Environmental Determinants of Enteric Infectious Disease

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Mortality

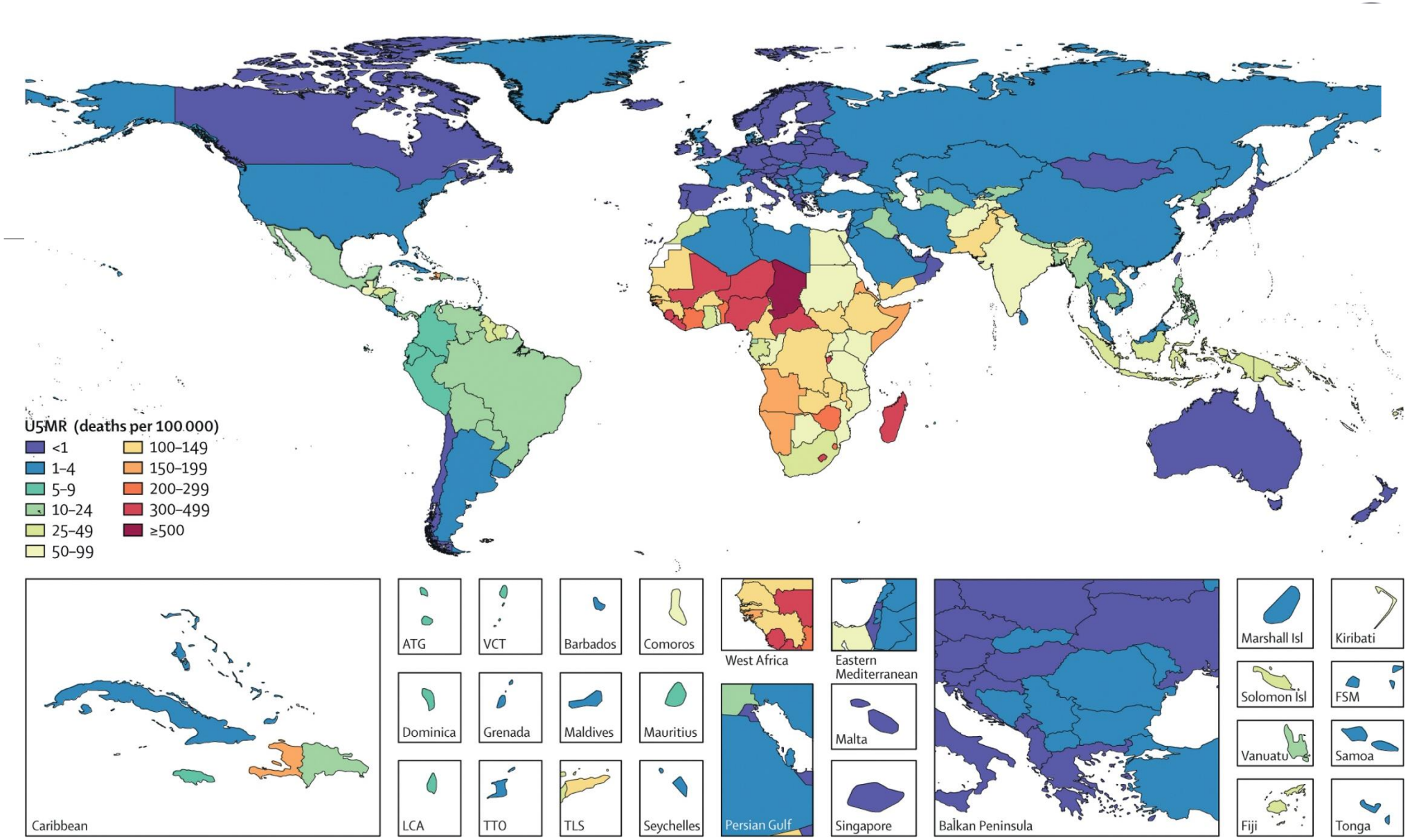
Globally, diarrhea kills 2,195 children every day

This is 1 out of 9 child deaths, worldwide

It is more than AIDS, malaria, and measles combined

It is the second leading cause of death in children less than five years old

Liu et al. (2012)



Worldwide distribution of deaths caused by diarrhea in children under 5 years of age in 2016.

Troeger et al. (2016) doi: 10.1016/S1473-3099(18)30362-1

Morbidity

Impaired **cognitive development**

Stunting

Reduced **vaccine response**

https://borgenproject.org/what-causes-stunting/

EID are preventable and treatable

In some cases, **vaccines** are available

Improved Water, Sanitation and Hygiene (**WASH**) infrastructure and behavior is critical

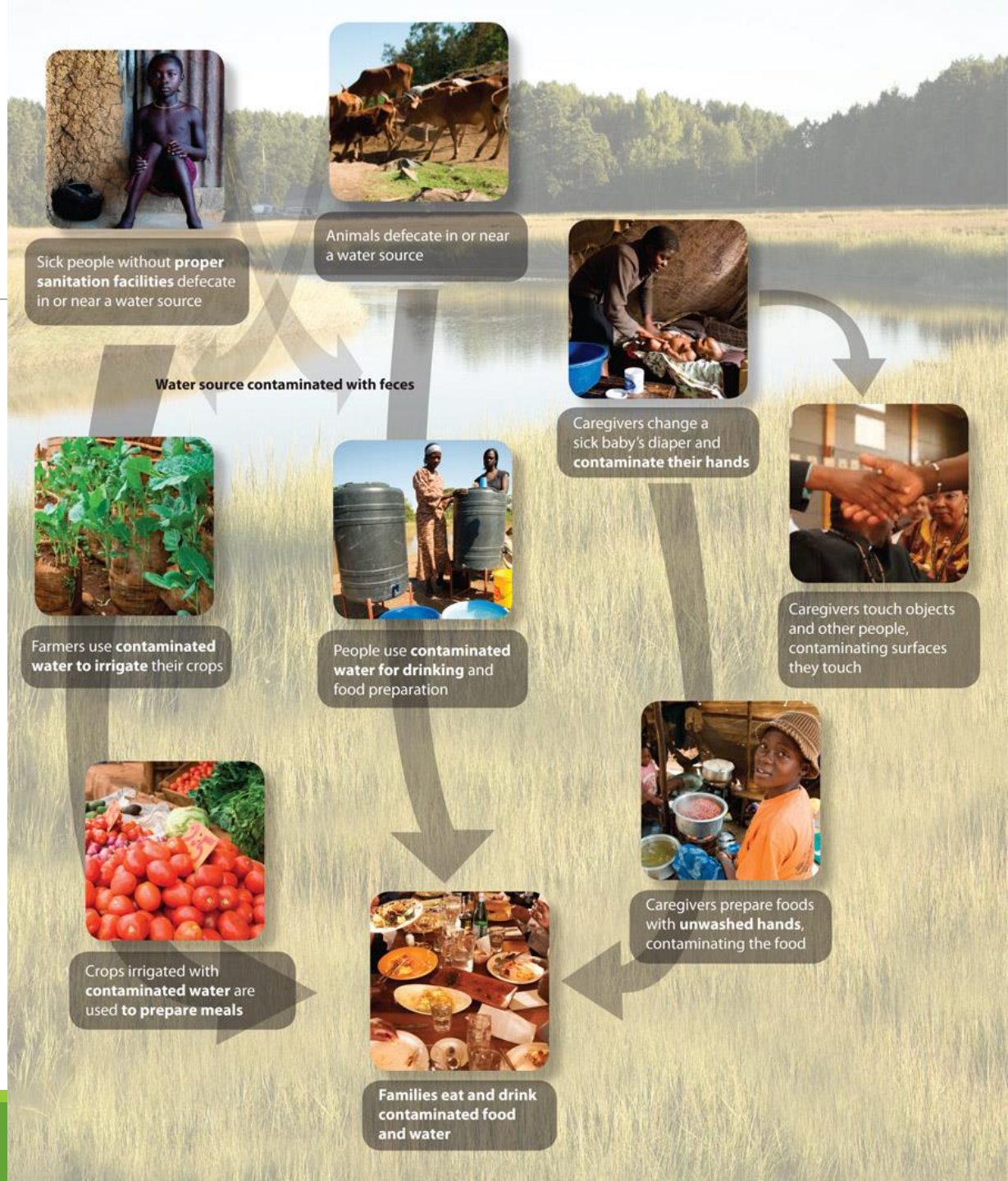
Those suffering from diarrhea can be treated with **oral rehydration therapy**

Hector Retamal/AFP/Getty Images

Project goal

Establish the feasibility of Earth Observation-informed EID risk mapping, monitoring, and prediction systems

Risk is environmentally mediated

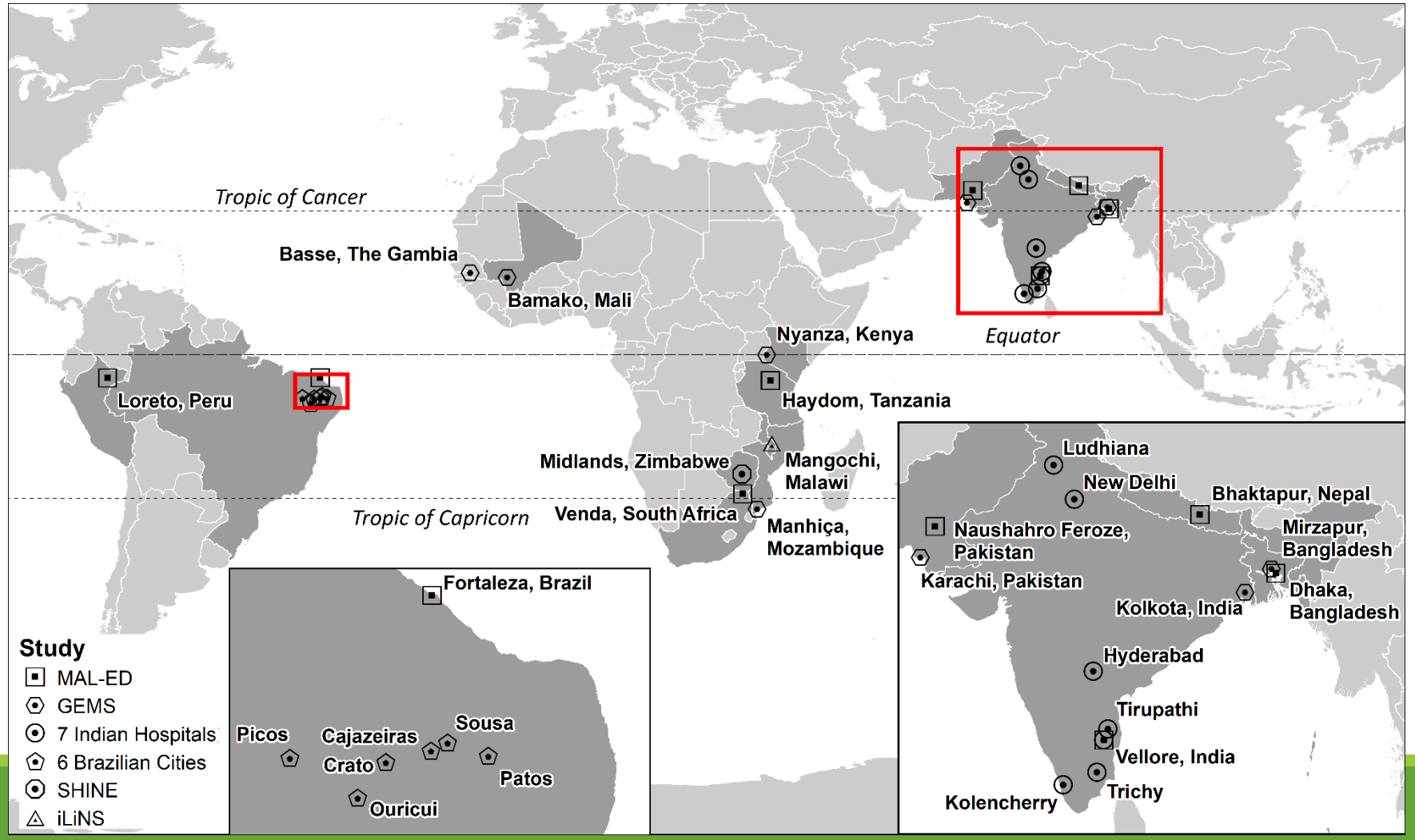


https://www.cdc.gov/healthywater/global/diarrhea-pathways.html

But it's complicated

	EID	Seasonality	Rainfall	Air Temp.	Humidity	Soil moisture	Wind speed	Surface pressure	Solar radiation	Travel	Water exposure	Eating/ food habits	Indoor crowding	Animal contact
Viral	Adenovirus	Unknown	-	-	-	-	-	-	-	-	↗	-	-	-
	Astrovirus	Winter	-	(↘)	-	-	-	-	-	-	↗	-	-	-
	Norovirus	Winter	↗	↘	(↘)	-	-	-	-	↗	-	-	(↗)	-
	Rotavirus	Winter	↘	↘	↘	(↘)	(↗)	↗	-	-	-	-	-	-
Bacterial	*Aeromonas* spp	Unknown	-	↗	-	-	-	-	-	↗	-	-	-	-
	Campylobact.	Spring	-	↗	-	-	-	-	(↘)	↗	↗	(✓)	-	(↗)
	Diarrh. *E. coli*	Summer	-	↗	-	-	-	-	-	↗	↗	(✓)	-	(↗)
	P. shigelloides	Summer	-	↗	-	-	-	-	-	↗	↗	✓	-	-
	Salmonellosis	Spring/summer	-	↗	-	-	-	-	-	(↗)	-	(✓)	-	(↗)
	Shigellosis	Late summer	-	-	-	-	-	-	-	↗	↗	-	-	-
	Cholera	Rainy season	↗	↗	↗	-	-	-	↗	-	-	-	-	-
	Y. enterocolitica	Winter	-	↘	-	-	-	-	-	-	-	-	-	(↗)
Parasitic	Cryptosporid.	Late summer	↗	↗	-	-	-	-	-	↗	↗	-	-	(↗)
	Cyclosporiasis	Rainy season	↗	-	-	-	-	-	-	-	(↗)	(✓)	-	(↗)
	Giardiasis	Late summer	↗	↗	-	-	-	-	-	↗	↗	-	-	(↗)
	Amebiasis	Summer/autumn	-	-	-	-	-	-	-	(↗)	-	-	-	-
	Helminthiasis	Rainy season	(↘)	↗	↗	(↘)	-	-	-	-	-	-	-	-

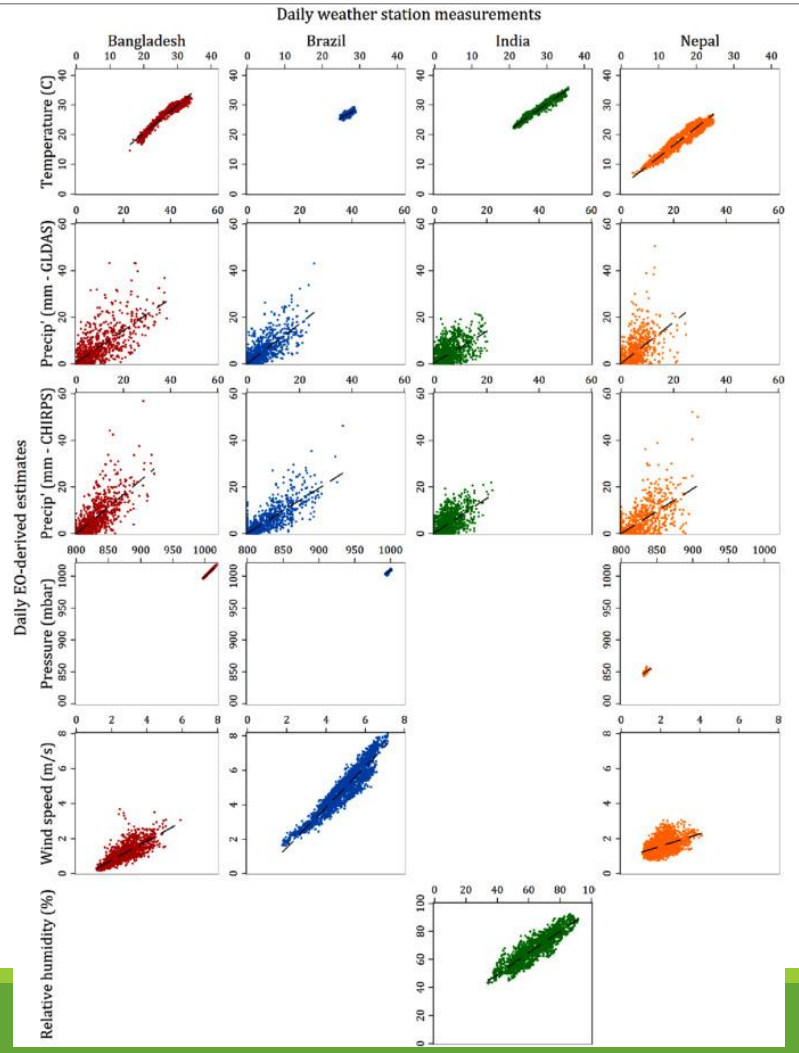
We need detailed data on infections



Paired with data on environment

None of these infection studies included collection of data on climate or environment.

Earth Observations offer an opportunity to fill this gap.



Colston et al. (2018)

Objectives

Develop process-informed statistical models to **predict EID burden**

Use objective regionalization to create **a global EID-oriented classification system**

Apply statistical models and regionalization to generate **global maps of the potential burden and dominant seasonality of each EID**

Implement a **map-based data server and visualization platform**

Accomplishments

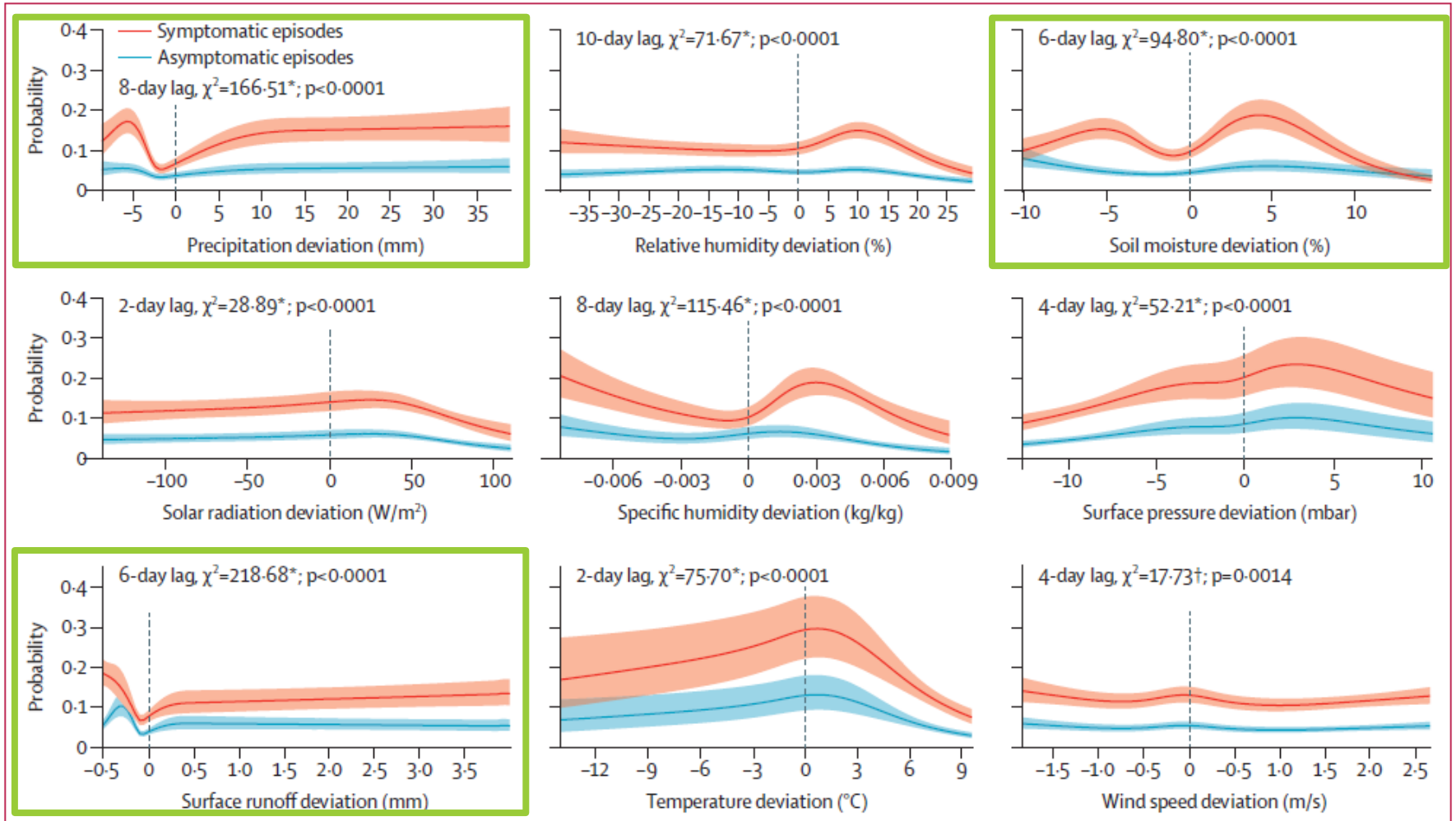
PY1:

1. Evaluated EO performance at MAL-ED sites, and published results collaboratively with MAL-ED site PIs (Colston et al., 2018)
2. Generated a preliminary rotavirus prediction model based on MAL-ED site data and Earth Observations

PY2:

1. Published the results of the rotavirus model collaboratively with site PIs (Colston et al., 2019)
2. Performed preliminary regionalization based on rotavirus predictors
3. Built template visualization app in Tethys
4. Participated in NASA's pilot commercial data buy program

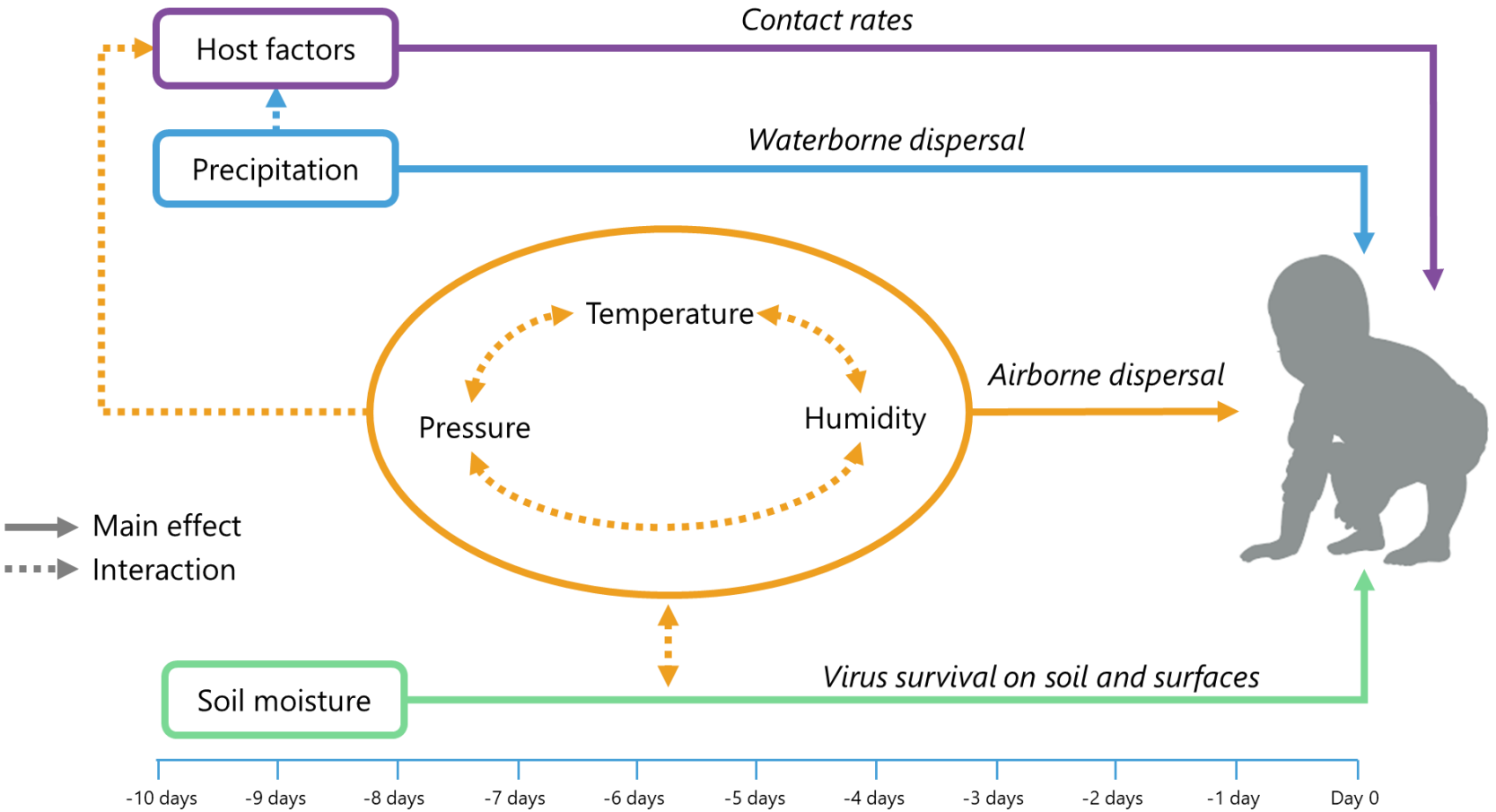
Published rotavirus model



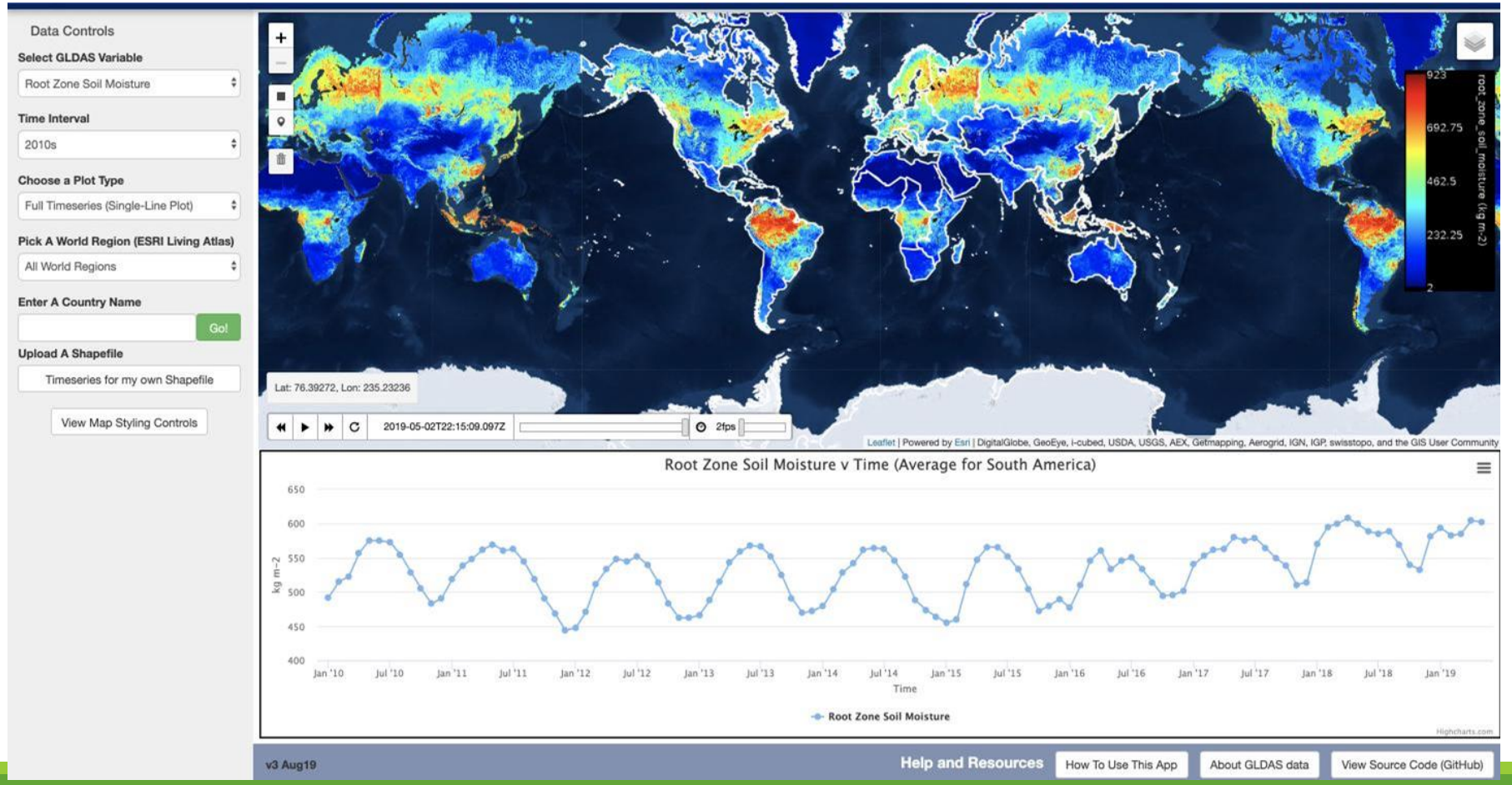
Rotavirus infection probability as a function of deseasonalized anomalies in hydrometeorological variables, pooled across all MAL-ED sites

Colston et al. (2019)

Rotavirus transmission pathways



Tethys App


Data Controls
Select GLDAS Variable
Root Zone Soil Moisture
Time Interval
2010s
Choose a Plot Type
Full Timeseries (Single-Line Plot)
Pick A World Region (ESRI Living Atlas)
All World Regions
Enter A Country Name
Go!
Upload A Shapefile
Timeseries for my own Shapefile
View Map Styling Controls
Lat: 76.39272, Lon: 235.23236
2019-05-02T22:15:09.097Z
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923
692.75
462.5
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2
root_zone_soil_moisture (kg m-2)
Leaflet | Powered by Esri | DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Root Zone Soil Moisture v Time (Average for South America)
650
600
550
500
450
400
kg m-2
Jan '10
Jul '10
Jan '11
Jul '11
Jan '12
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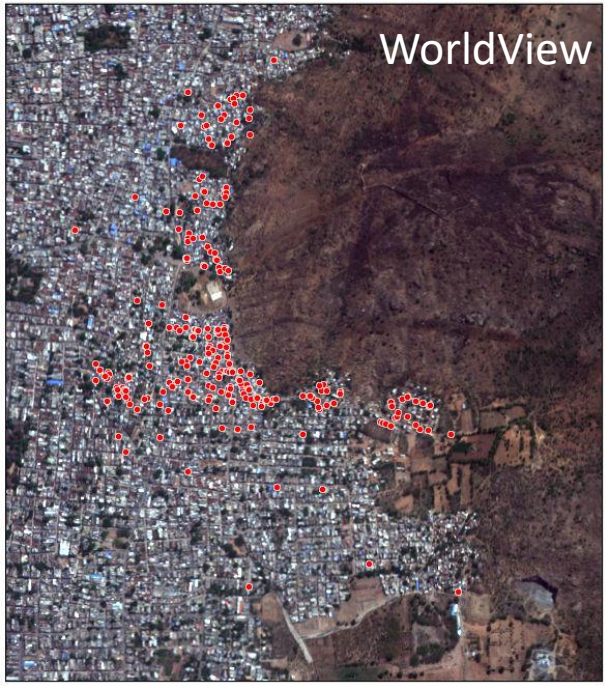
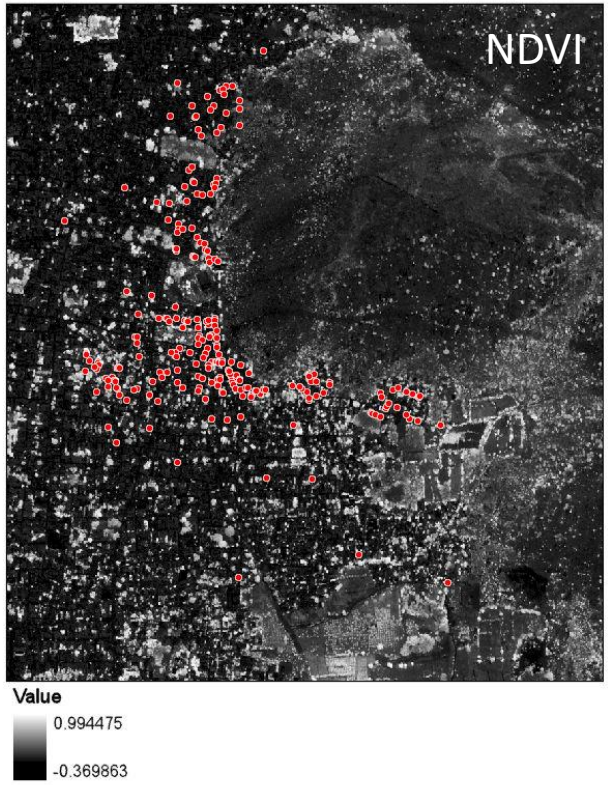
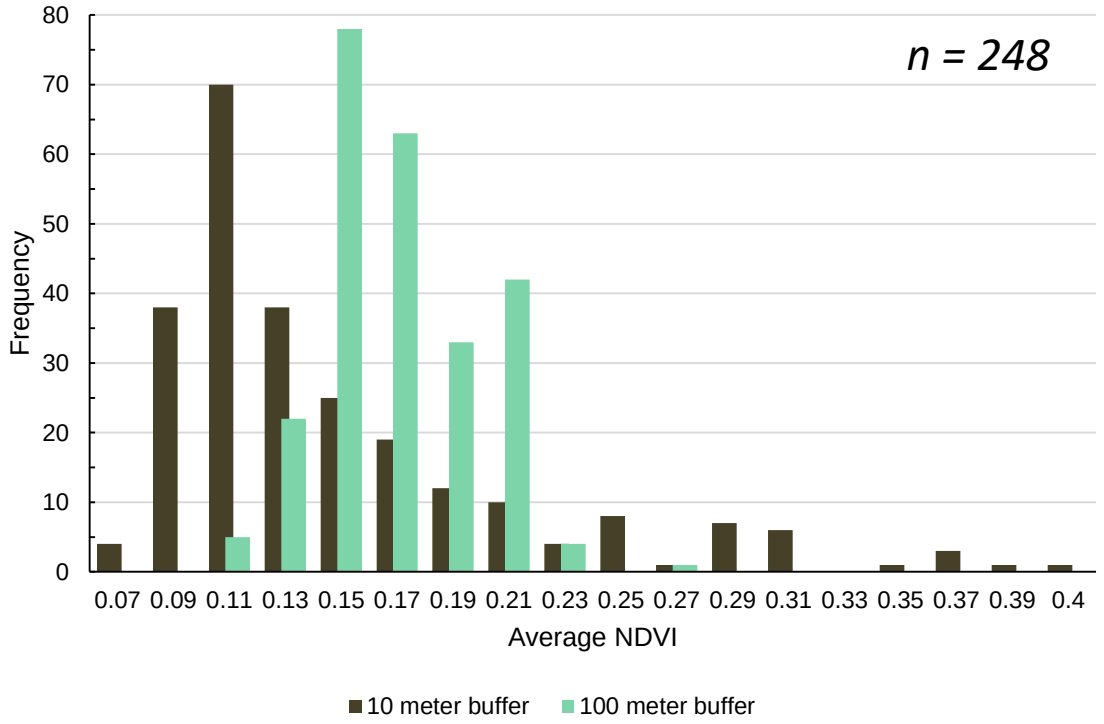
Jan '16
Jul '16
Jan '17
Jul '17
Jan '18
Jul '18
Jan '19
Time
Root Zone Soil Moisture
Highcharts.com
v3 Aug19
Help and Resources
How To Use This App
About GLDAS data
View Source Code (GitHub)

Pilot Commercial Data Buy Program







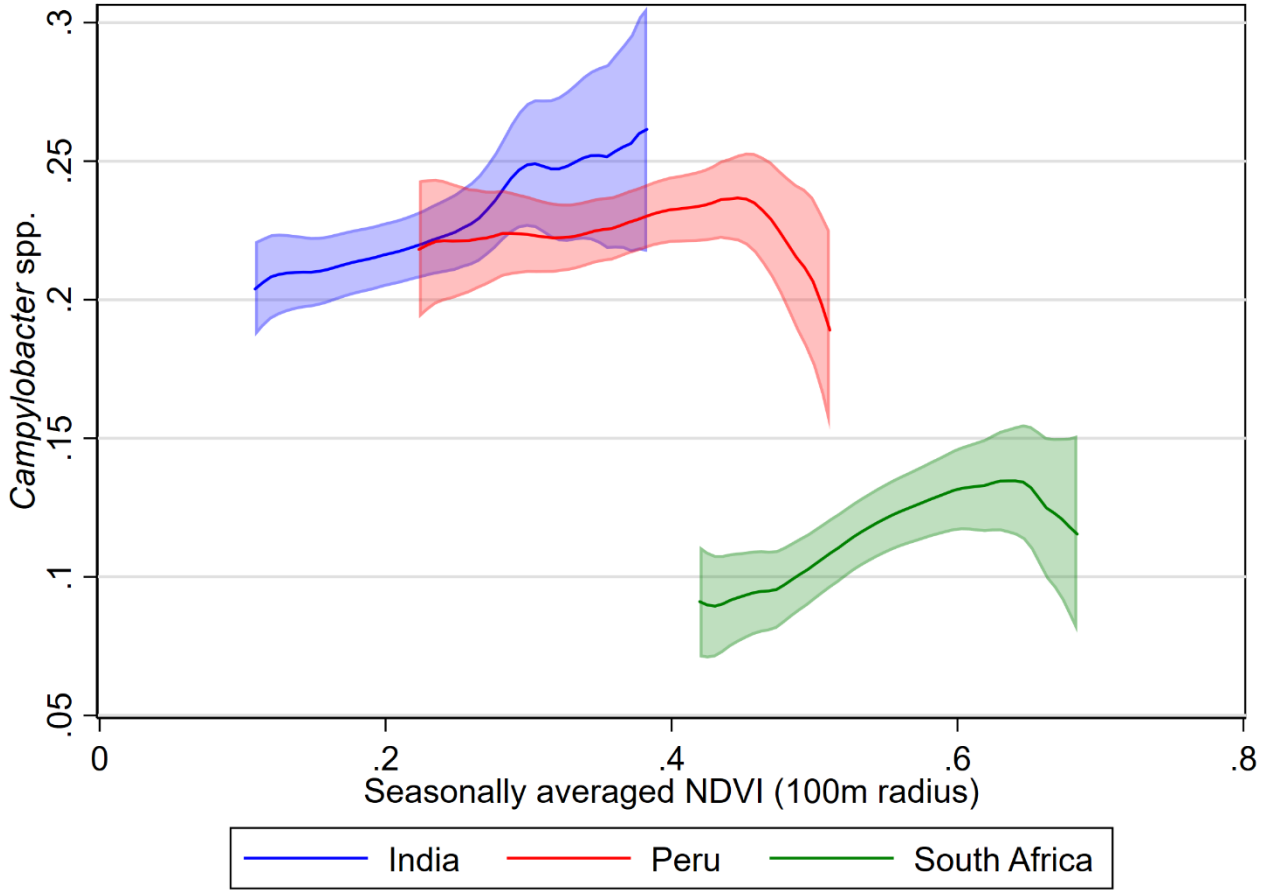
Pilot Commercial Data Buy Program

We do see **household-scale variability** in NDVI, NDWI, and other variables within sites.

We are just beginning to analyze relationships with EID cases.

This has been **harder than anticipated**.

- It is difficult to get geolocated household level data across sites
- It has been difficult to find data buy imagery for our period of analysis



Next steps

Complete regionalization for *rotavirus* and port to the Tethys app, share results with MAL-ED collaborators

Finish the risk models for *Campylobacter* and pathogenic *E. coli*

Perform household scale risk analysis for the commercial data buy program

Challenges:

The household scale analysis might not meet expectations

Communicating uncertainties in the regionalized prediction models

ARL

Current: ARL 4

Expectation: ARL 5 by end of calendar year: delivering results to partners in October

Goal: ARL 7

Thank You