

# StatEO

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# Artificial Intelligence for Reliable Land Use Statistics: Opportunities and Challenges from Switzerland

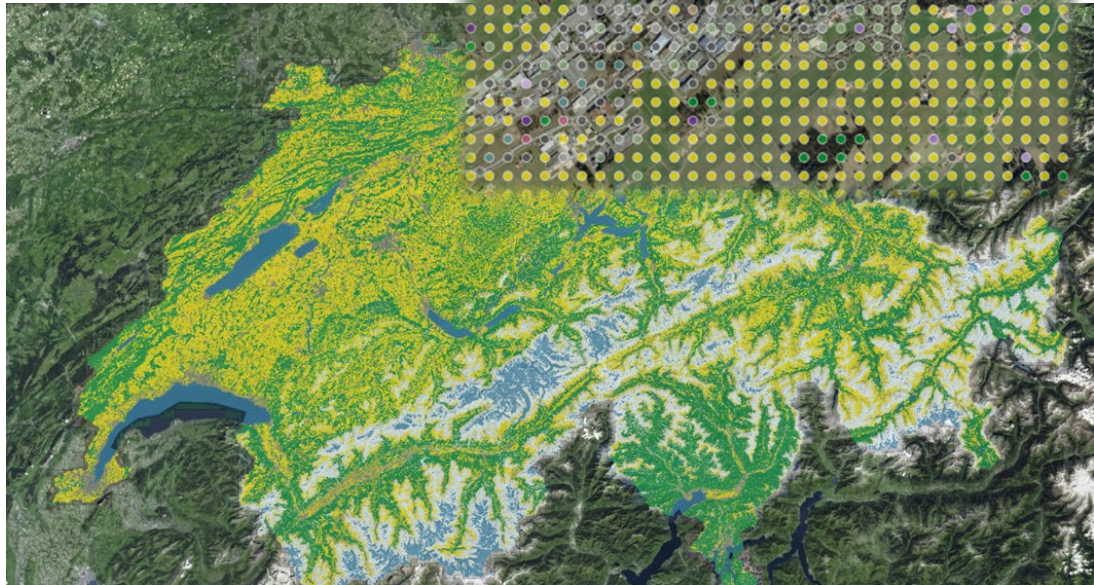


Gillian Milani, Michèle Gillard, Romain Douard  
Federal Office of Statistics, Switzerland

# Land use statistics

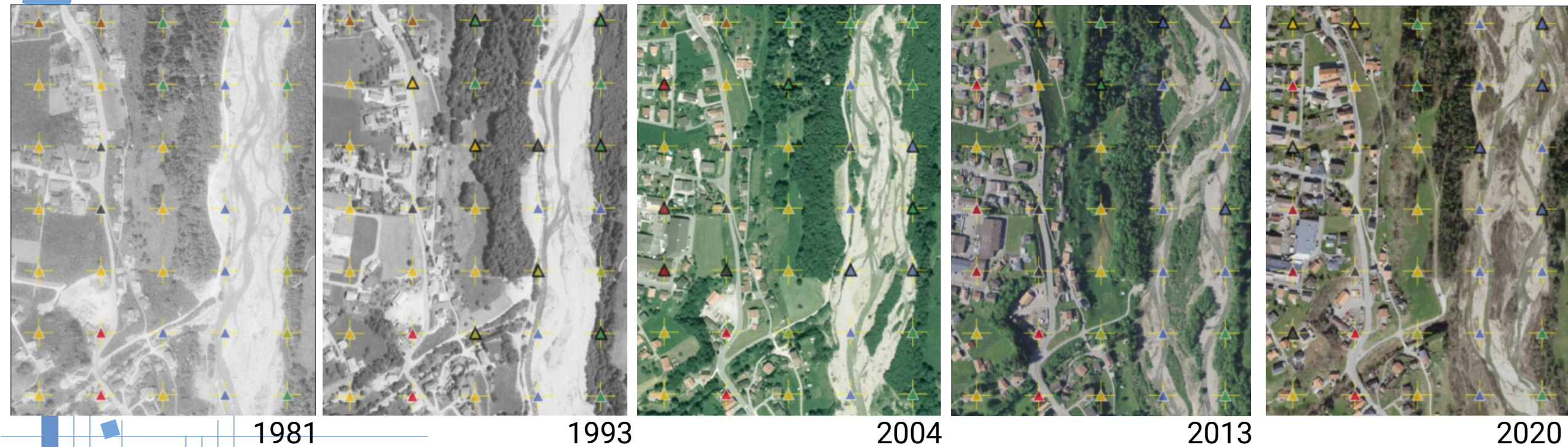
- Land cover with 27 classes
- Land use with 46 classes
- Based on 4 millions sample points equally spaced on a regular 100m grid
- Visual Interpretation of aerial images by experts

101	Industrial and commercial areas > 1 ha
102	Industrial and commercial areas < 1 ha
103	Residential areas (one and two-family houses)
104	Residential areas (terraced houses)
105	Residential areas (blocks of flats)
106	Public buildings and surroundings
107	Agricultural buildings and surroundings
108	Unspecified buildings and surroundings



# Land use statistics: a valuable time series

- Information on the state and evolution of land use and land cover
- Long-term statistical series since 1979, based on the interpretation of aerial photographs



1981

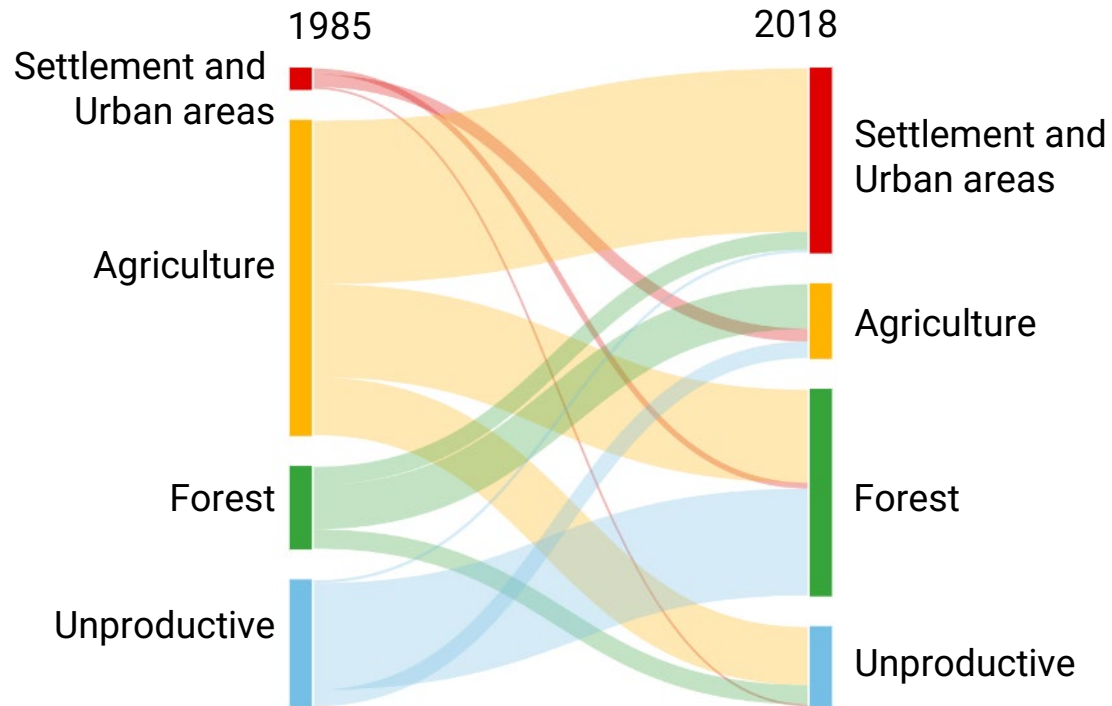
1993

2004

2013

2020

# Monitoring the changes

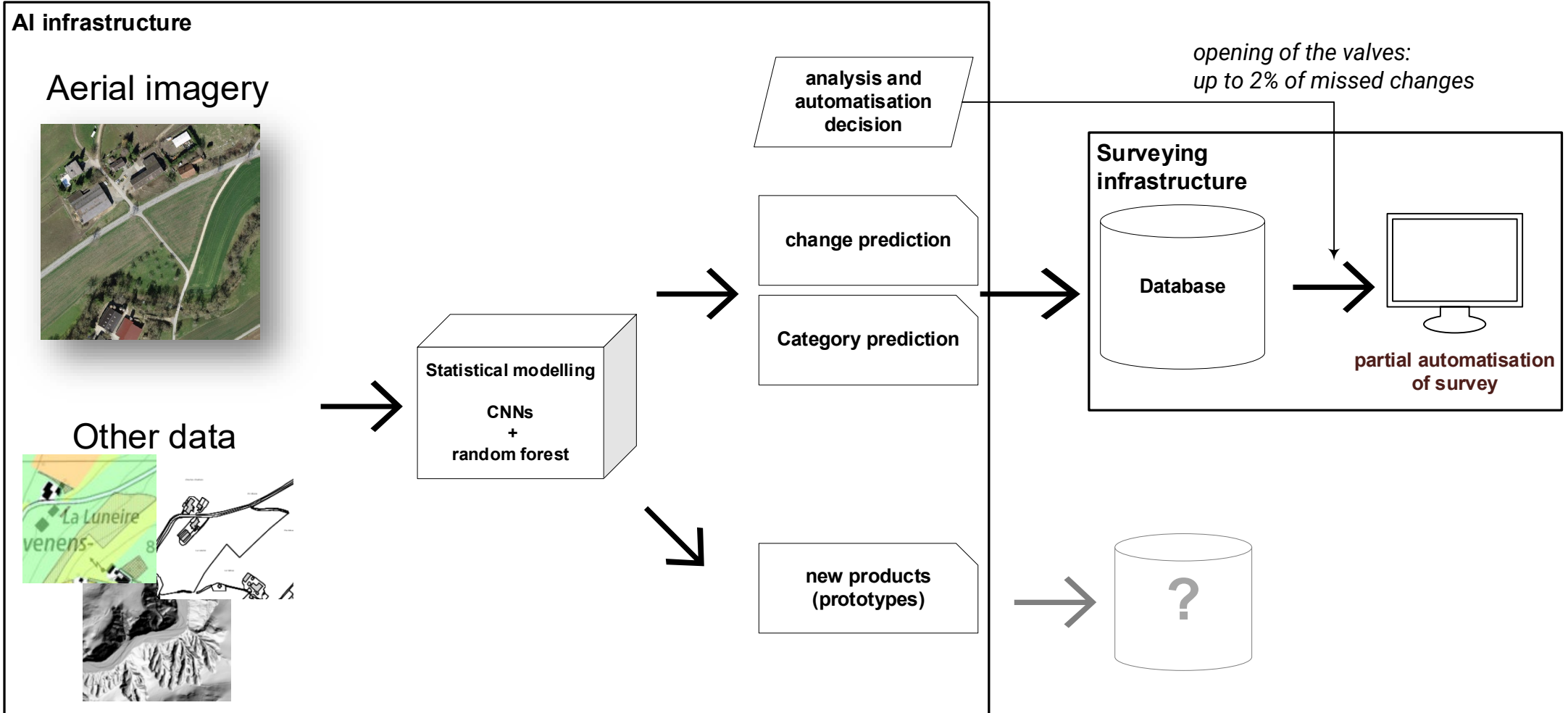


## Rate of changes

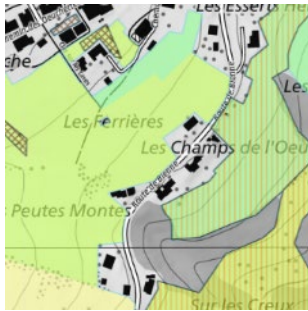
Considering 4 main categories  
**~0.2% per year**

Considering 46 LU categories and  
27 LC categories  
**0.5-1% per year**

- Often, decision-making is based on the changes, not the absolute values
- Monitoring changes can only be achieved through highly accurate and reliable data
- A-priori change fractions should help designing surveys and automated products



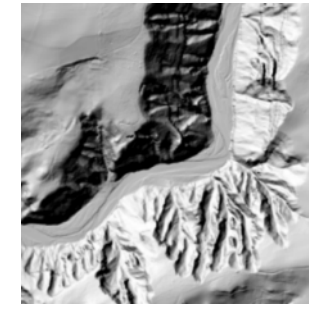
# Data to feed the model



Agricultural land use information



Vector topographic maps



DHM



Cadastral survey



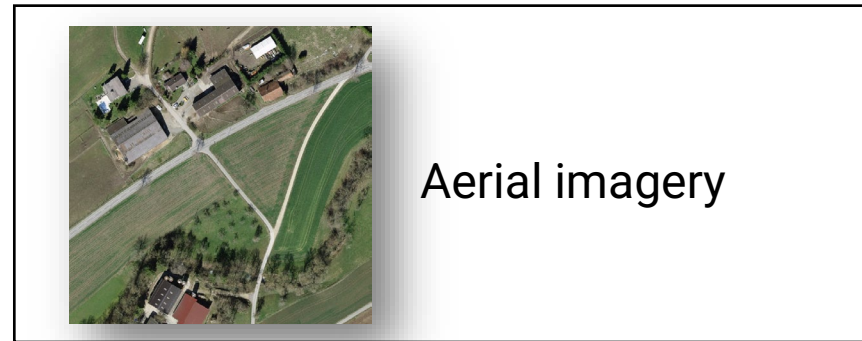
Land use statistics data (neighbourhood relationship)



Canopy Height Model



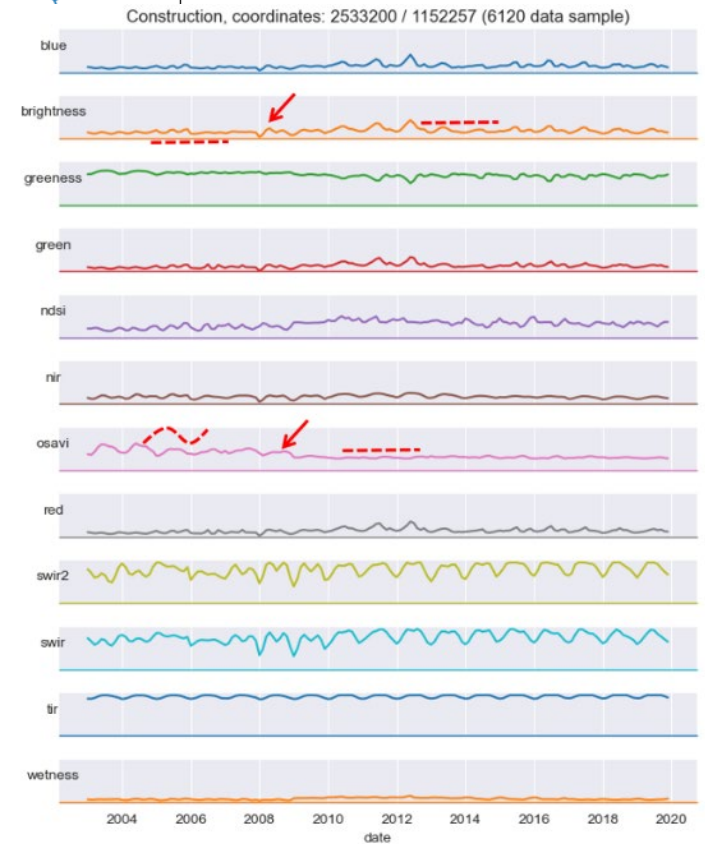
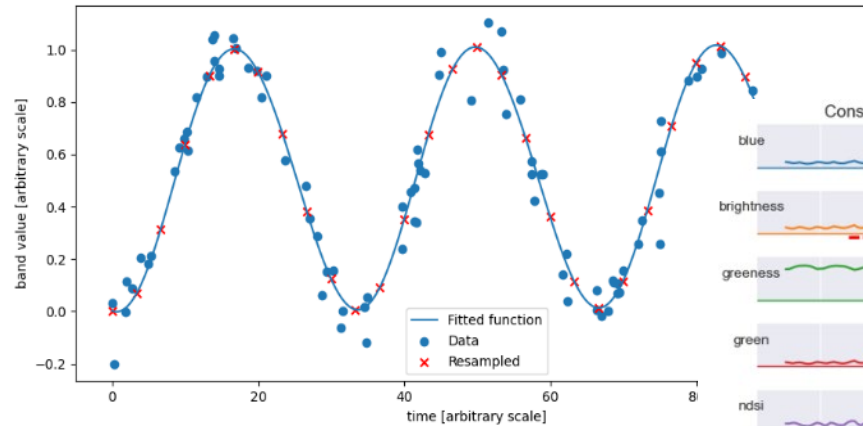
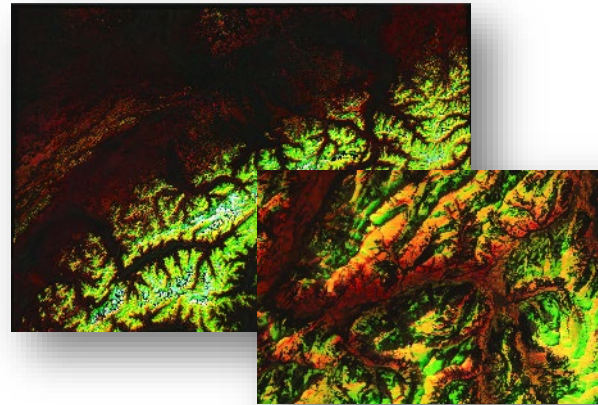
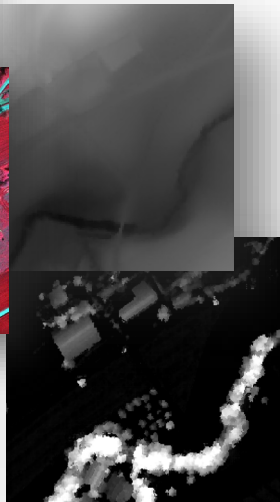
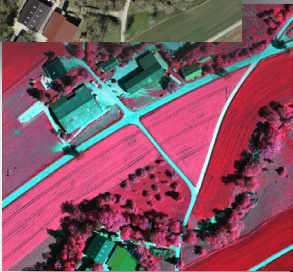
Administrative units



Aerial imagery

# More data to feed the model ?

Orthoimages RGB  
Orthoimages NIR  
height and terrain



Satellite data (Landsat)

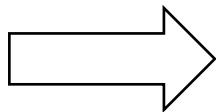
# By-product of the automatisisation

Towards a fully automatic produced land cover / land use high resolution layer ?



*High resolution land cover layer produced using:*

- 1. segmentation of aerial photographs*
- 2. classification of segments*
- 3. correction of specific artefacts using complementary data*

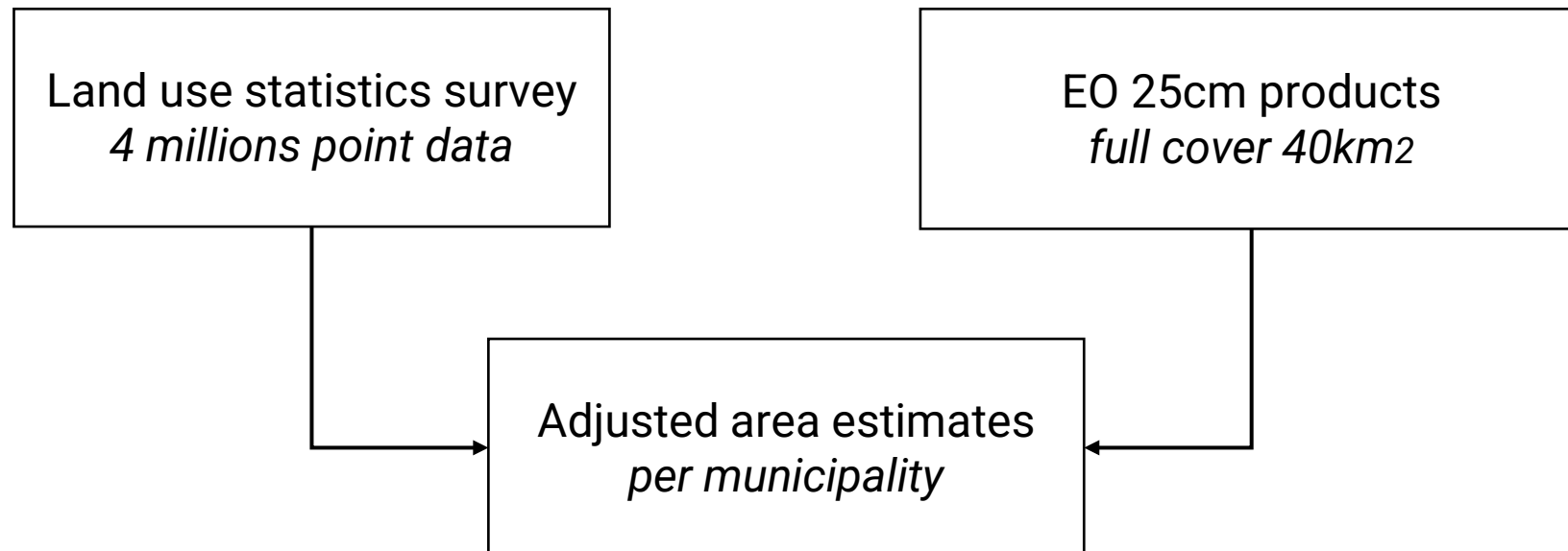


Useful to extract statistical estimates on small areas



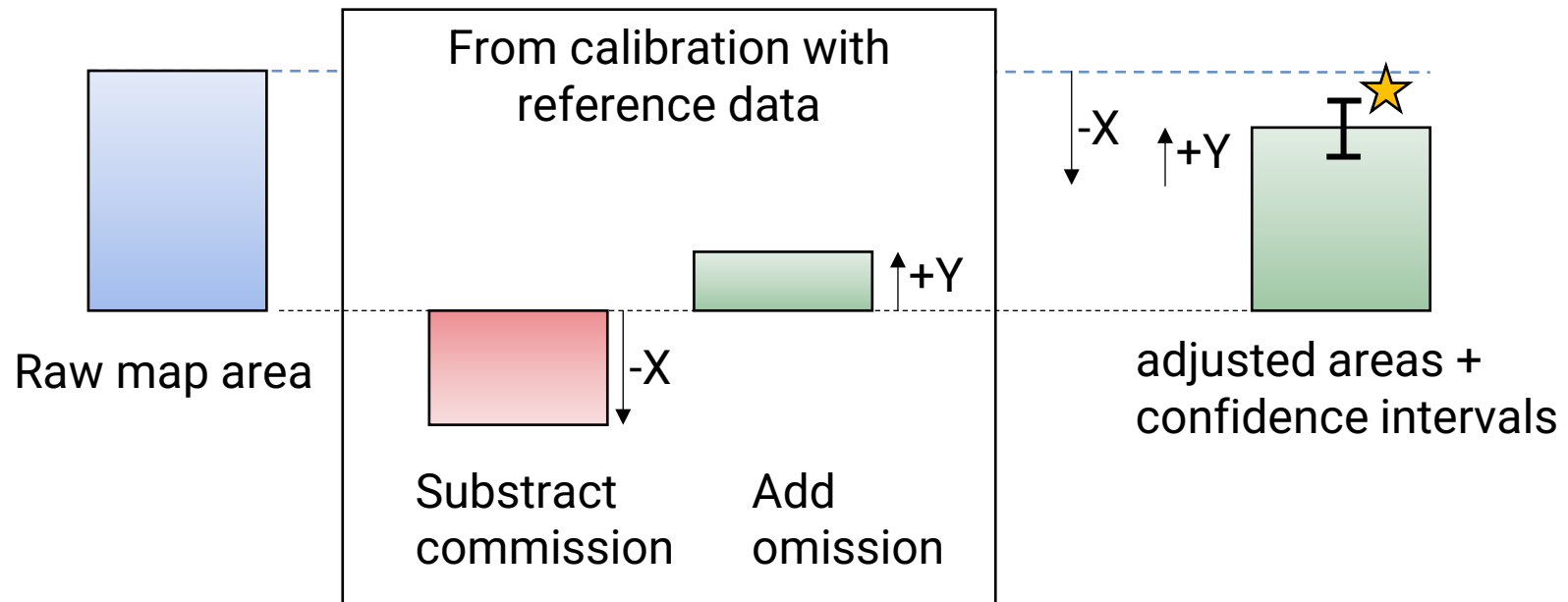
# Land cover statistics on small area regions

The idea is to combine the strengths of two information sources with different characteristics: one exhaustive and the other accurate.



# Land cover statistics on small area regions

A first step is to use reference data as calibration for pixel counting.  
A next step is to use reference data as calibration for pixel likelihood.



## Artificial Intelligence for Reliable Land Use Statistics: Opportunities and Challenges from Switzerland

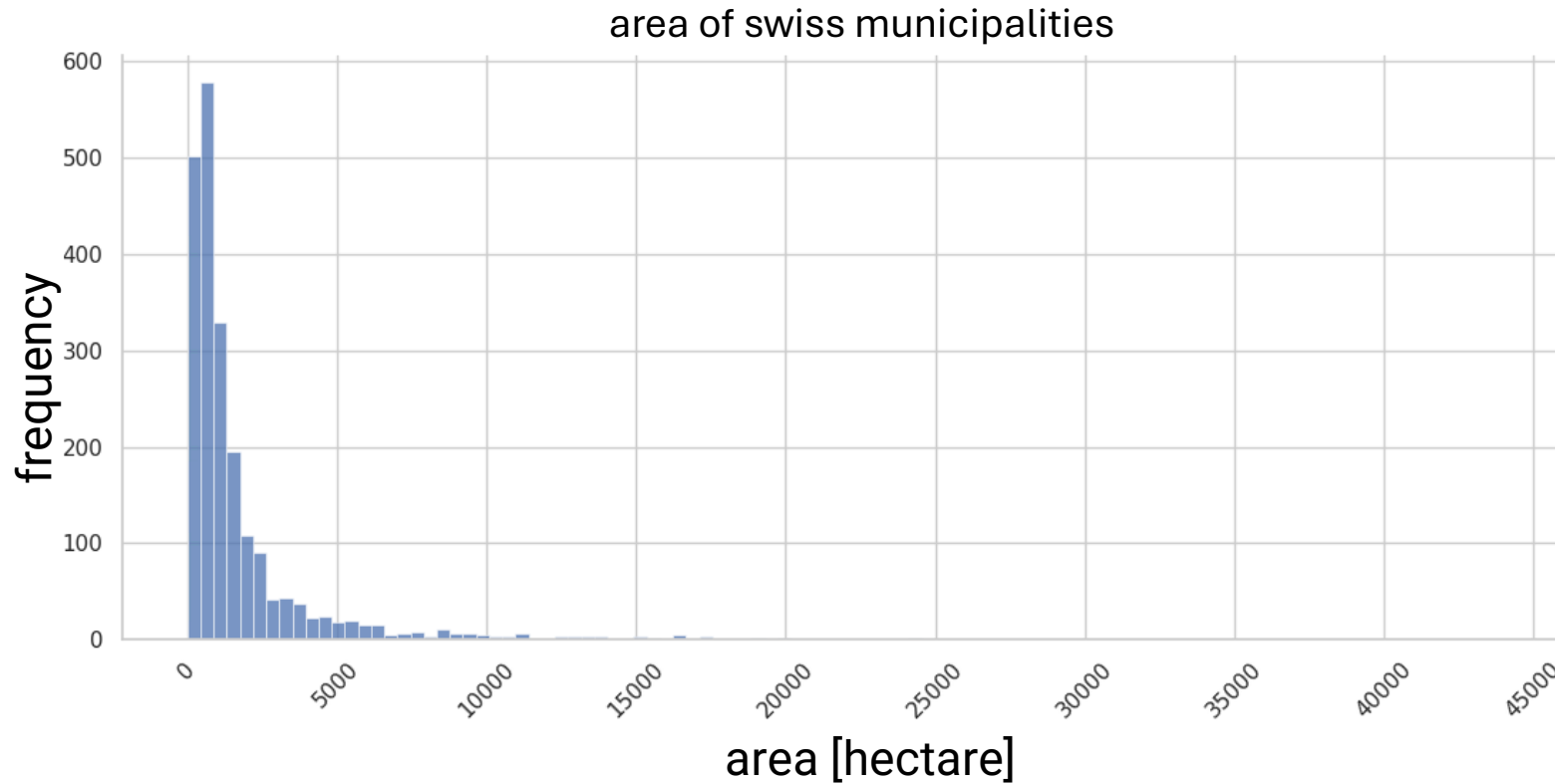
1. Changes in land cover and land use are crucial. The actual rate of change should inform the pre-analysis calculations and determine the level of precision required for mapping products.
2. In our case, high-resolution aerial images bring the most to the classifier. Satellite time series have been removed from the classification system due to efficiency.
3. In general, the focus should not be on fully automated products. Instead, the synergies between automatization and manual labelling should be integrated from the design of new system and at every following stages. While not a priority, fully automated products can be generated as a quick win using (future) productive systems.

## Inspiration for questions

1. What are the next steps for the development ?
2. What is the total cost of the solution ?
3. Why did you use Landsat and not sentinel 2 for ADELE 1 ?
4. What is the main source of information of the interpreters ? how do they prioritize data sources in case of temporal inconsistencies ?
5. Has a unified model consisting of a single module been considered ?
6. Would it not be possible to achieve significant synergy through the partial automation of several administrative products ?
7. Would it be possible to carry out the automation using only satellite imagery? How much did the satellite images used for ADELE 1 cost ?
8. What are the best ways to improve the accuracy of the model ?
9. Are data from registers (buildings, population, etc.) used ?
10. How does the tool handle the protection of personal data ?
11. Have you considered using the 'area adjustment' (Olofsson 2013) for change estimates ?
12. Why not using Lidar Data for the automatization ?
13. What measures have you taken to ensure that the introduction of bias is monitored in the long term ?
14. Have you tried building specialized models for hard classes ?

# Municipalities as small area regions

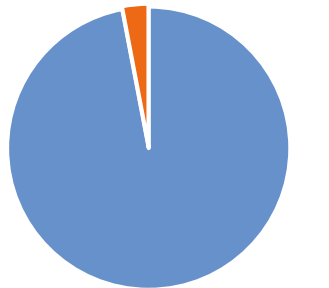
Many of the swiss municipalities cover areas smaller than 1'000 hectares.  
How can we guarantee robust statistics for small areas ?



# Bringing automatisisation in the process

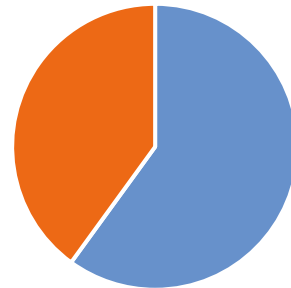
Goal of the automatisisation:  
Keeping the same pace of 9-year survey, while maintaining the quality of the time series, but with lower resources

Points without automatisisation



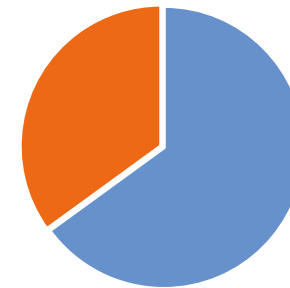
■ interpreted ■ not interpreted

Points with automatisisation



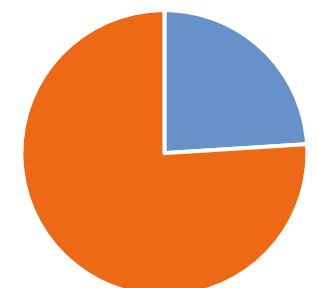
■ interpreted ■ not interpreted

Controls without automatization



■ controlled ■ not controlled

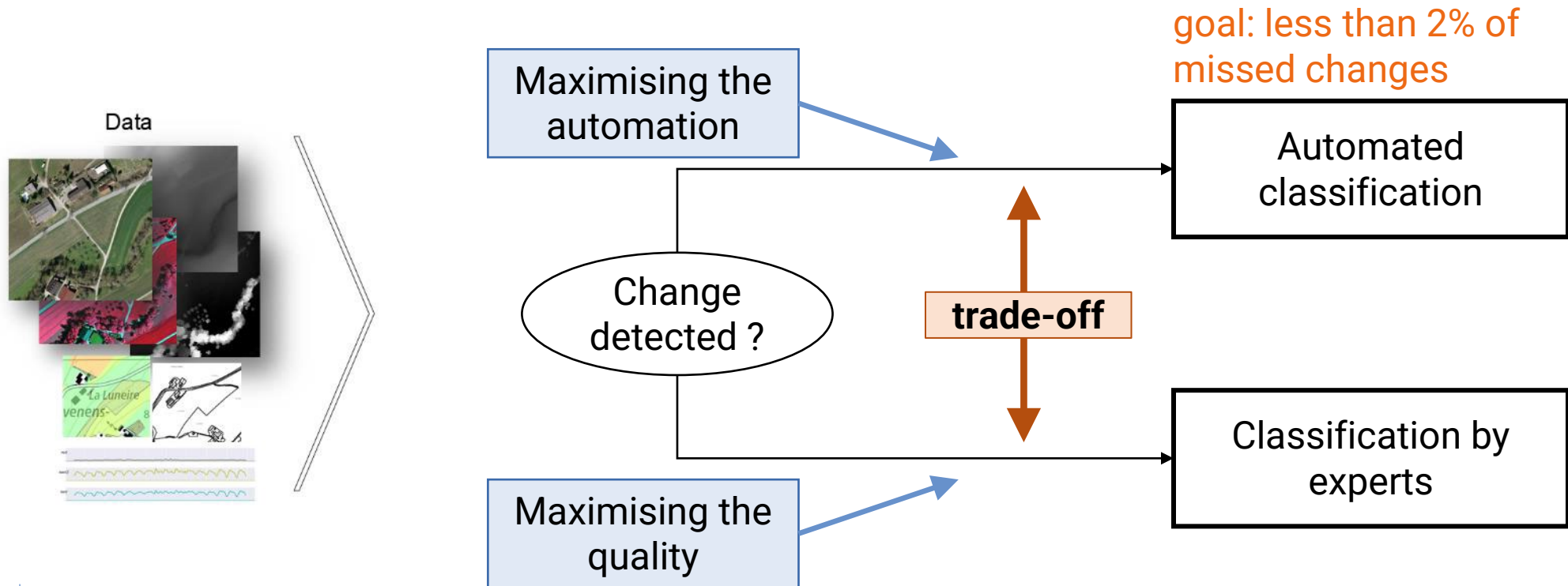
Controls with automatisisation



■ controlled ■ not controlled

# Today : an assistance for interpreters

Integration of automatisisation into the survey process:  
A balance between quality and efficiency



# How to choose among the data ?

Orthoimages RGB	Orthoimages NIR	Ancillary	Satellite	Score F1
X				0.71
	X			0.70
X	X			0.72
		X		0.61
			X	0.29
		X	X	0.60
X		X	X	0.73
X		X		0.73

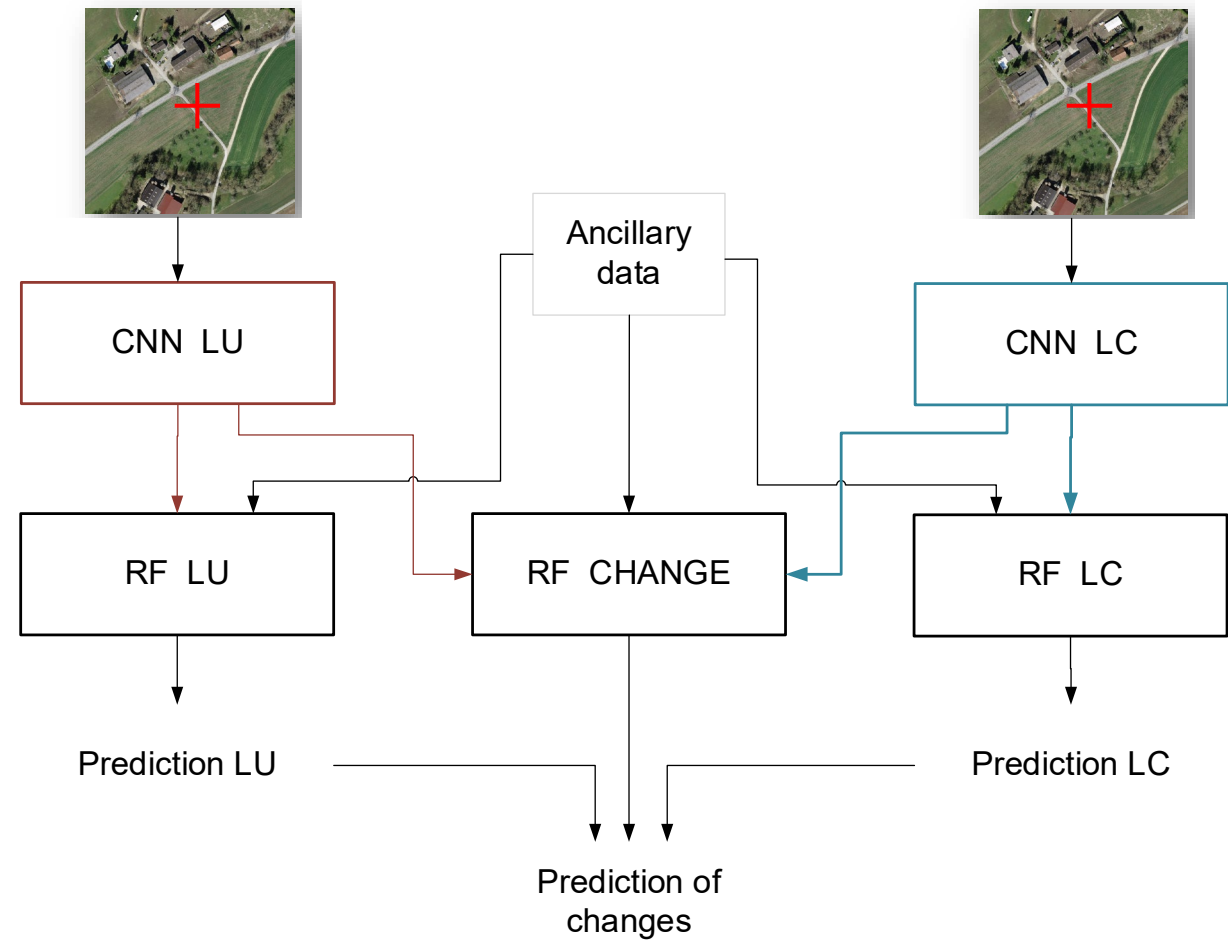
Orthoimages RGB + NIR: huge volume of data

Orthoimages RGB + Ancillary: best combination for the production

→ Accurate results are important. Keeping data management simple is also a factor for success!

# Automatisation as statistical modelling

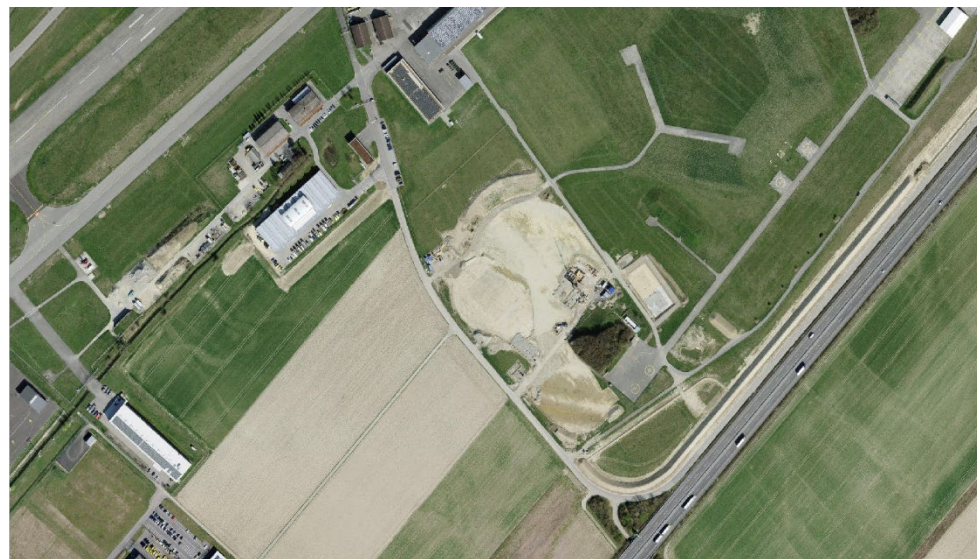
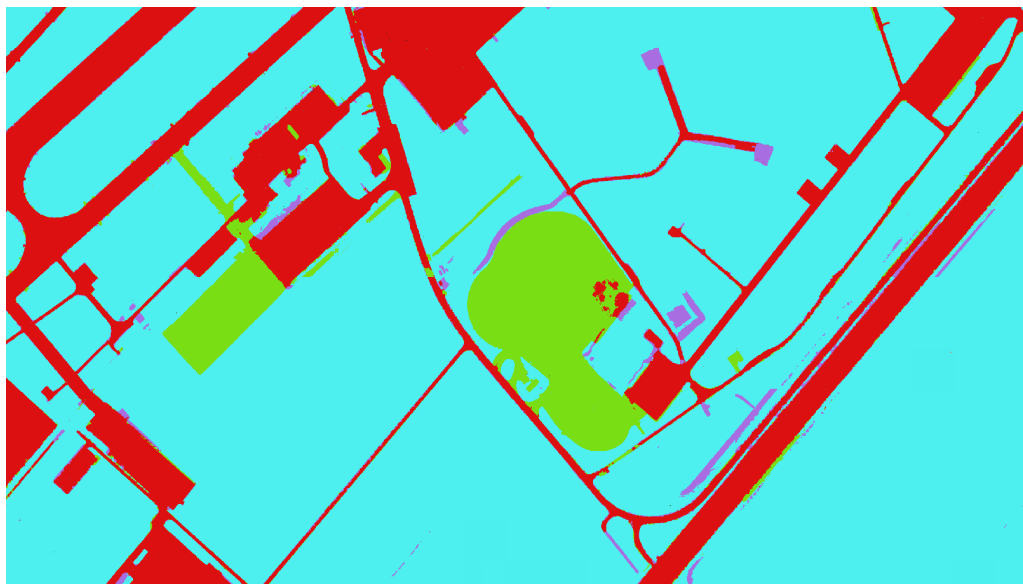
Ground truth : sample of 880'000  
labelled coordinates over 3 surveys  
(among > 9mio available)



# Examples of analysis

Detection of new impervious areas

2020



2023

Swiss land use statistics — Nomenclature of Land cover (NOLC04)

6 Principal domains und 27 Basic categories

10 Artificial areas	11 Consolidated surfaces 12 Buildings 13 Greenhouses 14 Gardens with border and patch structures 15 Lawns 16 Trees in artificial areas 17 Mix of small structures <div style="float: right; margin-left: 20px;">             } Sealed surfaces           </div>
20 Grass and herb vegetation	21 Grass and herb vegetation
30 Brush vegetation	31 Shrubs 32 Brush meadows 33 Short-stem fruit trees 34 Vines 35 Permanent garden plants and brush crops
40 Tree vegetation	41 Closed forest 42 Forest edges 43 Forest strips 44 Open forest 45 Brush forest 46 Linear woods 47 Clusters of trees
50 Bare land	51 Solid rock 52 Granular soil 53 Rocky areas
60 Watery areas	61 Water 62 Glacier, perpetual snow 63 Wetlands 64 Reedy marshes
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">Legend</div> <b>10 - 60 = Principal domains NOLC04_6</b> 11 - 64 = Basic categories NOLC04_27	

Source: SFSO – Land use statistics

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Swiss land use statistics — Nomenclature of Land use (NOLU04)  
4 principal domains, 10 classes und 46 basic categories

Settlement and urban areas		Agricultural areas	
<b>100 Building areas</b>	101 Industrial and commercial areas > 1 ha 102 Industrial and commercial areas < 1 ha 103 Residential areas (one and two-family houses) 104 Residential areas (terraced houses) 105 Residential areas (blocks of flats) 106 Public buildings and surroundings 107 Agricultural buildings and surroundings 108 Unspecified buildings and surroundings	<b>200 Orchards, vineyards, horticulture</b>	201 Orchards 202 Vineyards 203 Horticulture
<b>120 Transport surfaces</b>	121 Motorways 122 Roads 123 Parking areas 124 Railway surfaces 125 Airports and airfields	<b>220 Arable and Grassland</b>	221 Arable land, in general 222 Semi-natural grassland, in general 223 Farm pastures, in general
<b>140 Special urban areas</b>	141 Energy supply plants 142 Waste water treatment plants 143 Other supply or waste treatment plants 144 Dumps 145 Quarries, mines 146 Construction sites 147 Unexploited urban areas	<b>240 Alpine grazing areas</b>	241 Alpine meadows, in general 242 Alpine pastures, in general 243 Alpine sheep grazing pastures, in general
<b>160 Recreational areas and cemeteries</b>	161 Public parks 162 Sports facilities 163 Golf courses 164 Camping areas 165 Garden allotments 166 Cemeteries	In general: All these categories may also include trees (LC44/46/47)	
<b>Legend</b>	100 - 420 = Aggregation NOLU04_10 101 - 424 = Basic categories NOLU04_46	<b>Forest areas</b>	
		<b>300 Forest (not used for agricultural purposes)</b>	301 Forest 302 Afforestation 303 Lumbering areas 304 Damaged forest
		<b>Unproductive areas</b>	
		<b>400 Lakes and rivers</b>	401 Lakes 402 Rivers, streams 403 Flood protection structures
		<b>420 Unproductive land</b>	421 Unused 422 Avalanche and rockfall protection structures 423 Alpine sports facilities 424 Landscape interventions

Source: SFSO – Land use statistics

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