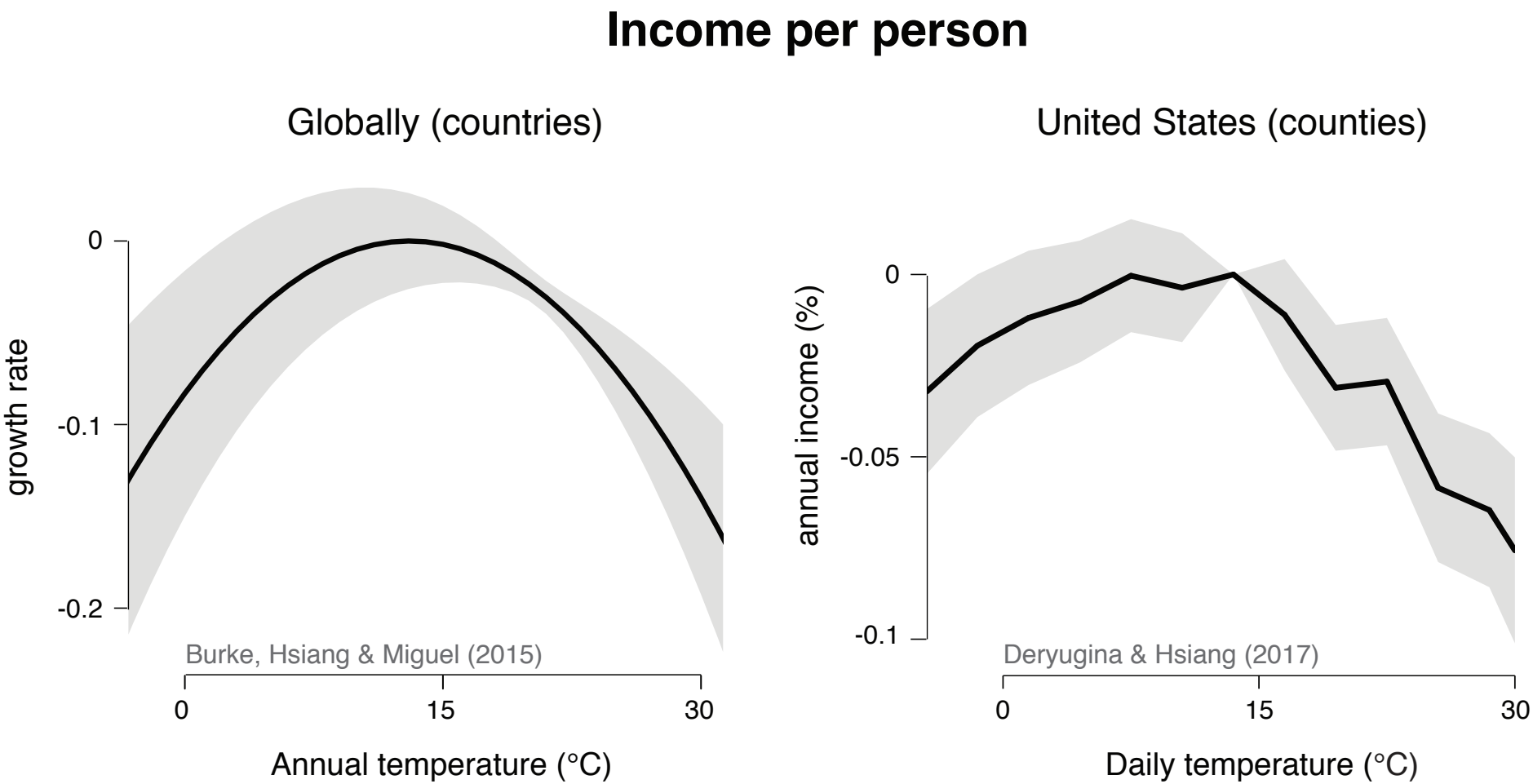
Burke, Hsiang, Miguel (Nature, 2015)

Rich vs Poor? Early vs late?

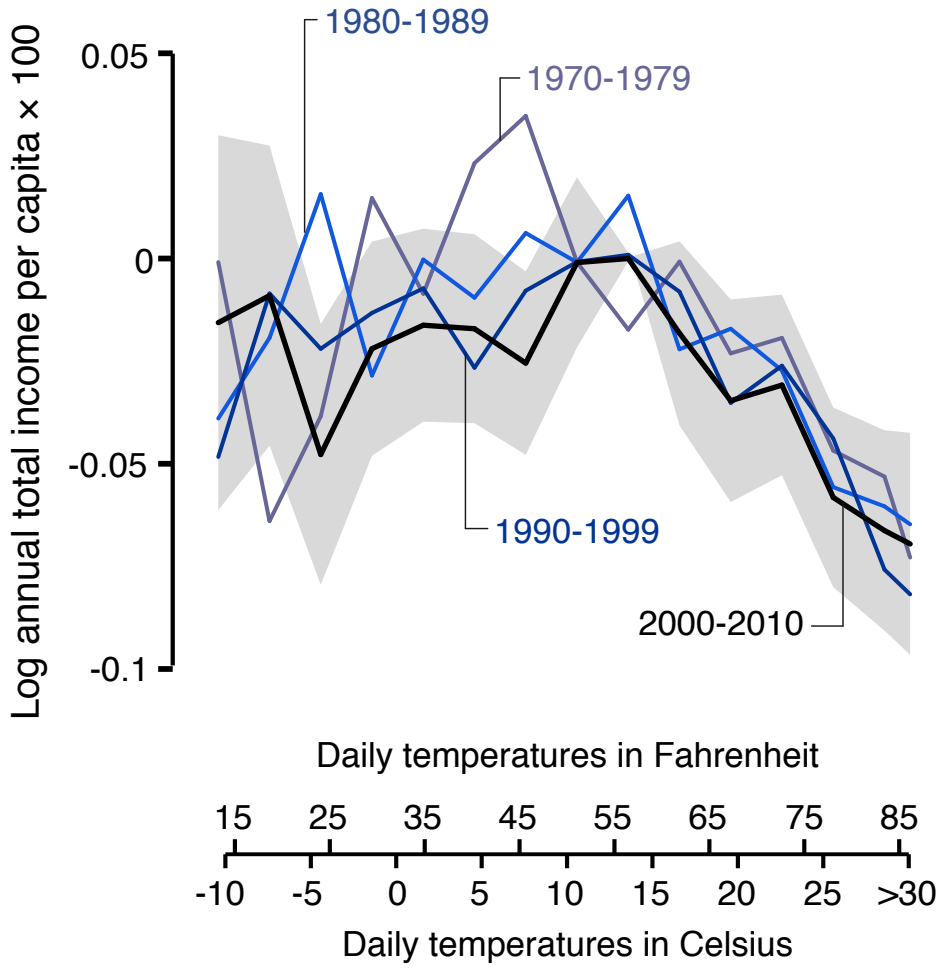


Burke, Hsiang, Miguel (2015)

Really in rich countries? Check in USA



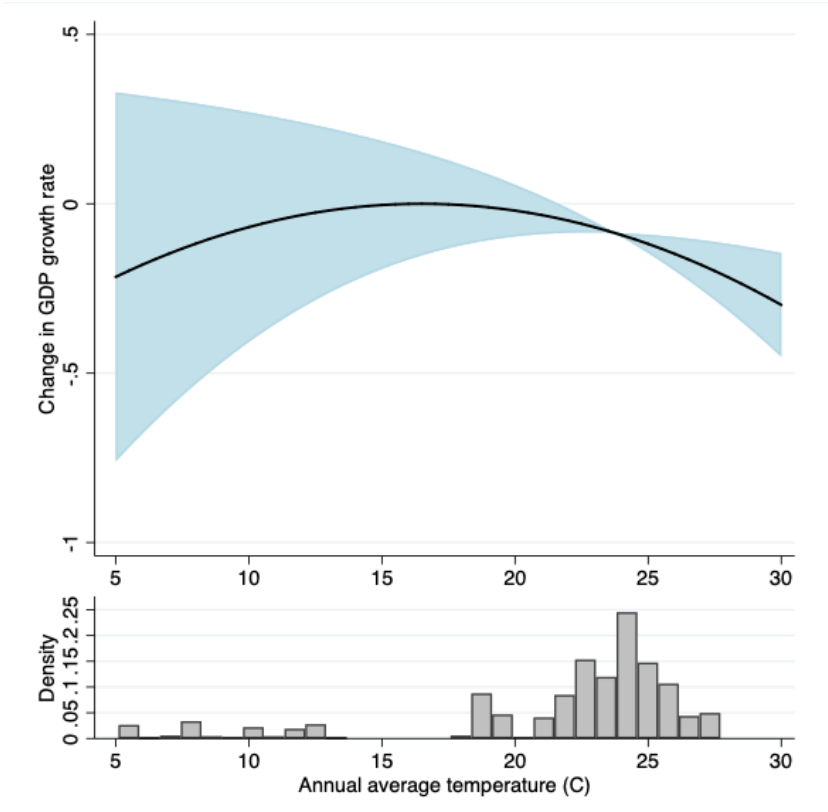
Effect in USA is stable over time



Deryugina & Hsiang (2017)

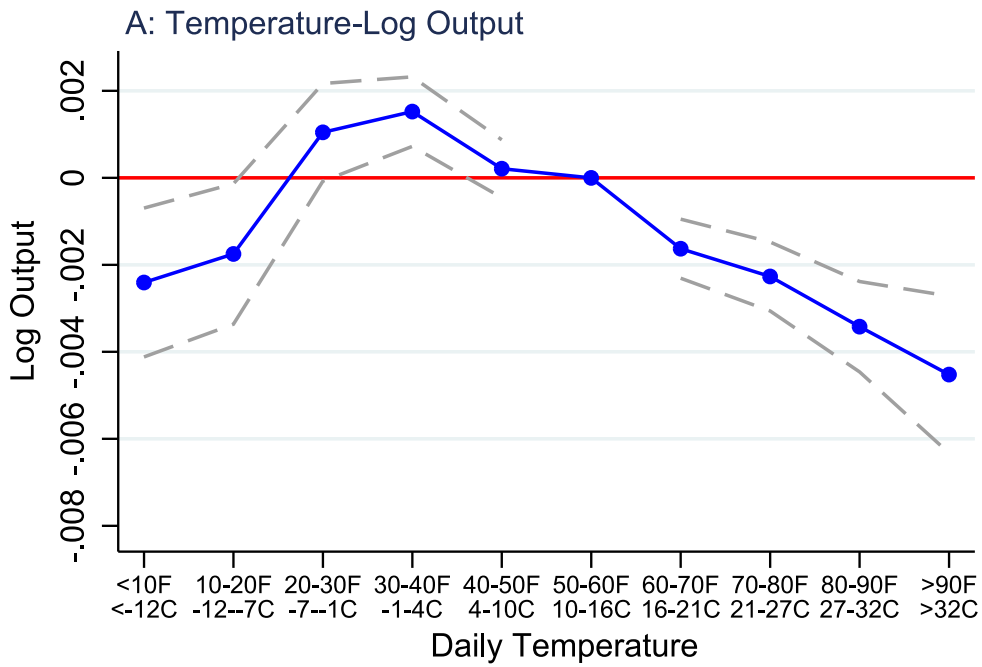
Replication with alternative data sets & samples

India



Jain et al (2019)

China

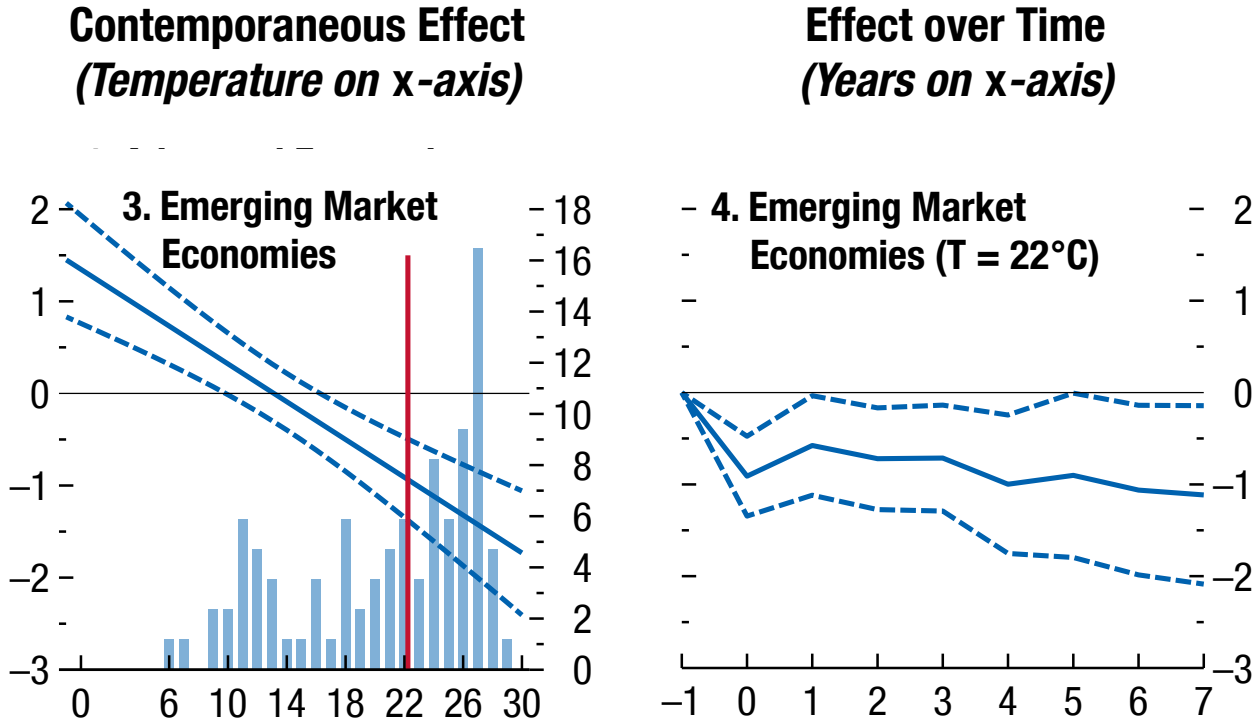


Zhang et al (2018)

Also: Brazil, Indonesia, Europe, etc.

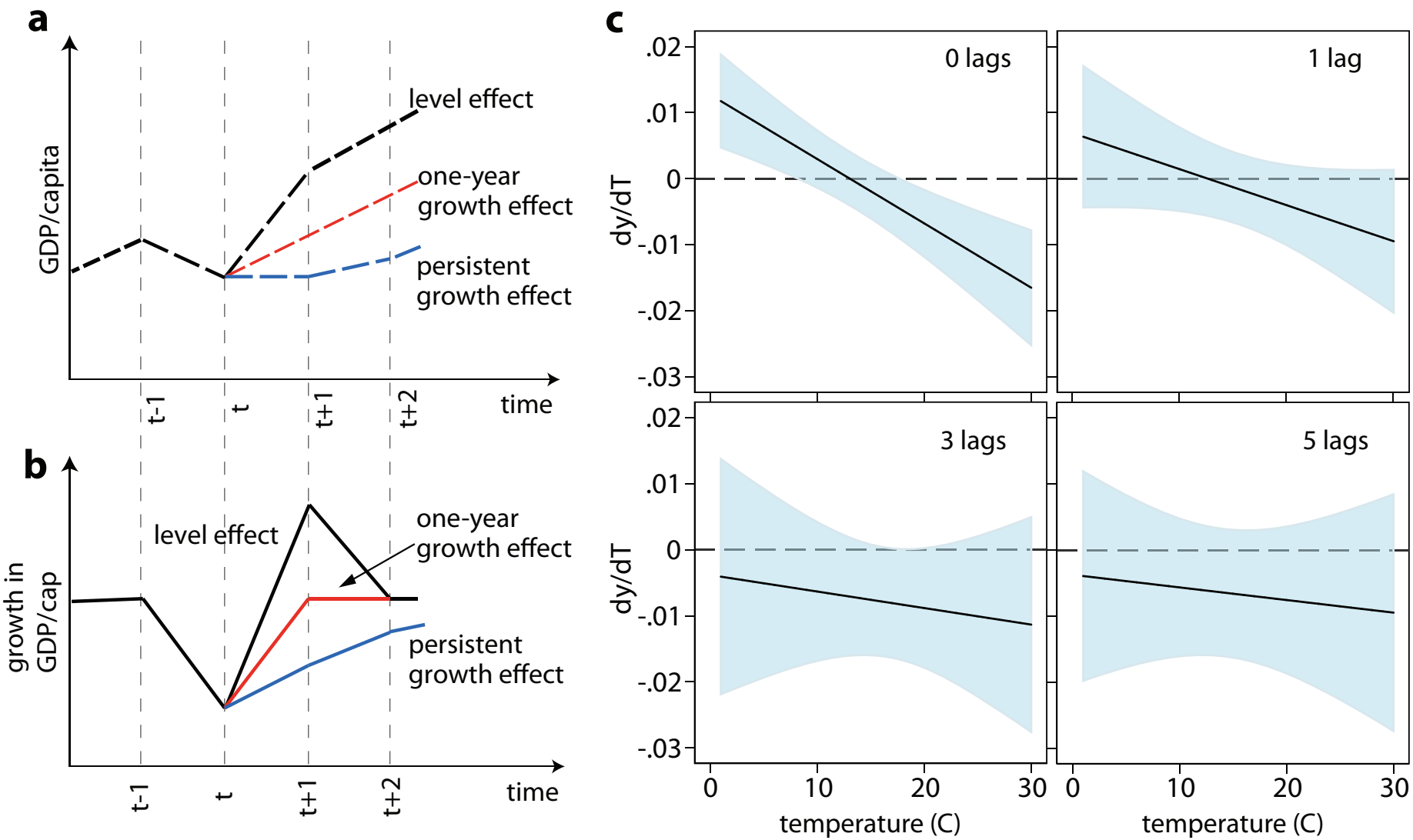
Replication by the IMF

Figure 3.7. Effect of Temperature Increase on Real per Capita Output
(Percent)



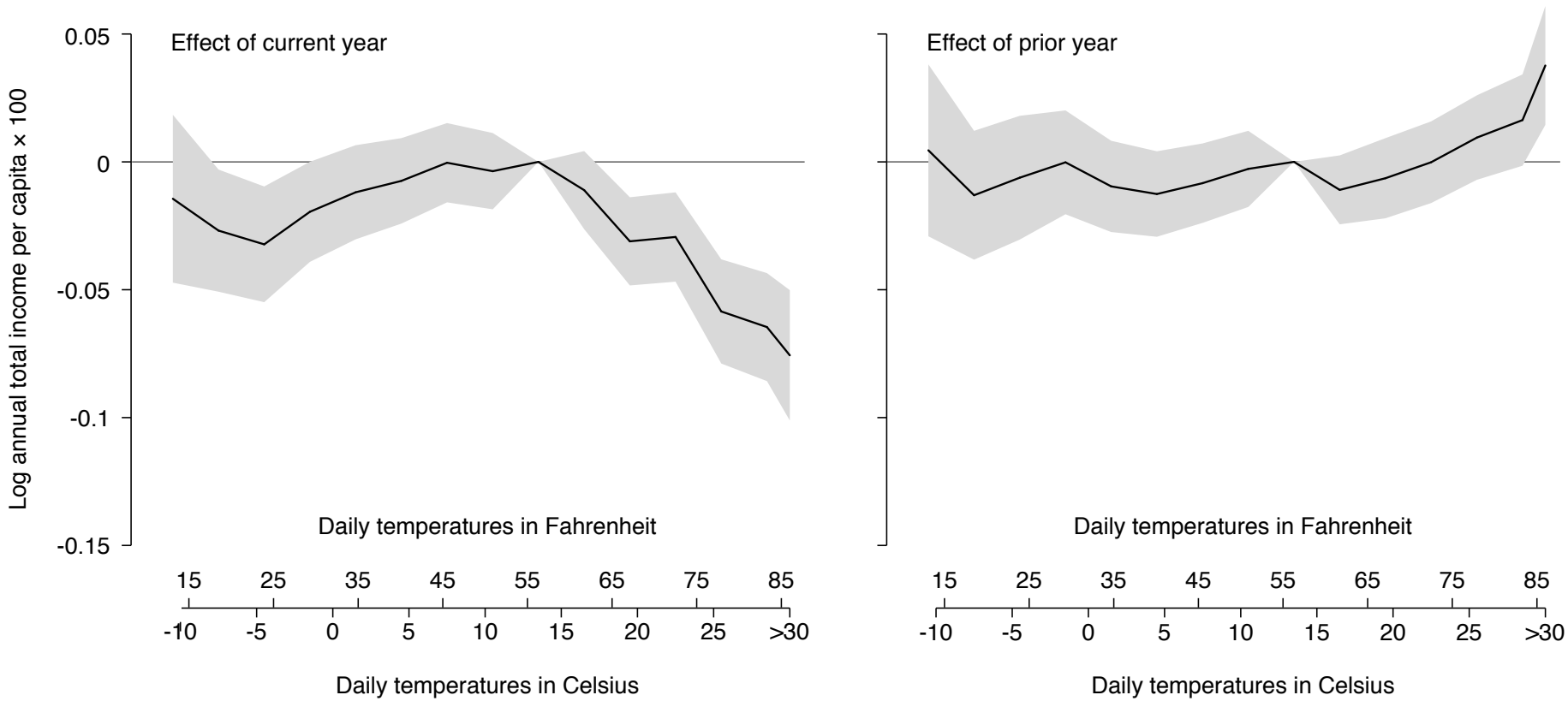
World Economic Outlook (2017)

Is it really a growth effect? (Global)



Burke, Hsiang, Miguel (2015)

Is it really a growth effect? (USA)



Deryugina & Hsiang (2017)

Why is this happening?

1. Populations are adapting

2. Adaptation is a reallocation of resources

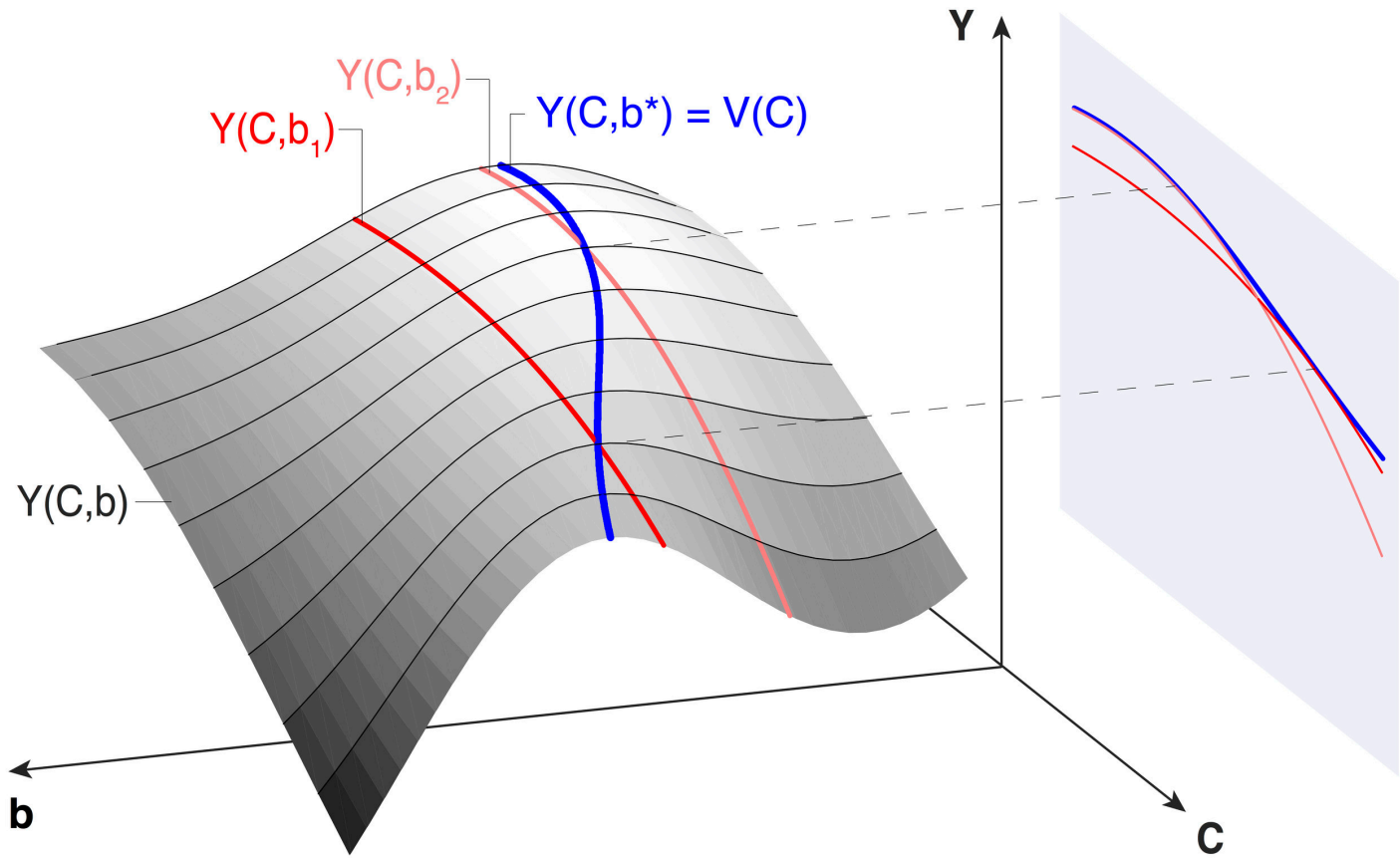
3. In response, markets maximize total revenue (Koopmans, 1957)

4. Opportunity costs of reallocated resources lowers output

5. This is effect can be measured "exactly" by observing weather shocks (Envelope Theorem)

Deryugina & Hsiang (2017)

The "Marginal Product of Climate"



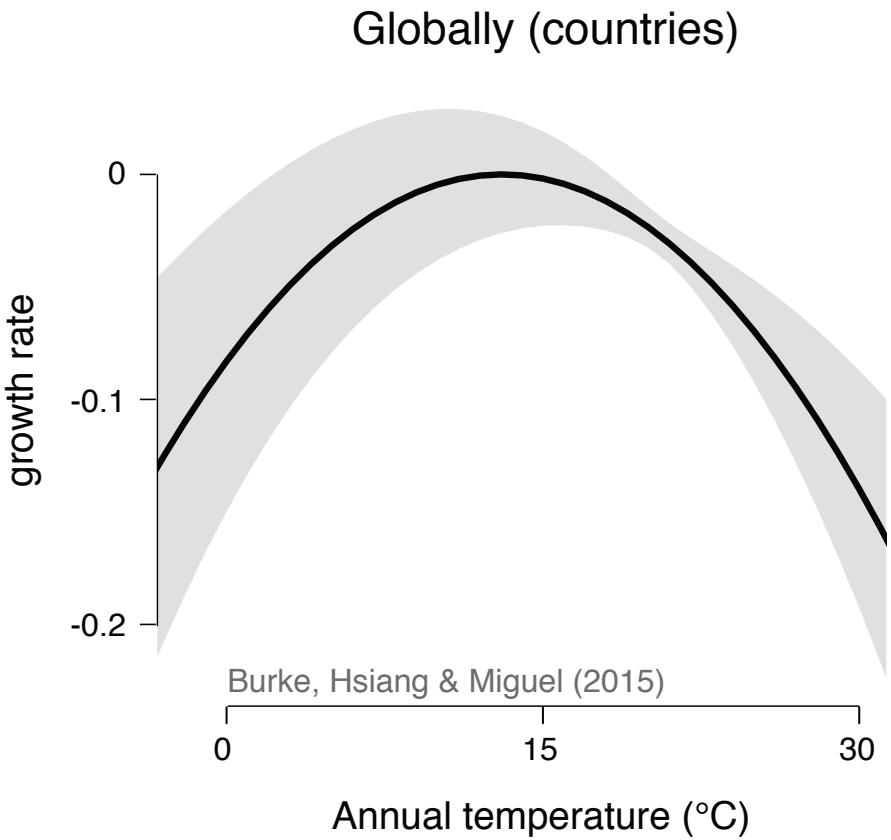
b = adaptation **C** = climate **Y** = income

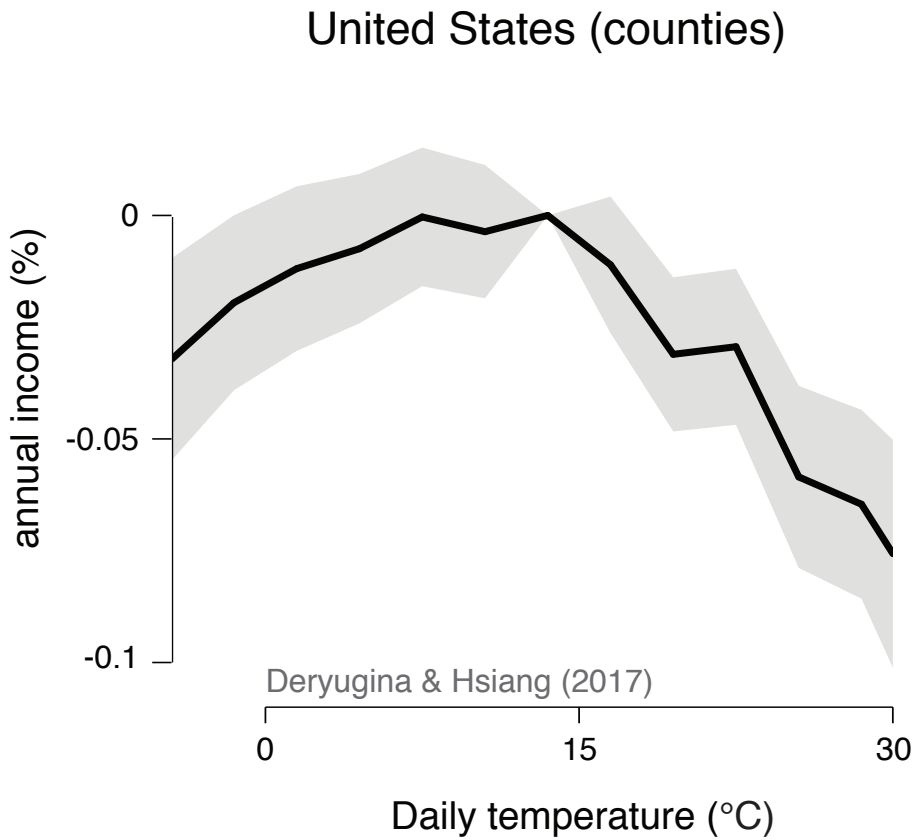
V(C) = value function for climate

Deryugina & Hsiang (2017)

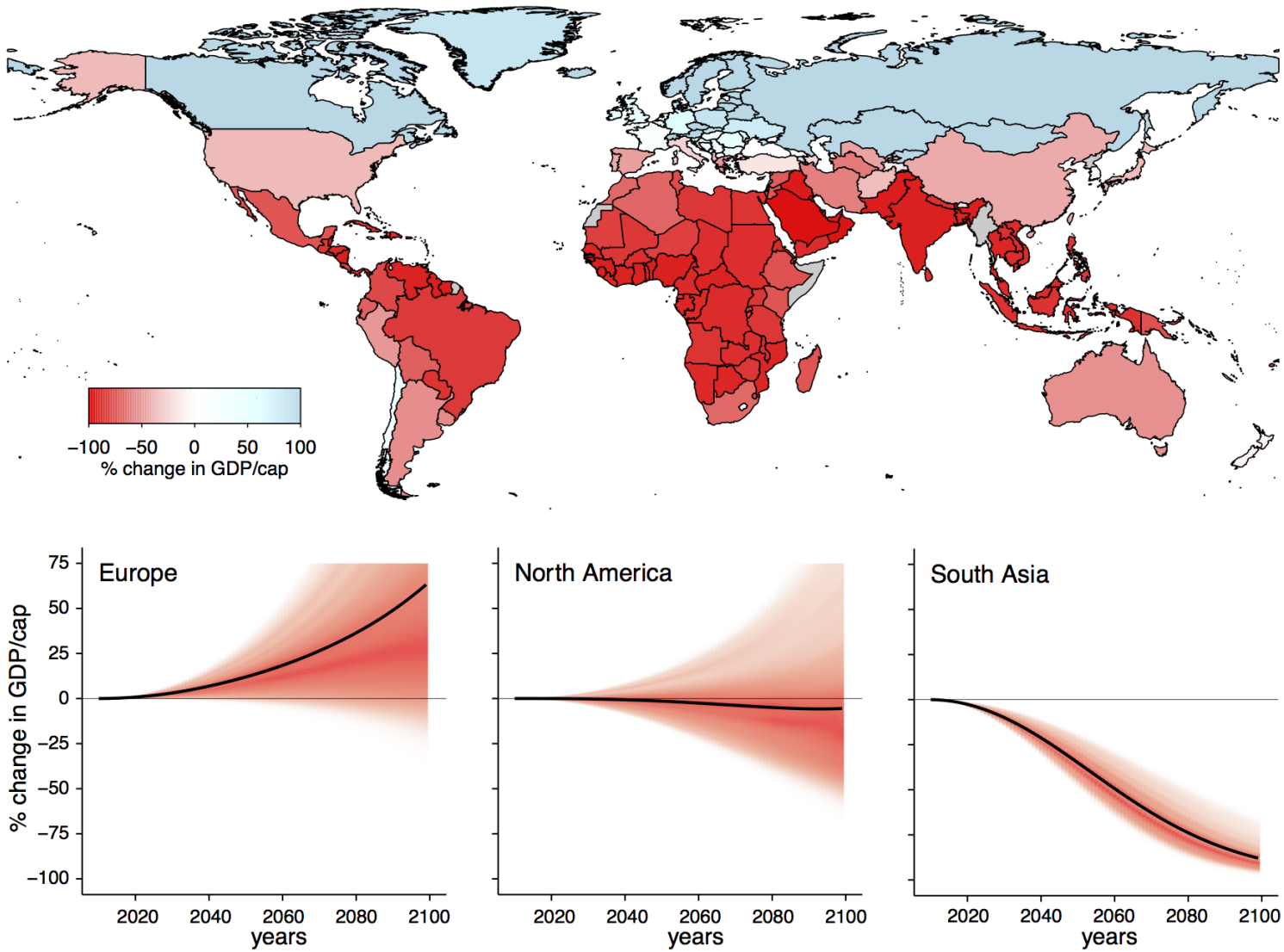
The "Marginal Product of Climate"

Income per person



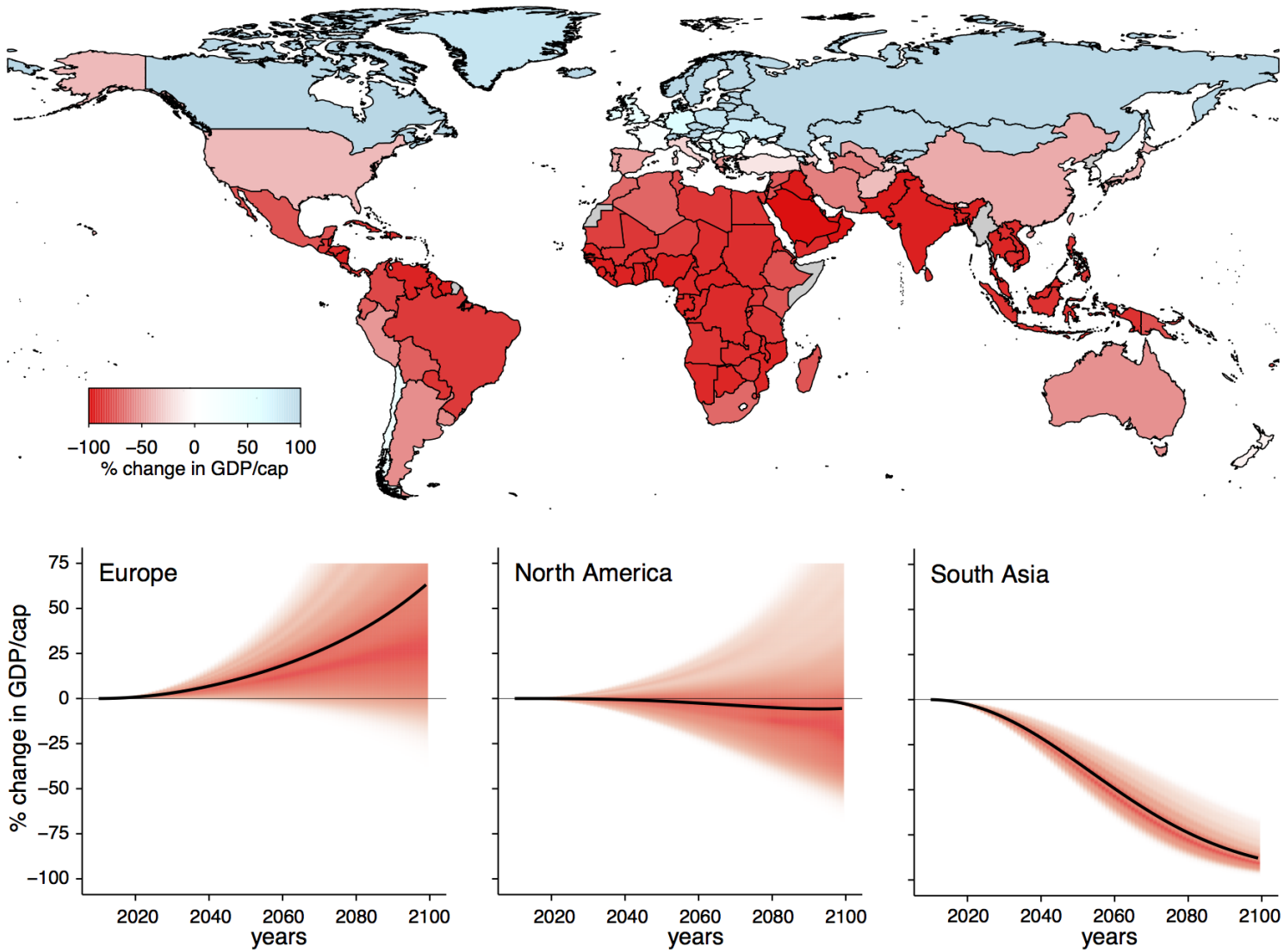


Projecting forward (avg loss $\sim$ 23% World GDP)



Burke, Hsiang & Miguel (Nature 2015)

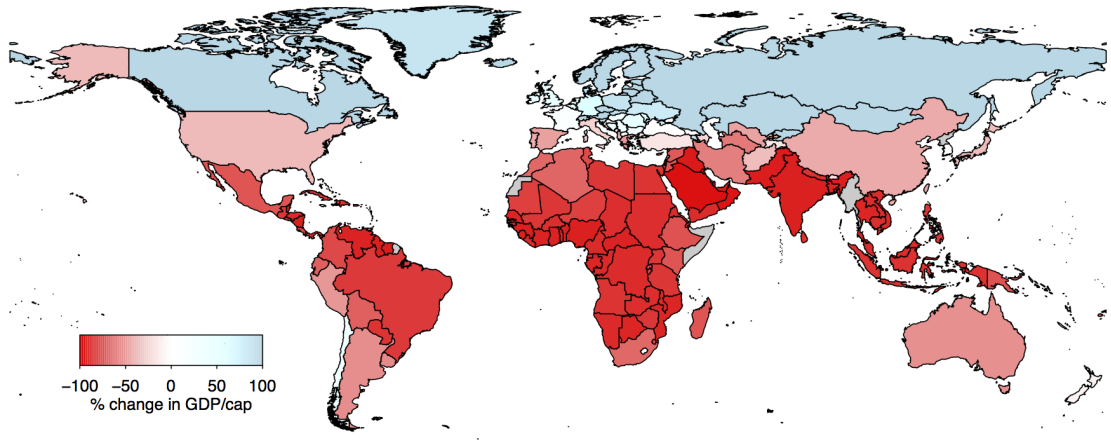
Can trade address these unequal impacts?



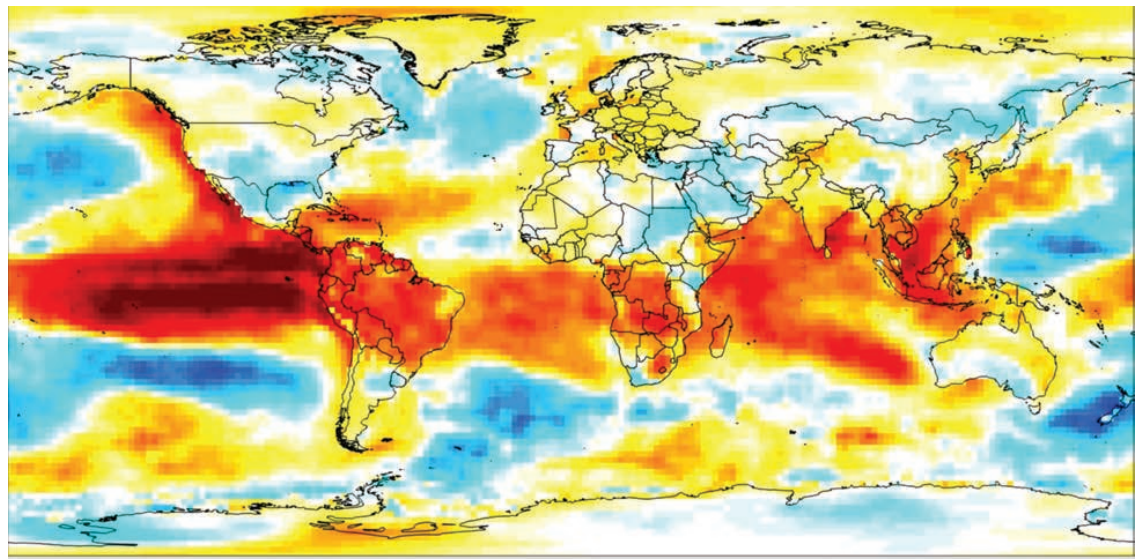
Burke, Hsiang & Miguel (Nature 2015)

Spatial correlation × trade cost = problem

climate change →



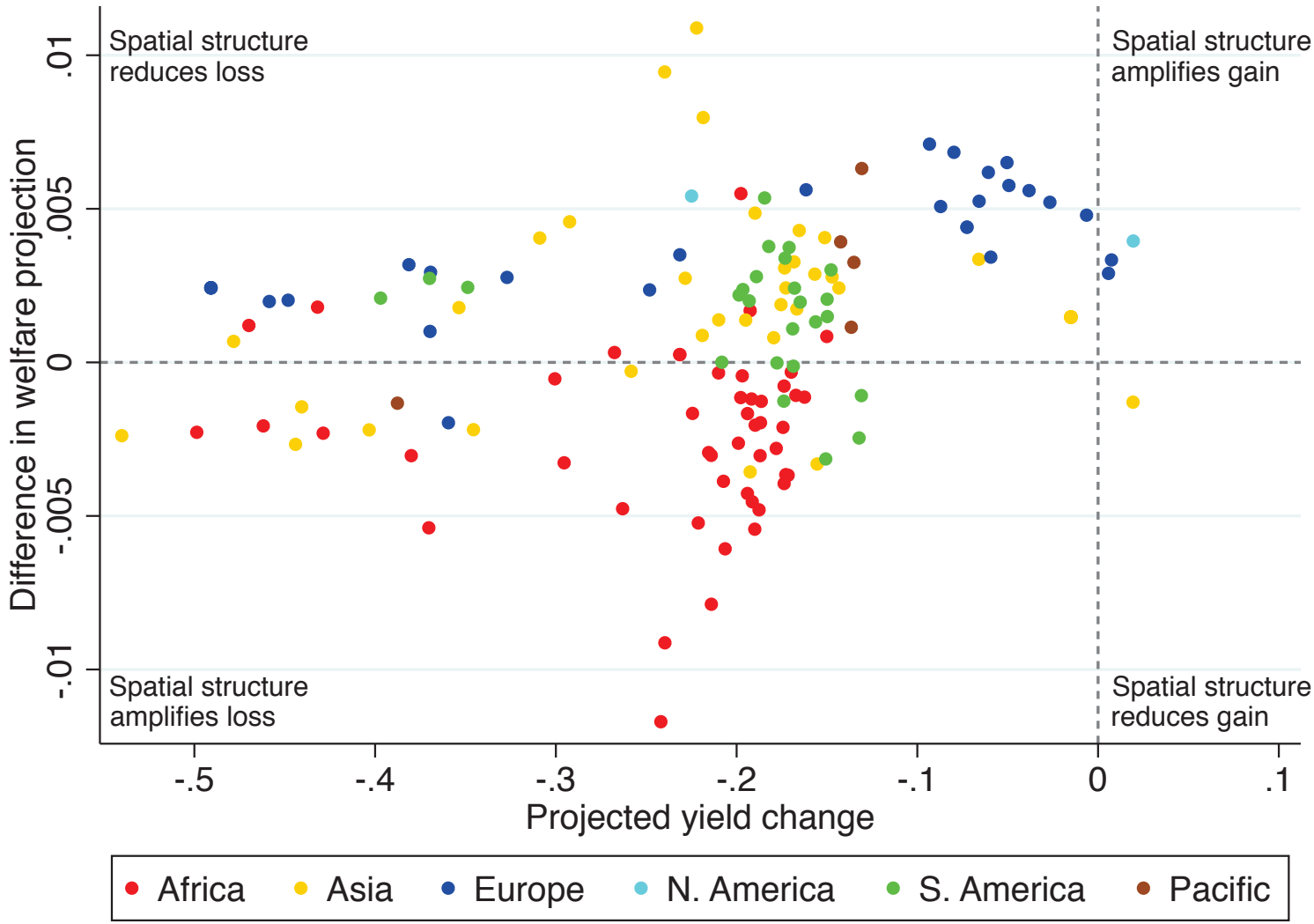
El Nino →



NOTES: This map depicts pixel-level correlations between ENSO in December and average temperature during the following February for 1961–2013. Red areas are hotter with warmer ENSO conditions. Blue areas are cooler with warmer ENSO conditions.

Dingel, Meng & Hsiang (2021)

Spatial correlation amplifies welfare inequality via trade



Dingel, Meng & Hsiang (2021)

Take home points

Empirical approaches are tractable.

Repeated hurricanes slow growth substantially.

Temperature has a nonlinear effect on growth.

$\rightarrow$ US & globally

$\rightarrow$ widely reproducible result

Spatial correlation of impacts limit benefits of trade.

Thank you

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