

Semantic Earth Observation Data Cube Infrastructures

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

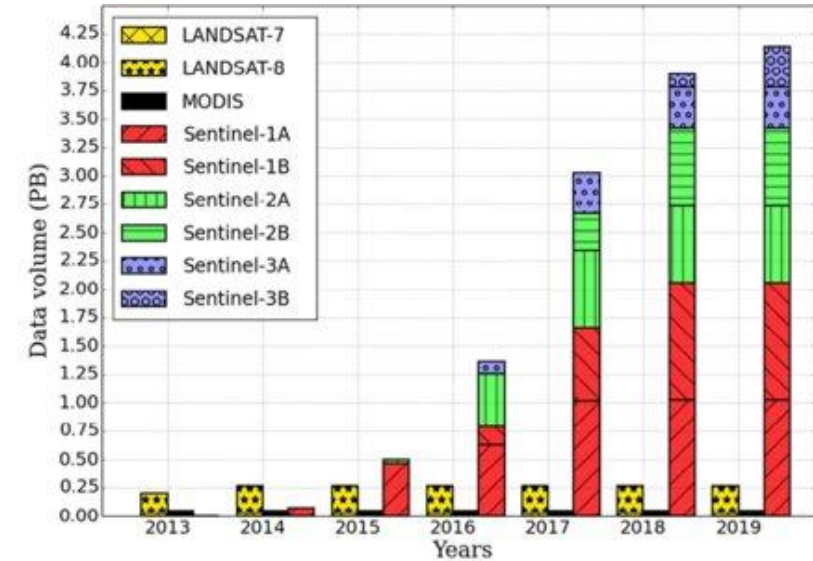
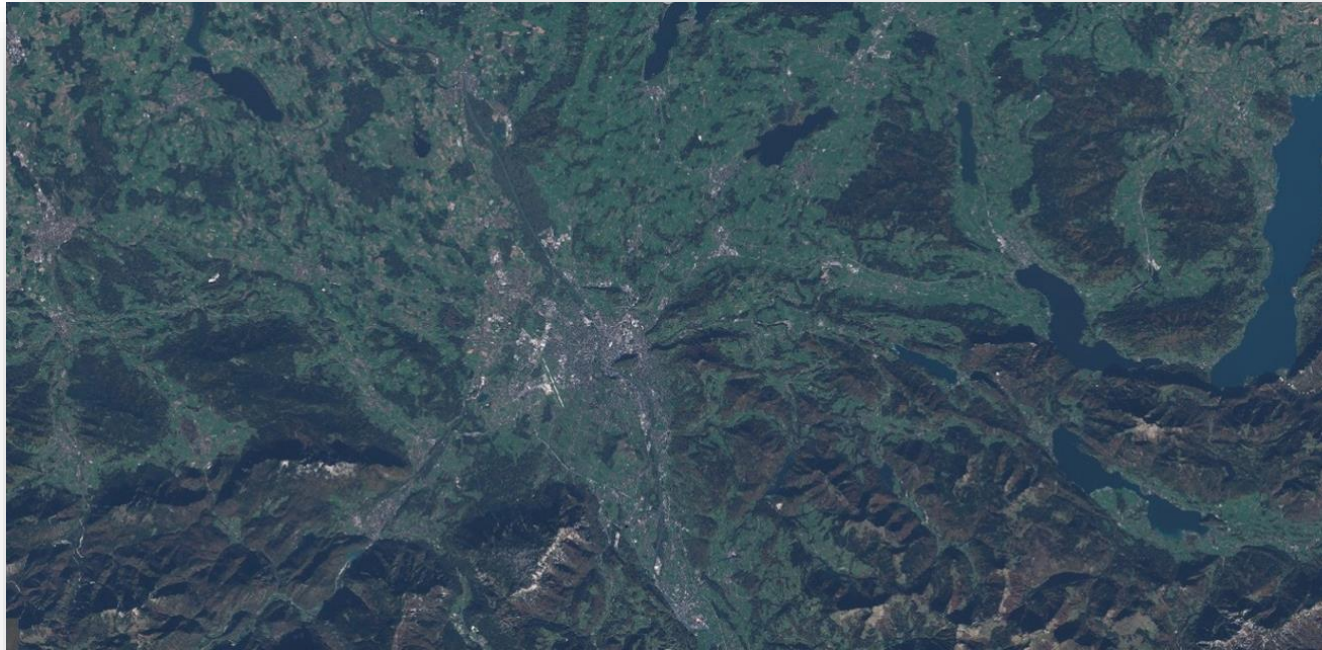
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Andrea Baraldi², Dirk Tiede¹

¹Department of Geoinformatics - Z_GIS, Paris Lodron University Salzburg, Austria

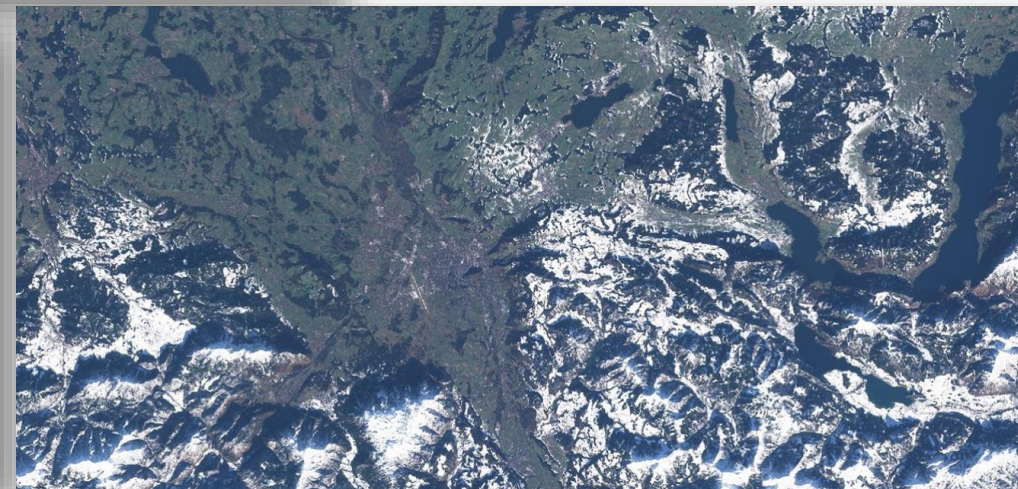
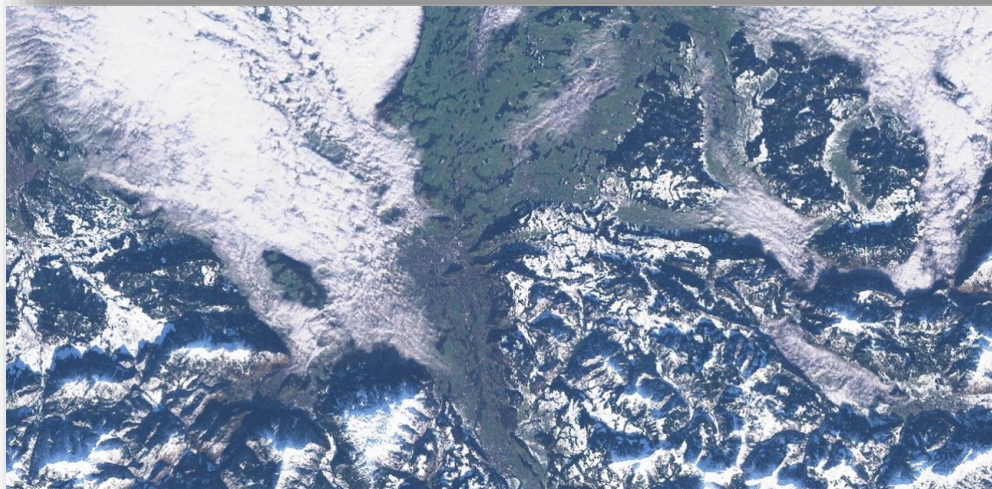
²Spatial Services GmbH, Salzburg, Austria



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>



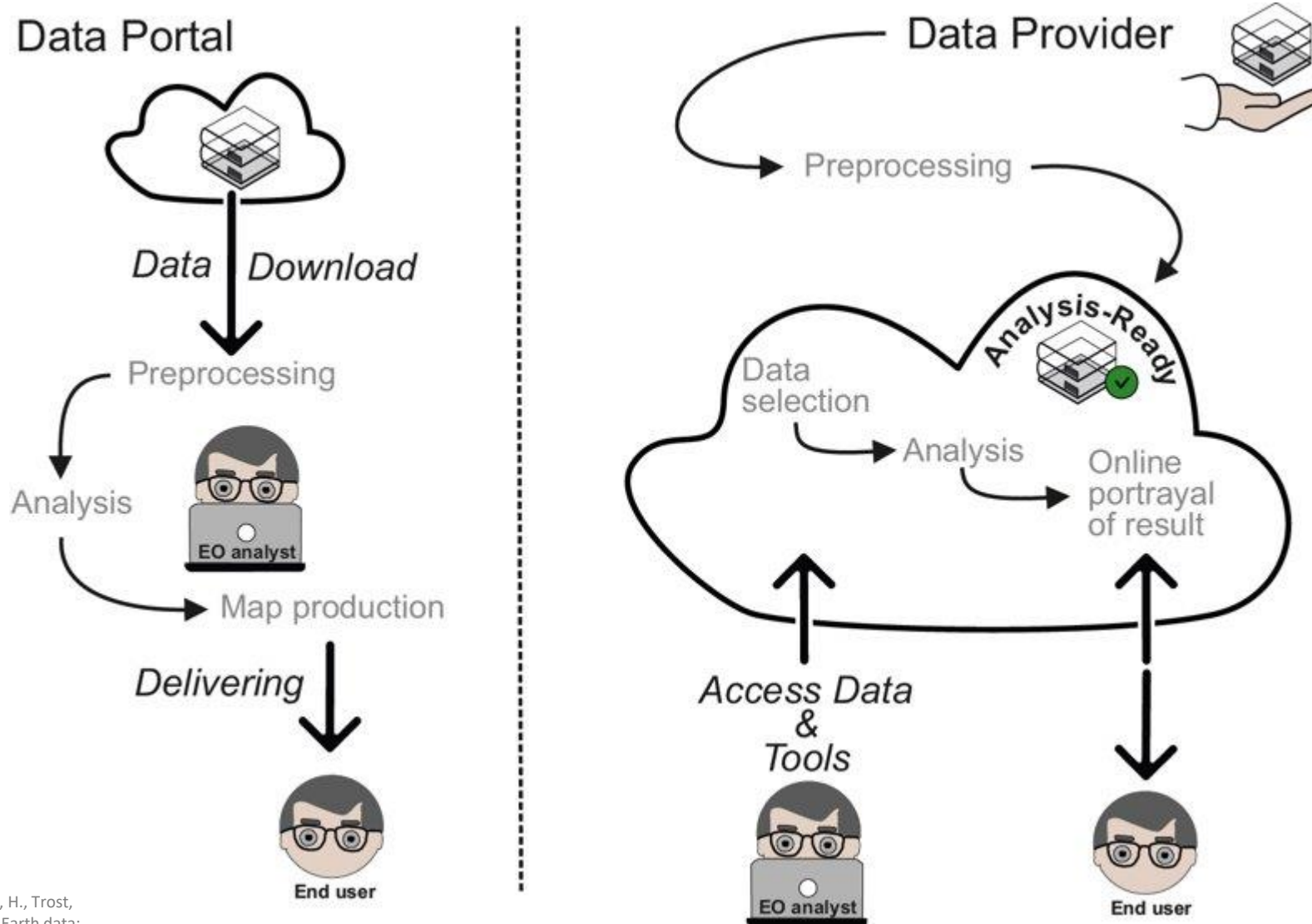
Sentinel-2 with 13 spectral bands

At least every 5 days an image

~ 8 mio. images / year



Changes in workflows

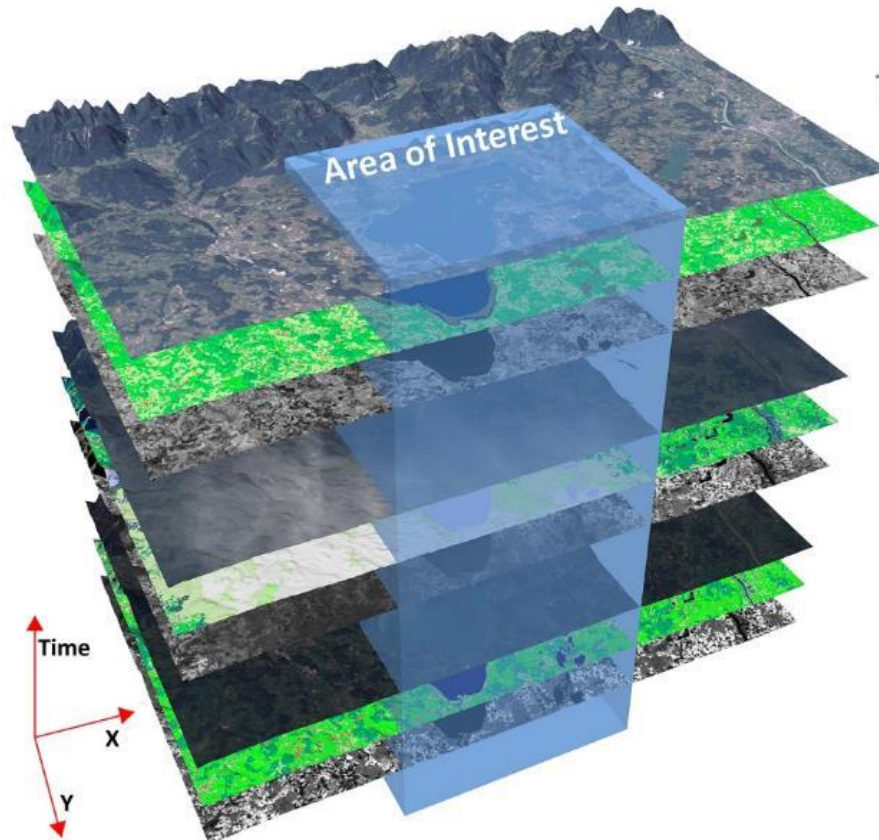


From: Sudmanns, M., Tiede, D., Lang, S., Bergstedt, H., Trost, G., Augustin, H., Baraldi, A., Blaschke, T., 2019. Big Earth data: disruptive changes in Earth observation data management and analysis? Int. J. Digit. Earth 0, 1–19.
<https://doi.org/10.1080/17538947.2019.1585976>



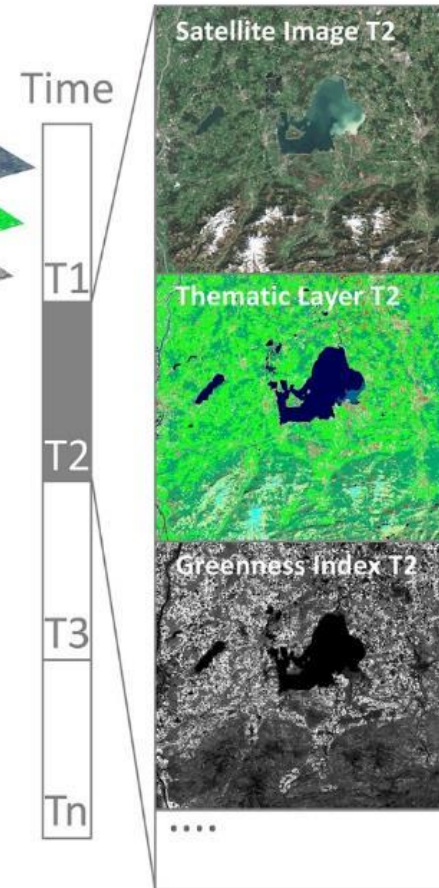
Key components of a semantic EO data cube

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



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

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

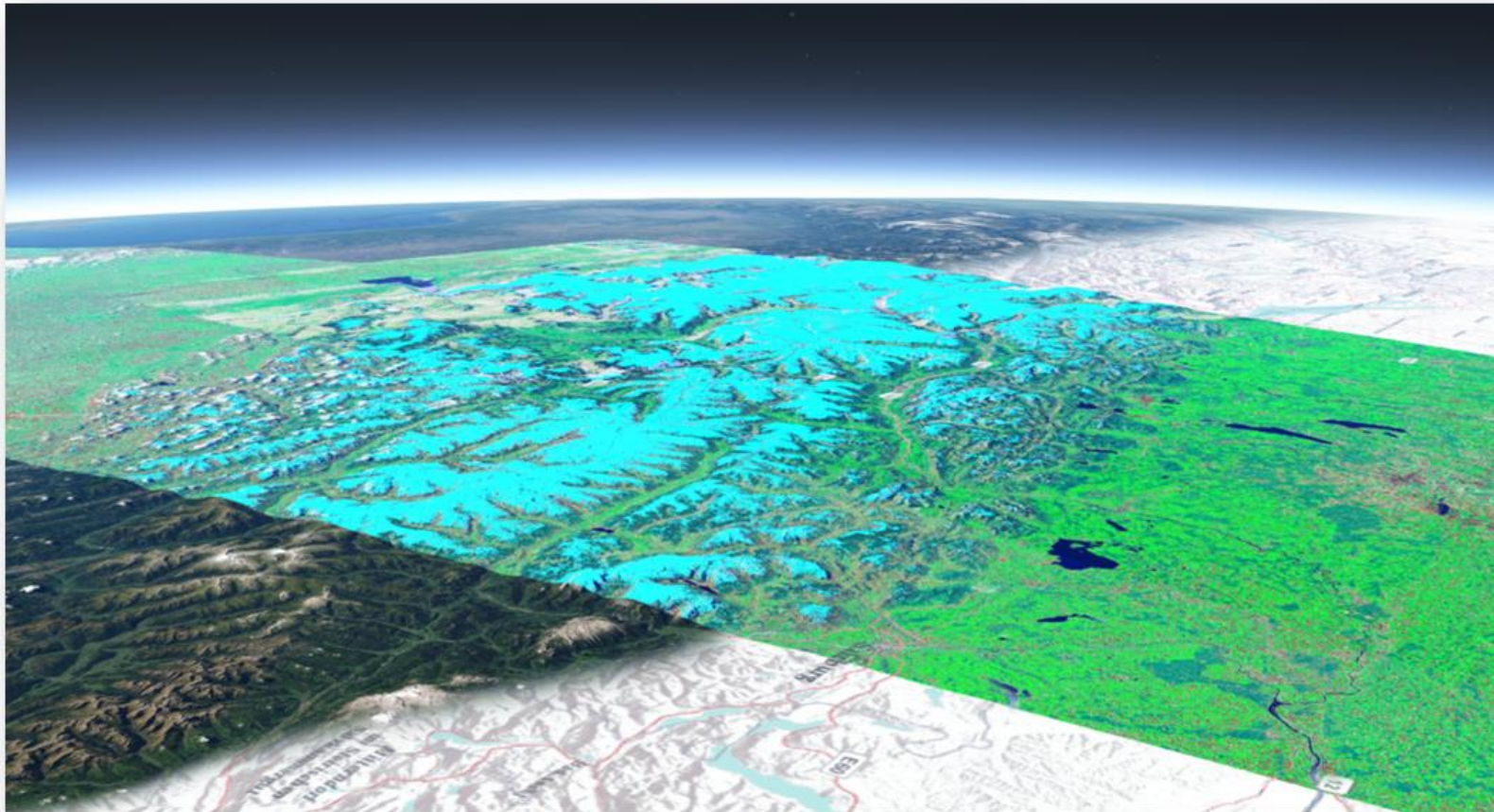


③ Web-based inference engine: **High-level semantic querying**

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



SIAM spectral categorization

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



A satellite image of a landscape, likely the Austrian/German border, showing a river and several lakes. The image is overlaid with a spectral categorization, where different colors represent different land cover types. The colors are primarily shades of green, with some brown and blue areas. The river is a prominent feature, winding through the landscape. The lakes are scattered throughout, with some being quite large. The overall appearance is a complex, textured map of the terrain.

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

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:

```
1 import datacube
2
3 aoi = {
4     'time': ('2017-01-01', '2018-01-01')
5     'lat': (47.9, 47.6),
6     'lon': (12.8, 13.1),
7 }
8
9 dc = datacube.Datacube()
10 data = dc.load(product='sentinel-2',
11               measurements=['b4', 'b3', 'b2'],
12               **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>

The screenshot shows the Sen2Cube web interface. On the left, there is a 'Knowledgebase' panel with a 'Selected model' dropdown set to 'Simple Water Count'. Below it are sections for 'Factbase' (Spatial Subset and Temporal Subset) and 'Inference' (Quick preview and Start inference). The main area is a map of Austria with a red outline. Overlaid on the map is a query builder interface with the following elements:

- name:** Basic Water Count
- semantic concepts:**
 - entity name: water
 - properties:
 - property name: colour
 - rules:
 - with: appearance Color type
 - do: evaluate in value list
 - category: Deep water or shadow
 - category: Shallow water or shadow
 - category: Turbid water or shadow
 - category: Salty Shallow Water
- in.1
- application:**
 - result name: water count
 - instructions:
 - with: entity water
 - do: reduce over time using count
 - export: yes

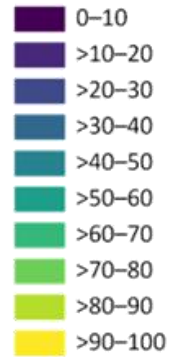
Van der Meer, L., Sudmanns, M., Augustin, H., Baraldi, A., & Tiede, D. (2022). Semantic querying in Earth observation data cubes. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 503-510.



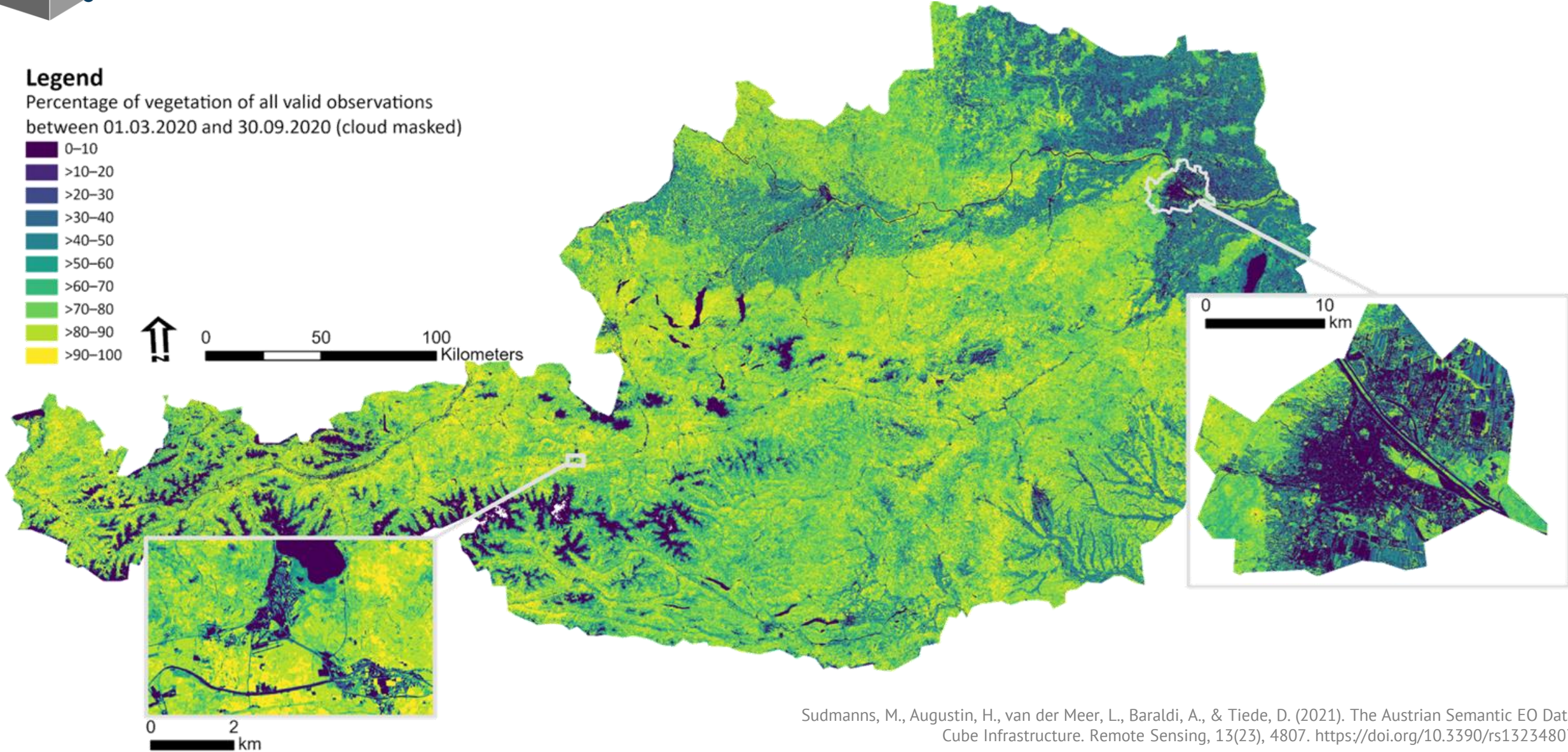
Example 1: National-wide information layers

Legend

Percentage of vegetation of all valid observations between 01.03.2020 and 30.09.2020 (cloud masked)



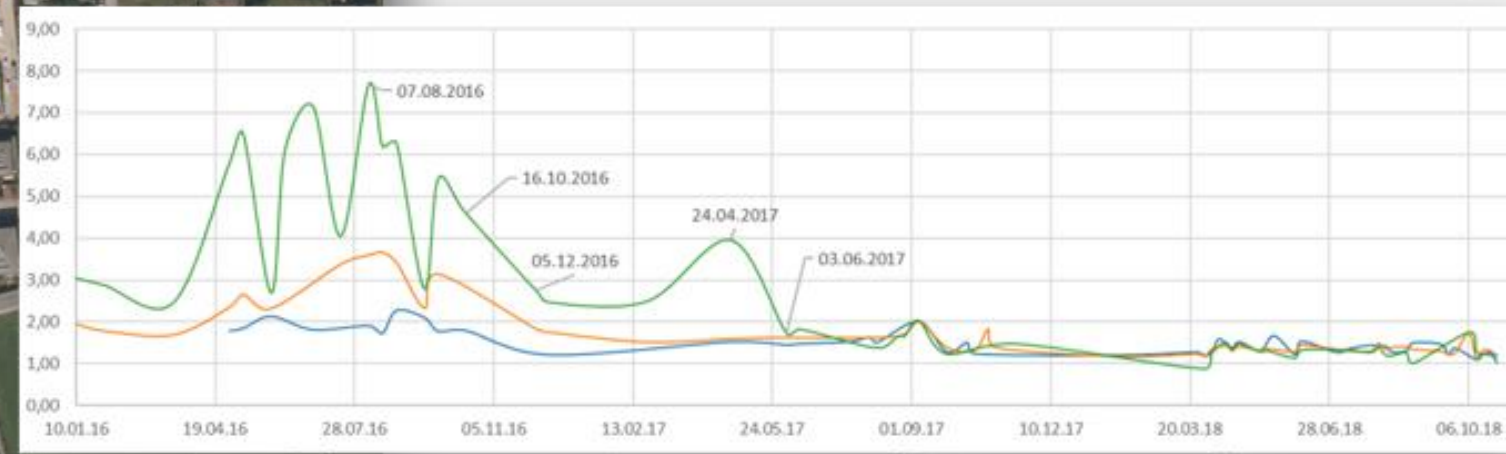
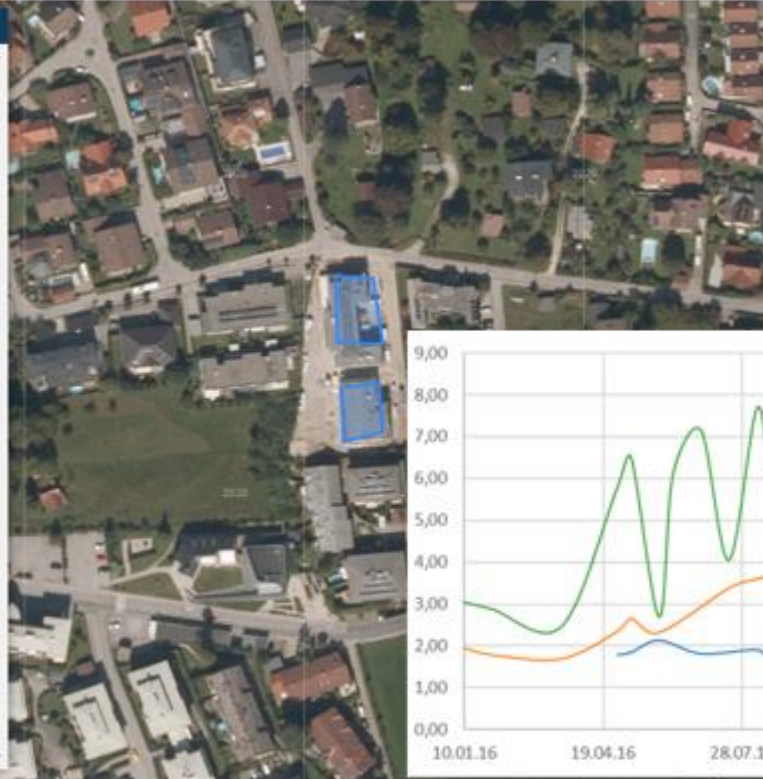
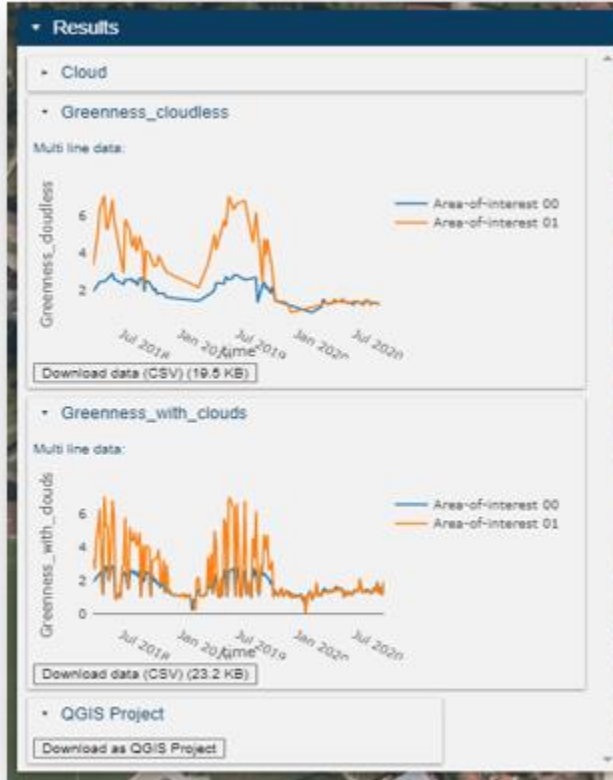
0 50 100 Kilometers



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**

The image displays two screenshots of the Sen2Cube web application. The top screenshot shows the main interface with a map of Austria and a control panel on the left. The control panel includes sections for Knowledgebase, Factbase, Spatial subset, Temporal subset, and Inference. A red box highlights a 'Switch factbase' dropdown menu with three options: Afghanistan, Austria, and North-Western Syria. The bottom screenshot shows a detailed view of the 'Factbase: Austria' data cube. It includes a map of Austria and a 'General information' panel with the following details:

General information	
Title	Austria
Description	Sen2Cube.at data cube for Austria
Project name	Sen2Cube
Contact	Martin Sudmanns (info@sen2cube.at)
Status	OK
Temporal information	
Begin date	Sat Jul 04 2015 02:00:00 GMT+0200 (Central European Summer Time)
End date	Thu Jan 20 2022 01:00:00 GMT+0100 (Central European Standard Time)
Updates	Daily
Technical information	
Sensor	sentinel-2
Spatial resolution (x/y) in meter	10,10
Preview scale	10
Coordinate system (EPSG-Code)	3035
Coordinate system (WKT)	PROJCS["ETRS89 / LAEA Europe",GEOGCS["ETRS89",DATUM["European_Terrestrial_Reference_System
Semantic information	
Layout	Default



sen2cube  .at

Demo available:
info@sen2cube.at

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