



SURFACE SOIL MOISTURE ESTIMATION

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Summer School on Remote Sensing

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OBJECTIVE



WHAT

Show how to map the surface soil moisture over agricultural plots and grasslands

HOW

FREE and OPEN SOURCE

DATA

- Radar : Sentinel 1
- Optical : Sentinel 2

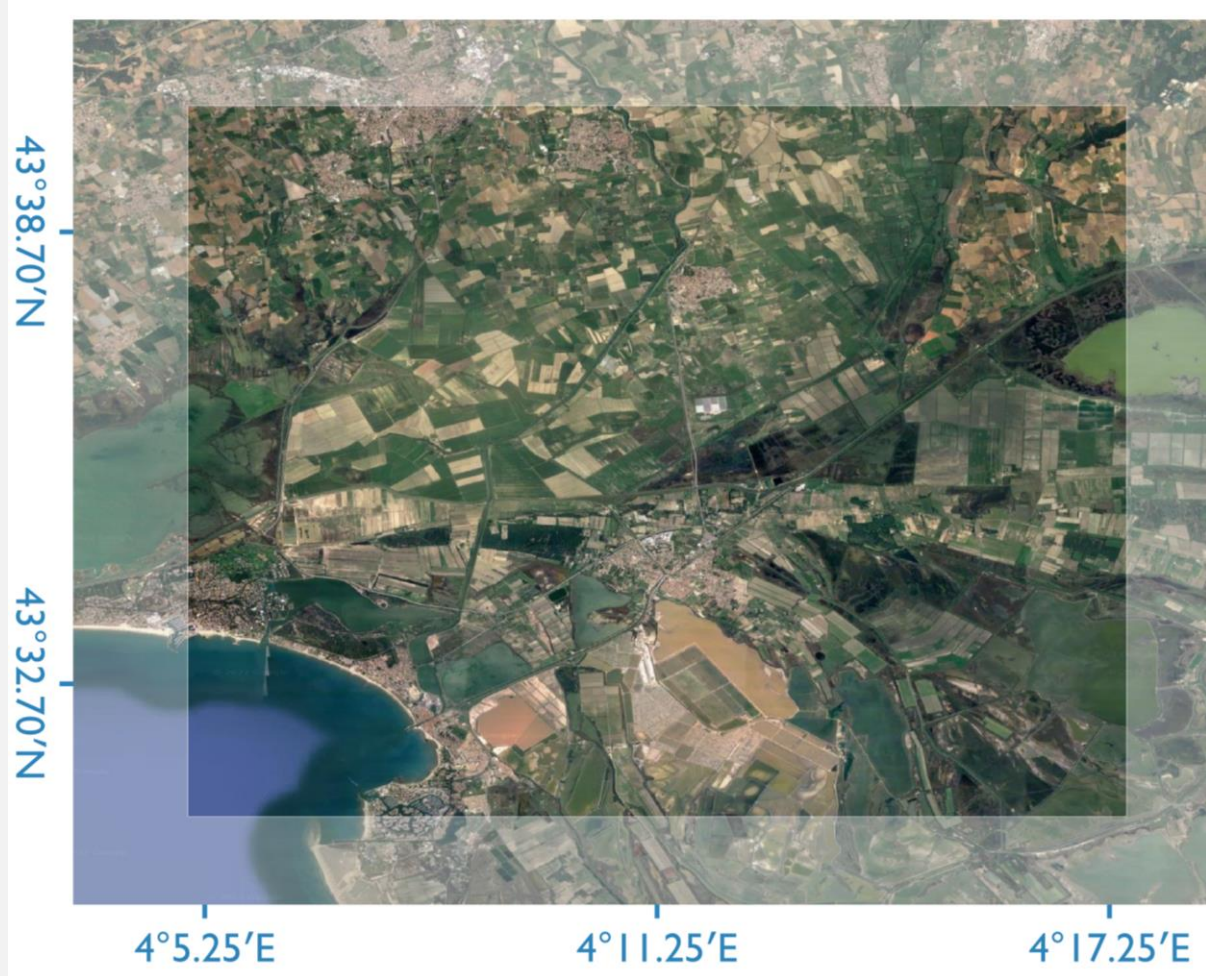
SOFTWARE

- QGIS
- SNAP
- Python

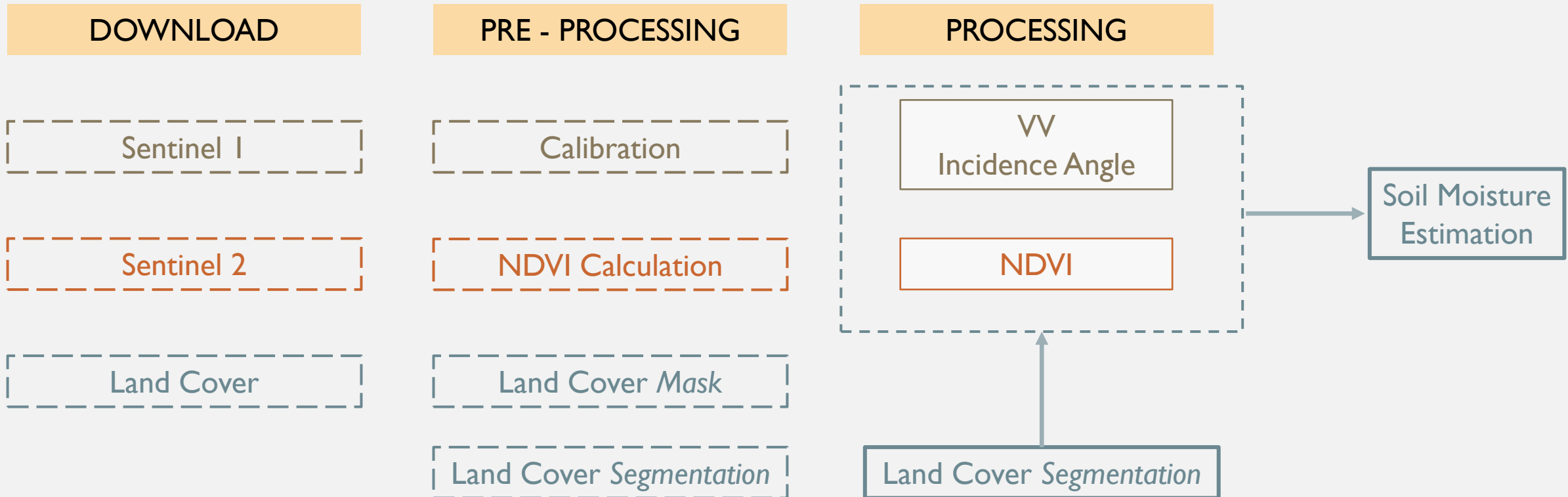
STUDY SITE



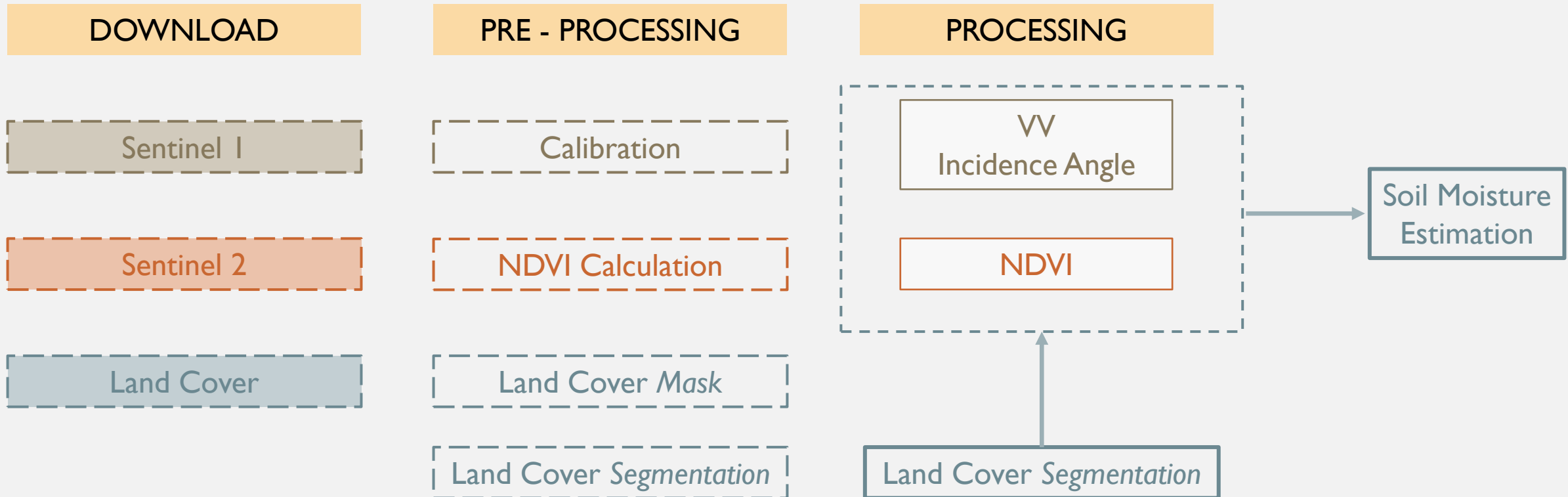
Study site located at 5 km east of Montpellier city, in the south of France



WORKFLOW



WORKFLOW



DATA DOWNLOAD



Sentinel 1

Image acquired	17 / 04 / 2022
Product type	GRD – Ground Range Detected
Sensor mode	IW – Interferometric Wide
Orbit	Evening – number 59

<https://scihub.copernicus.eu/dhus/#/home>



Diurnal effects
Morning Dew
(moisture condensation)
Freeze Detection

Sentinel 2

Image acquired	18 / 04 / 2022
Level	Level 2A FRE – Corrected for atmospheric and slope effects
Tile	T31TEJ

<https://theia.cnes.fr/atdistrib/rocket/#/search?page=1&collection=SENTINEL2&processingLevel=LEVEL3A>

DATA DOWNLOAD



Land Cover

Lebanon	CNRS
France	Occupation du sol ¹ RPG ²
Europe	Corine Land Cover ³
World	Copernicus Global Land Cover ⁴

- ¹ <https://theia.cnes.fr/atdistrib/rocket/#!/search?collection=OSO>
- ² <https://geoservices.ign.fr/rpg#telechargement>
- ³ <https://geoservices.ign.fr/rpg#telechargement>
- ³ <https://www.geoportail.gouv.fr/donnees/corine-land-cover-2018>
- ³ <https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=mapview>
- ⁴ <https://lcviewer.vito.be/2015>

WORKFLOW



DOWNLOAD

Sentinel 1

Sentinel 2

Land Cover

PRE - PROCESSING

Calibration

NDVI Calculation

Land Cover Mask

Land Cover Segmentation

VV
Incidence Angle

NDVI

Land Cover Segmentation

Soil Moisture
Estimation

DATA

PRE - PROCESSING



SI Calibration

- Two processing steps : CONSISTS

- Radiometric calibration : Digital number \rightarrow Radar backscattering coefficient CONVERT
- Geometric correction : \rightarrow Orthorectified images (corrected for geographic location and slope effects)

PROVIDE

- SNAP software :

- Import image in Snap
- Create a graph of processing chain :
 - Calibration
 - Ortho-rectification



WORKFLOW



DOWNLOAD

Sentinel 1

Sentinel 2

Land Cover

PRE - PROCESSING

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VV
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Land Cover Segmentation

Soil Moisture
Estimation

DATA

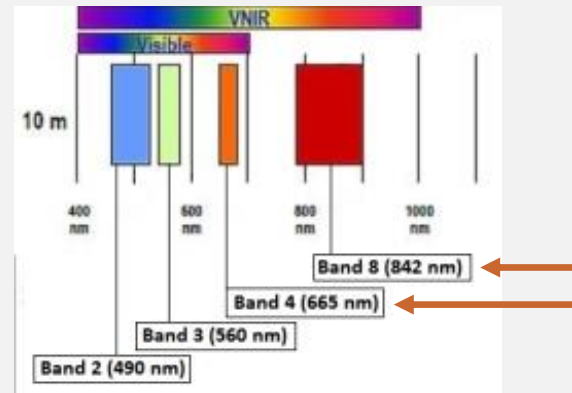
PRE - PROCESSING



NDVI Calculation

- From S2 images to the NDVI vegetation index

$$NDVI = \frac{NIR - RED}{NIR + RED} \times 100$$



- QGIS software :
 - Open B4 and B8 rasters
 - “ Raster calculator ”
 - “Re-projected” to WGS-84
 - “Clip” to site extent

Raster calculator

Parámetros Registro

Expression

Capas

Operadores

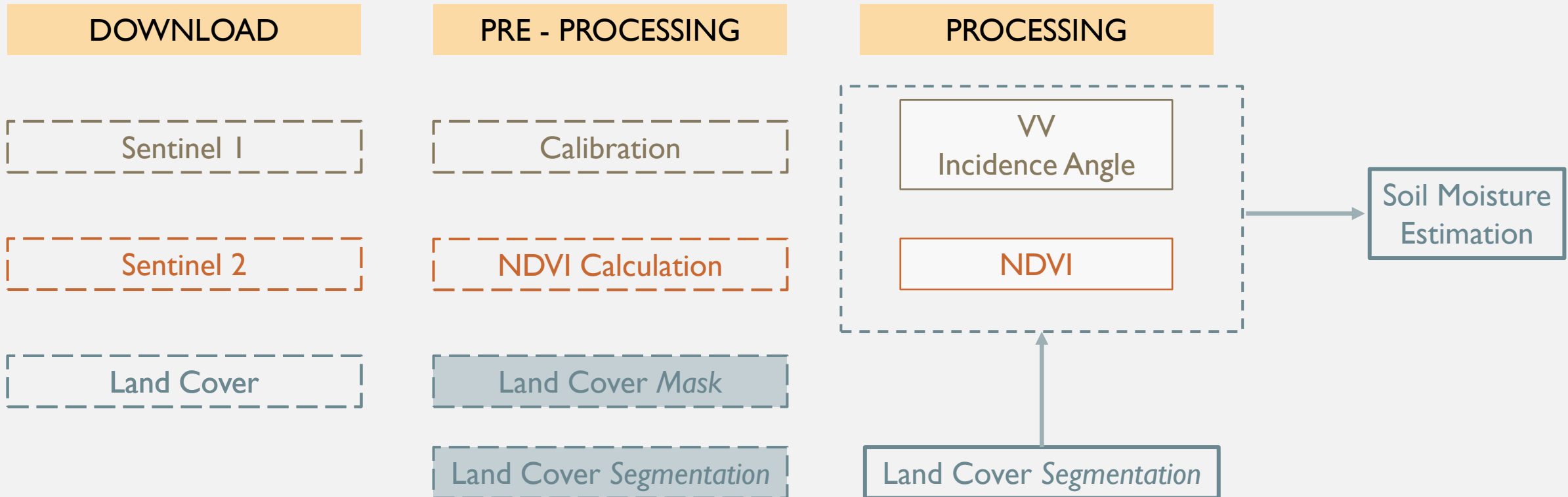
SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B8@1
SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B4@1

Expression

```
100 * ( ( "SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B8@1" - "SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B4@1" ) / ( "SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B8@1" + "SENTINEL2B_20220323-104852-167_L2A_T31TEJ_C_V3-0_FRE_B4@1" ) )
```



WORKFLOW

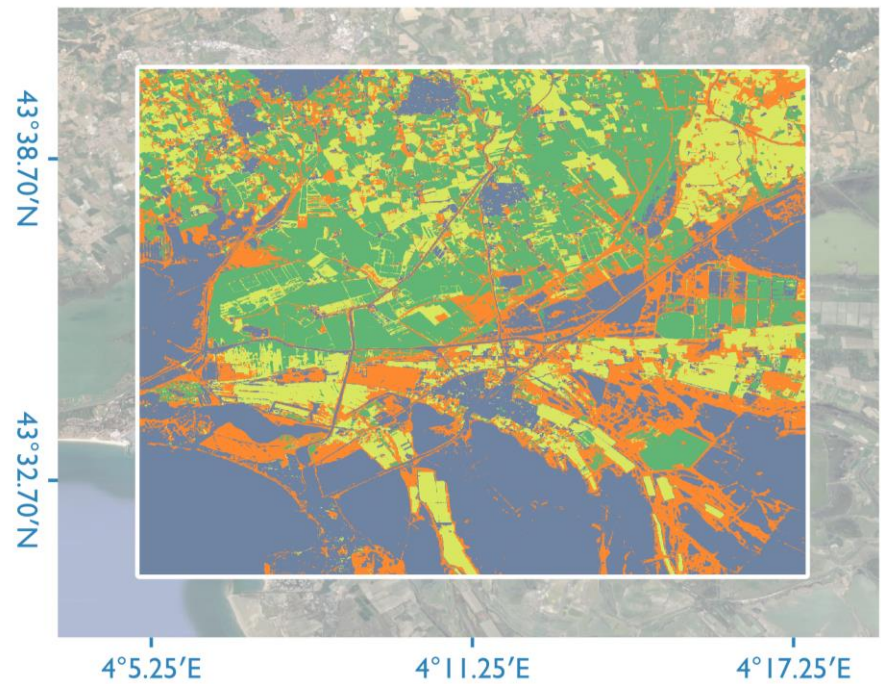


DATA





PRE - PROCESSING

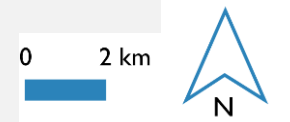
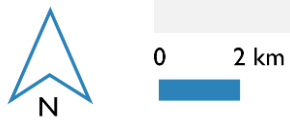
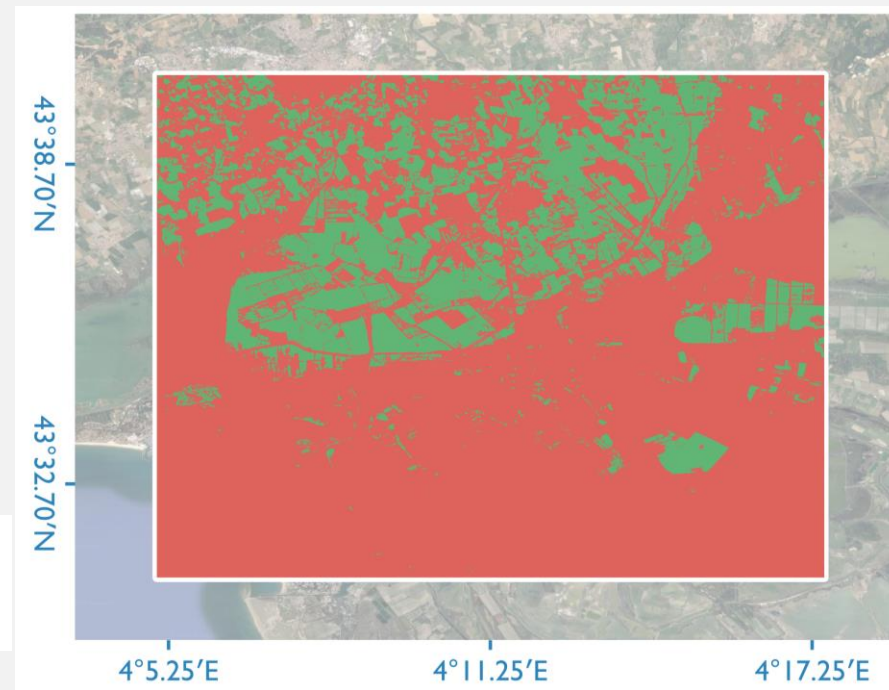
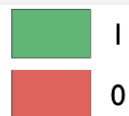


Land Cover Mask



Land Cover (OSO, 2020)

-  Farmland
-  Semi-Natural Vegetation
-  Non-Vegetated Surfaces
-  Farmland - Orchards and Vineyards



DATA

PRE - PROCESSING



Land Cover Mask



- QGIS software :
 - Open Land Cover image
 - “Raster Calculator” + Super Impose (OTB)
 - Expression :

5 : Winter oilseed

10 : Corn

6 : Straw cereals

11 : Rice

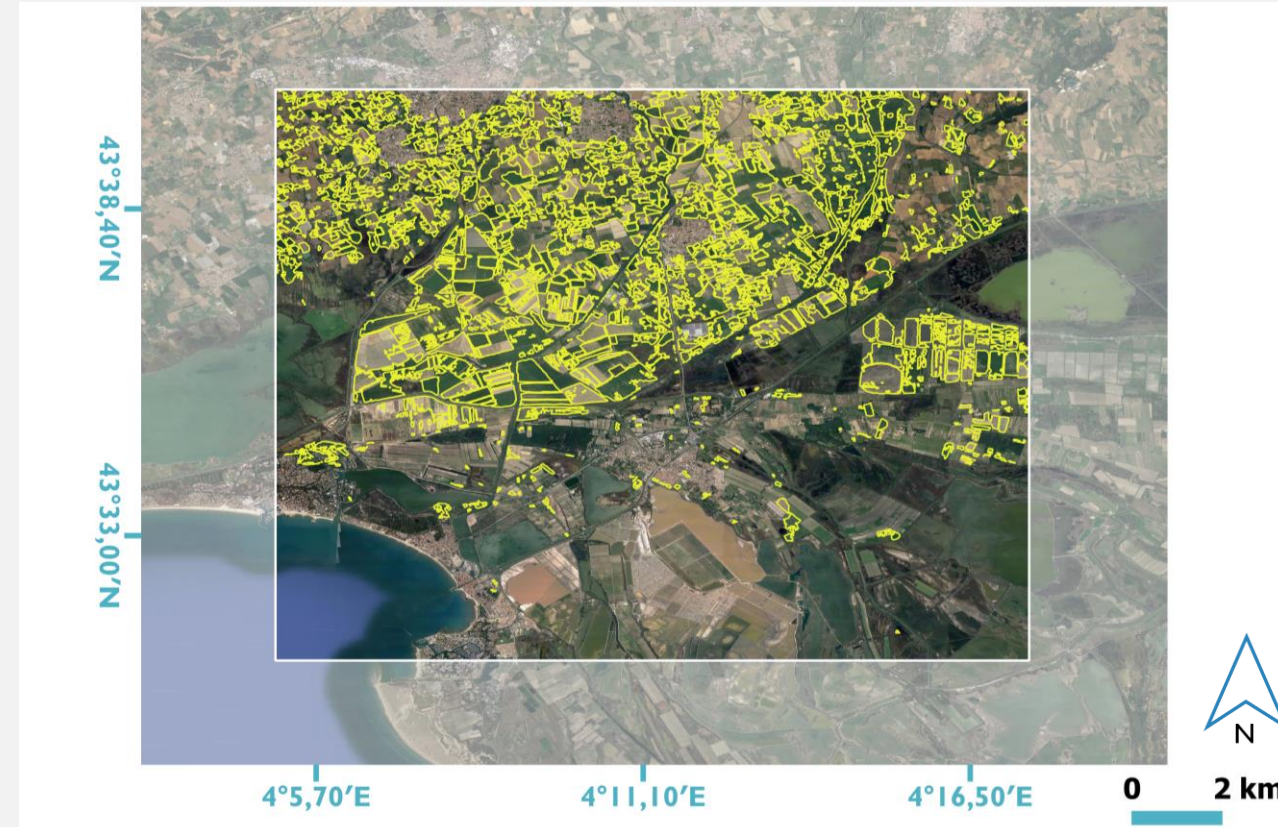
7 : Spring oilseeds

12 : Tubers and roots

8 : Soy

13 : Orchards

9 : Sunflower



DATA

PRE - PROCESSING

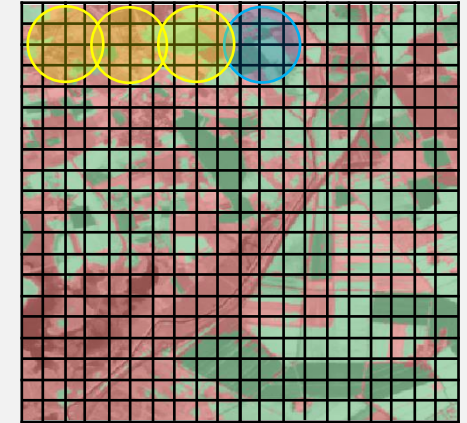
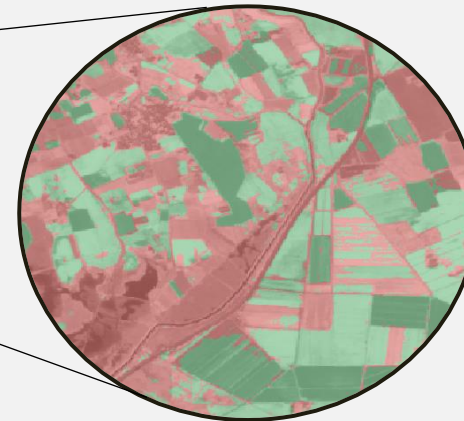


Land Cover Segmentation



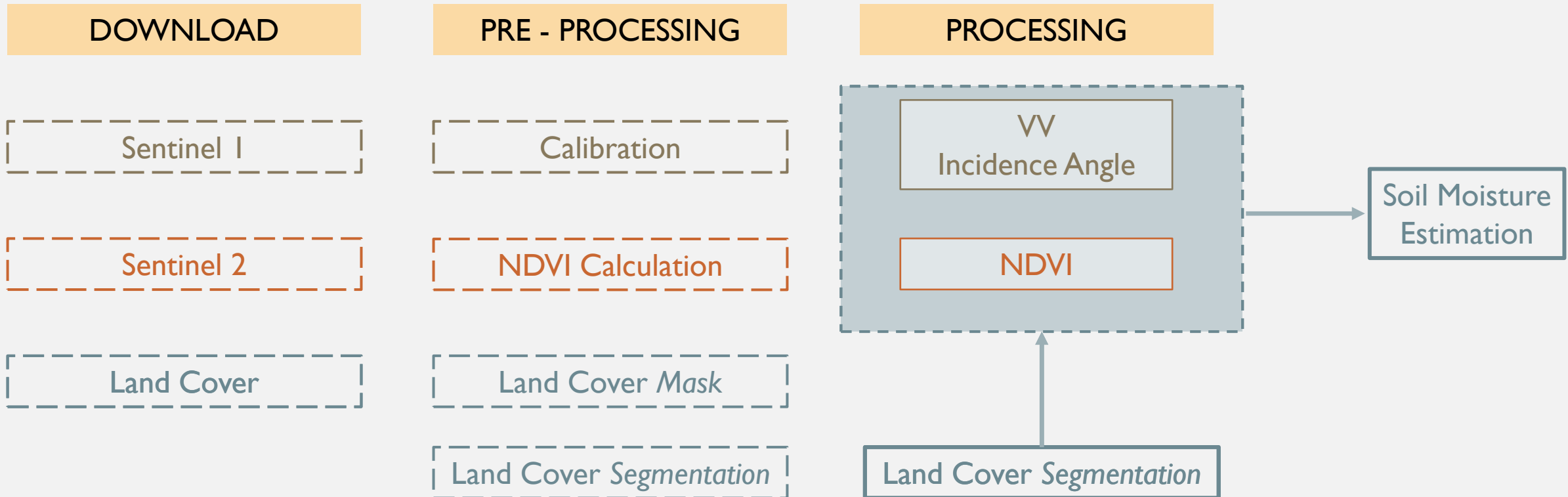
NDVI Image

Land Cover Mask

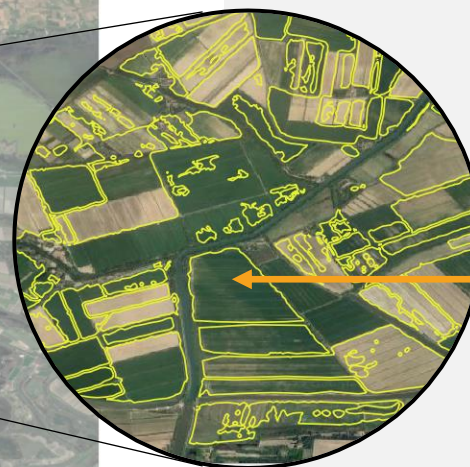
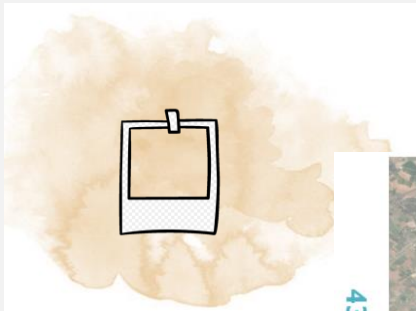


- QGIS software :
 - Open NDVI and Land Cover mask
 - “Segmentation” (OTB) →
 - Geometric corrections
 - Algorithm : meanshift
 - Spatial radius : 30 pixels
 - Range radius : 10
- “Smooth” + “Buffer” + “Zonal Statistics”

WORKFLOW



DATA PROCESSING



Zonal Statistics :

SI W
Incidence angle
NDVI

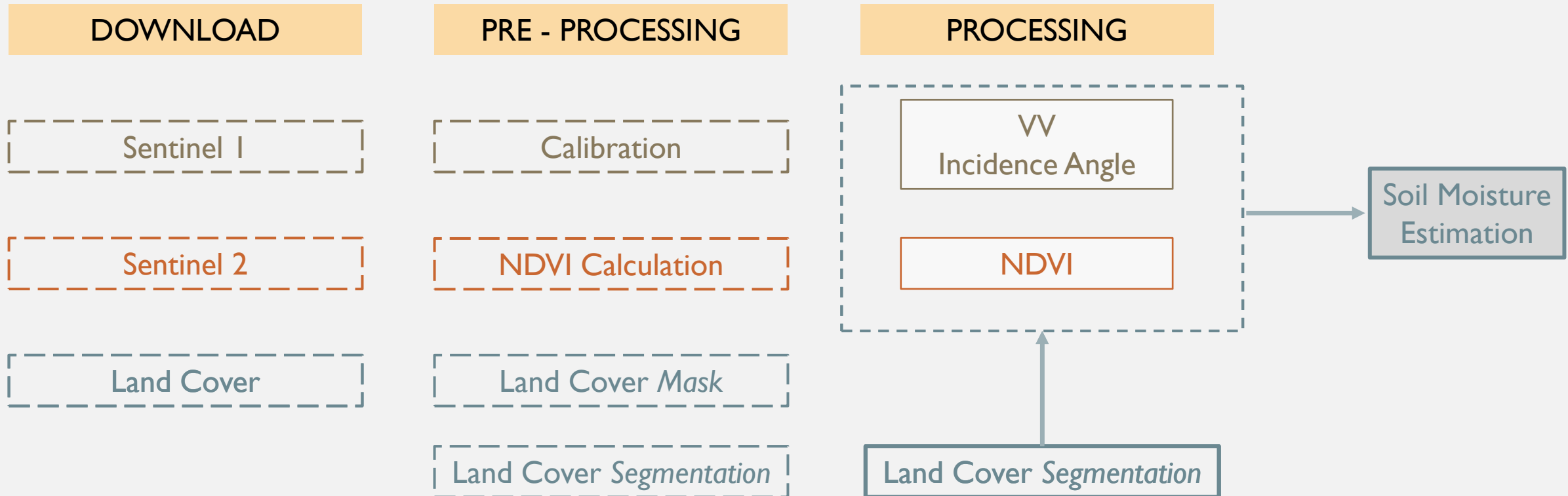
DATA PROCESSING



- QGIS software :
 - Open NDVI / SI VV image / Incidence Angle → *Raster*
 - Open Segmentation filtered → *Shape*
 - “Zonal Statistics”
 - Export to CSV

1	DN	M_VVmean	M_INCmean	M_NDVImean
2	17	0.02	40.29	56.87
3	18	0.05	40.40	51.93
4	20	0.05	40.41	10.93
5	23	0.08	40.39	16.00
6	24	0.12	40.58	62.10
7	25	0.08	40.65	43.16
8	26	0.07	40.66	65.15
9	30	0.07	40.64	9.93
10	35	0.06	40.60	42.39
11	41	0.03	40.43	66.09
12	52	0.06	40.68	11.65
13	53	0.08	40.63	11.15
14	56	0.08	40.59	61.21
15	57	0.07	40.71	43.38

WORKFLOW

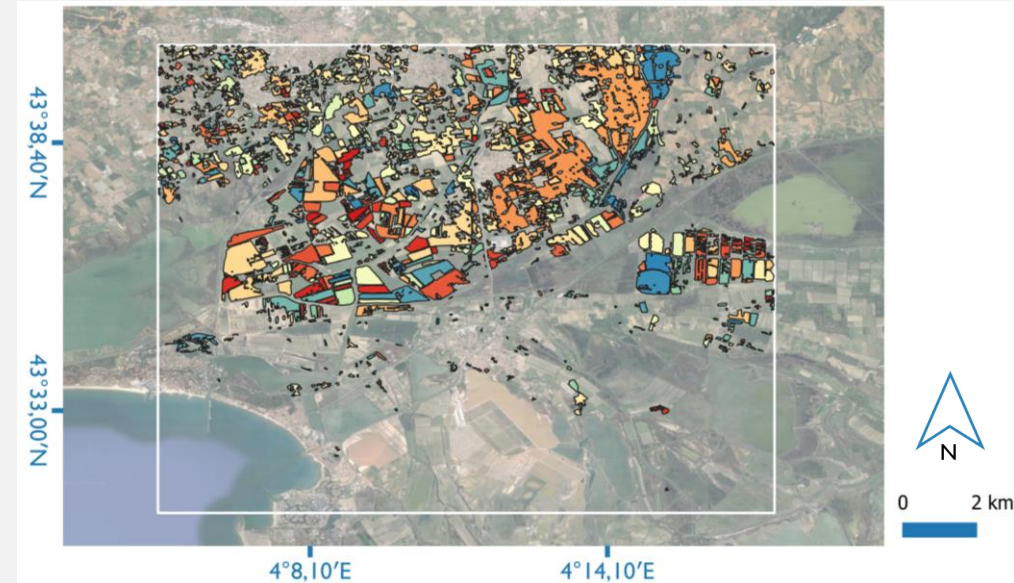


DATA PROCESSING



Zonal Statistics :
SI VV
Incidence angle
NDVI

INVERSION



- Python IDLE

- QGIS software :

- Open the “Estimation Soil Moisture” → *Text file*
- Open the RPG filter → *Shape*
- Join both tables by ID



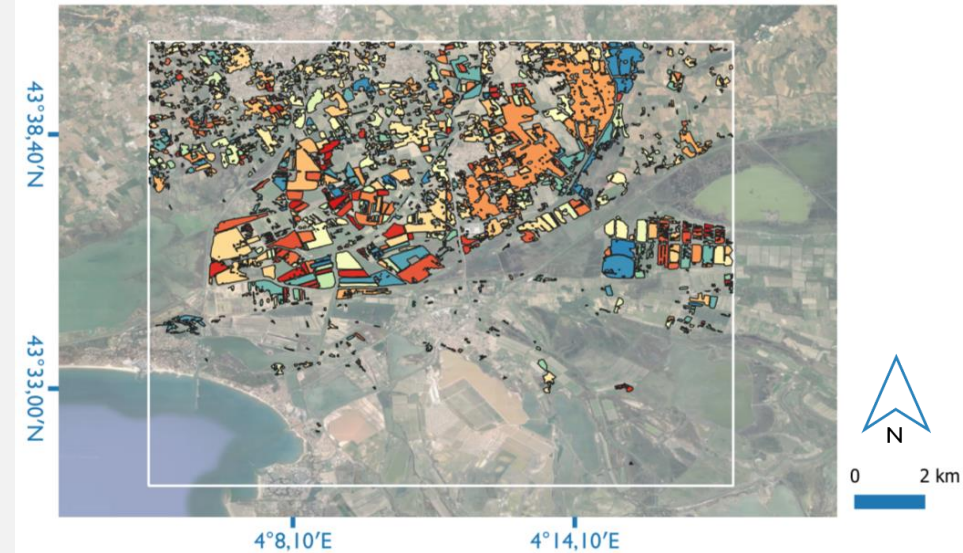
THANK YOU FOR YOUR
ATTENTION

DATA PROCESSING



Zonal Statistics :
SI VV
Incidence angle
NDVI

INVERSION



Inversion Model :

- Based on NN technique → Machine learning method trained on training dataset → Predicting Moisture
- Training is done using **synthetic data** derived from physical and empirical models (IEM + WCM)

50 % → Training

Best Path

50 % → Validation

Comparison with Moisture value

+ Test : Terrain

	INC	NDVI	Moisture	VV
Steps	40	55	5	15
	41	56	5,5	15,2
	

LEBANON STUDY AREA

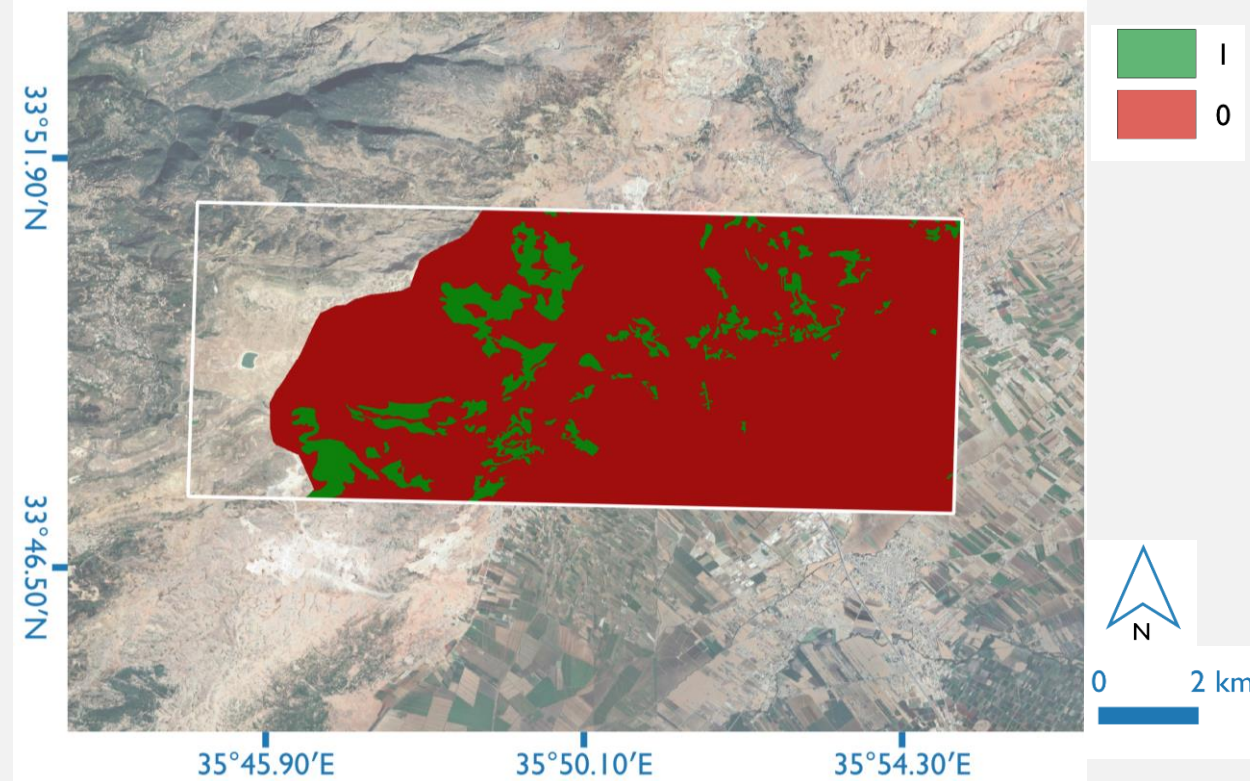
DATA PRE - PROCESSING



- QGIS software :
 - Open Land Cover vector
 - “Rasterization” (OTB) + Raster calculator + SuperImpose (OTB)
 - Expression :

Level I	400 : Grassland
	200 : Agricultural area

Land Cover Mask



MAP ELEMENTS

