Improving knowledge discovery from synthetic aperture radar images using the linked open data cloud and Sextant

Charalampos Nikolaou, Kostis Kyzirakos, Konstantina Bereta, Kallirroi Dogani, Stella Giannakopoulou, Panayiotis Smeros, George Garbis, Manolis Koubarakis

Daniela E. Molina, Octavian C. Dumitru, Gottfried Schwarz, Mihai Datcu

National and Kapodistrian University of Athens, Greece

German Aerospace Center (DLR), Germany

DLR

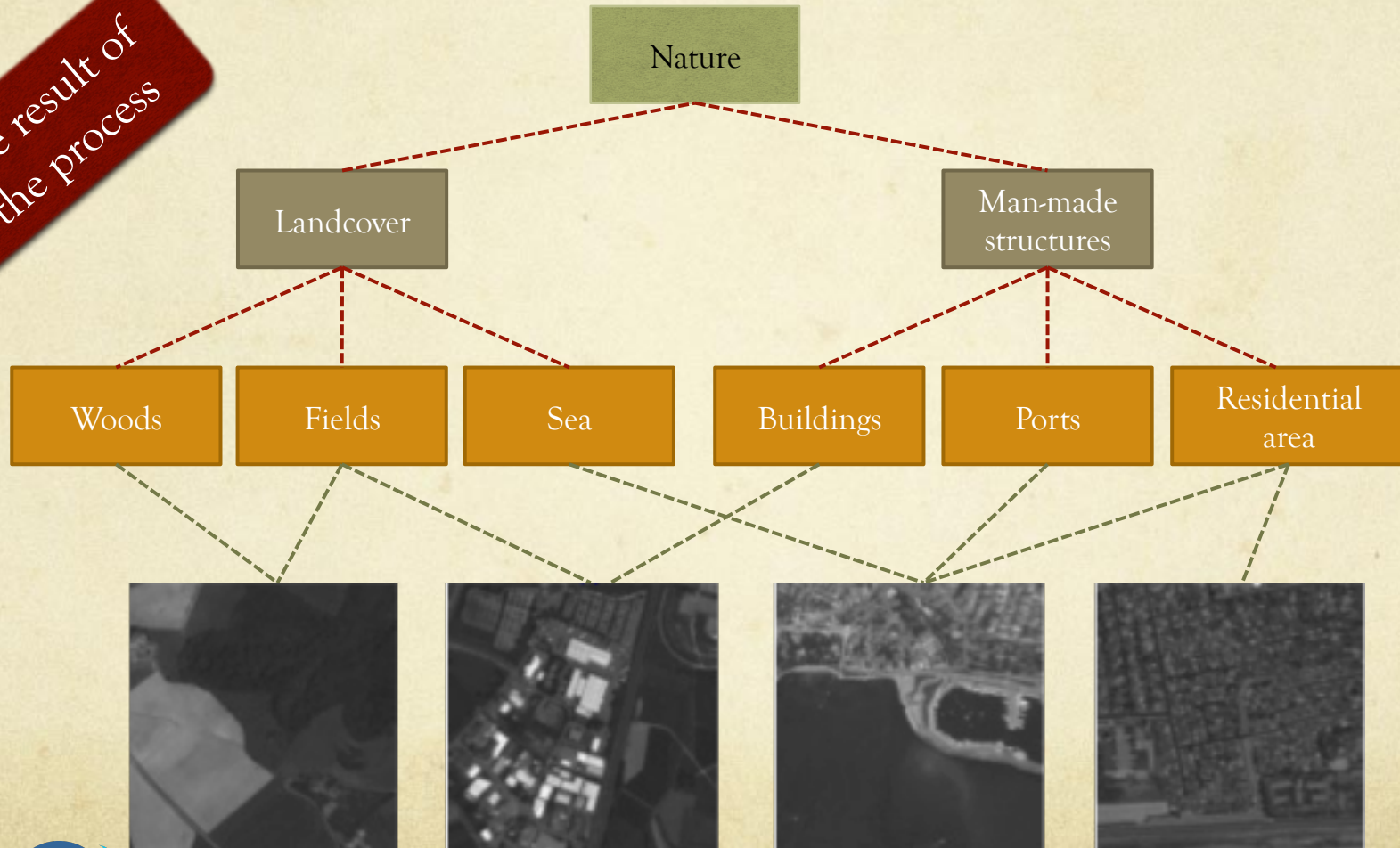**TELEIOS**

Outline

- Knowledge discovery from EO images in DLR

- The linked open data cloud

- The tool Sextant

- Improving knowledge discovery using Sextant

- Conclusions

Knowledge discovery and semantic annotation in DLR
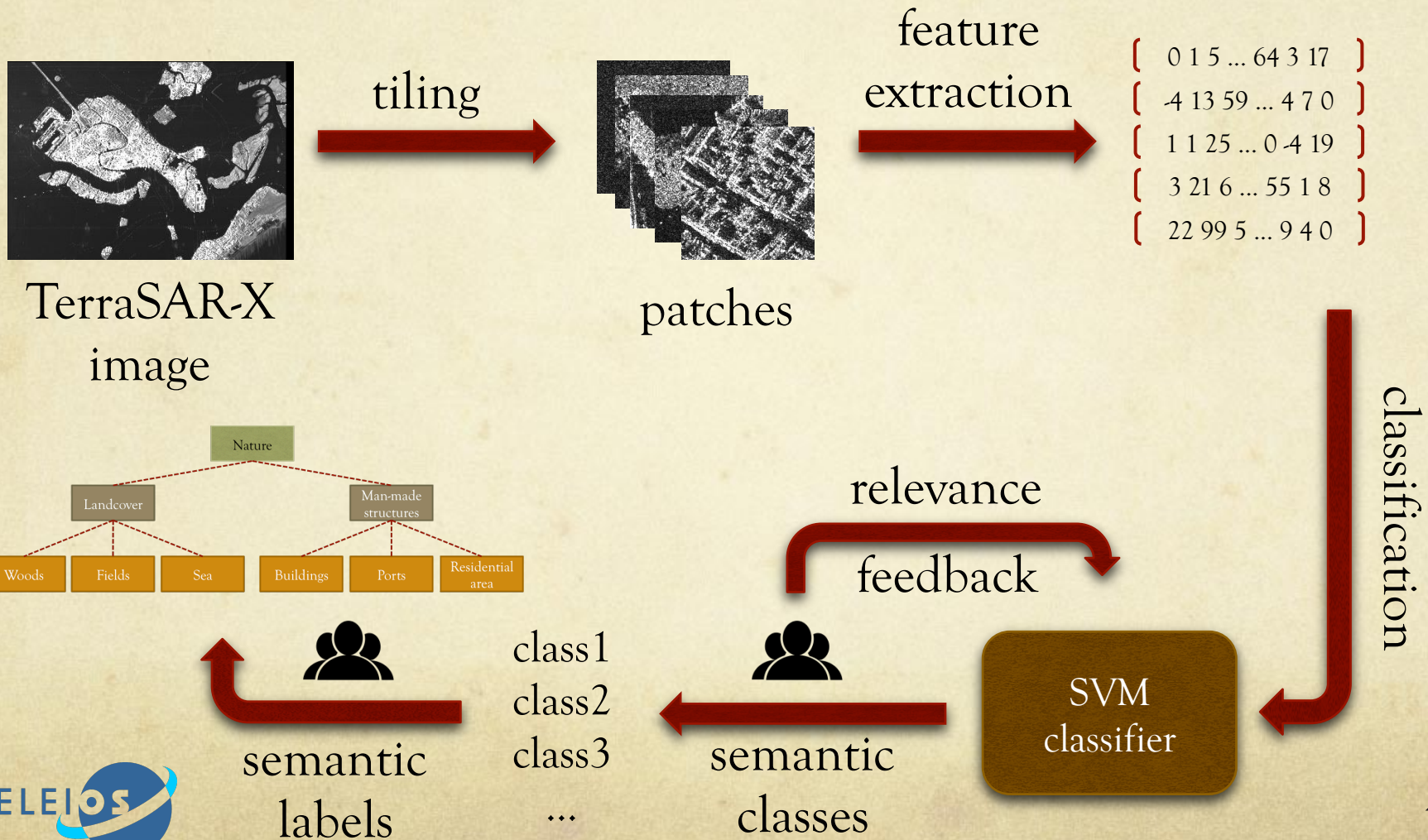
Knowledge discovery and semantic annotation in DLR

Knowledge discovery and semantic annotation in DLR

No. of scenes / No. of patches	No. of semantic categories	Methodology
109 scenes 110,000 patches	850 categories	• Support Vector Machine • Relevance Feedback

Woods   Fields   Sea   Buildings   Ports   Residential

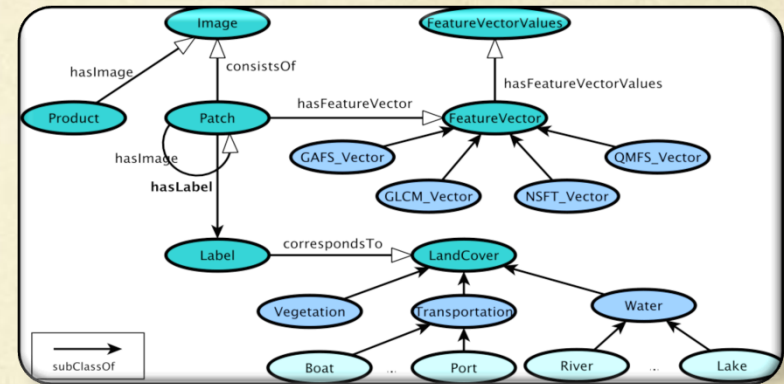| Type of areas	Scene location
Urban and infrastructure areas	• Africa – 5 scenes • Asia – 21 scenes • Europe – 48 scenes • Middle East – 8 scenes • North America – 16 scenes • South America – 11 scenes

TELEIOS

DLR

Data modeling for knowledge discovery and semantic annotation

○ Conceptual modeling of the **knowledge discovery process** and the **semantic classes** using an **OWL ontology**

○ Use **geospatial** and **temporal extensions** of the **SPARQL query language** to query such data
(e.g., GeoSPARQL and stSPARQL)

BENEFITS

○ High expressivity

○ Declarative querying (e.g., "find all satellite images with patches containing water limited on the north by a port")

○ Combination with other data sources
  ✓ **high-quality** GIS data
  ✓ **emerging/dynamic** web resources and **linked geospatial data**

# Data modeling for knowledge discovery and semantic annotation

- Conceptual modeling of the **knowledge discovery process** and the **semantic classes** using an **OWL ontology**

- Use **geospatial** and **temporal extensions** of the **SPARQL query language** to query such data (e.g., GeoSPARQL and stSPARQL)

BENEFITS

- High expressivity

- Declarative querying (e.g., "find all satellite images with patches containing water limited on the north by a port")

- Combination with other data sources
  - ✓ **high-quality** GIS data
  - ✓ **emerging/dynamic** web resources and **linked geospatial data**

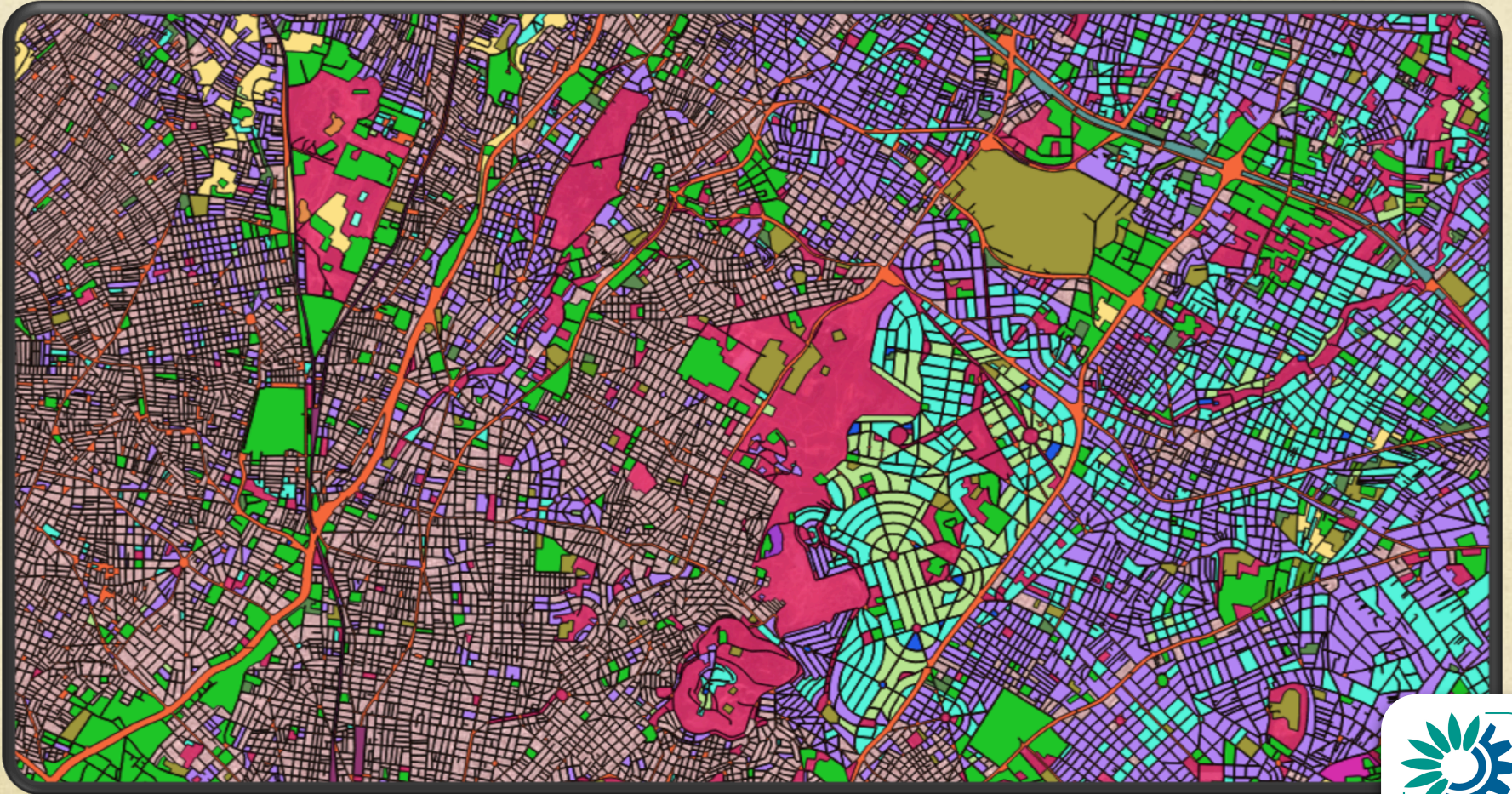# The Linked Open Data cloud

As of September 2011
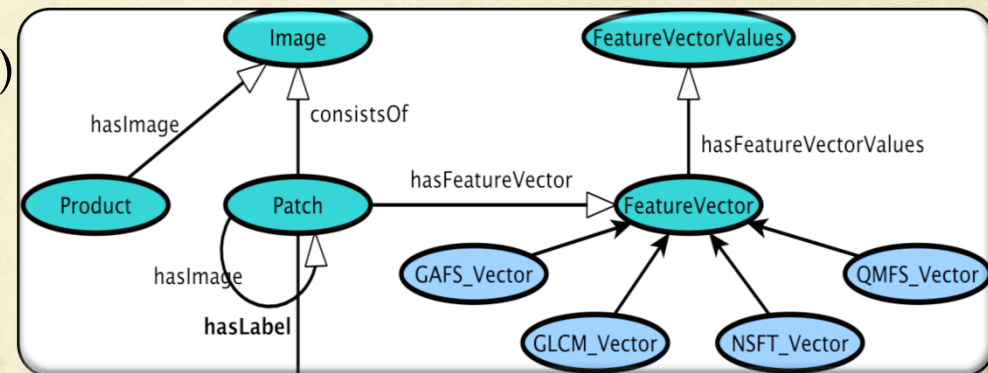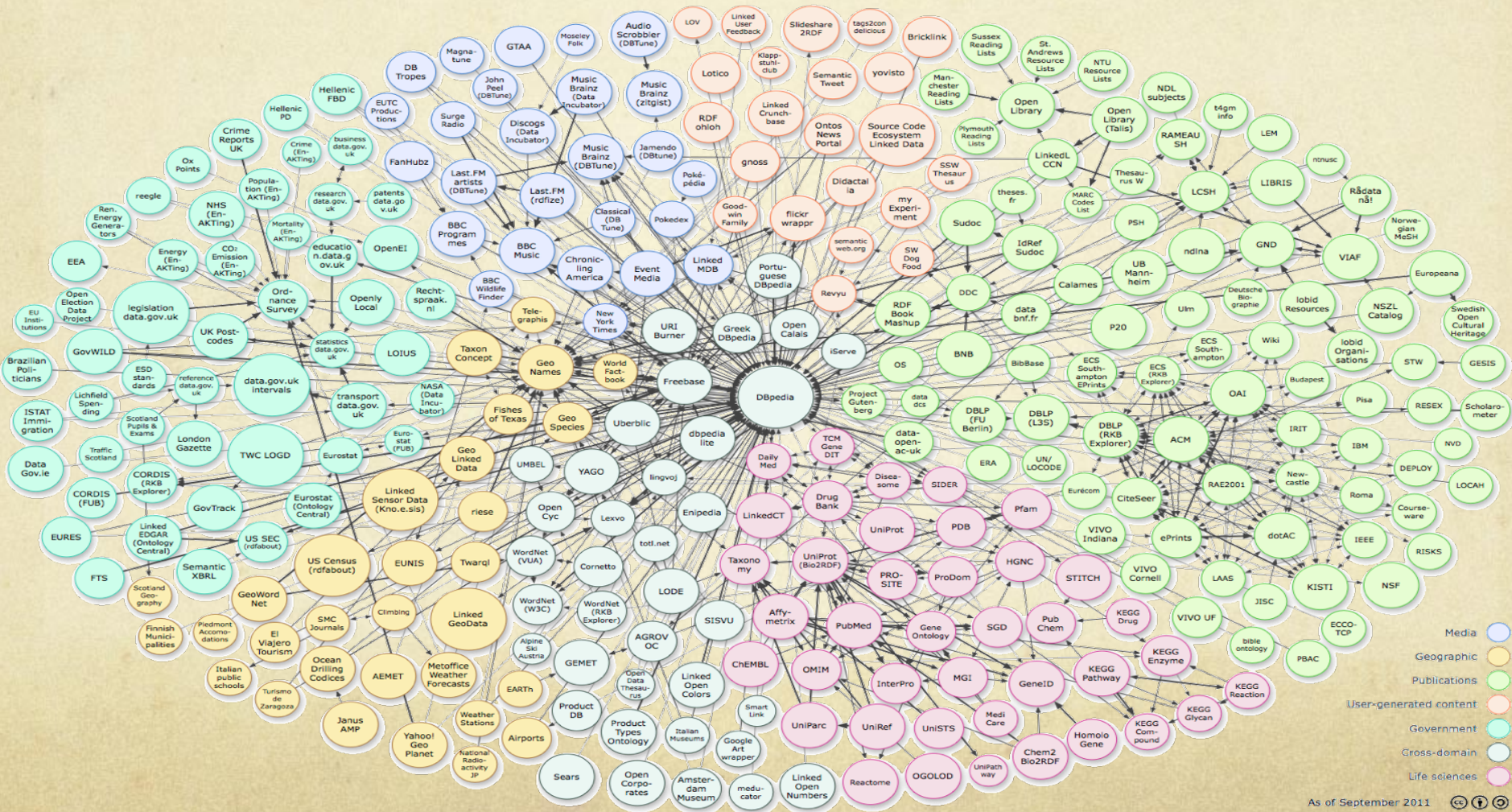
CORINE Land Cover (CLC)
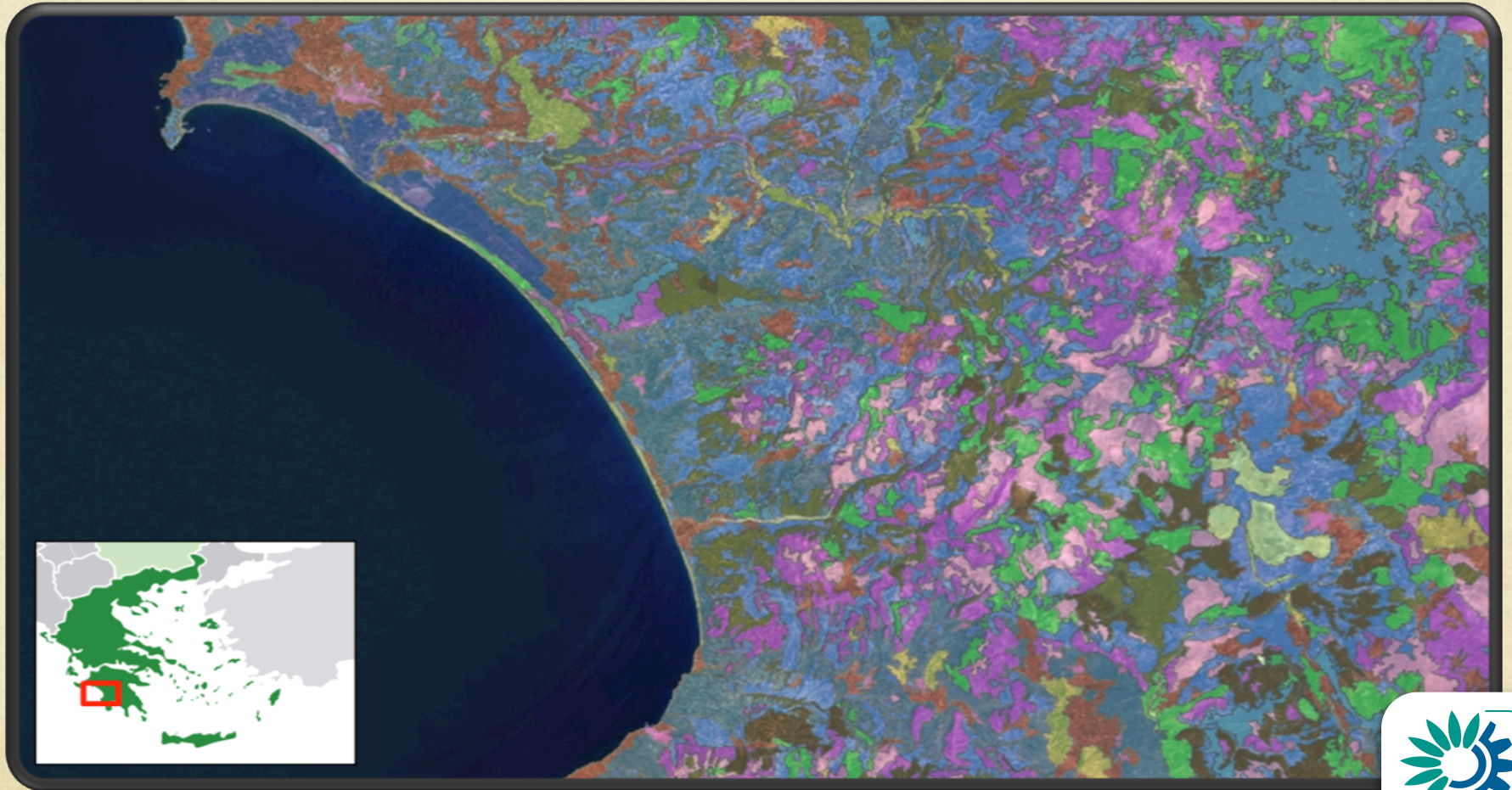
Available on **datahub** as linked data

Urban Atlas (UA)

Available on ▦ datahub as linked data

Open Street Map (OSM)

Sextant

A web-based tool for

- **browsing** and **exploring** linked geospatial data

- **creating thematic maps** produced by querying the **spatial** and **temporal** dimensions of **linked data** and other geospatial data sources in **OGC standard file formats** (e.g., KML)

- **sharing** and **collaborative editing** of thematic maps

OPEN SOURCE

Find more at:
http://sextant.di.uoa.gr/

Interoperable with well-known GIS tools (e.g., ArcGIS, QGIS, Google Earth)

Improving the knowledge discovery process of DLR using Sextant
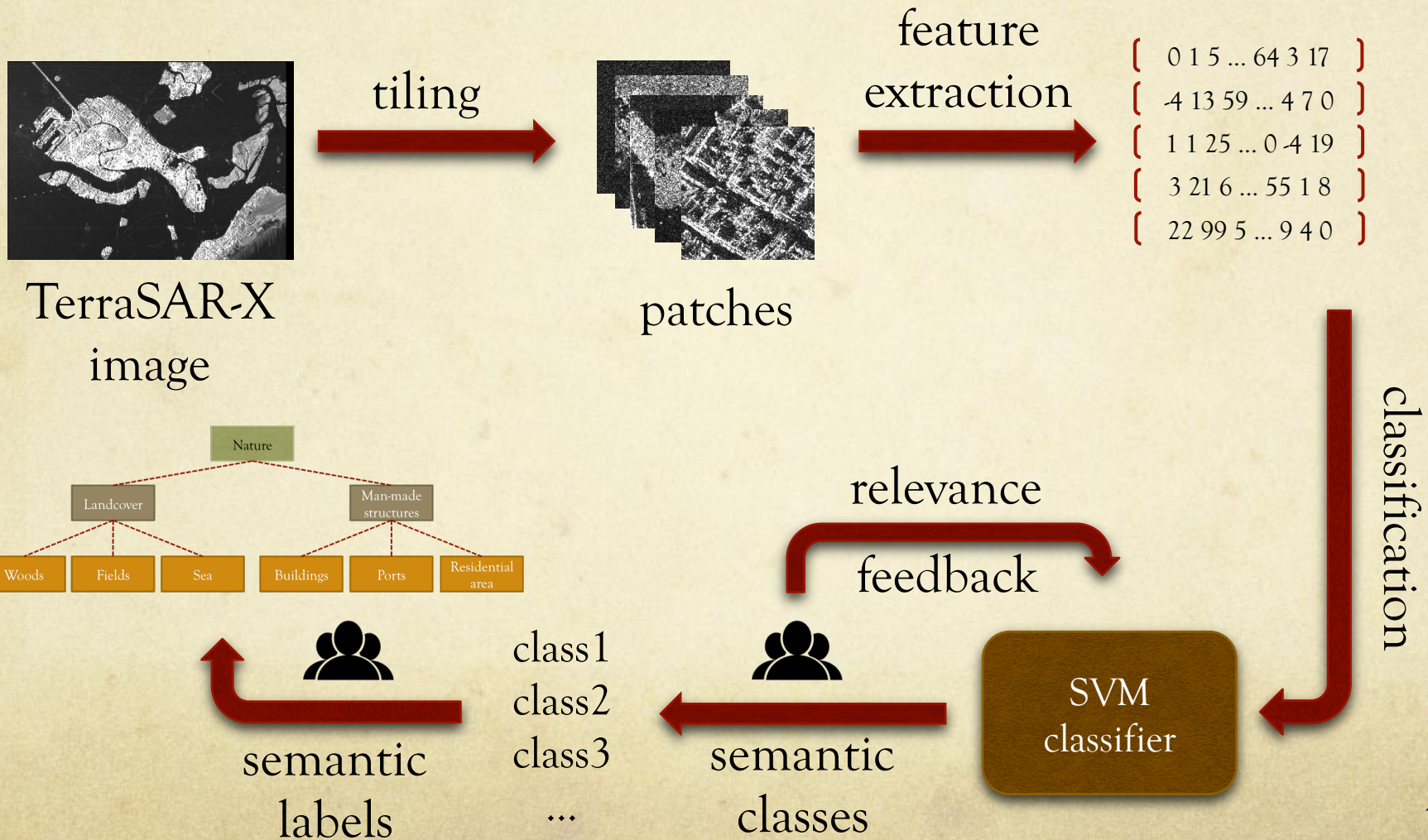
Improving the knowledge discovery process of DLR using Sextant

TerraSAR-X image

tiling
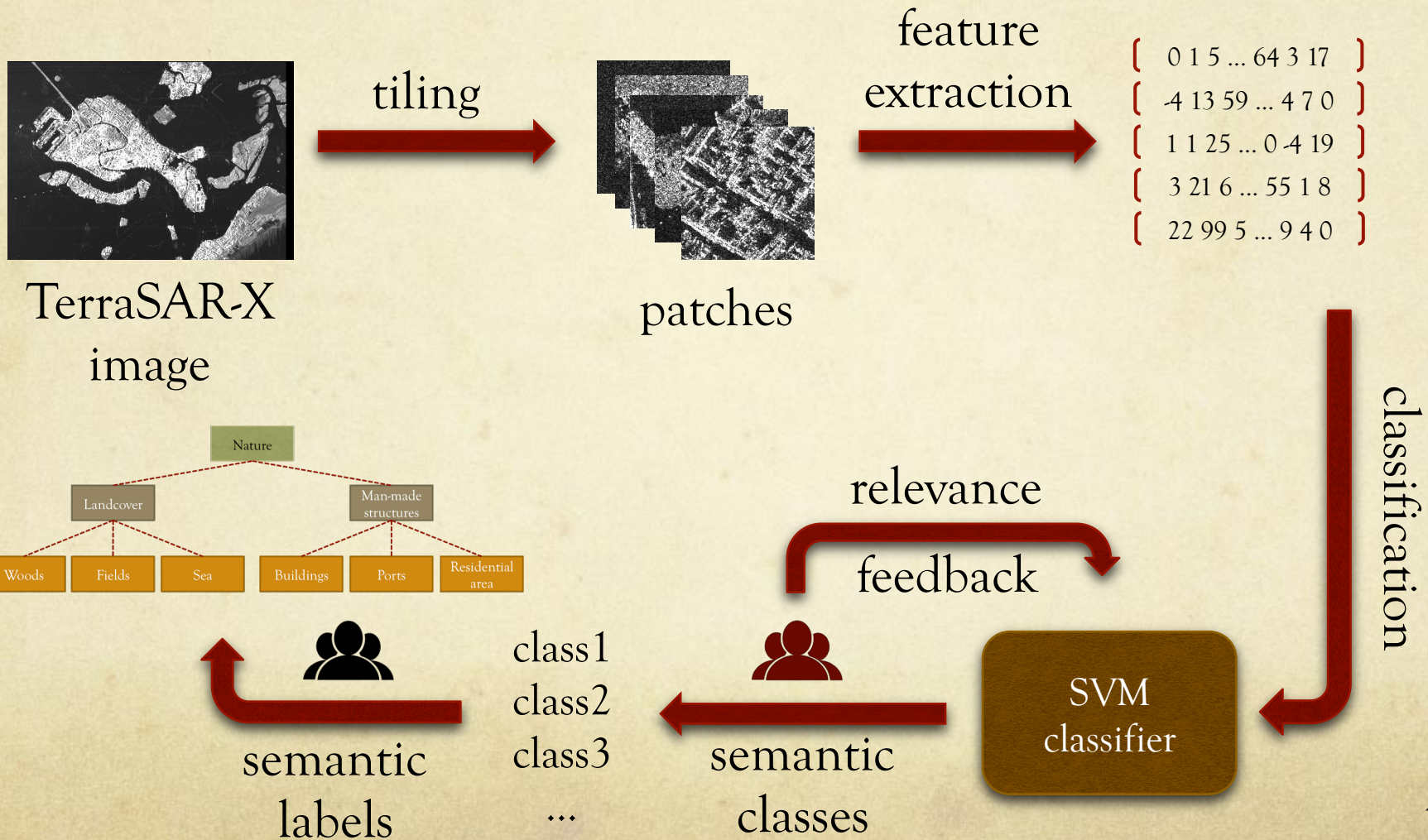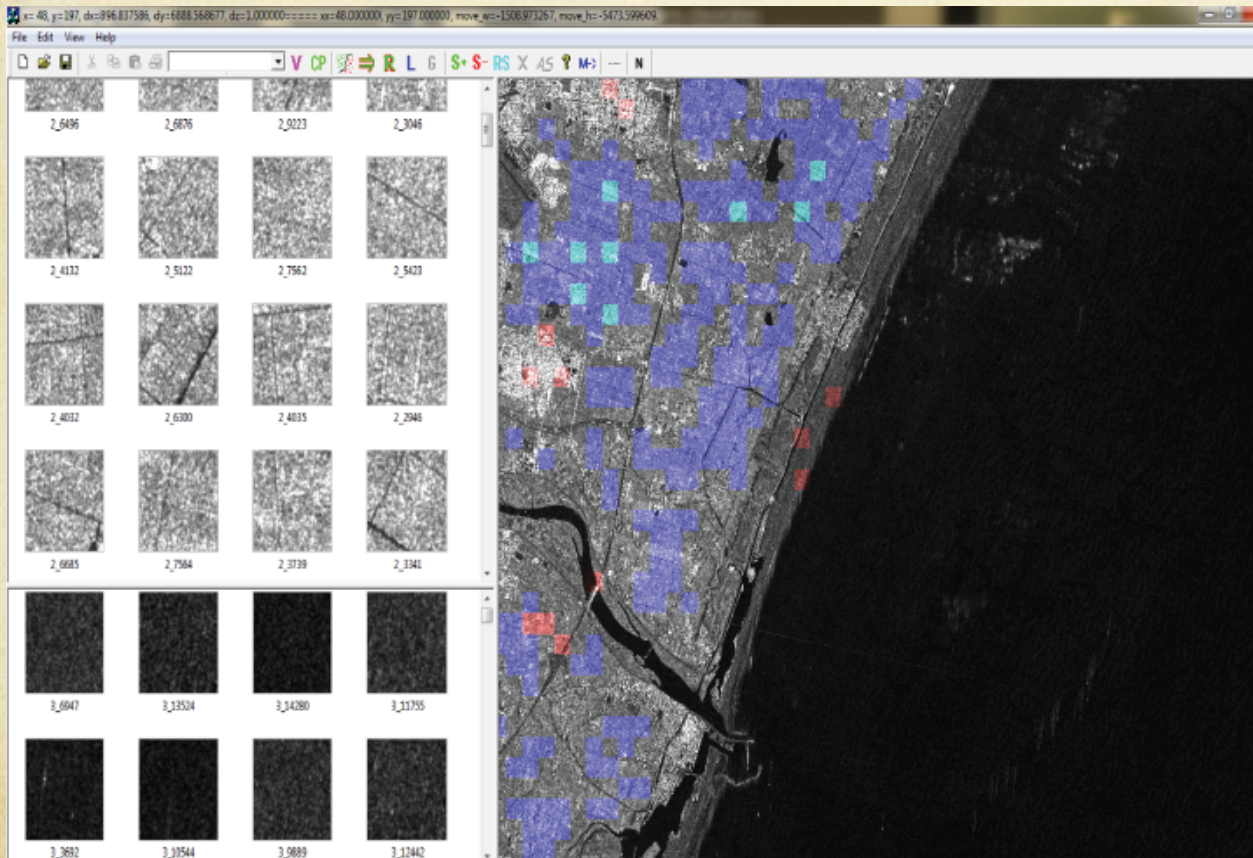
patches

feature extraction

$\begin{bmatrix} 0\ 1\ 5\ ... \ 64\ 3\ 17 \\ -4\ 13\ 59\ ... \ 4\ 7\ 0 \\ 1\ 1\ 25\ ... \ 0\ -4\ 19 \\ 3\ 21\ 6\ ... \ 55\ 1\ 8 \\ 22\ 99\ 5\ ... \ 9\ 4\ 0 \end{bmatrix}$

classification

Nature

Landcover

Man-made structures

Woods | Fields | Sea | Buildings | Ports | Residential area

relevance feedback

semantic labels

class1
class2
class3
...

semantic classes

SVM classifier

DLR

SVM–RF: a semi-automatic process

Iterative annotation of TerraSAR-X image patches using the SVM classifier with a relevance feedback module (RF)

Green patches: positive examples

Red patches: negative examples

Blue patches: classified

SVM–RF: a semi-automatic process

Current status of SVM-RF

- **Cannot discern** the content of a patch

- Difficult to work on **radar images only**

- Man in the **loop**

Improvements using Sextant

- Bring in **auxiliary** geospatial **data sources**

- Bring in **background maps** (and any other WMS layer)

- **Automate** using logical **if-then** rules

Improving the knowledge discovery process of DLR using Sextant

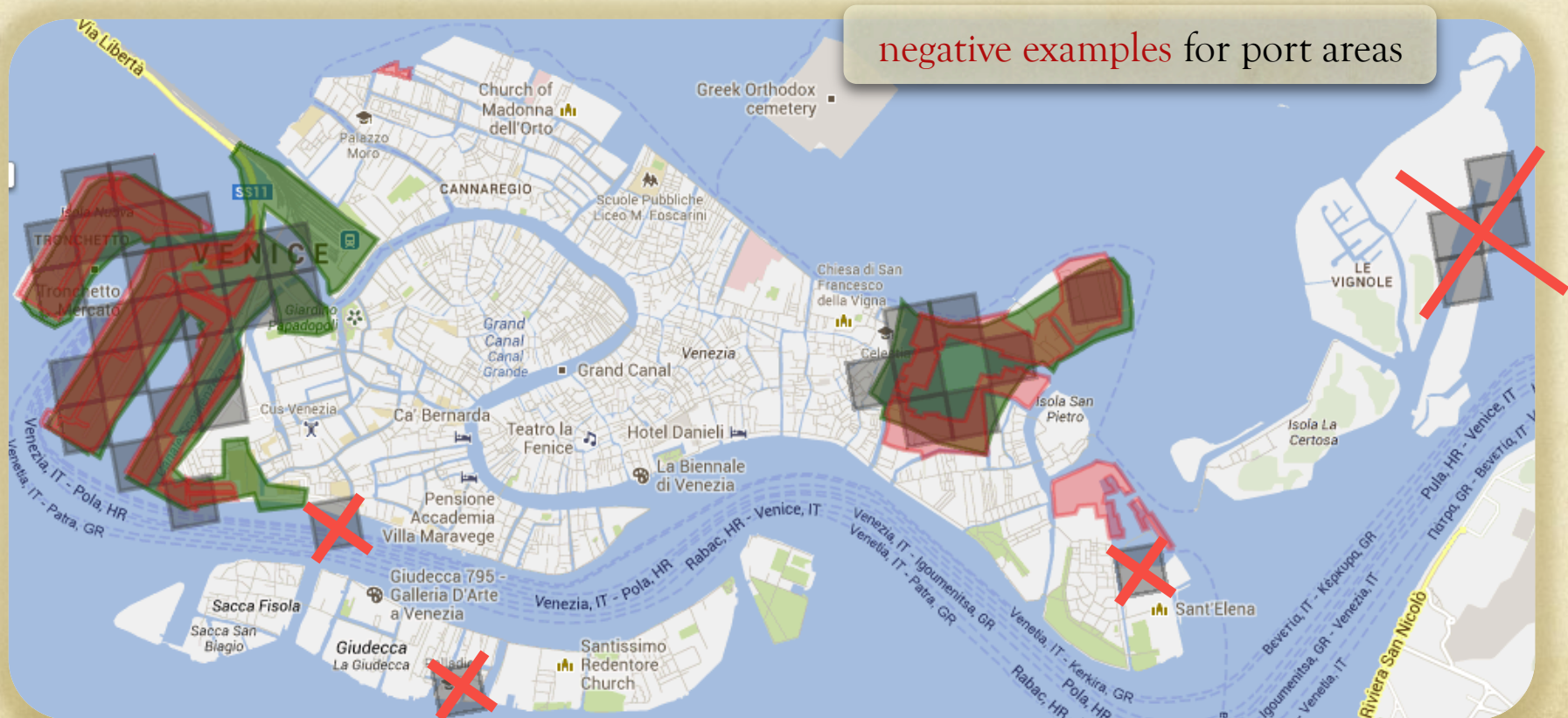Validation of patch annotations corresponding to **port areas**

CLC   DLR   UA

http://bit.ly/sextant-venice-ports

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **port areas**

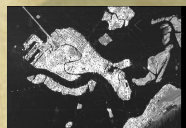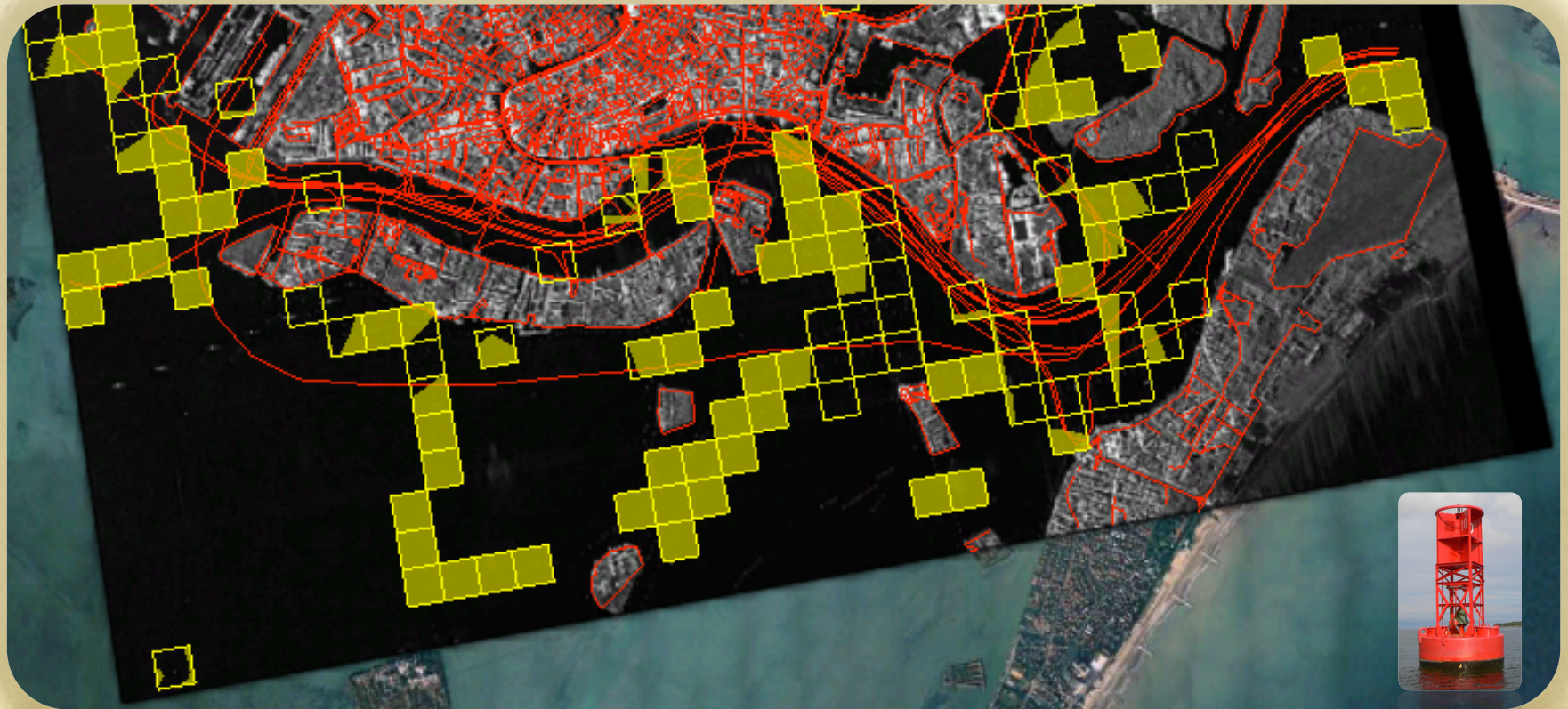negative examples for port areas
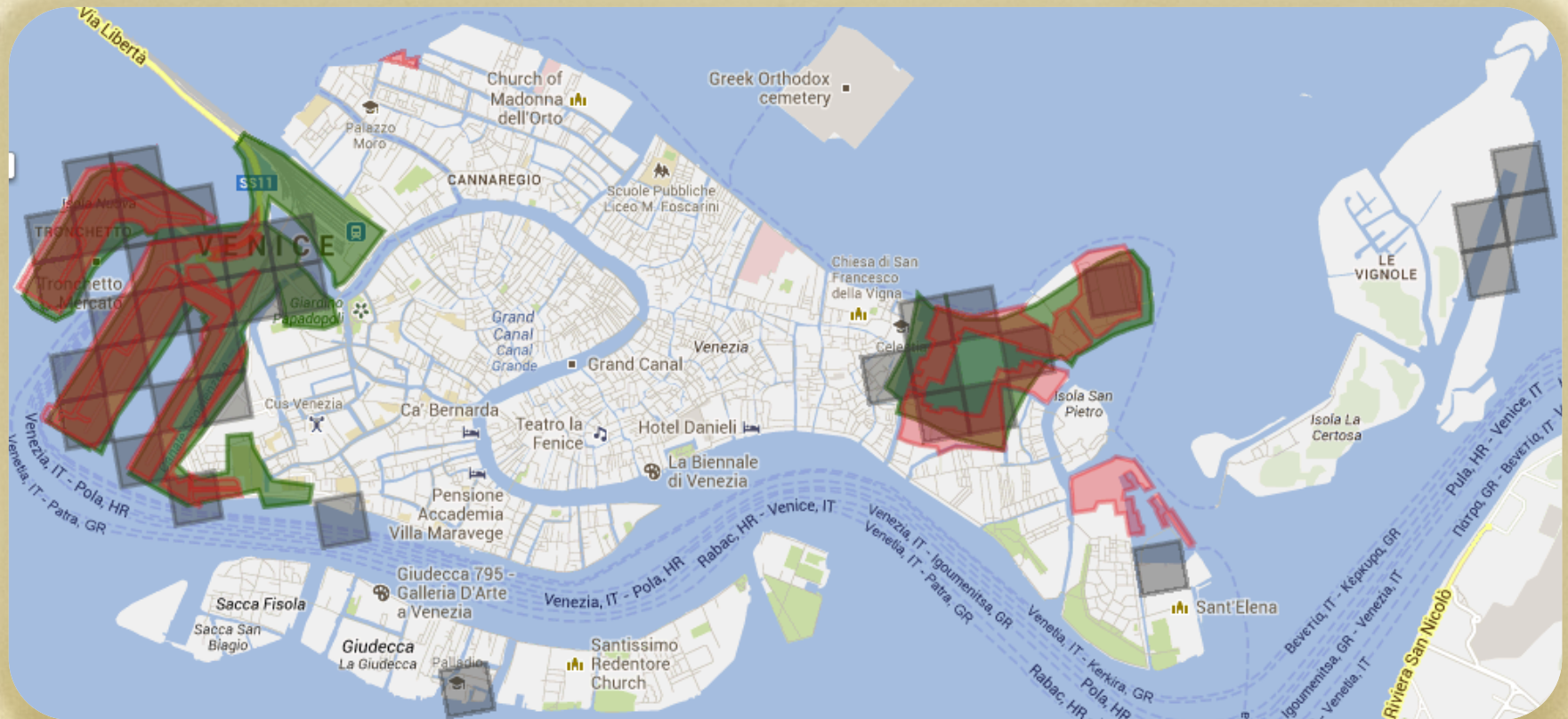
CLC   DLR   UA

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **buoys**

TerraSAR-X image
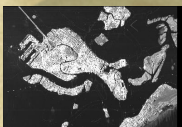
———————— road network (OSM)

buoys (DLR)

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **buoys**

logical **if-then** rules

```
1 if patch.annotation = "buoy" AND
     patch.inside(sea) AND
2    FORALL other_patch.annotation = "water_way"
3    AND ( NOT patch.near(other_patch) OR
                patch.intersects(other_patch) )
4 then
5    patch.remove_annotation()
6 fi
```

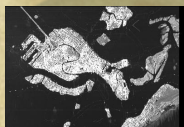TerraSAR-X
image

———— road network
(OSM)

buoys
(DLR)

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **buoys**

logical **if-then** rules

```
1 if patch.annotation = "buoy" AND
     patch.inside(sea) AND
2   FORALL other_patch.annotation = "water_way"
3   AND ( NOT patch.near(other_patch) OR
                patch.intersects(other_patch) )
4 then
5   patch.remove_annotation()
6 fi
```
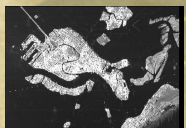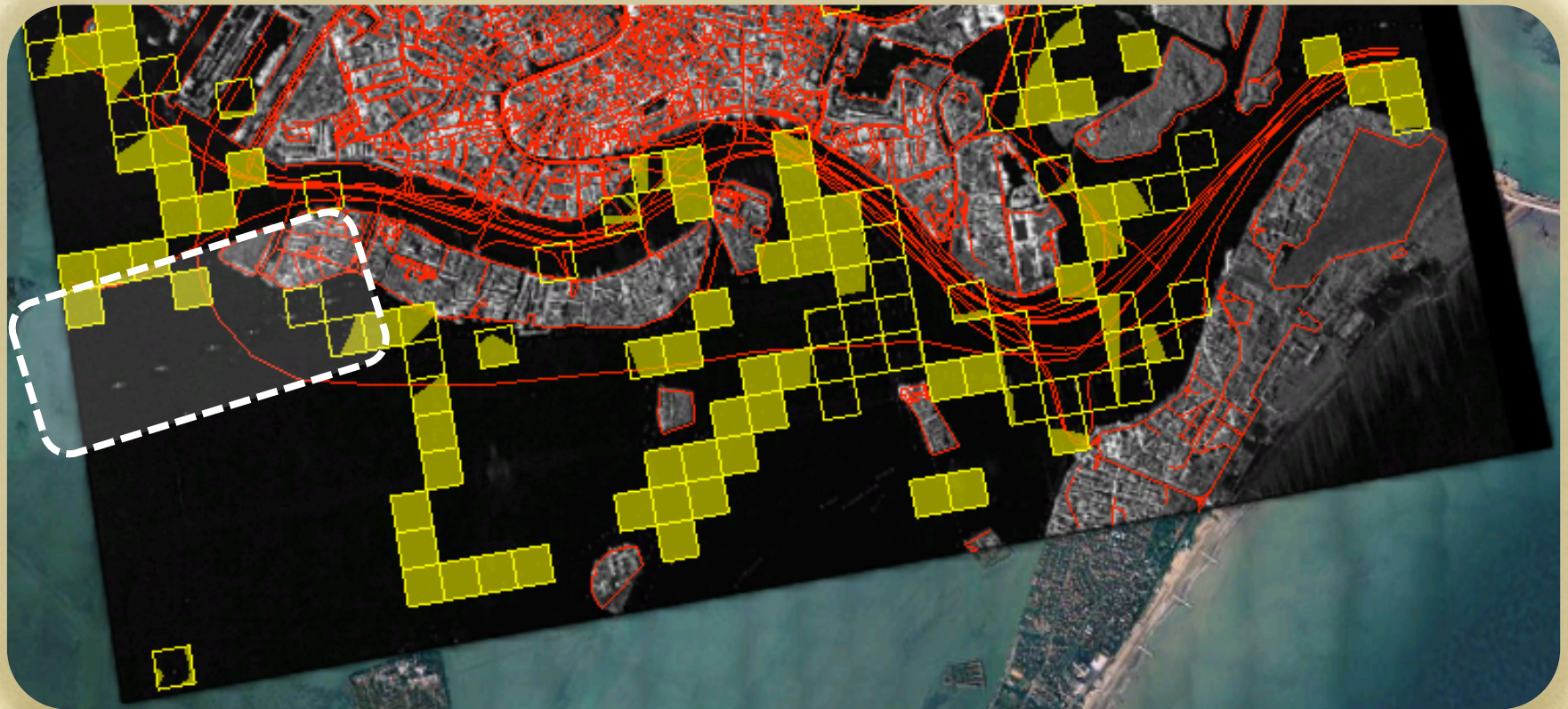
TerraSAR-X
image

_____ road network
(OSM)

buoys
(DLR)

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **buoys**

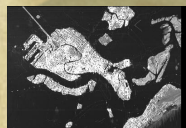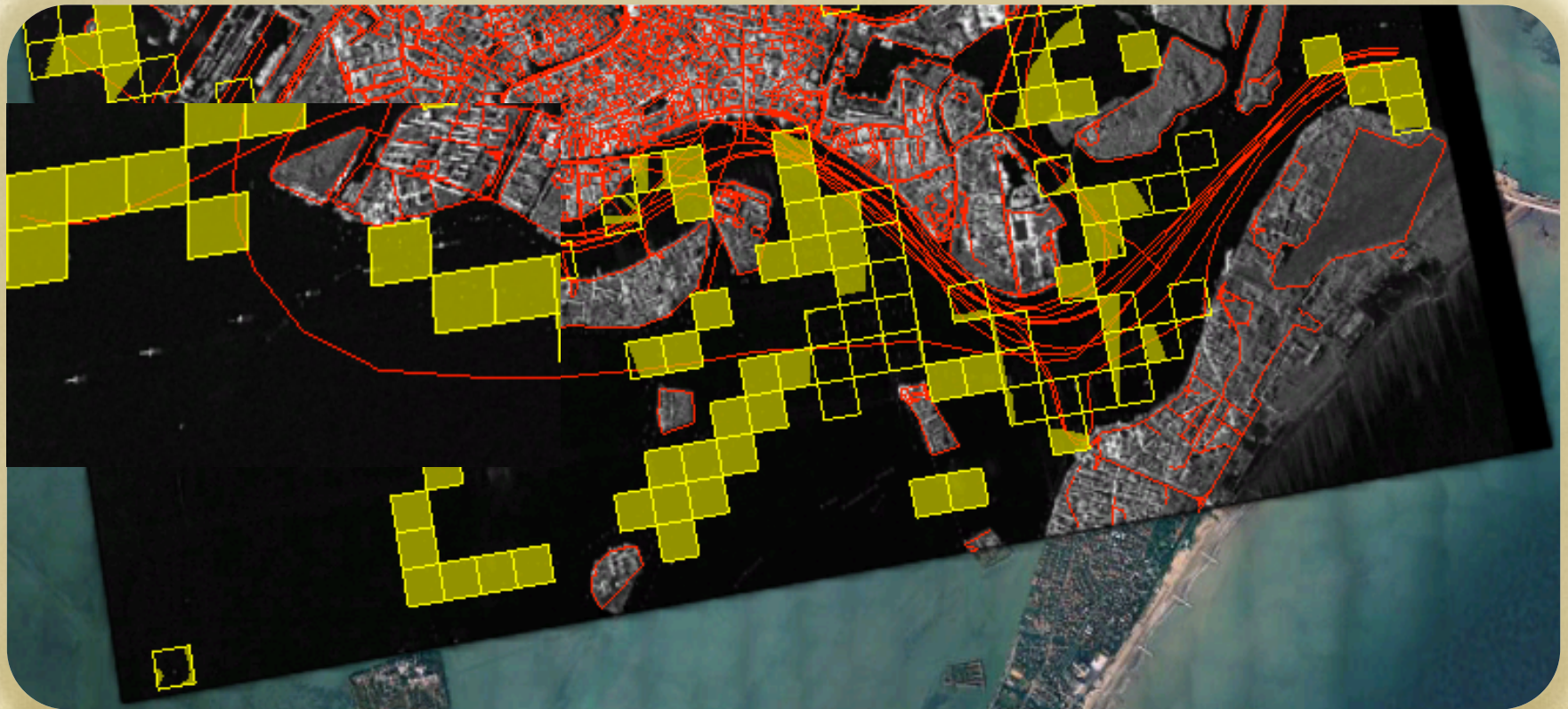TerraSAR-X
image

road network
(OSM)

buoys
(DLR)

Improving the knowledge discovery process of DLR using Sextant

Validation of patch annotations corresponding to **buoys**

TerraSAR-X image

——————— road network (OSM)

buoys (DLR)
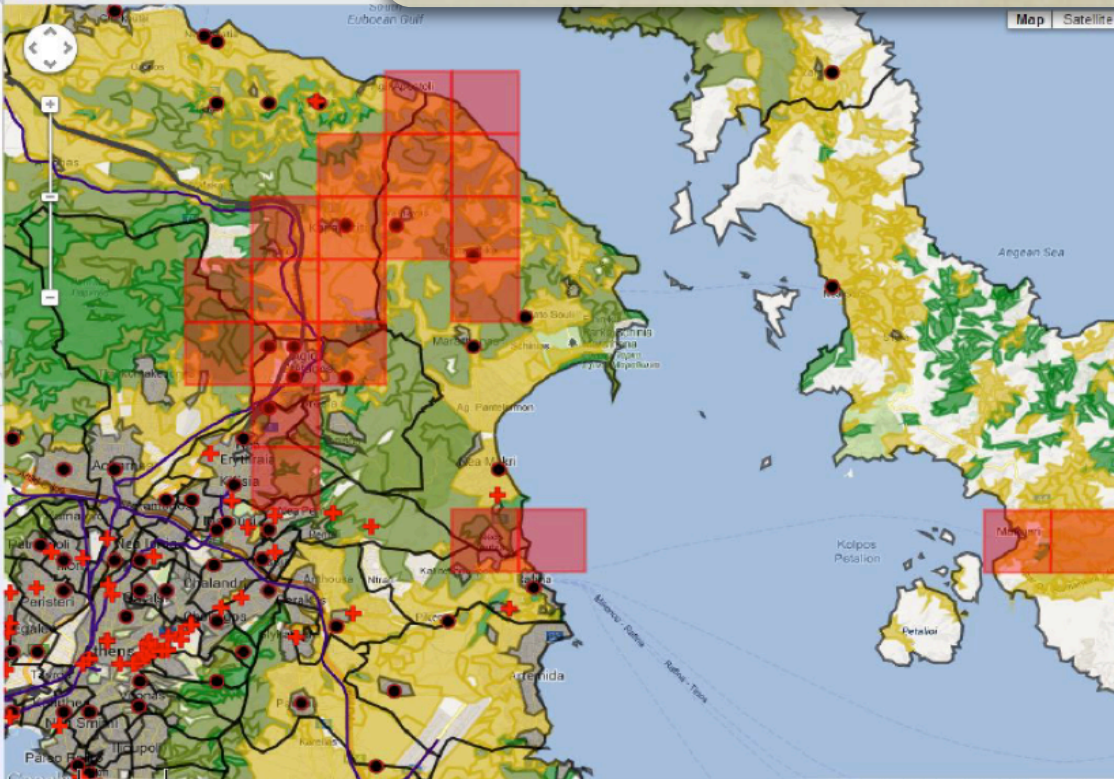
Other applications of Sextant

Rapid mapping

Other applications of Sextant

Evolution of land cover

http://bit.ly/sextant-land-cover-evolution
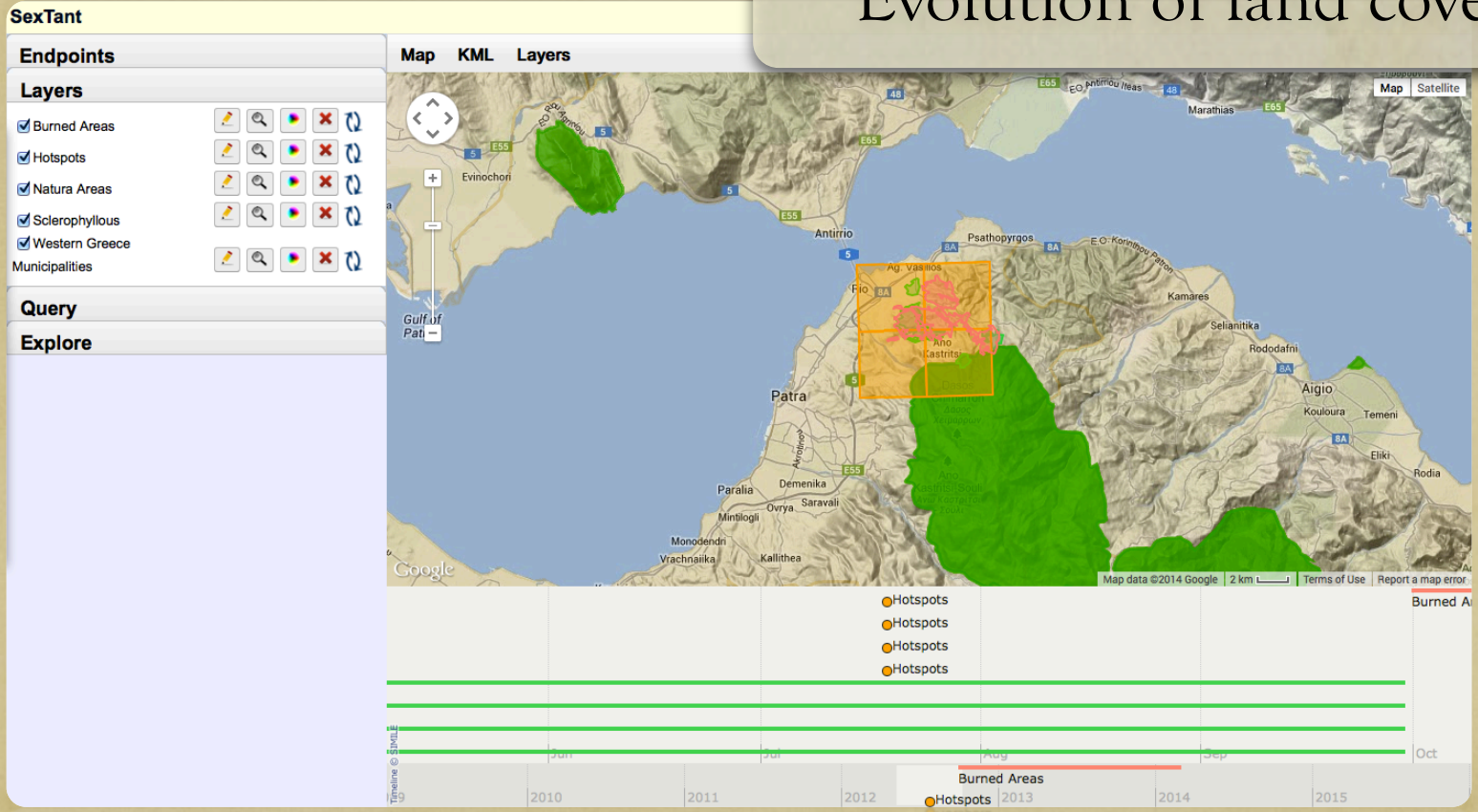
Other applications of Sextant

Monitoring of fire fronts

http://bit.ly/sextant-fire-front-monitor
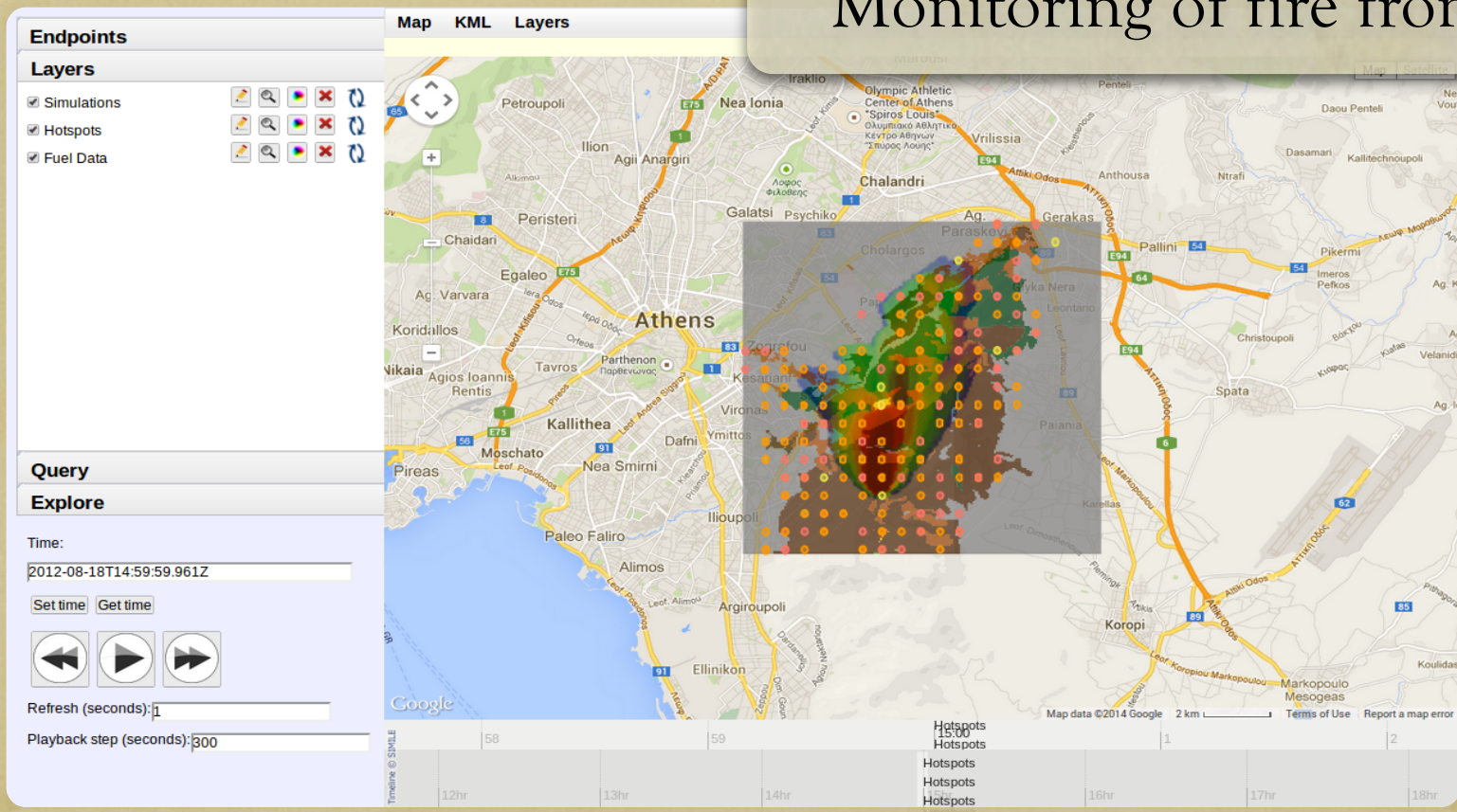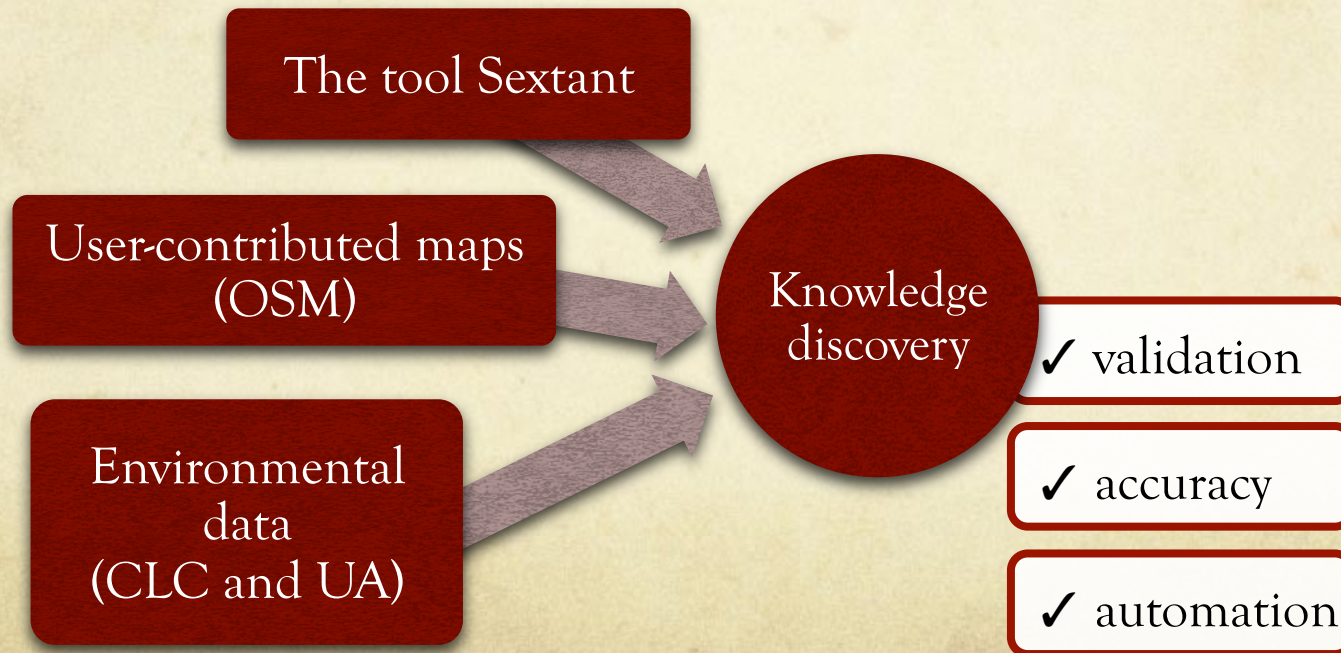
SWeFS

Sextant is being extended

✓ Map registry

✓ Legend information

✓ Production of statistical maps

✓ Development of appropriate interfaces for mobile platforms

✓ Query builder integration

✓ Support of more file formats: ESRI shapefiles, JPEG JFIF, FITS, etc.

Tell us about your needs!

Conclusions

○ Knowledge discovery and semantic annotation of TerraSAR-X images in DLR

○ Linked open data and semantic web technologies can prove useful to (and enhance) EO products

The tool Sextant

User-contributed maps (OSM)

Environmental data (CLC and UA)

Knowledge discovery

✓ validation

✓ accuracy

✓ automation

Thank you

Useful links

○ TELEIOS project
http://earthobservatory.eu/

○ Linked EO data
http://datahub.io/organization/teleios

○ Sextant
http://sextant.di.uoa.gr/

○ Strabon
http://strabon.di.uoa.gr/