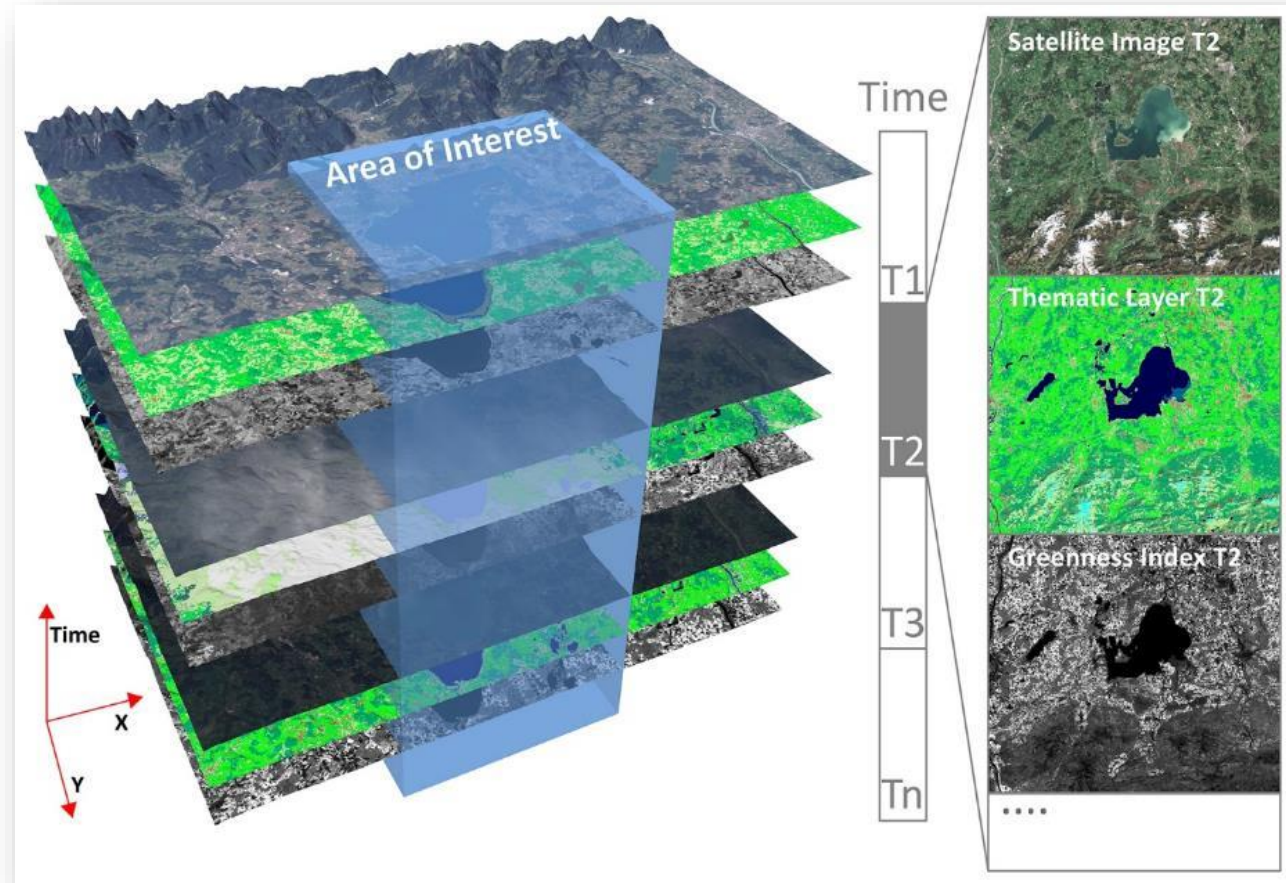


# Semantic EO data cubes - programming-free big data analysis



**Dirk Tiede**

**Assoc. Prof., Department of Geoinformatics – Z\_GIS**

**University of Salzburg, Austria**

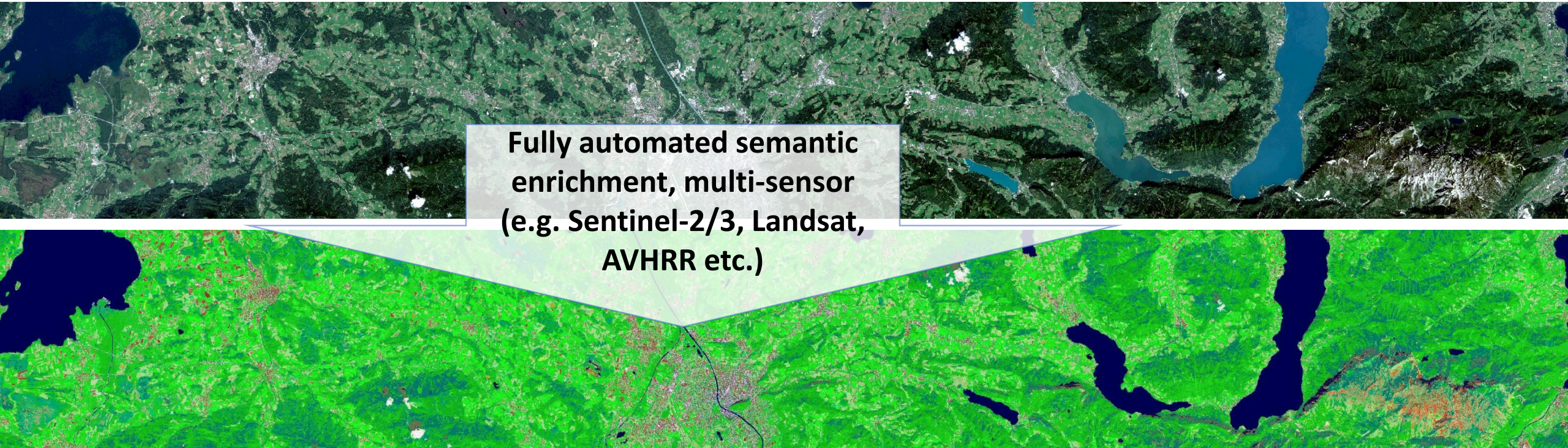
**Contributors:** Martin Sudmanns, Hannah Augustin, Lucas van der Meer, Steffen Reichel



# Semantic EO data cubes

*"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."*

From: Augustin, H., Sudmanns, M., Tiede, D., Lang, S., Baraldi, A., 2019. Semantic Earth Observation Data Cubes. Data 4. <https://doi.org/10.3390/data4030102>

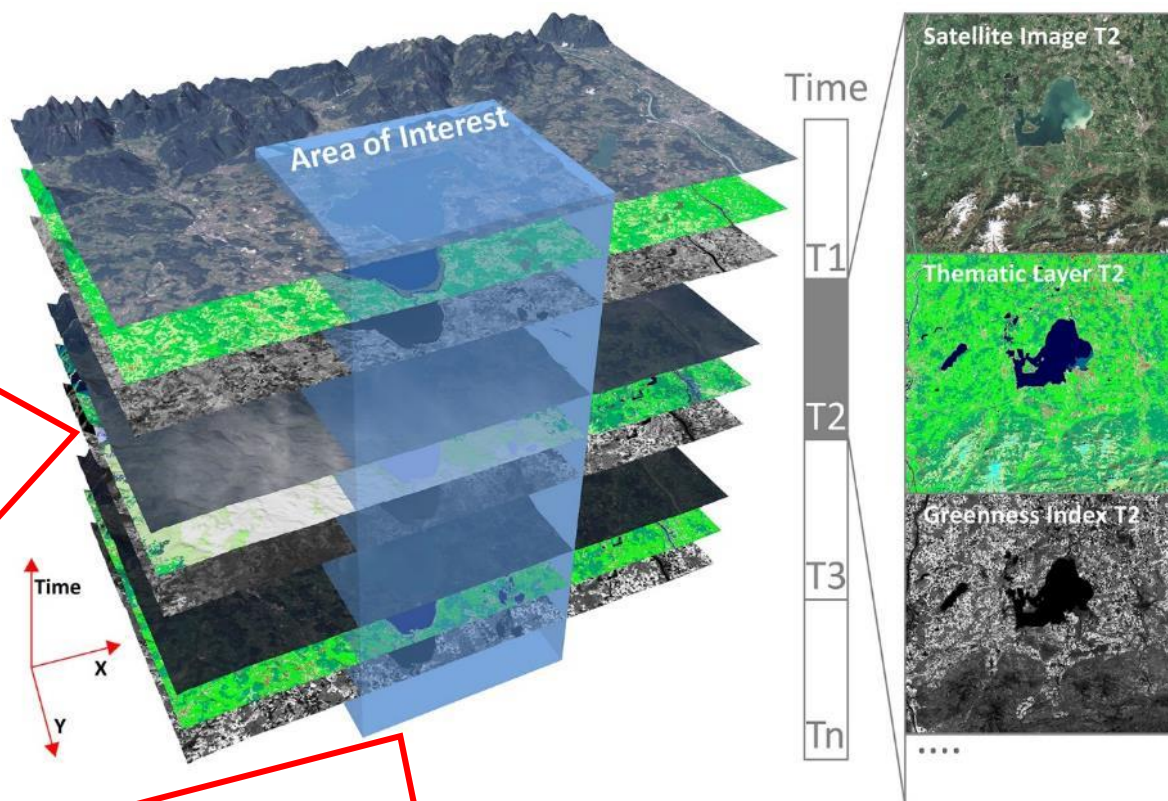




# Key concept of Sen2Cube.at for spatiotemporal analytics of multi-source EO big data

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 using a specific semantic query language interpreting human-like queries / thematic descriptions

# Sentinel-2 Semantic Data Cube for Austria

sen2cube.at Sentinel-2 semantic data and information cube

dirk.tiede  
dirk.tiede@sbg.ac.at

Knowledgebase

Selected model (click to view/edit)

01 - Count Water Presence

Available models  
Browse all models

Factbase

Spatial Subset

Draw Area of Interest

Or use GeoJSON dataset: Upload URL

Temporal Subset

Between 17.05.2016 and 25.11.2020

Inference

☐ Quick preview

Start inference All inferences

DISABLED

Sen2Cube.at data cube for... Syrian datacube sample

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

in.2

in.3

in.4

application

result name water\_count

instructions

with entity water

do reduce over time using count

export yes

www.sen2cube.at

https://manual.sen2cube.at

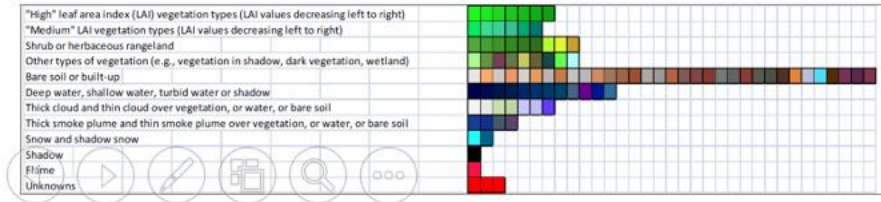
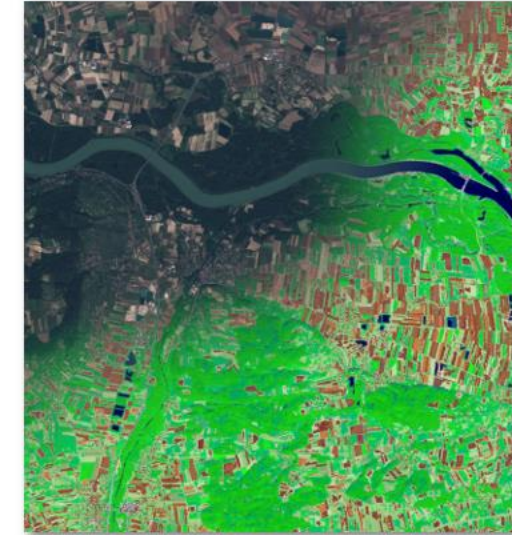
All in-house developed,  
worldwide first semantic EO  
data cube

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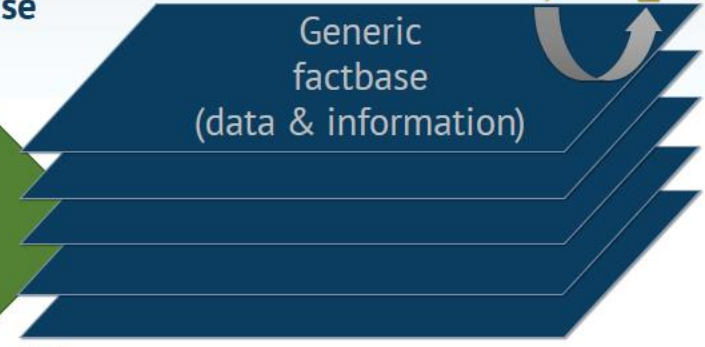
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# The Sen2Cube.at national semantic Earth observation data cube for Austria



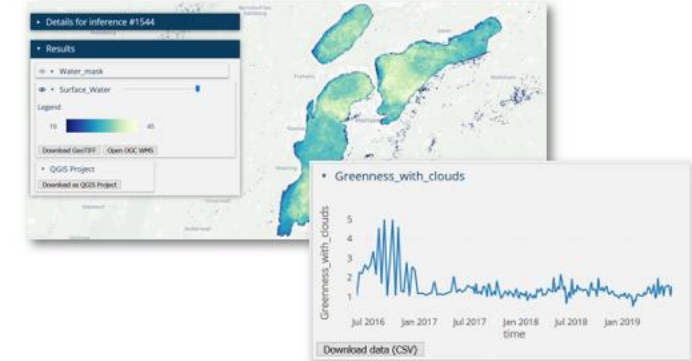
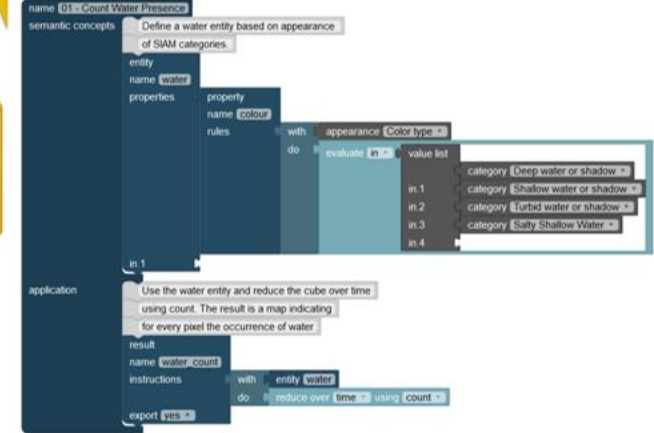
3 Web-based **graphical inference engine** translates semantic models from the **knowledgebase** into data cube queries against the **factbase**



1 Worldwide applicable **automatic semantic enrichment** in different granularities with **SIAM™**

2 EO data cube in a **scalable Docker infrastructure** as application-agnostic, generic factbase

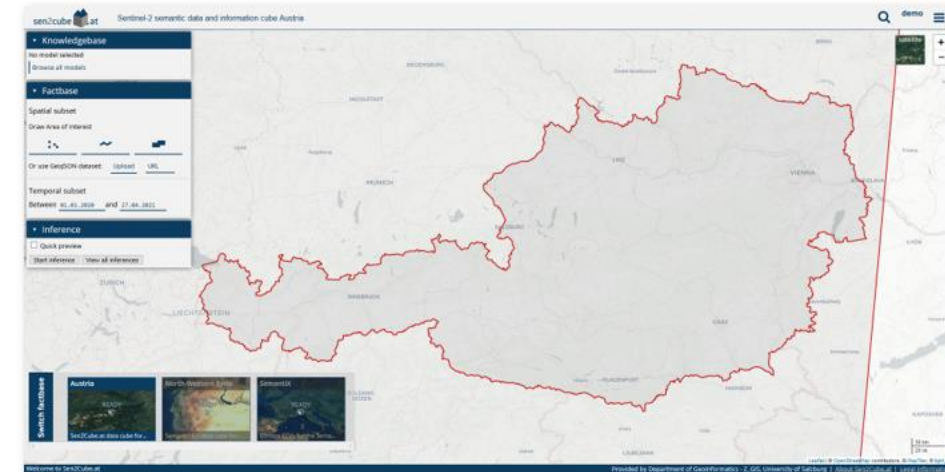
4 Semantic querying language with application-specific **visual models** and custom outputs:



2015 today 20 TB data 11.350 images



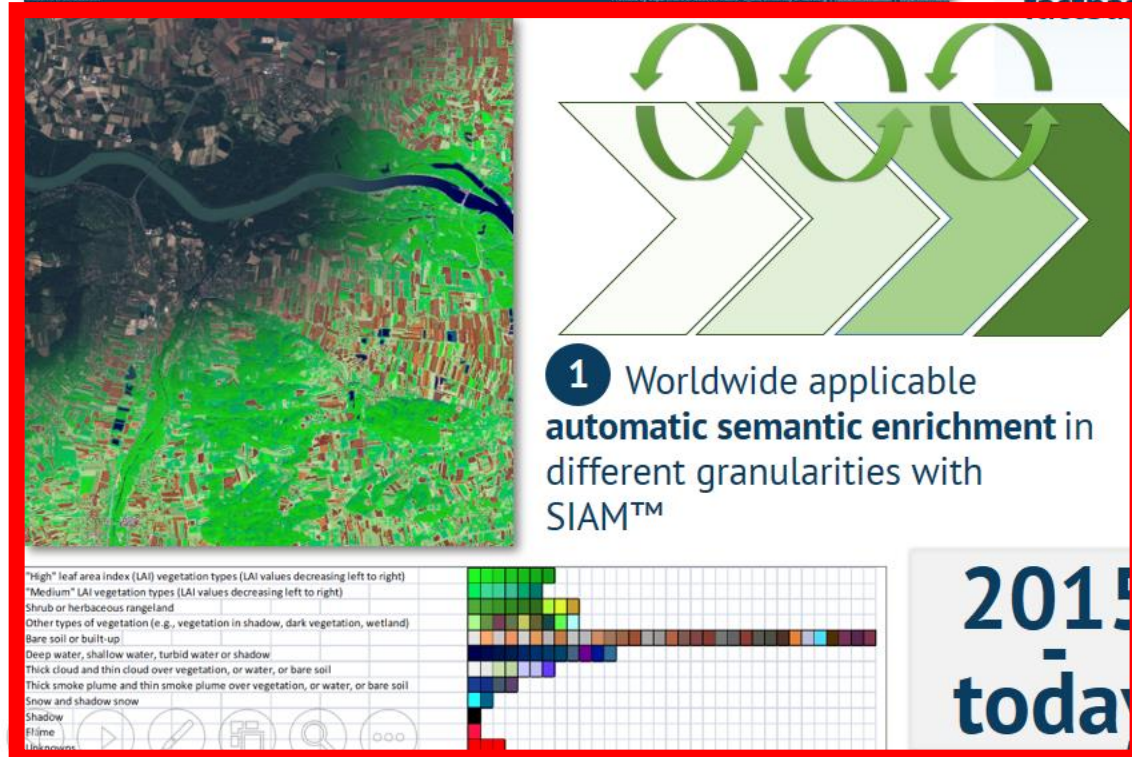
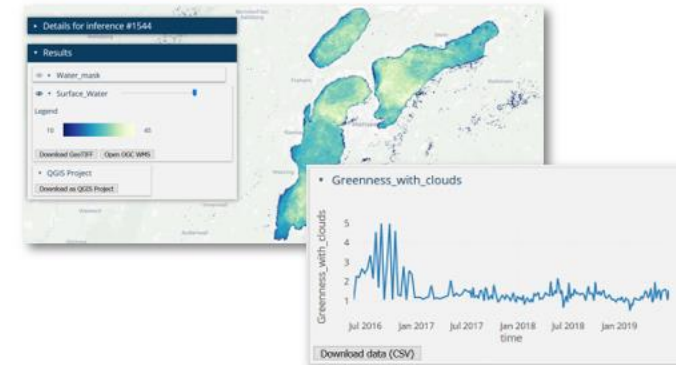
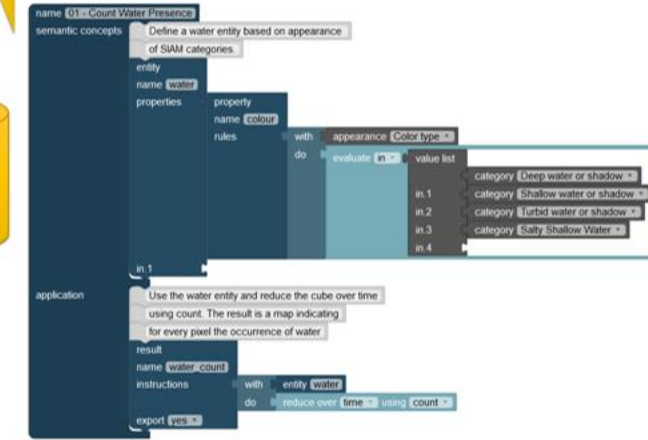
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2015  
today

20 TB  
data

11.350  
images



Sen2Cube.at is a project funded under the Austrian Space Applications Programme (ASAP 14)  
Poster created: April 2021





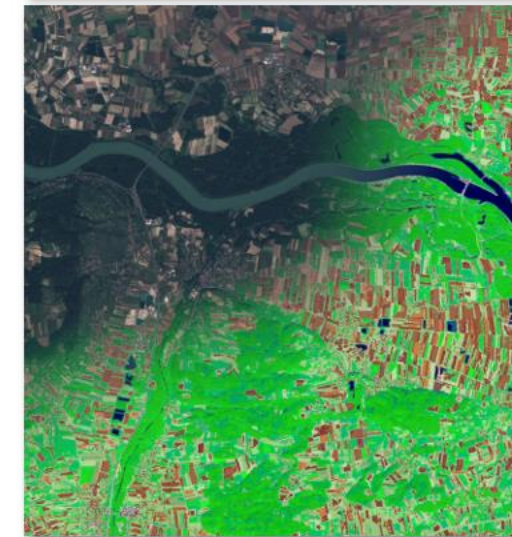
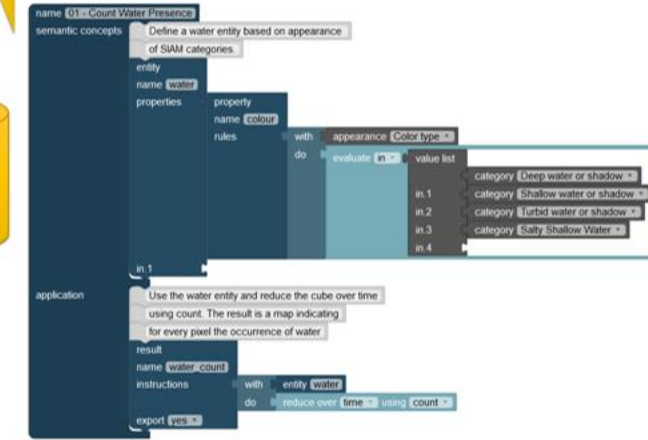
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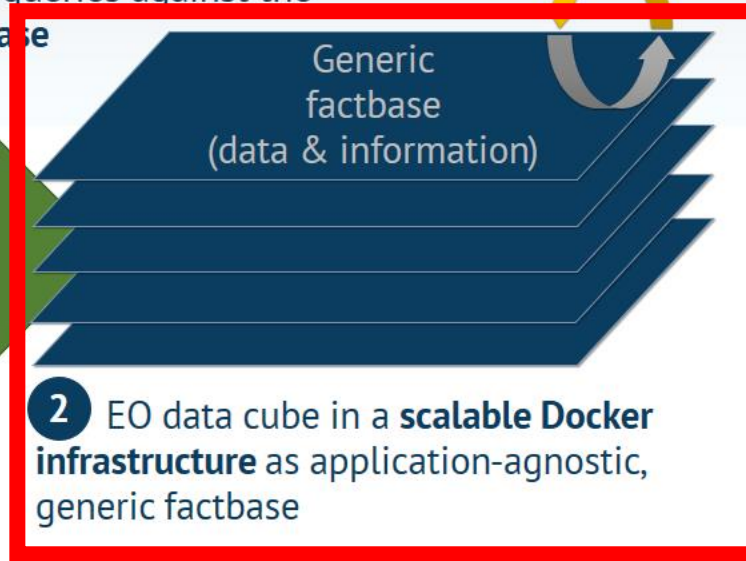
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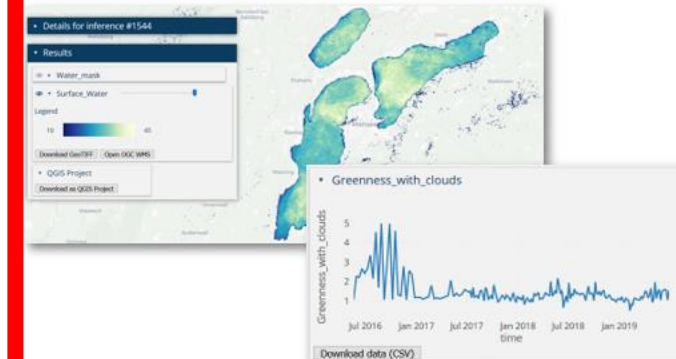
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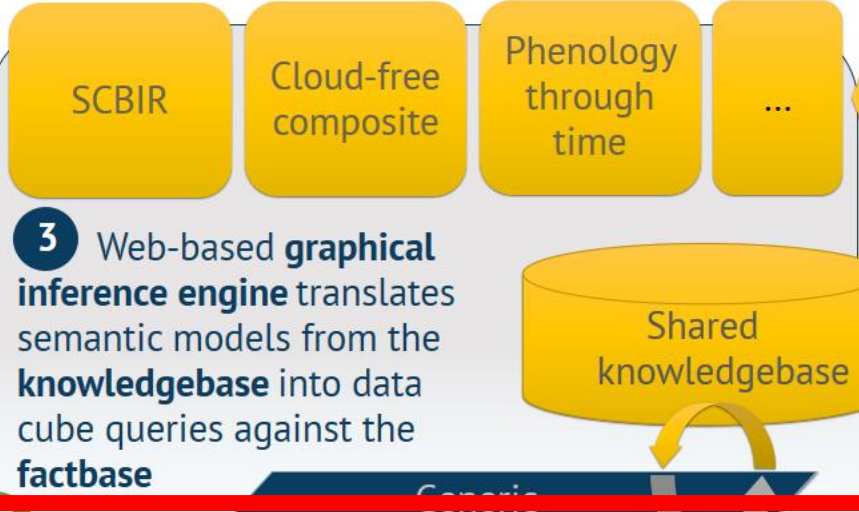
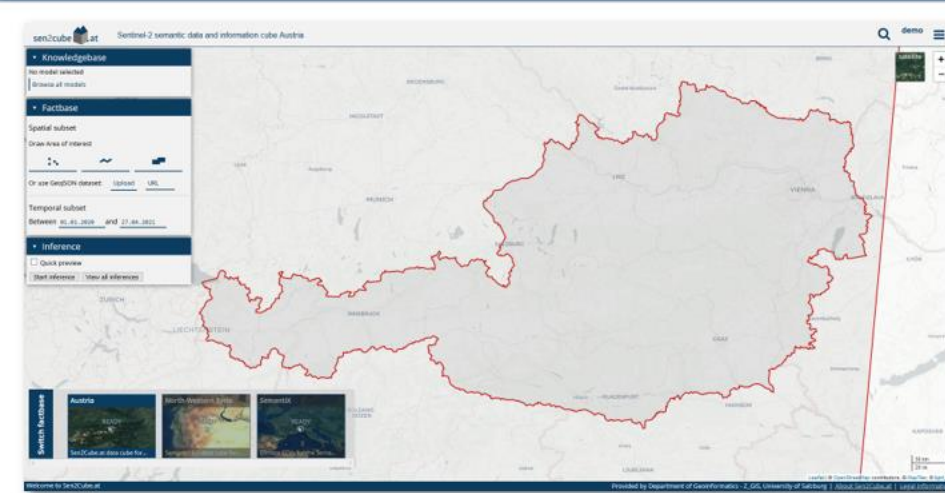


Sen2Cube.at is a project funded under the Austrian Space Applications Programme (ASAP 14)  
Poster created: April 2021

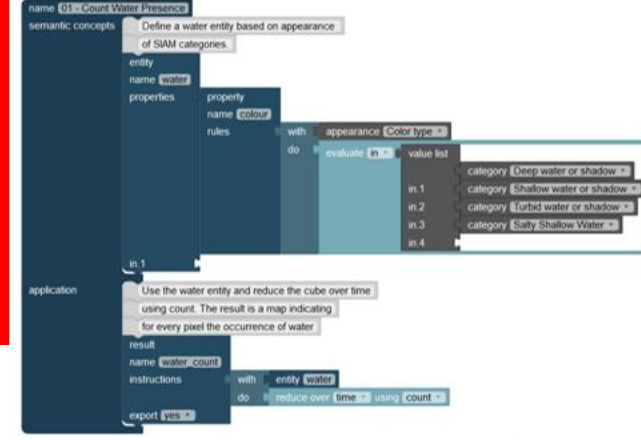




# The Sen2Cube.at national semantic Earth observation data cube for Austria

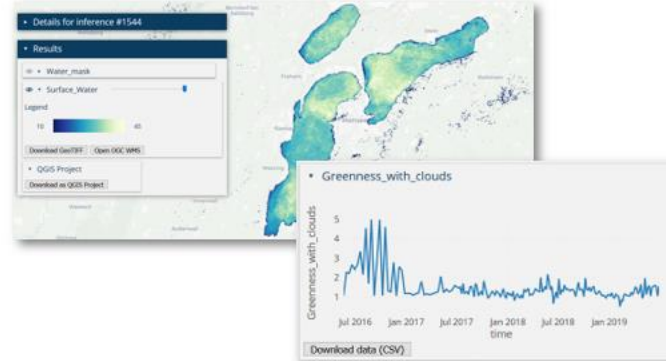


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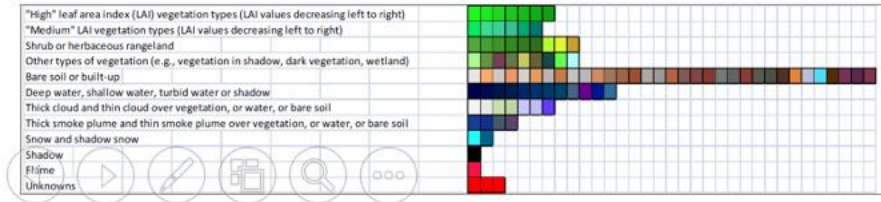
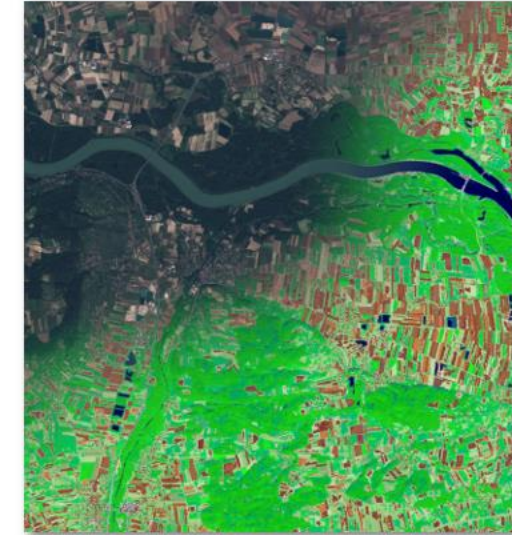
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2015 today 20 TB data 11.350 images



# The Sen2Cube.at national semantic Earth observation data cube for Austria

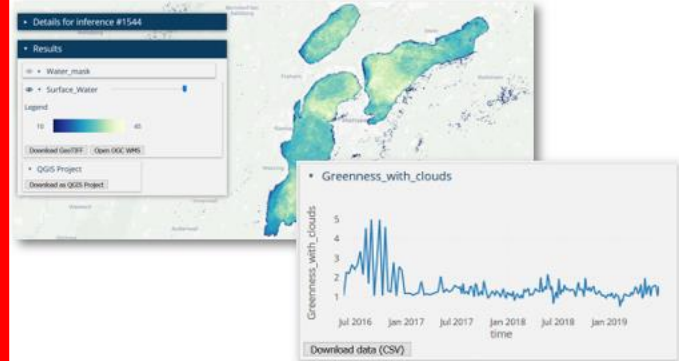
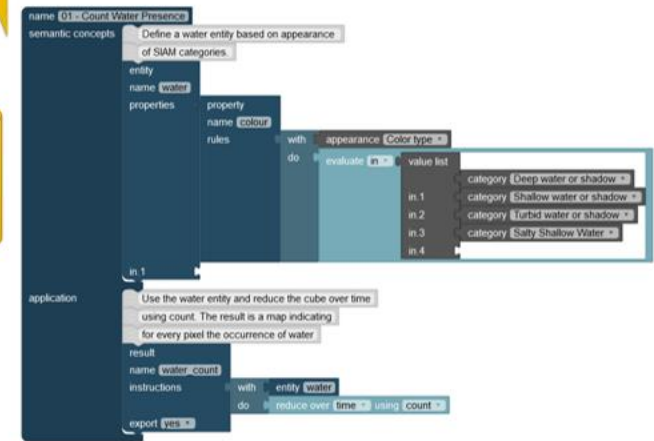


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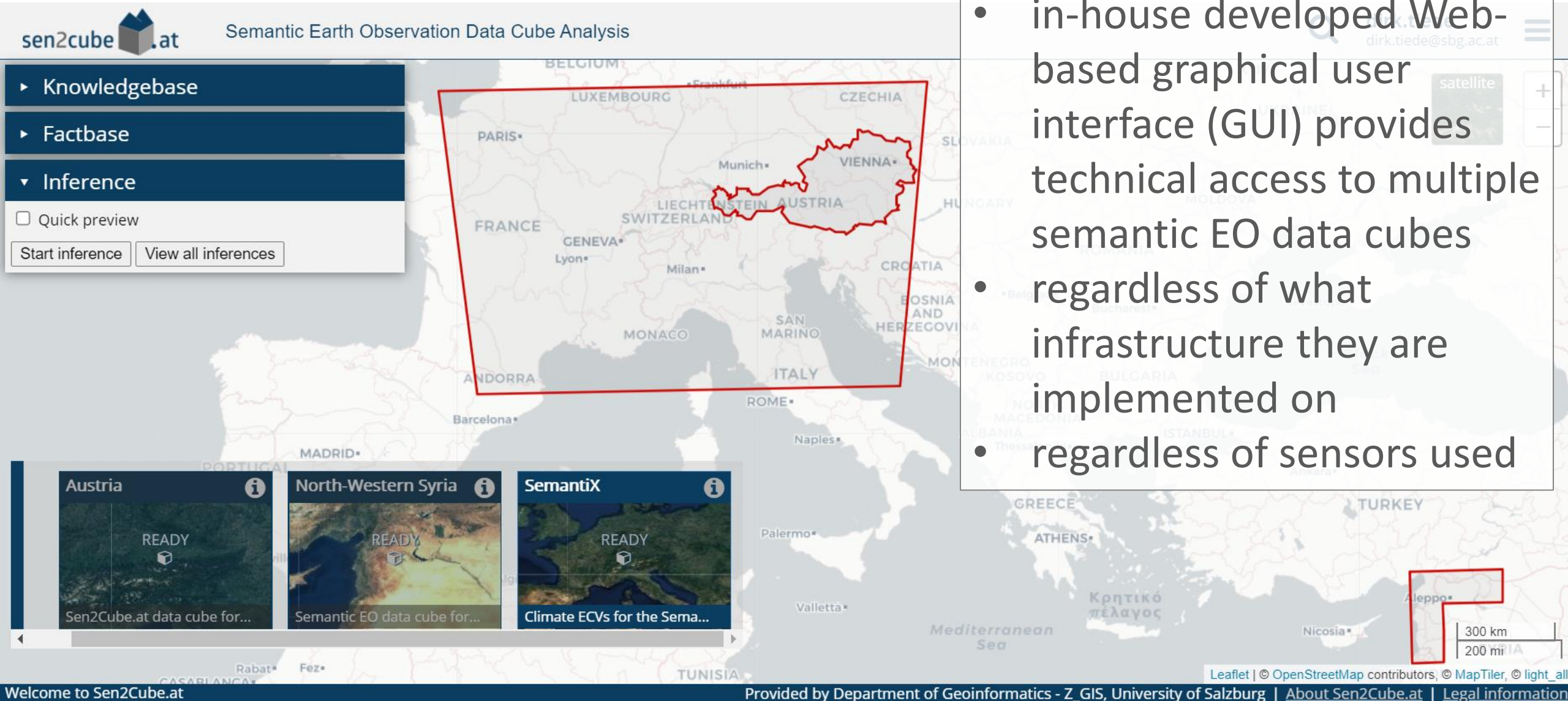
2015 today

20 TB data

11.350 images



# Accessing multiple semantic EO data cubes in one graphical user interface (GUI)



sen2cube.at Semantic Earth Observation Data Cube Analysis

- Knowledgebase
- Factbase
- Inference
  - ☐ Quick preview
  - Start inference View all inferences

Austria North-Western Syria SemantiX

READY READY READY

Sen2Cube.at data cube for... Semantic EO data cube for... Climate ECVs for the Sema...

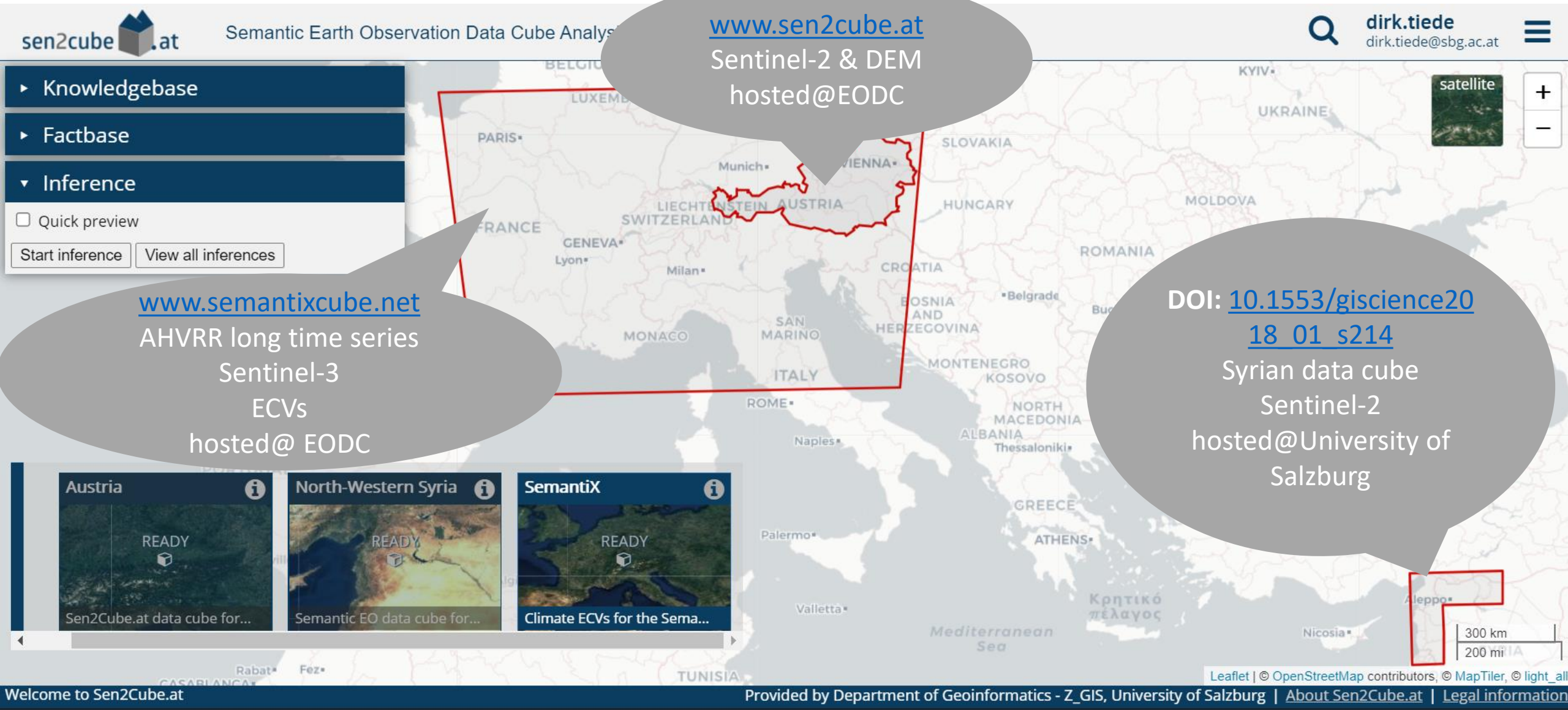
300 km 200 mi

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Welcome to Sen2Cube.at Provided by Department of Geoinformatics - Z\_GIS, University of Salzburg | About Sen2Cube.at | Legal information

- in-house developed Web-based graphical user interface (GUI) provides technical access to multiple semantic EO data cubes
- regardless of what infrastructure they are implemented on
- regardless of sensors used



# Accessing multiple semantic EO data cubes in one graphical user interface (GUI)



**sen2cube.at** Semantic Earth Observation Data Cube Analysis

Search: **dirk.tiede**  
dirk.tiede@sbg.ac.at

Knowledgebase  
Factbase  
Inference  
☐ Quick preview  
Start inference View all inferences

[www.sen2cube.at](http://www.sen2cube.at)  
Sentinel-2 & DEM  
hosted@EODC

[www.semantixcube.net](http://www.semantixcube.net)  
AHVRR long time series  
Sentinel-3  
ECVs  
hosted@ EODC

DOI: [10.1553/giscience2018.01.s214](https://doi.org/10.1553/giscience2018.01.s214)  
Syrian data cube  
Sentinel-2  
hosted@University of Salzburg

Austria  
READY  
Sen2Cube.at data cube for...

North-Western Syria  
READY  
Semantic EO data cube for...

SemantiX  
READY  
Climate ECVs for the Sema...

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# Accessing multiple semantic EO data cubes in one graphical user interface (GUI)

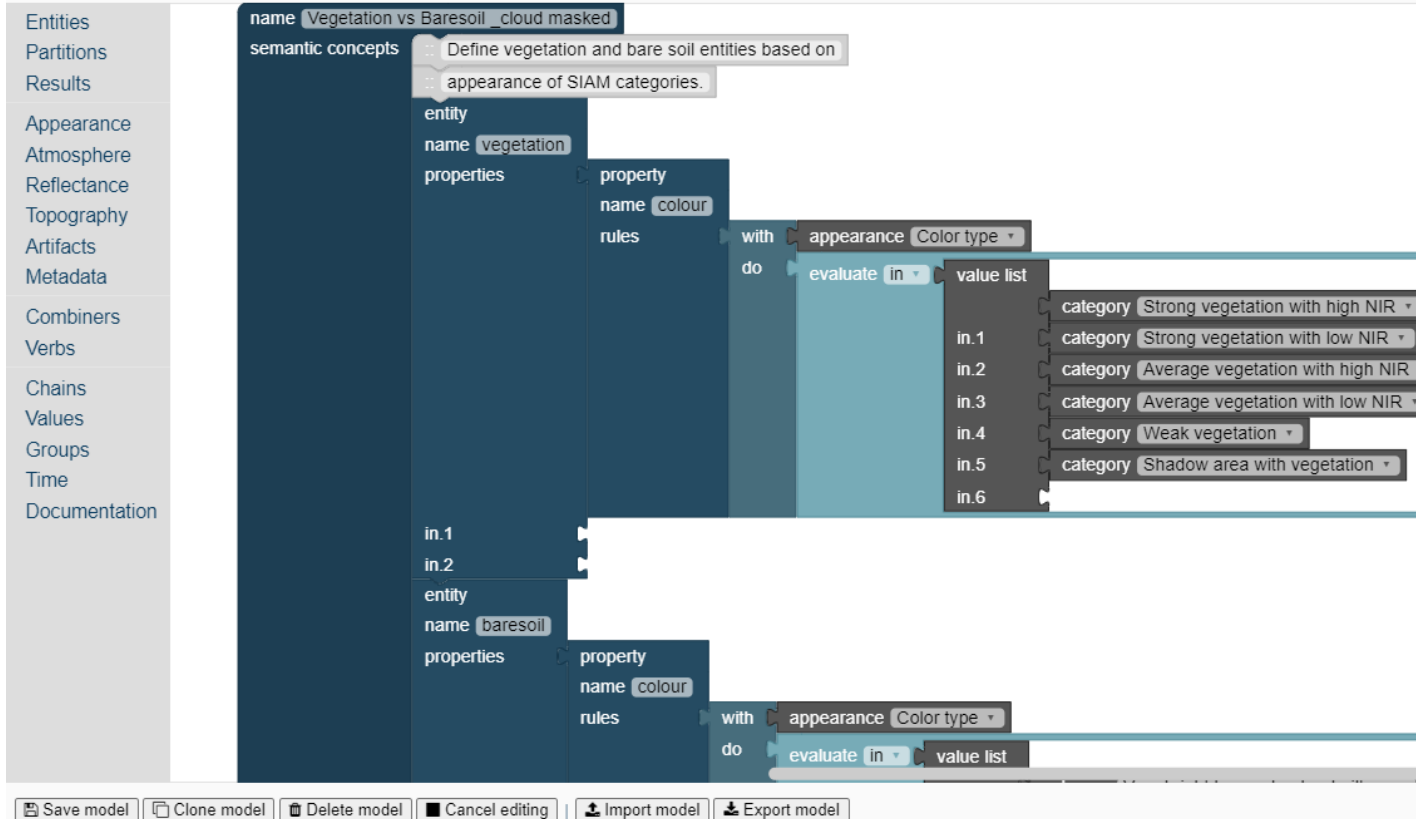
- GUI is designed to create semantic models using a graphical language
- an inference engine is able to evaluate these models against existing semantic EO data cubes based on a user's defined area and timespan of interest
- Examples can be:
  - Semantic content based image retrieval
  - Complex analysis of land cover/ land cover change through time
  - On-the-fly cloud free mosaics through time in any user defined time span
  - Etc...
- Querying on a semantic level allows the transferability of semantic models across EO data cubes



# Demo

Knowledgebase: Edit model

Model: Vegetation vs Baresoil \_cloud masked



Semantic model to analyse vegetation versus bare-soil occurrence over time based on semantic categories (**no thresholds used, no programming skills necessary**)

- Results are in addition cloud/snow filtered also based on the available semantic categories
- Models can be seen as explainable AI, combining physical model based semantic enrichment + human expert knowledge in the model generation
- Reproducible / transferable between AOIs and data sets / different sensors



# Cloud masked vegetation vs bare soil comparison across cubes and sensors





# Outlook - Applications



**SemantiX**

opening EO data to the public

- inferences on ECVs (essential climate variables as semantic elements) using the same Web-frontend
- Eventually users will run inferences via a citizen science mobile app...

Project partners:

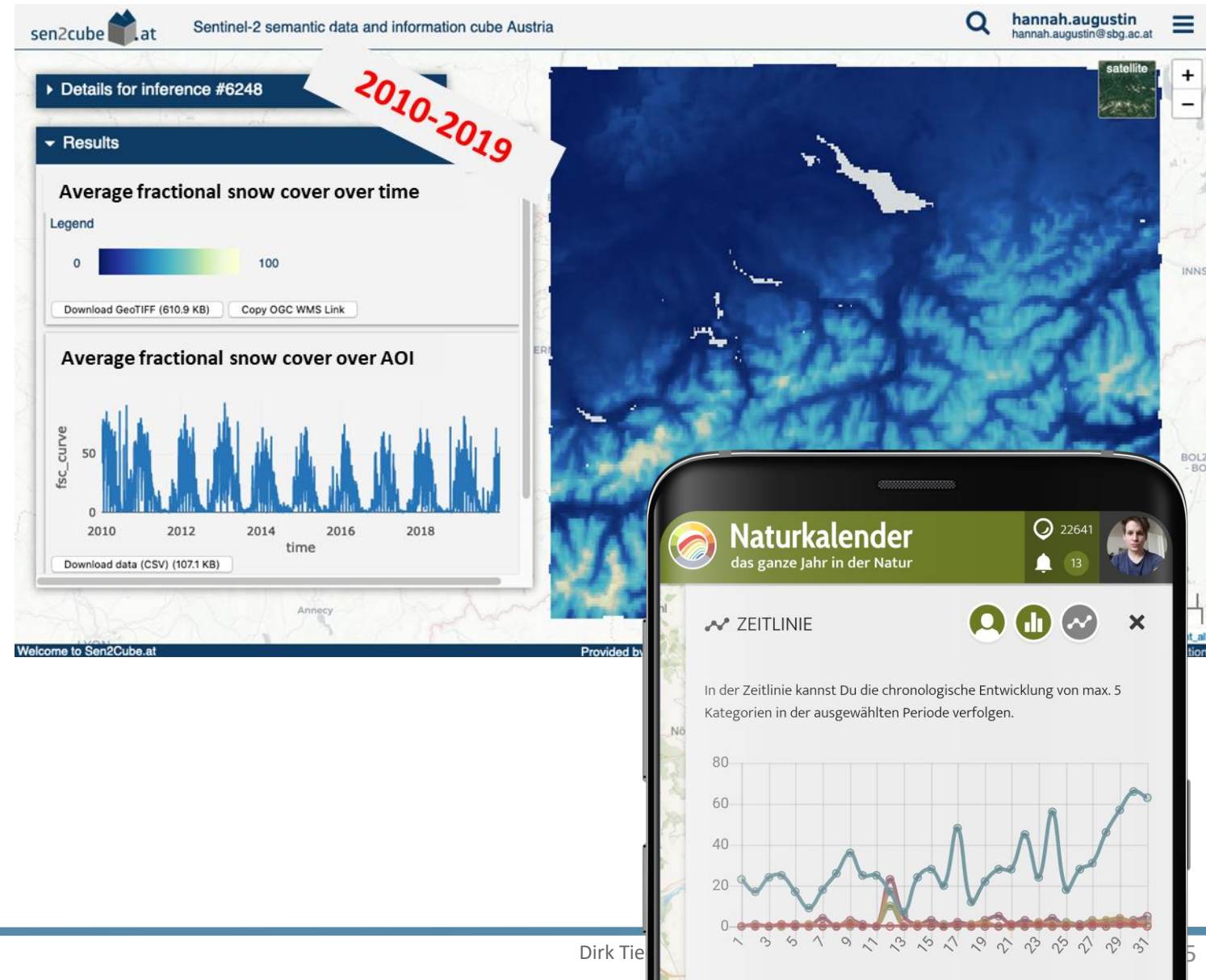
**u<sup>b</sup>**

**UNIVERSITÄT  
BERN**

 **spatial**services

**SPOTTERON**

**Z\_GIS**



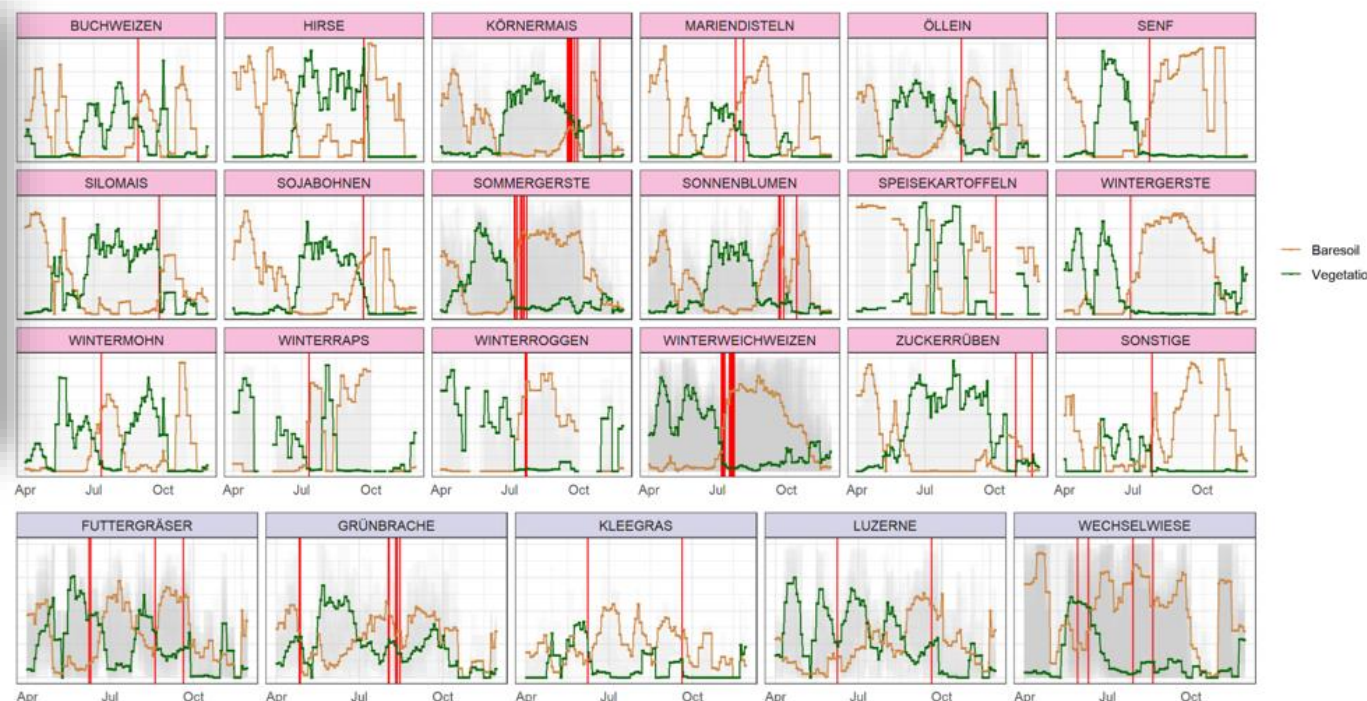
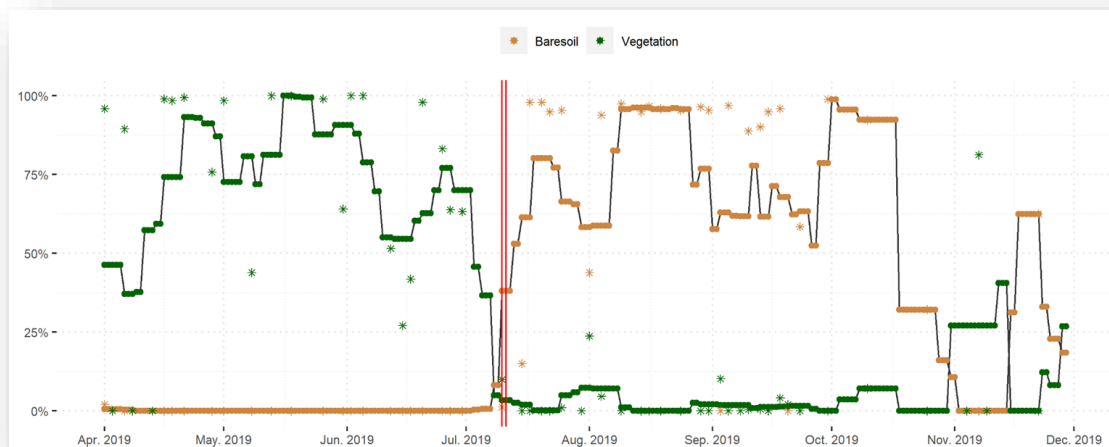


# Outlook - Applications

- Automatic detection of mowing and harvesting events within semantic EO data cubes using semantic concepts instead of vegetation indices only



Time series per parcel: SIAM groups



In cooperation with





# Outlook - Applications

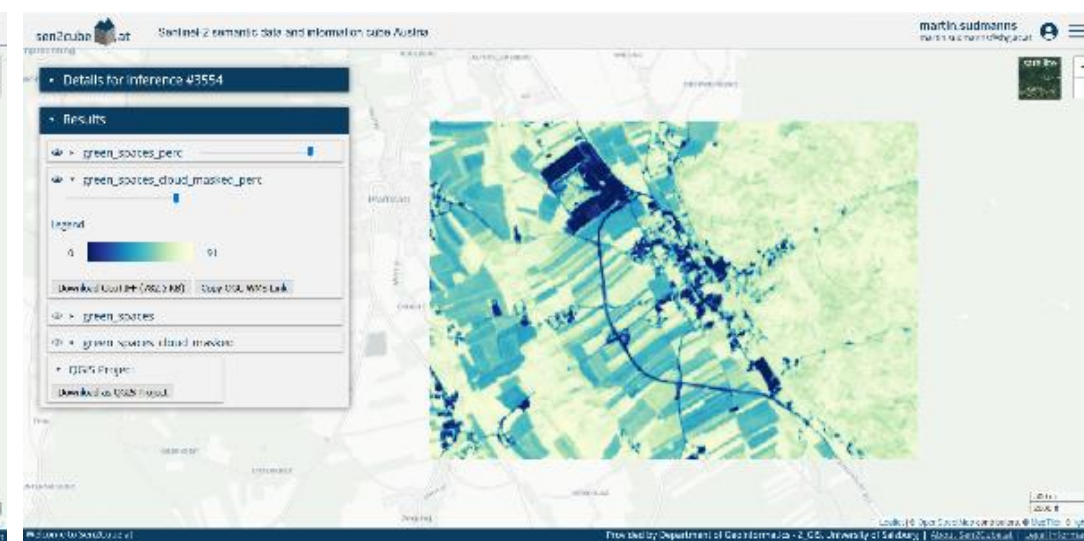
## *SIMS* (soil sealing identification and monitoring system, ASAP 17):

- improve analysis of human-induced soil sealing processes and support monitoring, decision-making and reporting activities in Austria.
- remove barriers between EO midstream technology and downstream applications by allowing non-experts to conduct custom big EO data analysis on-demand in an interactive, reproducible, repeatable and easily accessible approach

Query with datasets between 2015 and 2016 (left) and between 2016 and 2020 (right).

Distinctly visible in the comparison of the two results is the newly constructed road (Munderfing, Upper Austria).

→ quantification of changes and detection of events within a single query in semantic EO data cubes





# Thank you for your attention!

Assoc Prof Dr Dirk Tiede | Head EO Analytics  
University of Salzburg | Department of Geoinformatics - Z\_GIS  
E-mail: [dirk.tiede@sbg.ac.at](mailto:dirk.tiede@sbg.ac.at)



**SemantiX**  
opening EO data to the public

SemantiX is funded by the Swiss Space Office (SSO) and FFG under the Austrian Space Applications Programme (ASAP 16).



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