Observations from space help scientists get one step ahead of the tiny but deadly mosquito

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Credit: AI-generated image (disclaimer)

Each year, nearly three-quarters of a million people die from mosquito-borne diseases, and with climate change the problem is getting worse. EU researchers are giving public health officials the tools they need to take targeted action fast.

Some of the deadliest animals have the smallest bites. It is a stark fact that every year more than a billion people succumb to diseases such as malaria, dengue, Zika and yellow fever. Each year these infections, carried and transmitted by bloodsucking mosquitos, account for some 700,000 deaths globally. Malaria, which represents more than half of these, is tragically most lethal for children aged under five.

Endemic already across sub-Saharan Africa, Southeast Asia and Latin America, there are warning signs these diseases are coming closer to home for those in Europe. Global trade and travel offer routes for mosquitoes to spread. Changing weather patterns, compounded by climate change, provide the conditions for species once consigned to history books to re-establish populations in Europe.

Global swarming

This threat is illustrated most visibly on the dashboard of the Early Warning System for Mosquito Borne Diseases (EYWA). Its charts for malaria, dengue, Zika, Chikungunya and West Nile virus all show a similar, worrying, upward trajectory. Since 2008, malaria cases across Europe have risen by 62%, dengue, Zika and Chikungunya are up by a remarkable 700%, and cases of West Nile virus spiked dramatically in 2018.

"The problem is really big," said Dr. Haris Kontoes, Research Director at the Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing at the National Observatory of Athens and EYWA network coordinator. "It was always a big problem considering that millions of people are affected worldwide, but in the last 10 years these diseases have been increasingly transmitted in Europe, even northern European countries," he explained.

Highlighting recent extreme flooding events, which have seen mosquito

numbers swell by up to ten times in Germany, Kontoes believes our changing climate is fuelling this trend, and the problem is growing: "In the past, these diseases were known mainly in tropical zones, but the impact of climate change is altering ecosystems and the development of mosquito populations across Europe."

Getting ahead of the curve

In response, Kontoes and his team in the EO BEYOND Center at NOA, in collaboration with core partners, Ecodevelopment, and the Laboratory of Atmospheric Physics of the University of Patras, and colleagues from 13 more partner organizations from France, Germany, Greece, Italy and Serbia, developed EYWA.

The system is helping local officials to get one step ahead of a mosquito outbreak by providing a vital early warning to take preventative action. It combines advanced modeling with Earth Observation data from the Copernicus satellites, alongside latest health, entomological (the branch of zoology concerned with the study of insects), citizen and environmental insights.

EYWA was recently awarded the inaugural European Innovation Council's (EIC) Horizon Prize on Early Warning for Epidemics, netting €5 million to further expand.

"Before EYWA we didn't know with much detail the specific areas that represented high risk of transmission of pathogens," said Kontoes. "With EYWA we have precise, and more detailed knowledge about the settlements mosquitos are expected to develop. Knowing this in advance, public health authorities can take early measures to combat the mosquito presence."

Such preventative measures include intensified spraying in high-risk

zones, but also targeted door-to-door campaigns to encourage residents to avoid leaving standing water in tanks where mosquitoes breed. The campaigns also involve mobilizing a scientific community to deploy mosquito traps.

"Knowing the population and level of mosquitos infected by viruses from trap data, we can have a much clearer idea of the precise epidemiological and entomological threat," Kontoes explained. In the nine European regions where EYWA has been operational over the past three years, there has been a massive reduction in mosquitos by up to half. Over the long term, this could drastically cut the numbers of people getting seriously ill.

The team are also using mobile apps, such as Mosquito Vision and e-bite , to develop better interactions with citizens about current mosquito alert levels.

New insights from citizen science

Kontoes and partners are not alone in spearheading ambitious tech-driven solutions to the growing mosquito threat. Computational ecologist Professor Frederic Bartumeus from the Higher Council of Scientific Investigations in Catalonia, Spain, has devoted his entire career to analyzing animal movement data. But, from baboons in the savannah to seabirds in the Pacific, events turned his focus to human–mosquito ecological interactions in 2013.

"There were lots of tiger mosquitos in north-east Spain and I wanted to help tackle an issue affecting my region," he said. His solution? A new mobile app that encourages citizens to play the role of scientists by taking pictures of mosquitoes and recording their bites to complement data and improve the accuracy of model predictions.

Fast forward seven years and Mosquito Alert, the app Bartumeus and social scientist John Palmer developed, has had hundreds of thousands of downloads. And it seems asking users to take photos of mosquitos and record their bites is surprisingly popular: "People love it! And over time we build a picture of abundance and activity, which we can use to sort and identify species with machine learning," he added.

Mosquito Alert is a key part of FARSEER: The next generation early warning system for disease vectors, one of the other finalists for the EIC Horizon Prize. FARSEER fuses citizen science from Mosquito Alert with smart traps that automatically identify species and advanced modeling integrated into a spatial decision support system. It has already been demonstrated at the municipal level in Barcelona.

For public health officials, this system offers timely and targeted risk maps to a high degree of accuracy—down to 20 meters. For scientists, it is an open project that should speed up finding solutions. For citizens, it's a two-way public engagement process that both relies on their insights and helps build their awareness.

Dealing with dengue in Southeast Asia

The team behind the Dengue forecasting MOdel Satellite-based System (D-MOSS), another of the EIC Horizon Prize finalists, has the challenges posed by dengue fever in Southeast Asia firmly in their sights.

"The main reason we're focusing on dengue is because it is the fastest spreading mosquito-borne disease in the world, the number of people living in areas at risk of dengue outbreaks has increased substantially due to environmental change, and at the same time there is no specific treatment," explained Dr. Gina Tsarouchi from the research organization HR Wallingford, which leads the consortium.

D-MOSS triangulates satellite data with the latest local insights from partners on the ground about dengue cases, principally in Malaysia, Sri Lanka and Vietnam. Its aim is simple: to provide intelligence months in advance to help officials better target resources and control outbreaks.

"Traditionally, countries take action only after dengue cases have reached a certain level. D-MOSS helps them to take pre-emptive action which in the long-run will help them save resources and save lives," Tsarouchi said.

Thanks to strong relationships with local partners where it is operational, the D-MOSS team have helped co-design the tool so that it responds to their specific needs. Part of this development has been training for local officials, which has helped them get a clearer understanding of how to interpret and apply the probabilistic forecasts D-MOSS produces.

"Of course, the tool can only go so far," said Tsarouchi. "It can, for example, give you a 60% probability of an outbreak in a province of Vietnam in three months' time. But it cannot tell you exactly what to do with that information." There are separate conversations taking place with health ministries, with support from the World Health Organization (WHO), to determine threshold levels for preventative action.

Looking ahead

So, what is the future for these systems, and could there be an opportunity for working together?

EYWA is currently expanding its network—only this year it has added two new non-European countries, Côte d'Ivoire and Thailand, to the system. It is now collaborating with the European Commission's Joint Research Centre to support authorities in addressing future pandemic risk and set new EU standards. It was also recently integrated as a pilot

in the EU's e-shape community—the flagship project to improve the application of EuroGeo space data.

For FARSEER, the team will continue to focus on developing its individual components and look for opportunities to expand. "I'm very optimistic about the future," said Bartumeus. "I think what we're trying to do is going to be the standard in mosquito-borne disease control. These ideas of generating different source data, networking data and communities, are here to stay."

As for D-MOSS, the team behind it will look to expand its reach into other parts of Asia—Bangladesh, Cambodia, India, Pakistan, the Philippines, Singapore, and Thailand are all targets. Tsarouchi is positive about its future and its potential impact: "We can make D-MOSS available to any country that needs it, and it can lead to a reduction in dengue cases."

And as for the collaboration possibilities between the three finalists? "There is certainly a possibility to complement one another going forward," said Kontoes. "We will look for common opportunities and try to see if there are possibilities of joining forces."

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