



## Sentinel-2 Semantic Data & Information Cube Austria

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# Background



Make TBs of Earth observation (EO) data accessible & allow cloud-based analyses

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Upscale our **own analysis approach:** semantic EO data cubes



Tackle **new research topics that require big data processing** e.g., around SDGs



Requirements: Access to computing and storage resources

... but we are a small team (4 + students)



## Motivation

EO Analytics Infrastructure: support users to transform (geo) data into (geo)information



Scalability

Transferability

New user types without EO/technical expertise

Our approach: Semantic querying of multidimensional Earth observation data



## **Key components of a semantic EO data cube**

2 Data cube technology: **User-defined** areas-ofinterests and time intervals



Images: Every pixel semantically enriched (fully automated, no training samples)

+ additional (open) datasets (e.g. DEM)

## **High-level semantic querying**

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.



## **Overview**



#### Semantic enrichment

automatic worldwide applicable different granularities



#### Generic factbase data cube

scalable Docker infrastructure applicationagnostic, generic factbase

## Knowledgebase and inference engine

web-based **graphical inference engine** translates semantic models from the **knowledgebase** into data cube queries against the **factbase** 

### Semantic querying

semantic querying language application specific visual models custom output



SCBIR cloud-free p composite th vegetation

...



loss





## Semantic enrichment

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.

nttps://doi.org/10.1080/23312041.2018.1467254

#### Spectral categories of SIAM

"high" leaf area index (LAI) vegetation types (LAI values decreasing left to right)				
"medium" LAI vegetation types (LAI values decreasing left to right)				
shrub or herbaceous rangeland				
other types of vegetation (e.g., vegetation in shadow, dark vegetation, wetland)				
bare soil or built-up				
deep water, shallow water, turbid water or shadow				
thick cloud and thin cloud over vegetation, or water, or bare soil				
thick smoke plume and thin smoke plume over vegetation, or water, or bare soil				
snow and shadow snow				
shadow				
flame				
unknowns				

spectral categories of SIAM applied to image





## Semantic enrichment

## SIAM (Satellite Image Automatic Mapper) "multi-spectral colour naming"



Fully automated, based on a physical model



No parameter, no training-samples



near real-time (approx. 2 min. for a Sentinel-2 granule)



Scalable, parallelisable



multi-sensor support (at least TOA calibration)

## SIAM spectral categorization

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

## SIAM spectral categorization

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



semantic Data cube

Augustin, H., Sudmanns, M., Tiede, D., Lang, S., & Baraldi, A. (2019). Semantic Earth observation data cubes. Data, 4(3), 102.





semantic **QUERY** 





# semantic Model

#### **Vegetation change**

Searching for a pattern indicating vegetation loss

Observation time several months up to a year (e.g. march to november)

#### **Observation category sequence:**



New image **3,5** every days

in Austria



Generic Web interface: access to different semantic EO data cubes possible

Create, save and share semantic queries in a knowledgebase

**Open Source code:** https://github.com/zgis/semantique

sen2cube

Knowledgebase

Simple Wate Count

Available models Browse all models Factbase

Spatial Subset

25.

Draw Area of Interest

Or use GeotSON dataset:

Temporal Subset

 Inference Quick preview Start inference All inferences

Graphical User Interface

A., & Tiede, D. (2022). Semantic querying in Earth





## Example:

## How green is Austria?

Sudmanns, M., Augustin, H., van der Meer, L., Baraldi, A., & Tiede, D. (2021). The Austrian Semantic EO Data Cube Infrastructure. Remote Sensing, 13(23), 4807. https://doi.org/10.3390/rs13234807





## Why we need time series analysis of **Historic** data

Sudmanns, M., Augustin, H., van der Meer, L., Baraldi, A., & Tiede, D. (2021). The Austrian Semantic EO Data Cube Infrastructure. Remote Sensing, 13(23), 4807. https://doi.org/10.3390/rs13234807





#### showcasing

## **Applications**





## Clients and Interfaces

Sudmanns, M., Augustin, H., van der Meer, L., Baraldi, A., & Tiede, D. (2021). The Austrian Semantic EO Data Cube Infrastructure. Remote Sensing, 13(23), 4807. https://doi.org/10.3390/rs13234807

- Executing semantic models in the cloud ondemand
- standard JSON API
- Easy integration in existing software/clients

#### Mobile app



## Full ArcGIS Pro Integration





Nature`s Calendar citzen science app





(sen2cli) sen2cli07fa6b00b820b:-\$ sen2cli --help Usage: sen2cli [OPTIONS] COMMAND [ARGS]...

#### Options

--log\_file FILE Write log to this file instead of StdErr. -v, --verbose Verbose log output. Can be added up to three times for even mere verbosity (WANING, INFO, DEBUG). --beln Show this messame and writ.

#### mands:

inference Display / create / modify inferences session Session related commands like 'logir version Prints program version en2cl13 read2018570805200-5

## Command-line interface



**Example:** 

## Cloud-Desktop Integation



## How the OCRE project supported us ...

- ... access to large amount of cloud resources and direct access to the EO data sets at the EODC (<u>https://eodc.eu</u>)
- ... opening new research questions / topics (national-scale investigation)
- ...upscaling the semantic EO data cube(s)
- … 'in-kind' provision of our semantic EO data cubes to Master & PhD students and project partners

Read more in the OCRE success story https://www.ocre-project.eu/successstory/sentinel-2-semantic-datainformation-cube-austria





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data infrastructure used.

