**NASA DEVELOP National Program**

**Maryland - Goddard**

****

*Project Summary – Fall 2017*

**Western Europe Health & Air Quality**

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

**VPS Title:** Taking a Bite Out of Mosquito-borne Illness: Mapping and Monitoring Vector-borne Diseases in Western Europe

**Project Team**

***Project Team*:**

Gia Mancini (Project Lead), gia.mancini@nasa.gov

Douglas Gardiner

Victor Lenske

Dr. Sara Lubkin

Helen Plattner

Luisa Silva

Alison Thieme

Aaron Warga

***Advisors & Mentors*:**

Dr. Assaf Anyamba (Universities Space Research Association, NASA Goddard Space Flight Center)

Dr. John Bolten (NASA Goddard Space Flight Center)

**Project Overview**

***Project Synopsis*:**

Vector-borne diseases are known to run rampant through developing nations; however, these diseases are also becoming increasingly common in developed areas of the world. In recent years, Western Europe has seen a spike in vector-borne disease outbreaks. In response to this concern, researchers, citizen scientists, and several international organizations are working together as the Global Mosquito Alert Consortium to monitor mosquito habitats and breeding grounds. Even so, predicting and preventing outbreaks remains a serious challenge. The NASA DEVELOP team combined NASA Earth observations with the Global Mosquito Alert Consortium’s citizen science data to create a methodology and habitat suitability map to aid end users in monitoring and mitigating vector-borne disease outbreaks.

***Abstract*:**

Vector-borne diseases, caused by pathogens and parasites, are transmitted through living organism carriers known as vectors. Mosquitoes, the most common disease vectors, transmit illnesses such as Zika, West Nile, chikungunya, malaria, dengue, and yellow fever, which affect millions of people across the world and kill more than one million people each year. While vector-borne disease outbreaks are difficult to predict, the Global Mosquito Alert Consortium strives to monitor and mitigate outbreaks through research and citizen science. This approach presents several challenges, including a lack of data standardization across different regions. The NASA DEVELOP team utilized NASA Earth observations and Global Mosquito Alert Consortium citizen science data from countries in Western Europe in order to create a methodology and habitat suitability map to improve prediction models for vector-borne diseases. The MaxEnt habitat modeling software was used to combine different environmental factors and citizen science data to determine which variables are correlated with the presence of mosquitoes. These products will be implemented in an interactive, open-source platform in the subsequent term for easier visualization and representation of habitat suitability.

**Keywords:**

Vector-borne disease, mosquito, Western Europe, citizen science, ArcMap, MaxEnt, MODIS

***National Application Area Addressed:*** Health & Air Quality

***Study Location:*** Western Europe (Belgium, Italy, Spain, The Netherlands)

***Study Period:*** June 2016 – September 2017

***Community Concern:***

* Over one million people die each year from mosquito-borne diseases.
* Rising temperatures have increased suitable habitat area for disease vectors, expanding the range of mosquitoes and leading to an increased number of outbreaks.
* The citizen science data gathered from Belgium, Italy, Spain, and The Netherlands are not standardized, so a methodology is necessary to help streamline information-sharing between collaborators.

***Project Objectives:***

* Integrate NASA Earth observations and citizen science data in countries across Western Europe
* Determine environmental variables to map mosquito habitats and breeding grounds
* Create a methodology to improve outbreak prediction models for vector-borne diseases
* Visualize results on an interactive habitat suitability map

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Global Mosquito Alert Consortium** | Dr. John Palmer, Marie Curie Research Fellow and Professor | End User | Yes |
| **The Woodrow Wilson International Center for Scholars** | Dr. Anne Bowser, Senior Program Associate, Science and Technology Innovation Program | Collaborator | Yes |
| **Citizen Science Association** | Greg Newman, co-Chair, Data and Metadata Working Group  | Collaborator | Yes |
| **European Citizen Science Association** | Martin Brocklehurst, Policy Group Chair | Collaborator | Yes |
| **Institute for Global Environmental Strategies** | Dr. Russanne Low, Senior Scientist | Collaborator | Yes |
| **Wageningen University** | Dr. Arnold van Vliet, Biologist | Collaborator | No |
| **Sapienza Università Di Roma** | Dr. Beniamino Caputo, Medical Entomologist | Collaborator | No |

***Decision Making Practices & Policies***:

The end user of this project is the Global Mosquito Alert Consortium. This group is comprised of several independent citizen scientist projects focused on using mobile apps with geolocation capabilities to collect an array of vector data. The Global Mosquito Alert Consortium has obtained support from the United Nations Environment Programme (UNEP) to display mosquito data on UNEP’s Environment Live online platform. Governance of the organization is heterarchical, with Dr. John Palmer and Dr. Frederic Bartumeus acting as project co-leads and primary decision-makers, and coordinating with UNEP’s Environment Live digital development team. Directly below leadership, project participation in the Global Mosquito Alert Consortium is centralized through the Citizen Science Association (CSA) and the European Citizen Science Association (ECSA) in the United States and Europe, respectively.

***Project Benefit to End User***:

The methodology and habitat suitability map created by the NASA DEVELOP team will assist the Global Mosquito Alert Consortium in better predicting vector-borne illness outbreaks. The utilization of a prediction model that incorporates NASA Earth observations with citizen science data will allow the Global Mosquito Alert Consortium to monitor environmental variables and determine when preventative action is needed to mitigate an outbreak.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra MODIS** | Land Surface Temperature (LST), Vegetation Indices (VI) | LST and VI data were used as environmental variables for modeling mosquito habitat suitability. |
| **Aqua MODIS** | Land Surface Temperature (LST), Vegetation Indices (VI) | LST and VI data were used as environmental variables for modeling mosquito habitat suitability. |
| **GPM IMERG** | Precipitation | Precipitation was used as an environmental variable for modeling mosquito habitat suitability. |
| **SRTM**  | Elevation | Elevation was used as an environmental variable for modeling mosquito habitat suitability. |
| **Aqua AIRS** | Humidity | Humidity was used as an environmental variable for modeling mosquito habitat suitability. |

***Ancillary Datasets:***

GLOBE Observer Mosquito Habitat Mapper – *in situ* presence data for mosquitoes

Muggenradar mosquito presence locations – *in situ* presence data for mosquitoes

ZanzaMapp mosquito presence locations – *in situ* presence data for mosquitoes

Mosquito Alert mosquito presence locations – *in situ* presence data for mosquitoes and sampling effort data

European Union Copernicus Corine Land Cover (CLC2012) - land cover data for Western Europe

Gridded Population of the World, Version 4 (GPWv4) - population density data for Western Europe

Global Land Data Assimilation System - soil moisture data for Western Europe

***Modeling:***

Maximum Entropy (MaxEnt) (POC: Steven J. Phillips, AT&T Research)

***Software & Scripting:***

Esri ArcGIS v10.4.1 – raster manipulation/analysis, map creation

Python v2.7.10 - data conversion

MaxEnt v3.4.0 - habitat suitability modeling

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Western Europe Mosquito Abundance and Distribution Map Collection** | Terra MODIS, Aqua MODIS, GPM IMERG, SRTM, Aqua AIRS | A suite of static visualizations comparing the successful integration of citizen science data with Earth observations through statistical modeling provides partners with new methodologies for the surveillance and control of disease-carrying mosquitos.  | I |

**Project Handoff Package**

**Transition Plan:** End products will be transitioned in person during the final week of the term at The Woodrow Wilson International Center for Scholars located in Washington, D.C. At this time, the team will conduct a virtual handoff to discuss results and answer any questions to non-local partners. Software release is not required for this project.

*Project Continuation Plan*: During the second term, the results of term one will be integrated into an interactive, open-source map of Western Europe, showing the successful synthesis of citizen science data and Earth observations in order to monitor vector-borne diseases. Communication will be maintained throughout the second term with all partners ensuring engagement with and feedback about the tool once it passes through the software release process. The team will demonstrate the tool and discuss project results in-person at The Woodrow Wilson International Center for Scholars, with other partners joining virtually.

**Team POC:** Gia Mancini, gia.mancini@nasa.gov

**Partner POC**: Dr. Anne Bowser, Anne.Bowser@wilsoncenter.org

**Handoff Package:**

* Project Summary
* Technical Paper
* Poster
* Video Presentation
* Western Europe Mosquito Abundance and Distribution Map Collection

**References:**

Alimi, T. O., Fuller, D. O., Qualls, W. A., Herrera, S. V., Arevalo-Herrera, M., Quinones, M. L., Lacerda, M.

V. G., Beier, J. C. (2015). Predicting potential ranges of primary malaria vectors and malaria in northern South America based on projected changes in climate, land cover and human population*.* *Parasites & Vectors, 8*(1), 1-16. [https://doi.org/10.1186/s13071-015-1033-](https://doi.org/10.1186/s13071-015-1033-9)9

Altizer, S., Ostfeld, R. S., Johnson, P. T., Kutz, S., & Harvell, C. D. (2013). Climate change and infectious

diseases: From evidence to a predictive framework*.* *Science, 341*(6145), 514–519.

Anyamba, A., Linthicum, K. J., Small, J. L., Collins, K. M., Tucker, C. J., Pak, E. W., Britch, S. C., Eastman, J.

R., Pinzon, J. E., Russell, K. L. (2012). Climate Teleconnections and Recent Patterns of Human and Animal Disease Outbreaks*.* *PLoS Neglected Tropical Diseases*, *6*(1), e1465. https://doi.org/10.1371/journal.pntd.0001465

Hongoh, V., Berrang-Ford, L., Scott, M. E., & Lindsay, L. R. (2012). Expanding geographical distribution of

the mosquito, *Culex pipiens*, in Canada under climate change*.* *Applied Geography, 33*, 53–62. https://doi.org/10.1016/j.apgeog.2011.05.015

Johnson, B. J., & Sukhdeo, M. V. K. (2013). Drought-induced amplification of local and regional West Nile

virus infection rates in New Jersey*.* *Journal of Medical Entomology*, *50*(1), 195–204.

https://doi.org/10.1603/ME12035

Kazansky, Y., Wood, D., & Sutherlun, J. (2016). The current and potential role of satellite remote sensing in

the campaign against malaria*.* *Acta Astronautica*, *121*, 292–305. https://doi.org/10.1016/j.actaastro.2015.09.021

Linthicum, K. J., Anyamba, A., Tucker, C. J., Kelley, P. W., Myers, M. F., & Peters, C. J. (1999). Climate and

satellite indicators to forecast Rift Valley fever epidemics in Kenya*.* *Science, 285*(5426), 397–400.

Miller, J. (2010). Species Distribution Modeling: Species distribution modeling*.* *Geography Compass*, *4*(6), 490–

509. https://doi.org/10.1111/j.1749-8198.2010.00351.x

Morin, C. W., & Comrie, A. C. (2013). Regional and seasonal response of a West Nile virus vector to climate

change*.* *Proceedings of the National Academy of Sciences*, *110*(39), 15620–15625. https://doi.org/10.1073/pnas.1307135110

Neteler, M., Roiz, D., Rocchini, D., Castellani, C., & Rizzoli, A. (2011). Terra and Aqua satellites track tiger

mosquito invasion: Modelling the potential distribution of Aedes albopictus in north-eastern Italy*.* *International Journal of Health Geographics*, *10*(1), 49. https://doi.org/10.1186/1476-072X-10-49

Phillips, S. J., & Dudík, M. (2008). Modeling of species distributions with Maxent: New extensions and a

comprehensive evaluation*.* *Ecography*, *31*(2), 161–175.

Reiny, Samson. Using NASA Satellite Data to Predict Malaria Outbreaks.NASA. (2017).

https://www.nasa.gov/feature/goddard/2017/using-nasa-satellite-data-to-predict-malaria-outbreaks

Tonnang, H. E., Tchouassi, D. P., Juarez, H. S., Igweta, L. K., & Djouaka, R. F. (2014). Zoom in at African country level: Potential climate induced changes in areas of suitability for survival of malaria vectors. *International Journal of Health Geographics*, *13*(1), 12.