Using NASA Earth observing satellite data to predict, monitor, and respond to vector-borne disease

GLOBE Annual Meeting 2019
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GLOBE Mission Mosquito

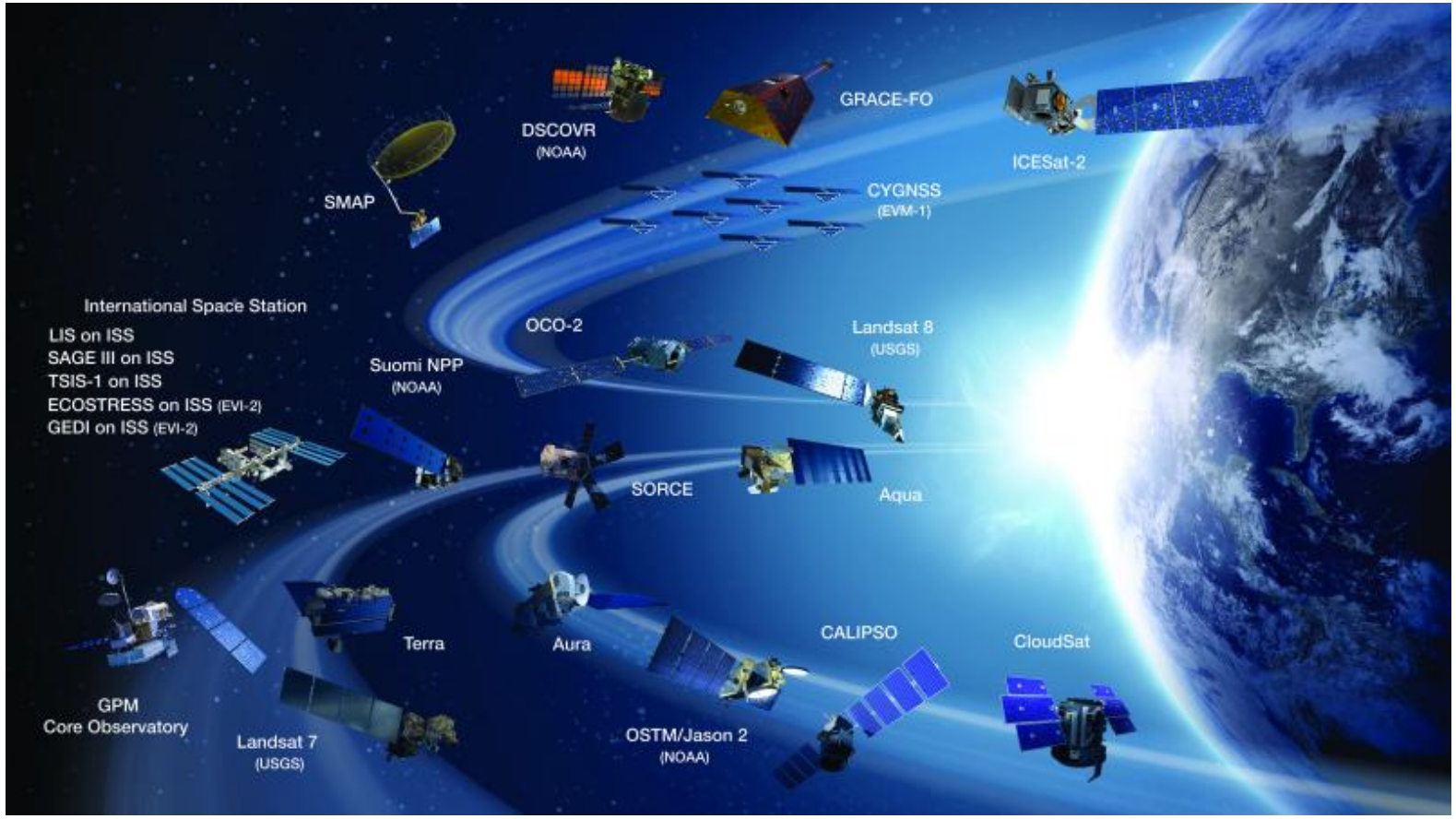
My presentation will cover:

- Introduction to NASA's Earth observations informing vector-borne disease applications

- Overview of the "*Mosquito Habitat Mapper*" tool

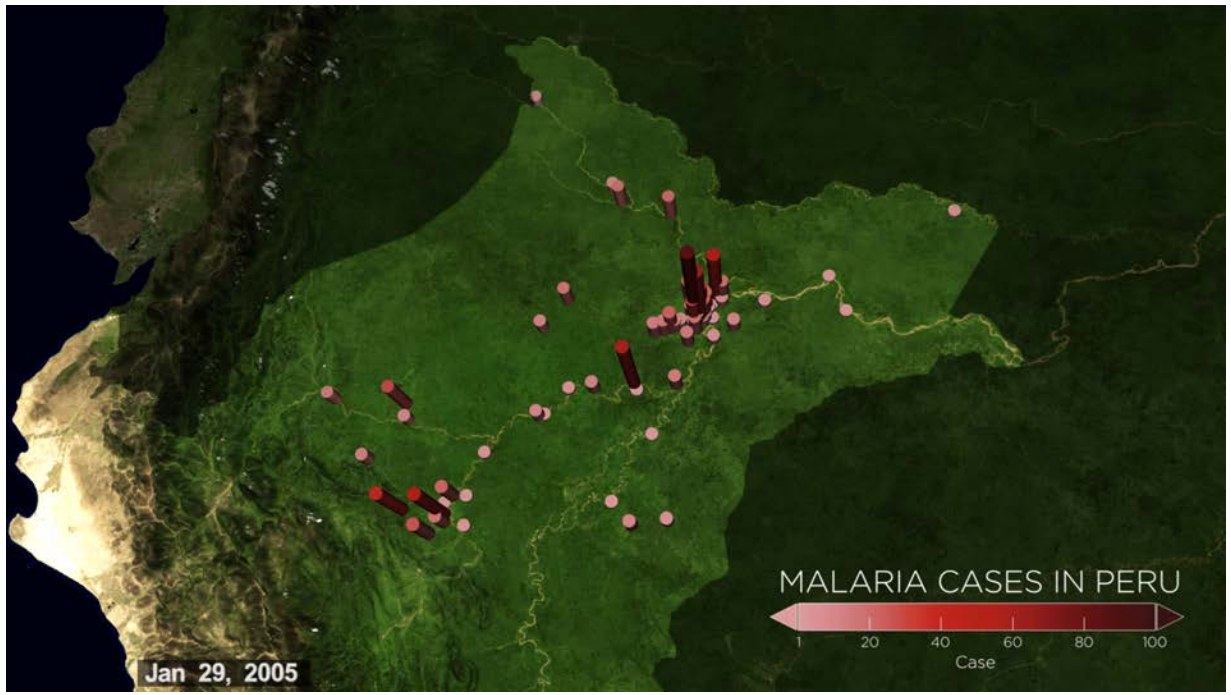
- The GLOBE "*Mission Mosquito*" campaign and our educational outreach efforts

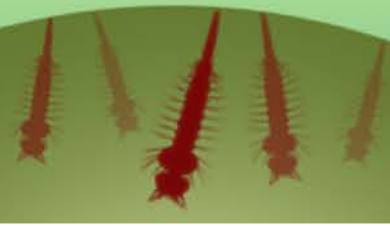
NASA Earth observing satellites



EOS environmental parameters

- Temperature
- Precipitation
- Vegetation
- Soil Moisture
- Humidity





Predicting Malaria Outbreaks With NASA Satellites: YouTube Link (4 minute, 17 second video)

The GPM "Disease Initiative"

- Way to highlight the real-world applications of the GPM mission
- Opportunity to reach out to potential end-users of GPM and other NASA EOS data
- Chance to interact with and better understand the needs and challenges facing public health professionals dealing with these diseases

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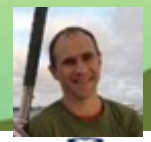
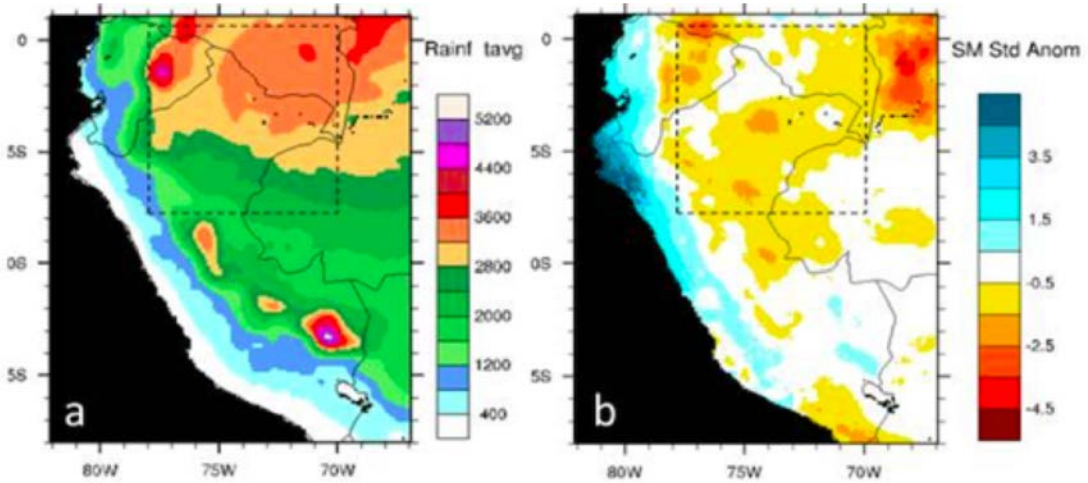


JOHNS HOPKINS UNIVERSITY

In the Amazon Rainforest, few animals are as dangerous to humans as mosquitos that transmit malaria. Predicting favorable conditions for mosquito breeding and survival relies on identifying areas with warm air temperatures and calm waters, such as ponds and puddles.

A map showing the rivers the Peruvian Amazon and surrounding areas.
Credits: NASA's Scientific Visualization Studio



Long-term mean annual precipitation for Peru and Ecuador based on TMPA data (1998-2013) (left) and an example of a monthly standardized soil moisture anomaly for March 1998 (right). The dashed box shows the approximate location of the western Amazon focus region.

To tackle this problem, a group of researchers are using a range of NASA satellites, including GPM, SMAP, Landsat, Terra and Aqua, to identify human and environmental events that typically precede an outbreak. With funding from NASA's Applied Sciences Program, they are working in partnership with the Peruvian government to develop a system that uses satellite and other data to help forecast outbreaks at the household level months in advance and prevent them from happening.

"We use TRMM/GPM to monitor rainfall conditions in data scarce regions of the western Amazon basin. The rainfall data drive a water balance model that is used to predict conditions favorable for mosquito breeding and survival, which in turn informs our malaria transmission risk estimates."
-Ben Zaitchik, John Hopkins University

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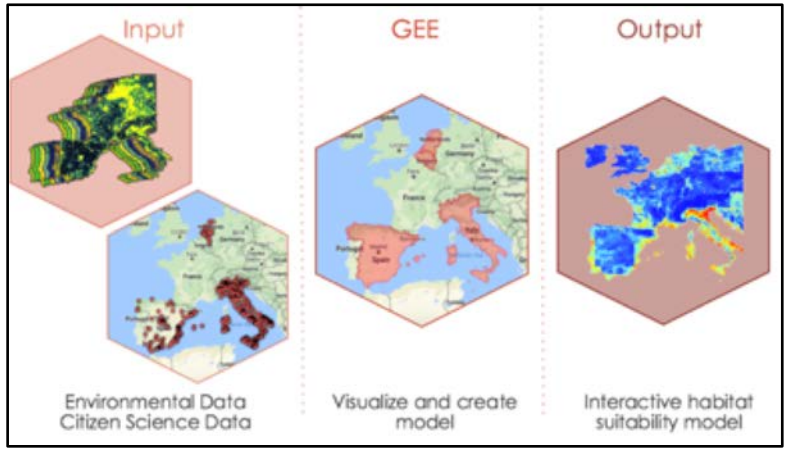
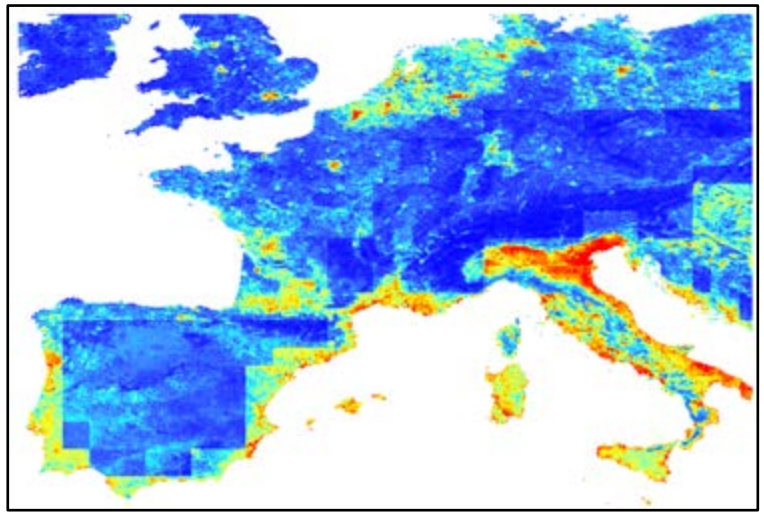
The NASA *DEVELOP* program worked with multiple organizations to integrate NASA Earth observations with citizen science data from Western Europe to understand the location and timing of disease outbreaks and improve outbreak predictions.





NASA and partners developed a shared, coordinated platform and protocol to leverage citizen science for the global surveillance and control of disease-carrying mosquitoes. Data from citizen scientists and environmental data from NASA Earth observations; including precipitation (from GPM IMERG), elevation, humidity, land cover, soil moisture, and land surface temperature; were used as parameters for a mosquito habitat suitability model and incorporated into a open-source interactive map.

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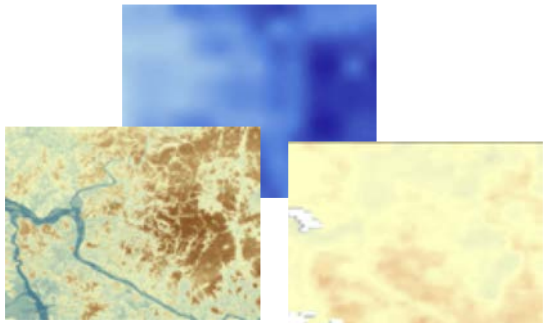
US Army Corps of Engineers
Engineer Research and Development Center

NASA satellite products have been incorporated into US Army Corps ERDC-GRL's "Vulnerability Assessment Software Tool: Spatial Analytics for Force Health and Readiness" (VAST-SAFHR), to predict the occurrence of dengue outbreaks in Cambodia.

CHIRPS Precipitation (5km)



NDVI (30m)

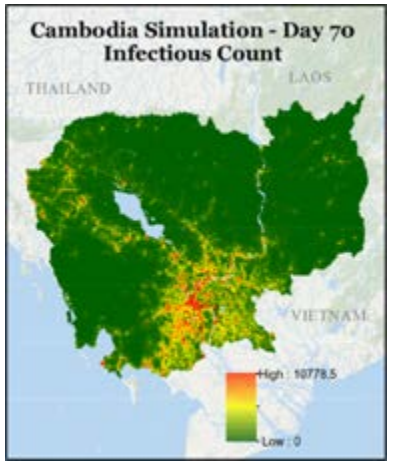
LST (1km)

Step 1: Combine NASA products into uniform pixel size

Provincial-Level Dengue Incident Rates*

Downscaled Pixel-Level Dengue Incident Rates

Step 2: Downscale Provincial-Level Disease Data

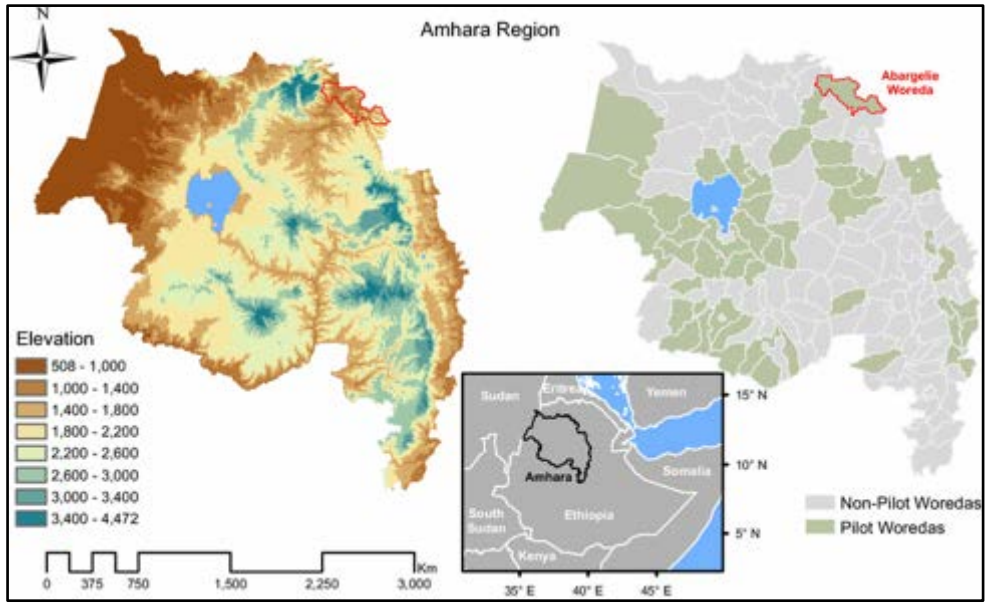


Step 3: Stochastic Simulation of Vector-Borne Disease

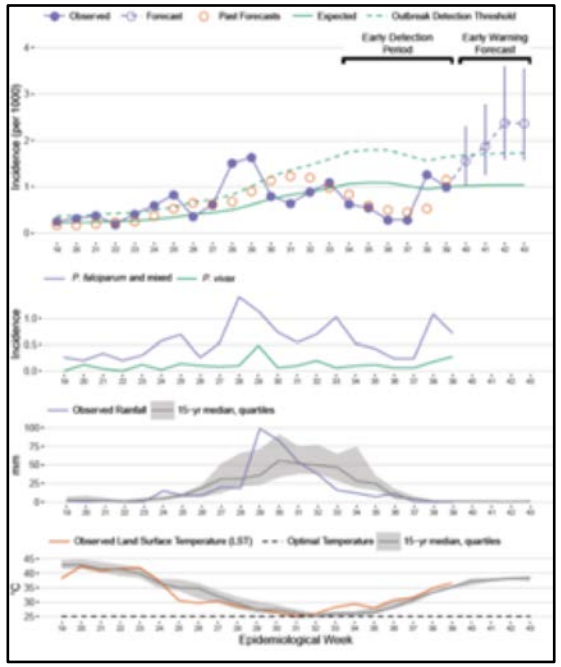
The purpose of VAST-SAFHR is to develop a computational framework to model, map and predict the spatial and temporal movement of dengue within Cambodia. The movement of dengue is highly dependent upon mosquitoes and their environment, which can be modeled with NASA derived products of Normalized Difference Vegetation Index (NDVI), land surface temperature (LST), and precipitation data using NASA sensors MODIS Terra and Aqua and TRMM/GPM. These environmental variables plus population density are used to calculate pixel level dengue incident rates which are then used to predict the occurrence of dengue outbreaks in Cambodia.

GLOBE Mission Mosquito

A collaboration between South Dakota State University (SDSU) scientists and public health stakeholders are using NASA satellite data as input variables for a web-based malaria informatics system for epidemiological and environmental data acquisition and harmonization. Specifically, GPM precipitation, MODIS land surface temperature, and MODIS surface reflectance are used for environmental data sources to develop malaria forecasts in the Amhara Region of Ethiopia.



Study Area: The Amhara region of Ethiopia, including 47 pilot districts that were select to encompass the most malaria-prone parts of the region.



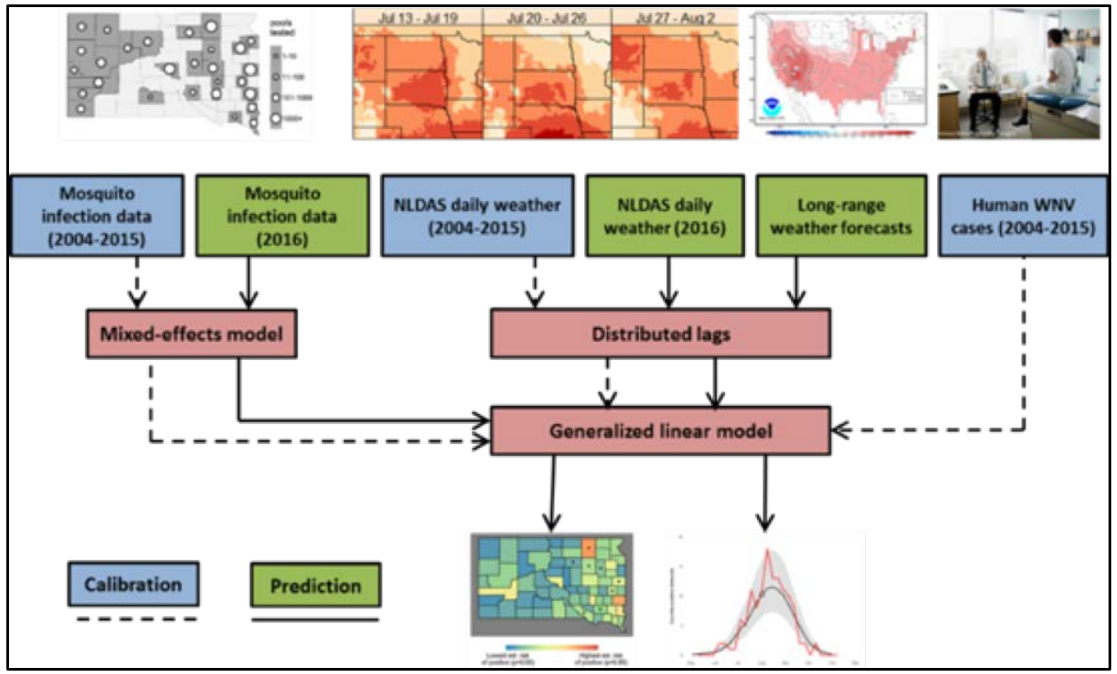
Example malaria forecasts generated for Abargelie districts in October 2016

Michael C. Wimberly (michael.wimberly@sdstate.edu), Geospatial Sciences Center of Excellence, South Dakota State University/
Supported by NIH-NIAID (R01AI079411, PI: Wimberly)/ See Merkord et al. (2017), Malaria Journal for more information

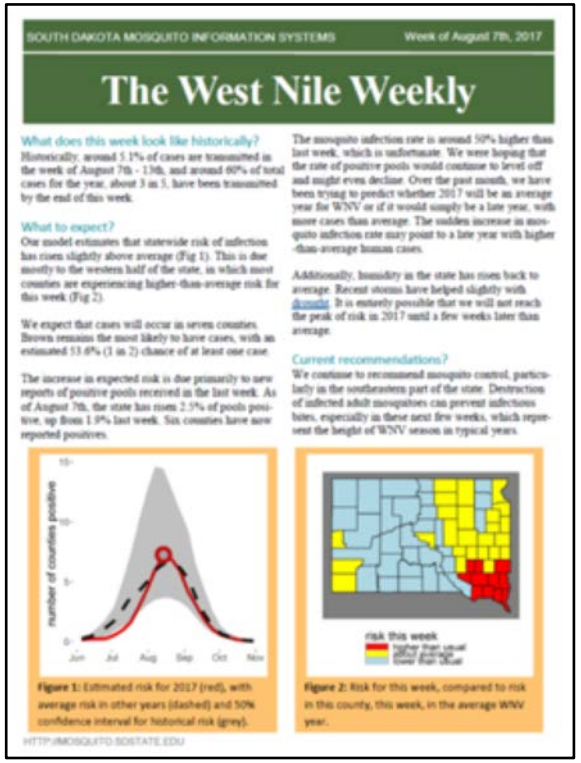
GLOBE Mission Mosquito

South Dakota State University

South Dakota State University (SDSU) scientists are using a web-based informatics system to integrate mosquito surveillance data with environmental data to predict outbreaks of West Nile virus in the Northern Great Plains of the United States. West Nile virus risk forecasts are generated using models that incorporate precipitation (GPM), temperature, and humidity from the North American Land Data Assimilation System (NLDAS) with recent infection rates from mosquito surveillance.



Schematic of West Nile virus forecasting using the South Dakota Mosquito Information System (SDMIS) illustrating data flows for calibration and prediction.


SOUTH DAKOTA MOSQUITO INFORMATION SYSTEMS — Week of August 7th, 2017

The West Nile Weekly

What does this week look like historically?

Historically, around 5.1% of cases are transmitted in the week of August 7th - 13th, and around 60% of total cases for the year, about 3 in 5, have been transmitted by the end of this week.

What to expect?

Our model estimates that statewide risk of infection has risen slightly above average (Fig 1). This is due mostly to the western half of the state, in which most counties are experiencing higher-than-average risk for this week (Fig 2).

We expect that cases will occur in seven counties. Brown remains the most likely to have cases, with an estimated 53.6% (1 in 2) chance of at least one case.

The increase in expected risk is due primarily to new reports of positive pools received in the last week. As of August 7th, the state has risen 2.5% of pools positive, up from 1.9% last week. Six counties have now reported positives.

The mosquito infection rate is around 50% higher than last week, which is unfortunate. We were hoping that the rate of positive pools would continue to level off and might even decline. Over the past month, we have been trying to predict whether 2017 will be an average year for WNV or if it would simply be a late year, with more cases than average. The sudden increase in mosquito infection rate may point to a late year with higher-than-average human cases.

Additionally, humidity in the state has risen back to average. Recent storms have helped slightly with drought. It is entirely possible that we will not reach the peak of risk in 2017 until a few weeks later than average.

Current recommendations?

We continue to recommend mosquito control, particularly in the southeastern part of the state. Destruction of infected adult mosquitoes can prevent infectious bites, especially in these next few weeks, which represent the height of WNV season in typical years.

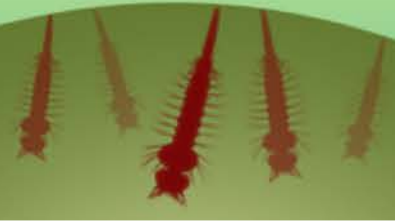
Figure 1: Estimated risk for 2017 (red), with average risk in other years (dashed) and 50% confidence interval for historical risk (grey).

Figure 2: Risk for this week, compared to risk in this county, this week, in the average WNV year.

HTTP://MOSQUITO.SDSTATE.EDU

West Nile virus forecast report from August 2017.

Michael C. Wimberly (michael.wimberly@sdstate.edu), Geospatial Sciences Center of Excellence, South Dakota State University/
Supported by NASA (NNX15AF74G, PI: Wimberly)/ See Davis et al. (2017), PLOS Currents: Outbreaks for more information



What is the "Mosquito Habitat Mapper"?

- A "tool" in the *GLOBE Observer* app
- Gives the observer the opportunity to help reduce the threat of mosquito-transmitted disease
- Has a continuum of ways observers can collect data
- Should be used during both active and non-active mosquito seasons
- Enables anyone (after doing a very short tutorial) to participate and collect and share their observations

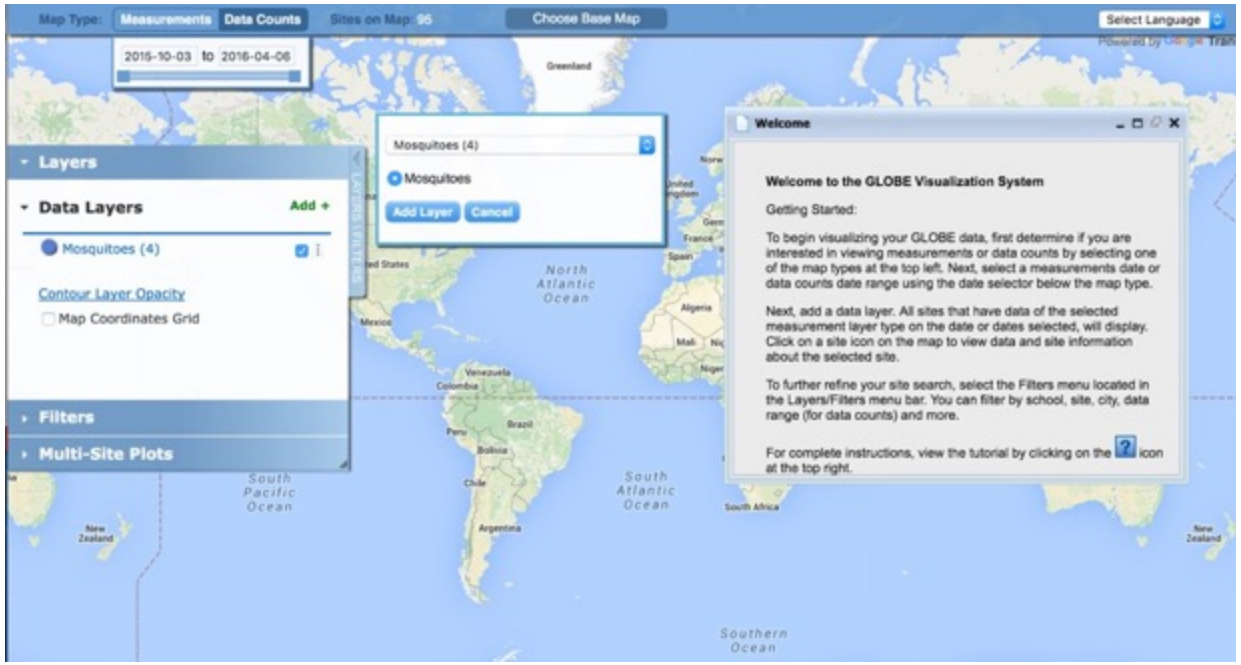
Mosquito Habitat Mapper

Four Steps- and you don't have to do all of them!

1. Identify potential mosquito breeding habitats
2. Sample and Count
3. Photograph and identify species of larvae
4. Eliminate breeding site

Visualize and Retrieve Data

GLOBE provides the ability to view and interact with data measured across the world. Use our visualization tool to map, graph, filter and export data that have been measured across GLOBE protocols.



Link to step-by-step tutorial on using the GLOBE Data Visualization Tool

The GLOBE "Mission Mosquito" Campaign

- Campaign connecting citizen scientists of all ages to monitor changes in the frequency, range, and distribution of potential disease vector mosquitoes
- Conduct research to explore how these vary in response to changes in environmental conditions
- Fusion of the GLOBE and the GLOBE Observer programs

GLOBE Mission Mosquito

Through this campaign, we plan to:

- Identify baseline (2018-2021) for range and distribution of vectors such as *Aedes aegypti* and *Aedes albopictus*.
- Identify seasonality of local mosquito vectors: first sighting, last sighting, period of greatest number of observations
- Quantify change in mosquito frequency and distribution at local, regional, national and global scales with specific reference to prevailing environmental parameters, such as precipitation, land cover, surface temperature, and soil moisture.

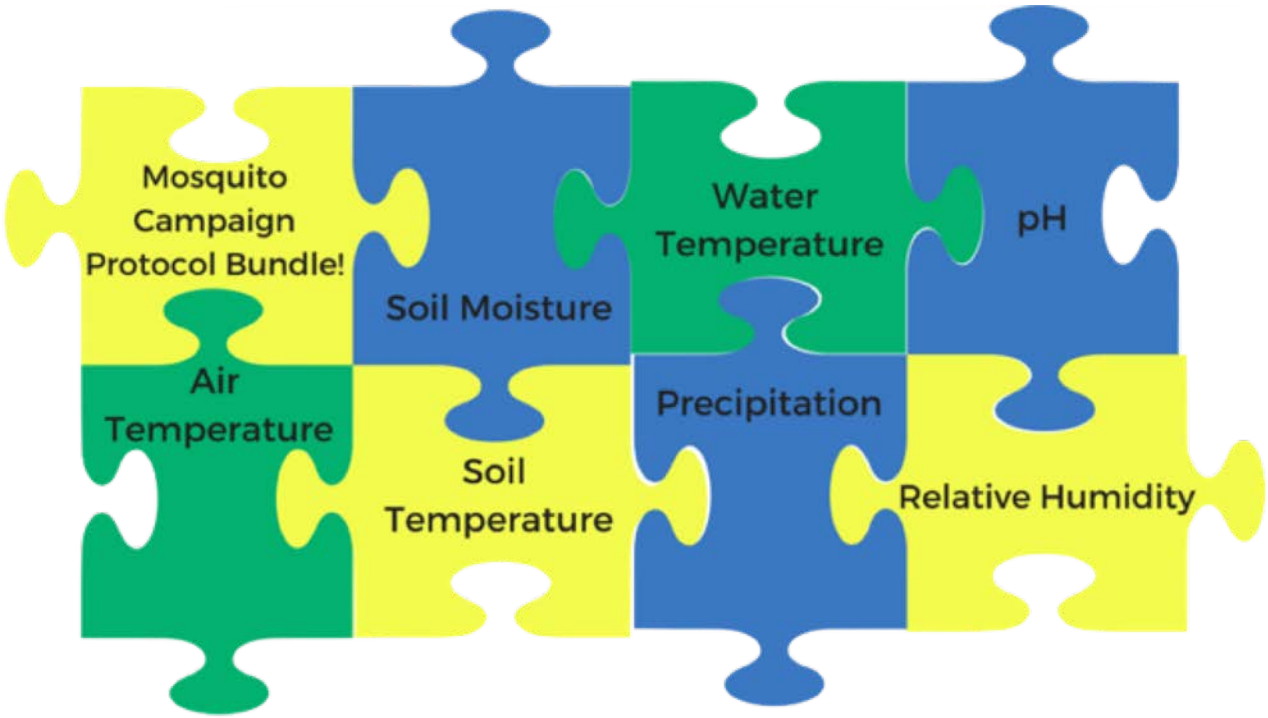
GLOBE Mission Mosquito

Formal Education Outreach includes:

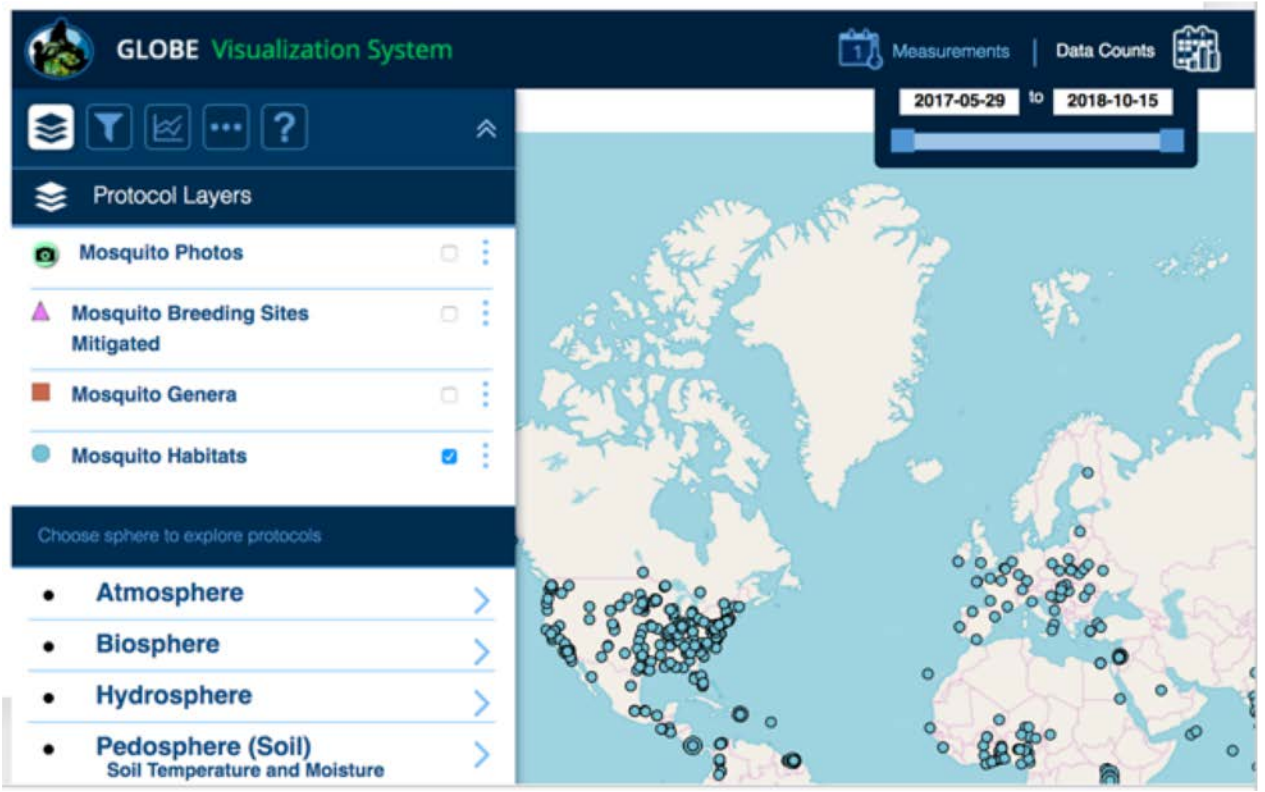
A collaborative community with

- Bi-monthly webinars
- Monthly newsletters
- Weekly "*Top MHM Data Collectors*"
- Assistance with IVSS science projects
- Ongoing "*Ask a Scientist*" opportunity
- "*Spotlights*" on GLOBE efforts

Using other protocols to find cause and effect relationships:



What kinds of questions can be answered using GLOBE Observer Mosquito Habitat Mapper data?



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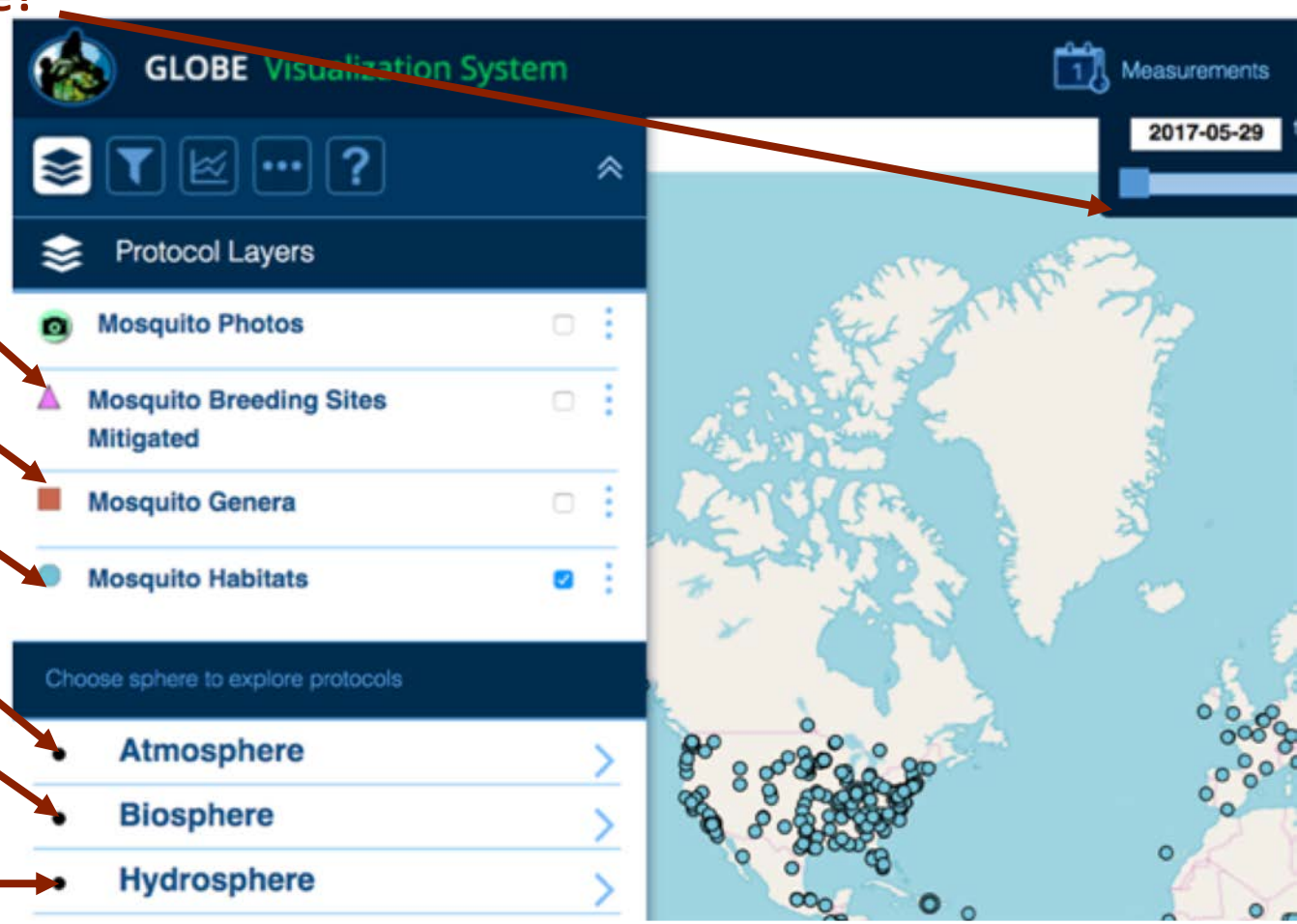
- At what rate are invasive species toward my home?
- What affect does human behavior have on eliminating mosquito borne disease?
- Is there a risk for West Nile virus or another mosquito disease in my community?
- How can we predict mosquito population explosions and reduce the risk of disease outbreaks?
- How is climate change affecting the range and distribution of different kinds of mosquitoes?
- How is human modification of the landscape impacting the distribution and populations of mosquitoes?
- What effect does water quality have on mosquito population size ?



Education collaboration includes-

- Schools with active vs. non-active mosquitoes
- Sharing “Best Practices”
- Developing “Community Action” campaigns to increase preventative behaviors
- Sharing investigative questions and research results

Science Collaboration includes

- **Go OK! Citizen Science Campaign**

Citizen scientists in the greater Oklahoma City metropolitan area were recruited to be part of GO OK!

This is an intensive monitoring campaign in Oklahoma which is part of NASA GLOBE Mission Mosquito. Citizen scientists monitor the presence of *Aedes* mosquitos during the mosquito season using the GLOBE Observer Mosquito Habitat Mapper mobile app.

Connect to other Campaigns and Efforts!

- GLOBE Zika Education and Prevention
- Trees Around the GLOBE Campaign
- GLOBE Observer Land Cover app

GLOBE ZIKA EDUCATION AND PREVENTION

Please get involved!

- Download and use the *GLOBE Observer* tools- especially the *Mosquito Habitat Mapper*!
- Join our webinars and share information about the *GLOBE Mission Mosquito* campaign
- Get on our *GLOBE Mission Mosquito* mailing list
- Feel free to contact me at dorian.w.Janney@nasa.gov if I can assist you in any way

Thank you for your time and energy!