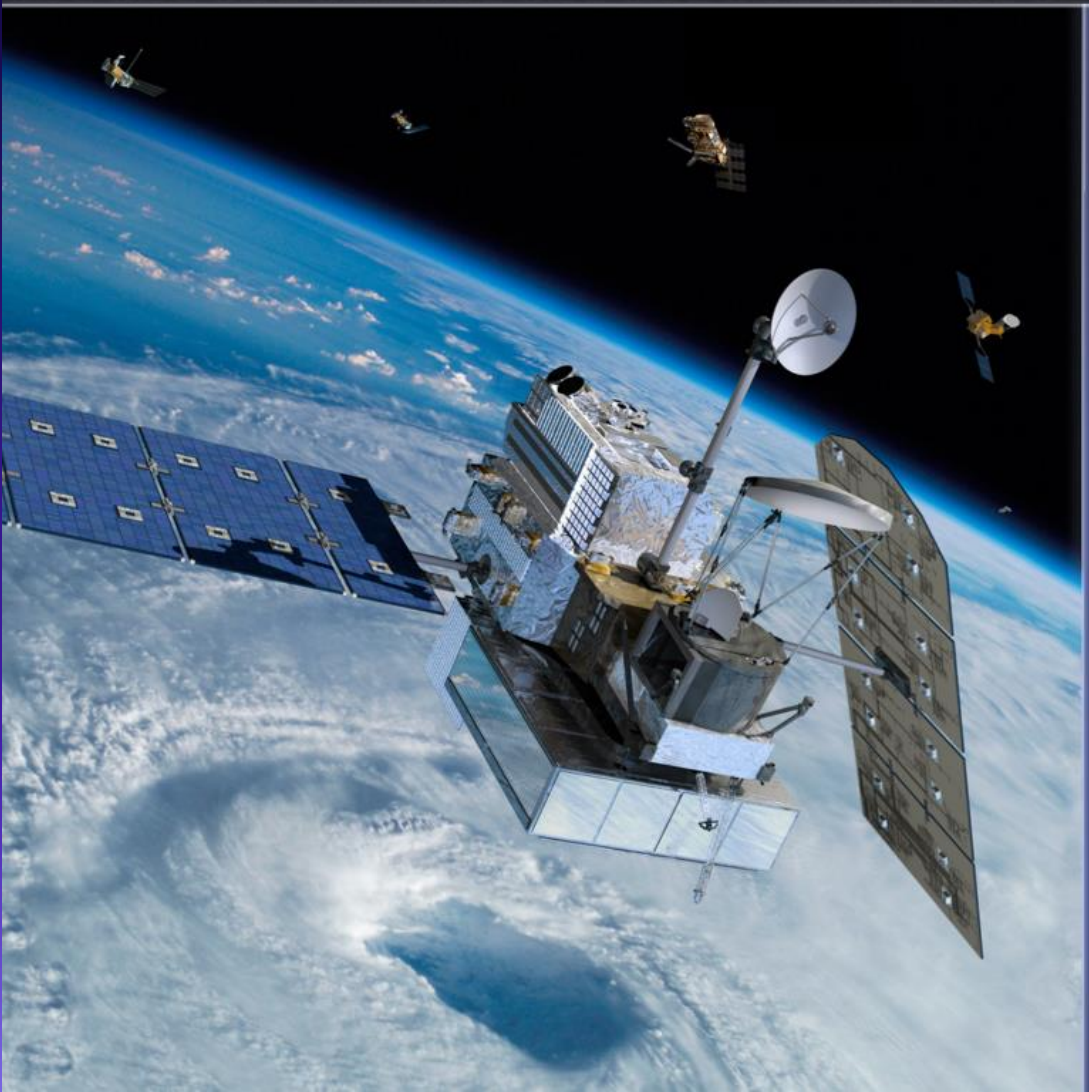
Using EOS data to understand and respond to vector-borne and water-related disease



Dorian Janney

Senior Education and Outreach Specialist

Dorian.w.janney@nasa.gov

NASA /GSFC

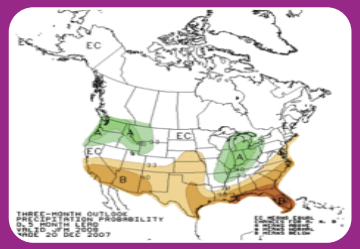
Societal Benefit Areas

Extreme Events and Disasters

- Landslides
- Floods
- Tropical cyclones
- Re-insurance

Water Resources and Agriculture

- Famine Early Warning System
- Drought
- Water Resource management
- Agriculture



Weather, Climate & Land Surface Modeling

- Numerical Weather Prediction
- Land System Modeling
- Global Climate Modeling

Public Health and Ecology

- Disease tracking
- Animal migration
- Food Security

EOS DATA Applications

- Routine observations of precipitation and other Earth Observation measurements are fundamental to help anticipate, predict and observe disease outbreak, disasters, and more
- By combining data from multiple satellites and relating that to what we see from the ground, we can get a much better understanding of how natural hazards are shaping our landscape and affecting us
- Having the vantage point of space is invaluable for observing how are Earth is changing, but observations from the ground are CRITICAL to improving these measurements

Water-related and Vector-borne Disease Initiative

Scope: an effort to explore linkages and research/operational applications of NASA EOS data and water-related and vector-borne disease

End Products:

1. Workshop on May 17th, 2018 in Wash., D.C.
2. End user stories, interviews, case studies
3. New visualizations and NASA stories
4. Activities to engage and inform the general public
5. Online resource page with resources for general public
6. Effort to maintain networking with interested parties
7. Ongoing effort to try to make data accessible

We need help!

- We are looking for:
  - Research case studies
  - Engagement with end user groups
  - New opportunities/ideas for how we can bridge the use of EO for water-related disease applications
  - User stories/case studies for website
  - Needs of end users that may align with what NASA satellite data may provide

- We are planning:
  - Spring 2018 Applications-focused workshop in the DC area

Today's Program

- New video Using NASA Satellite Data to Predict Malaria Outbreaks" (released in September)
- Dr. Ben Zaitchik- Early Warning System for Vector-borne Disease Risk in the Amazon
- Dr. Antar Jutla:
- Gia Mancini, Doug Gardiner, and Luisa Silva: DEVELOP Western Europe Citizen Science Mosquito Project
- Dorian Janney: How to Use the GLOBE Observer Mosquito Habitat Mapper and Using it to Participate in the ASTC "Global Experiment"

"Using NASA Satellite Data to Predict Malaria Outbreaks"

- Full resolution download: https://svs.gsfc.nasa.gov/12603

AN EARLY WARNING SYSTEM FOR VECTOR-BORNE DISEASE RISK IN THE AMAZON

PI: William Pan, Duke University
Co-I: Ben Zaitchik, JHU
Co-I: Beth Feingold, SUNY-Albany
Co-I: Robert Gerbasi, NAMRU-6

GEOGRAPHIC CONTEXT

Dominated by tropical forest

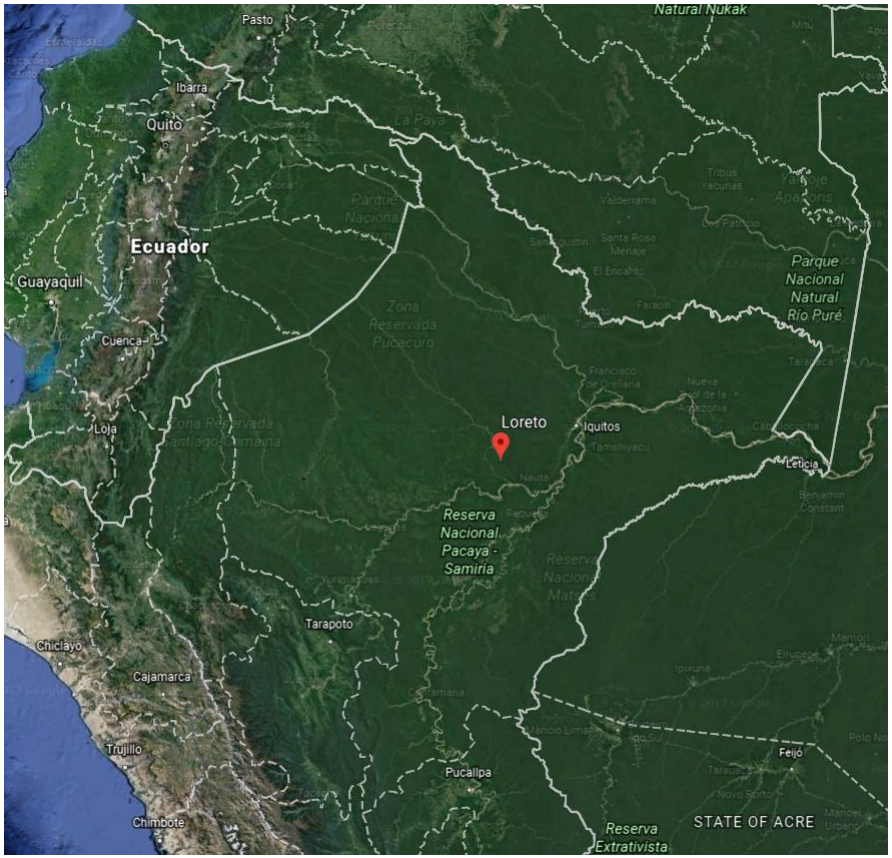
Hot and humid, with seasonal flooding

Rivers are transportation corridors

Active extractive economy

Significant seasonal migration

International borders are porous



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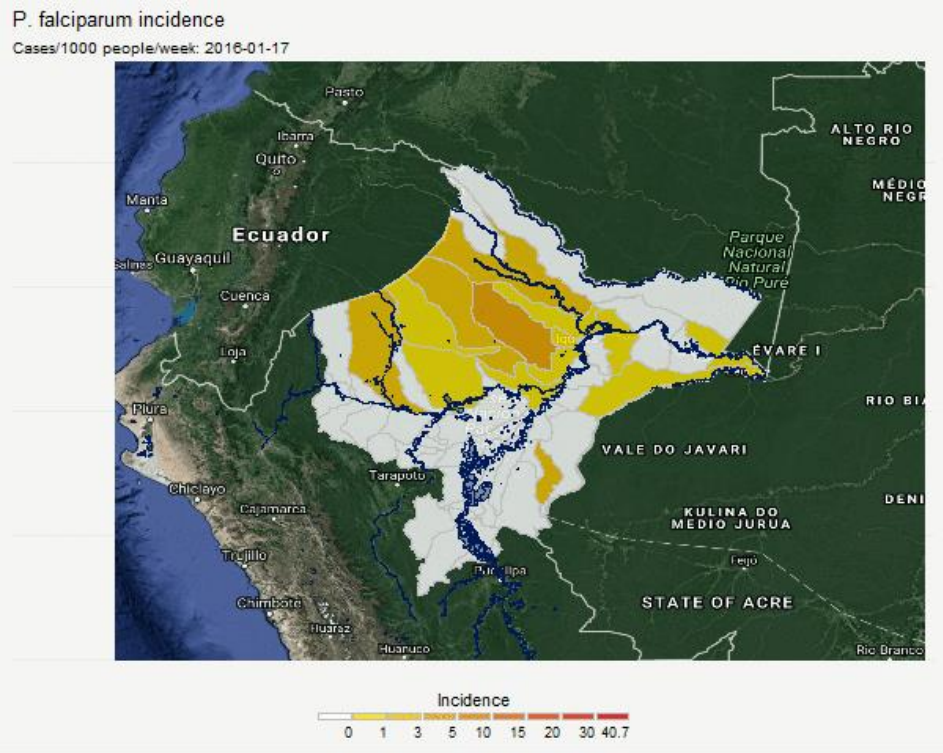
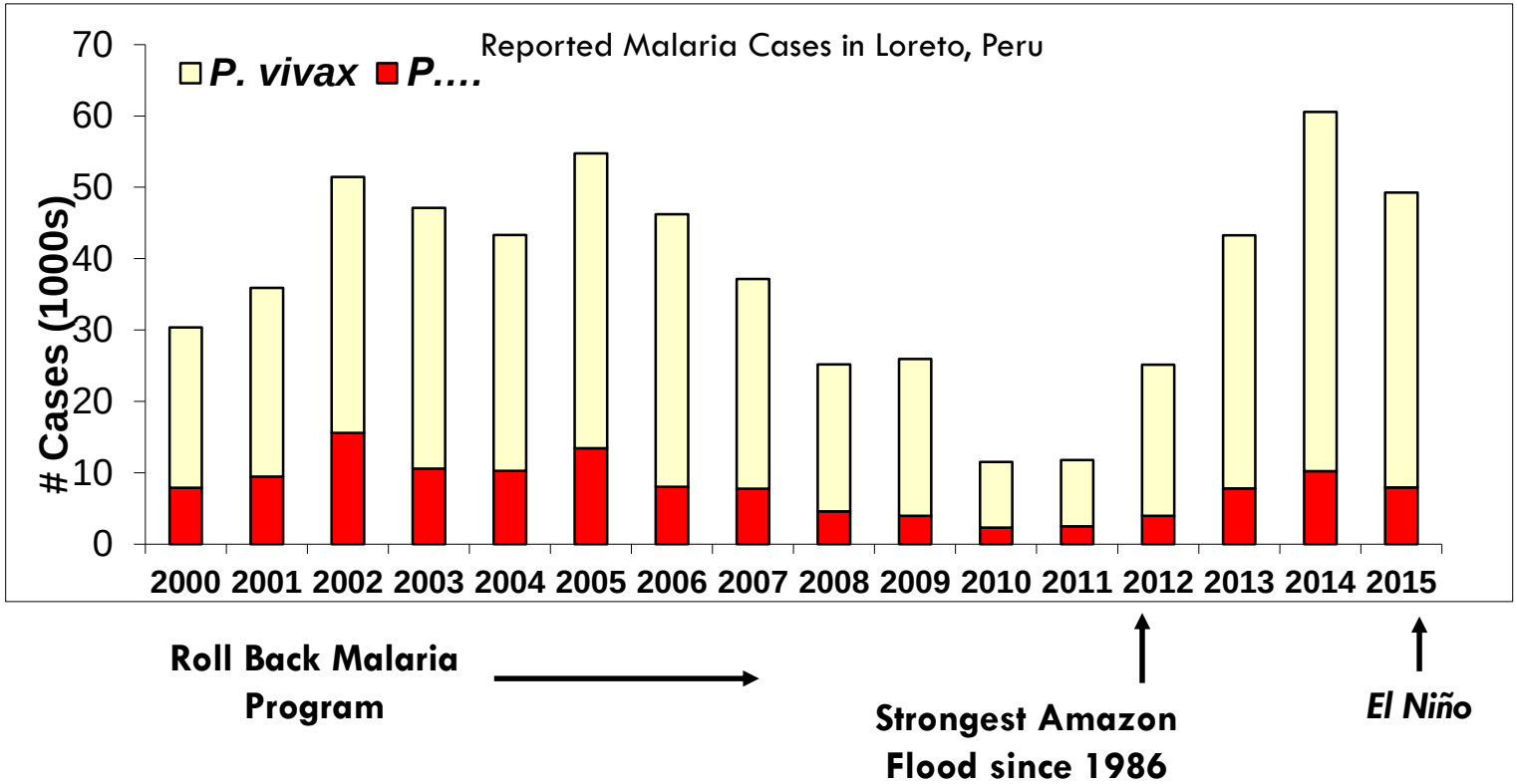


CONTEXT OF RECENT HISTORY



GOAL AND OBJECTIVES

Goal: Improve the efficiency of malaria interventions by providing earlier and more accurate risk warnings relative to current operational systems.

Objectives:

Optimize a hydro-meteorological monitoring and forecast system

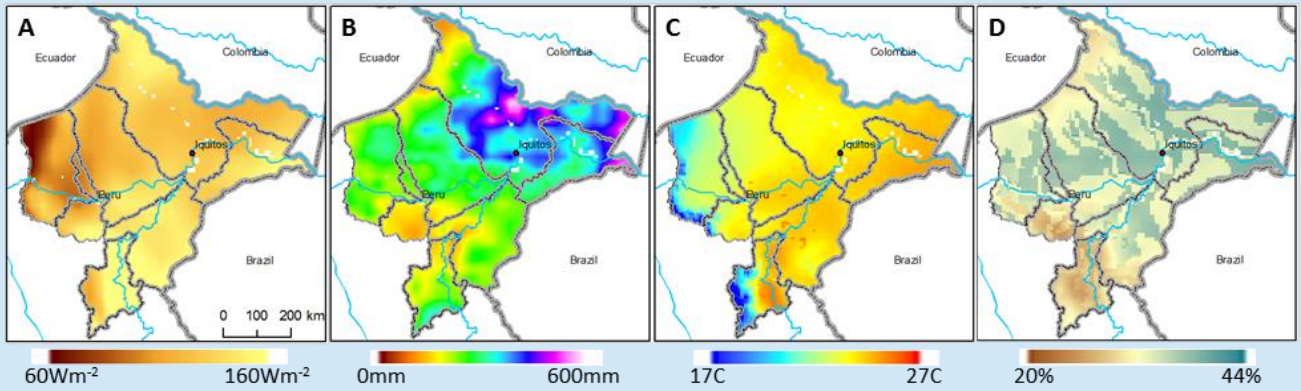
Generate actionable high-resolution malaria risk forecasts on a 1-3 month time horizon

Transfer forecast capabilities to the Peruvian and Ecuadorian Ministries of Health

Collaborate with Ministries to assess intervention options

METHODS

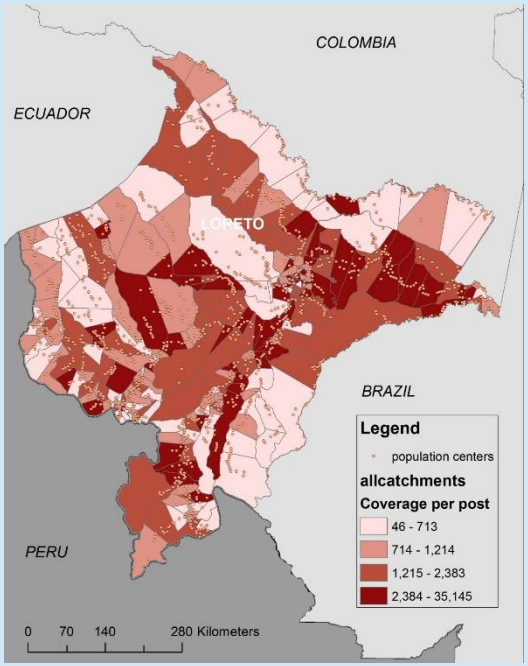
Environmental Data → Land Data Assimilation System (LDAS)



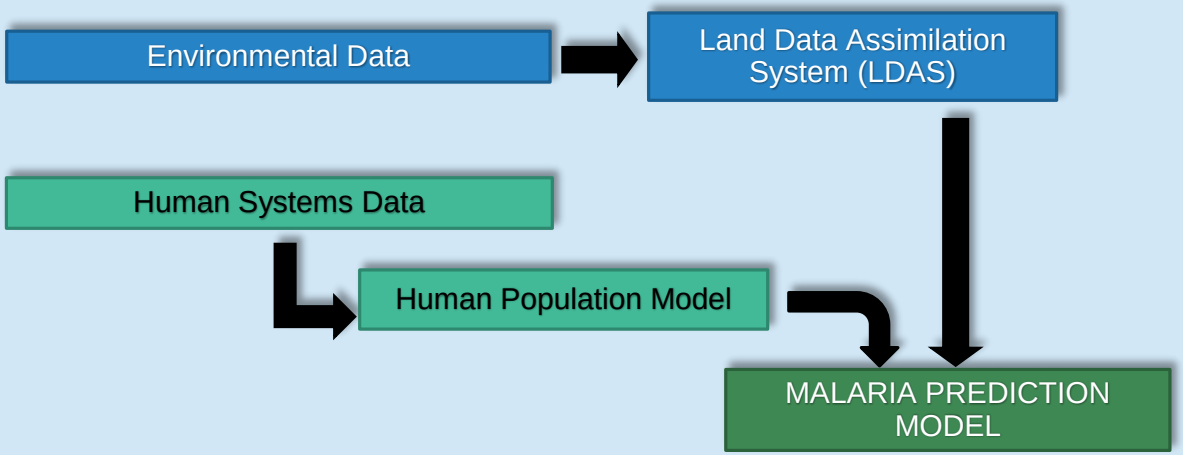
METHODS

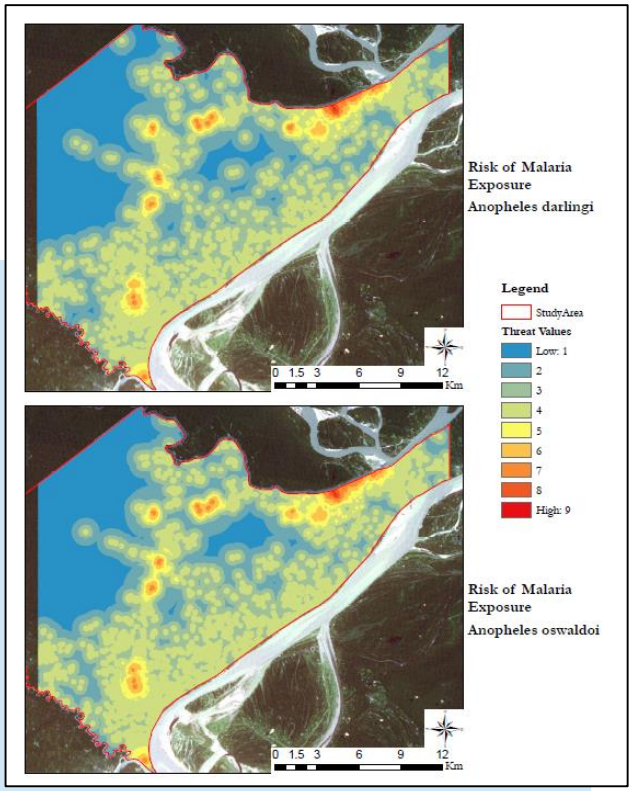
Environmental Data → Land Data Assimilation System (LDAS)

Human Systems Data → Human Population Model

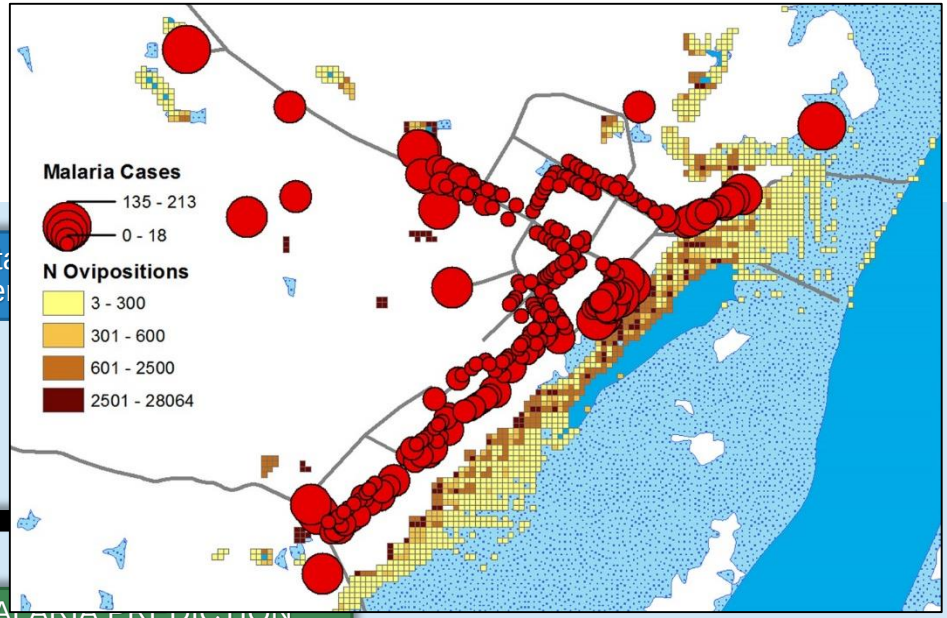


METHODS


Environmental Data
Land Data Assimilation System (LDAS)
Human Systems Data
Human Population Model
MALARIA PREDICTION MODEL


Risk of Malaria Exposure
Anopheles darlingi
Legend
StudyArea
Threat Values
Low: 1
2
3
4
5
6
7
8
High: 9
0 1.5 3 6 9 12
Km
Risk of Malaria Exposure
Anopheles oswaldoi
0 1.5 3 6 9 12
Km

METHODS



Environmental Data

Land Data
Syste

Human Systems Data

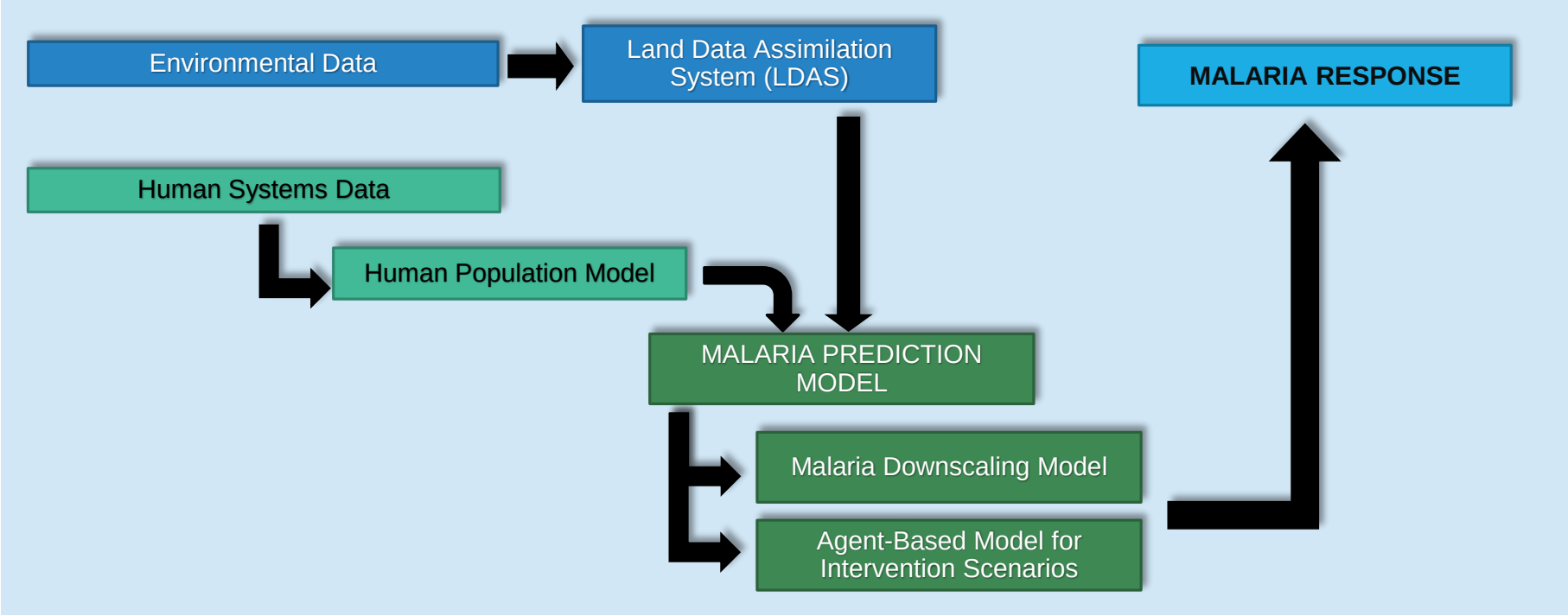
Human Population Model

MODEL

Malaria Downscaling Model

Agent-Based Model for Intervention Scenarios

METHODS


Environmental Data
Land Data Assimilation System (LDAS)
MALARIA RESPONSE
Human Systems Data
Human Population Model
MALARIA PREDICTION MODEL
Malaria Downscaling Model
Agent-Based Model for Intervention Scenarios

WHAT WE'VE LEARNED: THE GOOD

NASA precipitation products perform well in this region!

Our hydrological models capture variability in evapotranspiration and river flow.

Rainfall, temperature and soil moisture predict malaria cases 3-6 weeks in advance.

Partners are engaged, and the partnership is expanding.

WHAT WE'VE LEARNED: THE CHALLENGES

It's hard to know where the people are, and when they're there.

Longer lead times would be valuable

WHAT WE'VE LEARNED: THE CHALLENGES

It's hard to know where the people are, and when they're there.

Longer lead times would be valuable

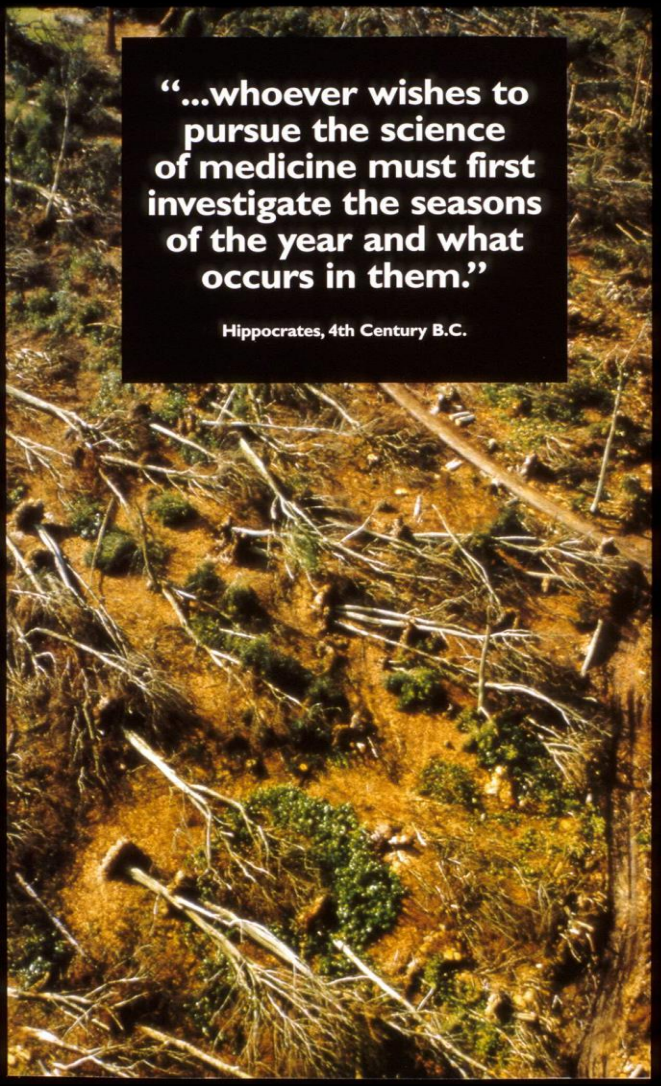
So . . .

MORE NASA TOOLS!

- Integrate Earth Observation to population and mobility models
- Implement subseasonal to seasonal forecast to predict the malaria predictors

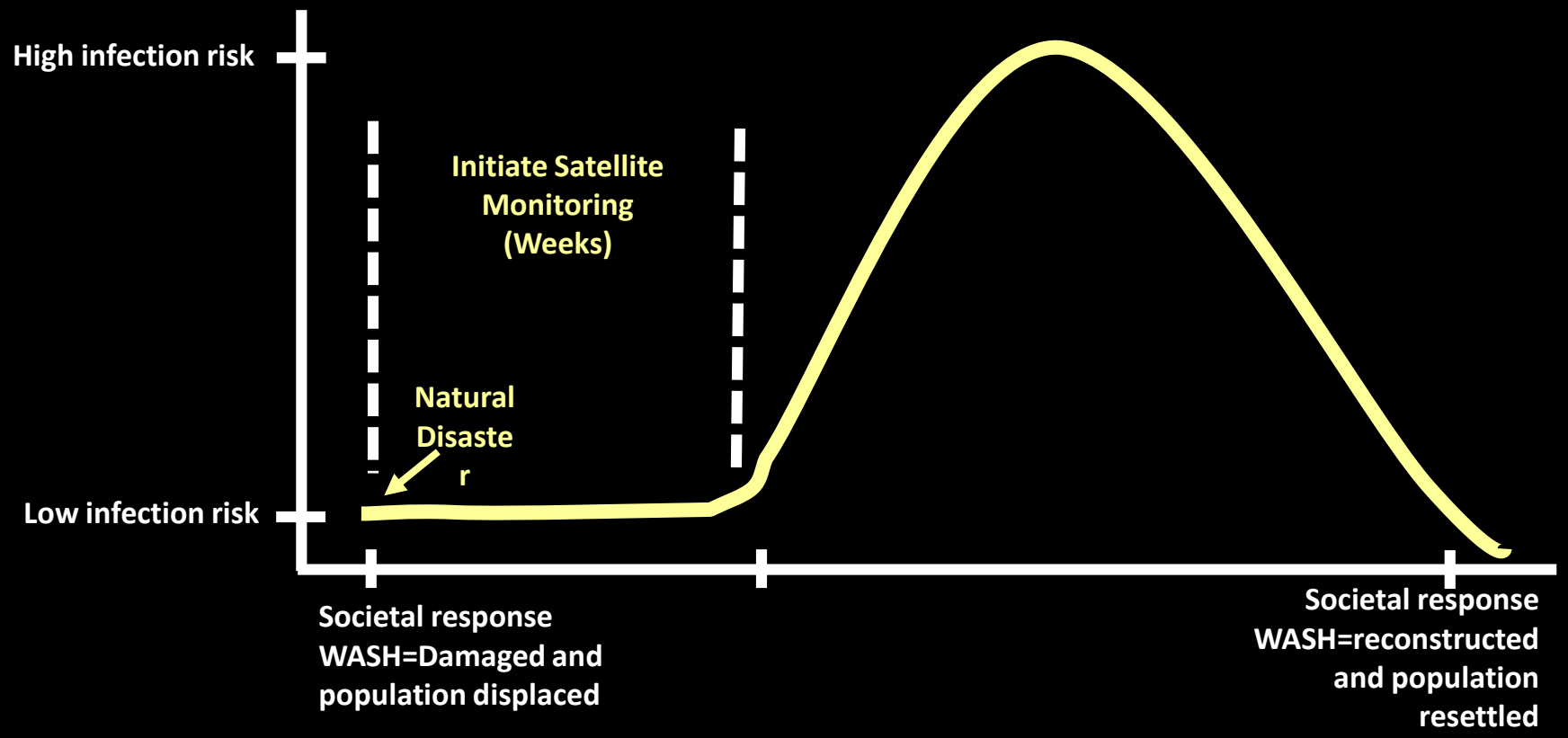
THANK YOU

zaitchik@jhu.edu

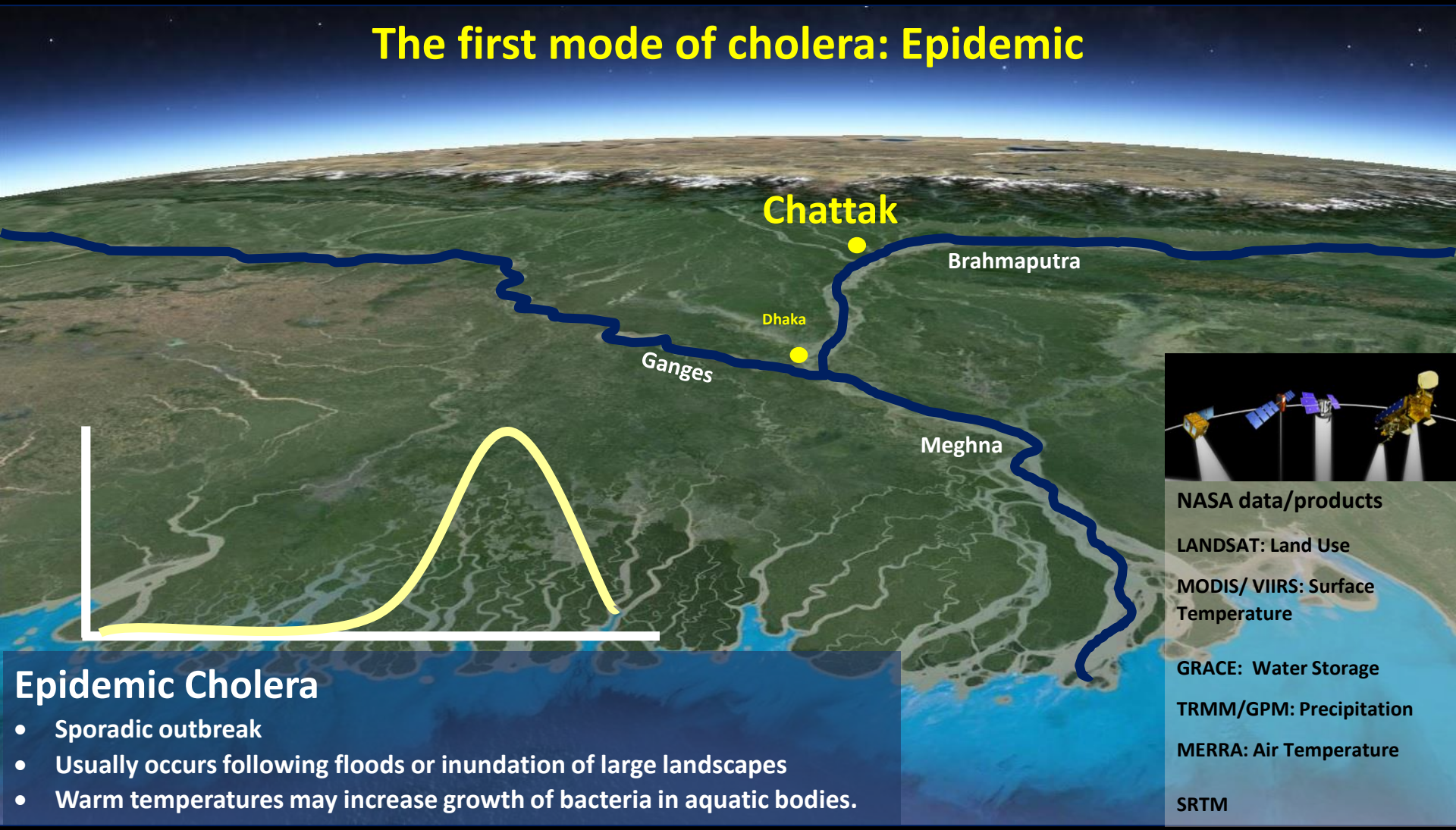


Satellites search for cholera: A modern Cassandra

Time period for opportunity to predict cholera



The first mode of cholera: Epidemic



Epidemic Cholera

- Sporadic outbreak
- Usually occurs following floods or inundation of large landscapes
- Warm temperatures may increase growth of bacteria in aquatic bodies.

NASA data/products

LANDSAT: Land Use

MODIS/ VIIRS: Surface Temperature

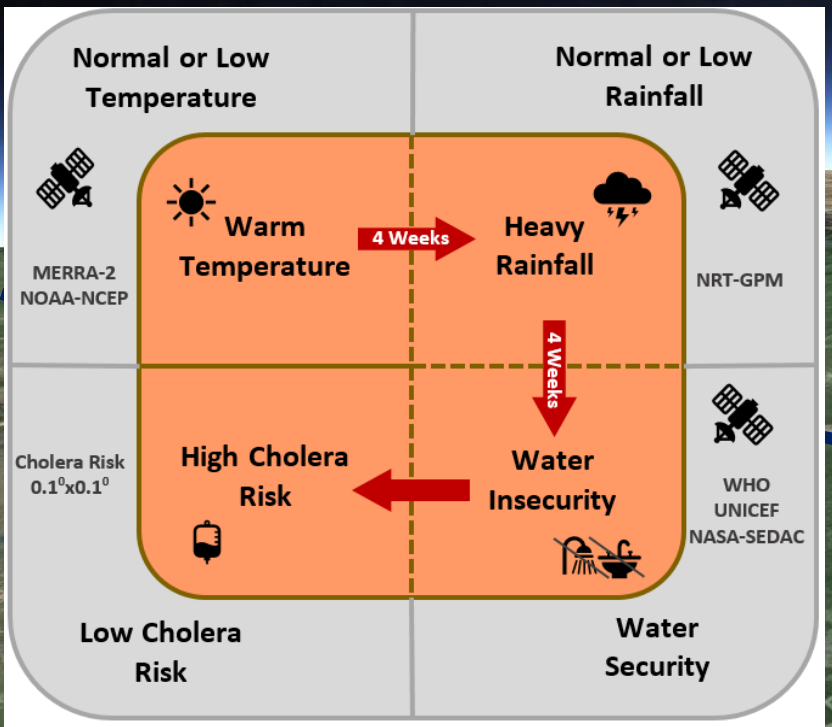
GRACE: Water Storage

TRMM/GPM: Precipitation

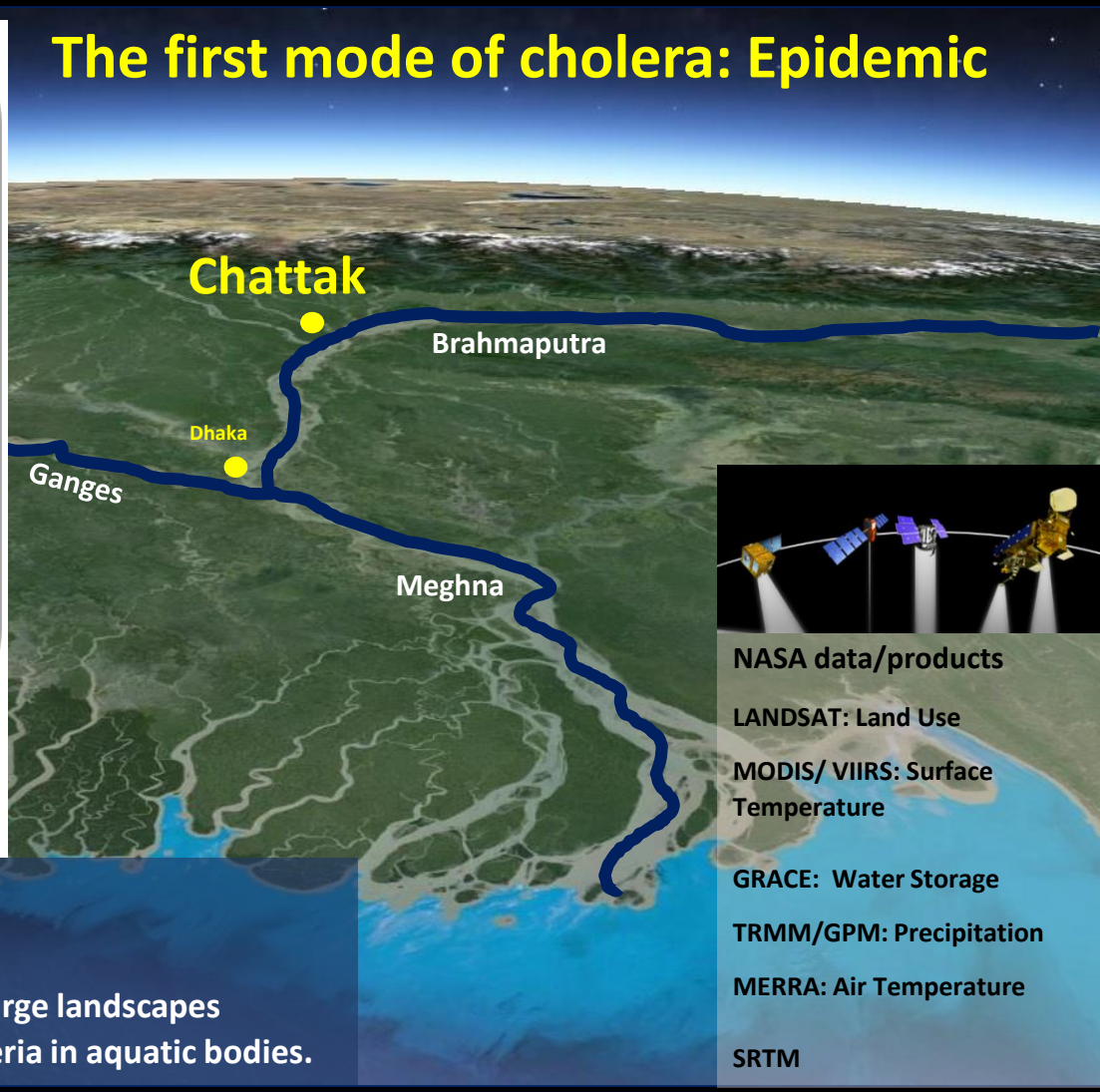
MERRA: Air Temperature

SRTM

The first mode of cholera: Epidemic



Warm temperature= above climatological average temperature
Heavy rainfall= above climatological average precipitation
Water insecurity=lack of access to water and sanitation access
High cholera risk=probability of cholera greater than 50%



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Epidemic Cholera

- Sporadic outbreak
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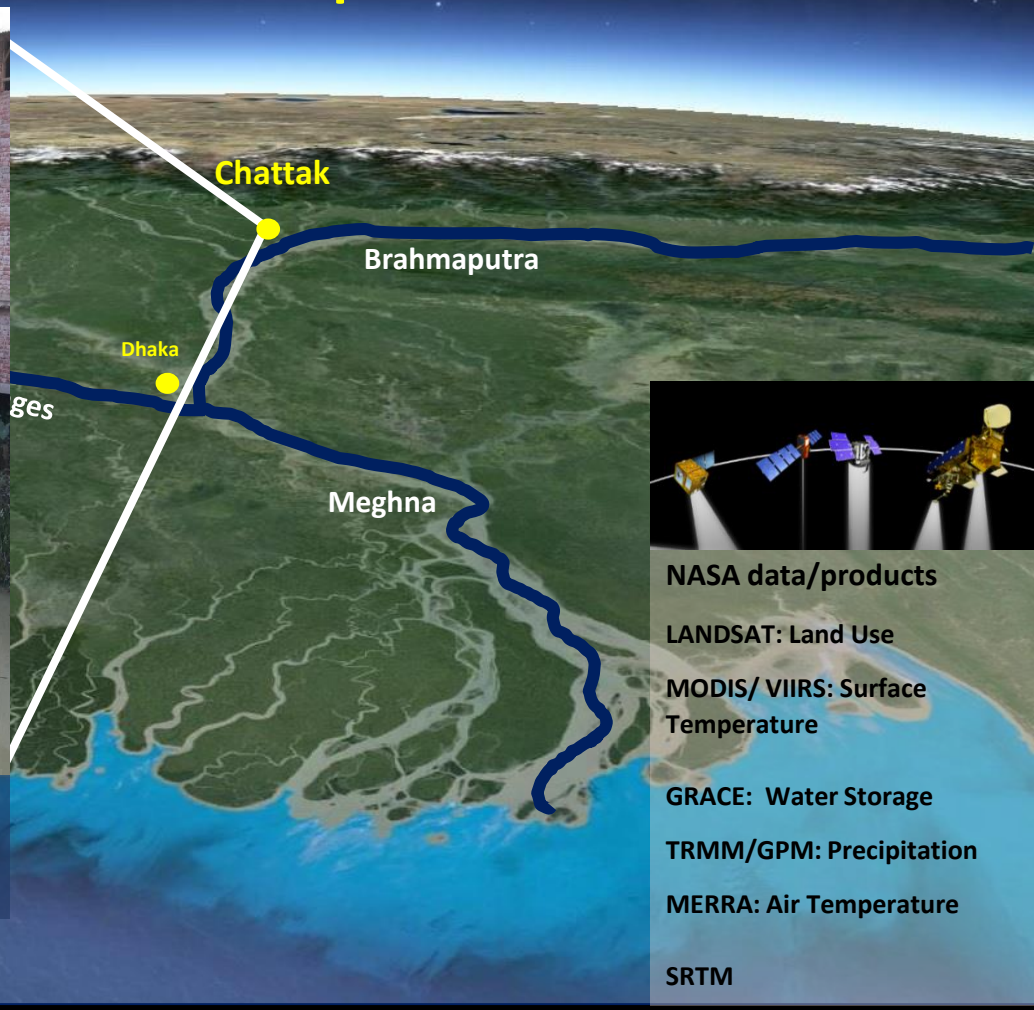
The first mode of cholera: Epidemic

Epidemic cholera following flooding in Chattak



NASA data/products

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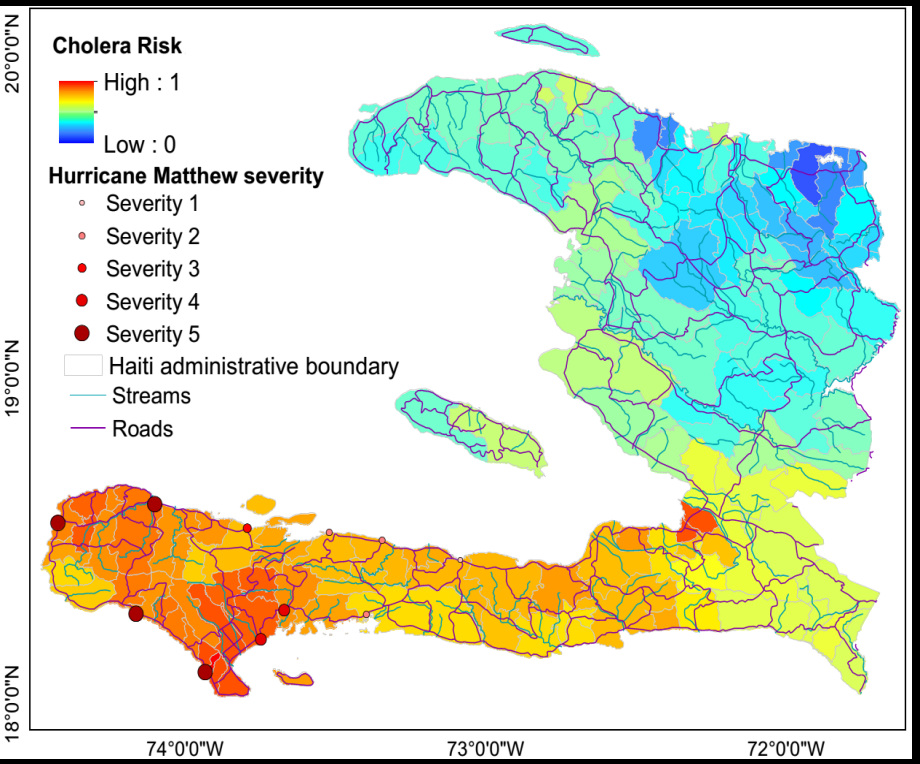
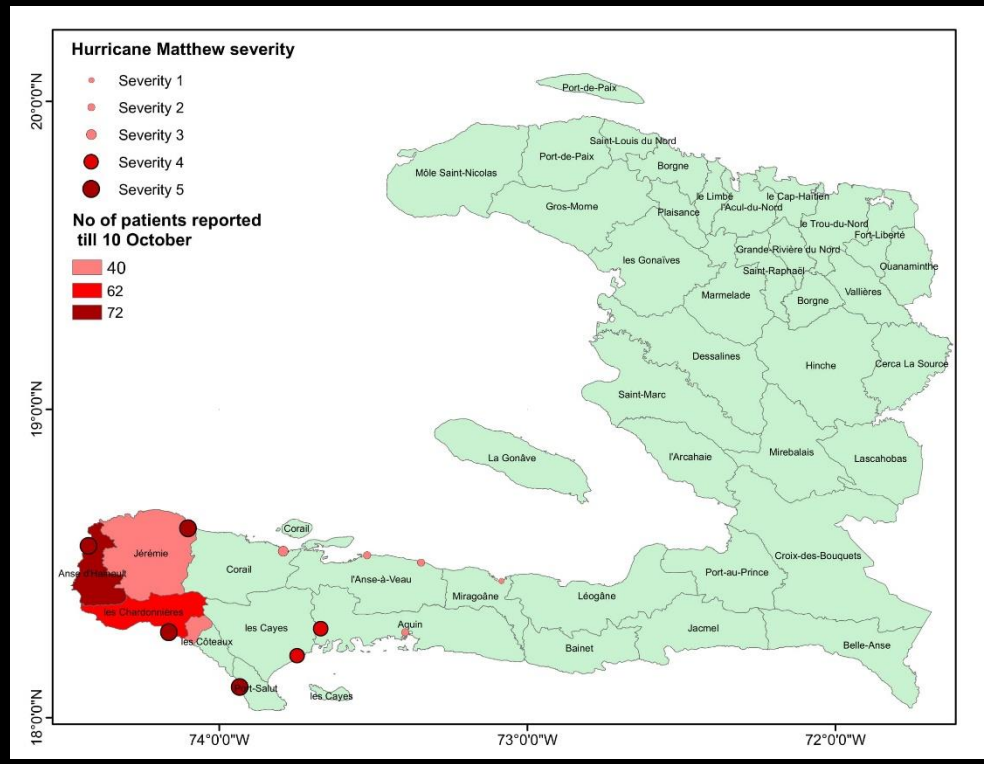
SRTM

Cholera in Haiti

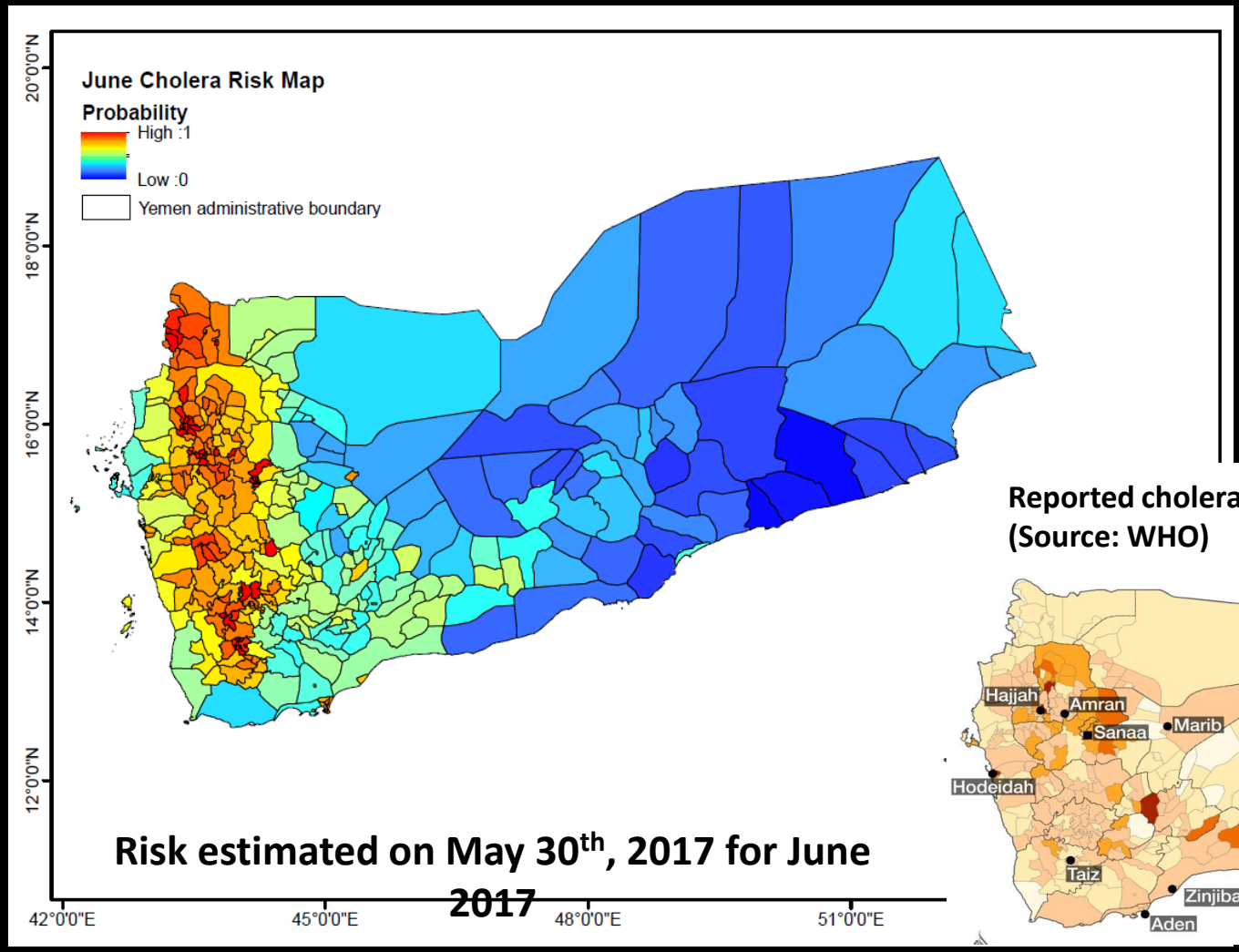


Prediction of October 2015 cholera depending on Hurricane Matthew severity



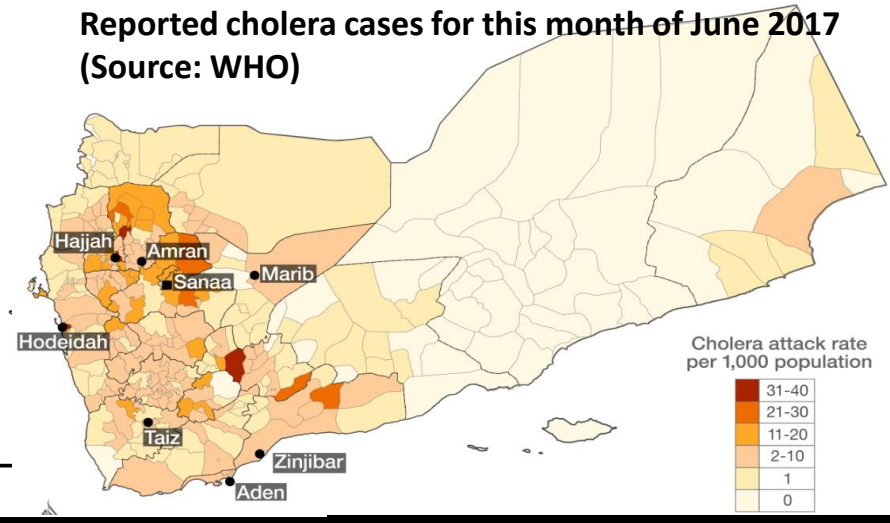
Actual cholera in October 2015 following Hurricane Matthew

Real-time cholera prediction for Yemen

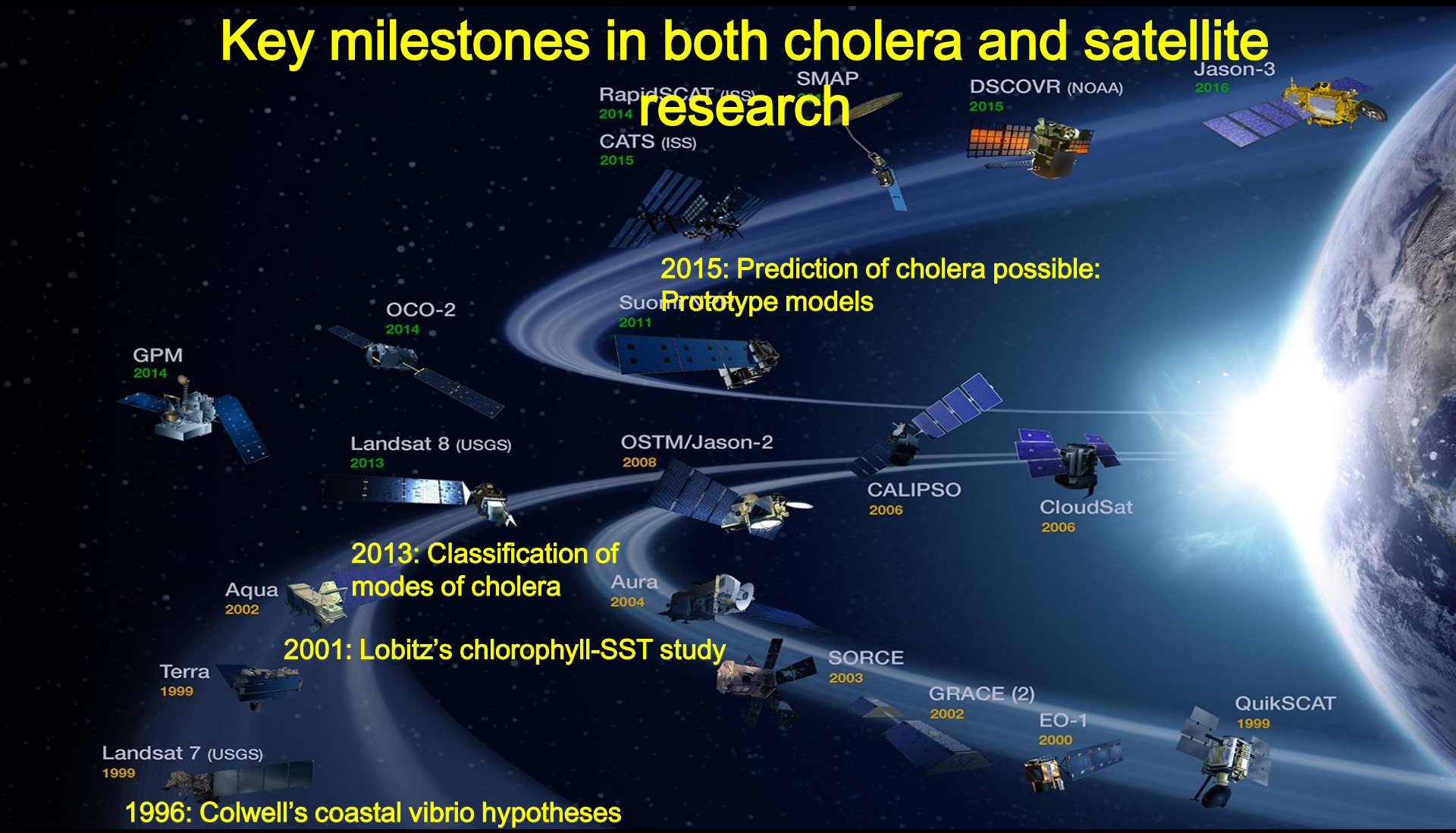


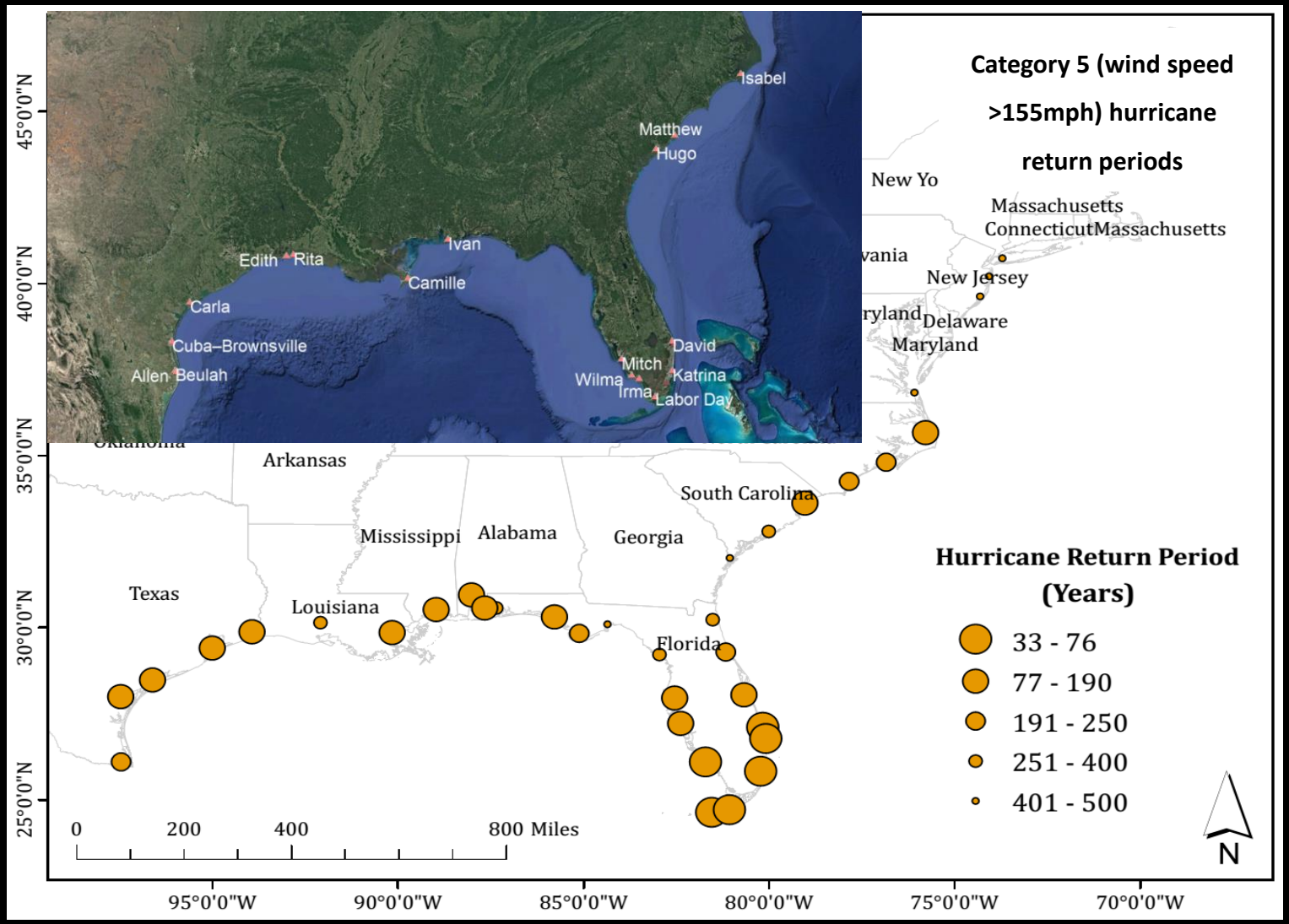
Risk estimated on May 30th, 2017 for June 2017

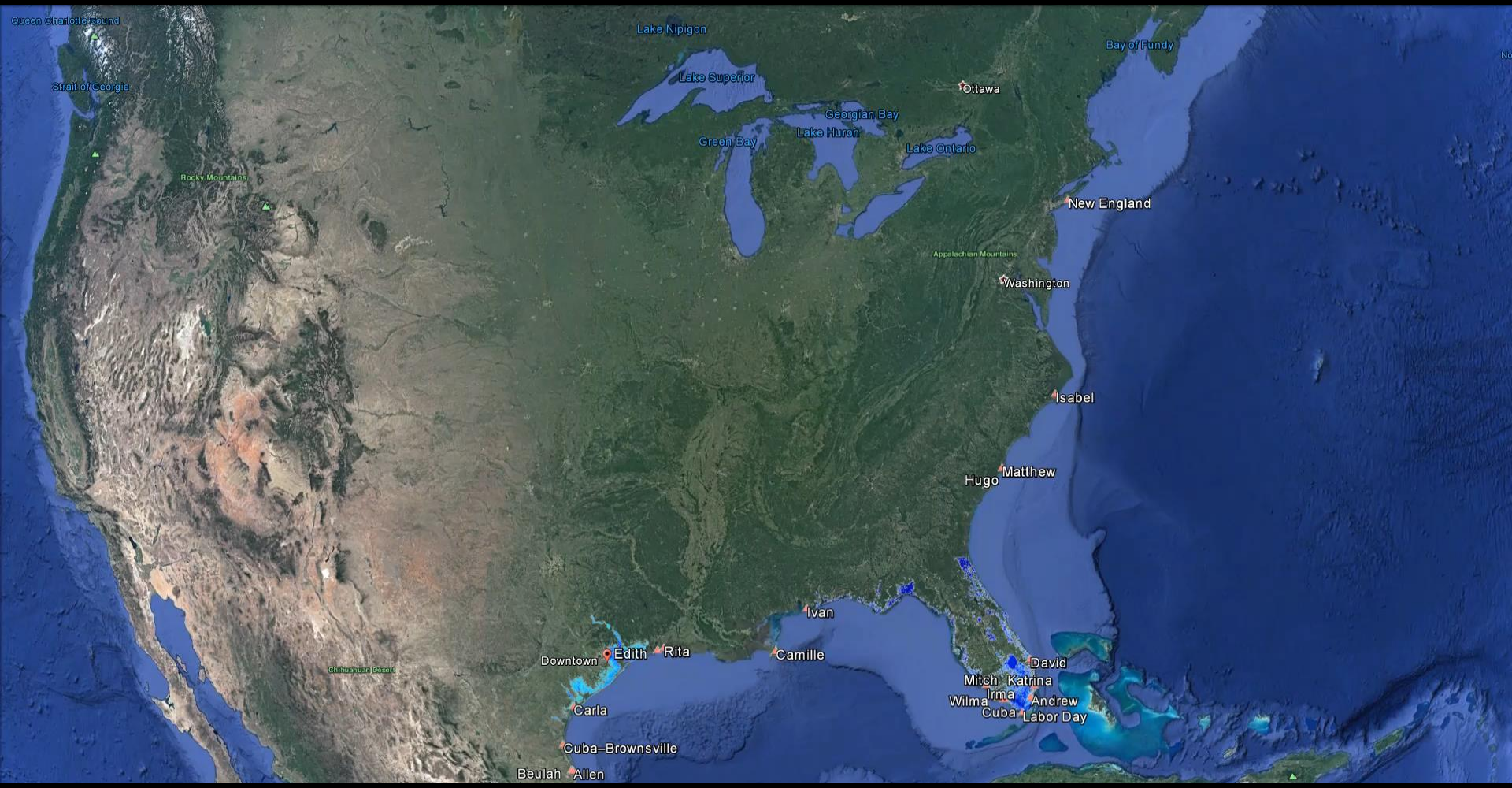
Reported cholera cases for this month of June 2017 (Source: WHO)



Key milestones in both cholera and satellite research




Category 5 (wind speed >155mph) hurricane return periods
Isabel
Matthew
Hugo
Ivan
Edith
Rita
Camille
Carla
Cuba–Brownsville
Allen
Beulah
David
Mitch
Wilma
Katrina
Irma
Labor Day
New Yo
Massachusetts
ConnecticutMassachusetts
New Jersey
Delaware
Maryland
Arkansas
South Carolina
Mississippi
Alabama
Georgia
Texas
Louisiana
Florida
Hurricane Return Period (Years)
33 - 76
77 - 190
191 - 250
251 - 400
401 - 500
0
200
400
800 Miles
N
45°0'0"N
40°0'0"N
35°0'0"N
30°0'0"N
25°0'0"N
95°0'0"W
90°0'0"W
85°0'0"W
80°0'0"W
75°0'0"W
70°0'0"W



Transfer of flood prediction from Bangladesh to USA: Hurricane Harvey

Understanding links between climate/weather systems and human health

Mechanisms to predict disease outbreaks based on access to safe water and provision of community hygiene (WASH)

Cholera Team

- Dr. Rita Colwell, University of Maryland, College Park, MD
- Dr. Antar Jutla, West Virginia University, Morgantown, WV
- Dr. Anwar Huq, University of Maryland, College Park, MD
- Dr. Ali Akanda, University of Rhode Island, Kingston, RI
- Dr. Sonia Aziz, Moravian College, PA
- Dr. Munir Alam, International Center for Diarrheal Research, Bangladesh

Supported by a research grant from
Health and Air Quality Program

National Aeronautics and
Space Administration

WESTERN EUROPE HEALTH & AIR QUALITY

Monitoring Mosquito Abundance and Distribution to Assist Vector-Borne Disease Management in Western Europe

Gia Mancini
Douglas Gardiner
Victor Lenske
Sara Lubkin, PhD
Helen Plattner
Luisa Silva
Alison Thieme
Aaron Warga

Maryland - Goddard

Fall 2017

Vector-borne Illness

- 17% of infectious diseases
- 1 million deaths per year
- Common vectors:
  - Mosquitoes
  - Ticks
  - Blackflies

Image Credit: Pixabay

Mosquito-borne Disease


Image Credit: Free Stock Photos

Common Diseases:

- Zika
- West Nile Virus
- Chikungunya
- Malaria
- Dengue
- Yellow fever

Project Partners

- Global Mosquito Alert Consortium
  - The Woodrow Wilson International Center for Scholars
  - Citizen Science Association
  - European Citizen Science Association
  - Muggenradar: Laboratory of Entomology & Environmental Systems Analysis Department at Wageningen University
  - ZanzaMapp: Sapienza Università Di Roma
- Institute for Global Environmental Strategies

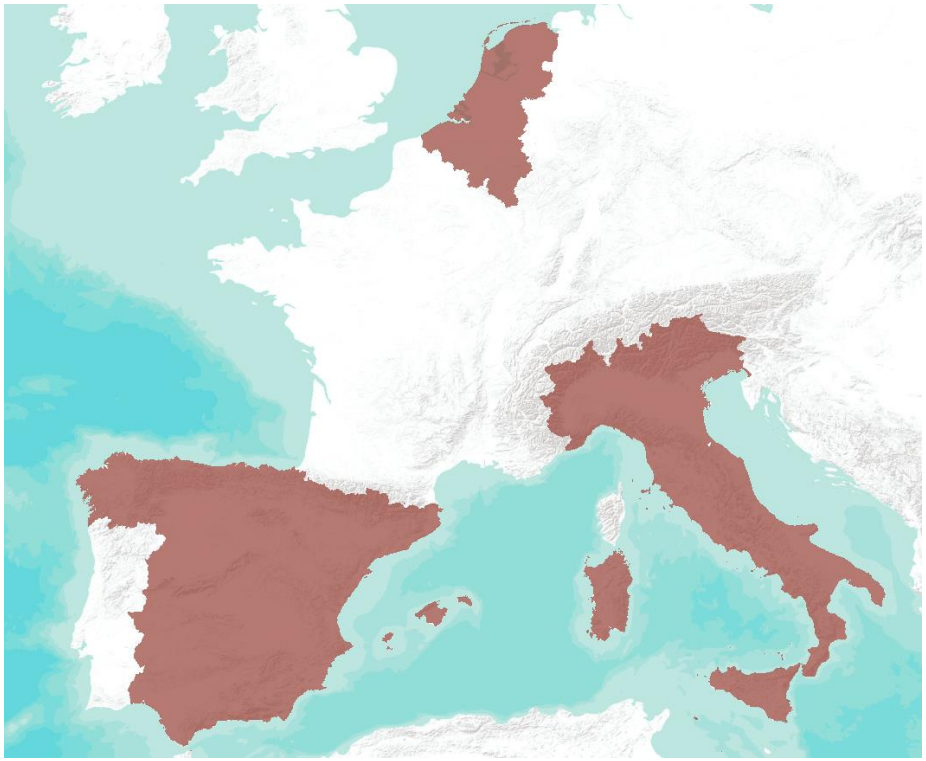
Partner Concerns

- Rising temperatures **expand** mosquito population range
- **Spread** of vector-borne diseases
- Integrating citizen science data from **multiple countries**

Study Area: Western Europe

Study Period:

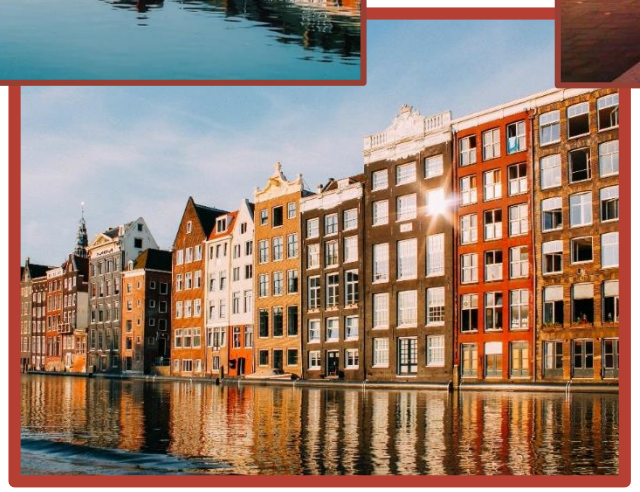
June 2016 – September 2017



Study Area: Western Europe

Belgium

Italy



The Netherlands

Spain

Image Credits: Max Pixel; PEXELS; Pixabay; Unsplash


Image Credit: Pexels

Citizen Science in Europe

- Research collected by citizens
- Geo-capable mobile apps
- Questionnaires when exposed to mosquitoes

Pros:

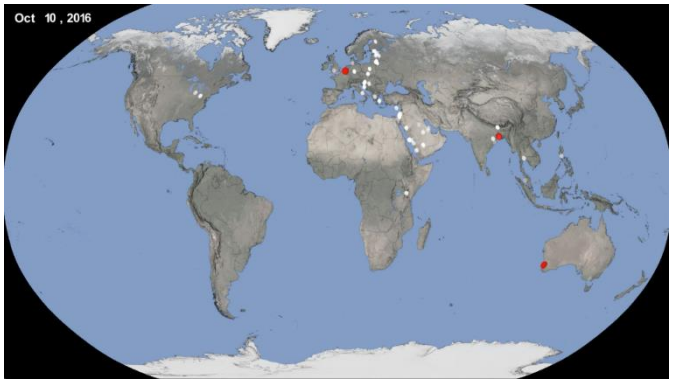
- Community involvement
- Convenience

Cons:

- Unreliable
- Awareness

Objectives

- Combine citizen science data with **NASA's remote sensing** capabilities
- Create a methodology to **incorporate additional countries** in the Global Mosquito Alert Consortium
- Identify key **environmental factors** that signal prime conditions for mosquitoes



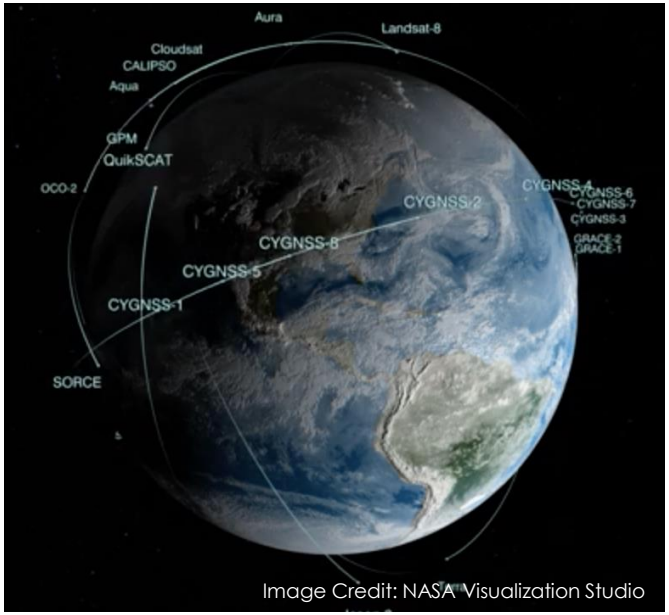
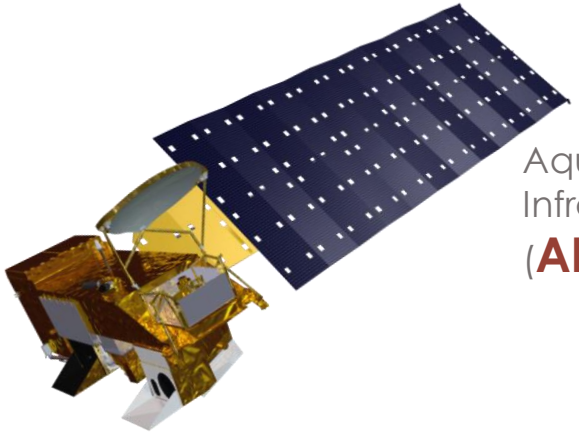
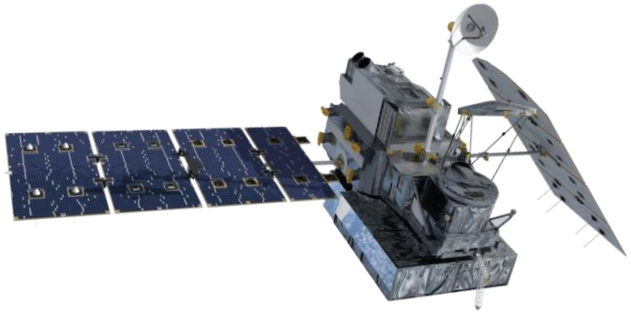


Image Credit: NASA Visualization Studio

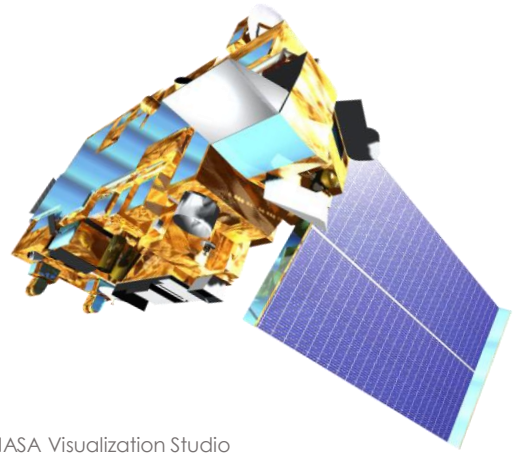
NASA Earth Observations



Aqua Atmospheric Infrared Sounder (**AIRS**)



Global Precipitation Measurement (**GPM**)



Terra Moderate Resolution Imaging Spectroradiometer (**MODIS**)

Shuttle Radar Topography Mission (**SRTM**)

Image Credit: NASA Visualization Studio

Environmental Factors

- Elevation
- Land Surface Temperature
- Precipitation
- NDVI
- Soil Moisture
- Humidity

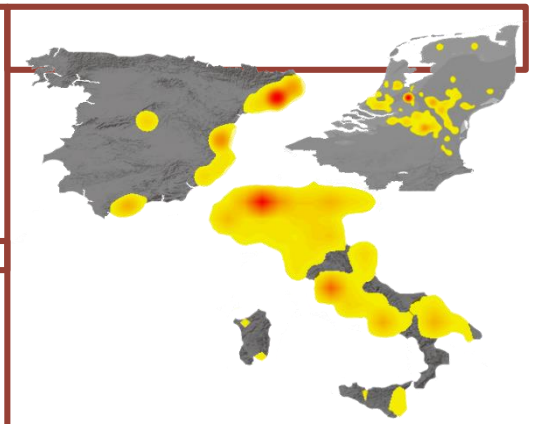
Methodology

Citizen Science Data

Hotspot Map

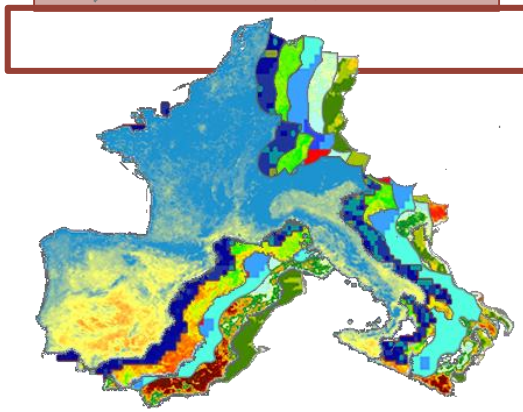
Belgium
Italy
The Netherlands
Spain

Mosquito
Activity
Density
Hotspot



Environmental Factors

NASA Earth Observations

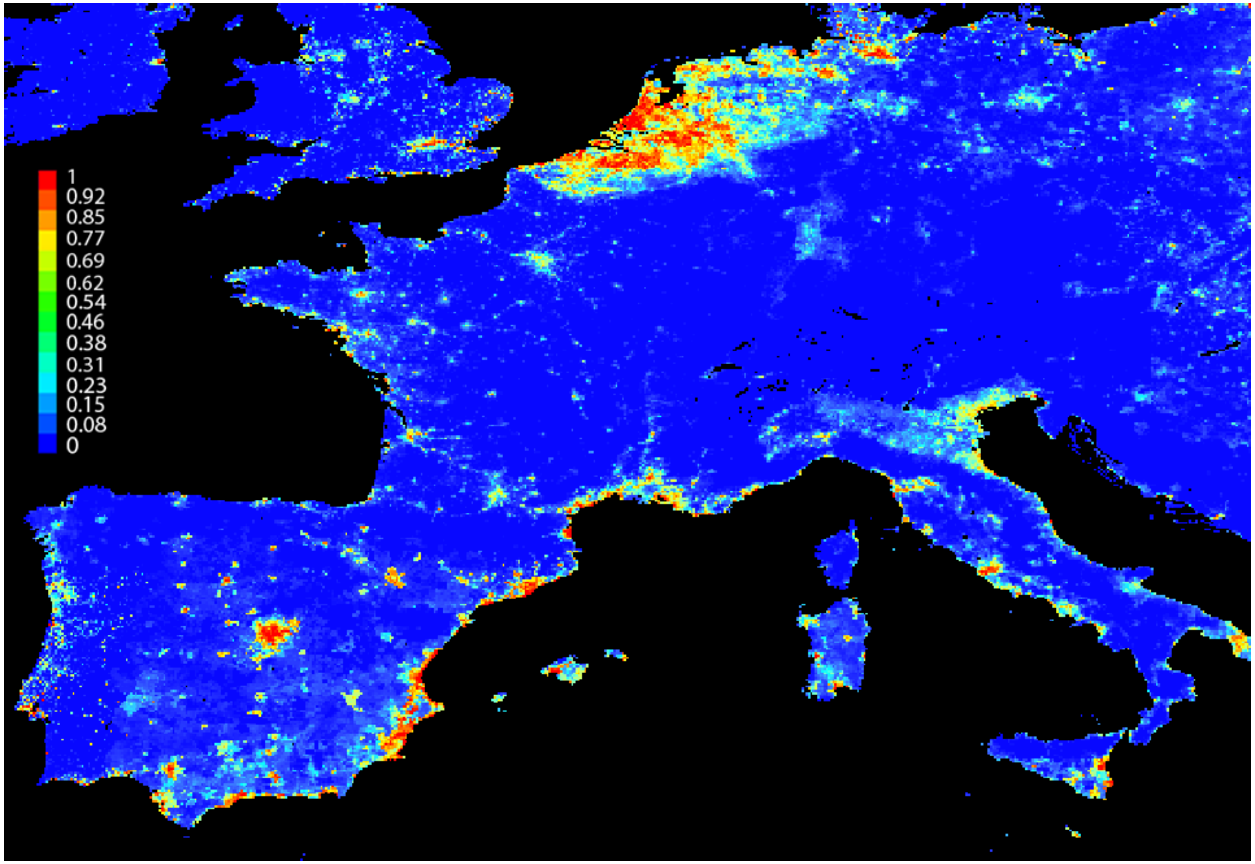


Land Surface Temperature
Soil Moisture
NDVI
Humidity
Elevation
Precipitation

TERRA
AQUA
GPM
SRTM

MaxEnt Habitat Suitability

Results: Habitat Suitability Map



Conclusions

- Mosquito activity occurrence is correlated with areas of **high population density and low elevation**.
- Mosquito activity increases and is **more widespread** during the summer months.
- The Global Mosquito Alert Consortium and participating organizations would benefit from **standardizing** citizen science data collection questionnaires in order to readily **compare datasets** across time and space.

Future Work

- This project will continue on for a second term
- Products will be implemented as an interactive map
- Open-source platform
  - Google Earth Engine

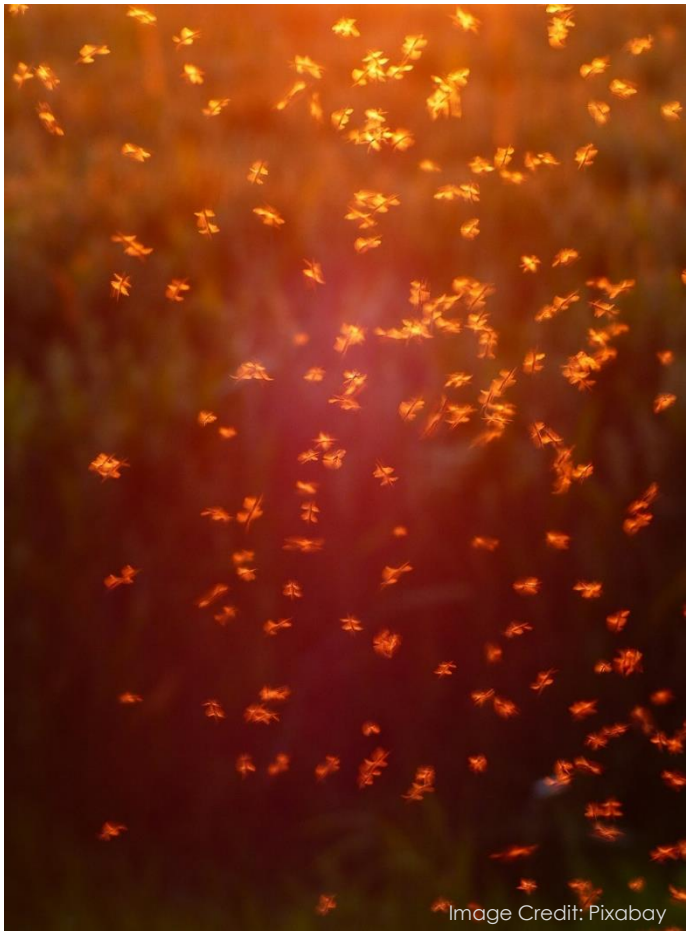


Image Credit: Pixabay

Acknowledgements

Assaf Anyamba, PhD, Universities Space Research Association

John Bolten, PhD, NASA Goddard Space Flight Center

John Palmer, PhD, Global Mosquito Alert Consortium

Anne Bowser, PhD, Woodrow Wilson International Center for Scholars

Greg Newman, PhD, Citizen Science Association

Martin Brocklehurst, European Citizen Science Association

Russanne Low, PhD, Institute for Global Environmental Strategies

Arnold van Vliet, PhD, and Sander Koenraadt, PhD, Wageningen University

Beniamino Caputo, PhD, and Alessandra Dellatorre, PhD, Sapienza Università Di Roma

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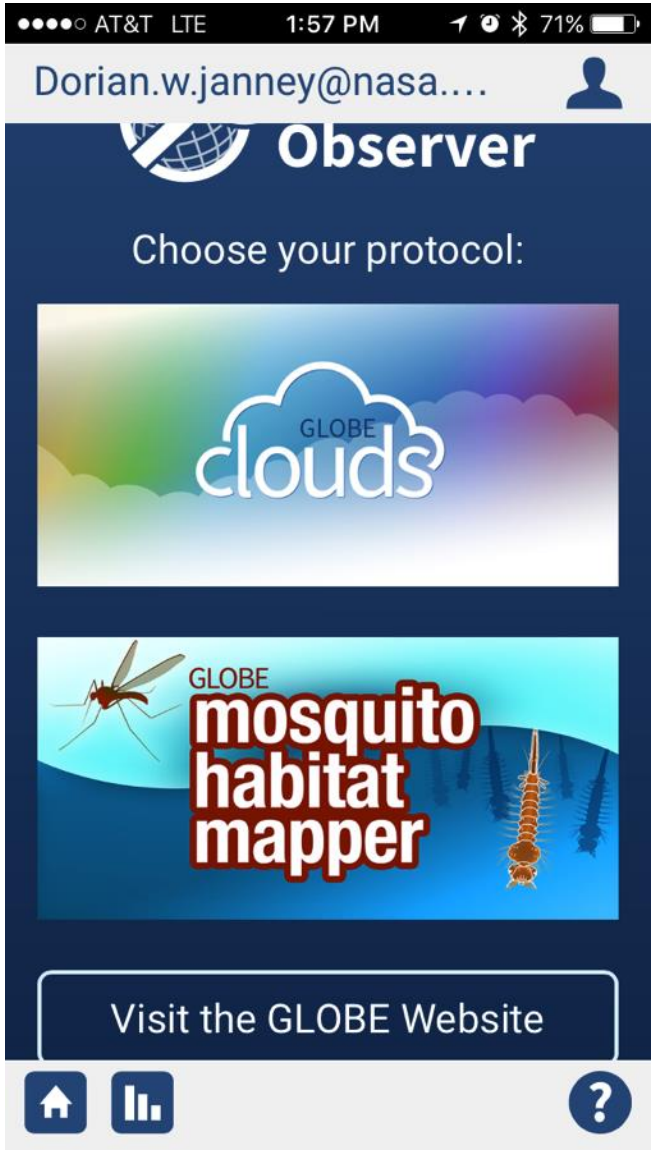
The GLOBE Observer "*Mosquito Habitat Mapper*" App

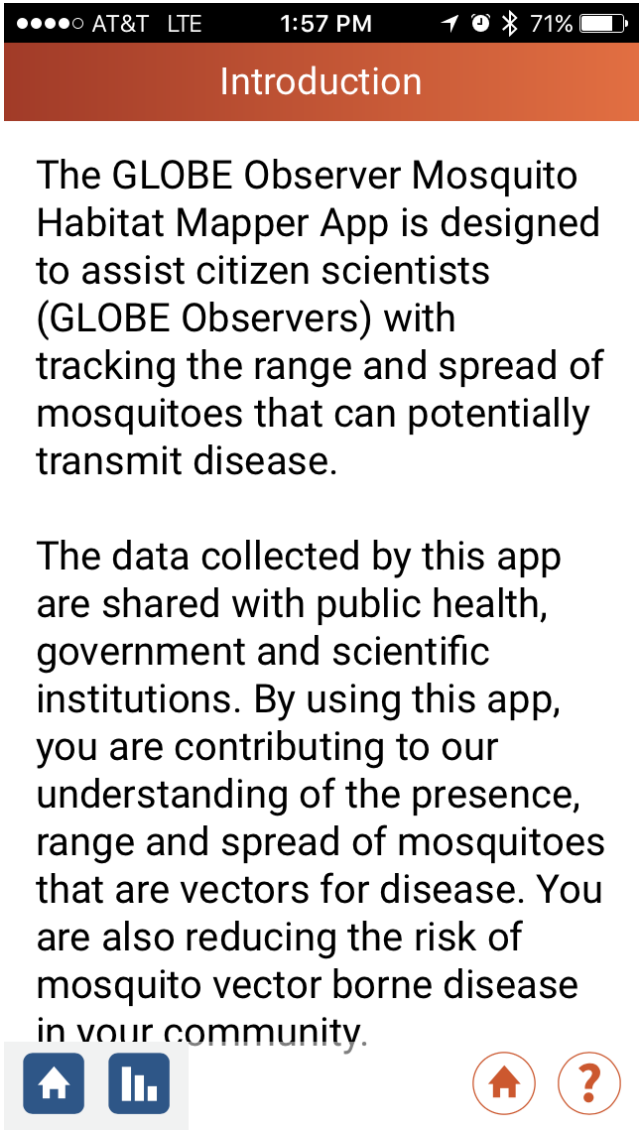
Dorian Janney
NASA/GSFC/ADNET
SSA/MA telecom
Nov. 7th, 2017

***Vision**: A worldwide community of students, teachers, scientists, and citizens working together to better understand, sustain, and improve Earth's environment at local, regional, and global scales.*

Mosquito Habitat Mapper

- Smart phone/tablet
- App store: “Globe Observer”
- One time password to start using it- email
- Internet not required for data collection

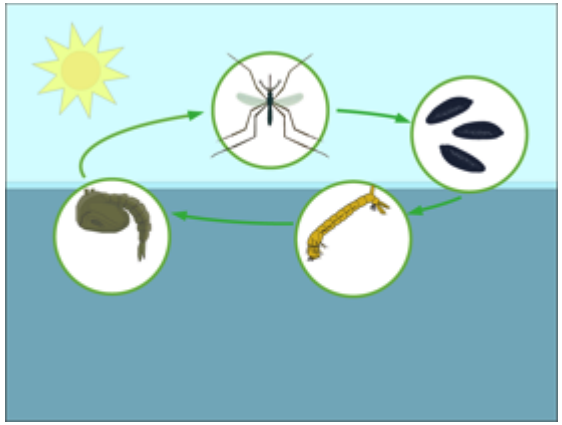




The GLOBE Observer Mosquito Habitat Mapper App is designed to assist citizen scientists (GLOBE Observers) with tracking the range and spread of mosquitoes that can potentially transmit disease.

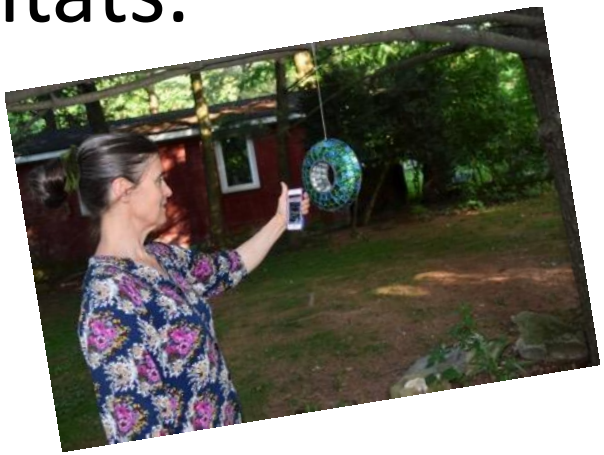
The data collected by this app are shared with public health, government and scientific institutions. By using this app, you are contributing to our understanding of the presence, range and spread of mosquitoes that are vectors for disease. You are also reducing the risk of mosquito vector borne disease in your community.

- Identify potential breeding sites
- Sample and Count larvae
  (these cannot hurt you nor transmit disease!)
- Identify larvae
- Eliminate breeding sites

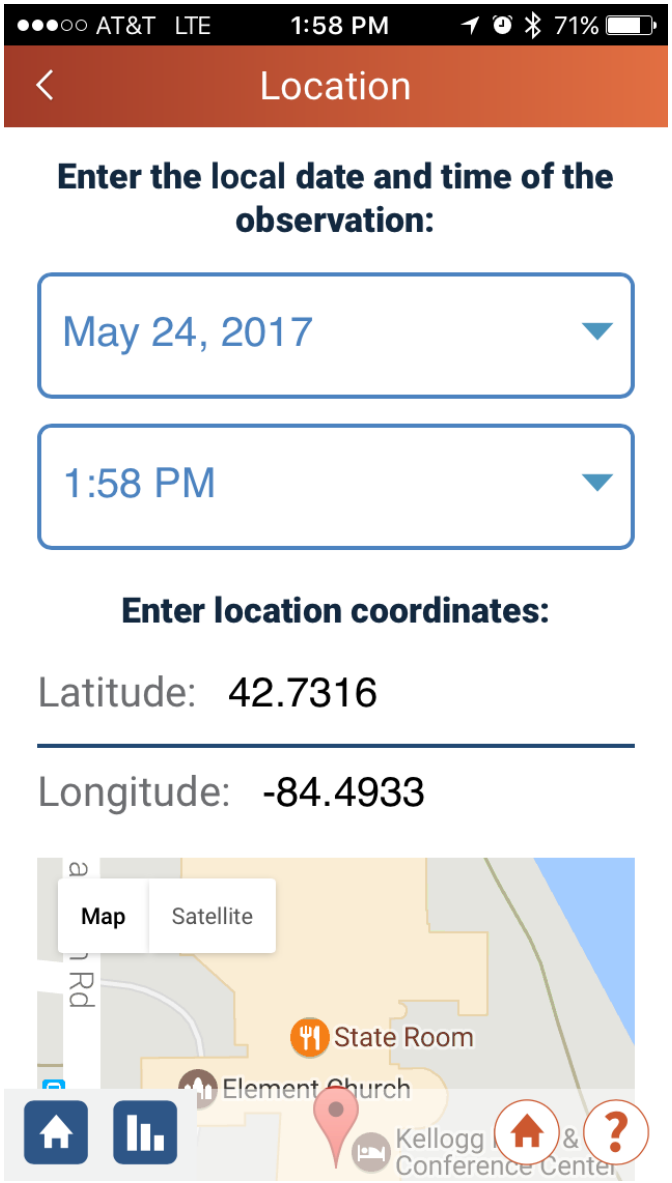


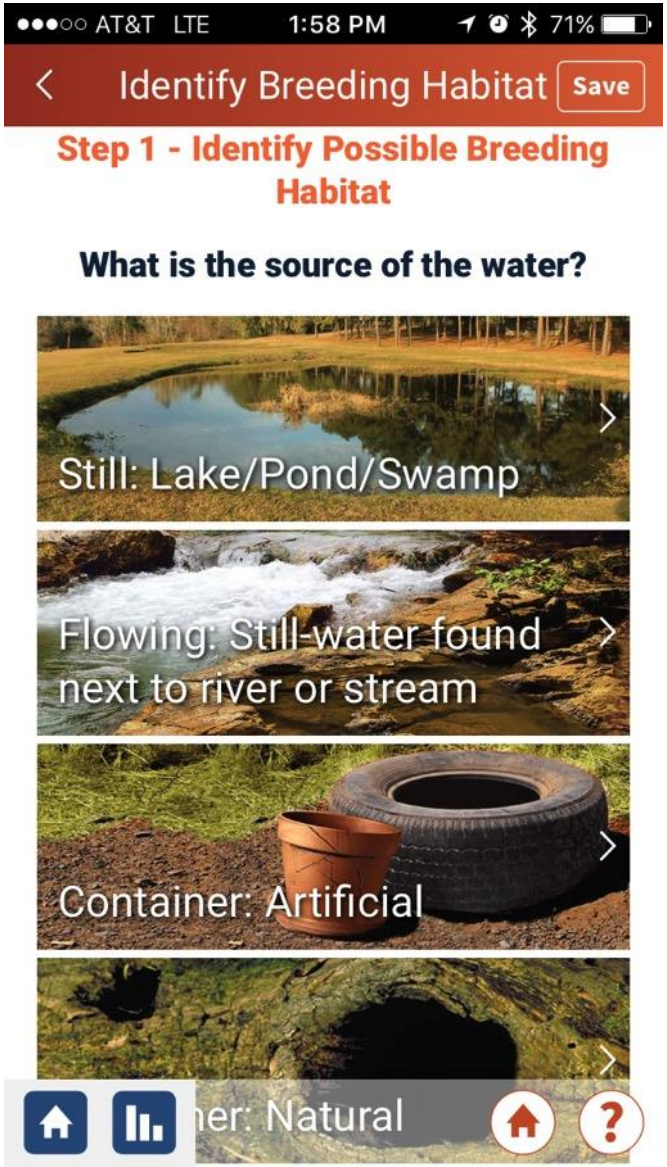
Step 1: Observe!

Identify Potential Mosquito Habitats- find water sources, natural or artificial, which may contain mosquito larvae. You will identify and photograph these habitats.

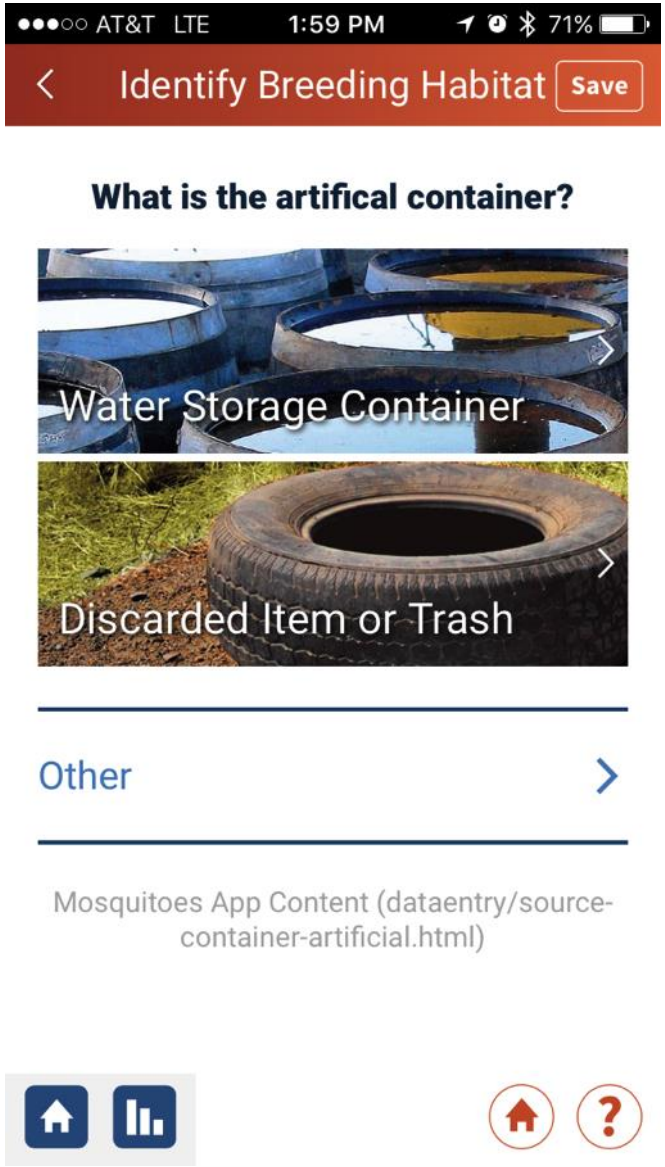


GLOBE mosquito habitat mapper





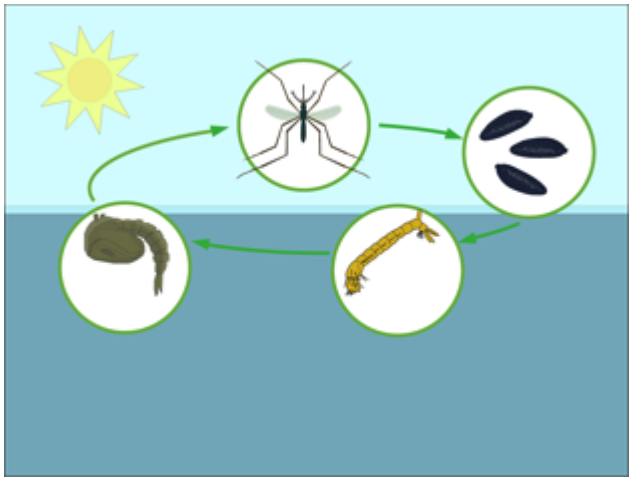
GLOBE mosquito habitat mapper



Step 2: Analyze

Sample and Count

You can use a cup, bulb syringe, or other container to obtain a sample and count the number of larvae.



GLOBE mosquito habitat mapper

AT&T LTE 2:03 PM 71%

Identify Breeding Habitat Save

Mosquito Larvae Visible?

Hint: Larvae hang just below the surface of the water to breathe. They have a characteristic wiggle motion when moving.

They can appear dark or light, depending on light reflection. Even if you don't see larvae, you may want to sample the water (next step) to confirm.

AT&T LTE 2:03 PM 71%

Identify Breeding Habitat Save

Mosquitoes picture comes from the mockup(dataentry/source-larvae-visible-1.jpg)

Can you see mosquito larvae in the water?

Yes

No

Not sure

Mosquitoes App Content (dataentry/source-larvae-visible.html)

GLOBE mosquito habitat mapper

●●●○○ AT&T LTE 2:06 PM 71%

Tips on Sampling

The mosquito larvae will be most densely located just below the surface of the water.

They will respond to light and vibration, so try to disturb them as little as possible.

Bulb syringe: Collapse bulb with your hand, insert tip of syringe just below surface, and rapidly suction the water into the tube.

Dipper or cup: Insert the lip of the cup just below the water surface and quickly skim the surface of the water until the cup is filled.

●●●○○ AT&T LTE 2:06 PM 71%

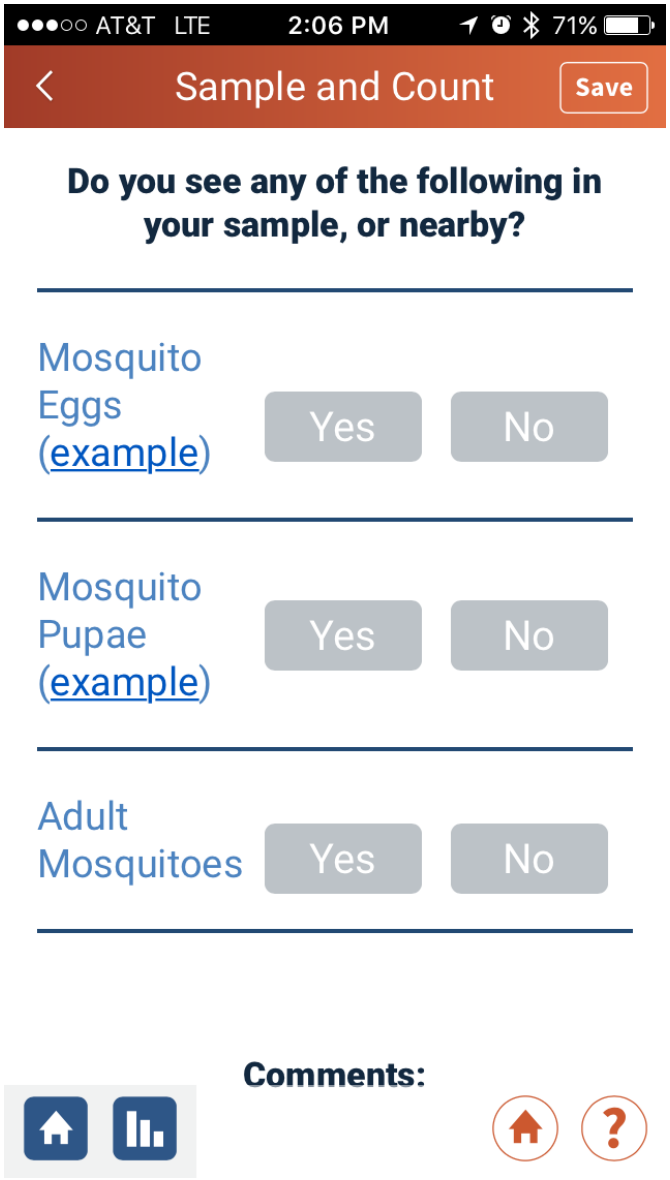
Sample and Count

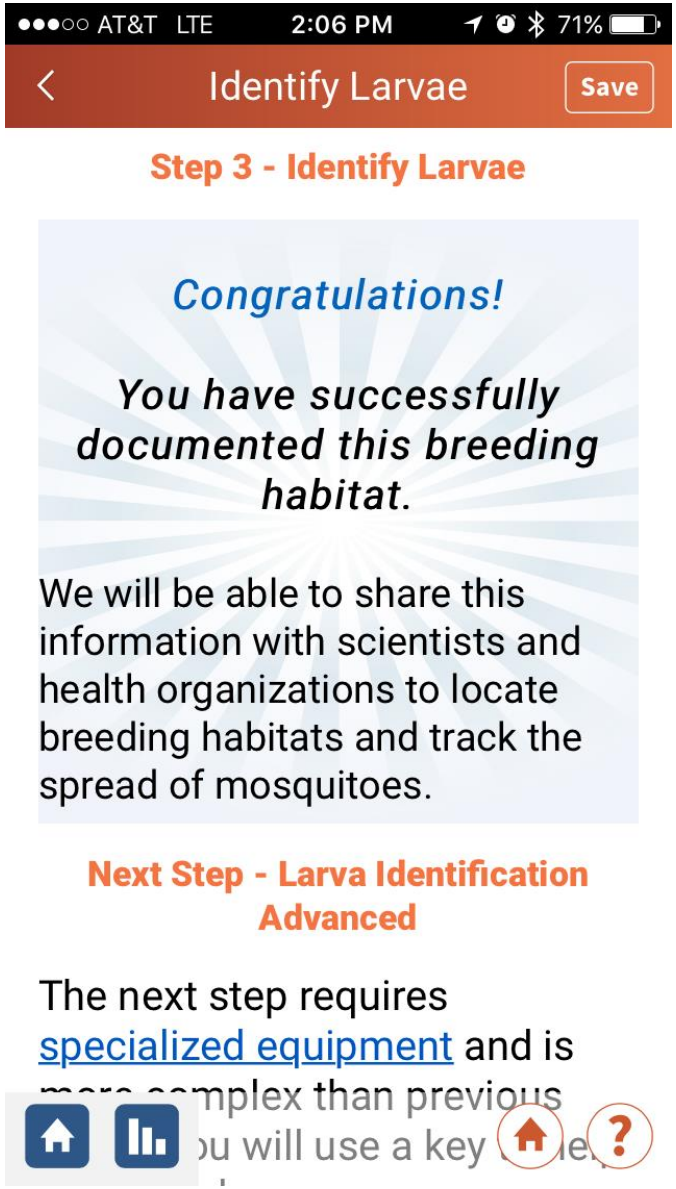
Save

How many larvae do you see?

- 0
- 1-25
- 26-50
- 51-100
- >100

see any of the following in
r sample, or nearby


AT&T LTE 2:06 PM 71%
Sample and Count
Save
Do you see any of the following in your sample, or nearby?
Mosquito Eggs (example)
Yes
No
Mosquito Pupae (example)
Yes
No
Adult Mosquitoes
Yes
No
Comments:


AT&T LTE 2:06 PM 71%
Identify Larvae
Save
Step 3 - Identify Larvae
Congratulations!
You have successfully documented this breeding habitat.
We will be able to share this information with scientists and health organizations to locate breeding habitats and track the spread of mosquitoes.
Next Step - Larva Identification Advanced
The next step requires specialized equipment and is
mplex than previous
u will use a key

Step 3: Analyze
Identify Larvae Type

You will select a representative larva for close-up photos to identify its genus. This will require specialized equipment such as a microscope or a macrolens attachment.

AT&T 2:35 PM 89%

Identify Larvae Save

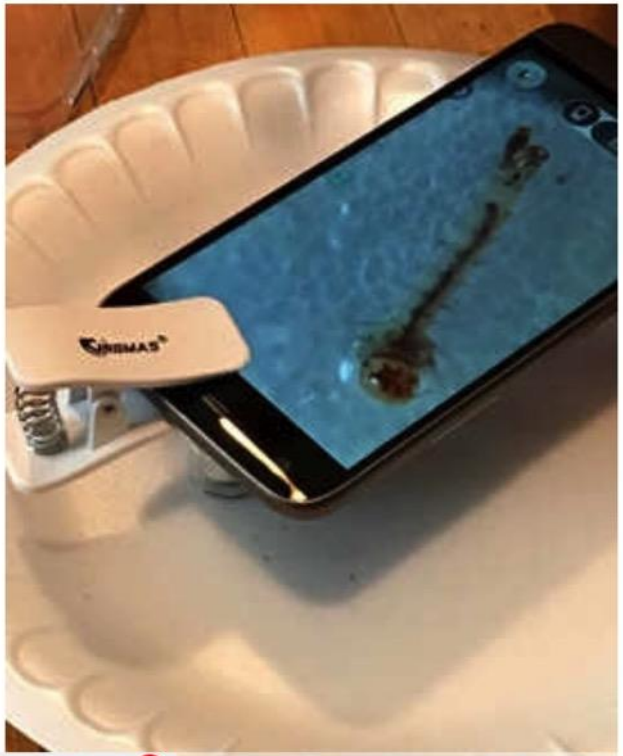
2) Eliminate as much water as possible by using a dropper, pouring off or by using a napkin to soak up excess water.

3) Look at the sample and select a large larva. You will want to suspend the larva in a drop of water for identification. A toothpick can be used to move the larva.

AT&T 2:35 PM 89%

Identify Larvae Save

4) Use your macro lens to take photos. An additional light source may improve the photo.



Step 4: Eliminate

When you are done, we will ask you to dump the water, or cover the water source with a lid or net, if possible, to eliminate the breeding habitat.

Your efforts are invaluable!

From the *New York Times*, April 20th, 2017-

"The best defense against Aedes mosquitoes turns out to be not big municipal gestures but small individual actions: destroying their habitat by emptying the pools of water where they reproduce…"

- The recently released GLOBE Observer *Mosquito Habitat Mapper* has been selected to form the core of the International *Global Experiment* for the next year.

- Museums, science centers, libraries, parks, and other interested groups of citizens will learn how to use the MHM and how to access NASA data sets to conduct research to determine how certain environmental variables impact the onset of mosquito-borne diseases.

- This presentation will describe this worldwide effort and share information about how to get groups involved in your region.

Initiative Empowers National Networks, Stakeholders and Governments to Generate and Access Real-time Data and Tools through UN Electronic Platform 'Environment Live"

Geneva, 8 May, 2017 – A new alliance of citizen-science organizations and UN Environment will be launched, Monday, in an effort to escalate the global fight against mosquito-borne diseases, responsible for killing close to 2.7 million people annually, mostly in Africa and Latin America. Overall mosquito borne cases are estimated at 500 million every year.

The new initiative, launched under the name '***Global Mosquito Alert'***, brings together thousands of scientists and volunteers from around the world to track and control mosquito borne viruses, including Zika, yellow fever, chikungunya, dengue, malaria and the West Nile virus. It is the first global platform dedicated to citizen science techniques to tackle the monitoring of mosquito populations.

The programme is expected to move forward as a collaboration involving the European, Australian and American Citizen Science Associations as well as the developing citizen science community in Southeast Asia.

Agreement to launch the initiative was reached at a two-day workshop that took place in Geneva earlier this month, organized by UN Environment, the Wilson Center's Science and Technology Innovation Program (STIP), and the European Citizen Science Association (ECSA).

Director of Science at UN Environment, Jacqueline McGlade, said, "The Global Mosquito Alert

GLOBE Observer mosquito habitat mapper

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GLOBAL EXPERIMENT

Using a new GLOBE app to track mosquitoes and mosquito borne diseases

The mosquito is the most dangerous animal in the world. While there are more than 3,500 species of mosquitoes, only about 200 species—and only their females—carry the diseases that are so harmful to humans. Some of these mosquitoes are responsible for spreading the Zika virus, which is implicated in serious birth defects found in thousands of babies in South America alone. Mosquito borne diseases kill close to 2.7 million people annually.

The good news is that we can make a difference in working together to eradicate these killers from our neighborhoods through awareness and action. The GLOBE Observer (GO) Program just released a tool enabling citizen scientists worldwide to use their mobile devices for identifying and eliminating potential mosquito breeding sites. Using the mobile application, GO Mosquito Habitat Mapper, citizen scientists will also be able to identify the mosquito species responsible for transmitting Zika, dengue, yellow fever, and chikungunya. They will

Join the Global Experiment!

- Access a suite of resources to assist science centers and science museums in training and responding to the Global Experiment.
- Learn which mosquito borne diseases have been found in an institution's country and region using World Health Organization, U.S. Centers for Disease Control, and local health records.
- Find out when and where outbreaks of mosquito borne diseases have occurred in an institution's region.

- See how many potential mosquito breeding sites science center and science museum visitors can identify and eliminate; keep a tally and images of breeding locations (natural and human made) and how these were eliminated.

- Use global precipitation measurement data to see how much precipitation fell in the three months preceding mosquito borne disease outbreaks to see if there is a correlation between precipitation amount and the onset of mosquito borne illnesses in humans.

- Explore data to see is there is a correlation between soil moisture and the onset of mosquito borne illnesses in humans.

- Use surface temperature data to see what the surface temperature conditions were like in the three months preceding the disease outbreaks, and use this data to see if institutions' visitors can determine a correlation between the surface temperature and the onset of mosquito borne illnesses in humans.

- Connect with local scientists and health professionals, and engage them in training sessions and local programming.

- Remember to have participants use the referral code 2468 so we can keep track of how many participants around the world are using this app as a result of your efforts!