



Automated updating of urban land cover maps using multitemporal Sentinel-1 data

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Outline

- Background / objective
- Data and test sites
- Processing chain
- Preliminary results and validation
- Conclusion & outlook



ESA Climate Change Initiative (CCI)

Goal is to provide stable, long-term, satellite-based essential climate variables (ECV) data products for climate modellers and researchers

14 ECVs were selected



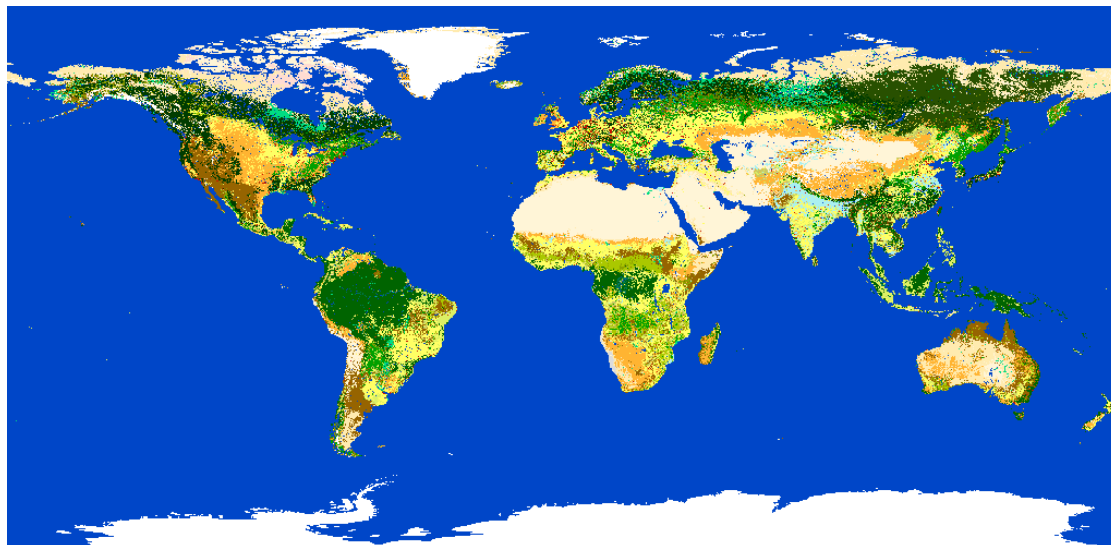
Land cover

(ESA Land Cover CCI project)



Urban area class

CCI-LC Map 2010





Round robin

Goal:

Demonstration of algorithms or processing chains of Sentinel-1 SAR data allowing to update / improve the existing urban class of the CCI-LC global land cover products

- ⇒ Start: September 2, 2015
- ⇒ End: December 1, 2015
- ⇒ Deliverables:
 - ⇒ Urban classification maps at 20 and / or 300m spatial resolution
 - ⇒ Algorithm Theoretical Baseline Document
- ⇒ Open and free

<http://maps.elie.ucl.ac.be/CCI/viewer/>

(Urban Round Robin button above the map, on the right)



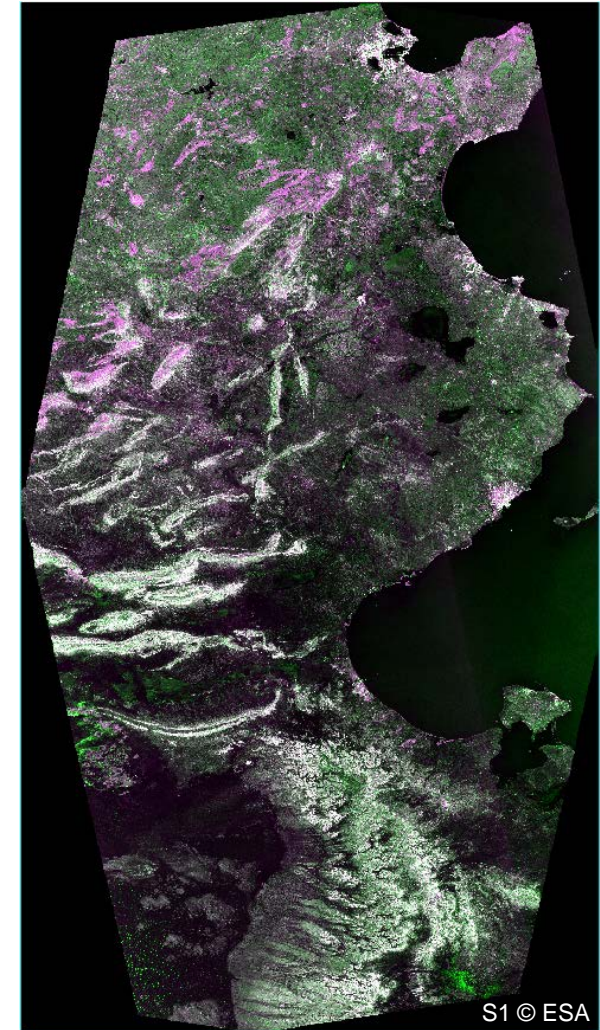
Semi-arid and arid regions in the Mediterranean and Northern Africa





Sentinel-1 data

- ⇒ Acquisition dates: October – December 2014
- ⇒ Time series of 14 – 16 scenes
- ⇒ Ascending and descending orbit
- ⇒ S1 GRDH product, VV and VH polarization
- ⇒ Pre-processing: Gamma software / IDL
- ⇒ Spatial resolution: ~20m
- ⇒ Multitemporal mean values

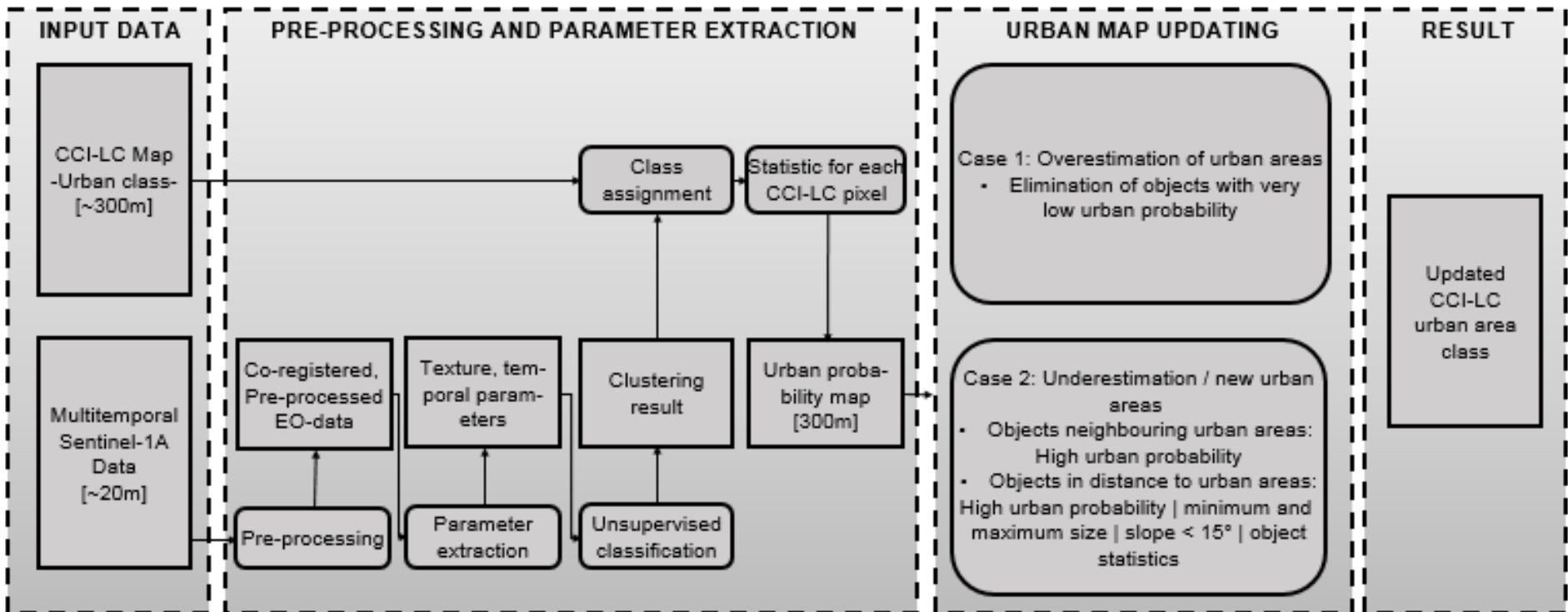


Tunisia
S1 VH-VV-VH

S1 © ESA



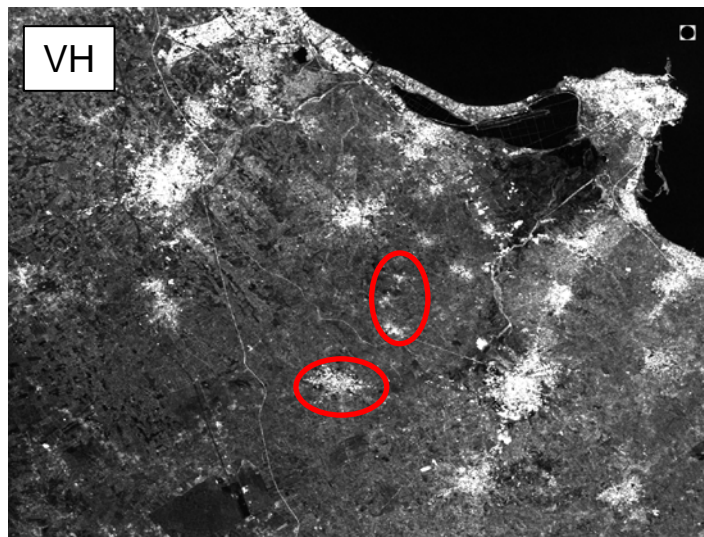
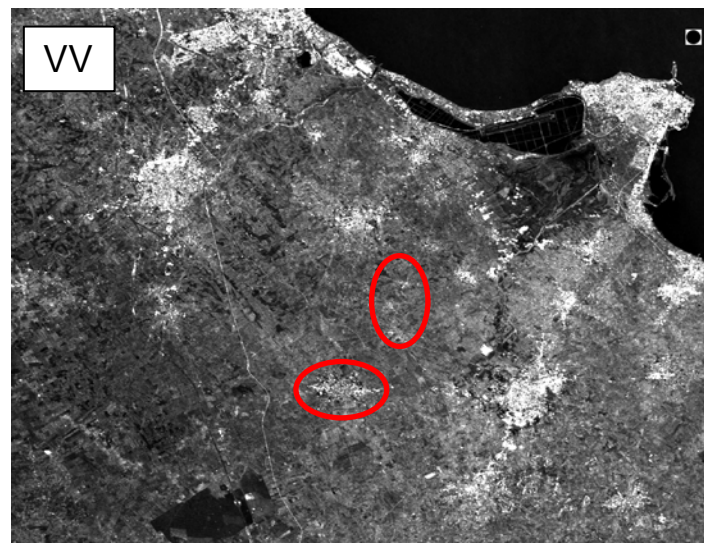
Processing chain - overview





Input data

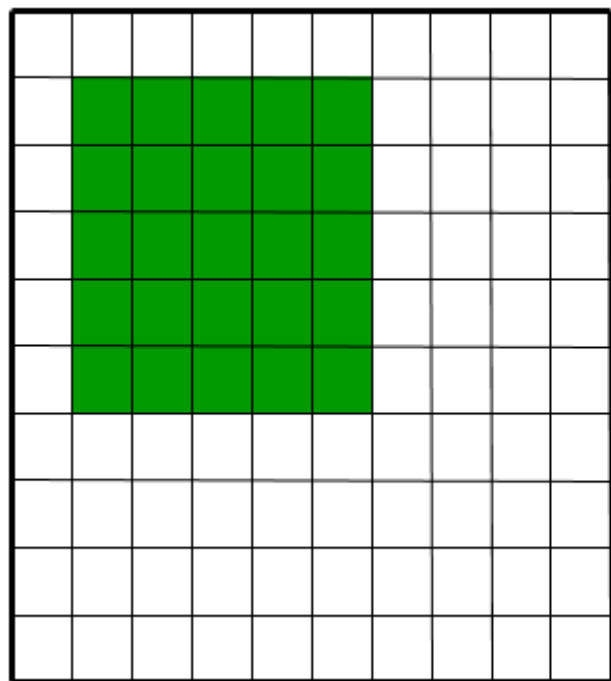
What about VH-polarisation?





Parameter extraction

Texture measures



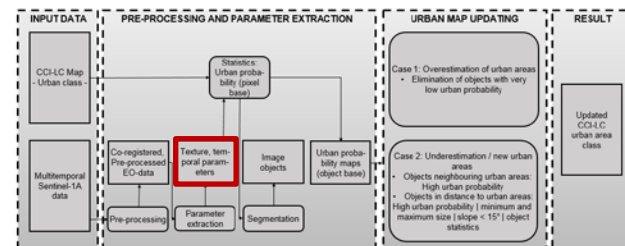
focal window size 5 x 5



5	7	1	11	3
15	9	8	2	5
2	6	4	12	10
3	5	13	1	3
14	9	6	4	9

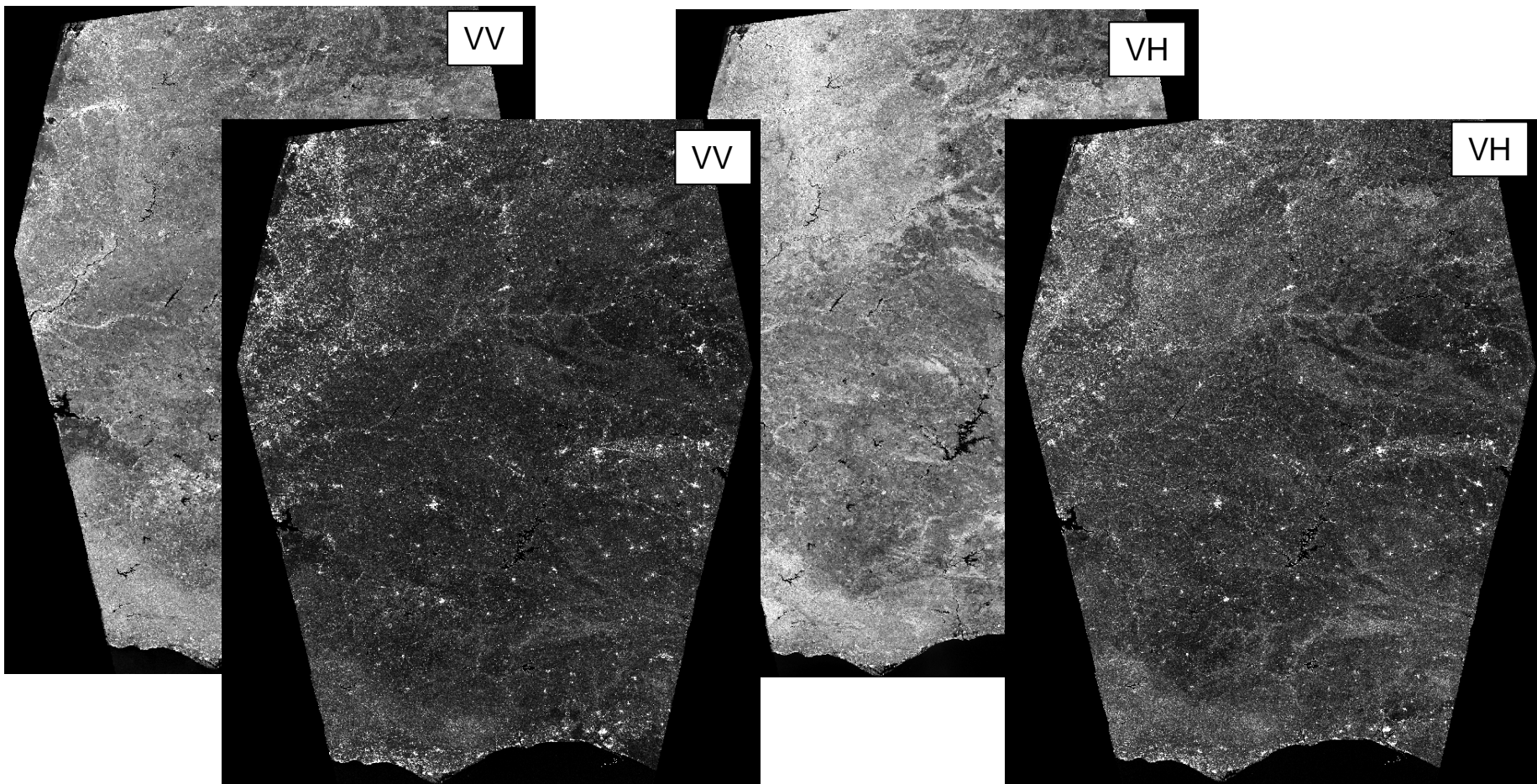
distance $r = 2$

Mean value of differences in radar backscatter between center pixel and its neighbouring pixels with a distance of 2





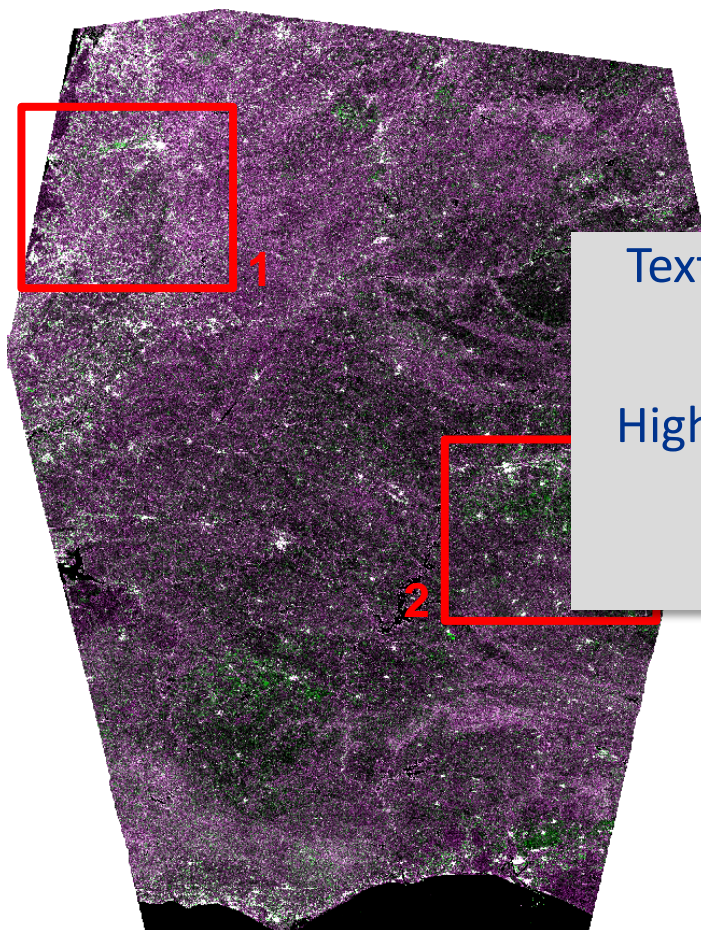
Parameter extraction - texture measures





Texture measures - Portugal

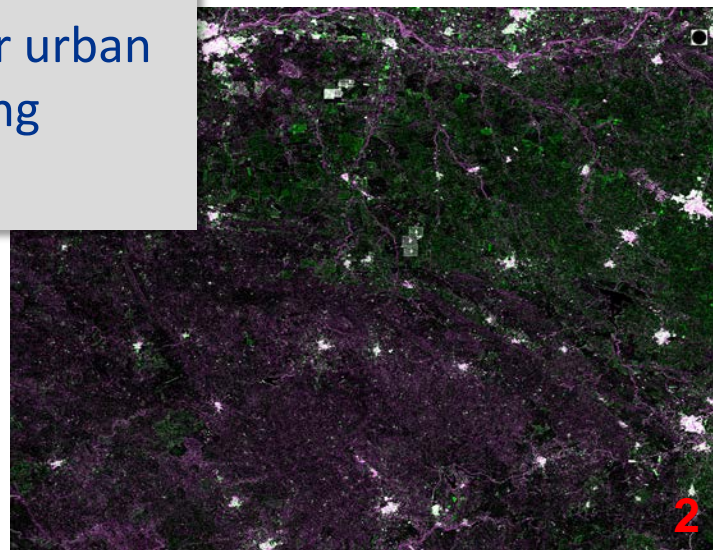
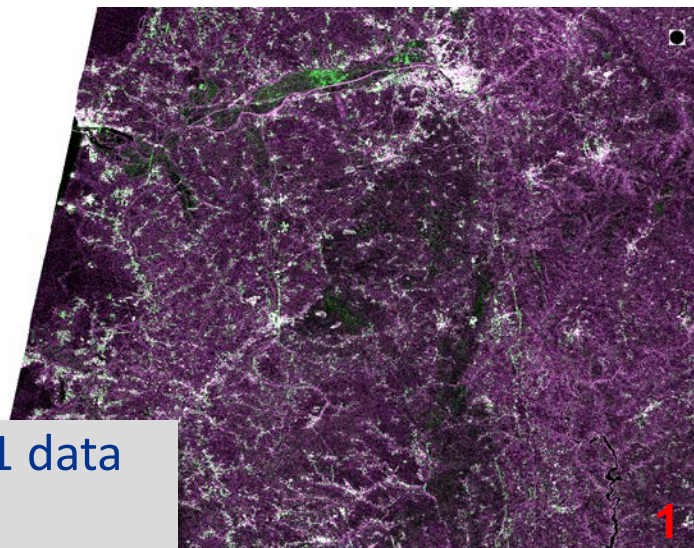
RGB-composite **VH** / **VV** / **VH**



Texture Sentinel-1 data



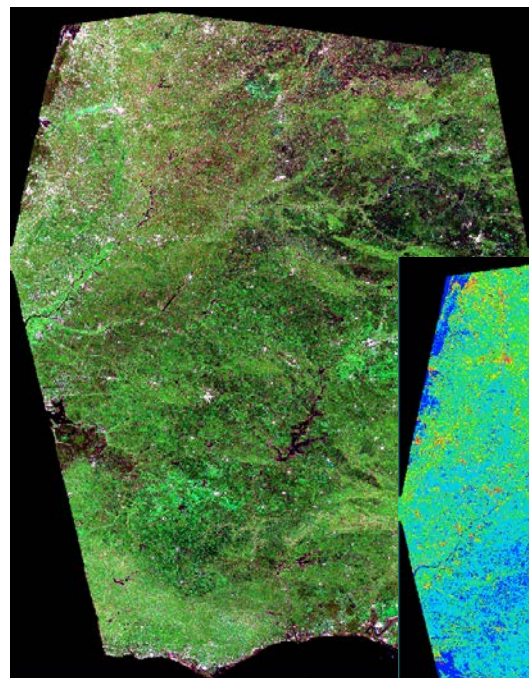
High potential for urban
area mapping



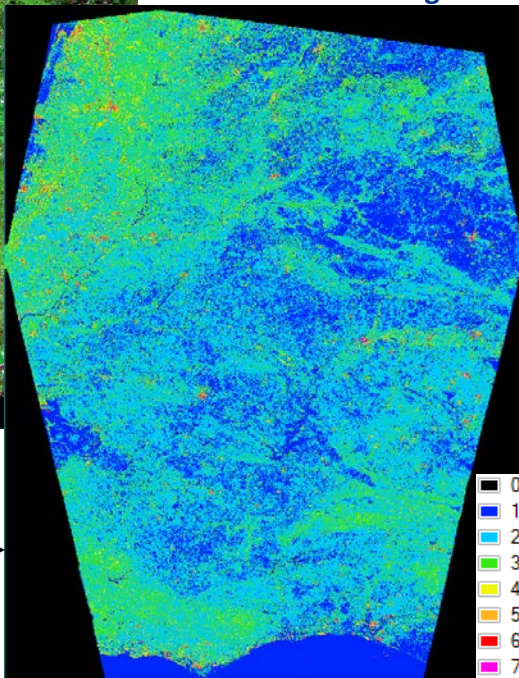


Unsupervised classification

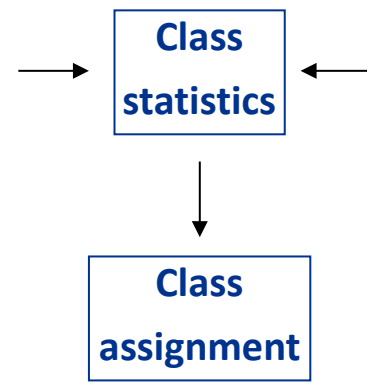
Texture VH / MMEAN VV / Texture VV



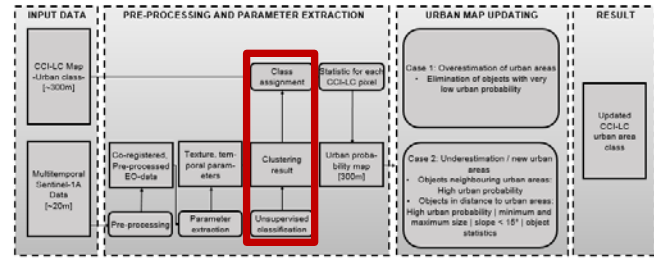
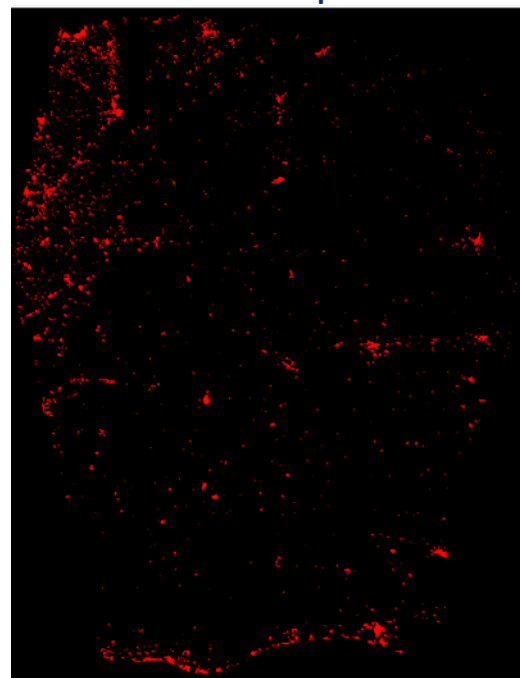
Clustering result



Classifi-
cation

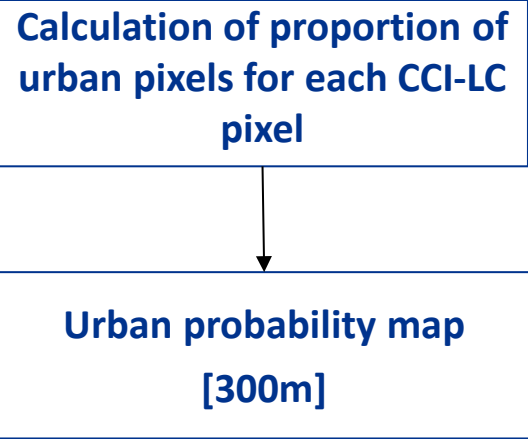
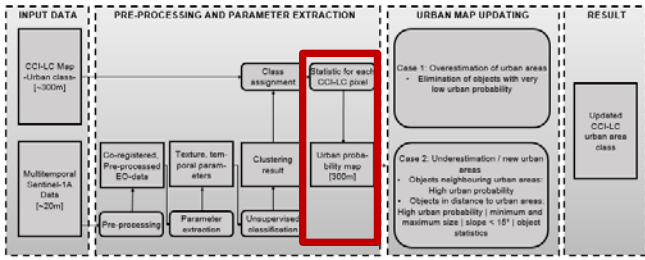


CCI-LC map – urban class





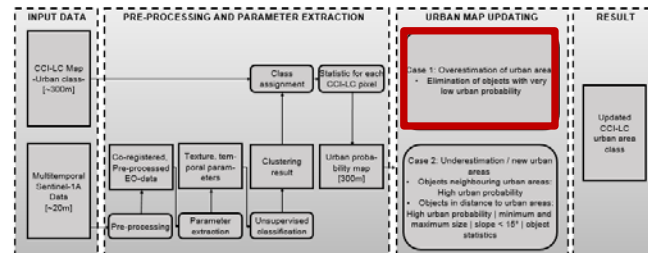
Unsupervised classification





Update process

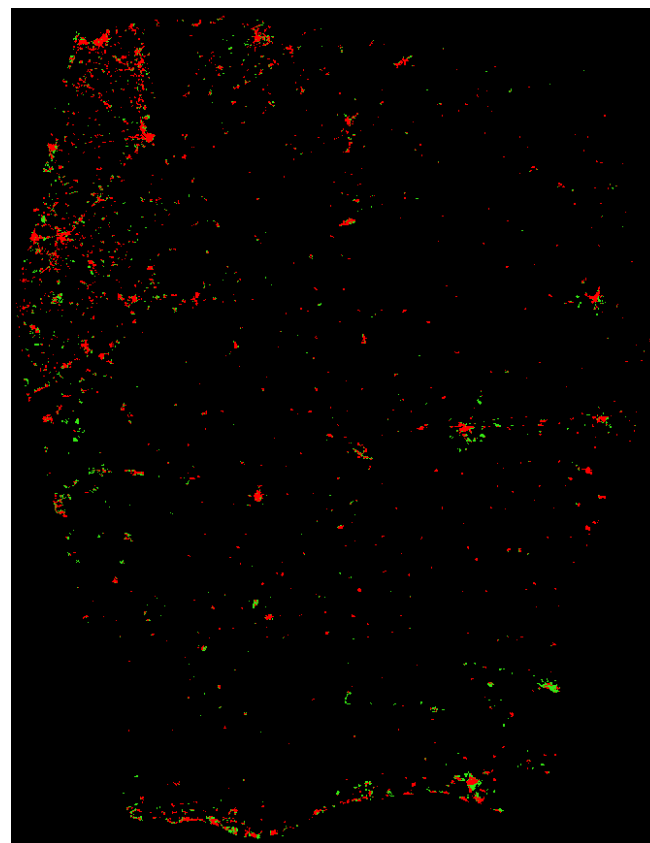
Case 1: urban → not urban



Urban
probability

<

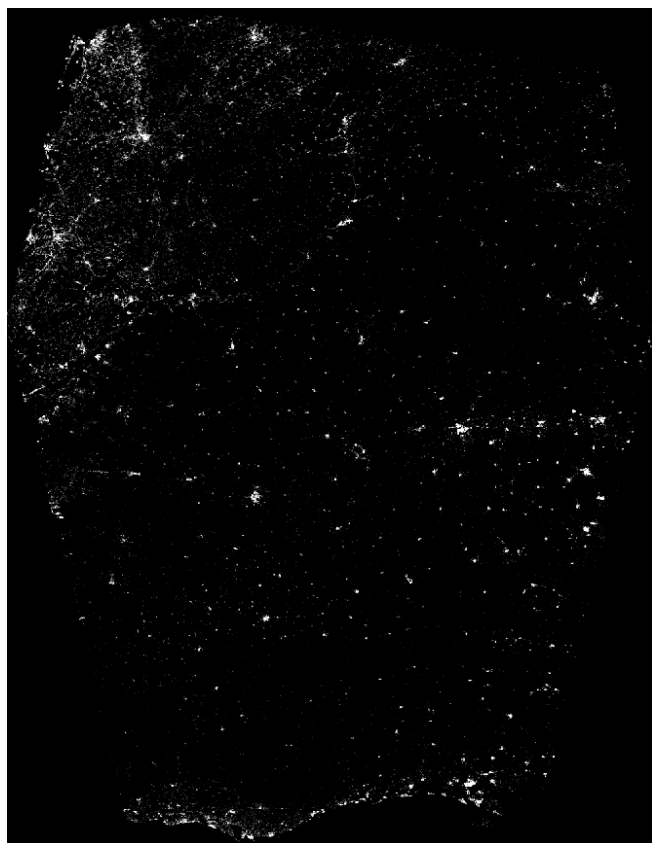
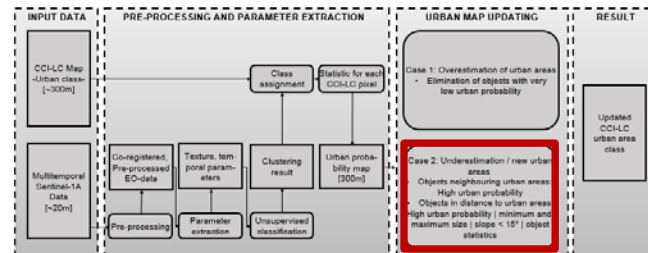
10%
(green)





Update process

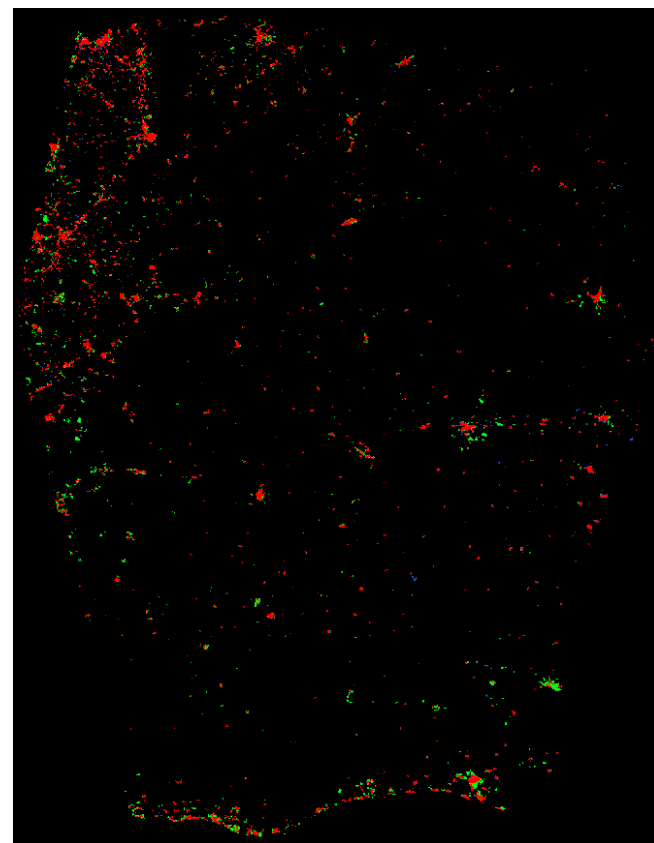
Case 2: not urban → urban (blue)



- Direct neighbour to urban area
- Urban probability >50%

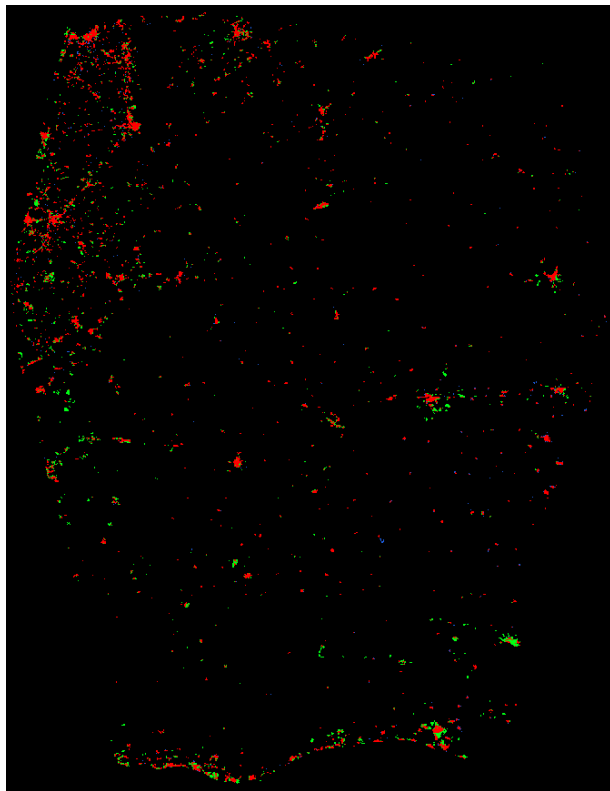
OR

- Urban probability >50%
- Size: 4 – 100 pixel
- Slope < 10°



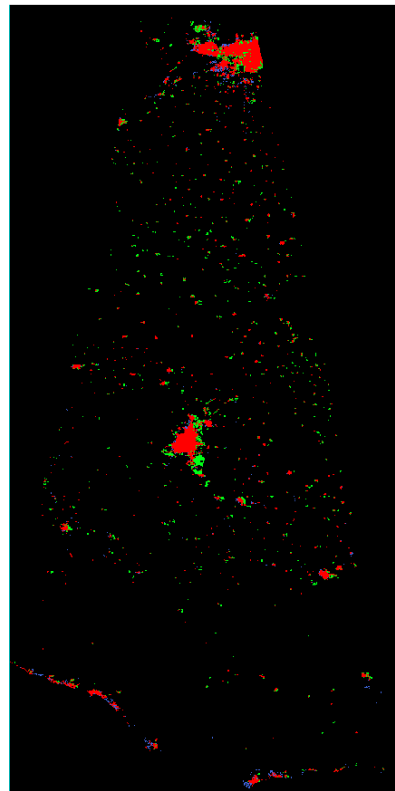


Results



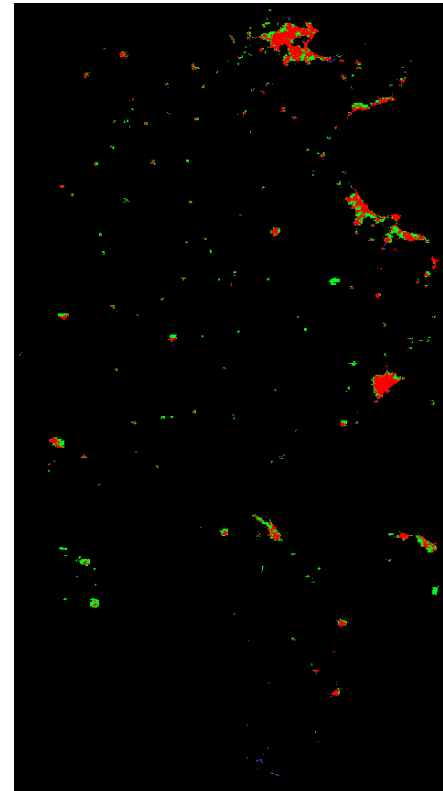
Portugal

 unchanged



Turkey

 urban → not urban

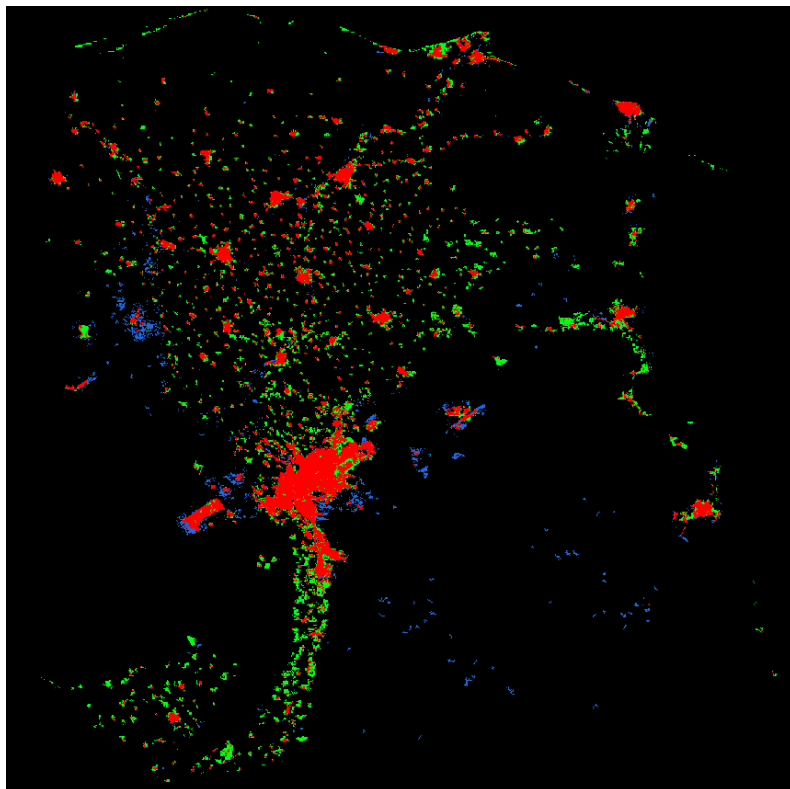


Tunisia

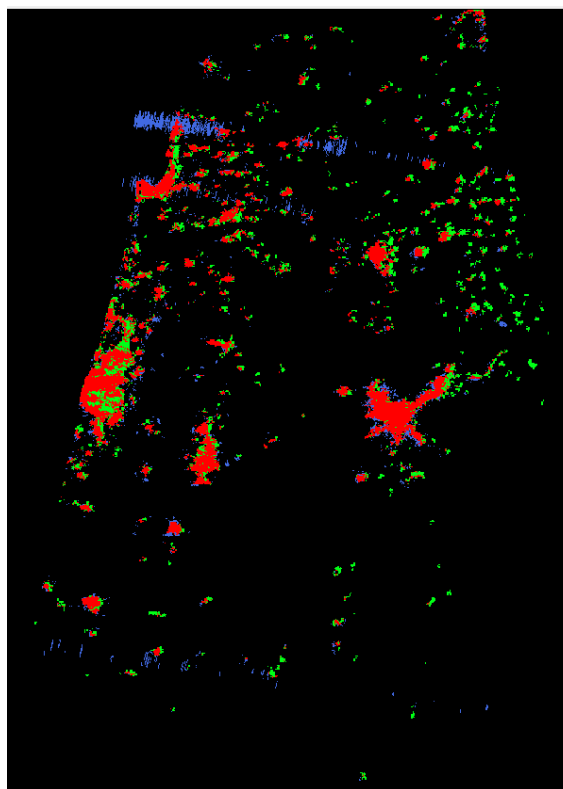
 not urban → urban



Results



Egypt



Israel

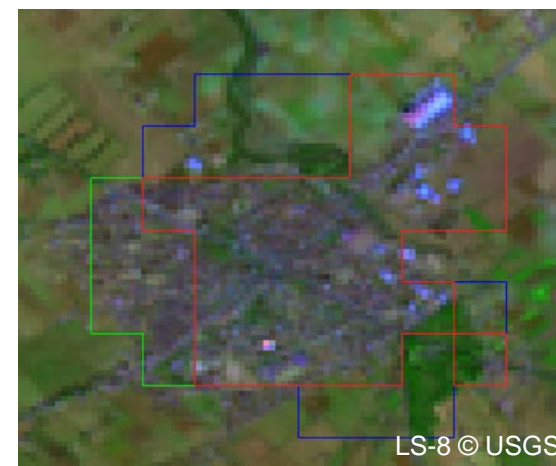
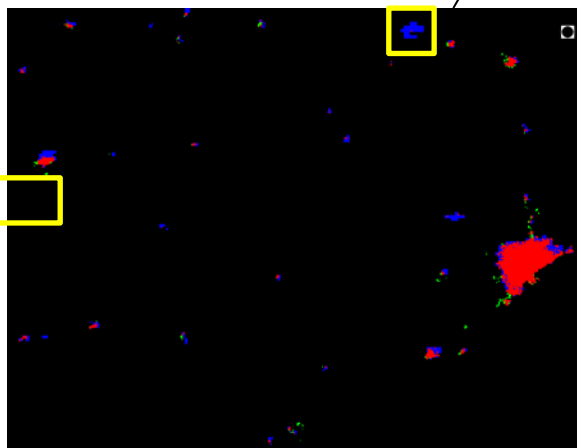
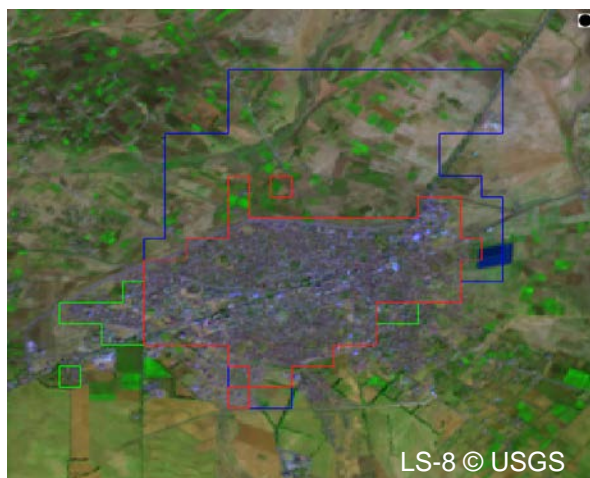
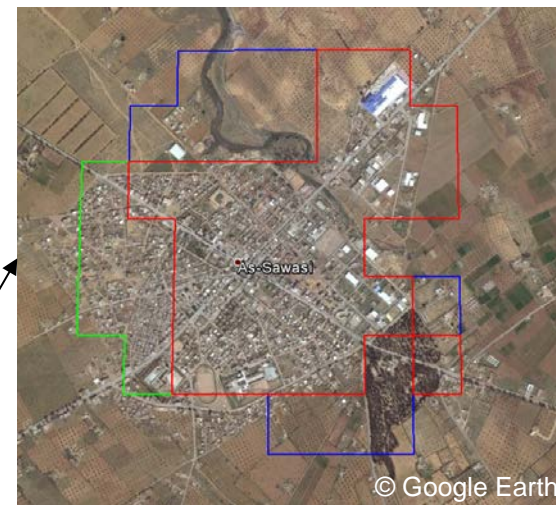
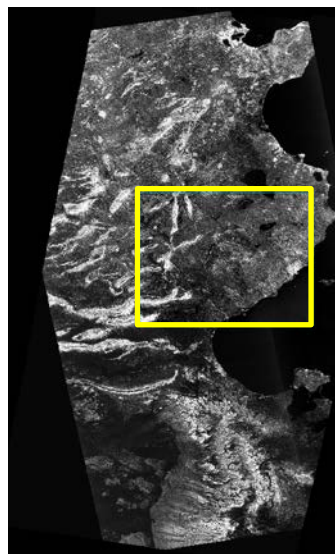
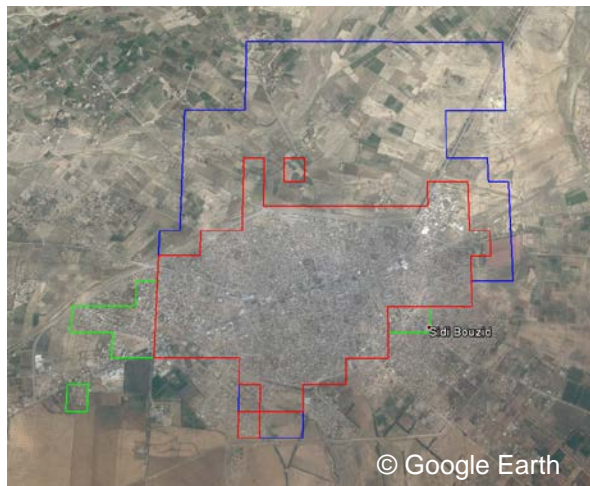
 unchanged

 urban → not urban

 not urban → urban

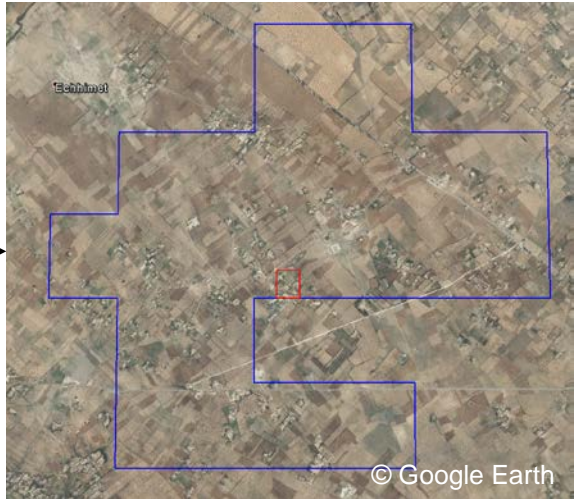
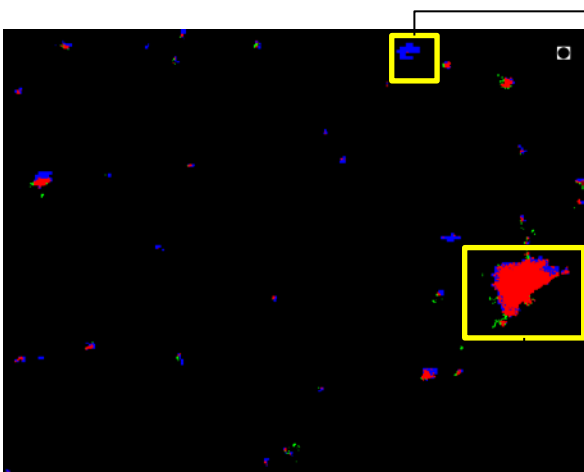
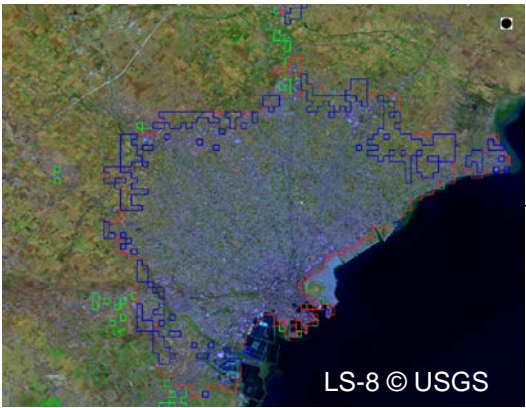
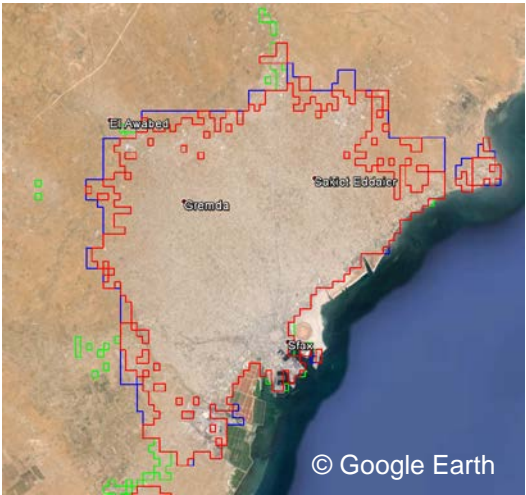


Comparison to LS-8 and Google Earth



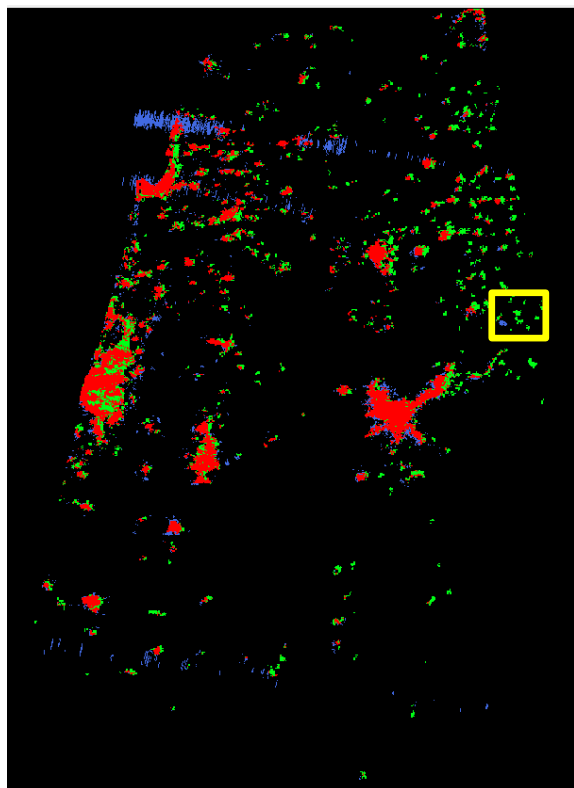


Comparison to LS-8 and Google Earth

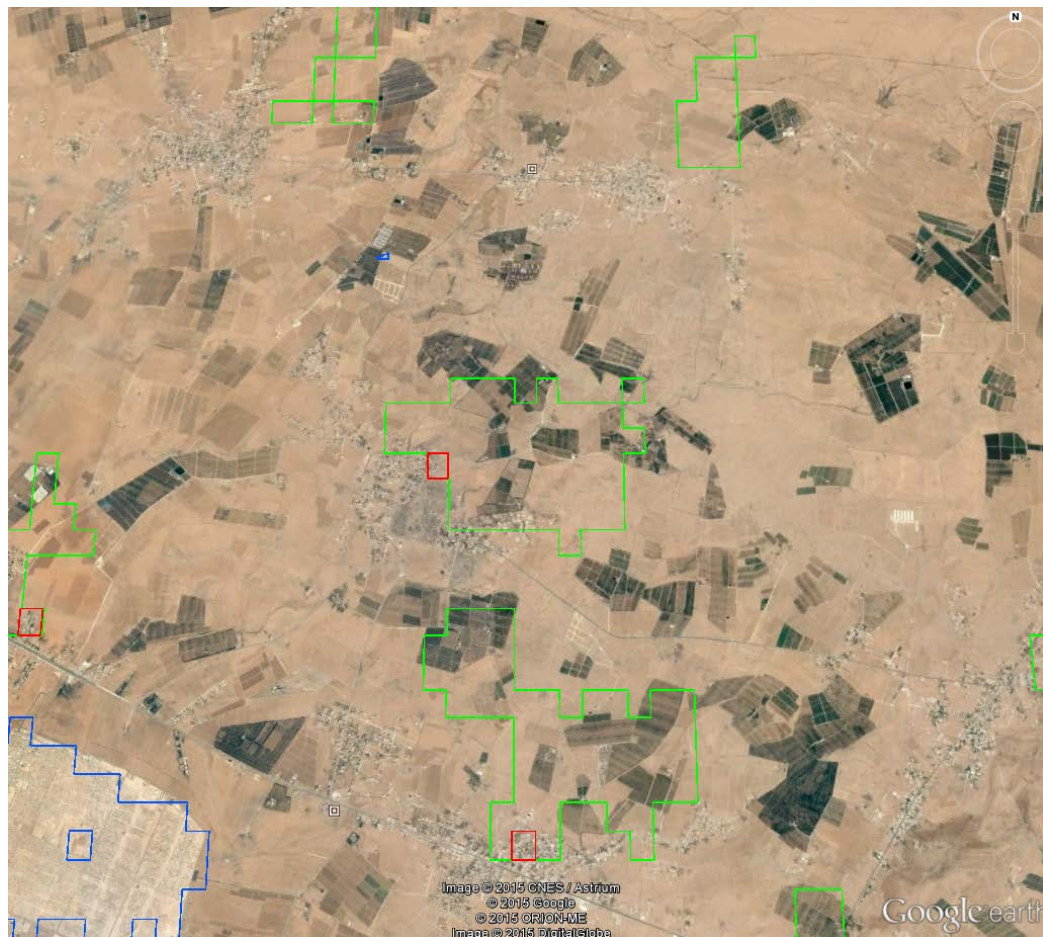




Comparison to Google Earth

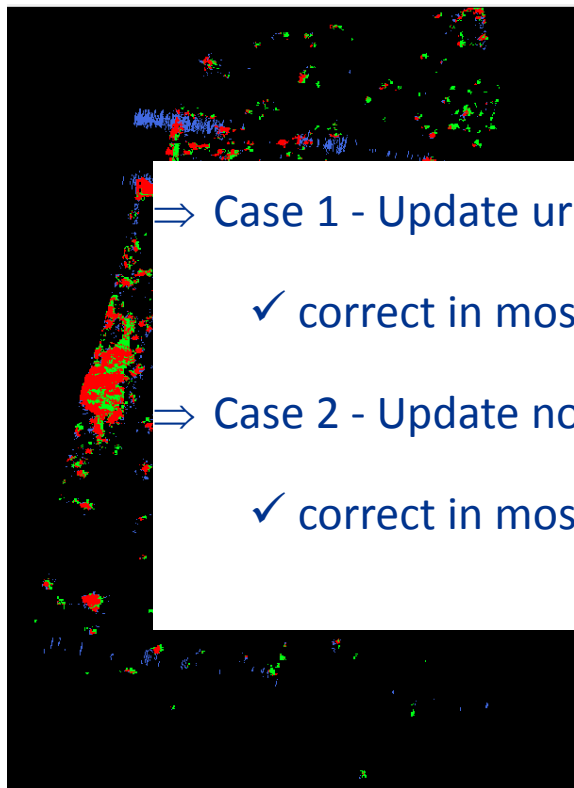


Israel





Comparison to Google Earth



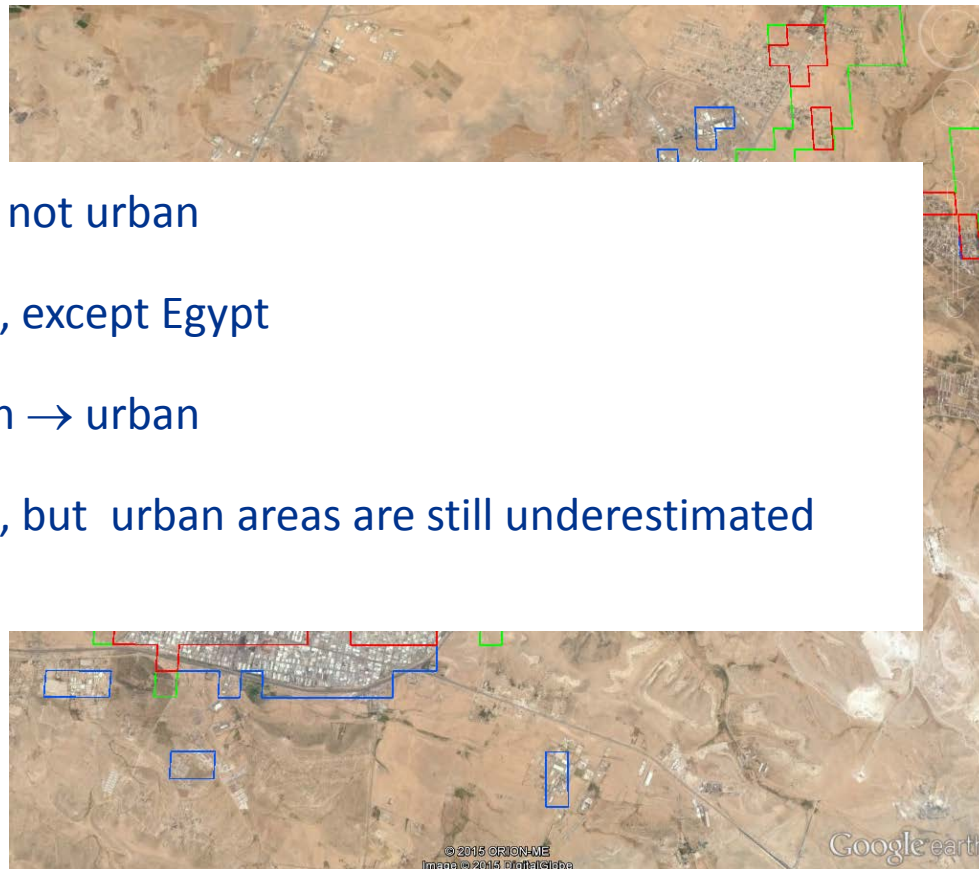
Israel

⇒ Case 1 - Update urban → not urban

✓ correct in most cases, except Egypt

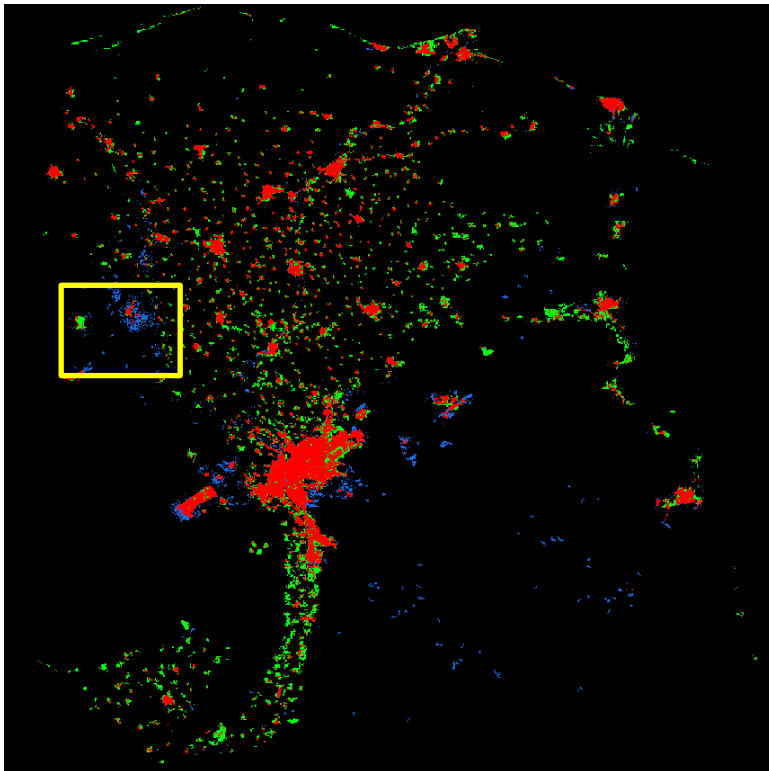
⇒ Case 2 - Update not urban → urban

✓ correct in most cases, but urban areas are still underestimated





Results for Egypt are not satisfactory



⇒ Misclassification with agriculture

⇒ Strong underestimation of urban areas, i.e.
urban probability $< 10\%$ for many settlements



Why?

⇒ Many fields characterized by a high radar backscatter from Oct-Dec

⇒ Low proportion of urban pixels for clusters extracted by unsupervised classification

⇒ Clusters important for urban area mapping are not assigned to urban class



Confusion matrix based on reference hexagons

Test site	Number reference hexagons	Product	Overall accuracy [%]	Commission [%]	Omission [%]	Kappa	Change OA [%]	Change Kappa
Portugal	478	CCI-LC map	83.89	31.38	0.84	0.68		
		Updated map	89.75	13.39	7.11	0.79	5.86	0.11
Israel	548	CCI-LC map	68.89	42.34	19.71	0.38		
		Updated map	87.04	12.77	13.14	0.74	18.15	0.36
Turkey	306	CCI-LC map	74.84	47.06	3.27	0.50		
		Updated map	83.01	26.80	7.19	0.66	8.17	0.16
Egypt	976	CCI-LC map	91.29	14.55	2.87	0.83		
		Updated map	79.41	7.58	33.61	0.59	11.88	0.24
Tunisia	470	CCI-LC map	77.66	31.06	13.62	0.55		
		Updated map	88.09	9.36	14.47	0.76	10.43	0.21

Summary



- New processing chain, completely implemented in IDL
- Flexibel with respect to input data (e.g. adaption for different regions, easy integration of optical data)
- No fixed thresholds
- Combination of pixel- and object-based elements
- Status: Improvement of current version of CCI-LC Map, but still much room for improvements
- Current limitations:
 - Regions of strong topography (masked)
 - Identification of urban structures not covered by CCI-LC Map
 - Egypt: mix-up with agriculture



Steps to improve the results

- Adaption of processing parameters for case 2 of the update process
- Selection of acquisition dates – focus on scenes acquired at the beginning of the main growing season and before / after main harvest time
 - ⇒ reduced misclassifications with agriculture
- Integration of additional post processing steps



Steps to improve the results

- Integration of optical data – synergy between optical and SAR
 - ⇒ reduced misclassification urban agriculture
 - ⇒ reduced impact of topography
- Combination of the algorithms developed at FSU and UPavia
 - ⇒ UPavia approach – next presentation by Andreas Salentinig



Thanks
for your attention!!!