GENERALIZABLE MAPPING OF HEDGES AND LINEAR WOODY FEATURES FROM EARTH OBSERVATION DATA: A NATIONAL PRODUCT FOR GERMANY

Dr. Thorsten Höser | DLR – Deutsches Fernerkundungsdatenzentrum

DLR

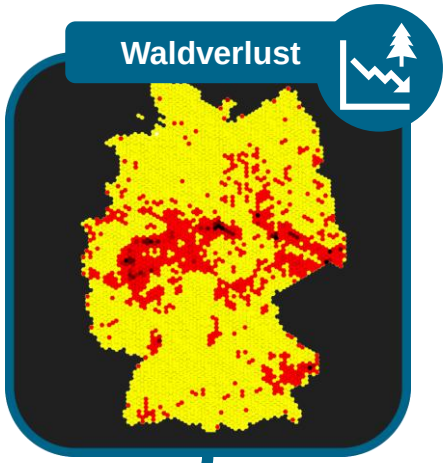
DLR-DFD

Dynamiken der Landoberfläche



Ottinger et al. 2017

Onshore Aquakultur



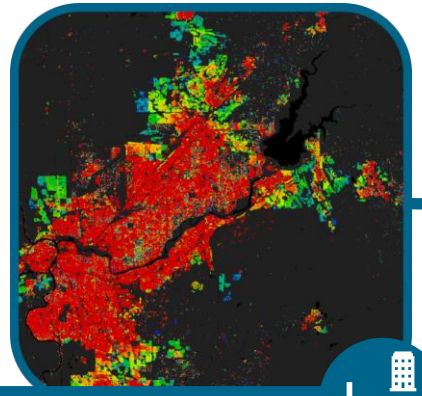
Thonfeld et al. 2022

Waldverlust



Hoeser et al. 2026

Hecken u. lineare Gehölze



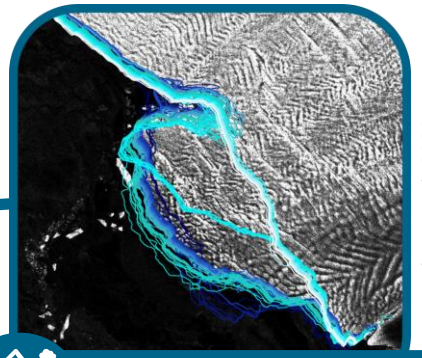
Marconcini et al. 2020

Globale Urbanisation

KI/AI
Artificial Intelligence

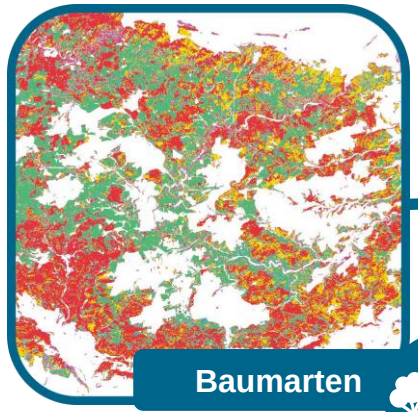
ML
Machine Learning

DL
Deep Learning



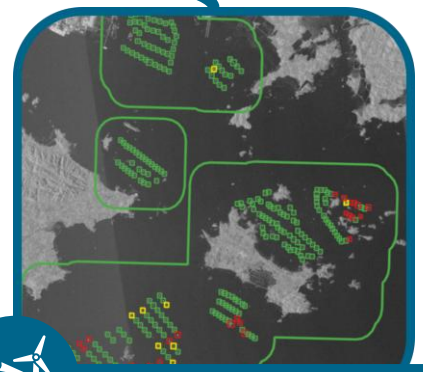
Baumhoer et al. 2023

Antarktischer Eisschelf



Wegler et al. 2025

Baumarten



Hoeser et al. 2022

Offshore Windparks

Remote Sensing Applications: Society and Environment 37 (2025) 101451

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Remote Sensing Applications: Society and Environment

journal homepage: www.elsevier.com/locate/rsase

Hedgerow map of Bavaria, Germany, based on orthophotos and convolutional neural networks

Verena Huber-García [a,*], Jennifer Kriese [a], Sarah Asam [a], Mariel Dirscherl [a], Michael Stellmach [b], Johanna Buchner [b], Kristel Kerler [b], Ursula Gessner [a]

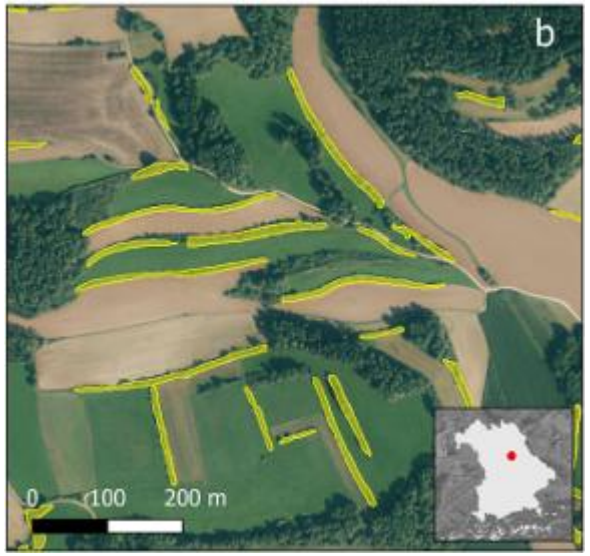
[a] German Aerospace Center e.V. (DLR), German Remote Sensing Data Center (DFD), Münchener Strasse 20, 82234, Wessling, Germany
[b] Bayerisches Landesamt für Umwelt (LfU), Ref. 51 Fachgrundlagen Naturschutz, Bgm.-Ulrich-Str. 160, 86179, Augsburg, Germany

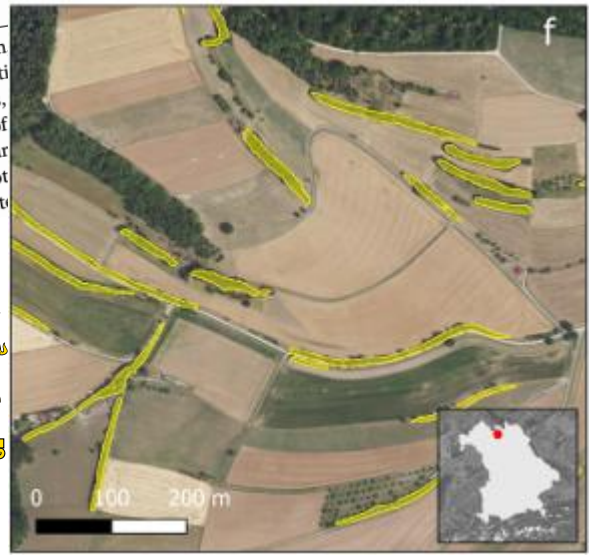
ARTICLE INFO

Keywords:
Linear woody vegetation
Biotopes
Aerial images
CNN
DeepLabV3
Small woody features

ABSTRACT

Hedgerows play a significant role in biodiversity preservation, carbon sequestration and the ecological integrity of rural landscapes. Understanding their current conditi development is therefore crucial for a range of stakeholders such as municipalities, or environmental organizations. The wall-to-wall mapping and characterization of situ is, however, very labour-, time- and cost-intensive. This impedes a regular adequate intervals. In the Federal State of Bavaria, Germany, the hedgerow biot repeated every 20–30 years for each district. State-wide consistent and up-to-dat

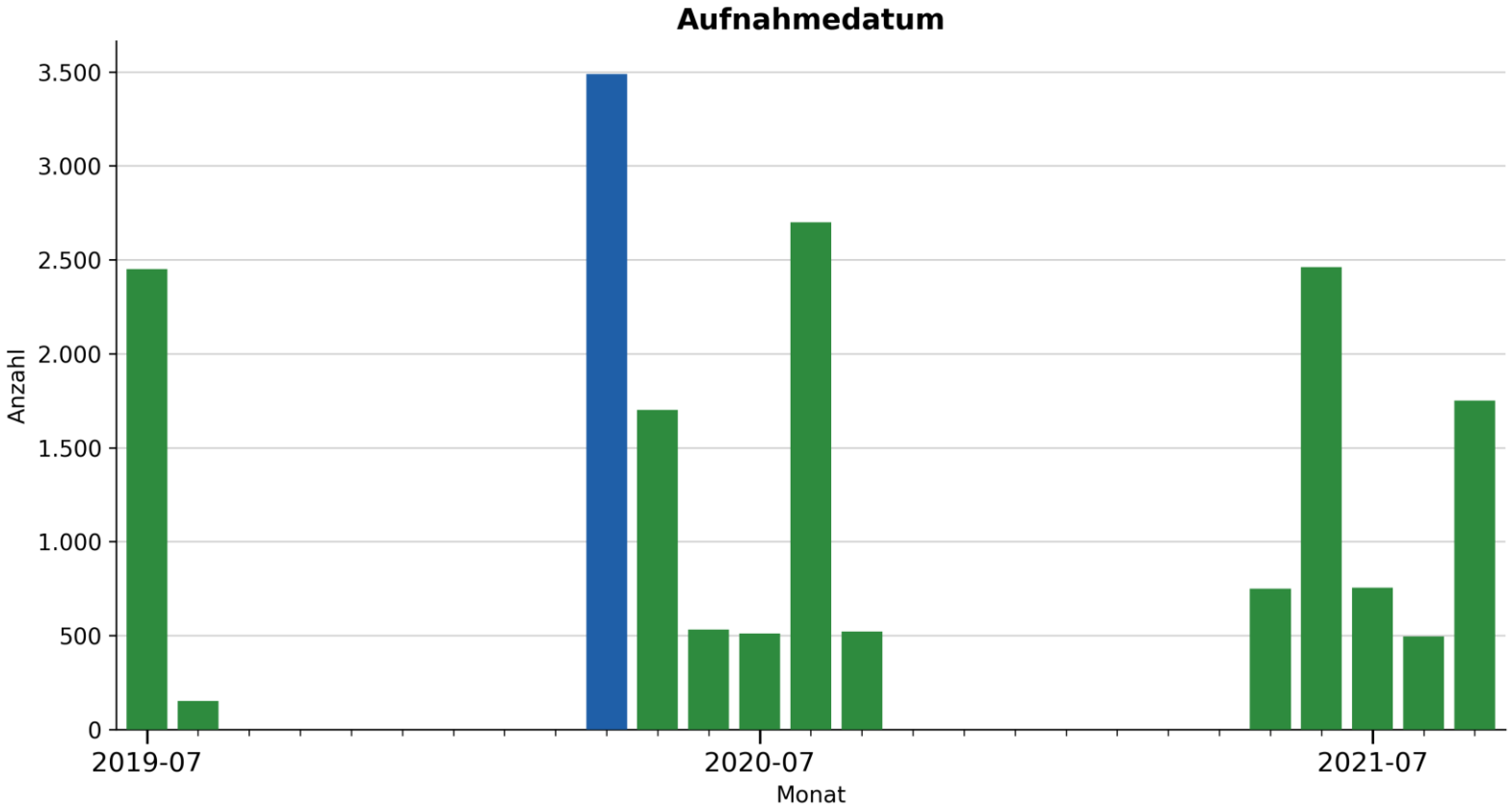


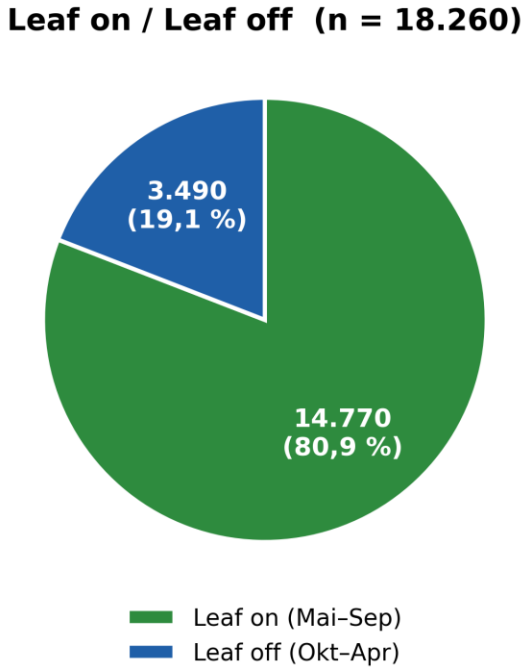


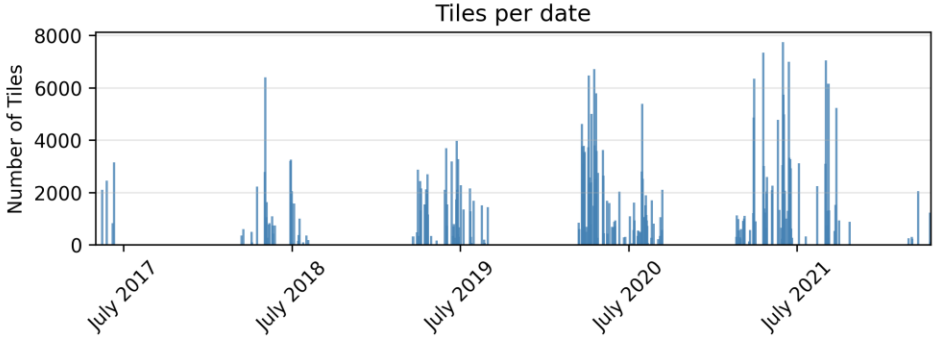


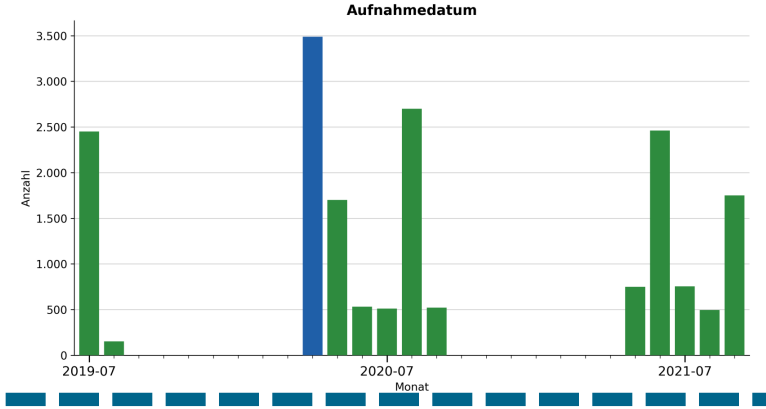


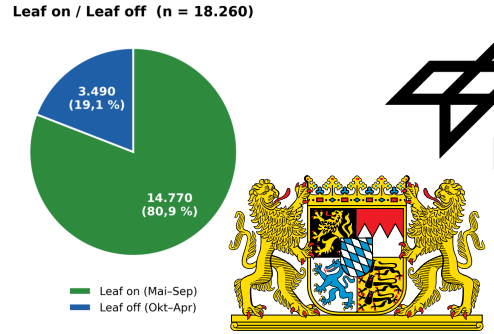
Does it scale to Germany?

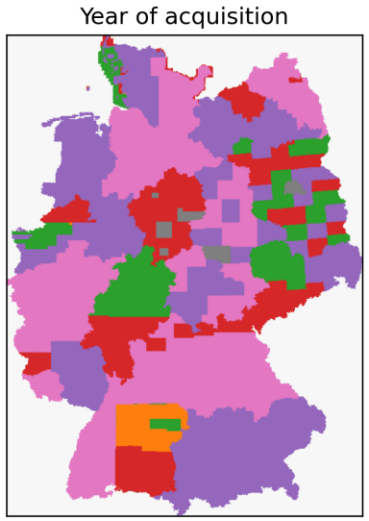

Aufnahmedatum
3.500
3.000
2.500
2.000
1.500
1.000
500
0
Anzahl
2019-07
2020-07
2021-07
Monat

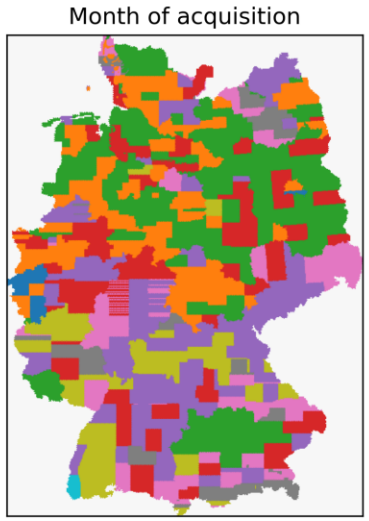

Leaf on / Leaf off (n = 18.260)
3.490
(19,1 %)
14.770
(80,9 %)
Leaf on (Mai–Sep)
Leaf off (Okt–Apr)

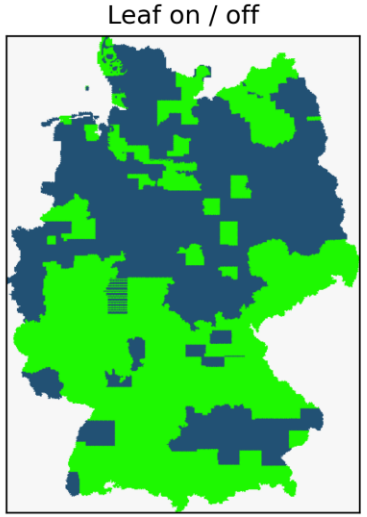

Tiles per date
Number of Tiles
8000
6000
4000
2000
0
July 2017
July 2018
July 2019
July 2020
July 2021

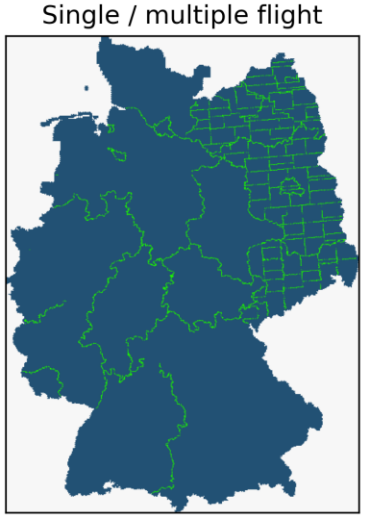

Aufnahmedatum
Anzahl
3.500
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Monat

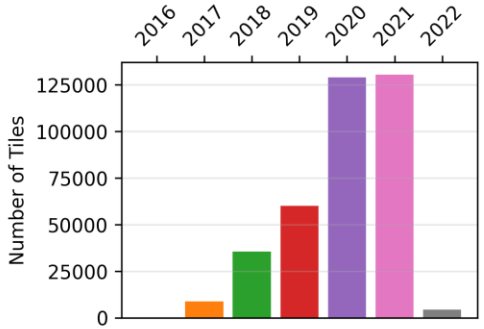

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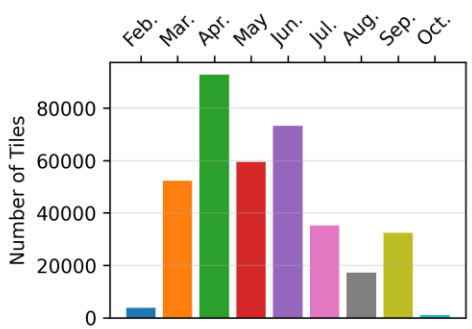

Year of acquisition

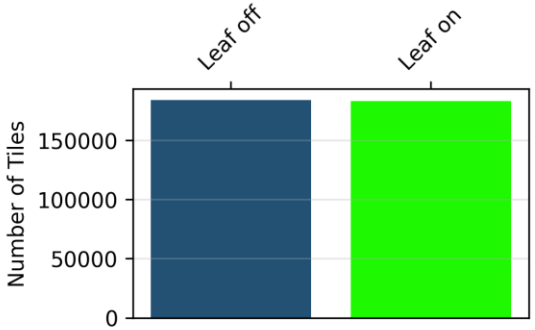

Month of acquisition

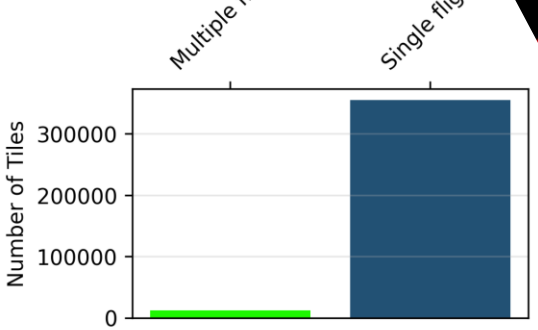

Leaf on / off

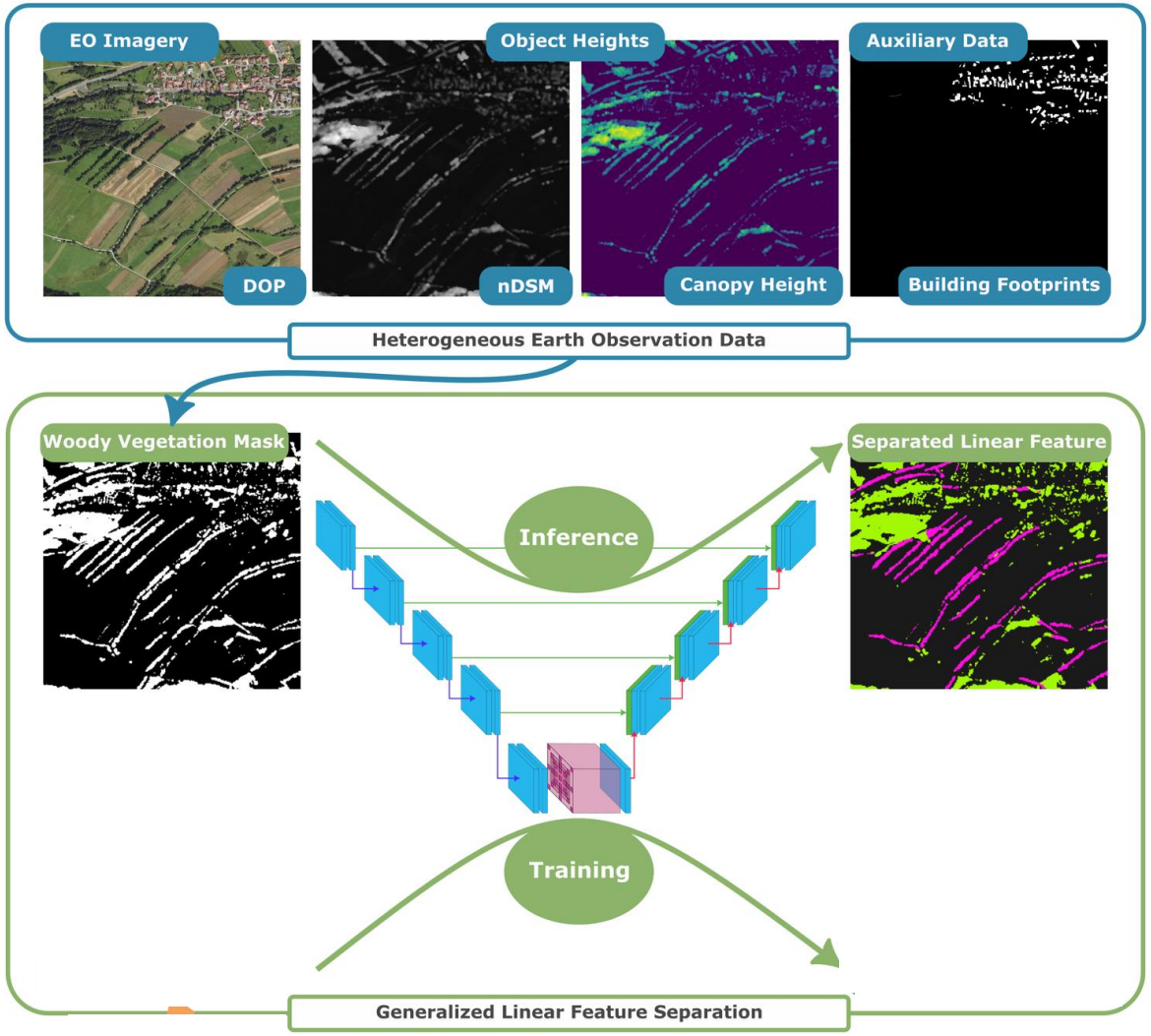

Single / multiple flight

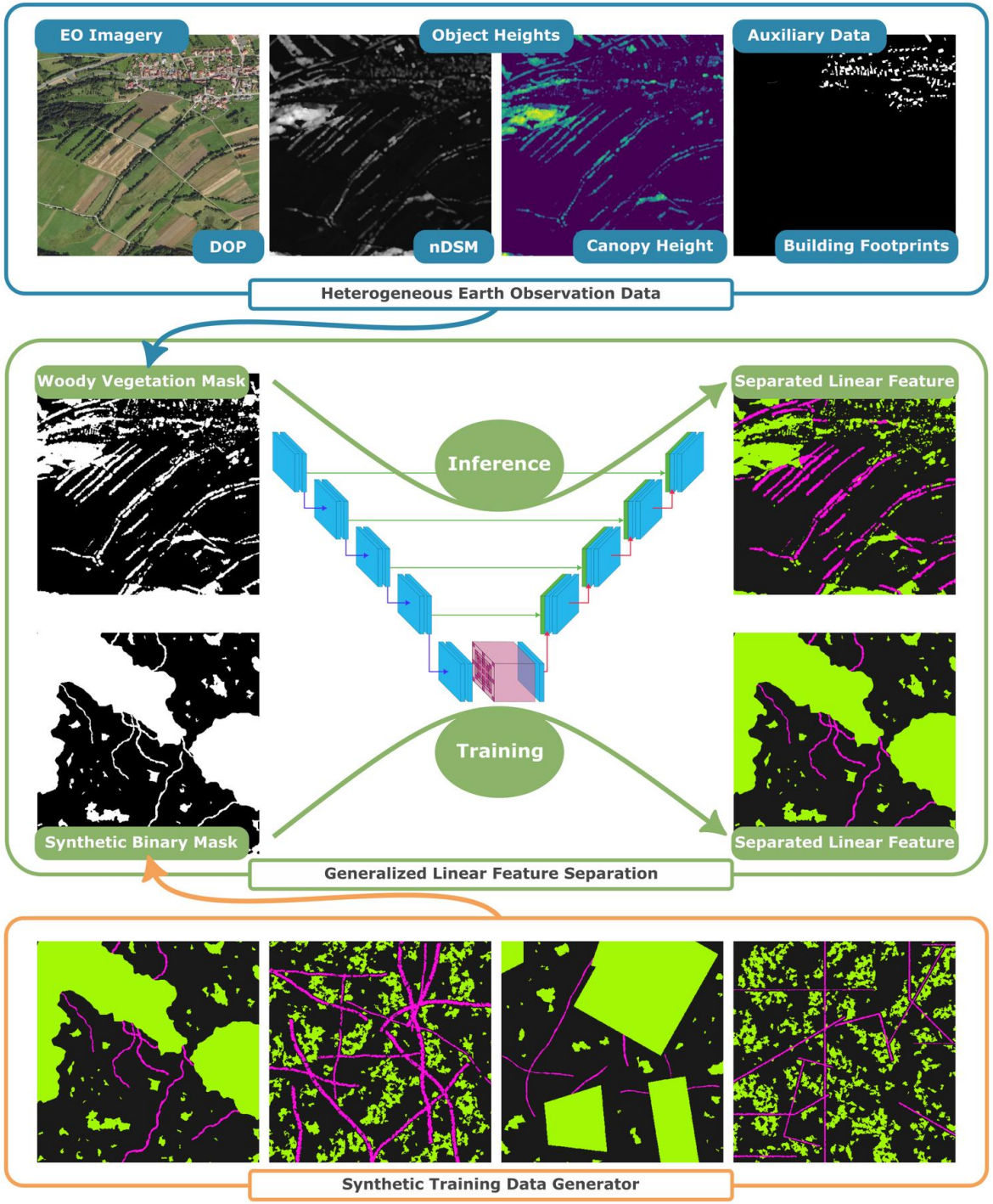

2016
2017
2018
2019
2020
2021
2022
Number of Tiles
125000
100000
75000
50000
25000
0

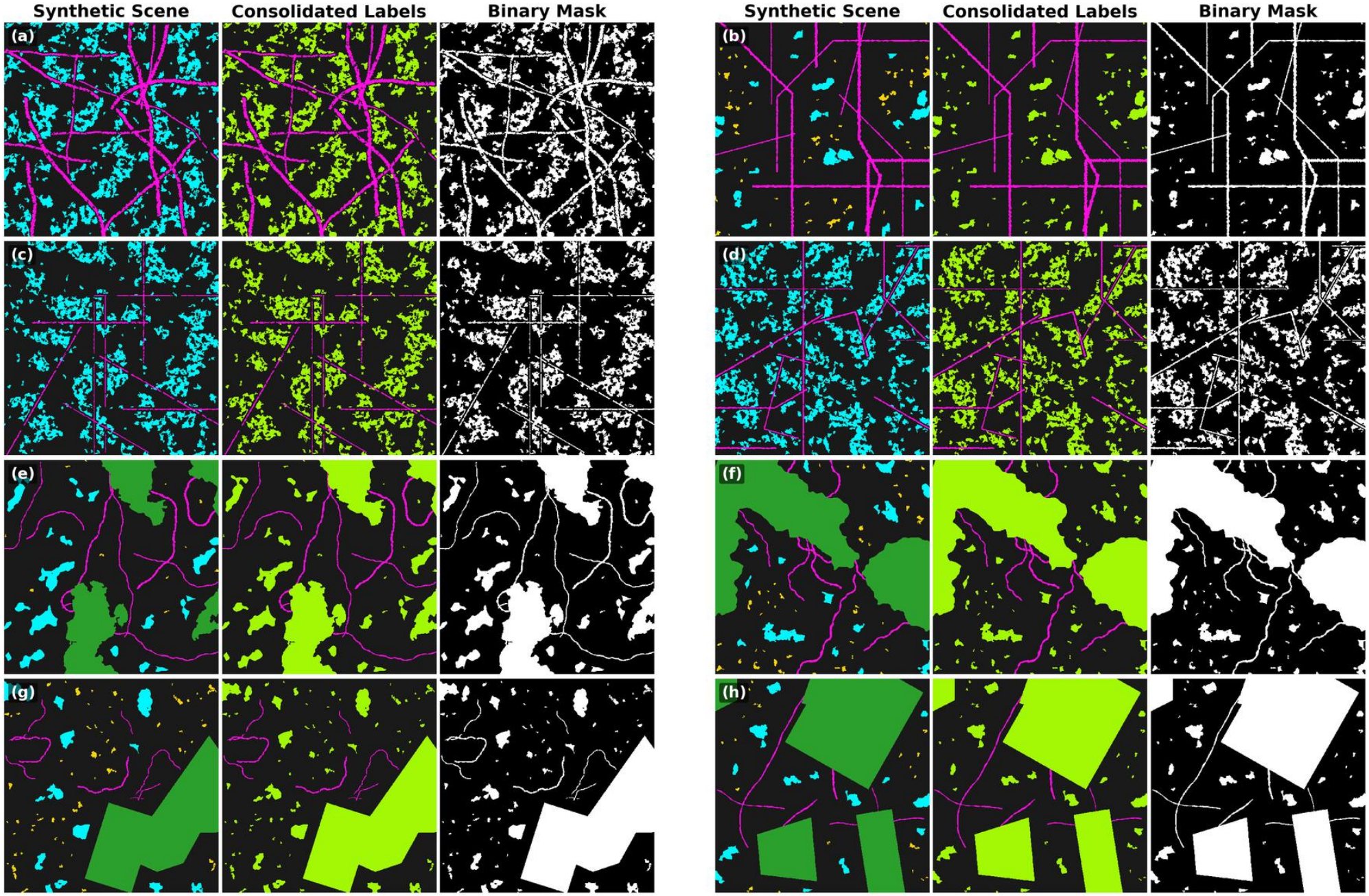

Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Number of Tiles
80000
60000
40000
20000
0

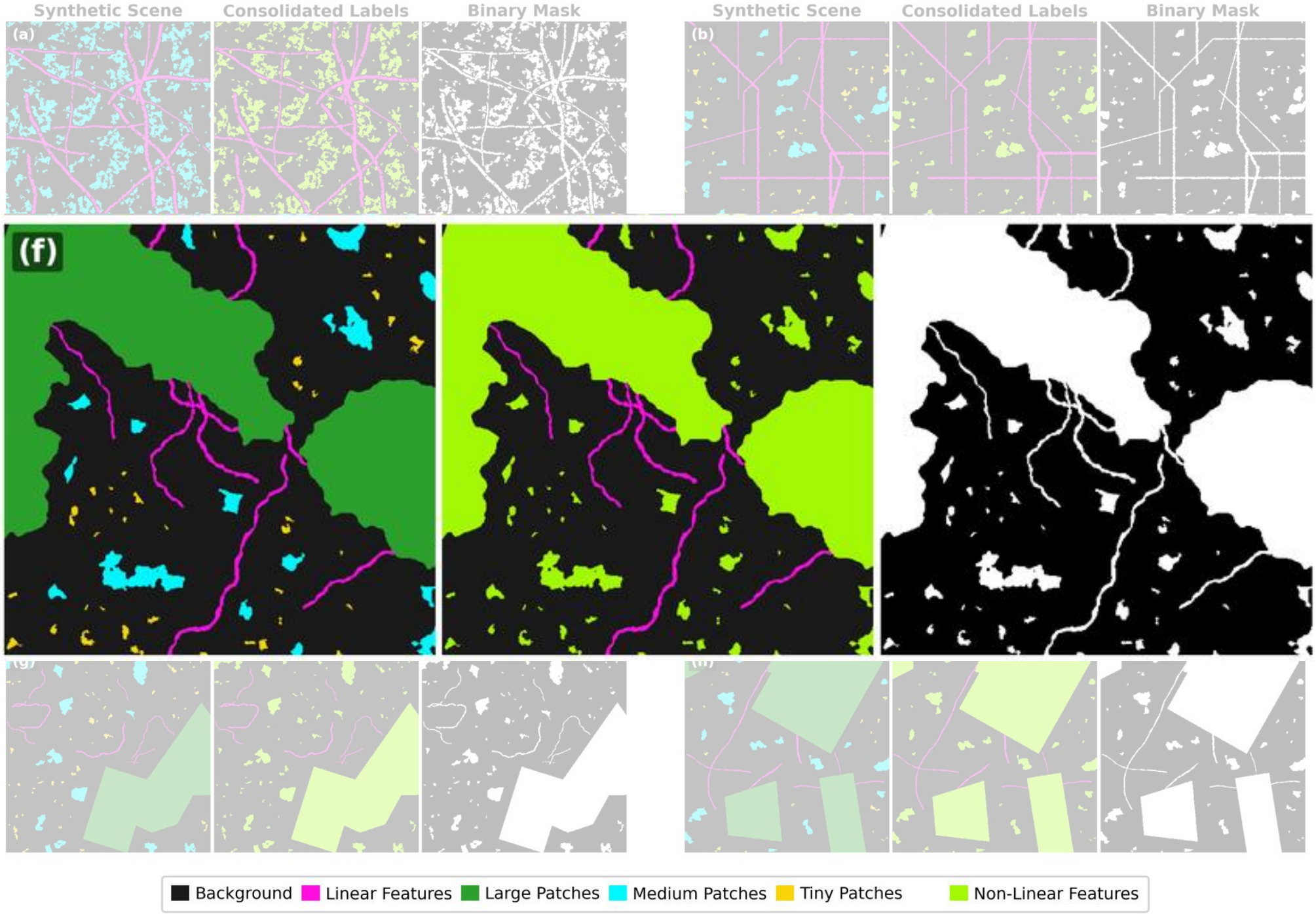

Leaf off
Leaf on
Number of Tiles
150000
100000
50000
0


Multiple flights
Single flight
Number of Tiles
300000
200000
100000
0

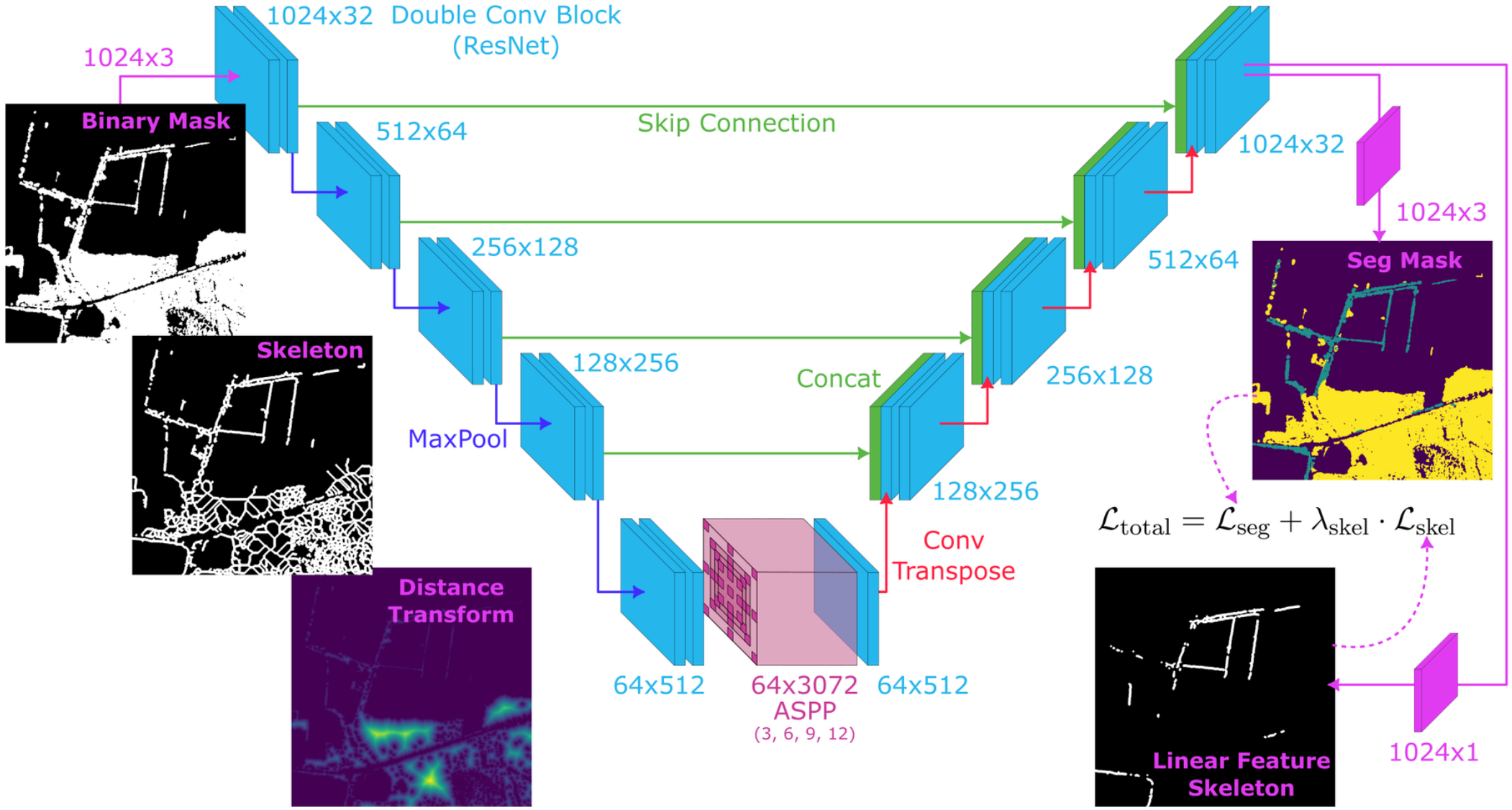

EO Imagery
DOP
Object Heights
nDSM
Canopy Height
Auxiliary Data
Building Footprints
Heterogeneous Earth Observation Data
Woody Vegetation Mask
Inference
Separated Linear Feature
Training
Generalized Linear Feature Separation

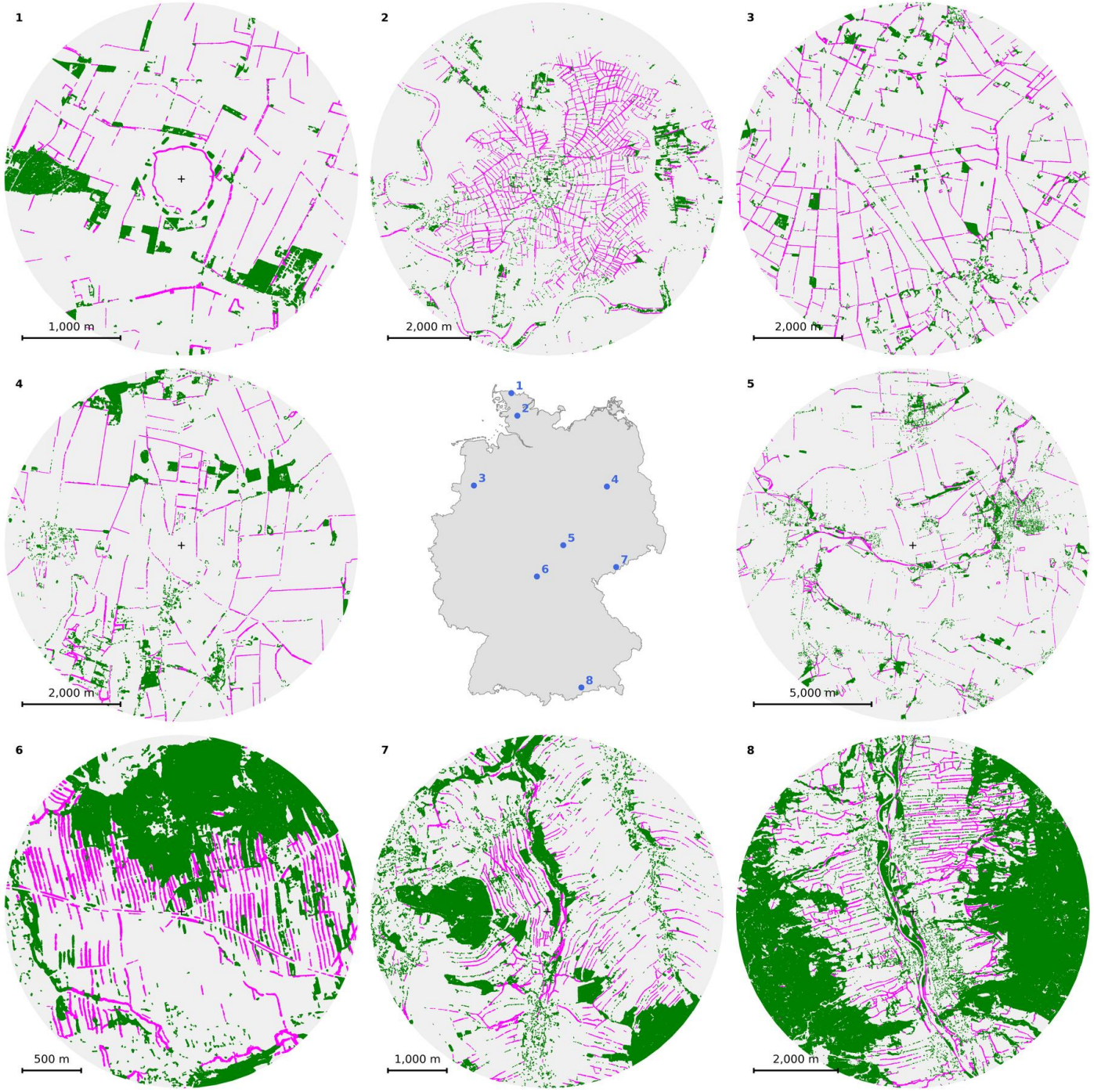

EO Imagery
DOP
Object Heights
nDSM
Canopy Height
Auxiliary Data
Building Footprints
Heterogeneous Earth Observation Data
Woody Vegetation Mask
Inference
Separated Linear Feature
Synthetic Binary Mask
Training
Separated Linear Feature
Generalized Linear Feature Separation
Synthetic Training Data Generator

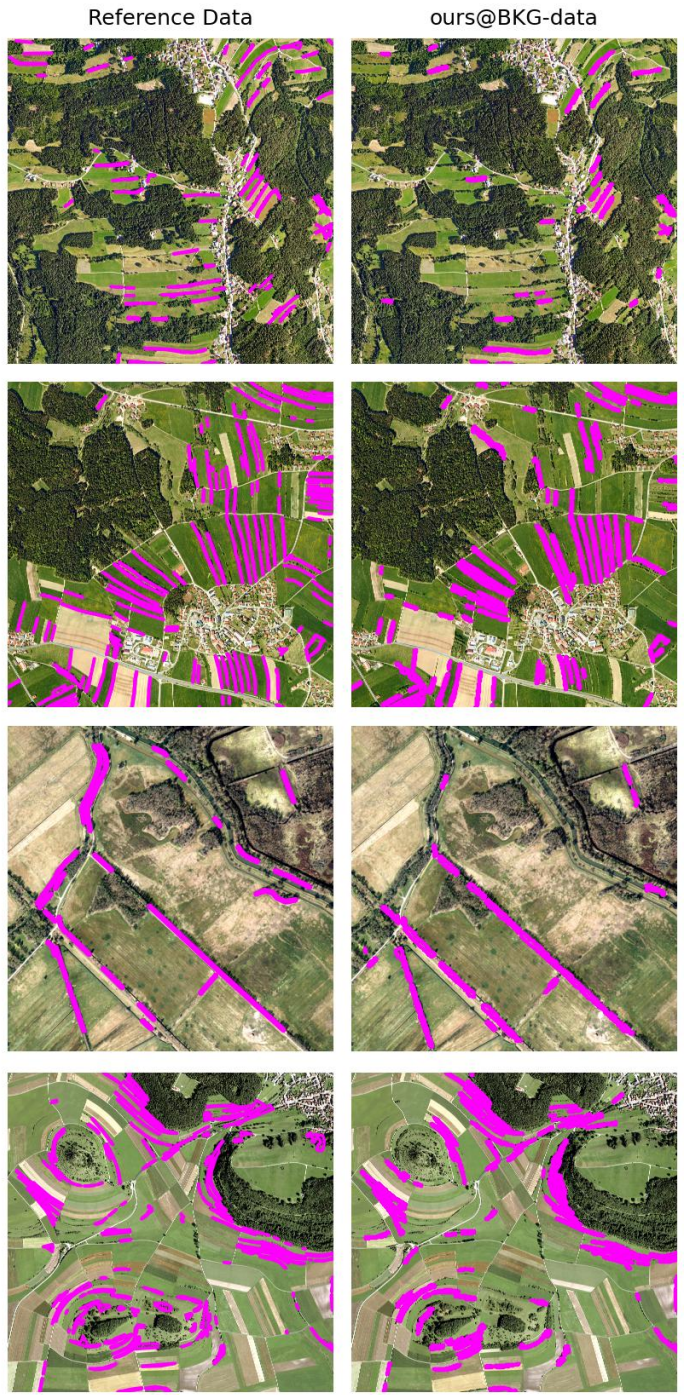

Synthetic Scene
Consolidated Labels
Binary Mask
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
Background
Linear Features
Large Patches
Medium Patches
Tiny Patches
Non-Linear Features

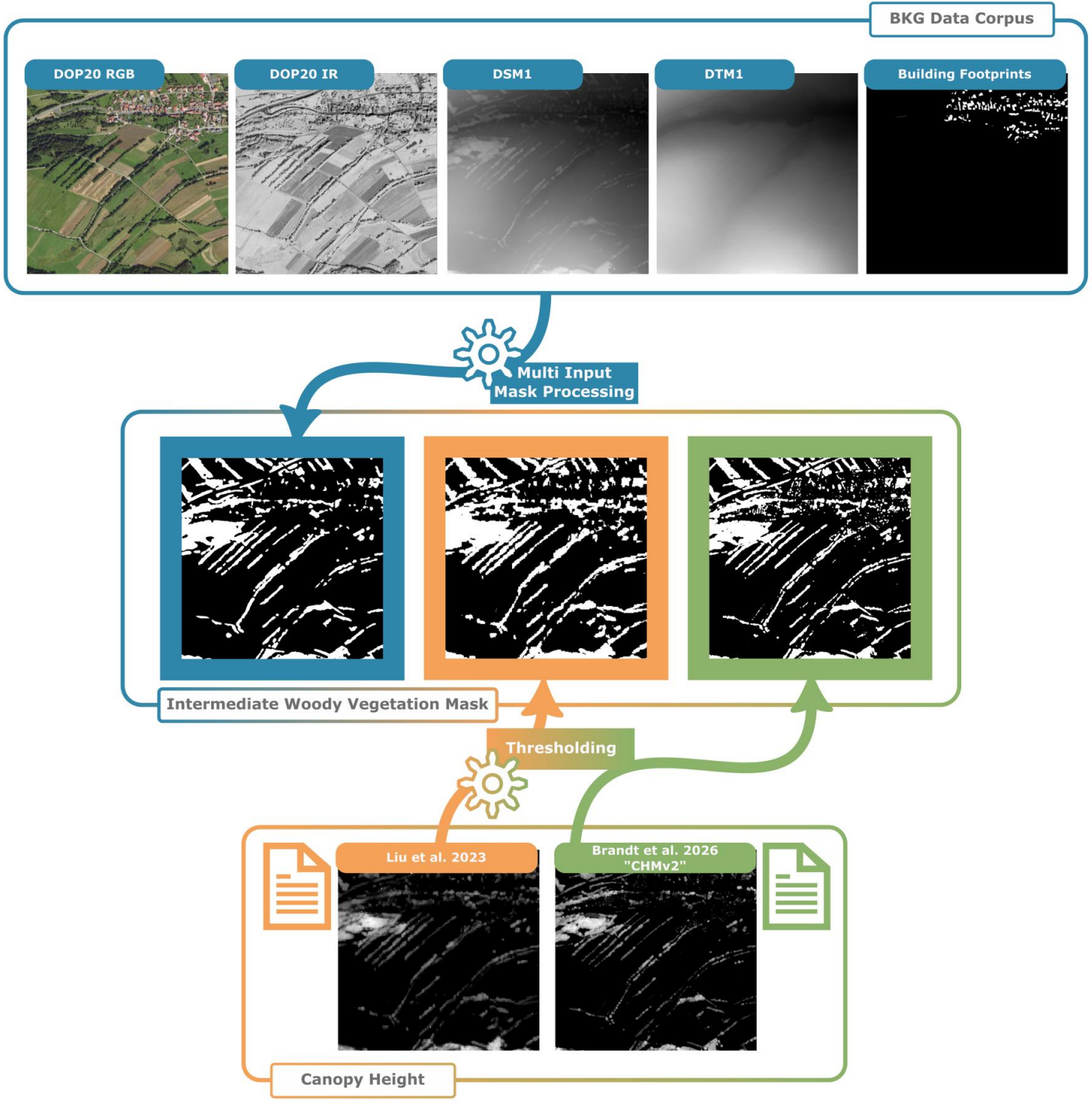

Synthetic Scene
Consolidated Labels
Binary Mask
(a)
Synthetic Scene
Consolidated Labels
Binary Mask
(b)
(f)
(g)
(h)
Background
Linear Features
Large Patches
Medium Patches
Tiny Patches
Non-Linear Features

Modellarchitektur und Kostenfunktionen

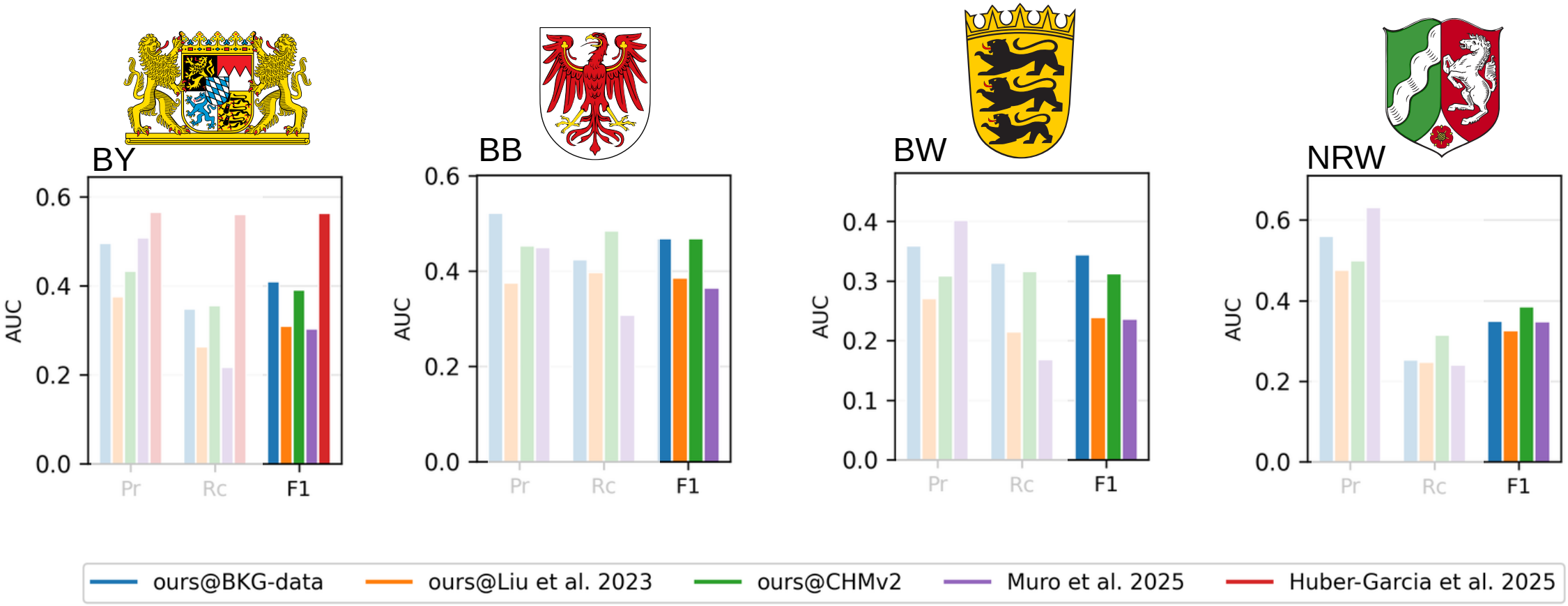


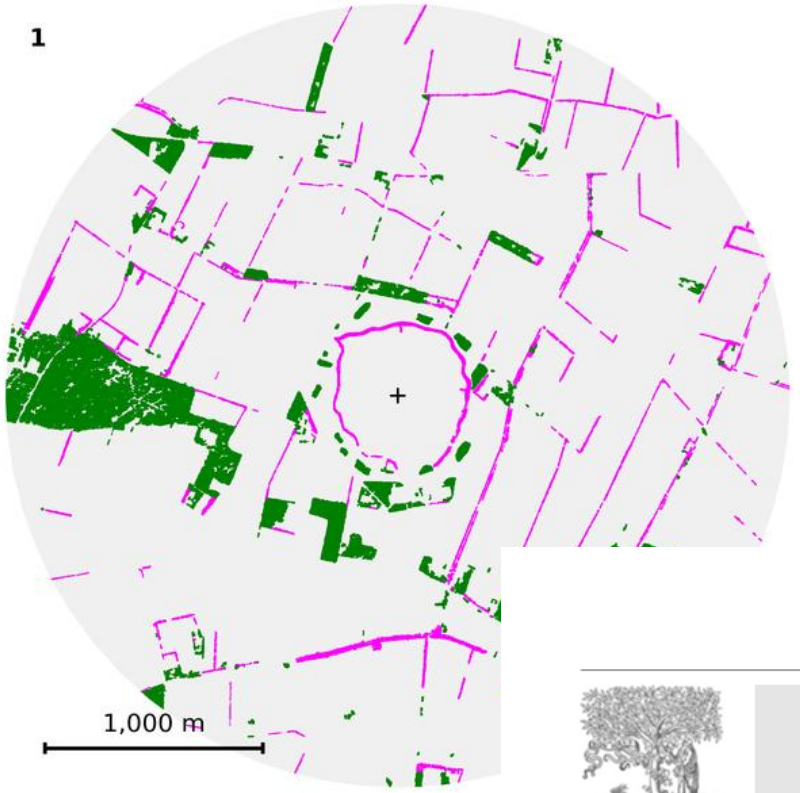

1
1,000 m
2
2,000 m
3
2,000 m
4
2,000 m
1
2
3
4
5
6
7
8
5
5,000 m
6
500 m
7
1,000 m
8
2,000 m


Reference Data
ours@BKG-data

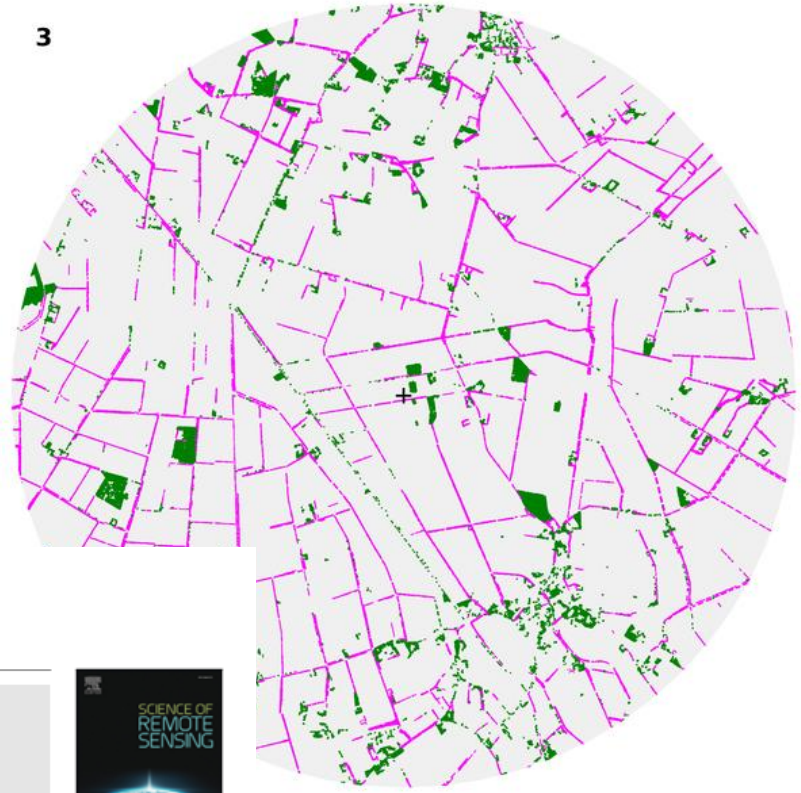

BKG Data Corpus
DOP20 RGB
DOP20 IR
DSM1
DTM1
Building Footprints
Multi Input
Mask Processing
Intermediate Woody Vegetation Mask
Thresholding
Liu et al. 2023
Brandt et al. 2026
"CHMv2"
Canopy Height

Evaluation und Vergleich mit existierenden Studien auf Testdaten

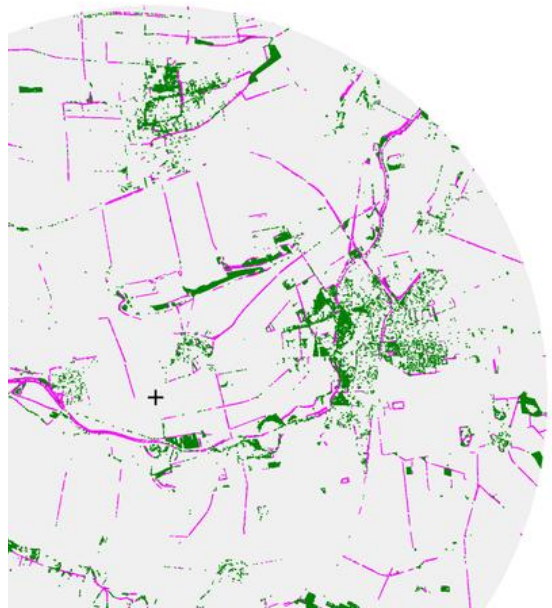












Science of Remote Sensing 14 (2026) 100489

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journal homepage: www.sciencedirect.com/journal/science-of-remote-sensing

Full Length Article

Towards generalizable mapping of hedges and linear woody features from Earth observation data: A national product for Germany

Thorsten Hoeser [a,*], Verena Huber-García [a], Sarah Asam [a], Ursula Gessner [a], Claudia Kuenzer [a,b]

[a] Earth Observation Center (EOC), German Aerospace Center (DLR), Oberpfaffenhofen, 82234 Wessling, Germany
[b] Institute for Geography and Geology, University of Wuerzburg, 97074 Wuerzburg, Germany

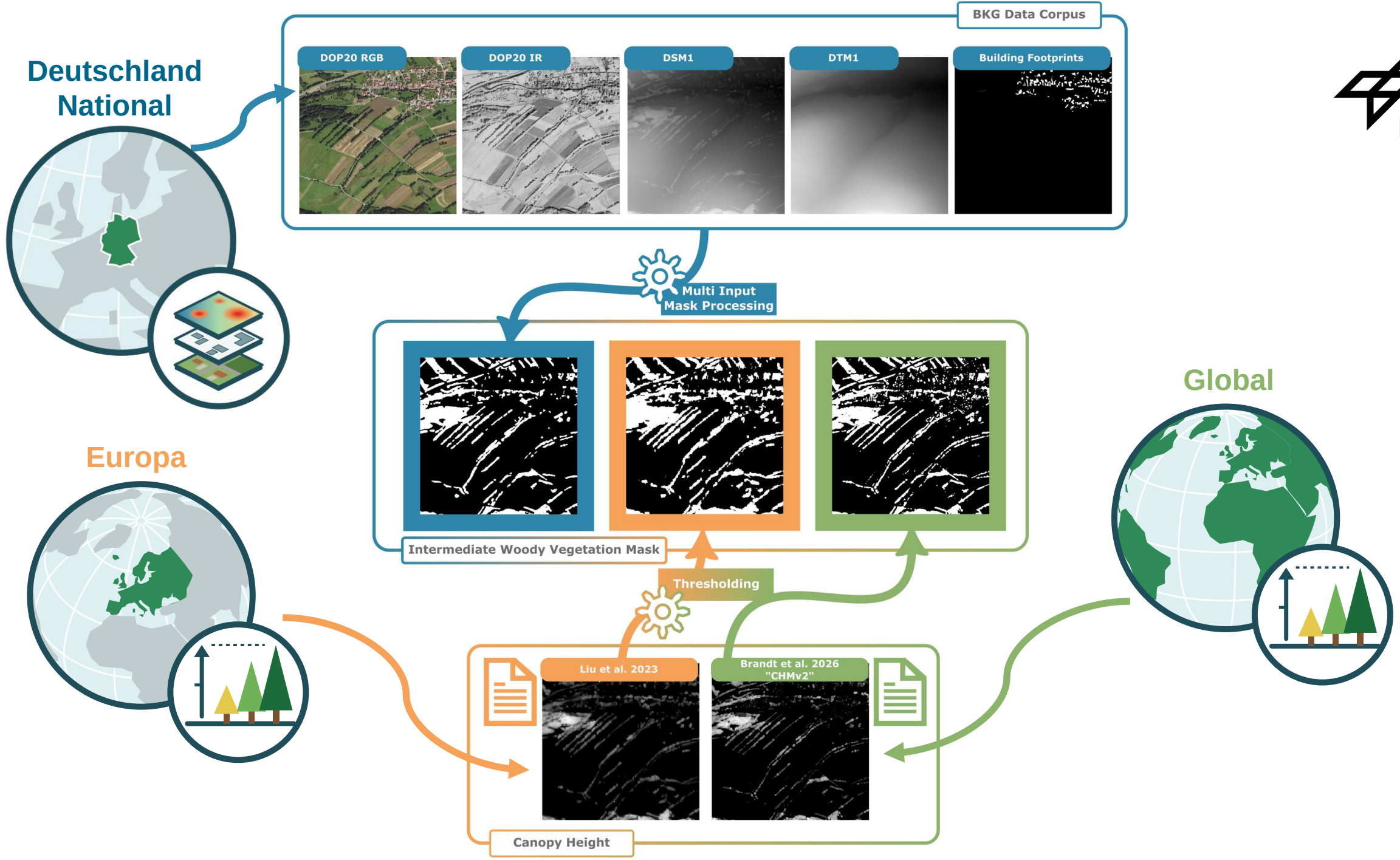
ARTICLE INFO

Dataset link: https://geoservice.dlr.de/web/

Keywords:
Remote sensing
Hedgerows
Tree lines
Riparian vegetation
Aerial imagery
Deep learning

ABSTRACT

Hedges and other linear woody features provide valuable ecosystem services, particularly within intensively managed agricultural landscapes. They are key elements for climate adaptation and biodiversity amongst others not only due to a largely varying flora, but also as a feeding-, resting-, and nesting place for many animals and insects including valuable pollinators. Therefore, they require dedicated management, preservation, and attention. Thus, systematic and large-scale mapping of these features from Earth observation data is of high importance. However, transferable and reusable workflows for linear woody feature mapping remain a key methodological challenge, given the diversity of sensor types, spatial resolutions, data acquisition conditions, and complex landscape variability encountered across study areas. We introduce a modular workflow built


Deutschland
National
BKG Data Corpus
DOP20 RGB
DOP20 IR
DSM1
DTM1
Building Footprints
Multi Input
Mask Processing
Intermediate Woody Vegetation Mask
Thresholding
Europa
Global
Liu et al. 2023
Brandt et al. 2026
"CHMv2"
Canopy Height

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Liu, S., Brandt, M., Nord-Larsen, T., Chave, J., Reiner, F., Lang, N., Tong, X., Ciais, P., Igel, C., Pascual, A., Guerra-Hernandez, J., Li, S., Mugabowindekwe, M., Saatchi, S., Yue, Y., Chen, Z., Fensholt, R., 2023. The overlooked contribution of trees outside forests to tree cover and woody biomass across europe. Sci. Adv. 9 (37), eadh4097.

Huber-García, J. Kriese, S. Asam, M. Dirscherl, M. Stellmach, J. Buchner, K. Kerler, and U. Gessner. Hedgerow map of bavaria, germany, based on orthophotos and convolutional neural networks. Remote Sensing Applications: Society and Environment, 37:101451, 2025.

T. Hoeser, V. Huber-García, S. Asam, U. Gessner, and C. Kuenzer. Towards generalizable mapping of hedges and linear woody features from earth observation data: a national product for germany. Science of Remote Sensing, 14:100489, 2026.