StatEO

5–7 May 2026 | ESA-ESRIN | Frascati (Rome), Italy

Generalising Earth Observation AI-ML pipelines for European statistics

Remco Paulussen, Statistics Netherlands

One-stop-shop for Artificial Intelligence / Machine Learning for Official Statistics

Grant Agreement Number: 101146355 (AIML4OS)

Generalising Earth Observation AI-ML pipelines for European statistics

StatEO26, Frascati, Italy, May 5-7, 2026

Remco Paulussen, Statistics Netherlands

Warsaw memorandum stipulates importance

2021 DGINS Conference – Earth Observation for Official Statistics
Warsaw, Poland | 27-28 October 2021

DGINS 2021 Varsovie

The Directors General of National Statistical Institutes and of Eurostat:

1. Acknowledge the urgent needs and the ongoing efforts to make extensive use of **Earth Observation data** in **official statistics.**
2. Support **SDG monitoring, agriculture, maritime stats**.
3. Provide **training** for statisticians in methodology & new technologies.
4. Develop **EU EO strategy**, standard methods, and shared testing spaces.
5. Enhance **cooperation** across NSIs, Eurostat, ESA, research centres, and industry.
6. Promote **AI, high-res satellites, open interoperable EO infrastructures**.

Possible applications

Agriculture (SAIO)

- Grassland management
- Crop types
- Crop yields

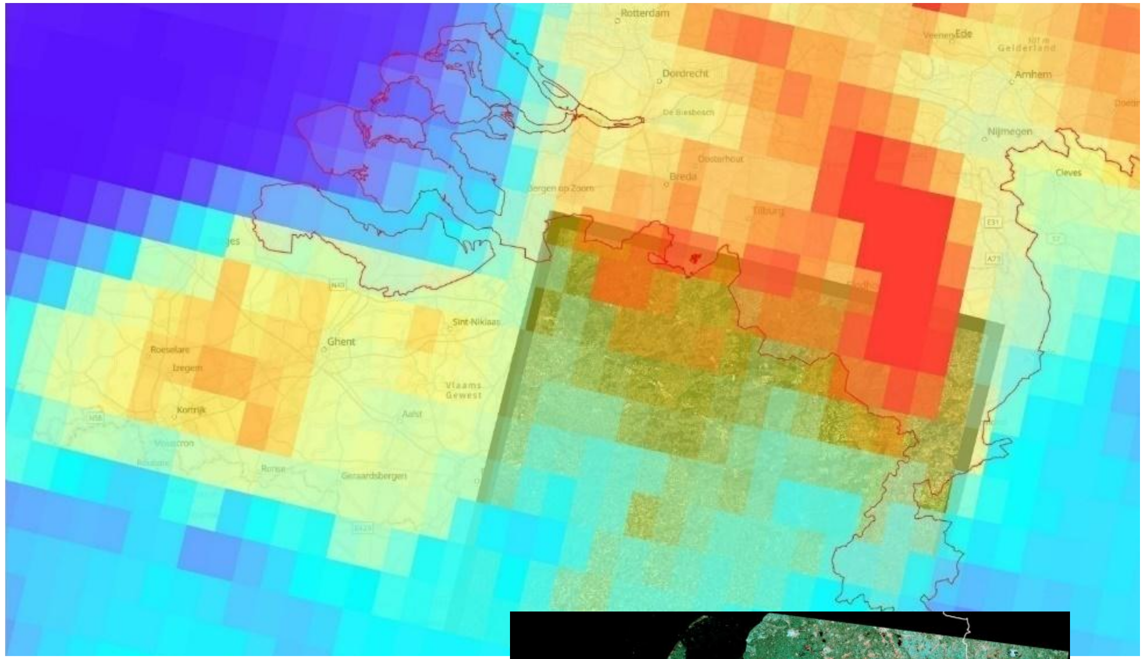
Land use

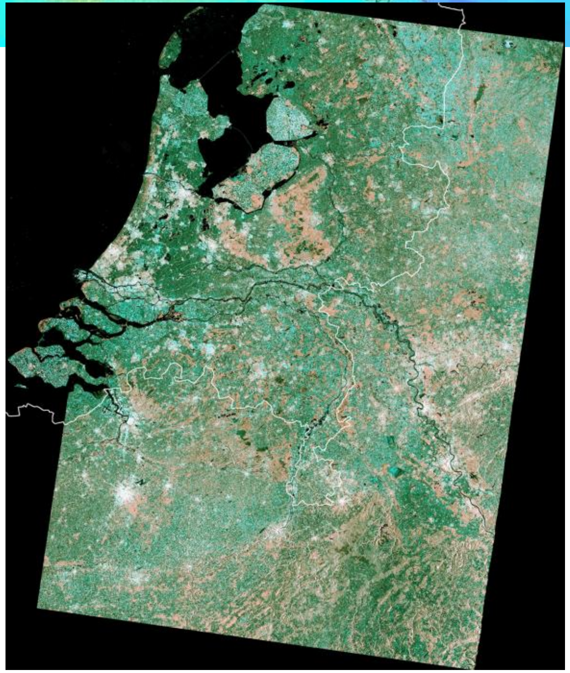
- Land cover / land use inventory
- Changes in land use
- Construction sites (duration of construction projects)
- Solar panels, wind turbines, parking lots, …
- Biodiversity (e.g. Net Primary Production)
- System of Environmental Economic Accounting (SEEA)

Air quality, emissions, pollution

- Combination with statistical socio-economic indicators (dashboards, broad welfare monitor)
- Possible: calibrating emission/concentration models

Ammonia concentration, June 2023 (tile 31UES)





NDVI (Normalized Difference Vegetation Index)

Key objectives of AIML4OS WP7

Several NSIs are developing AI/ML models using Earth Observation (satellites, aerial images, etc.)

Can we share our developments? Build once, run anywhere!

Research question: can these existing AI/ML pipelines and/or models be generalised over space (countries) and time (periods) and under what conditions?

If feasible, we will develop methodological and implementation guidelines

As a side-effect, we will have results in terms of (validated) predictions for other countries / timeframes than the original study

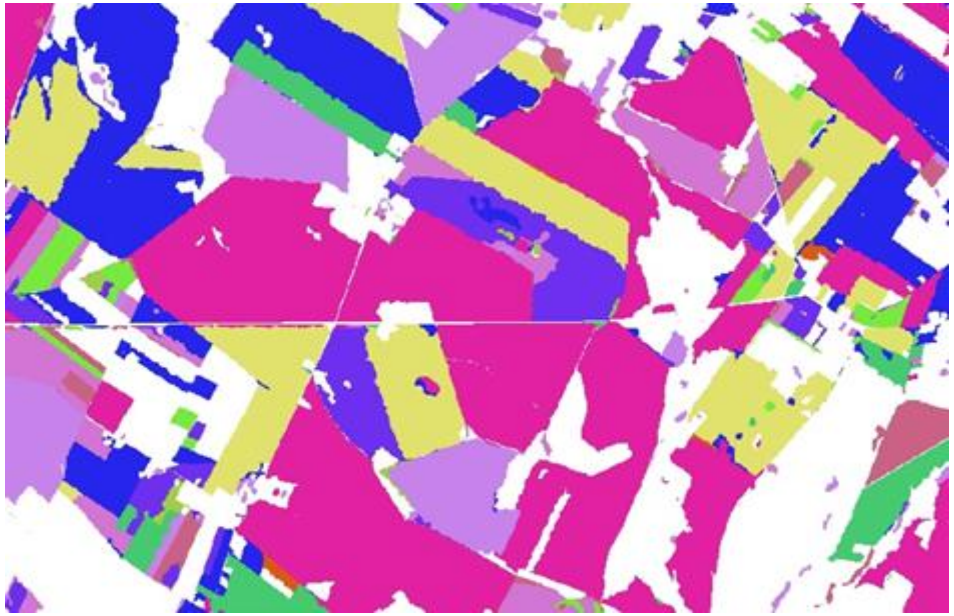
Selected EO models

Out of 25 existing models, we finally selected 2 models to take forward

Cos IA (land cover) – IGN, France

	Building		Deciduous
	Pervious surface		Brushwood
	Impervious surface		Vine
	Swimming pool		Grassland
	Bare soil		Crop
	Water		Plowed land
	Snow		Greenhouse
	Coniferous		

Crop mapping - GUS, Poland



kod_pow	pow_nazwa	kod_gm	gm_nazw	buraki cukrowe	gorczyca	gryka
0201	Powiat bolesławiecki	0201011	Bolesławiec (1)	0,00	0,00	9,24
		0201022	Bolesławiec (2)	27,74	16,46	262,15
		0201032	Gromadka (2)	5,33	4,68	78,06
		0201043	Nowogrodziec (3)	4,02	20,71	333,81
		0201052	Osiecznica (2)	0,00	0,04	116,04
		0201062	Warta Bolesławiecka (2)	118,82	3,23	78,46
	Powiat bolesławiecki Suma			155,92	45,11	877,75
0202	Powiat dzierżoniowski	0202011	Bielawa (1)	21,21	1,84	3,54
		0202021	Dzierżoniów (1)	35,67	0,14	1,39
		0202033	Pieszyce (3)	38,55	3,40	7,55
		0202041	Piława Górna (1)	8,50	0,85	0,73
		0202052	Dzierżoniów (2)	332,82	18,88	12,37
		0202062	Łagiewniki (2)	471,32	7,92	13,08
		0202073	Niemcza (3)	240,91	0,60	7,57
	Powiat dzierżoniowski Suma			1 148,98	33,62	46,24

Copernicus Data Space Ecosystem (CDSE)

- Both pipelines and models will be executed on the CDSE
- Eurostat has dedicated environment (Creodias/CloudFerro)
- Excellent support by CDSE (EC/ESA/Defis) and Eurostat

- Started with land cover model
- Free use of VMs with 64 cores and 5 TB data (aerial images)
- We have gained a lot of experience during this project

- The generic pipelines for both models are now available
- During this phase still some results are based on local processing

Land Cover pipeline

Preprocessing & Upload (Local Phase)

Local harmonisation heterogeneous orthophoto formats, band configurations, spatial resolutions, and coordinate reference systems

Inference (Cloud Phase)

GPU-enabled cloud processing using FLAIR deep learning algorithm for land cover classification

Vectorisation

Optional conversion raster outputs to vector products

Statistical Tables

Aggregated coverage statistics by land cover class with area and percentage calculations

Quality Assessment

Integrated comparison with LUCAS reference data and photointerpretation point. Computation of accuracy metrics, including top-1 accuracy, the Brier score (BS), the Brier Skill Score (BSS), and the soft Jaccard index

Case studies and first results

	Austria	Denmark	Italy
Orthophoto bands	RGB + NIR	R, G, B, NIR	RGB+NIR
Bit_dept	8-bit integer	32-bit	8-bit integer
Region	Salzburg (7.154 km²)	Region Hovedstaden (2.559 km²)	Veneto (18.399 km²)
Tiling	No	Yes (3613 tiles)	Yes (2253 tiles)
Available format	WMS, Geotiff	ECW	ECW
Spatial resolution	20 cm	10–12.5 cm	20 cm
Latest available year	2024	2024	2021

In Denmark, the quality assessment procedure was performed outside the pipeline on local computers

Region Hovedstaden (DK), 2024	#points	BS (0-1)	BSS	Jaccard-index	Accuracy
Manual photointerpretation	993	0.05	0.88	0.72	0.996
LUCAS 2018 strata	643	0.39	-0.46	0.26	0.739
LUCAS 2022 survey	361	0.38	-0.10	0.30	0.648

Multiclass Brier score (BS), Brier Skill Score (BSS)

Land Cover conclusions for now

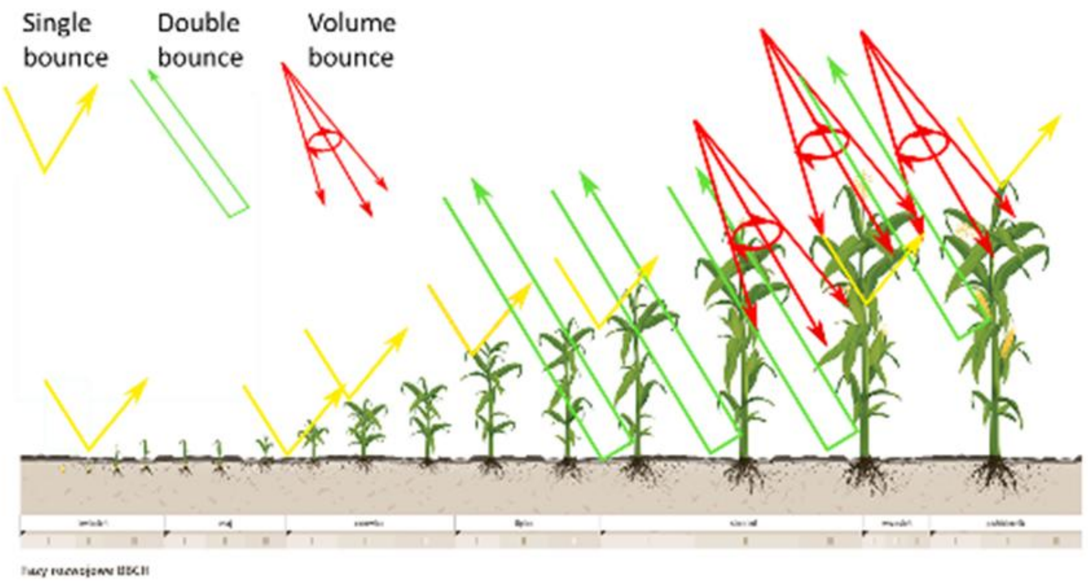
- At the current stage, generalization cannot yet be considered fully proven
- The land cover pipeline has been technically implemented and tested primarily in the Italian case (Veneto region)
- Full cross-country validation has not yet been completed
- Preliminary results from Denmark indicate strong agreement when validated with manual photointerpretation
- Less agreement when comparing with LUCAS-based reference data
- Might be due to differences in definitions FLAIR and LUCAS classes, difference between field observations and what is observable in orthophotos, temporal discrepancies (2024 versus 2018/2022)

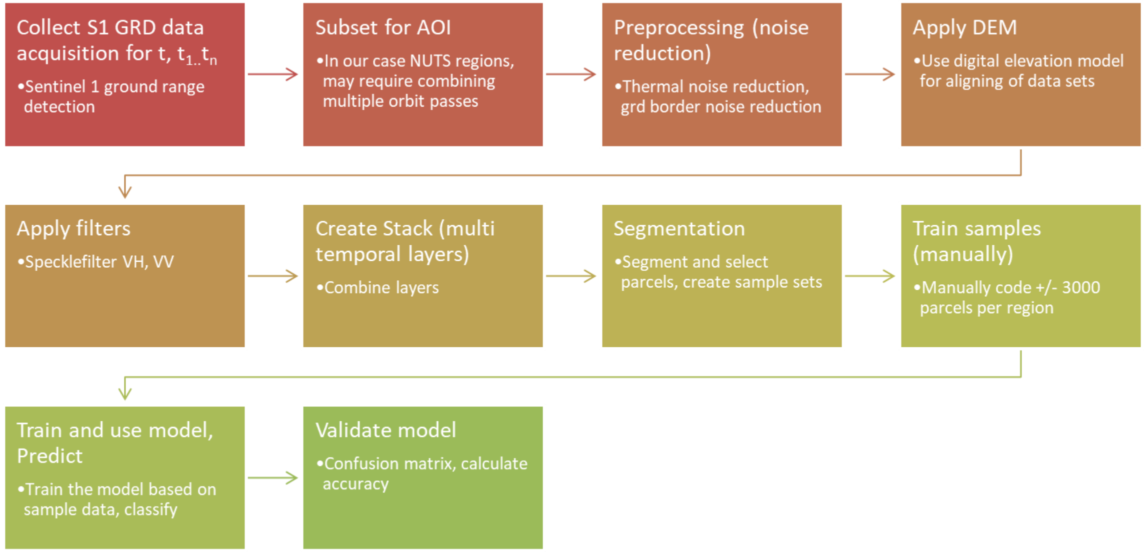
Land Cover next steps

- Running pipeline in the cloud environment for Denmark at NUTS2 regional level
- Testing and adapting the pipeline for Austria at NUTS2 level (resolving technical constraints related to orthophoto access and processing)
- Producing tables with land cover percentages for the different FLAIR classes for the participating countries at NUTS2 regional level
- Running the quality assessment procedure within the land cover pipeline for all participating countries at NUTS2 level
- The study could be extended to other regions or to the entire national territory of participating countries to further assess scalability, robustness, and usability under broader production conditions

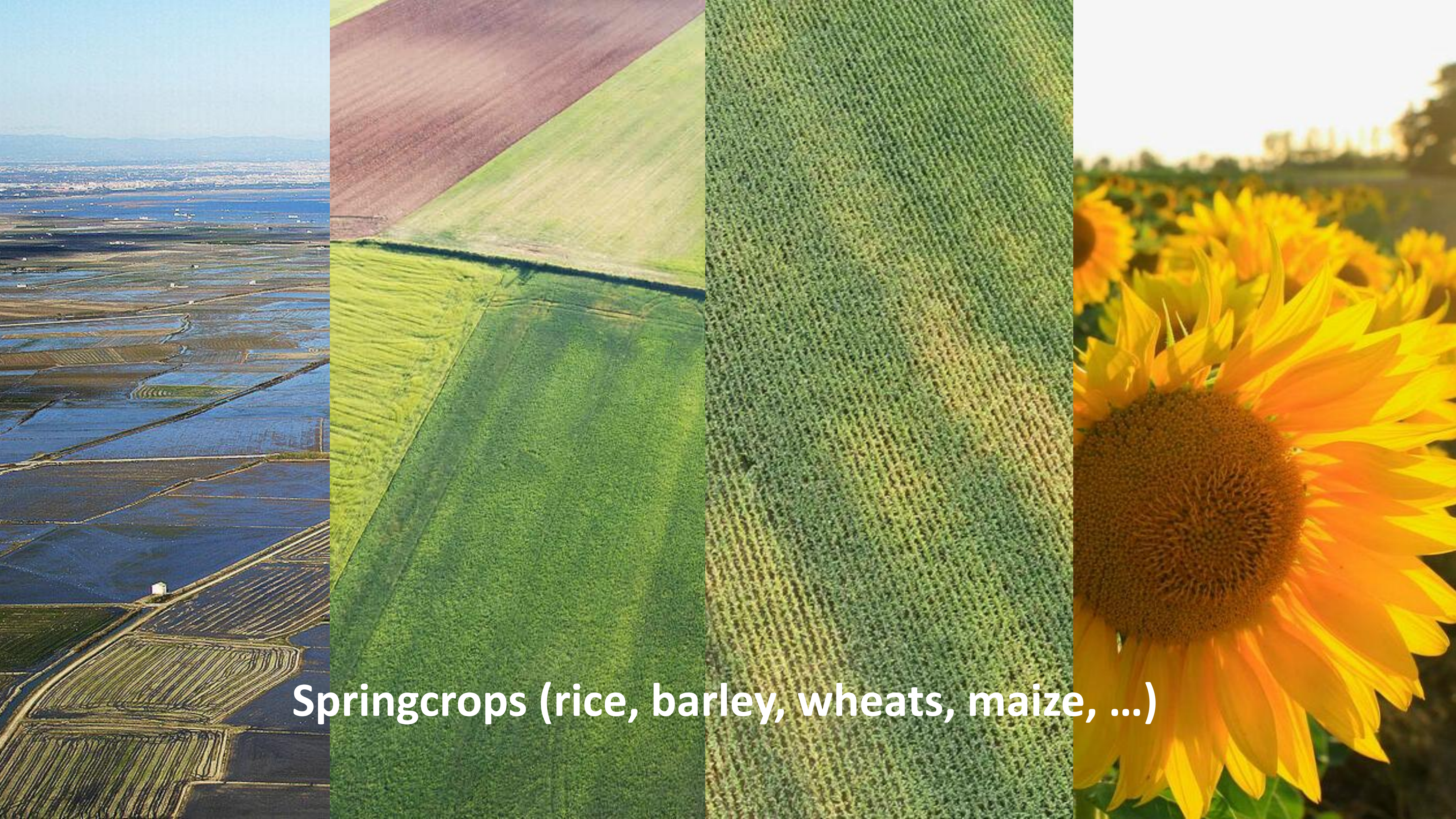
Crop Type pipeline

Sentinel-1 radar time series in combination with advanced object-based classification software






Wintercrops (oats, peas, wheats, barley, …)


Springcrops (rice, barley, wheats, maize, …)



Oilseed rapes (winter, spring)

Case studies and first results

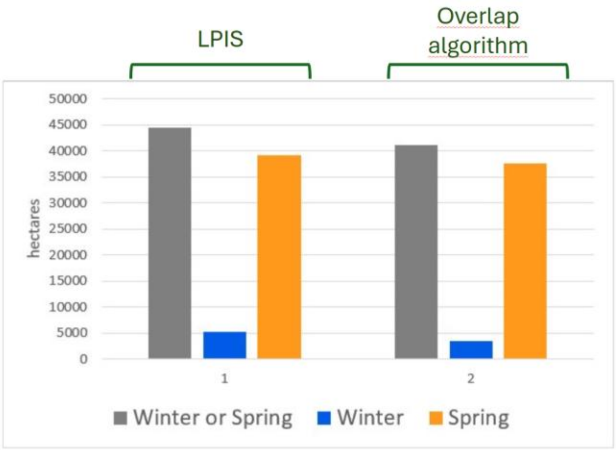
- Portugal: evaluating spatial overlap between model predictions and LPIS registry
- Ireland: like Portugal, but parcel-oriented validation logic
- Analysing segmentation behaviour and evaluating the structural properties of the object-based workflow (The Netherlands)
- Austria: evaluating transferability using manual classification (no LPIS)

20,546 parcels were correctly classified, resulting in an overall accuracy of 97.5%

Class	TRUE	FALSE
1-Spring	98.1%	1.9%
2-Winter	96.5%	3.5%
3- Winter Rapeseed	98.7%	1.3%
Grand Total	**97.5%**	**2.5%**

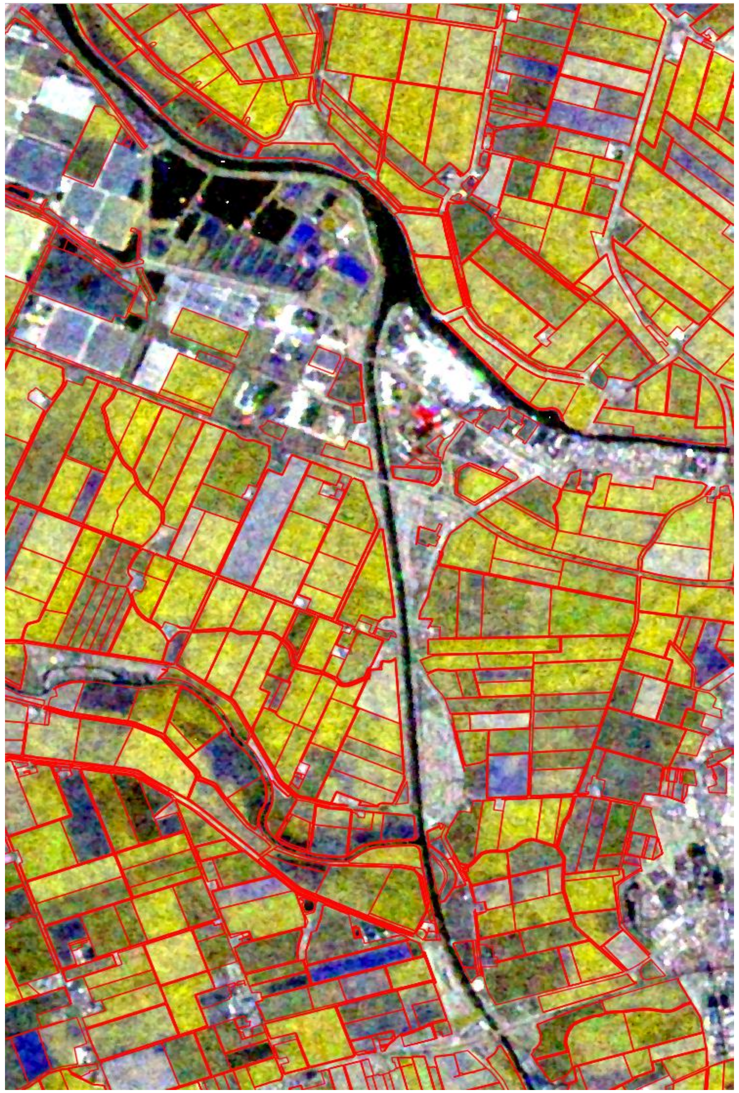
93% of the overlapping area is correctly classified

	LPIS	Overlap Algorithm	Match & NoMatch
WINTER & SPRING	44,442	41,179	93%
WINTER Crops	5,248	3,559	68%
SPRING Crops	39,194	37,620	96%



Segmentation results versus LPIS parcels





Crop Type conclusions for now

- Generalisation seems technically feasible (predicts reasonably well)
- Seasonal distinction between winter crops, spring crops and rapeseed appears robust across countries
- Segmentation study demonstrated that the object-based preprocessing component behaves in a structurally stable manner
- Simplified Ground Range Detected (GRD) based feature space does not support fine-grained crop classification (±300 classes)
- Generalisation in the sense of a fully transferable, country-independent production model has not yet been conclusively demonstrated

Crop Type next steps

- Further assess cross-country transferability
- Two structured experiments are planned. These experiments will clarify whether a single European-scale seasonal model is achievable or whether regionally adapted models remain necessary
- Enabling more detailed crop classification: preprocessing of Sentinel-1 Single Look Complex (SLC) data
- Validation procedures will also be strengthened: aggregated predictions with NUTS-level harvest statistics

Challenges at the Statistical Institutes

- ## Insufficient expert capacity available

  Few people with knowledge of earth observation available. Mitigation: form a pool of experts with flexible deployment

- ## Uncertain outcome and therefore lower urgency

  Constantly investigate the utility of earth observation data. This costs time and effort. Risks are not always taken

- ## Internal computing environment inadequate

  Earth observation data requires very intensive computing power (GPU, but also CPU) and storage. CDSE is the way forward

- ## Sensitive data complicates the use of CDSE

  CDSE is an external EU cloud platform. Microdata is sometimes required. Legal options under investigation: use of privacy-preserving techniques (PPT) or a dedicated area (private bucket)

- ## Governance of generic pipelines unclear

  Unclear who will support, maintain, and execute generic pipelines (SLA, frequency)