SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Regional on-site training and study tour on "Drought Risk Management Mainstreaming" (REG-7 and ST-6)

Crop production and agricultural drought monitoring

Presented by:

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24-27 September 2018, Murcia, Spain

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Dr. Salomón Montesinos

Educational Training:

Universidad Complutense de Madrid
Doctorate in Geological Sciences, Geological Engineering, with distinction *"cum laude"* and Extraordinary Award
1995

Currently:

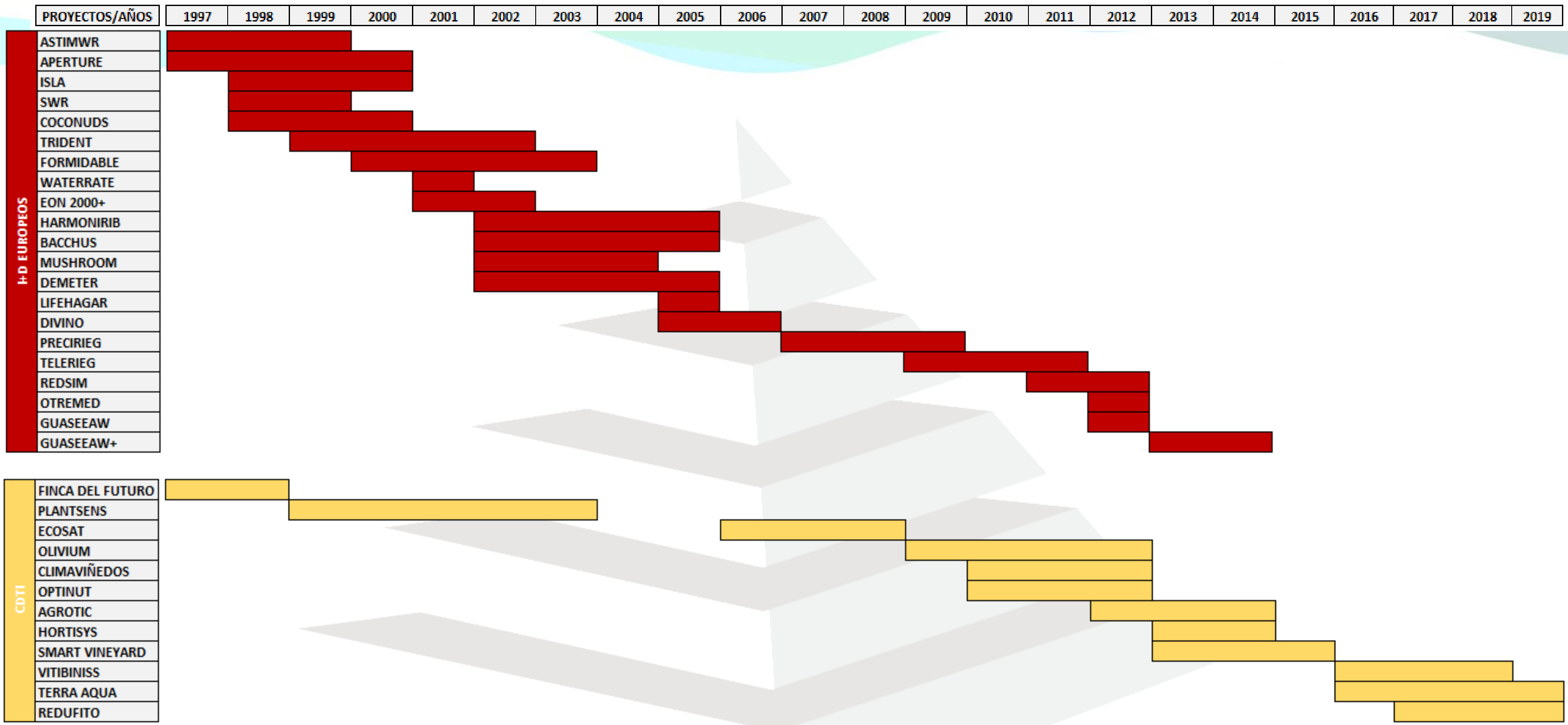
Managing Director
SM GEODIM
2013 – until now (5 years)

Associate Professor
CIVIL ENGINEER'S SCHOOL (UCLM)
2000 – until now (18 years), Ciudad Real, Spain

Coordinator of Technological Transfer
REMOTE SENSING SPANISH ASSOCIATION
2016 – until now

Master's Director of "UAV's Operational Applications in Engineering"
STRUCTURALIA
2018- until now

R&D Projects



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TELERIEG
REDSIM
OTREMED
GUASEEAW
GUASEEAW+
CDTI
FINCA DEL FUTURO
PLANTSENS
ECOSAT
OLIVIUM
CLIMAVIÑEDOS
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HORTISYS
SMART VINEYARD
VITIBINISS
TERRA AQUA
REDUFITO

Remote sensing and Drought

Drought can be monitored effectively over large areas using remote sensing.

Satellite-borne remote sensing data provides a **synoptic view of Earth surface**, and therefore can be used to evaluate drought occurrence spatially.

Several remotely-sensed drought indices have been developed and applied, which include duration, intensity, severity and spatial extent.

Normalized Difference Vegetation Index **(NDVI)** as a probe for vegetation health has been **one of most commonly used approaches to drought events monitoring**.

To improve the approach, **it has been advisable to combine vegetation index and temperature**. A combined NDVI and land surface temperature (LST) provides strong correlation and gives useful information to identification of agricultural drought as an early warning system.

Source: Sholihah et al, 2015

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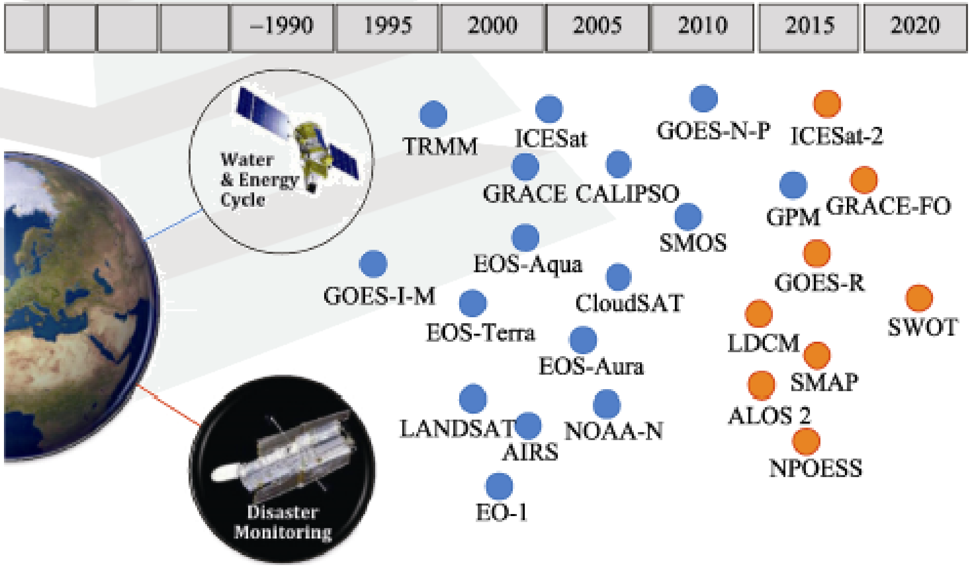
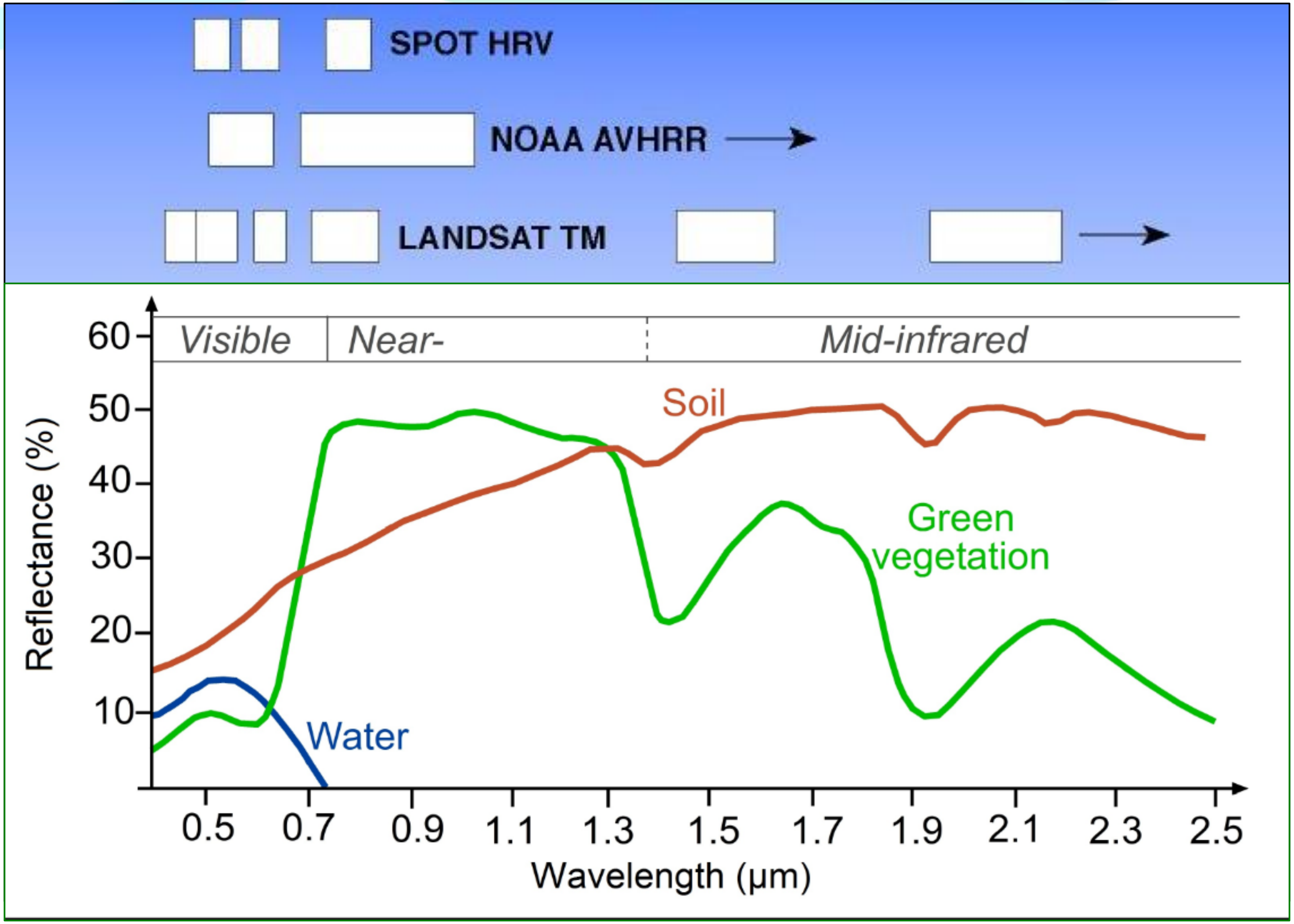
Satellite Monitoring of Drought

Many different satellites are used to monitor drought.

- **GOES, METEOSAT, INSAT, GMS** are used for prediction.
- **NOAA/AVHRR, IRS/WiFS, SPOT4/Vegetation** are used for monitoring and early warning.
- **TRMM, RESOURCESAT, MODIS** and **MERIS**.
- **LANDSAT, IRS, SPOT, Sentinel.**



Spectral Signature



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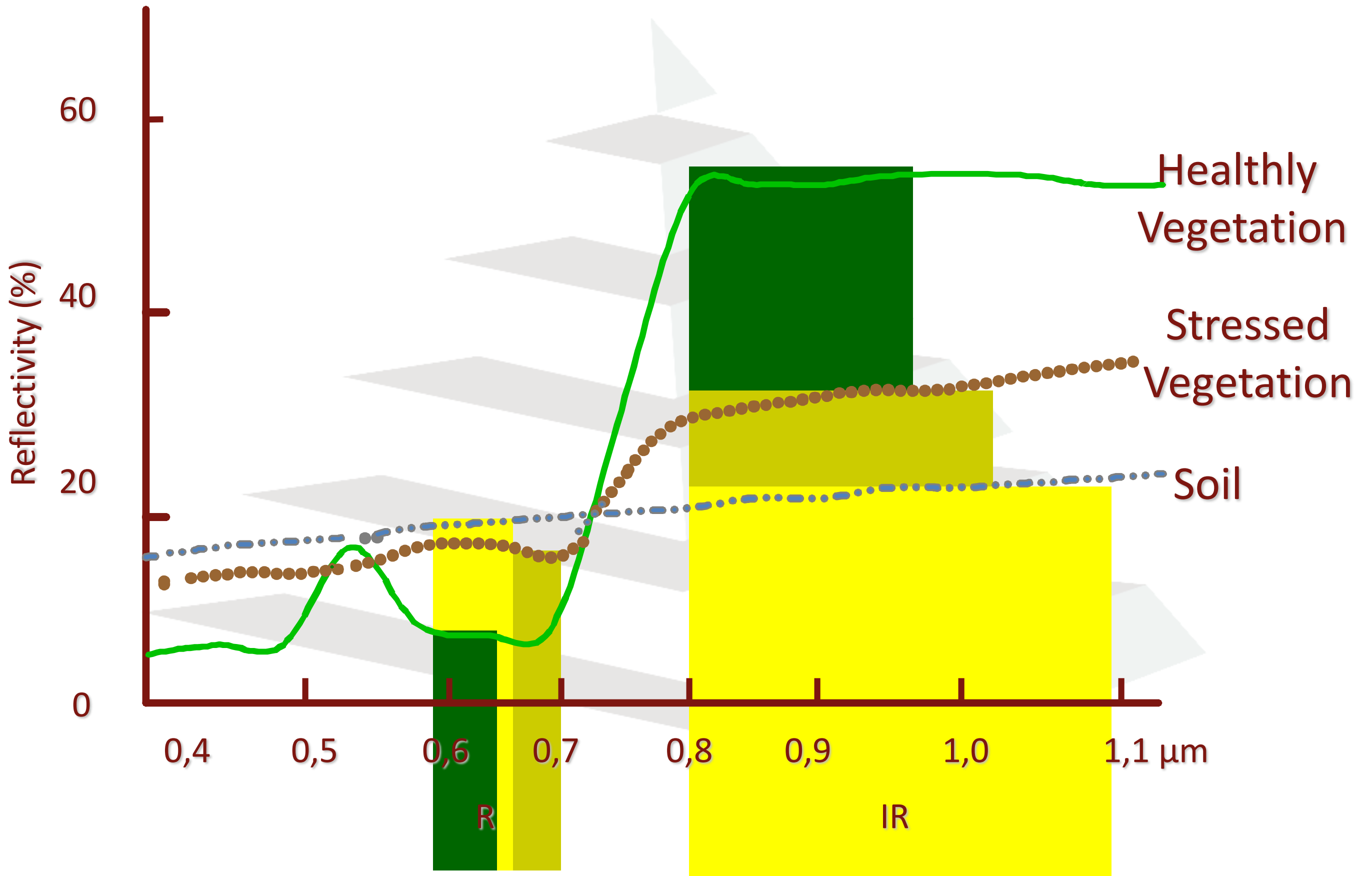
Vegetation Index



Vegetation Index

$RATIO = \frac{NIR}{R}$	Birth and McVey (1968)
$NDVI = \frac{NIR - R}{NIR + R}$	Rouse *et al.* (1974)
$SAVI = \frac{NIR - R}{(NIR + R)}(1+L)$	Huete (1988)
$TVI = \sqrt{\frac{(NIR - R)}{NIR + R}} + 0.5$	Deering *et al.* (1975)
$CTVI = \frac{NDVI + 0.5}{ABS\,(NDVI + 0.5)} \times \sqrt{ABS\,(NDVI + 0.5)}$	Perry and Lautenschlager (1984)
$TTVI = \sqrt{ABS\,(NDVI + 0.5)}$	Thiam (1997)
$RVI = \frac{R}{NIR}$	Richardson and Wiegand (1977)
$NRVI = \frac{RVI - 1}{RVI + 1}$	Baret and Guyot (1991)
$EVI = G\frac{NIR - R}{NIR + C_1R - C_2B + L}(1+L)$	Huete *et al.* (1999)

NIR = near infrared, R = red, B = blue, L = Soil adjustment factor, C_1 and C_2 are constants, G is a gain factor

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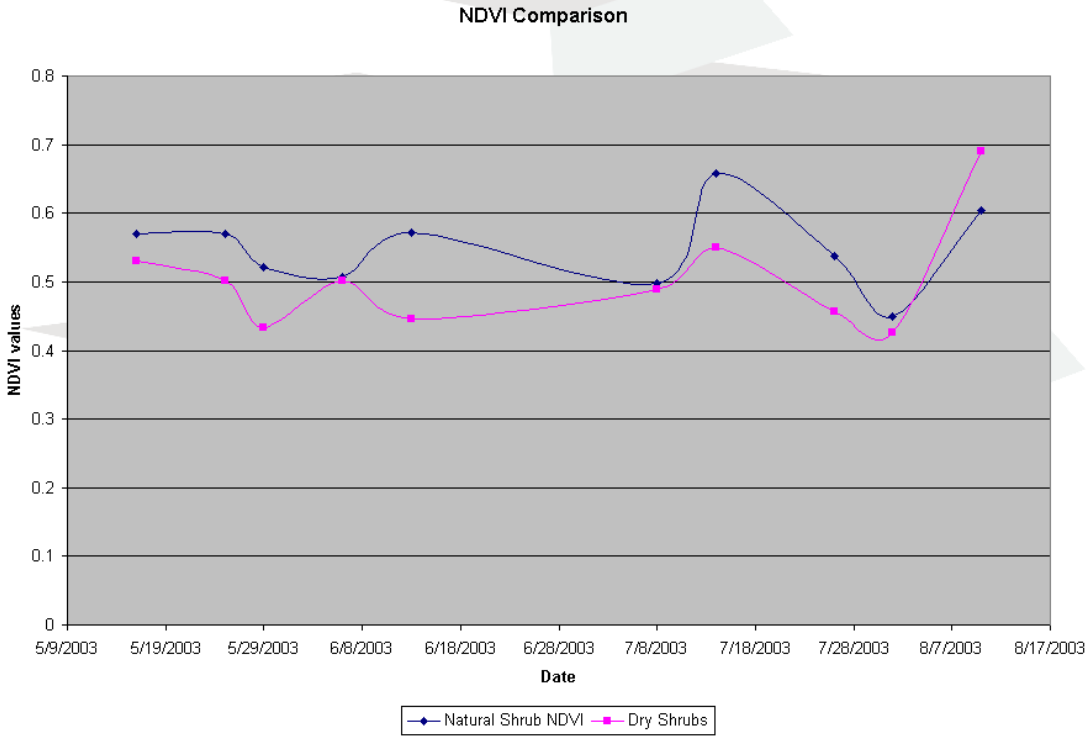
Normalized Difference Vegetation Index

NDVI changes with drought stresses; a drought-stressed plant will have a lower NDVI than a regular plant.

NDVI = (NIR – Red) / (NIR + Red)



Vegetation Condition Index

NDVI can be difficult to interpret when comparing different ecosystems

The Vegetation Condition Index **(VCI)** was proposed by Kogan (1990) **to separate the short-term weather signal from the ecological signal.**

$$\mathbf{VCI = (NDVI_{cur} - NDVI_{min}) / (NDVI_{max} - NDVI_{min})*100}$$

$NDVI_{max}$ and $NDVI_{min}$ are the maximum and minimum NDVI values from the historical data

$NDVI_{cur}$ is the NDVI for the date and location under review

VCI values range from 0 to 100.

Low values indicate poor vegetation conditions, possibly related to drought.

The VCI has shown good results in drought detection tracking and mapping.

However, use of **this index requires a long-term record of NDVI values**.

Developed with AVHRR data.

Thermal Condition Index

The VCI has been recommended as drought tool, however, using sole VCI was not enough to describe drought analysis accurately.

TCI was developed to capture different responses of vegetation to in-situ temperature as additional information. This can be achieved by employing thermal channels for drought monitoring:

$$TCI = (LST_{max} - LST_{cur}) / (LST_{max} + LST_{min}) * 100$$

LST_{max} and LST_{min} are the maximum and minimum LST values from the historical data

LST_{cur} is the LST for the date and location under review

TCI values range from 0 to 100.

Vegetation Health Index

Vegetation Health Index (VHI) has demonstrated a greater capability and has presented a better suitability in detecting drought.

It **considers both vegetation condition (VCI) and thermal condition of vegetation (TCI)** within a period of observation.

$$\mathbf{VHI} = a\mathbf{*VCI} + (1-a)\mathbf{*TCI}$$

Where, VHI is related to VCI and TCI by a

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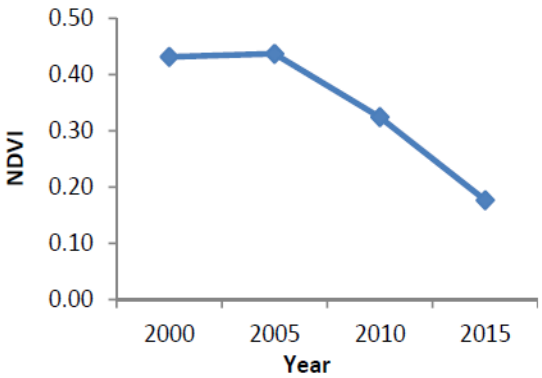
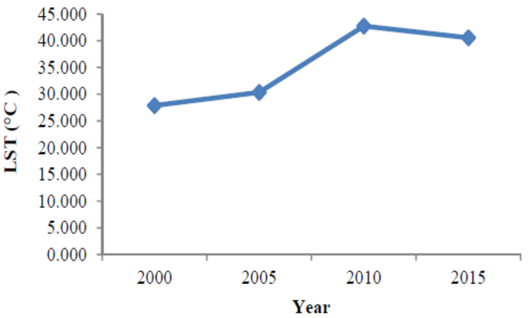
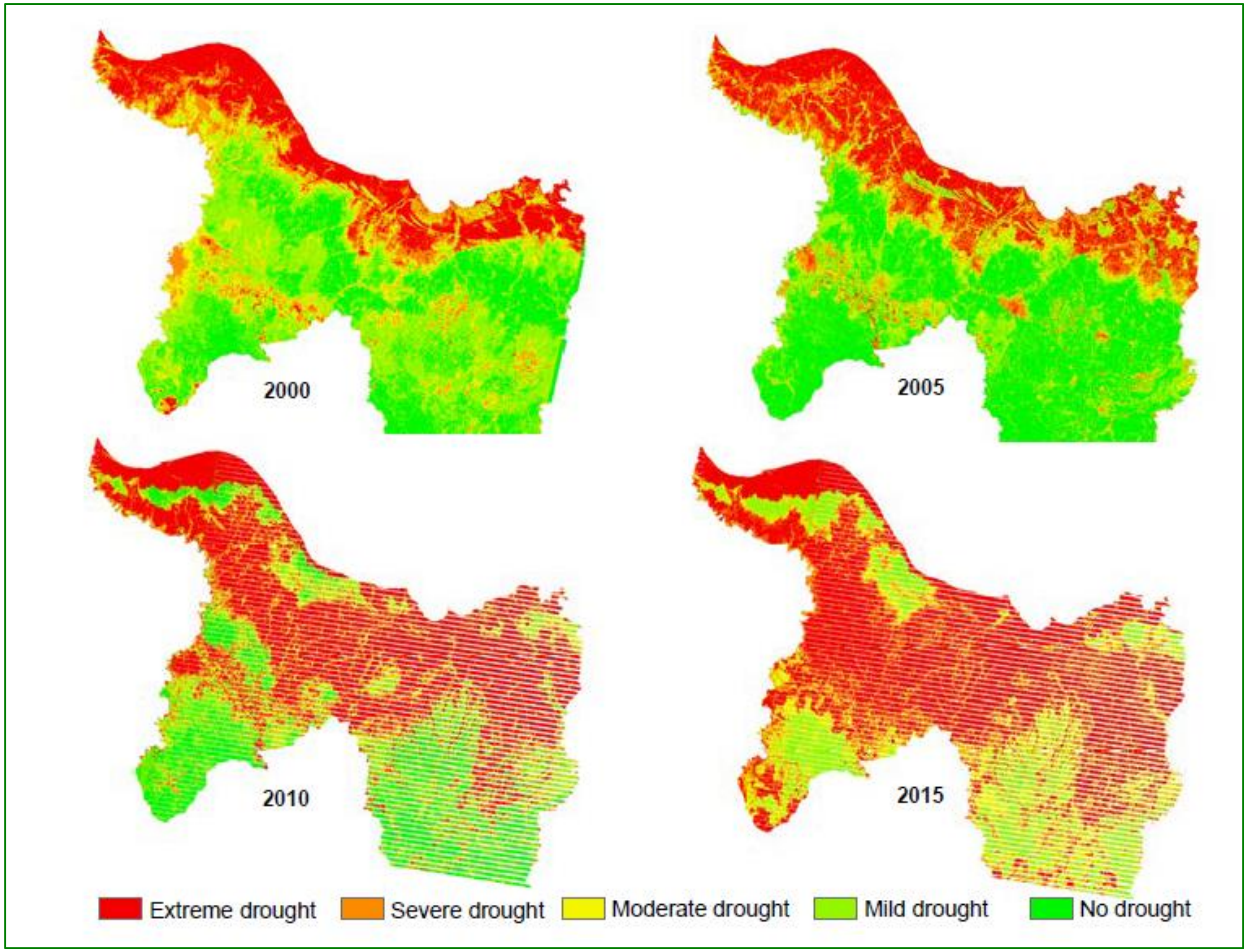
Vegetation Health Index







Source: Sholihah et al, 2015

Study case

Pasture Loss Insurance in Spain

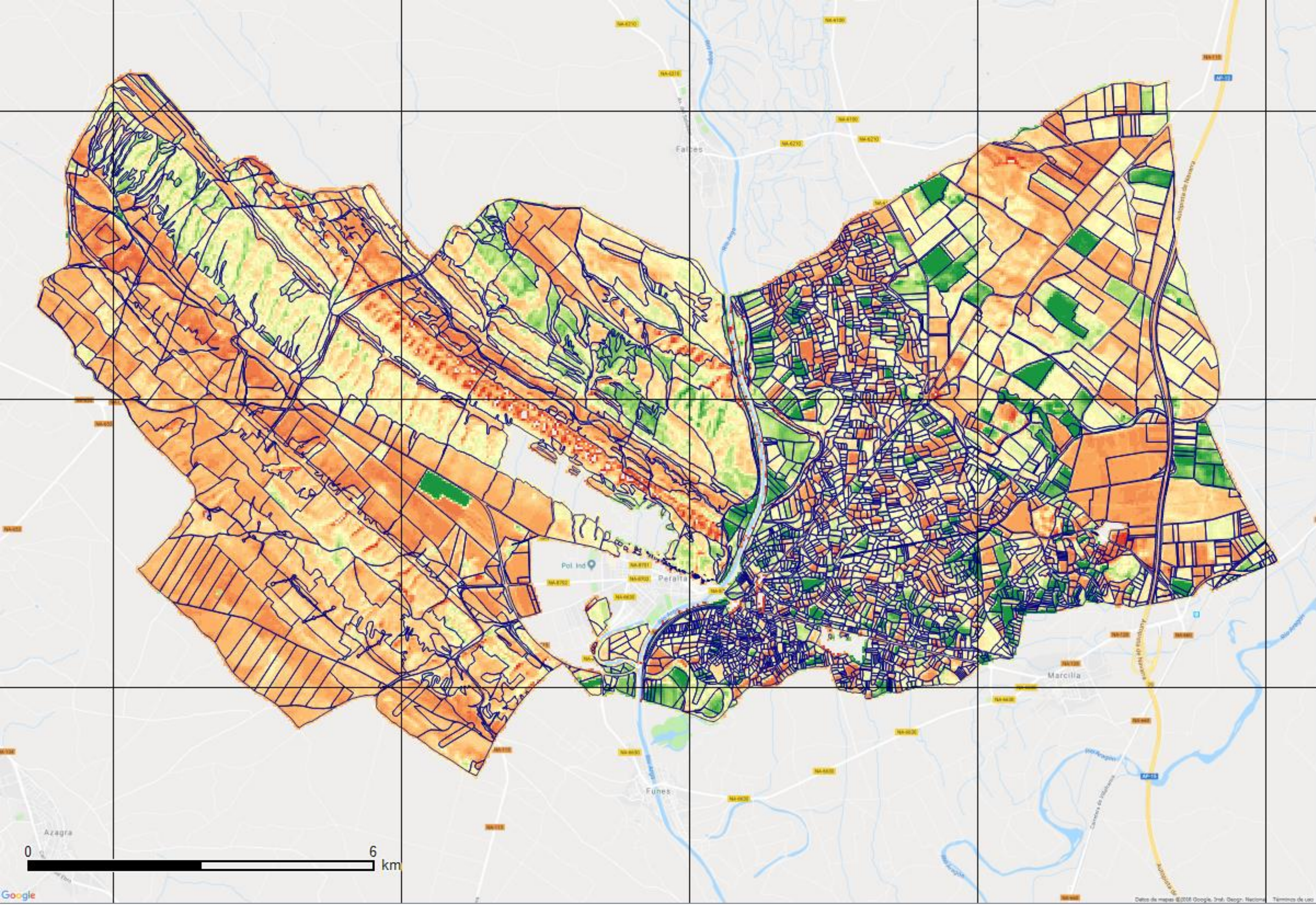
Only fools laugh at what they do not understand *(Honore de Balzac)*

Agricultural Insurance

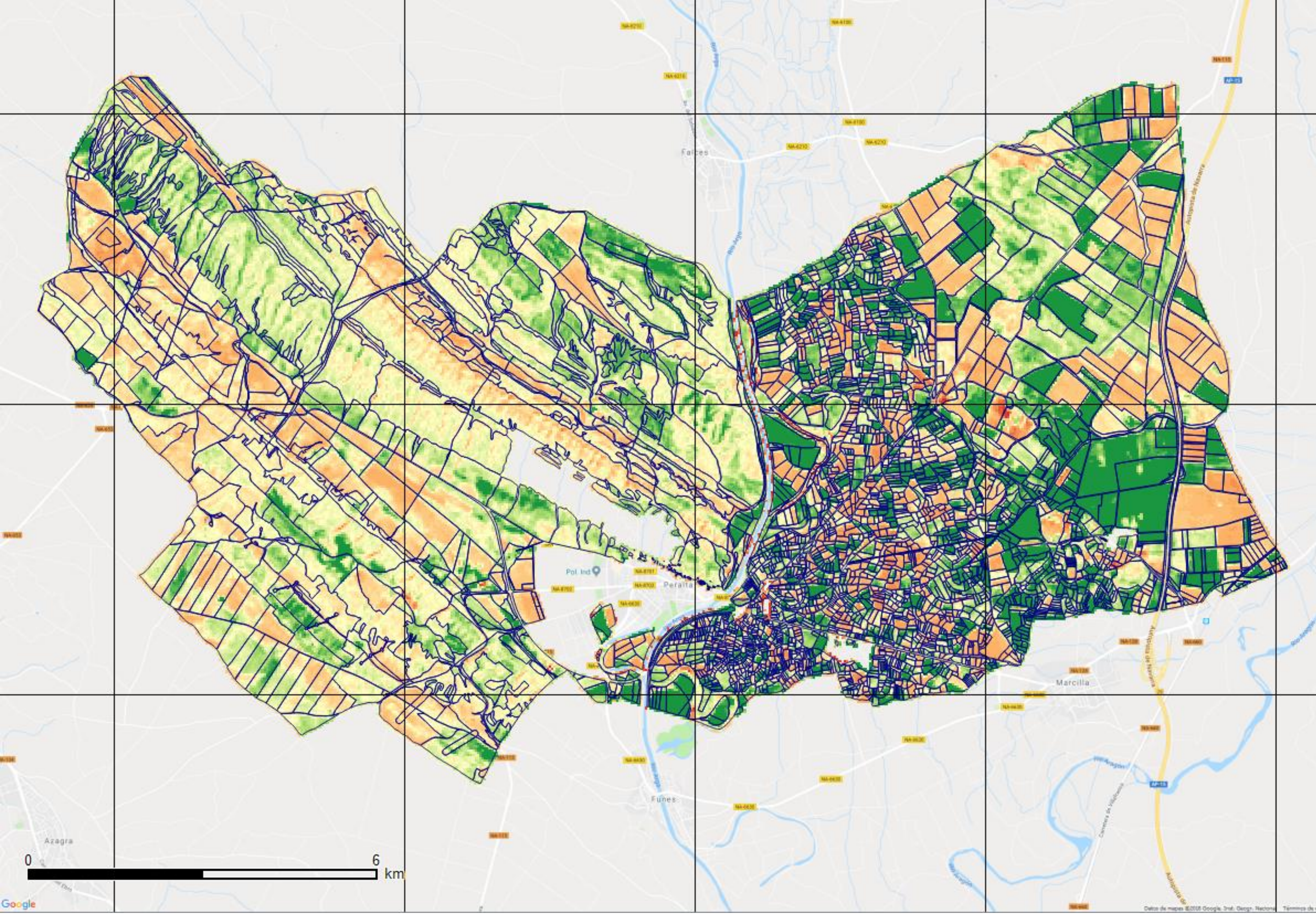
Spatial remote sensing has proven to be an operative tool in the field of agricultural insurance, being a basic data source in the **Compensation Insurance for Loss of Pastures**, where a cover has been designed for the lack of vegetation in the pastures destined to livestock feeding, calculating the NDVI of the region where the farm is located.

The operating system is simple, every ten days, by satellite, a measurement of the **vegetation index** of each region is made and **compared with the same decade of the period 2000-2014**. If the result is below a threshold determined at the average of said period, it is considered sinister.

All the data are registered in a GIS and the management is triggered automatically when the conditions established in the insurance contract are met.



PERALTA: NDVI 1/12/2013



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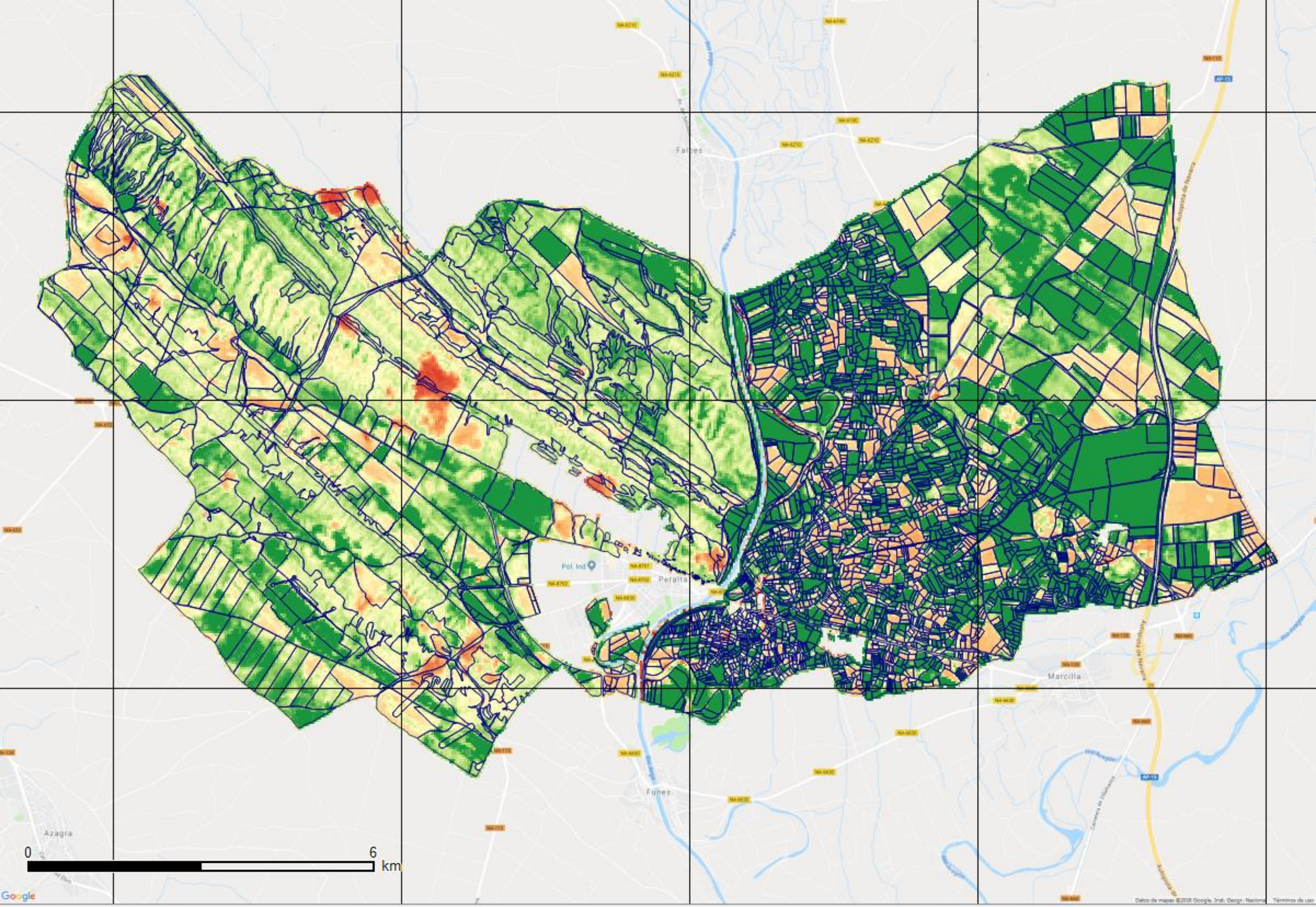
PERALTA: NDVI 7/03/2014



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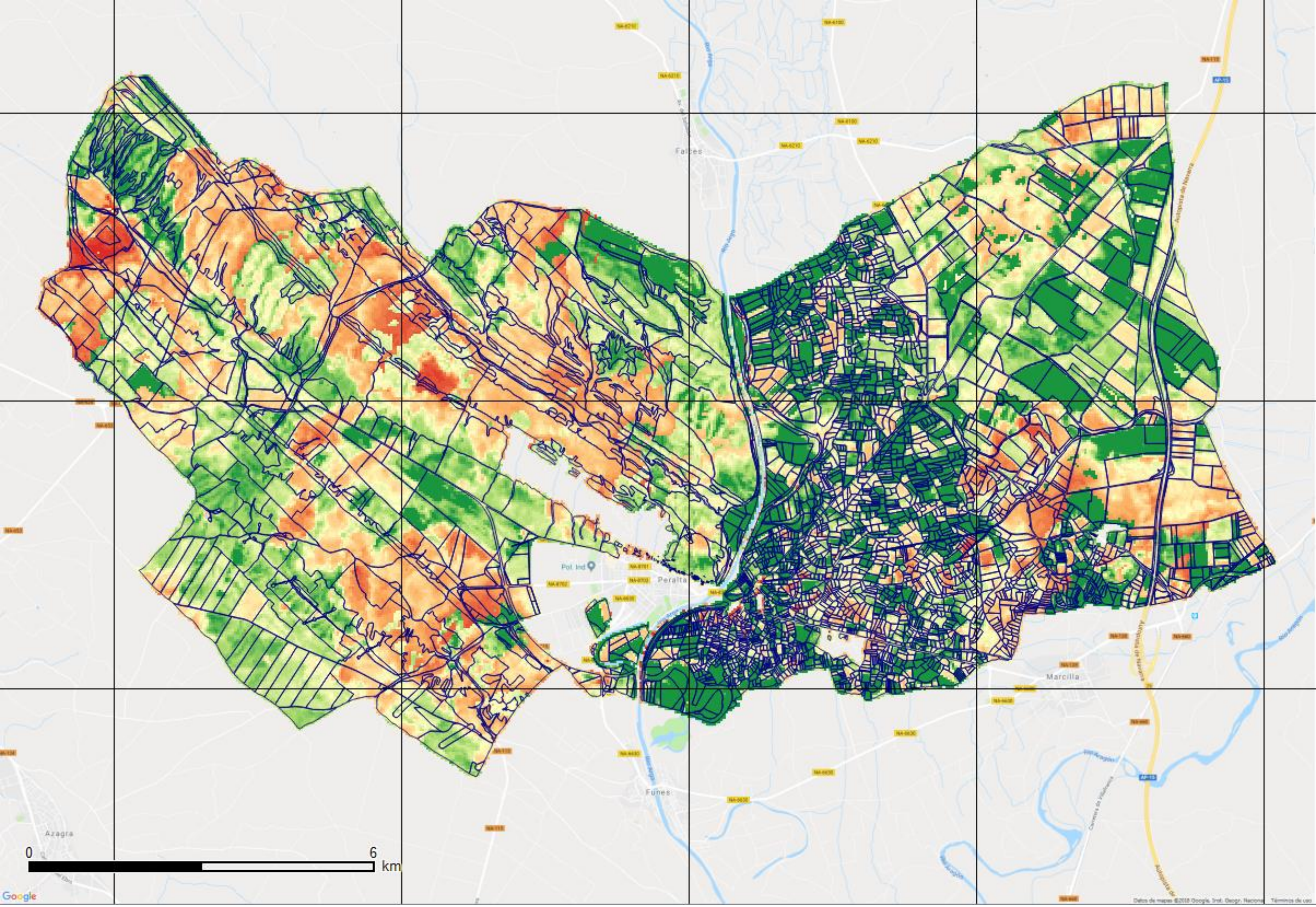
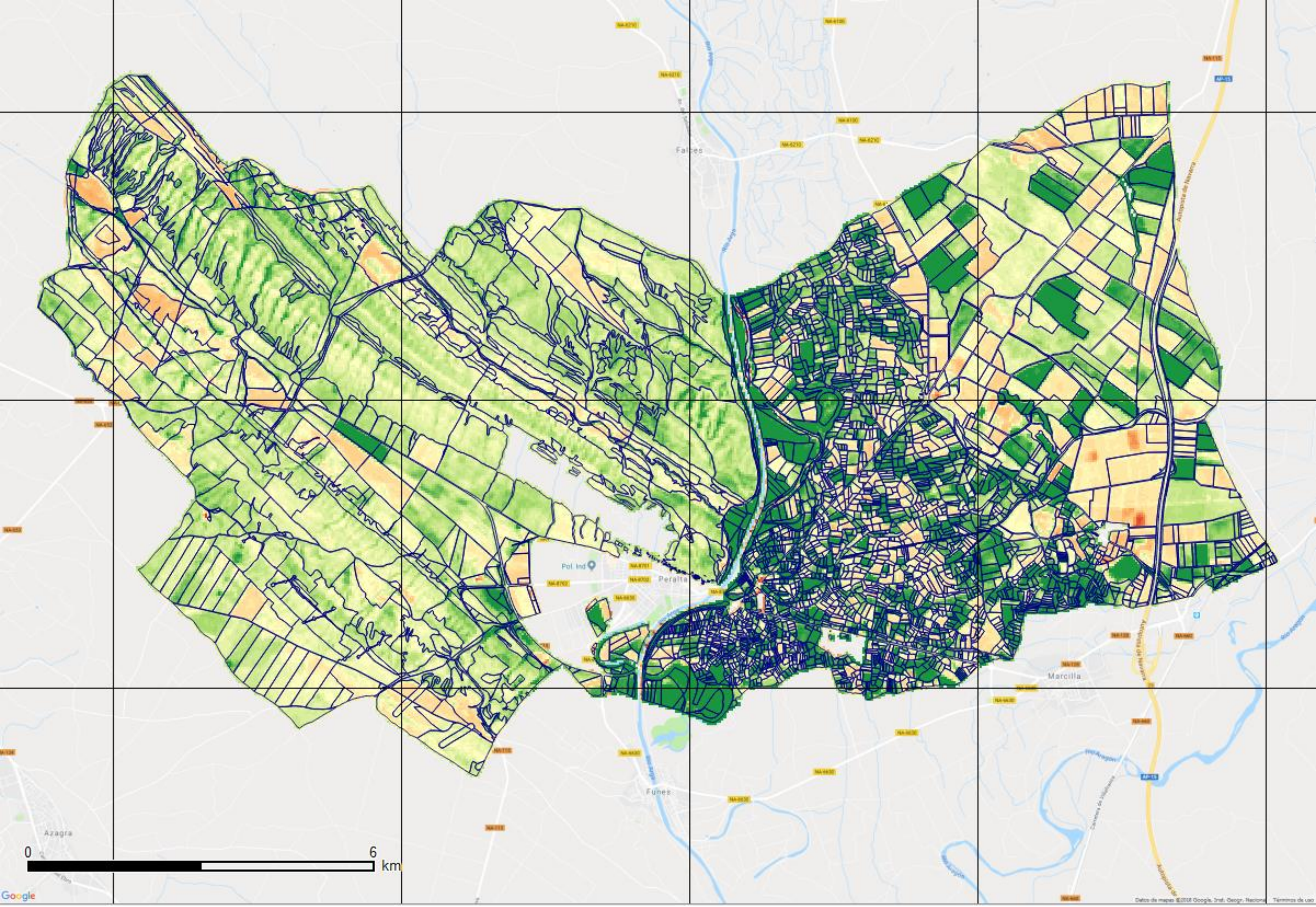
PERALTA: NDVI 8/04/2014



PERALTA: NDVI 26/05/2014



PERALTA: NDVI 11/06/2014

Study case

Cereal damages in La Mancha Alta (Spain)

Cereal damages

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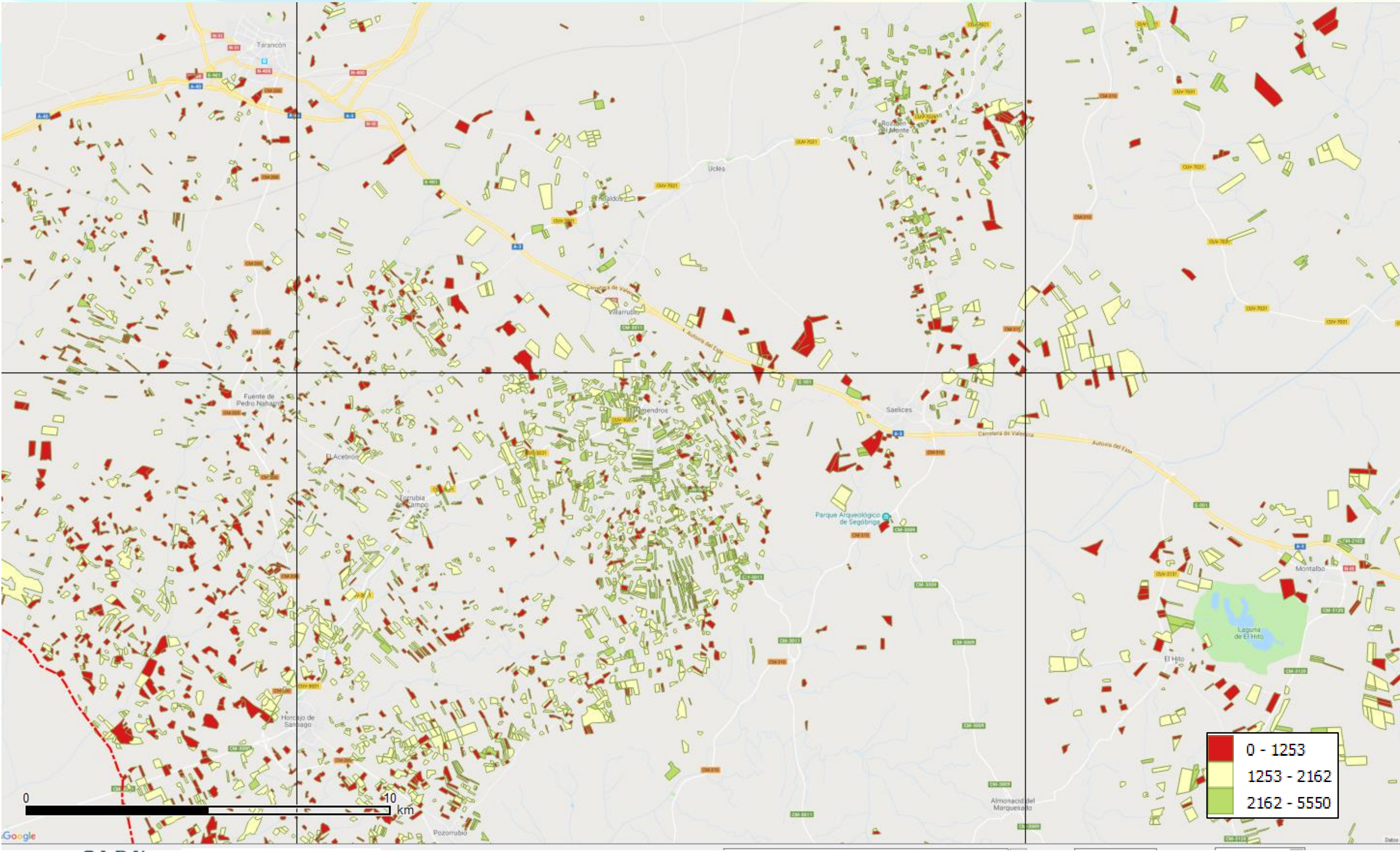
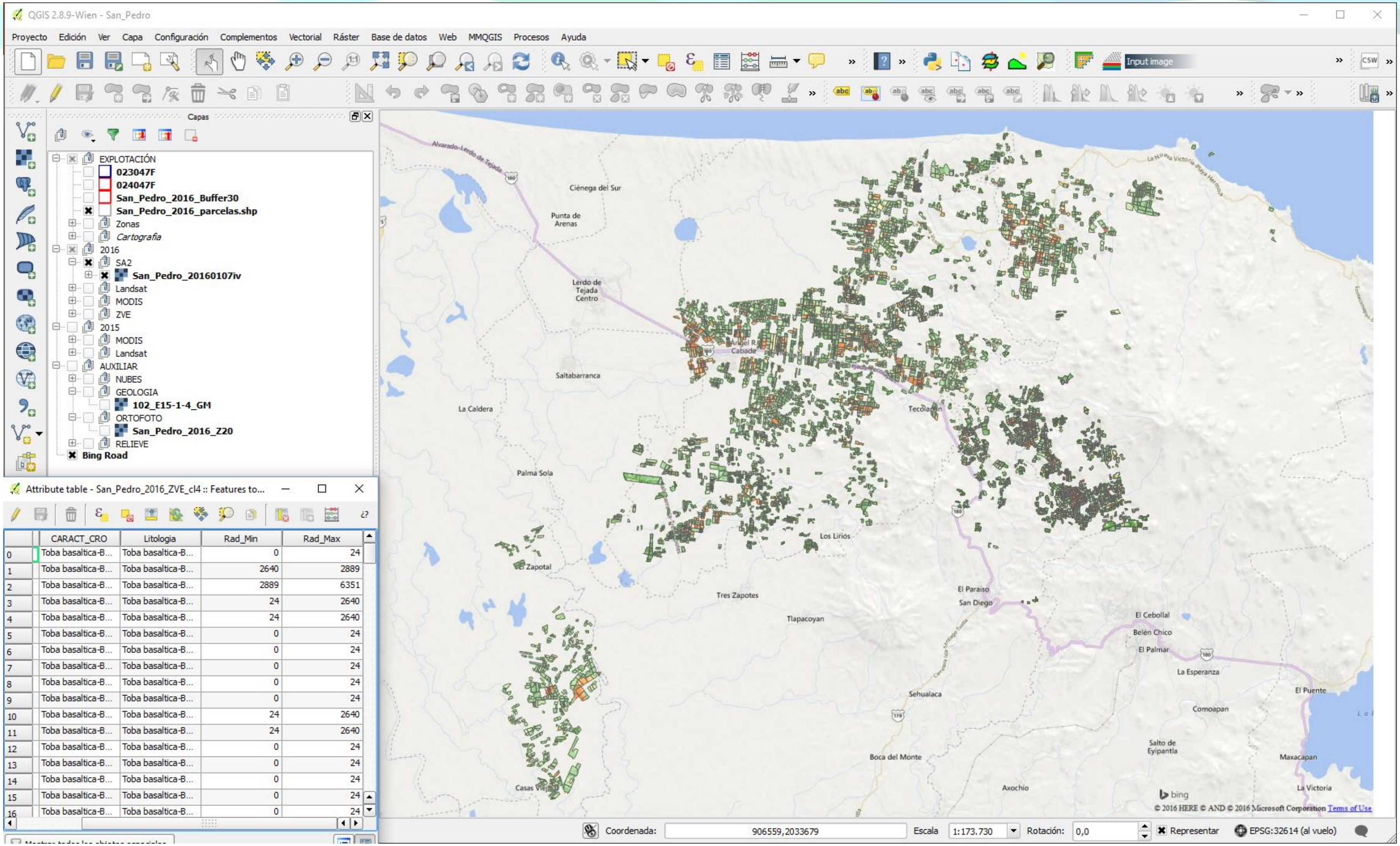
Cereal damages



Study case

Sugarcane in Veracruz (Mexico)

GIS Implementation



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WorldClim Version2

WorldClim version 2 has average monthly climate data for minimum, mean, and maximum temperature and for precipitation for 1970-2000.

You can download the variables for different spatial resolutions, from 30 seconds (~1 km^2) to 10 minutes (~340 km^2). Each download is a "zip" file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).

variable	10 minutes	5 minutes	2.5 minutes	30 seconds
minimum temperature (°C)	tmin 10m	tmin 5m	tmin 2.5m	tmin 30s
maximum temperature (°C)	tmax 10m	tmax 5m	tmax 2.5m	tmax 30s
average temperature (°C)	tavg 10m	tavg 5m	tavg 2.5m	tavg 30s
precipitation (mm)	prec 10m	prec 5m	prec 2.5m	prec 30s
solar radiation (kJ m^{-2} day^{-1})	srad 10m	srad 5m	srad 2.5m	srad 30s
wind speed (m s^{-1})	wind 10m	wind 5m	wind 2.5m	wind 30s
water vapor pressure (kPa)	vapr 10m	vapr 5m	vapr 2.5m	vapr 30s

Below you can download the standard (19) WorldClim Bioclimatic variables for WorldClim version 2. They are the average for the years 1970-2000. Each download is a "zip" file containing 19 GeoTiff (.tif) files, one for each month of the variables.

variable	10 minutes	5 minutes	2.5 minutes	30 seconds
Bioclimatic variables	bio 10m	bio 5m	bio 2.5m	bio 30s

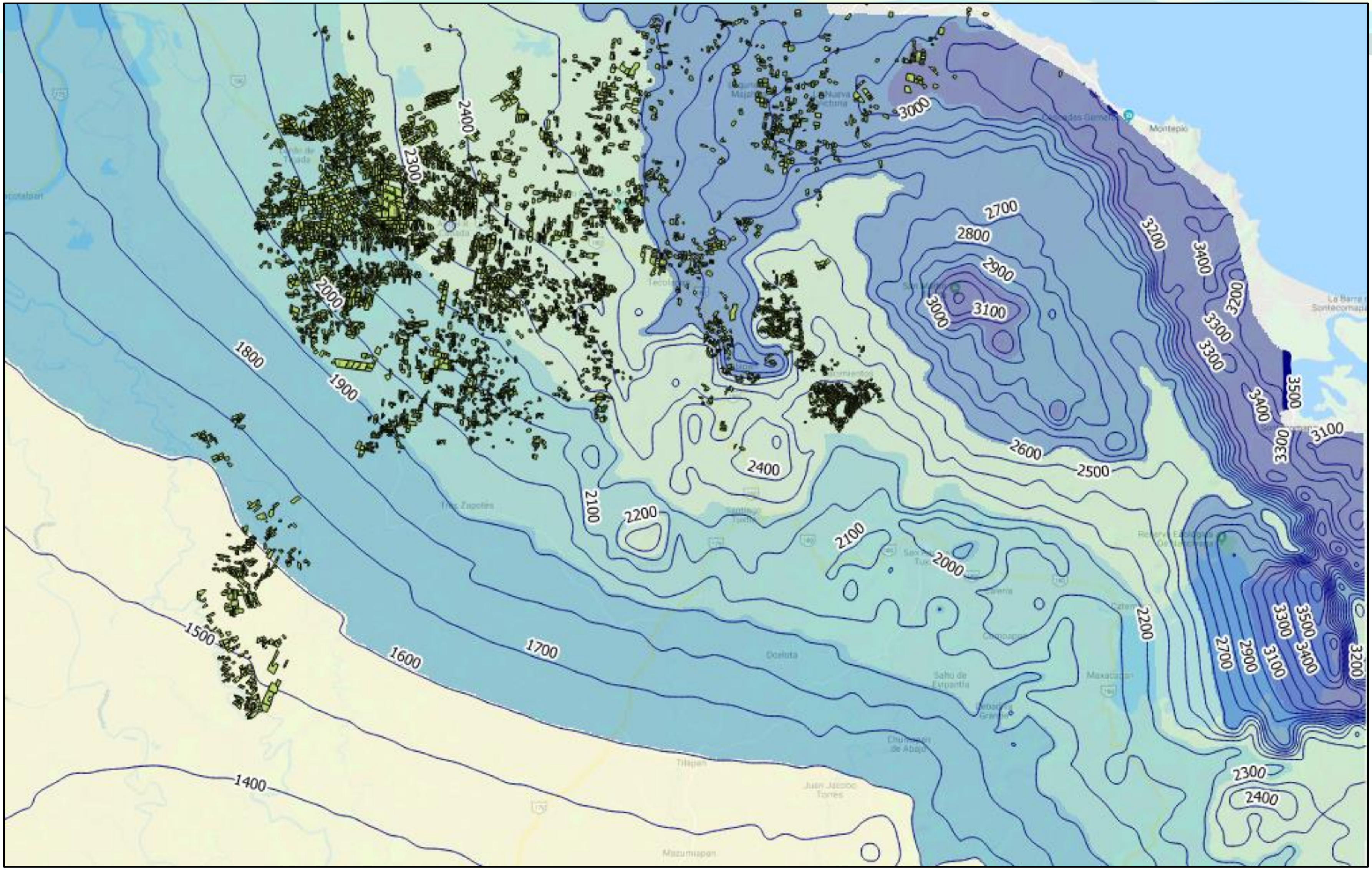
Bioclimatic variables

Bioclimatic variables are **derived from the monthly temperature and rainfall values** in order to generate more biologically meaningful variables.

BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

A common application is **to predict species ranges with climate data** as predictors.

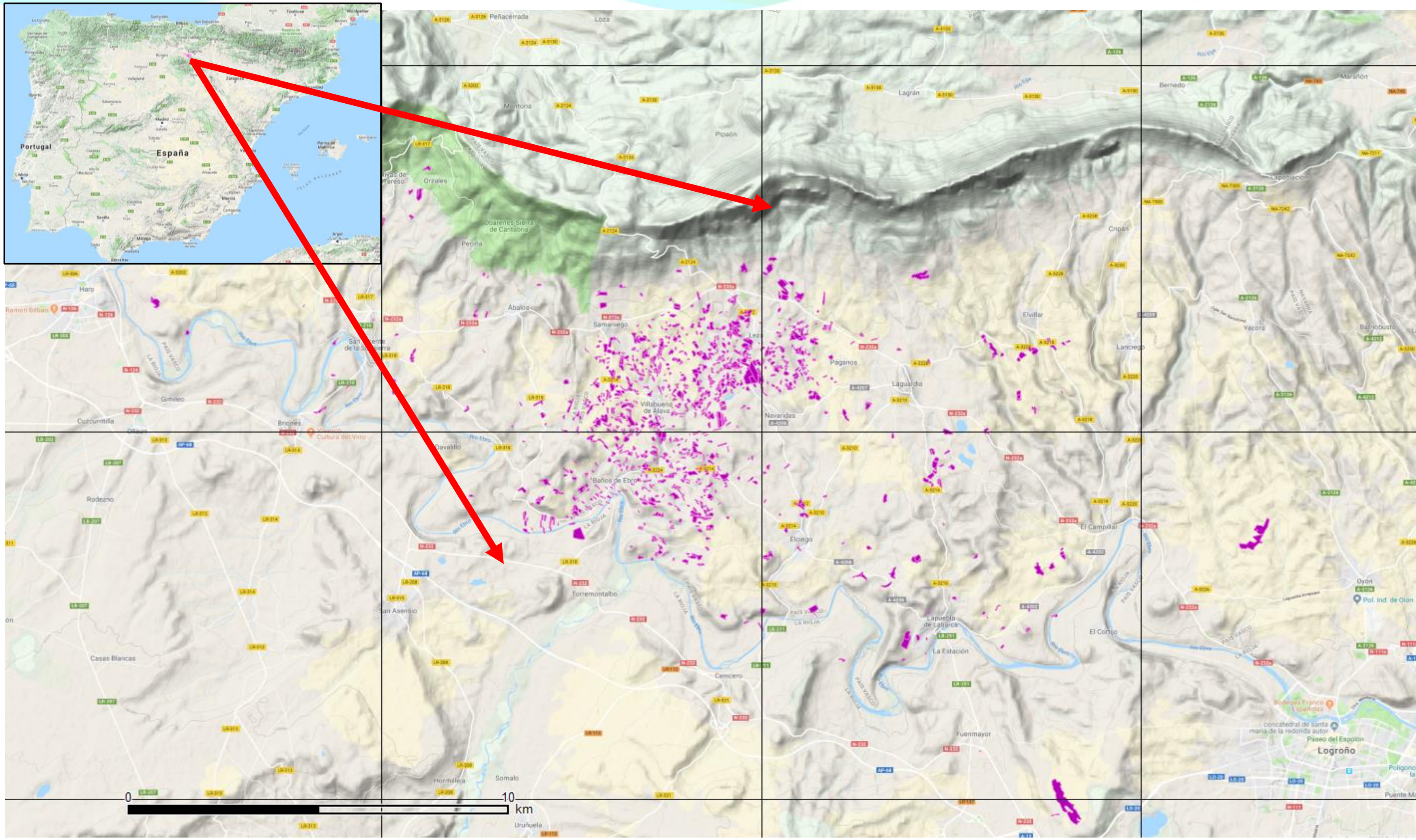
Historical Rainfall Zonification



Study case

Rainfed vineyard in Rioja alta (Spain)

Rainfed vineyard



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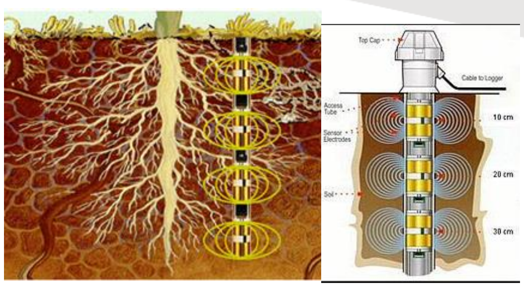
SMART Methodology: Temporal variability

Using in situ sensors

Climate

PLANTSENS Dendrometer (Patented)



Soil Humidity

Nutrition sensor (Patented)

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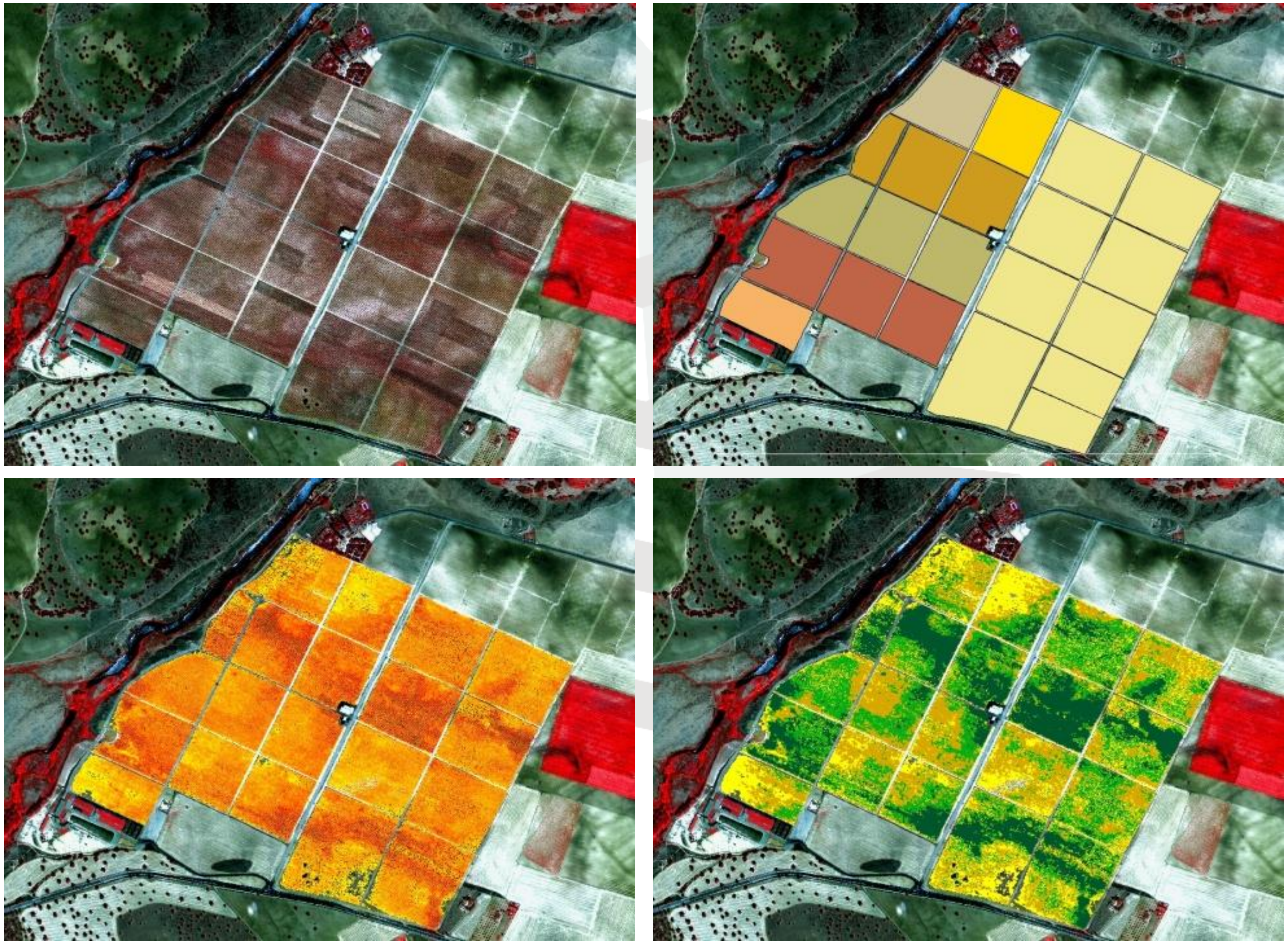
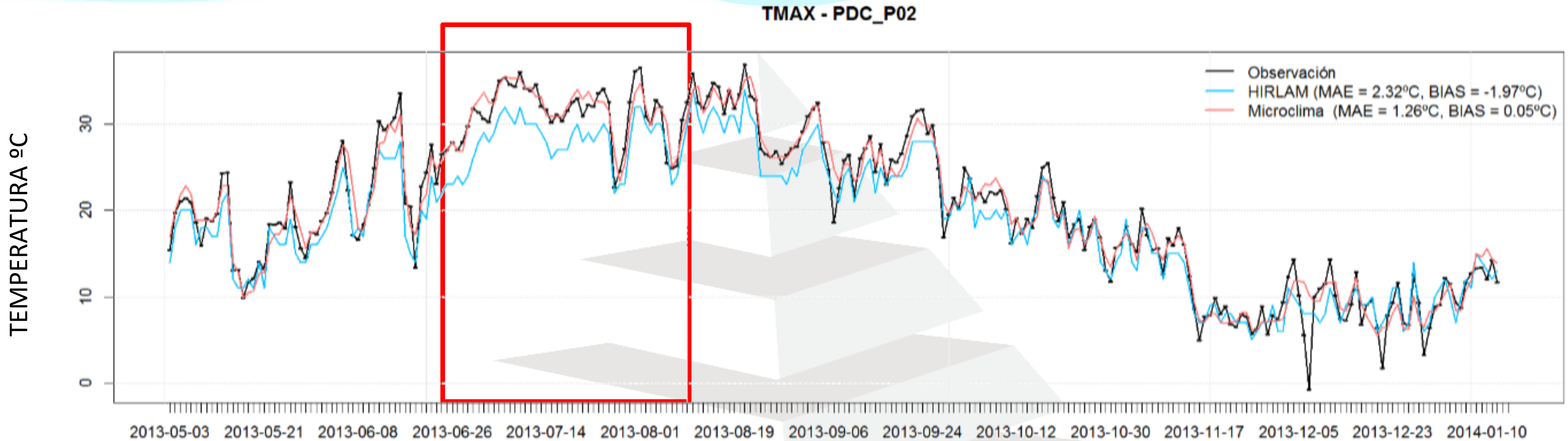
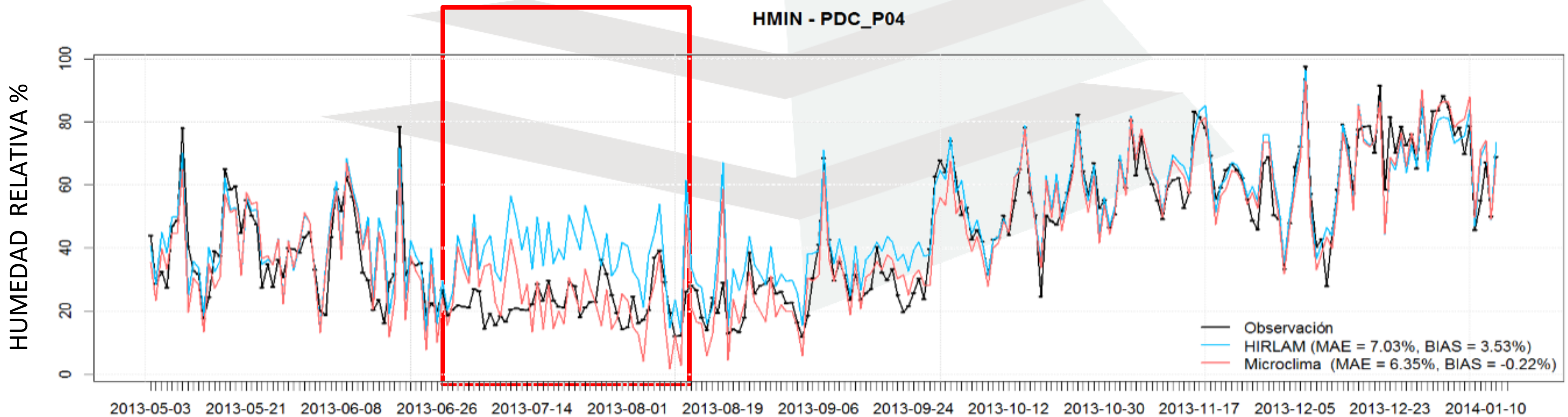
SMART Methodology: Spatial variability

Using remote sensors



Microclimatic Forecast





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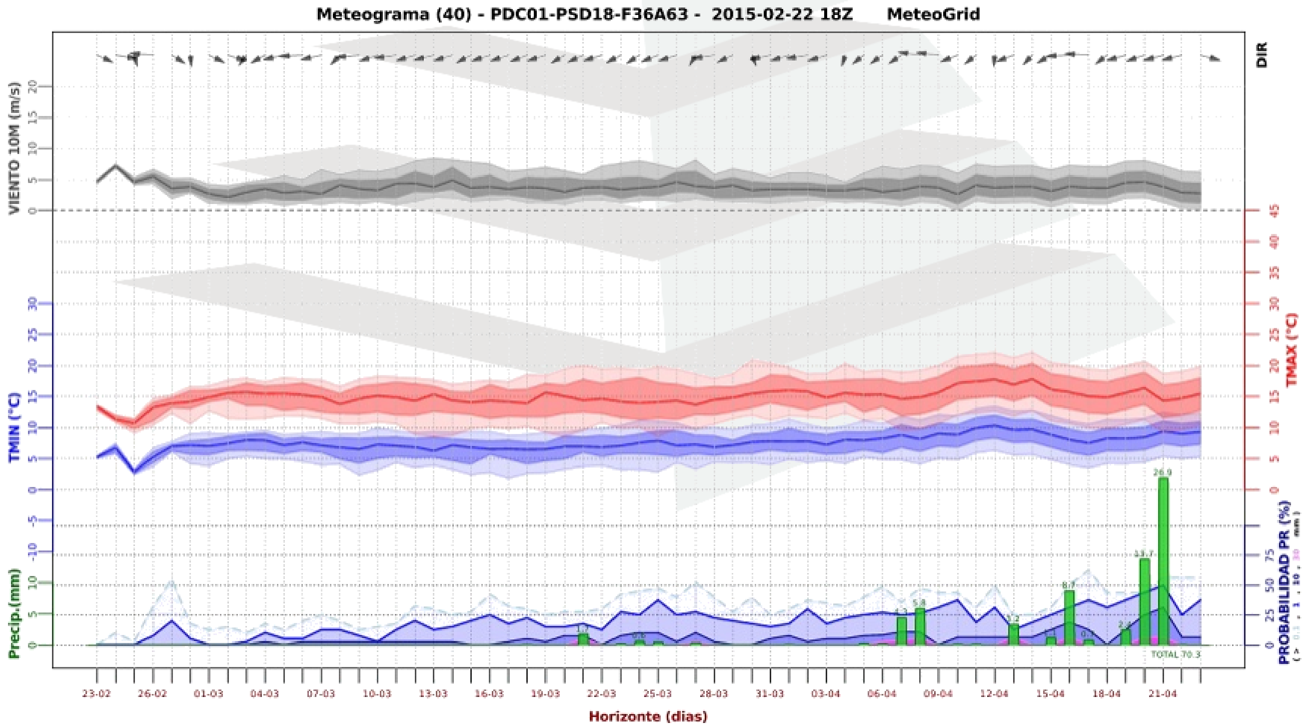
60-days Forecast

The 60-day forecast shows the 10%, 25%, 50%, 75% and 90% percentiles of the 40 simulations for wind speed (gray), maximum temperature (red) and minimum temperature (blue). Due to the natural variability and uncertainty of the models, the long-term prediction only presents an acceptable recovery for the horizon of + 20 days. However, the predictions show a change in trends.



This afternoon

What is Copernicus ?

Europe's eyes on Earth

Copernicus is the European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers **information services based on satellite Earth Observation and in situ (non-space) data**.

The Programme is coordinated and managed by the European Commission. It is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU Agencies and Mercator Ocean.

The information services provided are **freely and openly** accessible to its users.

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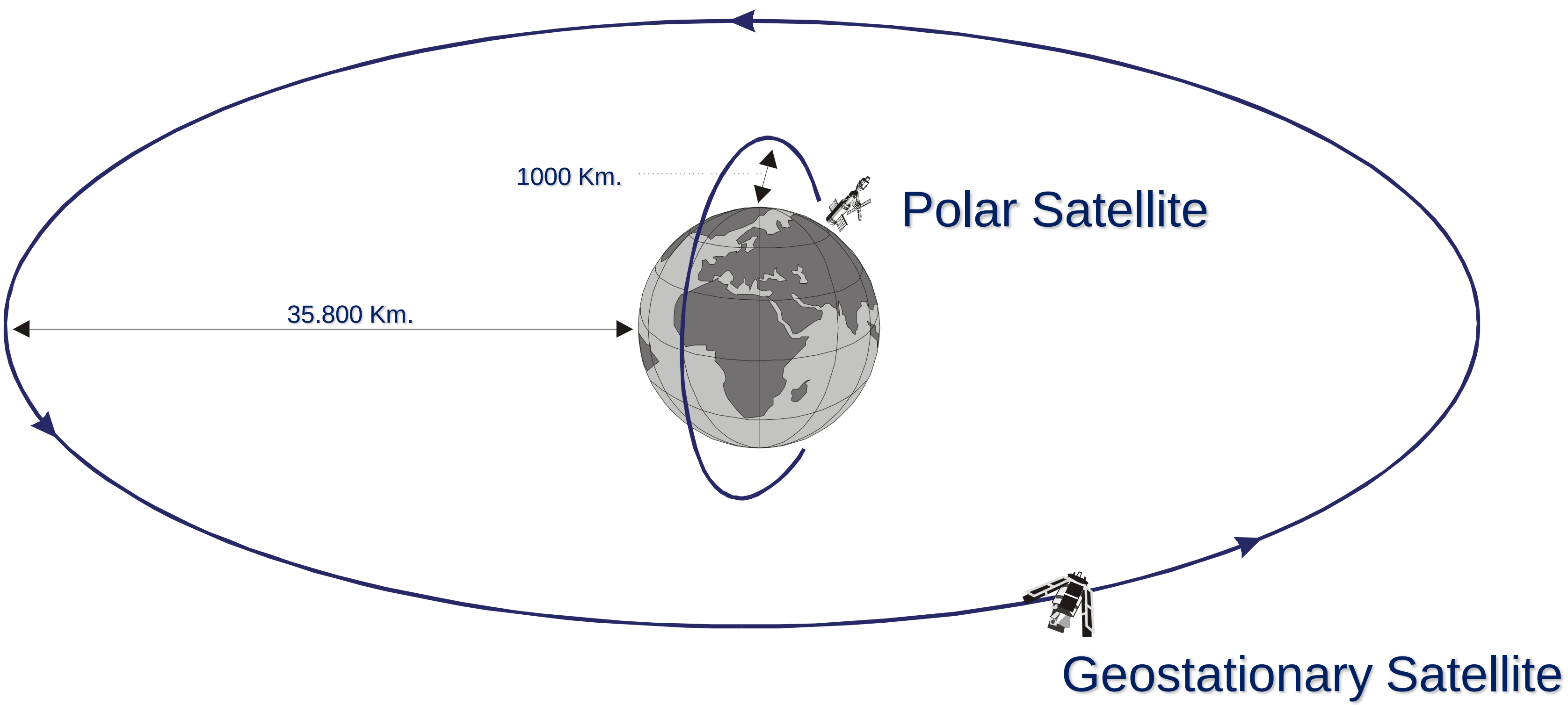
Type of satellites

This afternoon



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Tasks

This afternoon

- How Download QGIS software?
- How Download satellite images?
- Open Layers
- Cartographic Reference System (EPSG)
- Spectral bands
- Color composition
- Indices calculation
- Data integration
- Information Extraction

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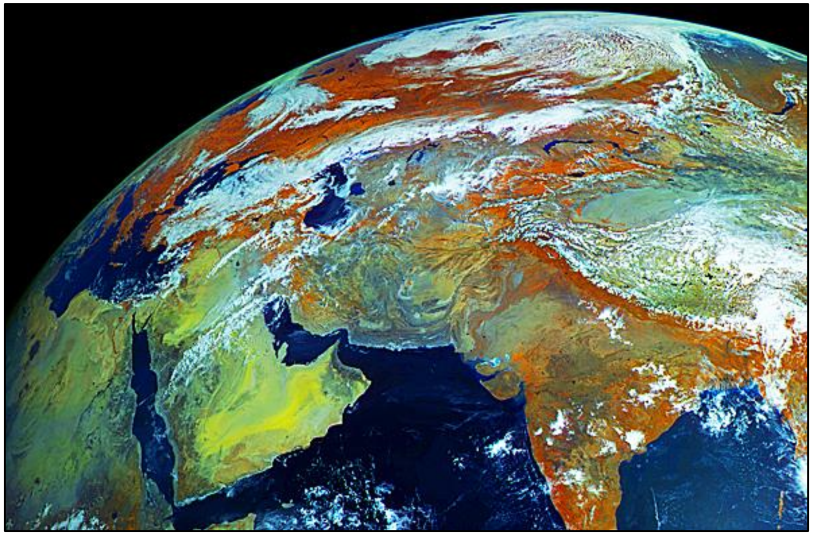
Working for a Sustainable Mediterranean, Caring for our Future

¡Gracias por su atención!



This Project is funded by the European Union