

# Sentinel-2 Semantic Data Cube Austria

sen2cube  .at

## Project partners



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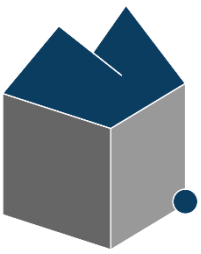
& Andrea Baraldi

Italian Space Agency (ASI)

Roma, Italy;

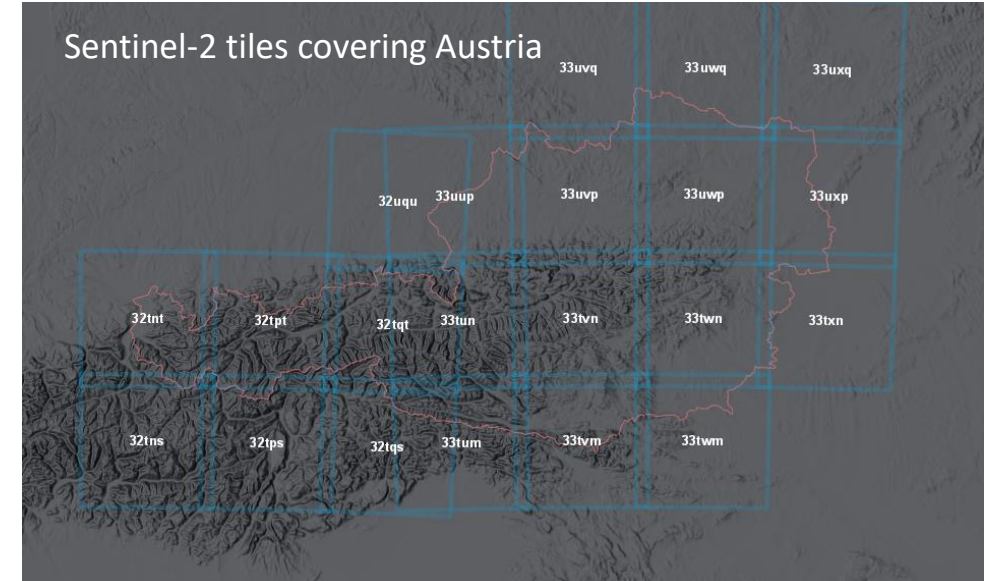
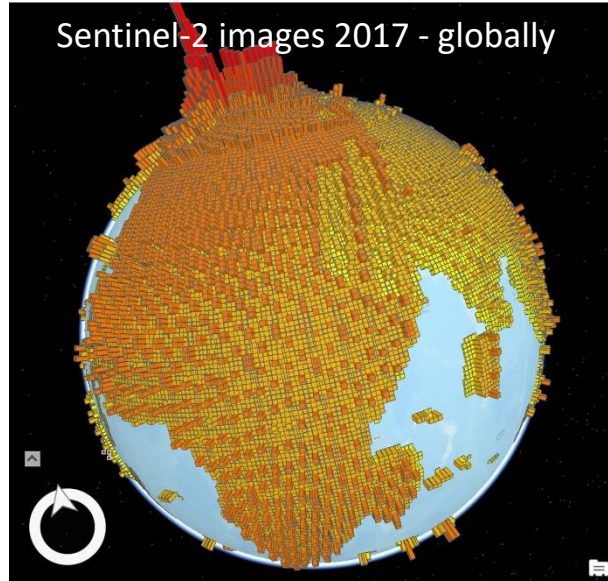


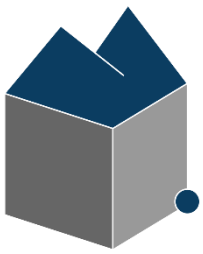
Sen2Cube.at is a project funded under  
the Austrian Space Applications  
Programme (ASAP 14)



# Sentinel-2 Semantic Data Cube Austria

- overarching goal ::: build an **Austrian data & information cube**
- exemplarily show that it is possible to:
  - conduct **semantic content-based image and information retrieval (SCBIR)** through time in big EO databases
  - **allow human users to query and analyse EO data on a higher semantic level** (i.e. based on at least basic land cover units and encoded ontologies)

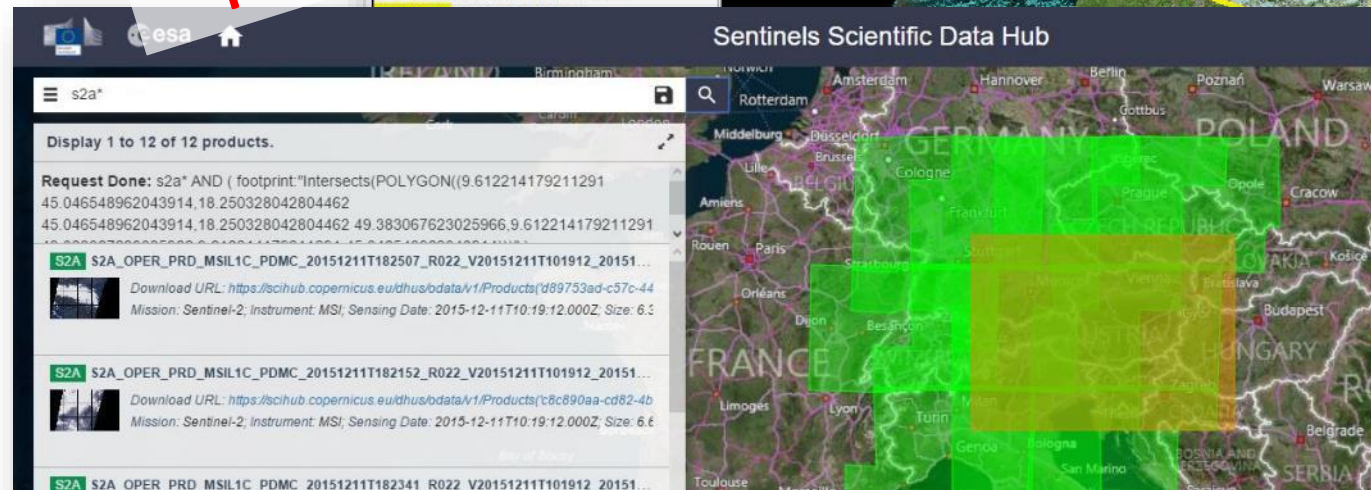
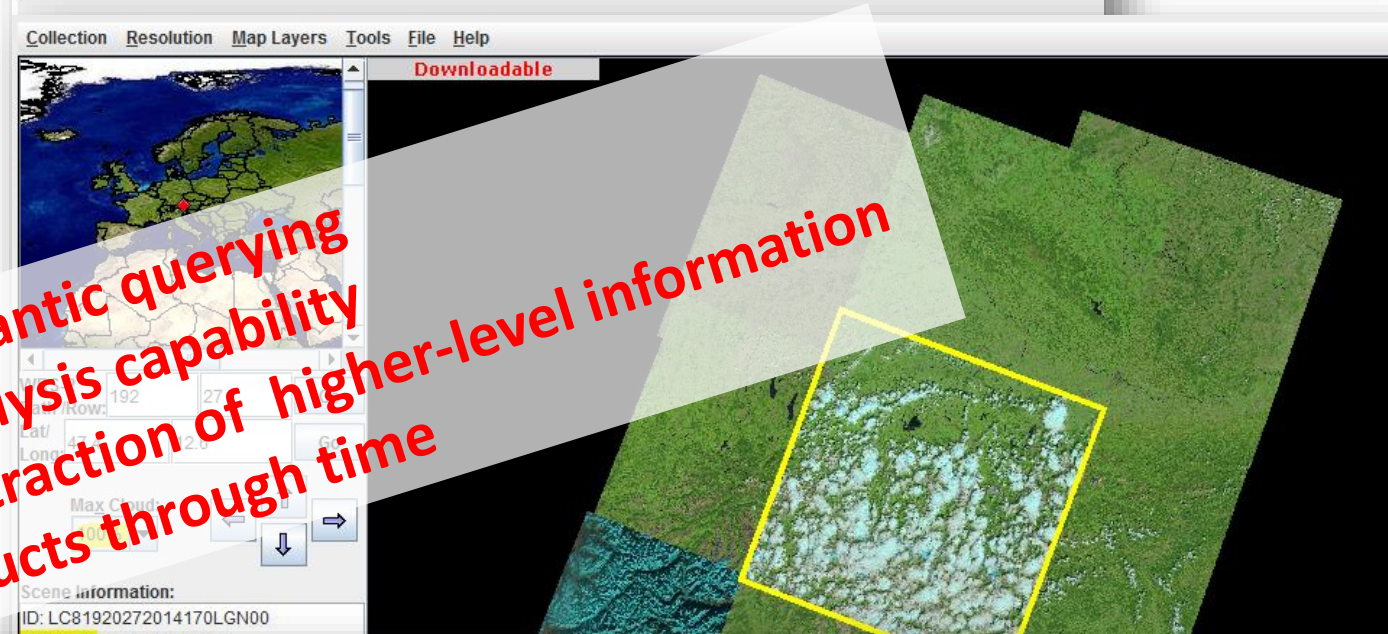


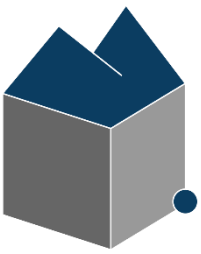


# "Conventional" queries of EO image archives

Conventional non-semantic queries of EO image archives (e.g., USGS Landsat, ESA Sentinel Data Hub). Search by:

- Metadata information.
  - ✓ Geographic area (AOI)
  - ✓ acquisition time
  - ✓ sensor
  - ✓ summary quality indexes (e.g., image-wide cloud cover)
- "thumbnail" image preview (RGB image QuickLook)





# Semantic Content Based Image Retrieval and Analysis

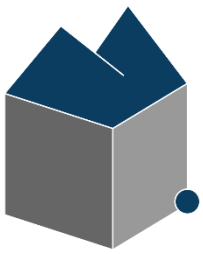
**Sen2Cube.at:** a Semantic Content Based Image and Information Retrieval System through time

- expected to cope with spatiotemporal semantic queries, such as:  
    **“retrieve all images where a lake is not covered by clouds and larger than a certain area”**
- information retrieval (semantic analysis) within the system is also possible, such as:  
    **"retrieve all pixels in the AOI flooded as least once in the selected time span"**

Such an **SCBIR** system must rely on **image understanding as a pre-condition**. This makes the SCBIR problem at least as difficult (or ill-posed) as vision.

➔ **No SCBIR (Semantic Content Based Image Retrieval) system in operating mode is available to date.**

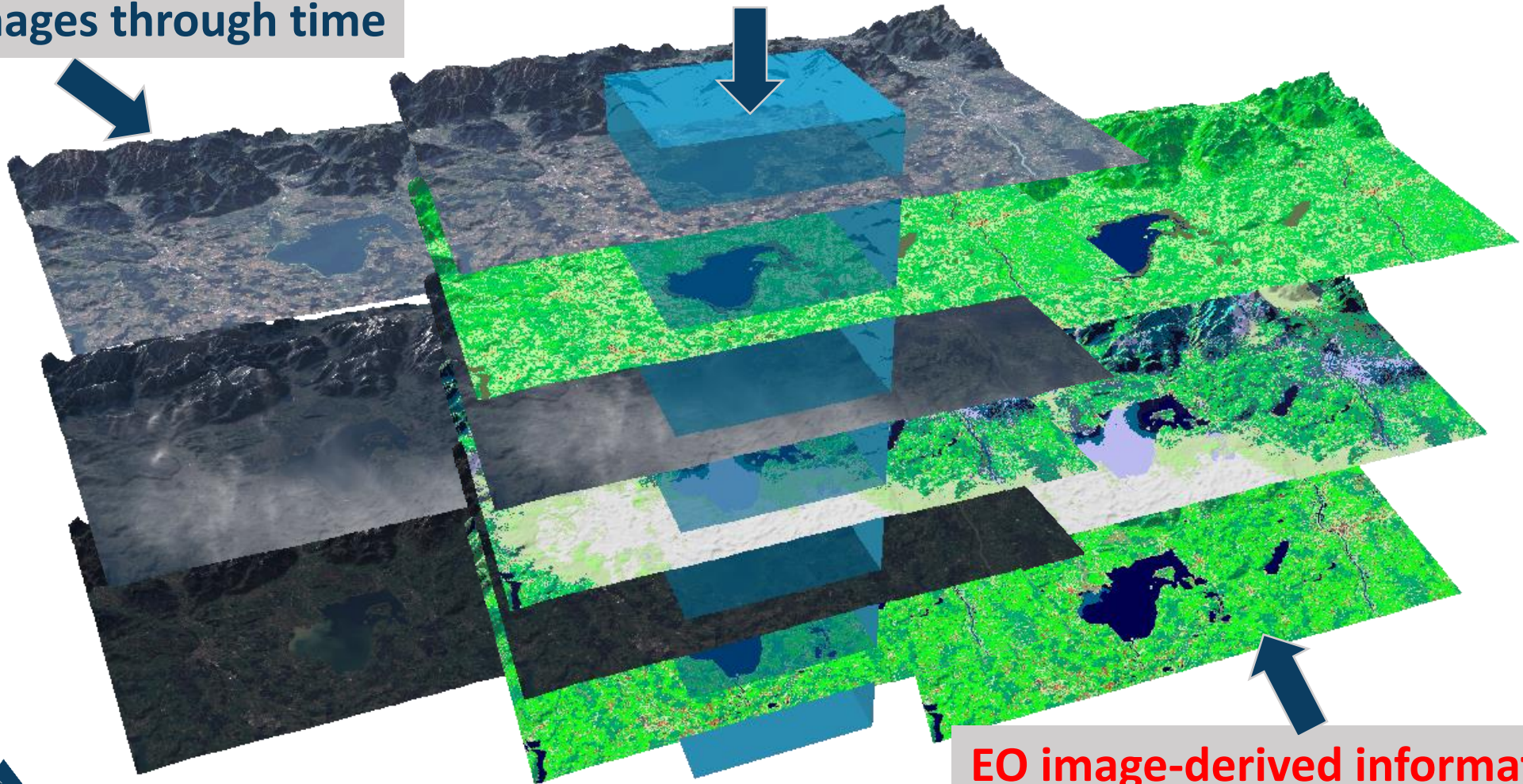
The screenshot displays the 'ImageQuerying - IQ | Semantic Query Interface'. It features a 'Tasklist' on the left with sections for 'Introduction and Help', 'Query User Support', and 'Metadata'. The 'Metadata' section includes a table for 'High leaf area index (LAI) vegetation types' and other categories. The main area shows a 'Query Protocol Window' for 'Region of Interest' with a map and a 'Thematic Map' showing extracted lakes and rivers. A 'Generate Thematic Map using Content-Based Filter: Extract Lakes and Rivers' button is visible. The bottom panel shows a query builder with filters for 'SIAM 33 classes', 'Area > 100000', and 'Compactness <= 2.5'. Red arrows and numbers 1, 2, and 3 highlight specific elements: 1 points to the map, 2 points to the query builder, and 3 points to the thematic map.



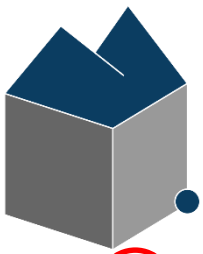
# Key concept of Sen2Cube.at for spatiotemporal analytics of multi-source EO big data

EO images through time

Area-of-interest (AOI) in a target-time (TT) window

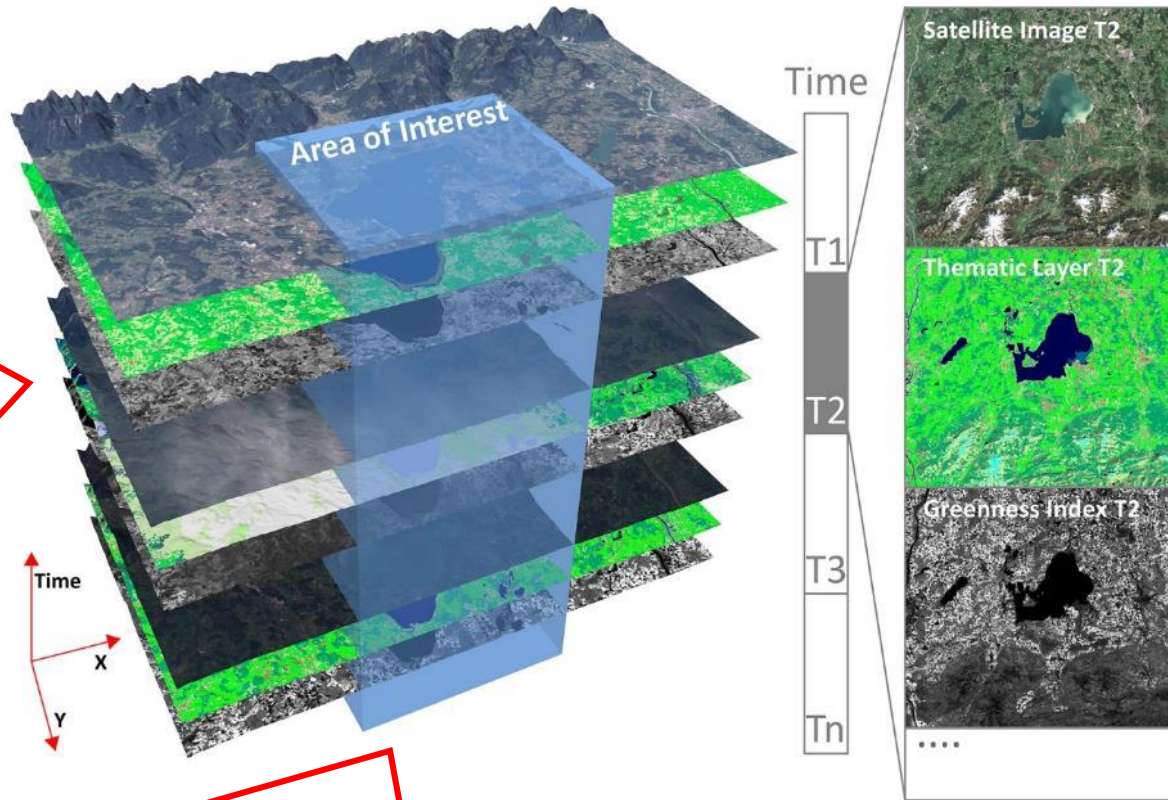


EO image-derived information layers



# Key concept of Sen2Cube.at for spatiotemporal analytics of multi-source EO big data

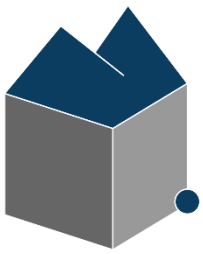
**2**  
Data cube system storing images and image derived products for fast querying



**1**  
Optical satellite image and associated *fully automatic data-derived* information layers

- The semantic enrichment used in Sen2Cube.at is based on a physical-model-based, spectral categorisation (SIAM) and additionally derived information.
- These processes will be fully automated and free of any user parametrisation.

**3**  
Semantic content-based queries through time and space in user defined AOIs by a graphical inference engine



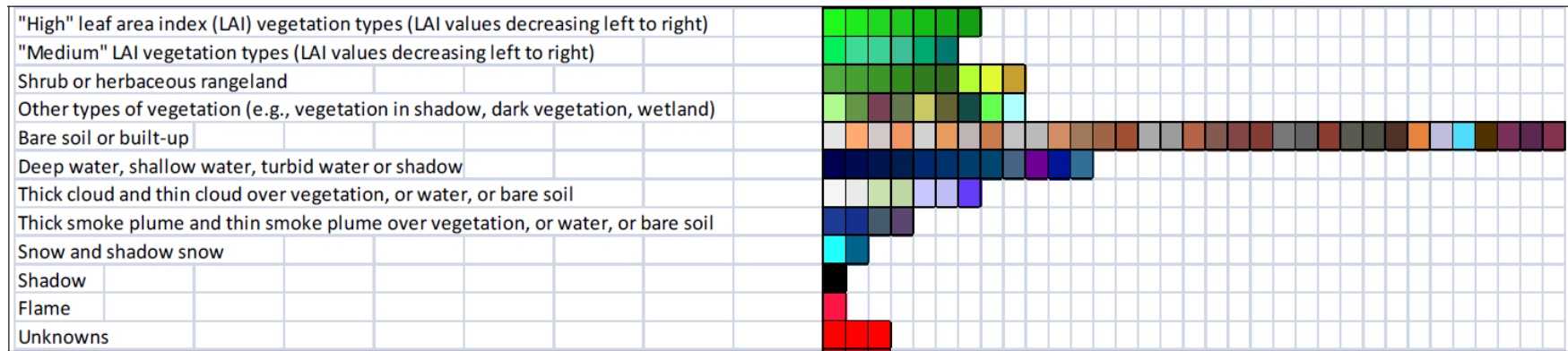
# SIAM spectral categorization

## SIAM spectral categorization

- fully automated
- parameter-free
- near real-time (ca. 5 min. per Sentinel-2 granule)
- scalable and parallelisable
- multi-sensor support

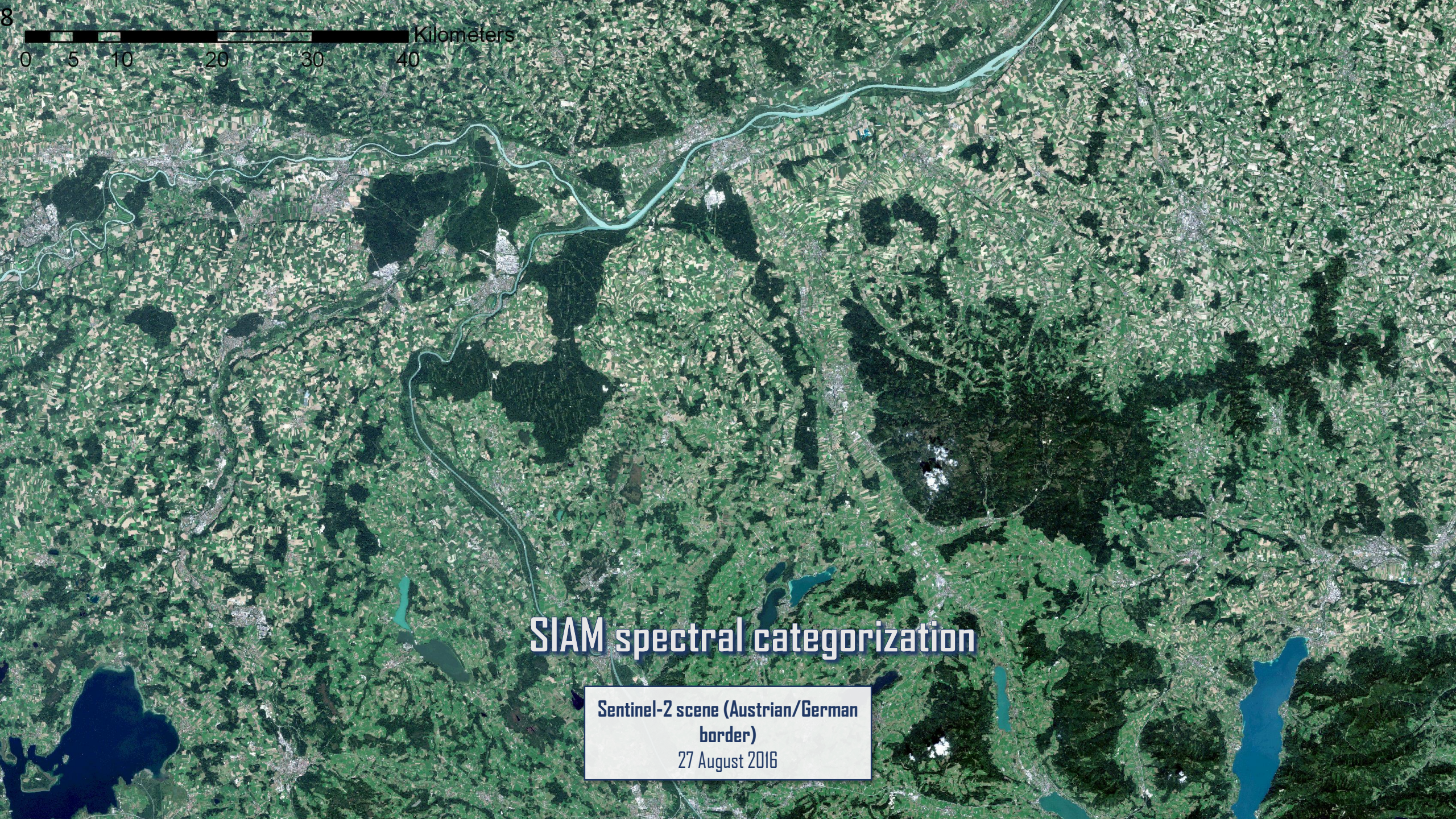
### Automatically generated information layers:

- pre-classification/spectral categorization: 18, 33, 48 and 96 classes
- multi-spectral **greenness index**
- binary **vegetation mask**
- 5 category **haze mask**



96 spectral classes (pre-classes) represented by pseudo-colours and associated semantics.

**See slides 4-7** for example images and results.



# SIAM spectral categorization

Sentinel-2 scene (Austrian/German border)  
27 August 2016





9

0 5 10 20 30 40 Kilometers

# SIAM spectral categorization

96 spectral categories  
(Austrian/German border)  
27 August 2016

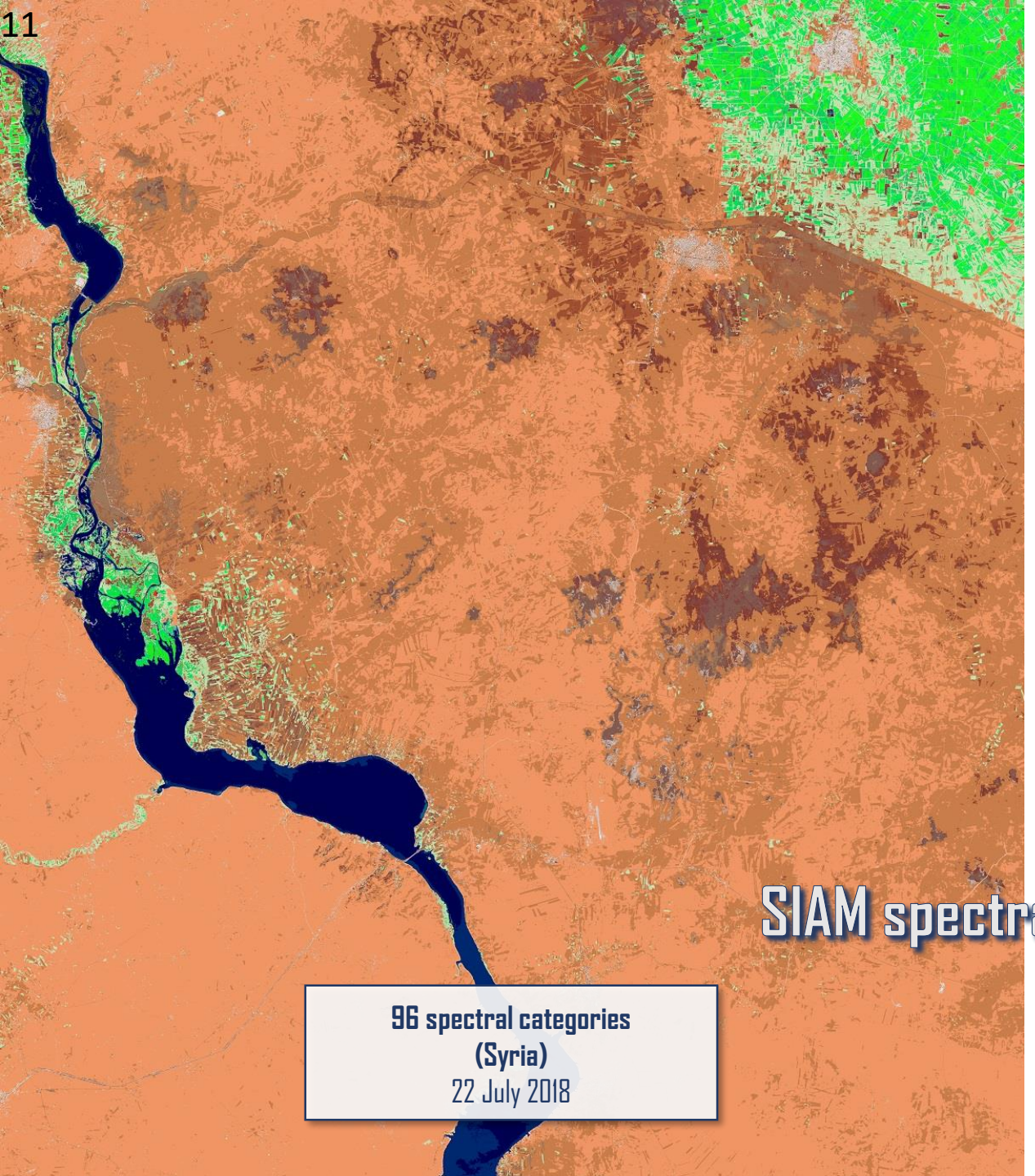


**Sentinel-2 scene  
(Syria)**  
22 July 2018

## SIAM spectral categorization



**Sentinel-2 scene  
(Cambodia)**  
21 April 2017

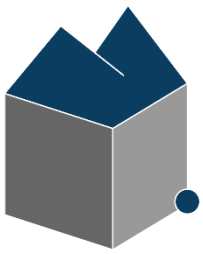


**96 spectral categories**  
**(Syria)**  
22 July 2018

**SIAM spectral categorization**



**96 spectral categories (Cambodia)**  
21 April 2017



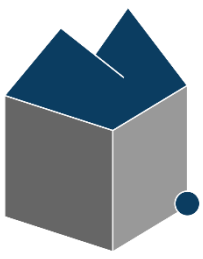
# Web-interface Development

Generic Web-Interface  
(Access of different data  
cube models)

The screenshot displays the IQ web interface, titled "IntelligentQuerying of Earth observation data and information". The interface is divided into several sections:

- Knowledgebase:** Features "Frequently used models" (Water through time, Vegetation) and "All available models" (Show all models).
- Spatio-temporal Selection:** Includes "Spatial Subset" (with icons for selection) and "Temporal Subset" (with date range: Between 15.10.2018 and 15.10.2018).
- Map:** A map showing the region around Salzburg, Austria, with a search location input.
- Buttons:** "Start Inference" (green) and "Stop" (blue) buttons are visible above the map.
- Target area (Datacube):** Two datacube thumbnails are shown: "Martin's Salzburg DC" (The one and only Salzburg DC!) and "Hannah's Syria Cube" (The one and only Syria DC!).
- Dialog Box:** A "Knowledgebase: Edit model" dialog is open, showing a rule editor for "Urban development". The rule is: "Condense images of Layer 1 using mode AND". The "When" conditions are: "Layer 1 change to # 0 then" and "Cells Contain # 0 all then".

The interface includes a footer with "Please login" and "Provided by Department of Geoinformatics - Z\_GIS, University of Salzburg".



## Semantic Data Cube – Syrian example

(© H. Augustin, 2018)

## First, connect to the datacube

```
In [6]: dc = datacube.Datacube(app='siam_syria_10km')
        api = datacube.api.API(datacube=dc)
```

## Get extent information about a specific product in the datacube.

```
In [7]: product = 'siam_utm37n_10km'
        products = dc.list_products()
        platform = products.platform[products.name == product].values[0]

        #
        # Get the pixel resolution of the selected product
        #
        resolution = products.resolution[products.name == product]
        lat_dist = resolution.values[0][0]
        lon_dist = resolution.values[0][1]

        #
        # Get the extents of the cube
        #
        descriptor = api.get_descriptor({'platform': platform})[product]

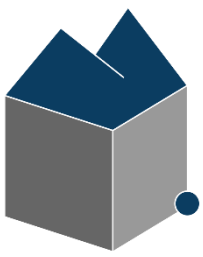
        min_date = descriptor['result_min'][0]
        min_lat = descriptor['result_min'][1]
        min_lon = descriptor['result_min'][2]

        min_date_str = str(min_date.year) + '-' + str(min_date.month) + '-' + str(min_date.day)

        max_date = descriptor['result_max'][0]
        max_lat = descriptor['result_max'][1]
        max_lon = descriptor['result_max'][2]

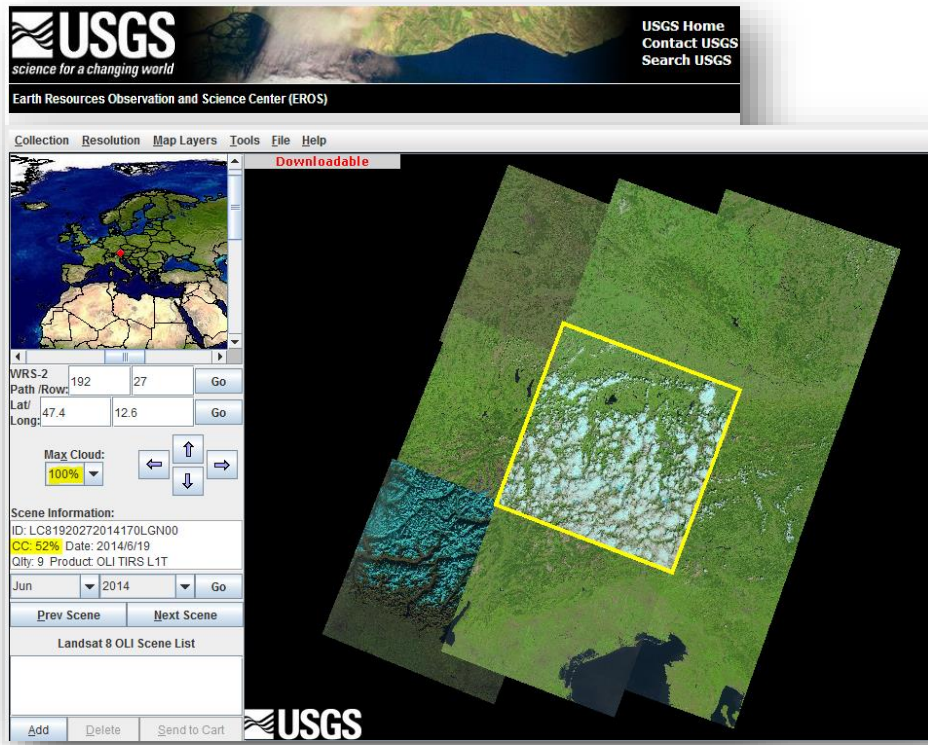
        max_date_str = str(max_date.year) + '-' + str(max_date.month) + '-' + str(max_date.day)

        #
        # Display metadata
        #
        generate_metadata_report(min_date_str, max_date_str,
                                min_lon, max_lon, lon_dist,
                                min_lat, max_lat, lat_dist)
        crs = products.crs[products.name == product]
        epsg_code = crs.values[0]
```

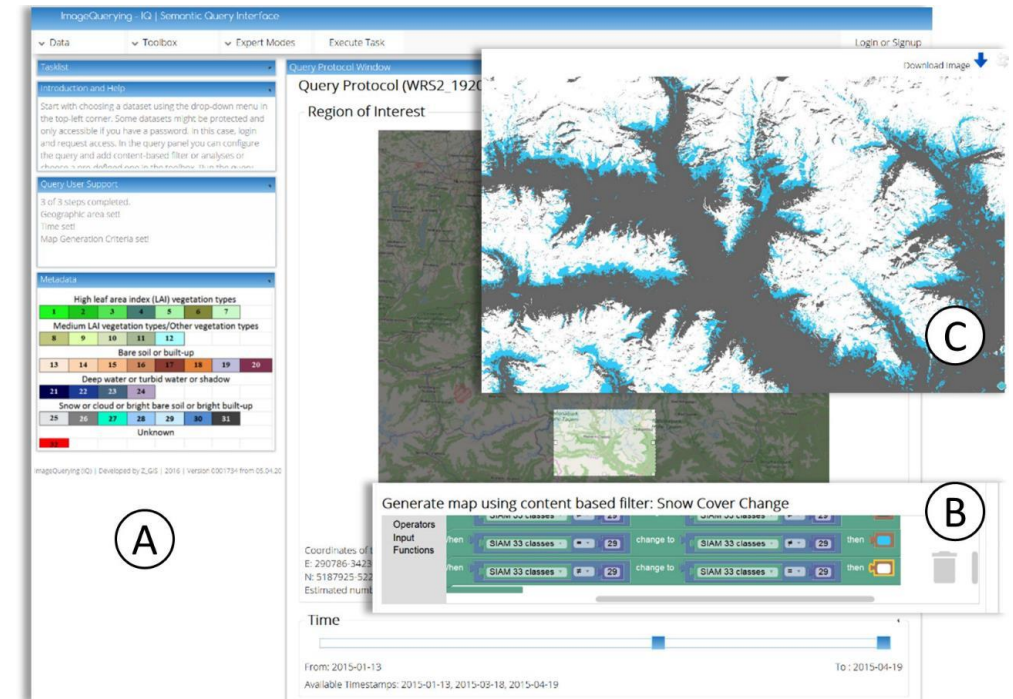


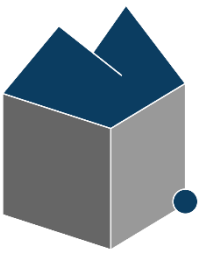
# Demo 1: semantic queries for content-based image retrieval

- develop knowledge-based semantic queries
- search and select Sentinel-2 scenes based on their content



An inference engine for enhanced querying will be programmed as a Web interface in a client-server solution.



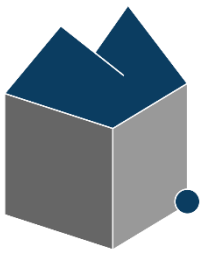


## Demo 2: user-defined cloud-free mosaics and composites

- apply pre-defined semantic queries through time
- user-defined areas-of-interest and timeframes
- better selection of best-suited pixels on the fly using semantics



Source: Sentinel-2

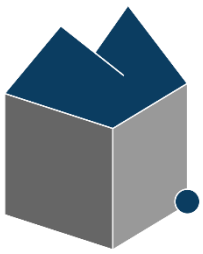


## Demo 3: location-based access

- historical data-derived trends where you are (or elsewhere)
  - location-based access
- example prototype developed in IQ4Sen
  - ZAMG project
  - implemented by SpaSe







**IQ**  
mobile

With this app you ask for information based on Earth observation data. Your question has to include your current position, a time span which you can choose and a topic which you can select.

Question progress monitor



What was the status of Snow

Topic

- Vegetation
- Snow**

during 01.12.2016 and 05.04.2017

Time Span

Begin: 01. Dec 2016  
End: 05. Apr 2017

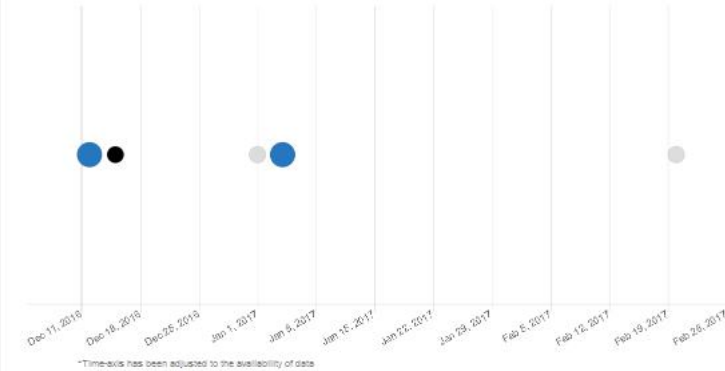
at 47.29 / 12.88

Location



?

What was the status of Snow during 01.12.2016 and 05.04.2017\* at 48.30 / 14.23?



What was the status of Vegetation during 01.12.2016 and 05.04.2017\* at 47.29 / 12.88?

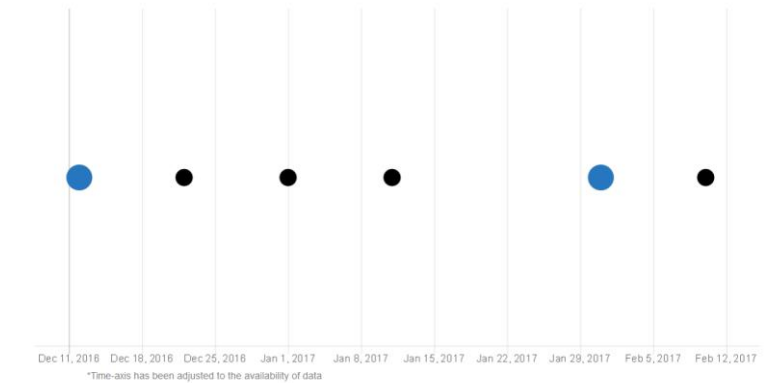


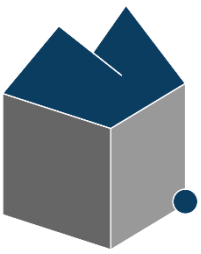
# Demo 3: location-based access

What was the status of Vegetation during 01.12.2016 and 05.04.2017\* at 47.90 / 15.26?



What was the status of Snow during 01.12.2016 and 05.04.2017\* at 47.90 / 15.26?



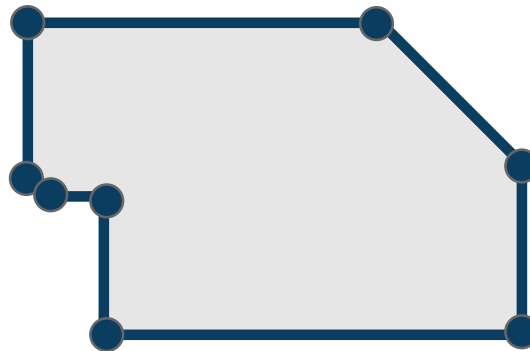


## Demo 4: per-parcel statistics

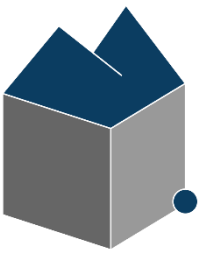
- allow user-defined parcel calculations for spectral and semantic profiles through time
- particularly relevant for forestry and agricultural domains



Source: Sentinel-2



- vegetation trends
- event detection
- when snow was last detected
- ...



# Thank you for your attention!

<http://sen2cube.at/>

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39<sup>th</sup> European Association of Remote Sensing Laboratories Symposium & 43<sup>rd</sup> General Assembly

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- Knowledge organising systems
- Interoperability
- Online processing | INSPIRE
- Data cubes
- EO data infrastructure
- Copernicus missions
- Current Sentinel and upcoming
- EO applications
- Societal benefits | SDGs
- In-situ data | Crowd mapping
- Geo-social networks
- New jobs
- Markets and opportunities

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