SENTINEL-2 SEMANTIC DATA & INFORMATION CUBE AUSTRIA

Project partners

AMA AgrarMarkt Austria

spatialservices

ZAMG

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Yet another data cube?

Source: ODC

Sentinel-2 Semantic Data & Information Cube Austria

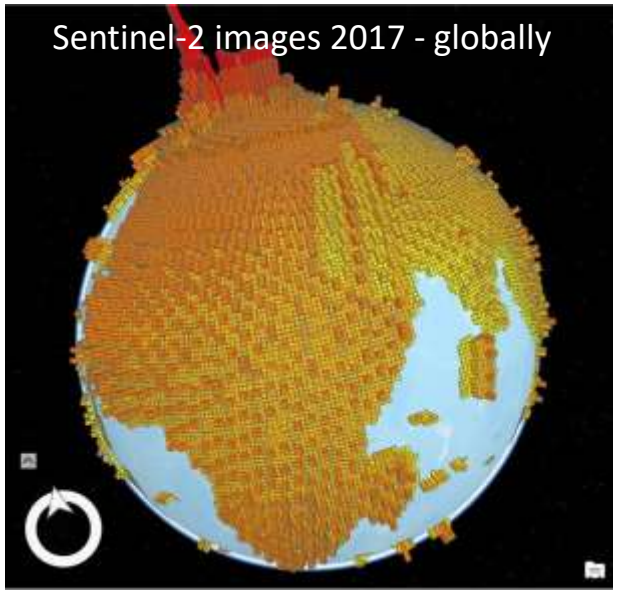
- goes **beyond state-of-the-art ARD** and the use of data cubes solely as data storage by **incorporating semantic enrichment** (i.e. initial, data-driven information extraction)
- we aim for a **generic, semantic EO data cube** concept driven by automatic integration of optical EO data and automatic generic semantic enrichment **in contrast to application-driven solutions** (e.g. forest application, crop cycles, specific composites etc.).
- **generic concept enables diverse queries and analysis possibilities directly within data cubes**, including semantic queries for replicable extraction of EO-based indicators /EO-based analysis from big EO data.

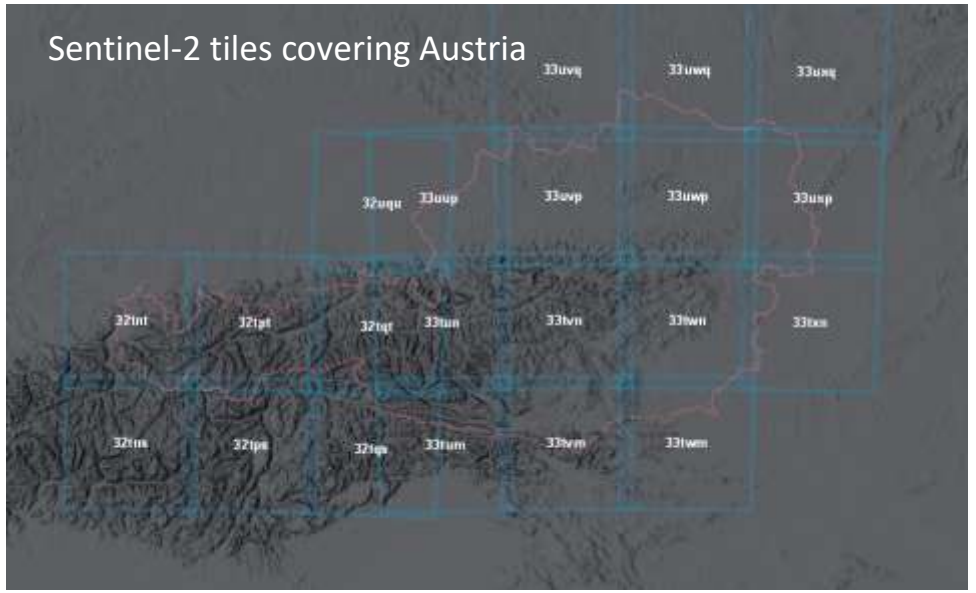
What are the differences?

Feature	File-based EO image hubs (e.g. Copernicus open access hub)	State-of-the-art data cubes	*Sen2Cube.at* data & information cube approach
Image download	✓	✓	✓
Metadata-based search	✓	✓	✓
Image-wide processing	✓	✓	✓
AOI-based processing	⊘	✓	✓
Time series analysis (statistical)	⊘	✓	✓
AOI-based cloud-free image search & mosaicking	⊘	⊘	✓
Time series analysis (semantic)	⊘	⊘	✓
Semantic content-based image retrieval (SCBIR)	⊘	⊘	✓
Content-based best pixel selection for cloud-free composites	⊘	⊘	✓
No expert-knowledge required to produce information on a higher level	⊘	⊘	✓
Generic approach with re-usable and sharable tools	⊘	⊘	✓
Additional data (e.g. DEM) can be used in the high-level queries	⊘	⊘	✓

Sentinel-2 Semantic Data & Information 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)





Semantic Content Based Image Retrieval and Analysis

Semantic Content Based **Image and Information Retrieval** System through time

- expected to cope with spatiotemporal **semantic queries**, such as:

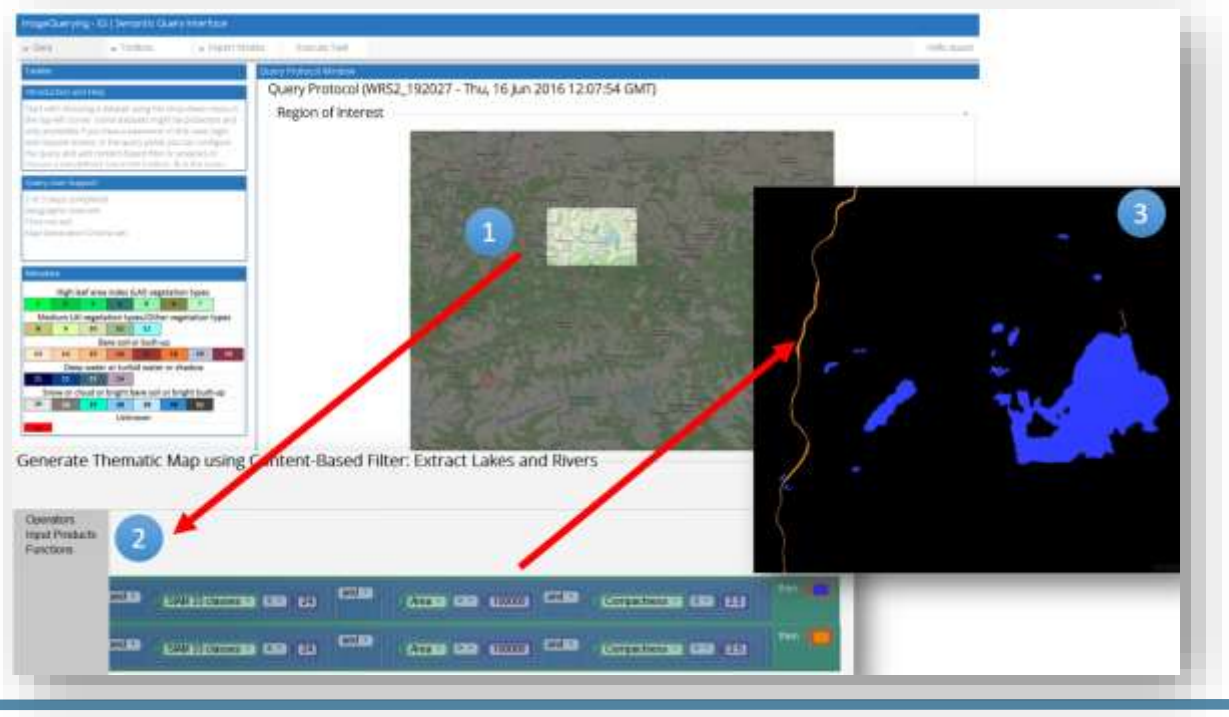
  “retrieve all images where a lake is not covered by clouds and larger than a certain area”

- 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**.

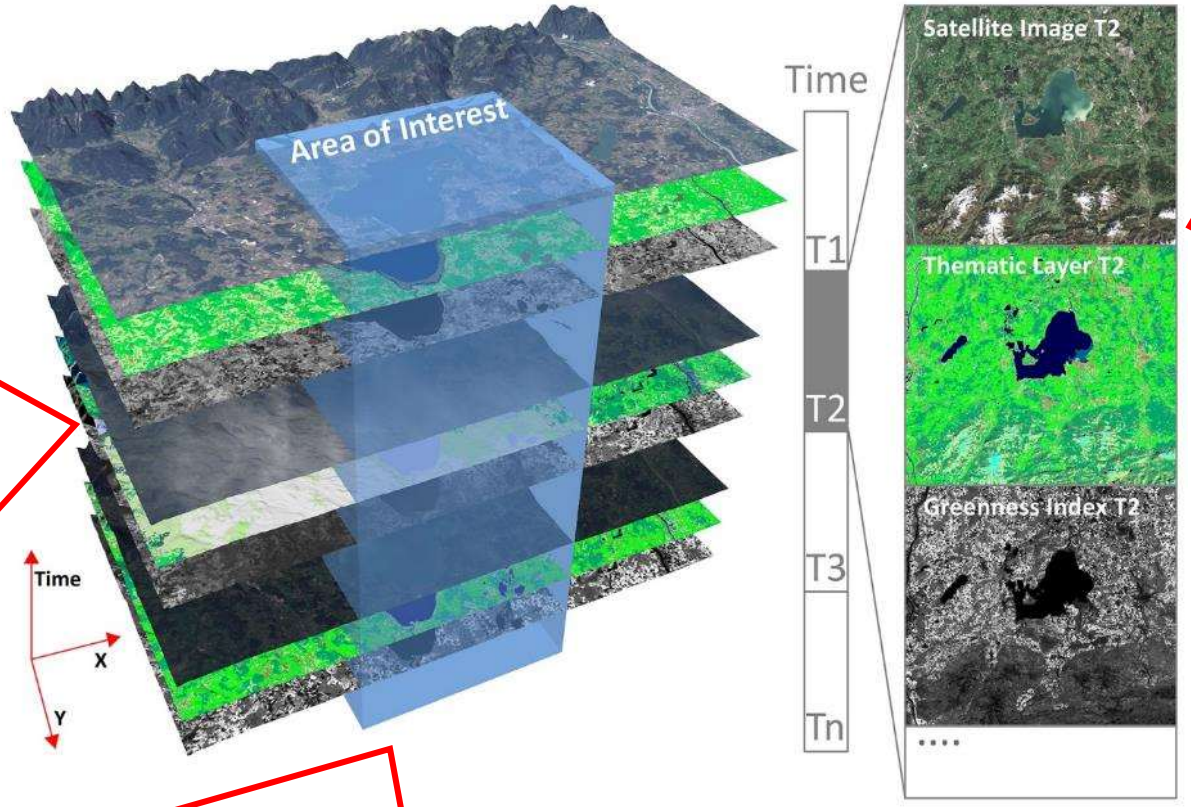
- **No SCBIR system in operating mode is available to date.**



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

2

Data cube technologies: Data cube system storing images and image derived products query-optimised not acquisition-optimised



1

Automatic semantic enrichment: Optical satellite image and associated *fully automatic data*-derived information layers
+ additional (open) data like e.g. DEMs

3

Web-based inference engine: Semantic content-based queries through time and space in user defined AOIs

from Tiede, D., Baraldi, A., Sudmanns, M., Belgiu, M., Lang, S., 2017. Architecture and Prototypical Implementation of a Semantic Querying System for Big Earth Observation Image Bases. Eur. J. Remote Sens. 50, 452–463. doi:10.1080/22797254.2017.1357432

sen2cube.at

SIAM spectral categorization

1

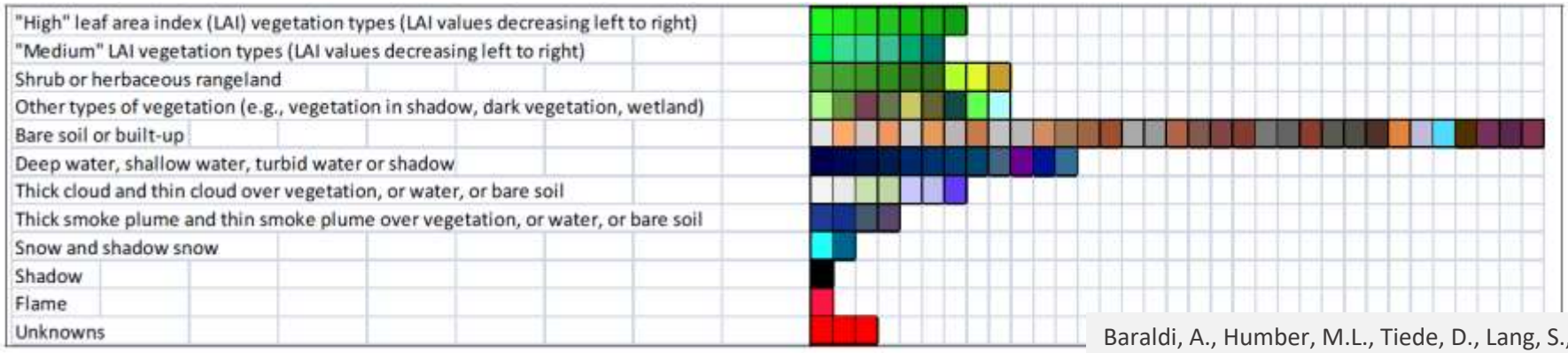
SIAM (Satellite Image Automatic Mapper) spectral categorization

- fully automated, physical model based
- parameter-free, no samples needed
- near real-time (ca. 5 min. per Sentinel-2 granule)
- scalable and parallelisable
- multi-sensor support (at least TOA calibrated)

➔ **Expert system - GOFAI**

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**

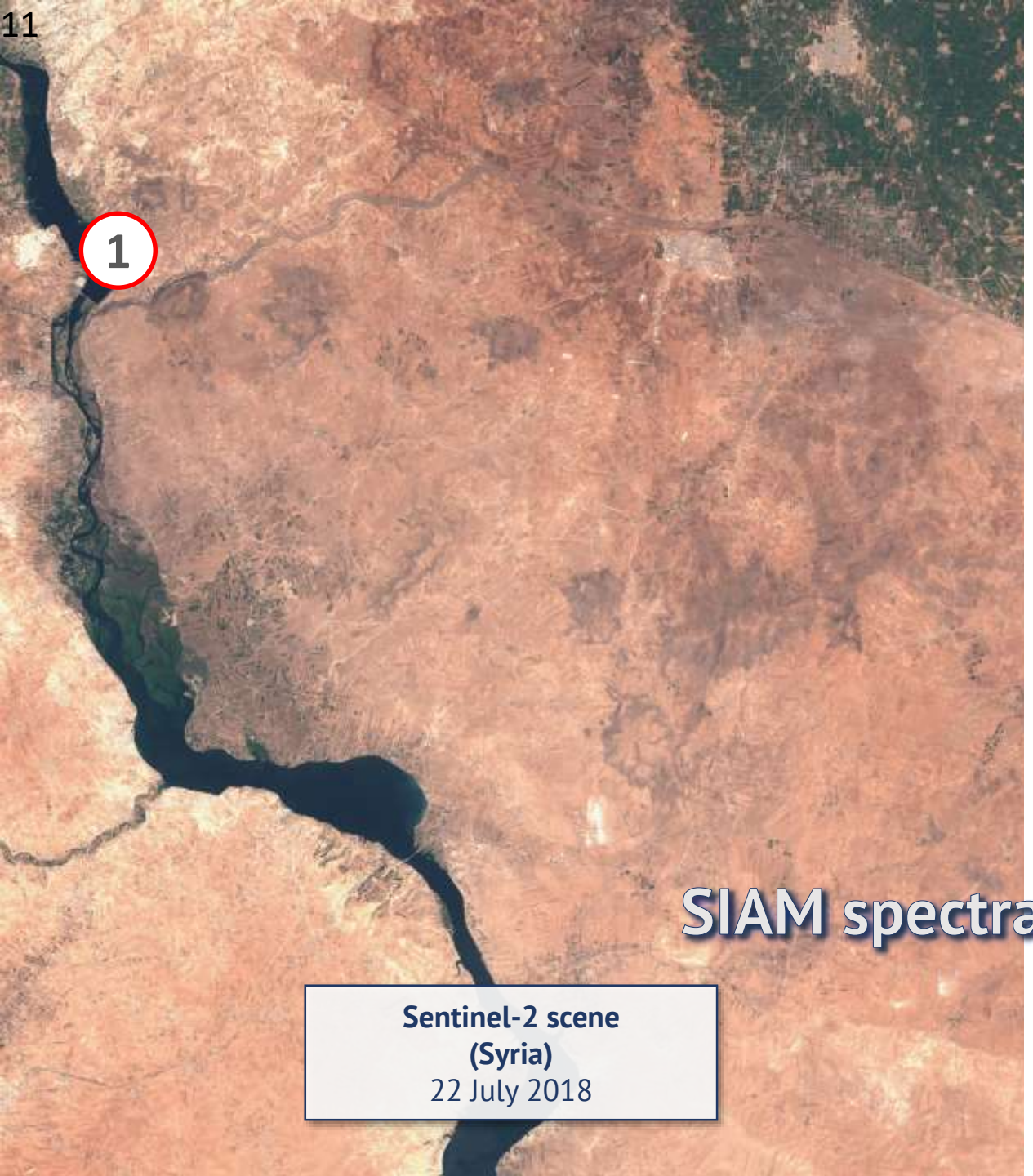


96 spectral classes (pre-classes) represented by pseudo-colours and associated semantics.

Baraldi, A., Humber, M.L., Tiede, D., Lang, S., 2018. GEO-CEOS stage 4 validation of the Satellite Image Automatic Mapper lightweight computer program for ESA Earth observation level 2 product generation – Part 2: Validation. Cogent Geosci. 4, 1–52. https://doi.org/10.1080/23312041.2018.1467254


9
Kilometers
0 5 10 20 30 40
1
SIAM spectral categorization
Sentinel-2 scene
(Austrian/German border)
27 August 2016

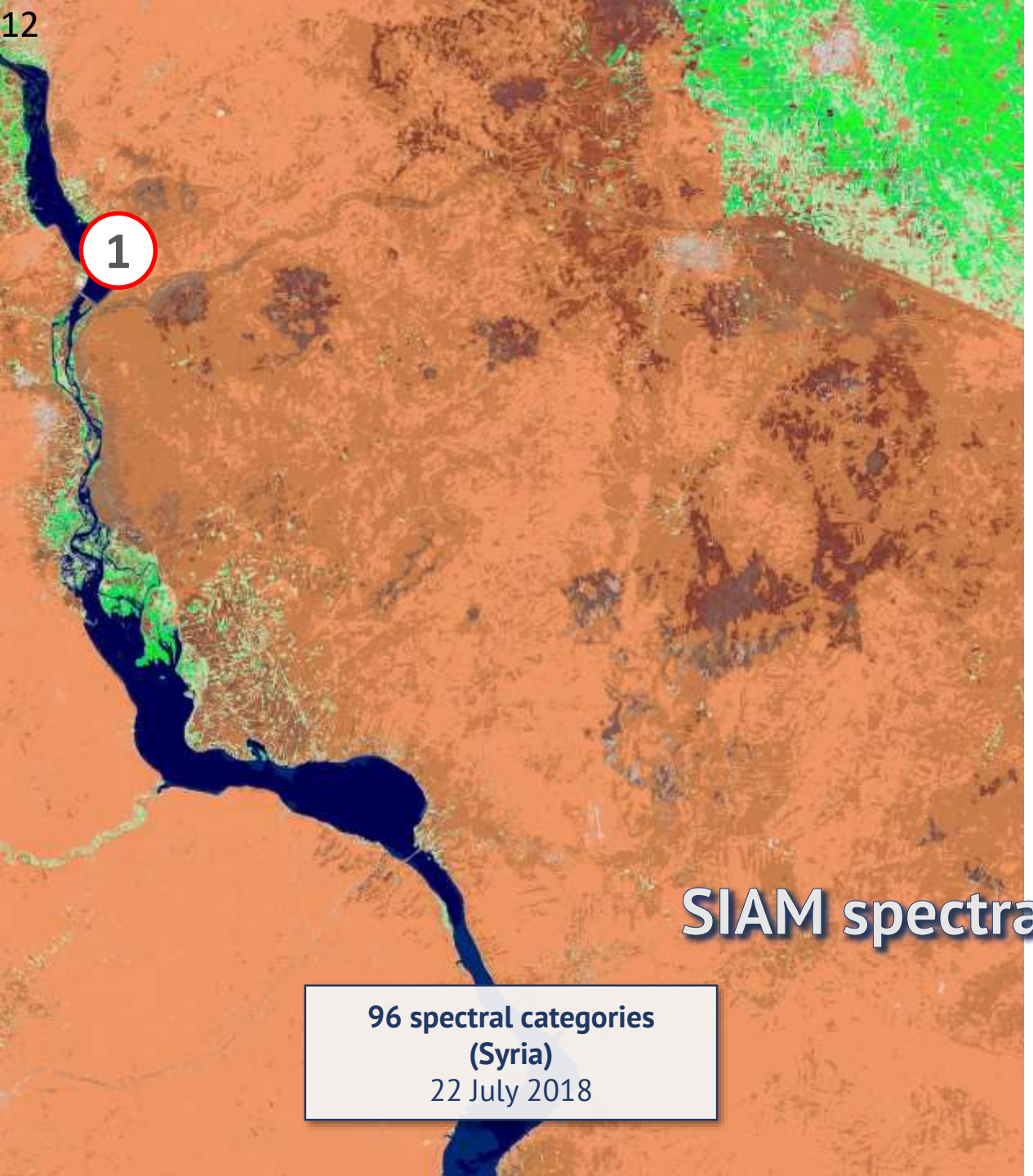

10
Kilometers
0 5 10 20 30 40
1
SIAM spectral categorization
96 spectral categories
(Austrian/German border)
27 August 2016



SIAM spectral categorization

Sentinel-2 scene
(Syria)
22 July 2018

Sentinel-2 scene
(Cambodia)
21 April 2017



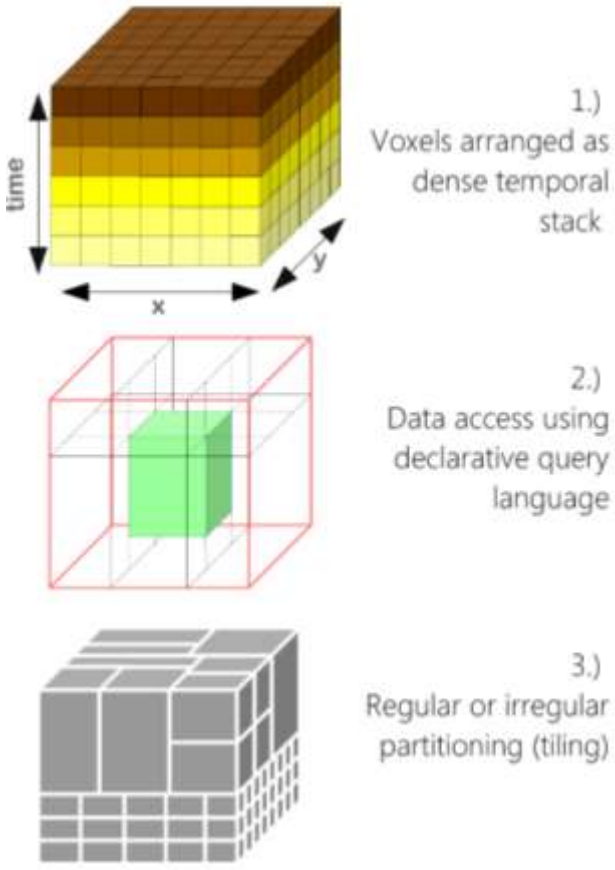
SIAM spectral categorization

96 spectral categories (Syria)
22 July 2018

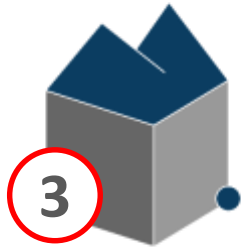
96 spectral categories (Cambodia)
21 April 2017

Geospatial Data Cubes

- store data **query-optimised, not acquisition-optimised**
- **different** access **methods (API, query language) data cubes as infrastructure**
- provide a **logical view** on the data
  - index external files
  - data as multi-dimensional array
- different solutions are considered in the approach (here: rasdaman or ODC)



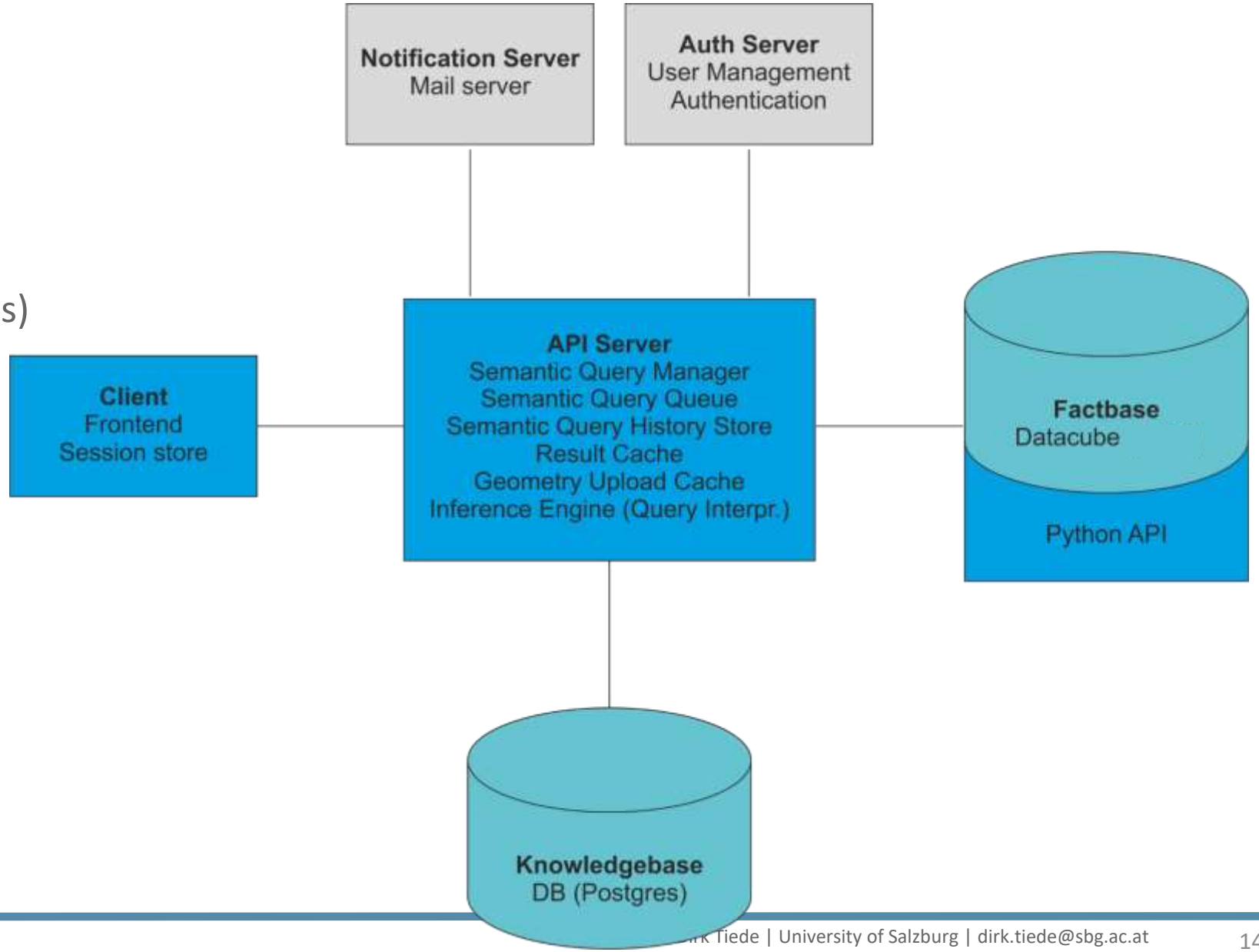
Tiede, Dirk; Baraldi, Andrea; Sudmanns, Martin; Belgiu, Mariana; Lang, Stefan (2017): Architecture and prototypical implementation of a semantic querying system for big Earth observation image bases. In European journal of remote sensing 50 (1), pp. 452–463. DOI: 10.1080/22797254.2017.1357432.



Web-based inference engine

Server structure

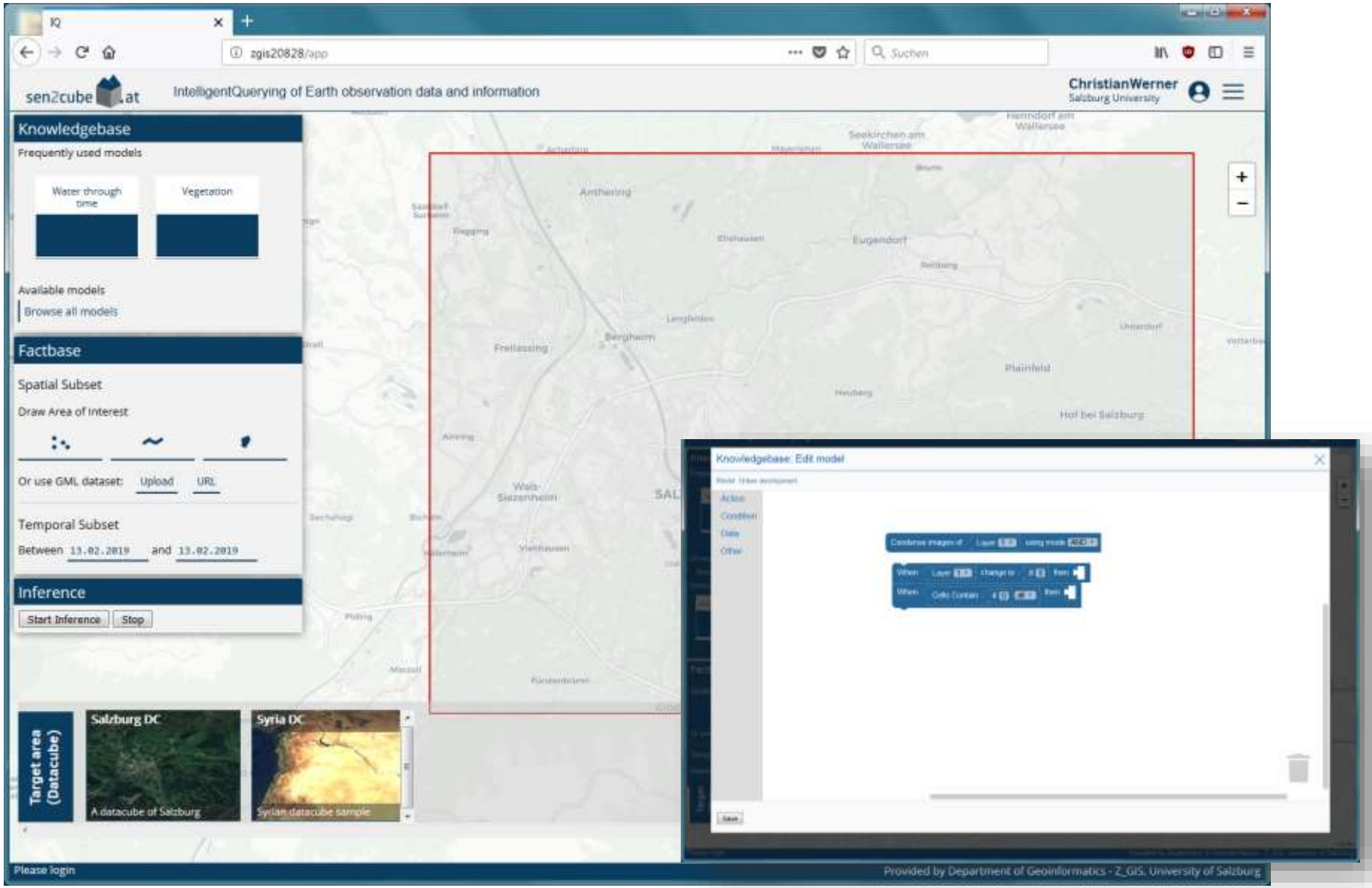
- Client
- Central API server
- Knowledgebase (Expert/User Queries)
- Factbase (data + information layers)
- Future:
  - Auth Server, User Mgmt
  - Notification Server



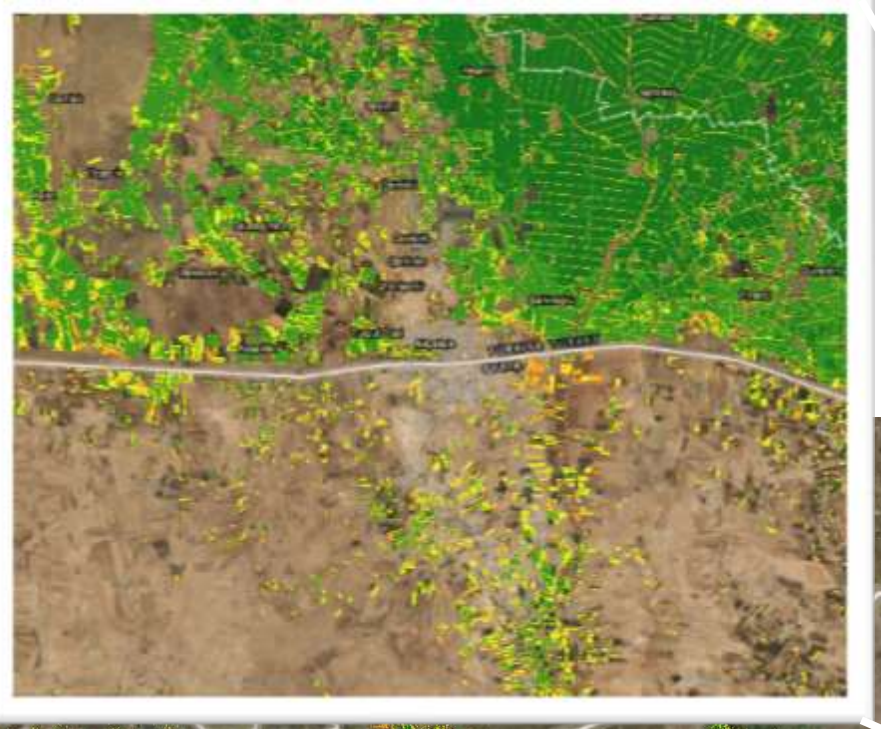
Web-based inference engine

3

Generic Web-Interface (access to different data cubes possible)



- 30,000 km2, vegetation change from 2017-08-15 to 2017-09-15
- < 20 minutes analysis time on a basic VM, which included areas with 5 up to 11 temporal images
- data cube: ~750 Sentinel-2 images + associated information layers (permanently growing – fully automated download, processing and ingestion pipeline)



Example of a generic data and information data cube up and running (Northern Syria)

EO data: Sentinel-2

Data cube: ODC

Interface: Jupyter Notebook

Augustin, H., M. Sudmanns, D. Tiede, and A. Baraldi, "A Semantic Earth Observation Data Cube for Monitoring Environmental Changes during the Syrian Conflict," GI_Forum, vol. 1, no. 1, pp. 214–227, 2018.

Services

Services based on the generic approach.....

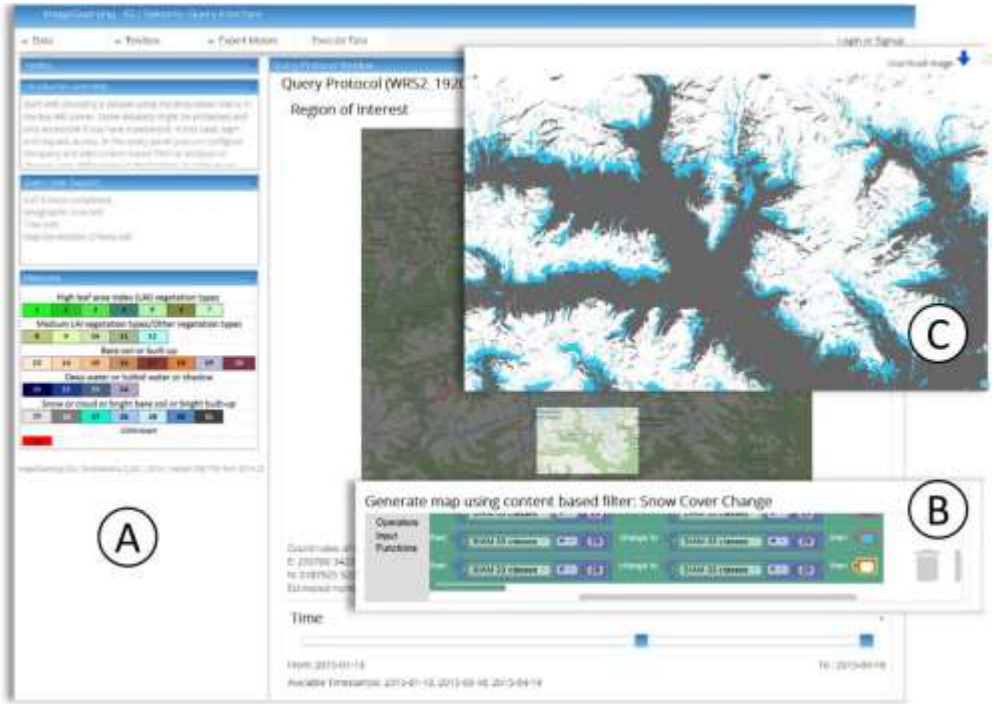
➔ a broad application range can benefit from Sen2Cube.at's innovation of a generic data & information cube.

➔ the following service demonstrations will be derived and developed from different use cases

Demo 1: semantic queries for content-based image retrieval

- develop knowledge-based semantic queries for SCBIR
- search and select Sentinel-2 scenes (several thousand) based on their content – including "dark" data

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

Mosaics and composites

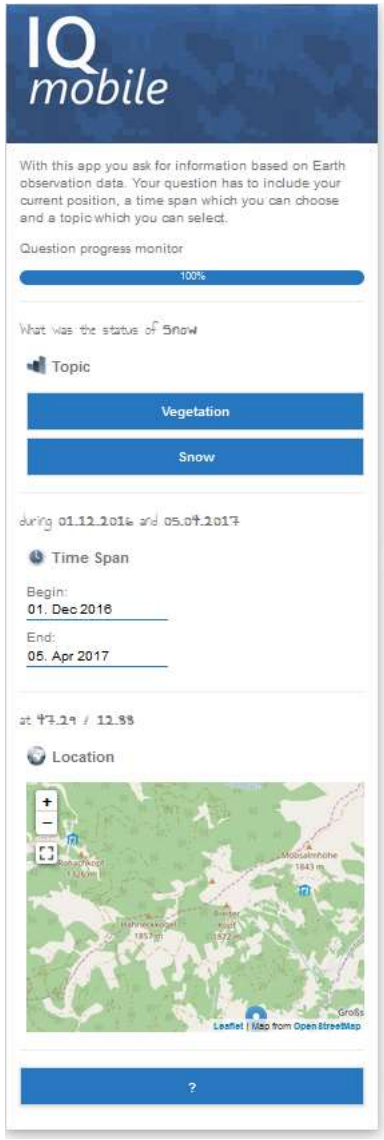
- apply pre-defined semantic queries through time
- user-defined areas-of-interest and timeframes
- better selection of best-suited pixels (from all available data) on the fly using semantics

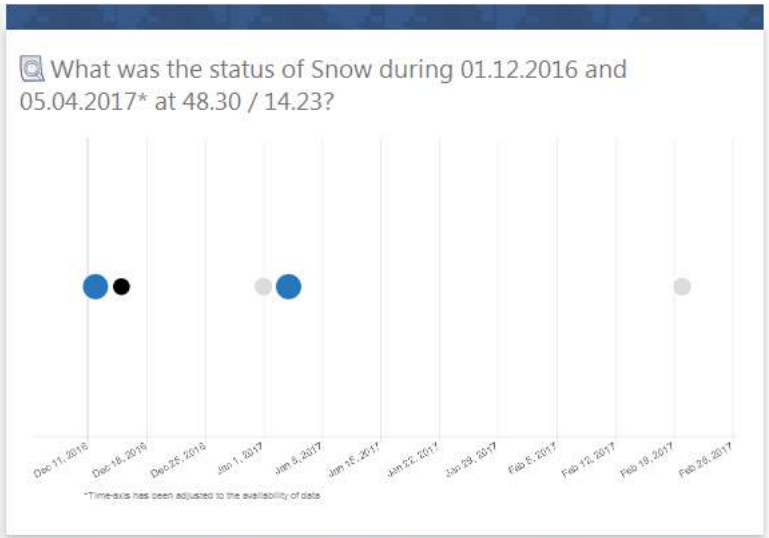
Source: Sentinel-2

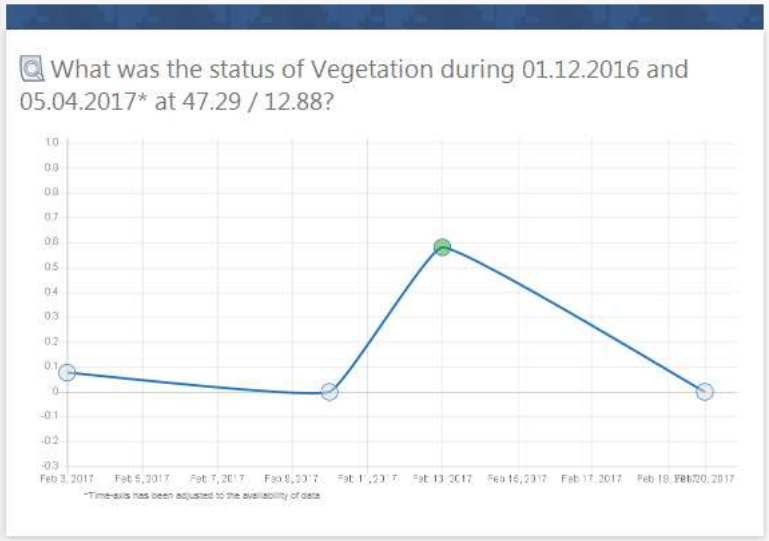
Demo 3: location-based access

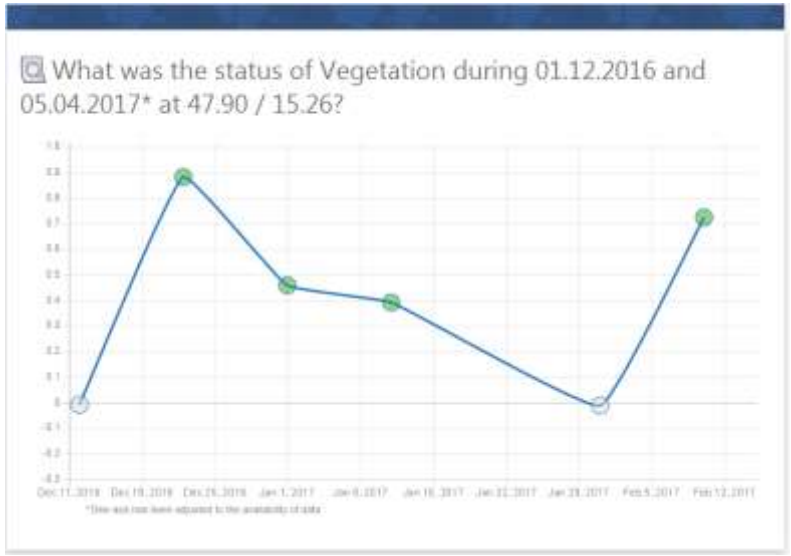
- historical data-derived trends where you are (or elsewhere)
  - location-based access on-the-fly
  - mobile App
- example prototype already developed in IQ4Sen
  - ZAMG project
  - implemented by SpatialServices

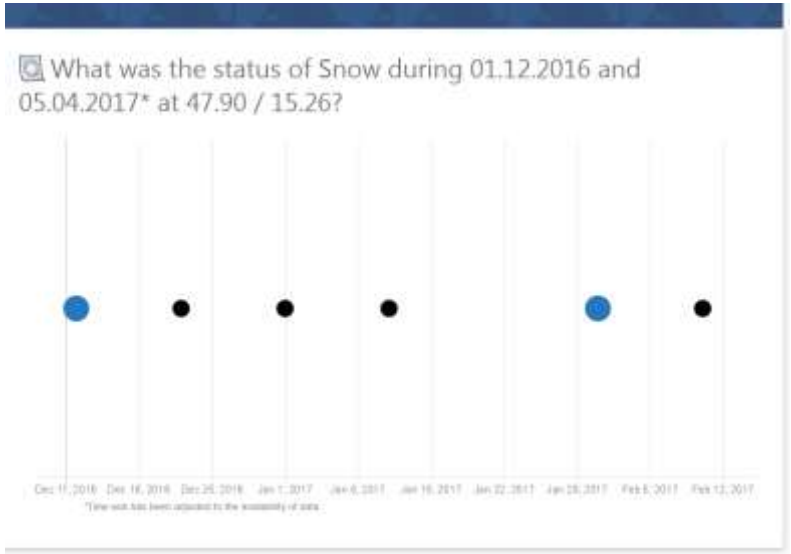
Demo 3: location-based access







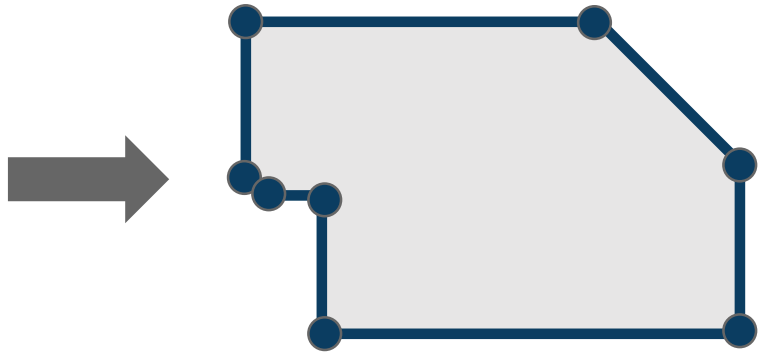




Demo 4: per-parcel statistics

- allow user-defined parcel calculations for spectral and semantic profiles through time (upload of user defined geometry)
- 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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FFG Promoting innovation
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