Testing different remote sensing compositing periods for soil organic carbon (SOC) content extraction in areas across Germany

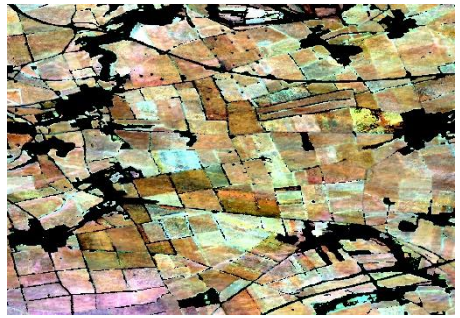
S. Zepp (simone.zepp@dlr.de), M. Bachmann, M. Möller, B. van Wesemael, M. Steininger, M. Wiesmeier, U. Heiden

1. objectives and EO data

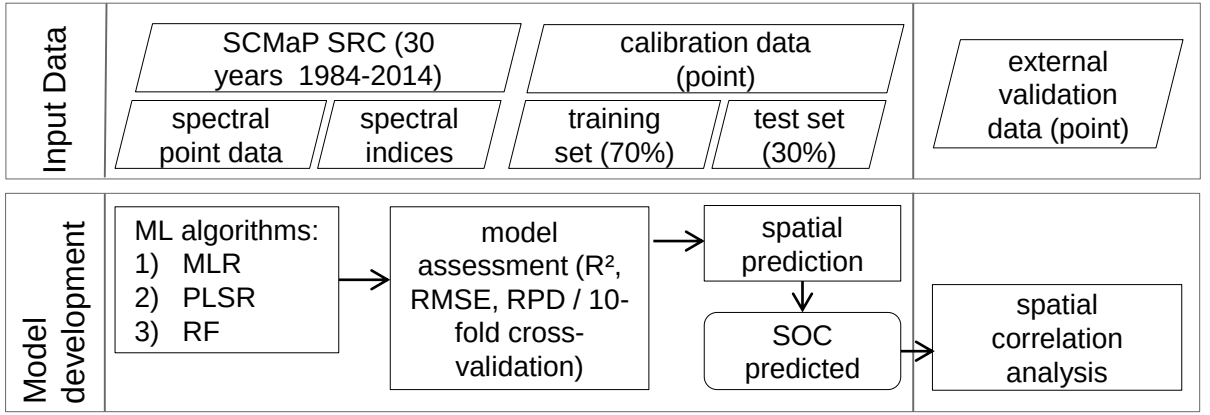
SOC estimation in Germany using EO datasets:

- Applicability of SCMaP multi-year soil reflectance composites (SRC) for SOC estimation.
- Development and validation of a prediction model.
- Test of spatial and temporal transferability.

SCMaP soil reflectance composites

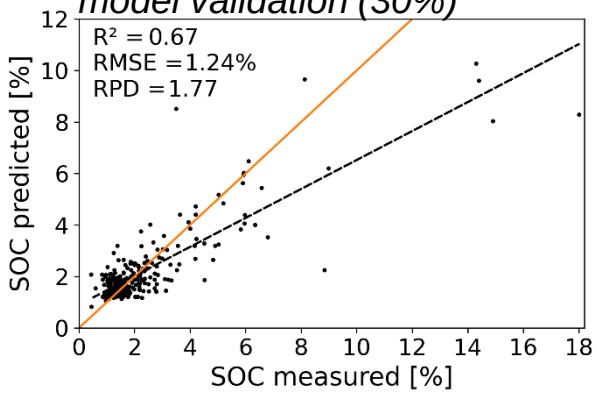


2. model development (I)

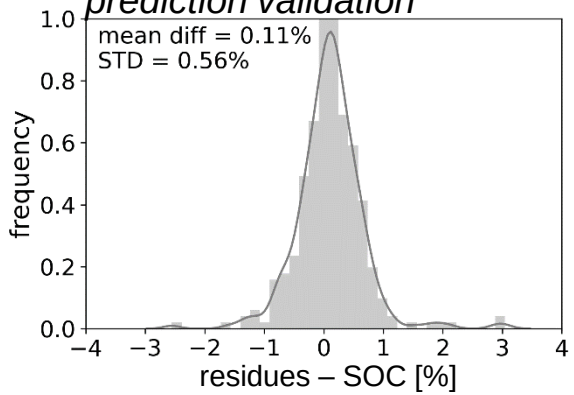


3. model development (II)

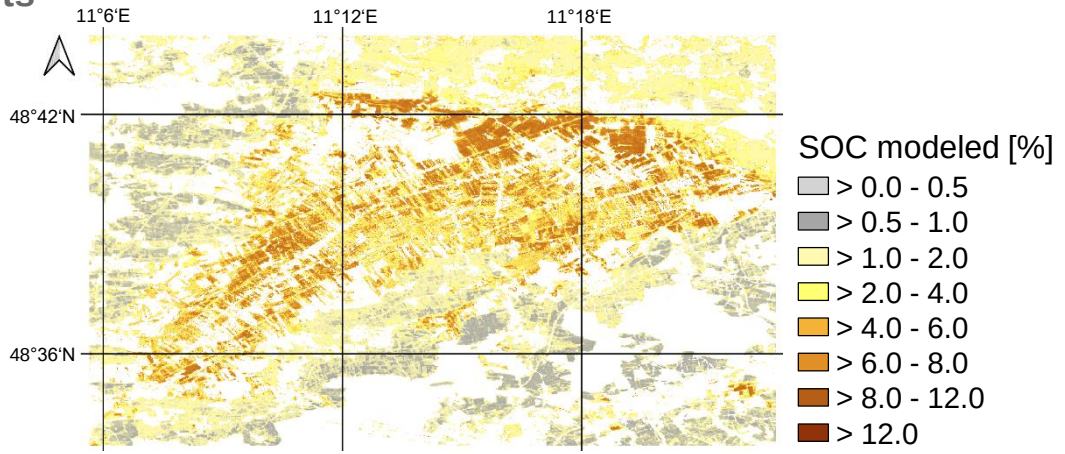
model validation (30%)



prediction validation



4. results



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S. Zepp[1], M. Bachmann[1], M. Möller[2], B. van Wesemael[3], M. Steininger[4], M. Wiesmeier[5], U. Heiden[1]

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1 German Aerospace Center (DLR)
2 Julius Kühn-Institut (JKI)
3 Universitè catholique de Louvain
4 Mitteldeutsches Institut für angewandte Standortkunden und Bodenschutz (MISB)
5 Bavarian State Research Center for Agriculture

1. Research questions & objectives

- Can the SCMaP (Soil Composite Mapping Processor) soil reflectance composites (SRC) from 1984-2014 based on Landsat imagery be used for SOC estimation?

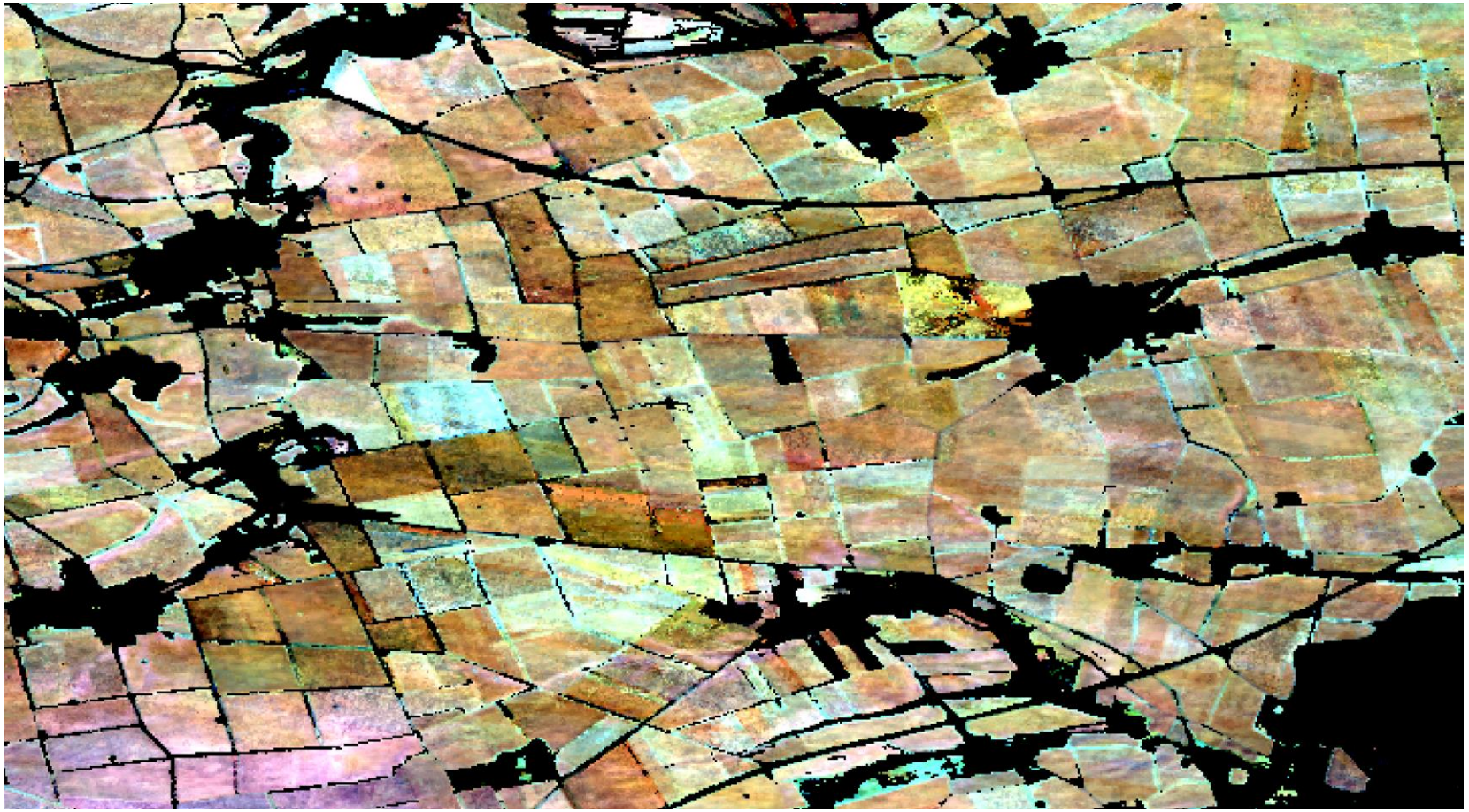
- Development and validation of a prediction model for the federal state of Bavaria.

- Test of spatial and temporal transferability to other regions in Germany and to different SCMaP compositing periods.

2. Data source

- SCMaP soil reflectance composites (SRC) -

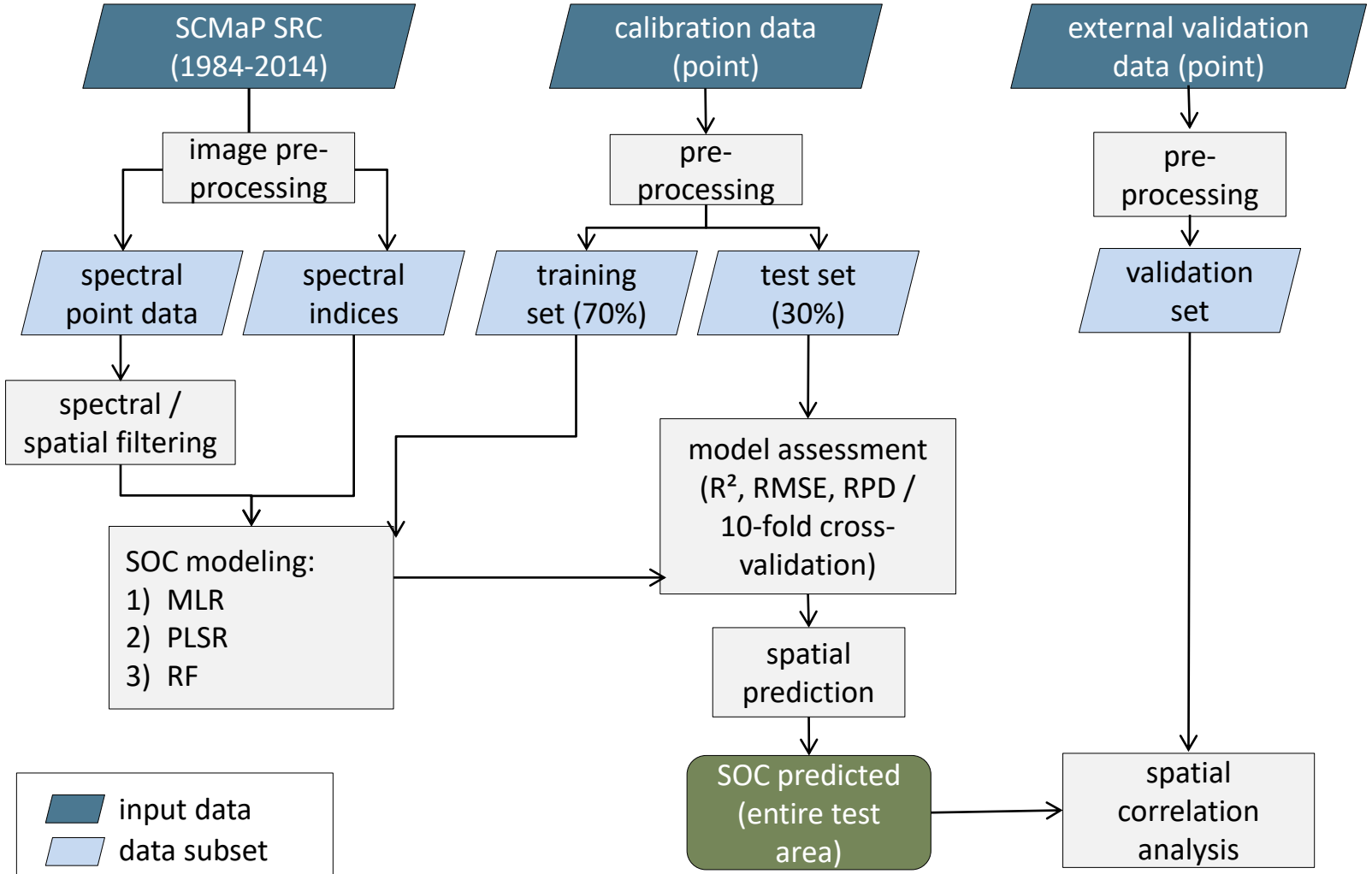
Exposed soil reflectance composite, 2015-19, RGB (SWIRII – SWIRI – Red)



- SCMaP (Soil Compositing Mapping Processor)* soil reflectance composites
- Operational processor for area-wide soil products with high spatial resolution

*** Rogge et al. 2018** – Building an exposed soil composite processor (SCMaP) for mapping spatial and temporal characteristics of soils with Landsat imagery (1984-2014)

3. Methodology
- model development -



SCMaP (30 years)

image pre-processing

spectral indices

SOC modeling
- MLR
- PLSR
- RF

calibration data

pre-processing

external validation dataset

SCMaP soil reflectance data:
- 30 year composite (1984-2014)

- Extracting point data
- Averaging: center pixel and 8 neighbour pixel
- Quality assessment

Spectral Indices:
BI, BI2, EVI, NBR2, SCMaPI, MSAVI2, LSWI, NDSI, RI, BSI, CI, TVI, V, GNDVI, SATVI, NDVI, GSAVI, GOSAVI, SAVI

Comparison of different ML algorithms:
MLR – multiple Linear Regression
PLSR – Partial Least Square Regression
RF – Random Forest

Field data:
- 2500 samples (1985-2017)

- Intersection with SCMaP composite
- Points between 1984-2014

External independent validation dataset (Bavaria):
- 352 samples (2000-2008)

3. Methodology

- model calibration / validation -

Results of the model calibration (cal) the 10-fold cross validation (cv) and the model validation (val)

algorithm	Input data setup	R^2			RMSE			RPD		
		cal	cv	val	cal	cv	val	cal	cv	val
MLR	R	0.4	0.8	0.48	1.48	1.5	1.5	1.27	1.27	1.39
	RI_all	0.6	0.55	0.59	1.2	1.29	1.44	1.44	1.44	1.57
	RI_sel	0.52	0.48	0.57	1.32	1.37	1.37	1.39	1.39	1.52
PLSR	R	0.4	0.38	0.47	1.48	1.50	1.51	1.29	1.27	1.38
	RI_all	0.51	0.48	0.56	1.34	1.37	1.38	1.43	1.40	1.51
	RI_sel	0.51	0.48	0.56	1.34	1.37	1.39	1.43	1.39	1.50
RF	R	0.91	0.53	0.67	0.9	1.31	1.25	3.25	1.46	1.74
	RI_all	0.86	0.58	0.67	0.71	1.24	1.24	2.67	1.54	1.75
	RI_sel	0.86	0.58	0.62	0.72	1.23	1.35	2.65	1.55	1.62

Comparison of machine learning algorithms:

- MLR (multiple linear regression)
- PLSR (partial least square regression)
- RF (random forest)

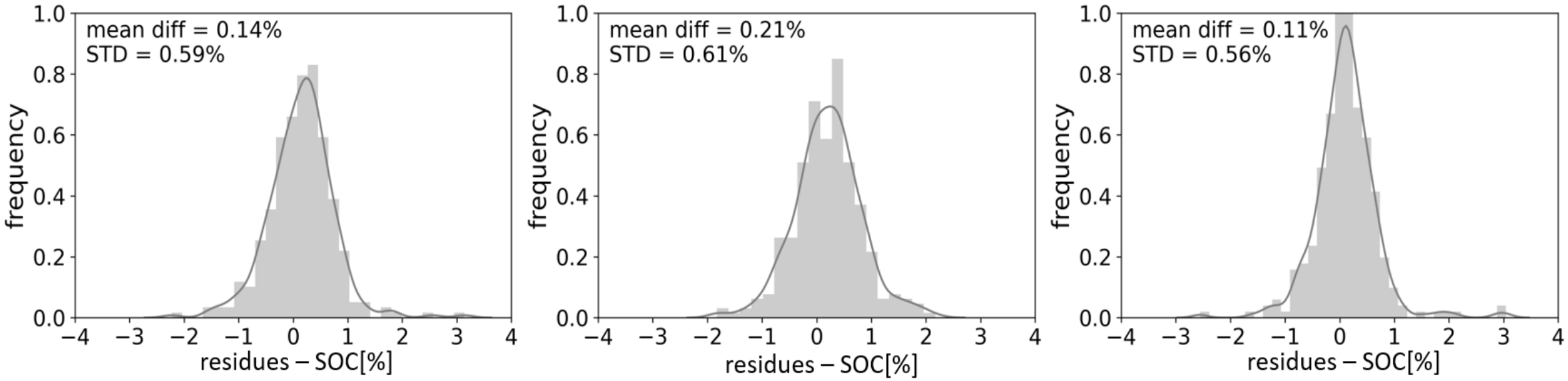
Comparison of data settings:

- R (reflectances)
- RI_all (reflectances and all Indices)
- RI_sel (reflectances and individually per algorithm selected Indices)

3. Methodology

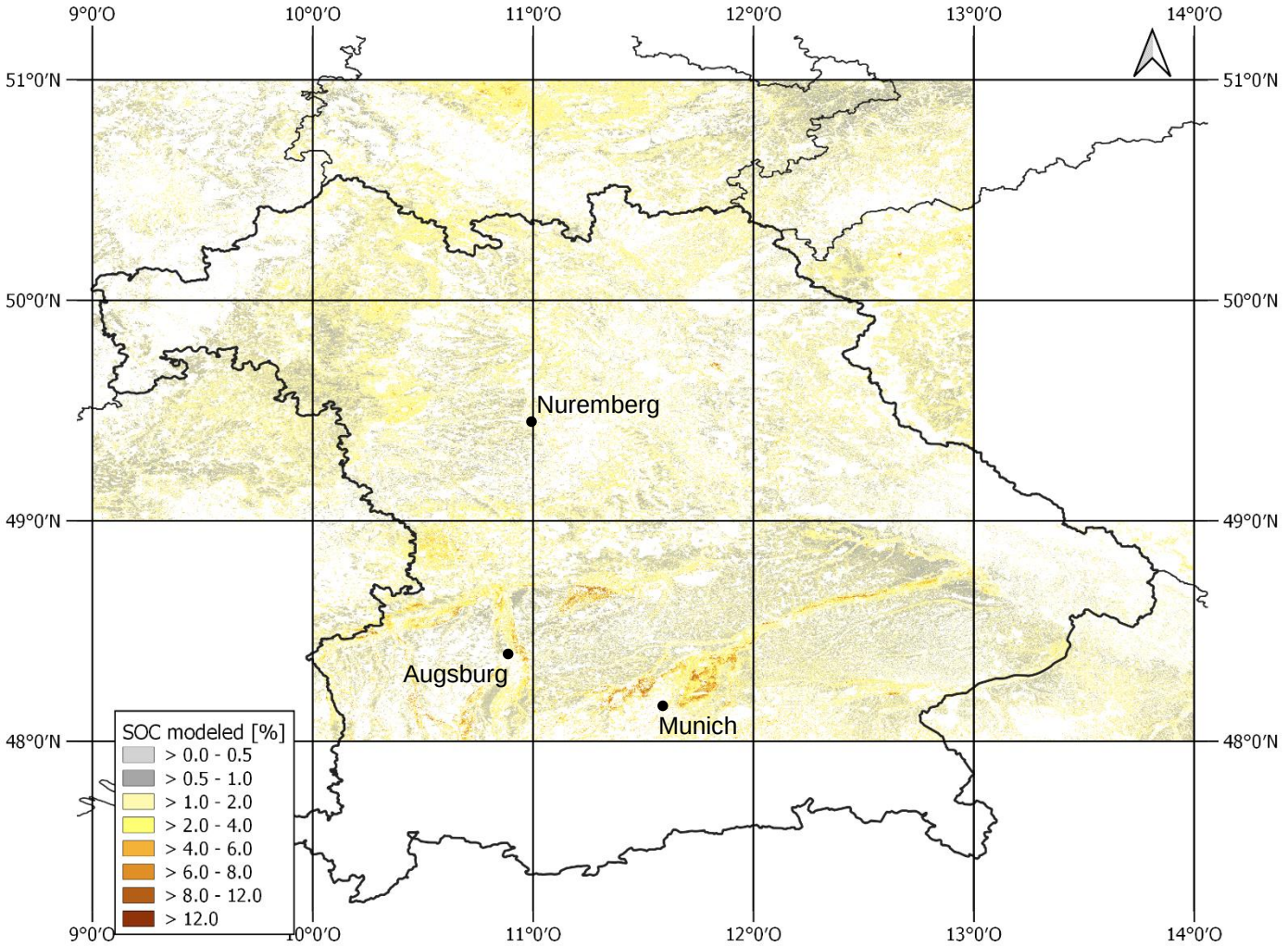
- prediction validation -

Prediction validation using an external independent dataset (308 samples)



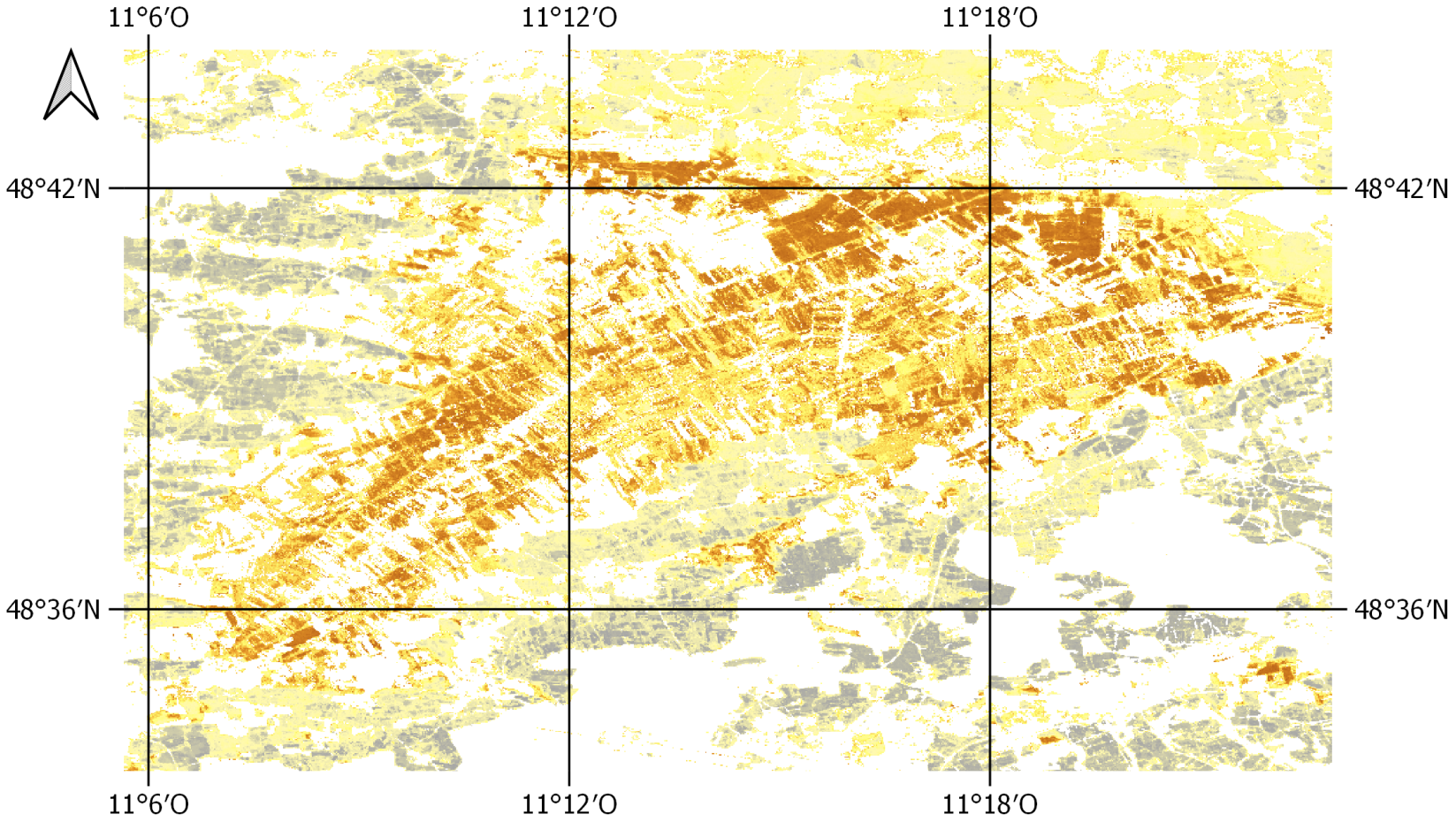
4. Results

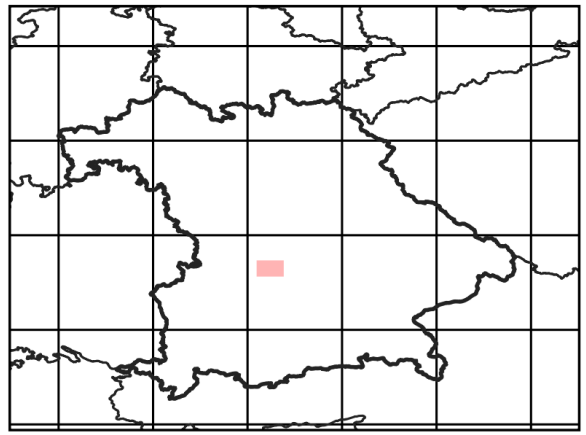
- spatial prediction – Bavaria -



4. Results

- spatial prediction – Bavaria -



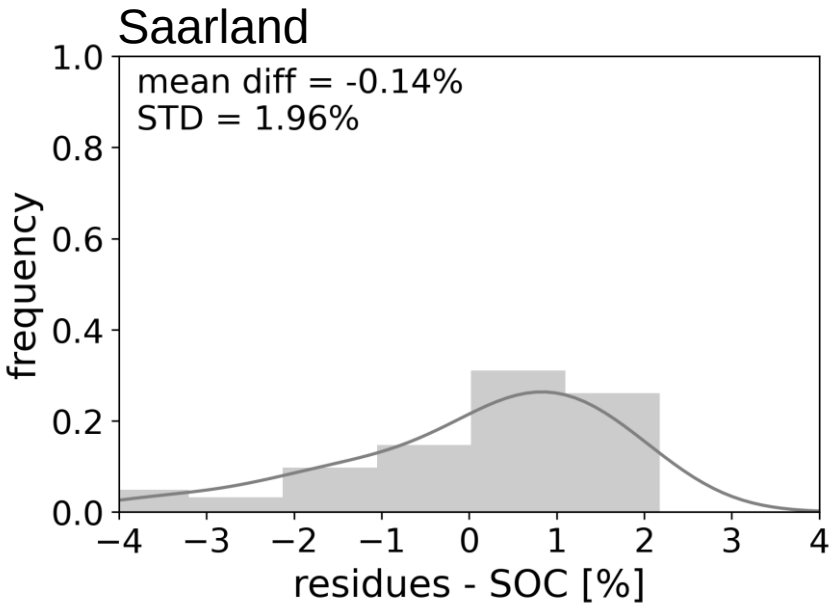


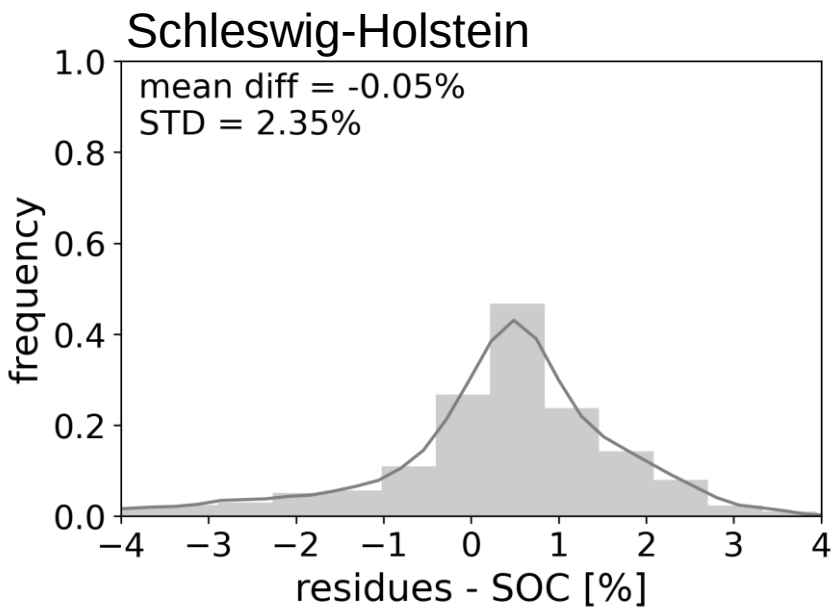
SOC modeled [%]
- > 0.0 - 0.5
- > 0.5 - 1.0
- > 1.0 - 2.0
- > 2.0 - 4.0
- > 4.0 - 6.0
- > 6.0 - 8.0
- > 8.0 - 12.0
- > 12.0

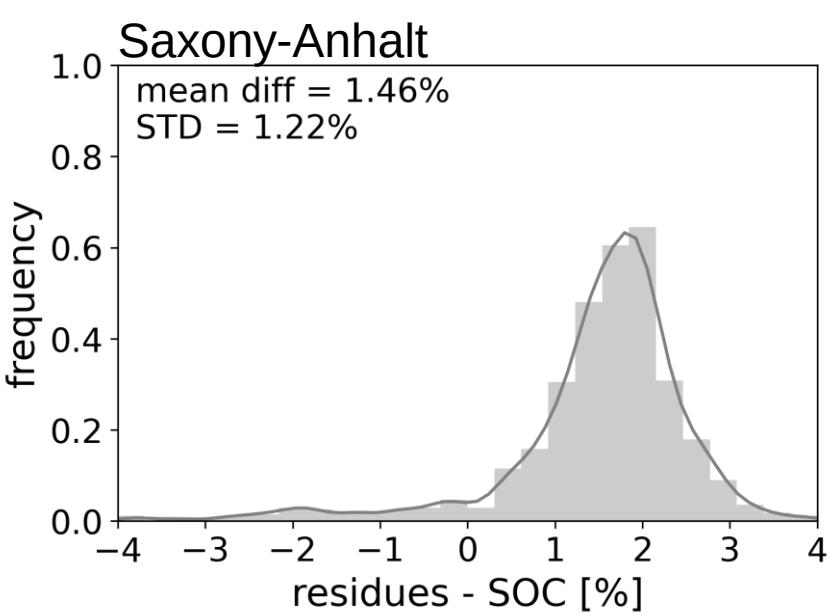
4. Results

- spatial transferability -

Prediction validation using independent validation datasets per federal state

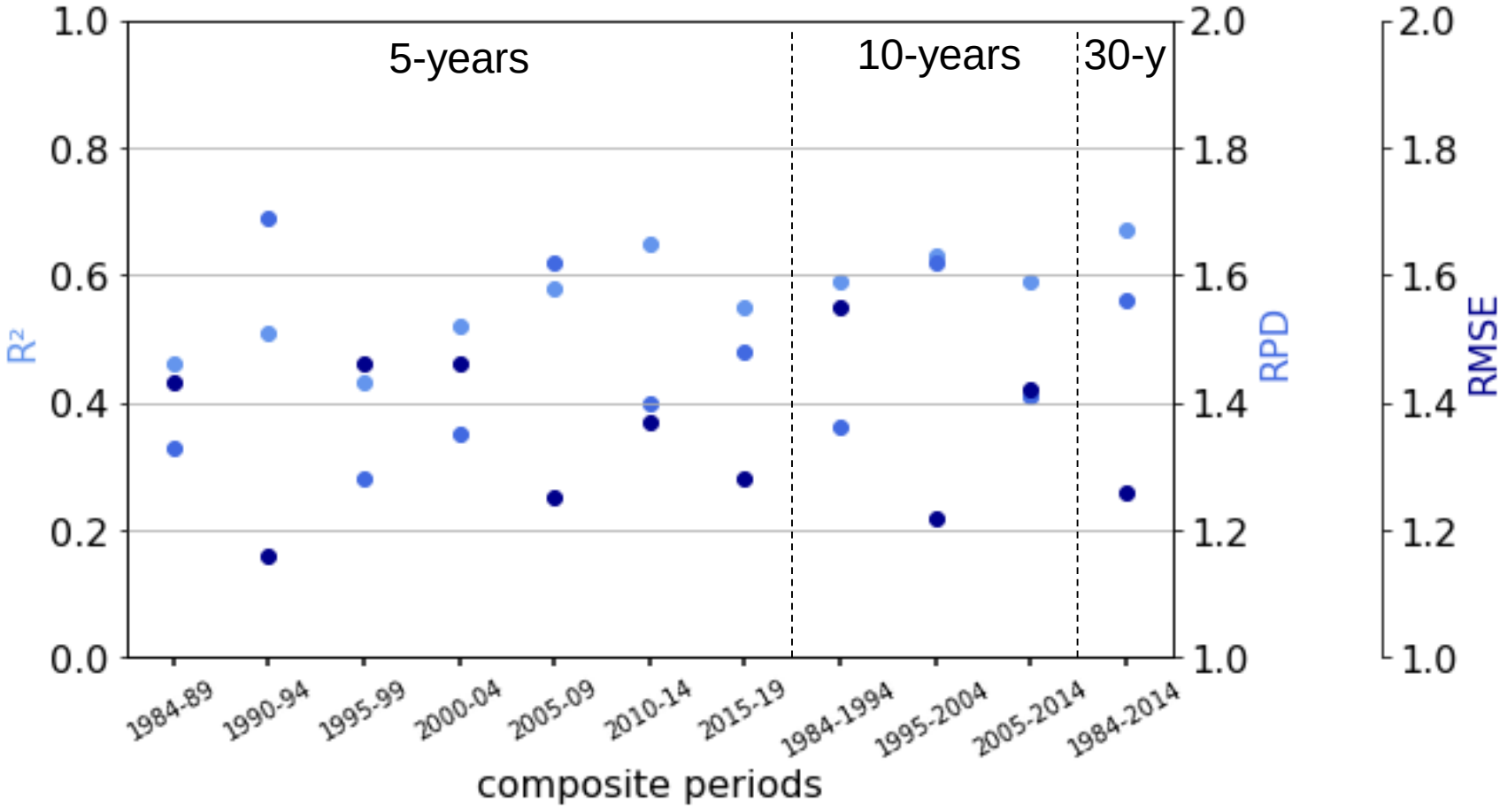






4. Results

- temporal transferability -



investigation of influencing parameters:

- distribution of soil samples,
- number cloudless scenes per pixel included in the soil composites,
- saisonality of the extraction of exposed soils across the different time periods,
- spectral influence of the different Landsat sensors.

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