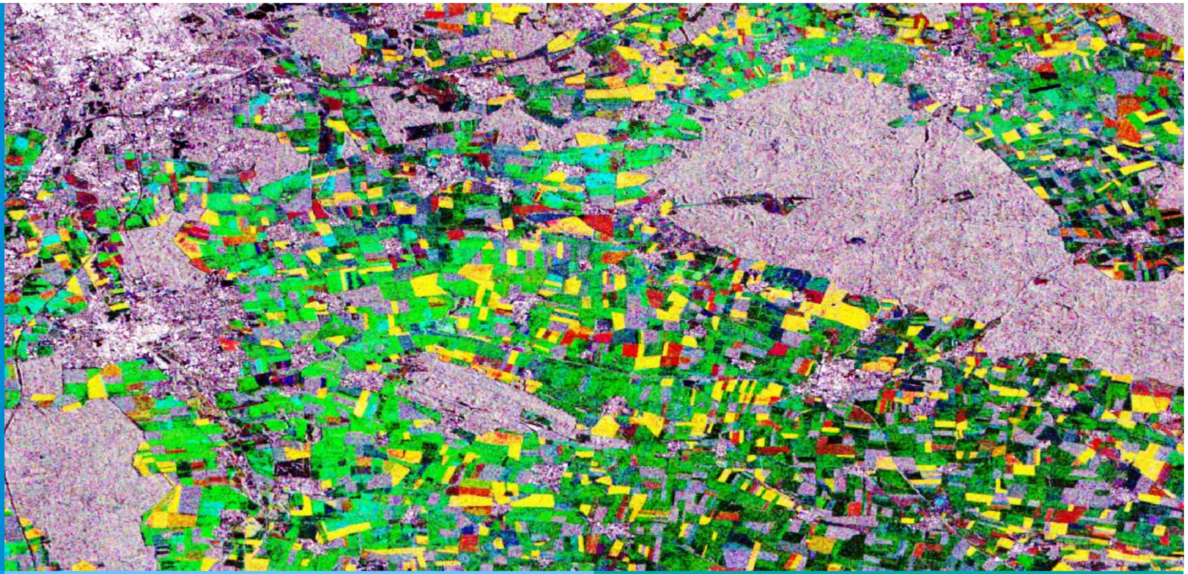
Use of Sentinel in agriculture: potentials and challenges

Die Nutzung von Sentinel Fernerkundungsdaten für die Politikfolgenabschätzung aus der Perspektive der landwirtschaftlichen Ressortforschung

A. Gocht, H. Lilienthal*, N. Röder, A. Holtgrave, A. Ortmann, G. Tetteh, T. Asmuß

Thünen Institute, Julius-Kühn* Institute, Braunschweig, Germany



Braunschweig

Motivation – Investing in remote sensing approaches

- Integrated Administration and Control System (IACS) has limitations
  - Does not cover all land, no yields, no grassland intensities
  - has high administrative burden (getting it and processing)
- CAP IA models operate at EU level where IACS is not available
- Fast CAP policy cycles made official statistical data useless
- We wanted to reduce the effort in harmonizing official statistics (Thünen-Atlas, CAPDIS, AGRI-DE …)

Alexander Gocht, Ann-Kathrin Holtgrave

Motivation – Investing in remote sensing approaches

- How far can Sentinel be used for a **German wide monitoring** of the environment, soil and agriculture related topics
- How good is the **explanatory power** and **consistency** with other statistics
- What **technical and human resources** do we need in the future and can RS substitute existing work loads

Alexander Gocht, Ann-Kathrin Holtgrave

Team at Thünen



Biodiversität

Ländliche Räume



Agrarklimaschutz

Betriebswirtschaft


Internationale Waldwirtschaft und Forstökonomie



Waldökosysteme

https://www.thuenen.de/de/infrastruktur/Thuenen-Fernerkundung/team/

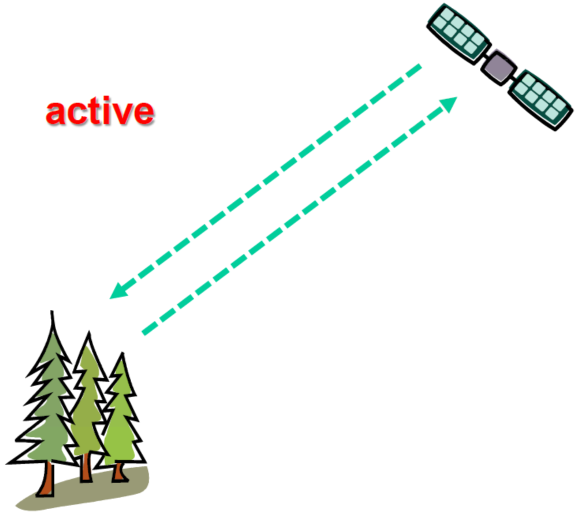
Alexander Gocht, Ann-Kathrin Holtgrave

Sentinel 1

Alexander Gocht, Ann-Kathrin Holtgrave

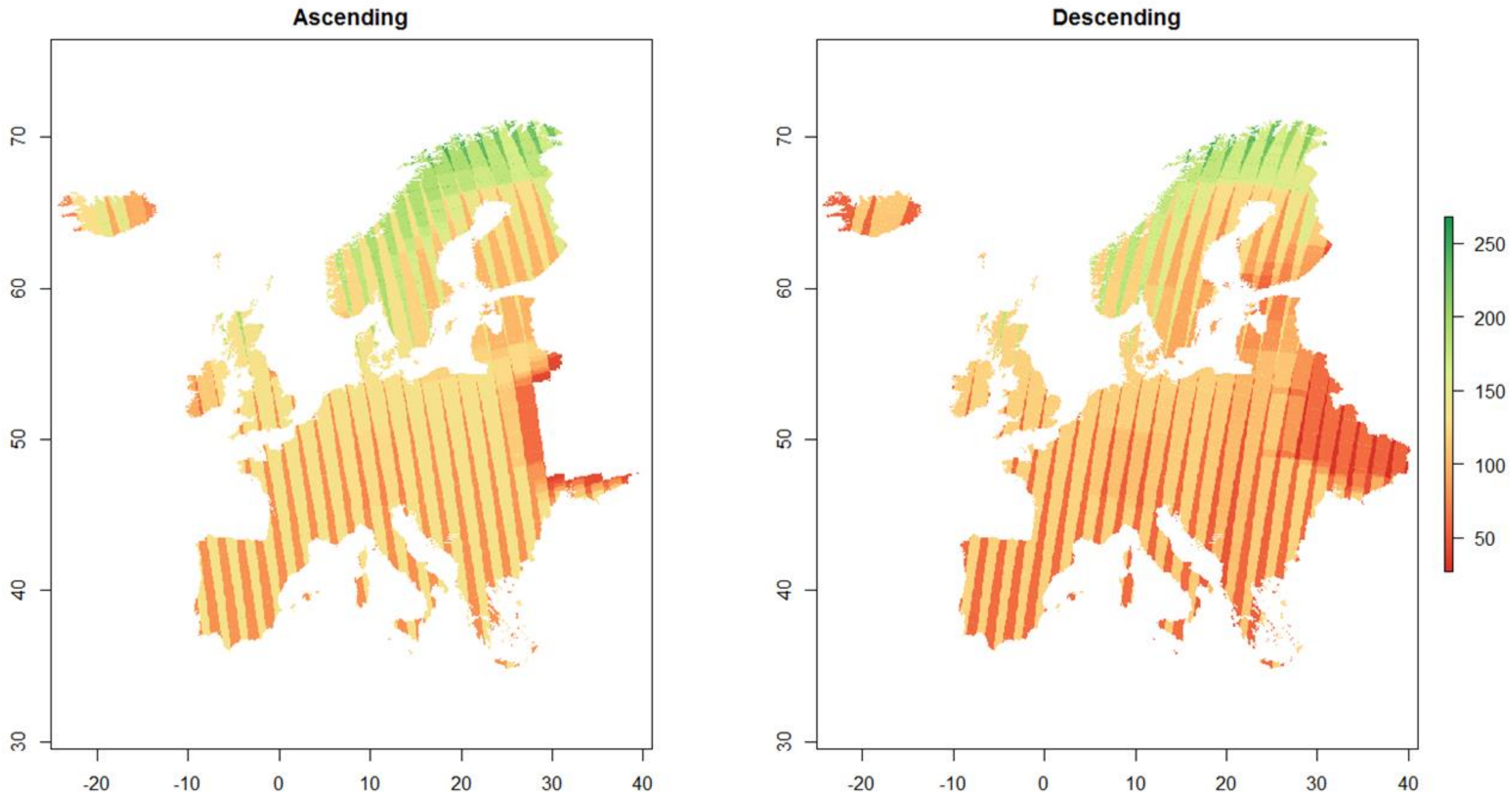
Sentinel 1 A/B (Synthetic Aperture Radar - SAR)

- Advantages
  - Active sensor, independent of the illumination
  - independent of weather status (clouds, rains) as microwaves have the ability to penetrate clouds, rain, vegetation canopies, dry soils
  - sensors give an indication of the physical structure
  - Multi temporal (ascending/descending)
- Disadvantages
  - backscatter values are sensitive to rain events/moisture
  - "salt and pepper-effect"
  - time and consuming pre-processing



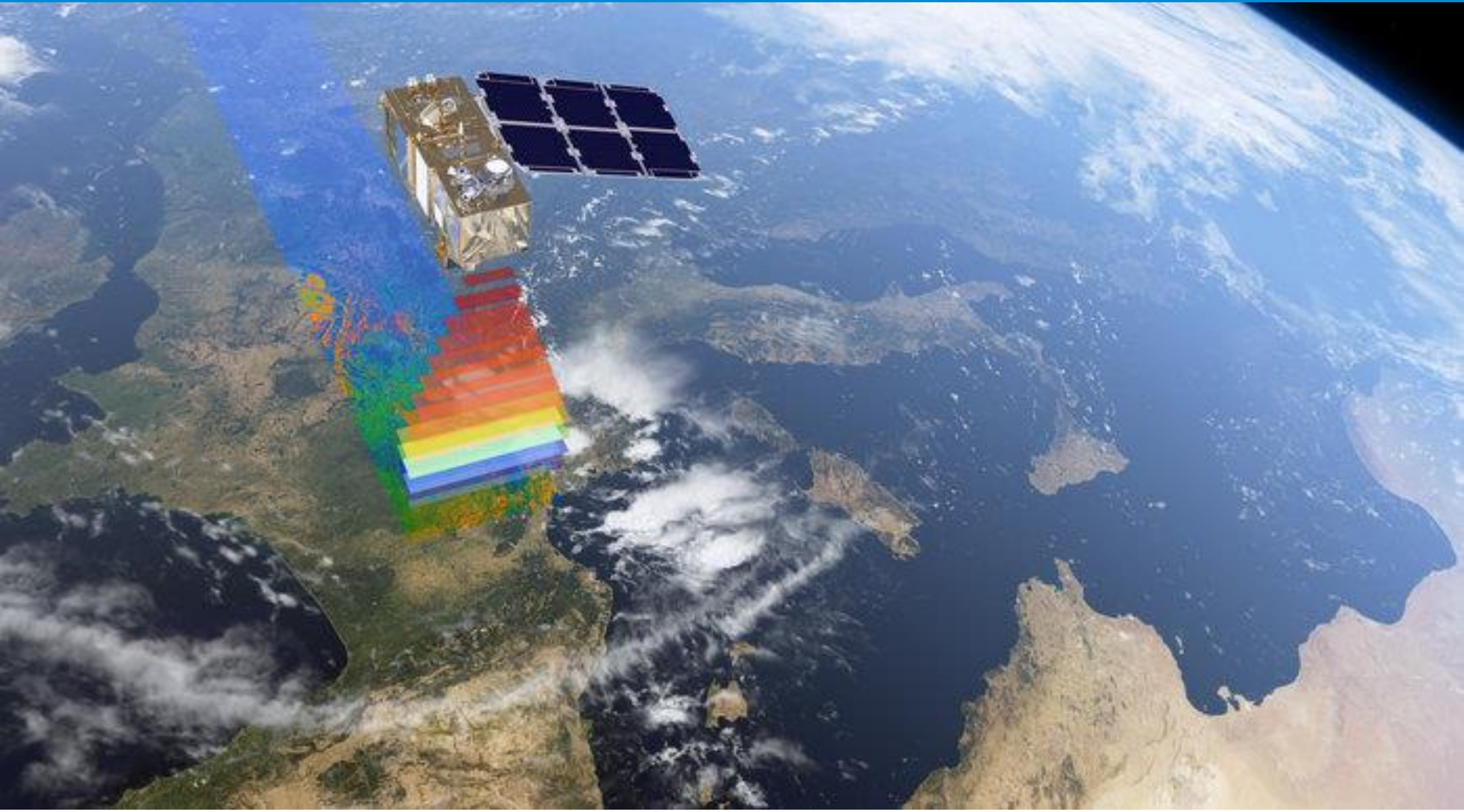
Alexander Gocht, Ann-Kathrin Holtgrave

Muli-temporal-S1: no of observations in 2017



Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

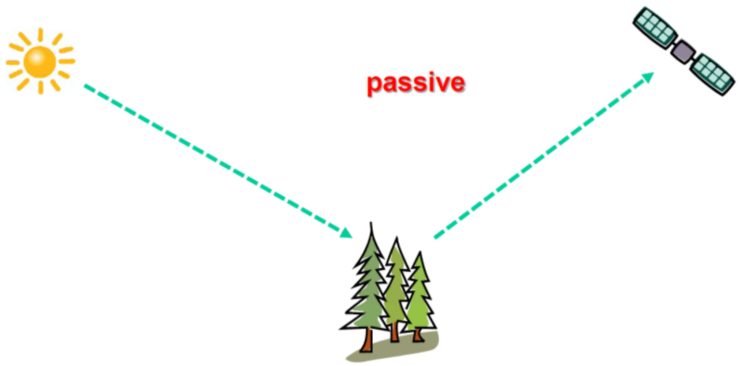
Sentinel 2

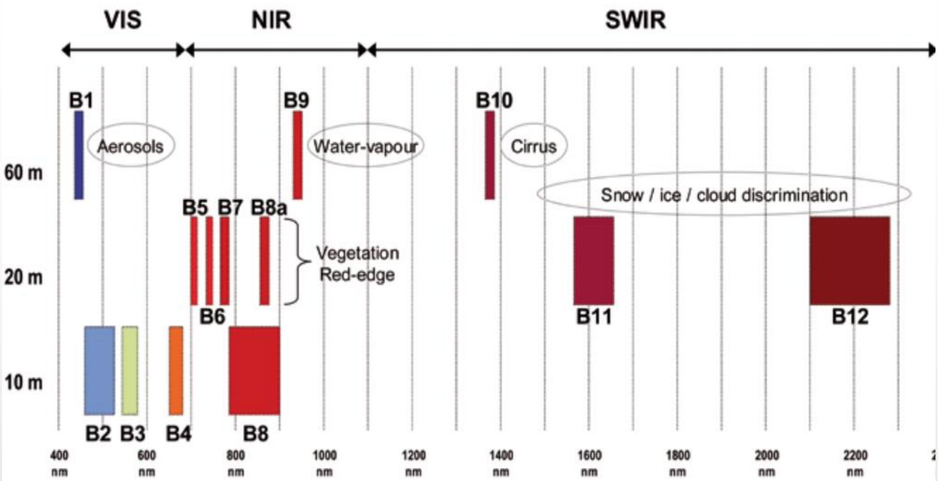


Alexander Gocht, Ann-Kathrin Holtgrave

Sentinel 2 A/B

- Advantage
  - Easy access, less sensitive data processing
  - Bands for measuring vegetation
  - Image charm
- Disadvantages
  - Depend on the sun (brightness)
  - Cloud coverage matters

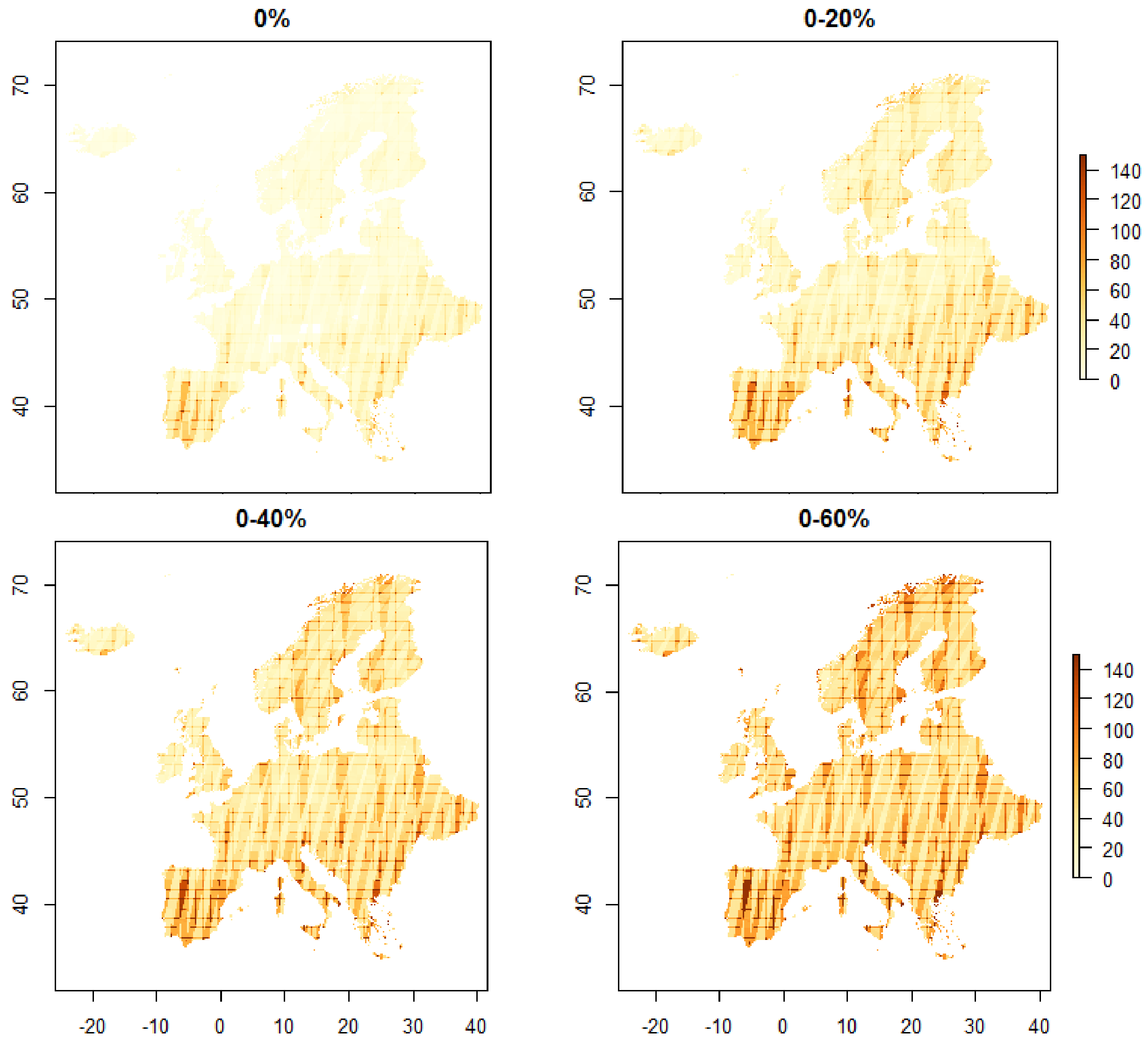




Alexander Gocht, Ann-Kathrin Holtgrave

THÜNEN

S2: Cloud Cover in Percentage range and number of observations in 2017



THÜNEN

S1 and S2 together

- Advantages
  - Full, Free and Open data policy
  - Long-term financing and planning security
  - Complementary (physical and biophysical)
- Disadvantage
  - raw data volumes several TB per year
  - areas for applications needs minimum set of pixels and depends on the shape of the object (parcel, hedges)

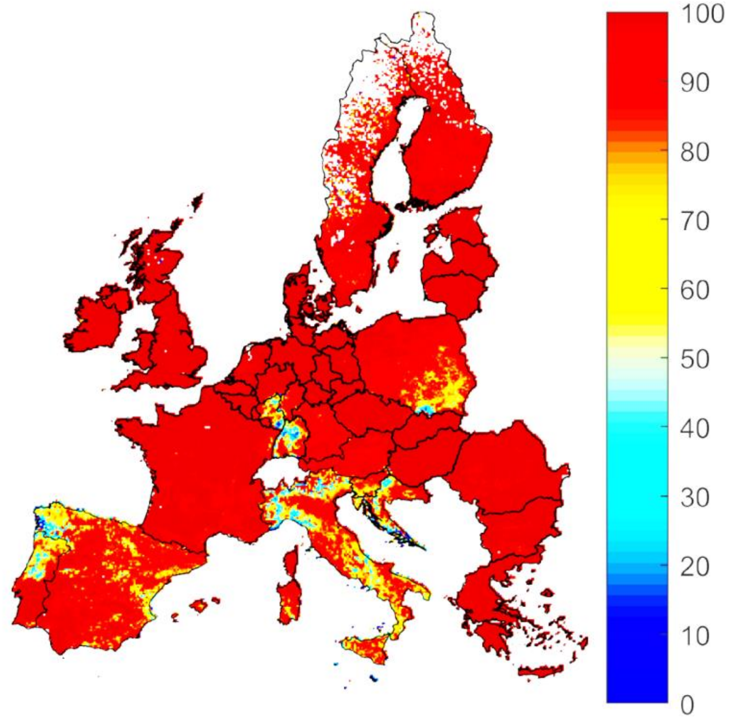


Figure A23: EU distribution of territories, based on 10km x 10km grid with the percentage of agricultural area covered by reference parcels that are bigger than 0.5 ha (blue is 0% and red is 100%), a proxy for possible non suitability for monitoring, requiring further analysis

Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Ziel gruppe	Aufgaben	Anwender-szenarien	Land-nutzung	Kultur-art & Frucht-folgen	Ertrag	Zwisch en-früchte	Schnitt-häufig-keit	Grünland -umbruch	Land-schafts-elemente (SWF)	Baum-arten-erkennung	Struktur-merkmale Biomasse
				Ackerland			Grünland			Wald	
Thünen & JKI	Biodiversitäts-Monitoring	UN-Agenda 2030, Europäische Biodiversitäts-strategie									
	Treibhausgasberichter-stattung Land und Forst	UNFCCC, Kyoto-Protokoll, EU-Verordnung 525/2013									
	Bundeswaldinventur	Bundeswaldgesetz	Waldflächen-schätzung								
	Ertragsstatistik und Flächenstatistik	AgrStatG			Modellierung						
	Erosionsschutz	BBodSchG		Modellierung							
	Schaderregerbefall	PflSchG									
	Gemeinsame Agrarpolitik Politikfolgenabschätzung	IA EU-COM									
Landwirt	Anbauplanung Schlagkartei Precision Farming										
Andere Behörden Verwaltung	Dokumentation, Kontrolle …										

Alexander Gocht, Ann-Kathrin Holtgrave

Segmentation of parcels (landscape objectives)

Challenge:

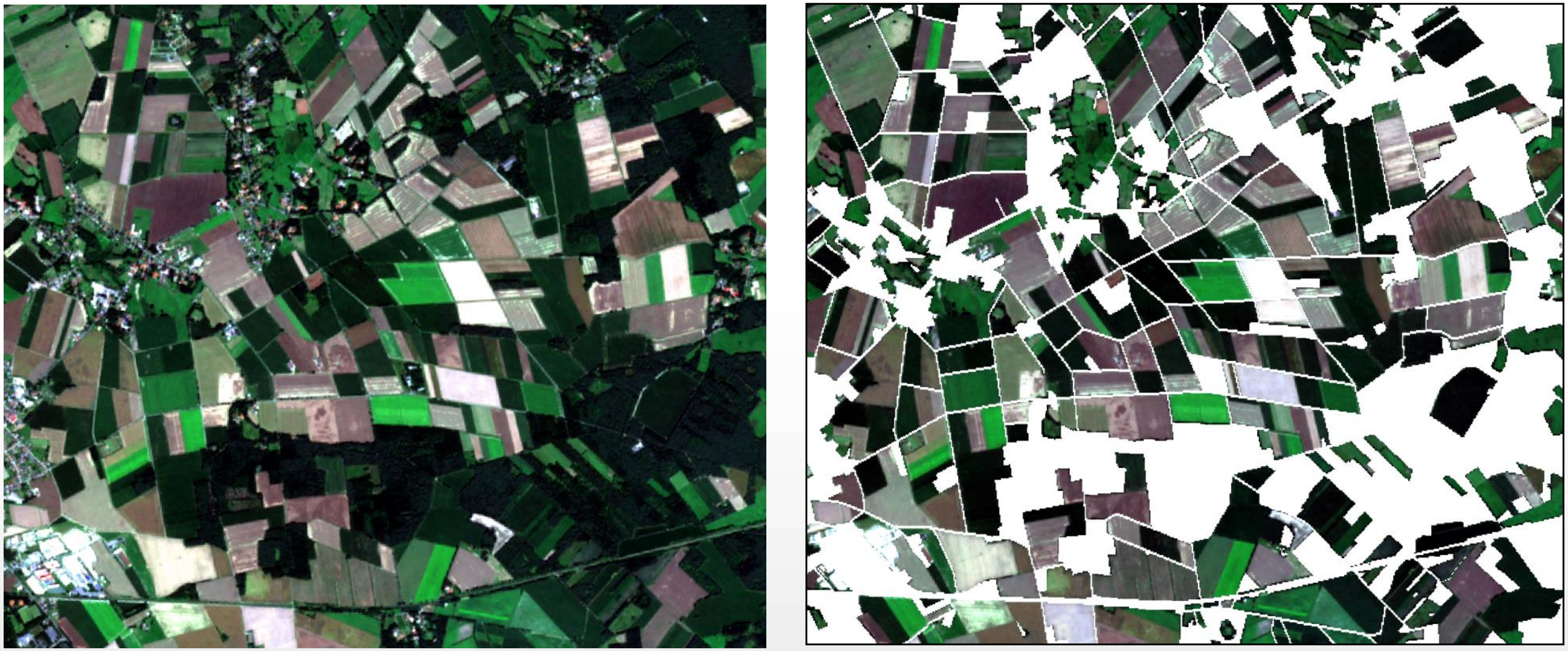
- We need to know the objects to look at (of we have no raster approach)
- Agricultural cropping parcels change over years
- LPIS might not always be a good reference

Source: Documents on the introduction of monitoring to substitute OTSC (JRC)

Alexander Gocht, Ann-Kathrin Holtgrave

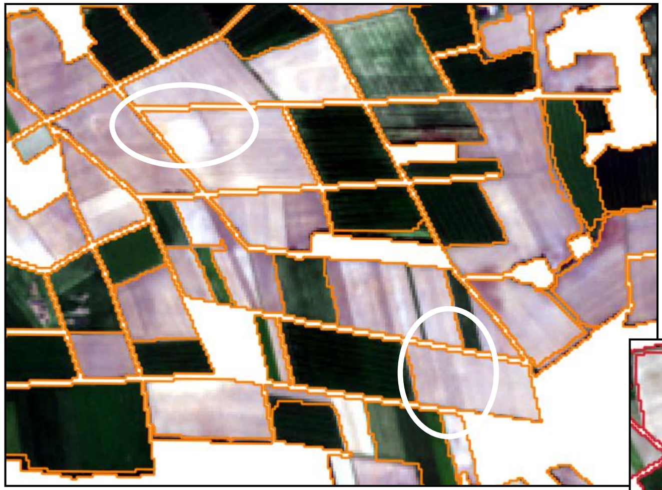
Masking

Mask out non-agricultural areas (forests, built-up, streets, ..) using ATKIS and OSM



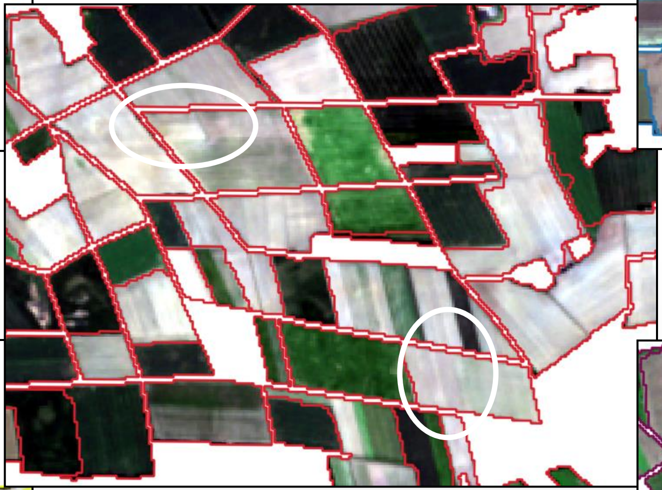
Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

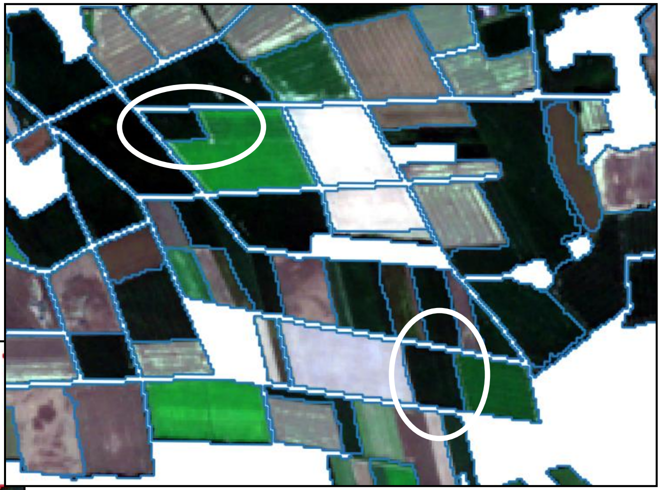
Segmentation of different dates



30.04.2017

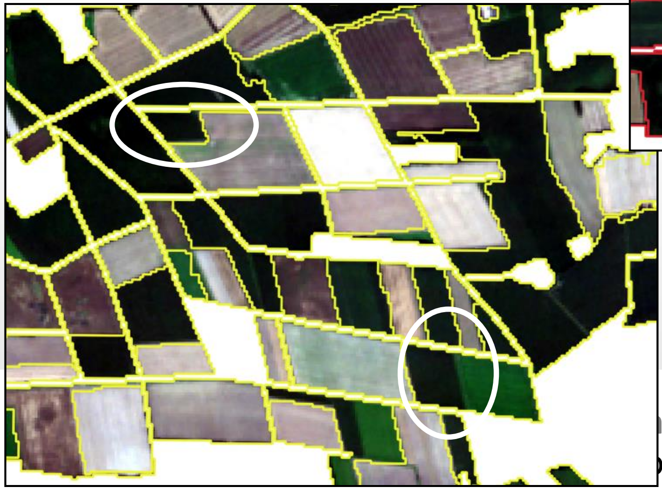
02.06.2017



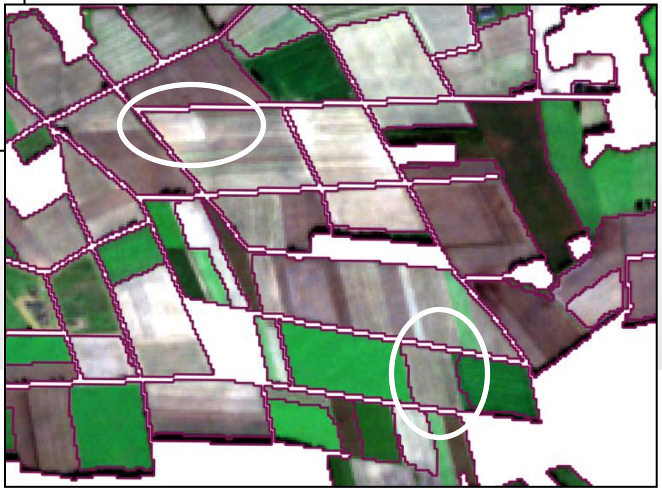


19.07.2017

23.08.2017



15.10.2017



Crop classification/detection

Aim

- Find best optical/radar proxies to identify cops using multi-temporal images
- The phonological behavior of crops throughout the growing season to separate different crops

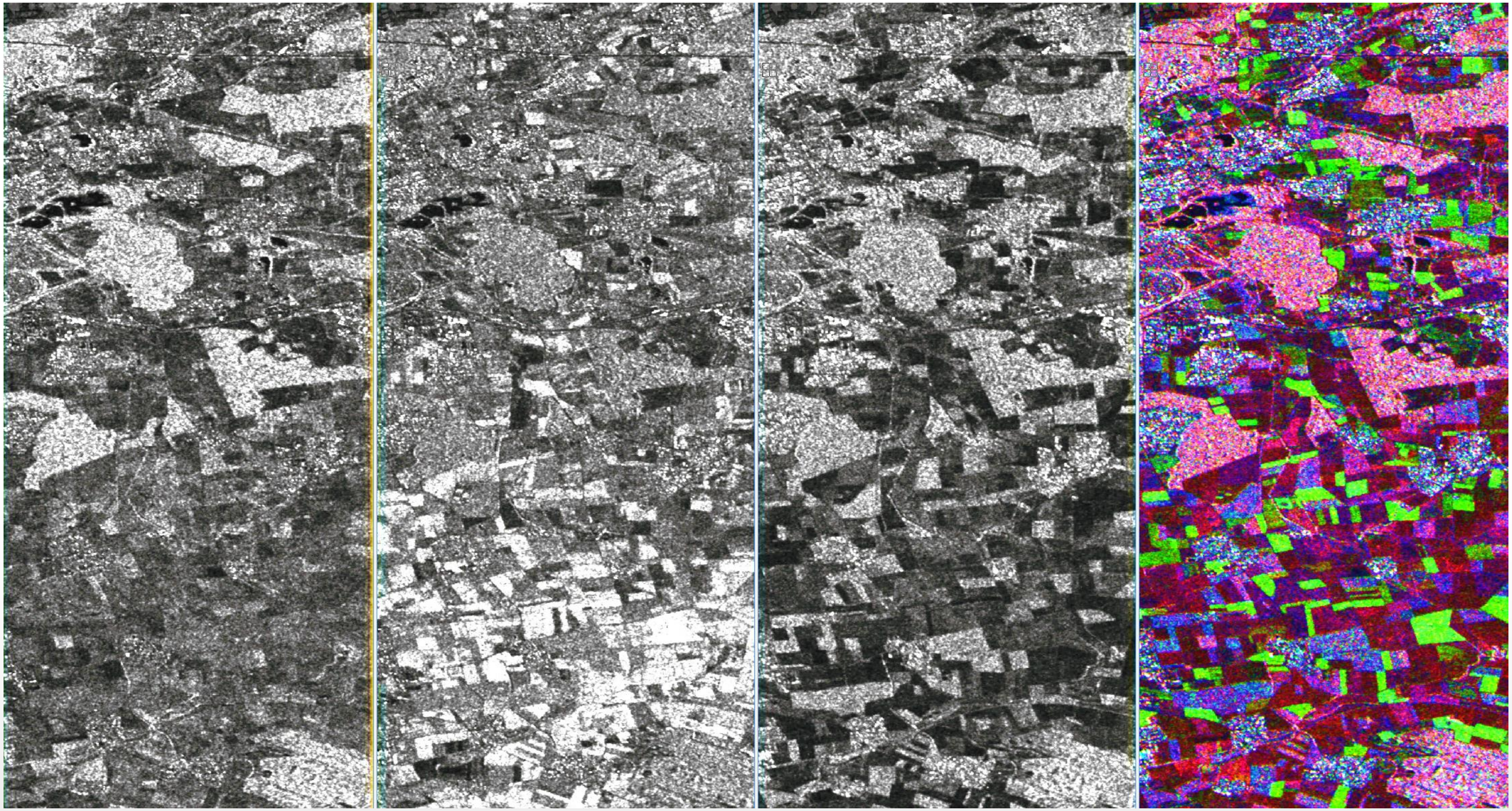
Approach

- Sentinel-2 for Agriculture project (Sen2-Agri) and others developed approach which based on optical data (Normalized Difference Vegetation Index (NDVI)) using ASTAR, Spot5, LandSAT
- Use of both S1/S2
- Increase in classification accuracy
- supervised classification of multi-temporal images -> challenge is ground truth data

Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

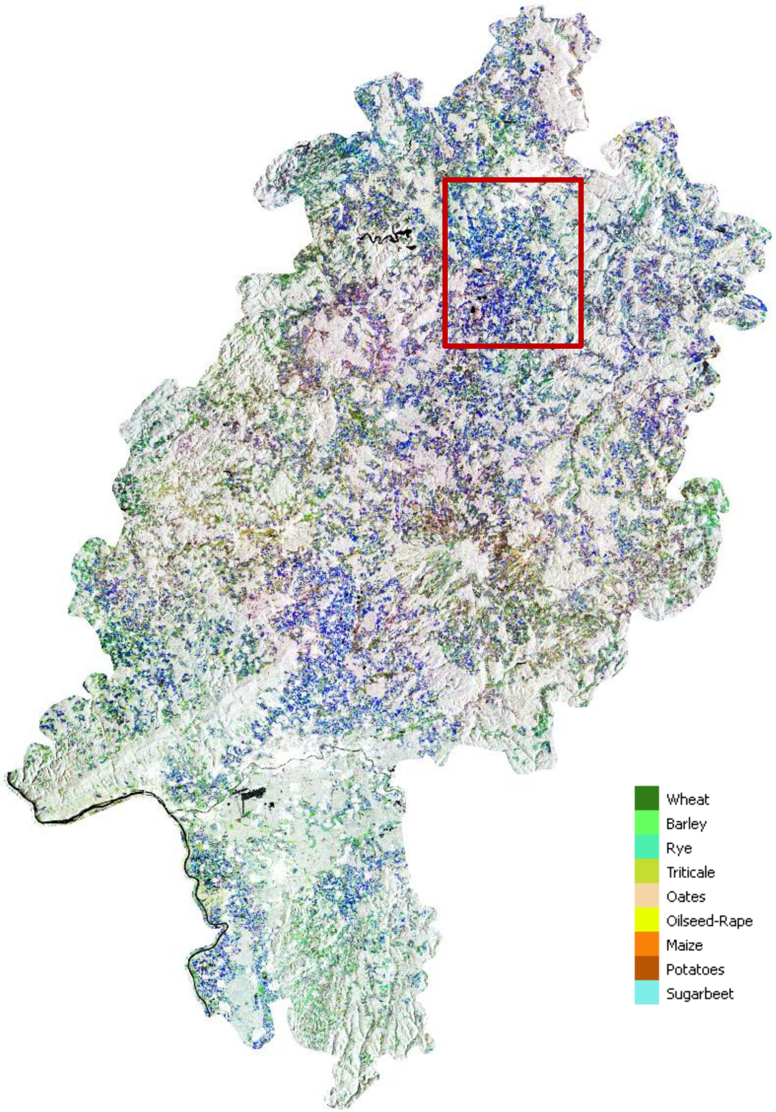
Braunschweig: 2017

12Feb 5/July 3/August Composite

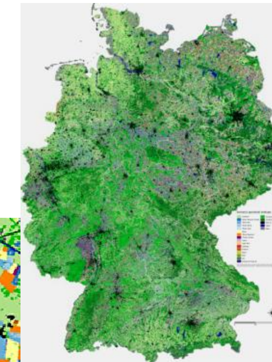


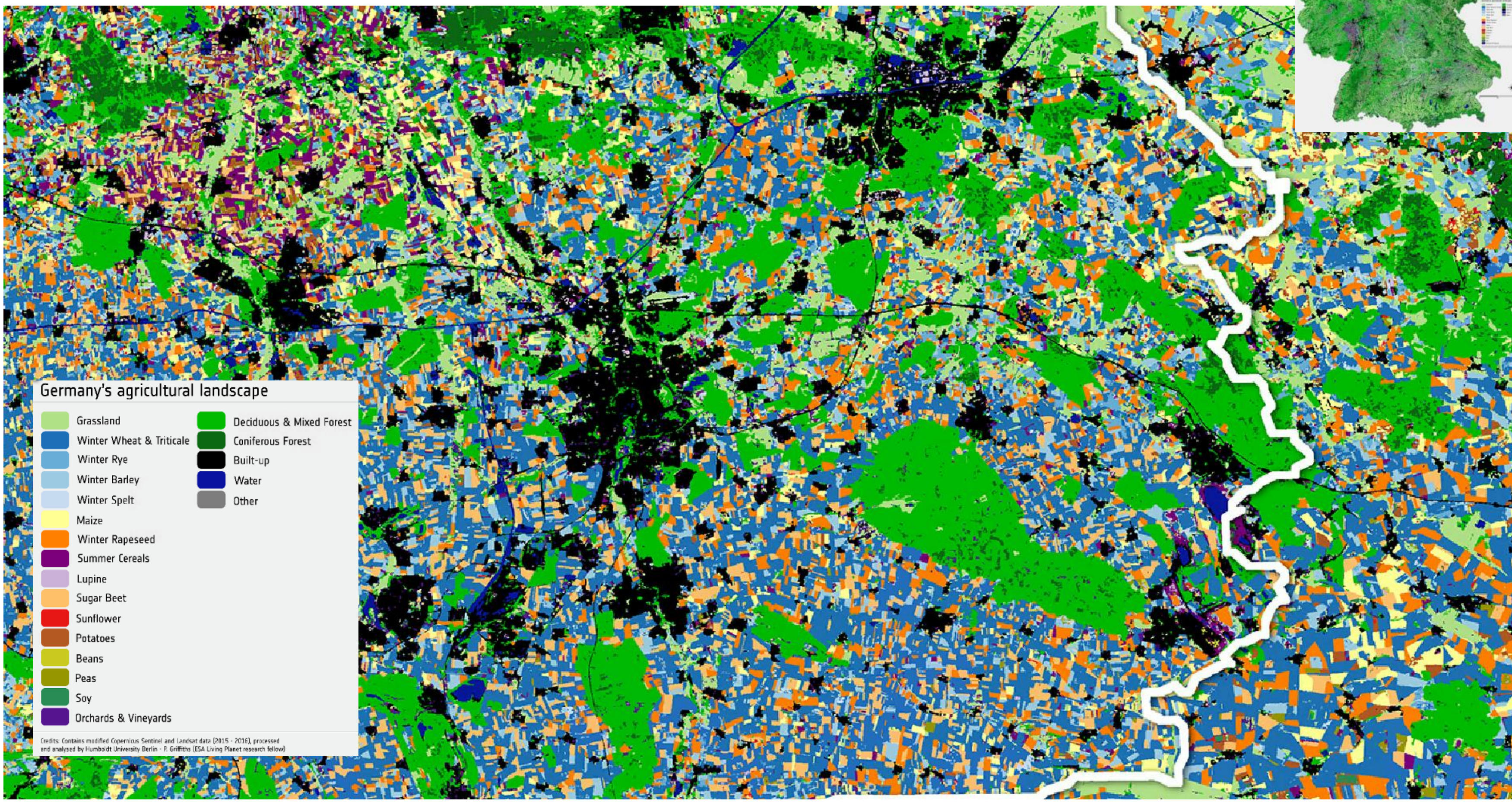
Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Sentinel 1 based crop classification



Sentinel 2 and Landsat data (2015-2016)





Source: Modified Copernicus Sentinel and Landsat data (2015–16), processed and analysed by Humboldt University Berlin/P. Griffiths (ESA Living Planet Research Fellow) in collaboration with the Leibniz Centre for Agricultural Landscape Research (ZALF). Data pre-processing: NASA and Harmonized Landsat–Sentinel initiative

Grassland intensities

Challenges

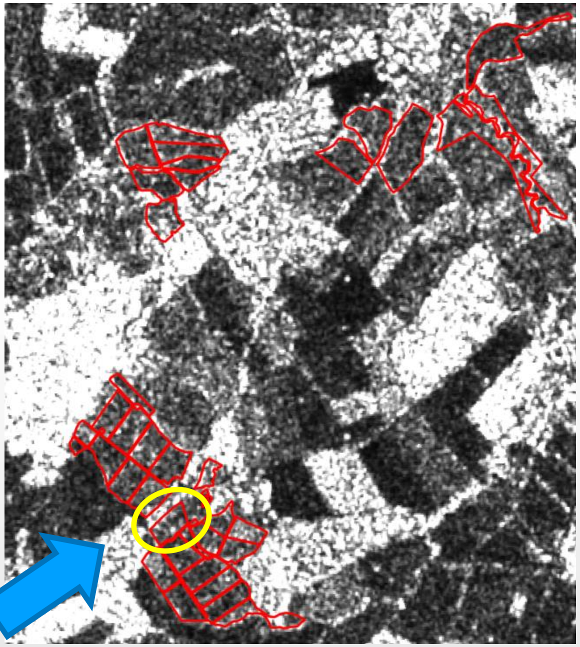
- S2 not suitable because of clouds for mowing events (Buddeberg et al. 2016)
- S1->Steepness (shadows, foreshortening, layover)
- Raining events can interfere with signals/change signals
- Ground truth missing for grassland yields or mowing events
- Multiple use of grassland (mowing, grazing, abandoned)

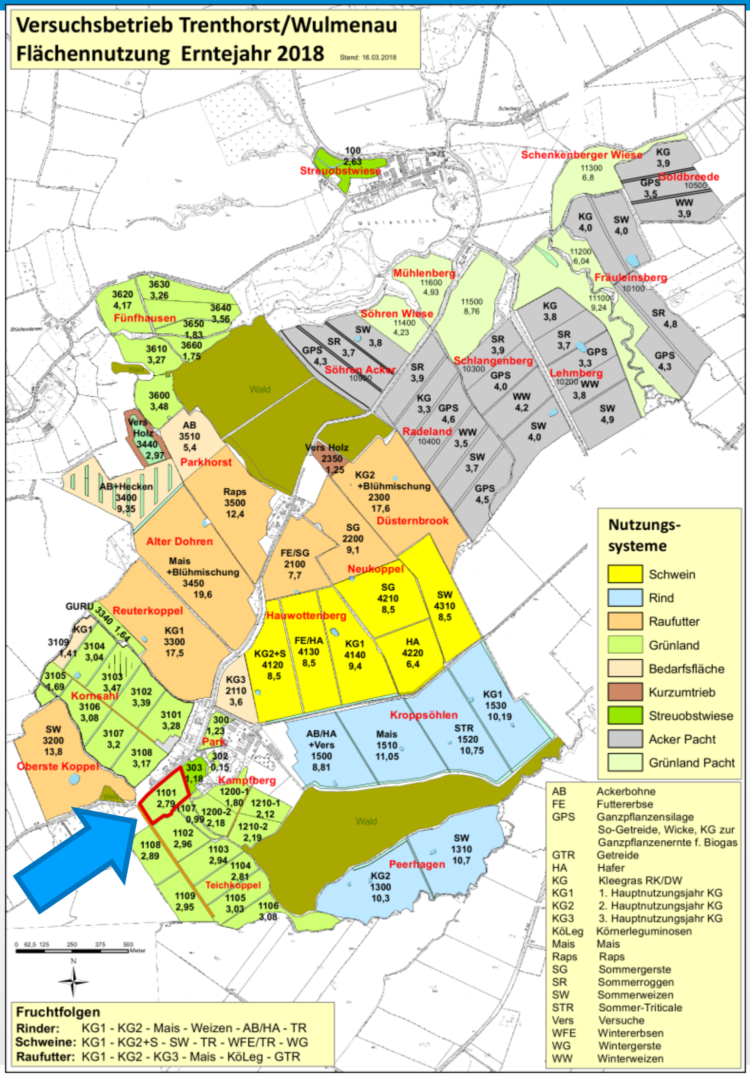
Approach

- Sentinel 1 multi-temporal backscatter and coherence analysis
- Intensity increases after cutting (Bargiel et al. 2010)
- Control for rain events

Grassland in Trenthorst

- Permanent pastures
- 1-2 mowing(s)
- Example: 1101, 2.79ha





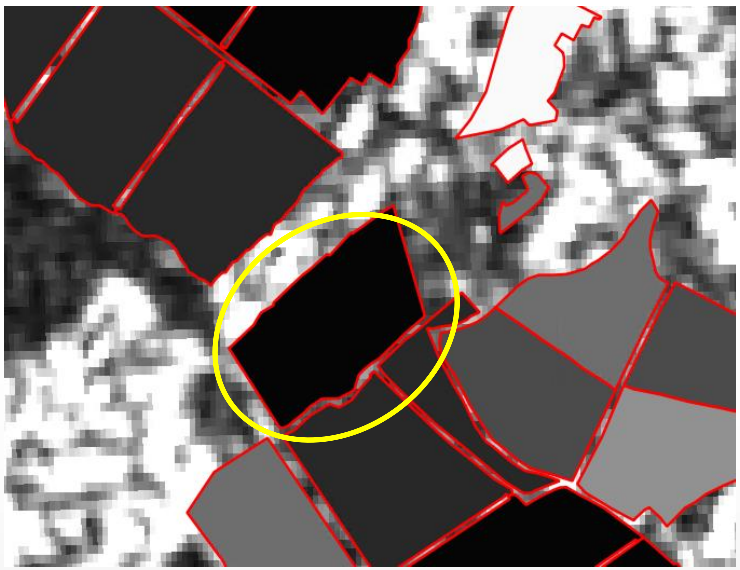
Alexander Gocht, Ann-Kathrin Holtgrave

Themenfeld Pflanzenbau - Fernerkundung

THÜNEN

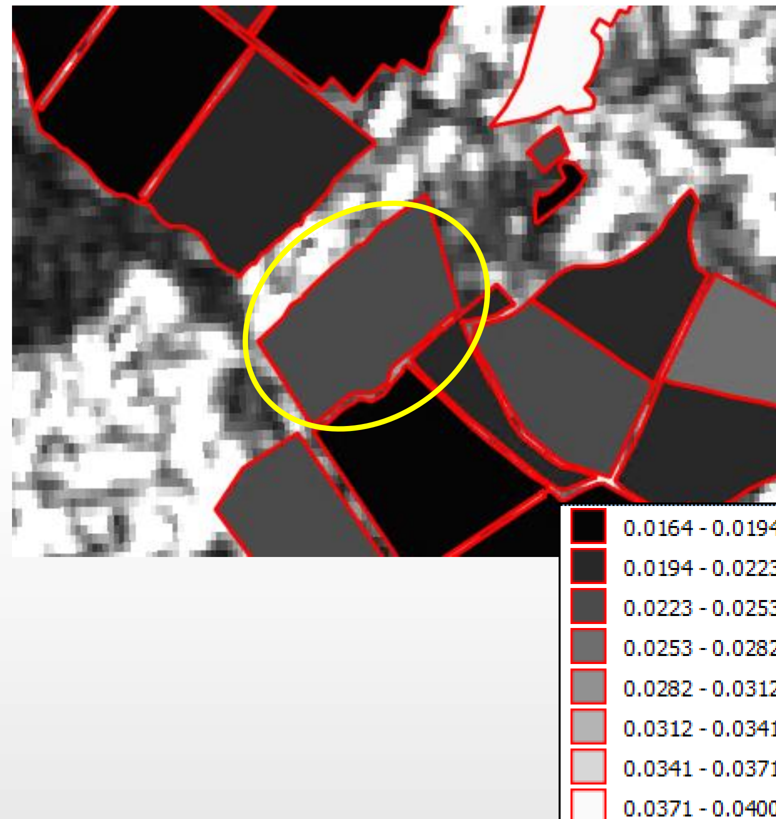
Mean backscatter

15.05.2017

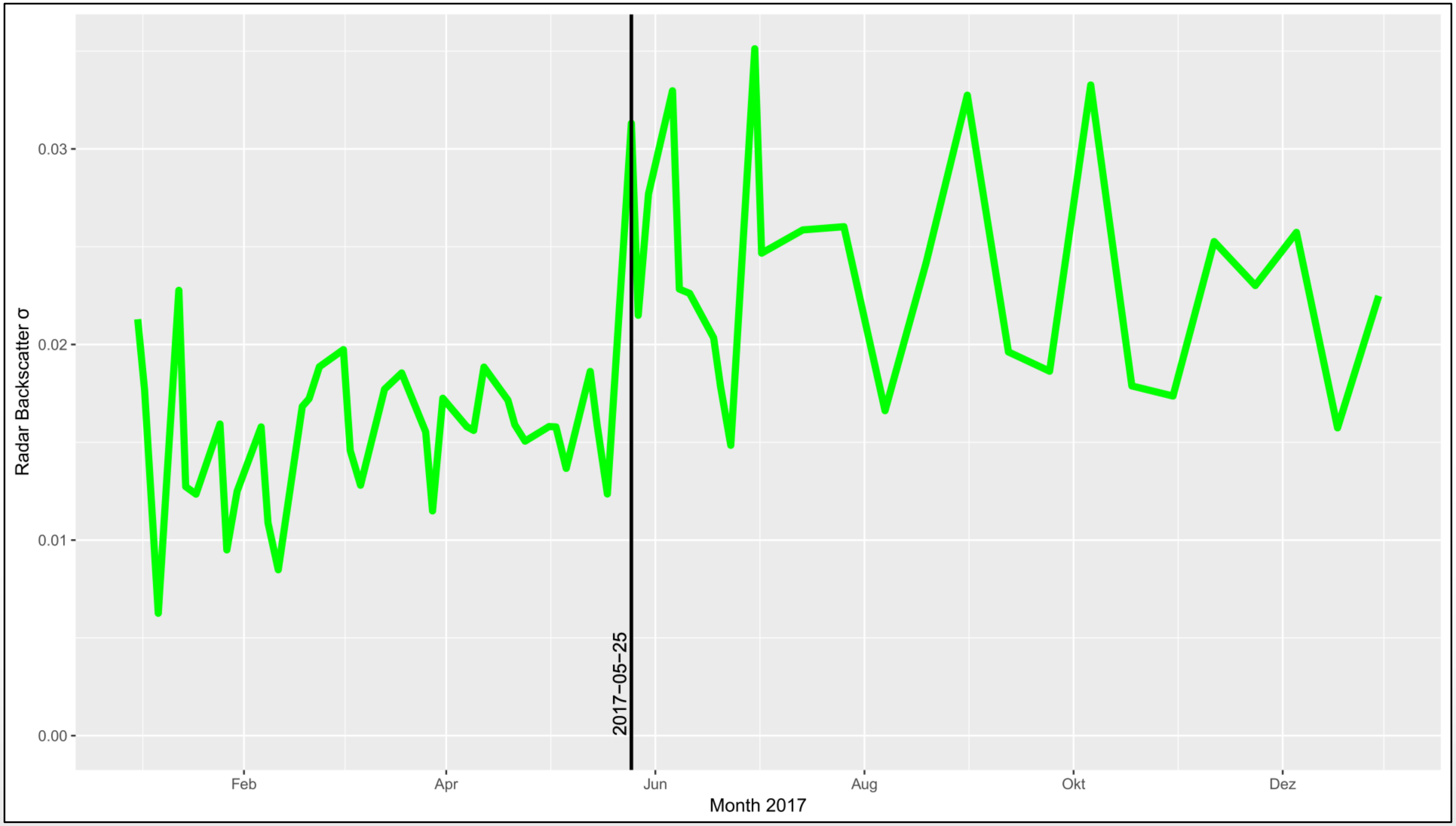


Cut

27.05.2017

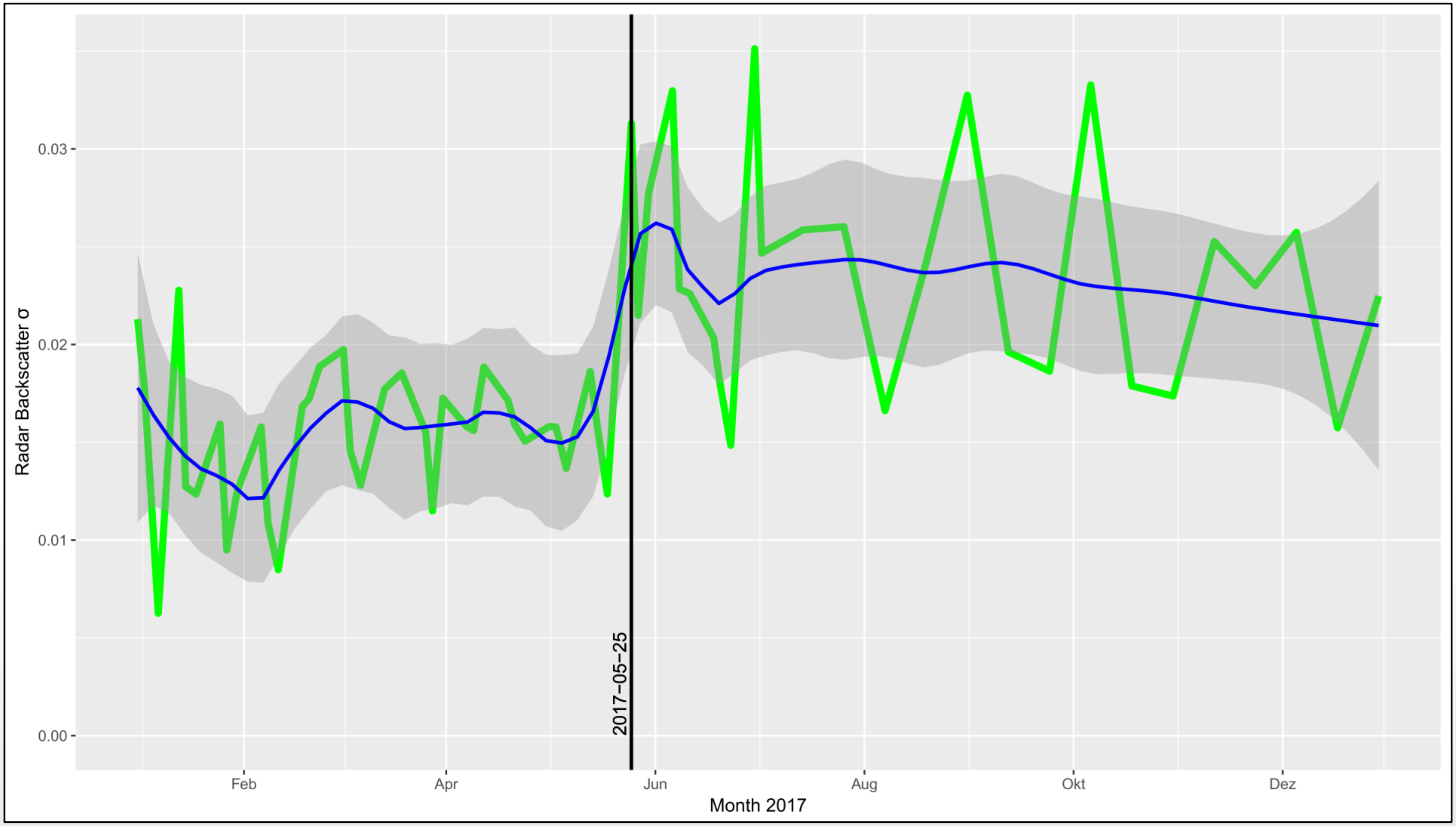


Backscatter mean - Field 1101 in 2017



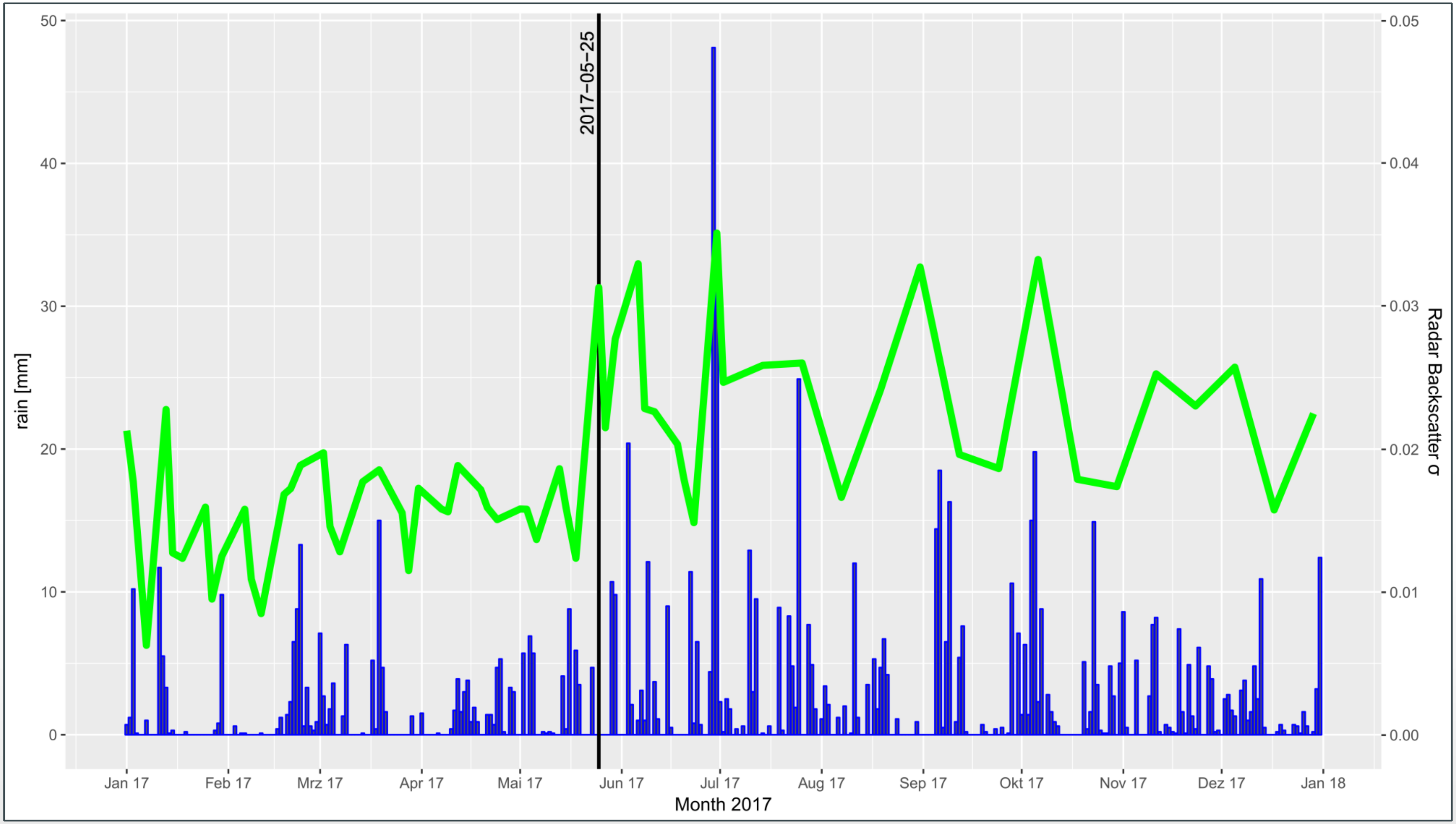
Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Backscatter mean of Field 1101 in 2017



Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Backscatter mean of Field 1101 in 2017 - rain



Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Biodiversity

Challenges

- Gradient between habitats, no clearly defined classes/land parcels
- Spectral dominance of rare species?

Aim

- Differentiate biodiversity patterns in extensively used grasslands
- Test predictors to map biodiversity patterns

Approach

- Optical traits from Sentinel-2 imagery, possibly RapidEye
- Texture analysis from aerial imagery – heterogeneity as a proxy for diversity (species or functional diversity)

Alexander Gocht, Ann-Kathrin Holtgrave

Monitoring groundwater table depth

Background

- Water table depth play a key role for all peatland functions
- Monitoring and controlling restoration actions

Aim

– Correlation analysis at points between backscatter (Sentinel 1) and water table depth

Approach

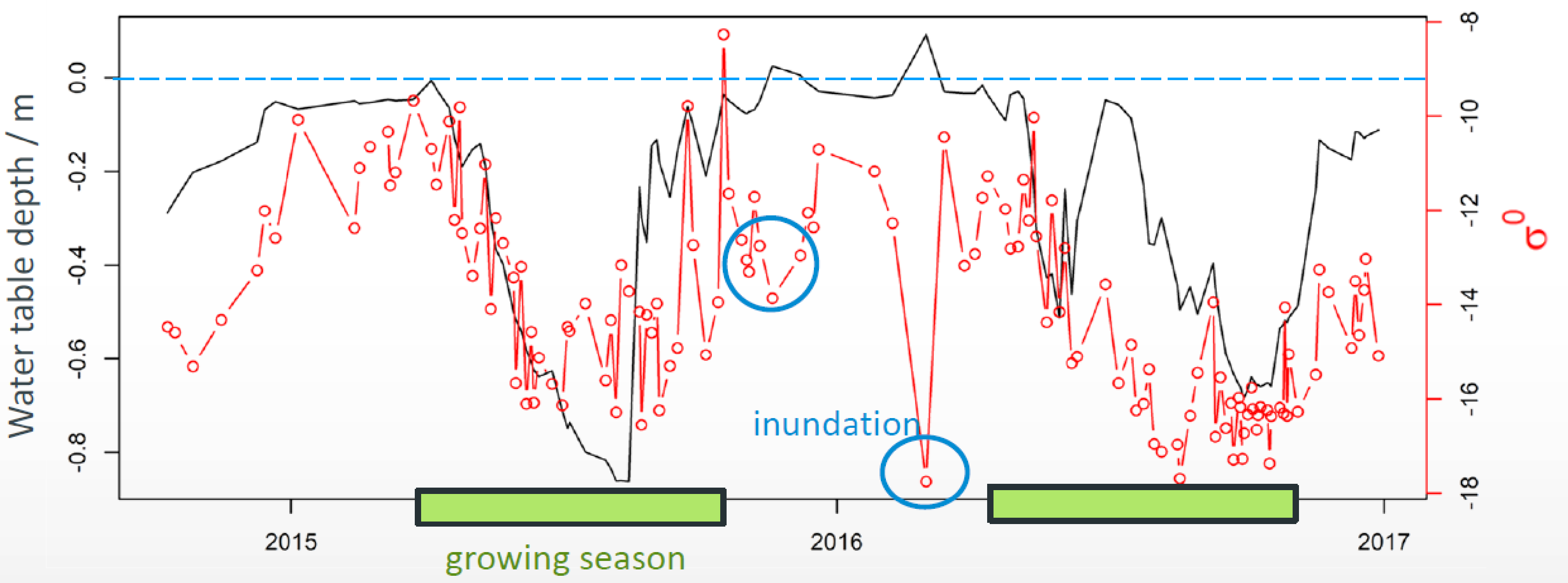
– High correlation to the vegetation growth

– Depending on Soil properties

Training data set: field data

Alexander Gocht, Ann-Kathrin Holtgrave
Themenfeld Pflanzenbau - Fernerkundung

Time Series of backscatter and water table depth in the region "Ochsenmoor"



Alexander Gocht, Ann-Kathrin Holtgrave

Projects from FLF

- Development of a cluster for remote sensing products for agriculture (AGRO-DE)
- Identification of low yield areas (Copernicus4ECA)
- Identification of yield potential (RiflE)
- crop yield estimate (SatAgrarStat)
- Decision support for grassland management (SattGrün)

Alexander Gocht, Ann-Kathrin Holtgrave

Conclusion: development of routines/data

- Besides pictures we need …
- A **standardized** and **automated** approaches for agro-environmental products (Agri2Sen for crop detection ??)
- Shorten the way from **sensor** to the **researcher** (sen4cap)
- Access (WFS) to pre-processed data from which we can statistically draw samples (small regions, points ..) -> to train learning algorithm; instead of downloading/processing file which cover 250 km
- We need an automatic **outlier detection algorithms** (snow, rain) to find meteorological phenomena
- S2 cloud cover -> combining S1 and Landsat is required -> provide all in one?

Alexander Gocht, Ann-Kathrin Holtgrave

Conclusion: Ground truth data

- Sensor data are "only" useful together with **training data** and **transferability accurateness** (over region and years)
- free access to **ground truth** data, maybe provided by the MS similar to a **regulatory frameworks** like IACS or FADN particular for yield and grassland management information, crops, landscape elements …
- Strengthen the cooperation with **farmers** to get GT data (precision farming) -> MS wide EIP-Agri or extending and increasing LUCAS survey
- Only with **open ground truth data** we can measure the quality of a product (relevant for CAP) and to set standards, as good concepts for keeping the data confidentiality of training data in Cloud Computing are missing

Some other aspects we need to working on ..

- Understanding of how good sentinel products **fit to current monitoring** approaches (Official statistics, FSS, FADN, IACS-> indicator calculation)
- Institutional setting needs to be established in CAP IA for Remote Sensing data products to strategically harvest results and explore scalability

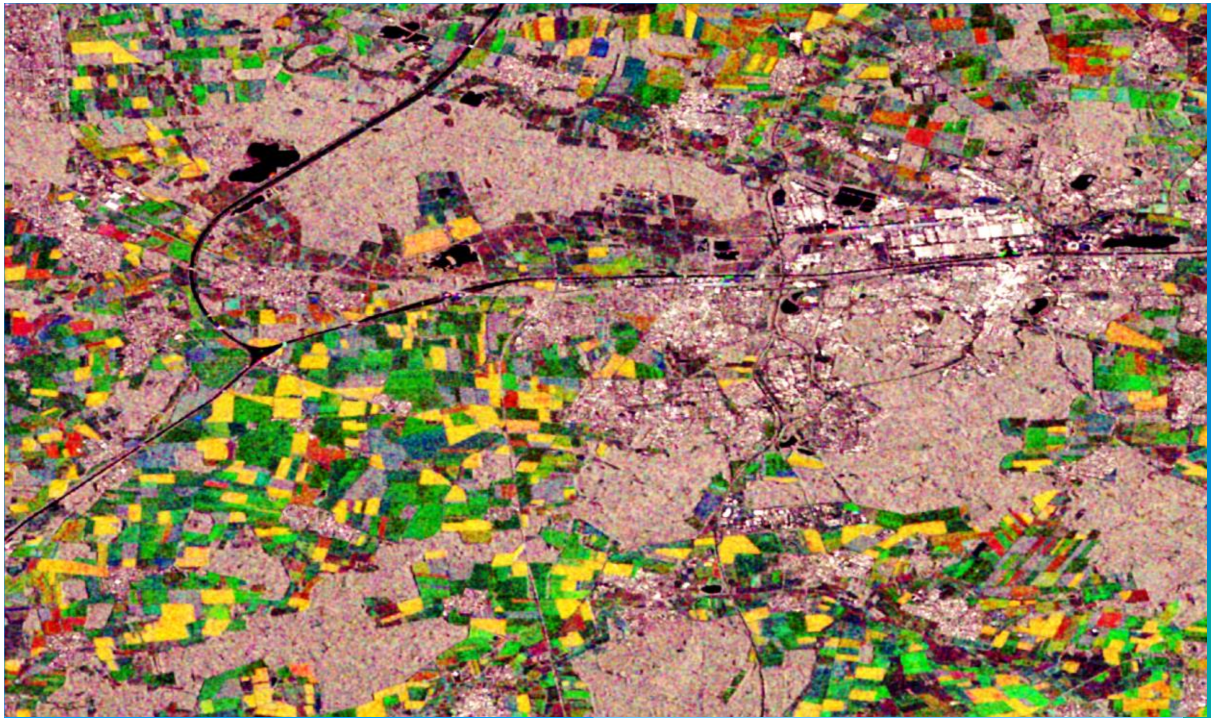
Alexander Gocht, Ann-Kathrin Holtgrave

Questions reloaded

- How far can Sentinel be used for a **German wide monitoring** of the environment, soil and agriculture related topics
  - Parcel Size, Weather impacts (clouds), GT data availability, combination of S1/S2/LandSat/ …
- How good is the **explanatory power** and **consistency** with other statistics
  - Work in progress
- What **technical and human resources** do we need in the future and can RS substitute existing work loads
  - depends on how good “central” solutions will be and how the access to GT data will be organized

Alexander Gocht, Ann-Kathrin Holtgrave

www.thuenen.de/de/infrastruktur/thuenen-fernerkundung



alexander.gocht@thuenen.de