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The threat of vector-borne diseases in the Middle East region and Members preparedness

17th Conference of the Regional Commission for the Middle East Riyadh, Saudi Arabia

Paolo Calistri
IZS-Teramo
3 October 2023

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Today we are going to talk about…

- Three vector-borne diseases of major concern:
  - Lumpy Skin Disease
  - Rift Valley Fever
  - African Horse sickness

- Drivers of disease
- Strategies for better preparedness and response

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LUMPY SKIN DISEASE-overview

A viral disease of **cattle** characterised by severe losses, especially in naive animals.

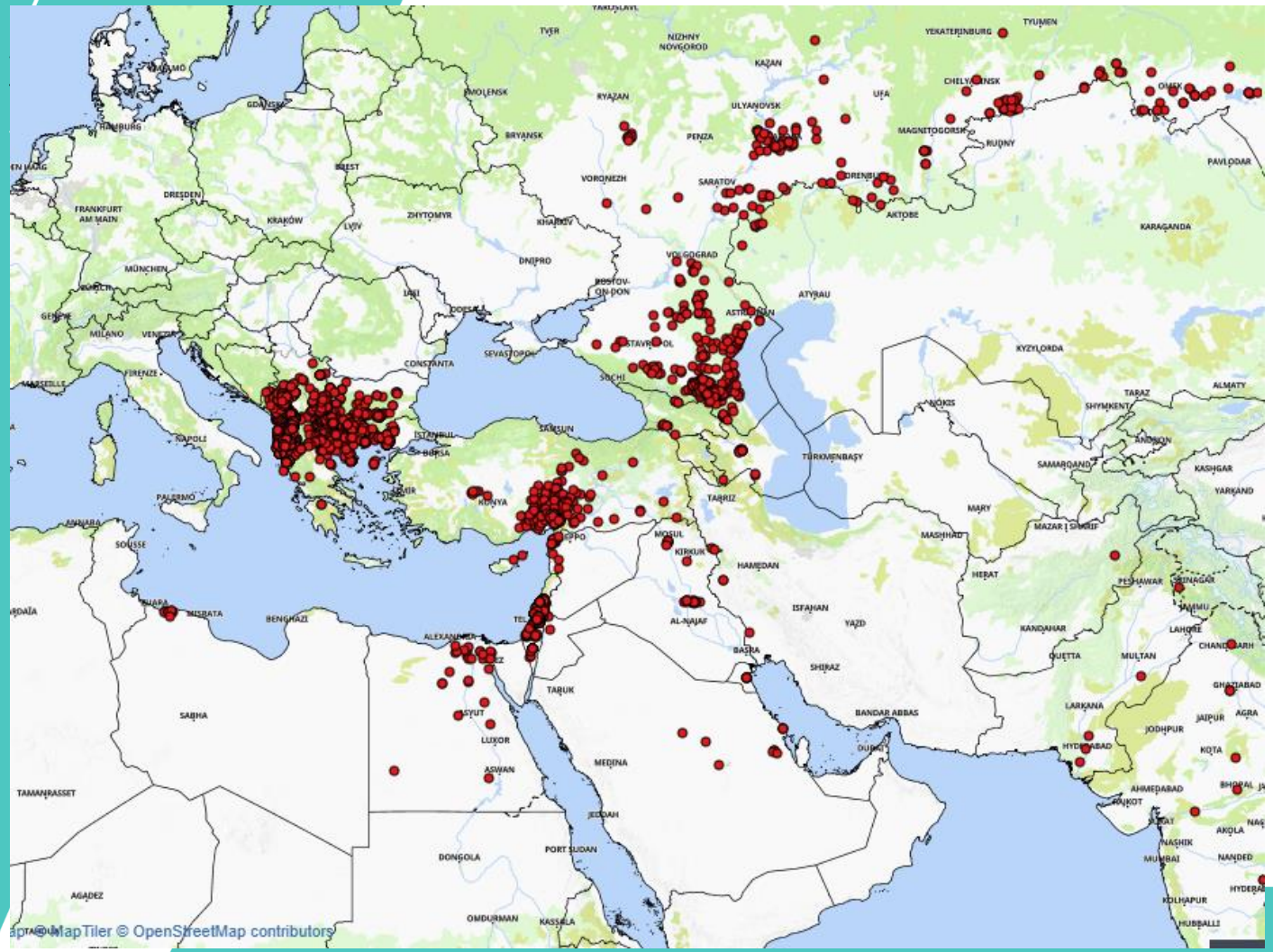
Family Poxviridae,
Subfamily Chordopoxviridae
Genus *Capripoxvirus*.

Symptoms include:

- Fever,
- Nodules on the skin, mucous membranes and internal organs
- Emaciation
- Enlarged lymph nodes
- Edema of the skin
- Sometimes death

Mechanical vectors:
Mosquitoes, biting flies and ticks

LSD – Historical perspective



1929- 1989 in Africa mainly in cattle

1989 Israel

1991-2010 WOAH official report of outbreaks in Kuwait in Lebanon Yemen, United Arab Emirates, Bahrain, Israel in and Oman, in cattle

2012: outbreaks in Turkey, Jordan, Iraq , Palestinian Autonomous Territories, Azerbaijan, Iran and Kuwait

2015 111 outbreaks in Greece; first epidemic in Russia and Saudi Arabia

2015-2021 outbreaks and cases reported in Europe, Georgia, Kazakhstan, Albania, Bulgaria, Montenegro, North Macedonia and Serbia

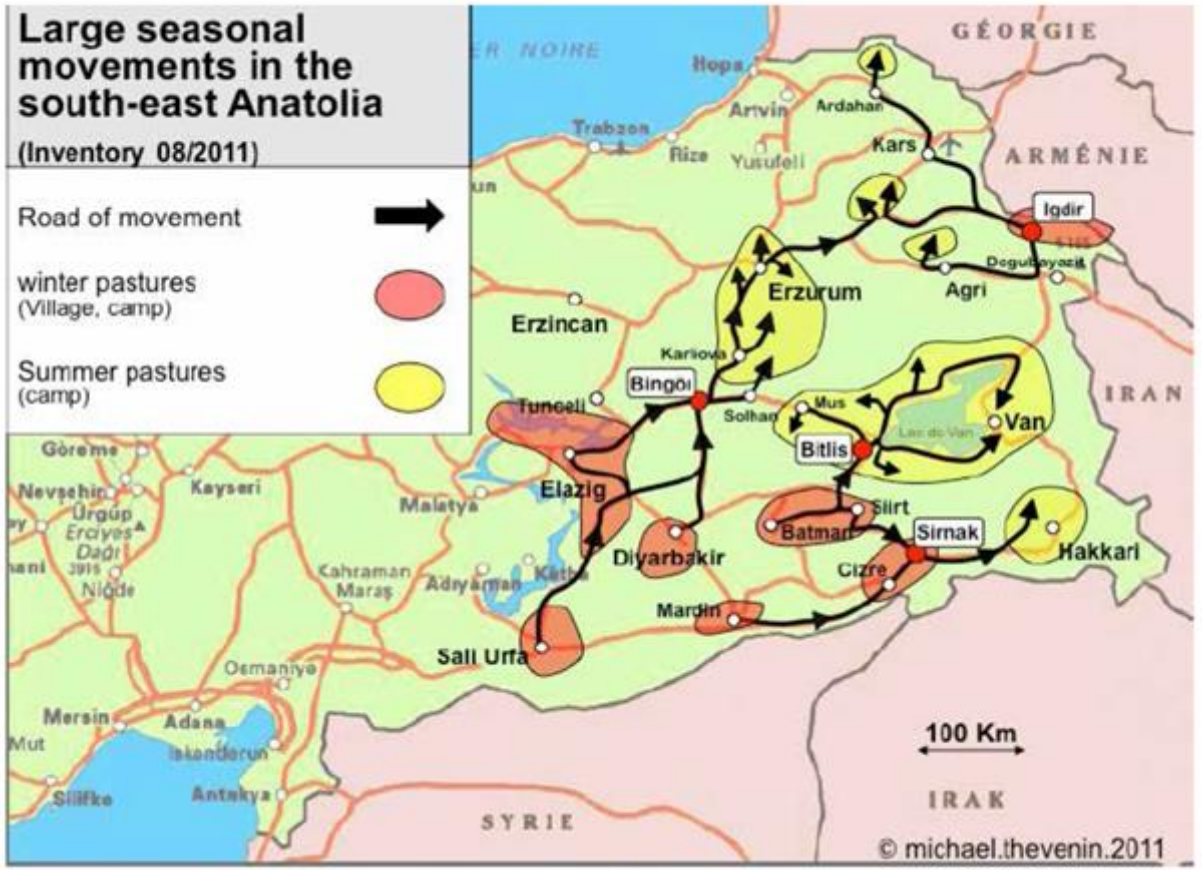
2021-2023 **in the last two years three countries reported the disease for the first time: Afghanistan, Indonesia and Lybia**

(in the map) **1970-2023** LSD outbreaks (source: FAO Empres-i)

LUMPY SKIN DISEASE–overview

- Major risks → **movements** of animals from infected areas
- Abundance of hematophagous vectors and the presence of insects breeding sites on the farm (**stagnant water and manure**)

Map B. Large seasonal movements in southeast Anatolia.



Source: Thevenin Pastoralism: Research, Policy and Practice 2011 1:23 doi:10.1186/2041-7136-1-23

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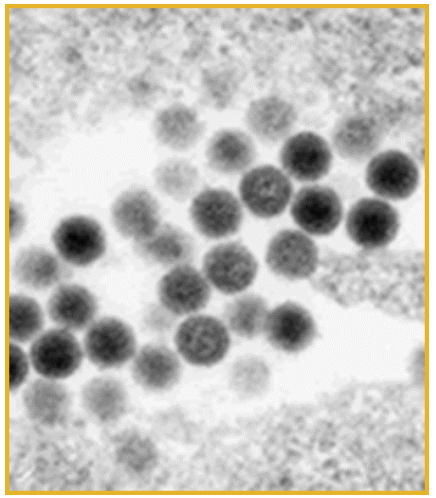
RIFT VALLEY FEVER-overview

RVF is a mosquito-borne viral disease affecting both domestic and wild ruminants, especially sheep, cattle and goats as well as humans (WOAH, 2019)

Young lambs and goats (kids) mortality rates of 70-100%.

Calves and sheep: mortality rates of 20-70%

Adult animals and humans mortality rates less than 10%



Family Phenuiviridae
Order Bunyavirales.

Symptoms include:

- Fever
- Listlessness
- Anorexia
- Disinclination to move
- Abortions and high morbidity and mortality rates in neonatal animals.
- "Abortion storm" in sheep

Vectors:
primarily by Culex spp.
and Aedes spp. mosquitoes

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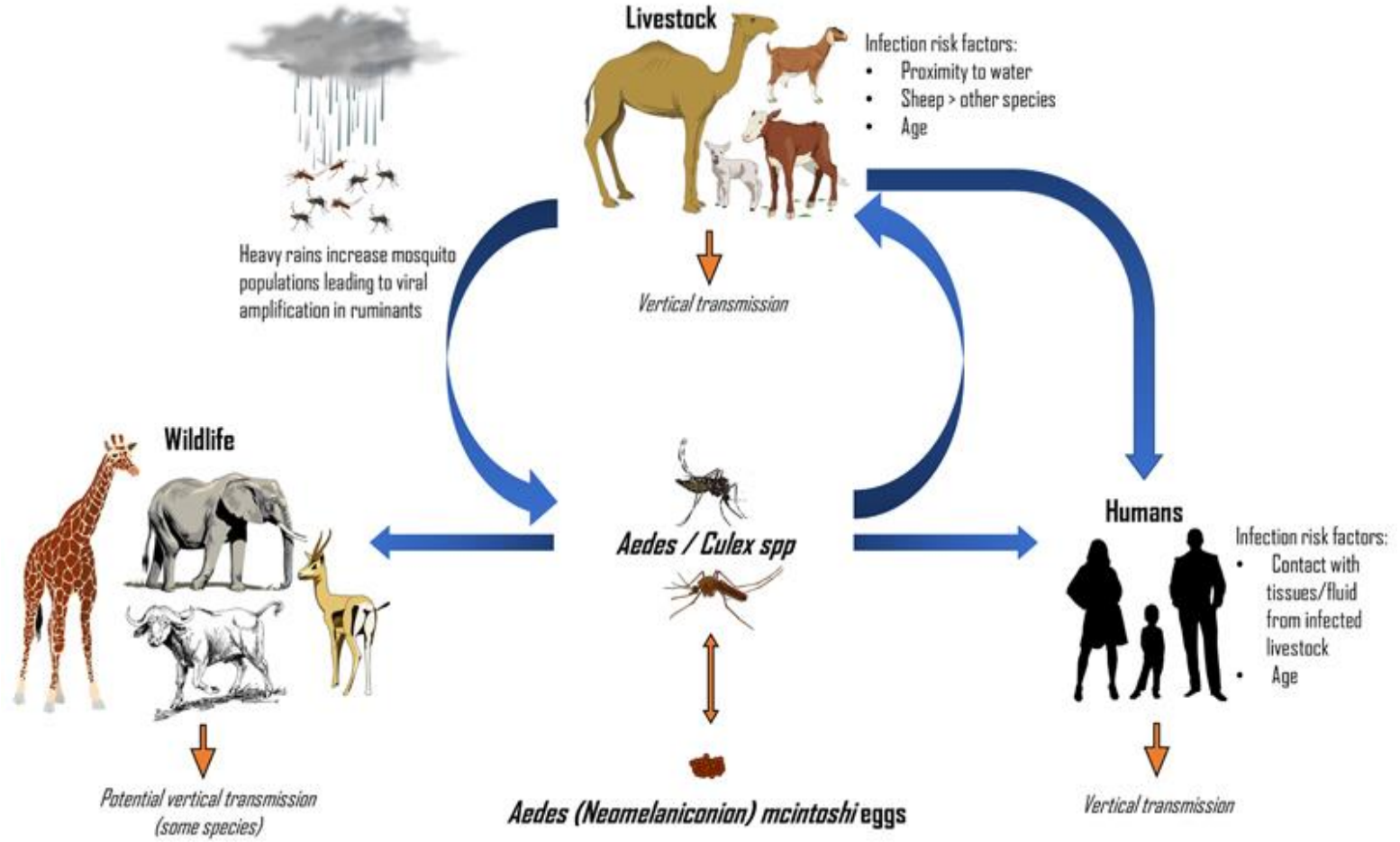
RIFT VALLEY FEVER–overview



Wright D. et al., 2019

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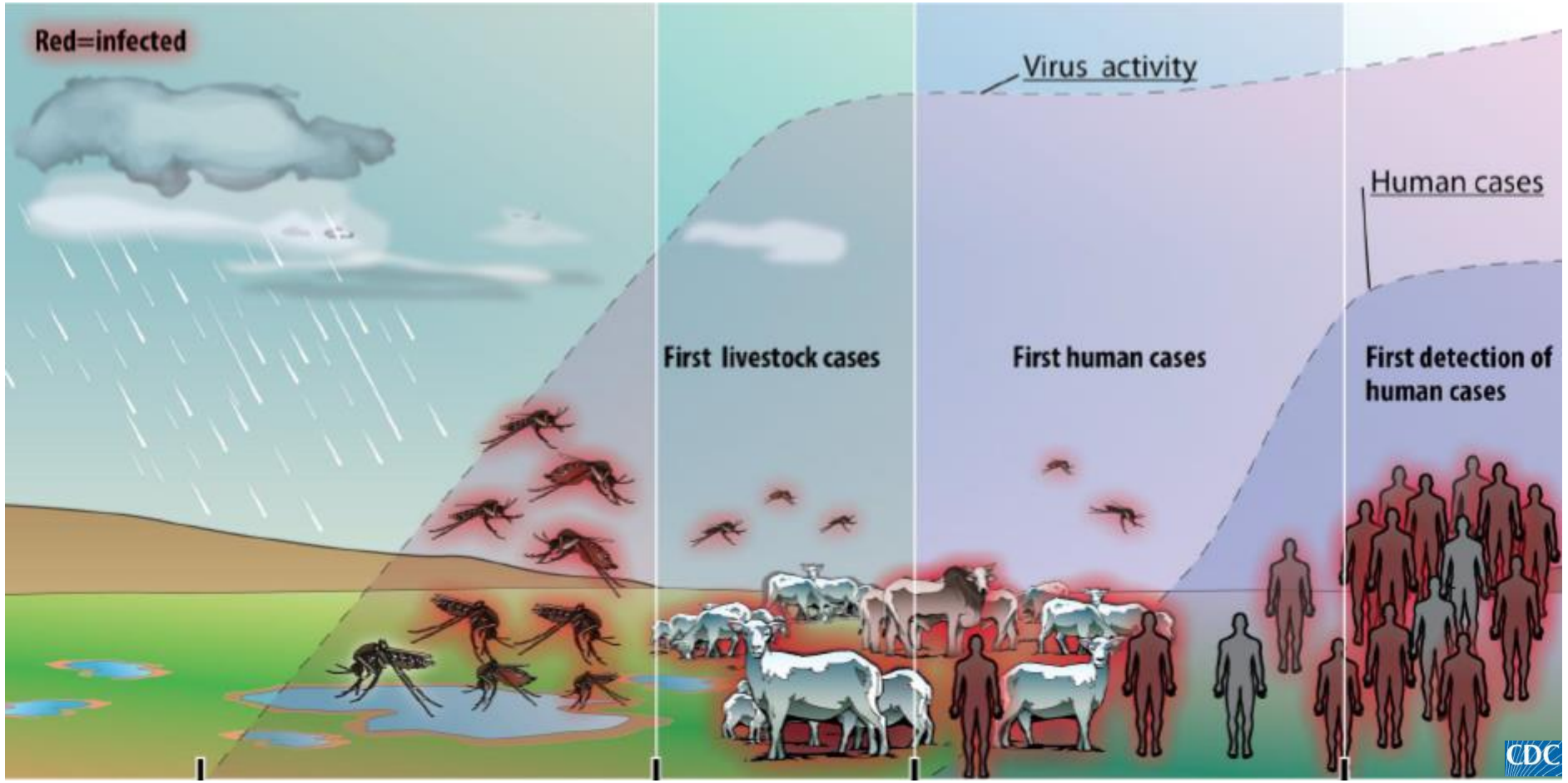

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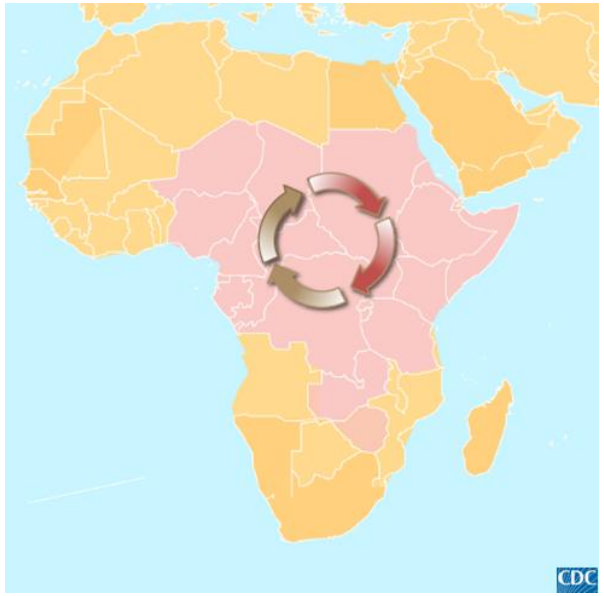

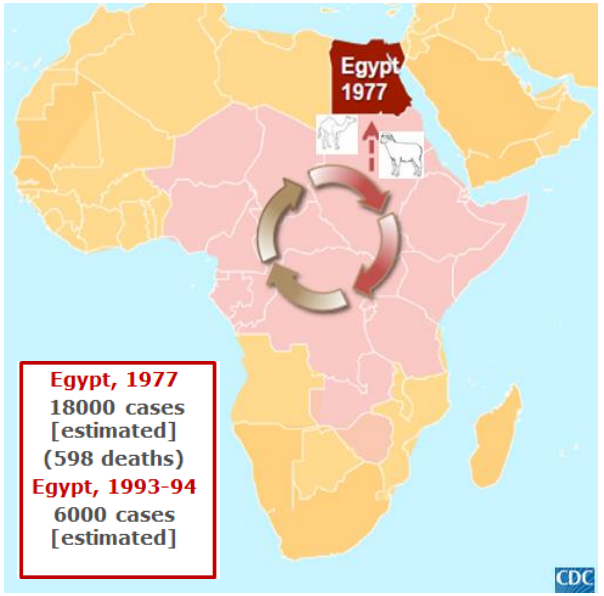

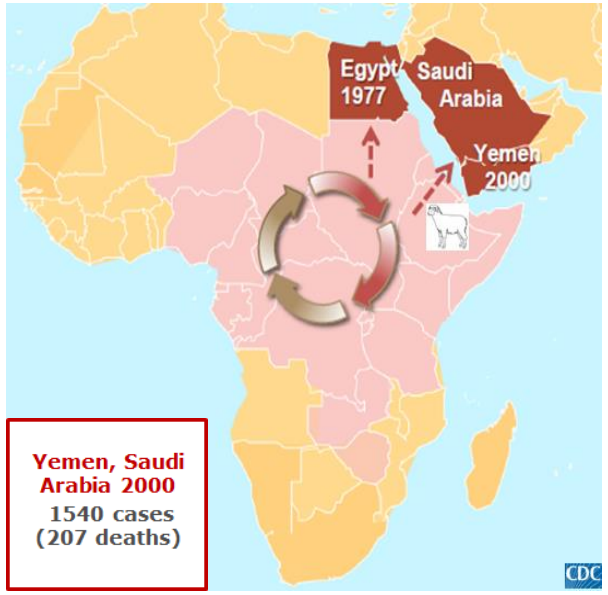

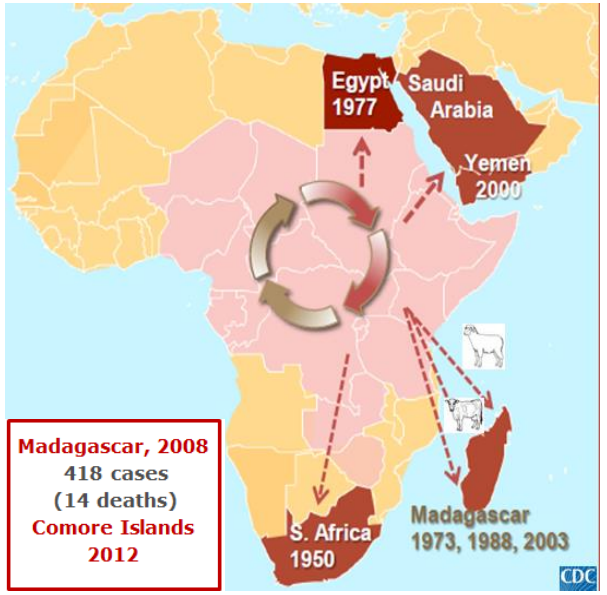

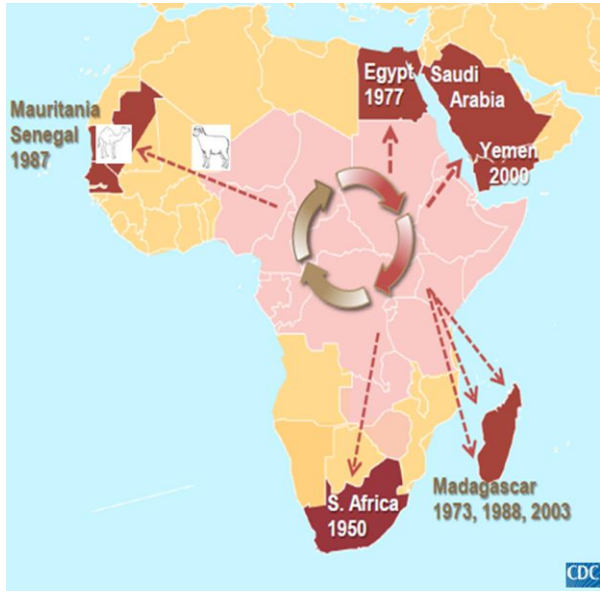

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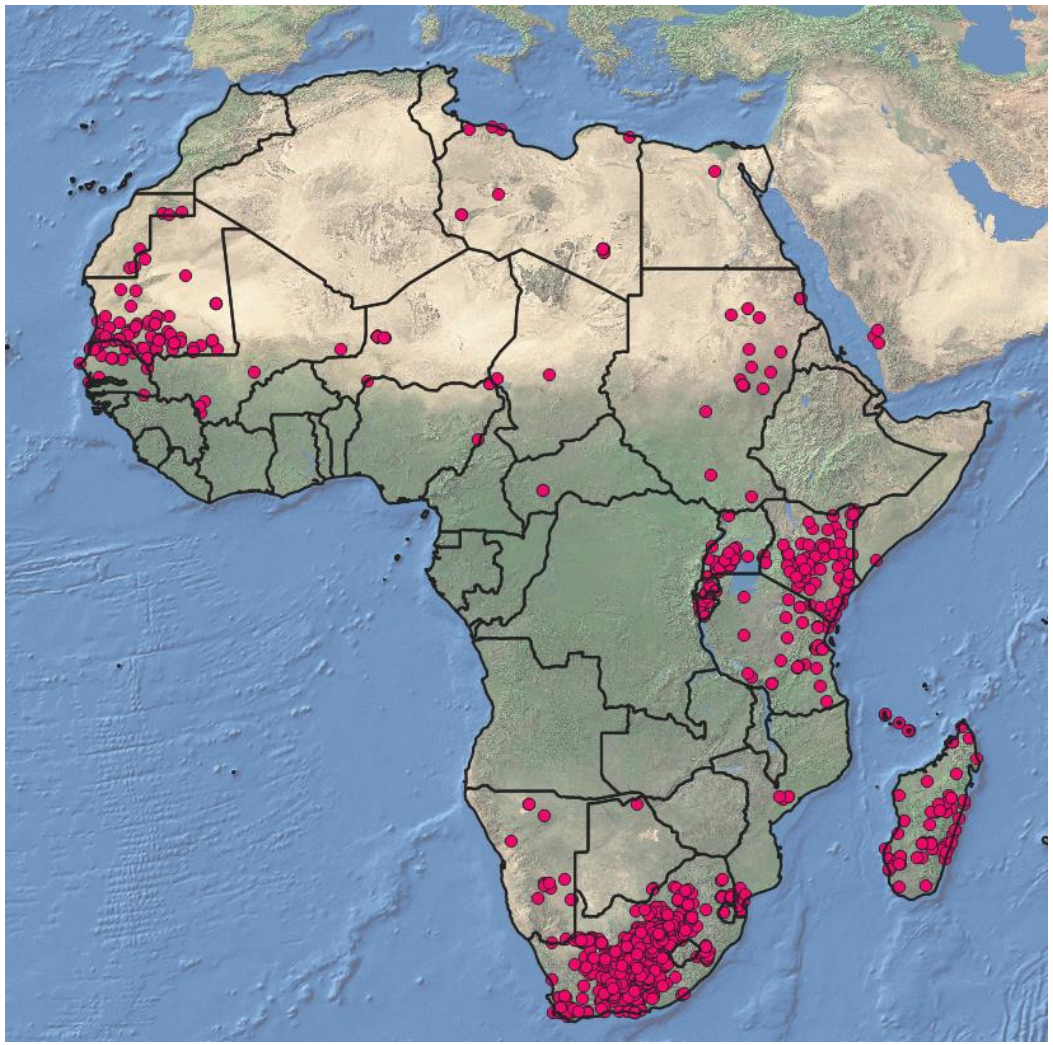
RVF cases (animals / humans) 2004-2022



Source: EMPRES-i

AFRICAN HORSE SICKNESS- overview

African horse sickness (AHS) is a non-contagious viral disease of the **solipeds** transmitted by the bite of hematophagous insects of the genus **Culicoides**

Usual hosts are equids: **horses, mules, donkeys and zebra**. **Reservoir host** are believed to be **zebras**

AHS is not zoonotic

Family Reoviridae
Genus Orbivirus

Mortality rate:
Horses 70-95%
Mules around 50%
Donkeys around 10%
Zebra and **African donkeys** subclinical

Vectors:
Culicoides spp. **C. imicola** and **C. bolitinos**
Occasional: **Culex**, **Anopheles** and **Aedes** spp.; ticks – **Hyalomma**, **Rhipicephalus**; and possibly biting flies – **Stomoxys** and **Tabanus**

Sub-acute form of African horse sickness in a horse during an outbreak in Namibia between 2006 and 2013 . Scacchia M. et al.,2015

Peracute/acute form of African horse sickness in a horse during an outbreak in Namibia between 2006 and 2013. Scacchia M. et al.,2015

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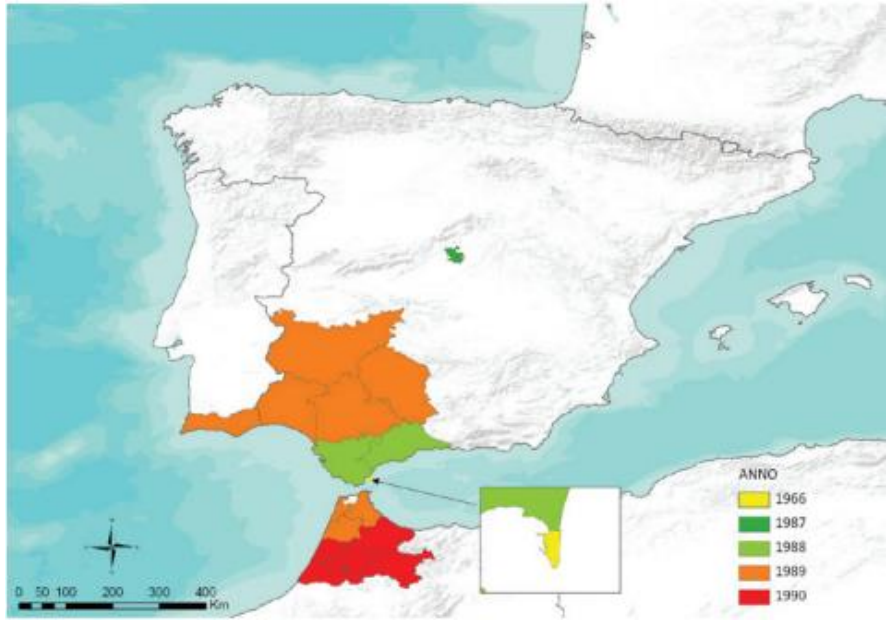
AHS-Historical perspective



Spread of African horse sickness in the Iberian Peninsula during of the epidemics of 1966 and 1987-1990- BENV https://www.izs.it/BENV_NEW/index.html

1943–1944 in Egypt, Syria, Jordan, Lebanon and Palestine

1959– 1960 outbreaks which caused the death of over 300,000 equids occurred in the Middle_East and Southwest Asia (Cyprus, Turkey, Lebanon, Iran, Iraq, Syria, Jordan, Palestine, Pakistan and India)

1965 AHS was first reported in Morocco before reaching Algeria and Tunisia and crossing the Strait of Gibraltar into Spain in 1966. Serotype 9

1987: second epizootic in Spain. Despite 38.000 equids vaccinated it propagated to Portugal and Morocco in 1989. Serotype 4

2007 till now West and East Africa numerous outbreaks with mild clinical outcomes

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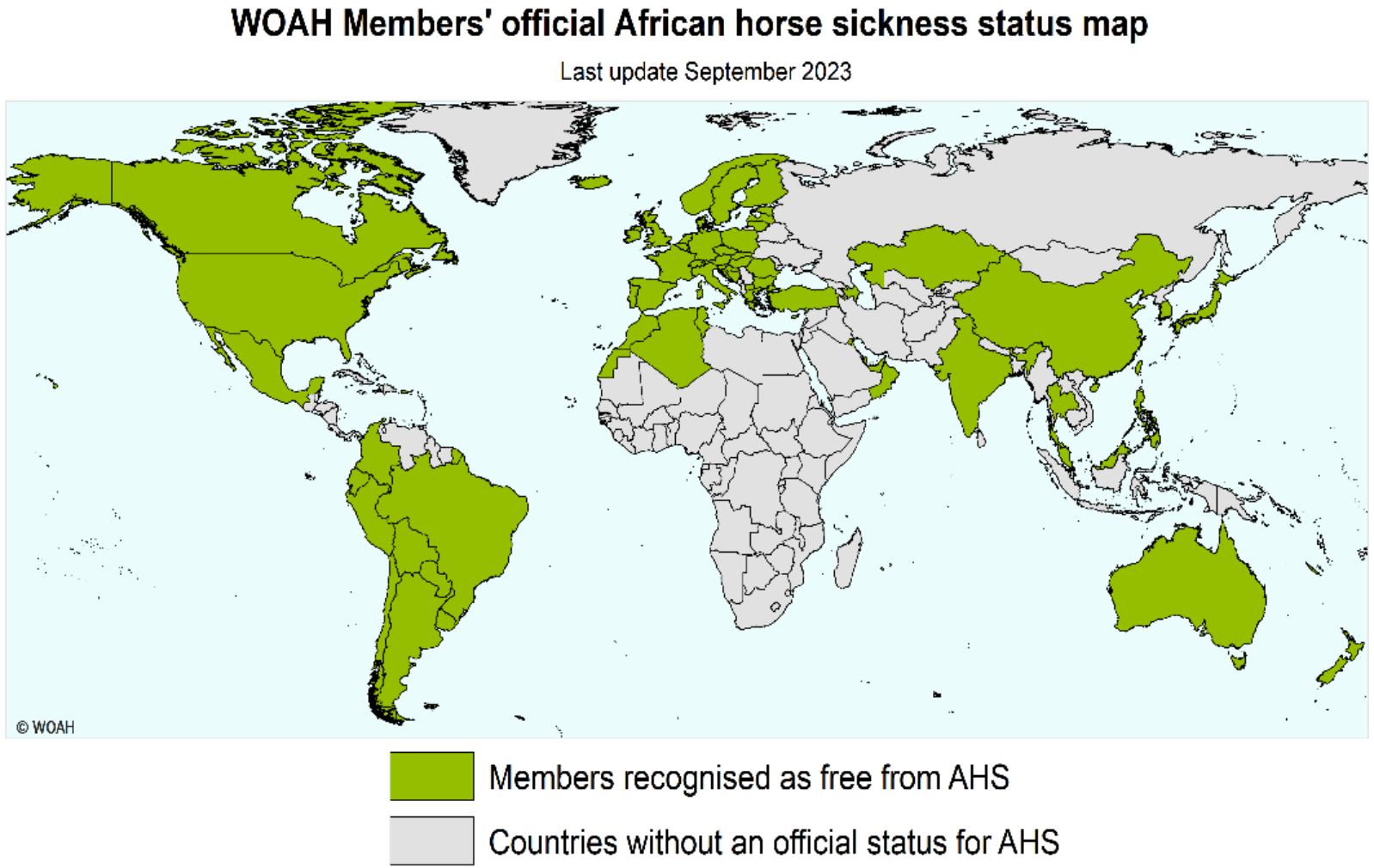
AHS-Historical perspective



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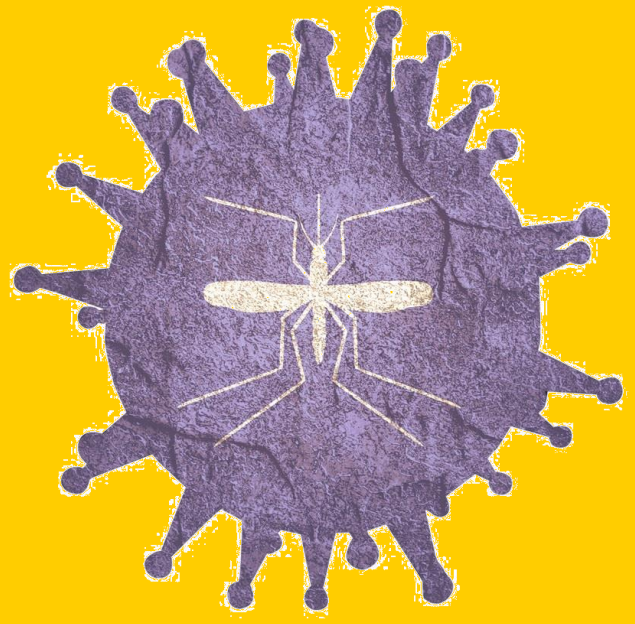
Drivers of vectorborne diseases



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Drivers of diseases

- **DRIVERS** → factors that are associated with the occurrence of the disease. Drivers support or facilitate the emergence/spread of disease in animal populations
- The **identification** of such factors represents an important aspect to strengthen the rapid implementation of measures in case of occurrence (or increased risk) of epidemics, or in prevention strategies

- Usually human infection is an *epi-phenomenon*

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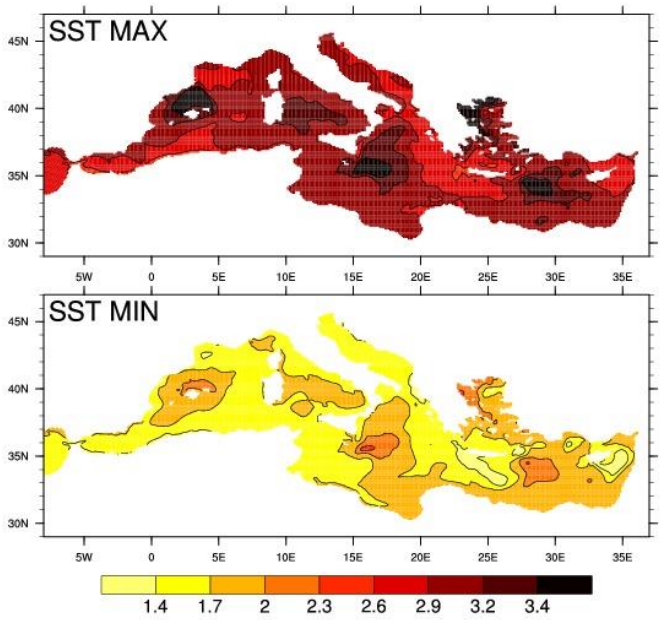
Environmental drivers

Environmental drivers refer to the ecological and climatic factors influencing mosquito presence and abundance.



- Climate change
- Flooding
- Desertification
- Other phenomena

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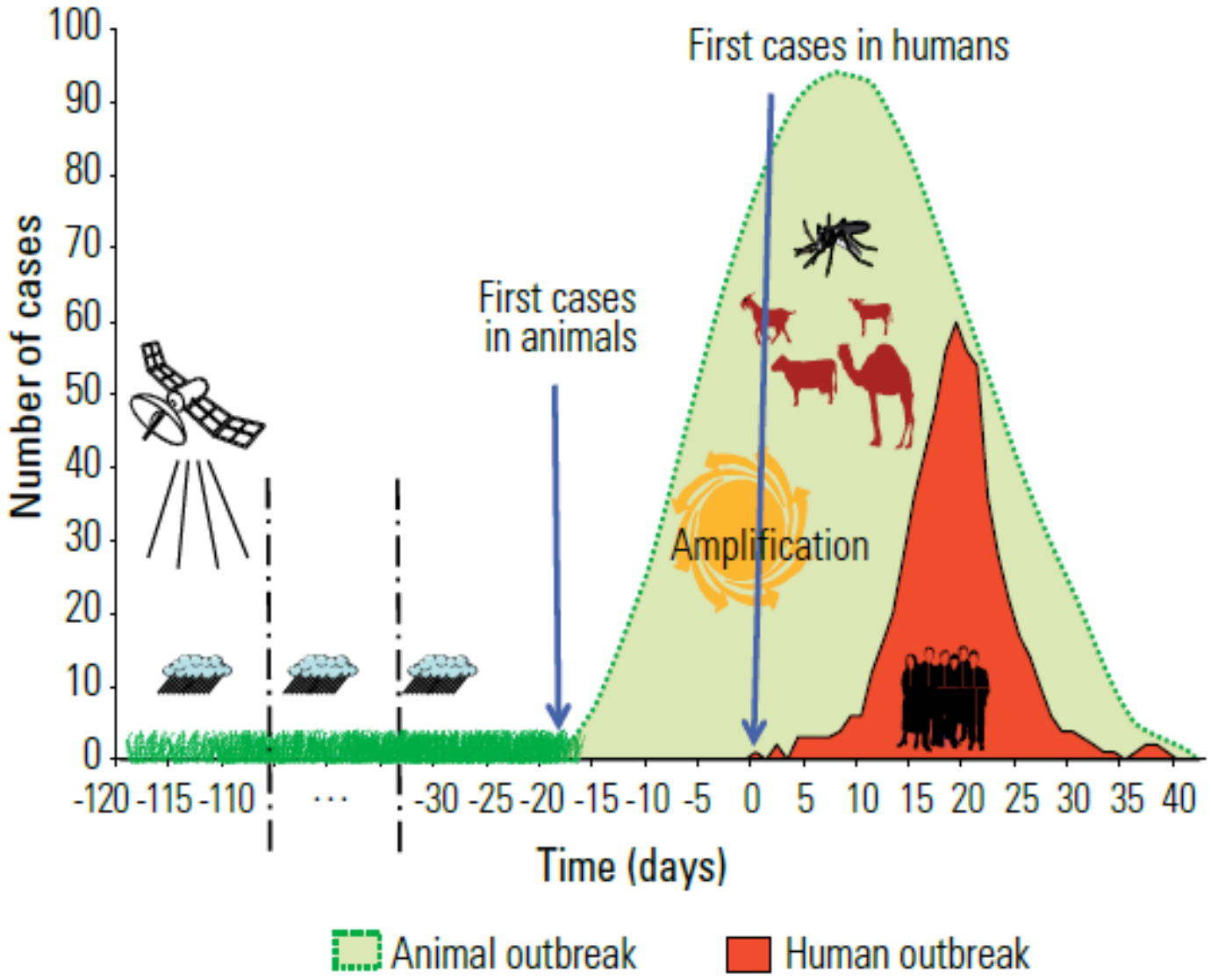
RVF



Elapsed time between events in 2006-2007 RVF outbreak in Kenya

Event	Average elapsed days since previous event
Onset of heavy rains	0
Mosquito swarms	23.6
First case in livestock	16.8
First case in human	17.5

On average, the onset of the first cases in livestock was only 17 days after mosquito swarms and approximately 40 days after heavy rains. Human cases were observed around 18 days after the first livestock cases (Jost et al., 2010).

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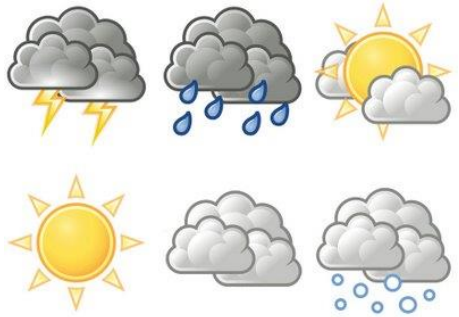
Climate and vector borne diseases

- Different kind of impacts:
  - directly, through the effect on vectors and pathogens
  - indirectly, through the influence on ecology and behaviour of hosts



Vectorial capacity

$$\text{Vectorial capacity} = \frac{ma^2Vp^n}{-\ln p}$$

Temperatures
Rainfalls
.....

where,
m = number of vectors per host
a = number of blood meals taken by a vector per host, per day [ma = biting rate]
V = vector competence (the proportion of vectors capable of agent transmission)
p = daily survival probability of the vector
n = extrinsic incubation period in days

- Vectorial capacity: daily rate at which future inoculations arise from a currently infective case
- It is an expression of the number of infections that the population of a given vector would distribute per case, per day, at a given place and time

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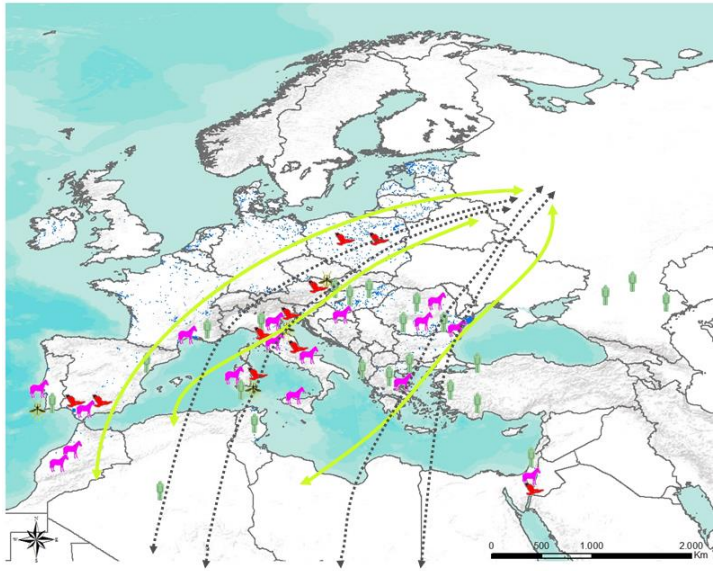
Drivers of disease

- Ecological factors that determine mosquito abundance
- Uncontrolled movement of animals between regions and borders
- Global trade
- Human and animal migrations



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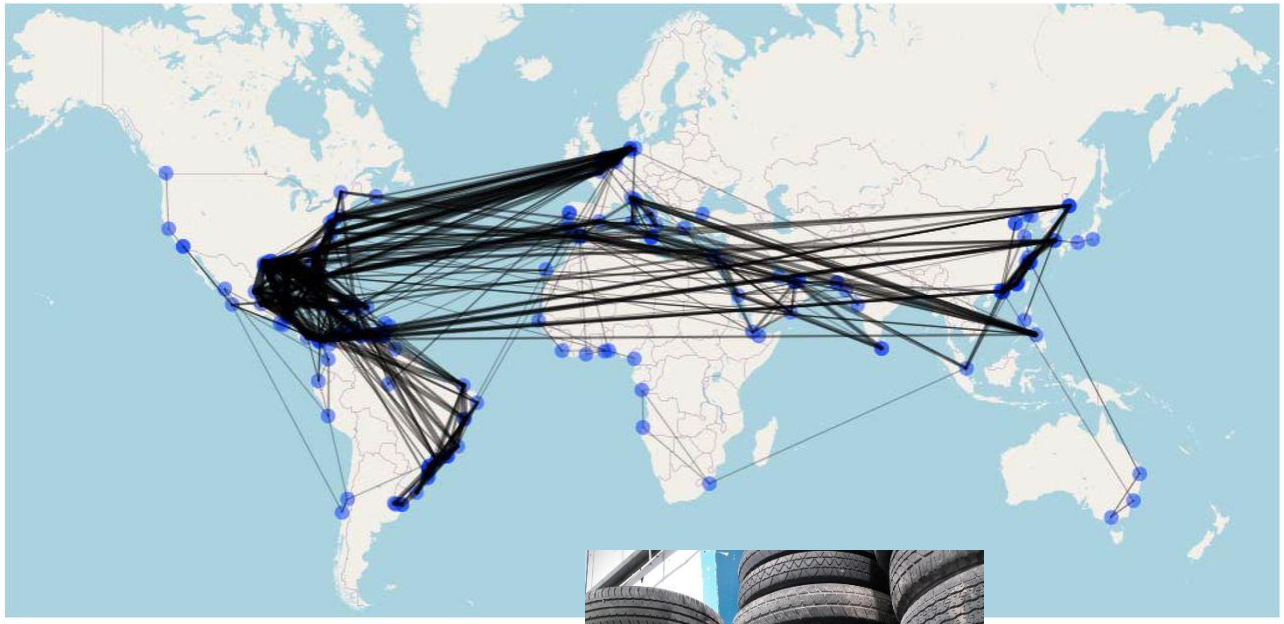
Human-mediated drivers

Global shipping network

It has been suggested as a pathway for the establishment and reintroduction of *Aedes aegypti* and *Aedes albopictus* primarily via the tire trade.



Janna R. et al., 2022

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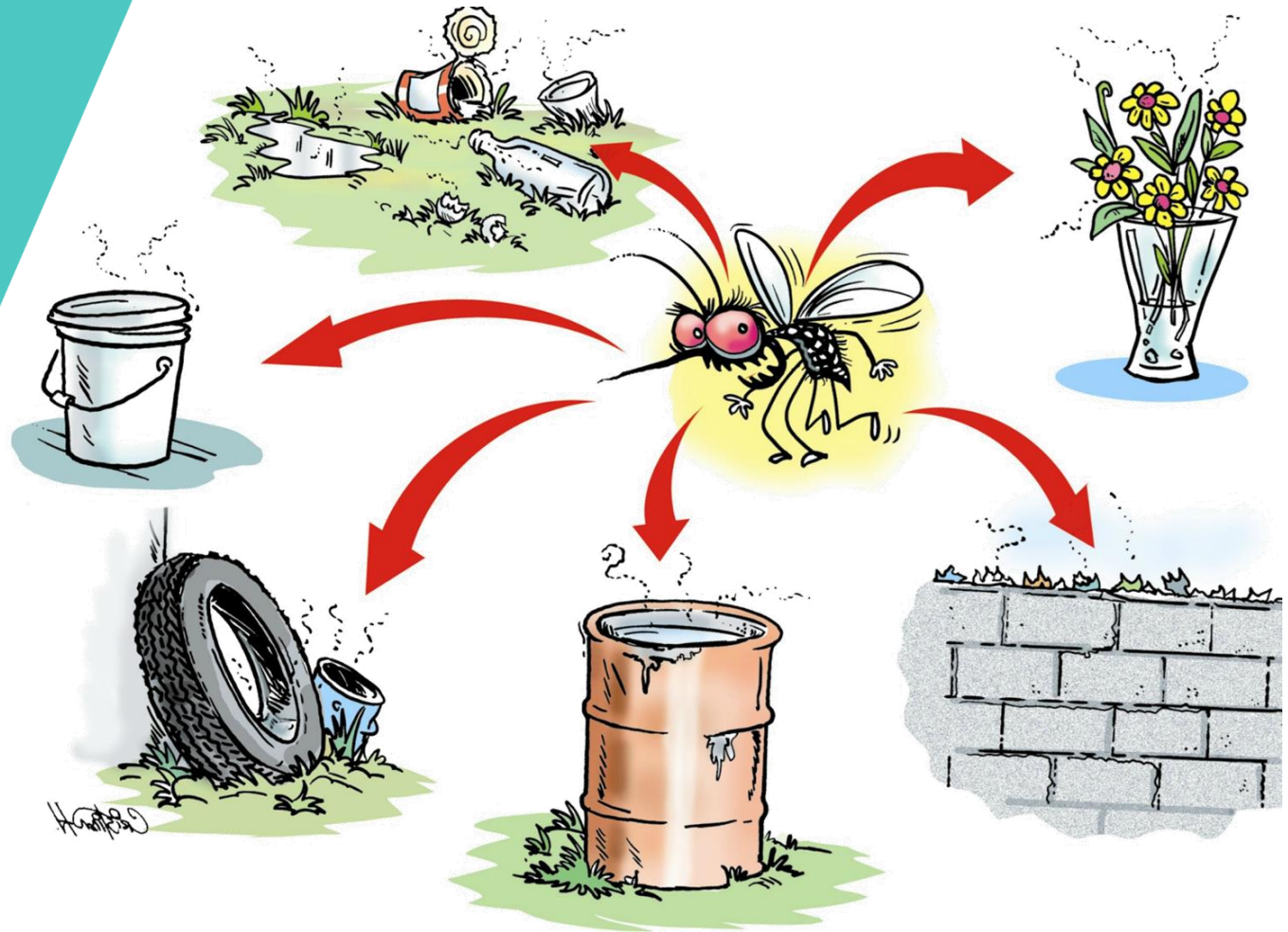
The human activities component



Also at small scale.....

Examples of human activities influencing the presence and abundance of mosquitoes

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Strategies for better preparedness and response

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Key points for control and response strategies

During **the inter-epidemic period** -> to build the capacity to respond to new outbreaks.

- One Health coordination (for zoonoses)
- National action plans
- Surveillance and risk assessment
- Forecasting and early warning systems
- Disease control strategies [vaccination]
- Capacity building

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Key points for control and response strategies

In the **pre-epidemic period** (starting when forecasts of future weather conditions are indicating the presence of conditions consistent with the emergence of the disease)

- Mobilization of resources
- Activation of logistics for sample collection
- Verification of laboratory and health system capacities
- Surveillance intensification
- Reinforcement of animal movement control [and vaccination activities]
- Risk communication

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Key points for control and response strategies

In the **epidemic phase**

- Surveillance and notification system
- Disease control
- Risk communication and social mobilization

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Key points for control and response strategies

In **post-epidemic period**

- Surveillance
  - serosurvey to measure herd immunity
- Study and impact assessment
- Economic and social impact mitigation

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Regional strategies

- For TADs a sole national approach is inadequate for contrasting the geographic spread of the infection
- Clear example: LSD spread and the vaccination strategy put in place in 2016-2017 all over the Balkan region

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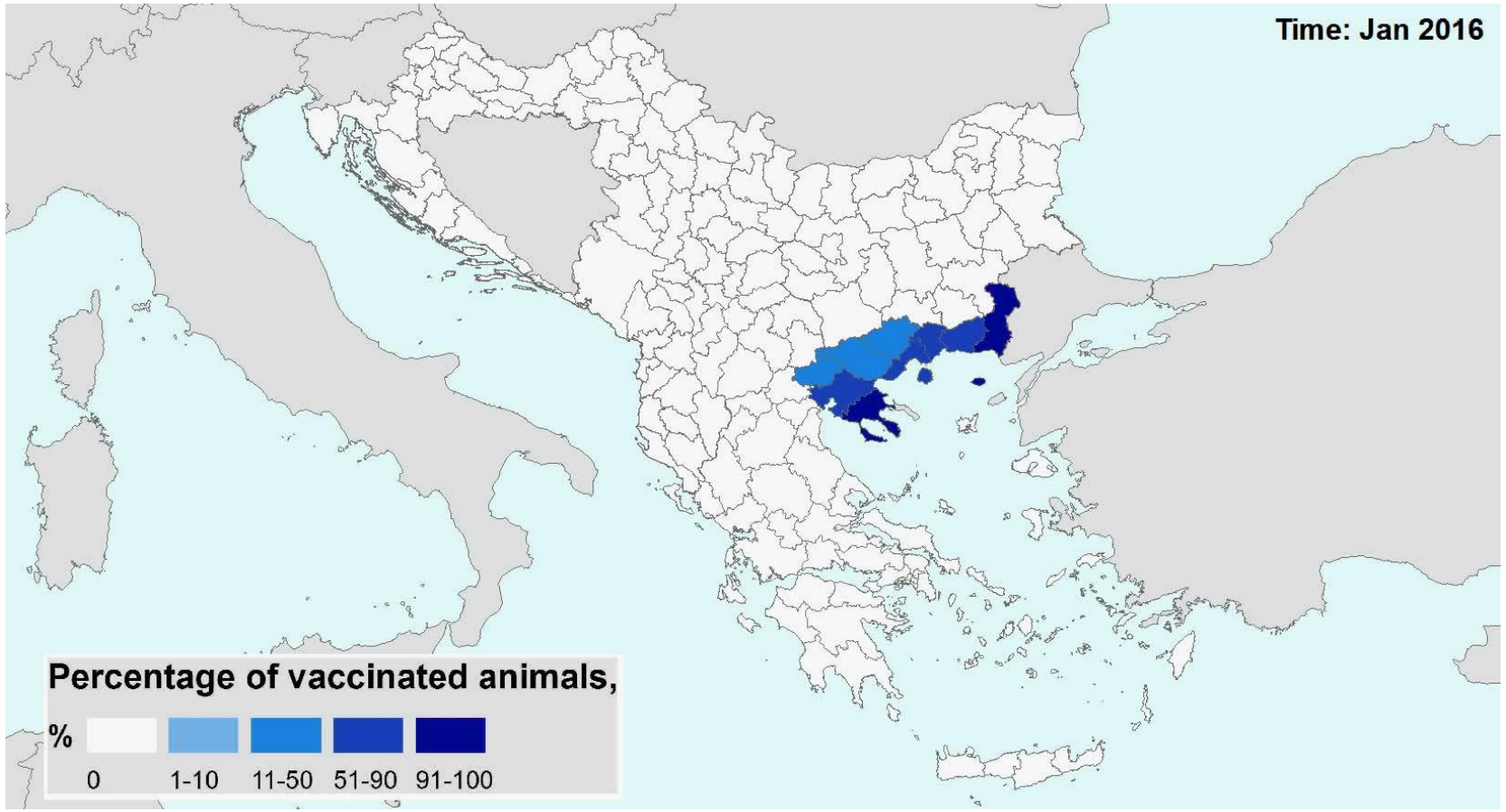
Regional strategies: an example

The LSD regional vaccination strategy in SE Europe



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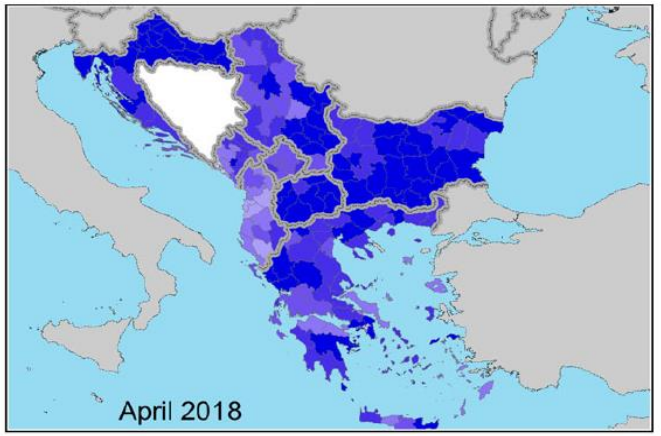
The LSD regional vaccination strategy in SE Europe

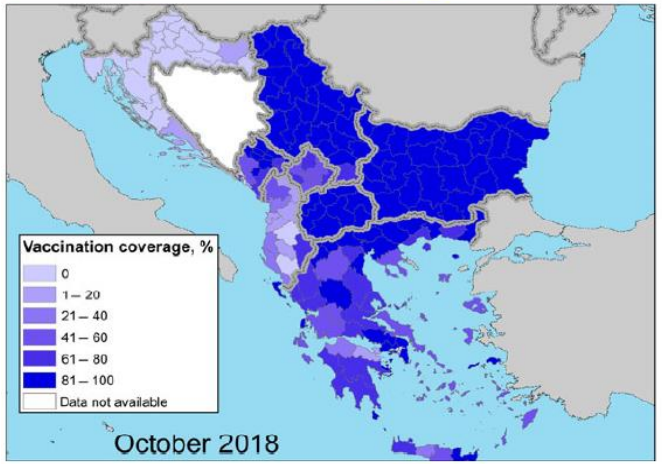
2018

All countries in SE Europe (Albania, Bosnia and Herzegovina, Bulgaria, Greece, Kosovo, Montenegro, Serbia, North Macedonia) continued to vaccinate against LSD in 2018, with the exception of Croatia.

In 2018, **no outbreaks of LSD were reported in the Balkan region**, after a decline in the number of outbreaks reported in 2017 (385) compared to 2016 (7,483).

→ Confirmed the effectiveness of the vaccination campaign and the coordinated control measures put in place in the region.





EFSAScientific report on lumpy skin disease II, 2018 & EFSA Scientific report on lumpy skin disease III 2019

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Surveillance

Any control and response strategy cannot be implemented without the support of **an effective surveillance system**

- Passive surveillance and disease reporting
  - case definitions and notification systems in place
- Syndromic surveillance
- Sentinel surveillance
- Targeted studies
  - longitudinal or case-control studies for prevalence and risk factors estimation
- Vector surveillance

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Surveillance

- To increase the efficiency and the efficacy of the surveillance a risk-based approach should be followed
- Risk-based surveillance takes into account
  - Locations
  - Target species
  - Period of the year

more at risk, on the basis of risk assessment, risk mapping, forecasting systems

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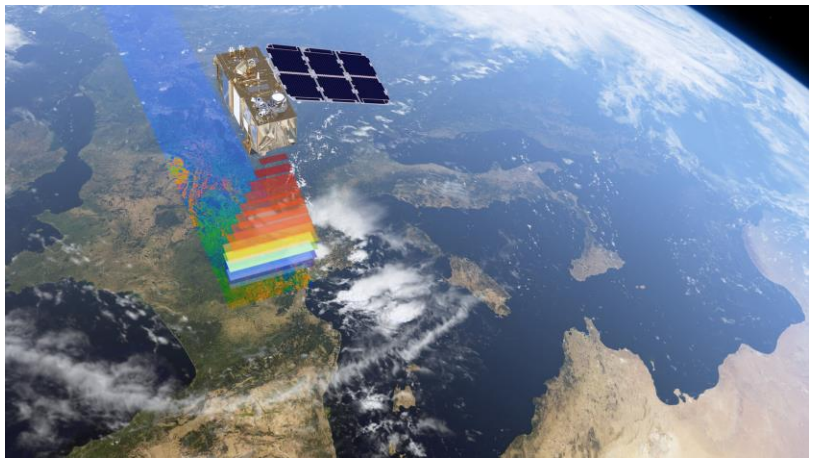
Earth Observation

The increasing abundance of remote sensing (RS) and Earth Observation (EO) data, with a variety of spatial and temporal resolutions and biophysical products (land surface temperature, normalized difference vegetation index, soil moisture, etc.) offers enormous opportunities for VBD investigations

Defining Ecoregions and Prototyping on EO-based Vector-borne Disease Surveillance System for North Africa (PROVNA)

WOAH Project



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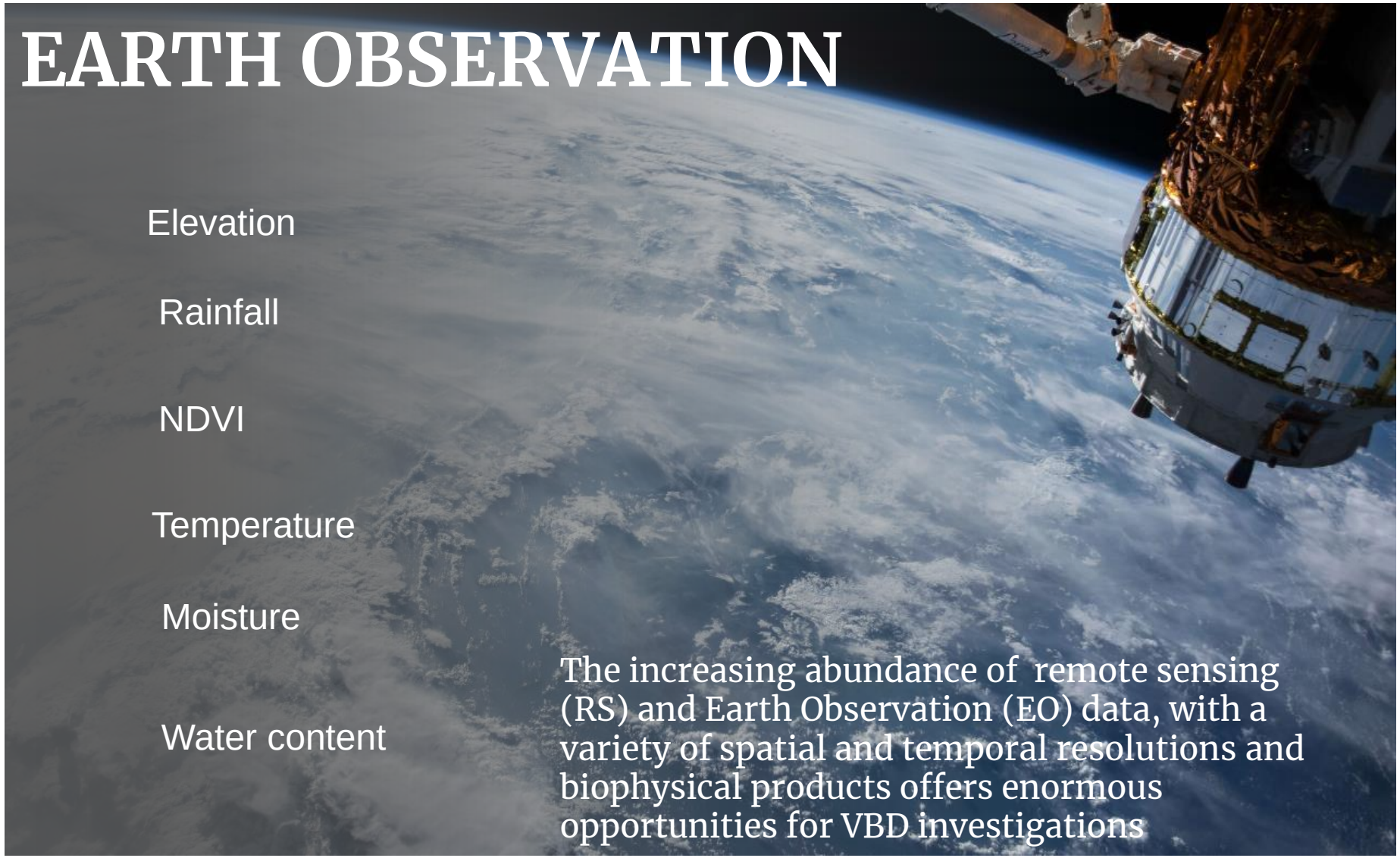
EARTH OBSERVATION



Elevation

Rainfall

NDVI

Temperature

Moisture

Water content

The increasing abundance of remote sensing (RS) and Earth Observation (EO) data, with a variety of spatial and temporal resolutions and biophysical products offers enormous opportunities for VBD investigations

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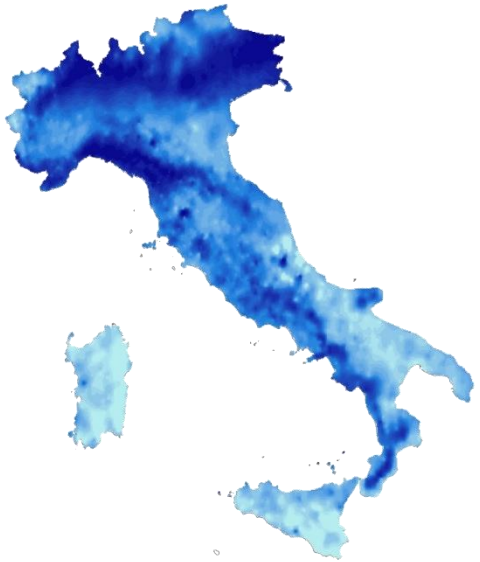
Ecoregionalization

The process through which the territory is classified into similar areas according to specific environmental and climatic factors

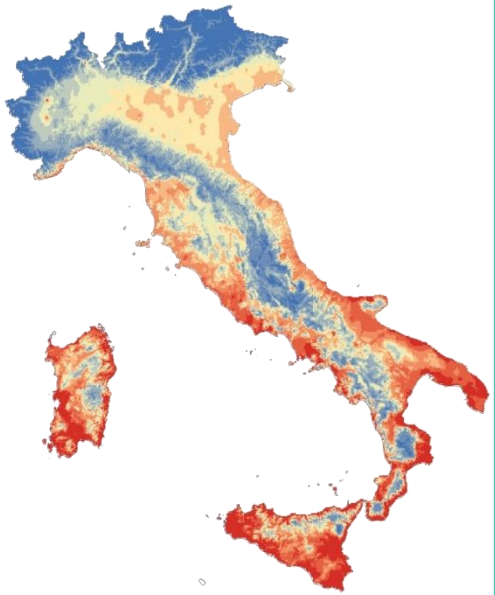
elevation

NDVI

rainfall



temperature



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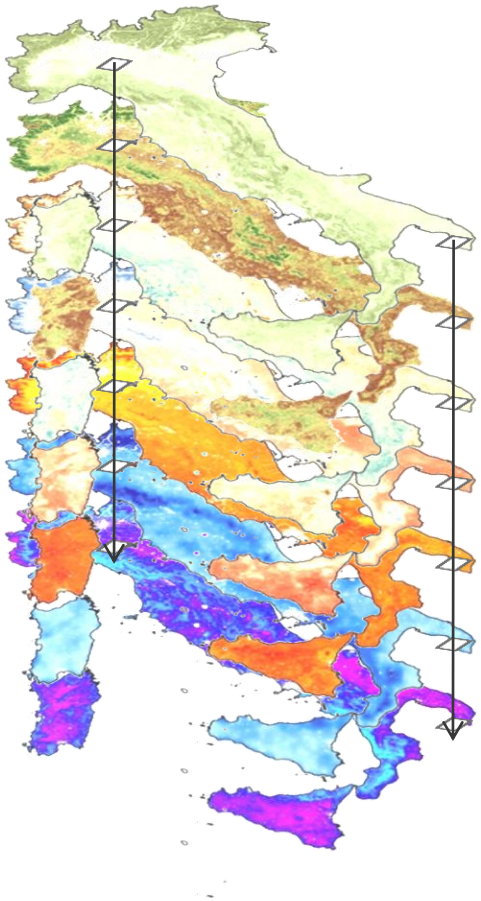
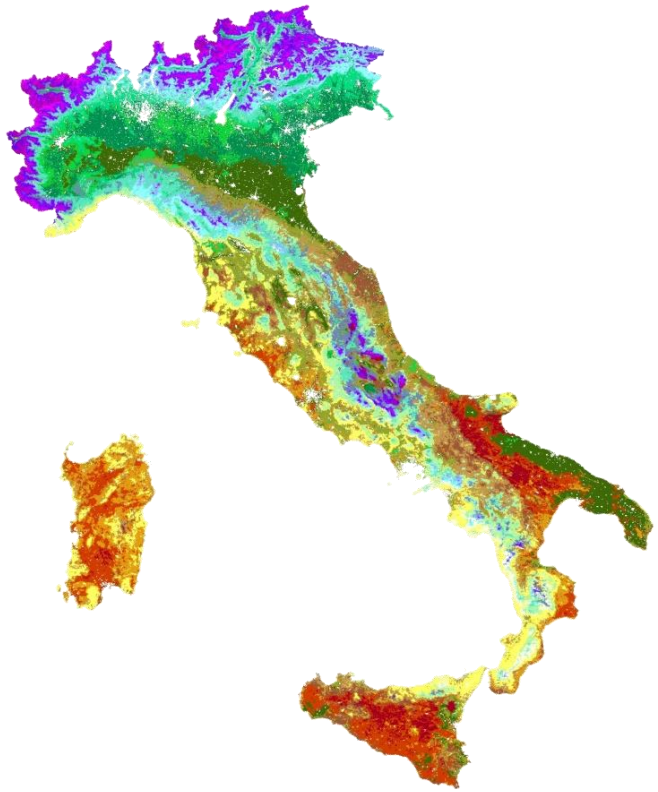
Ecoregions





Ippoliti et al. PLoS ONE 14(7): e0219072.

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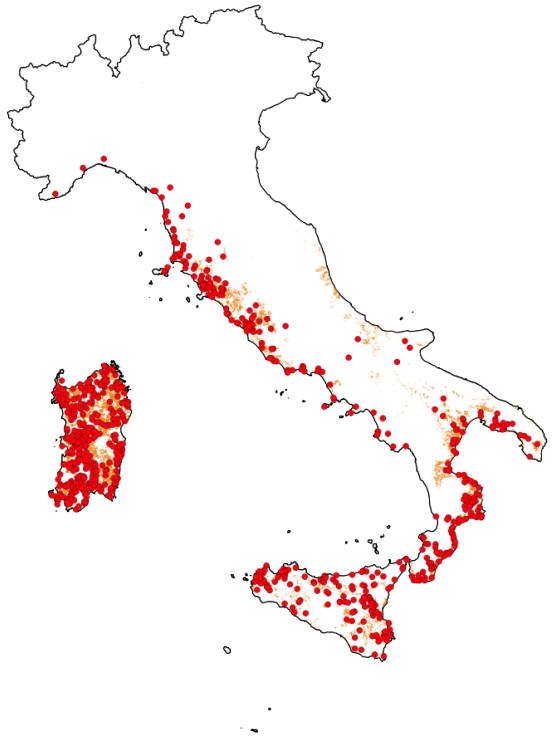
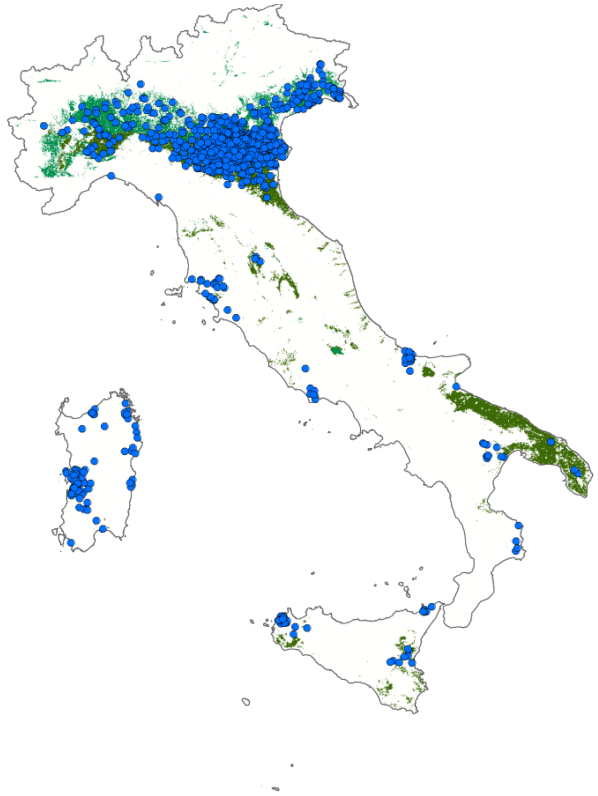
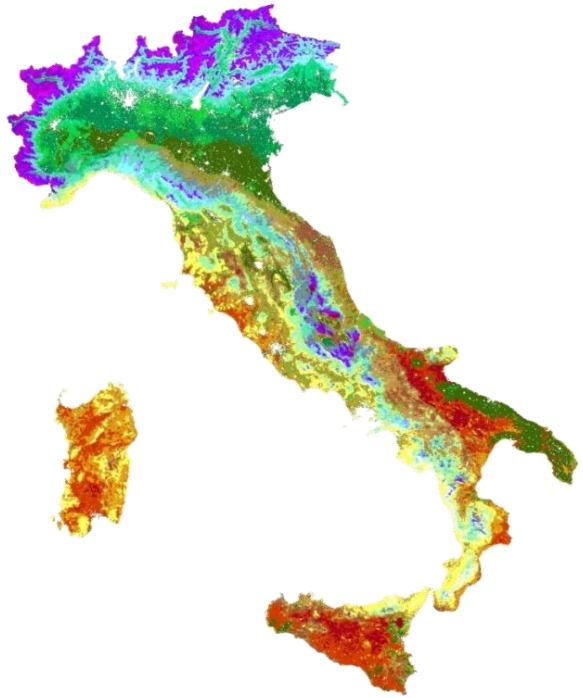
Such an approach…what for?

C. imicola



WND cases





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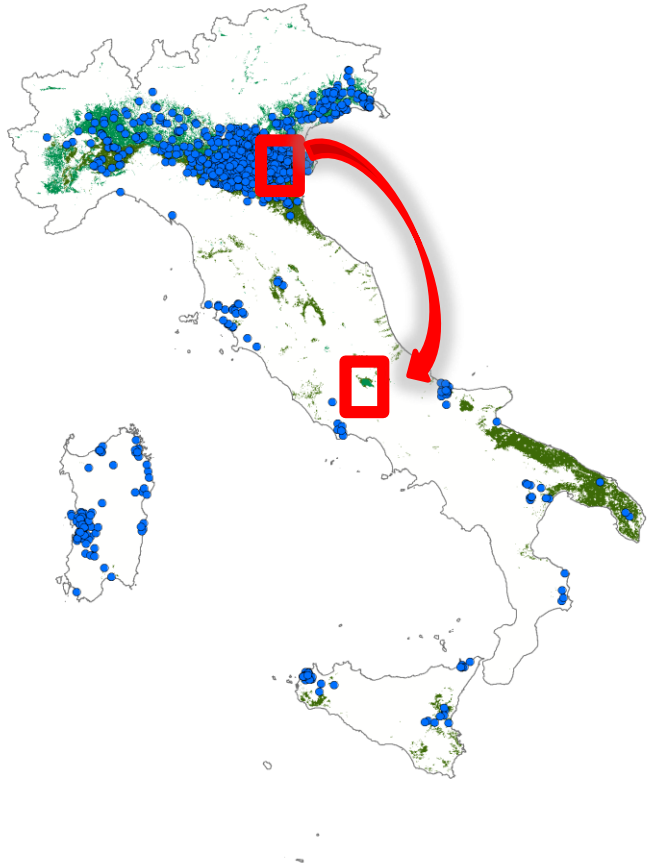
Such an approach…what for?

ecoregions 9, 17



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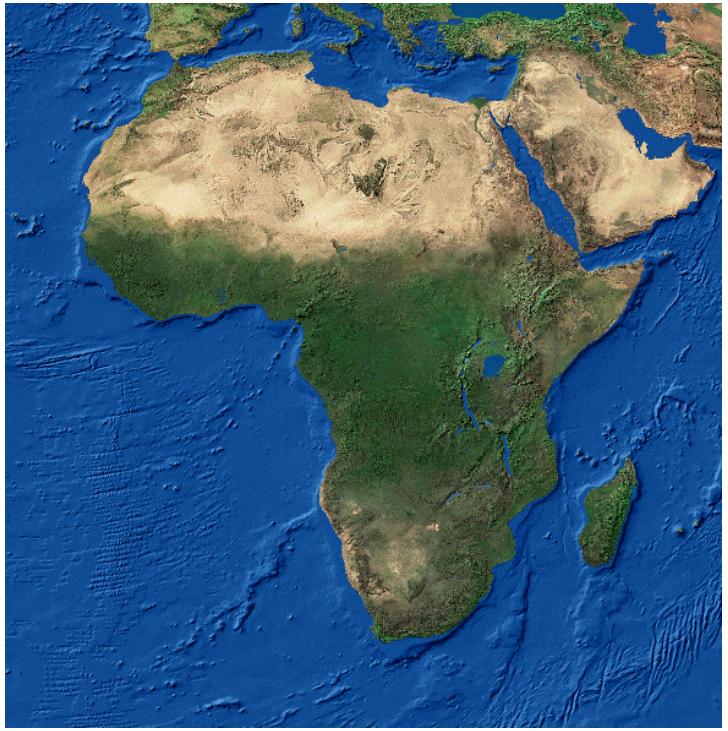
WOAH Project

Defining Ecoregions and Prototyping on EO-based Vector-borne Disease Surveillance System for North Africa (PROVNA)

- To define the “ecoregions” of the **North African** territory (Mauritania, Morocco, Algeria, Tunisia, Libya and Egypt), characterized by distinct environmental and climatic factors
- To build a customised prototype application (PROVNA) in the North Africa region for monitoring vector-borne diseases

The disease selected for the project is

Rift Valley Fever (RVF)



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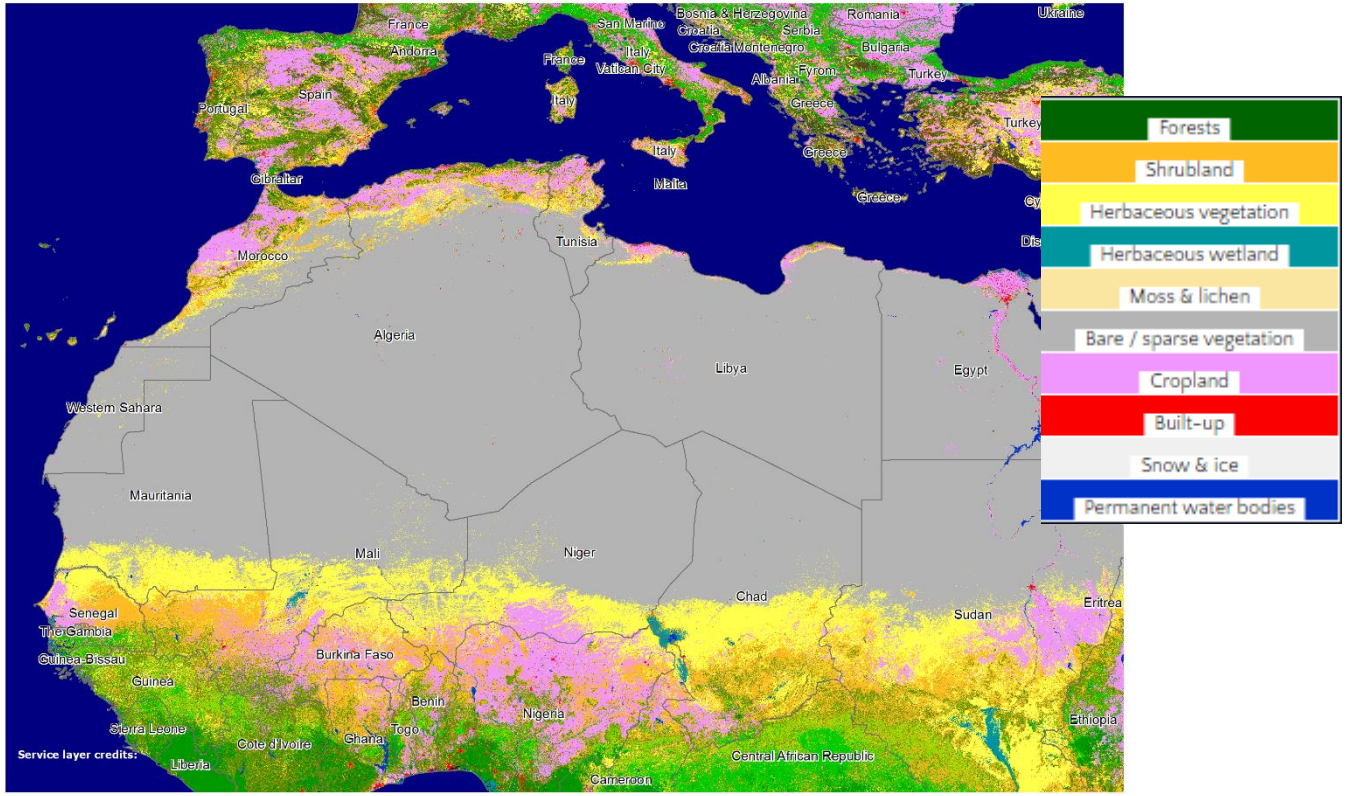
PROVNA will support:

- Risk based surveillance
- Early warning systems
- Assessment of risks of VBD introduction and persistence

Further geographical layers, describing additional risk factors (e.g. animal movement pathways, etc.) can be added to increase the precision of the categorization

Machine Learning techniques will assure the proper inclusion of each variable in an iterative way



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Selected EO datasets

Parameter	Dataset	Coverage		Resolution		Source
		Spatial	Period	Spatial	Temporal	
Rainfall	TAMSAT (Tropical Applications of Meteorology using SATellite data and ground-based observations)	Africa	1983 – Present	4km x 4km	Daily	University Reading/NCAS /NCEO
Land Surface Temperature	Moderate Resolution Imaging Spectroradiometer (MODIS)	Global	2000 - Current	1 Km x 1 Km	8-days	NASA
Vegetation Index (NDVI)	Moderate Resolution Imaging Spectroradiometer (MODIS)	Global	2000 - Current	0.25 Km x 0.25 Km	16-days	NASA
Soil Moisture	Soil Moisture Active Passive (SMAP) Level 4 (L4) data product Surface and Root Zone Soil Moisture Geo physical Data	Global	2015 – Current	9km x 9km	3-hours, daily	NASA
NDWI	Normalised Difference Water Index (NDWI) from MODIS surface reflectance	Global	2000 - Current	0.25 Km x 0.25 Km	8-days	NASA
Elevation	Copernicus Digital Elevation Model (DSM)	Global	2019	30 m x 30 m	-	Copernicus EU

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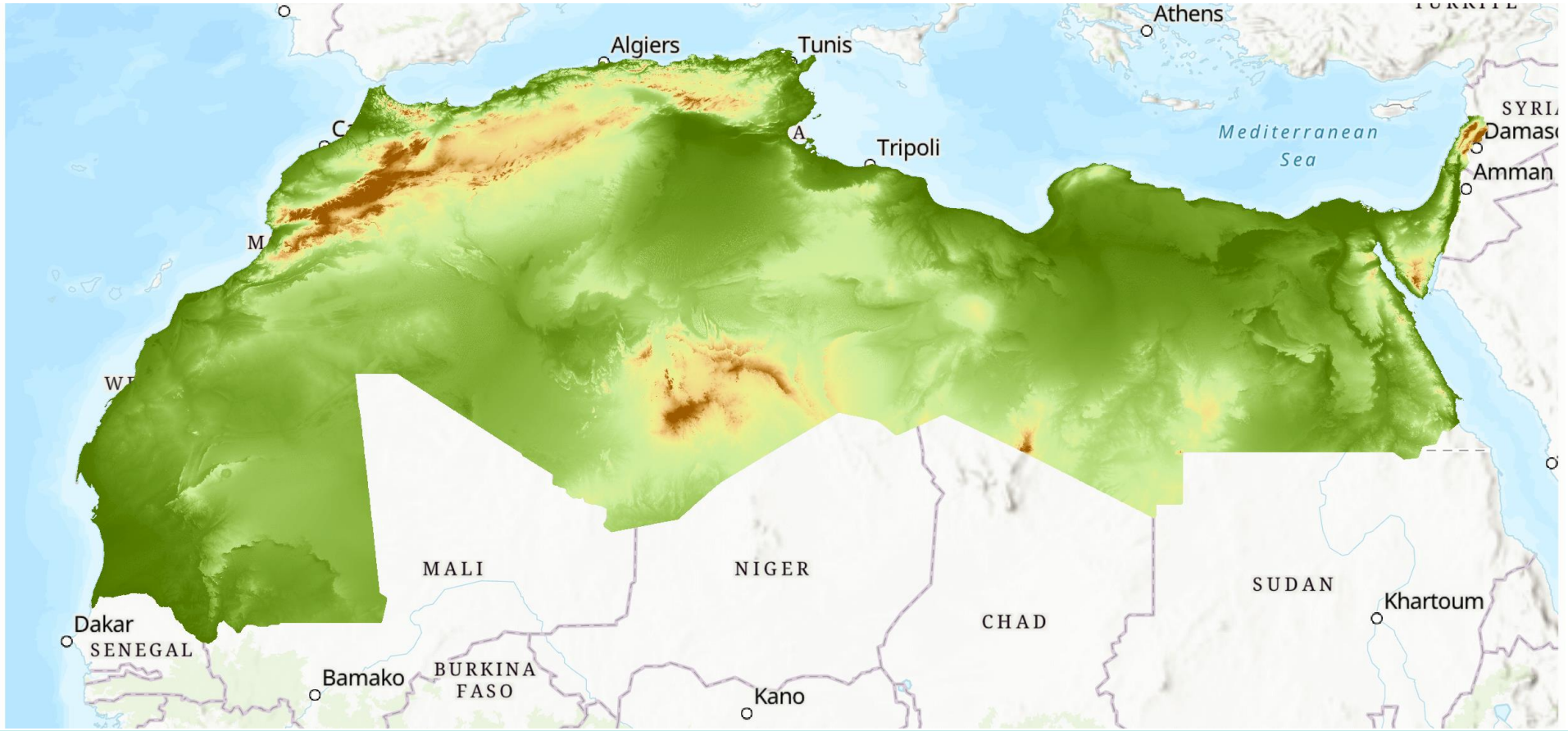
Digital Elevation Model (altitude above sea level)



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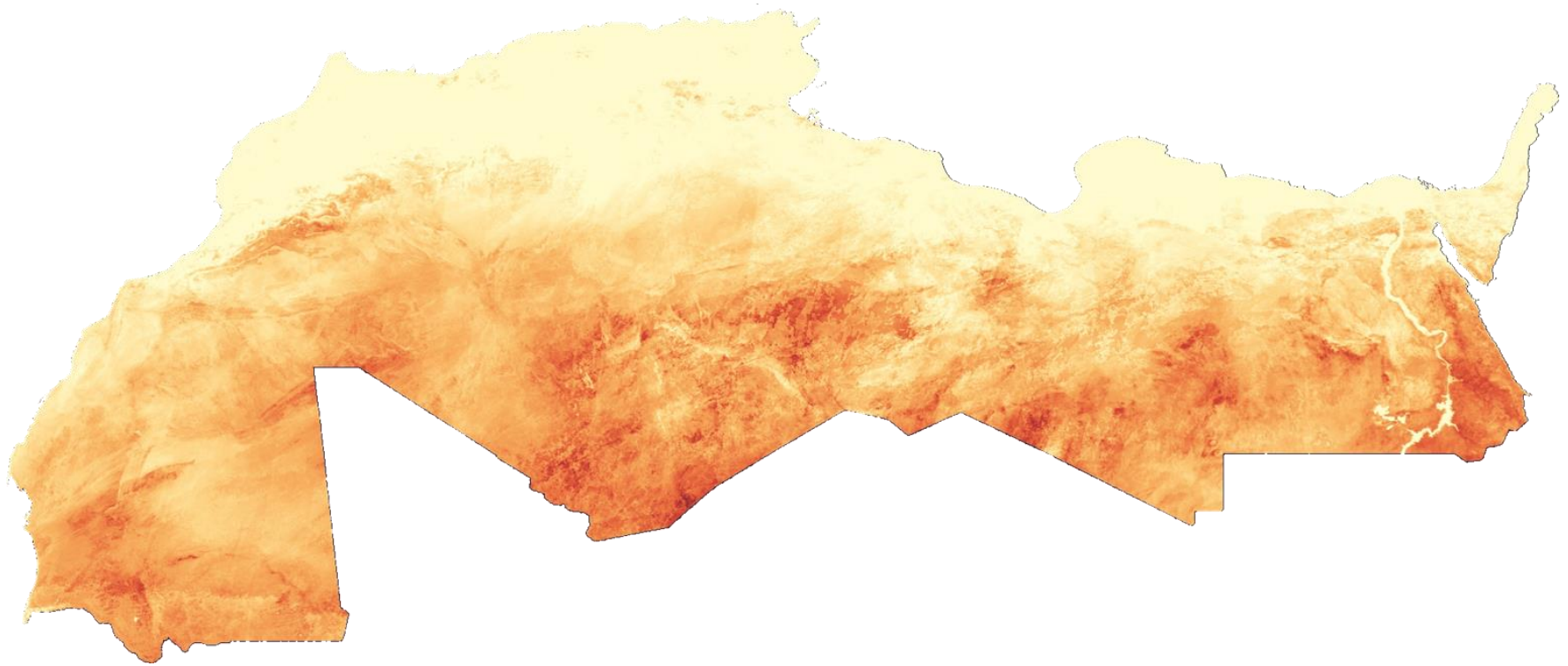
Land Surface Temperature daytime

Average of the period (16-days): 22 March 2022 – 07 April 2022



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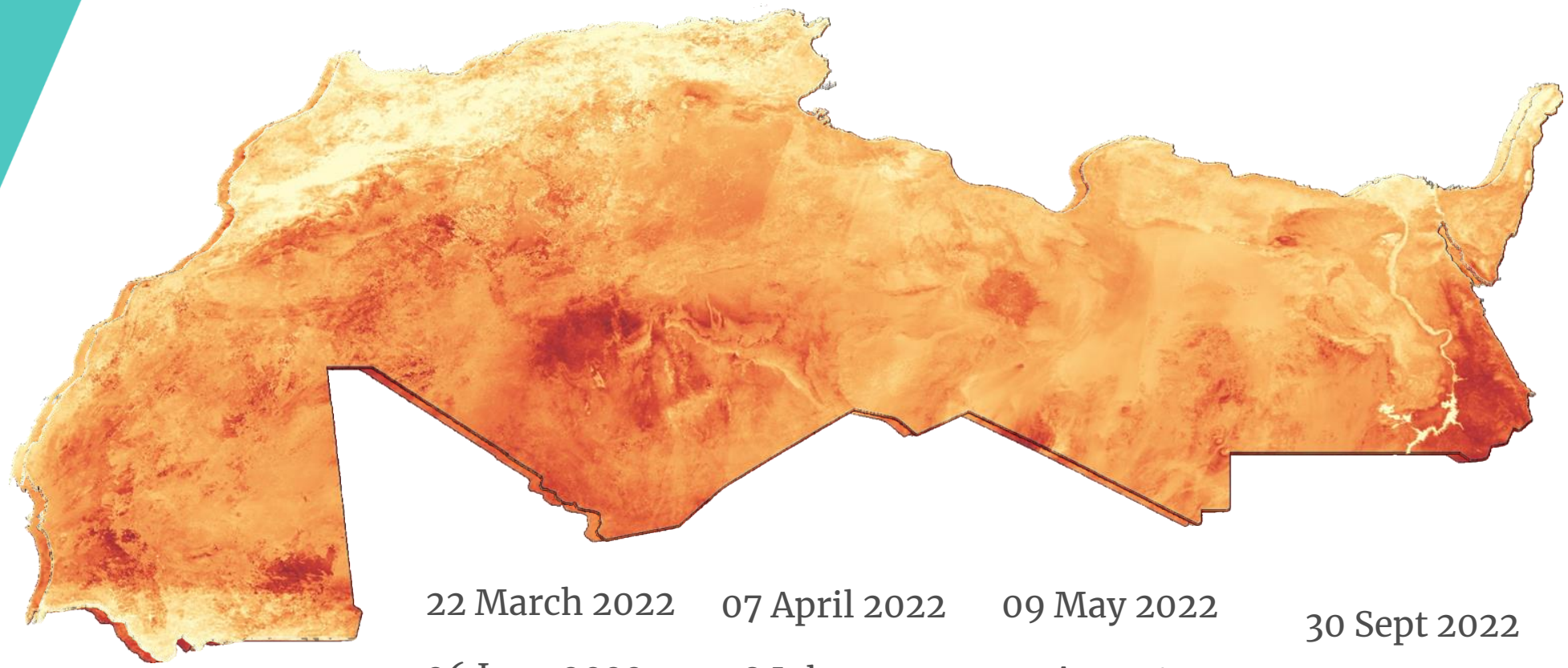
Land Surface Temperature daytime

Animation across 2022



22 March 2022 | 07 April 2022 | 09 May 2022 | 30 Sept 2022

26 June 2022 | 28 July 2022 | 29 August 2022

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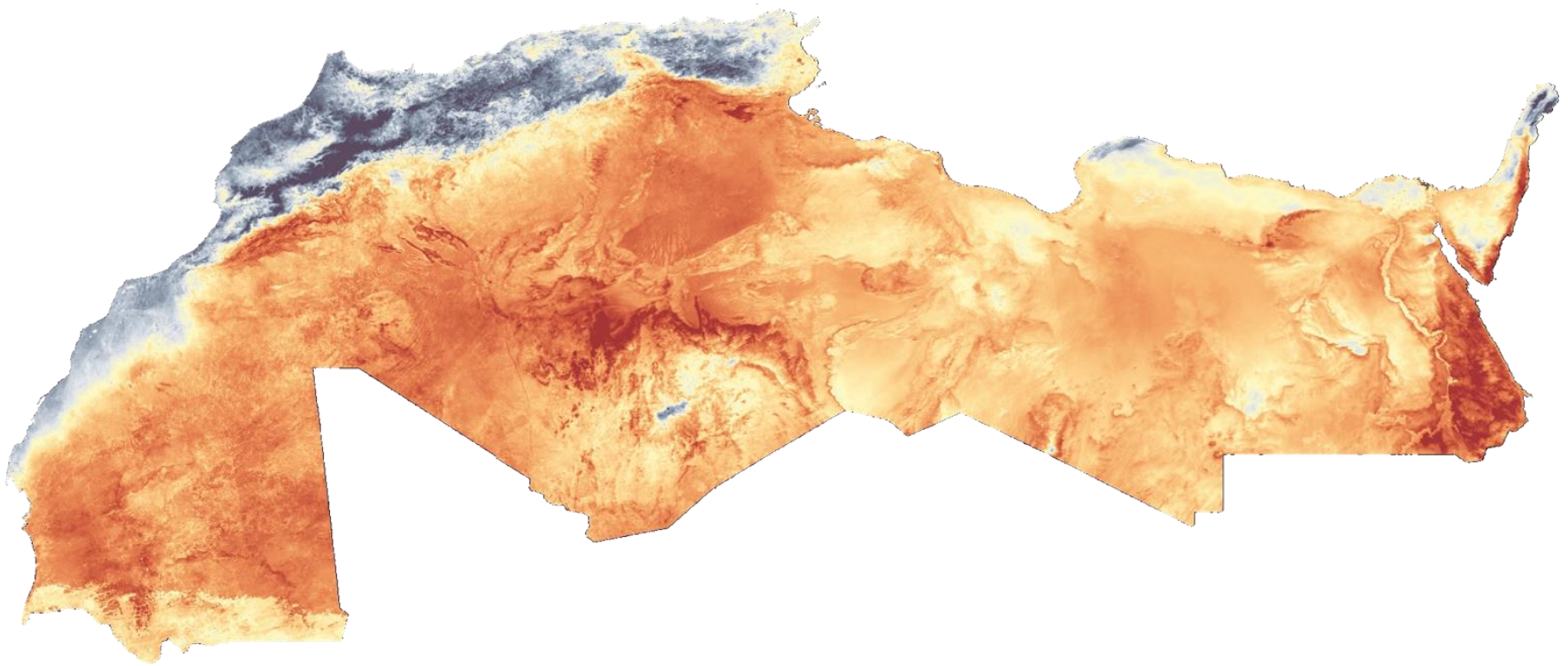
Land Surface Temperature night-time

Average of the period (16-days): 22 March 2022 – 07 April 2022



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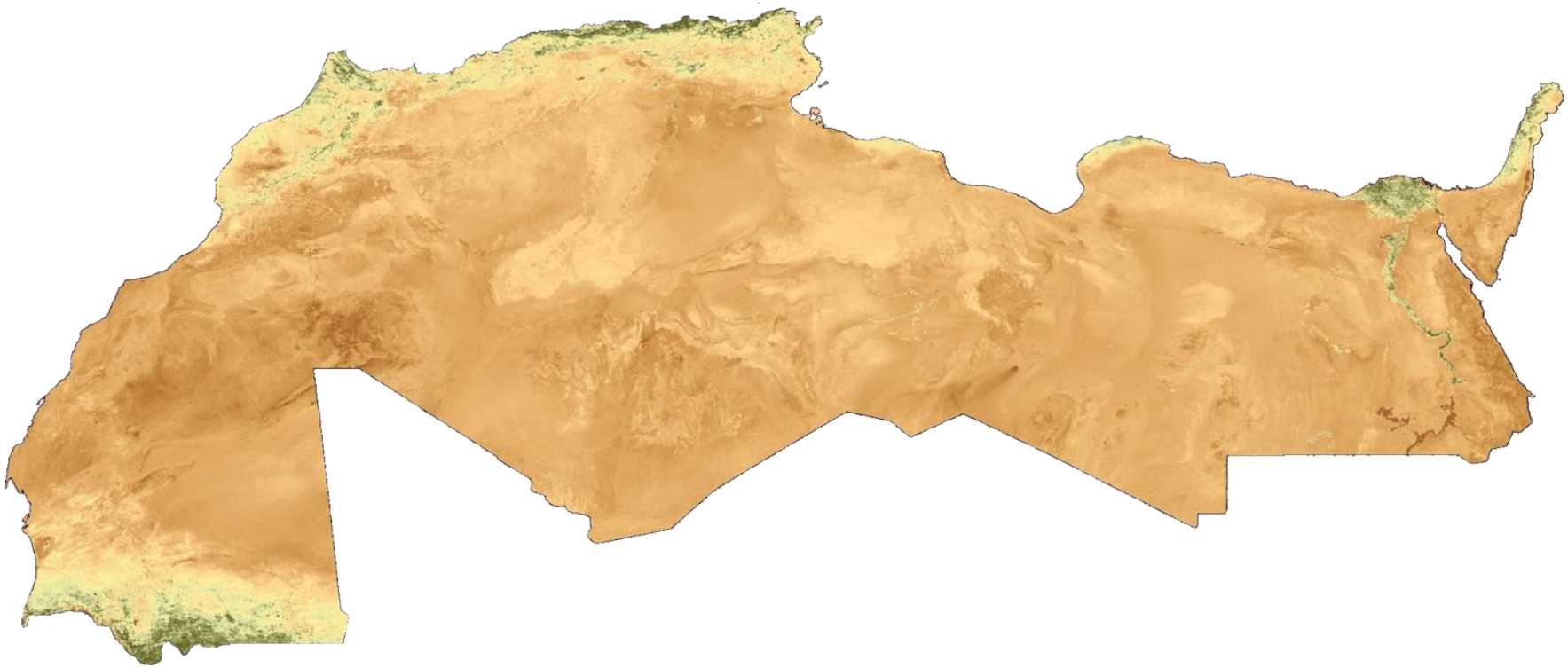
Normalized Difference Vegetation Index (NDVI)

Average of the period (16-days): 30 September 2022 – 15 October 2022



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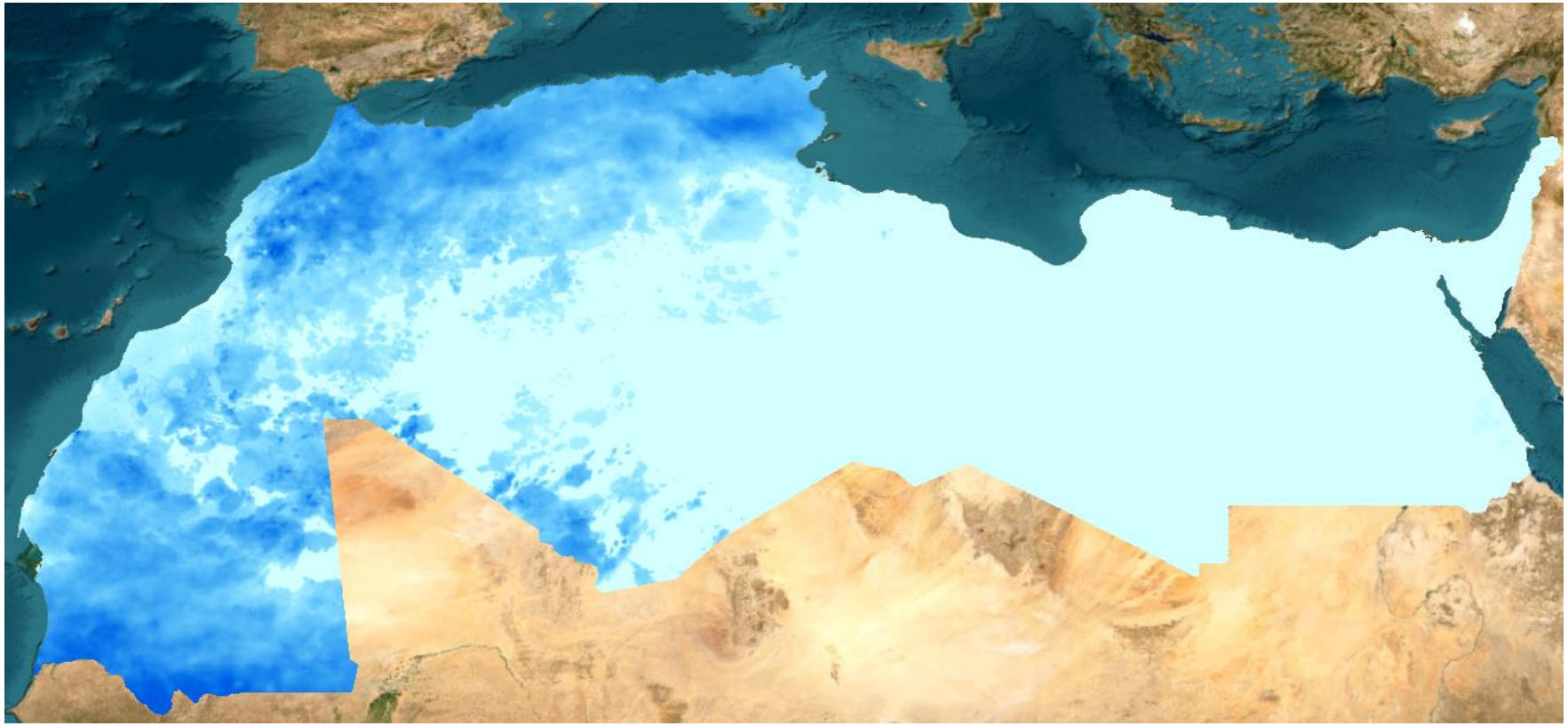
Precipitation (rainfall)

Accumulated rainfall in 29/08/2022 – 13/09/2022



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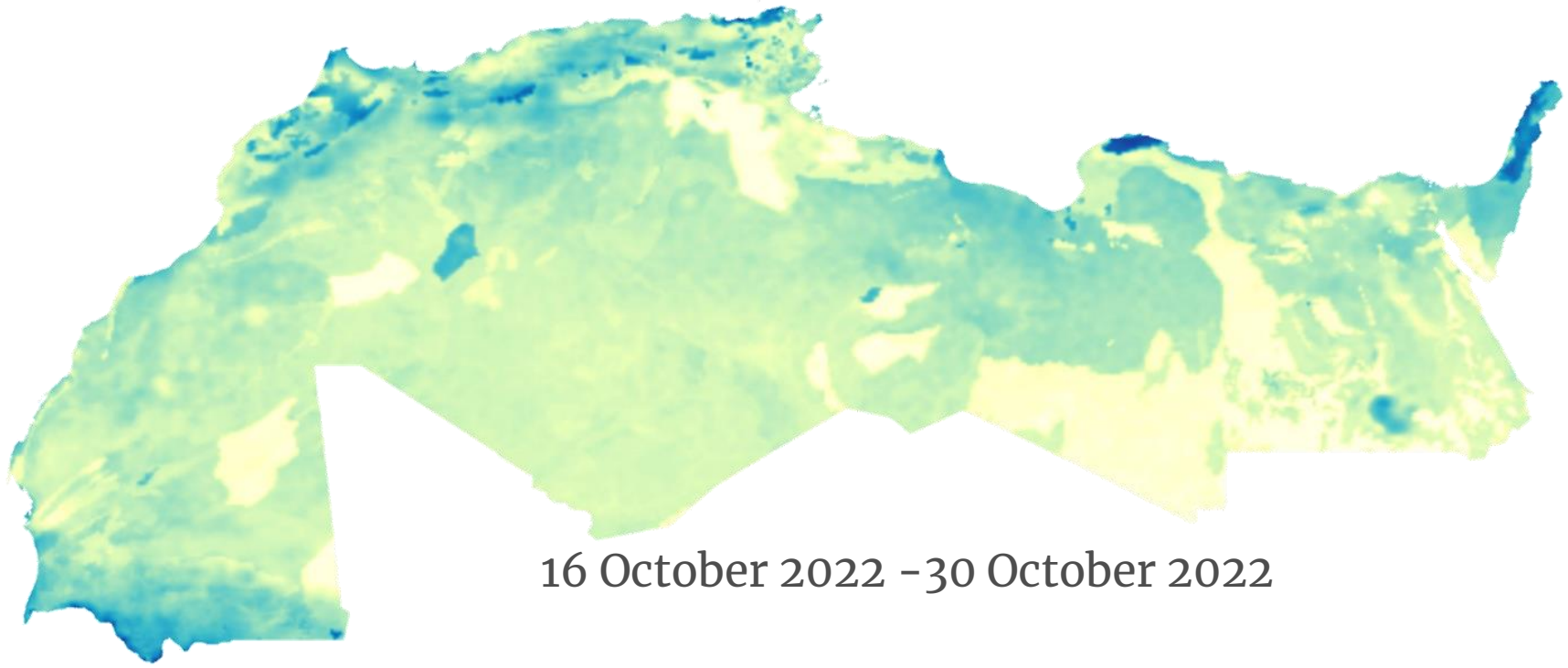
Surface Soil Moisture

Surface water availability is an important determinant of vector habitat suitability.



16 October 2022 -30 October 2022

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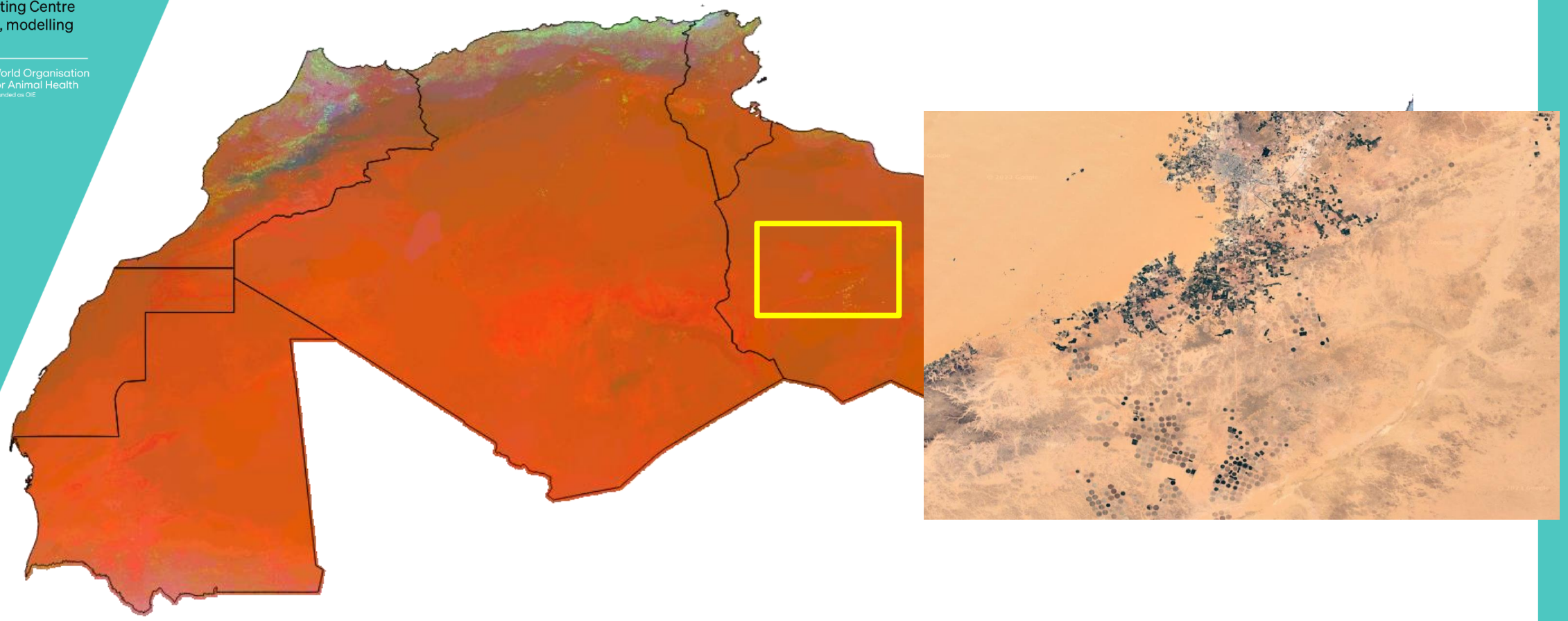
Preliminary eco-regions definition



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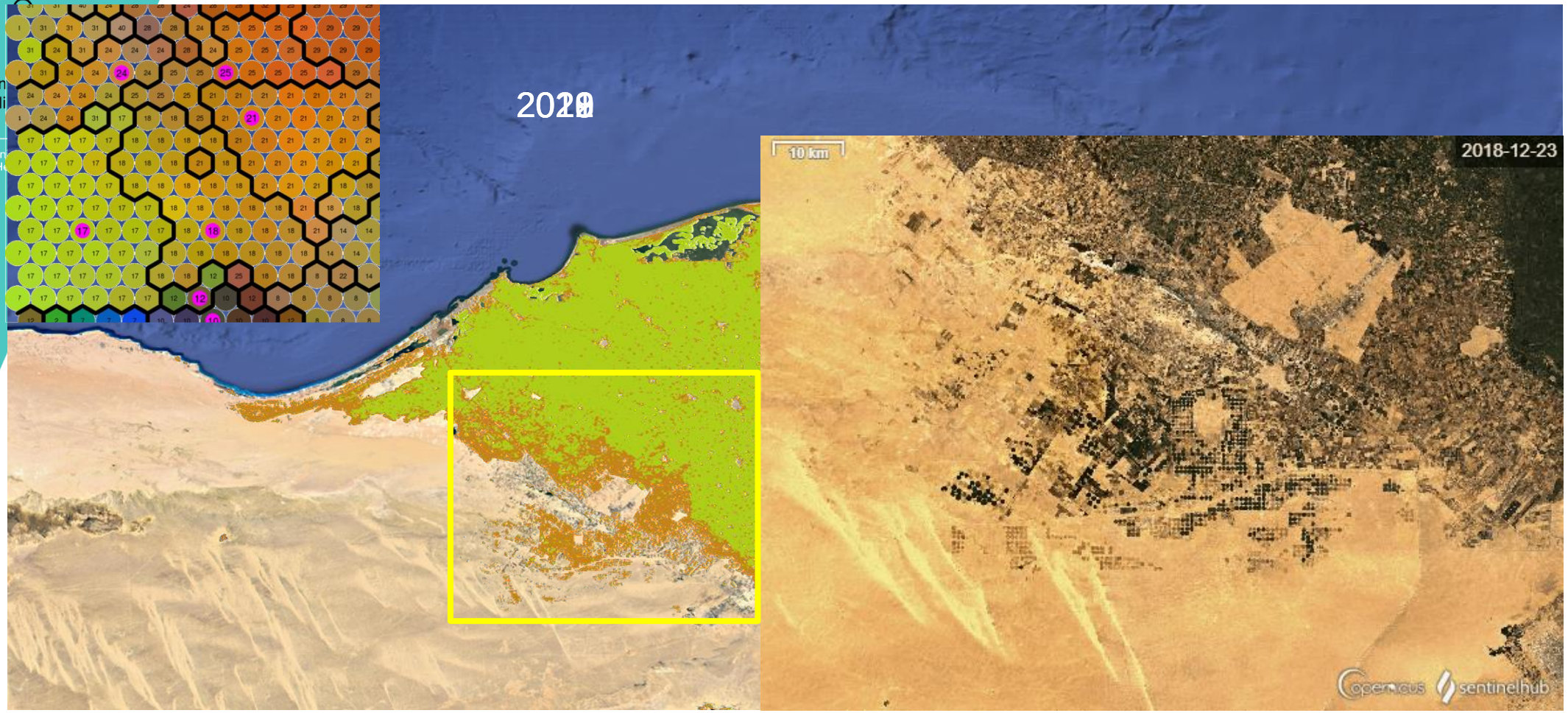

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Thank you for the attention!