**NASA DEVELOP National Program**

****Jet Propulsion Laboratory (Pasadena, CA)

**Fall 2013**

**Brazil Health and Air Quality**

*Utilizing NASA Earth Observations for Forecasting Dengue Vector-Borne Disease Outbreaks*

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**Applied Sciences National Applications Addressed:**

Health and Air Quality

**Study Area:** Brazil

**Study Period:** January 2000 – Present

**Community Concerns**

* Vector-borne diseases (VBD) claim hundreds of thousands of lives annually, particularly impacting underdeveloped and developing countries.
* Dengue is the fastest growing vector-borne disease globally.
* In the last fifty years dengue has increased 30-fold, infecting up to 100 million people annually and is now considered by the World Health Organization to be the most important mosquito-borne viral disease in the world, with pandemic potential.

**Word Blurb**

In the last fifty years, dengue has infected up to 100 million people annually and is now considered by the World Health Organization to be the most important mosquito-borne viral disease in the world, with pandemic potential. The current project characterizes mosquito habitats through NASA Earth Observation remote sensing products and models to predict dengue risk. This effort will help improve efficiency and save man-hours associated with field assessments used to determine the likelihood of a dengue occurrence.

**Abstract**

The aim of this project was to provide an understanding of the interplay of environmental factors involved at locations prone to the spread, presence, and persistence of mosquito populations of *Aedes aegypti*, the primary dengue vector. The team utilized multi-temporal satellite remote-sensing data to obtain information regarding temperature, precipitation and humidity, as well as census data on population density for the entire country of Brazil. Temperature is associated with the duration of larval development and mosquito survival and, thus, is a critical variable in the prediction of dengue outbreaks. A version of the weather-driven entomological life-table simulation model by Focks & Haile (1993) was used in order to simulate the biological cycle of *Aedes aegypti*. This model provides an understanding of mosquito abundance as a function of temperature, which plays an important role in each stage of the mosquito’s biological cycle. The aim was to modify the model Focks & Haile describe, CIMSiM, to include temperature data obtained from the remote-sensing data from the study area. This will help researchers better determine areas at risk for dengue outbreaks. In collaboration with the California Department of Public Health (CDPH) for access to data on reported dengue fever cases, we investigated the correlation between remote sensing data and dengue disease incidence.

**Partners/Collaborators**

California Department of Public Health: James Tucker

**Current Management Practices & Policies**

Currently, the California Department of Public Health conducts field surveys as the predominant source of data collection to assess the risk of dengue for a given location. On-the-ground data collection methods are often time-consuming and costly. The under-reporting of mild and non-symptomatic cases of dengue fever further complicates these methods as compulsory notification most often only identifies cases of dengue hemorrhagic fever (DHF) or dengue shock syndrome (DSS). The application of remote sensing to the problem of dengue monitoring is expected to greatly enhance efforts by the CDPH.

**Benefit to End-User:**

* This project supplied a remotely-sensed data model that will allow the end-users to predict dengue outbreaks without performing costly and time-consuming field surveys.
* This project fostered collaboration between NASA’s Jet Propulsion Laboratory (JPL), DEVELOP, and California’s Department of Public Health (CDPH).

**Decision Support Tools**

* A framework that generates global maps of vector-borne disease outbreak risk

**Earth Observations & Parameters**

The following NASA sensors were utilized for this project:

1. The AIRS sensor on the Aqua satellite was utilized for air temperature and humidity.
2. The MODIS sensor was utilized on the Aqua and Terra satellite to measure land surface temperature and enhanced vegetation indices.
3. The PR-TMI sensor was utilized on the TRIMM satellite to measure precipitation.

**Models Utilized**

The container-inhabiting mosquito simulation model (CIMSiM) is a weather-driven entomological life-table simulation model of the primary dengue vector mosquito, *Aedes aegypti*, which provides inputs to the dengue simulation model (DENSiM). These models have been utilized for site-specific areas that require local surveys and weather information to parameterize the datasets. The goal was to modify these models to include remote sensing datasets as an improved method for dengue disease forecasting.

Description of the model:

The model was programed in MATLAB by incorporating various files to model different aspects of CIMSiM. In the model, the daily cycle at the various cohorts (egg, larval, pupa, adults) and their properties were incorporated. The status of the mosquito breeding habitats (containers) was also determined as either wet or dry (wet containers being ideal mosquito breeding conditions). Furthermore, the model focused on the development rate and the food weight function, both of which are described in Focks & Haile. Finally, several model variables were reexamined: larval weight gain, an important element because the higher the weight, the more eggs the individual lays as an adult; water temperature since it is a weather driven model; and the survival of the individual at the different cohorts.

The outputs of the model include plots that show the total number of individuals at each stage, the total number of days an individual spent at a specific cohort, and the total cohort counts which illustrate the emergence of the second generation. Moreover, the total population counts were plotted, which demonstrate the total number of individuals at each cohort. Finally, the model examined how climate is changing over the specified days.

A literature search revealed that mosquitos age with time, and thus it should be included in the model to reflect the true lifecycle of the mosquito. Furthermore, the literature reveals that mosquitoes do not develop properly in dense environments, but this will not be taken into account, rather focusing on containers that provide a normal environment for development.

**Ancillary Datasets Utilized**

CDPH and WHO - vector occurrence and magnitude data, disease occurrence data

**Software Utilized**

Esri ArcMap Desktop 10.1 and ArcScene - raster imagery and calculations, MATLAB - data modeling, Python for scripting of data extraction

**Imagery & Captions**

Precipitation data from the Tropical Rainfall Measuring Mission (or TRMM) NASA satellite, near surface temperature from the Atmospheric Infrared Sounder (or AIRS) instrument on the NASA Aqua satellite, and land surface temperature from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra NASA satellite provide inputs into the modified container inhabiting mosquito simulation model to help identify areas at high risk for dengue outbreaks over the country of Brazil.

