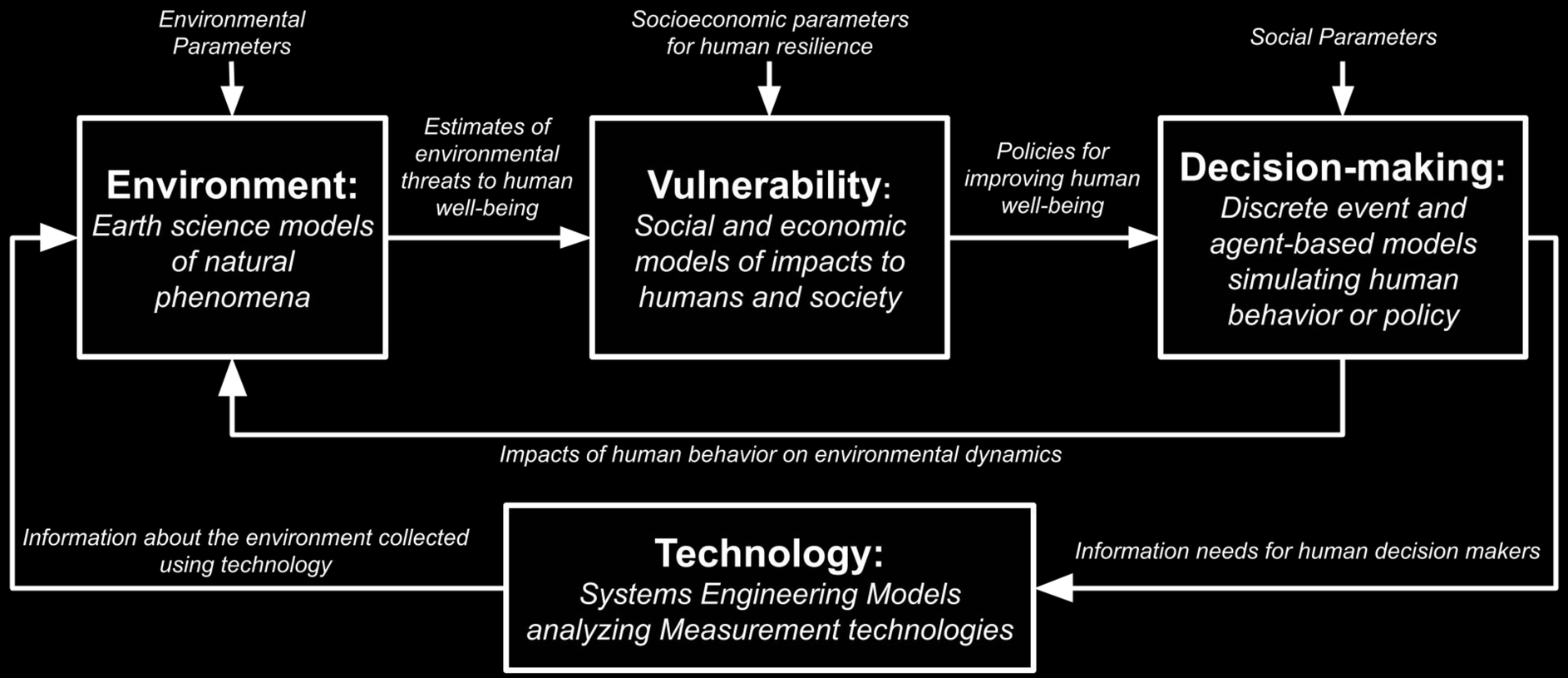
International Collaboration Aimed at Identifying Relevant Social, Policy, and Environmental Factors in the Progression of SARS-CoV2/COVID-19 in Six Metropolitan Areas

Jack Reid, Seamus Lombardo, David Lagomasino, Eric Ashcroft, Paulina Assmann, Carlos Ávila, Mary Bracho, Joana Caetano, Hanifa Denny, Mohammad Jalali, Felipe Mandarino, Amanda Payton, Joaquin Salas, Gilson Santos, Joga Setiawan, Eduina Teodoro, Katlyn Turner, Maggie Zheng, Danielle Wood

space enabled

EVDT Framework

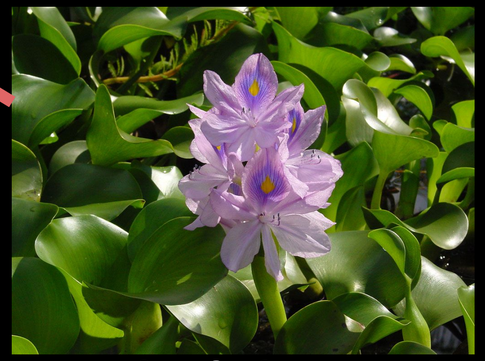


- What is happening in **the natural environment**?
- How will **humans be impacted** by what is happening in the natural environment?
- What **decisions are humans making** in response to environmental factors and why?
- What **technology system** can be designed to provide high quality information that supports human decision making?

Some Pre-Pandemic EVDT Applications

Mining in Ghana

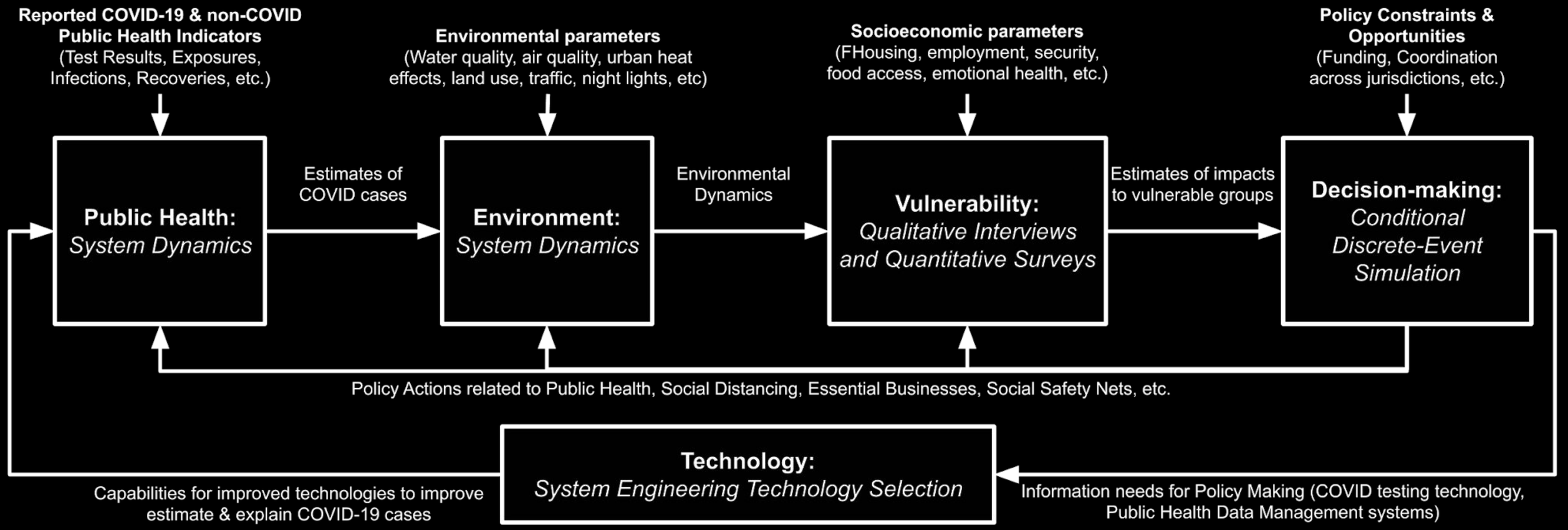
Mangroves in Rio de Janeiro



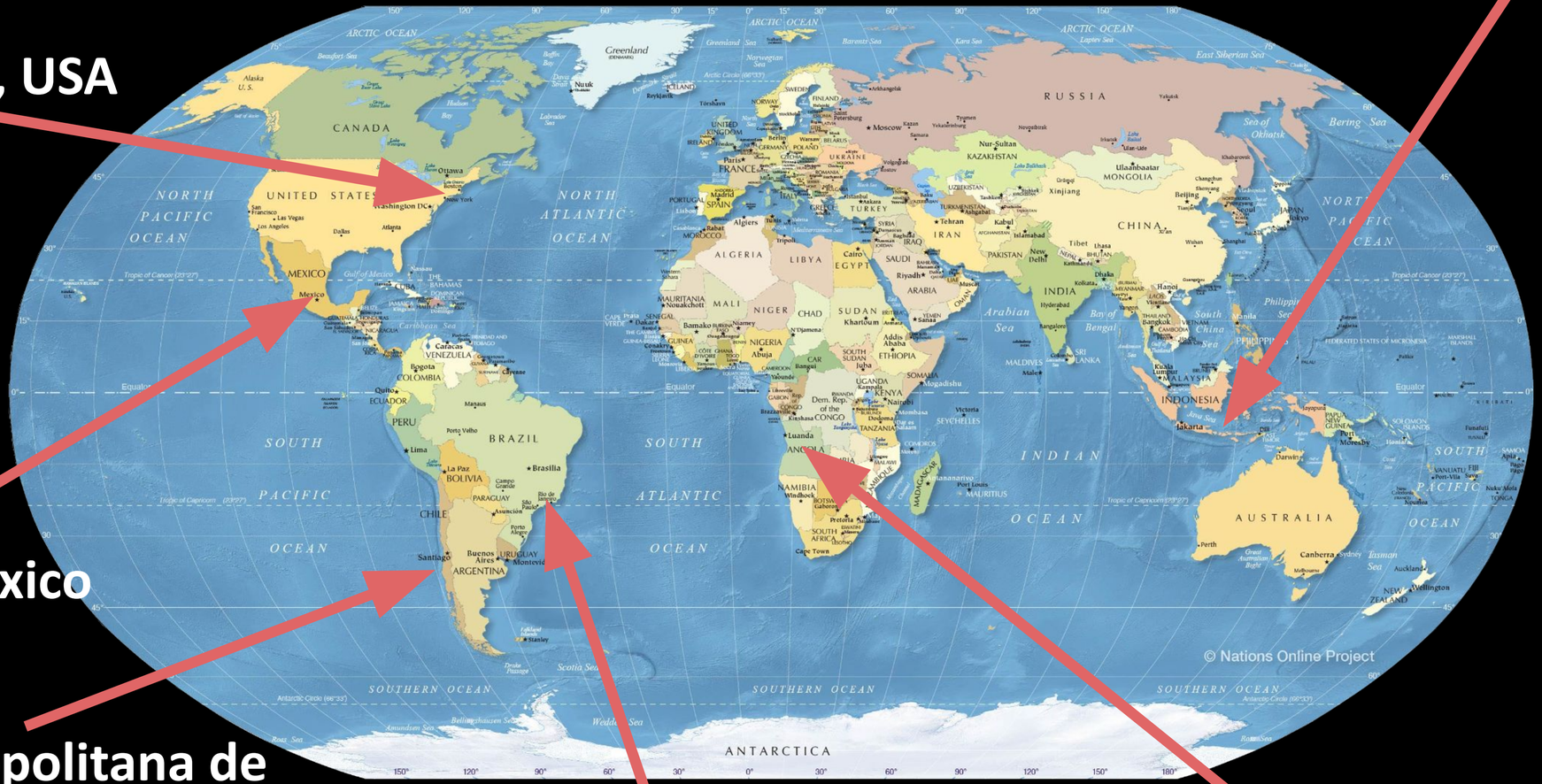
Water Hyacinth in Benin

Map adapted from the Nations Online Project.

Vida Decision Support System



Vida DSS International Network



Java & Sulawesi, Indonesia

Boston, USA

Querétaro, México

Región Metropolitana de Santiago, Chile

Rio de Janeiro, Brasil

Luanda, Angola

Map adapted from the Nations Online Project.

Brasil

México

Indonesia

Chile

Angola

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Datos-COVID19

El objetivo de la Mesa de Datos COVID-19 liderada por el Ministerio de Ciencia, Tecnología, Conocimiento e Innovación es disponer de información de nuestro país durante la pandemia para promover el uso de datos para investigación científica, clínica y para soluciones innovadoras que contribuyan a la toma de decisiones de las autoridades y la ciudadanía frente a esta pandemia. Se disponen los datos epidemiológicos provenientes del Ministerio de Salud (MINSAL) y datos de otras fuentes, documentados y abiertos para el análisis de la comunidad, en concordancia con la Ley Nº 19.628.

Ver https://minciencia.gob.cl/covid19/ para más información, incluyendo actas de las reuniones de la mesa y también los informes publicados a la fecha.

Data Products

Data Product 1 - Casos totales por comuna incremental: Archivo con valores separados por coma (csv) que concatena historia de publicaciones de MINSAL sobre casos confirmados totales por comuna. Contiene las columnas 'Región', 'Código Región', 'Comuna', 'Código comuna', 'Población', múltiples columnas correspondientes a '[fecha]', y una columna 'Tasa'. Incluye versión con serie de tiempo. Ver más.

Data Product 2 - Casos totales por comuna: Archivos con valores separados por coma (csv) con la información de casos confirmados notificados a nivel comunal por cada informe publicado. Cada archivo contiene las columnas 'Región', 'Código Región', 'Comuna', 'Código comuna', 'Población' y 'Casos Confirmados'. Ver más.

Data Product 3 - Casos totales por región incremental: Archivo con valores separados por coma (csv) que concatena historia de publicaciones de casos totales por parte de MINSAL. El archivo contiene una columna 'Región', seguida por columnas correspondientes a '[fecha]'. Estas últimas columnas, '[fecha]', contienen los 'Casos Confirmados' reportados por el Ministerio de Salud de Chile en cada una de las fechas que se indican en las respectivas columnas. Incluye versión con serie de tiempo. Ver más.

Open in Colab

Ministerio de Ciencia, Tecnología, Conocimiento e Innovación

Gobierno de Chile

Bienvenido al jupyter notebook demo del MinCiencia

Para empezar

Este documento te permite interactuar con los datos que se encuentran en el repositorio del Ministerio de Ciencia, Tecnología, Conocimiento e Innovación. Estos datos son recopilados de las cifras oficiales publicadas por el Ministerio de Salud sobre la pandemia del COVID-19 en Chile.

Este notebook es un ejemplo y puedes usarlo como base para generar tus propios gráficos y/o productos. Los datos publicados están en https://colab.research.google.com/github/MinCiencia/output/blob/master

Para trabajar con los productos

Este notebook está escrito utilizando el lenguaje de programación Python versión 3.x, cuya lectura se facilita a programadores no expertos. Cada bloque de ejecución está separado en distintas celdas, es necesario "ejecutar" cada una en secuencia haciendo click en botón "play" que aparece al posicionar el mouse sobre el recuadro [ ] al inicio de cada celda. Una vez que la celda se ejecuta, aparece un número que indica el órden en que se ha ejecutado.

Una manera comun de manipular los datos, es usando pandas. Para cargar uno de los archivos en un dataframe. También es necesario utilizar numpy para los distintos cálculos

In [0]:
```
import numpy as np
import pandas as pd
```

Los datos están almacenados como tablas en formato csv. Algunas tablas están almacenadas por día. Es importante mantener el formato 'año-mes-día' (las comillas simples o dobles indican que es texto y no se ejecutará como una operación matemática)

In [0]:
```
# el símbolo # al inicio de la linea nos indica que esto es un comentario, no se ejecuta con el código
# date indica la fecha de los datos que queremos utilizar

date = '2020-04-20'
```

Para leer la tabla correspondiente al día escogido y se le asigna el nombre dataTotalRegion:

In [0]:
```
dataTotalRegion = pd.read_csv("https://raw.githubusercontent.com/MinCiencia/Datos-COVID19/master/output/producto4/"+date+"-CasosConfirmado
```

Utilizamos read_csv de pandas con el parámetro

```
# index_col = 'Region'
```

para indicar que el índice de la tabla son los nombres de las regiones. Los nombres de las columnas se listan a continuación

In [0]:
```
columnas = list(dataTotalRegion.columns.values)
columnas
```

Out[0]:
```
['Casos  nuevos', 'Casos  totales', '%  Casos  totales**', 'Fallecidos']
```

Podemos ver los valores de las columnas ejecutando en una celda

```
# dataTotalRegion
```


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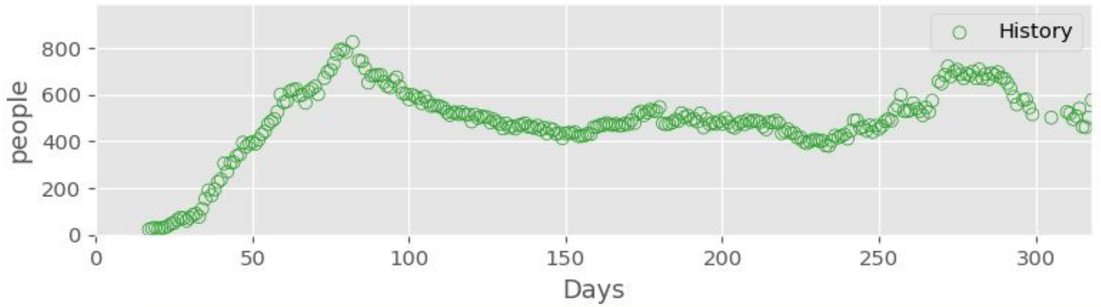
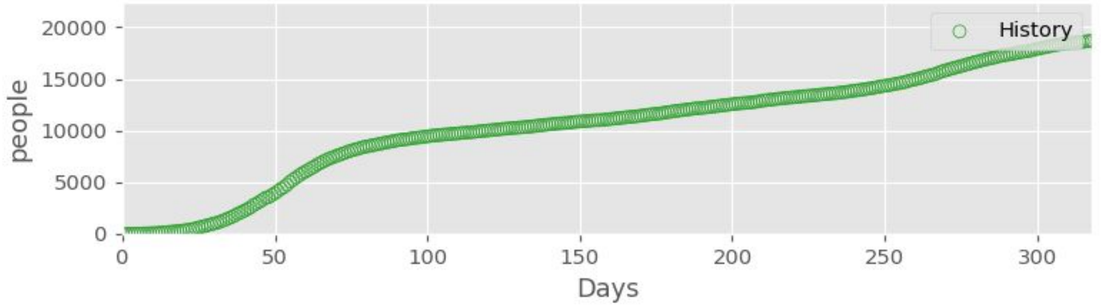
Data & Methods: Public Health

- COVID-19 health data collected by local authorities
  - Daily infections, hospitalizations, deaths, and recoveries
  - Daily PCR tests
  - Hospital bed capacity and availability
  - Ventilator use and availability
  - Vaccination rates

Graph 1: Hospitalized Population



Graph 2: Deaths



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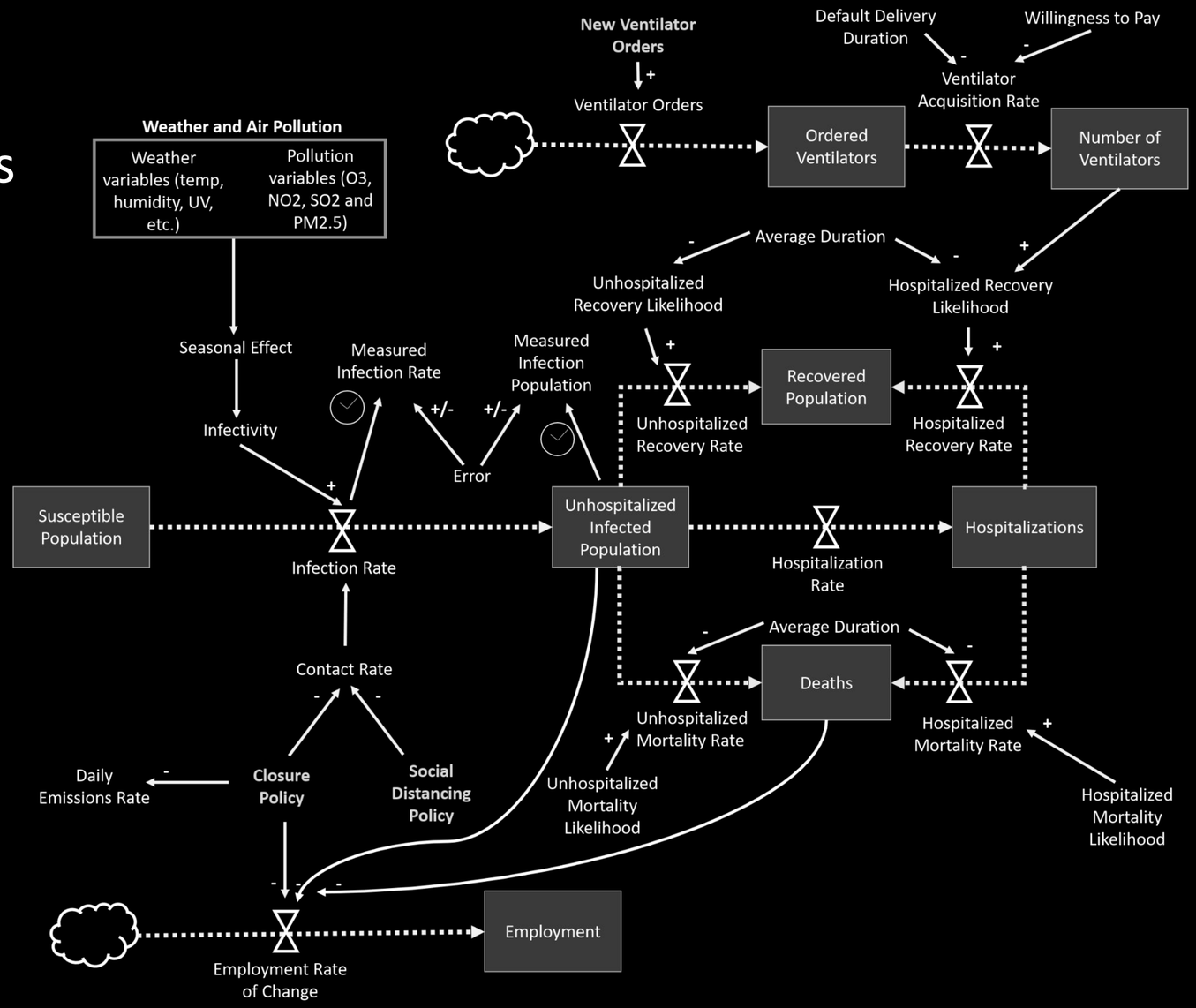
Data & Methods: Public Health

- Epidemiological Model: SEIR
- Modeling Approach: System Dynamics
- Integrates aspects of other Vida components
- Current version is non-spatial
- Adjusting assumptions and policy decisions can generate alternative scenarios



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Data & Methods: Environment

- Air Quality (O3, NO2, SO2, PM2.5, PM10)
  - Remote: Sentinel 5P
  - In-Situ: Monitoring Stations (Brazil & Chile)
- Nightlights
  - VIIRS: VNP46A2 & VNP46A3
- Water Quality (NDTI, NDWI, other indices)
  - Landsat 7 ETM+, Landsat 8 OLI, and PlanetScope

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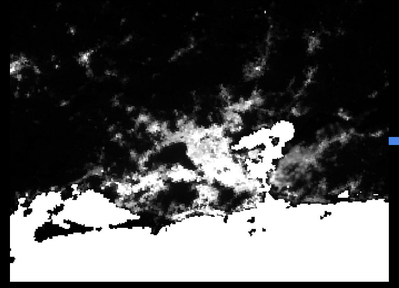
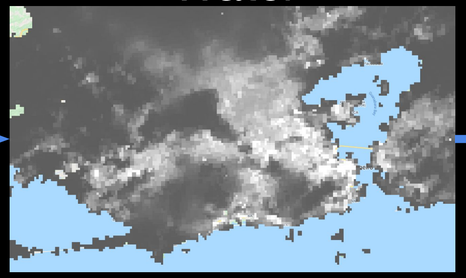
Nightlights Methodology

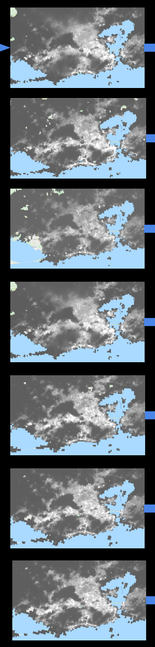
VNP46A2 Raw Image

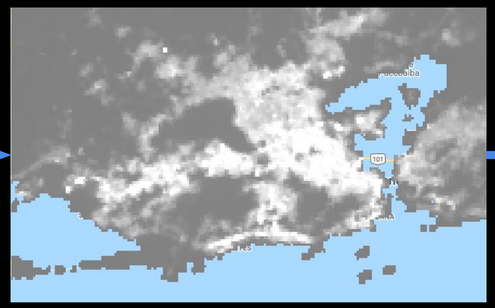


Filter
Area of Interest
Clouds
Water

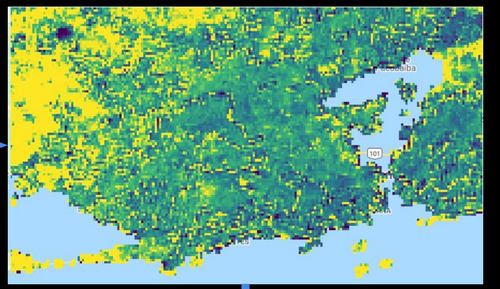


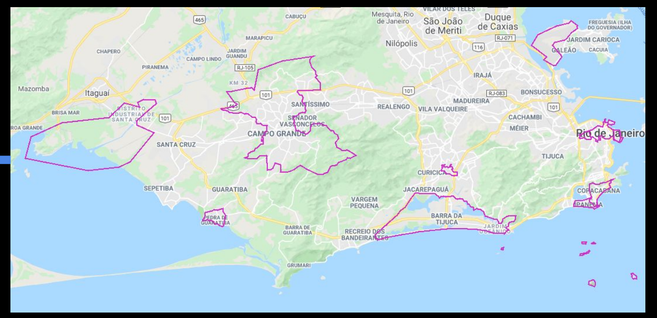
Weekly Averages





Percent Change Relative to 2019 Annual Average





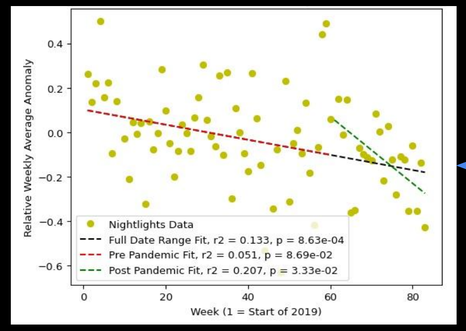
Select specific geographic subunits

Split Data into Temporal Categories

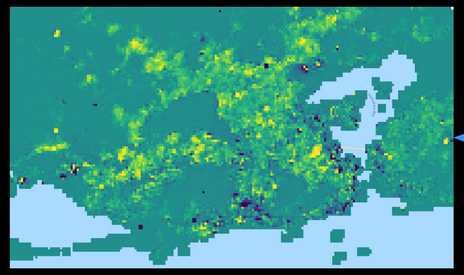
2019 - Start of Pandemic

Start of Pandemic - 1/Aug/21

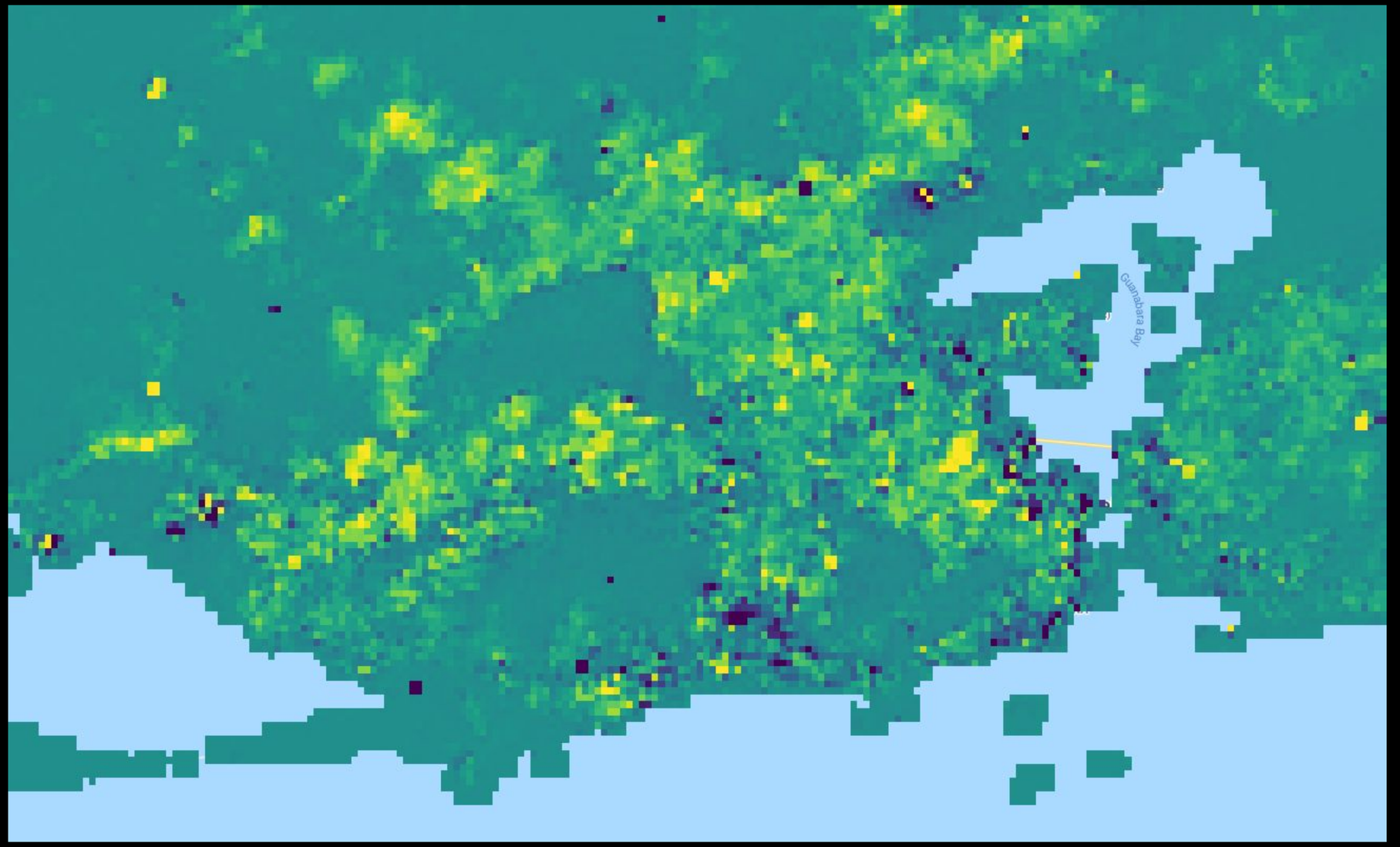
Statistical Analysis



Theil-Sen Slope Visualization



Visualization - Rio de Janeiro Changes (March - July, 2020)



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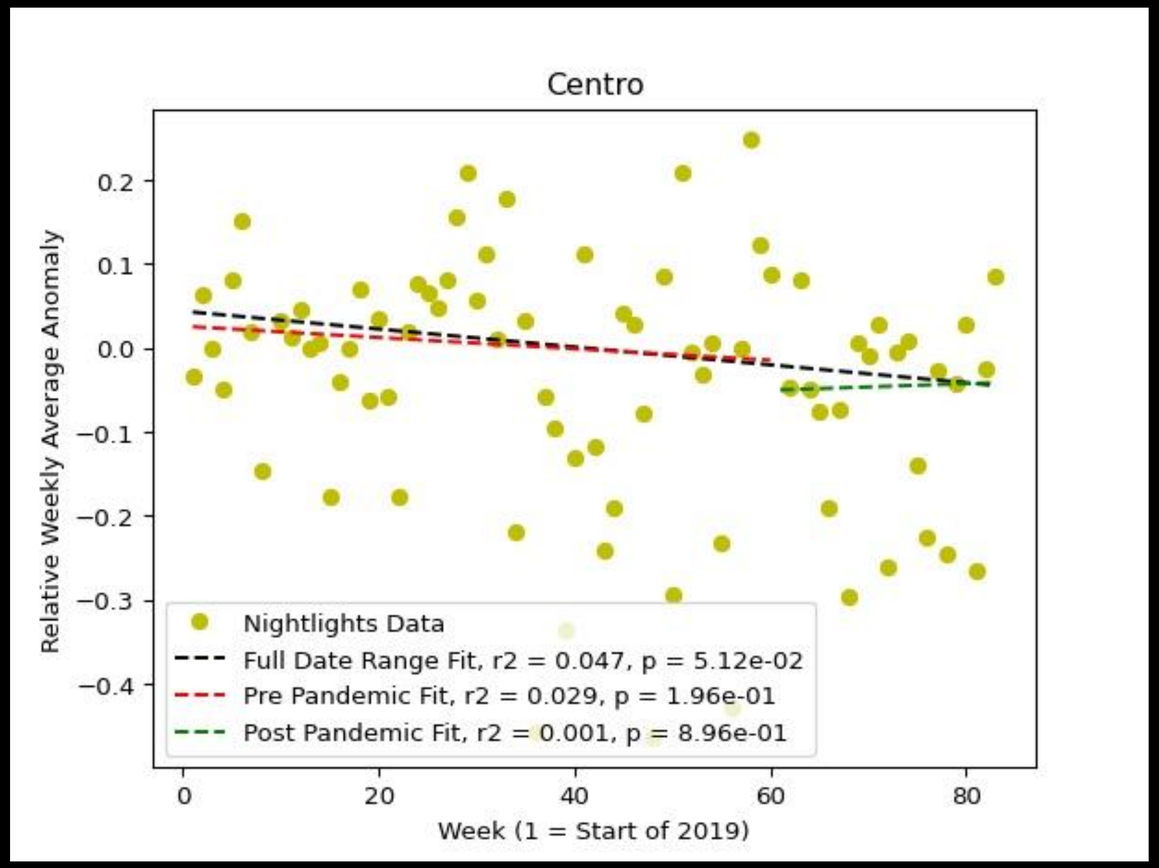
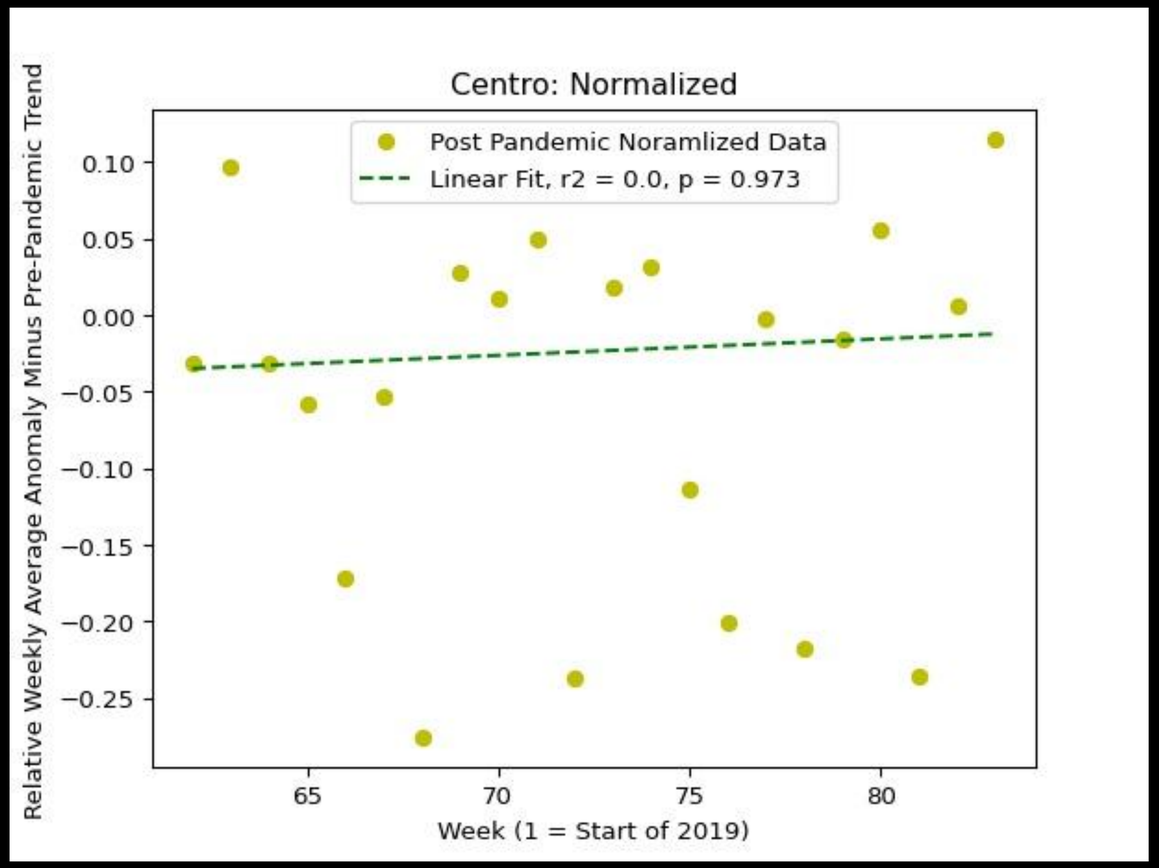
Nightlights Statistics - Rio Changes



Percent Change Relative to 2019 Annual Average



Normalized:
(Post Pandemic Data - Red Line Trend)

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Nightlights Rio de Janeiro Changes

Green = Evidence of Change
Red = No Evidence of Change
Orange = Darkening Trend
Blue = Brightening Trend

Darkened

Area	Type	Pre vs Post T-Test P-Value	Normalized Data Linear Fit P-Value	Pre Pandemic Trend (*1000)	Post Pandemic Trend (*1000)
Ipanema	Tourist	0.063	0.08	0.38	-6.00
Barra da Tijuca	Tourist	0.000	0.11	-0.64	-3.73
Santos Dumont Airport	Airport	0.005	0.12	-3.38	-15.00
Galeao Airport	Airport	0.000	0.24	-2.57	-7.22

No Change / Ambiguous

Cidade de Deus	Mixed Use / Residential	0.433	0.01	-0.50	6.92
City	Entire City	0.347	0.45	0.58	4.78
Cidade Nova	Downtown	0.604	0.88	-3.76	-3.27
Campo Grande	Suburb	0.503	0.93	0.25	0.62
Centro	Downtown	0.115	0.97	-0.67	0.40
Copacabana	Tourist	0.769	0.90	-1.44	-0.71

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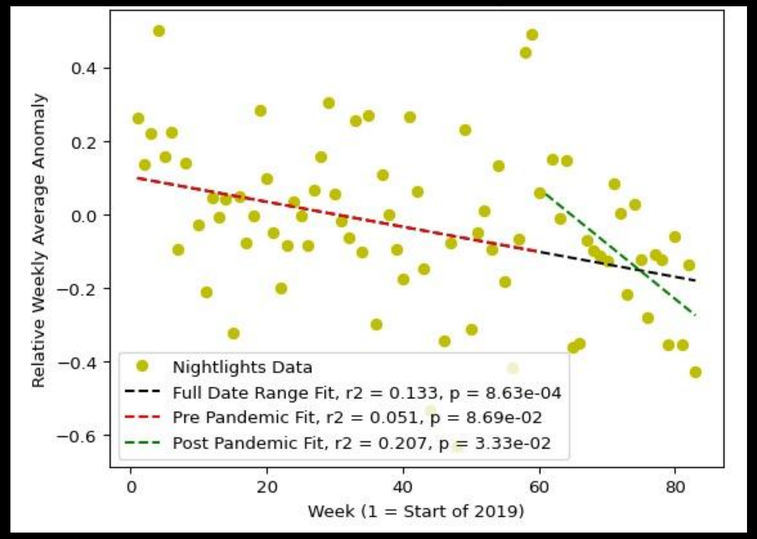
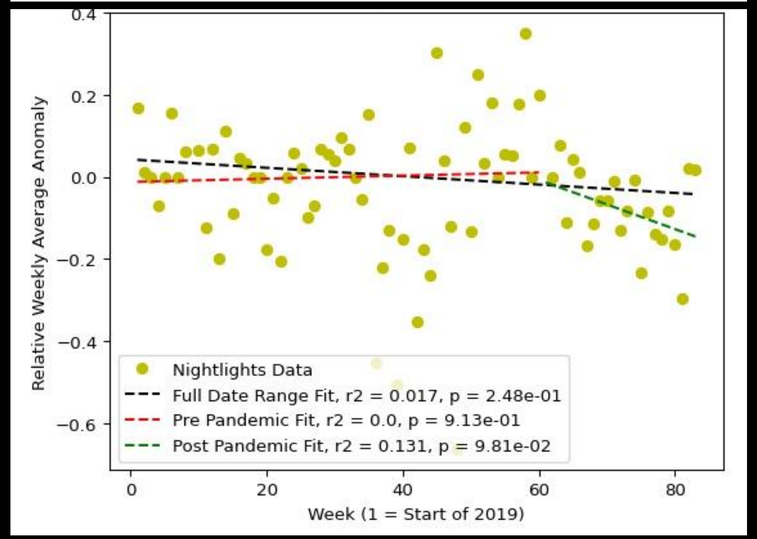
Rio de Janeiro, Brazil

Santos Dumont Airport

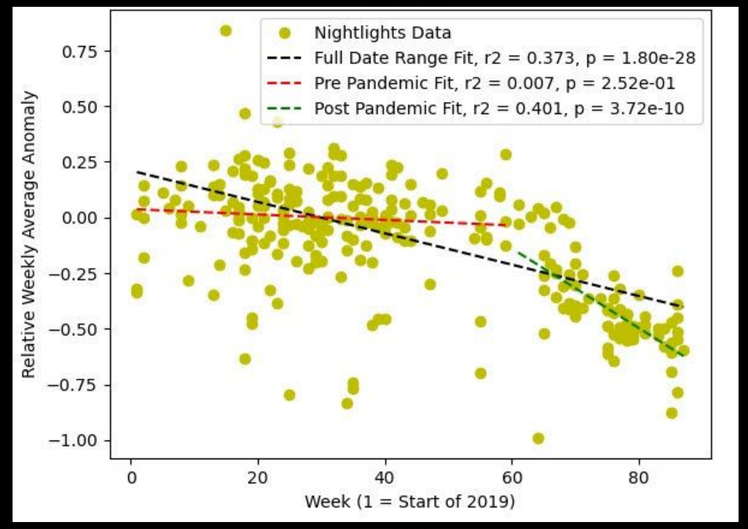


Ipanema

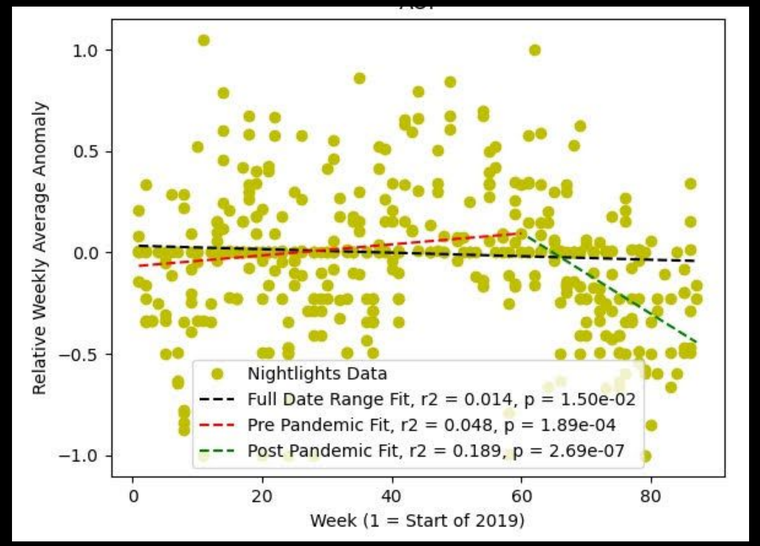


Bali, Indonesia

Ngurah Rai Airport



Island



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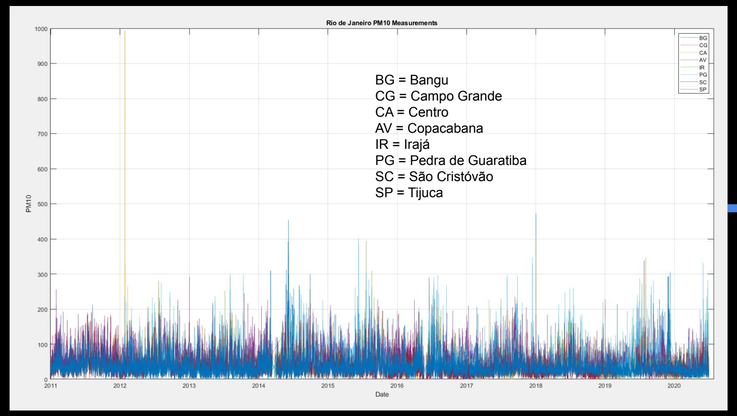
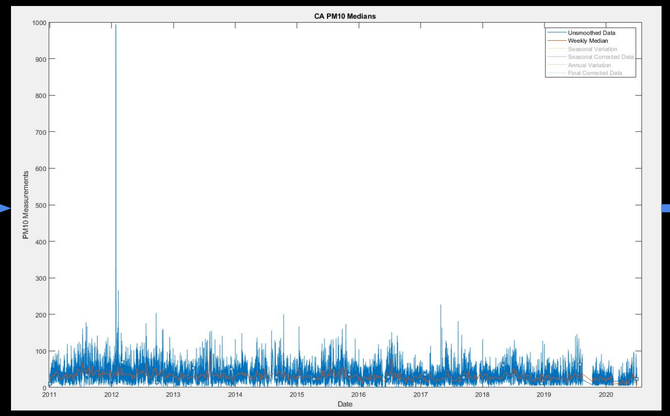
In-Situ Air Quality Methodology

BRAZIL

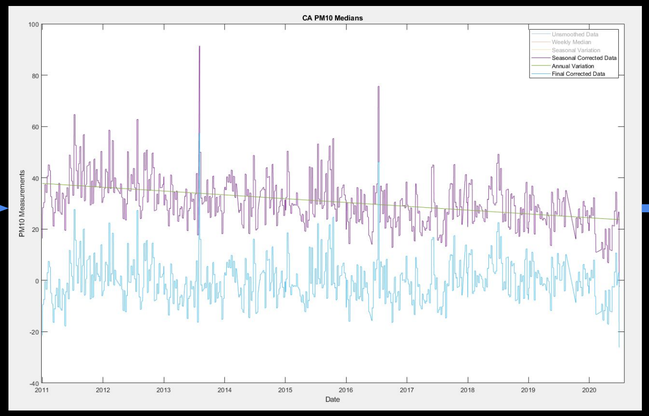
Raw Hourly Data from
MonitorAr (Rio de Janeiro)
SINCA (Chile)



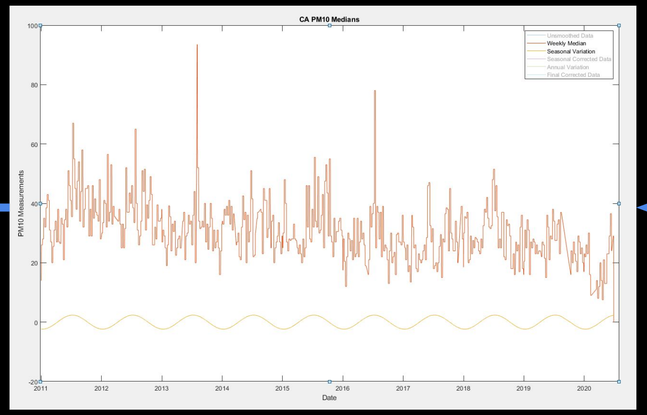
Weekly Averages



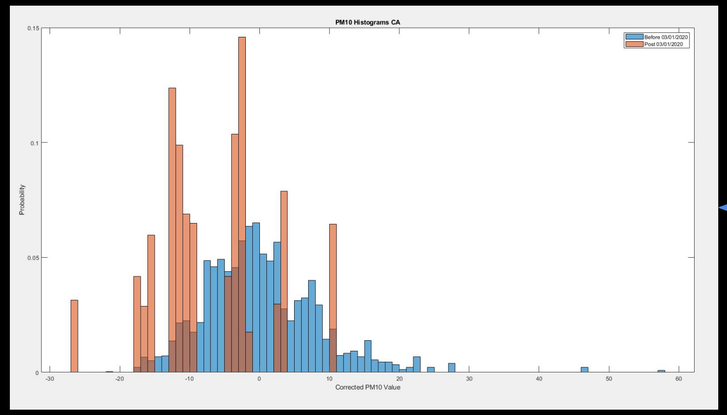
Normalize for secular trends



Normalize for periodic
(seasonal) trends



Statistical Analysis



Ex) Rio de Janeiro PM10 Changes

- Relatively small changes in air quality detected once seasonal and long-term trends are taken into account
- What changes do exist point to an increase in PM10

Area	Type	Pre vs Post T-Test P-Value	Anderson Darling P-Value	Change in Mean (*1000)
Copacabana	Tourist	0.956	0.14	-3.00
Bangu	Mixed Use / Residential	0.265	0.00	4.20
Centro	Downtown	0.012	0.00	1.38
Campo Grande	Mixed Use / Residential	0.381	0.02	5.10
Irajá	Urban / Residential	0.630	0.00	2.20
Pedra de Guara	Rural	0.784	0.08	1.40
São Cristóvão	Tourist	0.392	0.00	4.10
Tijuca	Mixed Use / Residential	0.084	0.00	9.70

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Next Step: Linking with Remote Sensing Data

In-Situ Measurements* (Brazil & Chile)

CH4
CO
Non-Methane Hydrocarbons
Total Hydrocarbons
NO
NO2
NOx
O3
PM2.5
PM10
SO2
Weather (temp, pres., radiance, etc.)

Sentinel 5-P

CH4
CO
HCHO
NO2
O3
SO2

*Not all measurement types are available at all in-situ sites.

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Data & Methods: Vulnerability

- Socioeconomic Data
  - Ex) Poverty Rates, Employment Rates, GDP
  - Sources: Local government authorities, NASA SEDAC
- Mobility & Transit Data
  - Telecoms-based mobility data (as reported by Google and local authorities)
  - Public transit usage (as reported by local authorities)
  - Airline Flights (as reported by local authorities)
  - Ship counts and wait periods (as detected in Sentinel radar imagery)

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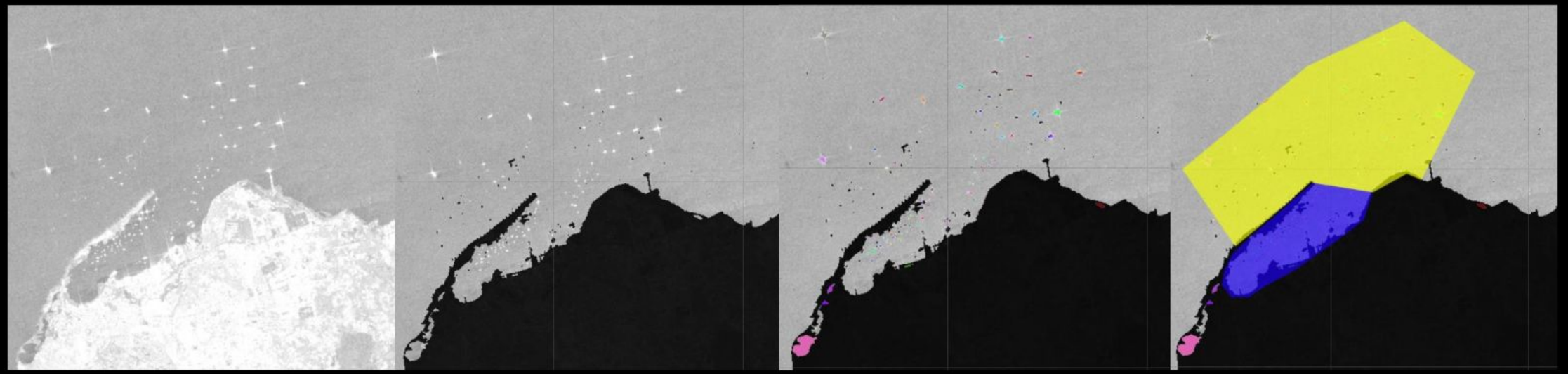
Ship Tracking Methodology



Sentinel Radar Imagery
- Reference: 2018 & 2019
- Observation: 2020

Mask out land/ permanent structures

Identify the individual ships

Count the number of ships in and outside the bay

Images and analysis done by Amanda Peyton

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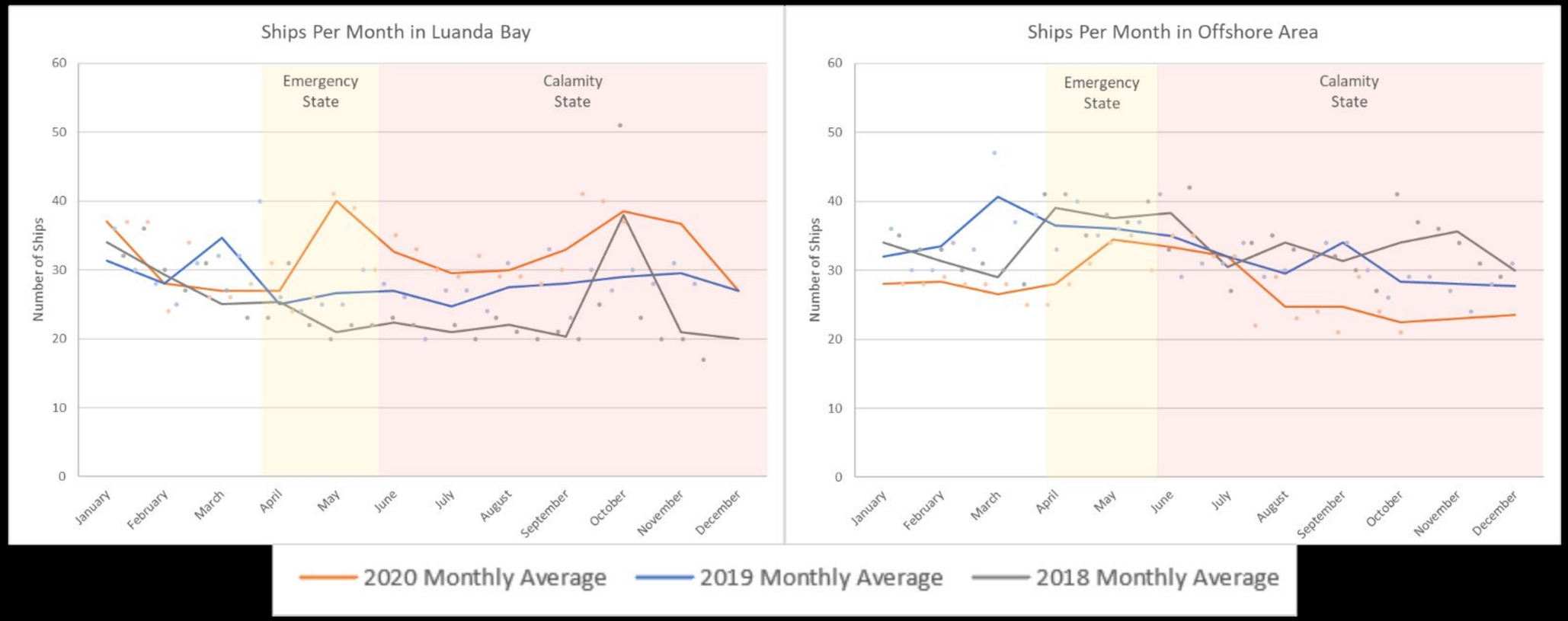
Ship Tracking Results

Measuring Ship Presence Over Time



Images and analysis done by Amanda Peyton

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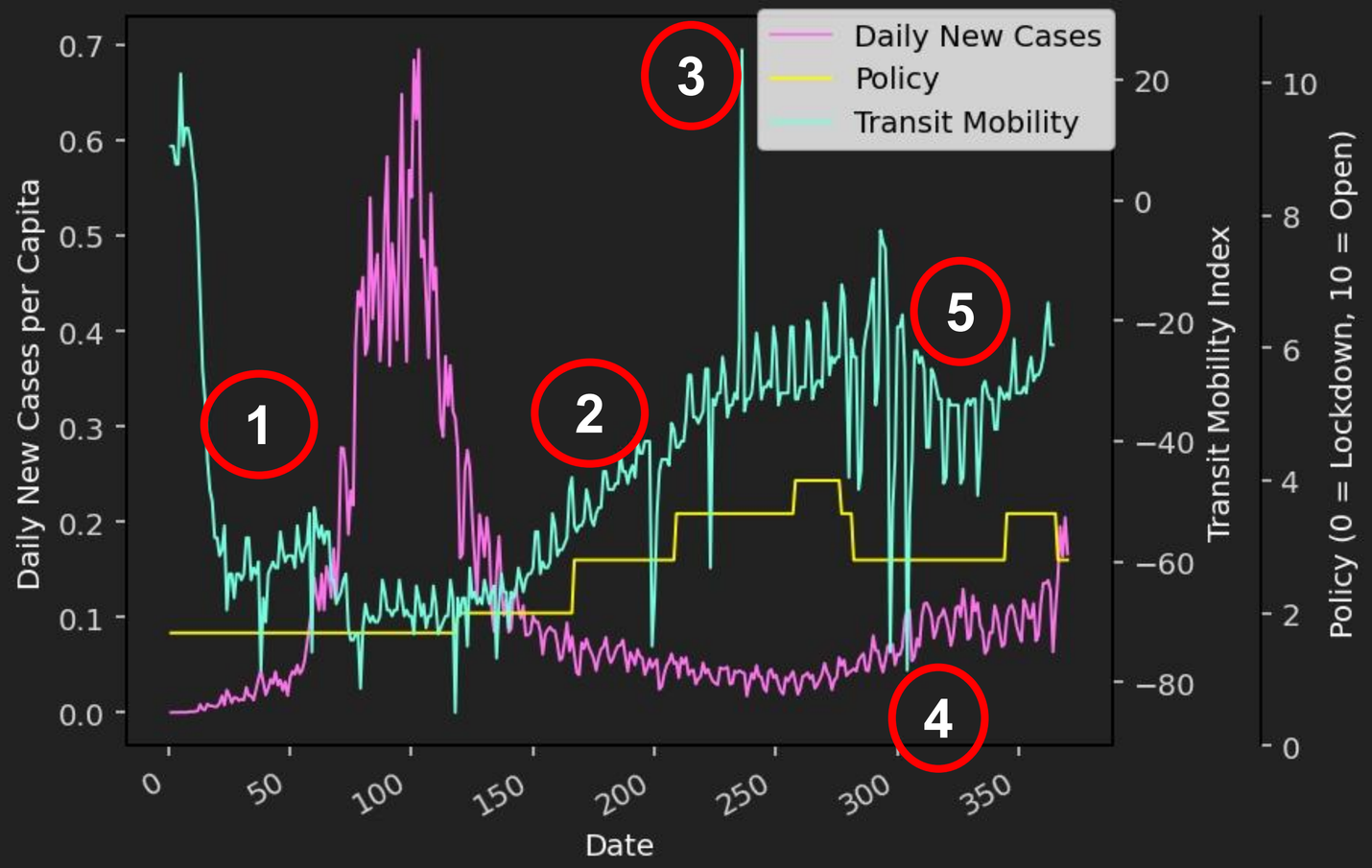
Ex) Metropolitana, Chile Mobility Changes



1. Mobility falls, notably *after* the initial wave of policy restrictions went into effect
2. As new cases decline and policy relaxes, mobility rises
3. Chile has a constitutional referendum
4. Christmas & New Years
5. A rise in new cases prompts a policy restriction, decreasing mobility temporarily

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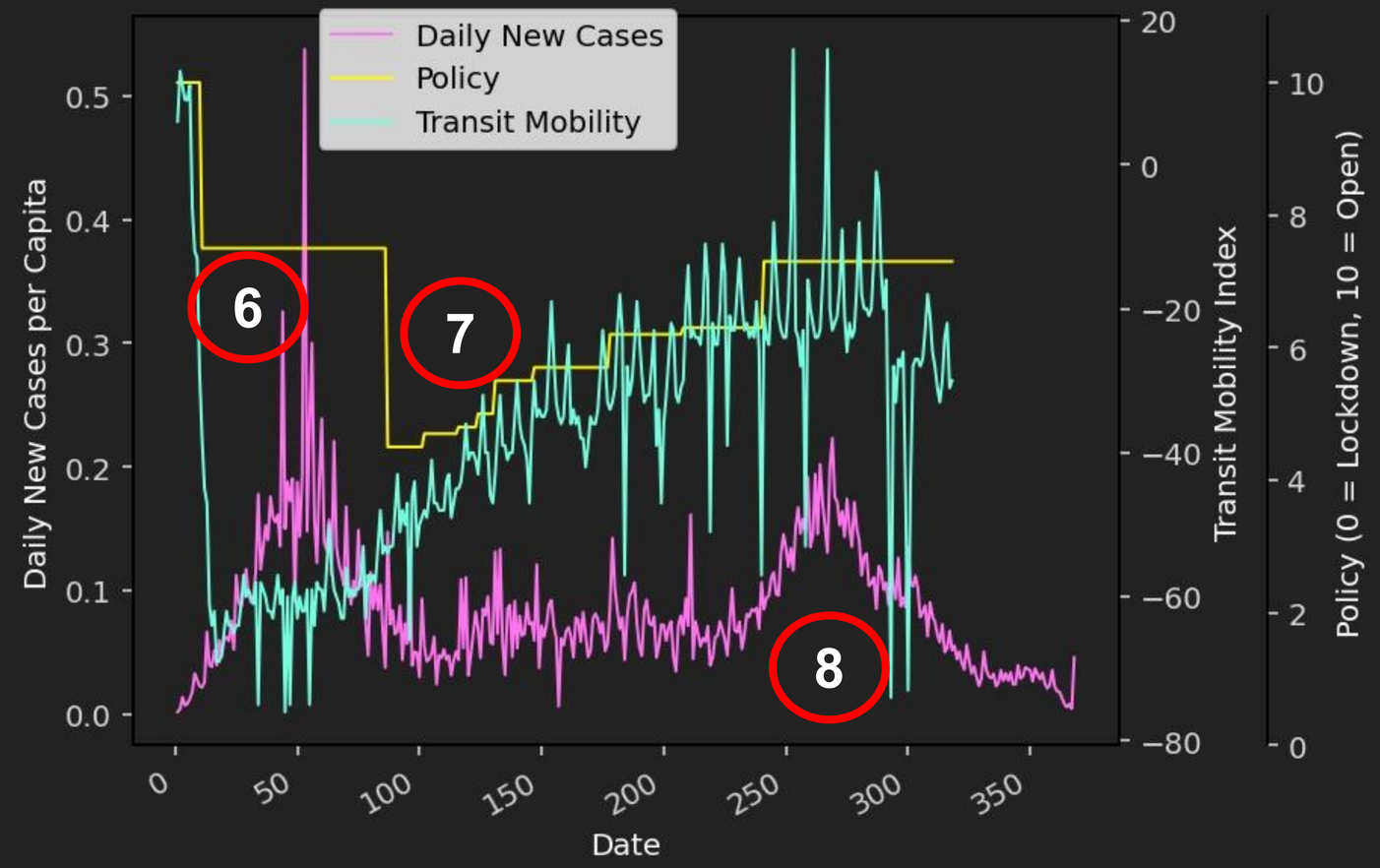
Ex) Rio de Janeiro Mobility Changes



6. Mobility falls, matching or even leading actual policy changes
7. Mobility rises, leading policy changes upwards as case counts fall
8. Mobility drops starkly for Christmas and New Years, then returns to a lower level than previously, following a rise in cases and a new government with different priorities.

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Data & Methods: Decision-making

- COVID-19 Social Distancing Requirements & Closures
  - Announcements, histories, definitions, and conditions created by local authorities
  - Ongoing effort to compare policies using standardized, quantitative comparisons based on the CoronaNet Research Project

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Data & Methods: Decision-making

Recovery Plan Indicators

updated 01/10/2020

Reference Date: 07/29/2020

GROUP	ANALYSIS PARAMETERS		PRIMARY INDICATORS	Comparison with previous days: F-1	D-5	D-4	D-3	D-2	D-1	07/16/2020 Ref. Previous Phase	7/29/2020 Result	WE ARE IN PHASE 6B (Since 01/10/2020): PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5	PHASE 6
HEALTH SYSTEM RESPONSE CAPACITY	Capacity of ICU beds	1	Percentage of occupancy of dedicated adult ICU beds COVID (ICU SRAG) METRO I SUS bed (7-day moving average)	✗	✓	✓	✓	✓	✓	69.4	71.2	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
		2	Occupancy rate of supplementary sector ICU beds (moving average 7 days) (a)	✗	✗	✗	✗	✗	✗	67.9	70.0	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
		3	Percentage of occupancy of life support beds REDE SUS Territory of the municipality (moving average 7 days)	✗	✓	✓	✓	✓	✓	76.0	77.0	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
		4	ICU COVID beds (REDE SUS) per 100k inhabitants (b)	✗	✗	✗	✗	✗	✓	6.59	6.41	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
TRANSMISSION LEVEL	Variation of deaths	5	Death Variation Rate by COVID19 in each period (Information released at 6 pm on the day, referring to the previous day) (c)	✗	=	✗	=	✓	✓	0.92	0.95	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
	Growth of hospitalized cases	6	Rate of Variation of Inpatients (Clinical + ICU) in each period (Information released at 6 pm on the day, referring to the previous day) (c)	✗	✓	✓	✓	✓	✓	0.92	0.95	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
	Variation of new cases	7	Number of cases reported by Influenza Syndrome (SG) in the last two epidemiological weeks of notification (d)	✓	✓	✓	=	=	=	16,554	13,931	Favorable	Favorable	Favorable	Favorable	Favorable	Not Favorable
OPINION FOR OPENING PHASE ACCORDING TO PRIMARY INDICATORS												Favorable	Favorable	Favorable	Favorable	Favorable	Not Favorable

For more information, see https://riocontraocorona.rio/ and http://inteligencia.rio/planoretomada

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Data & Methods: Decision-making

Timeline of 2020 COVID-19 Response in Angola

Images and analysis done by Amanda Peyton

User Interface

Jack Reid

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User Interface

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Ongoing and Future Work

- Automating data updates and ingestion
- Standardizing architecture to facilitate reuse
- Add simulation capabilities to the online version
- Improving visualizations
- Adding a spatial component to the epidemiological model
- Continue air quality and nightlight analysis, connect to mobility data

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Project Page:

https://www.media.mit.edu/projects/vida-decision-support-system/overview/

Code Repository:

https://github.com/mitmedialab/Vida_Modeling

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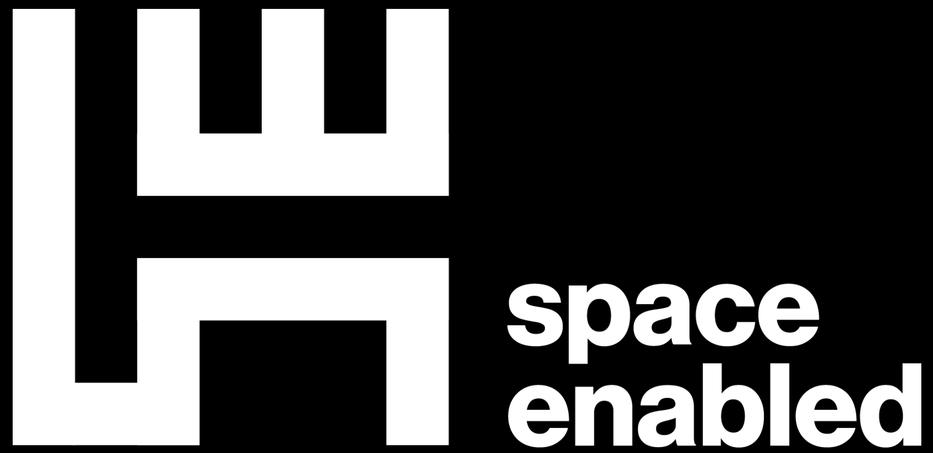
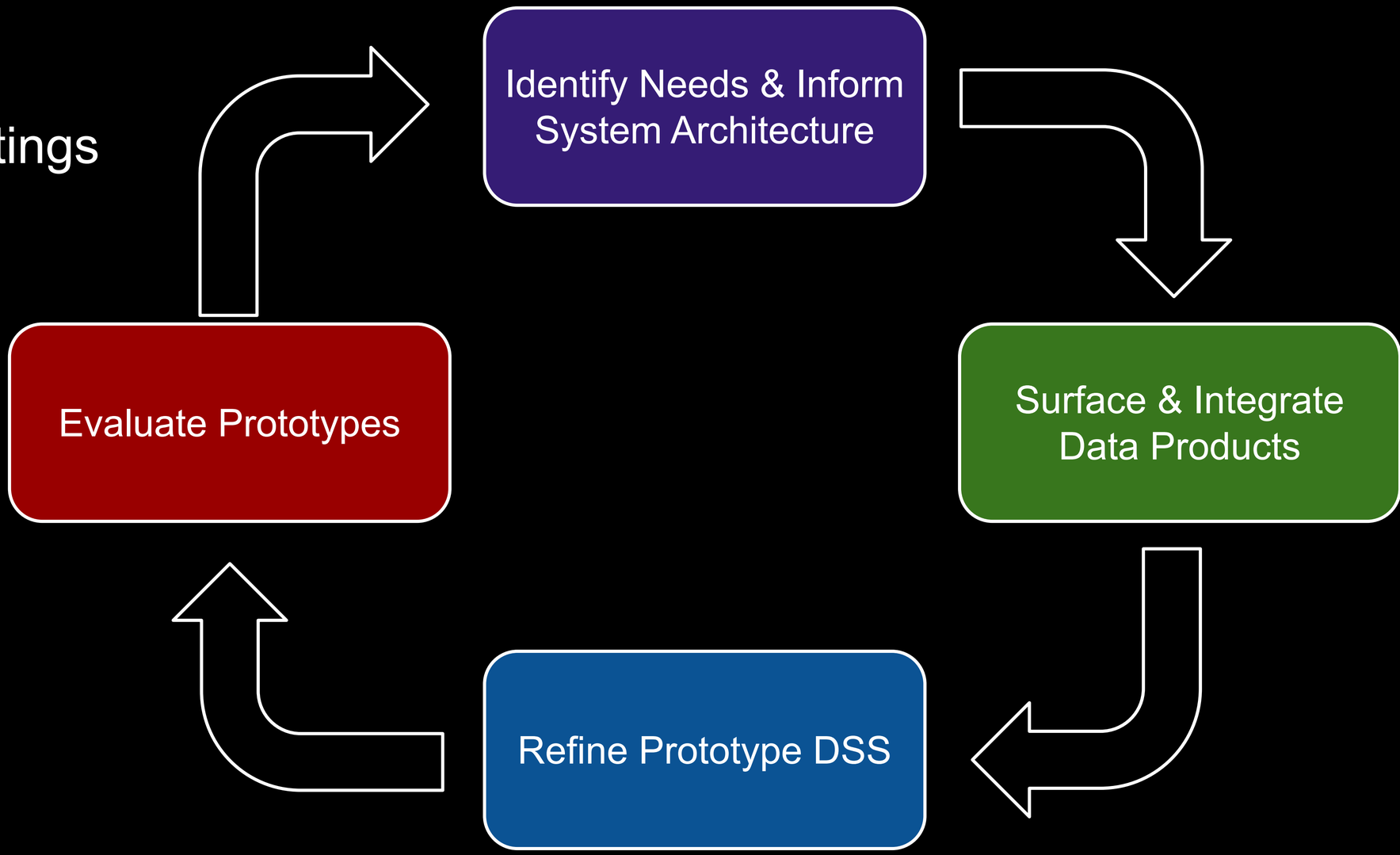
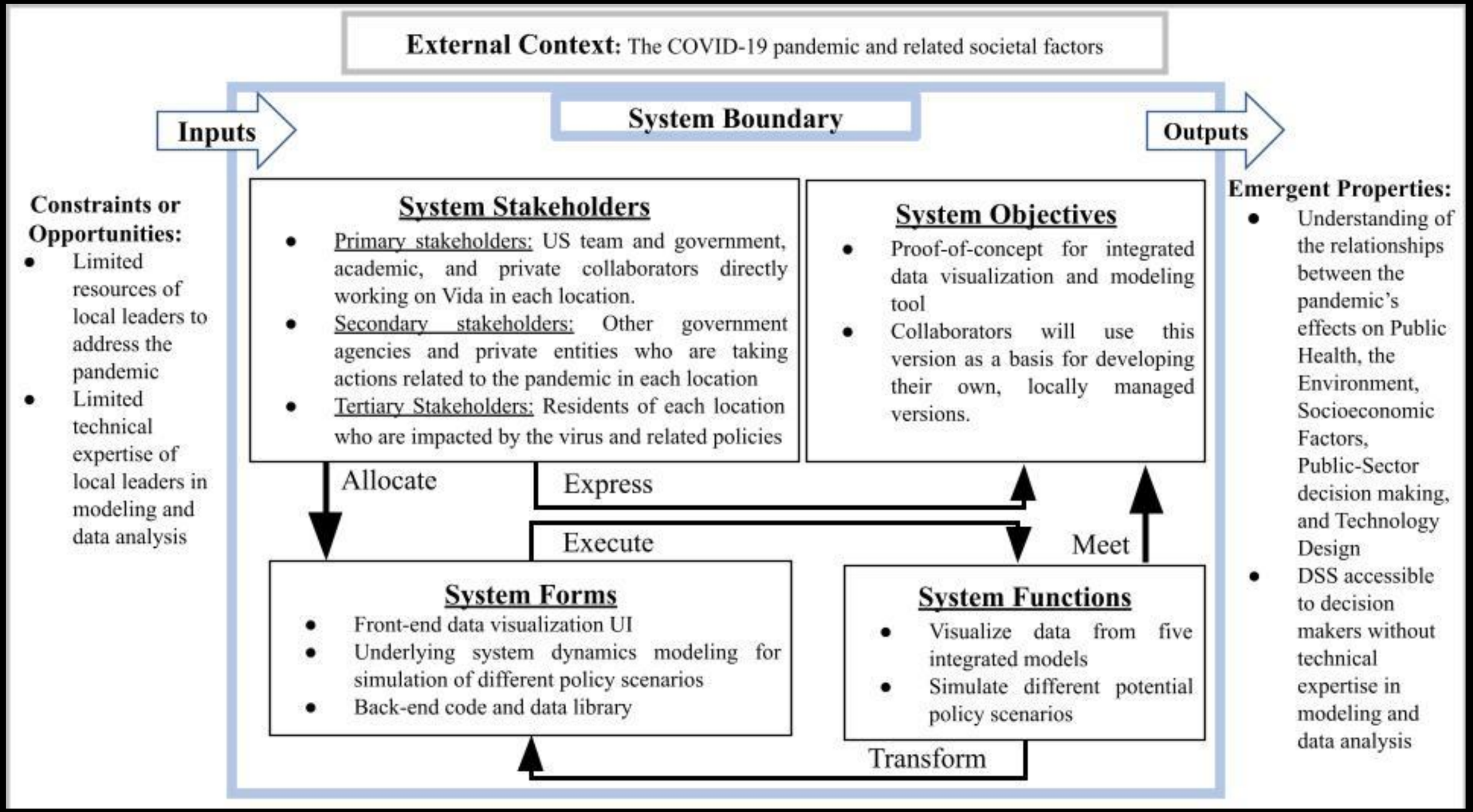


Stakeholder Involvement

- Weekly/Biweekly 1-on-1 meetings
- Monthly full network meetings
- Online collaboration
  - Data Repositories
  - Github
  - Browser-based DSS




External Context: The COVID-19 pandemic and related societal factors
Inputs
System Boundary
Outputs
Constraints or Opportunities:
Limited resources of local leaders to address the pandemic
Limited technical expertise of local leaders in modeling and data analysis
System Stakeholders
Primary stakeholders: US team and government, academic, and private collaborators directly working on Vida in each location.
Secondary stakeholders: Other government agencies and private entities who are taking actions related to the pandemic in each location
Tertiary Stakeholders: Residents of each location who are impacted by the virus and related policies
System Objectives
Proof-of-concept for integrated data visualization and modeling tool
Collaborators will use this version as a basis for developing their own, locally managed versions.
Allocate
Express
Execute
Meet
System Forms
Front-end data visualization UI
Underlying system dynamics modeling for simulation of different policy scenarios
Back-end code and data library
System Functions
Visualize data from five integrated models
Simulate different potential policy scenarios
Transform
Emergent Properties:
Understanding of the relationships between the pandemic's effects on Public Health, the Environment, Socioeconomic Factors, Public-Sector decision making, and Technology Design
DSS accessible to decision makers without technical expertise in modeling and data analysis