Accelerating application of Earth observation data

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GEO Secretariat

GROUP ON EARTH OBSERVATIONS

NAPEXPO CHILE 2023

convening

GEO brought together world leading cloud service and geospatial players to help low- and middle-income countries.

This was only possible because of an inclusive approach to support countries irrespective of geography, technology or vendor solutions.

GEO collaborations

aws

Google Earth Engine

Microsoft

EO Data Science

SINERGISE

esri

planet.

2019

17 COUNTRIES

$1.5m
+ $1m cap dev

2020

32 COUNTRIES

$3m
+ $1.5m cap dev

2021

18 COUNTRIES

$3m (50% cash)
+$1m cap dev

Programme experience: learning

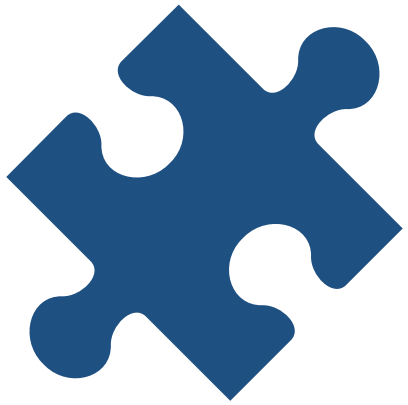
CHALLENGES

"Thanks for the credits, but how do I set up an account?"

"OK now I have an account now, but how do I access the credits now?"

"Right, I'm in! But how do I integrate the credits into my own systems?"

Programme experience: success



CAPACITY BUILDING

“Access to AWS cloud infrastructure and services is critical because our institutional capabilities do not allow us to host and administer the necessary environment on our own.”

Illegal amber mining monitoring project, **Ukraine**

Programme experience: success

INTEGRATED SYSTEMS FOR DECISION MAKING

“The GEO-GEE funding will enable us deliver a system that can be used to monitor forests as part of natural resources management, monitor urbanization for better planning and monitor floods/landslides in support of disaster management.”

Kenya Space Agency

Programme experience: success

ADVANCED TECHNOLOGY FOR SOCIAL IMPACT

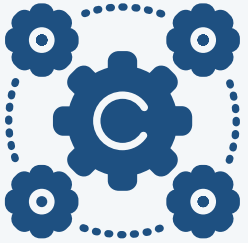
“Thanks to GEO-GEE funding and training, we now have a team capable of developing and implementing advanced geospatial analytical methods that utilise world leading technology, ensuring we can have maximum social impact.”

Vulnerable settlements projects, **Mexico**

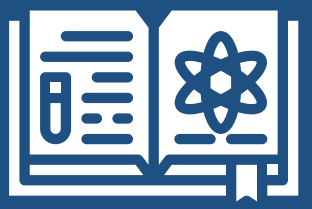
Sustainability aspects

More credits

New funding



GEO work programme



Other resources

Contacts

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GROUP ON EARTH OBSERVATIONS

NAPEXPO CHILE 2023

GEO4NAPS

Measuring adaptation with remotely sensed data products

Leo C. Zulu, Michigan State University, MI, USA

Allison Lassiter, University of Pennsylvania, PA, USA

Sosten Chiotha, Leadership for Environment and Development, Southern and Eastern Africa, Zomba, Malawi

David Stevens, Independent Scientist, Vienna, Austria

Tristan Grupp, University of Pennsylvania, PA, USA

GEO4NAPs strategy and main activities

1. **Identify core sets of indicators for measuring adaptation**
   - Literature review of indicators and definitions of adaptation
   - Geospatial data downloads and database construction
   - Field visits and consultation meetings with the NAP team, local experts and other stakeholders as the pilot country and user community seek input on main adaptation risks, needs, current interventions, and indicators/metrics and methods (visit conducted in July 2022)

2. **Apply the measurement method** to Malawi
   - Develop method for measuring adaptation, focing on Malawi
   - Update the analysis based on feedback

3. **Scale up** the measurement method to other LDCs

1. Background on adaptation indicators
2. Approach to measuring adaptation
3. SURVEY: Choosing adaptation indicators
4. SURVEY: What is the right spatial aggregation?
5. SURVEY: What is the right temporal aggregation?
6. Implementing the proposed method
7. Open discussion
8. Conclusion

1. Background on adaptation indicators

Context

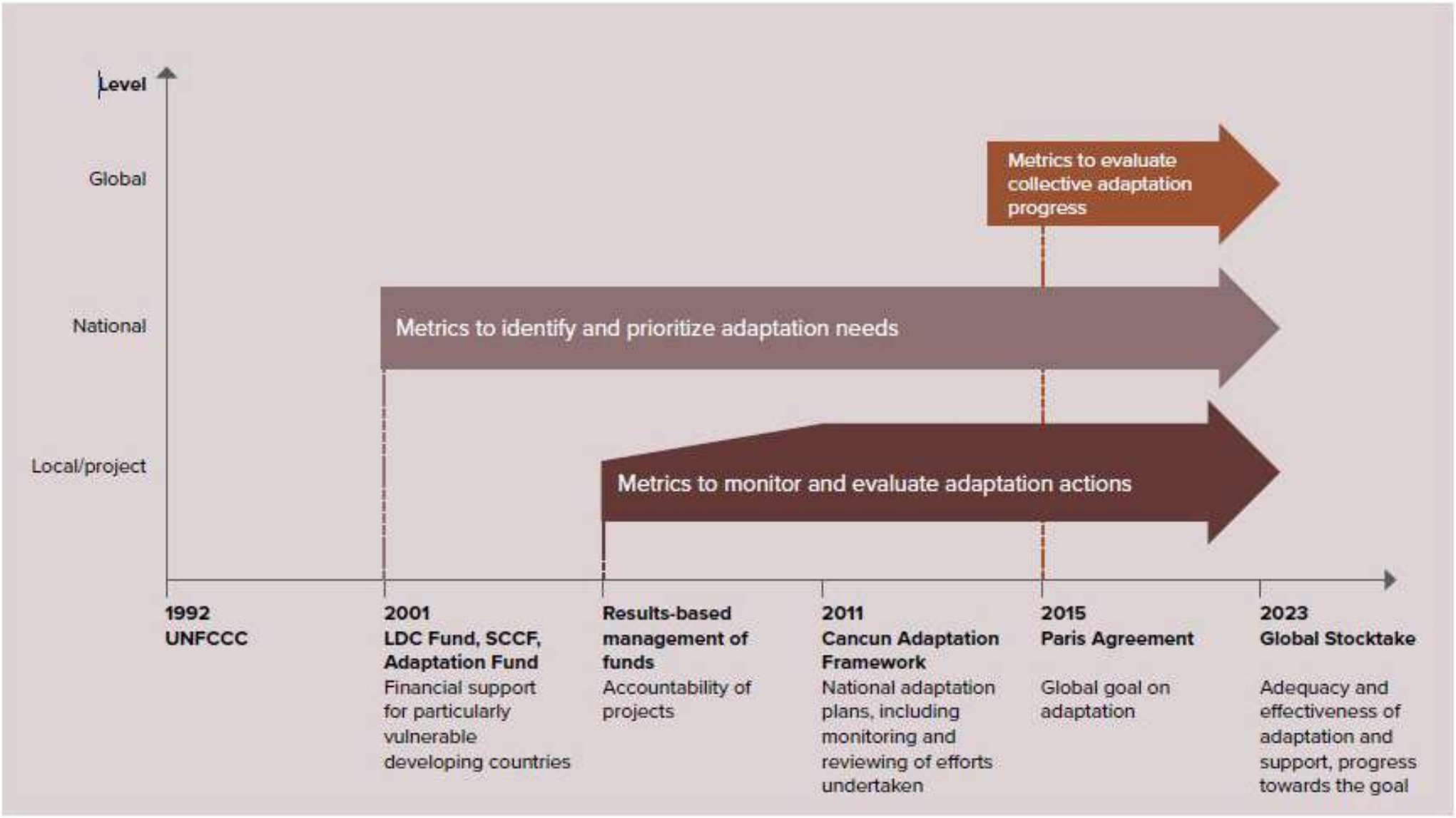
- Adaptation plans are receiving more investment and attention. Progress toward adaptation is limited to countries self-reporting to UNFCCC.

- Self-reporting is often based on inputs and processes, not **evidence** of effective adaptation outputs.

- Are there ways to measure adaptation outcomes?

Adaptation metrics under the UNFCCC over time

Figure 1. Evolution of functional needs of adaptation metrics over time in relation to the UNFCCC process



Source: Möhner 2018

Literature review: ideas on measuring adaptation

- "How can we measure, aggregate and compare climate change adaptation needs and results across activities, countries and sectors?" (Christensen, Martinez, Naswa, 2018)

- Challenges and opportunities in measuring adaptation with metrics (Leiter and Pringle, 2018)
  - Difficulties of defining "adaptation" and the "dependent variable problem"
  - absence of systematically collected data on adaptation actions and outcomes
  - Mismatch between the timescale over which adaptation plays out and the practical need for evaluation to inform policy
  - Studies remain overly narrow in thematic and geographic scope
  - Limited use of satellite data as a basis to obtain aggregate indicators and impacts of adaptation
  - Inadequate integrative research designs to capture aggregate impacts of adaptation interventions

Major lessons from national and sub-national experiences

- Maintain a clear picture of desired changes and outcomes and the causal pathway to achieve them
- Adapt indicators and metrics to local realities and to contextualize the results
- Stakeholder engagement is crucial: participatory discussions on metrics

Sources: IIED, 2014; Owens, 2010

Measuring adaptation

- Is it possible to use earth observation to observe evidence of adaptation?

- An evidence-based approach that leverages globally available **remote sensing data products** and **earth observations** has the potential to overcome existing hurdles:
    - Unclear outcomes or definitions of adaptation → define adaptation
    - Overly locally specific definitions of adaptation (not generalizable) → define indicators applicable to many contexts
    - Overly broad measures (not location-specific) → measure adaptation outcomes with high-resolution, local data

How do we know we've observed adaptation? What are the desired changes and outcomes?

- Which adaptation outcomes can we observe with aerial imagery?
  - Reduce risk and vulnerability
  - Enhance social well being
  - Improve environment
  - Increase economic resources
  - Strengthen institutions

- Some outcomes are directly visible, some may be indirectly visible, and some may be very challenge to perceive

Some adaptations are visible in aerial imagery

THE SAHEL REVOLUTION

- Since the early 1990's, farmers in Niger have re-greened approximately 5 million hectares of degraded land, an area the size of Costa Rica
- This has increased crop yields soil fertility, as well as sequestered carbon

Some adaptations are difficult to observe directly in imagery

INDIGENOUS TECHNICAL KNOWLEDGE

- Smaller-scale traditional practices to improve water scarcity and heat management
- May be able to indirectly observe because the community is more prepared to withstand greater environment conditions
  - I.e., even with heat, the acres of cropland persists

Tending a new windbreak, Burkina Faso

Constructing depressions to capture Rainwater *(Stock, 2012*

Source: Grant, 2015

Questions for today

- Which indicators can/should we observe over time to track adaptation outcomes?

- What is the best spatial resolution for evaluating these indicators to measure adaptation outcomes?
  - Sub-district, district, national, multi-national

- What is the best temporal resolution for evaluating these indicators to measure adaptation outcomes?
  - Daily, monthly, seasonally, annually

2. Approach to measuring adaptation

Working defining of adaptation

A location is adapted if it has stable or improving biophysical and socioeconomic conditions, regardless of climate stress

1. For this to be true, a place that is adapted can withstand or recover from extreme events: there is no observed change to the system, regardless of climate stress

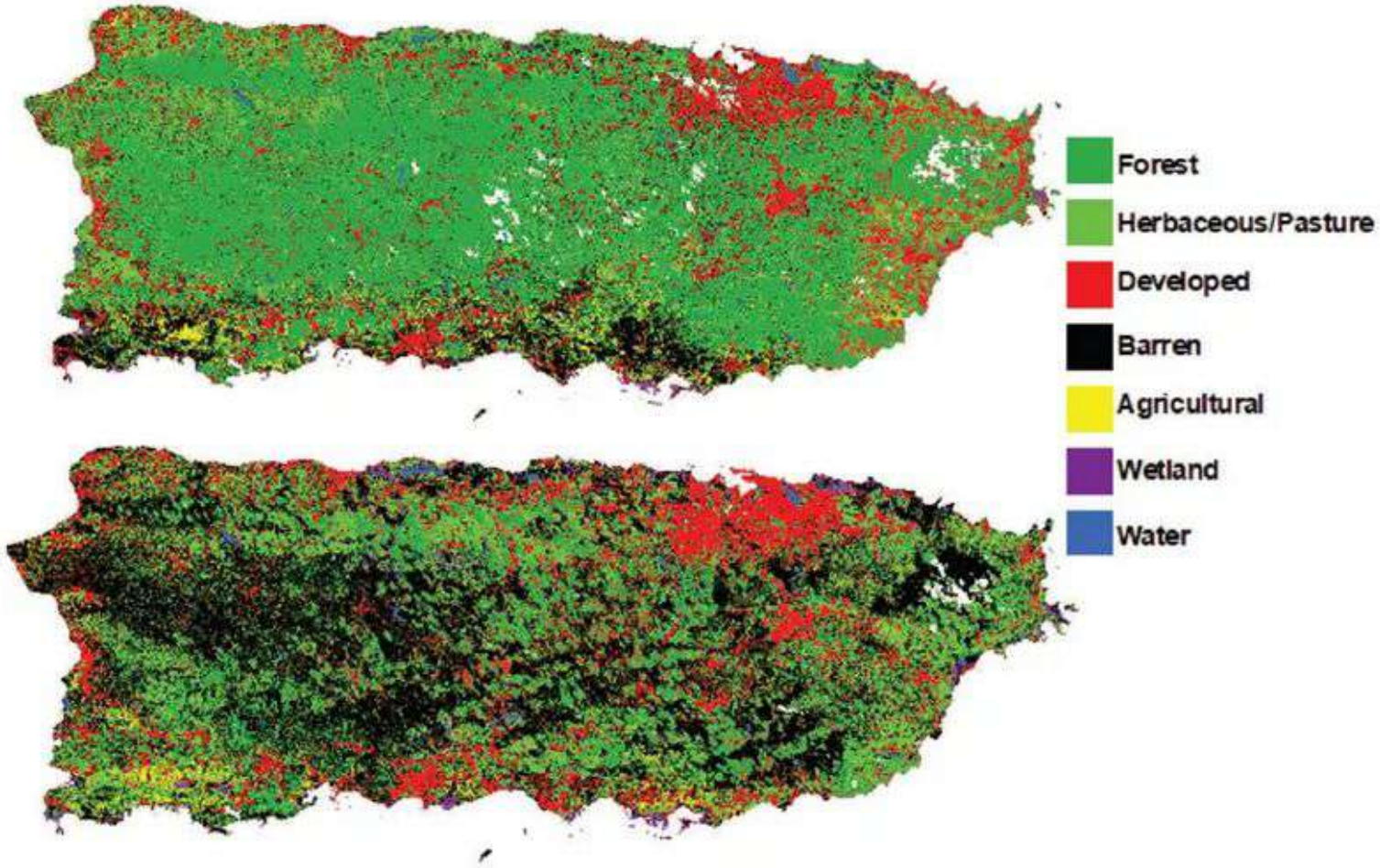
2. Conversely, a place that is not adapted shows declining conditions after an extreme event: systems decline in response to climate stress

Modeling approach

Do extreme events (heat, drought, flood) lead to changes in biophysical and socioeconomic responses represented by available data products?

1. Create a database of extreme events
2. Identify how indicators change after the extreme event
3. What are the best spatial and temporal resolutions for measuring change?

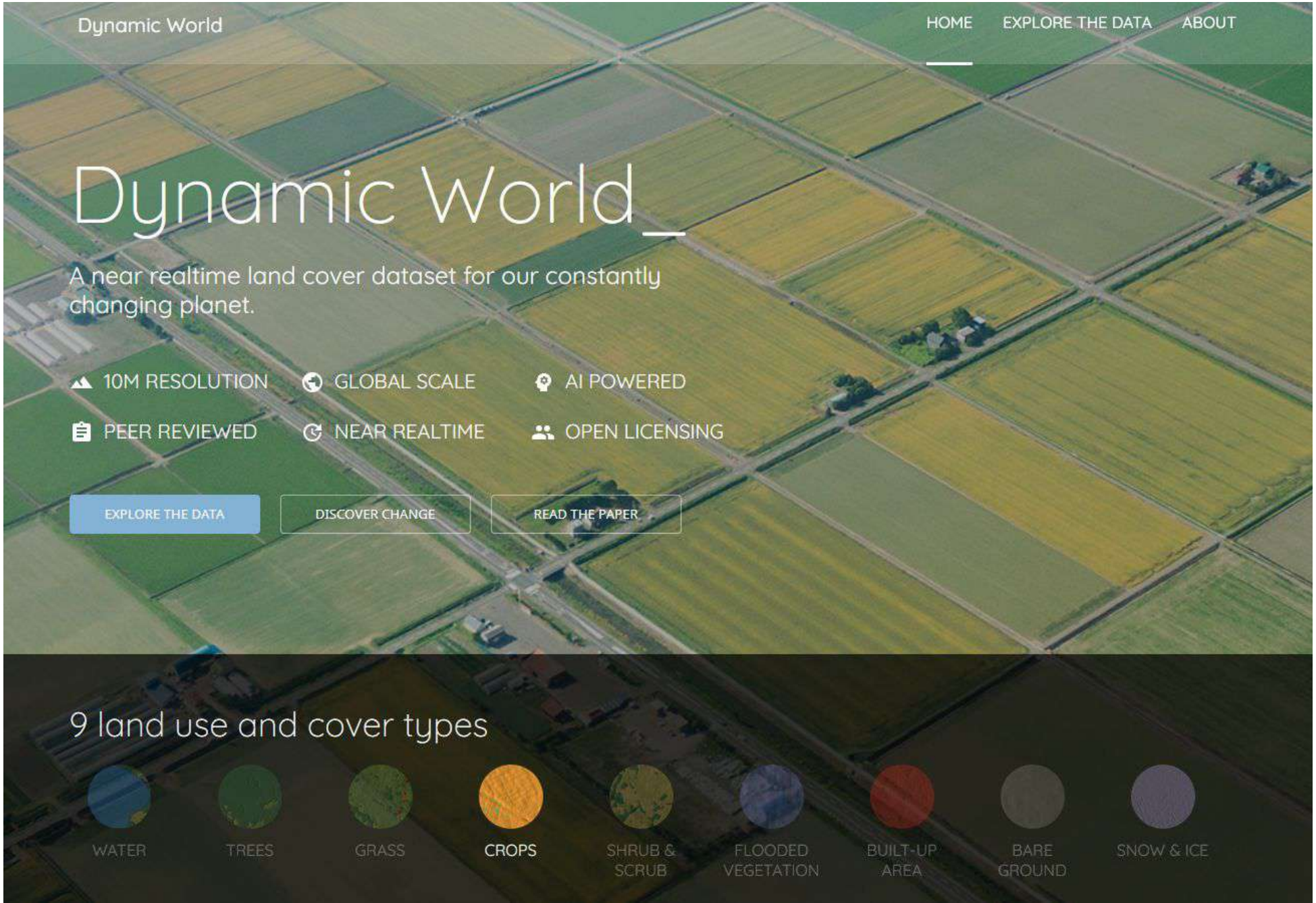
Change in land cover after an extreme event



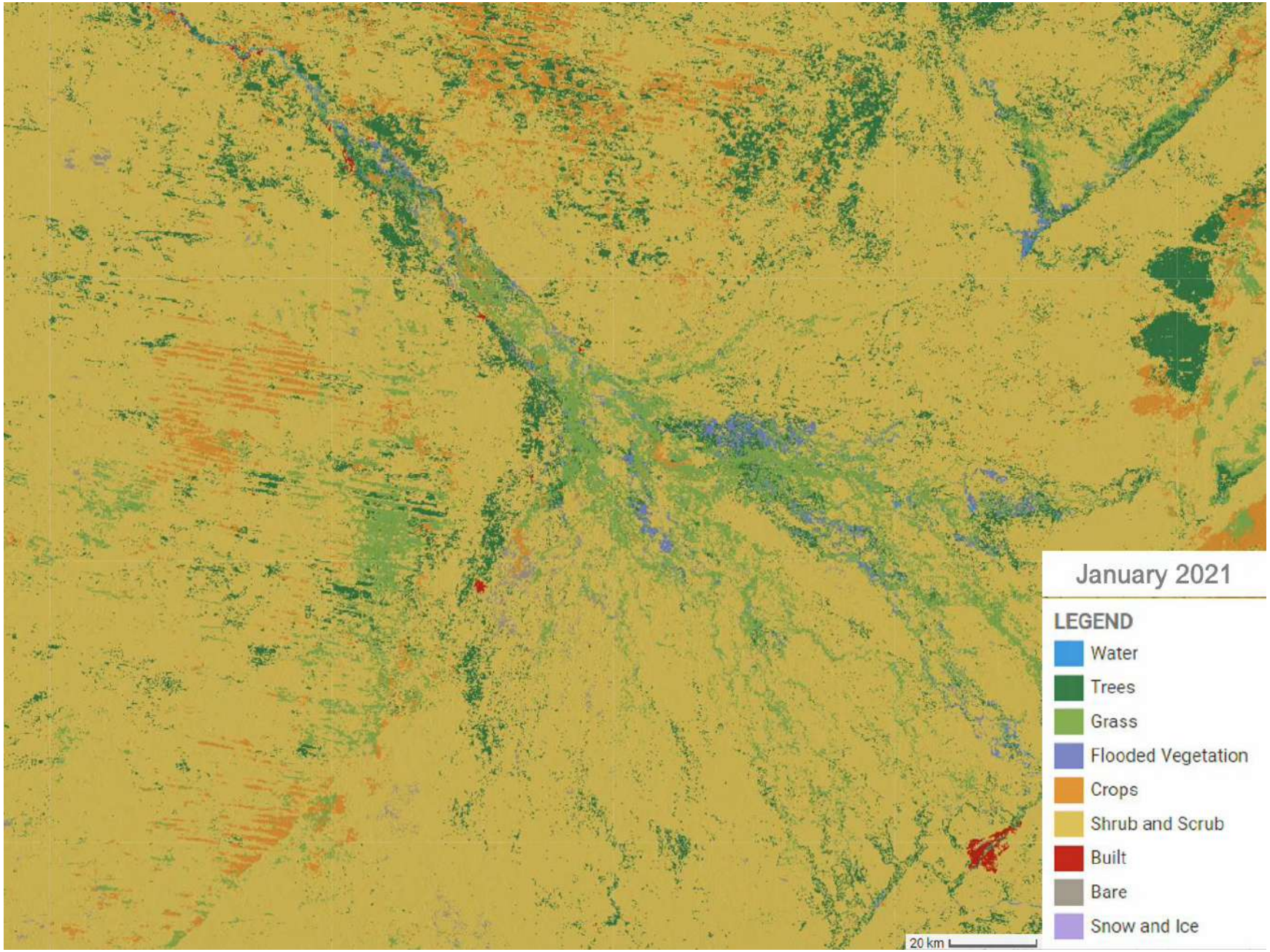
Devastation of Hurricane Maria to Puerto Rican Landscape

by C. Zhang 1 February 2021

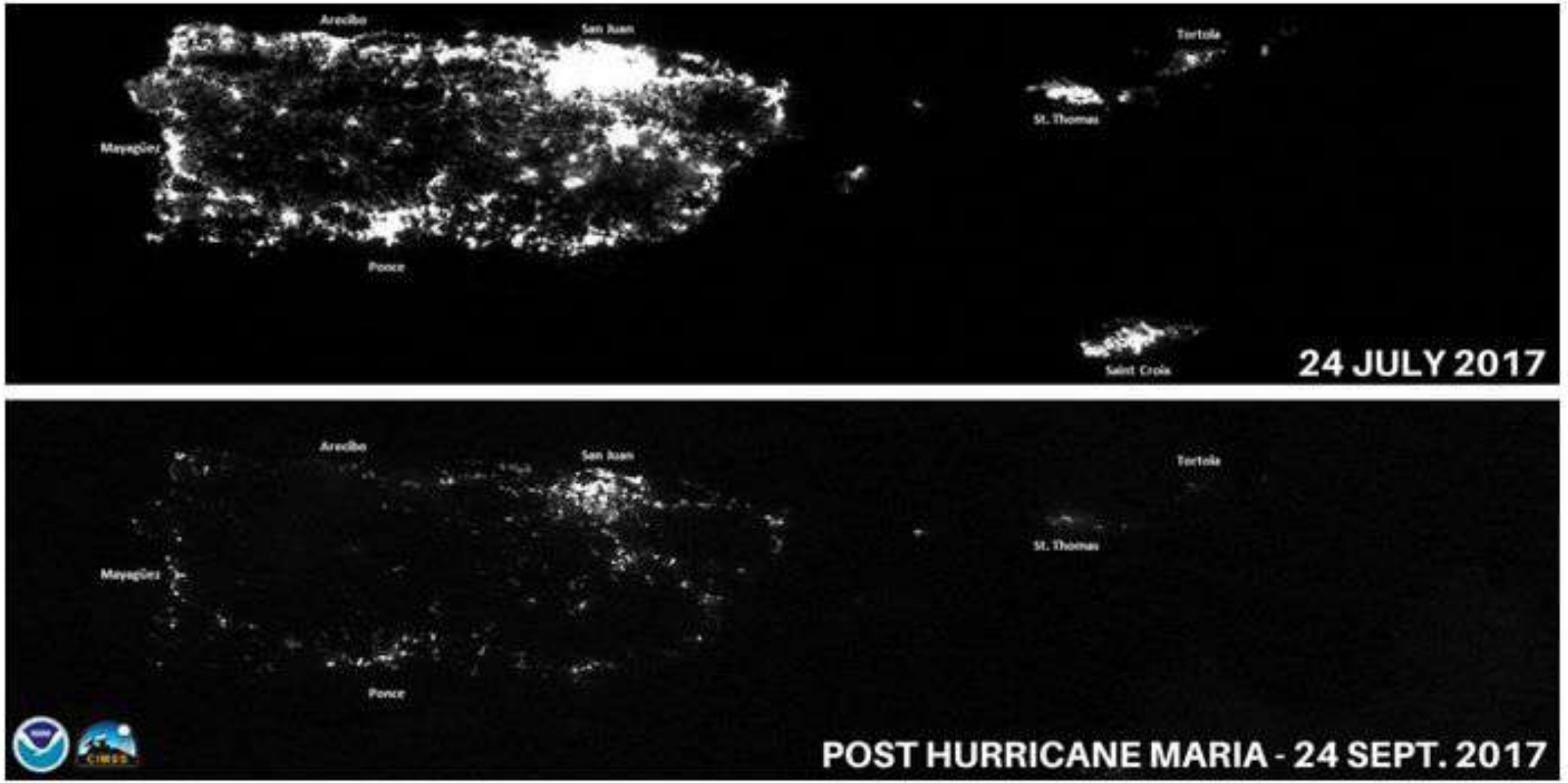
Categorizes land cover daily with 10 meter resolution



Daily landcover change in Okavango, Botswana



Change in luminosity (nighttime lights) -- available approximately every 2 weeks, 30 meter resolution



Source:
https://www.thephotoargus.com/hurricane-maria-before-and-after-night-satellite-images-of-puerto-rico/

3. Choosing adaptation indicators

Indicators from Earth Observations

1. What are earth observations?
   - They are data related to activity on the earth's surface
   - This data can be collected through satellites, on the ground sensors, geolocated surveying, citizen/local participation with recorded latitude/longitudes, and more

2. Why have we chosen earth observations as the basis for the indicators?
   - Many high-quality earth observations are available globally, allowing for standard models and frameworks of measuring adaptation
   - Global availability allows comparison of models across countries and regions
   - They are related to a location, so can be tied to other data such as country administrative boundaries or the location of disasters and more data

Framework for indicators based on outcomes

A location is adapted if it has stable or improving biophysical and socioeconomic conditions, regardless of climate stress

1. Biophysical
   - Water
   - Land
   - Biodiversity

2. Socioeconomic
   - Water
   - Land
   - Human health
   - Energy access
   - Economic and community stability

Initial indicators of biophysical and socioeconomic adaptation over time

Water	Land	Human Well-being	Biodiversity
Surface water area	Cropland area	Electricity access	Forested area patch size
Groundwater availability	Number of crops growing per year	Road access	Wetland area
Snow/ice area	Crop productivity (net primary productivity)	Share of paved roads	Surface water greenness
	Soil moisture	Road within floodplain	
	Built area (buildings, roads)	Built area within floodplain	
	Forested area		
	Inundated (flooded) land area		

Survey on adaptation indicators

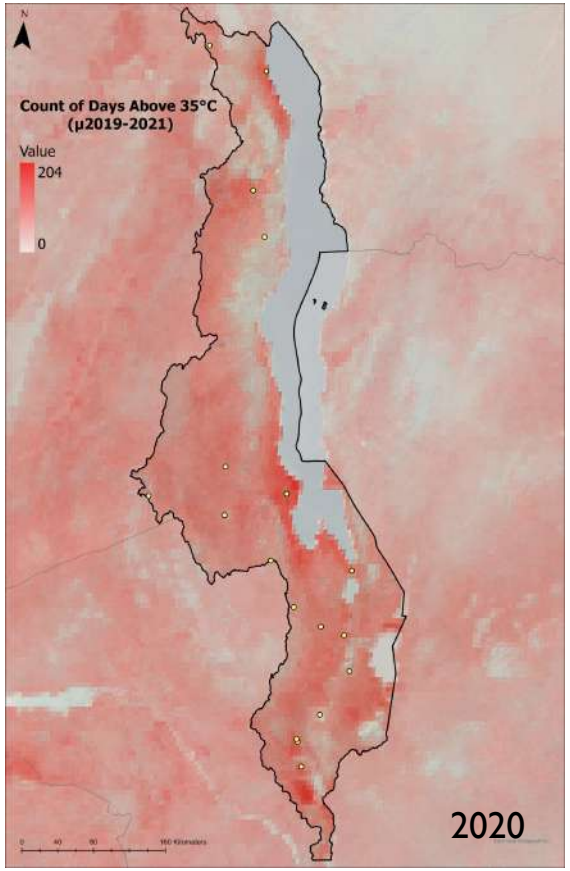
4. What is the right spatial aggregation?

Spatial Aggregation

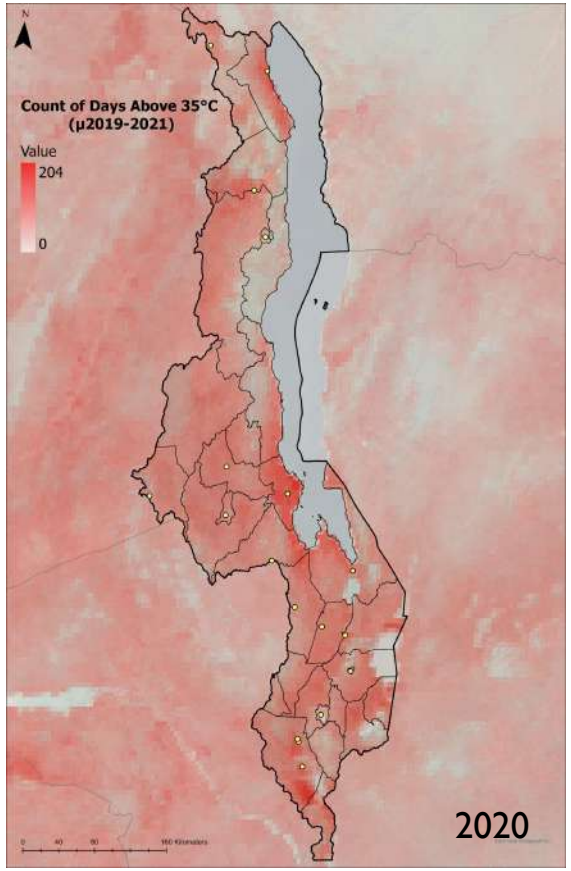
- What is the most appropriate spatial aggregation?
  - District
  - National
  - Regional
- Is a certain spatial scale more appropriate than another depending on the shock or the indicator?
- Aggregating disasters by maximum/minimum values or means over spatial scales
- Capturing disaster exposure?

Spatial Aggregation - High Temperature

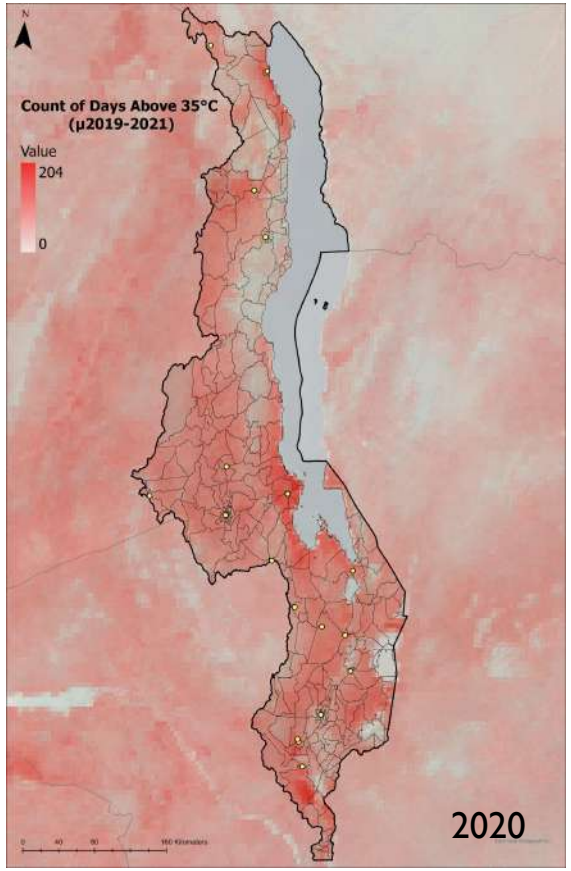
National



District

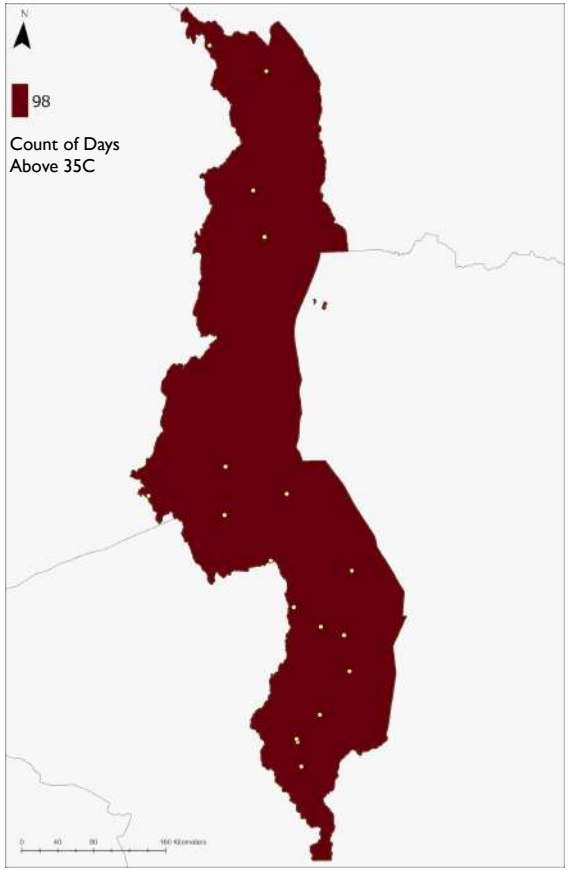


Sub-District

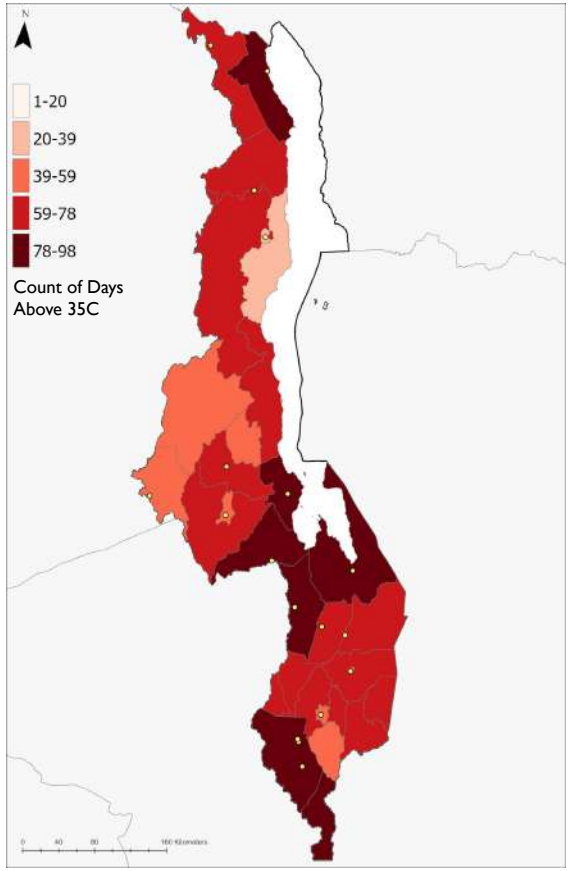


Spatial Aggregation - High Temperature

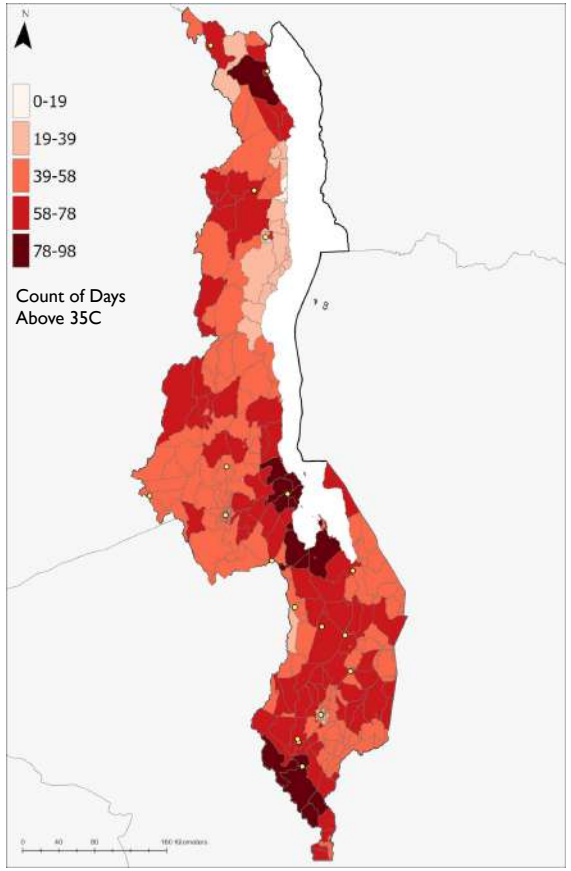
National



District



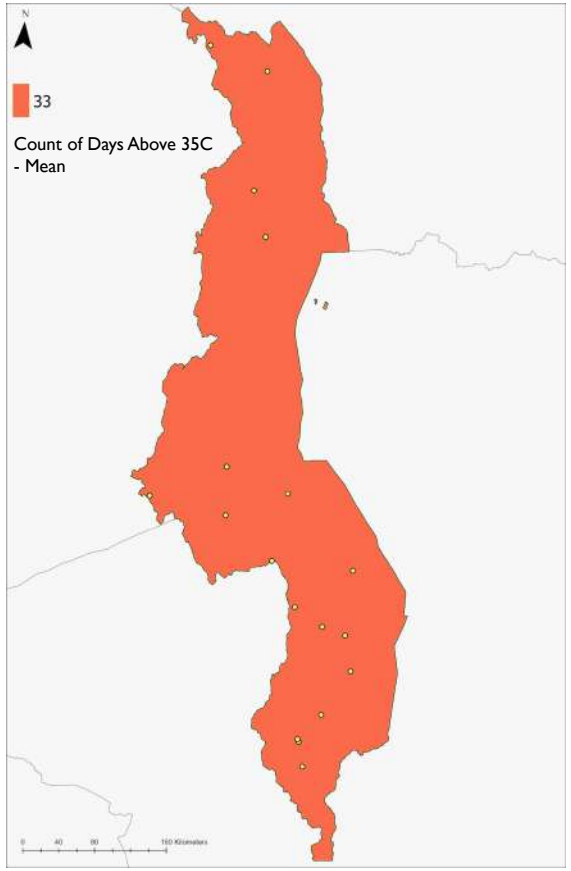
Sub-District



These images show the maximum pixel value within each spatial unit, or the largest observed number of hot days in each geography for one year.

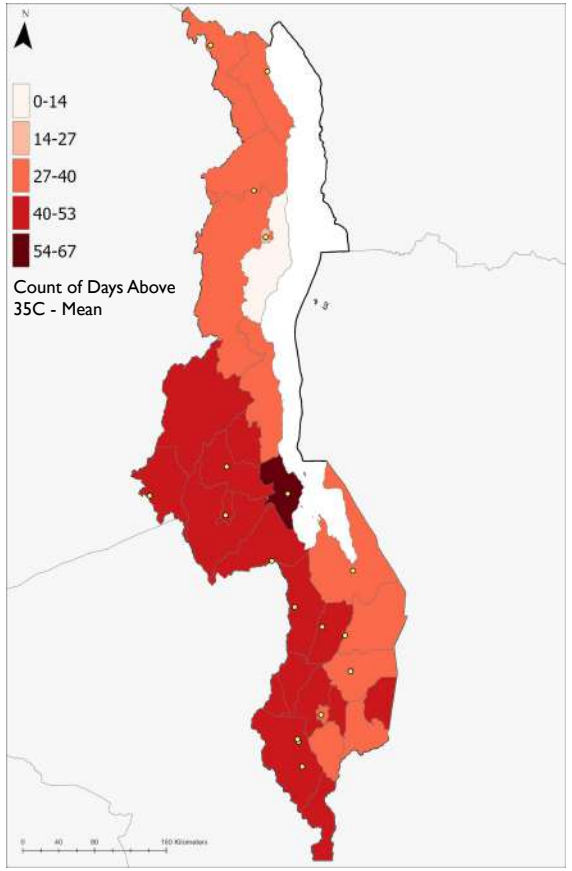
Spatial Aggregation - High Temperature

National



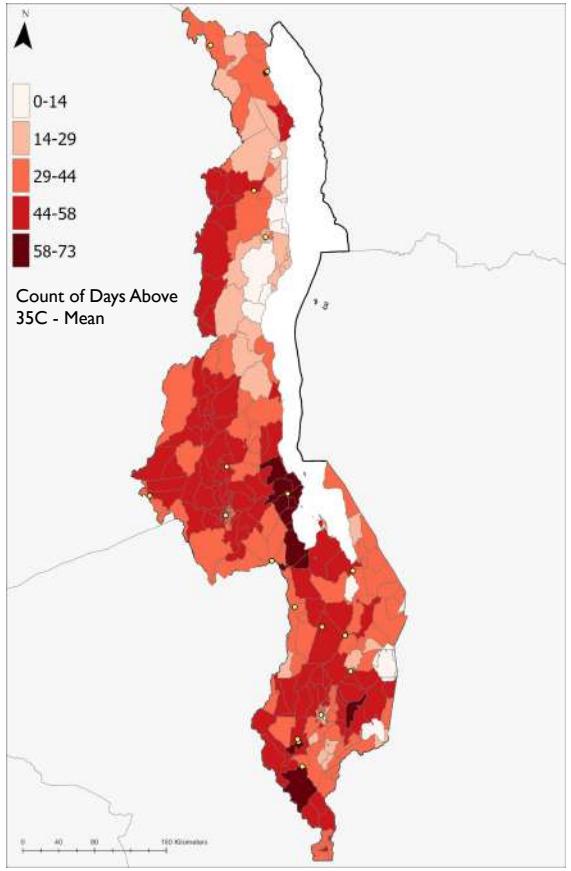
max range: 98, mean range: 33

District



max range: 1-98, mean range: 0-67

Sub-District

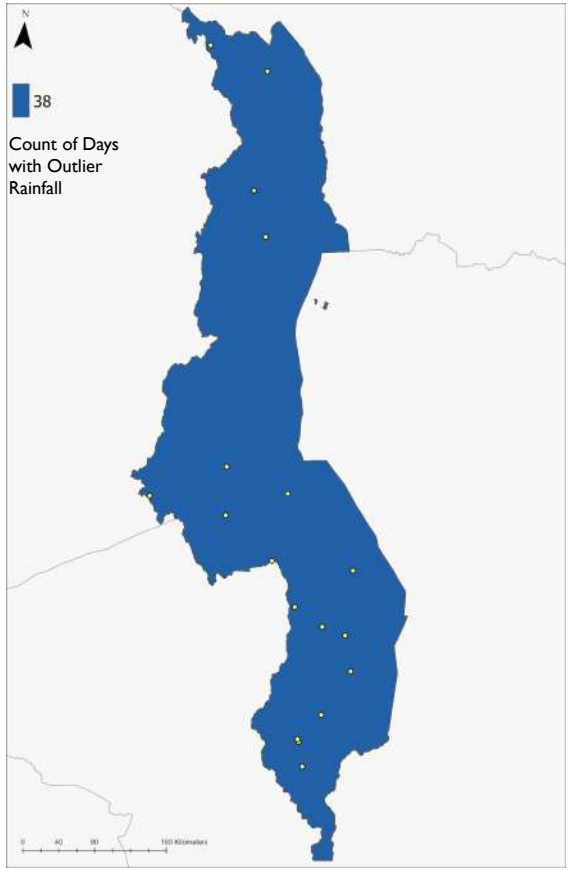


max range: 0-98, mean range: 0-73

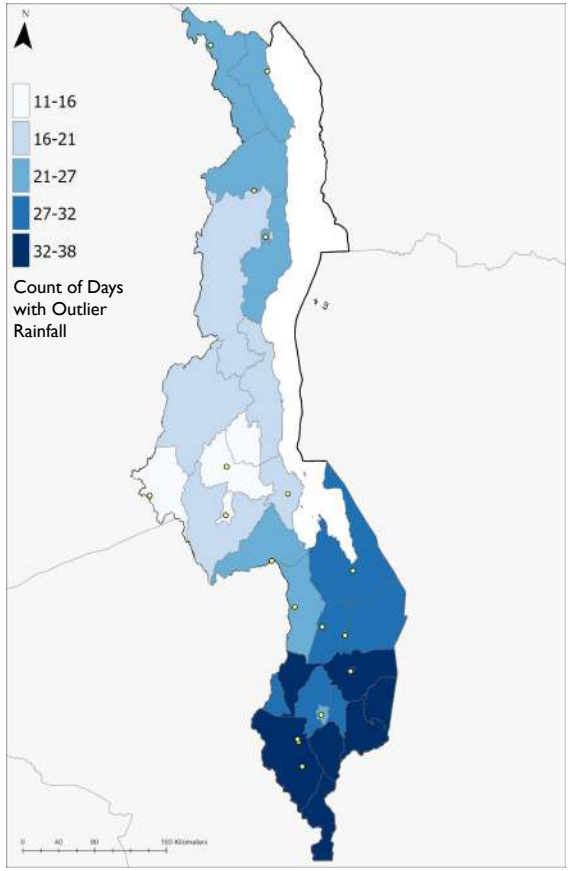
These images show the mean pixel value within each spatial unit, or the mean number of hot days in each geography for one year.

Spatial Aggregation - High Rainfall

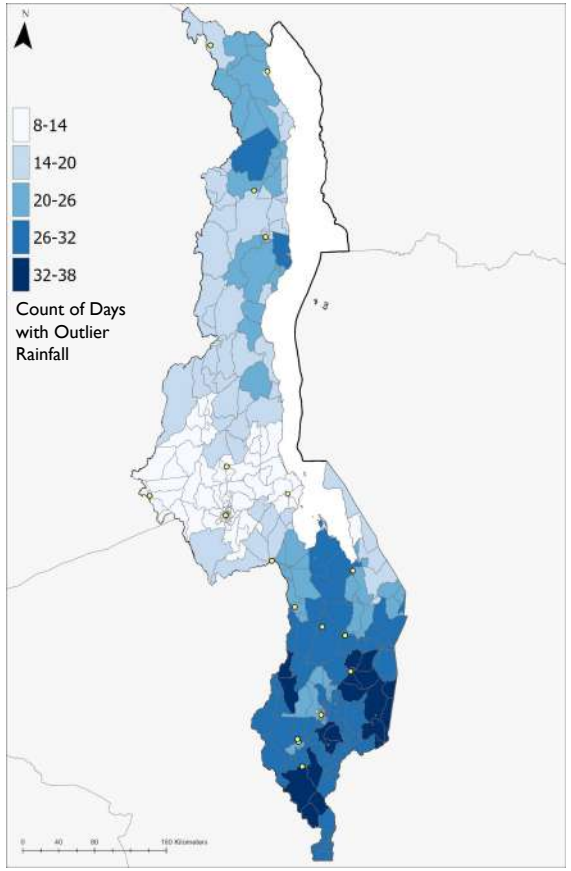
National



District

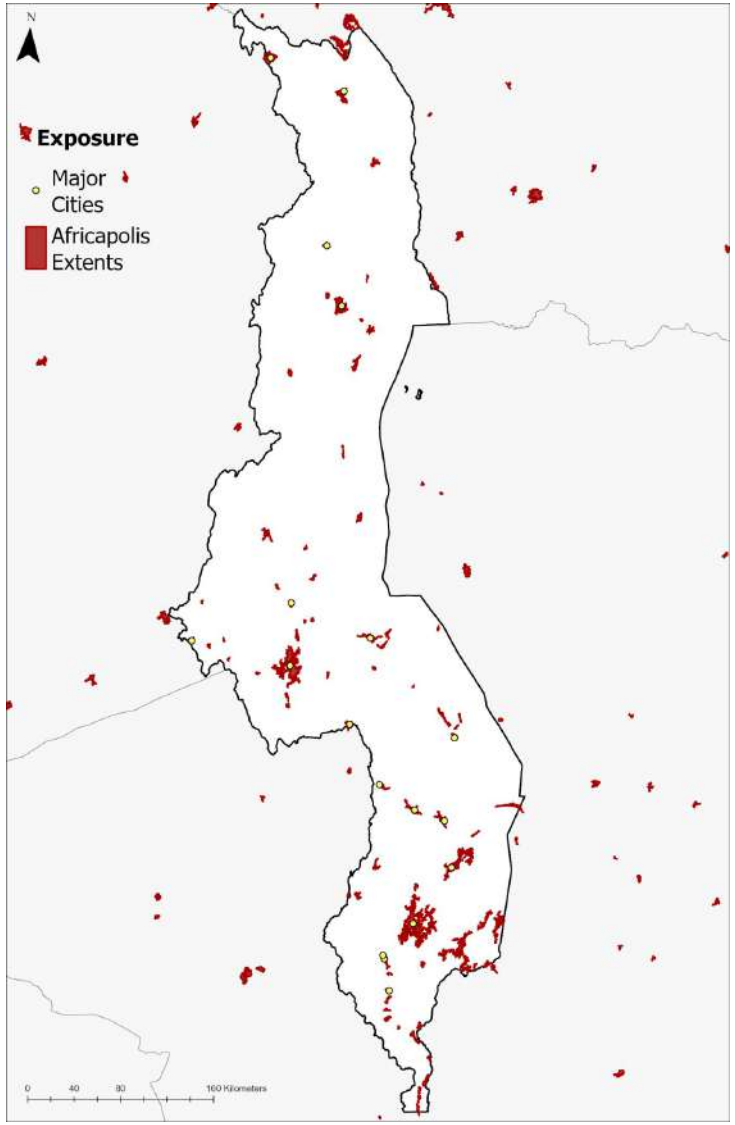


Sub-District



These images show the maximum pixel value within each spatial unit, or the largest observed number of heavy rainfall days in each geography for one year.

Spatial Aggregation - Exposure



For particular indicators or disasters, are they best understood in terms of exposure?

This map shows city extents in Malawi.

Does an urban spatial aggregation work better to capture certain responses to disaster?

Spatial Aggregation

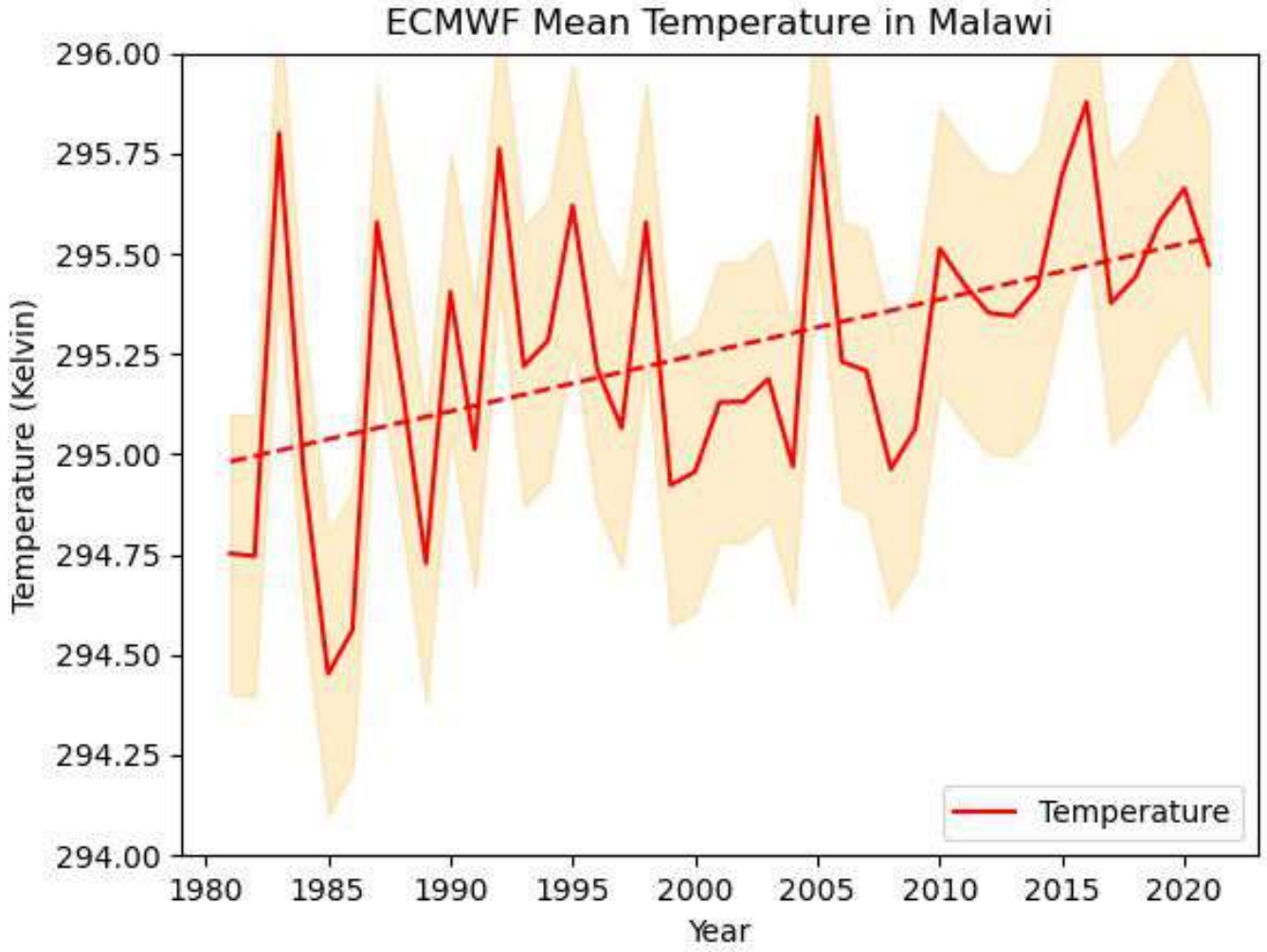
- What is the most appropriate spatial aggregation?
  - National
  - District
  - Sub-District
- Assessing disasters in terms of maximum/minimum values or means over spatial scales

5. What is the right temporal aggregation?

Temporal Aggregation

- Slow onset change
- What is the most appropriate temporal resolution?
  - Hourly
  - Daily
  - Monthly
  - Seasonally or Yearly
- Is a certain temporal scale more appropriate than another depending on the shock?
- Methods of identifying events: clusters, consecutive events, yearly/seasonal sums

Temporal Aggregation: Slow Onset Change



Our modeling for disasters look at climatic shocks within a year.

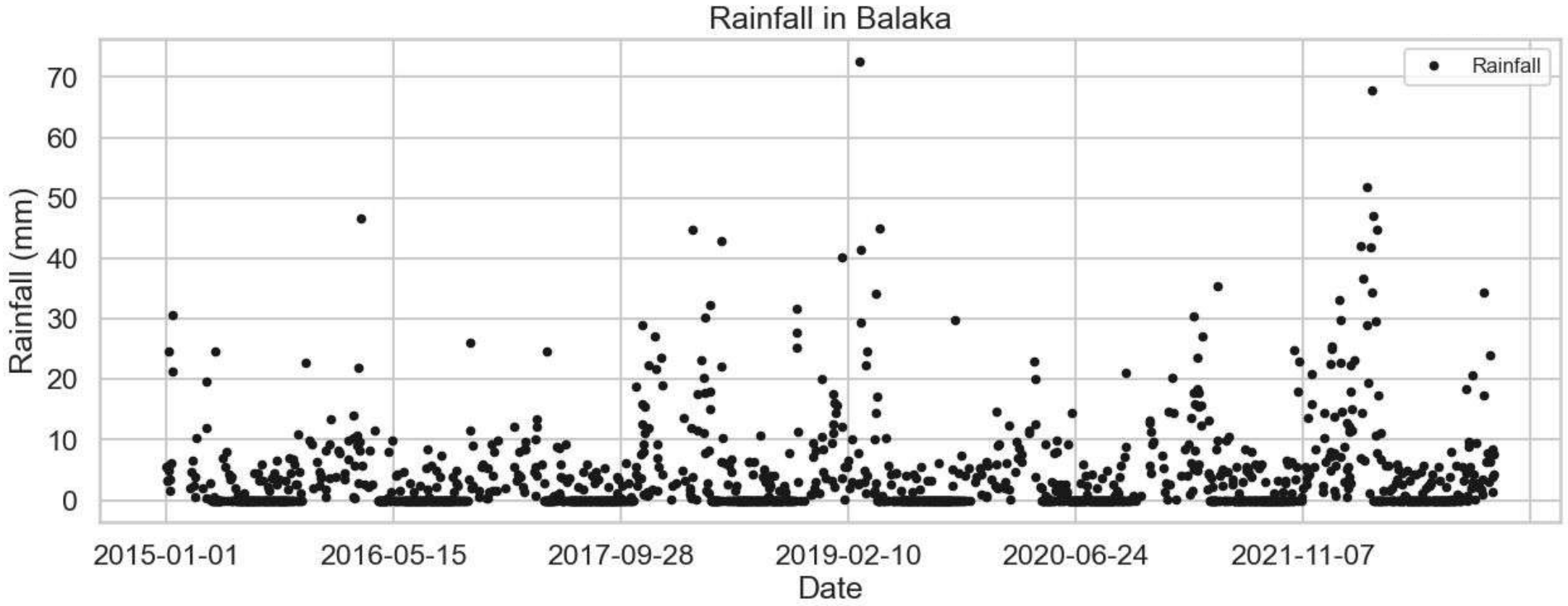
Before we begin discussing within-year dynamics, we would like to call attention to the fact that slow onset change is occurring alongside climatic shocks.

Response to a series of very hot days is more easy to measure. There is a single observable event.

Slow onset change is a more complex process to measure a response. It is nevertheless a shock that needs to be adapted to.

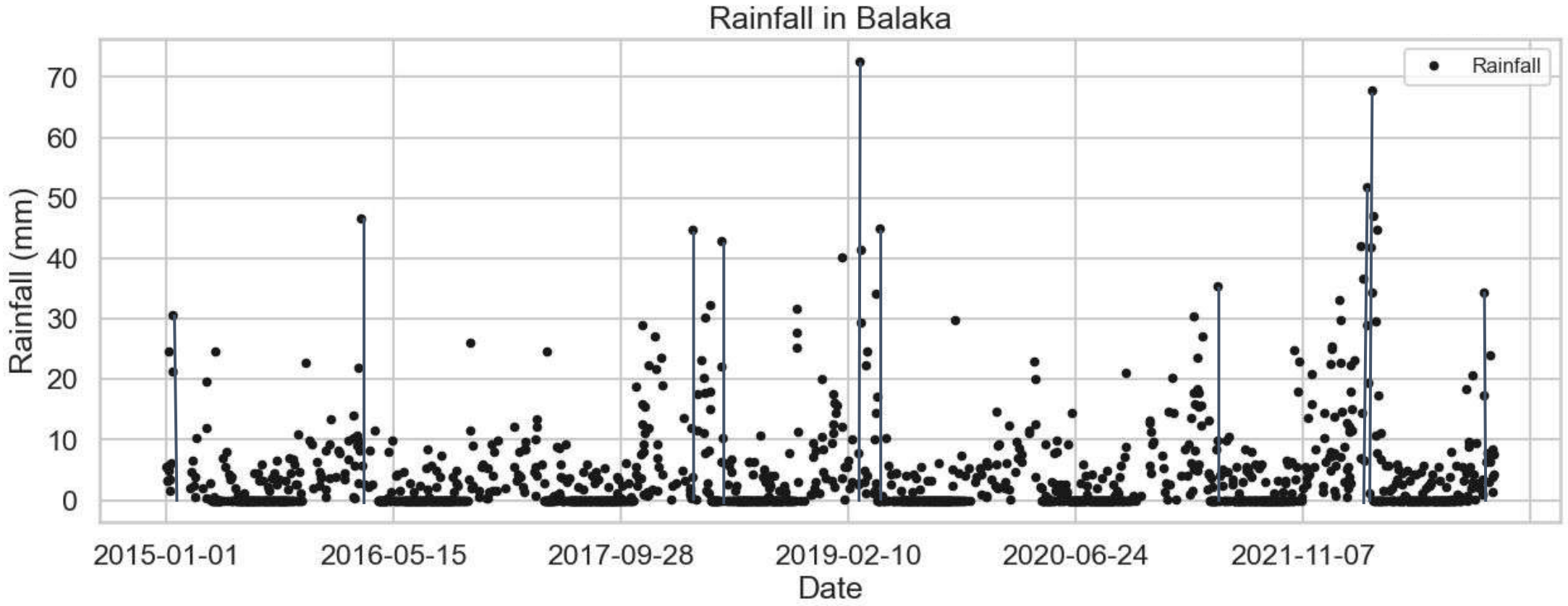
Temporal Aggregation: Daily

- Flooding: Single Events



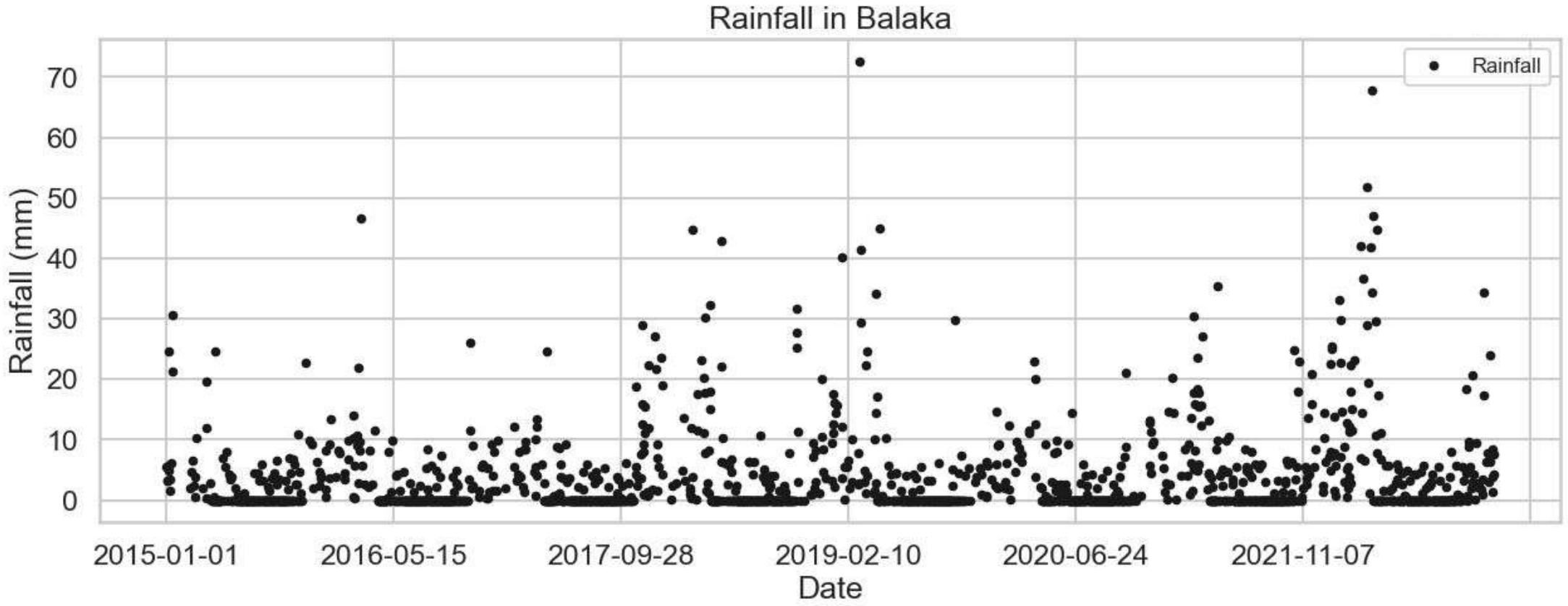
Temporal Aggregation: Daily

- Flooding: Single Events



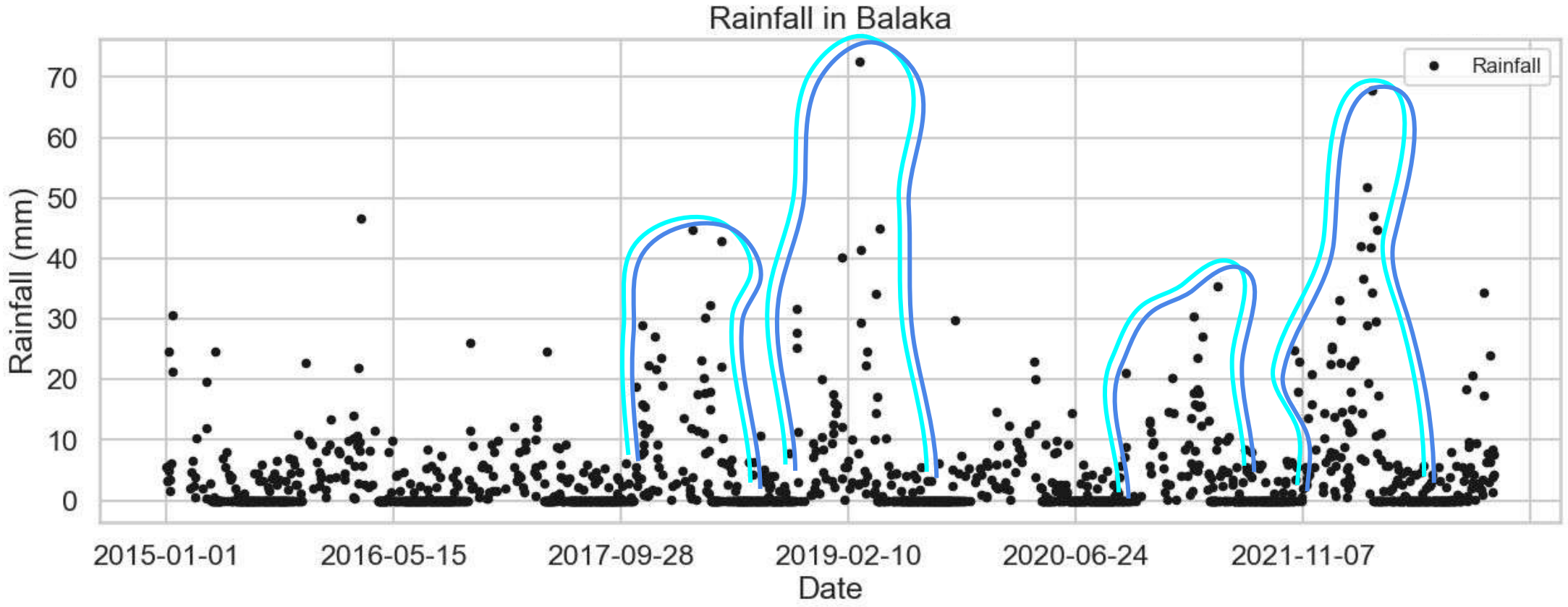
Temporal Aggregation: Monthly

- Flooding: Clusters of High Precipitation Days

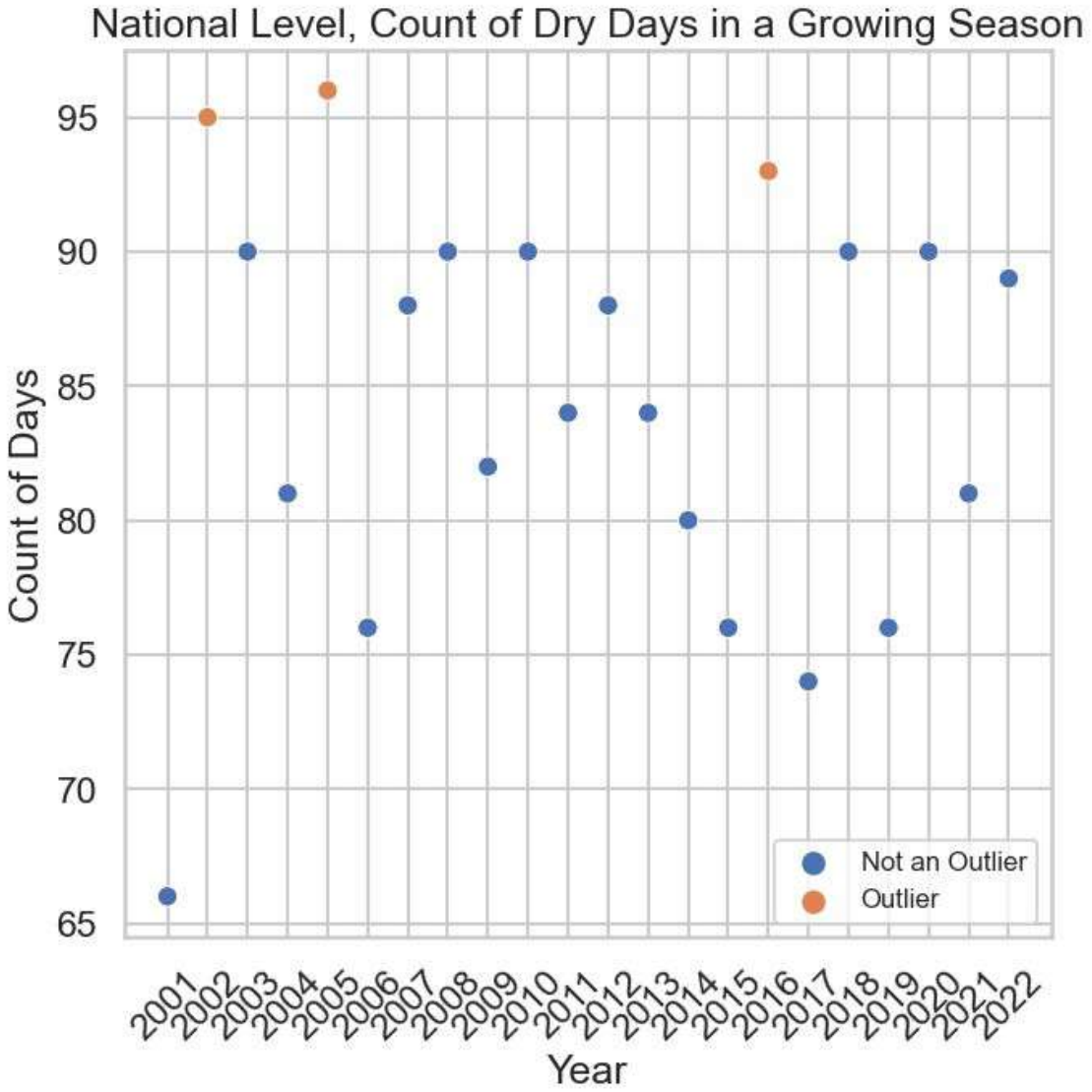


Temporal Aggregation: Monthly

- Flooding: Clusters of High Precipitation Days

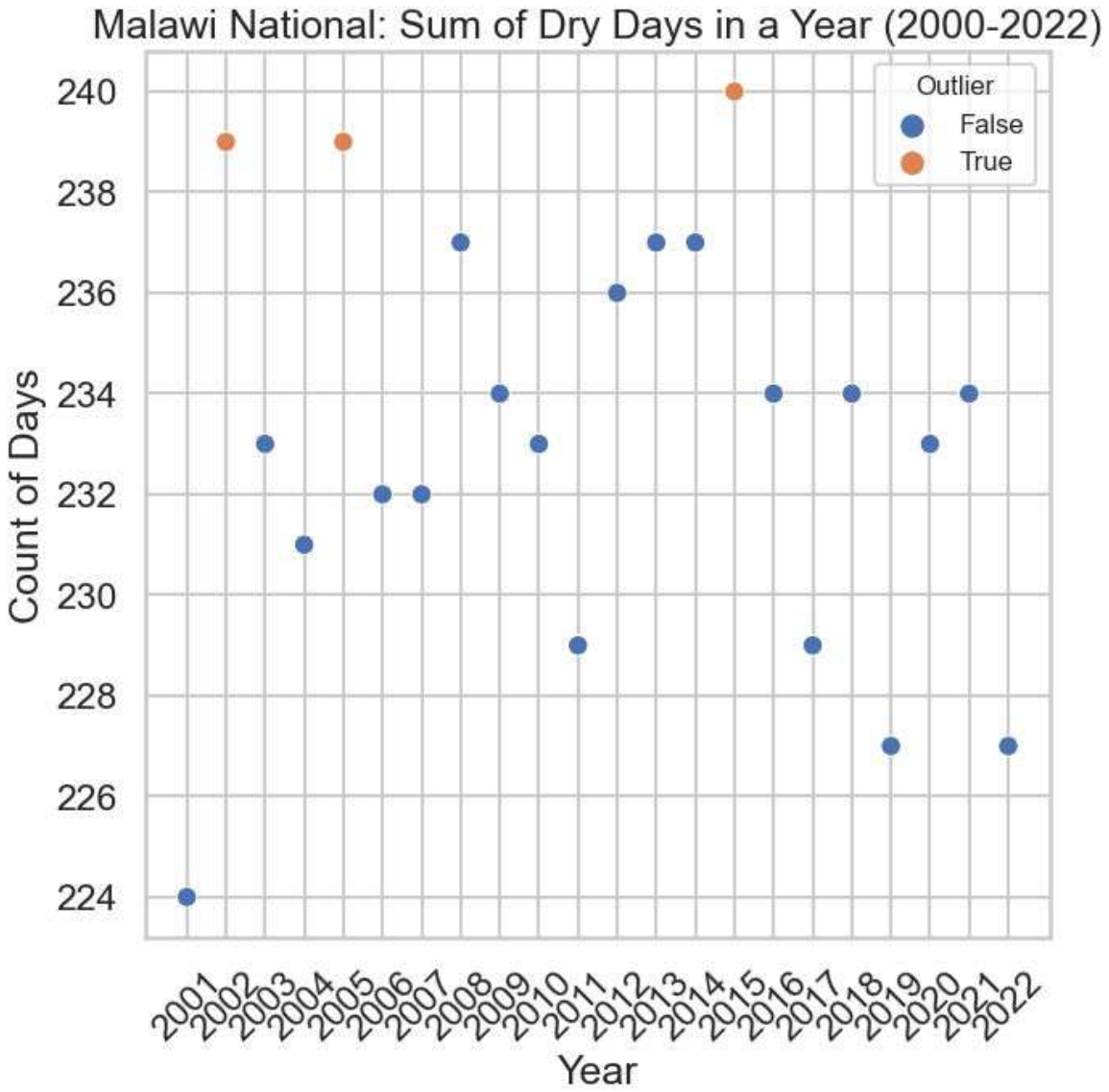


Temporal Aggregation



- Drought: Count of Dry Days in a Growing Season

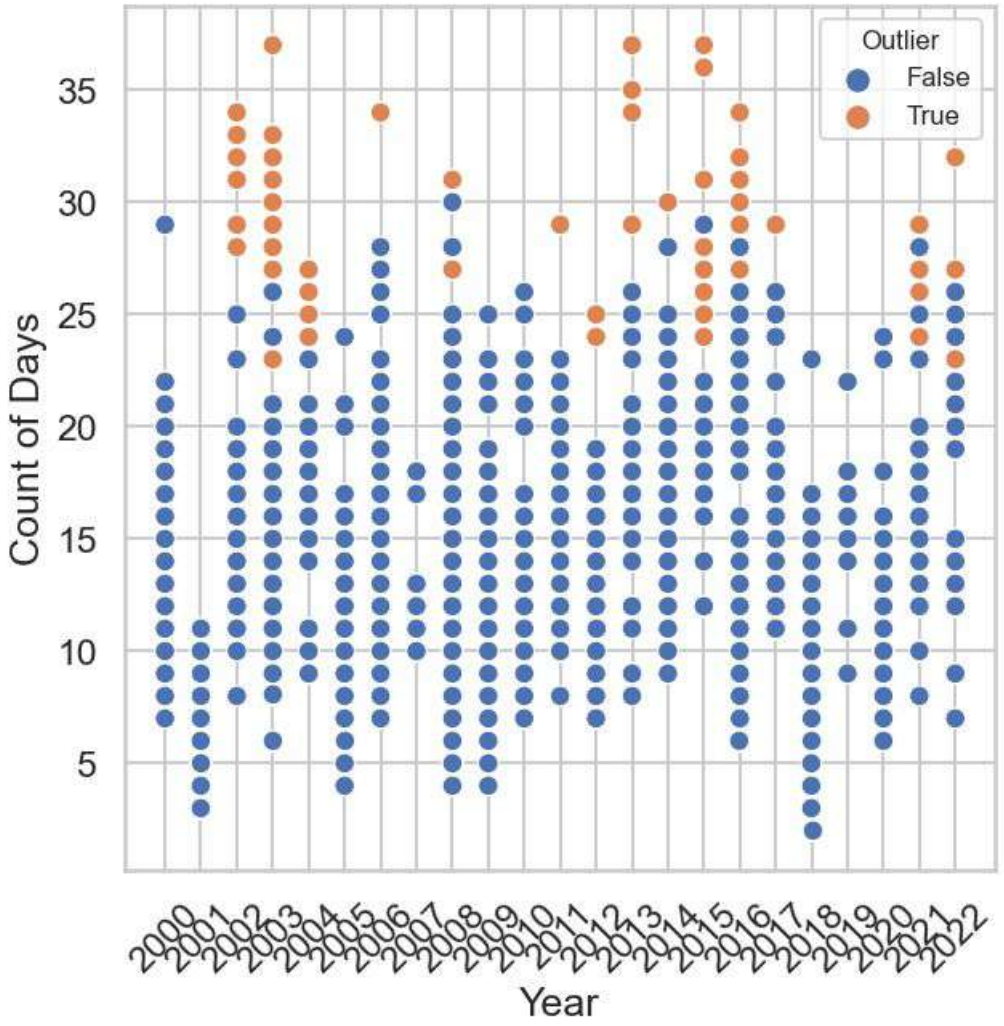
Temporal Aggregation



- Drought: Count of Dry Days Yearly

6. Implementing the proposed method

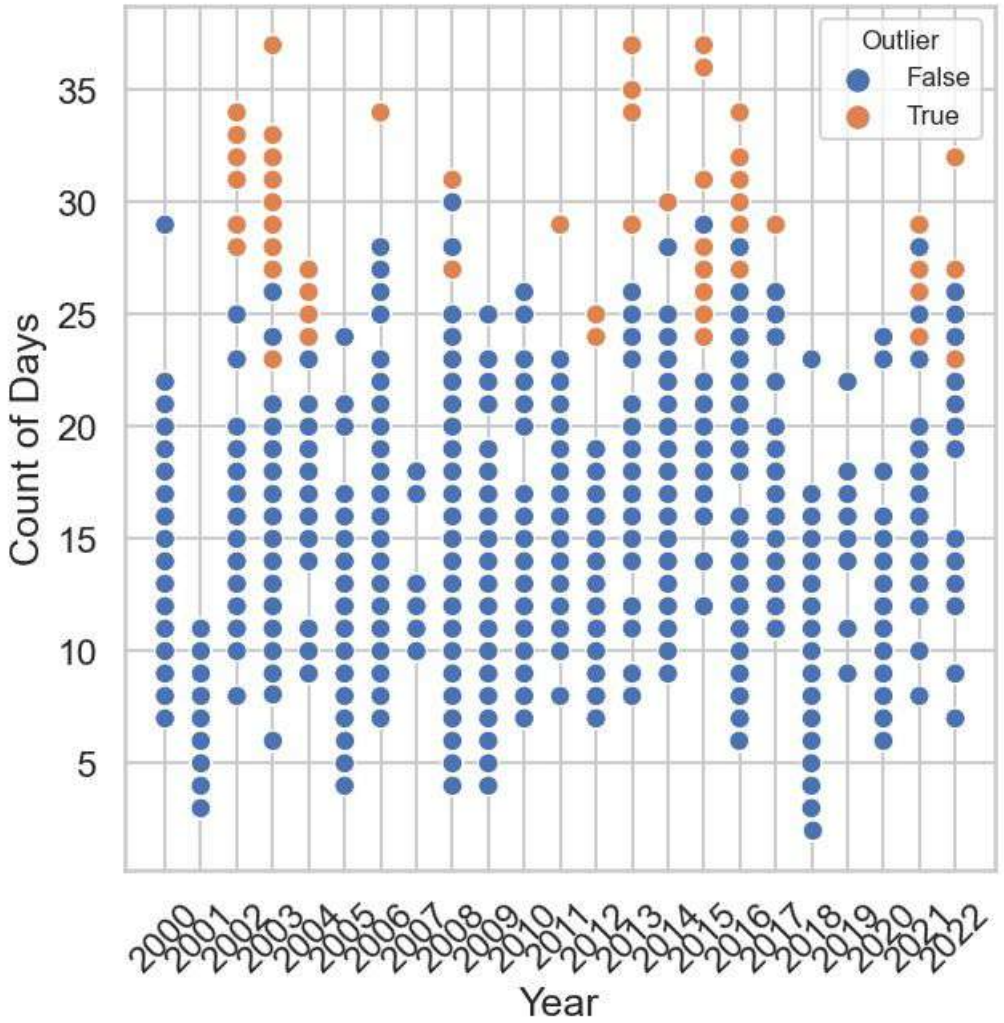
Shock and Response



- Each dot represents a geographic unit (district, sub-district)
- All orange dots represent a potential disaster

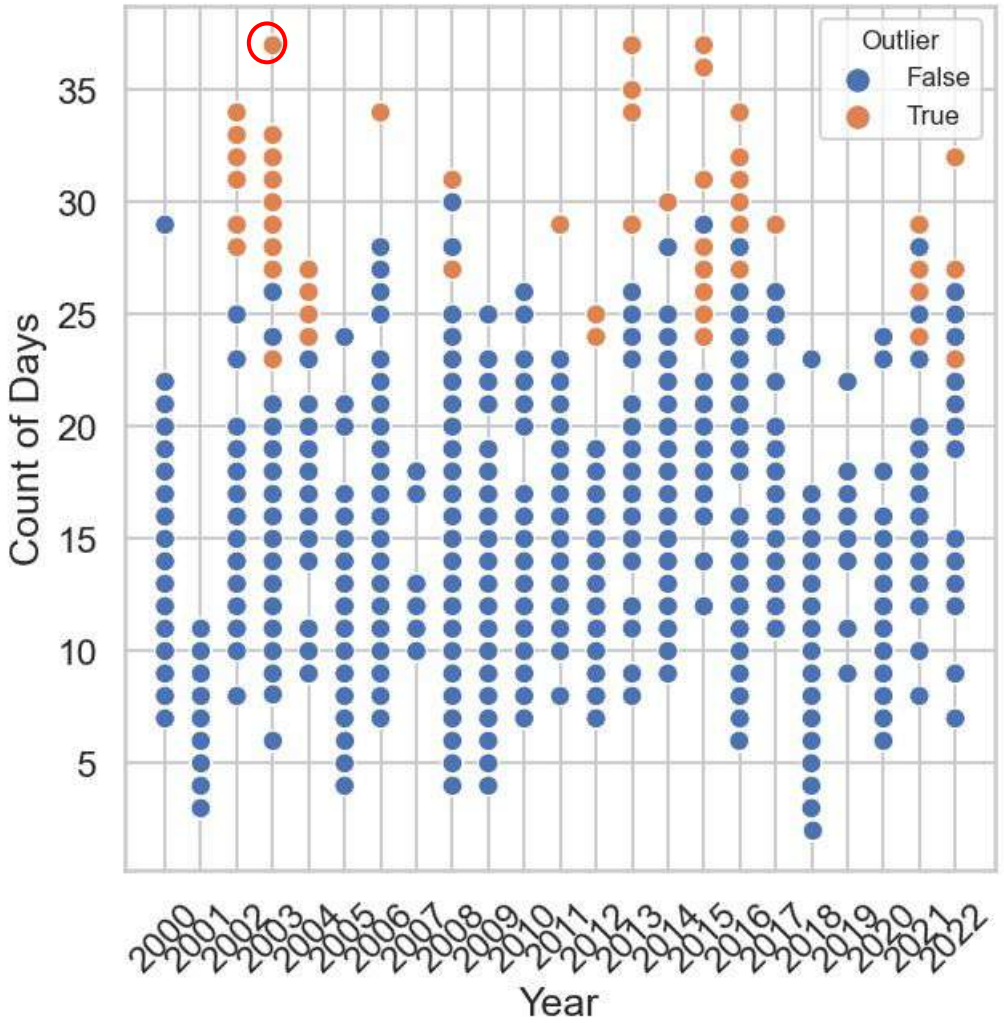
Shock and Response

Identify disasters in database



Shock and Response

Identify disasters in database



Shock and Response

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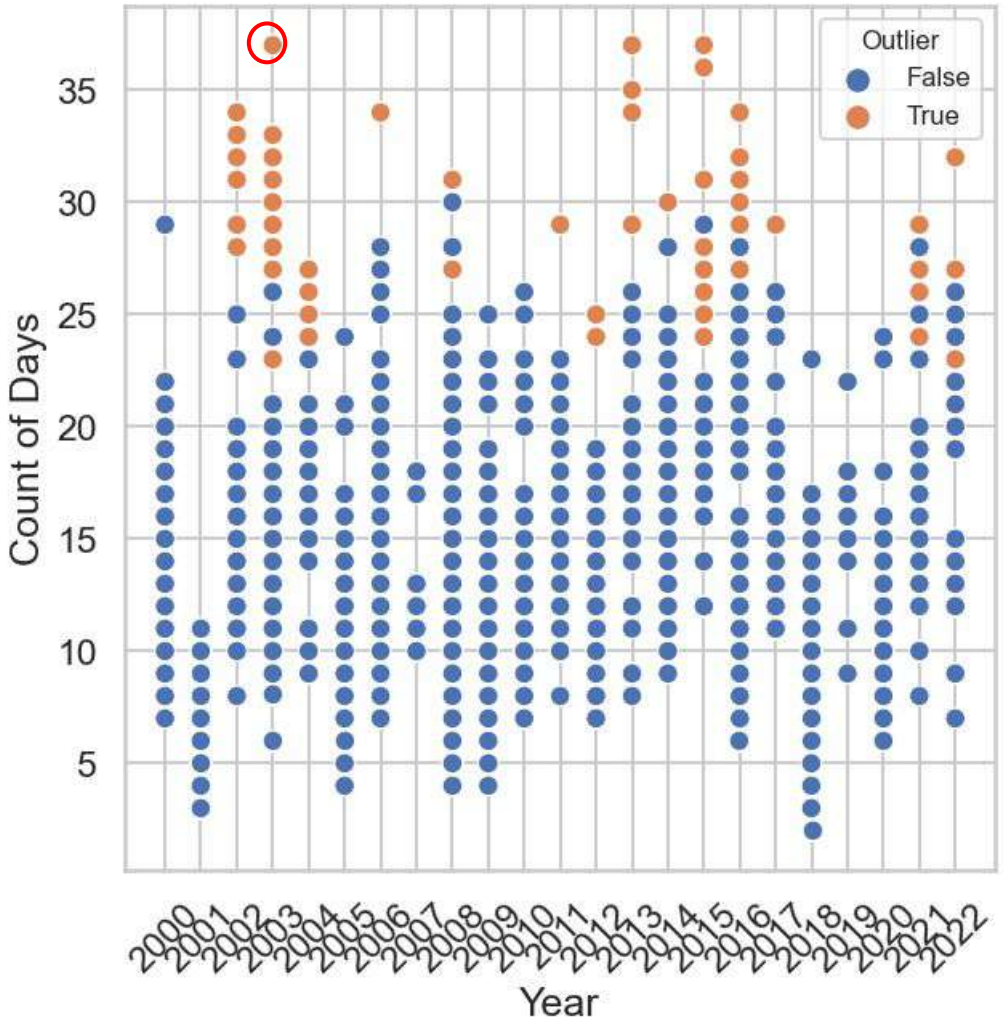
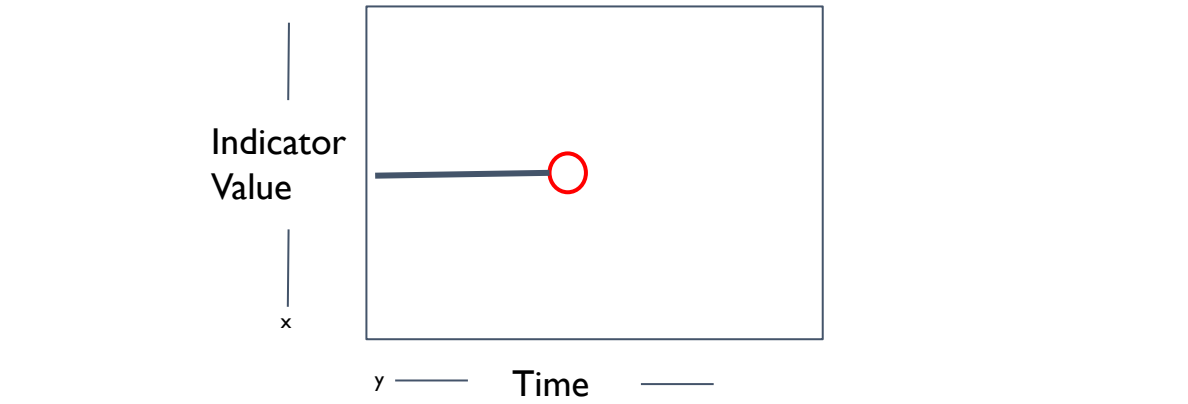
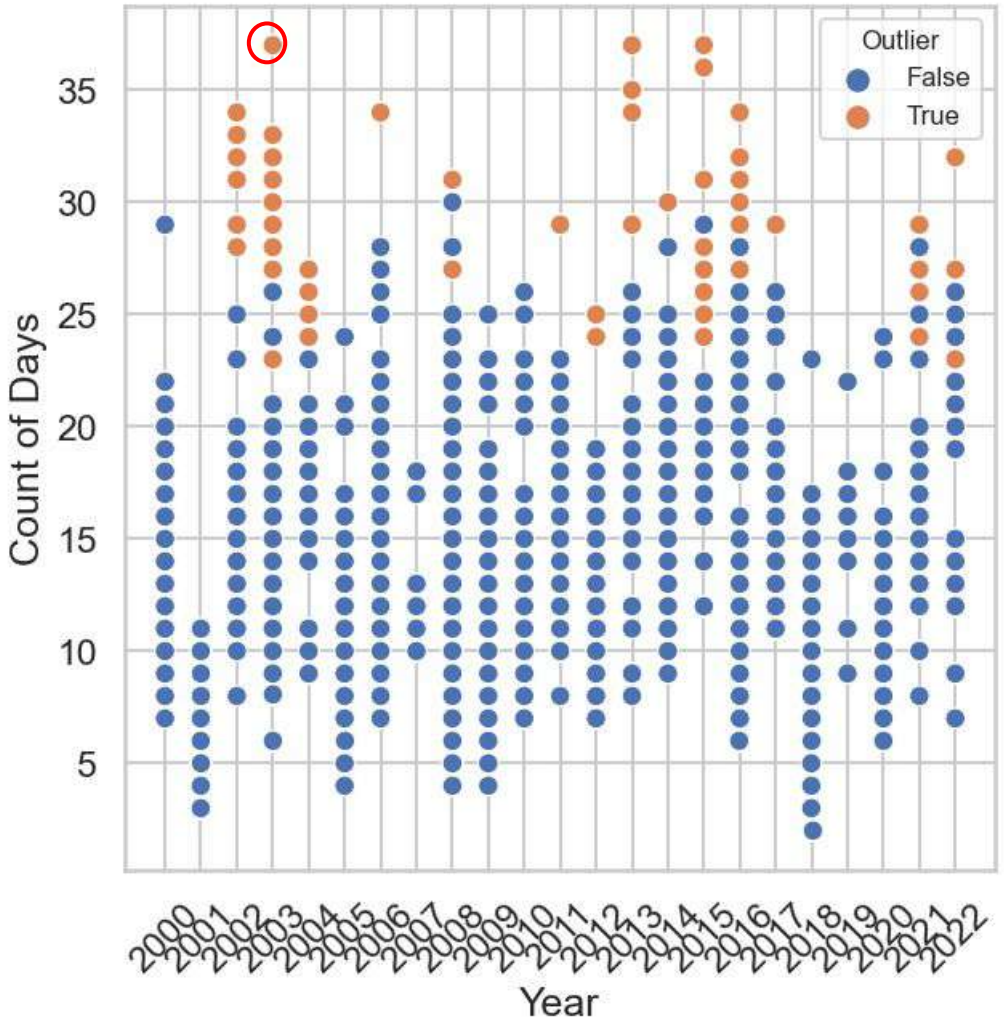


Determine Response in that Area

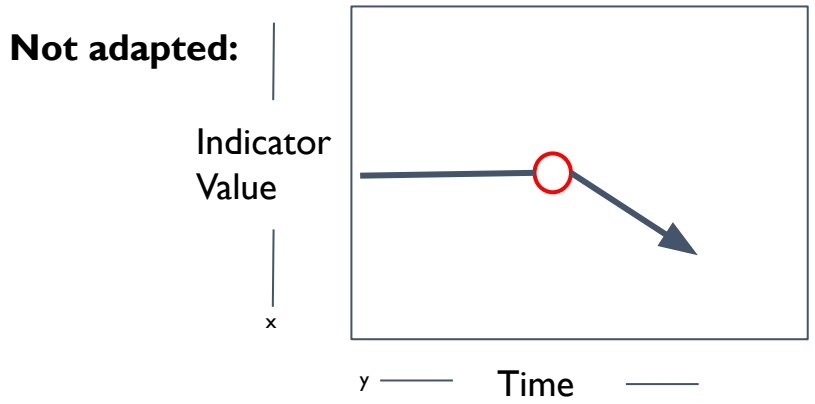


Shock and Response

Identify disasters in database

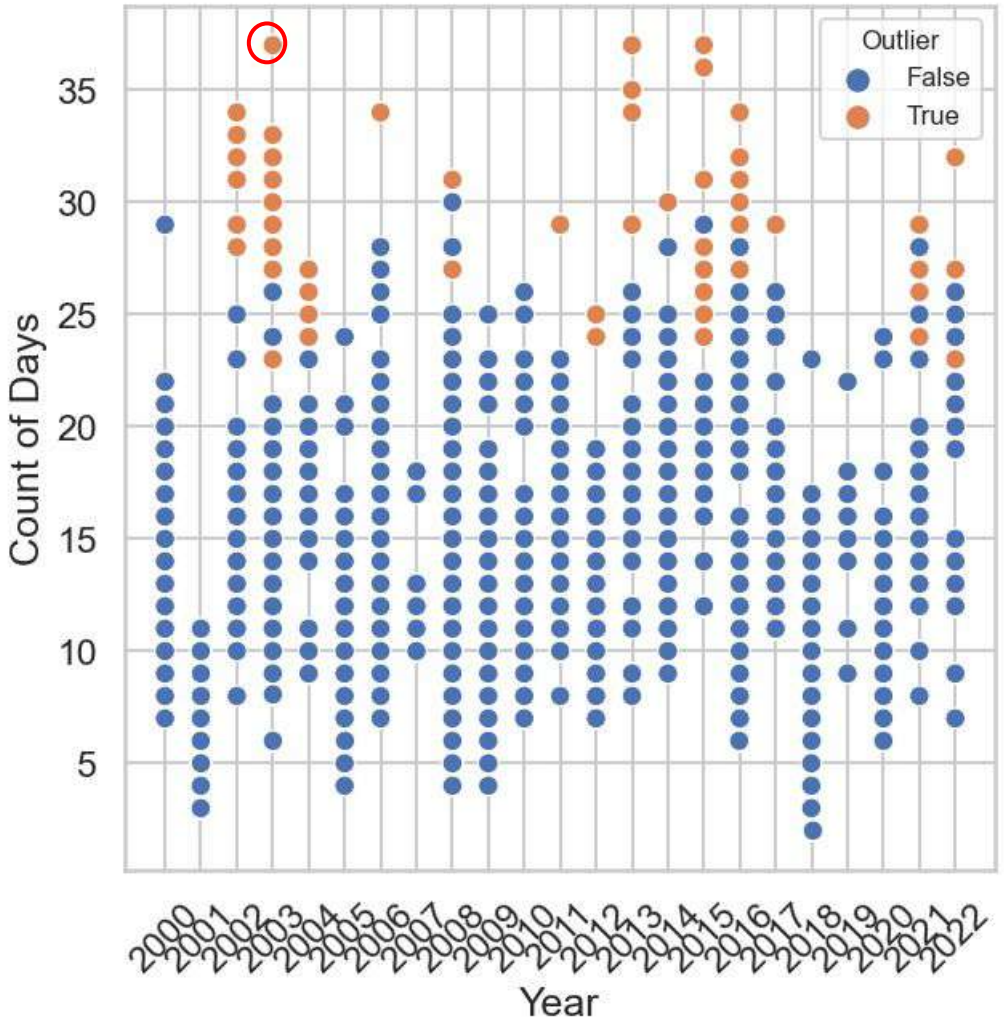


Determine Response in that Area



Shock and Response

Identify disasters in database



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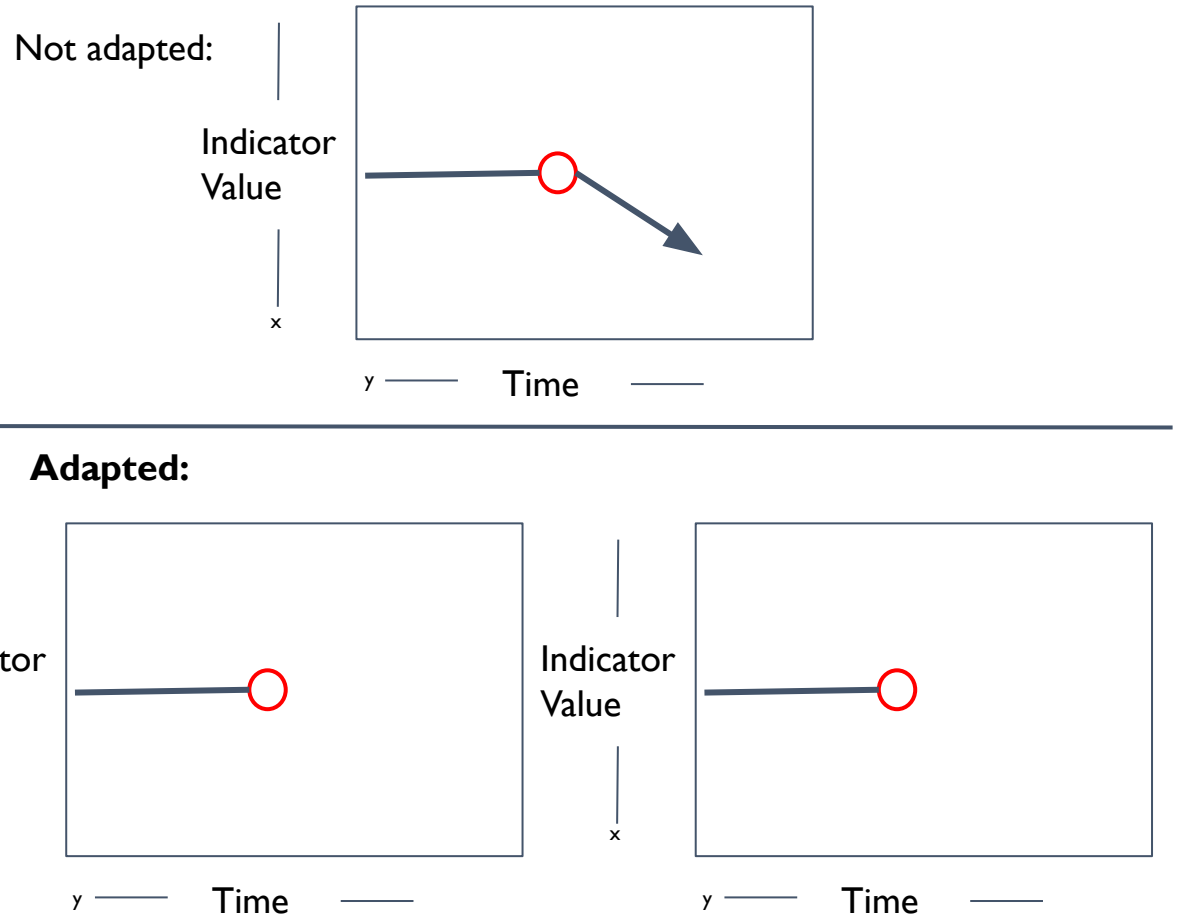
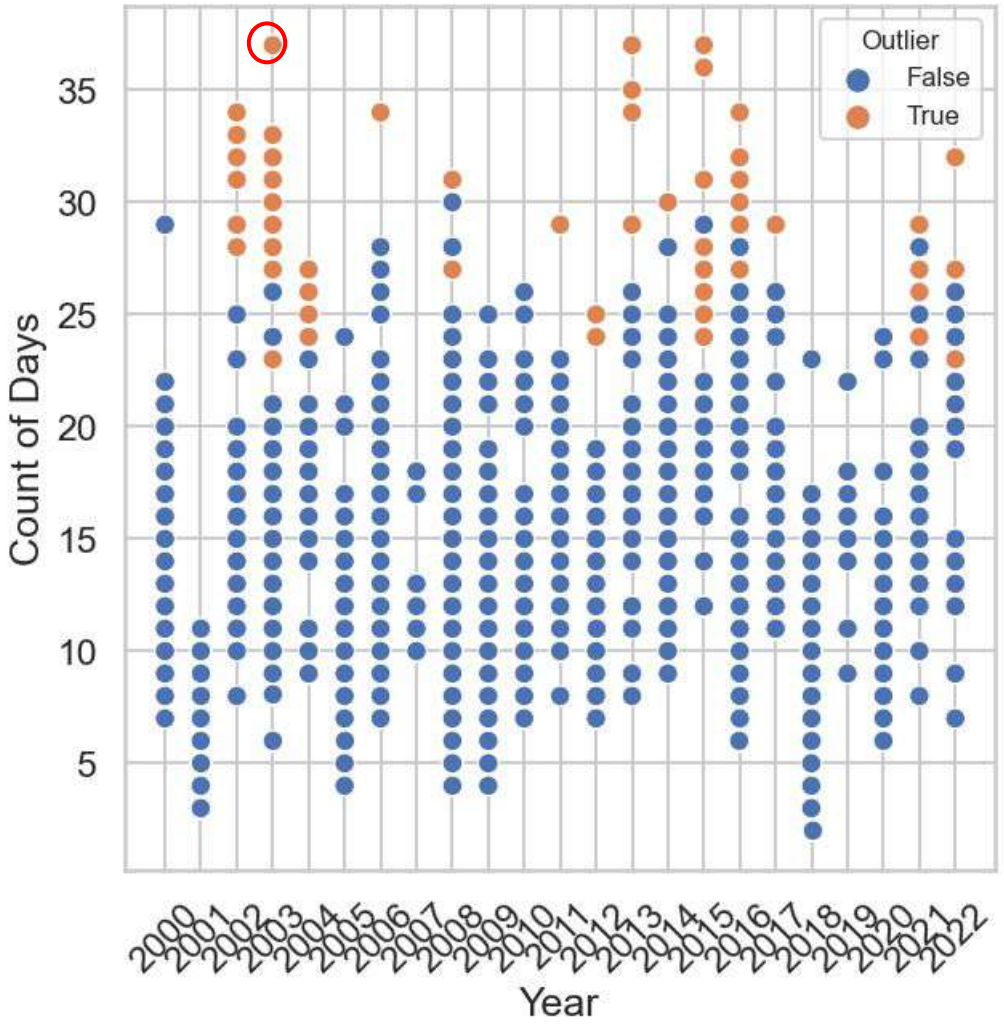
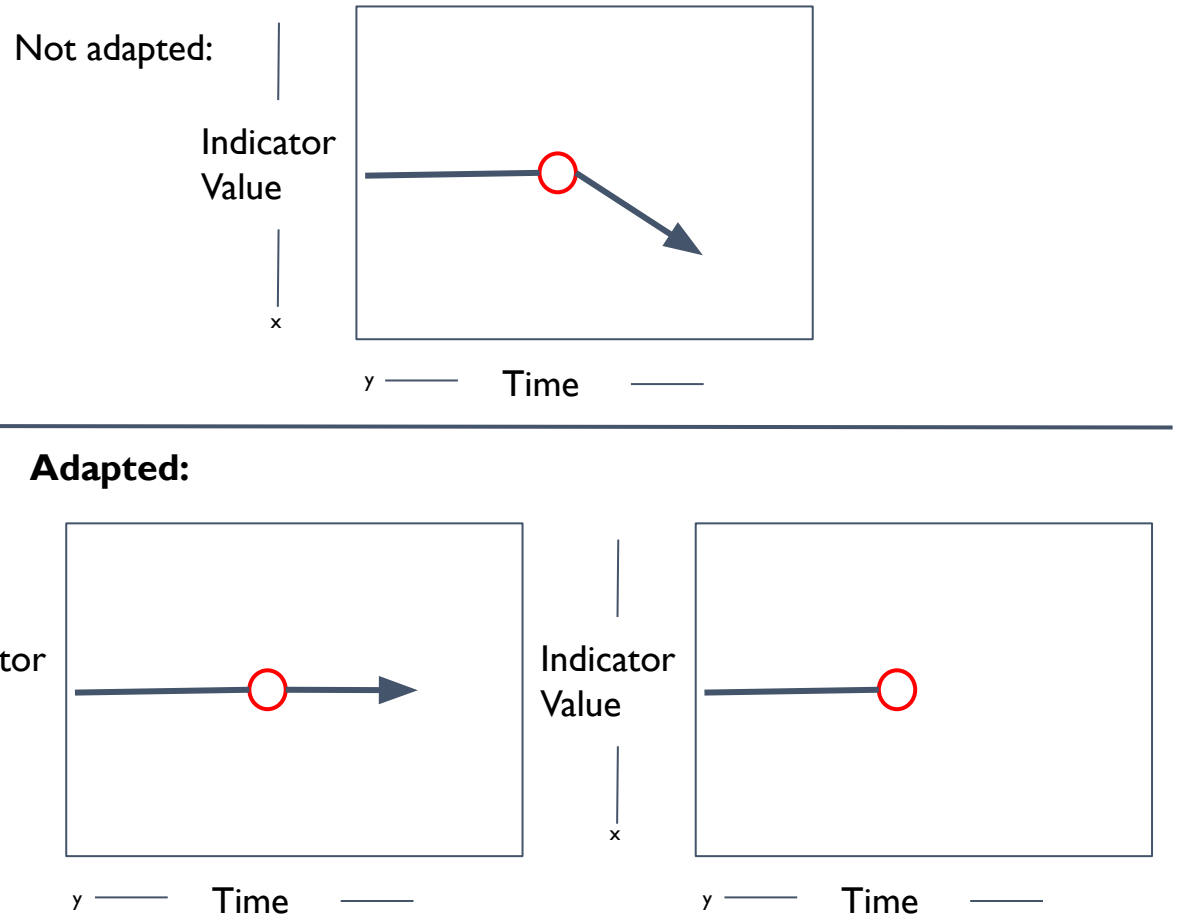


Shock and Response

Identify disasters in database

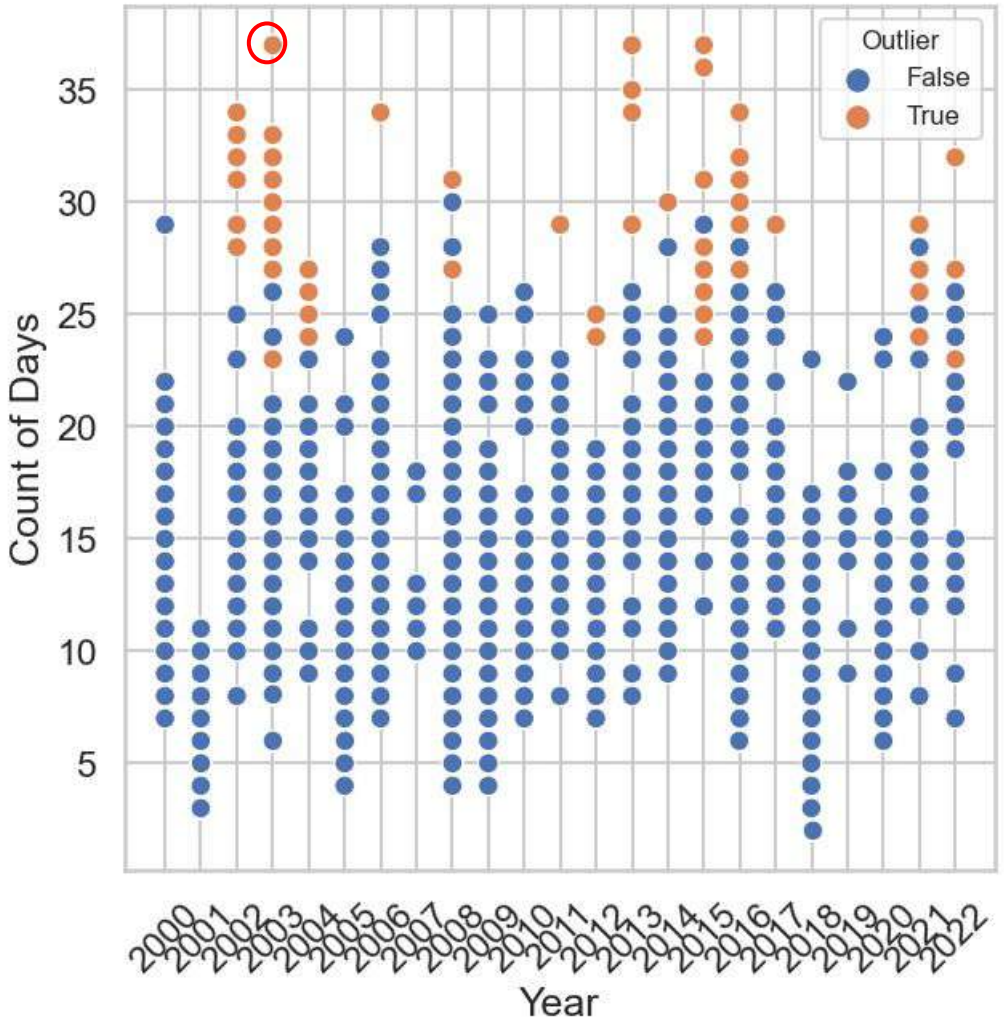


Determine Response in that Area

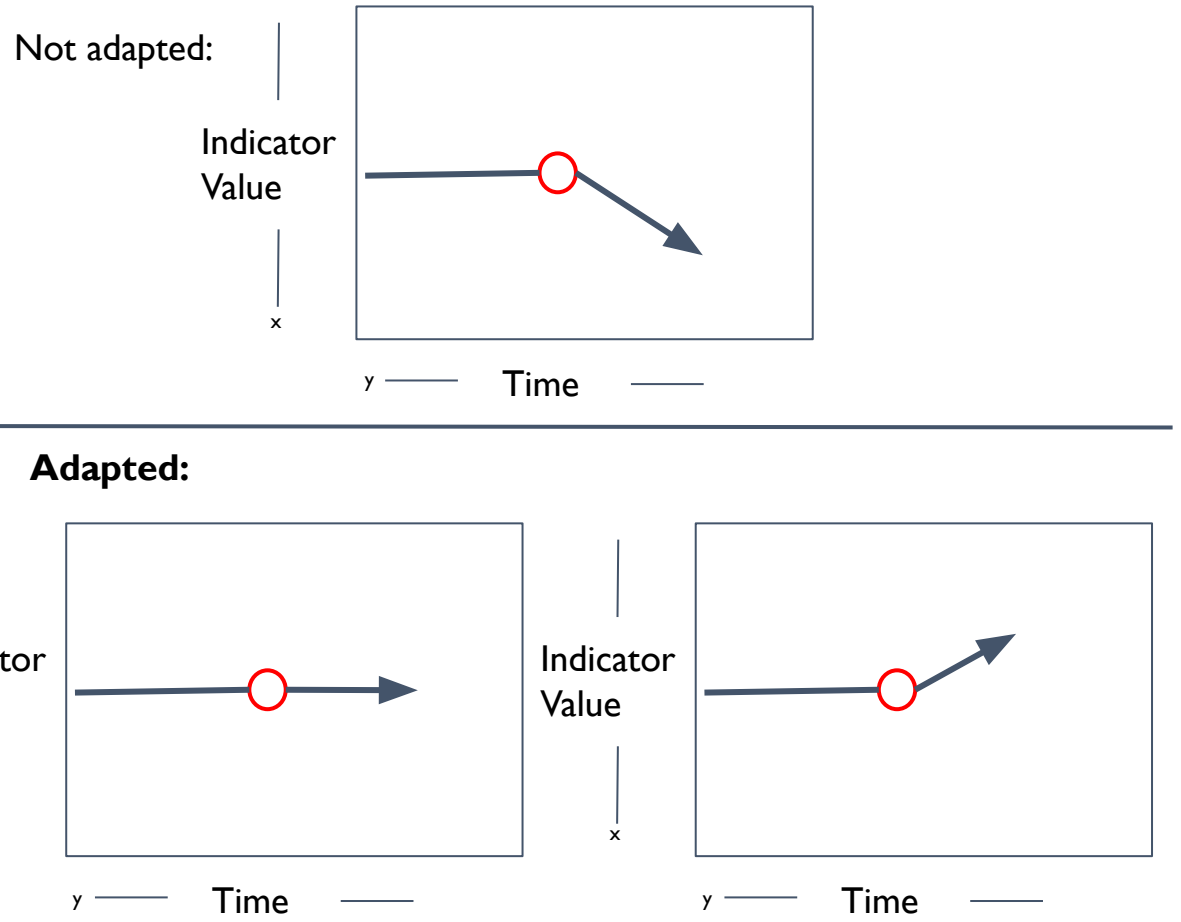


Shock and Response

Identify disasters in database



Determine Response in that Area



7. Open discussion

Open Discussion - Share Experience

1. How have you used available "Earth Observations" in your climate change work? Not only in adaptation but also in Mitigation and perhaps now Loss and Damage

2. Reflecting on what was presented in this session, what support do you need from your country to successfully incorporate and use earth observations data to monitor adaptation? Would you consider applying this method to evaluate your NAP performance?

8. Conclusion

Survey on adaptation indicators

Acknowledgements

- Grant Program: GEO-Microsoft Planetary Computer Credits Program
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GEO GROUP ON EARTH OBSERVATIONS

WORLD METEOROLOGICAL ORGANIZATION