Gauss Centre
“the temporal change of geospatial data”

Research agenda in the context of SDGs

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Motivation

Sustainable development goals (SDGs):

Relevance of land cover in the context of SDGs:

- Current status

→ What is there?

→ Planning of future.

- Evolution

→ Monitoring

→ Trends in changes?

→ Connection to social, and economic factors?

Motivation

Example „Goal 11 – sustainable cities and communities“:

Land cover (classification): Knowledge
- → Sealed areas
- → Vegetation

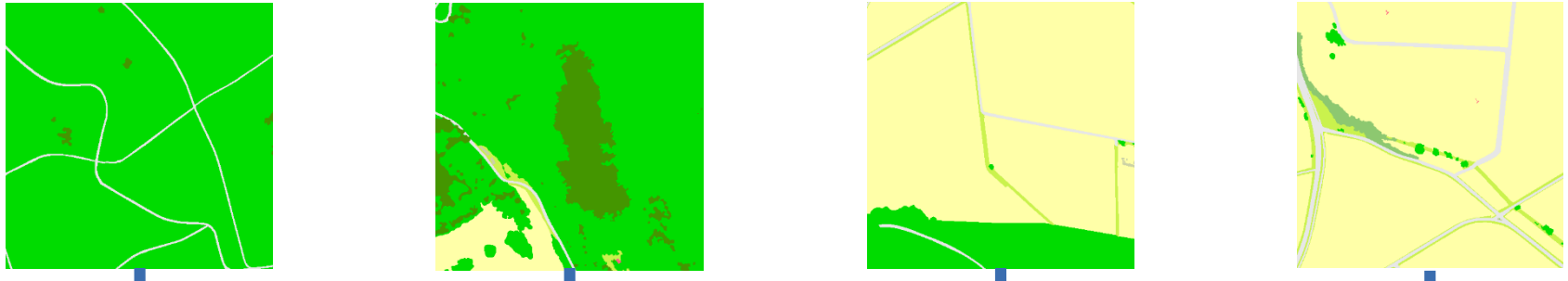
Goal 11:
- → Determine urban park
- → Need for green areas
- → Growth of a citiy

Motivation

Project goal: automated classification, organization, and analysis of geospatial data of varying age and quality

Geodata:

Land cover:



Time:

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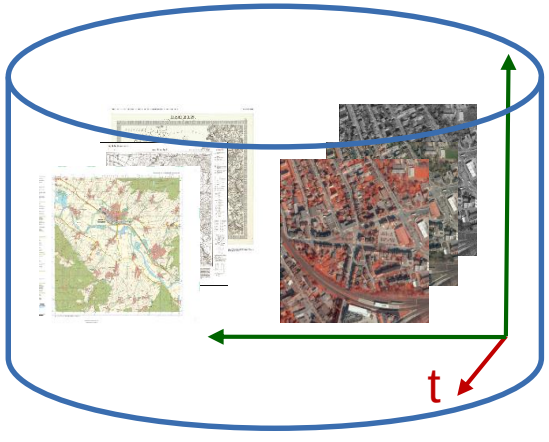
Project overview

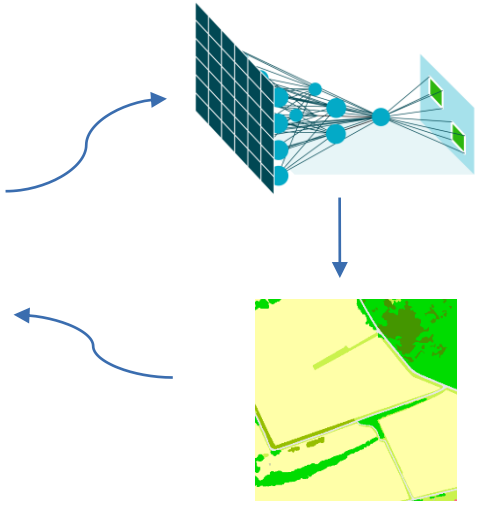
Project goal: automatic identification and analysis of land cover changes

Basis: historical and current geodata

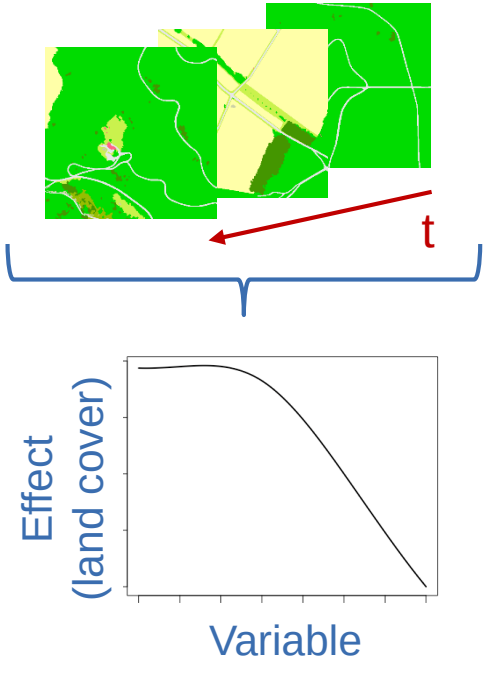
Requirement: Suitable data storage



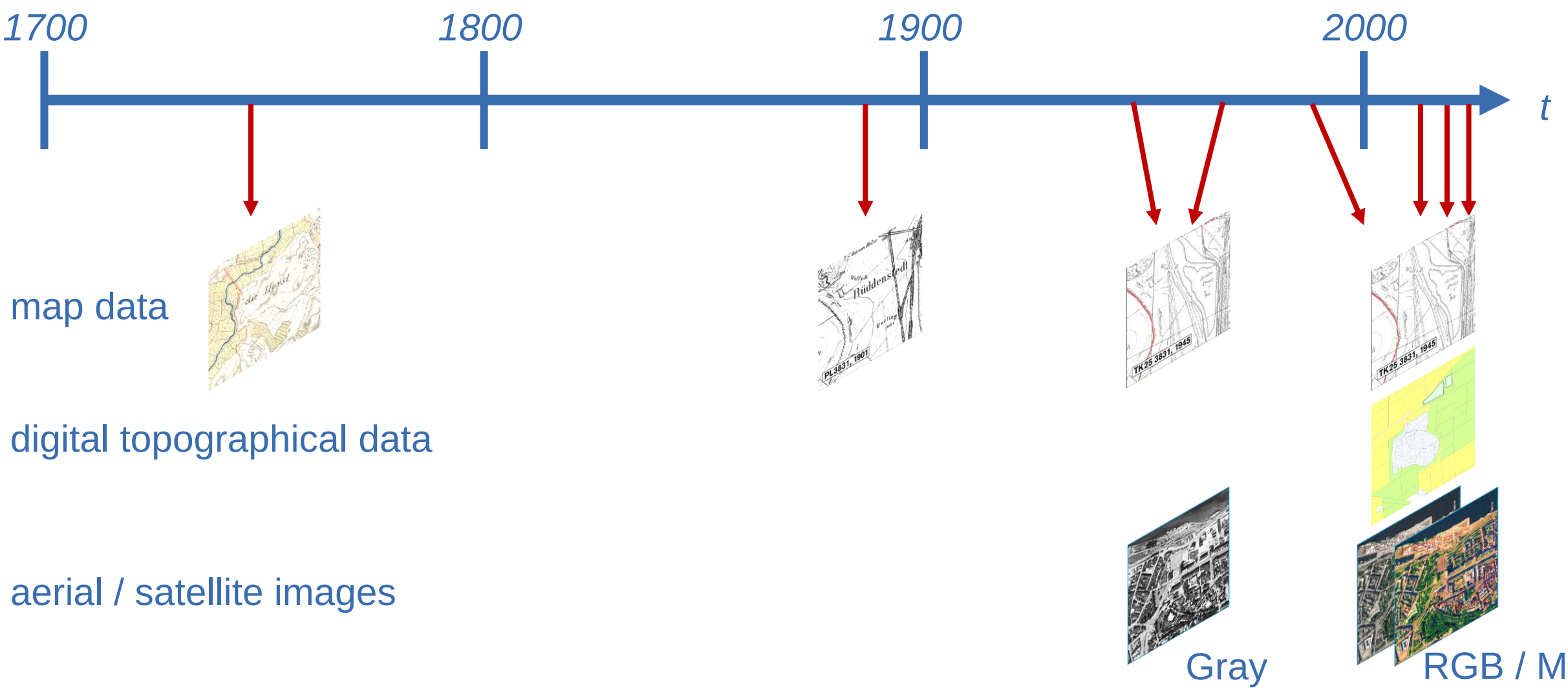
Semantics: Classification



Analysis: Statistical models



Historical and current geodata



Historical and current geodata

- Data from 18th century till „today“ (~2023)

  → long-term evolution observable (of some object types)

- Multiple epochs of interest

  → exploit temporal context

- Multiple data sources

  → complement and support each other

  → requires homogenization in data management

Suitable data storage

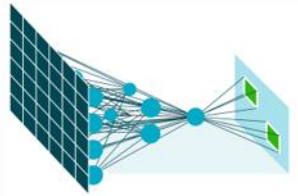
Research questions:

- How can historical and current data be stored together?
- What structures can be used to harmonize data from different sources in a database?
- How can changes over time be analyzed automatically?

Approach: Spatial database system

- Organize spatio-temporal vector data (e.g. digital topographic maps) and raster data (e.g. aerial and satellite imagery)
- Data cubes for representing time series
- Project-specific interface for spatial and temporal queries

Land cover classification (multi-modal, multi-temporal)



Research questions:

- Which object types can be derived reliably and with what accuracy from historical geodata?
- Which network architecture can deal with multi-modal and multi-temporal data of different spatial and spectral resolutions?
- How can such a network architecture be trained and how reliable are the results in case of noisy training data?
- How transferable is a resulting land cover classifier to other spatial and temporal domains in terms of accuracy?

Approach: Multi-modal multi-temporal land cover classification

First experiments: Multi-modal land cover classification

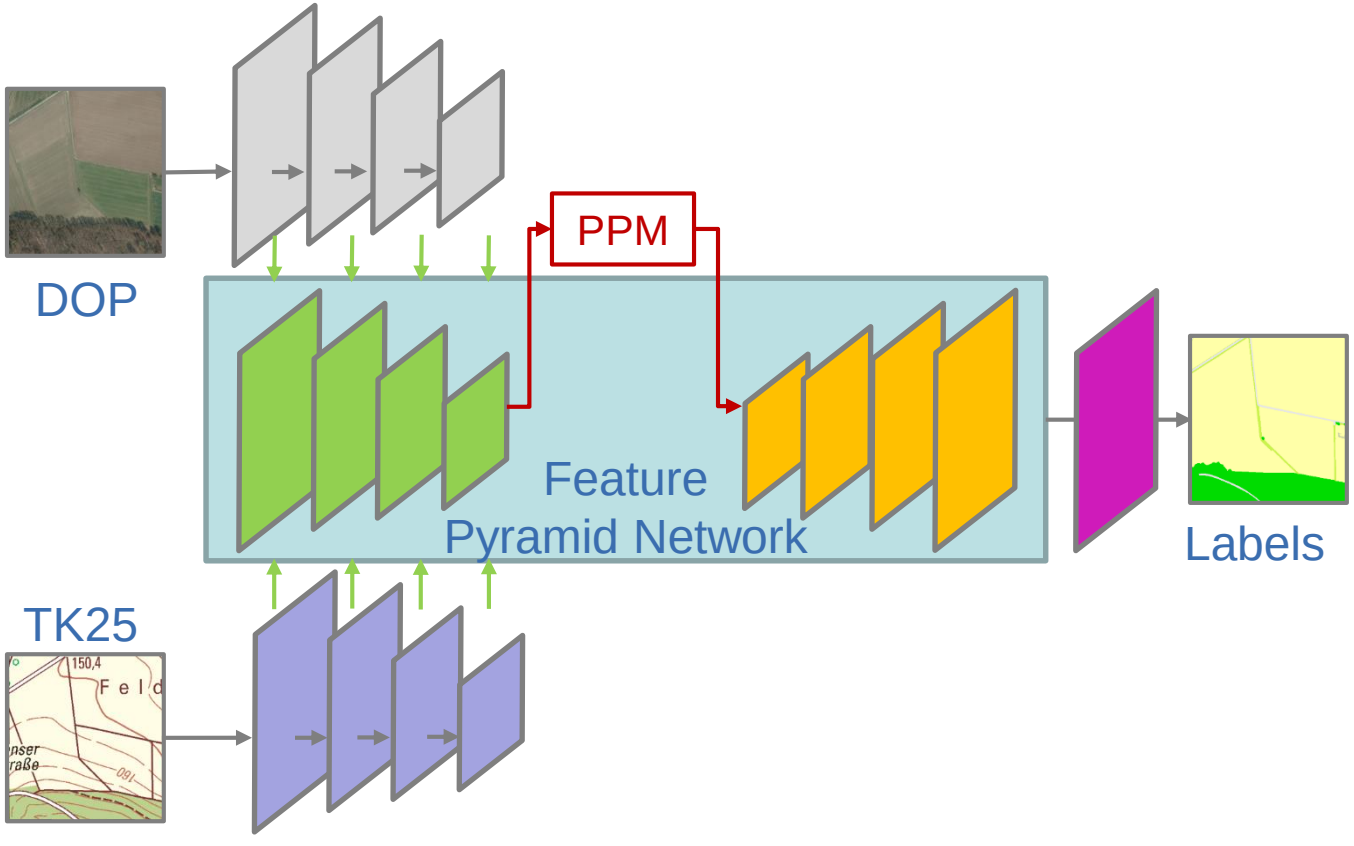
Goal of Classification: Correct prediction of land cover

Idea: exploit multiple modalities

Method „DOP + TK25“:

- Encoder per Modality (DOP, TK25)
- Fuse features of multiple modalities
- Multi-modal predictions

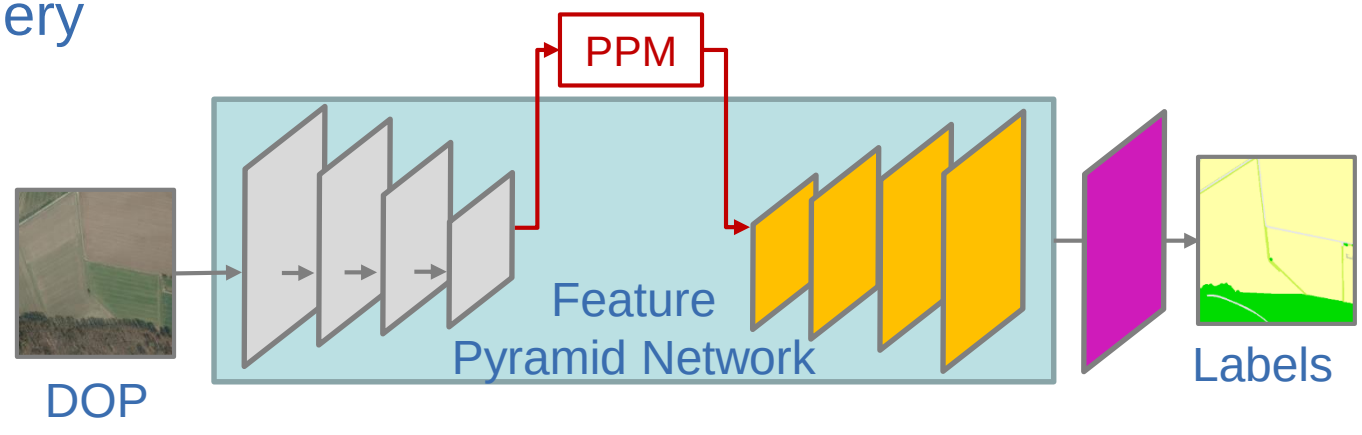
→ Complementary, supporting information



First experiments: Multi-modal land cover classification

Method „DOP“: For Comparison

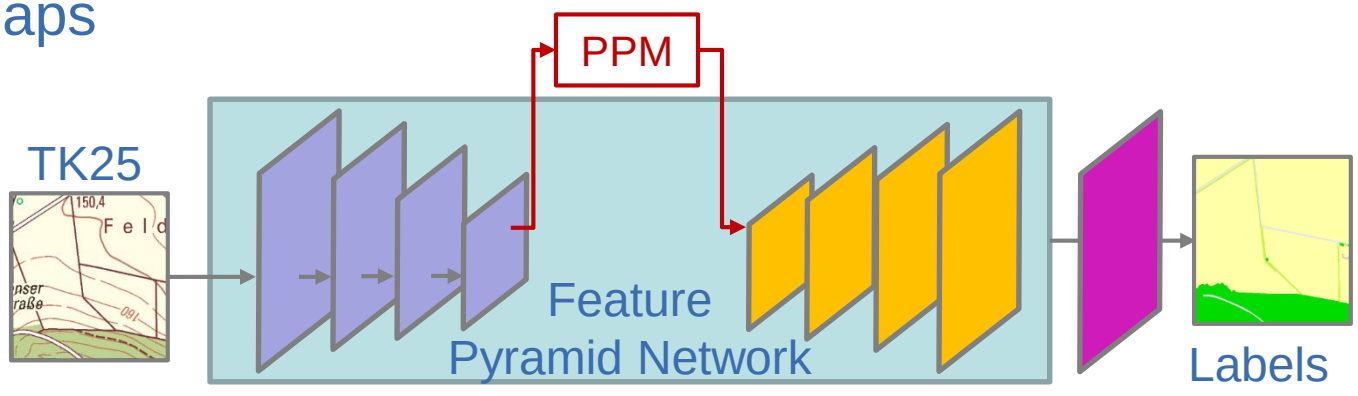
- Encoder for digital aerial orthophotos (DOP)
- Extract only features from aerial imagery
- Uni-modal DOP predictions



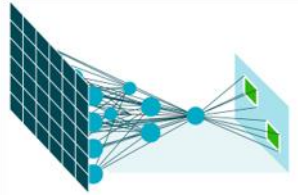
First experiments: Multi-modal land cover classification

Method „TK25“: For Comparison

- Encoder for scanned topographic maps 1:25 000 (TK25)
- Extract only features from (historic) maps
- Uni-modal map predictions

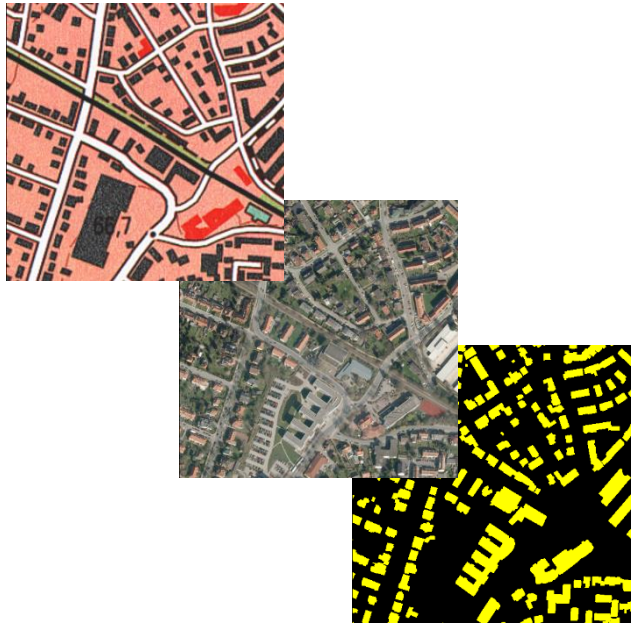


First experiments: Multi-modal land cover classification



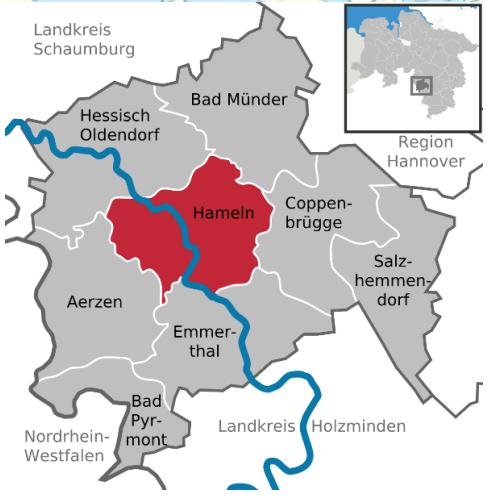
Data basis for test site in Hamelin:

- Modalities for the year 2010:
  - Topographic maps 1:25 000 (TK25)
  - Digital Orthophotos (DOP)
- Manually created land cover reference



Requirement for training:

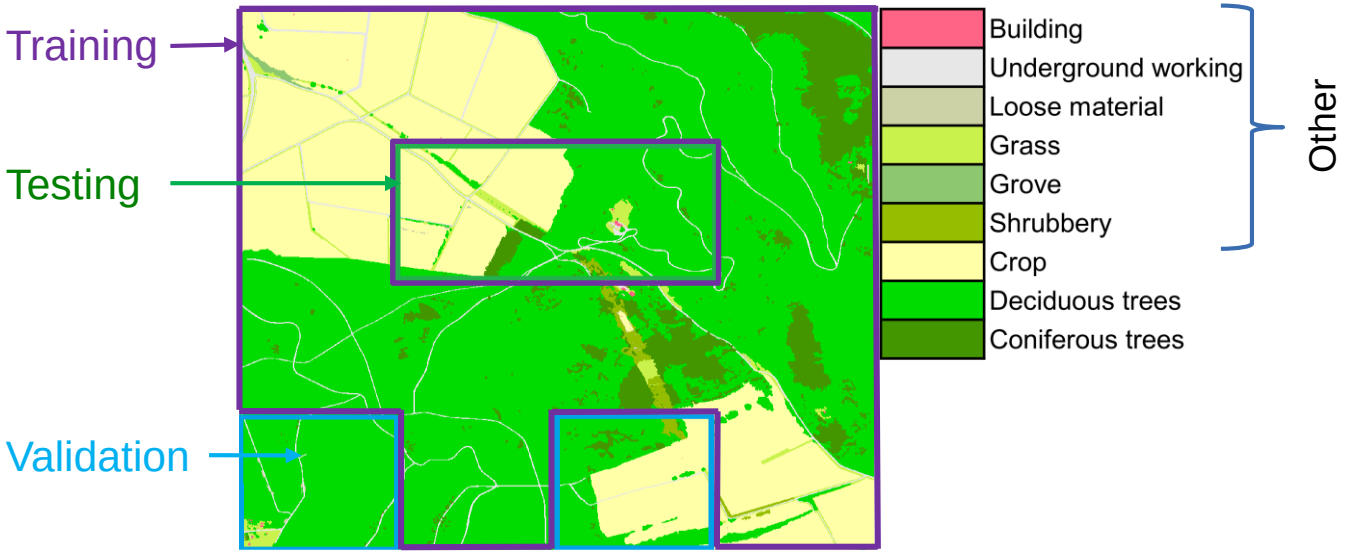
- Same ground distance → bilinear resampling to 1m
- Aligned pixels for all data (TK25, DOP, reference)

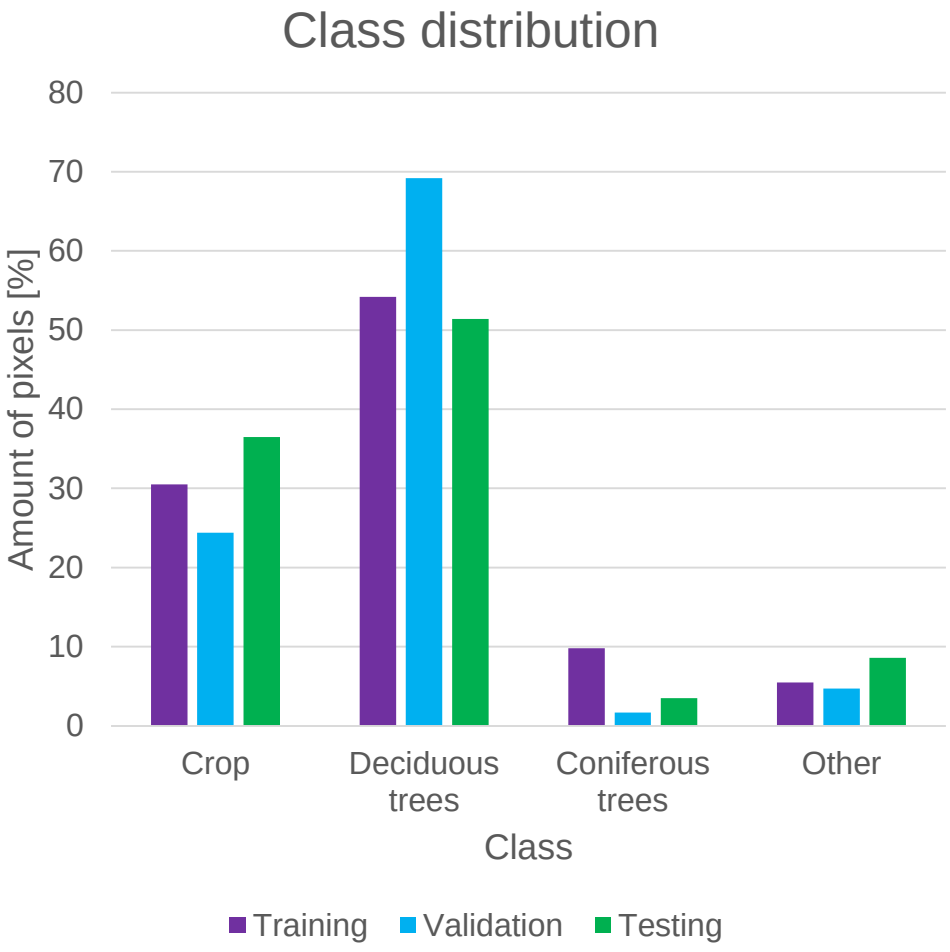


First experiments: Multi-modal land cover classification

Rural dataset:

- Area of 4km^2 in the north of Hamelin
- Multi-class classification: *3 vegetation + other*

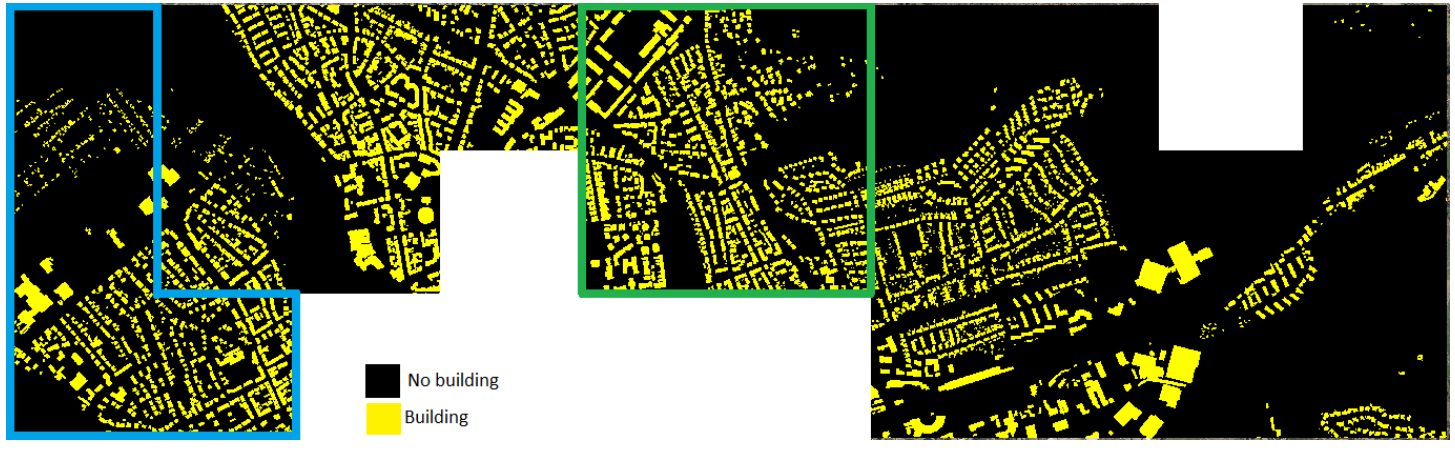




First experiments: Multi-modal land cover classification

Urban dataset:

- Area of 6km^2 in city of Hamelin
- Binary classification: *building* vs. *no building*



First experiments:
Multi-modal land cover classification

Results on the rural dataset:

- Quantitative:

Modality	Quality metric [%]		
	mF1	mIOU	OA
DOP + TK25	83.7	73.9	92.1
DOP	**84.4**	**74.8**	**92.4**
TK25	59.7	52.1	87.5

- Qualitative:

DOP TK25 Reference Prediction

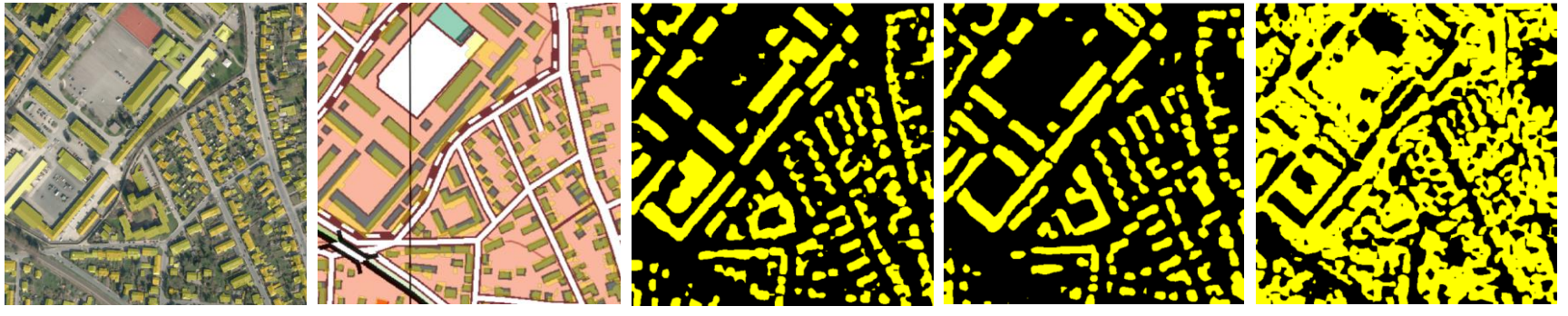
First experiments:
Multi-modal land cover classification

Results on the urban dataset:

- Quantitative:

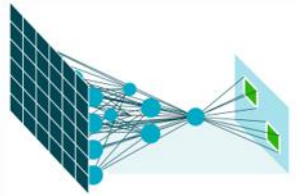
Modality	Quality metric [%]		
	mF1	mIOU	OA
DOP + TK25	62.2	46.0	65.1
DOP	**89.2**	**81.1**	**92.4**
TK25	81.2	69.6	86.9

- Qualitative:



DOP + L | TK25 + L | Pred. (DOP) | Pred. (TK) | Pred. (DOP+TK)

Land cover classification



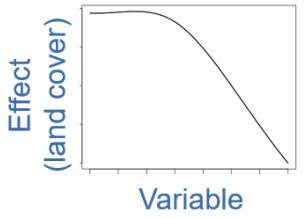
Next steps in the Gauss Centre:

- Improvement of multi-modal approach
  - → fusion principle, realization of fusion, supervision, …
- Predictions for other epochs
  - → multi-temporal classification

Relevant information for SDGs:

- Status of land cover:
  - → different types of vegetation, sealed areas as well as water bodies
- Evolution of land cover:
  - → recent epochs (> 2000): all (13-15) classes
  - → older epochs (< 2000 and particularly <1950): subset of classes

Statistical analysis

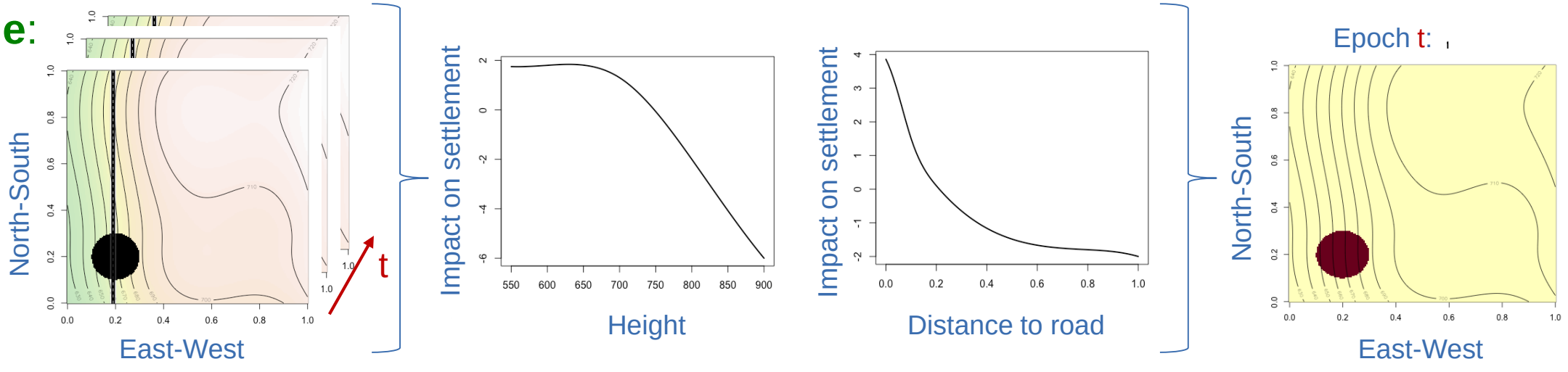


Research questions:

- Which factors have a (statistically) significant influence on the city's growth and to what extent?
- Into which areas are cities expanding and at what rate?

Approach: Statistical time series analysis

Example:



Conclusion

- The **project** outcome has huge potential to **provide valuable knowledge** in the context of the SDGs

  →Long-term evolution of different land cover types (18th century – today)

  →Exploitation of diverse geodata (multi-temporal, multi-modal, multi-sensor, …)

  →Understanding of land cover changes (statistical analysis)

- Resulting data will be made **available in the IOER Monitor** (Monitor of the Leibniz **I**nstitute **o**f **E**cological Urban and **R**egional Development, https://www.ioer.de/)

  →Accessible to the wider public

  →Accessible to decision makers dealing with SDGs

Project: **Gauss Centre**
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Initiation and funding:

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Realization and research:

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ikg

University of Glasgow | School of Mathematics & Statistics