CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Climate Migration and Immobility

Thanks for joining us!
The session will begin shortly.

UCLA Luskin Center for Innovation

Thank you to our event collaborators

SPONSOR

EDISON INTERNATIONAL®

PARTNERS

Atlantic Council
Adrienne Arsht-Rockefeller Foundation Resilience Center

American Society of Adaptation Professionals

Climate Resolve

EcoAdapt™

The Greenlining Institute

Island Press

LARC

Lincoln Institute of Land Policy

UC Davis Climate Adaptation Research Center

UCLA Center for Healthy Climate Solutions

Union of Concerned Scientists

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Widgets are resizable and movable

You can drag the presenter's video around your screen.

Have a question for presenters? Click the ? icon.

Hélène Benveniste
Harvard University

Timothy Foreman
King's College London

Stephanie Lackner
IE University

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM
MEASURING & REDUCING SOCIETAL IMPACTS

UCLA Luskin Center for Innovation

Hélène Benveniste

Postdoctoral Environmental Fellow, Harvard University

@HeleneBenvenist

Climate Change Increases Resource-Constrained Immobility

Climate Change Increases Resource-Constrained Immobility

UCLA Climate Adaptation Research Symposium 2021

Hélène Benveniste   Michael Oppenheimer   Marc Fleurbaey

Center for the Environment & Kennedy School, Harvard University
School of Public and International Affairs, Princeton University
Paris School of Economics, CNRS

Motivation

Climate Change and International Migration: A Timely Topic

Migration and Immobility: Two Sides of the Same Coin

Climate Change and International Migration: A Timely Topic

Migration and Immobility: Two Sides of the Same Coin

MOVE

Involuntary Consequence

Choice

STAY

Climate Change and International Migration: A Timely Topic

Migration and Immobility: Two Sides of the Same Coin

Resources

MOVE

STAY

Resource Constraints

Climate Change and International Migration: A Timely Topic

Migration and Immobility: Two Sides of the Same Coin

Resources

MOVE

STAY

Resource-Constrained Immobility

Resource Constraints

Climate Change and (Im)mobility: A Complex Effect

Groundswell, World Bank, 2018

How much will climate change constrain international migration?

This Project - Overview of Findings

Objectives

Model migration/remittance flows at income quintile level

Include it + income distributions in a climate-economy model

This Project - Overview of Findings

Objectives

Model migration/remittance flows at income quintile level

Include it + income distributions in a climate-economy model

Climate change decreases emigration of lowest income levels

$\geqslant$ 10% in some regions for medium devt/climate scenarios

$\leqslant$ 20% in most regions for pessimistic scenarios

Resource-constrained immobility key in climate-migration

Remittances do not compensate for damages from CC

Populations unable to leave will be extremely vulnerable

Relevant Literature

Involuntary (im)mobility

Zickgraf 2018, Nawrotski and DeWaard 2018, Carling 2002, Adams 2016, Lubkemann 2008, Ayeb-Karlsson et al. 2020

Empirical evidence of climate change effect on migration

Black et al. 2011, Rigaud et al. 2018, McLeman 2019, Cattaneo and Peri 2016, Adger et al. 2015

Climate change effect on poverty and inequality

Dennig et al. 2015, Rao et al. 2017, Diffenbaugh and Burke 2019, Mendelsohn et al. 2006, Hallegatte and Rozenberg 2017

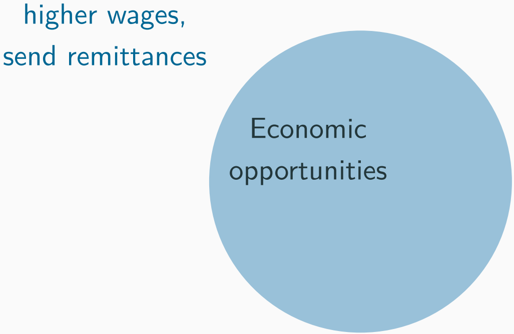
Migration projections in climate change context

Burzynski et al. 2019, Desmet and Rossi-Hansberg 2015, Cohen et al. 2008, Cruz and RH 2021, Benveniste et al. 2020

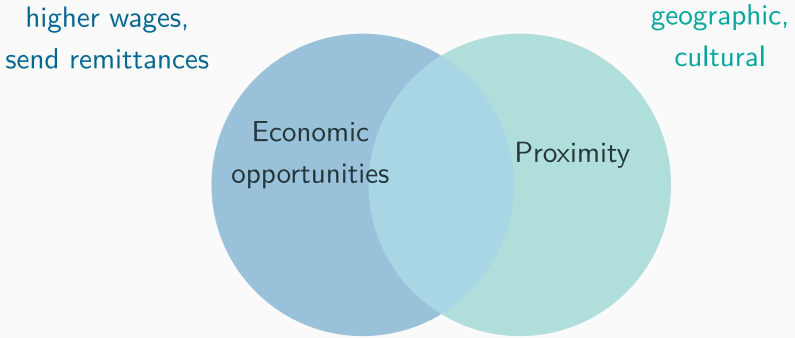
Methods

Major drivers of international, long-term migration

Major drivers of international, long-term migration

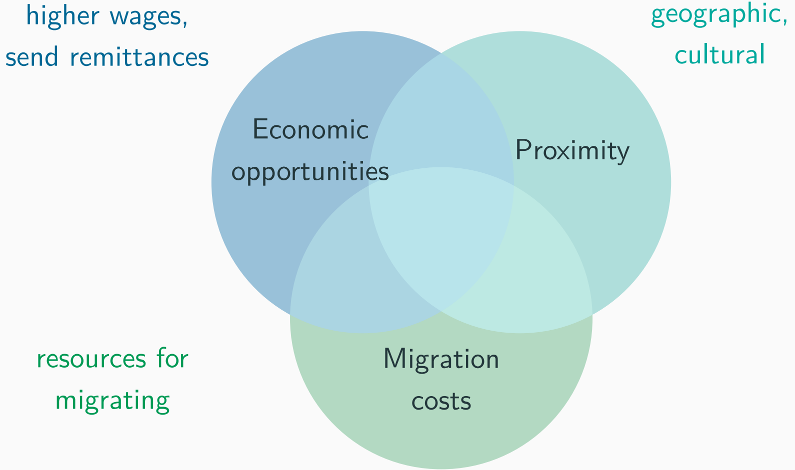


Major drivers of international, long-term migration



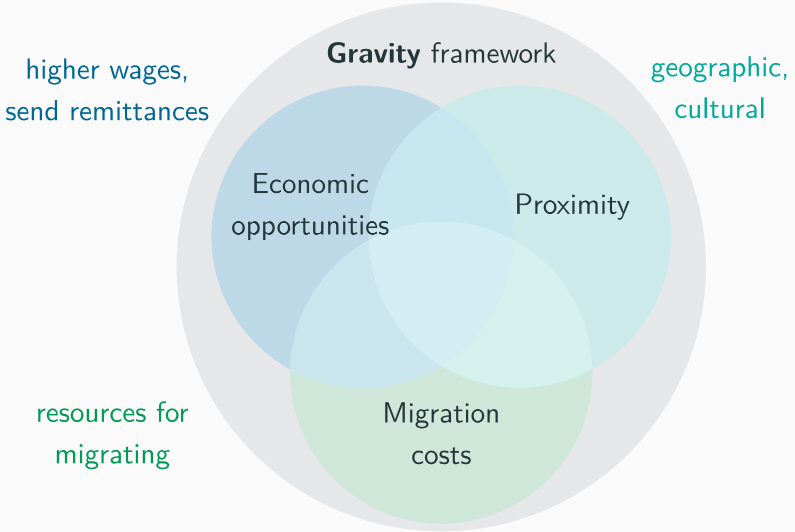
A Model of International Migration and Remittances

Major drivers of international, long-term migration



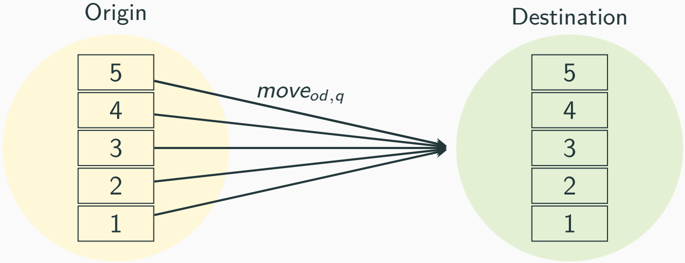
A Model of International Migration and Remittances

Major drivers of international, long-term migration

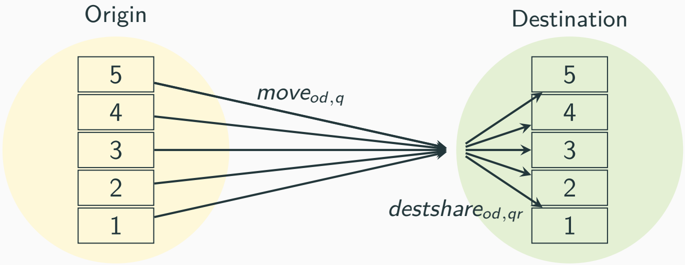


A Gravity Model at the Income Quintile Level

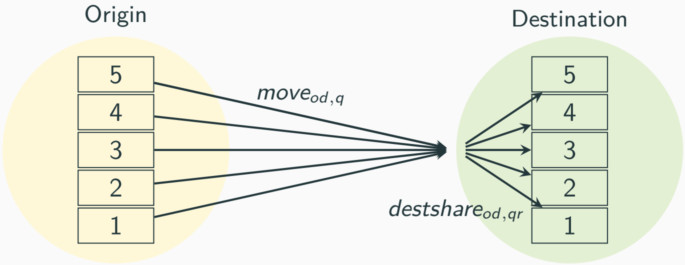
A Gravity Model at the Income Quintile Level



A Gravity Model at the Income Quintile Level



A Gravity Model at the Income Quintile Level



$$ln(move_{od,q}) = \beta_{0,q} + \beta_{1,q} ln(pop_{o,q}) + \beta_{2,q} ln(pop_{d,q})$$

$$+ \beta_{3,q} ln\left(\frac{ypc_d}{ypc_{o,q}}\right) + \beta_{5,q} \epsilon_{rems,od} + \beta_{6,q} remc_{od}$$

$$+ \beta_{4,q} ln(ypc_{o,q}) + \beta_{7,q} ln(dist_{od}) + \beta_{8,q} \mathbb{1}[lang]_{od} + \varepsilon_{odqr}$$

$$ln(destshare_{od,qr}) = \gamma_{0,r} + \gamma_{1,r} ln\left(\frac{ypc_d}{ypc_{o,q}}\right) + \varepsilon'_{odqr}$$

pop population sizes, *ypc* per capita incomes, distance, language

rems share of migrant's income sent as remittance, cost *remc*

▸ distribution equation ▸ remittances

Building a Dataset on Bilateral Migration per Income Level

▸ migrants' education ▸ migrants' income ▸ estimation strategy

Building a Dataset on Bilateral Migration per Income Level

Bilateral migrant stocks

World Bank

Bilateral migrant flows

Azose and Raftery 2018

migrants' education migrants' income estimation strategy

Building a Dataset on Bilateral Migration per Income Level

Bilateral migrant stocks

World Bank

↓

Bilateral migrant flows

Azose and Raftery 2018

Migrant flows per education

Shared Socioeconomic Pathways (SSP)

↓

Migrant flows per income

▸ migrants' education ▸ migrants' income ▸ estimation strategy

Building a Dataset on Bilateral Migration per Income Level

Bilateral migrant stocks

World Bank

Migrant flows per education

Shared Socioeconomic Pathways (SSP)

Bilateral migrant flows

Azose and Raftery 2018

Migrant flows per income

Assume: education correlated with income

migrant's income per education same as host

Bilateral migrant flows per income

migrants' education | migrants' income | estimation strategy

Estimating gravity equation and migrants' destination income

	Migrant flows for origin income quintile	
	origin quintile 1	origin quintile 5
Origin population	0.824***	0.805***
Destination population	0.719***	0.720***
Origin per capita GDP	1.808***	1.808***
Ratio of per capita GDP	1.166***	1.153***
N	24,100	24,100
R^2	0.554	0.543

	Migrants share to quintile at destination	
	destination quintile 1	destination quintile 5
Ratio of per capita GDP	0.142***	-0.149***
N	24,100	24,100
R^2	0.251	0.281

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Controls: remittance share, remittance cost, distance, language

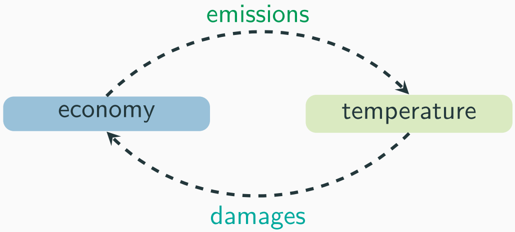
all q | other data | no rem. | quadratic | cubic | ratio av. | ratio spec. | gini

distribution all q | remittance share | other parameters | residuals | weights

Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

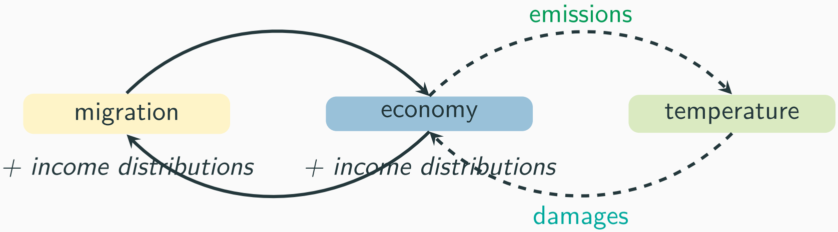
Integrated Assessment Models (IAM)



▸ IAM modeling ▸ Input scenarios ▸ World regions

Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

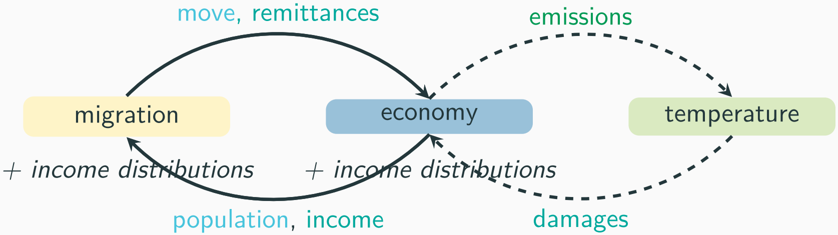
Integrated Assessment Models (IAM)



IAM modeling | Input scenarios | World regions

Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

Integrated Assessment Models (IAM)



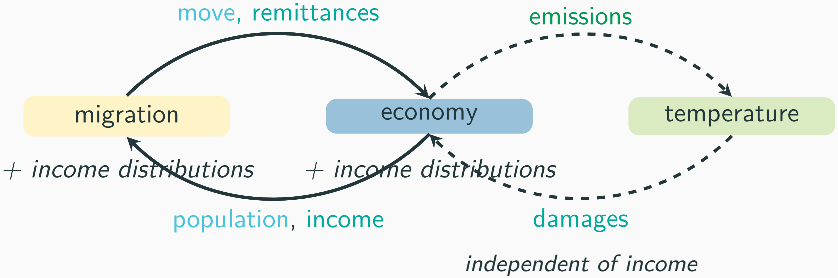
IAM modeling Input scenarios World regions

Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

FUND (Anthoff and Tol 2013)

Regional disaggregation: 16 regions

Version with income quintiles (Dennig et al. 2015)



▸ IAM modeling ▸ Input scenarios ▸ World regions

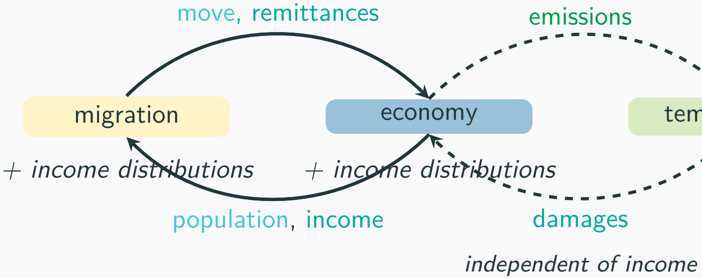
Including Climate Change Impacts on Resource Deprivation: Migration and Income Distributions in an IAM

FUND (Anthoff and Tol 2013)

Regional disaggregation: 16 regions

Version with income quintiles (Dennig et al. 2015)

Immobility: difference in poorest emigrants *with vs without* CC



IAM modeling · Input scenarios · World regions

Results & Policy Implications

Damages as Income Shocks on Poorest Populations

Medium scenario

Pessimistic scenario

Results in poorest quintile, for 2100

migrants' income profiles | other damage elasticities | all elasticities over time | SSP3-RCP7.0

Damages Not Compensated by Remittances in the Future

Medium scenario

Pessimistic scenario

Results in poorest quintile

▸ inequality ▸ inequality vs original SSP

Damages Not Compensated by Remittances in the Future

Medium scenario

Pessimistic scenario

Results in poorest quintile

▸ inequality ▸ inequality vs original SSP

Damages Not Compensated by Remittances in the Future

Medium scenario

Pessimistic scenario

Results in poorest quintile

▸ inequality ▸ inequality vs original SSP

Climate Change Decreases Mobility for Lowest Income Levels

Medium scenario

Results in poorest quintile, for 2100

Pink shades: climate change reduces outmigration of poorest populations

all elasticities · total numbers · calib. · catastrophic · damages prop. · damages invers.

Climate Change Decreases Mobility for Lowest Income Levels

Medium scenario

Pessimistic scenario

Results in poorest quintile, for 2100

Pink shades: climate change reduces outmigration of poorest populations

Climate Change Decreases Mobility for Lowest Income Levels

Medium scenario

Pessimistic scenario

Catastrophic damages

Results in poorest quintile, for 2100

Pink shades: climate change reduces outmigration of poorest populations

Conclusion & policy relevance

Resource-constrained immobility is not a rare circumstance

Likely to play a substantial role in the climate-migration nexus

Populations unable to leave will be extremely vulnerable

Policies might underestimate CC impacts

Questions?

helenebenveniste@fas.harvard.edu

Appendix

A gravity model at the income quintile level

Migration flows per income quintile at origin

Origin o, destination d, income quintile q at origin

$$
\begin{aligned}
ln(move_{od,q}) = {} & \beta_{0,q} + \beta_{1,q} ln(pop_{o,q}) + \beta_{2,q} ln(pop_{d,q}) \\
& + \beta_{3,q} ln\left(\frac{ypc_d}{ypc_{o,q}}\right) + \beta_{5,q}\epsilon_{rems,od} + \beta_{6,q} remc_{od} \\
& + \beta_{4,q} ln(ypc_{o,q}) + \beta_{7,q} ln(dist_{od}) + \beta_{8,q} \mathbb{1}[lang]_{od} \\
& + \varepsilon_{odqr}
\end{aligned}
$$

with *pop* quintile population sizes, *ypc* per capita incomes, *rems* share of migrant income sent as remittance, cost *remc*, *dist* distance btw regions, $\mathbb{1}[lang]$ common official language

back

Distributing migrants over destination income quintiles

Share of migrants per income quintile at destination

Income quintile r at destination

$$ln(destshare^*_{od,qr}) = \gamma_{0,r} + \gamma_{1,r} ln\left(\frac{ypc_d}{ypc_{o,q}}\right) + \varepsilon'_{odqr}$$

$$destshare_{od,qr} = \frac{destshare^*_{od,qr}}{\sum_r destshare^*_{od,qr}}$$

Number of migrants per location × quintile pair

$$move_{od,qr} = destshare_{od,qr}\left(\sum_r 1\right) move_{od,q}$$

back

Other key aspects of international migration

Remittances

$$ln(rems_{od}) = \alpha_0 + \alpha_1 ln(ypc_o) + \alpha_2 ln(ypc_d) + \alpha_3 remc_{od} + \epsilon_{od}$$

1^{st} generation migrants send remittances, their whole life

Migrants stay in same income quintile over time at destination

$$rem_{o,q} = \sum_d stock_{od,qr} \times ypc_{d,r} \times rems_{od} \times (1 - remc_{od}) - \sum_p stock_{po,sq} \times ypc_{o,q} \times rems_{po} \times (1 - remc_{po})$$

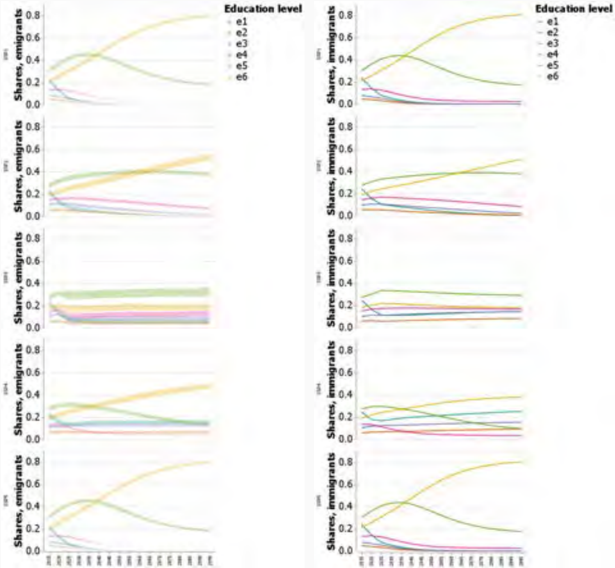
Risk of dying while attempting to migrate

$$deadmig_{o,q} = \mathbf{1}_{q \leq 3} \sum_d riskd_{od} \times move_{od,qr}$$

$$deadmigcost_{o,q} = \mathbf{1}_{q \leq 3} \sum_d riskd_{od} \times move_{od,qr} \times max(VSL_d, VSL_o)$$

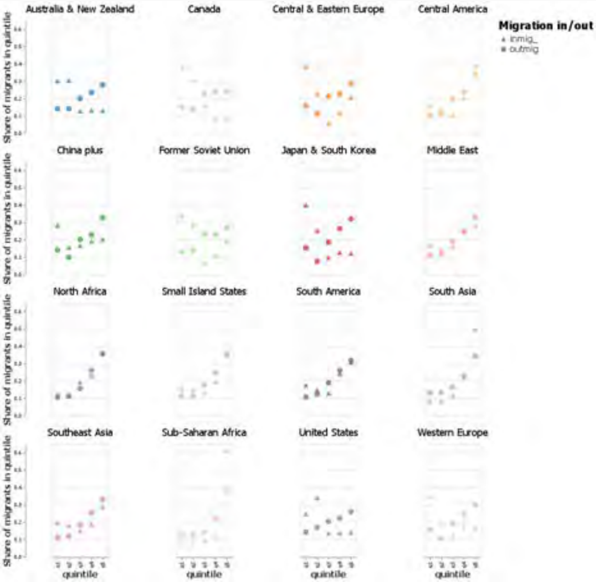
back

Migrants' education levels in SSP projections



back

Migrants' income levels in 2010-2015



back

Estimation strategy

Population, average income levels

World Development Indicators, World Bank

Income distributions

Gini coefficients for 2010-2015, SSP (Rao et al. 2019)

Remittances flows and costs

World Bank remittance matrices

Remittance Prices Worldwide

Estimation by OLS at country level

Separately for each origin quintile for gravity model

Separately for each destination quintile for distribution

back

Estimation of gravity equation

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.824***	0.809***	0.792***	0.807***	0.805***
Destination population	0.719***	0.717***	0.719***	0.718***	0.720***
Origin per capita GDP	1.808***	1.760***	1.865***	1.834***	1.808***
Ratio of per capita GDP	1.166***	1.174***	1.170***	1.166***	1.153***
Residuals for share of income	-0.002	-0.002	-0.001	-0.000	0.001
Cost of sending remittances	-22.604	-25.734	-24.555	-24.232	-24.610
Distance between countries	-1.100***	-1.081***	-1.099***	-1.086***	-1.120***
Common official language	1.433***	1.490***	1.422***	1.436***	1.320***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.554	0.540	0.549	0.545	0.543

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Estimation of migrants income levels at destination

	Share of migrants to a given quintile at destination				
	qdest1	qdest2	qdest3	qdest4	qdest5
Ratio of per capita GDP	0.142***	0.073***	0.027	0.023	-0.149***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.251	0.100	0.006	0.012	0.281

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Estimation of remittance share

Data: World Bank, 2017

$$ln(rems_{od}) = \alpha_0 + \alpha_1 ln(ypc_o) + \alpha_2 ln(ypc_d) + \alpha_3 remc_{od} + \epsilon_{od}$$

	Share of income sent as remittance
Destination per capita GDP	-0.603***
Ratio of per capita GDP	0.241**
Cost of sending remittances	-5.953
N	10,430
R^2	0.133

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Calibration of other migration parameters

How long migrants stay in region

Life expectancy: SSP projections, country level

Age when migrating: SSP2 2020, country education 5-yr age

Initial stock of migrants: bilateral stocks 2017 (World Bank)

+ income distribution: education migrants 2015-2020 (SSP)

+ age distribution: two distributions 2015-2020 (SSP)

Cost of sending remittances

$remc_{od}$: total cost in %, 2017 (RPW World Bank)

Risk of dying while attempting to migrate

$riskd_{od}$: data on missing migrants 2014-2018 (IOM)

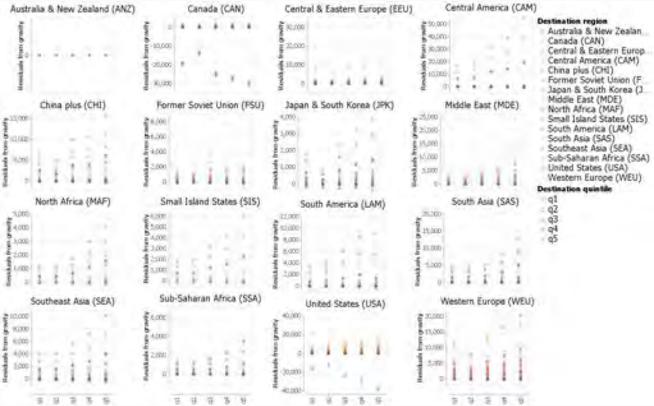
▸ weights

◂ back

Incorporating residuals from gravity estimation

Capture each migration corridor's specificity

$$move^{*}_{od,qr} = move_{od,qr} + \varepsilon_{odqr}$$



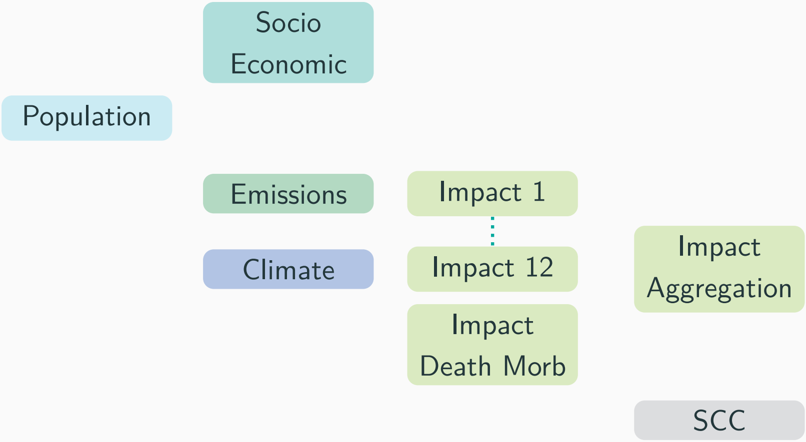
◂ back

World regions based on FUND

Name	Countries
USA	United States of America
Canada	Canada
Western Europe	Andorra, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, United Kingdom
Japan and South Korea	Japan, South Korea
Australia and New Zealand	Australia, New Zealand
Central and Eastern Europe	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, FYR Macedonia, Poland, Romania, Slovakia, Slovenia, Yugoslavia
Former Soviet Union	Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan
Middle East	Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, West Bank and Gaza, Yemen
Central America	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela
South Asia	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
Southeast Asia	Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, Singapore, Taiwan, Thailand, Vietnam
China plus	China, Hong Kong, North Korea, Macau, Mongolia
North Africa	Algeria, Egypt, Libya, Morocco, Tunisia, Western Sahara
Sub-Saharan Africa	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo-Brazzaville, Congo-Kinshasa, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea- Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe

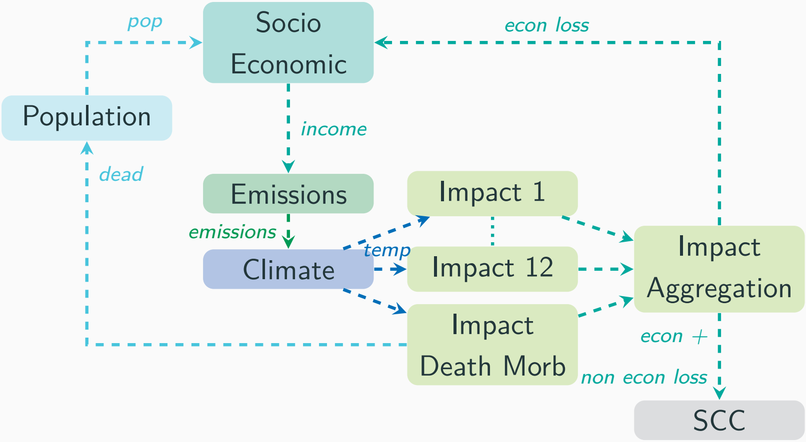
back

IAM Modeling



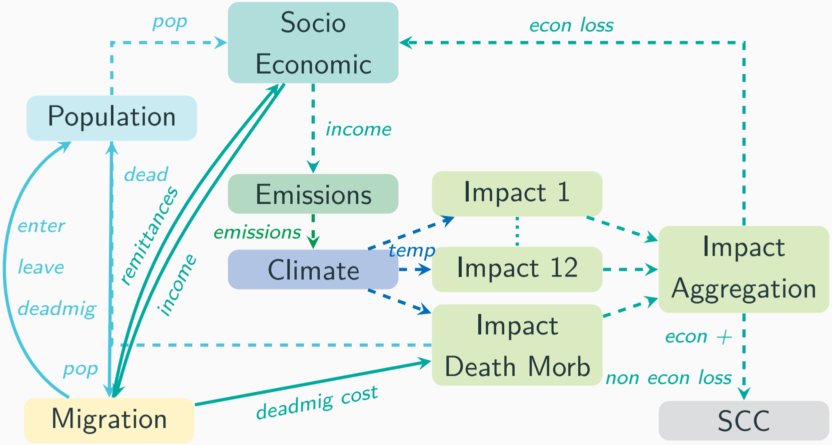
back

IAM Modeling



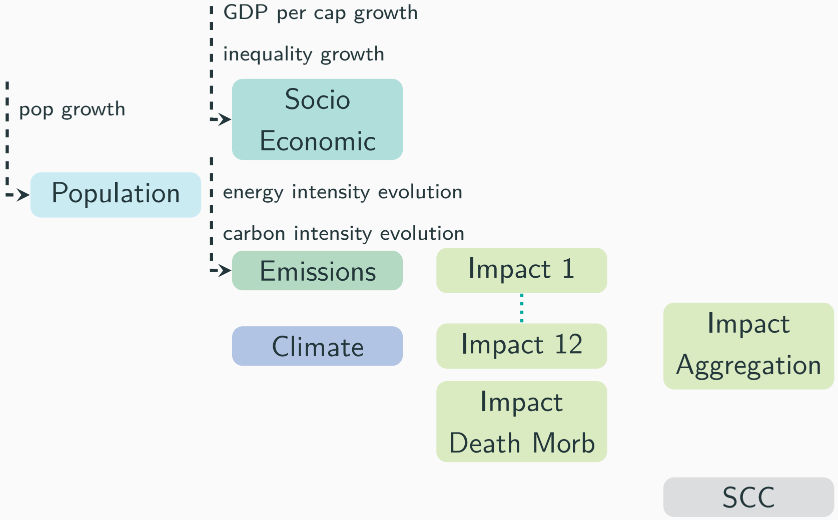
back

IAM Modeling



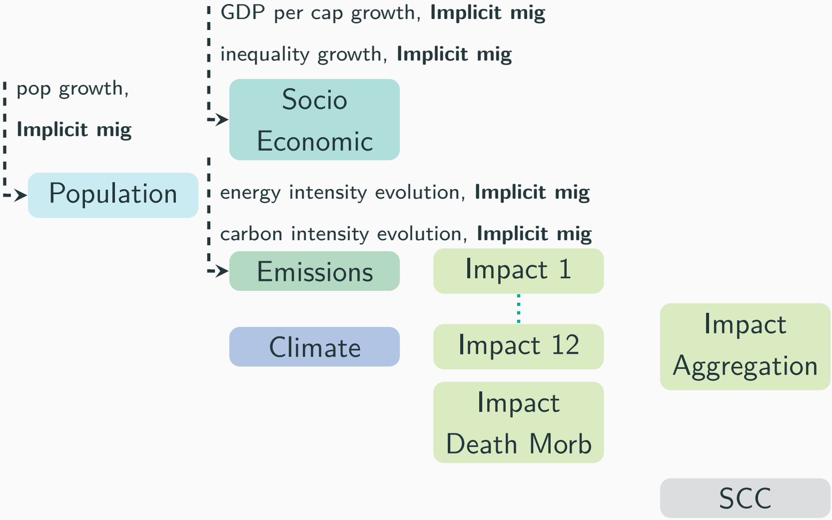
back

IAM Input Scenarios



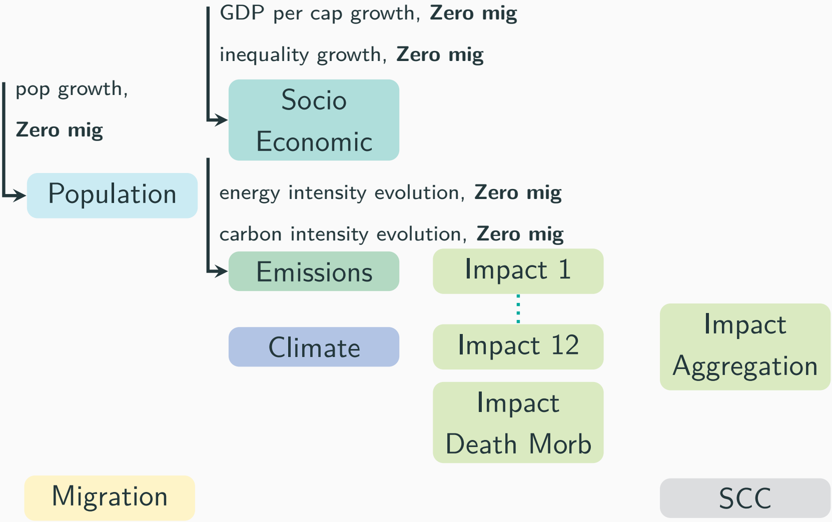
back

IAM Input Scenarios



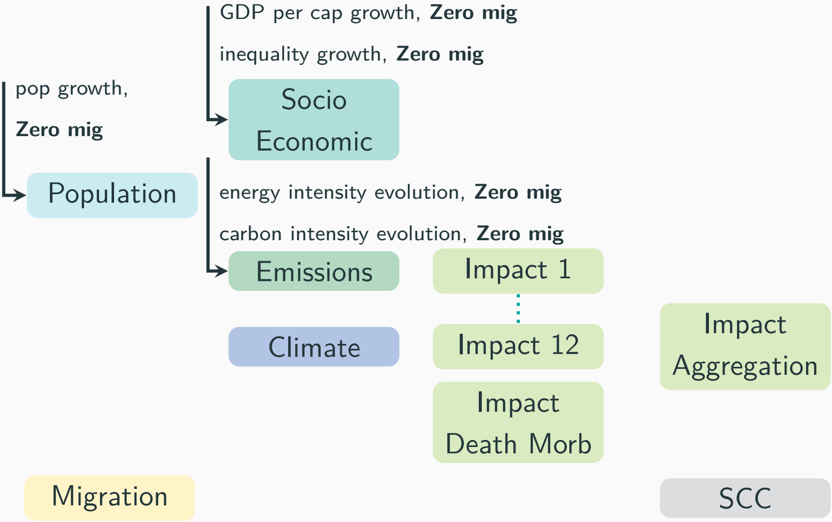
back

IAM Input Scenarios



back

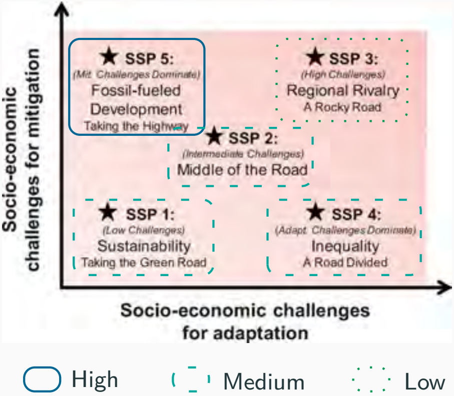
IAM Input Scenarios

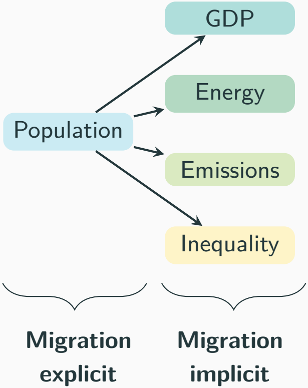


back

Avoid **double counting** of migration

The Shared Socioeconomic Pathways: Migration Assumptions





Sources: O'Neill et al. 2017, KC and Lutz 2017

Versions of SSP for Zero Migration

Population projections

Demographic model of population dynamics by KC 2020

GDP projections

Similar gravity model with explicit remittances

Energy consumption and GHG emissions projections

Assume climate policies, innovation, consumption not affected

Unaffected path along GDP per capita

Gini coefficients based on Rao et al. 2019

Migration-driven changes in education levels, public spending

Gini $\rightarrow$ income quintiles: lognormal distribution

Income quintiles $\rightarrow$ Gini: Lorenz curve

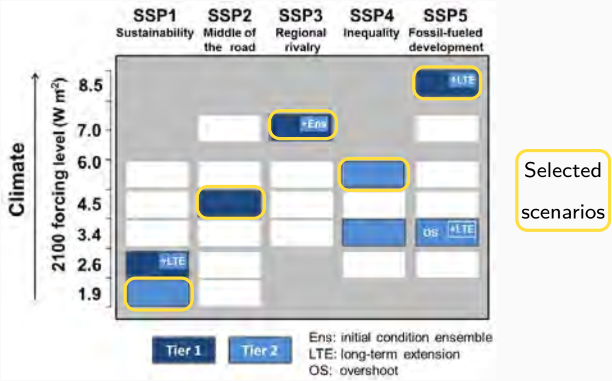
Extending SSP Scenarios for Input in FUND

Period	Population growth	GDP per capita growth	Inequality growth	Energy intensity of GDP growth	Carbon intensity of energy growth	Carbon price
2015-2100	Linearize from 5-year periods to yearly values					
1950-2015	UN World Population Prospects 2019	World Bank WDI when available, otherwise FUND scenario	World Bank WDI when available otherwise interpolate	Default FUND scenario	1990-2015: CMIP6 data 1950-1990: FUND scenario	0
2100-2300	Linear decline to 0 in 2200, then constant	Linear decline reaching 0		Fixed at 2090-2100 rate if < 0 in 2100, otherwise linear decline reaching 0		0
2300-3000	Steady state: growth rates $= 0$					

Emissions & Energy Consumption & Carbon Prices Scenarios

Development scenarios: Shared Socioeconomic Pathways (SSP) +

Climate scenarios: Representative Concentration Pathways (RCP)



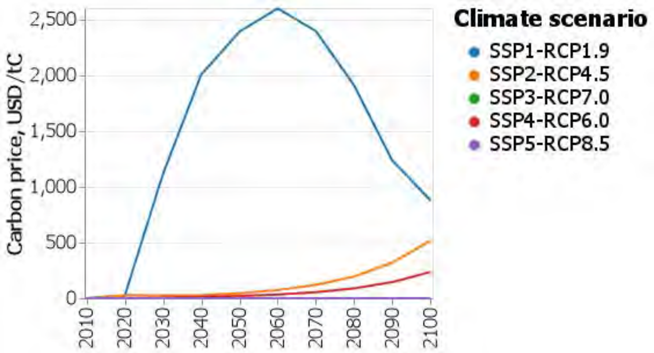
Source: O'Neill et al. (2016). CMIP6 data: Gidden et al. (2019)

back

Global Carbon Prices

Global carbon prices for each SSP-RCP as input in FUND

$\longrightarrow$ ensures consistent mitigation costs



Source: IIASA SSP Database

back

Producing results for a range of specifications

Quantifying climate change-related immobility

Difference in poorest emigrants for runs *with* vs *without* CC

Damages distribution onto income quintiles

Damages proportional, **indep.**, inversely prop. to income

Input scenarios of future development & climate change

Five SSP-Representative Concentration Pathways (RCP)

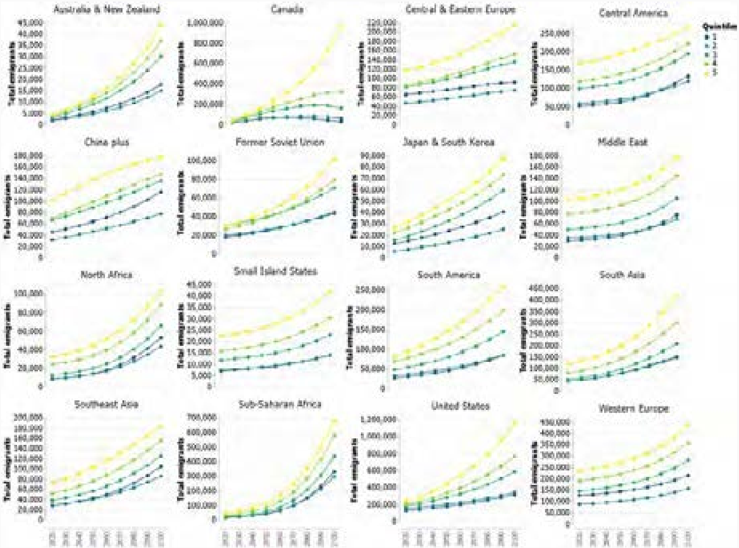
SSP2-RCP4.5 (**medium**), SSP3-RCP7.0 (**pessimistic**)

Damages functional form & calibration

Specification with **catastrophic** damages (Weitzman 2012)

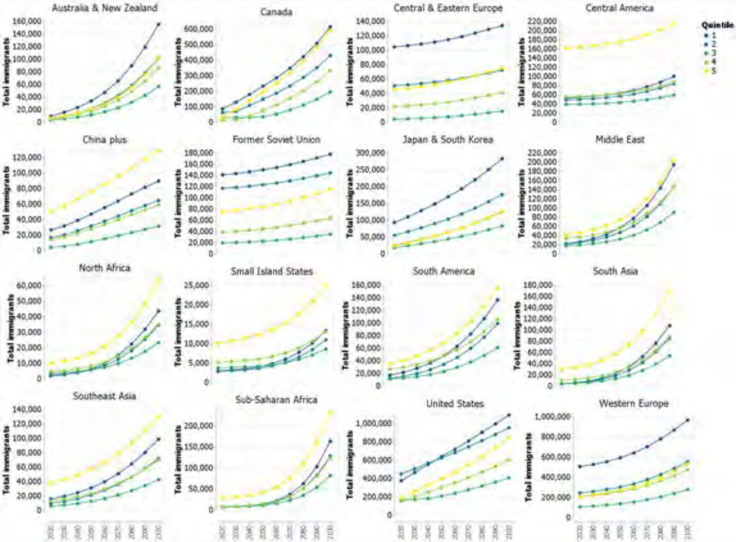
back

Income profiles of migrants



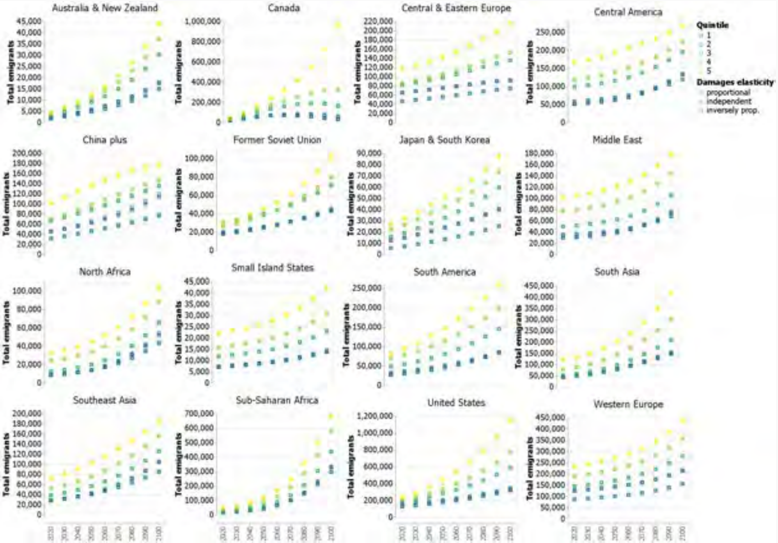
back

Income profiles of migrants



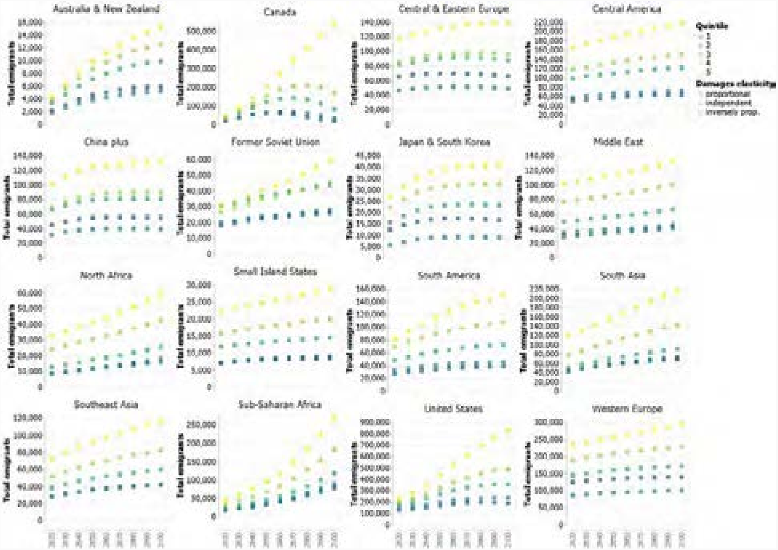
back

Income profiles of migrants for all damage elasticities



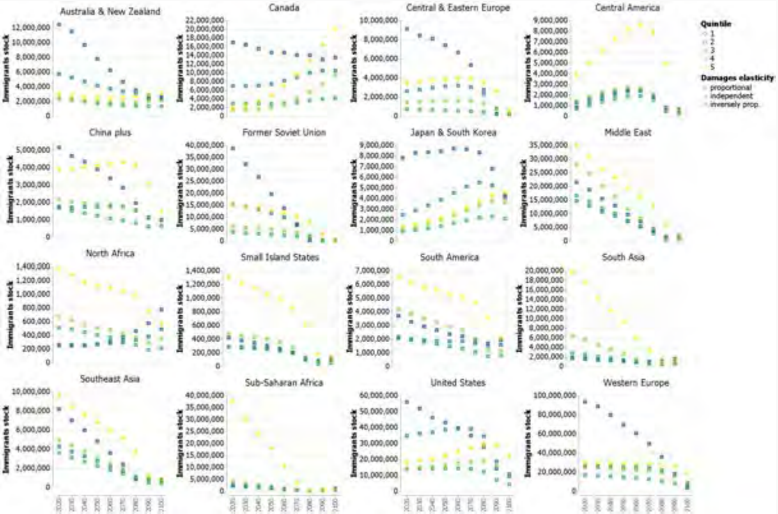
back

Income profiles of migrants for SSP3-RCP7.0

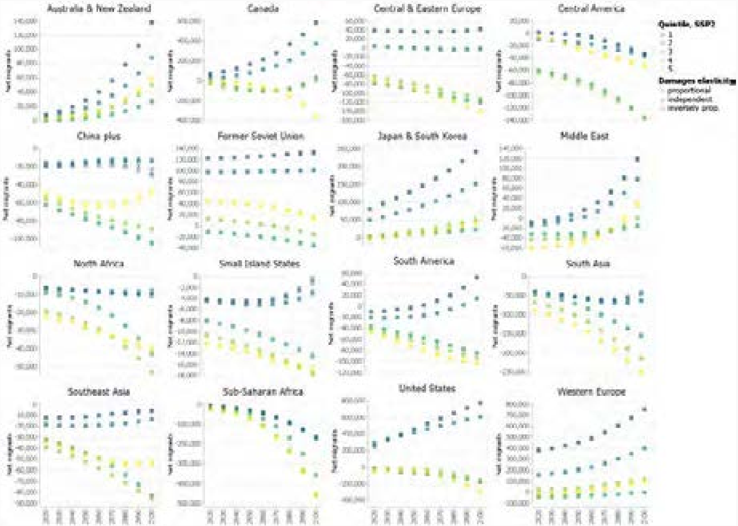


back

Cumulative number of migrants living abroad

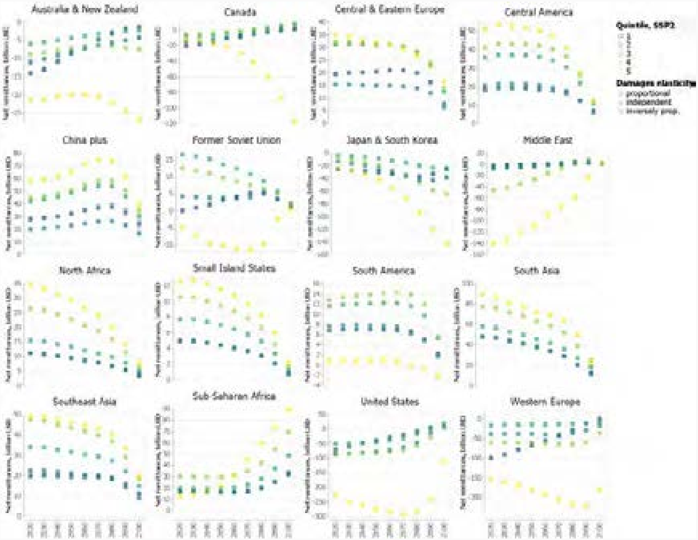


Net migration per income quintile



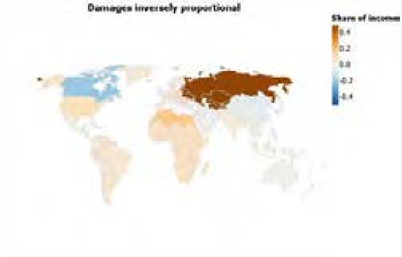
back

Net remittances per income quintile



back

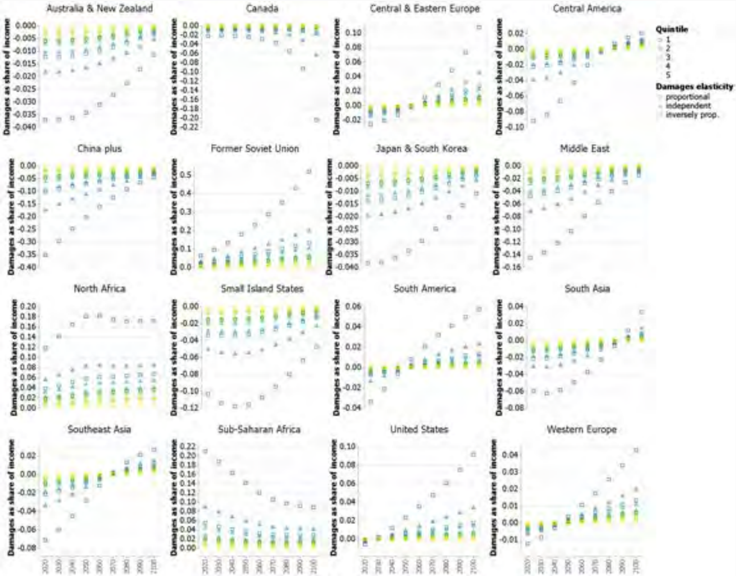
Damages on poorest populations for other elasticities



Results in quintile 1, for 2100, for SSP2-RCP4.5

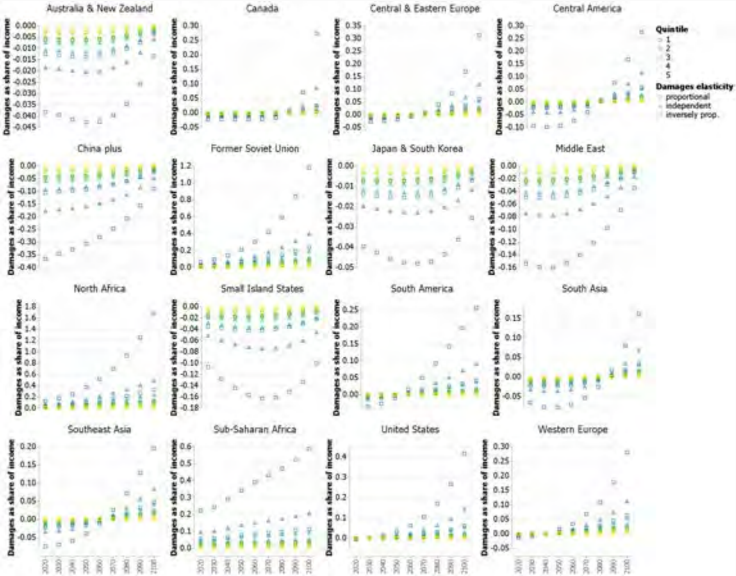
back

Damages as shocks on poorest populations for SSP2-RCP4.5



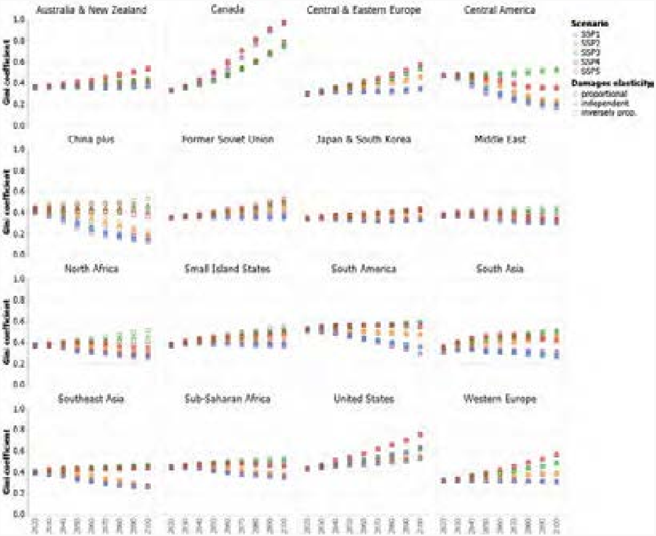
◂ back

Damages as shocks on poorest populations for SSP3-RCP7.0



back

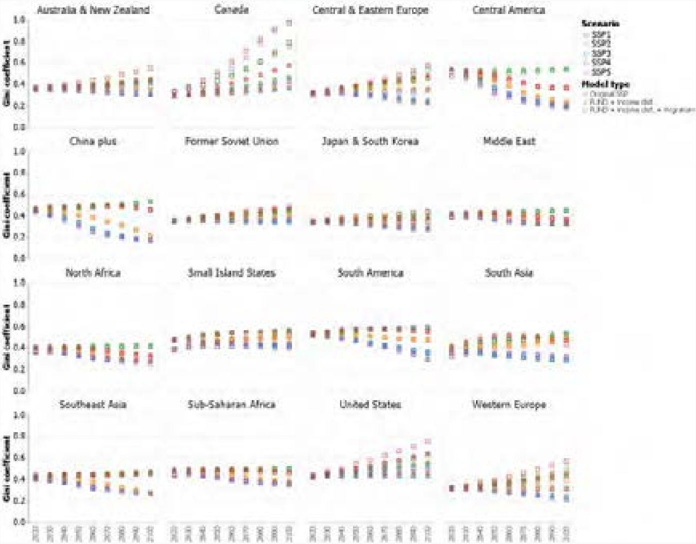
Within-region inequality



Damage elasticity affects inequality only in a few regions

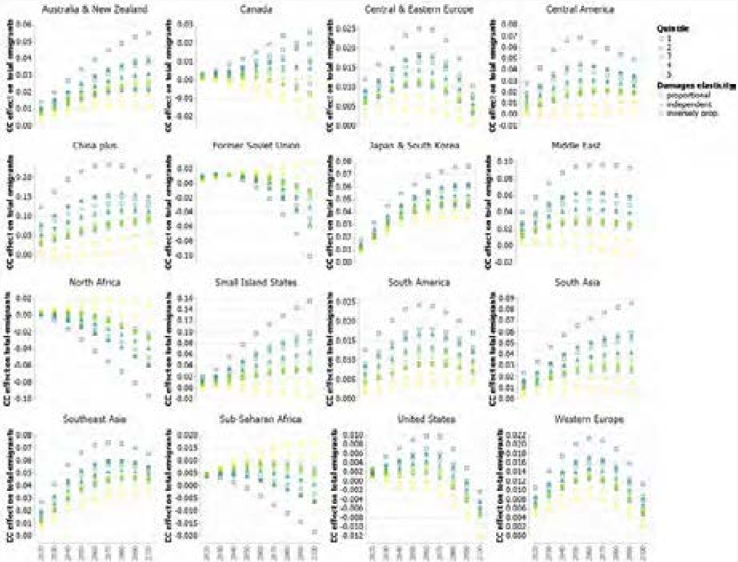
back

Within-region Gini coefficients vs original SSP



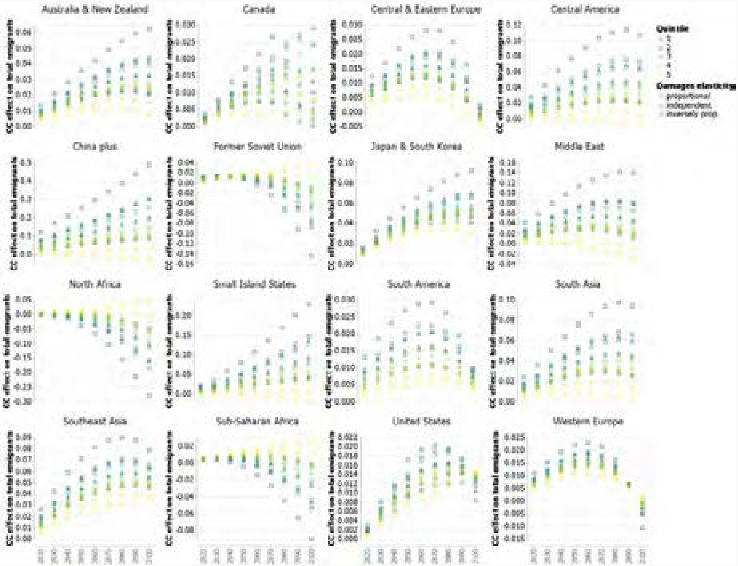
◂ back

CC effect on immobility for SSP2-RCP4.5



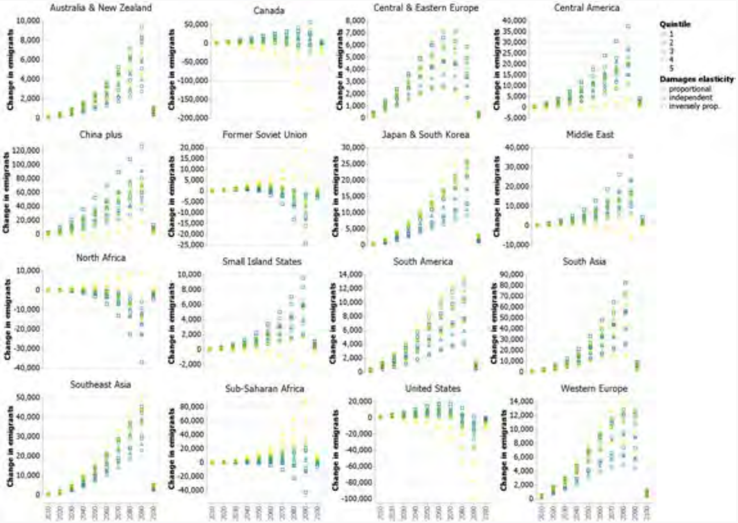
back

CC effect on immobility for SSP3-RCP7.0



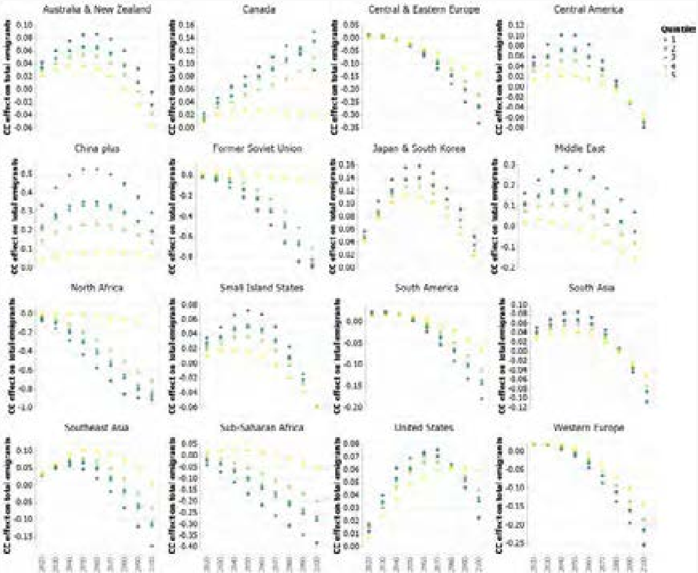
◂ back

CC effect on numbers of migrants per income quintile



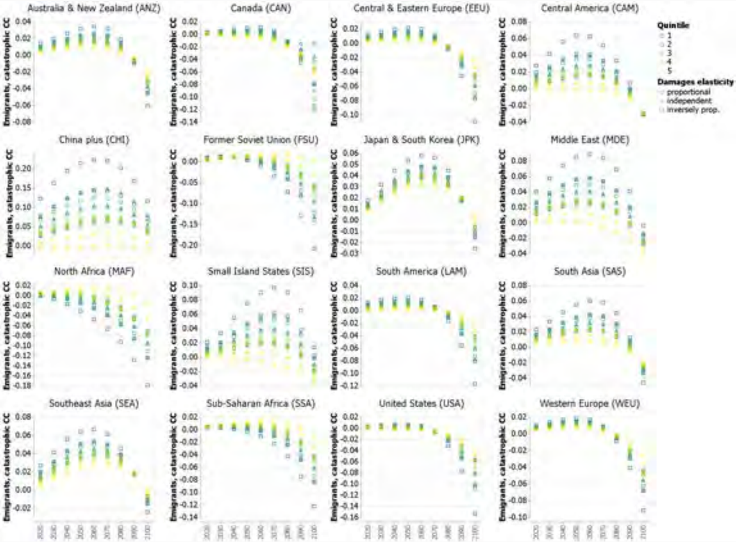
◂ back

Immobility with corrected calibration for SSP2-RCP4.5



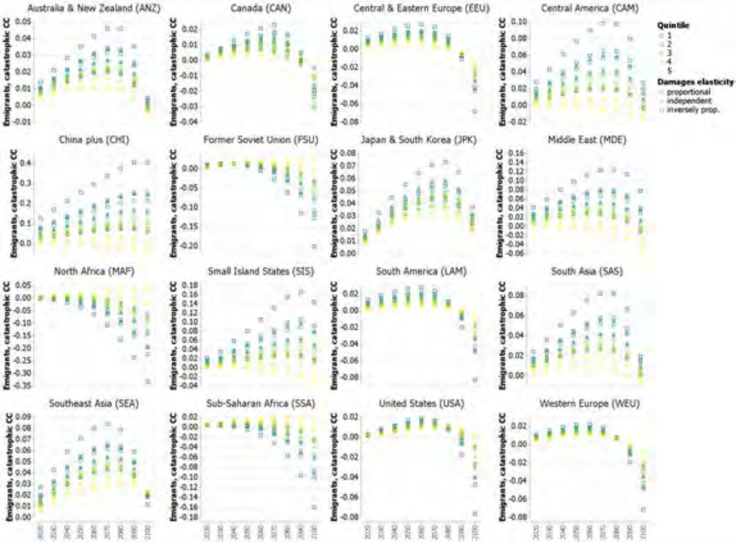
back

Immobility with catastrophic damages for SSP2-RCP4.5



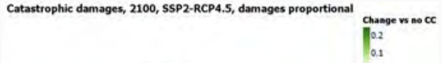
back

Immobility with catastrophic damages for SSP3-RCP7.0

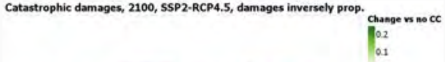


◂ back

Immobility when damages proportional to income



Immobility when damages inversely prop. to Income



Robustness check: gravity with other migration dataset

Derivation from stocks to flows using Abel 2018

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.716***	0.698***	0.684***	0.702***	0.709***
Destination population	0.726***	0.721***	0.722***	0.724***	0.726***
Origin per capita GDP	1.758***	1.665***	1.746***	1.698***	1.639***
Ratio of per capita GDP	1.487***	1.489***	1.483***	1.480***	1.479***
Residuals for share of income	0.005	0.005	0.005	0.006	0.006
Cost of sending remittances	-13.805	-16.647	-15.139	-14.794	-14.319
Distance between countries	-0.952***	-0.922***	-0.933***	-0.910***	-0.926***
Common official language	1.188***	1.293***	1.247***	1.280***	1.245***
N	15,765	15,765	15,765	15,765	15,765
R^2	0.436	0.423	0.426	0.425	0.428

$^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

back

Robustness check: gravity with income minus remittances

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.824***	0.809***	0.792***	0.807***	0.805***
Destination population	0.719***	0.717***	0.719***	0.718***	0.720***
Origin per capita GDP no rem	1.808***	1.760***	1.865***	1.833***	1.807***
Ratio of per capita GDP	1.166***	1.174***	1.170***	1.166***	1.153***
Residuals for share of income	-0.002	-0.002	-0.001	-0.000	0.001
Cost of sending remittances	-22.619	-25.743	-24.567	-24.240	-24.614
Distance between countries	-1.100***	-1.081***	-1.099***	-1.086***	-1.120***
Common official language	1.433***	1.490***	1.422***	1.436***	1.320***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.554	0.540	0.549	0.545	0.543

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Robustness check: gravity with quadratic origin income

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.851***	0.830***	0.810***	0.826***	0.810***
Destination population	0.720***	0.718***	0.720***	0.719***	0.722***
Origin per capita GDP	-0.151	-0.466	-0.826	-2.306	-4.977*
Origin per capita GDP squared	0.128**	0.135*	0.155*	0.229**	0.350***
Ratio of per capita GDP	1.176***	1.182***	1.177***	1.176***	1.165***
Residuals for share of income	-0.001	-0.001	0.000	0.001	0.004
Cost of sending remittances	-26.028	-28.520	-27.122	-27.068	-26.262
Distance between countries	-1.104***	-1.083***	-1.101***	-1.089***	-1.128***
Common official language	1.398***	1.464***	1.401***	1.415***	1.295***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.561	0.545	0.554	0.555	0.557

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

back

Robustness check: gravity with cubic origin income

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.851***	0.829***	0.809***	0.825***	0.811***
Destination population	0.721***	0.720***	0.721***	0.720***	0.723***
Origin per capita GDP	2.281	11.771	13.343	13.075	16.413
Origin per capita GDP squared	-0.204	-1.394	-1.522	-1.503	-1.872
Origin per capita GDP cubed	0.015	0.062	0.065	0.064	0.076
Ratio of per capita GDP	1.176***	1.183***	1.178***	1.176***	1.164***
Residuals for share of income	-0.002	-0.004	-0.002	-0.001	0.002
Cost of sending remittances	-25.774	-27.621	-26.342	-26.474	-26.011
Distance between countries	-1.108***	-1.095***	-1.111***	-1.096***	-1.132***
Common official language	1.393***	1.450***	1.389***	1.406***	1.286***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.561	0.547	0.556	0.556	0.558

$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

back

Robustness check: gravity with ratio of average per capita incomes

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.837***	0.820***	0.799***	0.808***	0.786***
Destination population	0.706***	0.710***	0.715***	0.717***	0.718***
Origin per capita GDP	1.449***	1.546***	1.753***	1.805***	1.806***
Ratio of per capita GDP	1.065***	1.130***	1.156***	1.165***	1.087***
Residuals for share of income	-0.002	-0.003	-0.002	-0.001	0.004
Cost of sending remittances	-20.998	-24.285	-23.475	-23.813	-26.333
Distance between countries	-1.057***	-1.042***	-1.070***	-1.075***	-1.169***
Common official language	1.624***	1.651***	1.537***	1.479***	1.154***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.540	0.533	0.547	0.545	0.533

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

back

Robustness check: gravity with ratio of specific per capita incomes

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.811***	0.797***	0.779***	0.795***	0.794***
Destination population	0.705***	0.703***	0.705***	0.704***	0.706***
Origin per capita GDP	1.381***	1.327***	1.430***	1.399***	1.375***
Ratio of per capita GDP	0.785***	0.791***	0.788***	0.786***	0.777***
Residuals for share of income	0.005	0.005	0.006	0.007	0.008
Cost of sending remittances	-23.518	-26.612	-25.398	-25.029	-25.304
Distance between countries	-1.126***	-1.105***	-1.123***	-1.109***	-1.139***
Common official language	1.391***	1.452***	1.387***	1.405***	1.300***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.517	0.502	0.511	0.507	0.505

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Robustness check: gravity with gini coefficients

	Bilateral migrant flows for a given origin income quintile				
	qorig1	qorig2	qorig3	qorig4	qorig5
Origin population	0.819***	0.805***	0.790***	0.807***	0.817***
Destination population	0.733***	0.732***	0.732***	0.732***	0.732***
Origin per capita GDP	1.809***	1.746***	1.832***	1.791***	1.751***
Ratio of per capita GDP	1.122***	1.127***	1.126***	1.122***	1.122***
Gini at origin	1.044	0.687	0.069	-0.281	-1.883
Gini at destination	-1.734	-1.857	-1.791	-1.846	-1.801
Residuals for share of income	-0.000	-0.000	0.000	0.001	0.001
Cost of sending remittances	-22.227	-25.248	-23.888	-23.404	-22.987
Distance between countries	-1.083***	-1.058***	-1.069***	-1.049***	-1.051***
Common official language	1.503***	1.584***	1.549***	1.590***	1.598***
N	24,100	24,100	24,100	24,100	24,100
R^2	0.517	0.502	0.511	0.507	0.505

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

back

Timothy Foreman

Postdoctoral Research Associate,
King's College London

@ForemanTim

Environmental Shocks and the Decision to Migrate

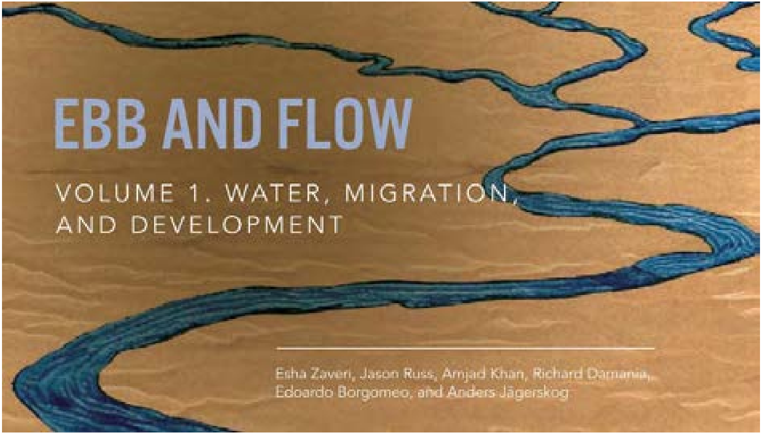
Environmental Shocks and the Decision to Migrate

Timothy Foreman

King's College London
& EIEE

September 8, 2021

Background



World Bank

Motivation

Khartoum, Sudan 2007

Main Contributions

- Using micro-level census data to assess the impact of climate on migration patters, both within and across countries
  - Show that long-term trends in temperature and precipitation impact migration across West Africa
  - Dust exposure decreases migration in this context, differing from others

Recent literature

Air pollution & migration

- Chen et al. (2017); Bayer et al. (2009)

Dust storm & air pollution impacts

- Ai and Polenske (2008); Graff Zivin and Neidell (2012); Hornbeck (2012); Hanna and Oliva (2015); Aragon et al. (2016); Arthi (2018); Birjandi-Feriz and Yousefi (2018)

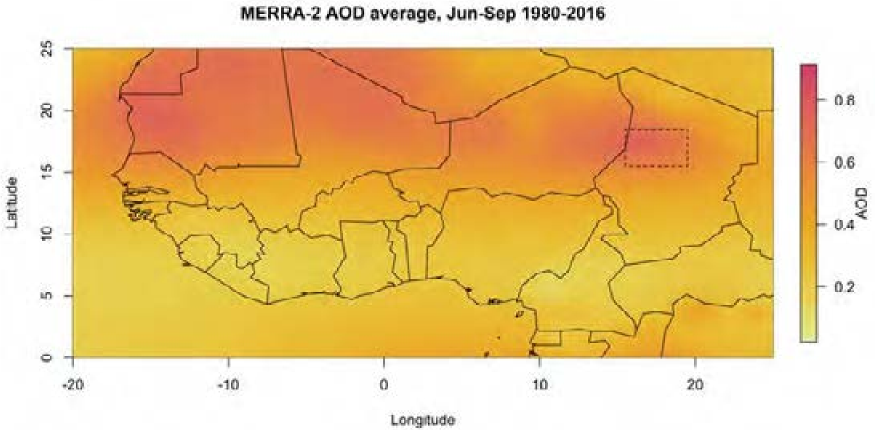
Climate & Migration

- Beine and Parsons (2016); Cattaneo and Peri (2016); Missirian and Schlenker (2017)

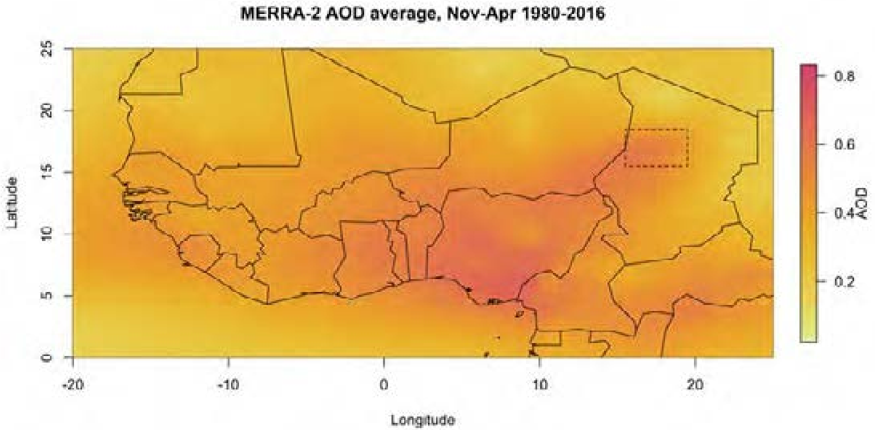
Dust data

- Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) assimilated Aerosol Optical Depth
  - $0.5° \times 0.625°$, daily resolution
- Concern: picking up other aerosols

West African Monsoon



West African Monsoon



Migration Data

- IPUMS-International
  - 10% sample of census data from many countries, standardized to the degree possible

Two Pieces

- First: Consider international migration based on censuses in the destination countries, use information on where respondents lived in prior years
- Second: Consider intranational migration across regions using census data from Burkina Faso and Senegal

Empirical Model- International Migration

$$\begin{aligned} Y_{ijt} = \beta_O D_{it} + \psi_O T_{it} + \eta_O P_{it} \\ + \beta_D D_{jt} + \psi_D T_{jt} + \eta_D P_{jt} \\ + \phi_{ij} + \alpha_t + \epsilon_{ijt} \end{aligned}$$

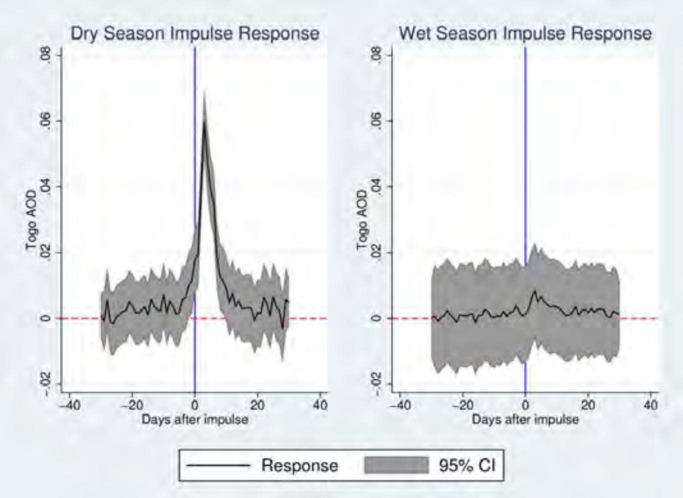
- $Y_{ijt} =$ Migration from i to j in year t
- D_{it} is the population-weighted average dust exposure over origin country i in year t
- T_{it} is the population-weighted average temperature over origin country i in year t
- P_{it} is the population-weighted average precipitation over origin country i in year t
- ϕ_{ij}, α_t allow for country pair fixed effects, year fixed effects
- ϵ_{ijt} allowed to be correlated within the origin country over time, standard errors clustered at origin country

Endogeneity in dust measurement

- Locally emitted dust
- Instrument using the Bodélé Depression
- Identifying assumption: Bodélé dust is uncorrelated with economic activity except through its effects on dust over the countries of interest

evidence

Dust Transport

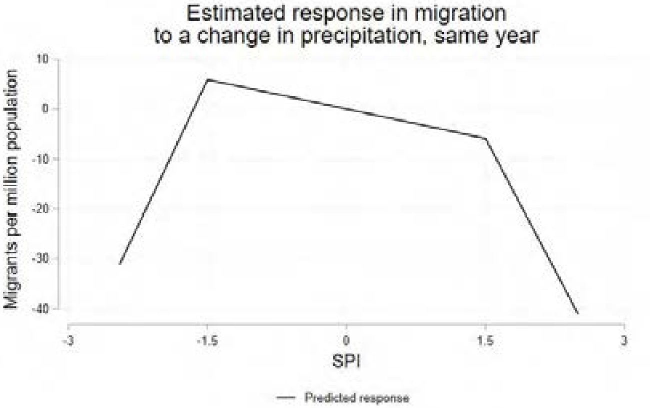


Results

VARIABLES	(1) Migration rate	(2) Migration rate	(3) Migration rate
Dust exposure, Origin	-265.149	-260.075	-258.851
	(167.124)	(163.755)	(159.753)
Temperature, Origin	0.369	0.313	0.289
	(0.295)	(0.308)	(0.376)
SPI, Origin	-8.752	-13.199	-13.693
	(14.309)	(15.279)	(15.384)
Excess SPI, Origin	-51.193	-45.458	-42.901
	(59.095)	(57.213)	(51.513)
Drought SPI, Origin	-3.342	3.583	3.803
	(42.317)	(42.426)	(41.986)
Observations	509	509	509
R-squared	0.138	0.139	0.139
Pair FE	X	X	X
First stage F-stat	322.9	289.9	291.9
Year trend		X	
Country-year trend			X

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Precipitation

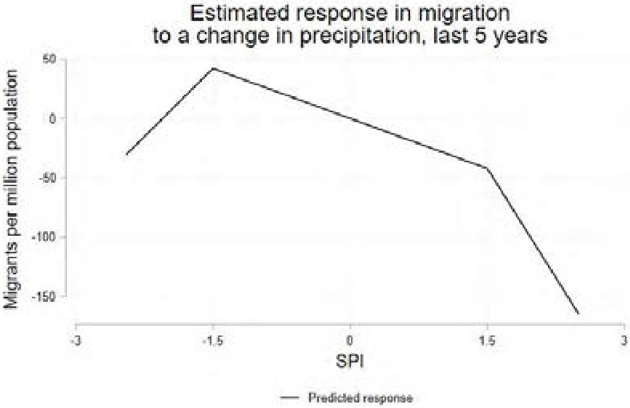


Results

VARIABLES	(1) Migration rate	(2) Migration rate	(3) Migration rate
Dust exposure, 5 years	-305.354	-290.614*	-290.640*
	(187.676)	(174.455)	(174.664)
Temperature, 5 years	0.475	0.553	0.578
	(0.438)	(0.463)	(0.407)
SPI, 5 years	-64.715	-111.668	-113.217
	(59.283)	(81.338)	(80.598)
Excess SPI, 5 years	-267.356	-217.714	-210.609
	(214.402)	(192.400)	(168.577)
Drought SPI, 5 years	82.527	155.631	157.779
	(80.486)	(115.298)	(114.181)
Observations	453	453	453
R-squared	0.015	0.150	0.150
Pair FE	X	X	X
First stage F-stat	645.8	602.3	600.8
Year trend		X	
Country-year trend			X

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Precipitation



Results

VARIABLES	(1) Senegal	(2) Burkina Faso
Temperature	0.041	0.000
	(0.024)	(0.003)
SPI	-0.139	-0.006
	(0.233)	(0.010)
Observations	1,272,466	3,123,562
R-squared	0.011	0.006
Year FE	X	X

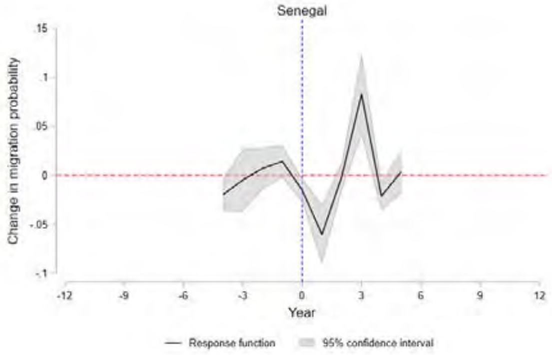
Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Results

VARIABLES	(1) Senegal	(2) Burkina Faso
Temperature (5 year mean)	0.126**	0.000
	(0.060)	(0.003)
SPI (5 year mean)	-0.060	-0.006
	(0.096)	(0.010)
Observations	1,272,466	3,123,562
R-squared	0.010	0.006
Year FE	X	X

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Over Time- Dust



Conclusions & Future Work

- Climate has long-term effects on migration, but little contemporaneously
- Dust exposure is a contributing factor
- The time dynamics are an important part of regional migration
- Will explore individual characteristics to determine who is moving

Stephanie Lackner

Assistant Professor, IE University

@slackner0

Population Movement Response to Hurricane Exposure - Tracked with Cellphone GPS Location Data

Population Movement Response to Hurricane Exposure - Tracked With Cellphone GPS Location Data

Stephanie Lackner[1], Michael Oppenheimer[2], and Elmira Kalhor[2]

[1]IE University, stephanie.lackner@ie.edu

[2]Princeton University

Climate Adaptation Research Symposium

September 8, 2021

Source:
SC National Guard,
170831-Z-AH923-081

Mobility and Migration

- Mobility during warning phase
- Mobility during storm
- Evacuation
- Displacement
- Migration
- Short/medium/long-term changes in mobility

Literature

- Interdisciplinary
- Migration after extreme events (e.g. Black et al. (2013), Cattaneo et al. (2019))
- Hurricane Katrina (e.g. Paxson & Rouse (2008), Fussell et al.(2009), Deryugina (2017))
- GPS Data (e.g. Bengtsson et al. (2011), Lu et al. (2012), Lu et al. (2016), Yabe (2019), Boas et al. (2020), Acosta (2020))

Hurricane Harvey

"Harvey [...] rapidly intensified into a category 4 hurricane [...] before making landfall along the middle Texas coast. The storm then stalled [...] dropping historic amounts of rainfall [...] Harvey is the second-most costly hurricane in U.S. history [...] at least 68 people died"

Source: National Hurricane Center Tropical Cyclone Report Hurricane Harvey (AL092017)

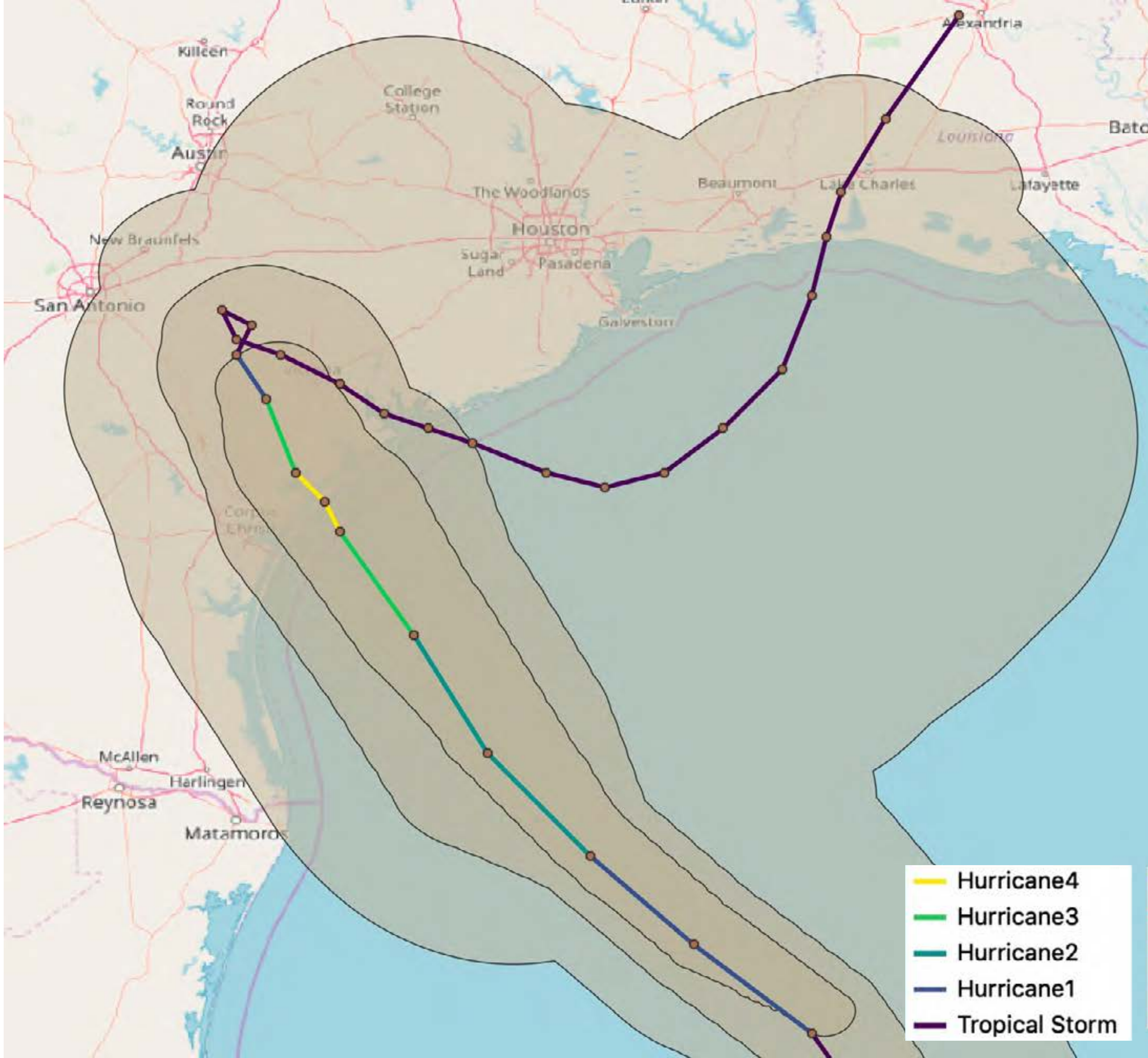
Timeline

8/17 tropical storm

8/24 first hurricane warning issued

8/26 first landfall

8/31 all tropical storm warnings discontinued

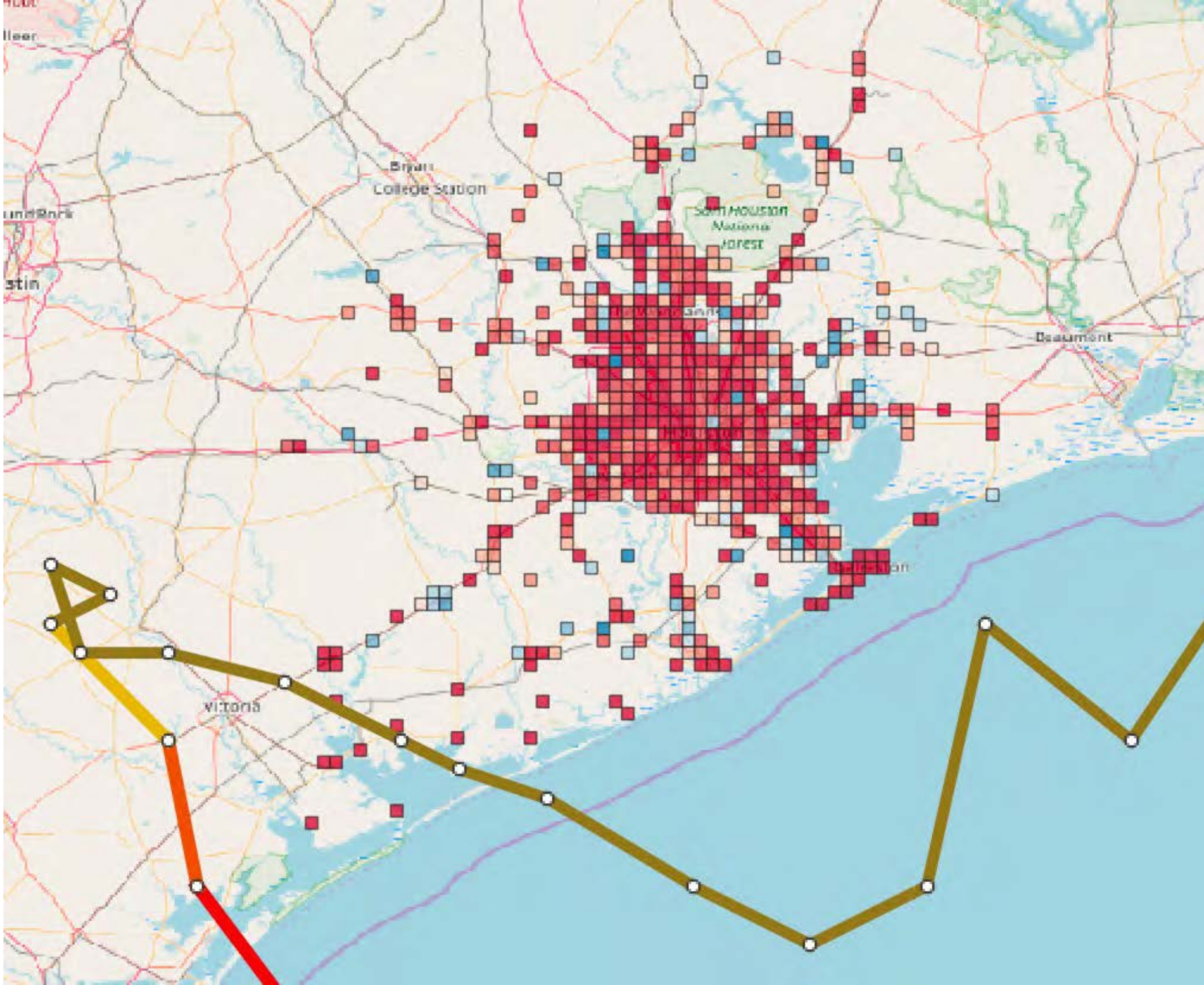


Data

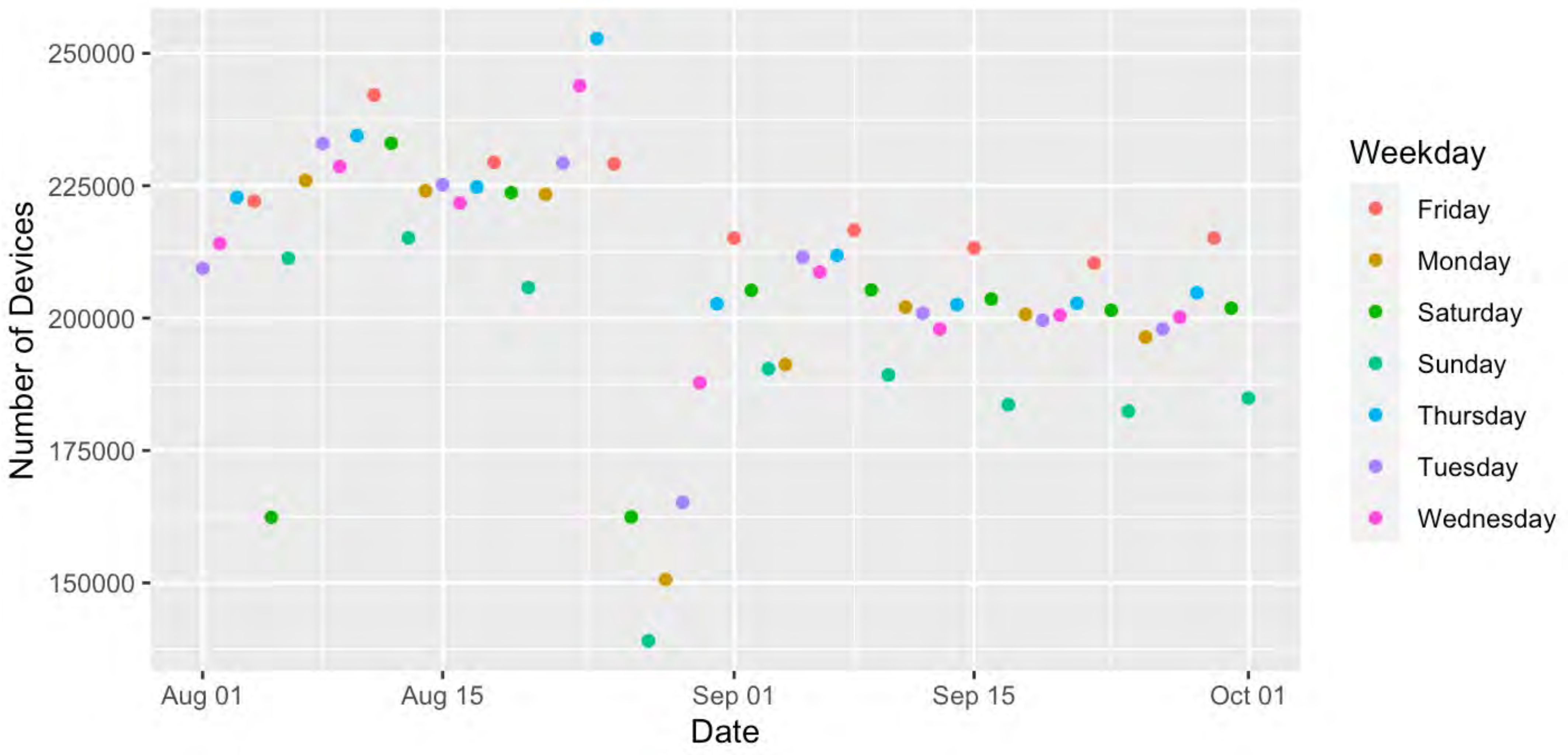
- GPS Data from PlaceIQ (private location intelligence provider)
- Hurricane Harvey Data
  - FEMA Flood Depths Grid Data
  - FEMA Building Damage Data
- ACS5 2016 census tract data

Activity During Harvey

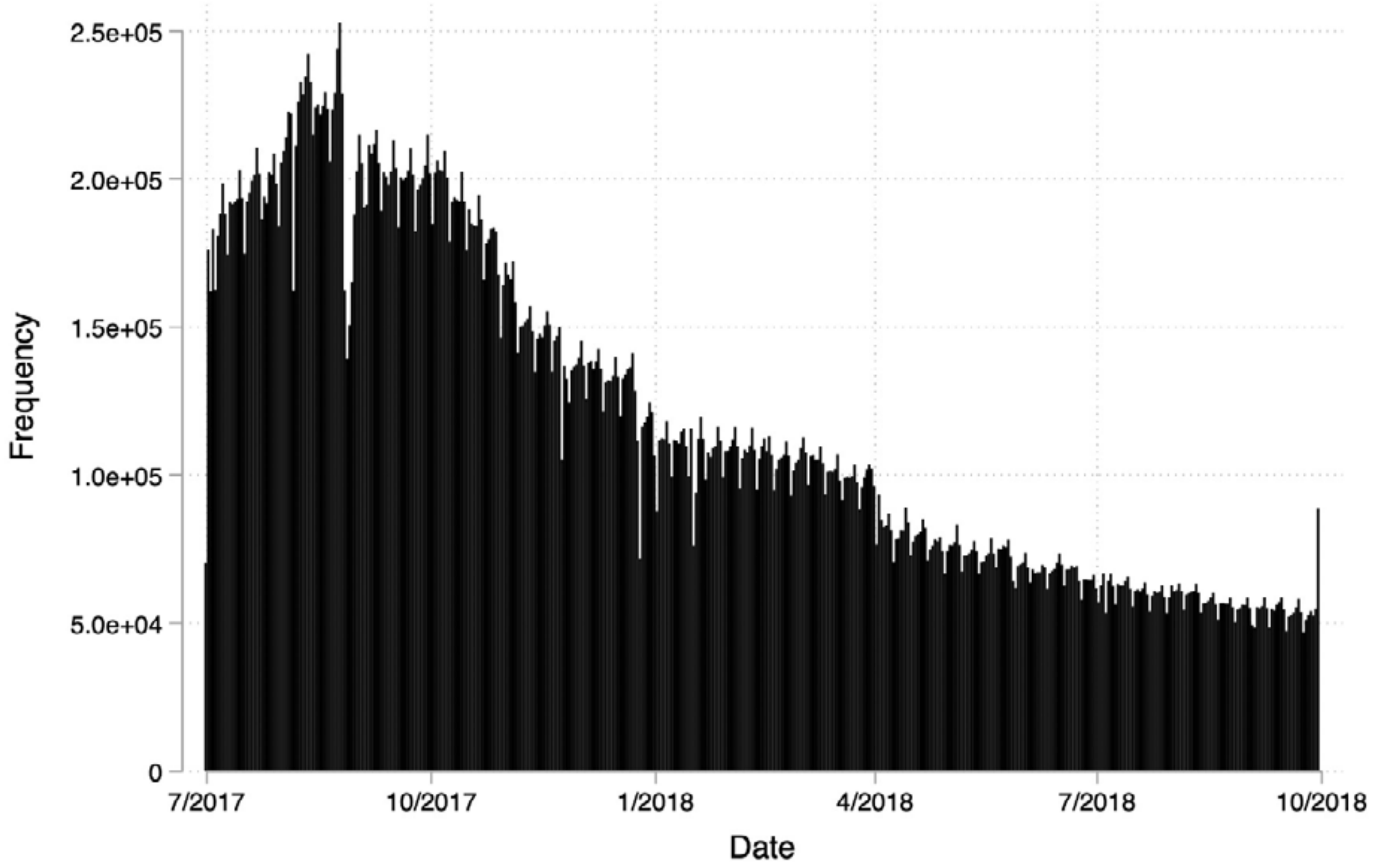
-1.0 - -0.5
-0.5 - -0.3
-0.3 - -0.2
-0.2 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.1
0.1 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 3.5



Daily Activity



Device Level Data Set

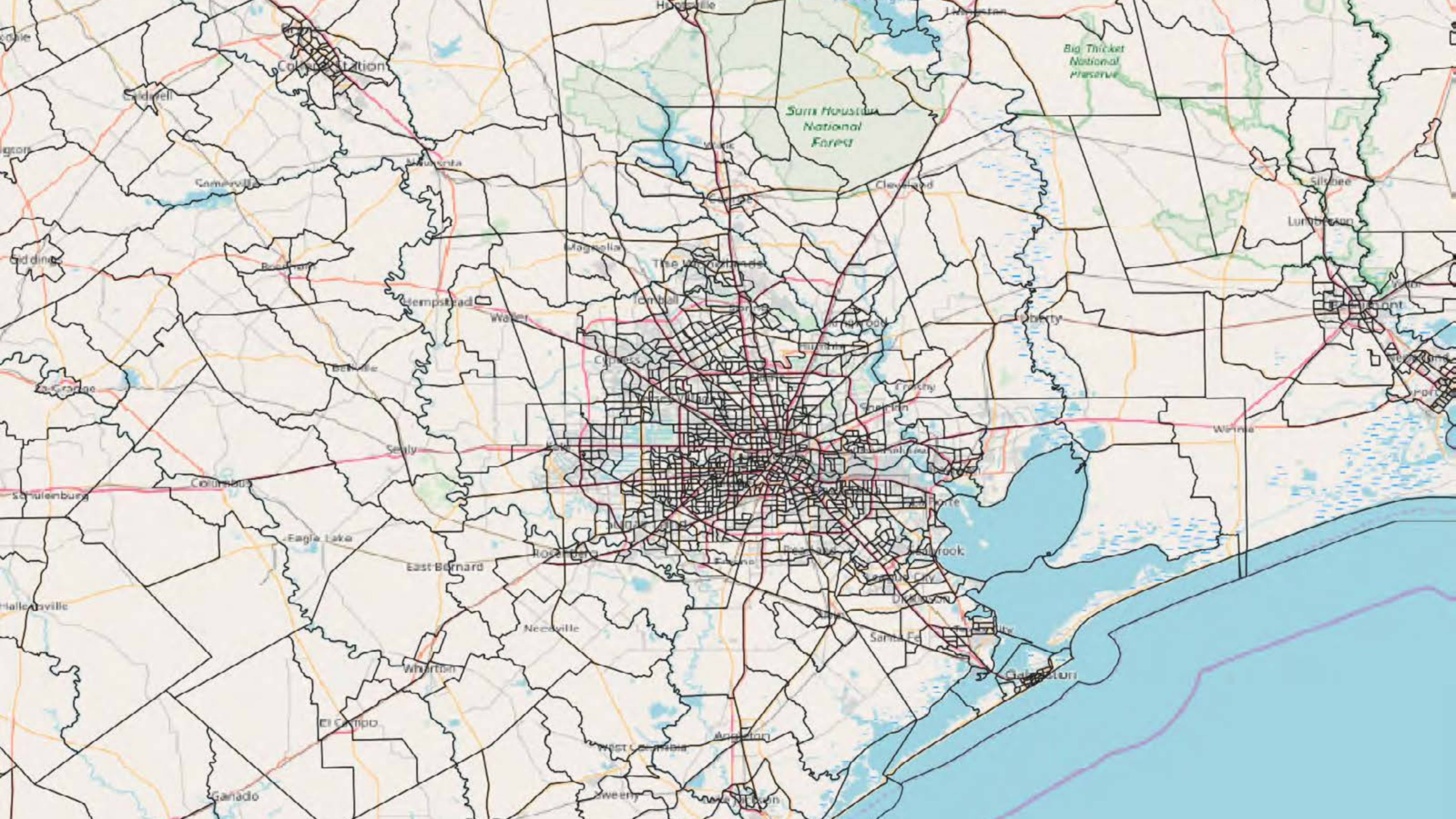


Summary

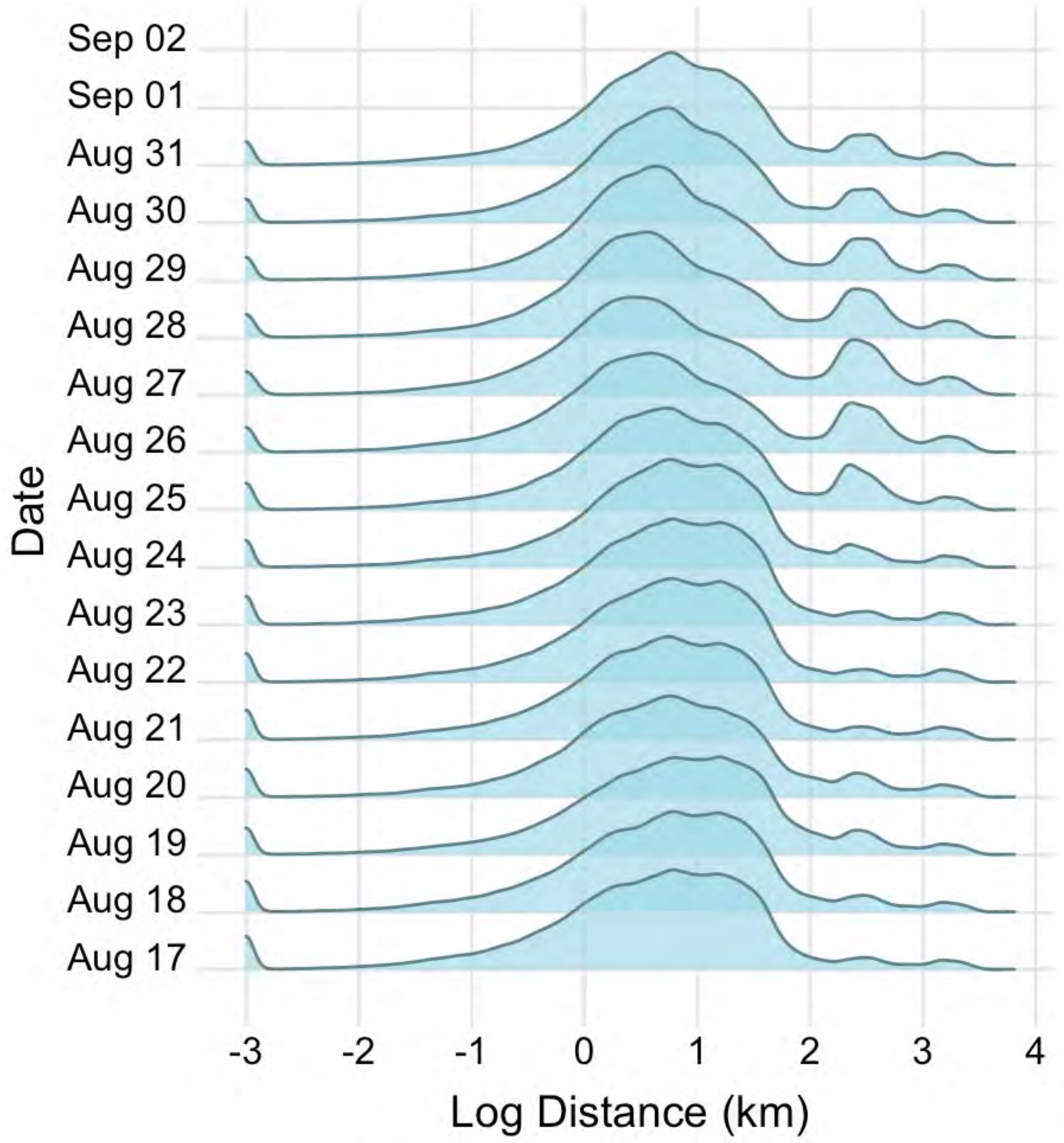
- Ca. 500,000 devices
- Ca. 55,000,000 device-days
- July 2017 – October 2018

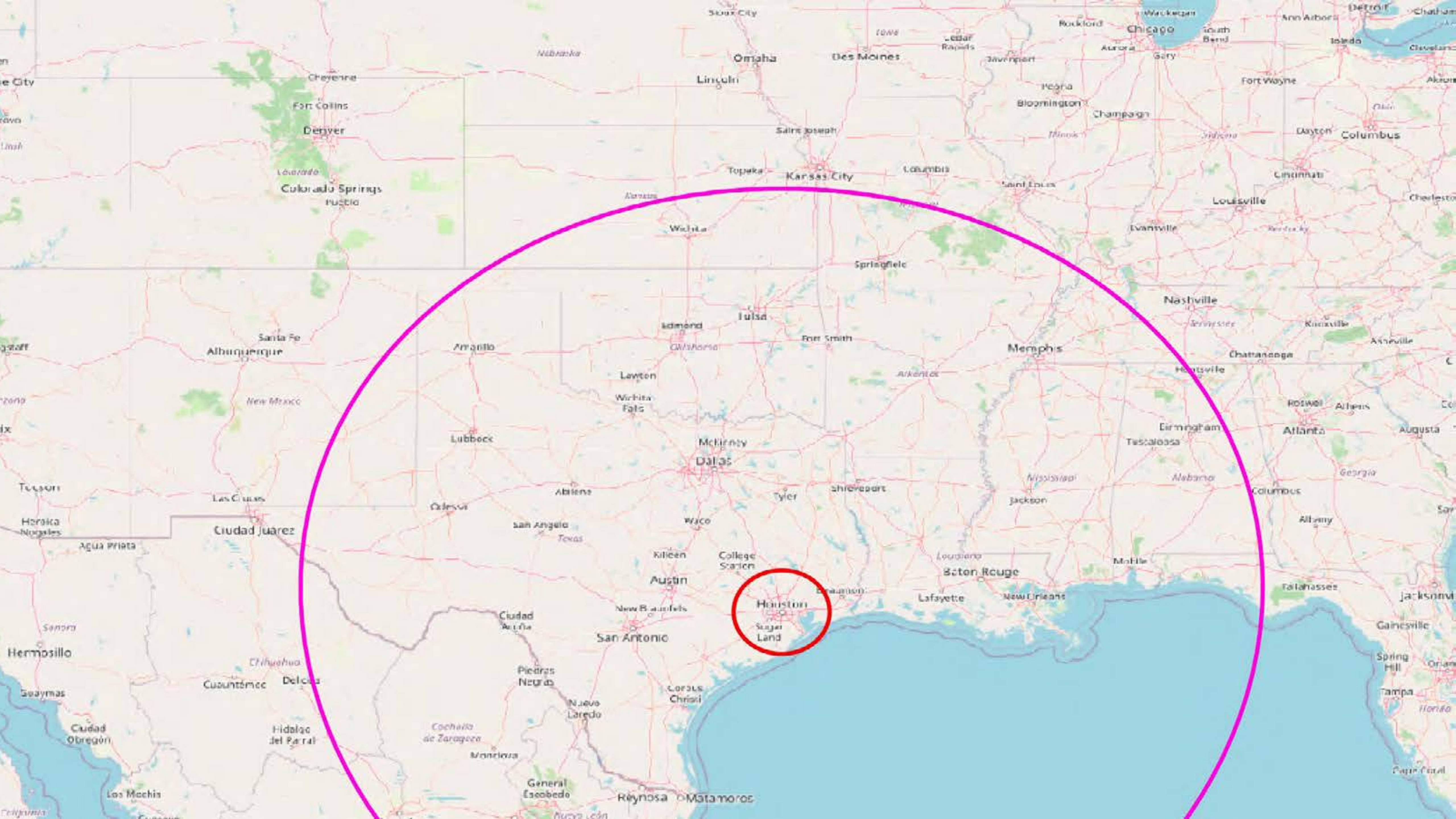
Usual Location ("home")

- Centroid of visits in most visited ZIP codes
- Census tract data
- Average flooding in census tract

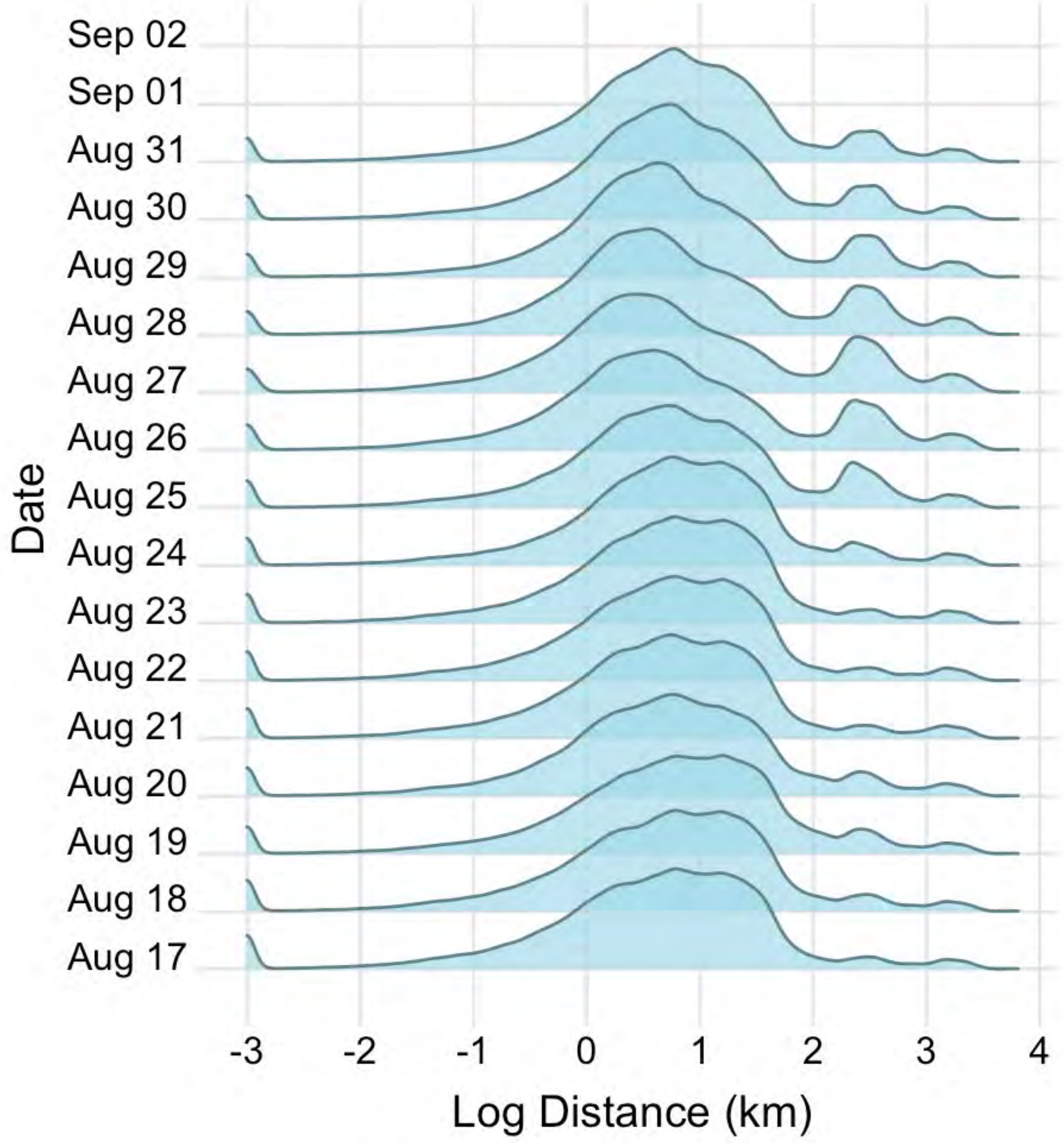

Big Thicket National Preserve
Sam Houston National Forest
Caldwell
Cleveland
Silsbee
Magnolia
Hempstead
Waller
Tomball
Cypress
Bellville
Crosby
Liberty
Winnie
Sealy
Columbus
Schulenburg
Eagle Lake
East Bernard
Needville
Santa Fe
Wharton
El Campo
Ganado
Sweeny

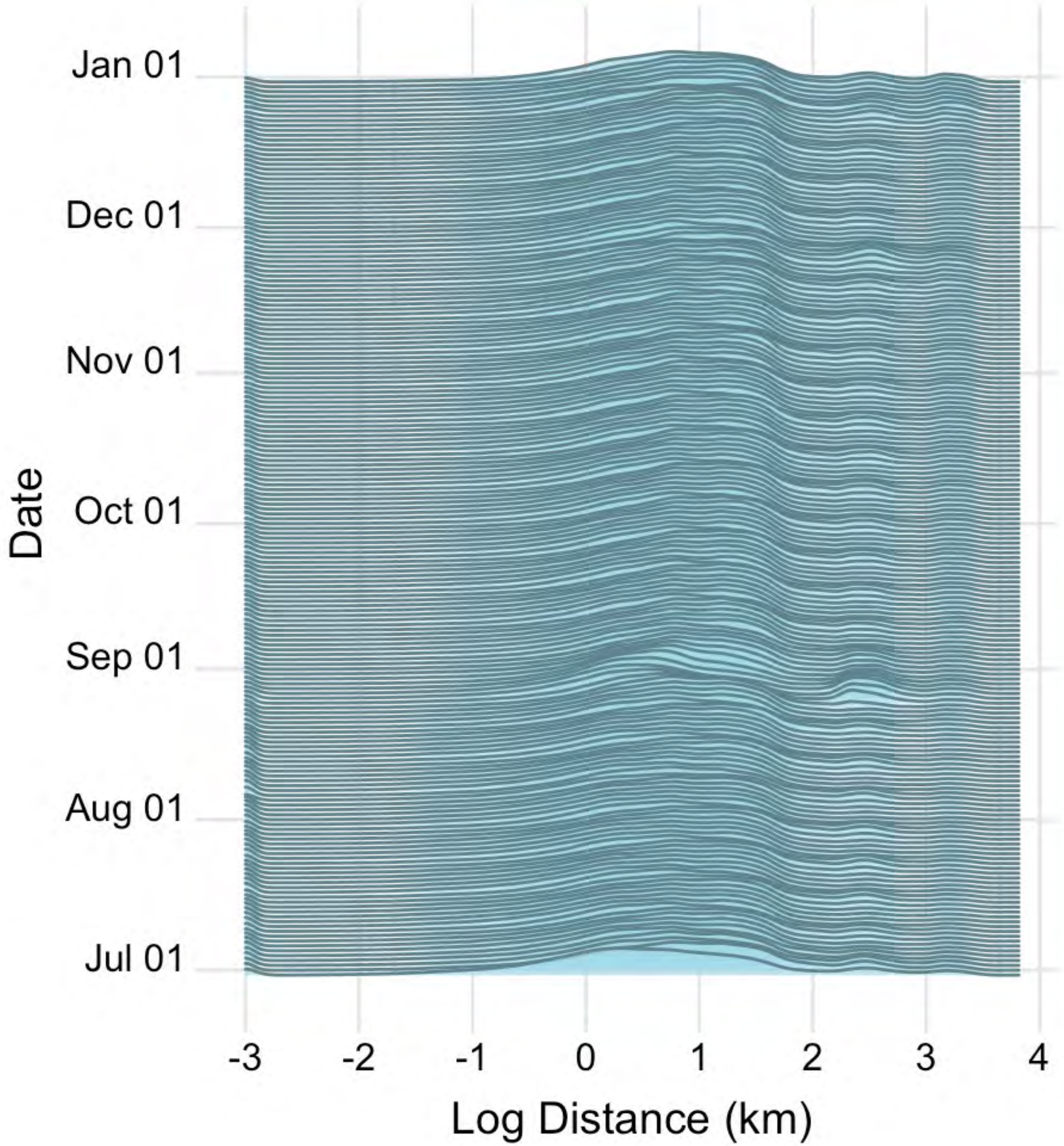
Distance from Usual Location




Sioux City
Omaha
Des Moines
Lincoln
Chicago
Rockford
Peoria
Bloomington
Champaign
Fort Wayne
Dayton
Columbus
Cheyenne
Fort Collins
Denver
Colorado Springs
Pueblo
Topeka
Kansas City
Columbia
Saint Louis
Cincinnati
Louisville
Evansville
Wichita
Springfield
Nashville
Tulsa
Edmond
Fort Smith
Memphis
Knoxville
Chattanooga
Santa Fe
Albuquerque
Amarillo
Lawton
Wichita Falls
New Mexico
Lubbock
McKinney
Dallas
Birmingham
Tuscaloosa
Atlanta
Augusta
Tucson
Las Cruces
Abilene
Odessa
Tyler
Shreveport
Jackson
Columbus
Ciudad Juarez
San Angelo
Texas
Waco
Killeen
College Station
Austin
Houston
Sugar Land
Baton Rouge
Lafayette
New Orleans
Mobile
Tallahassee
New Braunfels
San Antonio
Ciudad Acuña
Hermosillo
Cuauhtémoc
Piedras Negras
Corpus Christi
Nuevo Laredo
Ciudad Obregón
Hidalgo del Parral
Monclova
General Escobedo
Reynosa
Matamoros
Los Mochis

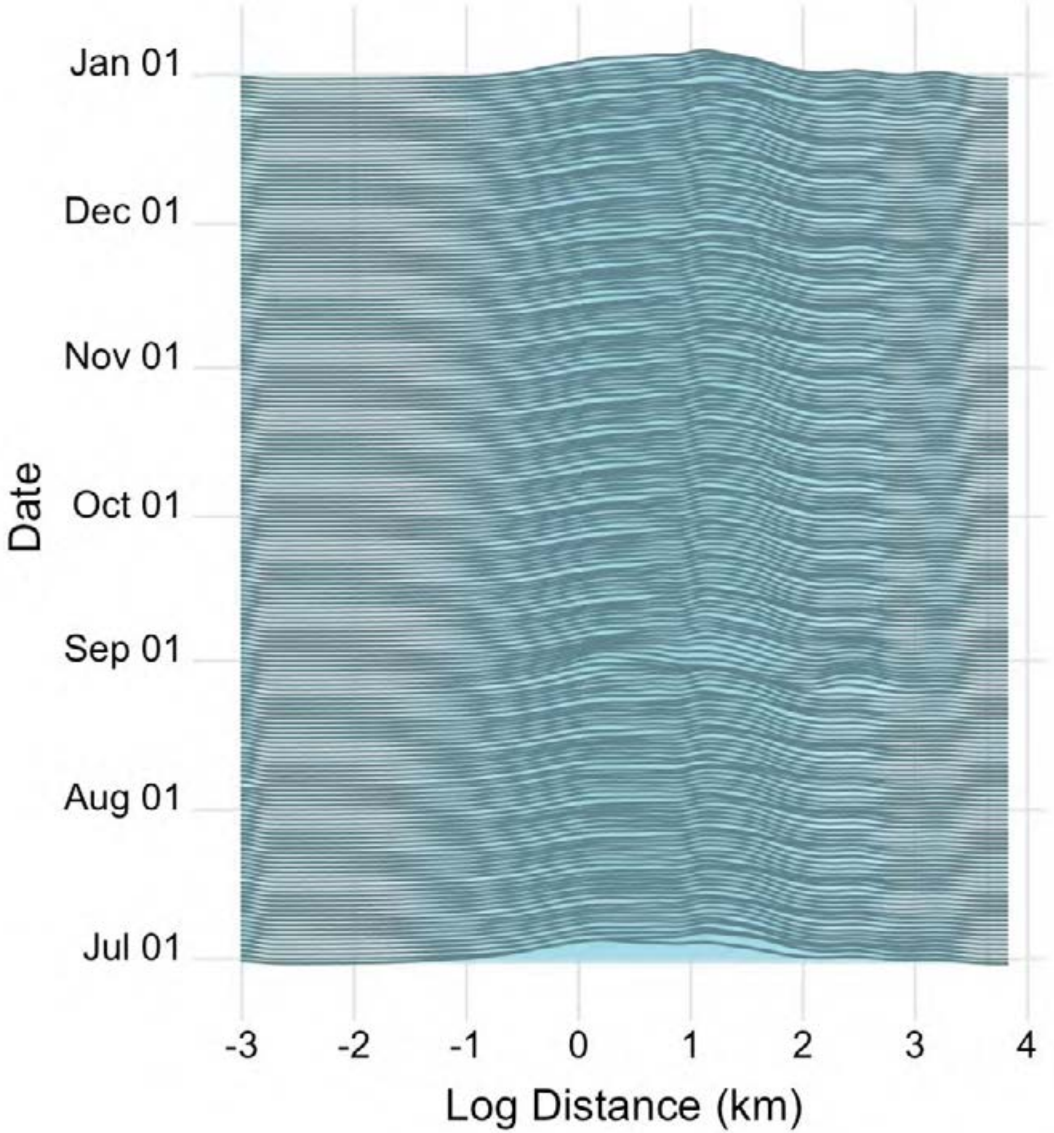
Distance from Usual Location

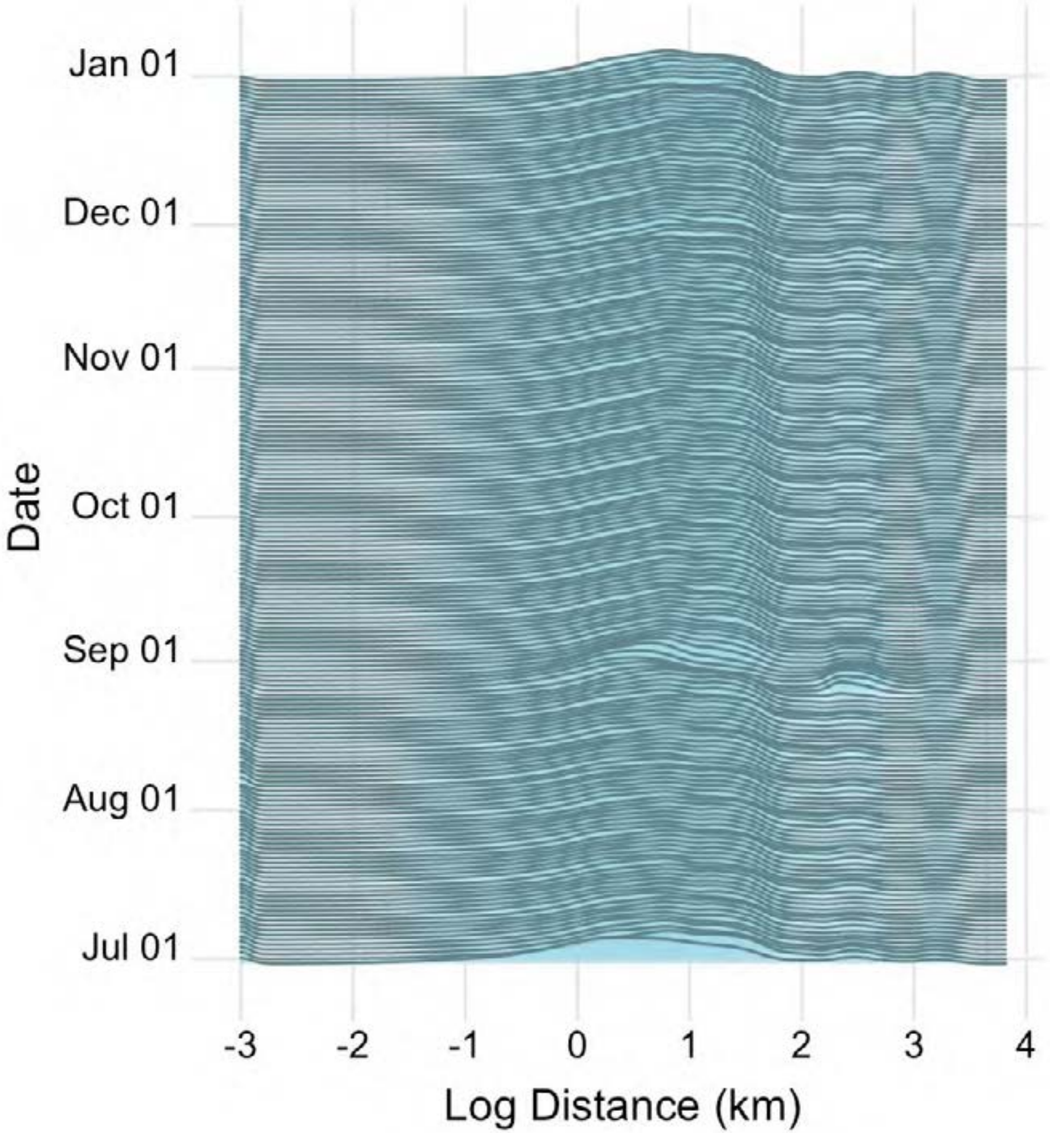




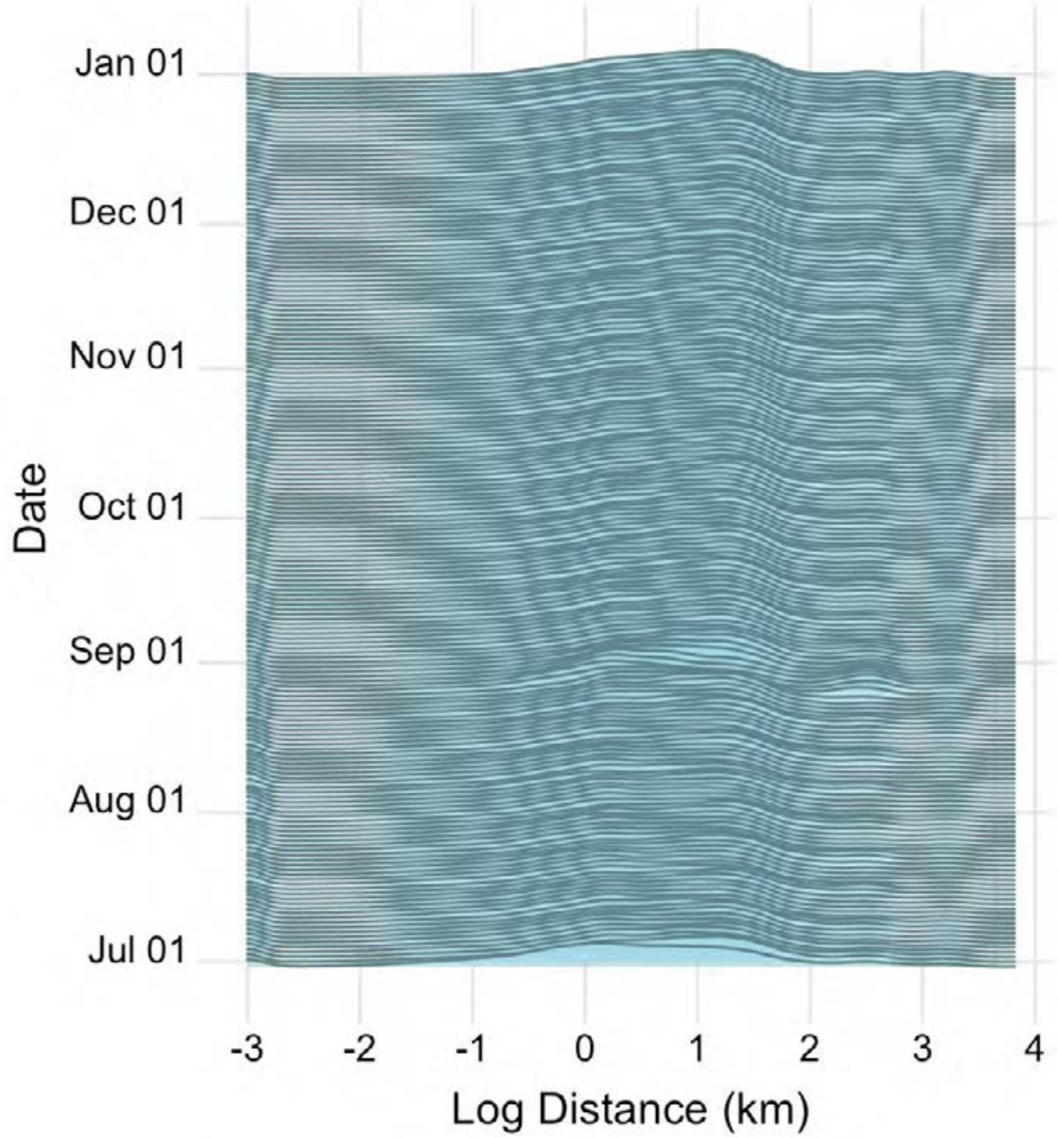
Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)

Flood

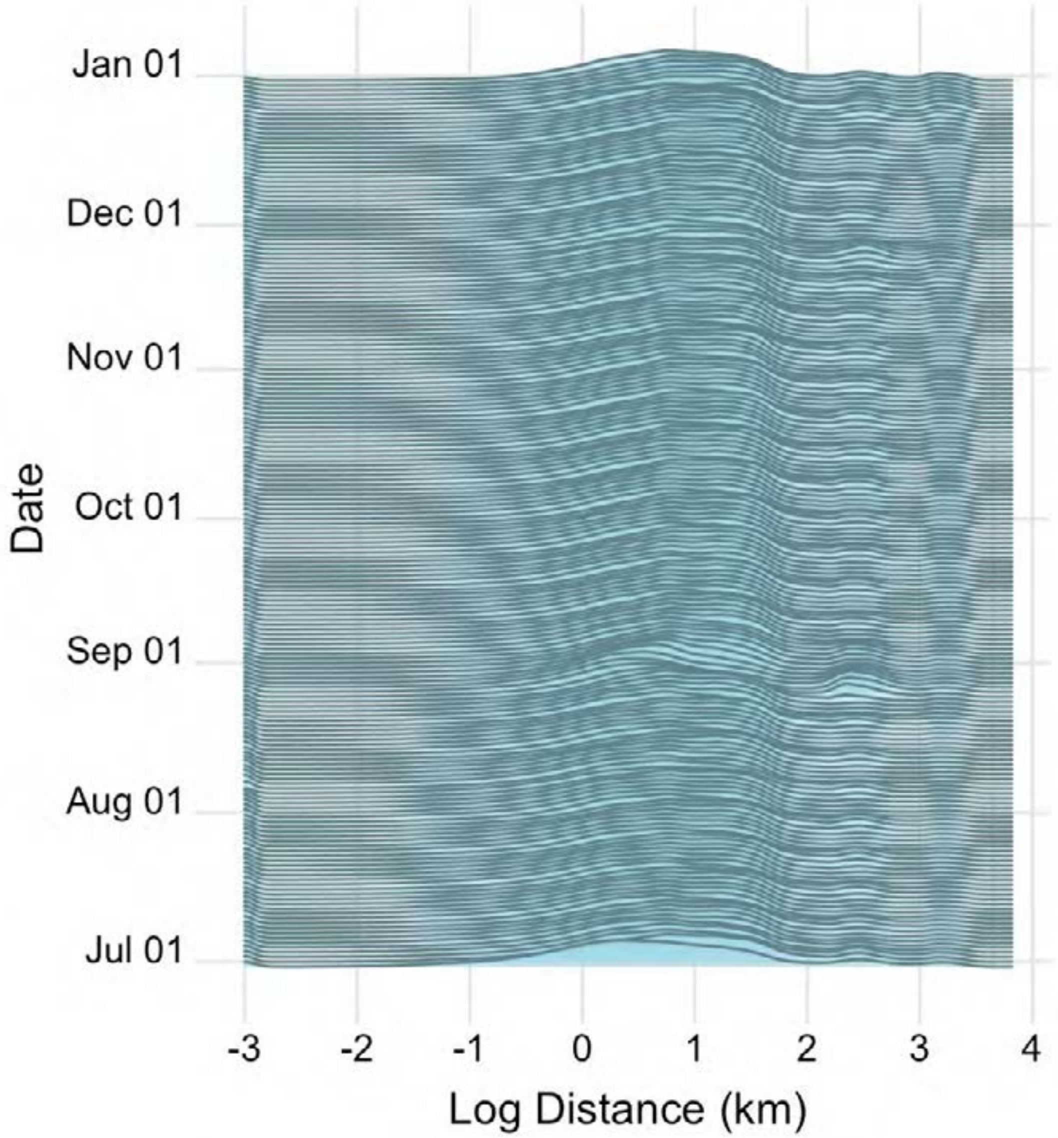

Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)


Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)

POVERTY

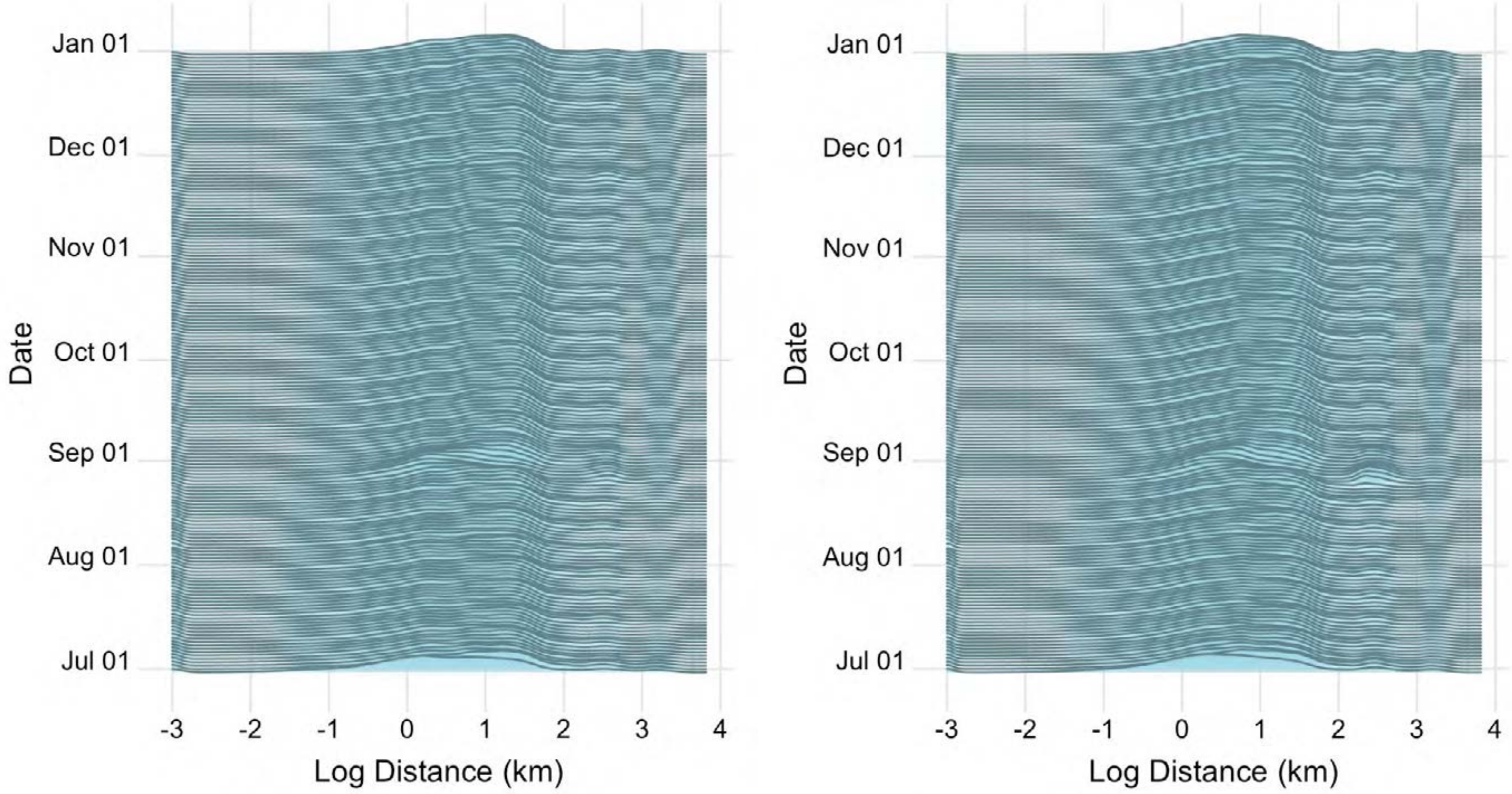


Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)



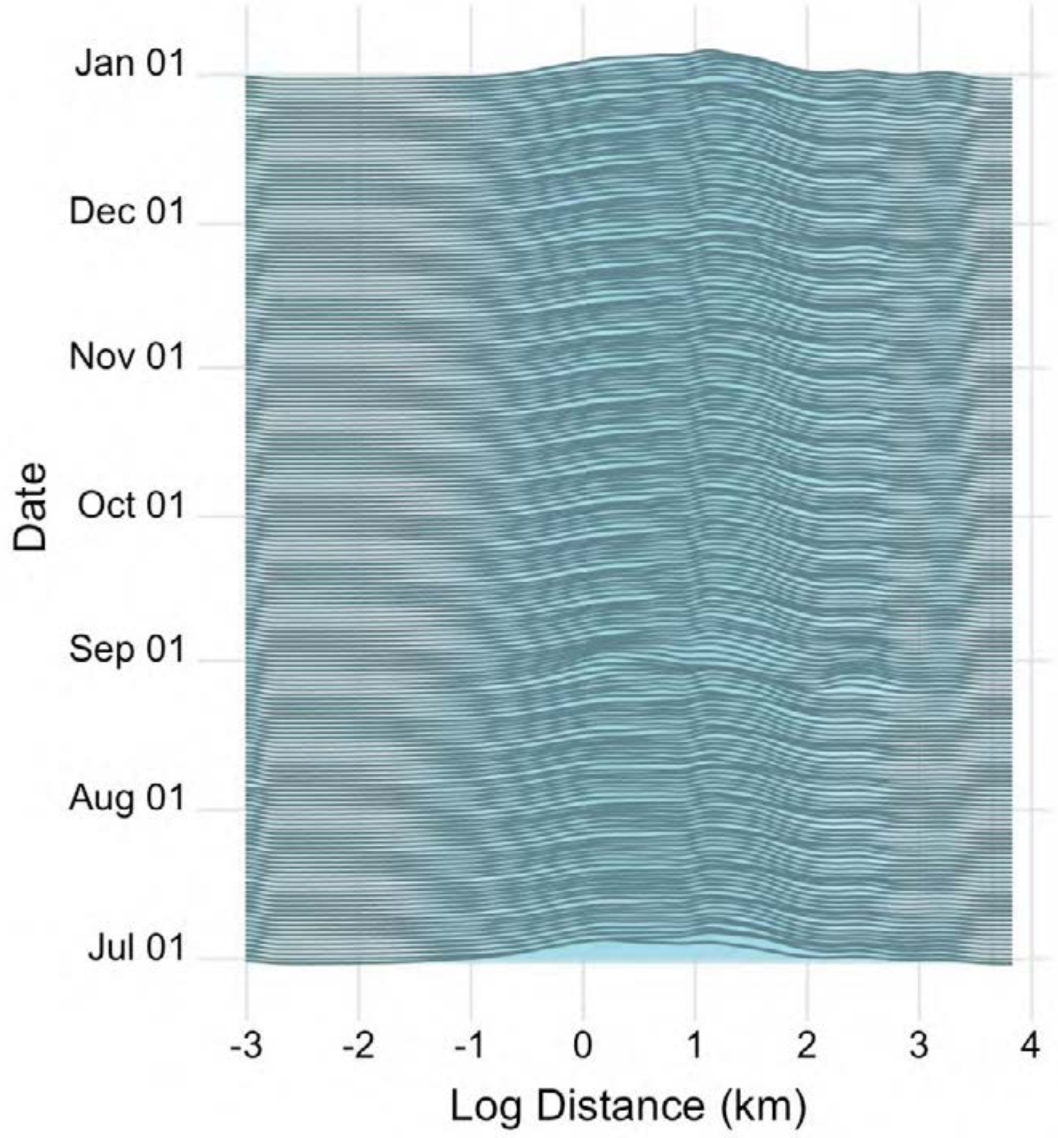
Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)

Black

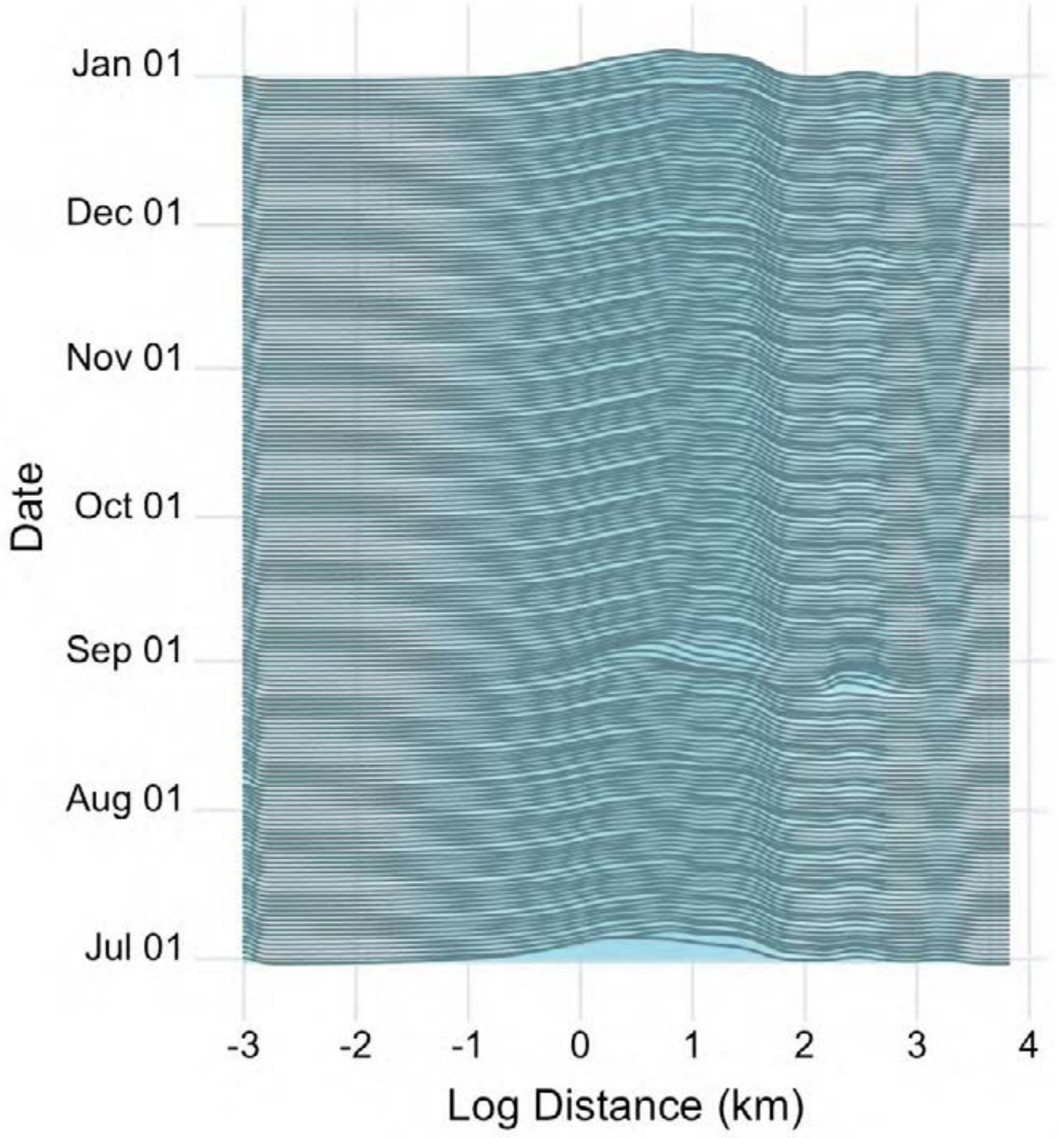


Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3 -2 -1 0 1 2 3 4
Log Distance (km)
Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3 -2 -1 0 1 2 3 4
Log Distance (km)

Flood

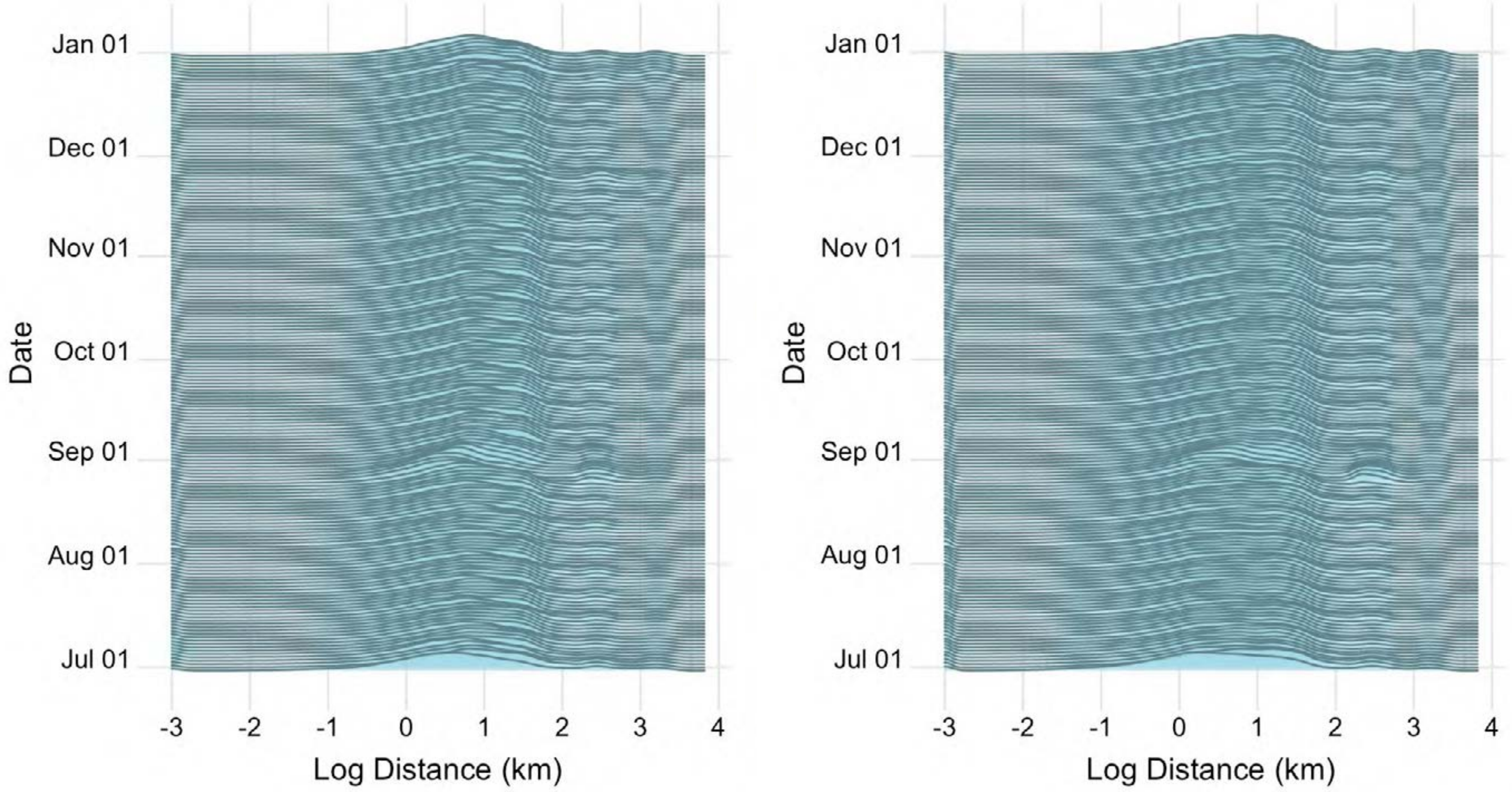


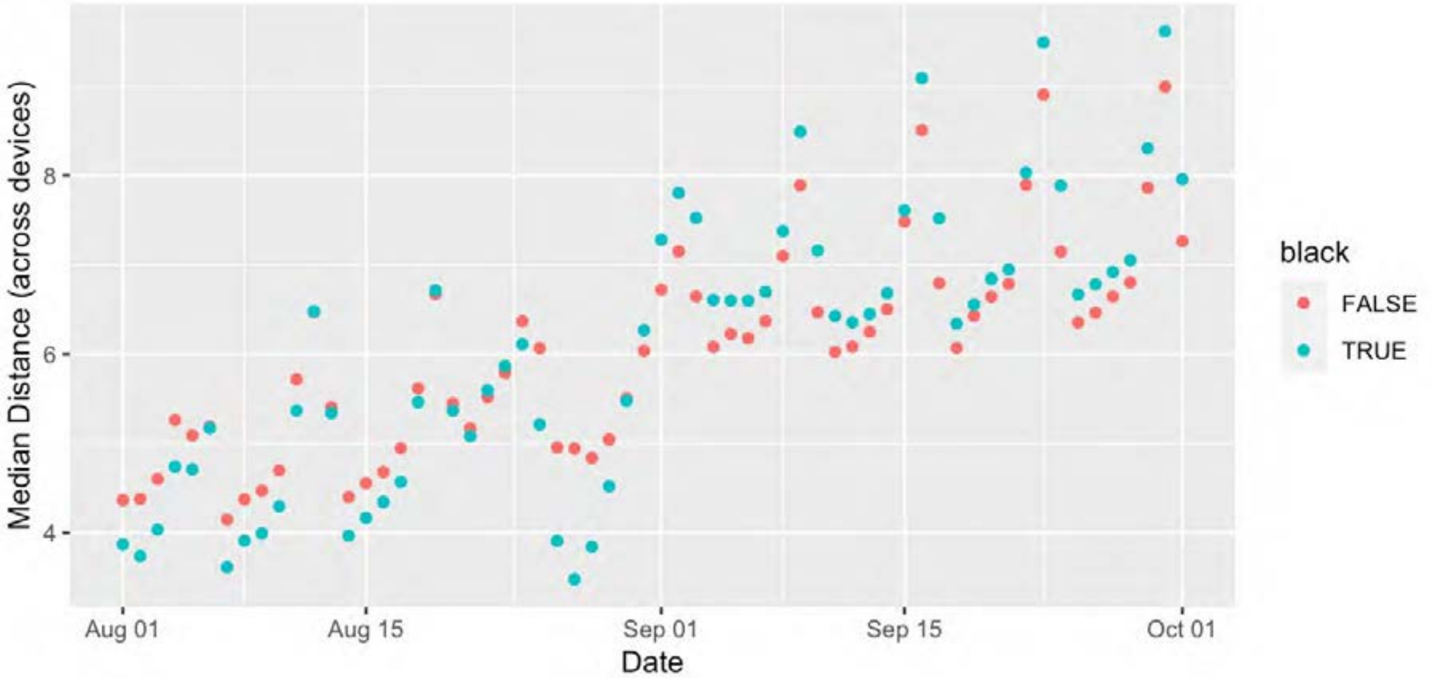
Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)



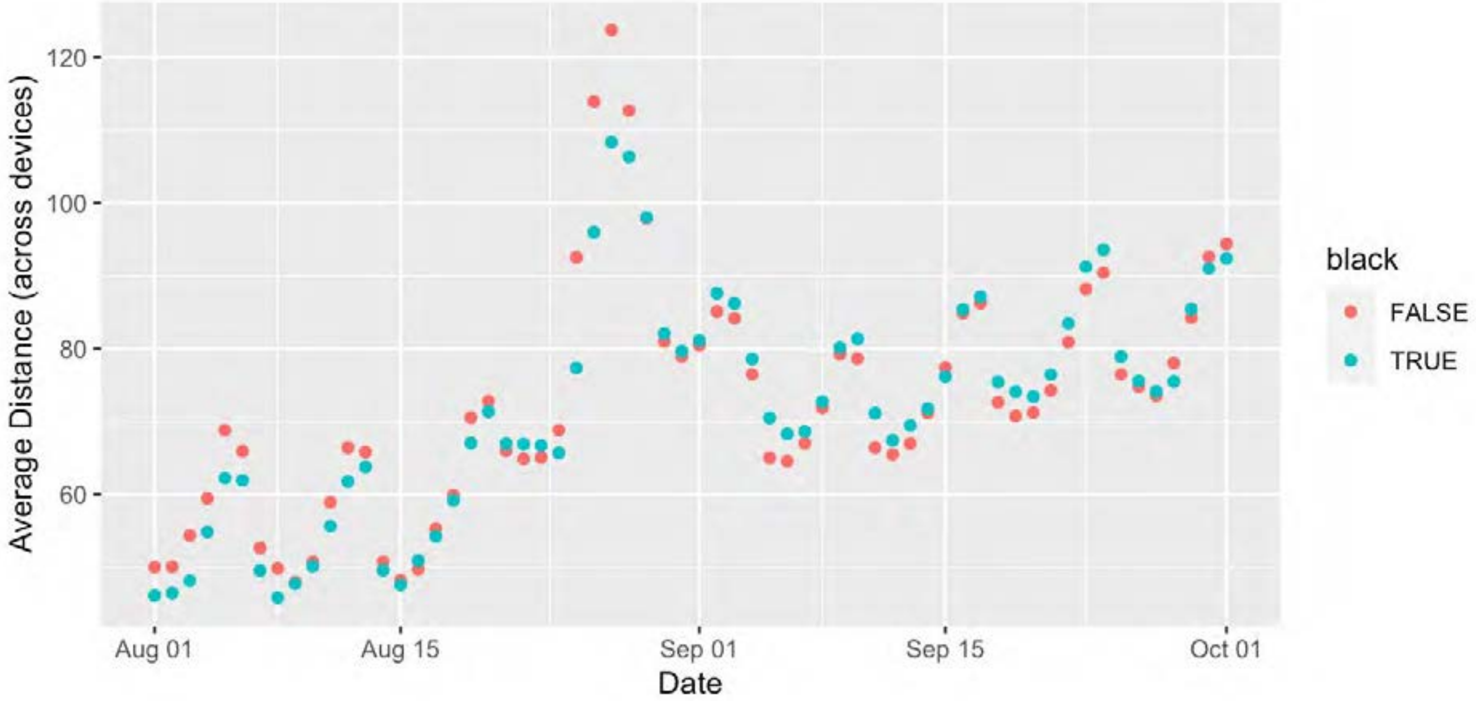
Jan 01
Dec 01
Nov 01
Oct 01
Sep 01
Aug 01
Jul 01
Date
-3
-2
-1
0
1
2
3
4
Log Distance (km)

Owner Occupied





Median Distance (across devices)
4
6
8
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Date
black
FALSE
TRUE



Average Distance (across devices)
60
80
100
120
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Date
black
FALSE
TRUE

Regression Analysis

$$Y_{i,t} = \alpha_i + T_t \times CT_i + \varepsilon_{i,t}$$

T_t Timing (6 separate periods)
CT_i Census tract characteristics

max_distance_t~d	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
timing						
August 24–25	16.03654	.4166596	38.49	0.000	15.2199	16.85318
August 26–27	44.23695	.6013688	73.56	0.000	43.05829	45.41562
August 28–31	27.47719	.3558762	77.21	0.000	26.77968	28.17469
September	18.54044	.1446854	128.14	0.000	18.25687	18.82402
after September	44.74033	.1166784	383.45	0.000	44.51164	44.96901
_cons	60.81715	.0969976	627.00	0.000	60.62703	61.00726

max_distance_to~d	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
timing						
August 24-25	17.6805	.4787398	36.93	0.000	16.74219	18.61881
August 26-27	47.59634	.6932225	68.66	0.000	46.23765	48.95503
August 28-31	29.59836	.4100922	72.17	0.000	28.79459	30.40213
September	19.4031	.1661491	116.78	0.000	19.07745	19.72875
after September	46.09998	.1341613	343.62	0.000	45.83703	46.36293
flooding	0	(omitted)				
timing#c.flooding						
August 24-25	-7.183298	.9707489	-7.40	0.000	-9.085931	-5.280665
August 26-27	-14.77129	1.387654	-10.64	0.000	-17.49105	-12.05154
August 28-31	-9.201179	.823676	-11.17	0.000	-10.81555	-7.586803
September	-3.78949	.3373715	-11.23	0.000	-4.450726	-3.128253
after September	-5.944983	.2712262	-21.92	0.000	-6.476576	-5.413389
_cons	60.82649	.0969832	627.19	0.000	60.63641	61.01658

max_distance_to~d	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
timing						
August 24-25	20.35002	.6744662	30.17	0.000	19.02809	21.67195
August 26-27	55.46899	.9556933	58.04	0.000	53.59586	57.34211
August 28-31	28.44357	.5641532	50.42	0.000	27.33785	29.54929
September	16.33457	.2312555	70.63	0.000	15.88132	16.78783
after September	42.15079	.188827	223.22	0.000	41.7807	42.52089
timing#flooding						
August 24-25#1	-8.679985	1.36666	-6.35	0.000	-11.35859	-6.00138
August 26-27#1	-18.2857	1.952196	-9.37	0.000	-22.11193	-14.45947
August 28-31#1	-9.170367	1.145872	-8.00	0.000	-11.41624	-6.9245
September#1	-1.277367	.4735432	-2.70	0.007	-2.205495	-.3492397
after September # 1	-1.861781	.3784813	-4.92	0.000	-2.603591	-1.119971
timing# c.mv_black_alone						
August 24-25	-18.53514	3.239567	-5.72	0.000	-24.88457	-12.1857
August 26-27	-55.74212	4.636544	-12.02	0.000	-64.82958	-46.65466
August 28-31	7.73922	2.738602	2.83	0.005	2.371658	13.10678
September	21.24377	1.083697	19.60	0.000	19.11976	23.36777
after September	27.54978	.9070207	30.37	0.000	25.77205	29.3275
timing#flooding# c.mv_black_alone						
August 24-25#1	8.199828	7.908285	1.04	0.300	-7.300127	23.69978
August 26-27#1	17.30828	11.44929	1.51	0.131	-5.131916	39.74847
August 28-31#1	2.221445	6.575643	0.34	0.735	-10.66658	15.10947
September#1	-16.36781	2.574519	-6.36	0.000	-21.41377	-11.32185
after September # 1	-28.74592	2.064901	-13.92	0.000	-32.79305	-24.69879
_cons	60.84307	.0970068	627.20	0.000	60.65294	61.0332

Main Regression Results

- Average distance increased by about 55km during Harvey.
- Still up by 16km in September 2017 and increases to 42km afterward.
- Less evacuation/distance from more flooding affected census tracts. Particularly during Harvey (-18km).
- Less evacuation/distance from black census tracts during Harvey (55km). More distance after Harvey.

Results

- Increased mobility pre-landfall phase of Harvey.
- Vulnerability related to race and socio-economic characteristics stronger factors than direct exposure.
- Pre-Harvey 29% of devices were active in the 10-100 km range from their usual location. During Harvey, only about 20%. Recovered quickly and increased to 33% by early September, increasing further into 2018.
- Pre-Harvey 5% of devices were active more than 100 km from their usual location. During Harvey it was 15%, and it went down to 6% by September 10.

Up next – 10:45am-12:15pm PT

SESSION 2.1

International Lessons on Climate Adaptation

SESSION 2.2

Before the Storm: Responses to Forecasts

SESSION 2.3

Quantifying and Minimizing the Impacts of Wildfires

SESSION 2.4

Proactive Planning for Resilient and Equitable Communities

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Thanks for tuning in!

UCLA Luskin Center for Innovation