Large scale detection of plastic covered crops using multispectral and SAR satellite data

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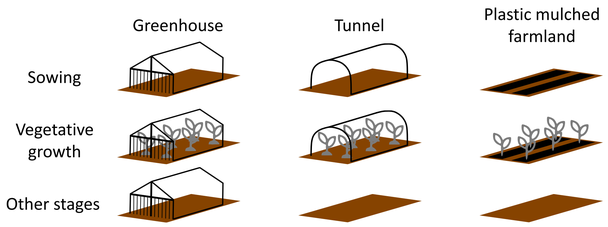
Background and Objective

- Multispectral satellite data have been effectively used to detect plastic covered crops. The use of SAR data is still limited.
- Plastic covered crops detection in large regions with heterogenous plasticultural management is still unexplored.
- Plasticulture mapping needs to account for the seasonal use of plastic foils.



The study aimed at providing a methodology for large scale mapping of plastic mulched farmlands, tunnels and greenhouses.

Material and Methods

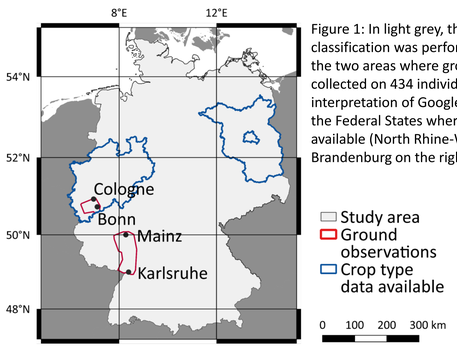
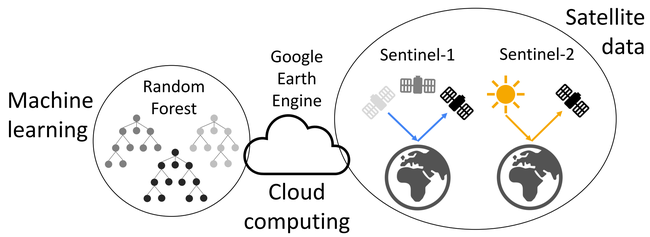


Figure 1: In light grey, the study area where the classification was performed (Germany). In red, are the two areas where ground observations were collected on 434 individual fields by visual interpretation of Google Earth images. In blue, are the Federal States where crop type data were available (North Rhine-Westphalia on the left, Brandenburg on the right).



Tackling seasonal use of plastic foils: a novel approach

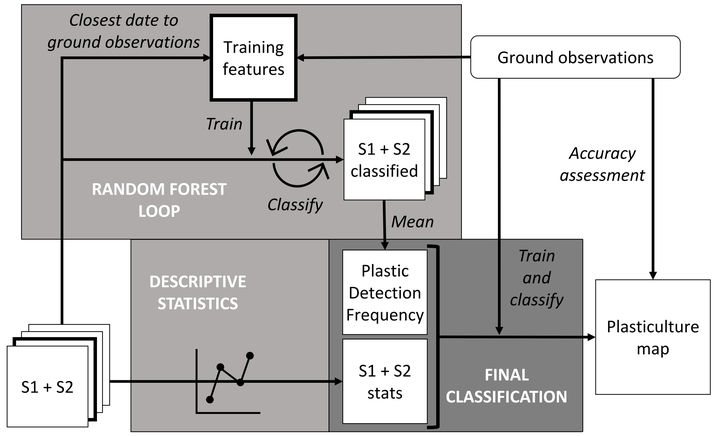


Figure 2: Operational workflow used to obtain the plasticulture map starting from the pre-processed input dataset: Sentinel-1 (S1) and Sentinel-2 (S2) data acquired in 2020. Light grey boxes: intermediate steps to get the features used in the final classification (dark grey box). The dataset used in the final classification contained 122 features, of which 121 resulted from describing the time series with 11 different statistics and 1 (Plastic Detection Frequency) resulted from the random forest loop.

Results

Accuracy assessment and feature importance

- The methodology reported accuracies in the range of 85-90% in the regions where ground observations were collected.
- The Plastic Detection Frequency resulted to be the most important feature in the classification.
- Following laboratory tests and simulations, radar features importance was related to the presence of metal frames in tunnels and greenhouses.

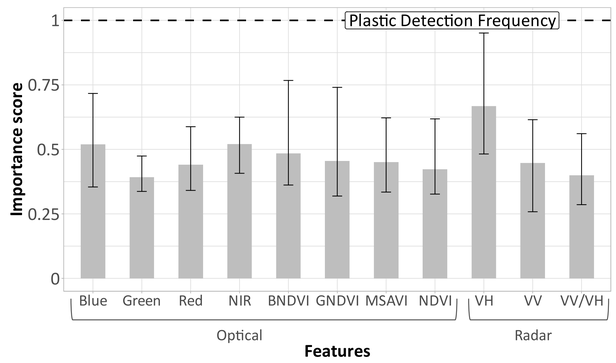


Figure 3: Feature importance score calculated in the final classification, relative to the most important feature (Plastic Detection Frequency). The height of the bars represents the average importance for the 11 original bands and indexes. The top and bottom parts of the error bars represent respectively the importance score of the most and the least important statistic, for each band and index.

Plasticulture map

- The output of the final classification is a land use map based on 4 classes: plastic free farmlands, plastic mulched farmlands, tunnels, greenhouses.
- The area covered by each plasticulture class was calculated for hexagons with an area of around 11500 ha, to highlight the presence of local plasticulture hotspots.

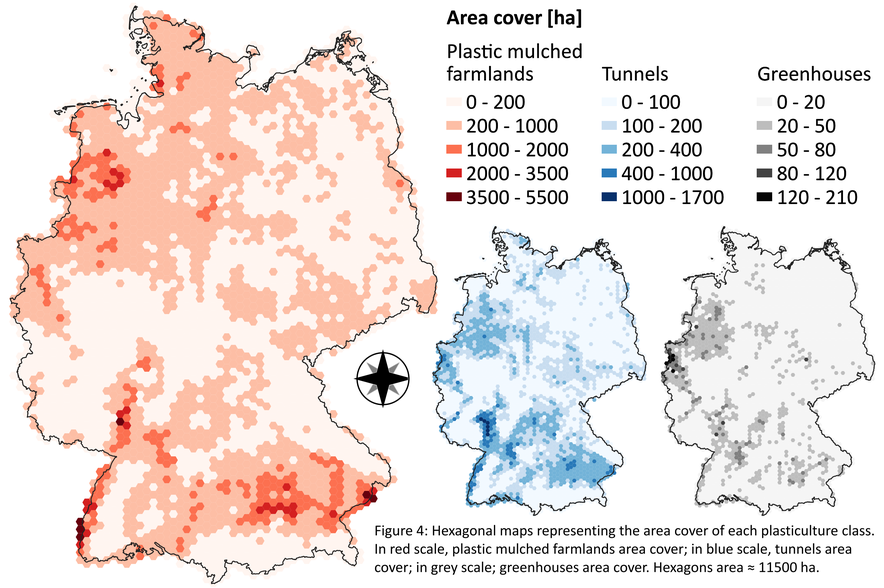


Figure 4: Hexagonal maps representing the area cover of each plasticulture class. In red scale, plastic mulched farmlands area cover; in blue scale, tunnels area cover; in grey scale; greenhouses area cover. Hexagons area ≈ 11500 ha.

- Vegetables, strawberry and asparagus resulted to have the highest relative area covered by plastic foils.
- Plastic foils were partially detected in relevant crop types like maize, potato, and sugar beet, leading to a potential overestimation of plasticulture area.

Conclusions

- The study provides for the first time an approach to map and monitor the area cover of different agricultural plastic foils in large and heterogenous regions.
- The Plastic Detection Frequency tackles the seasonal use of plastic foils while using dense time series.
- The sensitivity of SAR data to metal covers builds up a synergy with optical data by separating different types of plastic covers.
- Improvements in validation and training dataset are expected to tackle the challenges of plastic detection in relevant crop types.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955334

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Sharing is encouraged

Large scale detection of plastic covered crops using multispectral and SAR satellite data – supplementary material

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WATER SOIL RESOURCES

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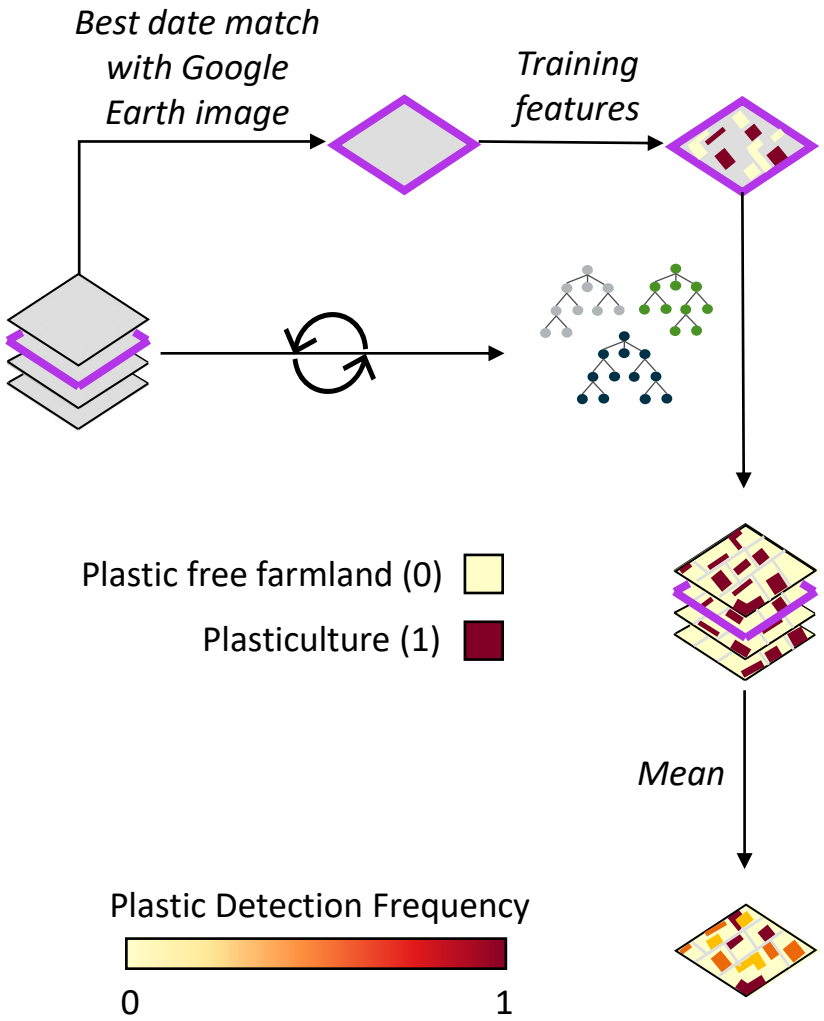
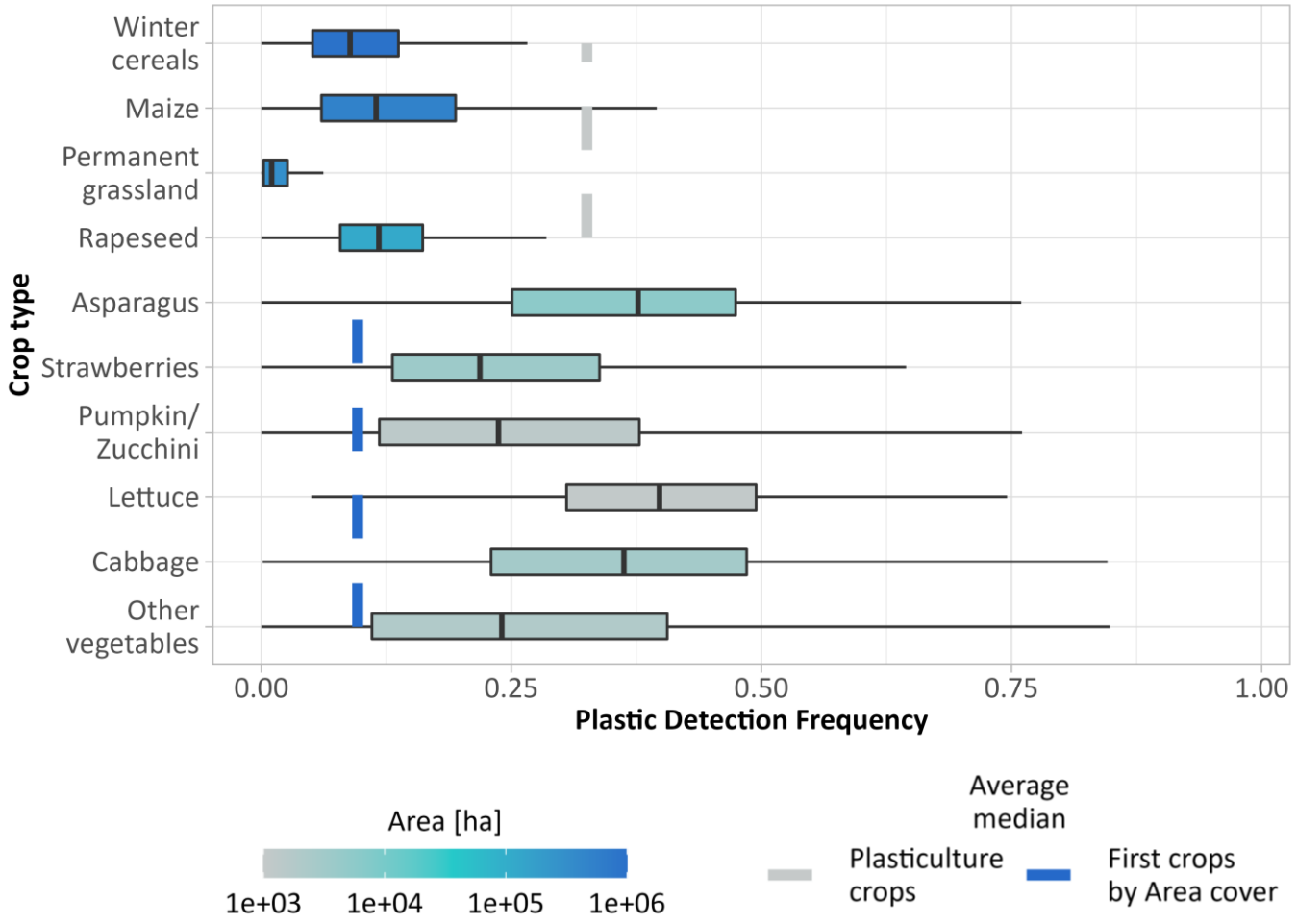
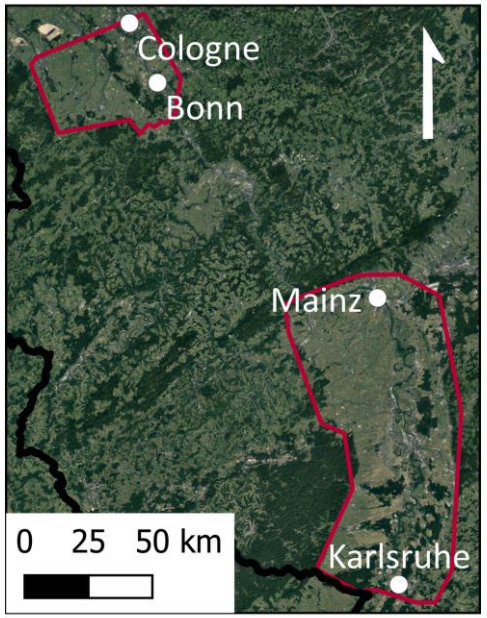
Universität Augsburg University

Plastic Detection Frequency – details and results





Results - Confusion matrix



German border

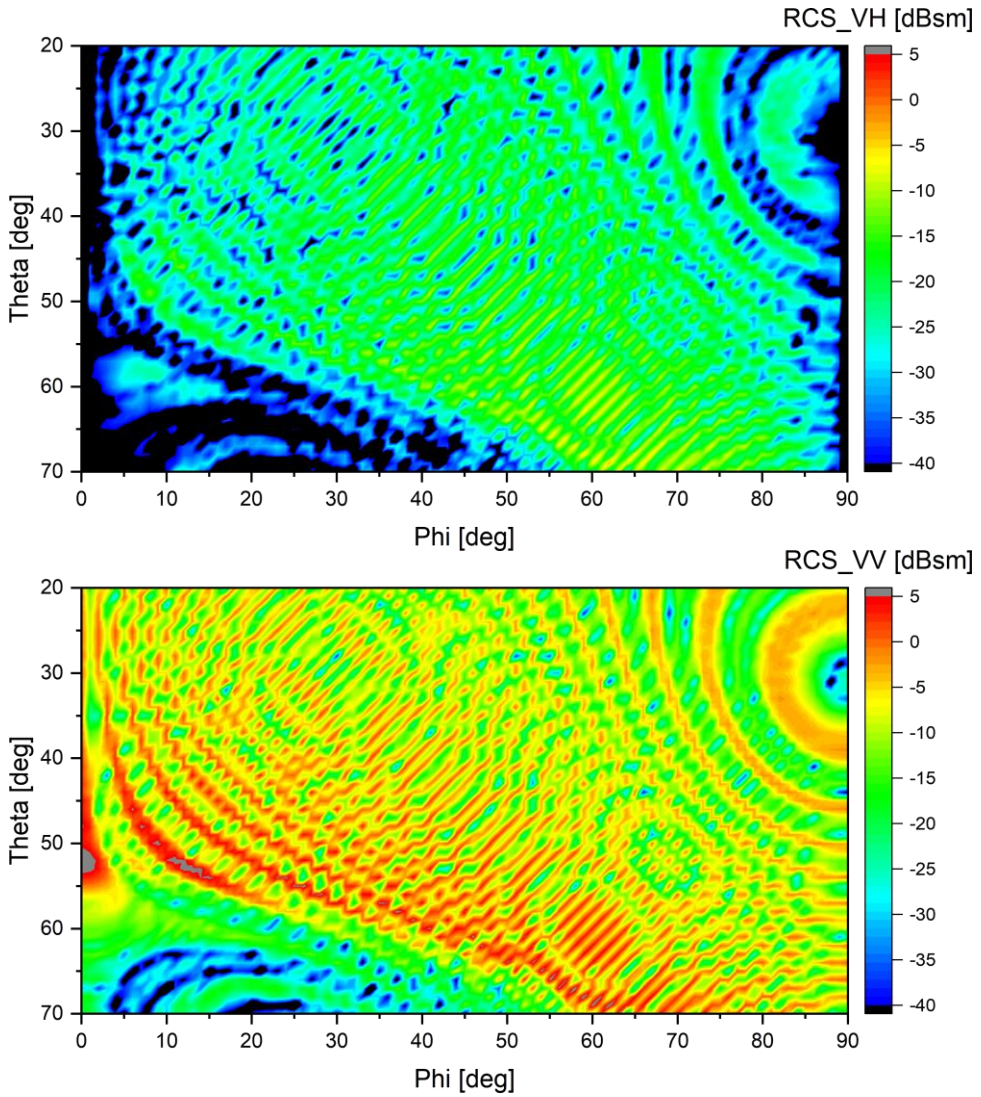
Ground Observations

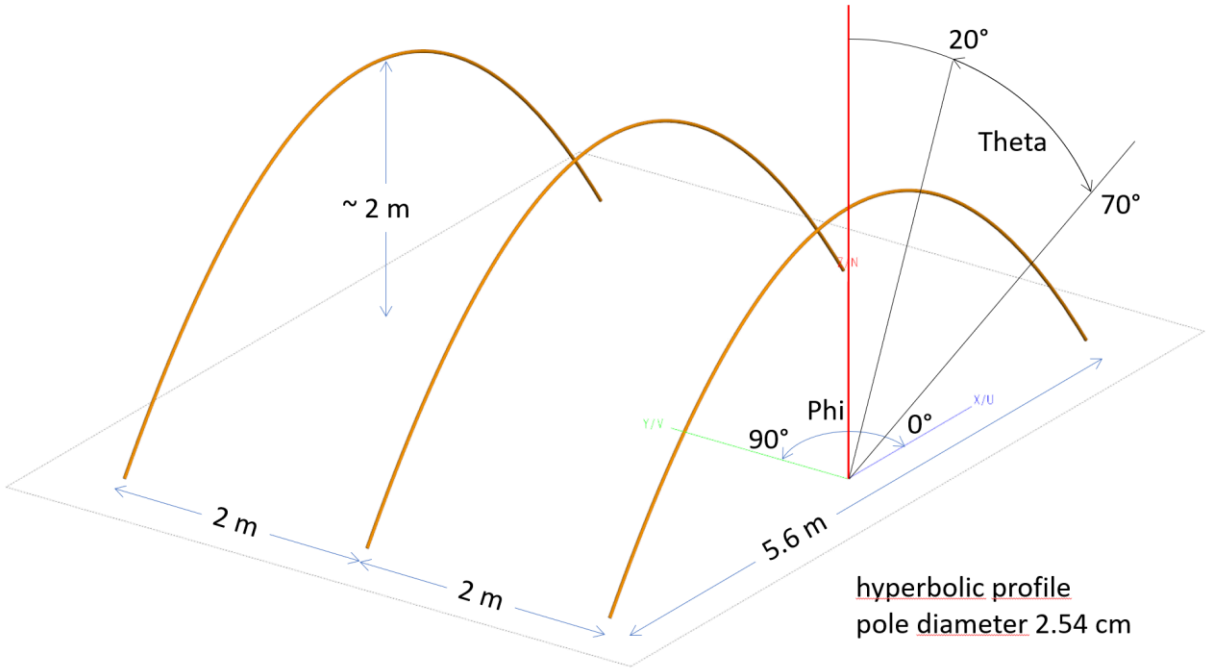
Image source: Google Earth

- Ground observations -> visual interpretation of Google Earth images
- Confusion matrix -> 40% of the ground observations
- Results shown in terms of pixels number

		Ground observations				
		Plastic free farmland	Plastic mulched farmland	Tunnels	Greenhouses	**User Accuracy**
Classification	Plastic free farmland	12749	689	10	0	94.8%
	Plastic mulched farmland	1351	7442	255	0	82.3%
	Tunnels	258	534	2825	29	77.5%
	Greenhouses	0	128	34	332	67.2%
	Producer Accuracy	88.8%	84.6%	90.4%	92%	**87.7%**

Results - Radar and metal frames: simulation results for a tunnel





Simulation results are from Gerald Rode, DLR-HR-AKS, Gerald.Rode@dlr.de

Results - Estimated area of plastic mulched farmlands for relevant crops

First 7 crops by plastic mulched farmland area cover (%) relative to a total area > 400 ha in North Rhine Westphalia and Brandenburg

Crop	Total area (ha)	Plastic mulched farmland (%)	Plastic mulched farmland (ha)
Rhubarb	804	69%	557
Asparagus	8784	68%	6009
Cabbage	2990	57%	1702
Lettuce	1125	54%	606
Pumpkin, zucchini	1393	45%	631
Strawberry	3723	35%	1310
Celery	496	34%	166

↑ %

↑ ha

Crop	Total area (ha)	Plastic mulched farmland (%)	Plastic mulched farmland (ha)
Maize	497395	14%	69674
Potatoes	40581	31%	12460
Sugar beet	57710	22%	12658
Winter rape	116789	9%	10661
Beans	12029	29%	3455
Asparagus	8784	68%	6009
Winter wheat	373219	0.6%	2413

First 7 crops by plastic mulched farmland absolute area cover (ha) in North Rhine Westphalia and Brandenburg