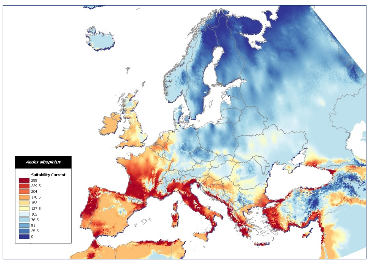


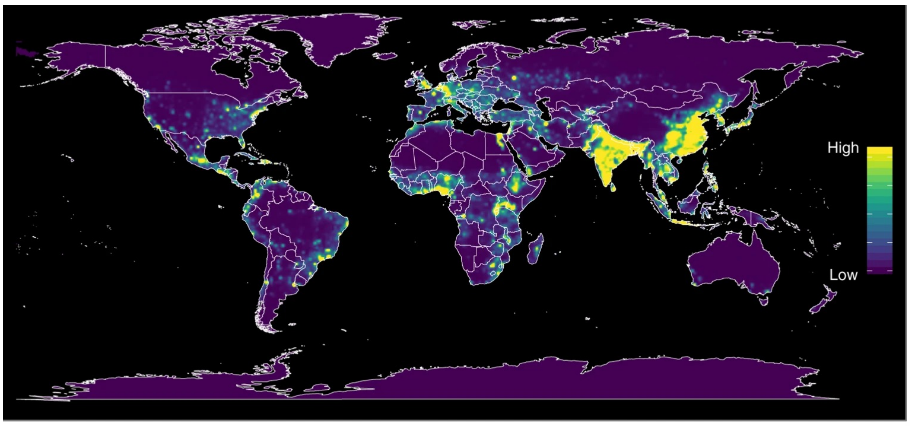

Seeing disease vectors from the sky: How far can we go?

Space for Healthcare – Brussels – 6 November 2023

A. Juache, C. Marsboom and G. Hendrickx

The problem

Increased risk for zoonotic EID events



Allen et al, **2017**, Nature Communications

The answer

There is a need for precise information on distribution, abundance, and spread of disease vectors and the diseases they transmit

But: Field surveys are labour intensive and expensive

These costs can be reduced by combining strategic sampling and spatial models and remote sensing data

But: This requires expertise and access to state-of-the-art tools and Remote Sensing data

VECMAP®

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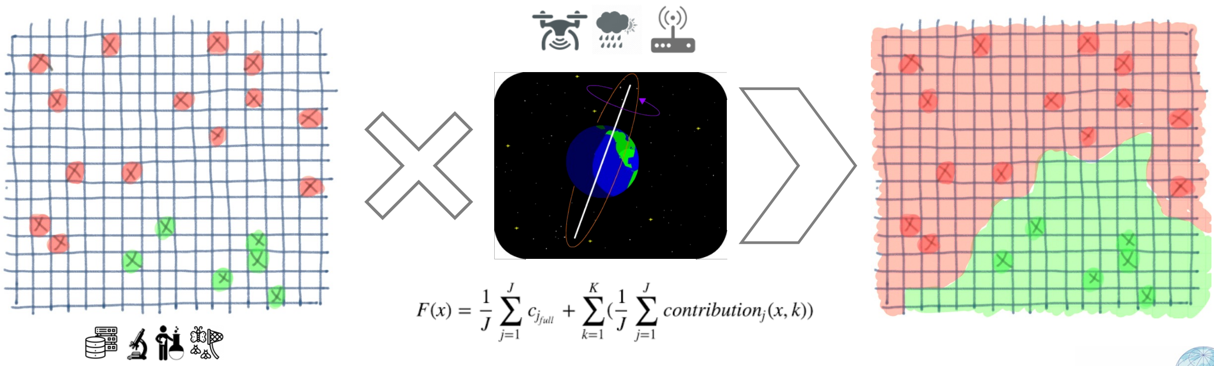
How can satellite imagery contribute?

VECMAP®



$$F(x) = \frac{1}{J}\sum_{j=1}^{J} c_{j_{full}} + \sum_{k=1}^{K}\left(\frac{1}{J}\sum_{j=1}^{J} contribution_j(x,k)\right)$$

Bringing risk mapping to the next level

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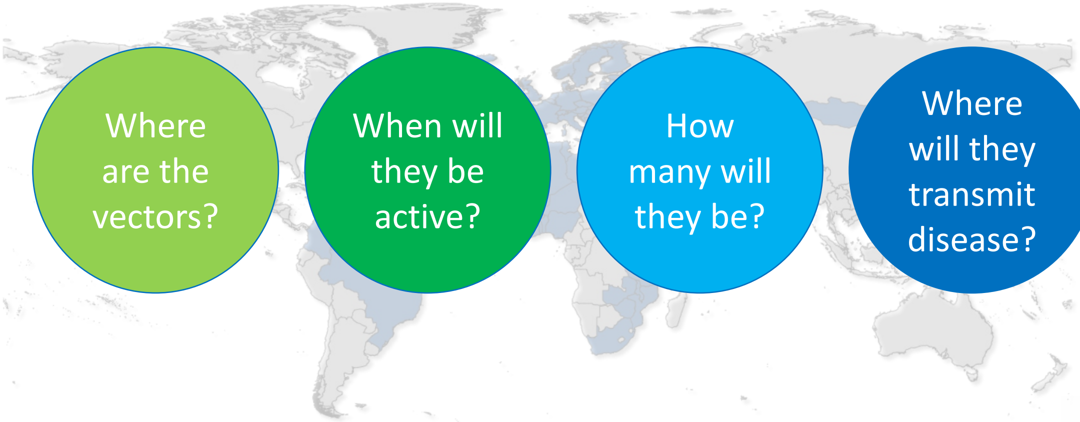
Which questions can be answered?



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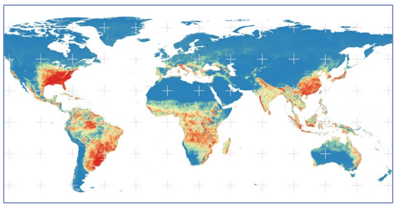
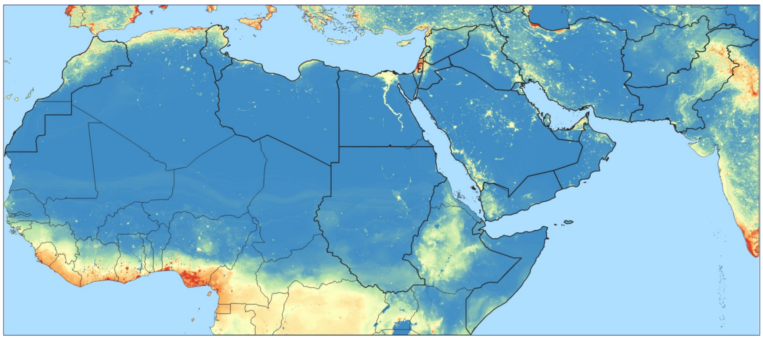
Where are the vectors?

Aedes albopictus



Global
Kraemer et al, 2015, eLIFE



WHO Eastern Mediterranean Region
Ducheyne et al, 2018,
Int. J. Health Geographics

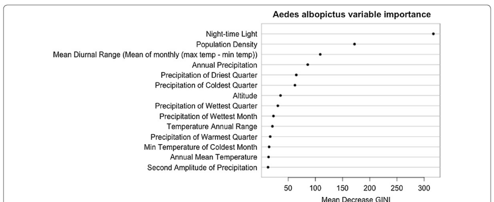


Fig. 11 Dot chart of variable importance for predicting the occurrence of *Ae. albopictus*. Only the 15 most important variables are given

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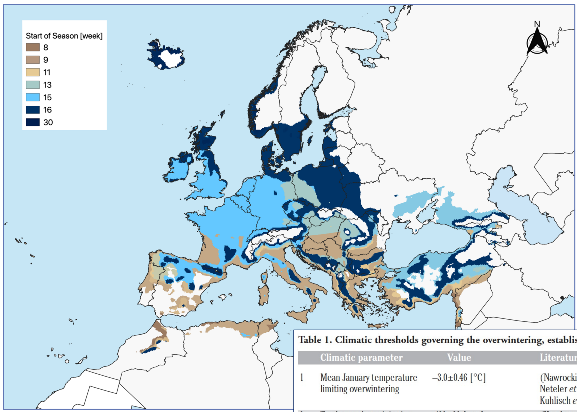
When will they be active?

Aedes albopictus



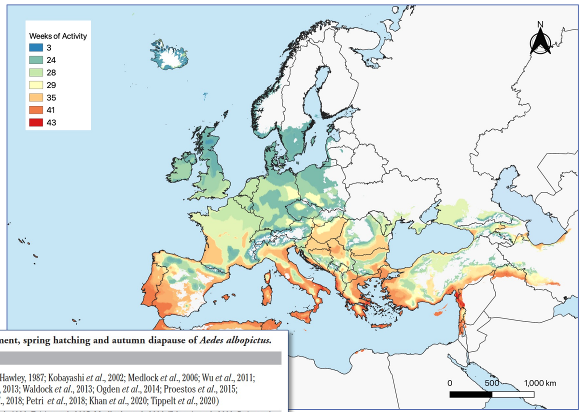


Table 1. Climatic thresholds governing the overwintering, establishment, spring hatching and autumn diapause of *Aedes albopictus*.

	Climatic parameter	Value	Literature
1	Mean January temperature limiting overwintering	–3.0±0.46 [°C]	(Nawrocki & Hawley, 1987; Kobayashi *et al*., 2002; Medlock *et al*., 2006; Wu *et al*., 2011; Neteler *et al*., 2013; Waldock *et al*., 2013; Ogden *et al*., 2014; Proestos *et al*., 2015; Kuhlisch *et al*., 2018; Petri *et al*., 2018; Khan *et al*., 2020; Tippelt *et al*., 2020)
2	Total annual precipitation limiting establishment	422±32 [mm]	(Knudsen *et al*., 1996; Eritja *et al*., 2005; Medlock *et al*., 2006; Takumi *et al*., 2009; Roiz *et al*., 2011; Neteler *et al*., 2013; Waldock *et al*., 2013; Ogden *et al*., 2014; Proestos *et al*., 2015; Cunze *et al*., 2016; Kuhlisch *et al*., 2018; Sherpa *et al*., 2019; Khan *et al*., 2020)
3	Critical temperature for spring hatching	10.6±0.36 [°C]	(Medlock *et al*., 2006; Romi *et al*., 2006; Takumi *et al*., 2009; Gatt *et al*., 2010; Mogi & Tuno, 2014; Flacio *et al*., 2016; Komagata *et al*., 2017)
4	Critical photoperiod for spring hatching	11.2±0.24 [h]	(Medlock *et al*., 2006; Romi *et al*., 2006; Takumi *et al*., 2009; Gatt *et al*., 2010; Flacio *et al*., 2016)
5	Critical temperature for autumn diapause	10.4±0.65 [°C]	(Medlock *et al*., 2006; Takumi *et al*., 2009; Mogi & Tuno, 2014; Pasquali *et al*., 2020)
6	Critical photoperiod for autumn diapause	13.3±0.06 [h]	(Focks *et al*., 1994; Toma *et al*., 2003; Medlock *et al*., 2006; Lacour *et al*., 2015; Tsunoda *et al*., 2015; Armbruster, 2016; Erguler *et al*., 2016; Xia *et al*., 2018; Pasquali *et al*., 2020)

Petric et al, 2021, Geospatial Health

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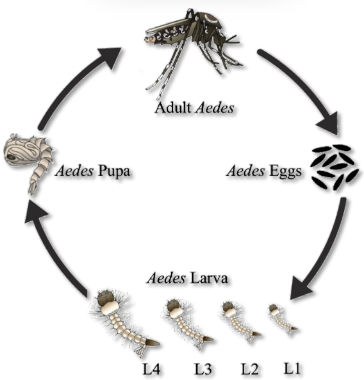
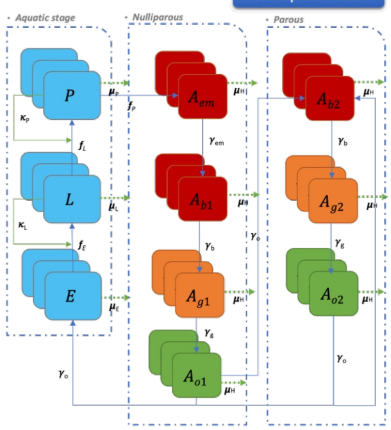
How many will they be?

Aedes aegypti



Conceptual Model

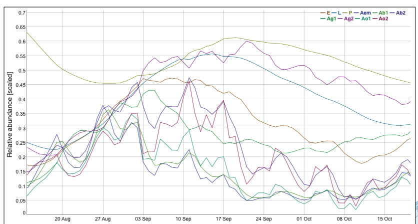


Petric 2021, PhD thesis

Table 3.4: Overview of model parameters for *Aedes aegypti*

Parameter	Description	*Aedes aegypti*	Unit
γ_{Aem}	Development rate of emerging adults	0.4	$days^{-1}$
γ_{Ab}	Development rate of bloodseeking adults	0.222	$days^{-1}$
γ_{Ao}	Ovipositing adult development rate	0.222	$days^{-1}$
$f_E(>0)$	Egg development rate f(T)	1	$days^{-1}$
f_P	Pupa development rate f(T)	$0.14 \cdot (e^{0.162(T-10)} - e^{0.162(35-10)-\frac{35-T}{5.007}})$	$days^{-1}$
f_L	Larva development rate f(T)	$\frac{f_P}{1.65}$	$days^{-1}$
$f_{Ag}(>0)$	Development rate of gestating adults f(T)	$f_{Ag} = \frac{T-T_{Ag}}{TDD_{Ag}} = \frac{T-10}{78}$	$days^{-1}$
m_E	Egg mortality rate f(T)	$m_E = \mu_E$	$days^{-1}$
m_L	Larval mortality rate f(T)	$e^{-T/2} + \mu_L$	$days^{-1}$
m_P	Pupa mortality rate f(T)	$e^{-T/2} + \mu_P$	$days^{-1}$
$m_A(>\mu_A)$	Mortality rate of A_bf(T)	0.135‡	$days^{-1}$
μ_E	Minimum egg mortality rate	0	$days^{-1}$
μ_L	Minimum larval mortality rate	0.0367	$days^{-1}$
μ_P	Minimum pupa mortality rate	0.12	$days^{-1}$
μ_{em}	Mortality rate during emergence	0.1	$days^{-1}$
μ_r	Mortality rate during bloodseeking	0.08	$days^{-1}$
μ_A	Minimum adult mortality rate	0.07	$days^{-1}$
κ_L	Carrying capacity for larvae	$8 \cdot 10^{10}$	nominal
κ_P	Carrying capacity for pupae	10^8	nominal
σ	Sex ratio at emergence	0.5	-
β	Number of eggs per A_o	$\beta_1 = 160(np)\beta_2 = 80(p)$ *	-

‡ Unpublished [38]
* np = nulliparous, p = parous



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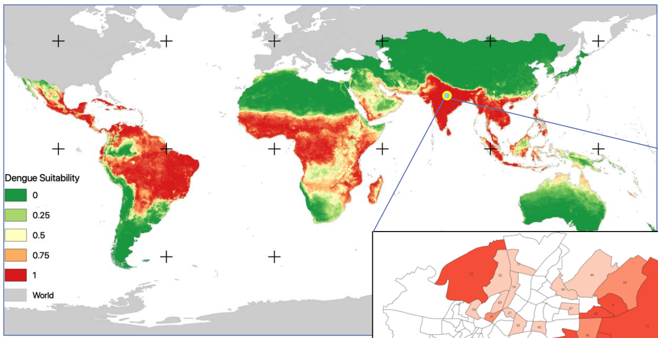
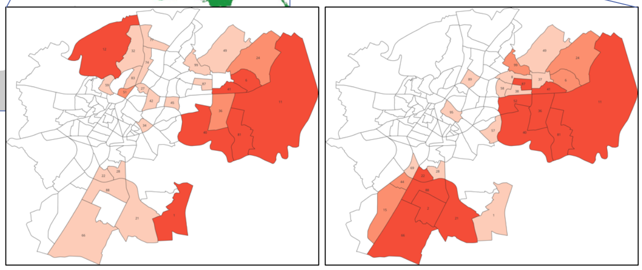
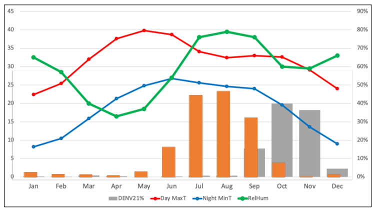
Where will they transmit disease?

Aedes aegypti / Aedes albopictus – DENGUE







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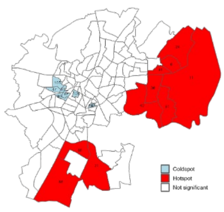
Where will they transmit disease?

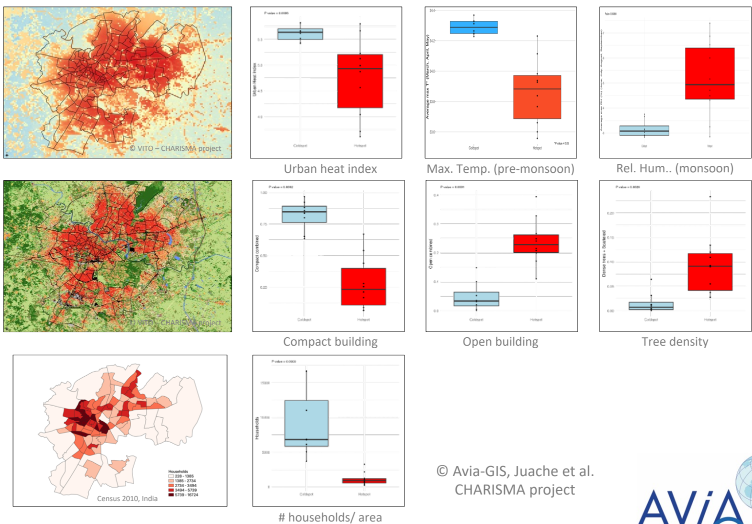
Aedes aegypti / Aedes albopictus – DENGUE



Climatic:
- Urban heat index
- Temperature
- Relative humidity

Urban Land Cover:
- Compact built
- Open built
- Tree cover

Socio-demographic:
- Households/km²



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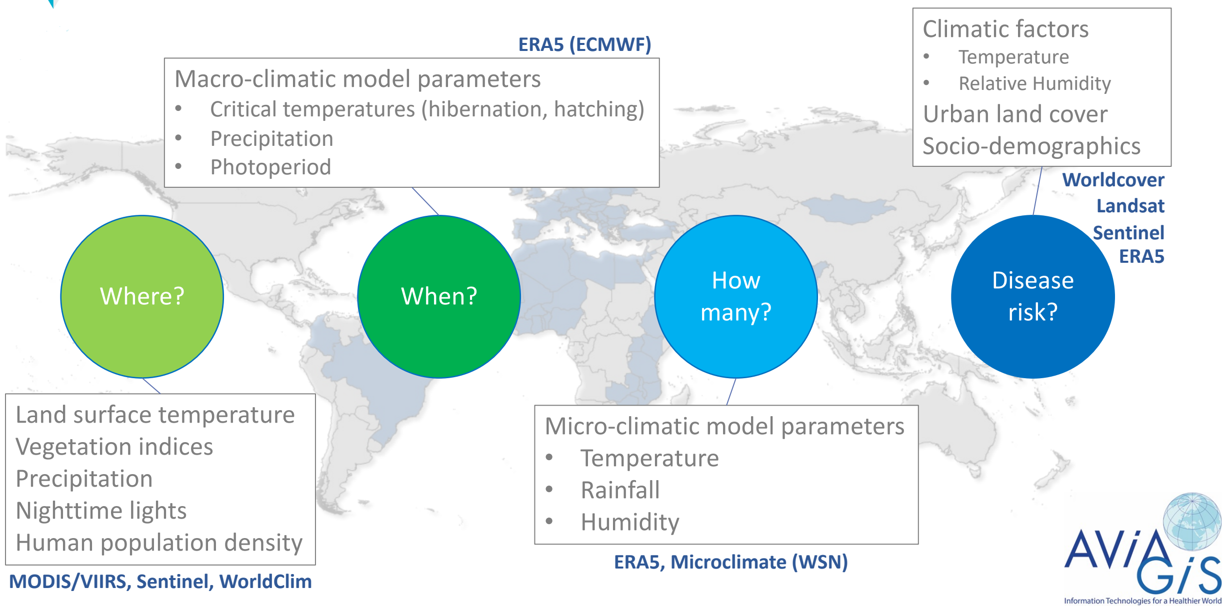
In conclusion: how can satellites contribute?



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