



Vlaanderen
is kwaliteitsvolle
omgeving

Machine Learning for High-Resolution Soil-Sealing Mapping: Opportunities and Challenges

Kasper Cockx¹, Joris Pieters², Peter Willems¹ & Stijn Vanacker¹

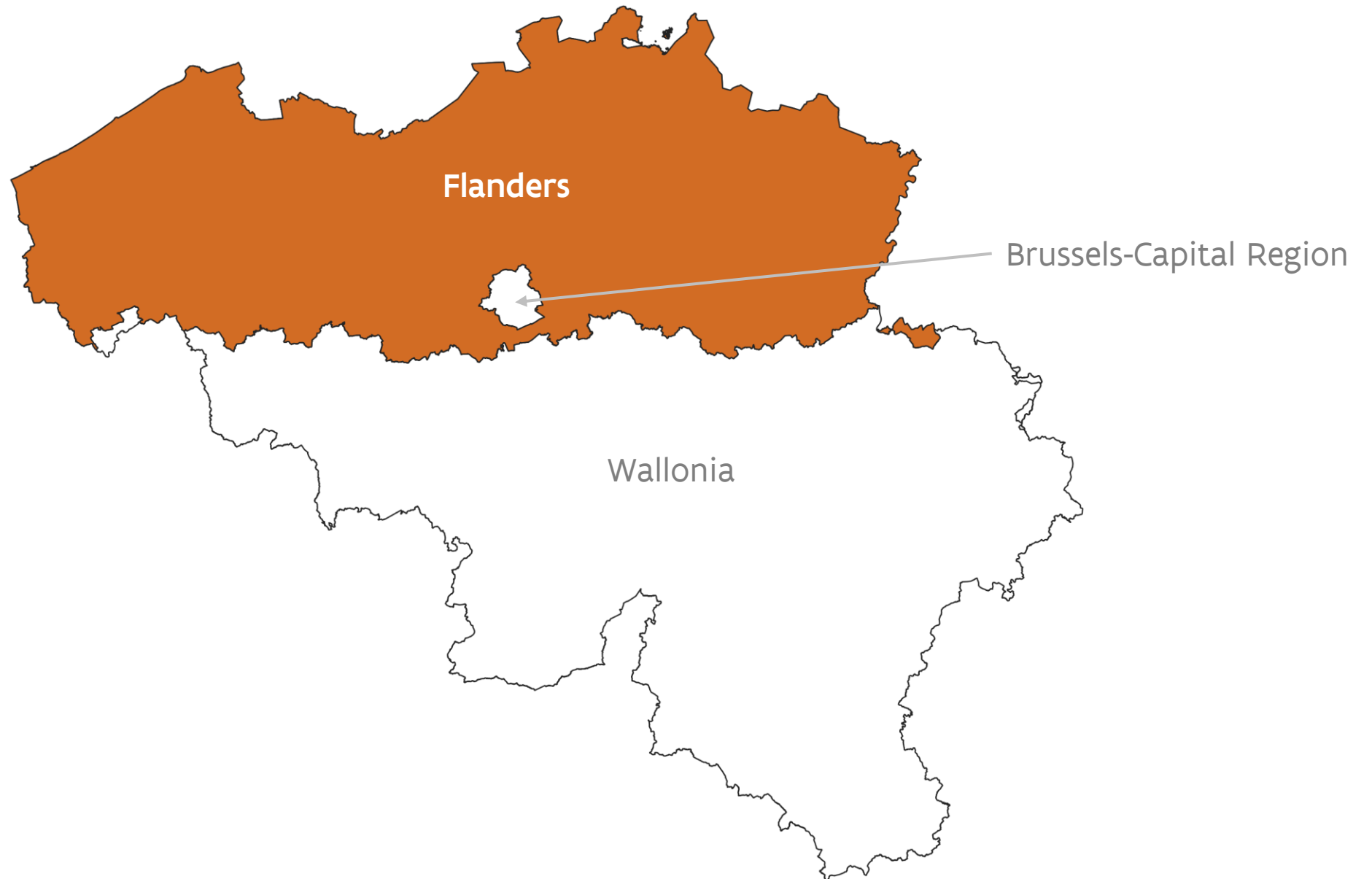
¹ Department of the Environment, Flemish government

² Keyrus

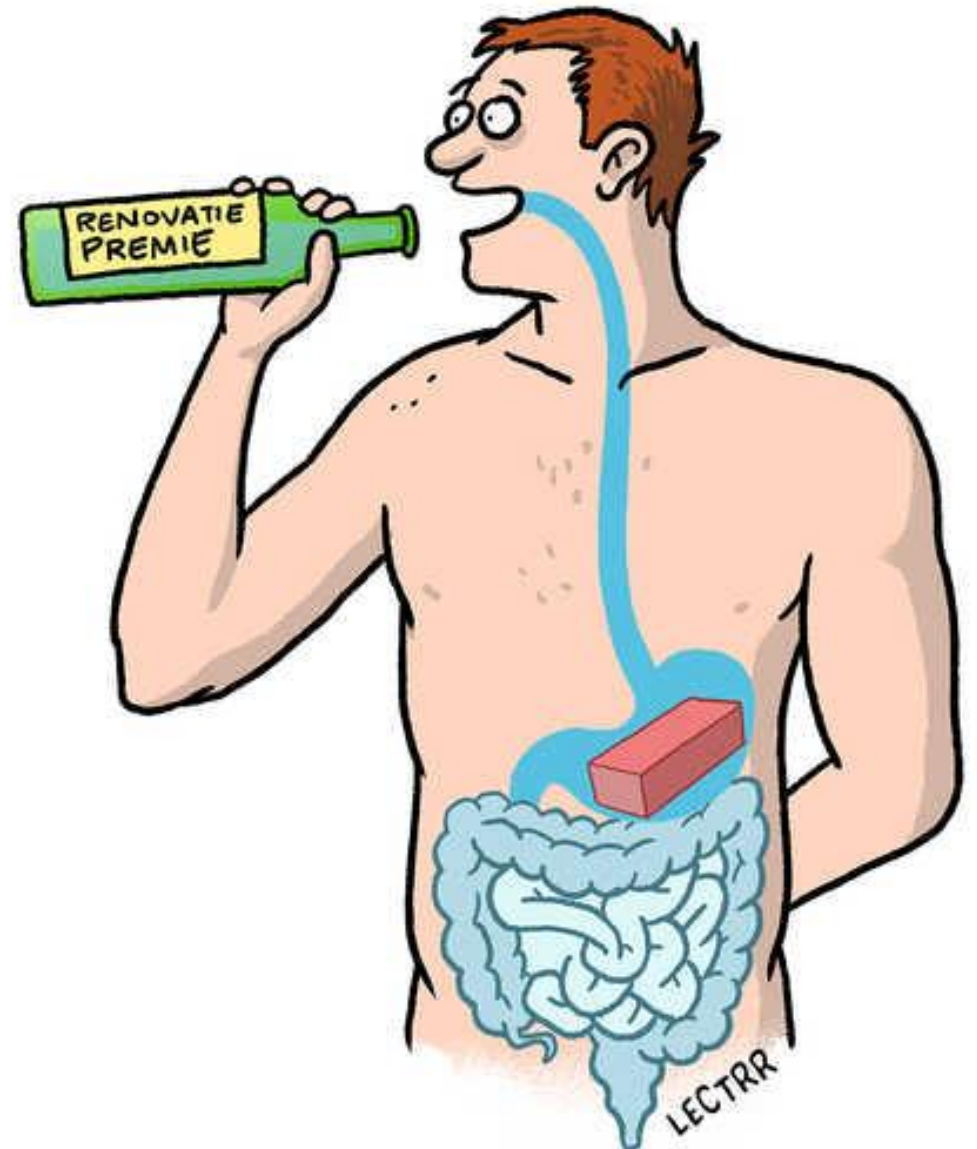
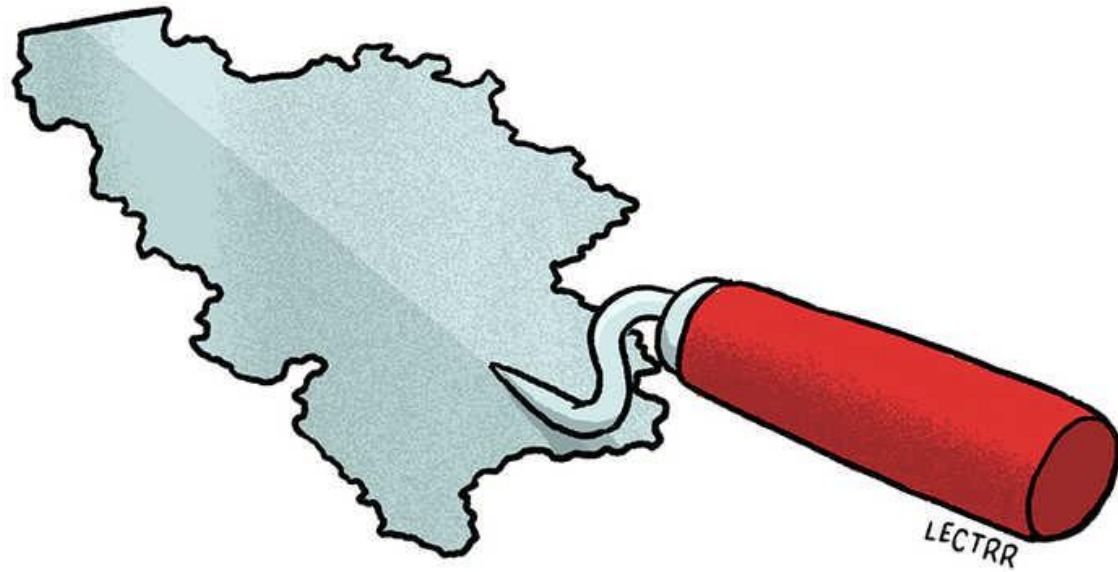
4 June 2026 | GeoAI

DEPARTEMENT
OMGEVING

Belgium: land of complexity ...



Belgium: ... and home to many buildings ...



Belgium: ... “anywhere you want”



Soil sealing

- ▶ Change in surface's nature/state by **artificial, (semi-)impervious materials**
- ▶ Loss of essential soil ecosystem services



Soil sealing in 2015 (%)



Malta



Flanders



The Netherlands



Belgium



Liechtenstein



Germany



Luxembourg



United Kingdom

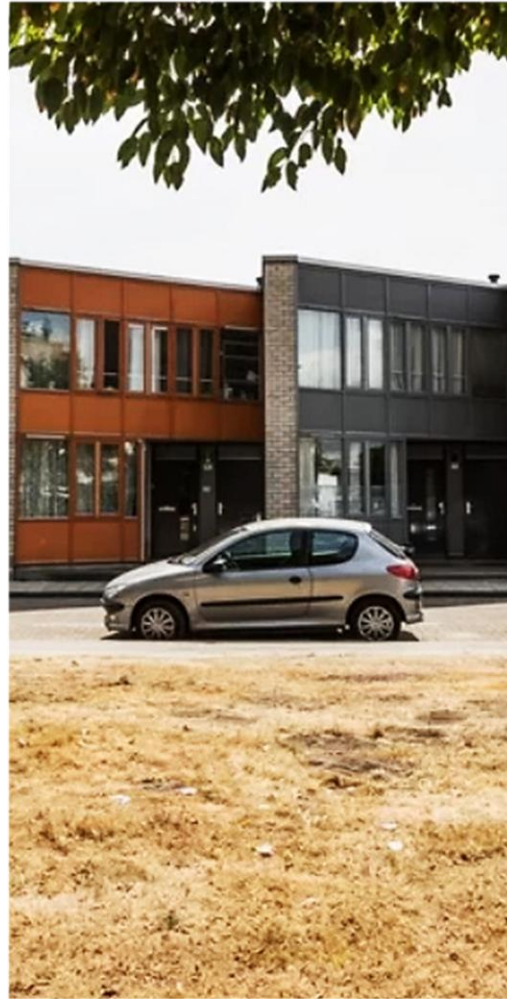


Denmark



Switzerland

Soil sealing

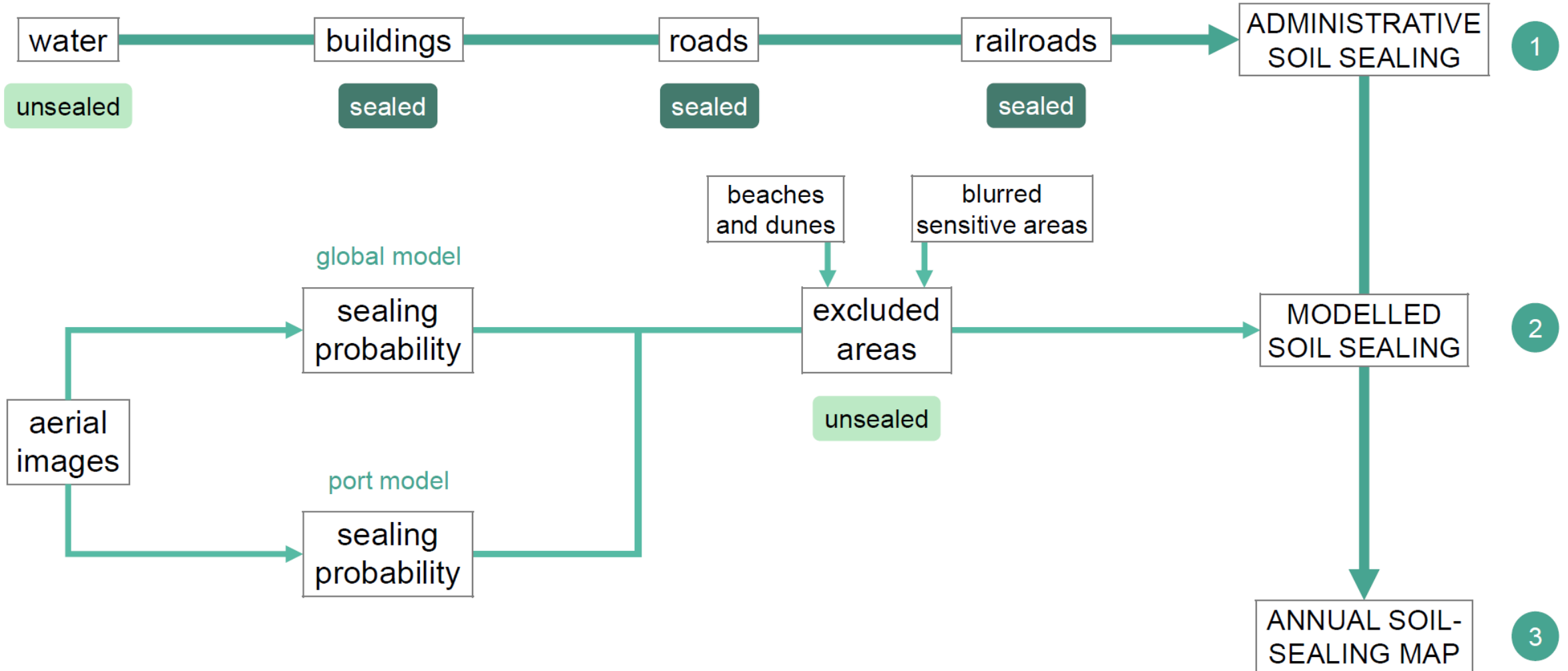


Soil sealing

- ▶ Need for sustainable spatial management
- ▶ Timely monitoring to guide policy measures
 - Opportunities through AI & data growth
 - Ancillary data sources & human expertise still required

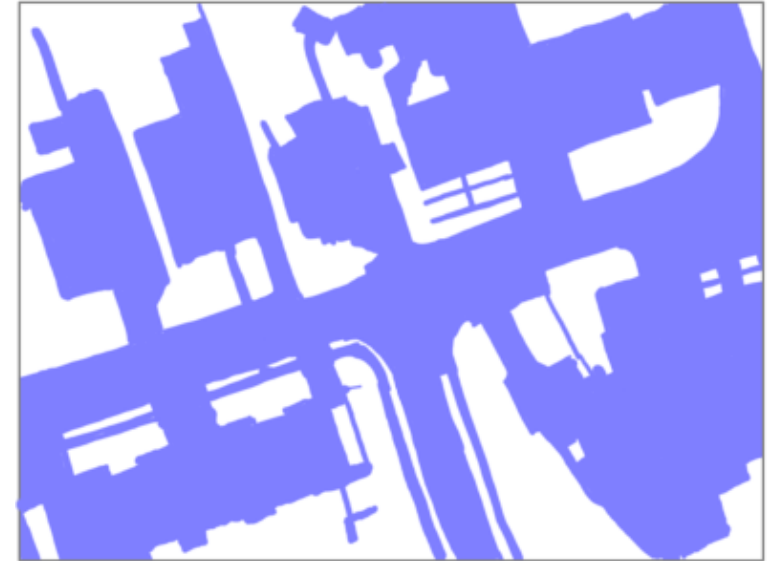
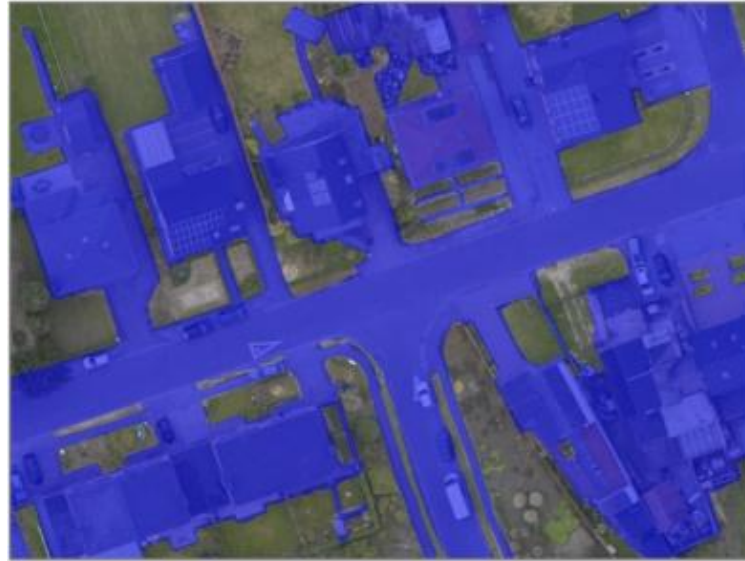
⇒ **automated approach for annual, high-resolution maps**

Our approach: label each pixel as sealed or unsealed



Modelled soil sealing: labelling

Ca. 5.000 ha by colleagues (2012 → 2020)



Modelled soil sealing: temporal correction

<u>corrected</u>	original	original	<u>corrected</u>
<i>t-1</i>	<i>t</i>	<i>t+1</i>	<i>t</i>
<i>unsealed</i>	sealed	sealed	sealed
sealed	<i>unsealed</i>	<i>unsealed</i>	<i>unsealed</i>
<i>unsealed</i>	sealed	<i>unsealed</i>	→ <i>unsealed</i>
sealed	<i>unsealed</i>	sealed	→ sealed

orthophoto
2022



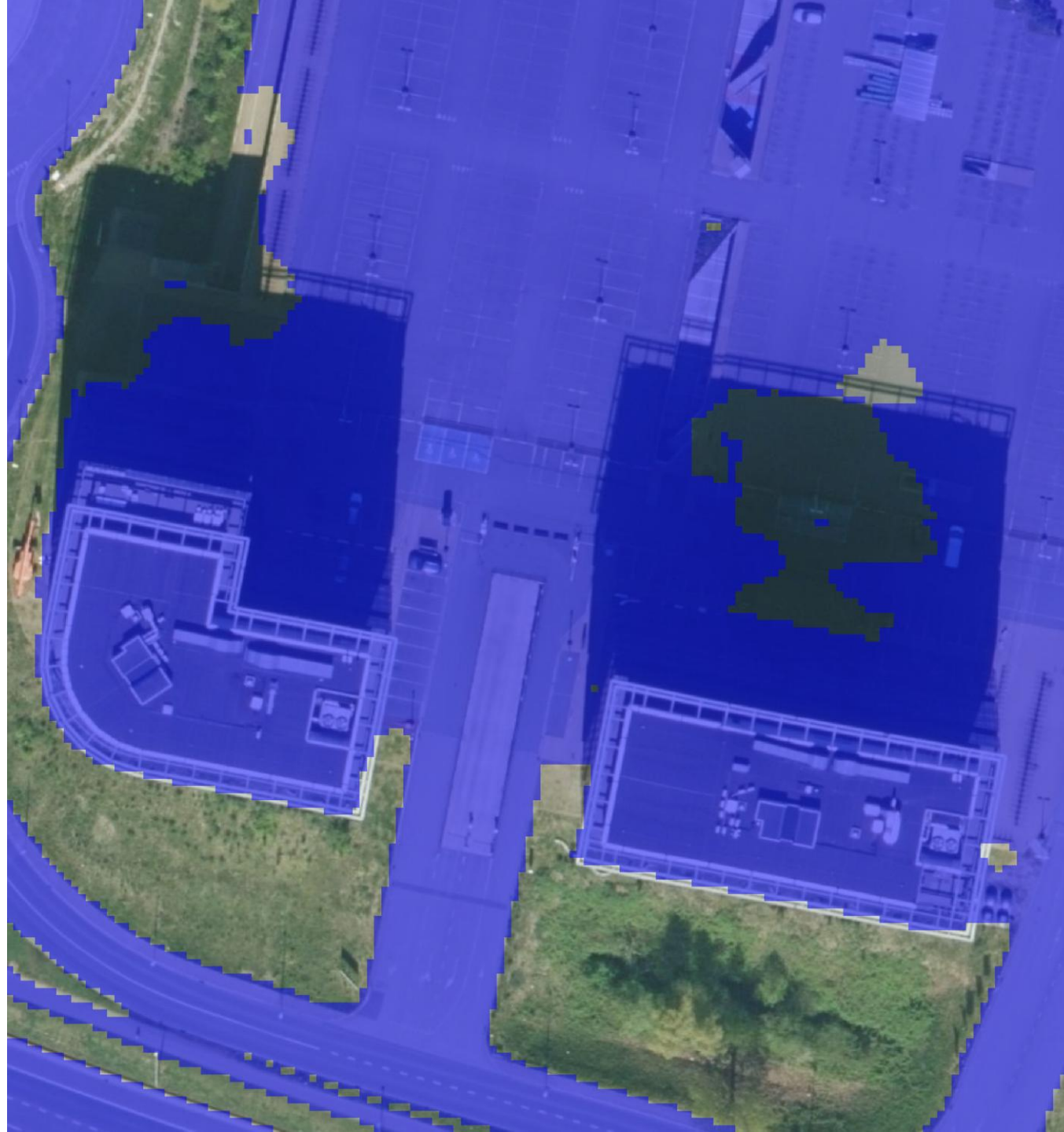
orthophoto
2023



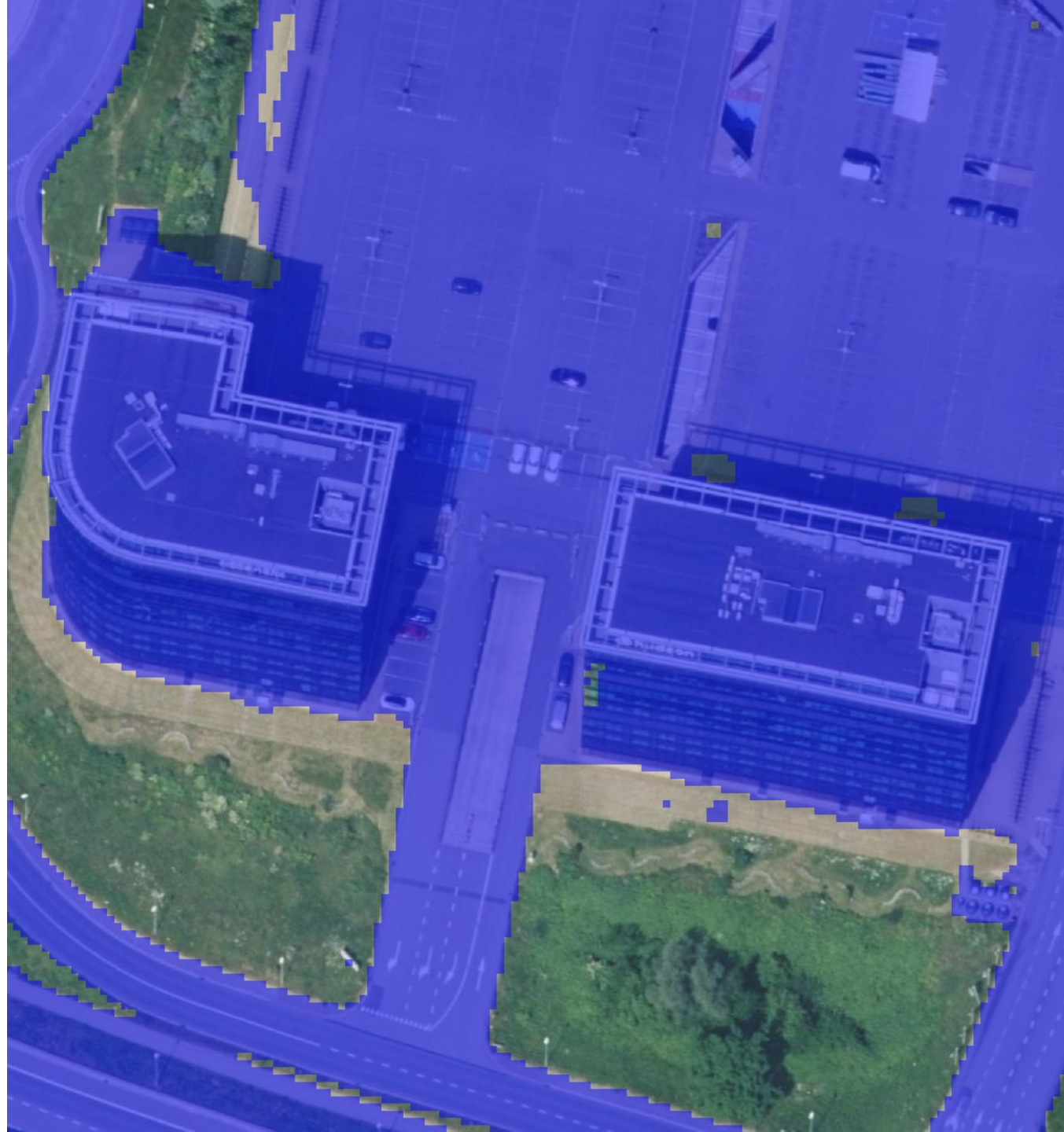
orthophoto
2024



sealed
2022



sealed
2023

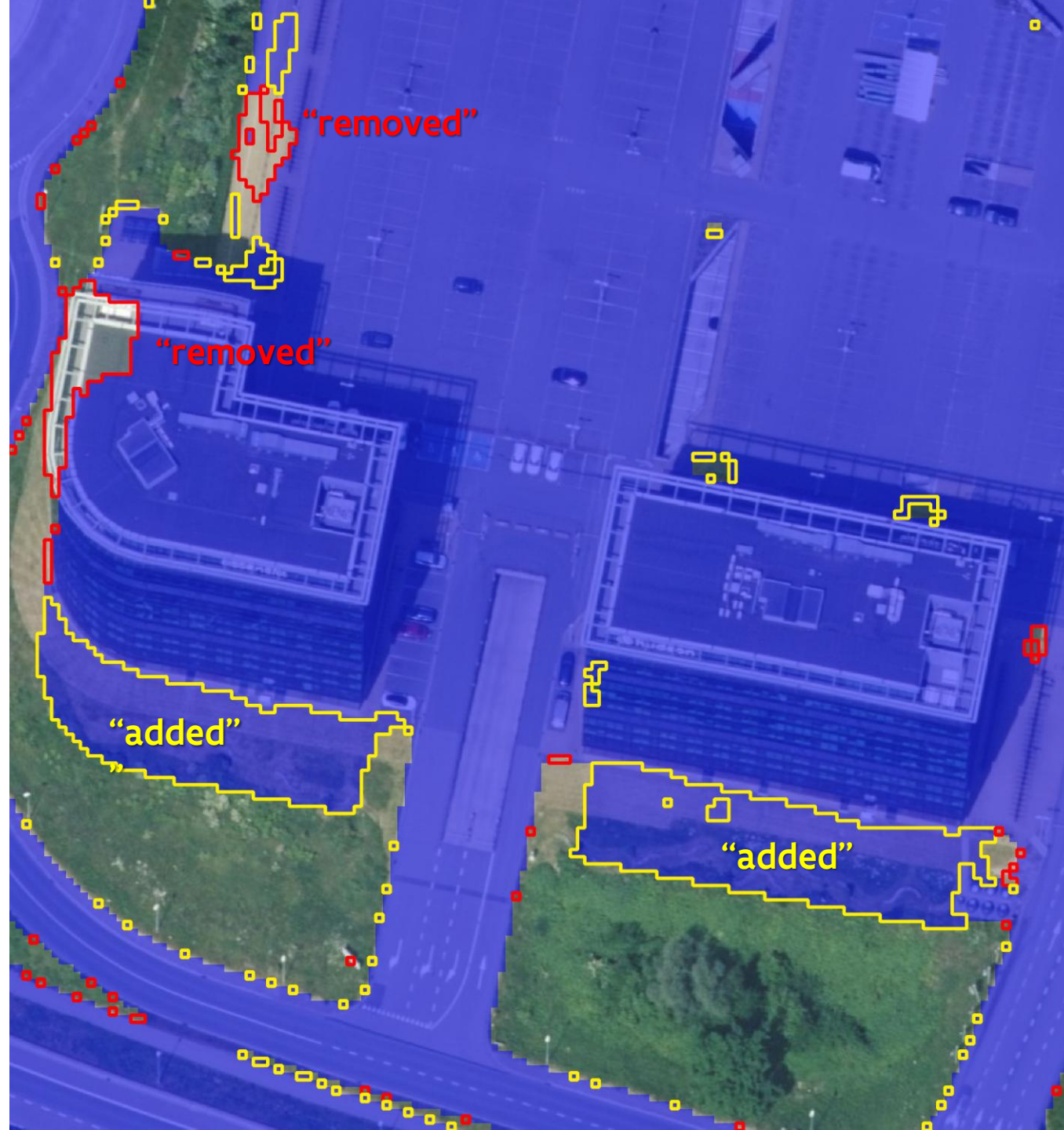


sealed
2024



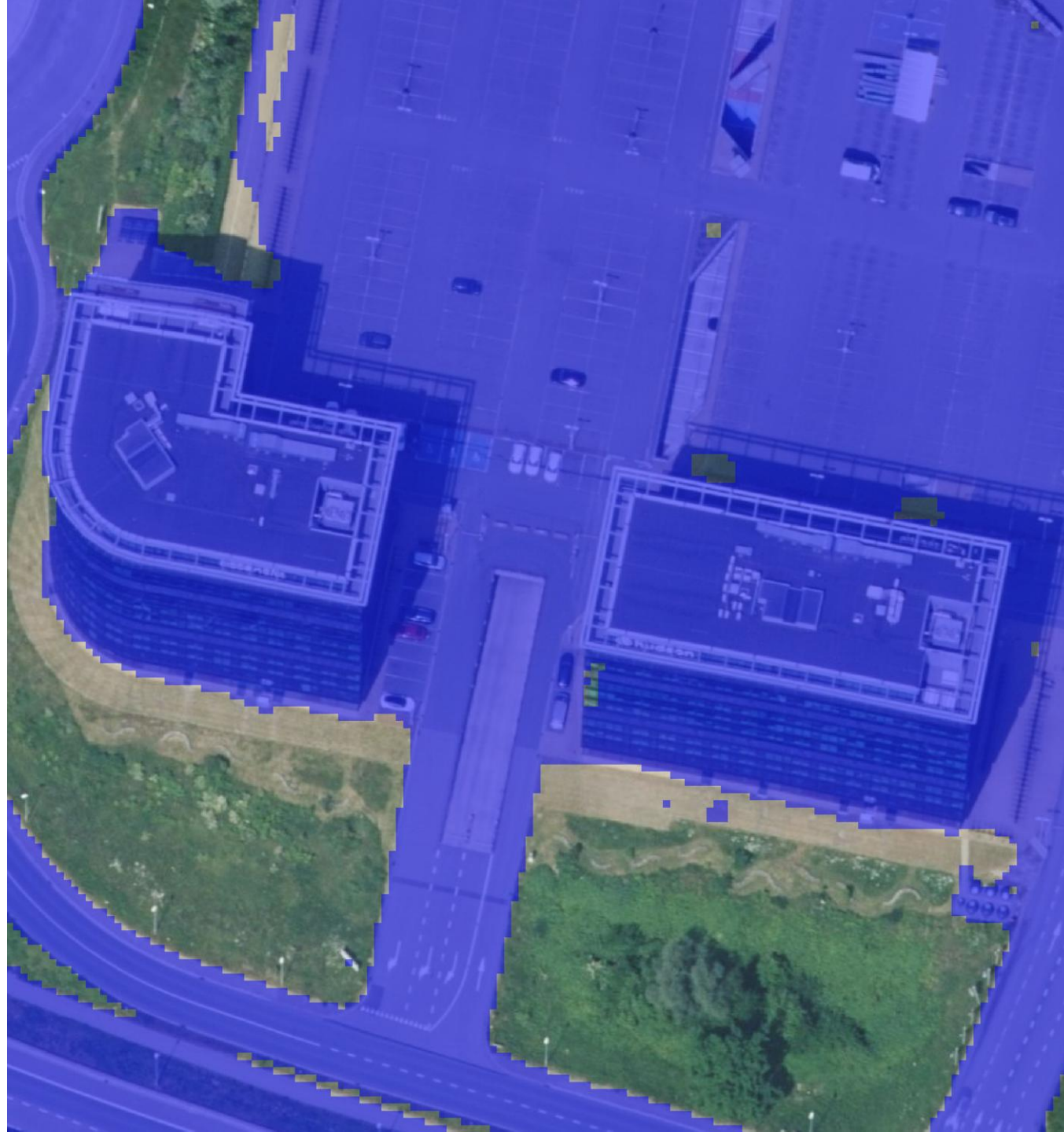
sealed
2023

with correction

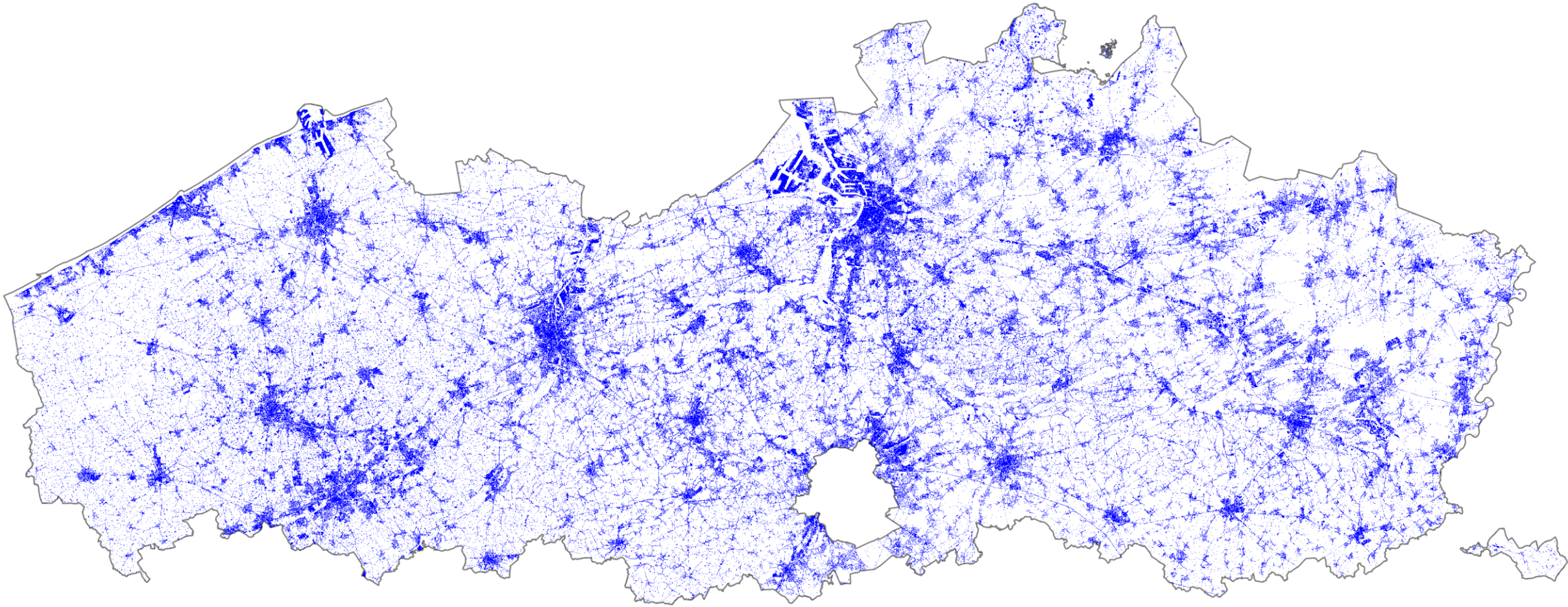


sealed
2023

without correction



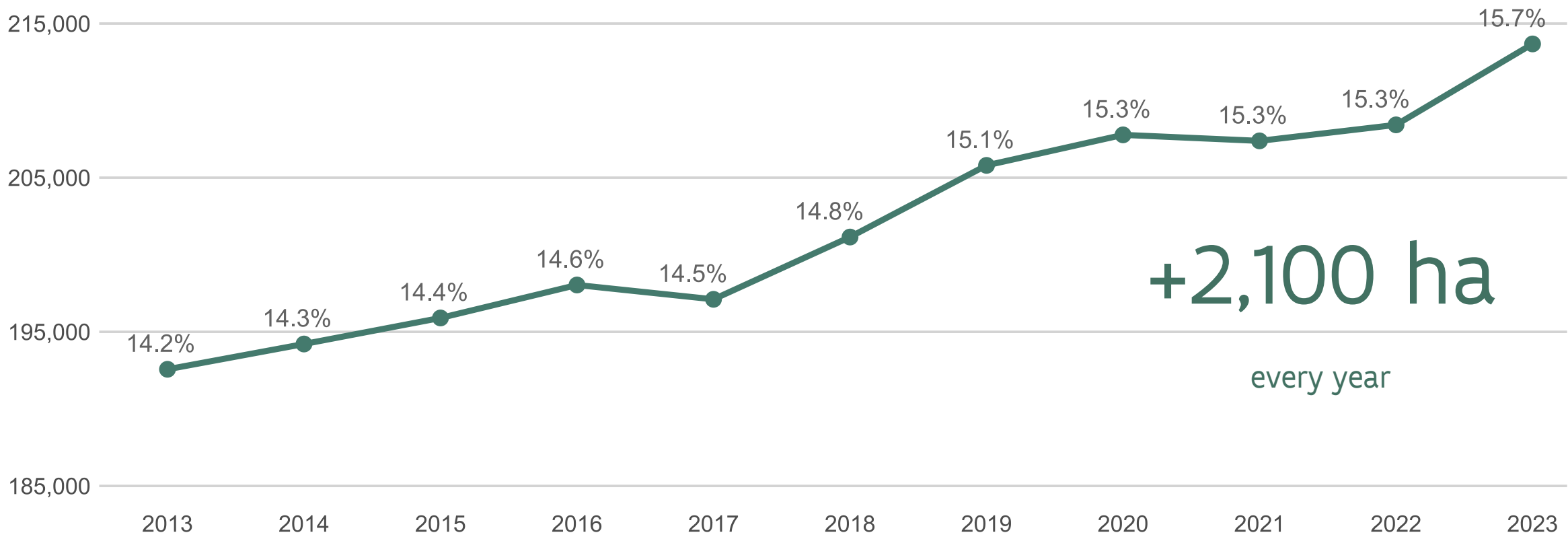
Final result: 1 m resolution with 97,8% accuracy







Sealed area in Flanders (ha)



Challenges (1)

► Model retraining

→ Less detection beyond initial training period (post-2020)

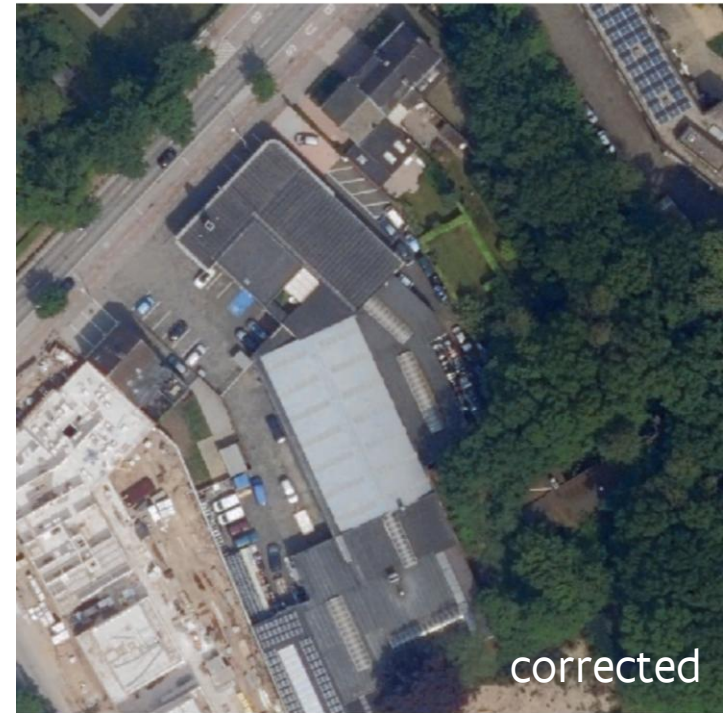
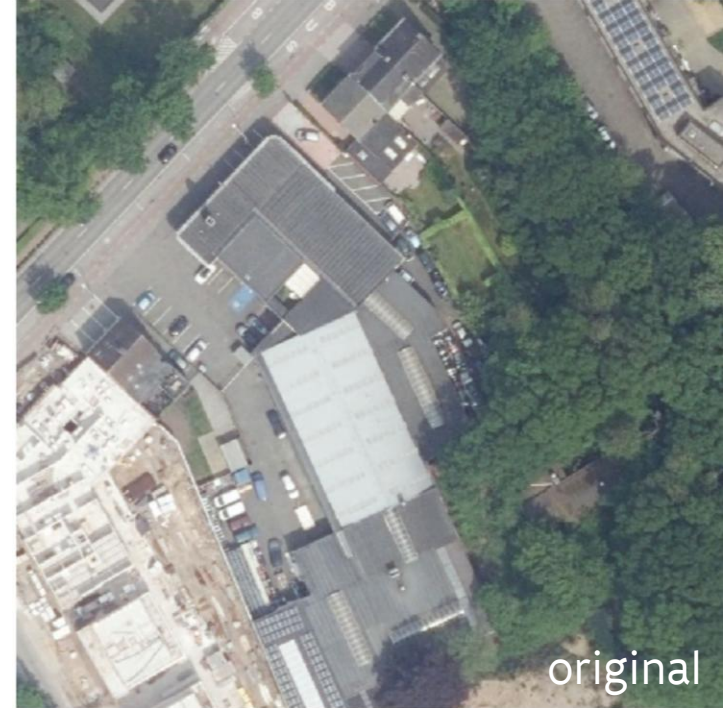
► Data harmonisation

→ Other road network in administrative database

× +65% km & different sealing categories

→ Colour distribution shifts produced model drift

× PCA correction



Challenges (2)

► Local inconsistencies

- Large homogeneous surfaces
 - × Inside and outside ports

► Change detection

- Non-permanent agricultural coverings
 - × Lack of data
- Shadows and seasonality
 - × Illusion of change

2021



2022



Challenges (3)

► Future directions

→ Tests on 2.5-cm dataset

× Additional complexity

► Structural limitations

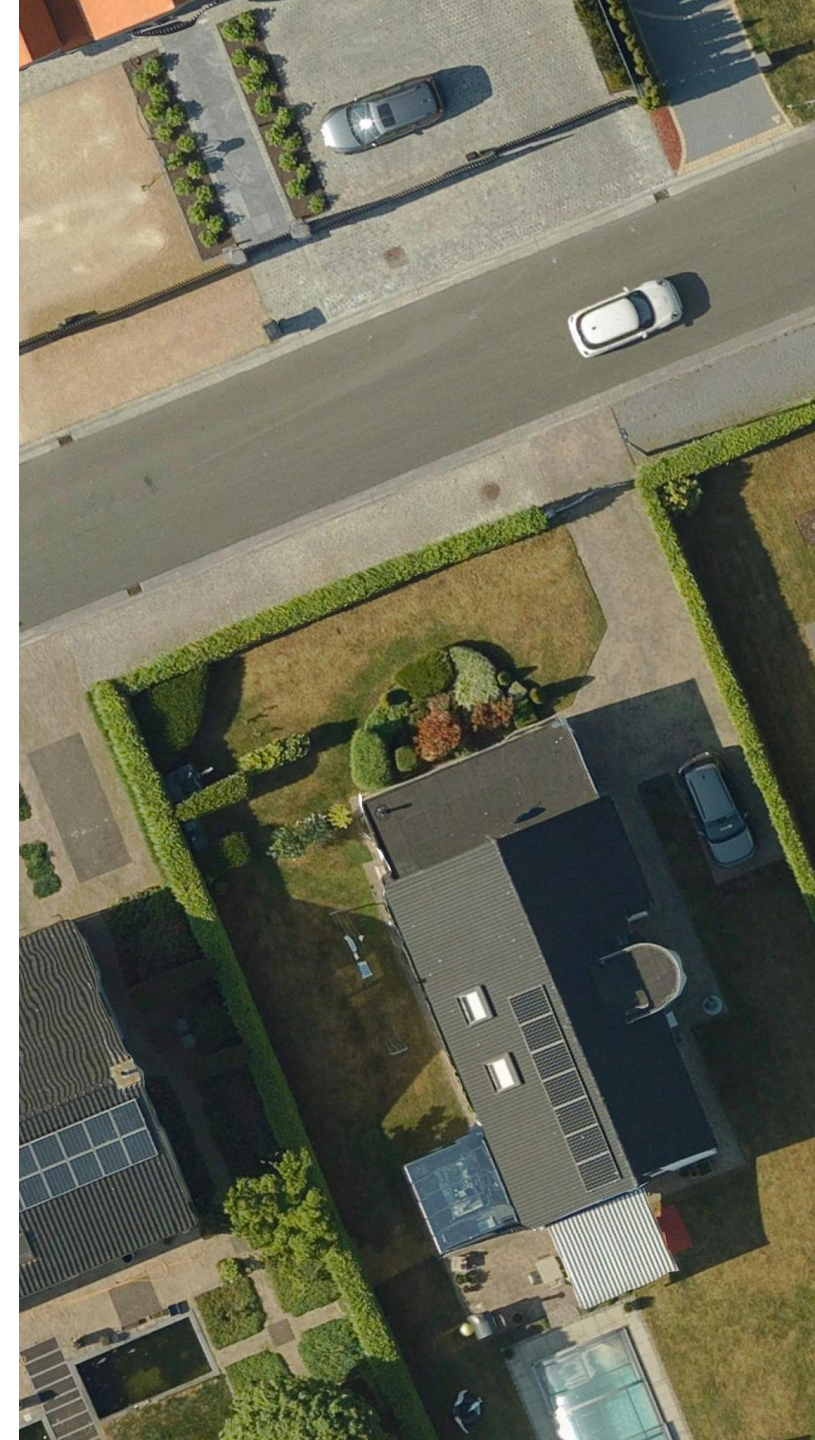
→ Training data production

× Time- and labour-intensive

→ Visible-spectrum imagery

× Invisible remains invisible

× Inclusion of infrared/thermal data: if annual and low/no cost



Check out the maps

and/or reach out to

kasper.cockx@vlaanderen.be

vlaanderen.be/datavindplaats/catalogus?q.LIKE=JaarBAK%201%20m

