

Wall-to-Wall Material Stock Mapping

A concept from Satellite Data to
Material Stock Mapping

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Background and Objectives

Material Stocks Modeling

There are two major approaches to material stocks surveys.

Top-down approach

- **Deduces** stock estimation from (national) **statistics**.
- Can be easily applied to **large areas**.

e.g. Fishman et al. 2014,
Wiedenhofer et al. 2015, Krausmann
et al. 2017, ...

Bottom-up approach

- **Induces** large area stock amounts from **single features**.
- Studies **small areas** and **aggregates** possible stock distribution.

e.g. Tanikawa et al. 2010, Kleemann
et al. 2016, Kleemann et al. 2017,

Remote Sensing for
material stocks mapping

Background and Objectives

Remote Sensing for Material Stocks Modeling

Remote Sensing offers a top-down perspective on material stocks over very large areas at a high spatial resolution.

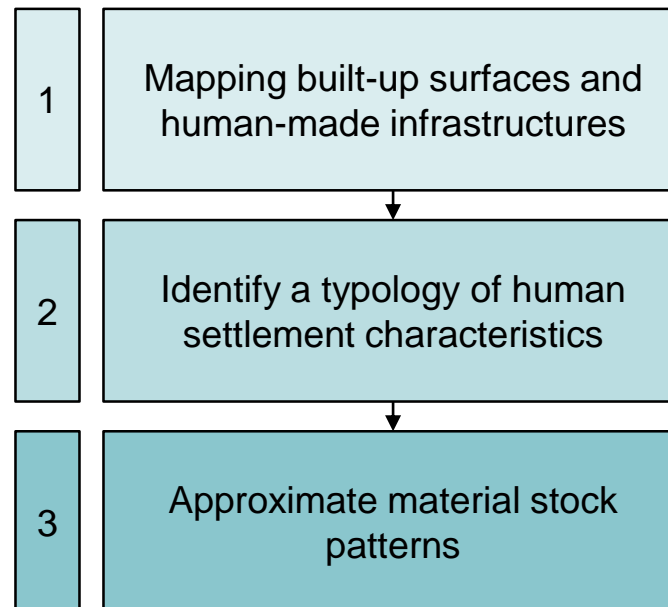


- Remote Sensing (RS) is **widely used** for land cover and land use mapping and could contribute to stocks modeling by **mapping stock-related features**.
- RS offers an **independent** top-down approach.
- Recent optical and radar sensors offer **worldwide consistent data at 10m resolution**.
- There is a **large method set** available for automated satellite imagery analysis.

Data and Methods

The Approach

We envisage a three-step approach to approximate material stock distribution in space and create wall-to-wall stock maps.



Data and Methods

Wall-to-Wall Land Cover Mapping

In a first step, land cover continuous fields mapping tells us where to look for stocks.

Data

Optical and radar remote sensing

Method

Machine Learning
Regression with
synthetic mixing

Product

Fractional multi-
class land cover
product



Sentinel-2

Best temporal coverage:
max 5/10 days since 2017
Spatial resolution: 10/20m
Spectral bands: 10 (13)

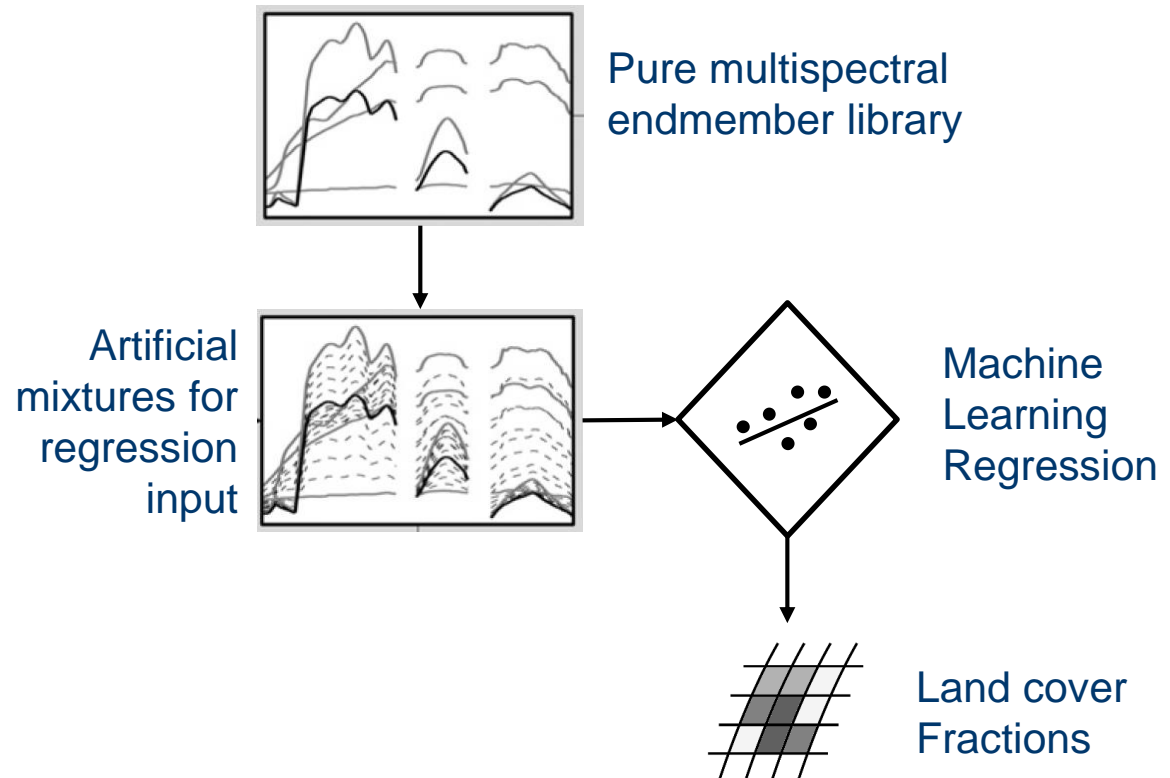
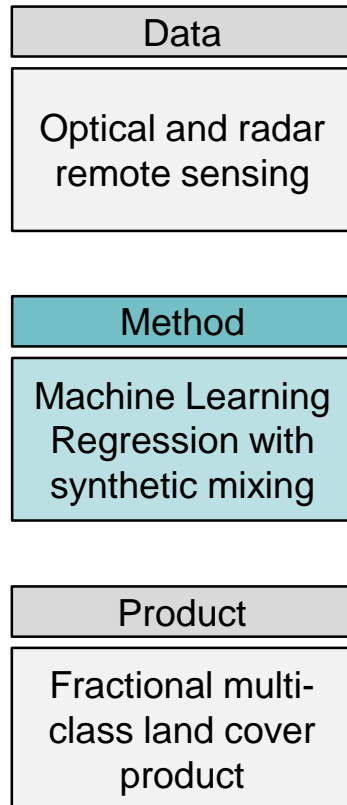


Sentinel-1

Best temporal coverage:
1-3 days since ~ 2014/16
Spatial resolution: 10m
Technology: C-Band SAR

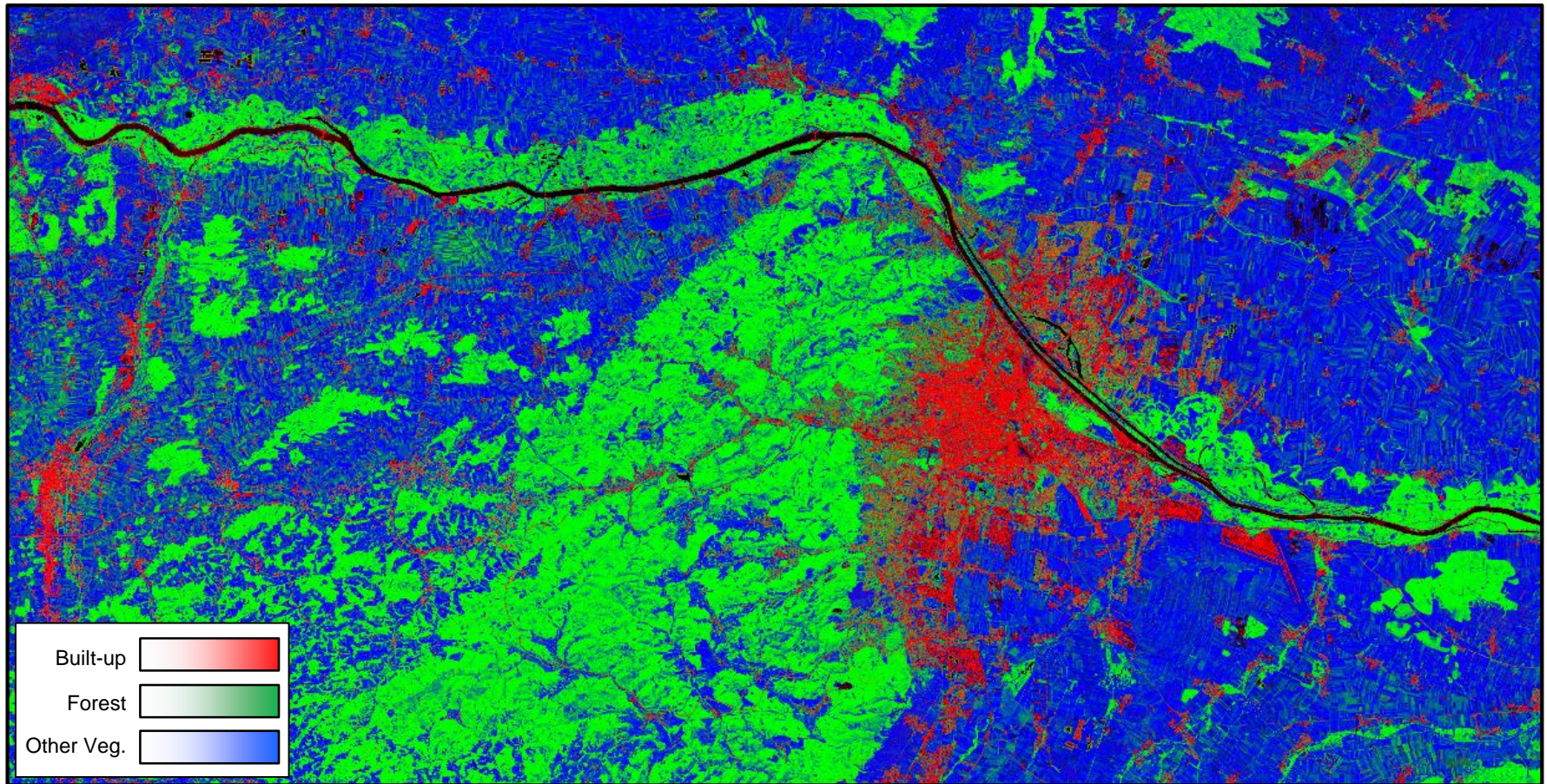
Data and Methods

Wall-to-Wall Land Cover Mapping



Data and Methods

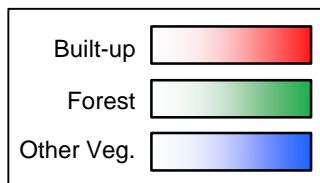
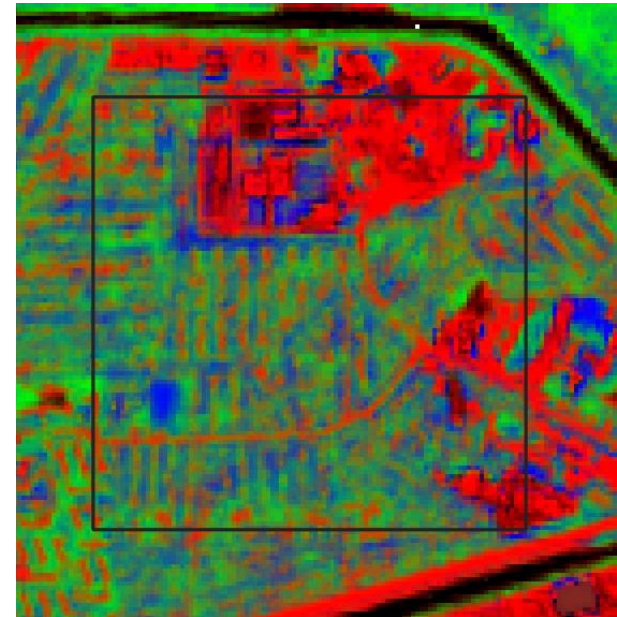
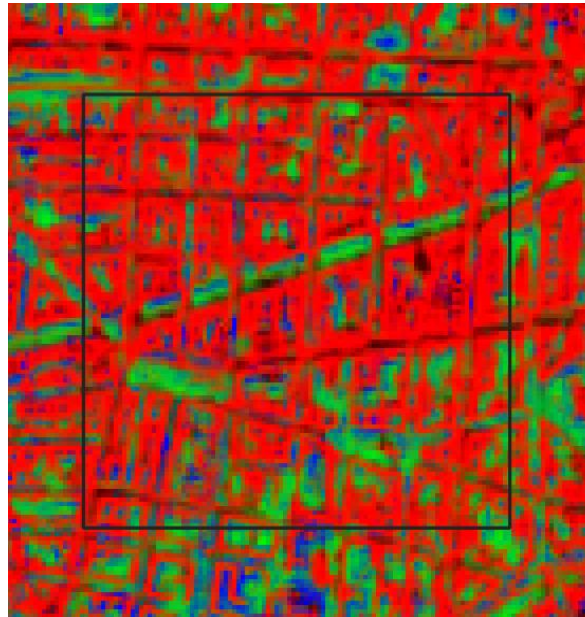
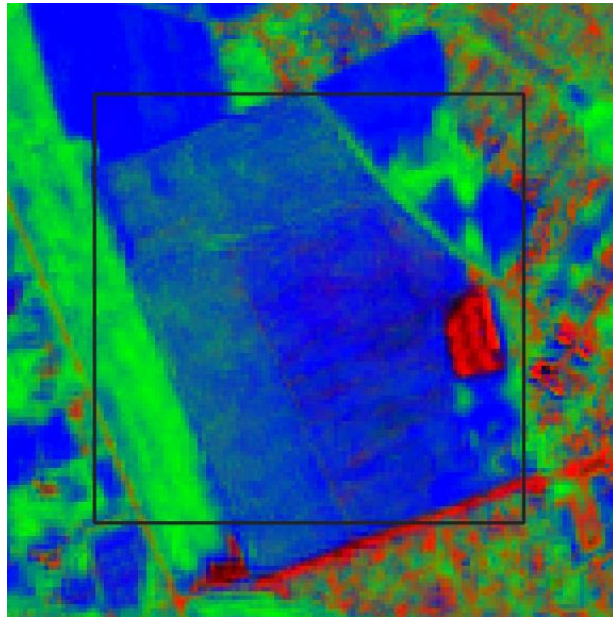
Wall-to-Wall Land Cover Mapping



- We can map land cover fractions of built-up surfaces, woody vegetation, non-woody vegetation and soil.

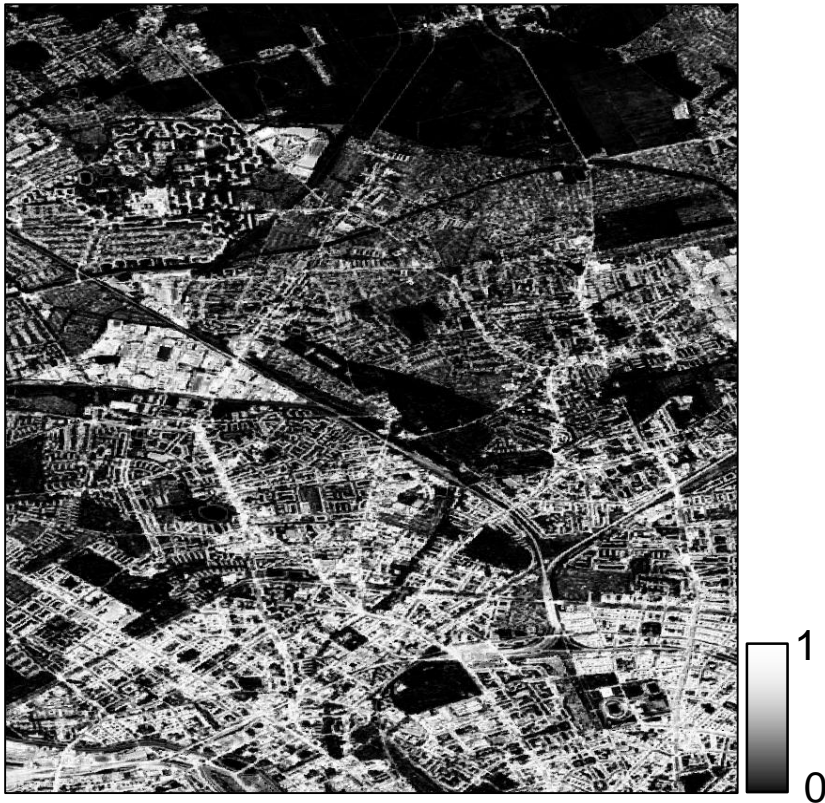
Data and Methods

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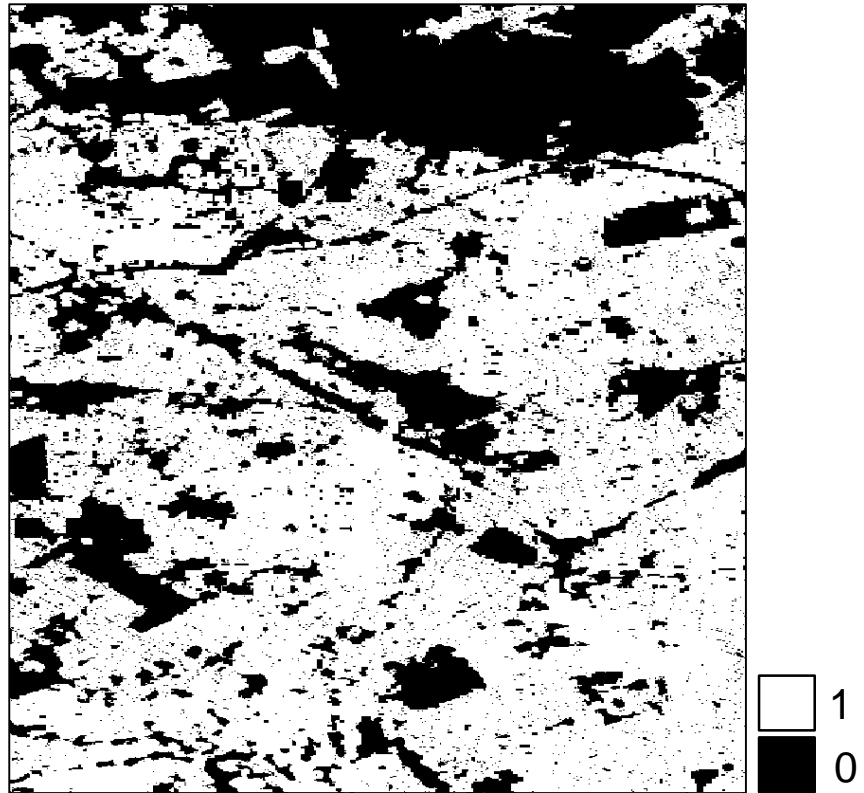


Data and Methods

Wall-to-Wall Land Cover Mapping



Built-up/infrastructure fractions, continuous



Global Urban Footprint, binary

Data and Methods

Wall-to-Wall Land Cover Mapping

Methodological Challenge of mapping land cover over large areas:
Phenology & Spectral resemblance



Data and Methods

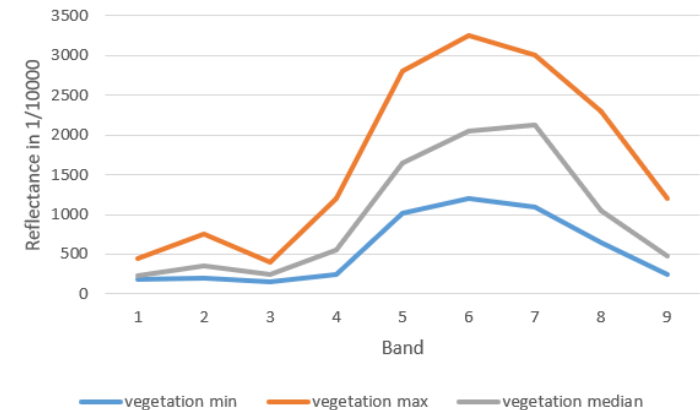
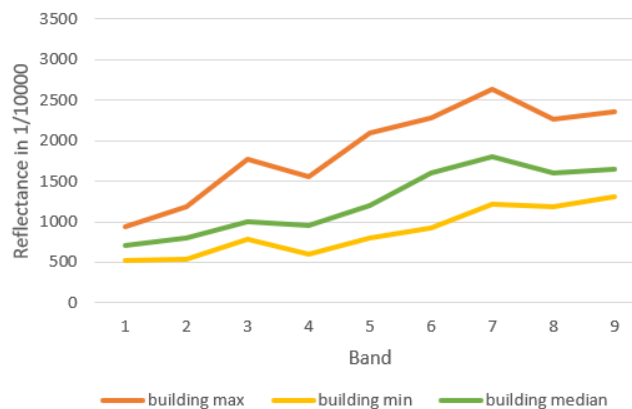
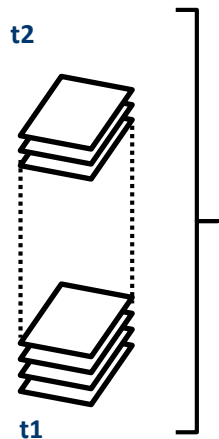
Wall-to-Wall Land Cover Mapping

Methodological Challenge: Mapping land cover over large areas

Seasonal land cover types have spectral variance

Some surface cover types **resemble spectrally**

Approach: Spectral-temporal metrics from image time series



Temporal Metrics of Sentinel-2 spectra / built-up (left) and vegetation (right)

Data and Methods

Wall-to-Wall Land Cover Mapping

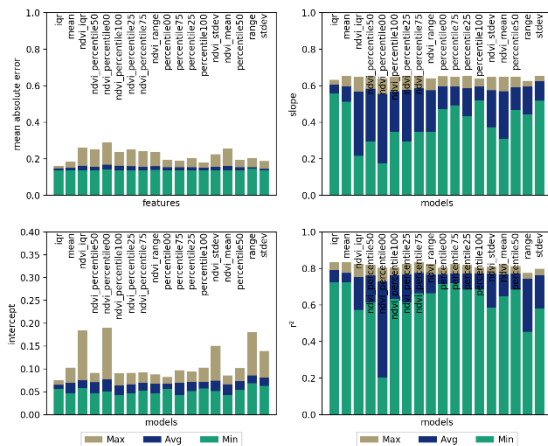
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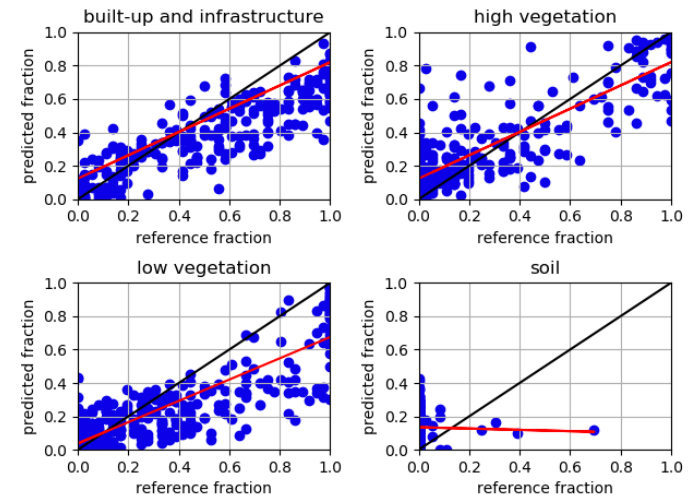
Quality metrics, max/min/avg per feature, imperviousness



Feature combination 1
Feature combination 2

...

Feature combination n



Systematic feature quality analysis

For each of about 1.000 models with a unique input feature combination

Example quality assessment for one model

Stable and robust land cover fraction model over large areas.

Data and Methods

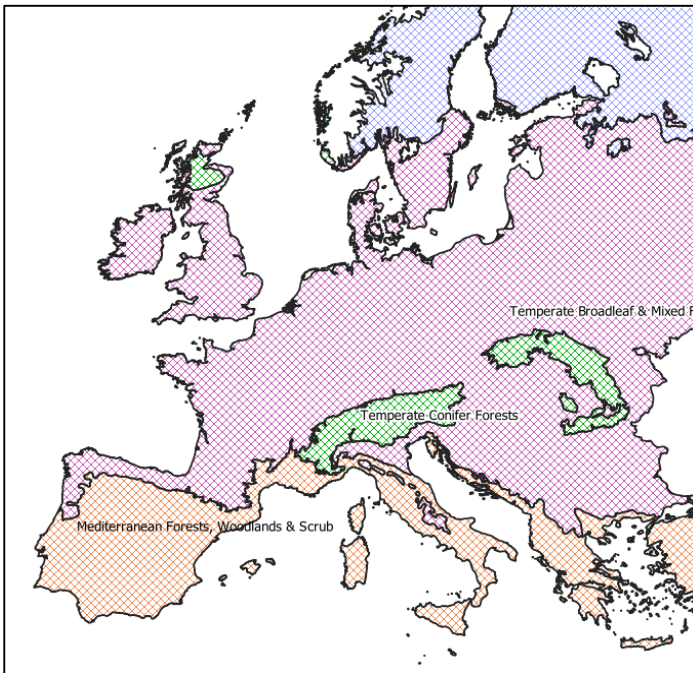
Wall-to-Wall Land Cover Mapping

Methodological Challenge: Mapping land cover over large areas

Spectrally different materials for built-up surfaces

Regional phenological differences affect methodology

Approach: Generalizing regression models over very large areas



How *regional* does a model need to be?

Can biomes, ecoregions (Olson et al. 2001), urban ecoregions (Schneider et al. 2010) or other concepts contribute to delineate regional models for land cover mapping?

Data and Methods

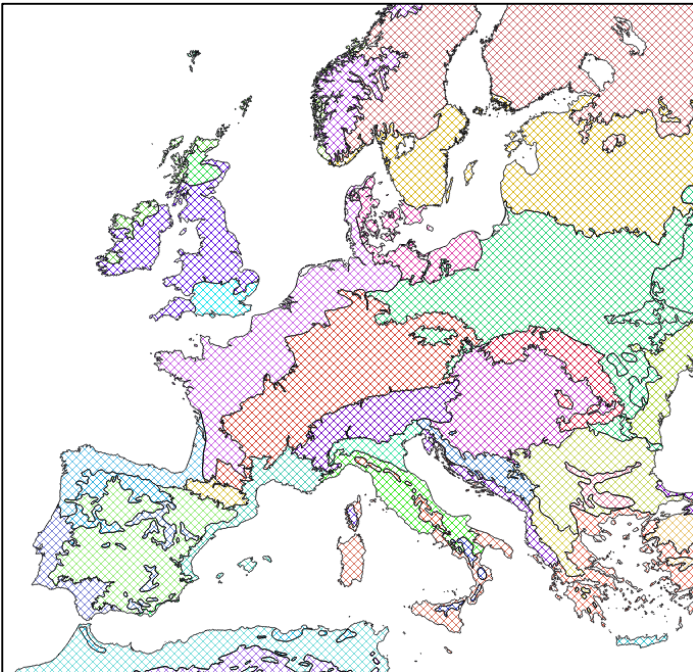
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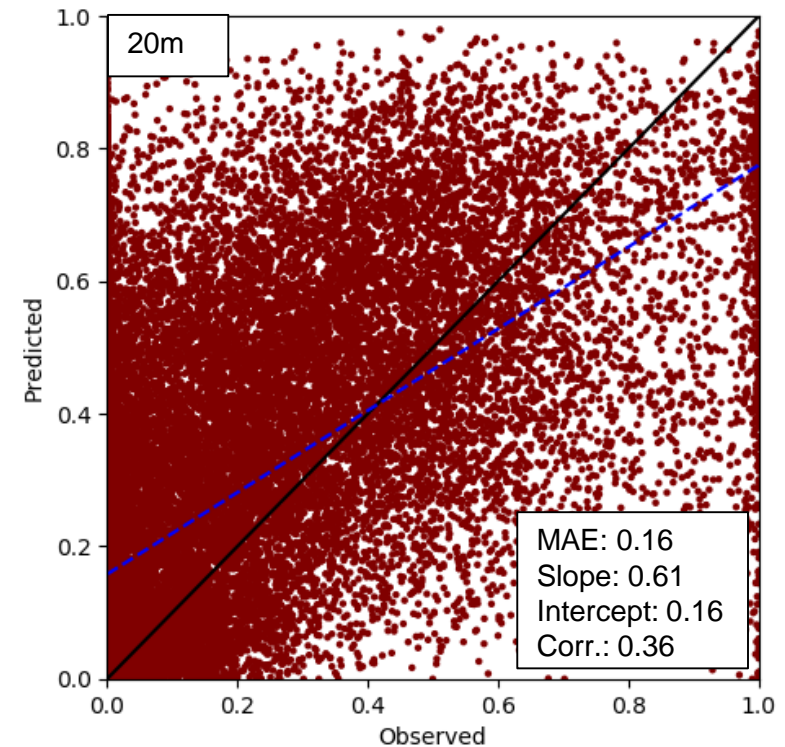
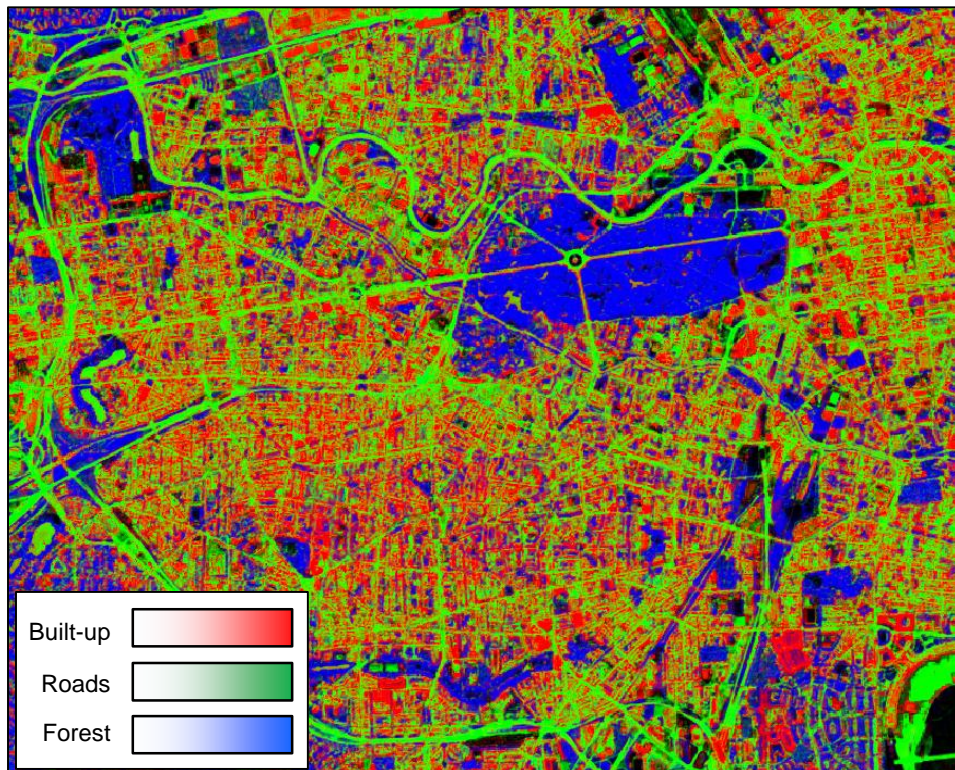
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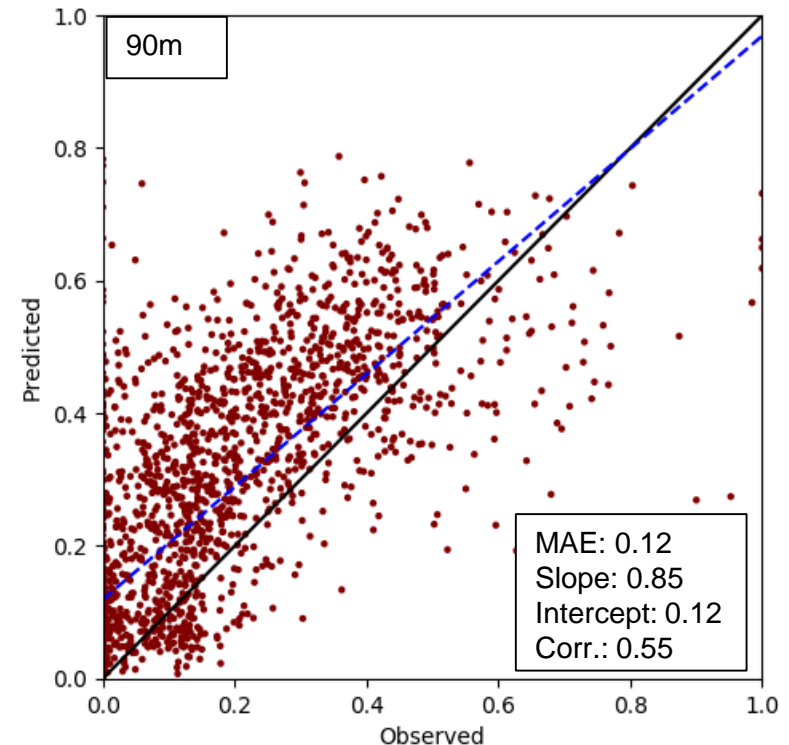
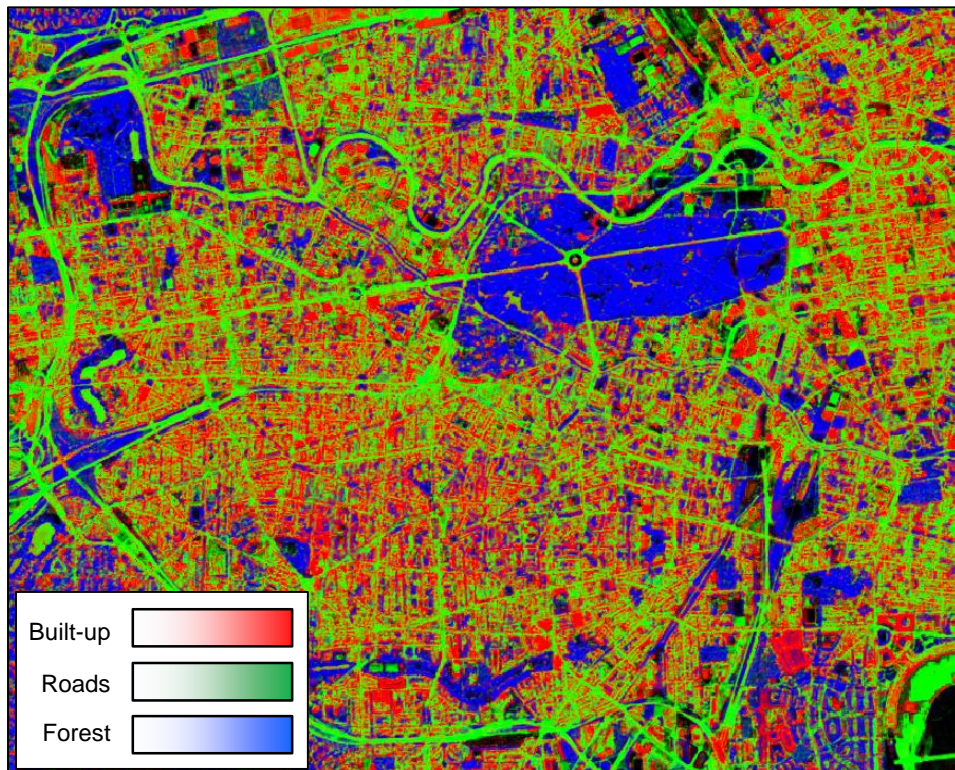
Experimental: Using Sentinel-1 radar imagery for distinguishing buildings from other built-up surfaces



Data and Methods

Wall-to-Wall Land Cover Mapping

Experimental: Using Sentinel-1 radar imagery for distinguishing buildings from other built-up surfaces



Data and Methods

Settlement Characterization

In a second step, settlement characteristics work as an indicator for material stock usage and patterns in the built environment.

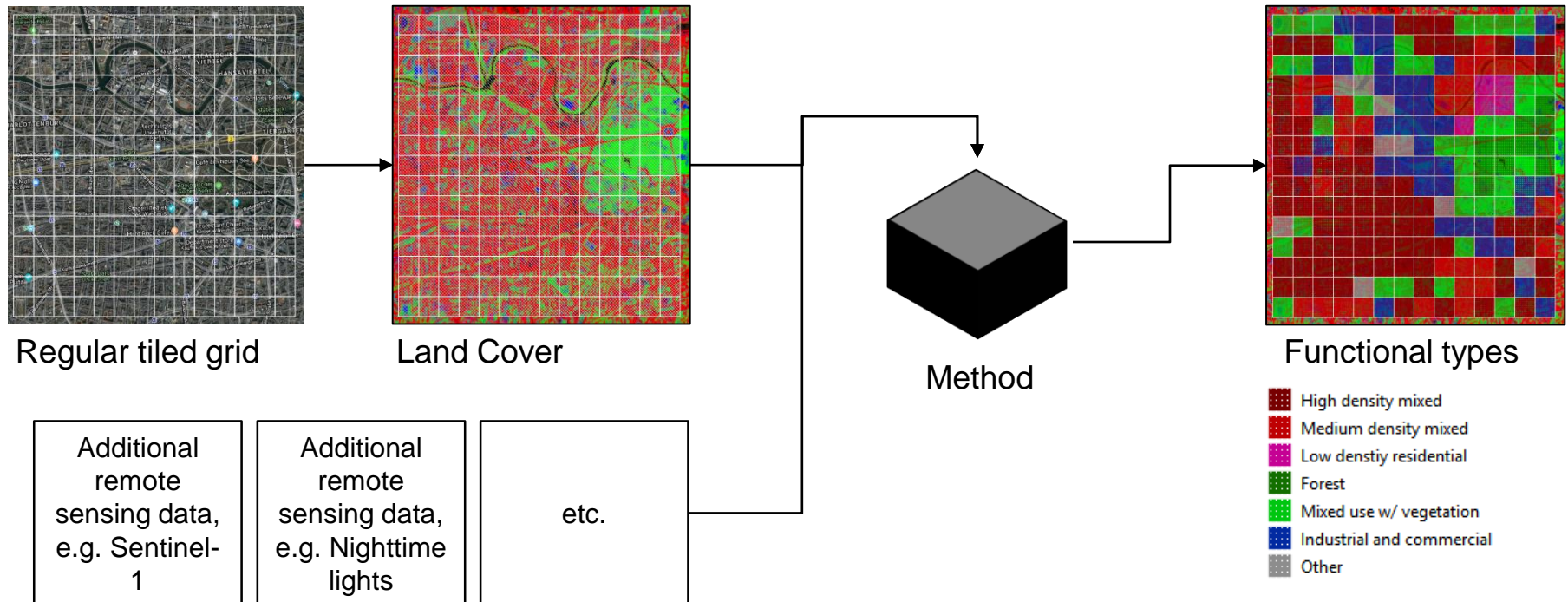
Build a **framework of target features for settlement characteristics** from remote sensing.

Indicator	Example values
Land cover	Built-up, Forest, Water, ...
Building density	High, Medium, Low,...
Building height	Very high, High, Medium,...
Urban form	Regular squared, European, Large patches
Structure type	Wooden, Wooden-brick, Brick, Concrete
Green component	Forest, Garden, Park, None
Function	Residential, Commercial, Industrial,...
...	...

Data and Methods

Settlement Functional Types

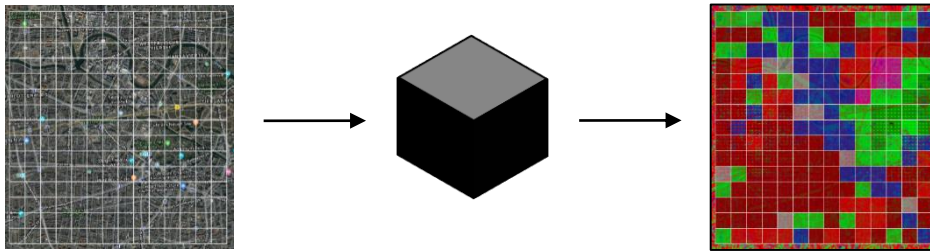
One challenging example is the identification of functional types.



Data and Methods

Settlement Functional Types

One challenging example is the identification of functional types.



Open Questions

... which framework for functional types to use?

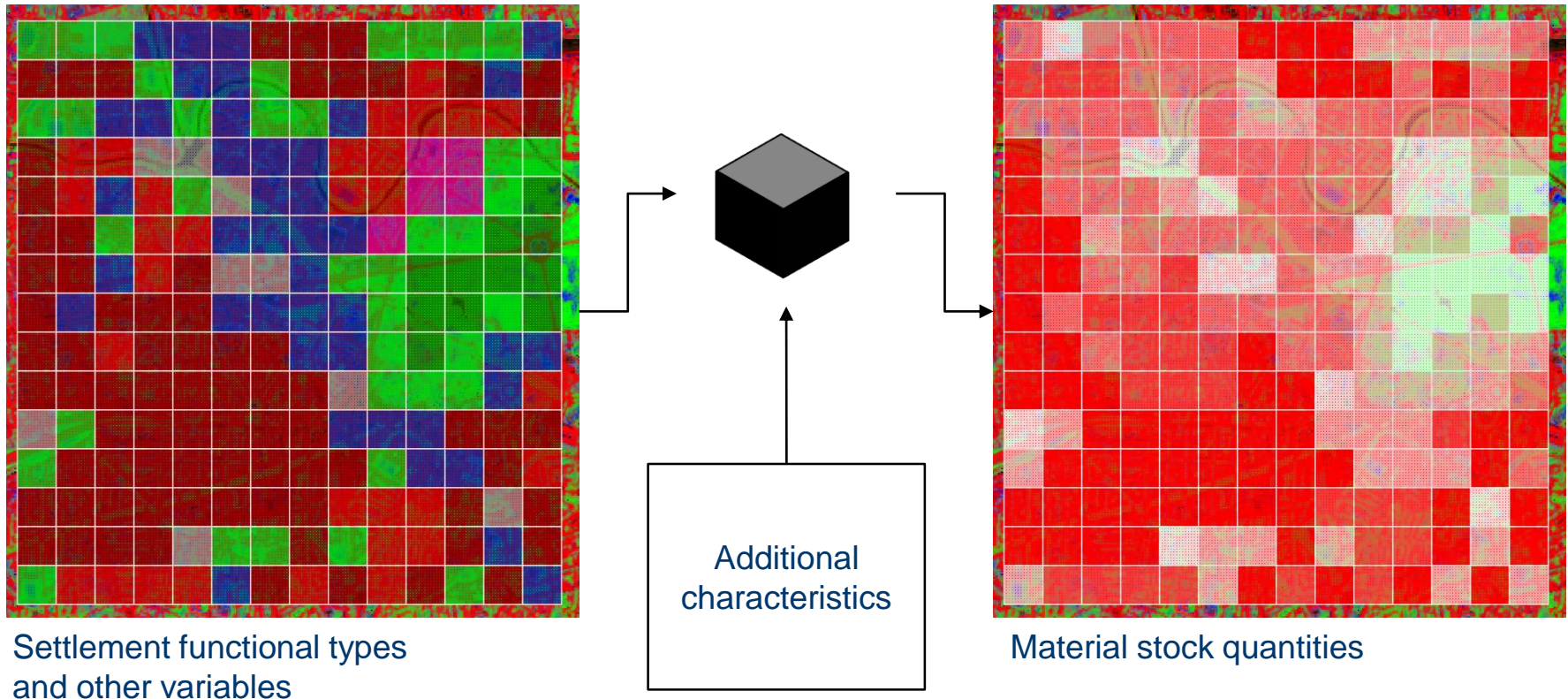
... what is a *homogeneous* settlement or neighborhood?

... what data, besides land cover, provides indicators for settlement functions?

Data and Methods

Linking Remote Sensing to Material Stocks

In a third step, information about human built-up features and their character are used to approximate material stock distribution.



Discussion

- Target variables for material stock estimation
- Framework for settlement typology
- Relate settlement characteristics to stocks
- Role of regional differences
- Thematic accuracy vs. methodological flexibility
- The role of socio-economic factors
- What can or can we not see with remote sensing

Thank you for your attention!



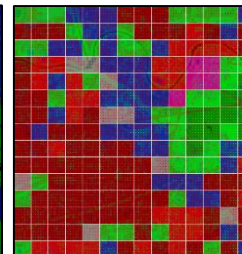
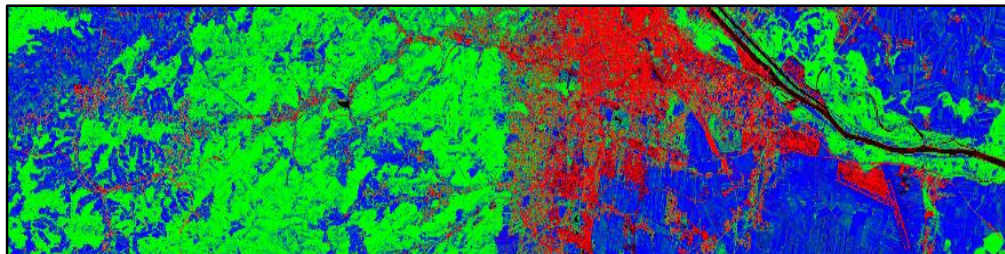
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