The developments and results associated to this presentation were funded under the Austrian Space Applications Programme (Sen2Cube.at, SIMS, SemantiX, INTERFACE) and C-SCALE (SPOTLIGHT)

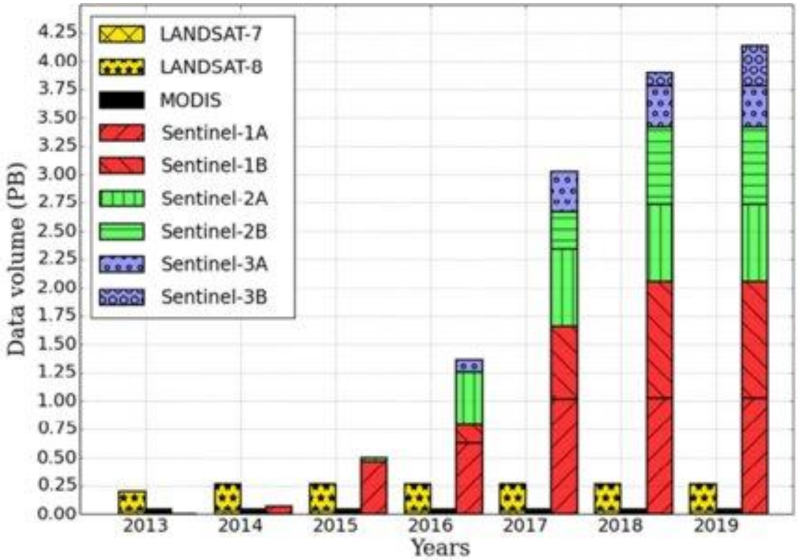
Semantic Earth Observation Data Cube Infrastructures

EOSC Future's Use Case Event on May 16, 2023

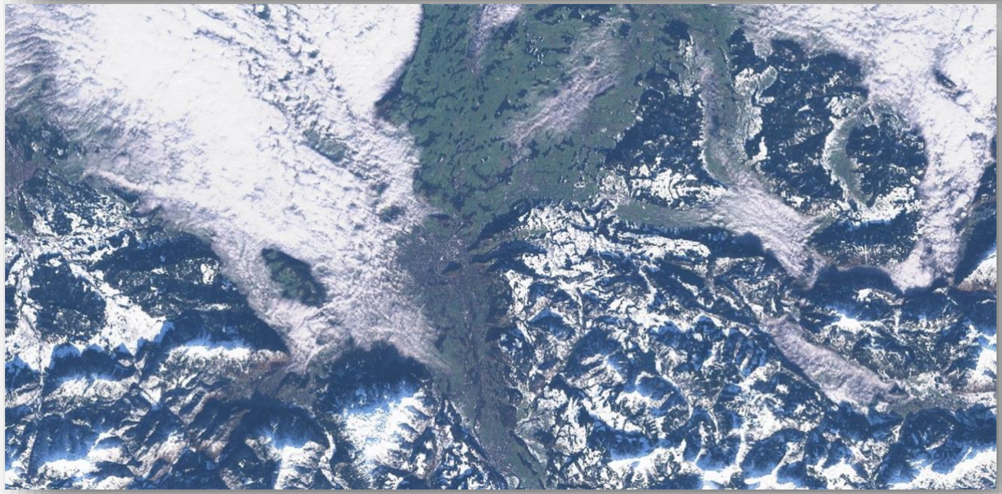
Martin Sudmanns[1], Hannah Augustin[1], Luke McQuade[1], Lucas van der Meer[1], Andrea Baraldi[2], Dirk Tiede[1]

[1]Department of Geoinformatics - Z_GIS, Paris Lodron University Salzburg, Austria
[2]Spatial Services GmbH, Salzburg, Austria

Motivation and introduction: Big EO Data



Soille, P., Burger, A., Marchi, D. de, Kempeneers, P., Rodriguez, D., Syrris, V., & Vasilev, V. (2018). A versatile data-intensive computing platform for information retrieval from big geospatial data. Future Generation Computer Systems, 81, 30–40. https://doi.org/10.1016/j.future.2017.11.007

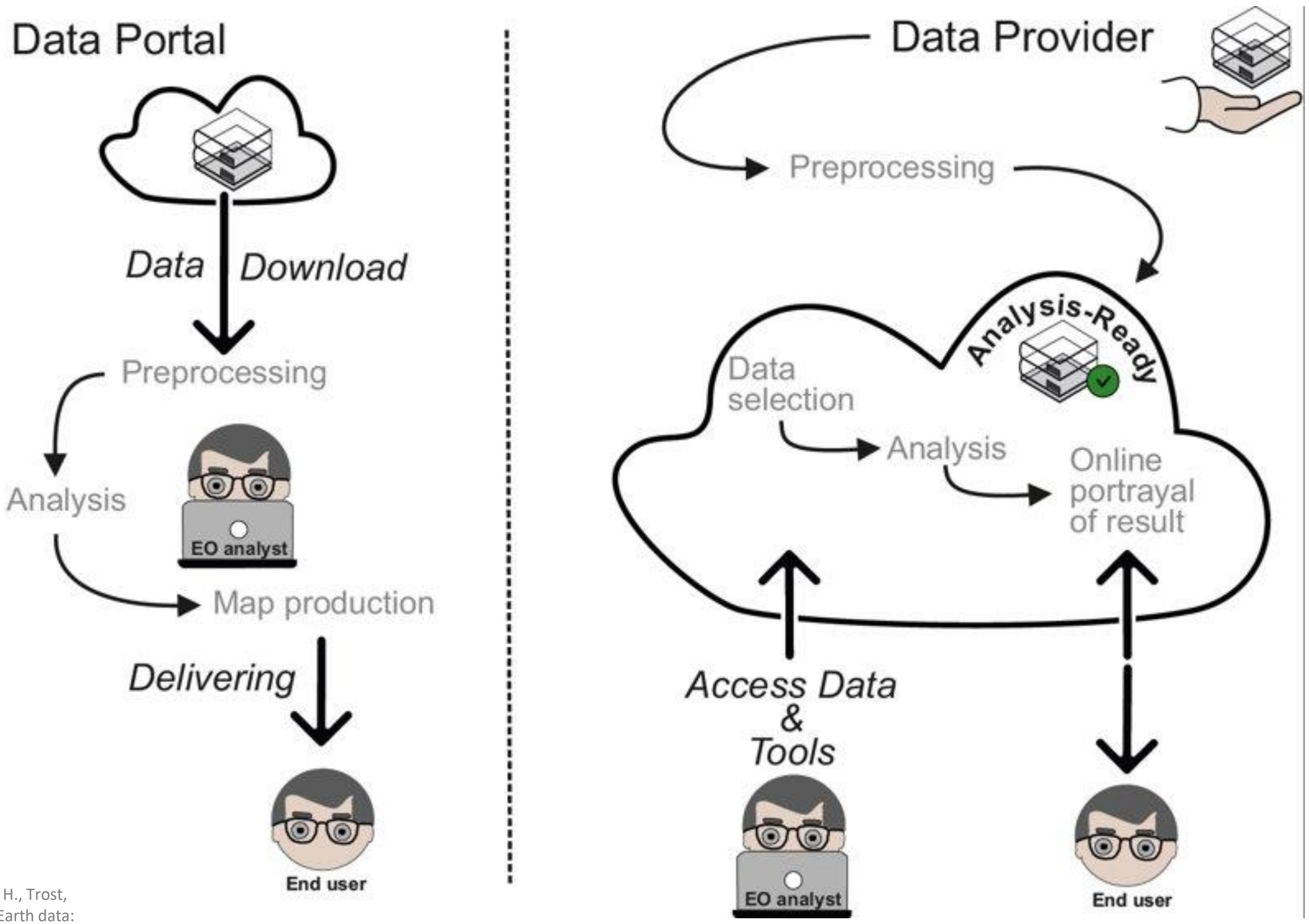


Sentinel-2 with 13 spectral bands

At least every 5 days an image

~ 8 mio. images / year

Changes in workflows



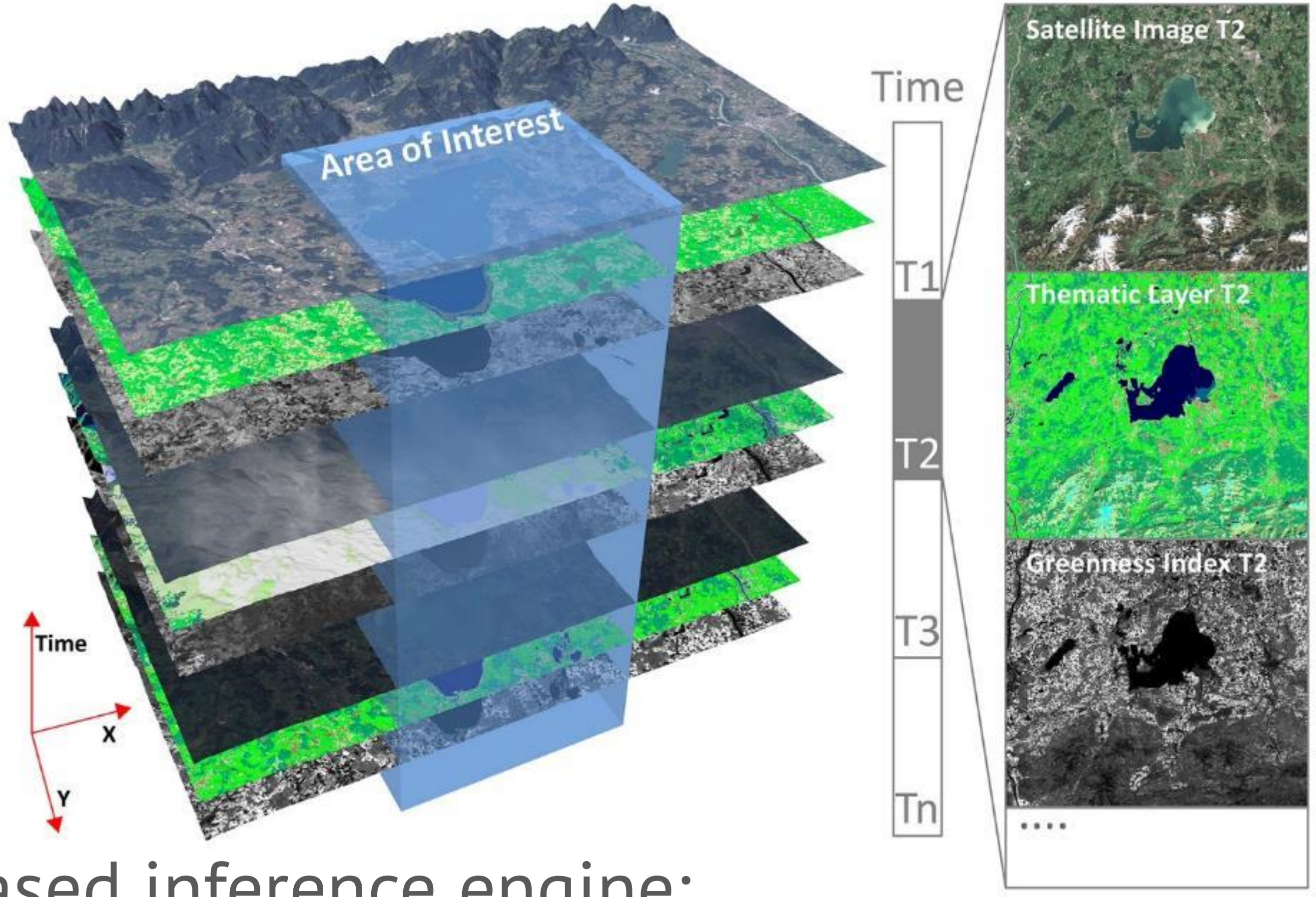
From: Sudmanns, M., Tiede, D., Lang, S., Bergstedt, H., Trost, G., Augustin, H., Baraldi, A., Blaschke, T., 2019. Big Earth data: disruptive changes in Earth observation data management and analysis? Int. J. Digit. Earth 0, 1–19. https://doi.org/10.1080/17538947.2019.1585976

Key components of a semantic EO data cube

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

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

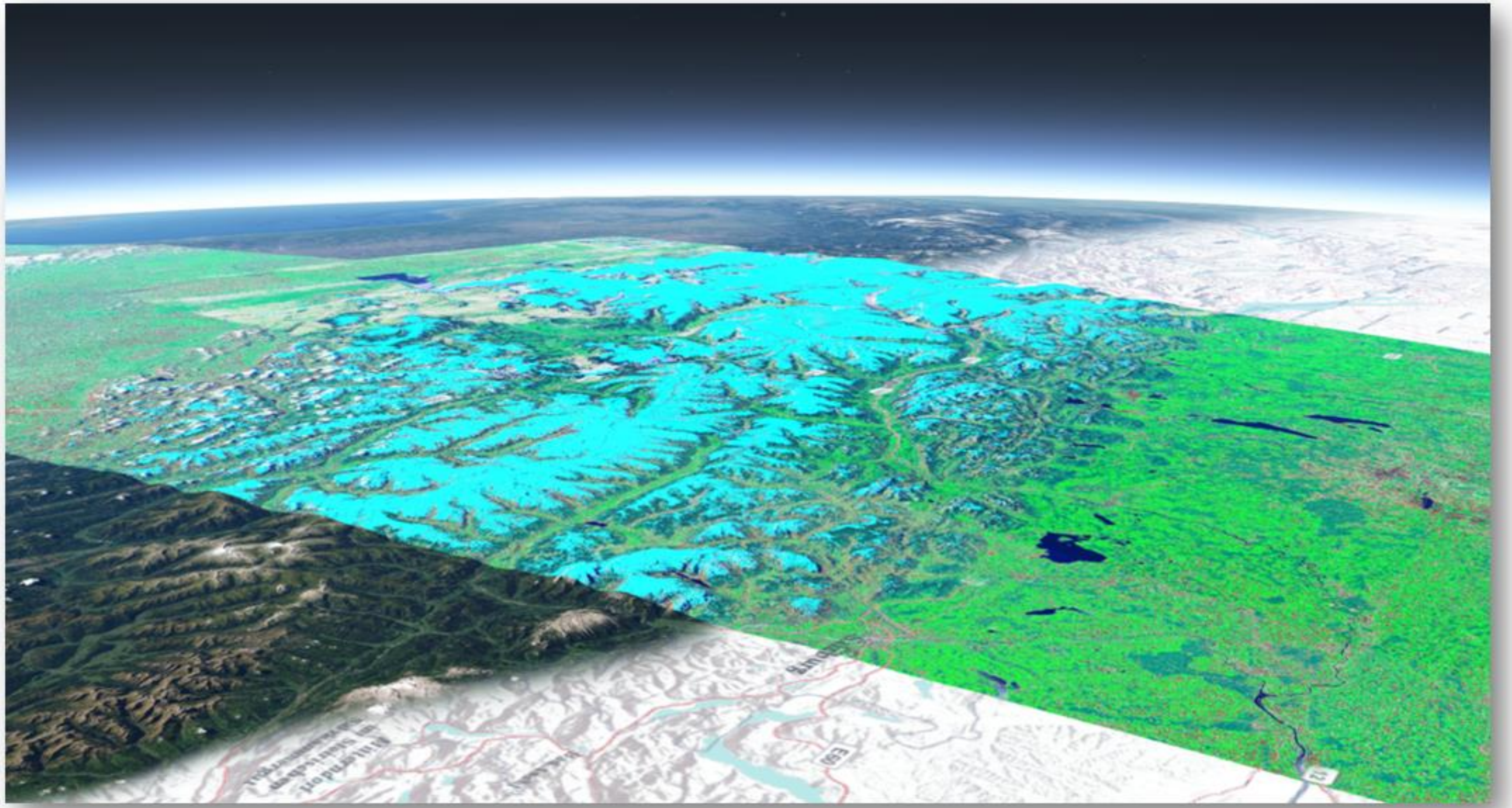
2 Data cube technology: **User-defined areas-of-interests and time intervals**



3 Web-based inference engine: **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.

① Semantic Enrichment



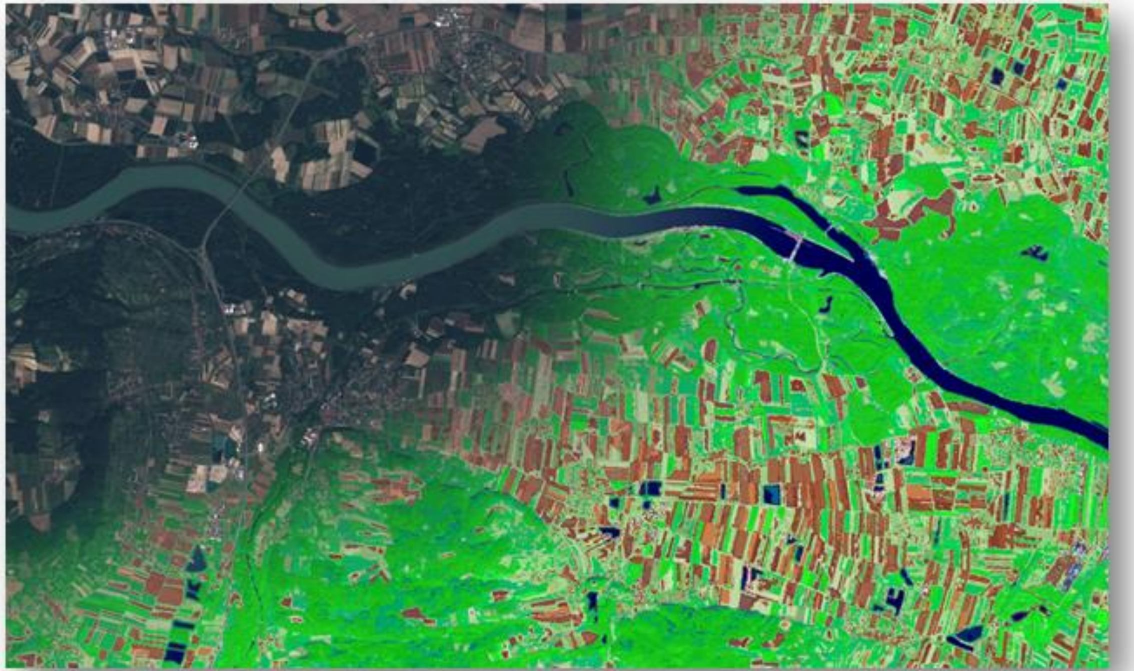
Every image **has a semantic skin/layer:**

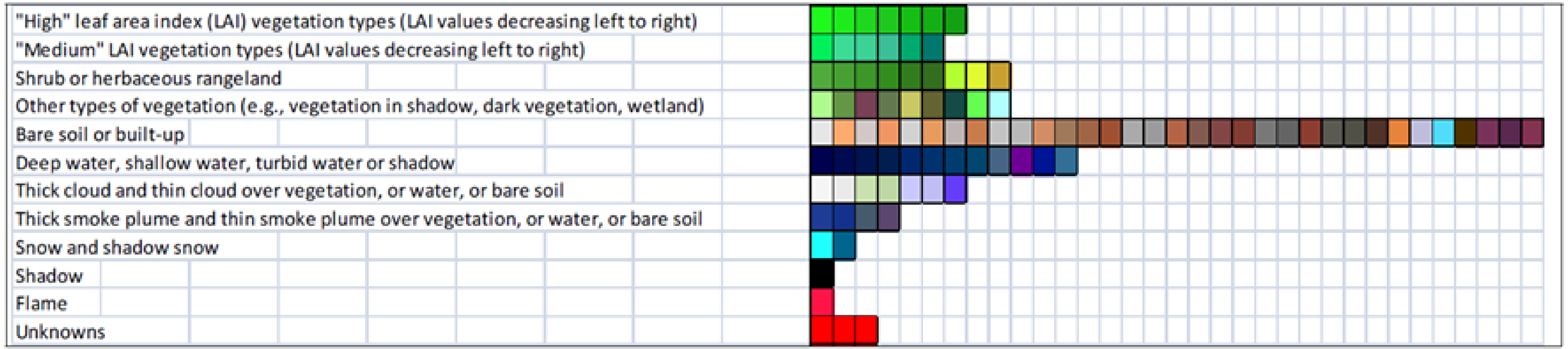
- Reflectance values are associated to **spectral categories**
- **Transferrable & generic:**
  - Time-series of categories allow specification of classes downstream
- Complex, **graphical analyses** are possible
- Rule-based: No black box

① 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)





96 spectral categories

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


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


1
SIAM spectral categorization
96 spectral categories
(Austrian/German border)
27 August 2016

② Data Cube technology

- Going beyond ARD: ***"A semantic EO data cube or a semantics-enabled EO data cube is a data cube, where for each observation at least one nominal (i.e., categorical) interpretation is available and can be queried in the same instance"***
- Scalable Docker-based architecture, deployed in the Cloud
- Open Data Cube

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

Temporally stacked EO images, either as **view** or as **physical data structure**.
Usually coupled with **analysis-ready data (ARD)**.

Main goal: Abstracting data storage from users:

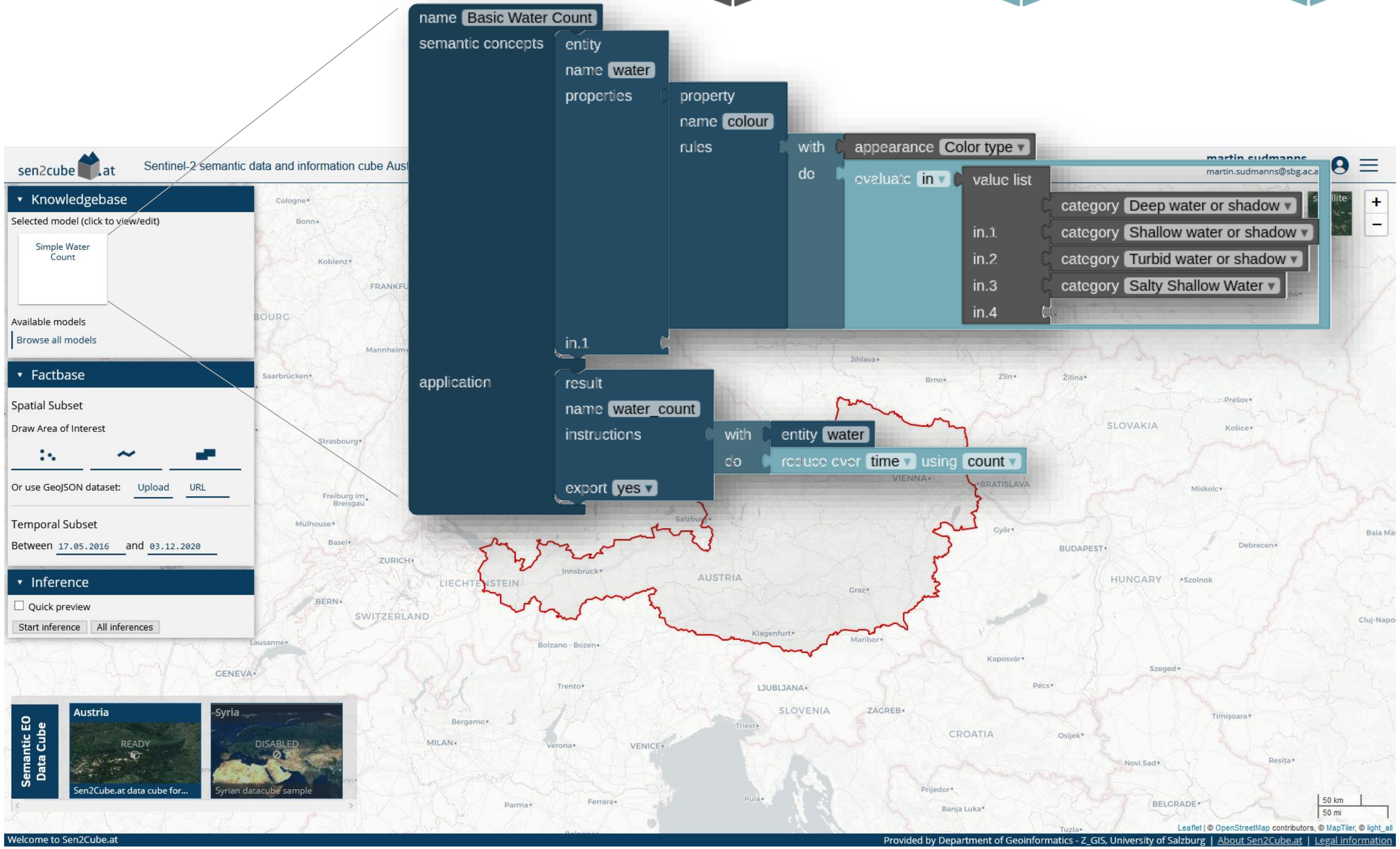
```
import datacube

aoi = {
  'time': ('2017-01-01', '2018-01-01')
  'lat': (47.9, 47.6),
  'lon': (12.8, 13.1),
}

dc = datacube.Datacube()
data = dc.load(product='sentinel-2',
     measurements=['b4', 'b3', 'b2'],
     **aoi)
```

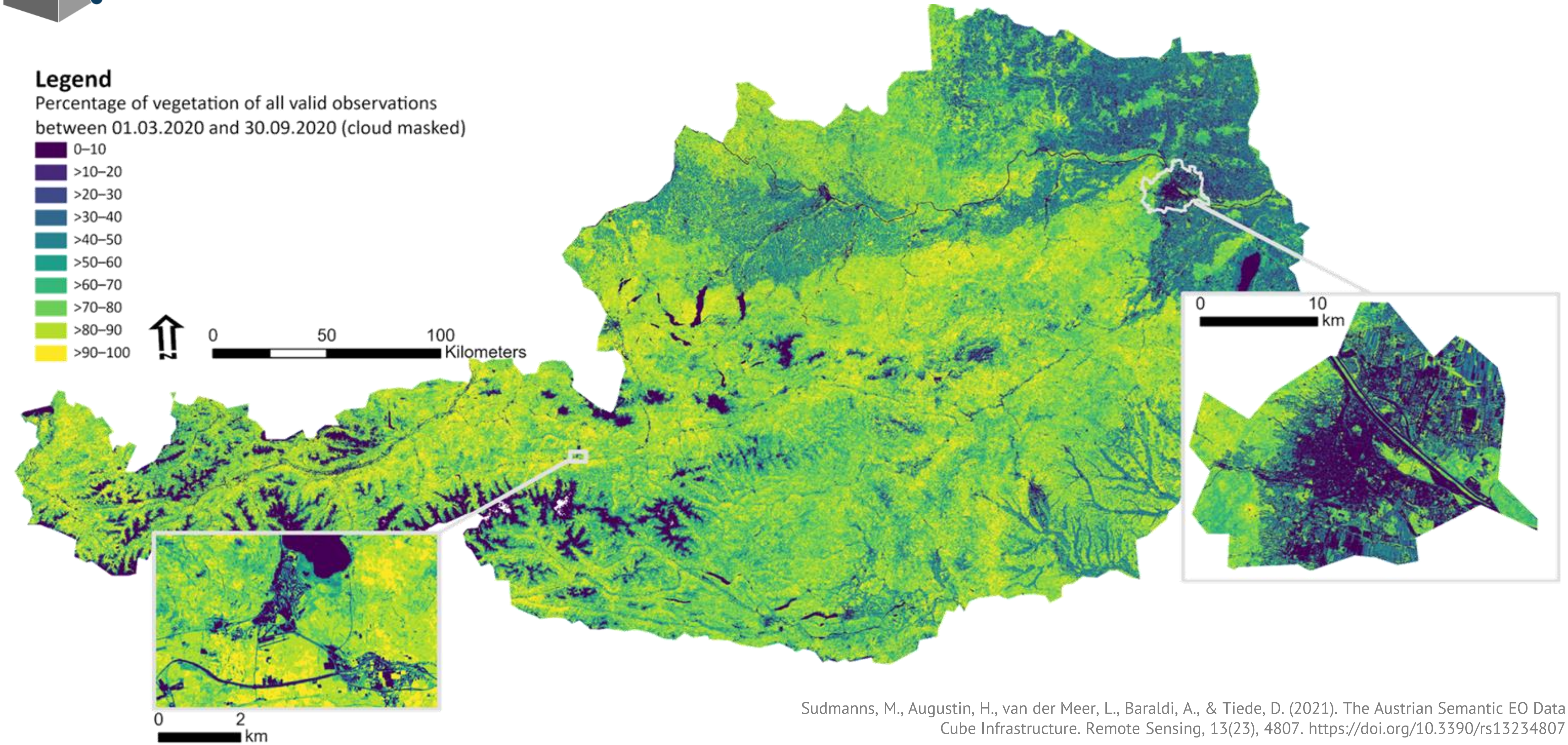
③ High-level semantic querying

- An **inference engine for semantic querying** as a Web interface in a client-server solution.
- Different and multiple output types are possible and depending on the query.
- **Generic Web interface:** access to different semantic EO data cubes possible (at the moment: Austria, parts of Syria and Afghanistan, alpine area)
- Create, save and share semantic queries in a **knowledgebase**
- **Open Source** code: https://github.com/zgis/semantique



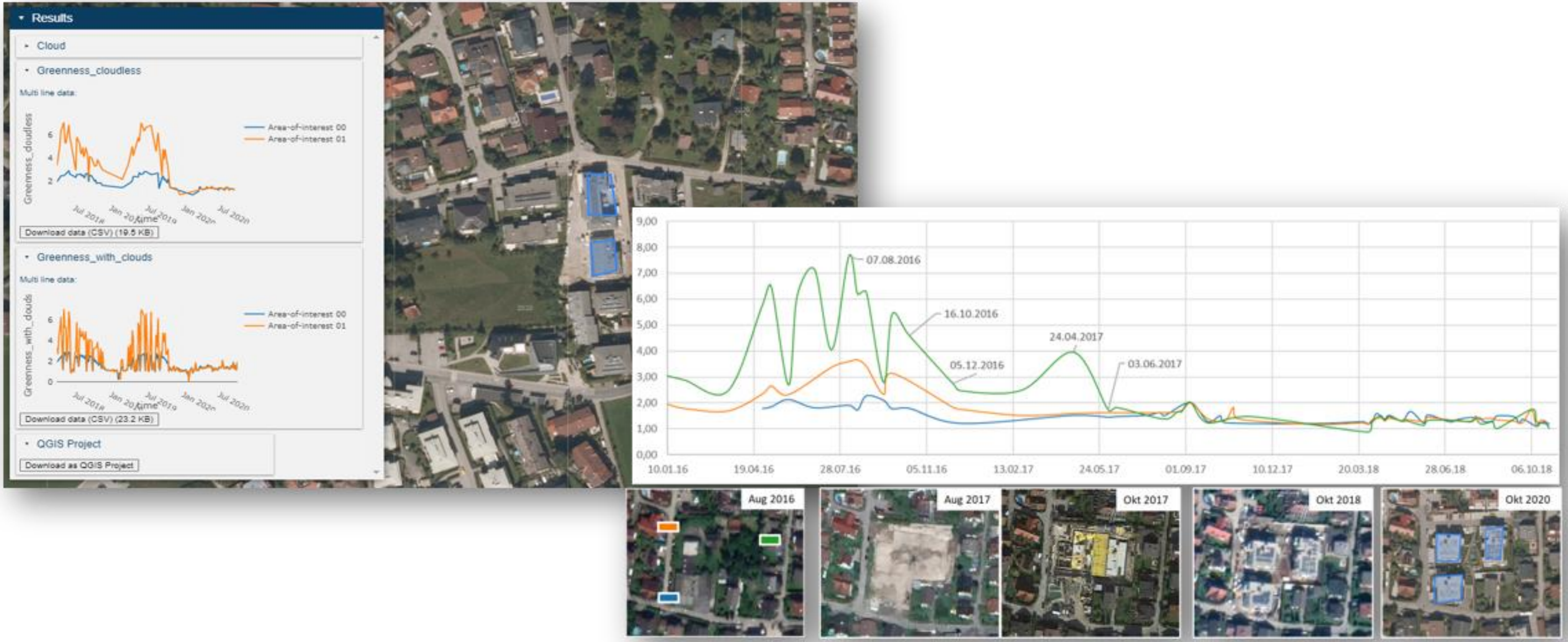
Van der Meer, L., Sudmanns, M., Augustin, H., Baraldi, A., & Tiede, D. (2022). Semantic querying in Earth observation data cubes. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 503-510.

Example 1: National-wide information layers



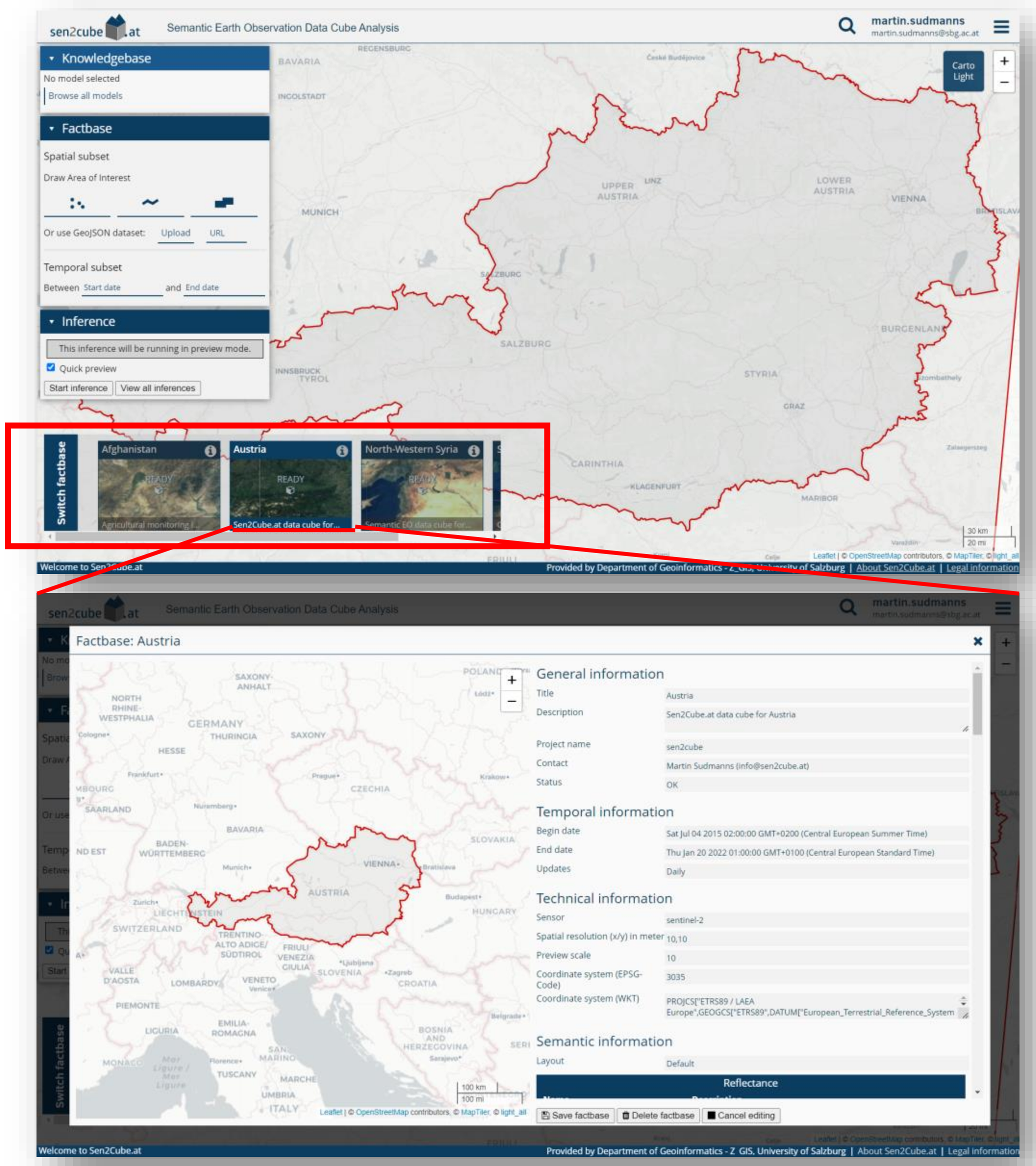
Sudmanns, M., Augustin, H., van der Meer, L., Baraldi, A., & Tiede, D. (2021). The Austrian Semantic EO Data Cube Infrastructure. Remote Sensing, 13(23), 4807. https://doi.org/10.3390/rs13234807

Example 2: Time series analysis of historic data – here: construction sites



Towards semantic EO data cubes on-demand

- Our architecture allows to use and operate **multiple semantic EO data cubes concurrently**
- Target: Allow **instantiation of new or temporary** semantic EO data cubes
- **Semantic enrichment** requires processing in the cloud
- Necessary condition: **Stable & fast access to high-quality data**



sen2cube.at
Demo available:
info@sen2cube.at

Dr. Martin Sudmanns
Paris Lodron University Salzburg | Department of Geoinformatics – Z_GIS
E-mail: martin.sudmanns@plus.ac.at
E-mail: info@sen2cube.at
Web: https://sen2cube.at

The developments and results associated to this presentation were funded under the Austrian Space Applications Programme (Sen2Cube.at, SIMS, SemantiX, INTERFACE) and C-SCALE (SPOTLIGHT)