**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Maryland – Goddard**

**Western Europe Health & Air Quality II**

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

**Project Overview**

***Project Synopsis*:** The objective of this project is 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. Project partners at the Global Mosquito Alert Consortium, the Woodrow Wilson International Center for Scholars, the Citizen Science Association (CSA), and the Institute for Global Environmental Strategies are working towards a shared, coordinated platform and protocol to leverage citizen science for the global surveillance and control of disease-carrying mosquitoes. During Term II, the results of Term I will be integrated into an open-source interactive map of Western Europe, showing the successful culmination of citizen science data and Earth observations, including Terra MODIS, Aqua MODIS, and GPM IMERG, in order to monitor vector-borne diseases. The results of this project will help advance the use of citizen science in scientific research while incorporating technology to assist further research.

***Community Concern:*** Vector-borne diseases are pathogens that are transmitted to human populations by an arthropod vector. Over one million people worldwide die from mosquito-borne illnesses every year, including malaria, Zika, West Nile, yellow fever, and dengue. However, fighting these is insurmountable without an understanding of the environmental conditions that promote mosquito breeding. Partner organizations are working to monitor and eradicate mosquito-borne disease risk through citizen science. But existing approaches have two limitations: (1) diverse types of data (on species presence, breeding, etc.) are rarely integrated and information collected by local initiatives is not always combined with national or global-scale data, and (2) while scientists are working to understand how satellite data can improve predictions on the timing and location of disease outbreaks, there is a need to integrate remote sensing data with information collected by citizen scientists for ground truth validation.

***Source of Project Idea:*** In February 2017, the Center Lead of DEVELOP at Goddard Space Flight Center

(GSFC), met with Anne Bowser, PhD, at the Wilson Center to discuss potential collaborations towards the

Global Mosquito Alert using Earth observations. The idea for the project was formalized during a workshop held at the United Nations Environment Programme (UNEP) in April 2017. The workshop was co-hosted by

UNEP, The Woodrow Wilson International Center for Scholars, and the European Citizen Science

Association (ECSA). The primary result of this workshop was a commitment from all hosting partners as well as attendees to contribute to the Global Mosquito Alert – a shared, coordinated platform and protocol to leverage citizen science for the global surveillance and control of disease-carrying mosquitoes.

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

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

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

***Advisor:*** Dr. Assaf Anyamba (Universities Space Research Association)

**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, Pompeu Fabra University, Barcelona | 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, Advisor | 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 |

***End-User Overview***

***End User’s Current Decision-Making Process:*** 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 several different types of vector data. The Global Mosquito Alert Consortium has obtained support from UNEP to display mosquito data on UNEP’s Environment Live web 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 interfacing with UNEP’s Environment Live digital development team. Directly below leadership, project participation in the Global Mosquito Alert Consortium is centralized through CSA and ECSA in the United States and Europe.

***End User’s Capacity to Use NASA Earth Observations:***

*Global Mosquito Alert Consortium* – The Global Mosquito Alert Consortium is actively developing procedures and projects for public health officials and mosquito control agencies worldwide. This network of officials employs models of mosquito vector population growth, invasive species range expansion, and epidemics that have historically been based on remotely sensed environmental data. This project will add data that can be considered in these models by providing near-sensed, ground based observations and support the development of vector-borne disease risk model.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*The Woodrow Wilson International Center for Scholars* – The Wilson Center will provide strategic guidance, connect

 the DEVELOP team with project partners, and support the team through bi-weekly meetings. The

Wilson Center will disseminate the project’s results through the Global Mosquito Alert Consortium

 and to partners at the Federal Community of Practice for Crowdsourcing and Citizen Science.

*Citizen Science Association* – The Data and Metadata Working Group of the Citizen Science Association will

conduct outreach on this project in the US and internationally, emphasizing the value of triangulating

citizen science and remote sensing data to solve health challenges.

*European Citizen Science Association* – The European Citizen Science Association will conduct outreach on this

project in Europe and internationally, emphasizing the value of triangulating citizen science and

remote sensing data to solve health challenges.

*Institute for Global Environmental Strategies* – The Institute for Global Environmental Strategies will conduct

outreach on this project in the US and internationally, emphasizing the value of triangulating citizen

science and remote sensing data to solve health challenges.

***Dissemination by Boundary Organizations*:**

*Global Mosquito Alert Consortium* – The Global Mosquito Alert Consortium is housed on the UNEP

Environment Live website, providing this project and workshop with high profile, international

visibility. Through their extensive network of partner organizations, the Global Mosquito Alert

Consortium is well poised to transition project results and methodologies to groups who are in need

of mosquito vector data to plan risk management strategies.

*The Woodrow Wilson International Center for Scholars* – The Wilson Center hosts the Science and Technology

Innovation Lab, which promotes open and interoperable citizen science data. The lab is also a key

component of CitizenScience.gov, as well as a participant in the Global Mosquito Alert Consortium.

The Wilson Center is well poised to transition project results and methodologies to groups who are

in need of mosquito vector data to plan risk management strategies.

*Citizen Science Association* – CSA promotes the use of citizen science data in the US and internationally. Their

goal is to advance the field of citizen science through innovation and collaboration, and currently

partner with natural history museums in the US and Europe, along with other international

organizations. Their partnerships allow the capacity to transition project results and methodologies

to groups who are in need of mosquito vector data to plan risk management strategies.

*European Citizen Science Association* – ECSA draws on over 200 individual and organizational members from

over 28 countries across the European Union and beyond. They have grown from an informal

network of researchers and communicators interested in Citizen Science into the European

reference network of Citizen Science initiatives. Through their extensive network of partner

organizations, ECSA is well poised to transition project results and methodologies to groups who

are in need of mosquito vector data to plan risk management strategies.

*Institute for Global Environmental Strategies* – The Institute for Global Environmental Strategies focuses on space

science education, communication, and outreach. They work closely with US and international

partners to foster cooperation in using Earth observations, and members of their staff work closely

with the NASA Earth Science Education and Public Outreach Forum, as well as GLOBE Observer.

The institution is well poised to transition project results and methodologies to groups who are in

need of mosquito vector data to plan risk management strategies.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team lead will serve as the main point of contact for communication with project partners. They will communicate through bi-weekly teleconferences and email updates as necessary.

***Transition Plan*:** End products will be transitioned in person during week 10 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 will likely be required.

***Letters of Support*:** Dr. John Palmer, Marie Curie Research Fellow and Professor, Pompeu Fabra University, Barcelona

**Earth Observations Overview**

***Earth Observations:***

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

***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 – land cover

NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPW) version 4

***Modeling:***

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

***Software & Scripting:***

Google Earth Engine API – acquisition, mapping, classification of MODIS data

Esri ArcGIS – raster manipulation, analysis, map creation

R – data extraction and statistical analysis

Exelis ENVI – raster manipulation/analysis

TerrSet – species distribution modeling

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Google Earth Engine Interactive Vector-Borne Risk Map**  | Partners will use the Google Earth Engine interface to process additional imagery and citizen science data and to create risk maps, which can be layered with socio-economic data.  | The instruments on board the Terra (MODIS), Aqua (MODIS), GPM (IMERG), and SRTM platforms will be used in deriving bioclimatic variables for modeling mosquito risk with citizen science and ancillary data. | IV |

***End-User Benefit*:** The proposed work will provide data summaries and maps that can be used by public health authorities in decision-making processes with respect to mosquito vector control and disease risk abatement. Additionally, data products will provide the Global Mosquito Alert Consortium with a proof of concept showing how mosquito vector data collected by citizen scientists can be combined with satellite data to provide critical planning and analysis tools to reduce the health risks posed by mosquitoes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 terms: 2017 Fall to 2018 Spring

***Multi-Term Objectives:***

* **Term 1:** 2017 Fall (GSFC) – Western Europe Health & Air Quality
	+ The first term of the project created methodology and ran models to understand the location and timing of disease outbreaks and improve predictions for vector-borne disease. Close partner interaction with visits to partner offices in Washington, DC as well as virtual meetings with European counterparts helped to ensure a collaborative endeavor. The first term set the stage for a subsequent term when the model will be implemented in a near real-time tool created in Google Earth Engine incorporating socio-economic data.End products were transitioned in person during the final week of the term at The Woodrow Wilson International Center for Scholars located in Washington, D.C.
* **Term 2 (Proposed Term):** 2017 Fall (GSFC) – Western Europe Health & Air Quality II
	+ The second term of the project will integrate the results of the model into an open source platform, Google Earth Engine, providing partners with an interactive map comparing the successful integration of citizen science data with Earth observations allowing for near real-time monitoring of vector-borne disease in Western Europe. Communication will be maintained throughout the second term with all partners ensuring engagement and feedback of the tool once it passes through the software release process. Handoff will be in-person at the Wilson Center, with other partners joining virtually to demo the tool and discuss results of the project.

***Previous Terms:***

2017 Fall (GSFC) – Western Europe Health & Air Quality: Monitoring Mosquito Abundance and Distribution to Assist Vector-Borne Disease Management in Western Europe

***Related DEVELOP Work:***

Spring 2013 (IRI) – Ethiopia Health & Air Quality: Utilizing NASA EOS to Improve Early Warning and Mitigation of Malaria in Ethiopia

Fall 2013 (JPL) – Utilizing NASA Earth Observations for Forecasting Dengue Vector-Borne Disease Outbreaks

Fall 2014 (IRI) – Zanzibar Health & Air Quality: Creating a Land Cover Map Using NASA Earth Observations to Identify Locations of Malaria Transmission in Zanzibar

Spring 2016 (ARC) – Puerto Rico Health & Air Quality: A Geospatial Assessment of Environmental Variability in Puerto Rico and Its Relation to Confirmed Dengue Fever Cases

**Notes & References:**

***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*, 1-16

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

diseases: From evidence to a predictive framework. *Science*, *341*, 514–9

Anyamba, A. Small, J., Britch, S., Tucker, C., Pak, E., Reynolds, C., Crutchfield, J., & Linthicum, K. (2014).

Recent weather extremes and impact on agricultural production and vector-borne disease outbreak patterns. *PLoS ONE*, *9*(3), 1-9. doi:10.1371/journal.pone.0092538

Anyamba, A., Chretien, J., Small, J., Tucker, C.J., Formenty, P.B., Richardson, J.H.,…Linthicum, K.J. (2009).

Prediction of a Rift Valley fever outbreak. *Proceedings of the National Academy of Sciences*, *106*, 955–959

Anyamba, A., Linthicum, K.J., Small, J.L., Collins, K.M., Tucker, C., Pak, E.W….Russell, K.L. (2012).

Climate teleconnections and recent patterns of human and animal disease outbreaks. *PLoS Neglected Tropical Diseases, 6*(1), e1465

Federal Crowdsourcing and Citizen Science Toolkit 2016. Retrieved from https://crowdsourcing-

toolkit.sites.usa.gov/

Hahn, M., Monaghan, A., Eisen, R., Delorey, R., Lindsey, N., & Fisher, M. (2005). Meteorological conditions

associated with increased incidence of West Nile virus disease in the United States, 2004-2012. *The American Journal of Tropical Medicine and Hygiene, 92*, 1013-1022

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

mosquito, Culex pipiens, in Canada under climate change. *Applied Geography, 33,* 53-62

Hotez, P. (2016, April 8). Opinion | Zika Is Coming. *New York Times* Retrieved from

<https://www.nytimes.com/2016/04/09/opinion/zika-is-coming.html?mcubz=1>

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

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

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

Kindhauser, M. K., Allen, T., Frank, V., Santhana, R. S., & Dye, C. (2016). Zika: The origin and spread of a

mosquito-borne virus. *Bulletin of the World Health Organization, 94*(9), 675-686C

Linthicum, K. J. (1999). Climate and satellite indicators to forecast Rift Valley Fever epidemics in Kenya.

*Science, 285*(5426), 397-400

Monaghan, A. J., Sampson, K. M., Steinhoff, D. F., Ernst, K. C., Ebi, K. L., Jones, B., &amp; Hayden, M. H.

(2016). The potential impacts of 21st century climatic and population changes on human exposure to the virus vector mosquito Aedes aegypti. *Climatic Change*, 1-14

Monaghan, A. J., Morin, C. W., Steinhoff, D. F., Wilhelmi, O., Hayden, M., Quattrochi, D. A., … Ernst, K.

(2016). On the seasonal occurrence and abundance of the Zika Virus vector mosquito *Aedes Aegypti* in the contiguous United States. *PLoS Currents, 8*

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

Using Satellites to Predict Malaria Risk | NOAA NESDIS. (n.d.). Retrieved from

[http://www.nesdis.noaa.gov/news\_archives/using\_satellite\_to\_predict\_malaria\_risk.html#sthash.8ZLv447Q.dpuf](http://www.nesdis.noaa.gov/news_archives/using_satellite_to_predict_malaria_risk.html#sthash.8ZLv447Q)

Thackeray, S. J. (2016). Phenological sensitivity to climate across taxa and trophic levels. *Nature, 535*, 241-245