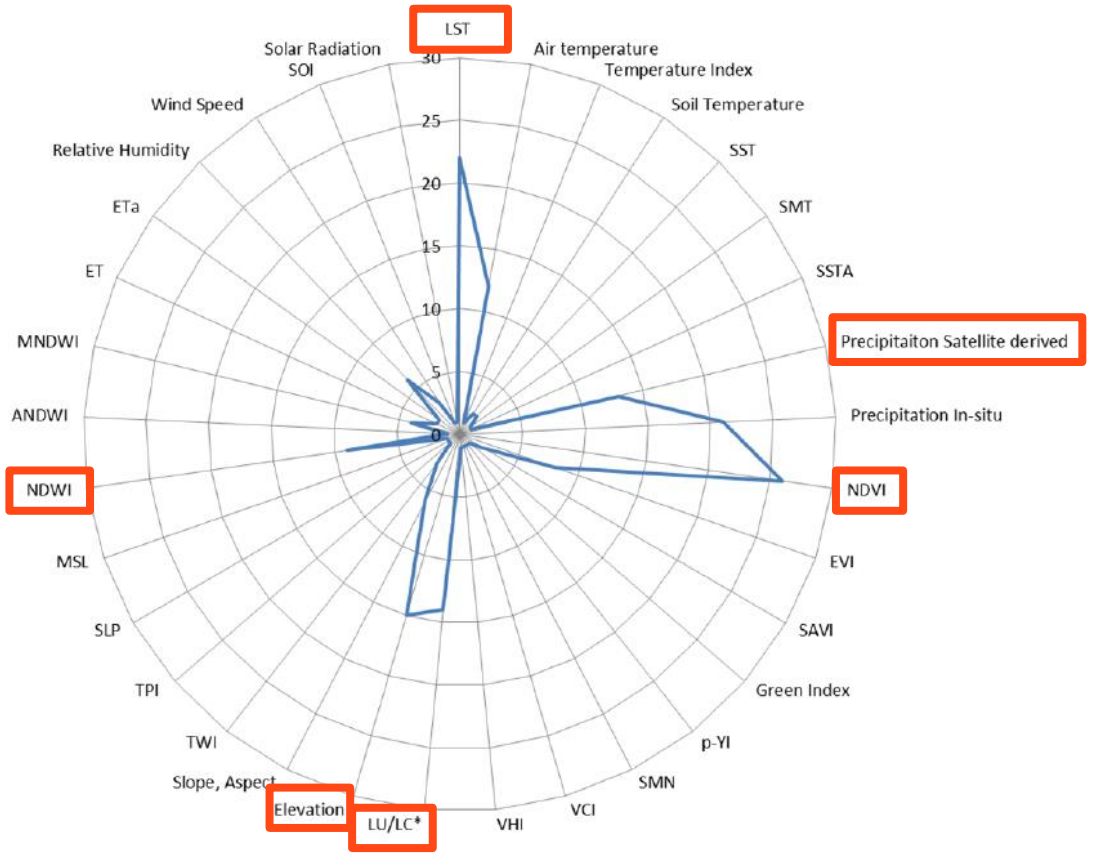
Defining Ecoregions and Prototyping on EO-based Vector-borne Disease Surveillance System for North Africa (PROVNA)

- IZSAM - WOAH Collaborating Center for Epidemiology
- WOAH Office North Africa in Tunis

Final meeting – PROVNA project – July 2 2024

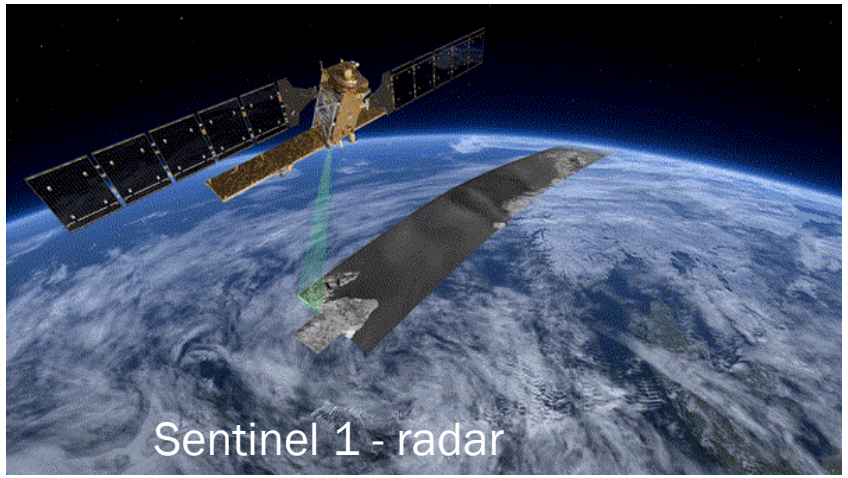
IZS.IT

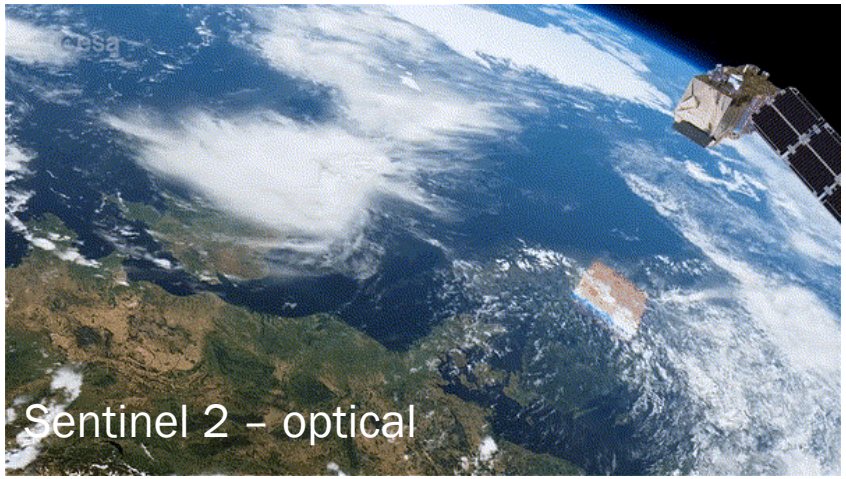
Climatic and Environmental variables in vector-borne diseases



Parselia et al. Satellite Earth Observation Data in Epidemiological Modeling of Malaria, Dengue and West Nile Virus: A Scoping Review. Remote Sens. 2019, 11, 1862; doi:10.3390/rs11161862

Earth Observation





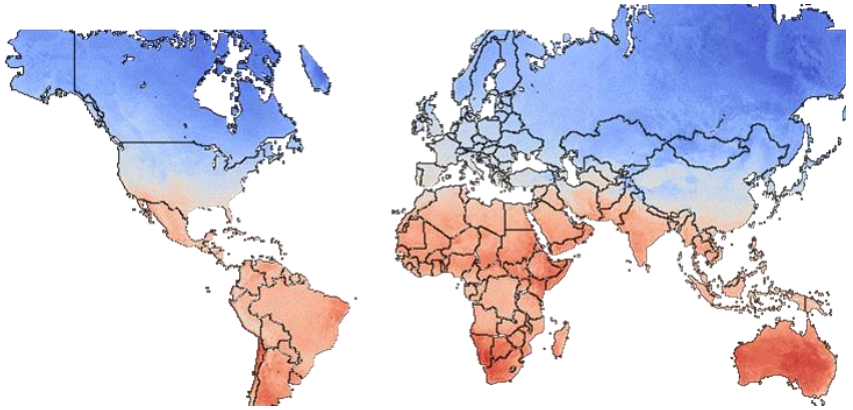
EO provides:

- **accurate** geo-locations for contiguous target areas;
- **objective**, consistent measurements of physical properties of the Earth and its atmosphere that can be interpreted to define its features and conditions;
- **repeated** coverage to enable detection of changes in features and/or their condition.

Earth Observation data

Terra – Aqua satellites

- Spatial resolution: 250 m, 500m, 1 km
- Temporal resolution: 1-2 days

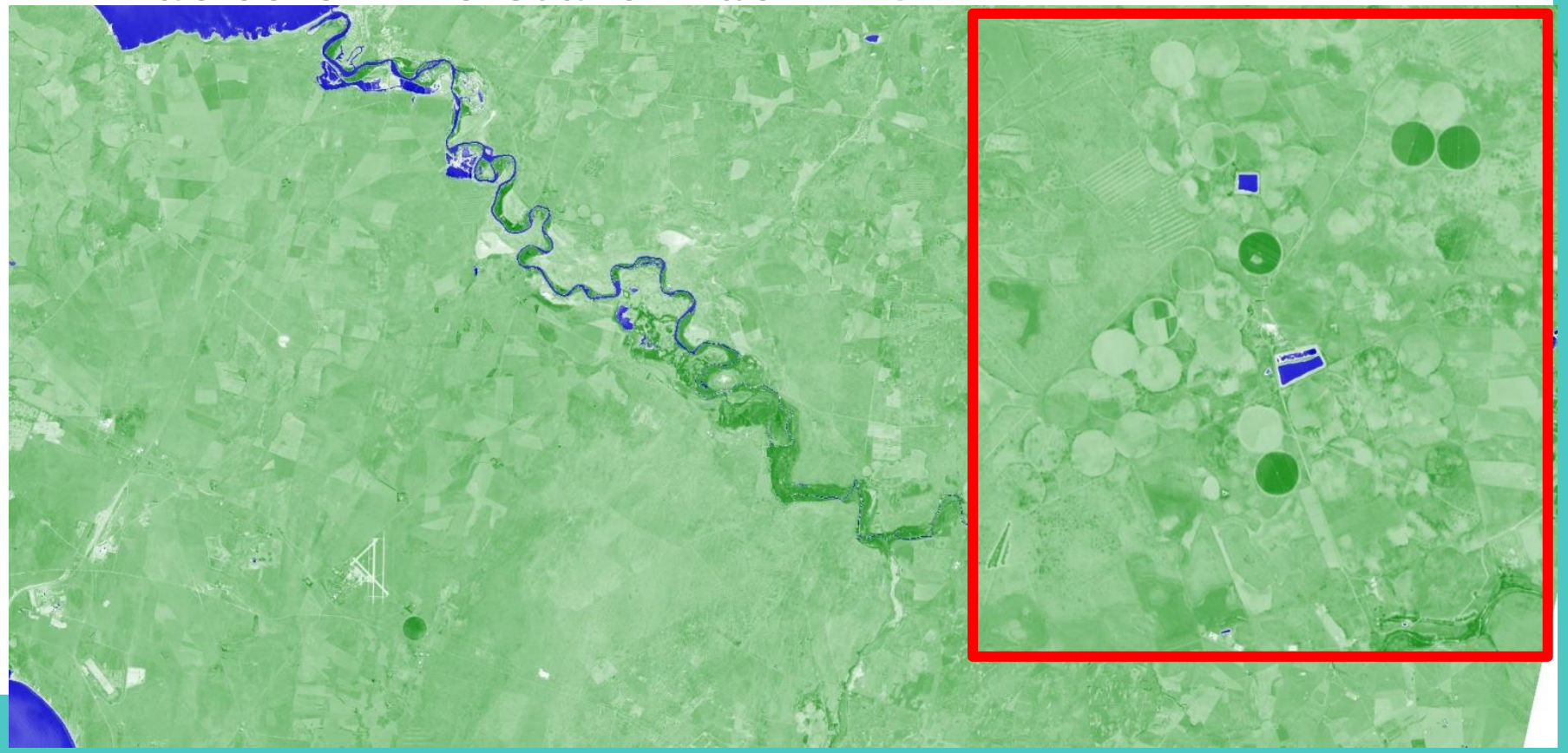


Land Surface Temperature

Normalised Difference Vegetation Index

Copernicus programme

True color Moisture index NDWI

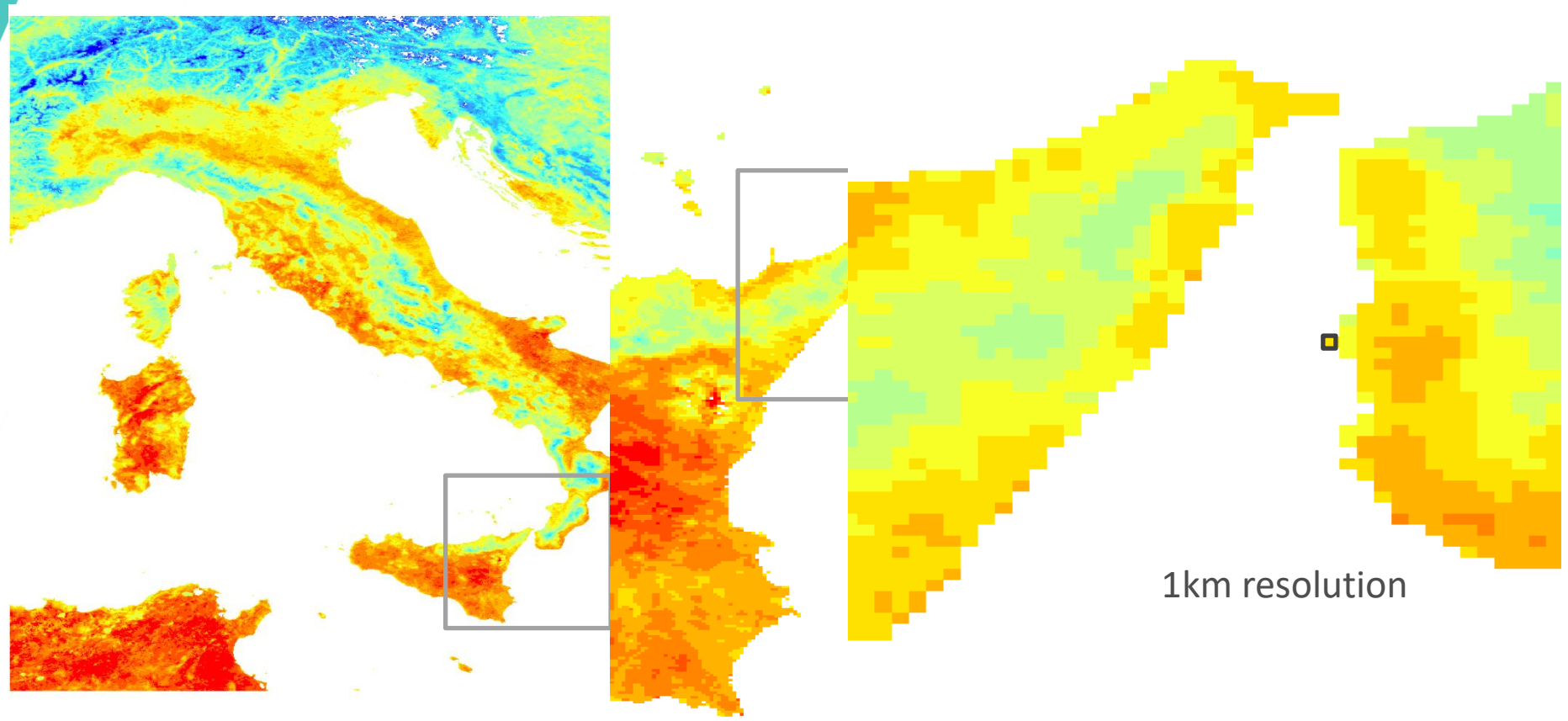


Spatial resolution S-2:
10 m, 20m, 60m

Temporal resolution: 5 days

Earth Observation data

Temperature MODIS 1 km



1km resolution

PROVNA project
Research objectives

1. to define the “ecoregions” of the North African territory (Mauritania, Morocco, Algeria, Tunisia, Libya and Egypt), each one characterized by distinct environmental and climatic factors, on the assumption that similar areas (in space and / or time) are subject to similar diseases (especially vector-borne diseases);
2. to build a customised prototype application to identify areas at risk for RVF in North Africa region. This system combines static inputs with other EO-dynamic variables like NDVI, rainfall to demonstrate this capability and use by various Veterinary Services in the region.

Ecoregionalization

It is the process through which a territory is classified into **similar areas** according to specific **environmental** and **climatic** factors. The climate and the environment strongly influence the presence and distribution of vectors responsible for significant human and animal diseases worldwide. It is then useful to develop a map of similar eco-climatic regions adopting a **data-driven spatial clustering approach** using recent and detailed spatial data on climatic and environmental factors.

PROVNA

World Organisation for Animal Health
Founded as OIE

IZS TERAMO
ISTITUTO ZOOPROFILATTICO SPERIMENTALE DELL'ABRUZZO E DEL MOLISE "G. CAPORALE"

Area of Interest

Project phases

26/04/2022

Phase 1. Definition of the requirements

Activity 1.1: literature review
Activity 1.2: definition of EO data
Activity 1.3: definition of system architecture and statistical analysis

Phase 2: EO data preparation

Activity 2.1: data retrieval
Activity 2.2: manipulation and processing of EO data

Phase 3: Statistical model/analyses - Ecoregions

Activity 3.1: Super SOM (Unsupervised Neural Network)

Phase 4: Ecoregion map evaluation/validation/application and prototype development

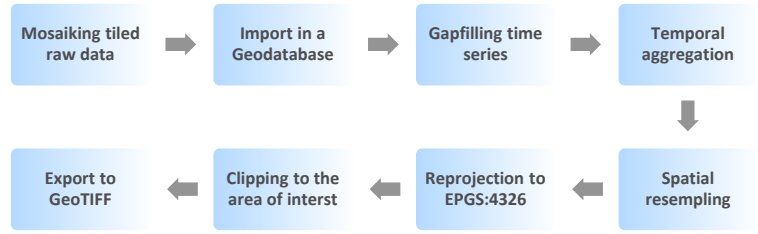
Activity 4.1: disease data/risk areas and ecoregions comparison
Activity 4.2: Web Based Prototype Application Development

Phase 5: Communication and dissemination

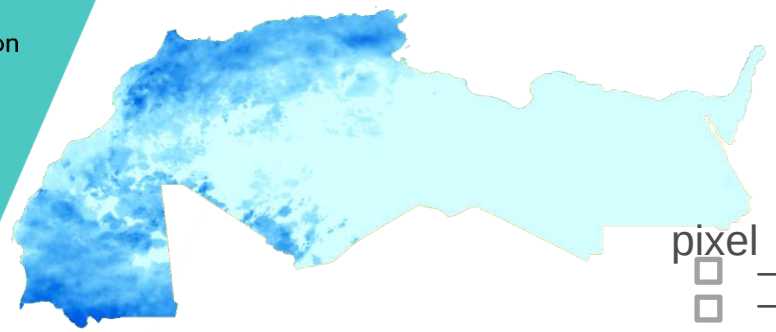
31/06/2024

ECOREGIONALIZATION in North Africa

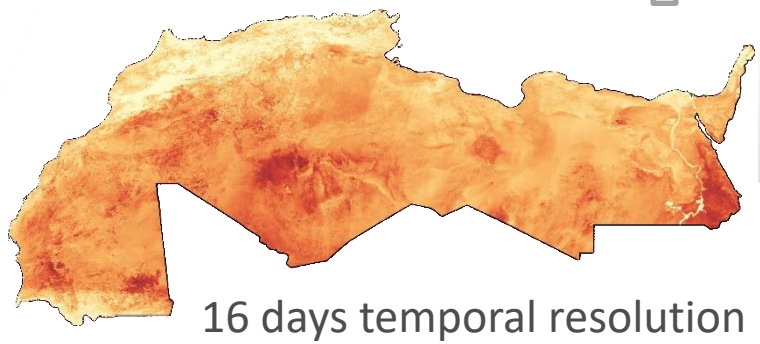
Earth Observation data (2018-2022)



rainfall



250 mt spatial resolution

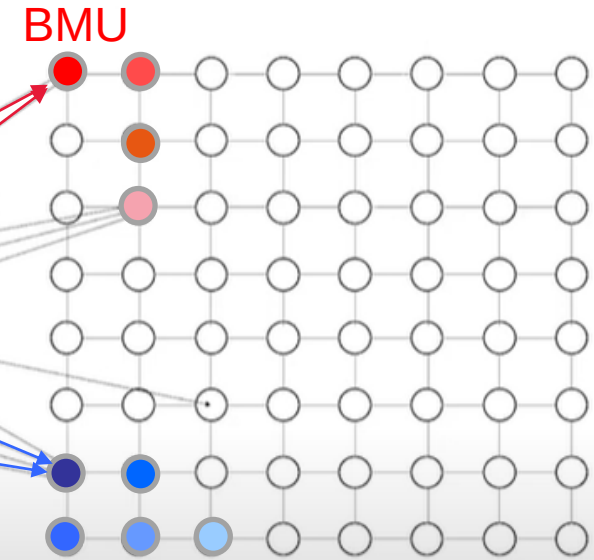


16 days temporal resolution

pixel

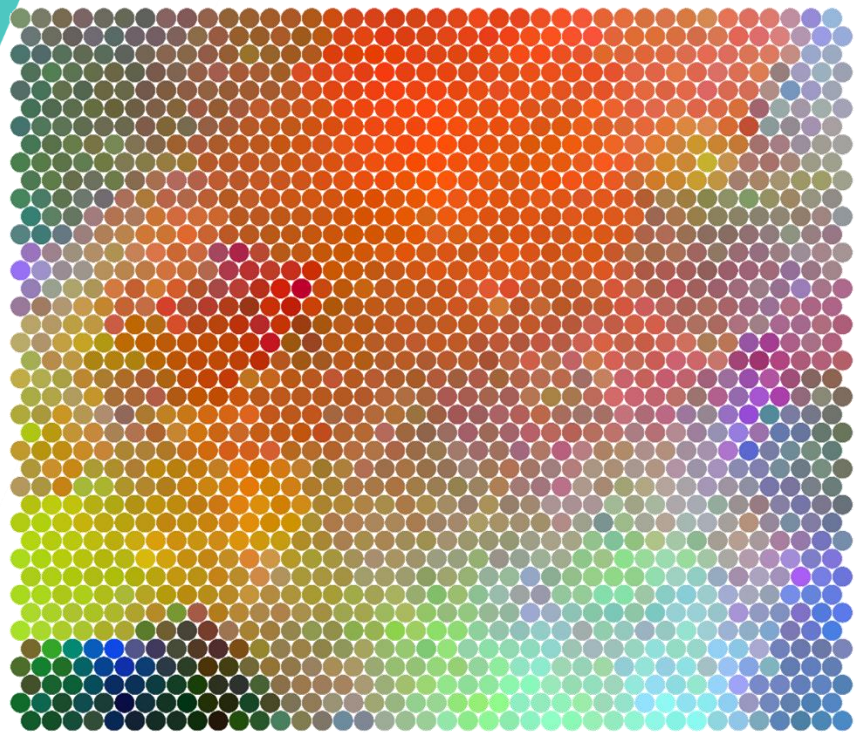
LSTD..... SM

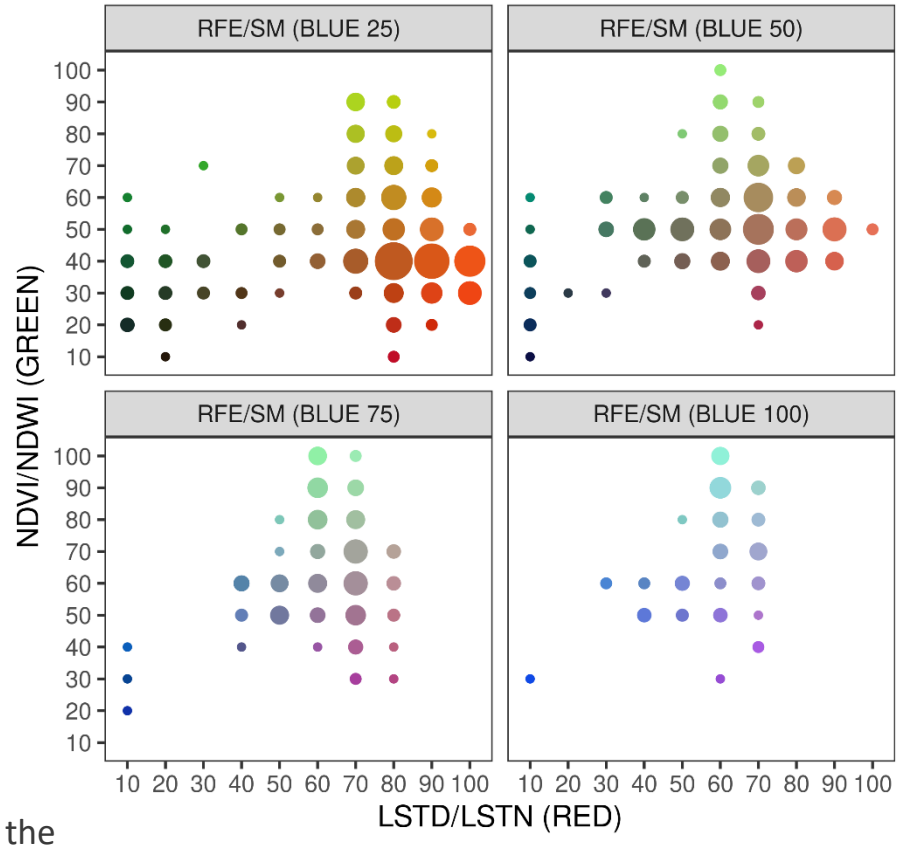
{0.831189, 0.433826, 0.114847}
{0.428795, 0.399229, 0.881367}
{0.325843, 0.209812, 0.930411}
{0.246075, 0.468707, 0.972764}
{0.219395, 0.115503, 0.455577}
{0.387547, 0.148913, 0.537185}
{0.0245103, 0.672357, 0.0145895}
{0.233873, 0.419769, 0.494448}
{0.983612, 0.396847, 0.200075}
{0.0644331, 0.453388, 0.899624}
...



40x40 grid

Self Organizing Maps – Model result





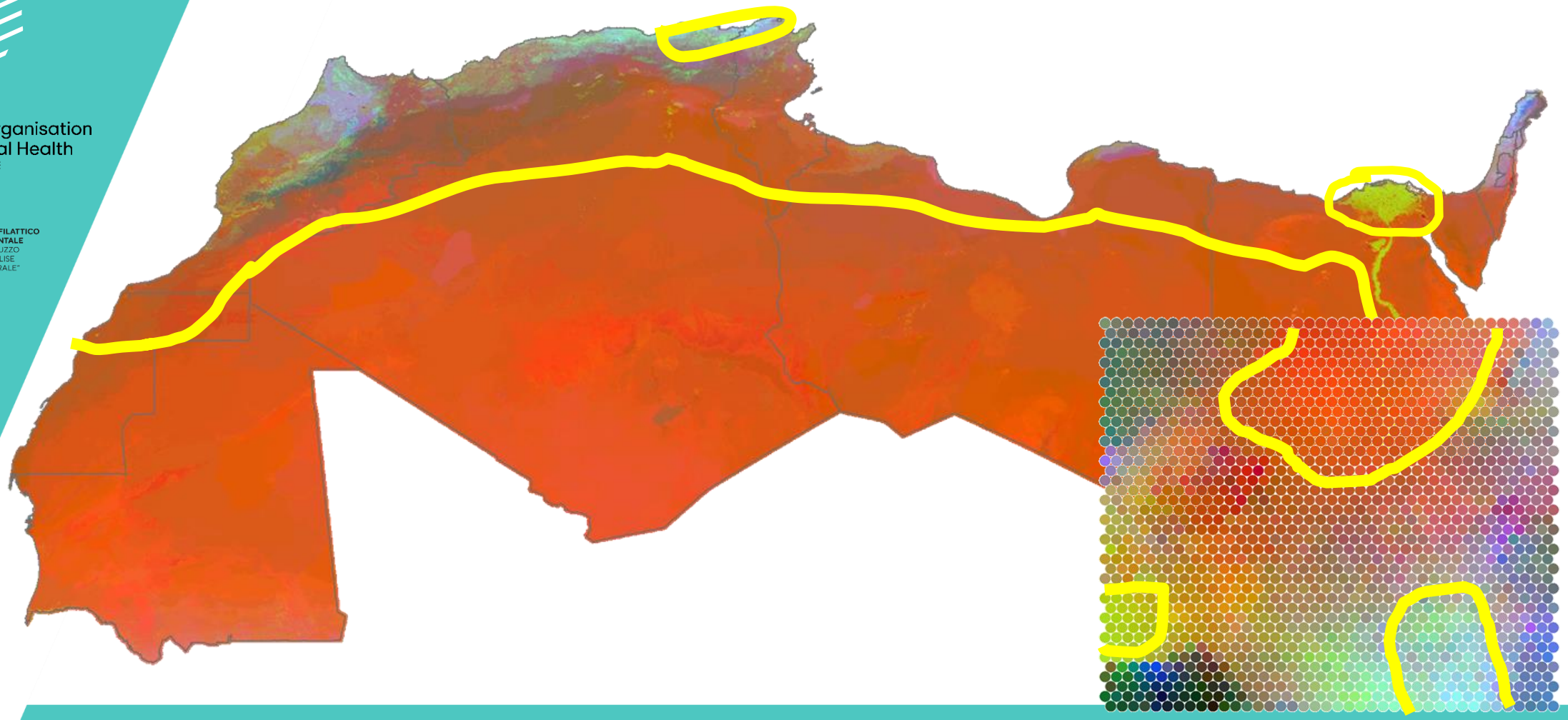
The 1600 nodes were RGB coded. Each color was assigned to each neuron based on the weight of each variable in the node. The Red channel was reserved to the highest weight of LSTD and LSTN, the Green to NDVI and NDWI and Blue to rainfall and soil moisture

PROVNA

World Organisation for Animal Health
Founded as OIE

IZS TERAMO
ISTITUTO ZOOPROFILATTICO SPERIMENTALE DELL'ABRUZZO E DEL MOLISE "G. CAPORALE"

ECOREGIONALIZATION in North Africa

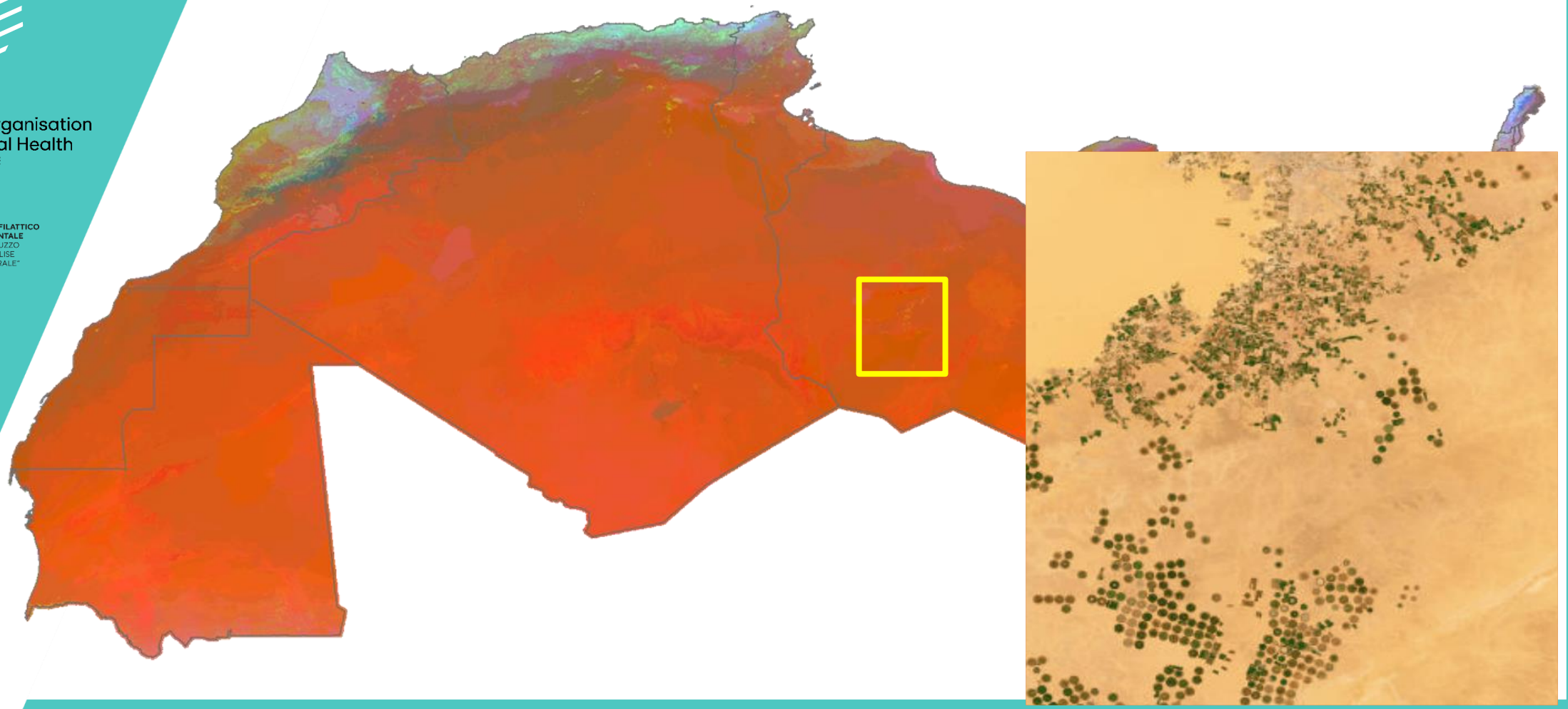


PROVNA

World Organisation for Animal Health
Founded as OIE

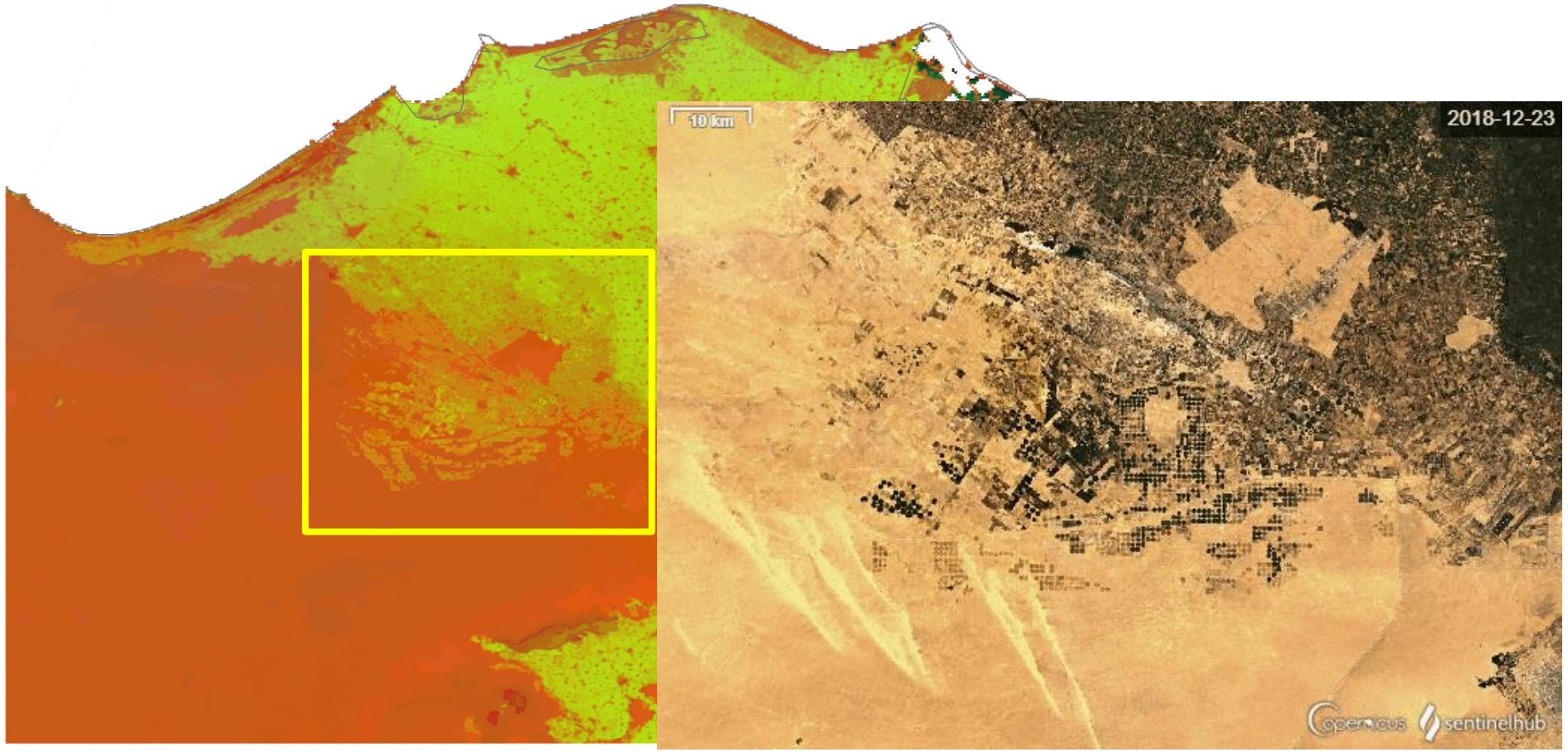
IZS TERAMO
ISTITUTO ZOOPROFILATTICO SPERIMENTALE DELL'ABRUZZO E DEL MOLISE "G. CAPORALE"

ECOREGIONALIZATION in North Africa

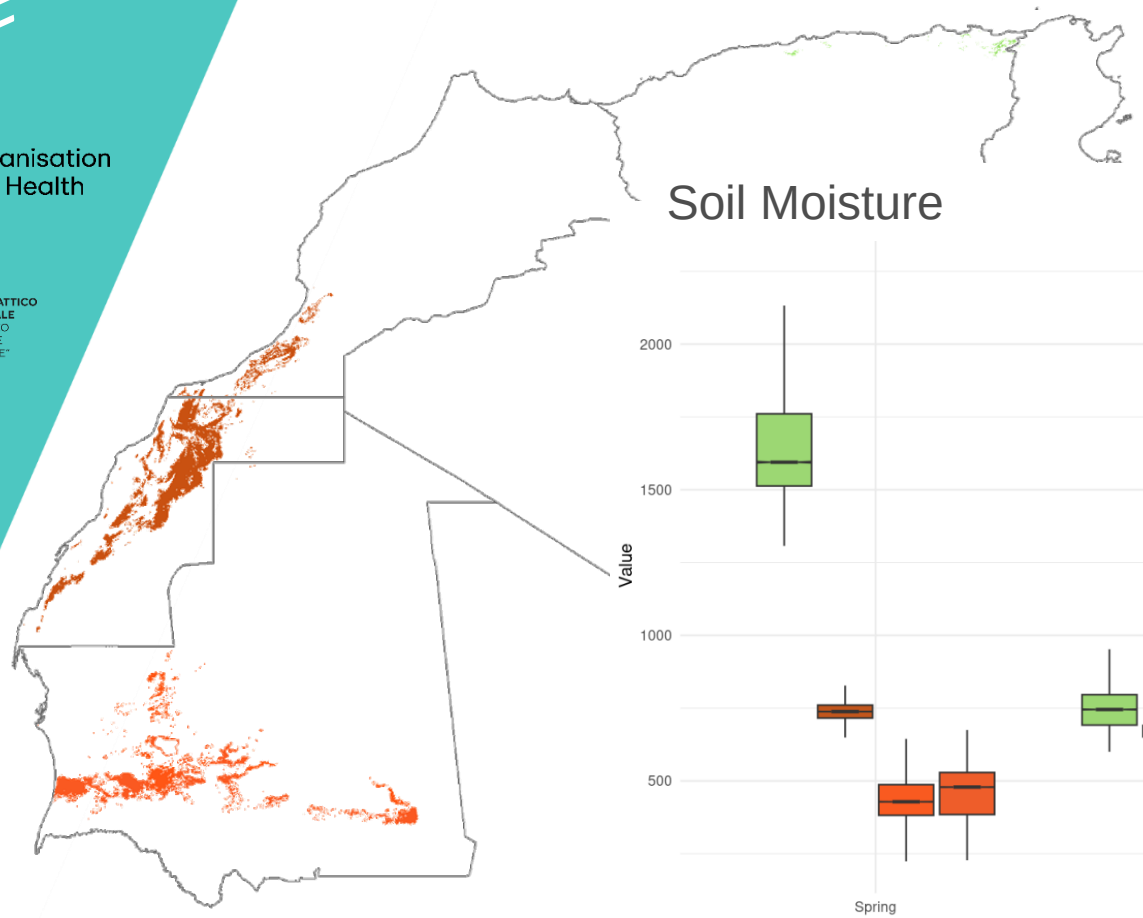


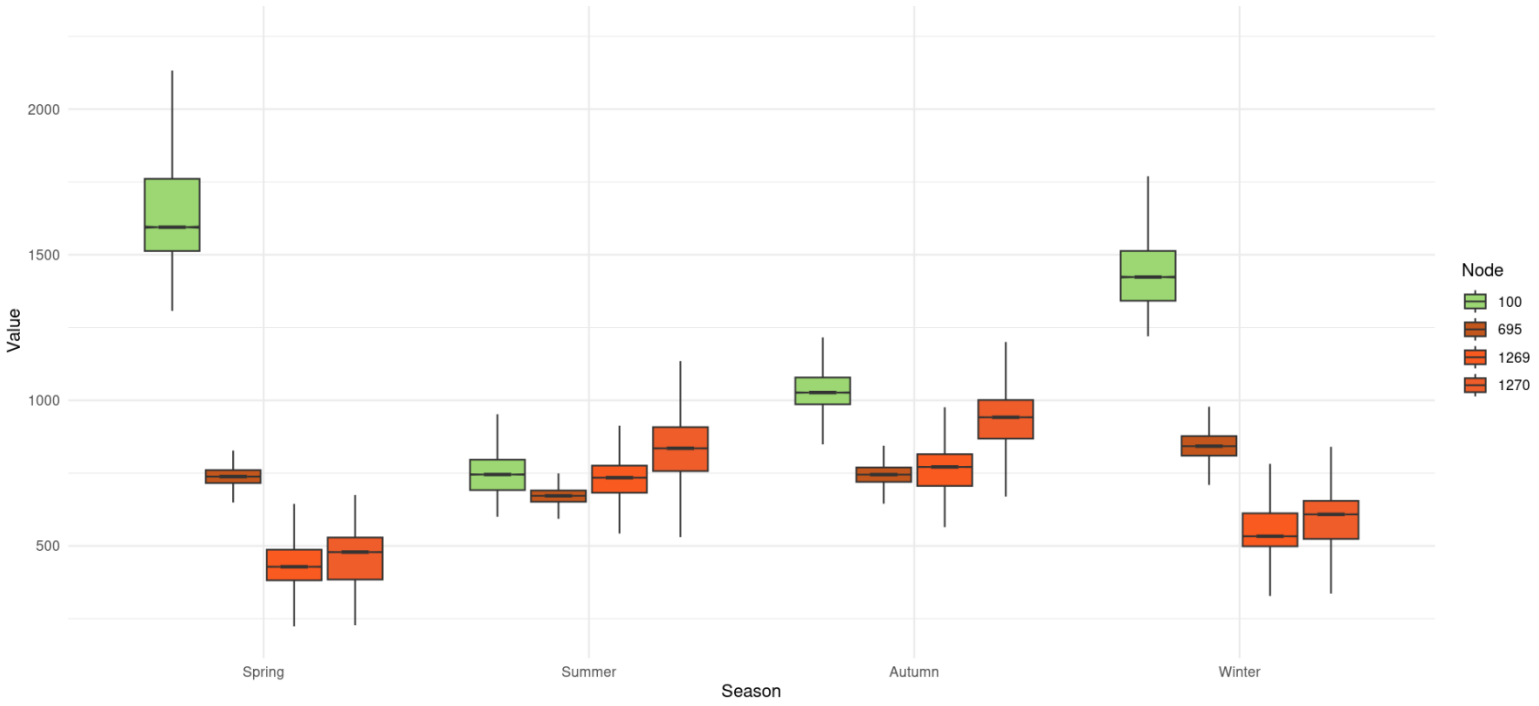
ECOREGIONALIZATION in North Africa

2022



ECOREGIONALIZATION in North Africa



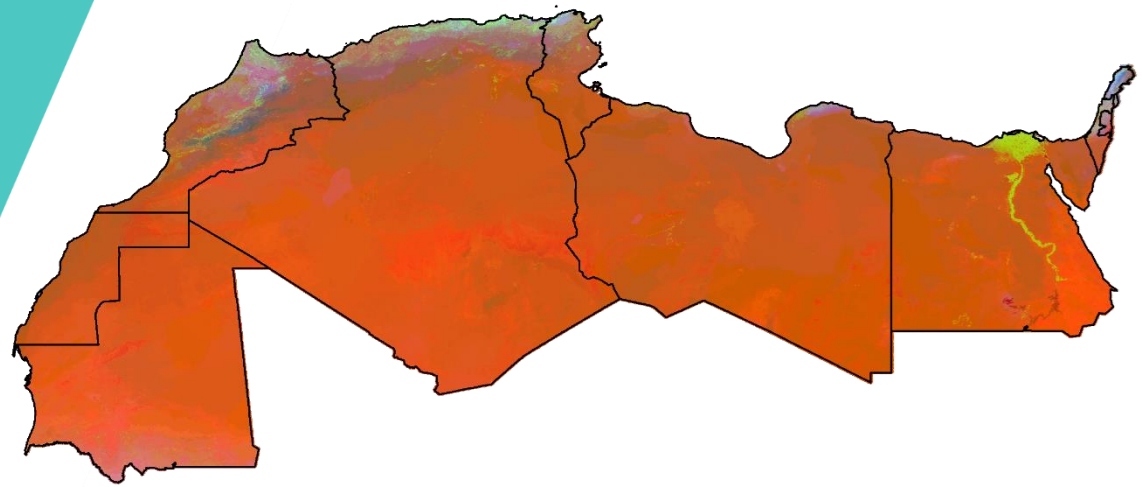


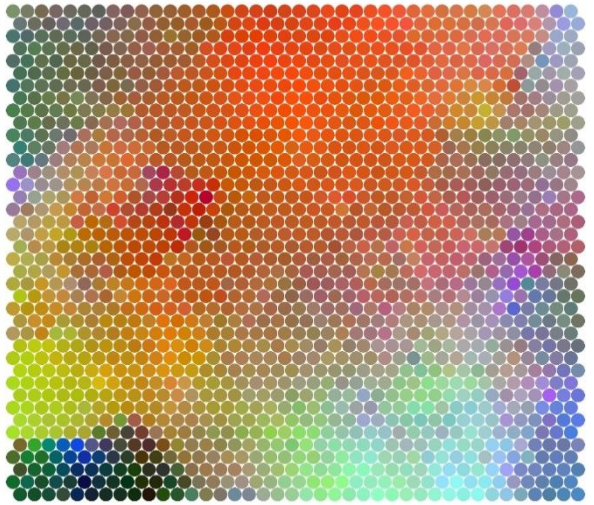
PROVNA

World Organisation for Animal Health
Founded as OIE

IZS TERAMO
ISTITUTO ZOOPROFILATTICO SPERIMENTALE DELL'ABRUZZO E DEL MOLISE "G. CAPORALE"

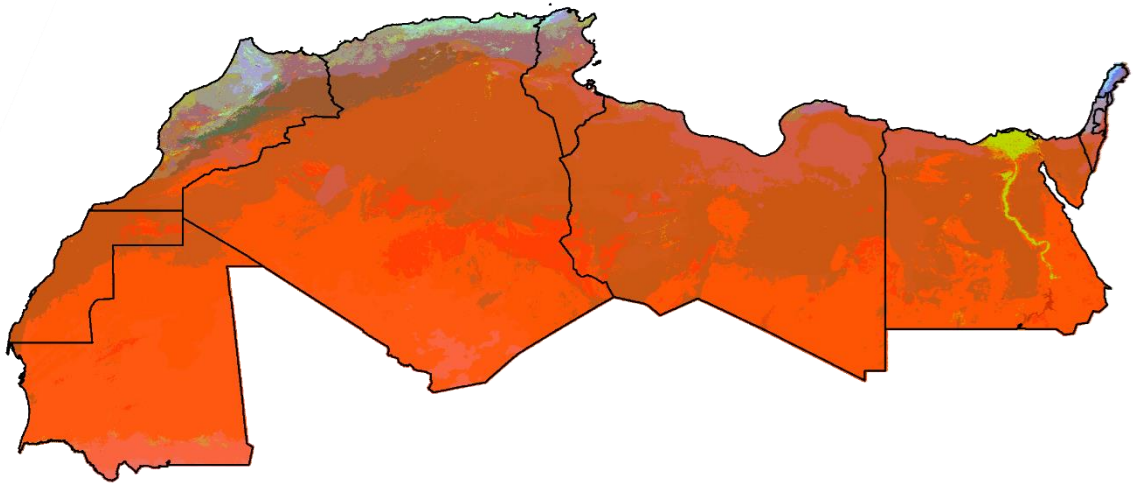
1600 ecoregions

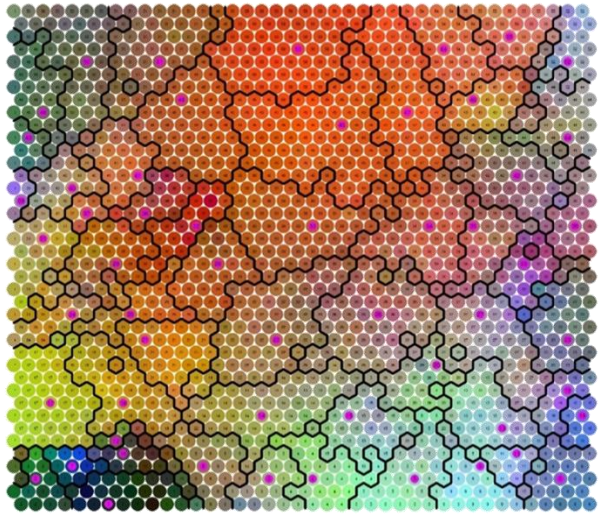




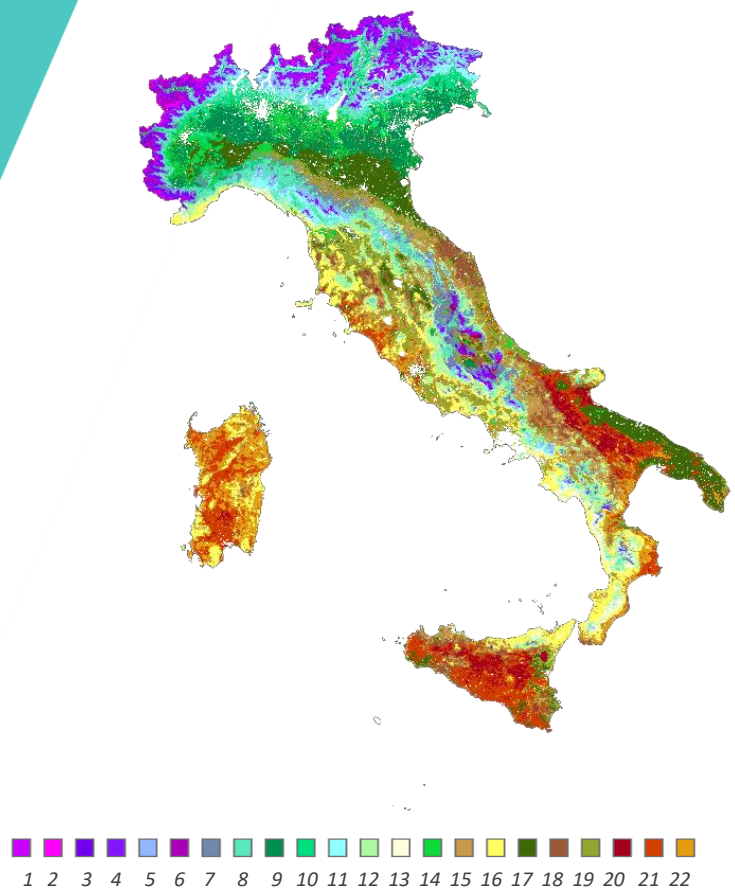
Cluster : Affinity propagation

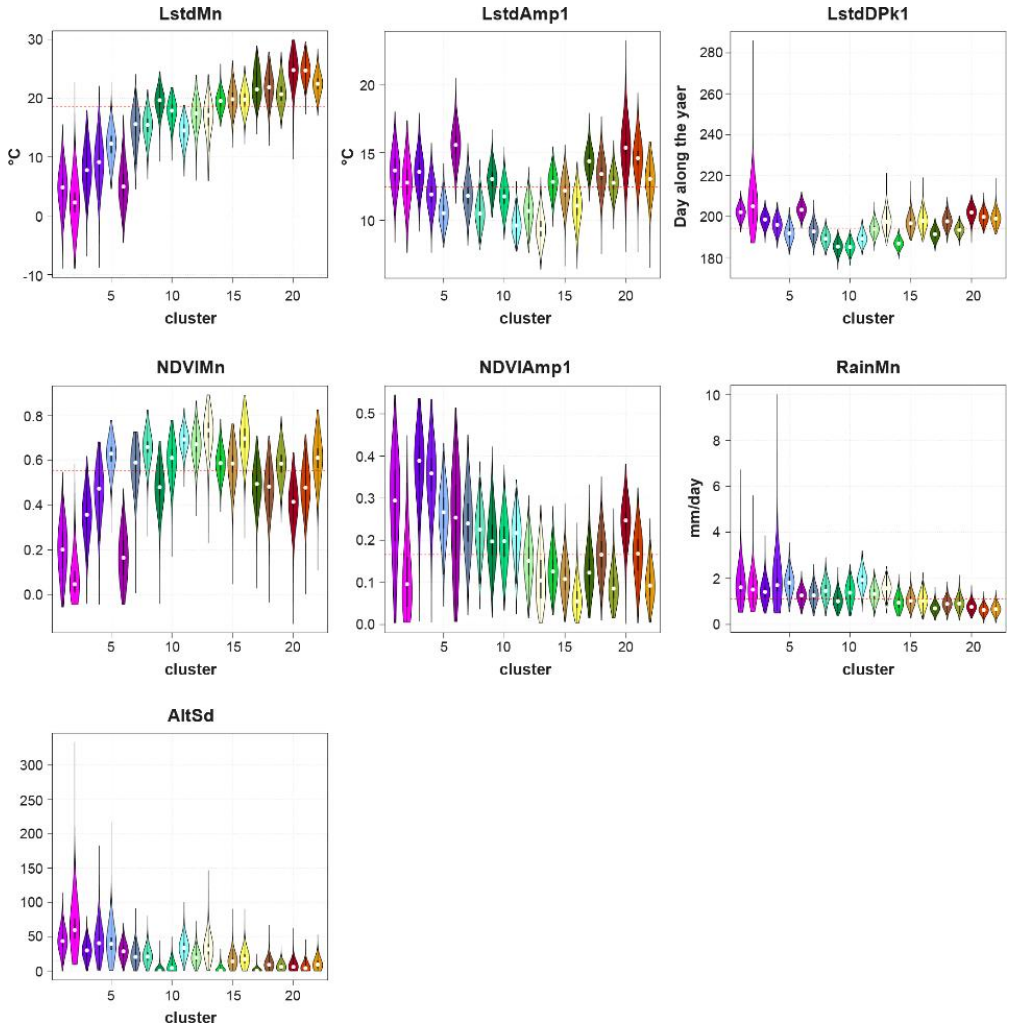
55 ecoregions





ECOREGIONS in Italy

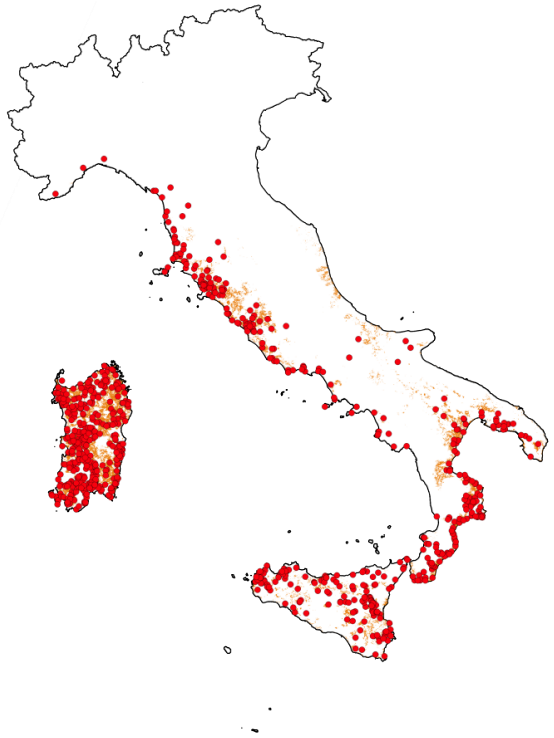




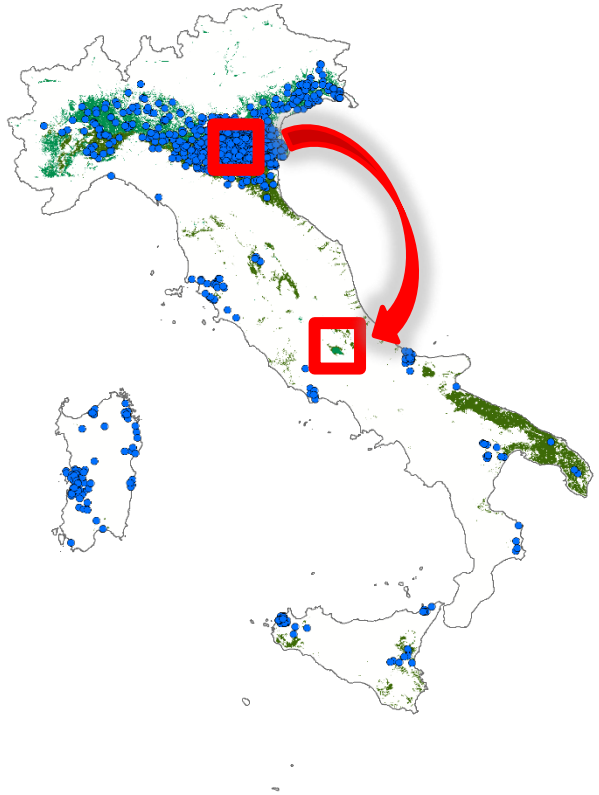
Ippoliti et al. PLoS ONE 14(7): e0219072.

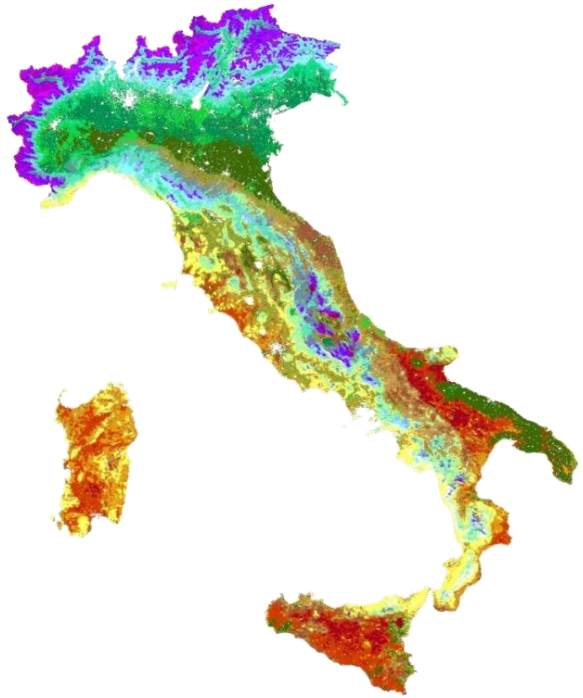
ECOREGIONS in Italy

C. imicola



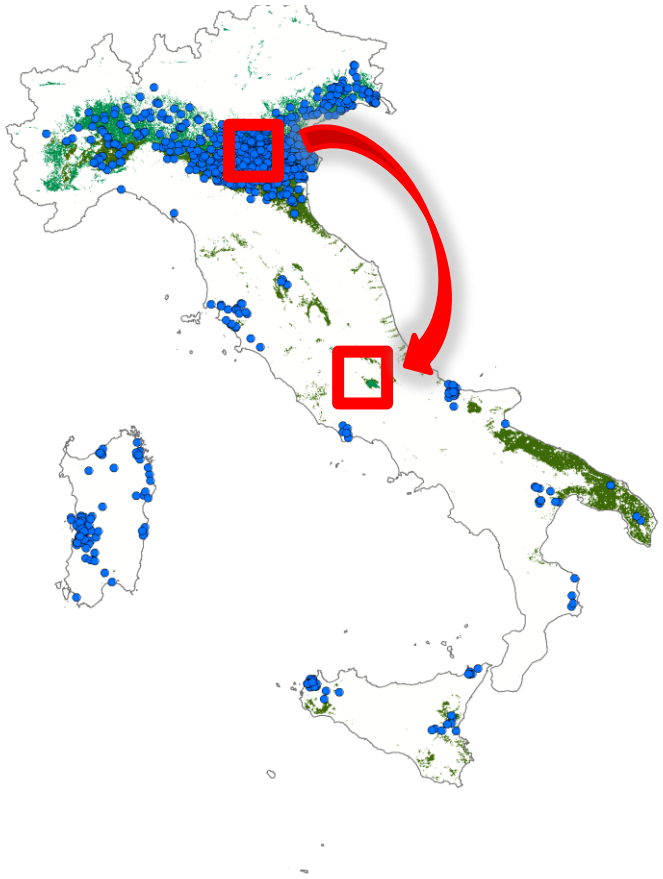
WNV circulation



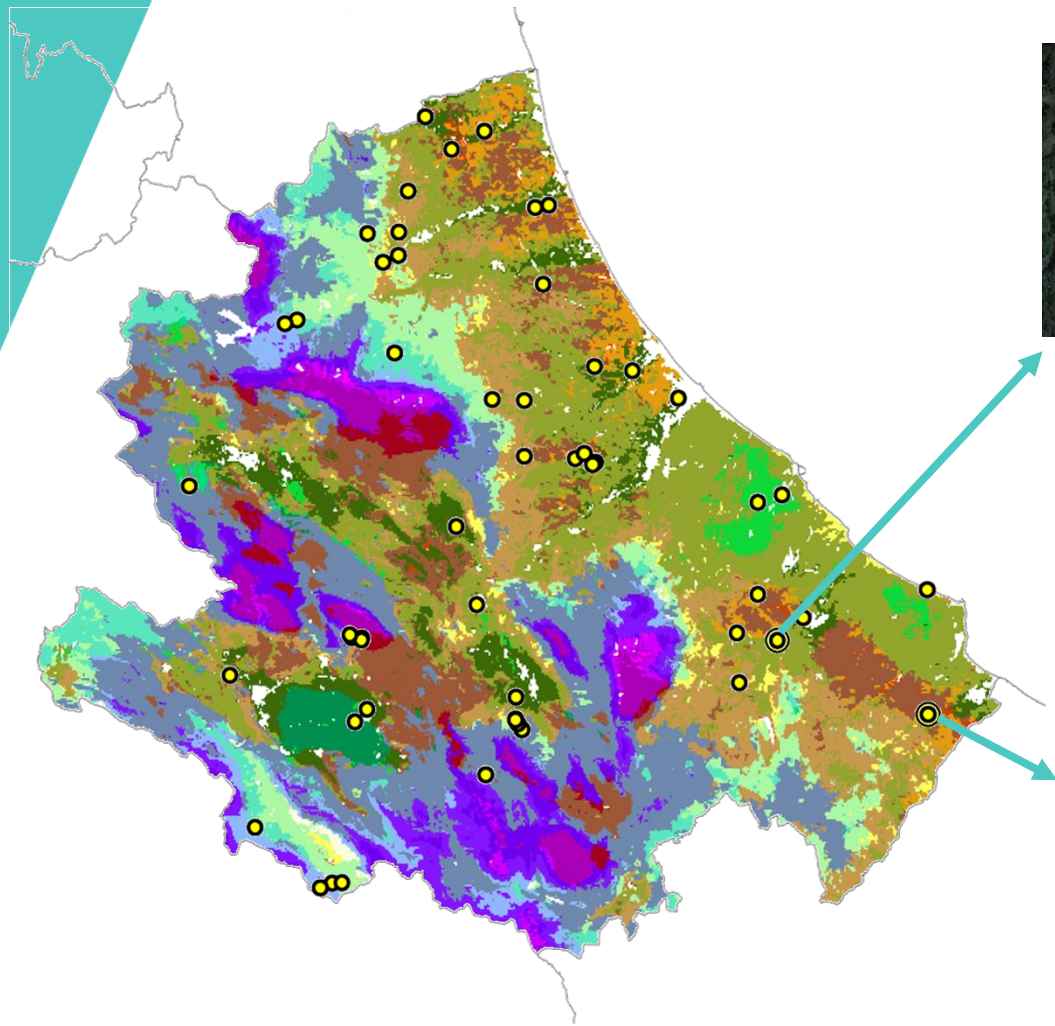


Such an approach…what for?

ecoregions 9, 17



ECOREGIONS and mosquitoes



Altino (CH) 2019-2022
6407 mosquitoes 13 species
5395 (84,2%) *Cx. pipiens* s.l.

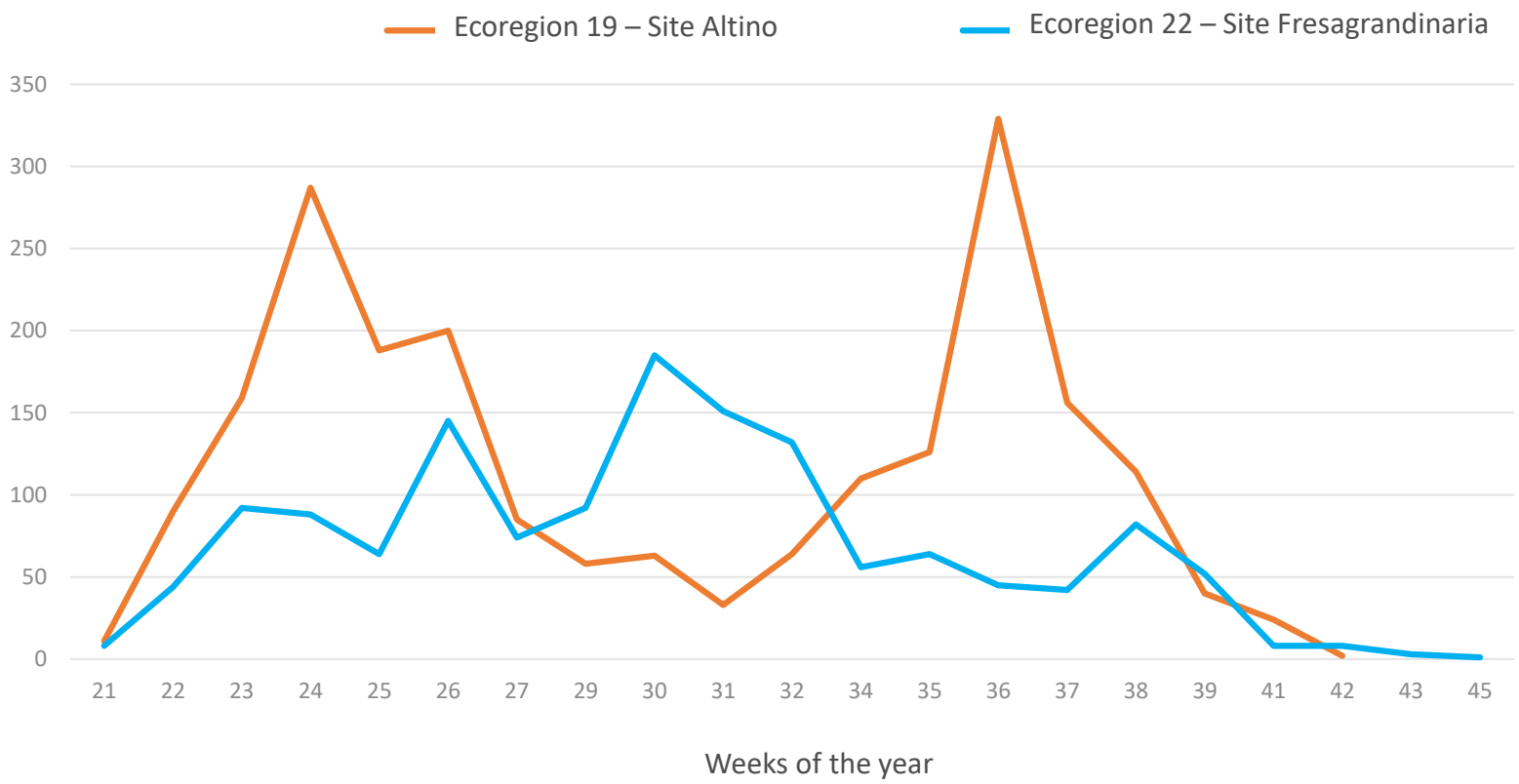
ecoregion 19

ecoregion 22

Fresagrandinaria (CH) 2019-2022
4478 mosquitoes 16 species
3486 (77,8%) *Cx. pipiens s.l.*

ECOREGIONALIZATION and vector-borne disease

DIFFERENT ECOREGIONS
Culex pipiens 2020



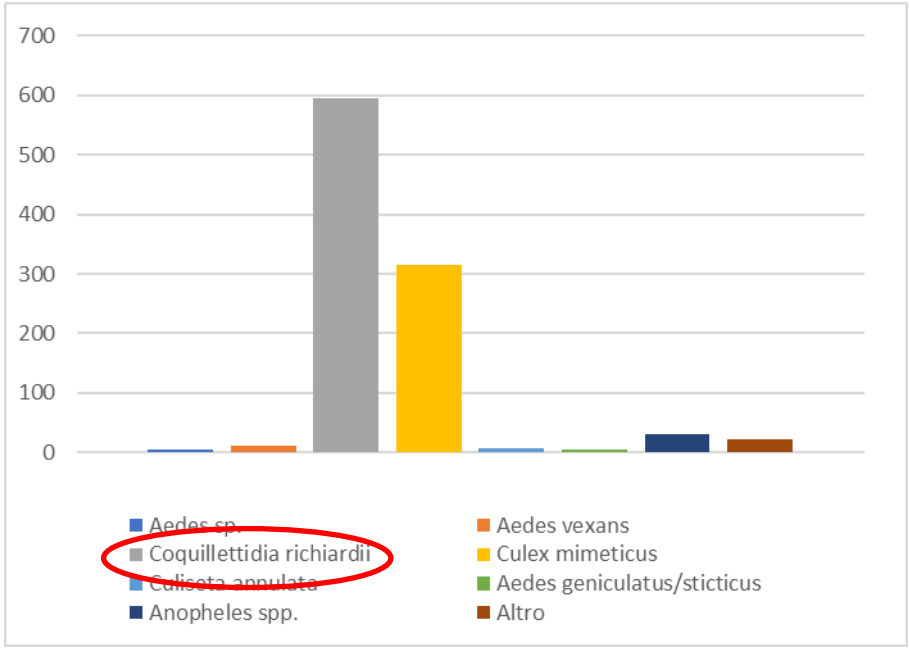
ECOREGIONALIZATION and vector-borne disease

DIFFERENT ECOREGIONS 2019-2022

Cx pipiens 5395

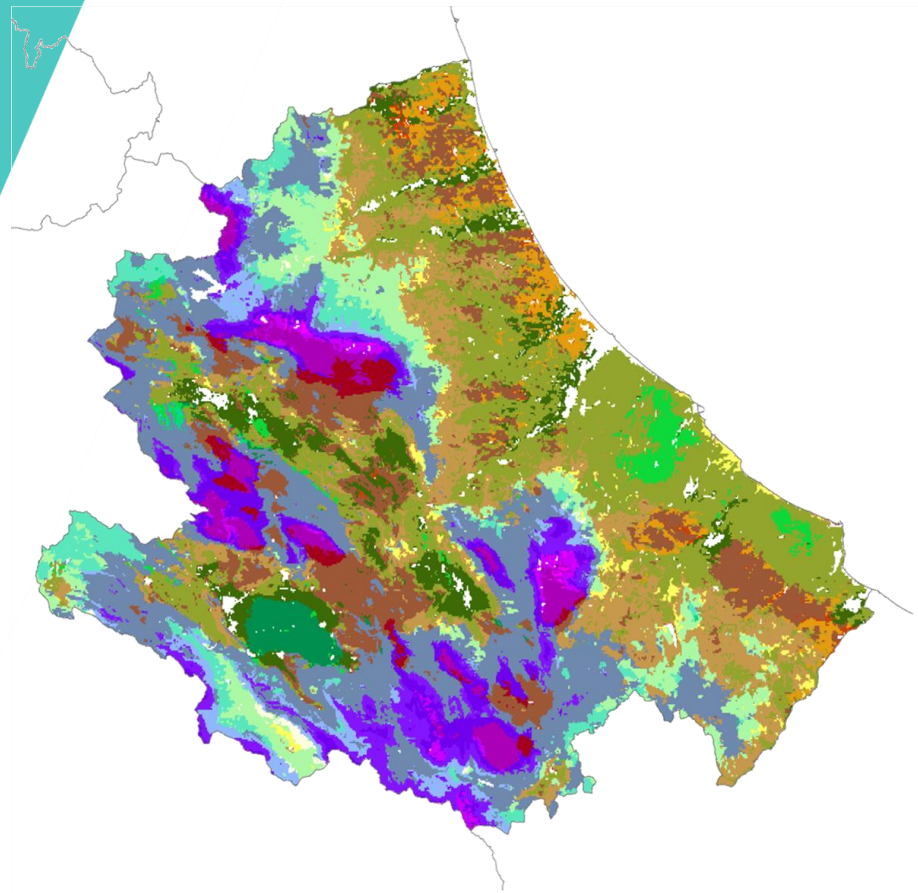
Ecoregion 19 – Site Altino

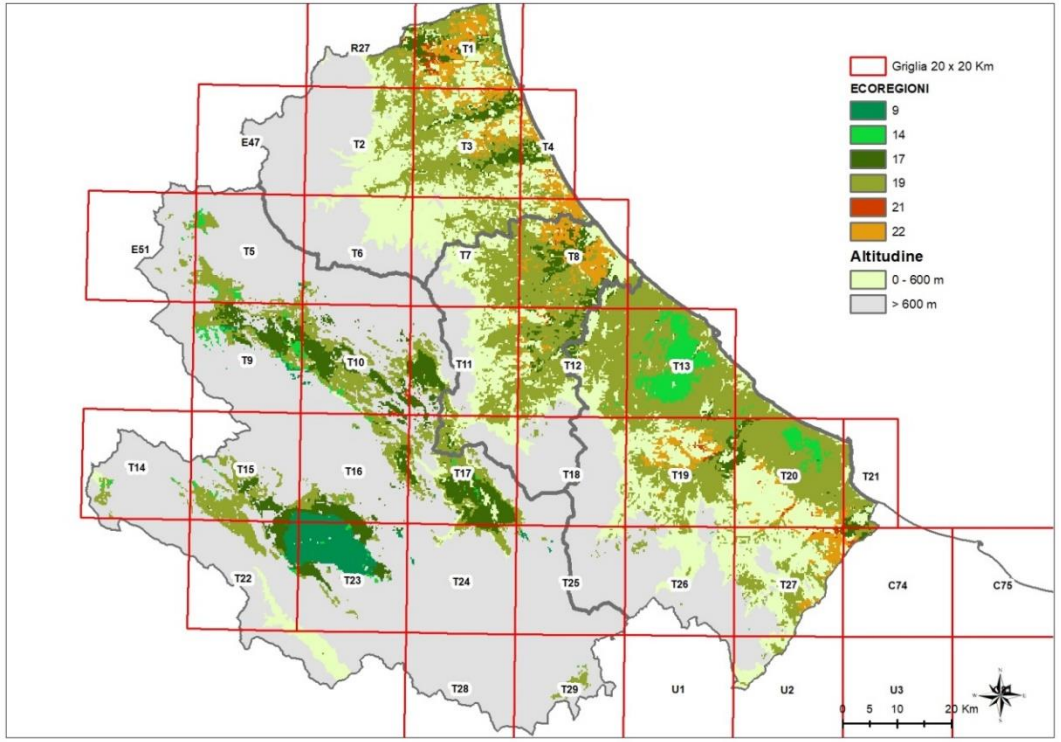
Cx. pipiens 3486



Ecoregion 22 – Site Fresagrandinaria

ECOREGIONS and WNV surveillance





Conclusion ECOREGIONS in North Africa

Ecoregions are useful for Veterinary Services and Authorities to plan targeted surveillance with optimization of human and financial resources.
In Italy this approach is part of the surveillance process for West Nile.

What next for ECOREGIONS in North Africa

1. To be fully validated we should better define the level of similarity/difference between ecoregions with the help of Countries
2. Integrate field data for vector-borne diseases to better test and compare with where possible

Thank you