**Predicting Malaria Outbreaks with NASA Satellites**

Have you ever been bitten by a mosquito? Most of us have, and find ourselves annoyed when our skin rises up in an angry bump and itches like crazy. Did you know that these pesky little insects are actually the world’s most dangerous animal? Mosquito transmitted diseases; such as malaria, dengue fever, and Zika; account for over 2.7 million deaths per year worldwide. There are over 3,500 species of mosquitoes, and fortunately, less than 100 of these transmit disease to humans.

Malaria is a preventable disease that can be life-threatening. It is caused by the Plasmodium parasite, and is spread to people through being bitten by an adult female mosquito. Nearly half the world is at risk to contract malaria, and although malaria was [eliminated in the United States](https://www.npr.org/sections/goatsandsoda/2017/04/24/525405956/malaria-wiped-out-in-u-s-but-still-plagues-u-s-hospitals) in the early 1950’s, this disease has been increasing in citizens who traveled to countries where the parasite is still active. The rate of people being infected and dying from this disease has decreased in the past decade, but on Nov. 29th, 2017, the WHO (World Health Organization) reported that the [progress has stalled](http://www.who.int/malaria/en/). The good news is that we can use NASA satellite data to predict when the environmental conditions are right for mosquitoes to be active, enabling health officials to pinpoint where and when to send resources to stop the disease in its tracks.

In this activity, you will learn how NASA satellite data has been used to predict the onset of malaria in the Amazon regions of both Brazil and Peru as an example of real-world applications of NASA Earth-observing satellite data. You will be guided in collecting and analyzing NASA data to gain an appreciation of how this is possible, as well as to see how you might explore environmental data for any part of the world. You may choose to use the embedded hyperlinks to learn more about certain content, or may prefer to simply wander through at your own pace and only dig deeper when you so desire.

The best place to start is to watch the video (4:18) entitled “[Using NASA Satellite Data to Predict Malaria Outbreaks](https://www.nasa.gov/feature/goddard/2017/using-nasa-satellite-data-to-predict-malaria-outbreaks)”. One of the key points this video brings home is that there are a number of environmental and human factors to consider when trying to determine where and when outbreaks of this deadly disease may occur. Determining where the *Anopheles darling*, the primary species which spreads malaria in the Amazon region, are breeding will enable public health officials to have a twelve-week head start to send the resources to the region. As William Pan, the principal investigator of this study, says, “The key to our malaria forecasting tool lies in pinpointing areas where prime breeding grounds for these mosquitoes overlap simultaneously with human populations.” Ensuring that people in the area where these mosquitoes are active have resources such as insecticide-treated bed nets and indoor sprays can stop an outbreak of malaria in its tracks.

NASA Earth-observing satellites are able to use remote-sensing to measure many environmental variables. You can watch this [short video](https://pmm.nasa.gov/education/videos/water-falls-getting-big-picture) to learn more about how this is done and the many variables that are being measured.

Let’s take each of these environmental variables and explore them on at a time.

Temperature:

Think about when mosquitoes are active and biting. Many of us in North America find that the summer brings these pesky bugs our way, and we might surmise that this means that mosquitoes need warmer temperatures to survive. Although the exact temperature range varies depending on many factors, it appears that mosquitoes function best at ~ 27°C/80o F (300o K), become lethargic at ~16°C /60o F (289o K) and cannot function below ~10°C/50oF (283o K). The [CDC](https://www.cdc.gov/malaria/about/distribution.html) (Centers for Disease Control) states that “Temperature is particularly critical. For example, at temperatures below ~ 20°C/68°F (293oK), *Plasmodium falciparum* (which causes severe malaria) cannot complete its growth cycle in the *Anopheles* mosquito, and thus cannot be transmitted.” Kelvin is being included here as these are the units you will see the NASA EOS temperature data reported in.

<https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD11C1_M_LSTDA>

To take a look at NASA satellite temperature data, we will first go to [NASA Worldview](https://worldview.earthdata.nasa.gov/). While you may want to take a tour later, go ahead and click on “Skip Tour” for now. Go to the menu on the upper left, and click on the “eye” icon to open “Place Labels” and “Coastlines/Borders/Roads”. There will be a third overlay entitled “Coastlines” which you can keep open. Then go down to “Base Layers”, and click on “Add Layers”. Go to the Search at the top of the list, and enter “temperature”. Wow- did you have any idea that NASA Earth-observing satellites are measuring temperature in so many ways?

For this activity, let’s go with “Surface Air Temperature (Night, Monthly) and set the parameters (using the little curvy icon that is to the right of the overlay) to change the opacity (somewhere around 60% seems good) and the thresholds to a lower value of 293 K and an upper value of 305 K. Then you want to zoom in to the locate the region of Peru where the Amazon is located.

Precipitation:

Soil Moisture:

Vegetation:

My notes from the article: Predicting where these mosquitos will flourish relies on identifying areas with warm air temperatures and calm waters, such as ponds and puddles, which they need for laying eggs. Researchers are turning to the Land Data Assimilation System, or LDAS: a land-surface modeling effort supported by NASA and other organizations. NASA satellites, such as Landsat, Global Precipitation Measurement, and Terra and Aqua, serve as inputs for LDAS, which in turn provides ongoing information on precipitation, temperature, soil moisture and vegetation around the world. While not identifying puddles and ponds outright, LDAS shows where they are very likely to form. For example, flooding may overflow riverbanks or heavy rains can saturate the soil, allowing water to pool.

Below is a chart of the environmental variables, the approximate parameters which are necessary for *Anopheles darlingi* mosquitoes to breed and bite, and the NASA Earth-observing satellite and instrument being used to measure that variable.

|  |  |  |
| --- | --- | --- |
| **Environmental variable** | **parameters** | **NASA EOS** |
| temperature | Above 20°C or ~ 293 K | Terra/MODIS |
| precipitation | At least ? | GPM/ IMERG |
| humidity | At least ? | Aqua/AIRS |
| soil moisture |  |  |

Recent research on temperature- malaria tie: <http://www.pnas.org/content/107/34/15135.full>