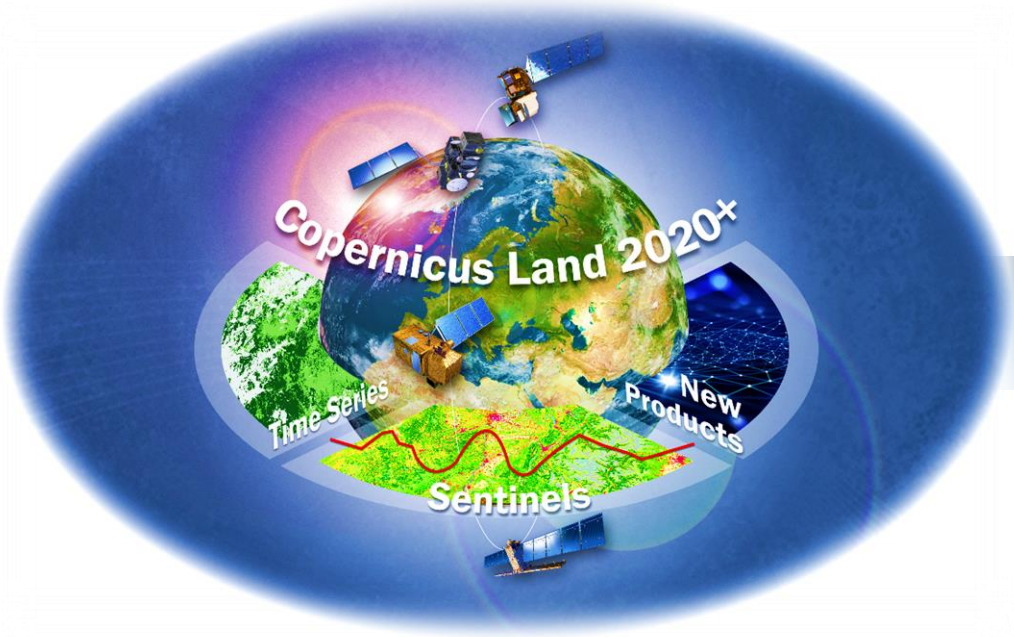



Evolution of Copernicus Land Services based on Sentinel data
IGARSS Symposium
Wednesday, 25 July 2018
Valencia, Spain

ECoLaSS

Horizon 2020
Call - Earth Observation:
EO-3-2016: Evolution of Copernicus services

# *Crop Mapping For A Future Copernicus Agricultural Service The ECoLaSS Project:*

***Linda Moser (GAF AG)***

***Linda Moser, Gernot Ramminger, Markus Probeck, Christoph Rieke, Benjamin Mack, Cornelia Storch, Carolin Sommer, Christopher Sandow, Regine Richter, Marcus Sindram, Anna Homolka, Hannes Ott, Martin Ickerott, and Axel Relin***

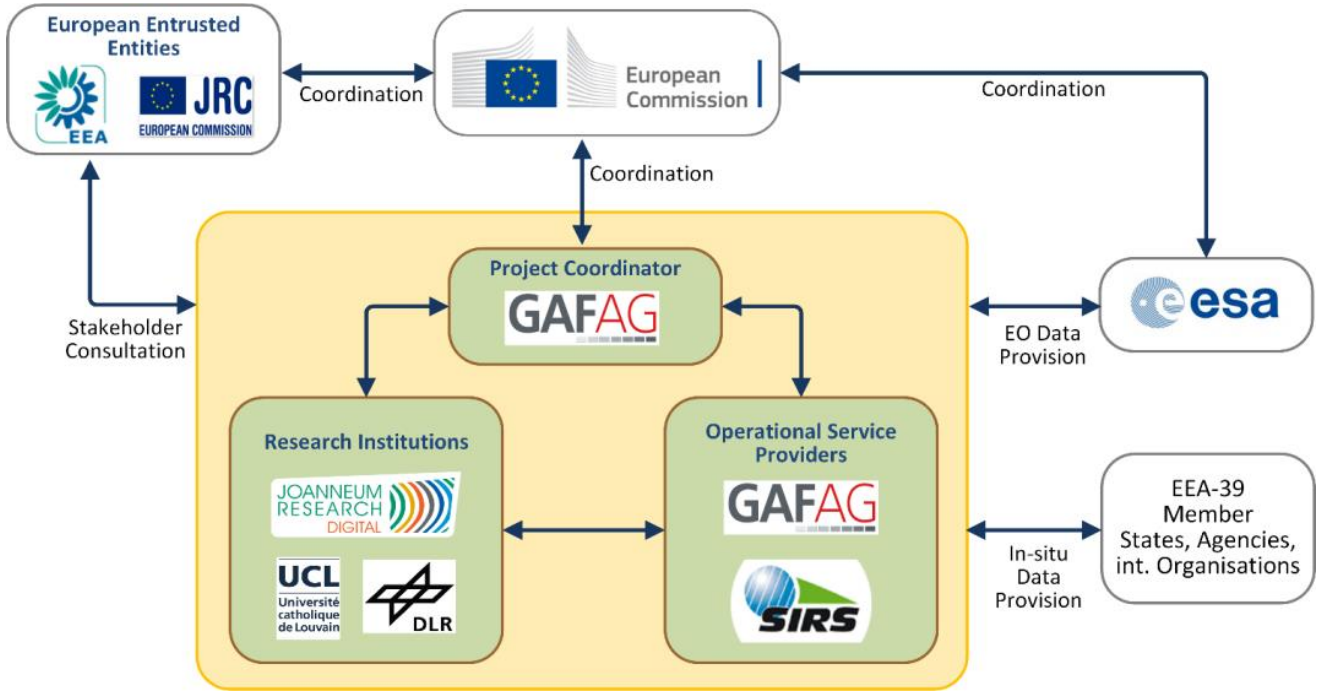
GAFAG
SIRS A CLS GROUP COMPANY
JOANNEUM RESEARCH
UCL Université catholique de Louvain
DLR

# H2020 ECoLaSS – Objectives & Setup

**ECoLaSS**: "**E**volution of **Co**pernicus **La**nd **S**ervices based on **S**entinel data"

**Key Objective** = **improve** existing & develop **novel** products/services for future operational pan-European & Global Copernicus Land Components 2020+:

## Organizational Setup




**Horizon 2020**

## Dates & Timing:

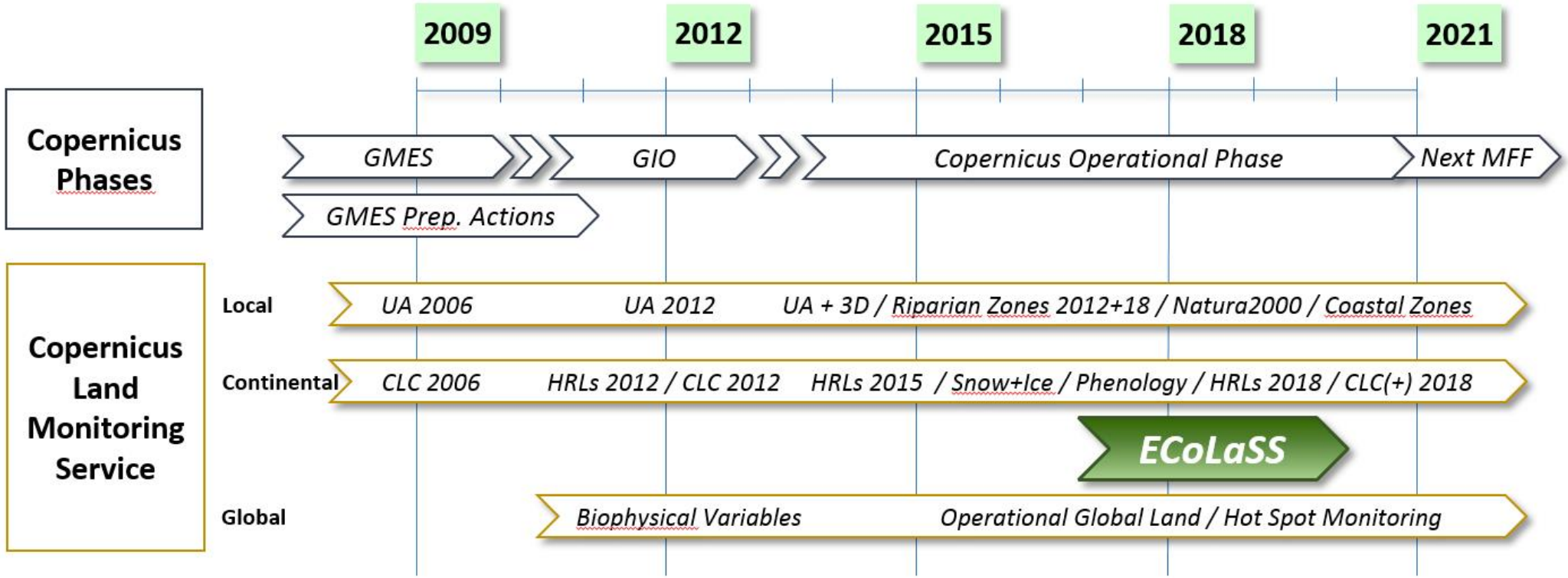
- Dez 2015: Horizon 2020 WP, Call: „*Evolution of Copernicus Land Monitoring Services*"
- **Jan 2017: Project Start**

→ Runtime: **Jan 2017–Dec 2019 (3 years)**

# H2020 ECoLaSS – Objectives & Timeline

**ECoLaSS**: "**E**volution of **Co**pernicus **La**nd **S**ervices based on **S**entinel data"

**Key Objective** = **improve** existing & develop **novel** products/services for future operational pan-European & Global Copernicus Land Components 2020+:

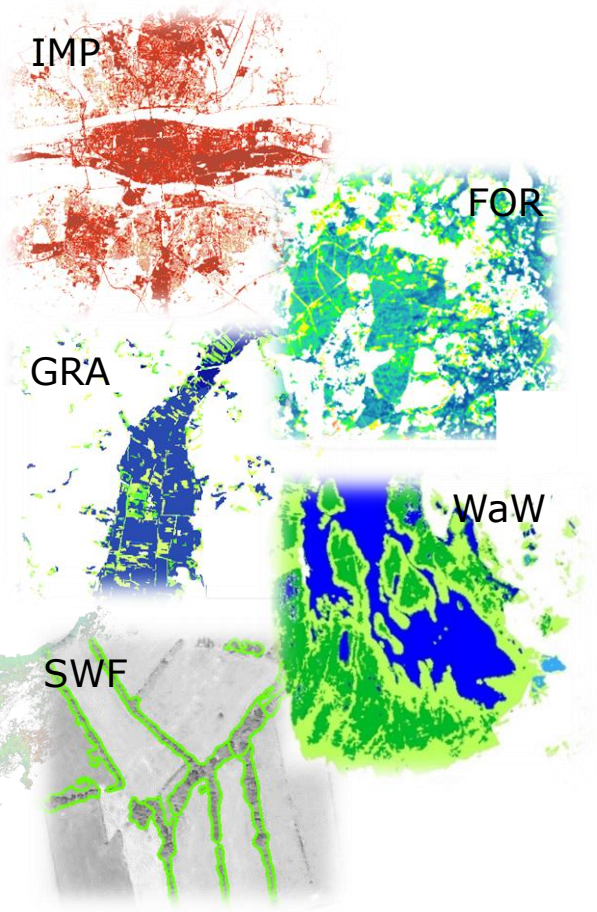


# Background: High Resolution Layers (HRLs) 2015

## Copernicus Land Monitoring Service – High Resolution Layers (HRLs) 2015

**Updated & new HRLs 2015:**

- **Imperviousness (sealed areas) (IMP)**
- **Forest (FOR)**
- **Grassland (GRA)**
- **Water/Wetness (WaW)**
- **Small Woody Features (SWF)**


**Requirements:**

- **Consistent and harmonized** products across **EEA-39 – 5.8 Mio km²**
- **65,000 HR; 35,000 SAR; > 100,000 VHR**
  **→ denser S1a/b & S2a/b & LS 8 time series**
- **Thematic accuracies:** exceeding **85–90%**
  **→ Increased Automation**
- **20 m** high spatial resolution/5 m and 1:5000 vector product (SWF) **→ 10m**
- **Change layers → yearly incremental updates** 2012/2015 (FOR), 2006/2009/2012/2015 (IMP)

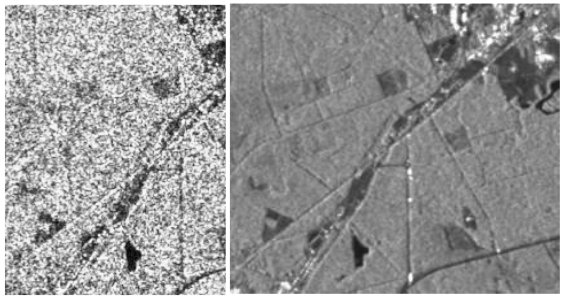


**Consortium:**

GAF AG, GeoVille, SIRS, e-Geos (only GRA)

L. Moser/G. Ramminger et al. (2017): Sentinel-based Evolution of Copernicus Land Services on Continental and Global Scale: http://worldcover2017.esa.int/files/2.3-p2.pdf

# H2020 ECoLaSS – Concept



High volume data processing chains

Impervious-ness

Agriculture

Forest

Grassland

New Products

Service Requirements

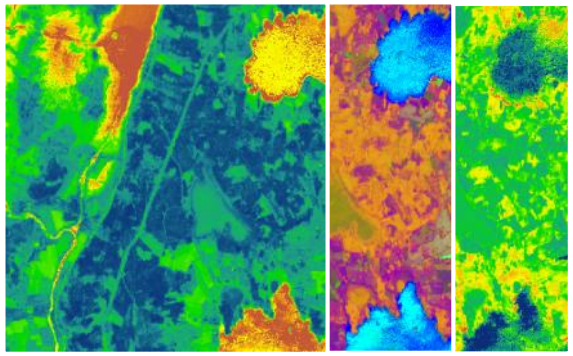
Methods

Prototypes

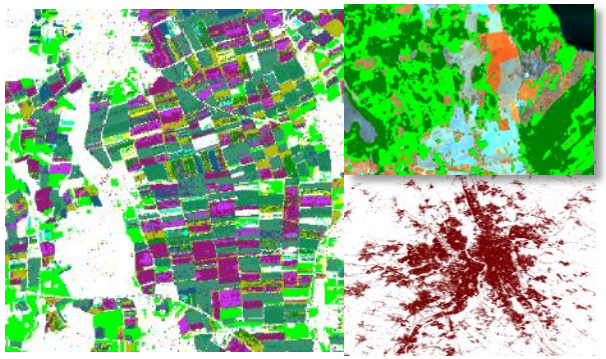
Operationalization

2020+

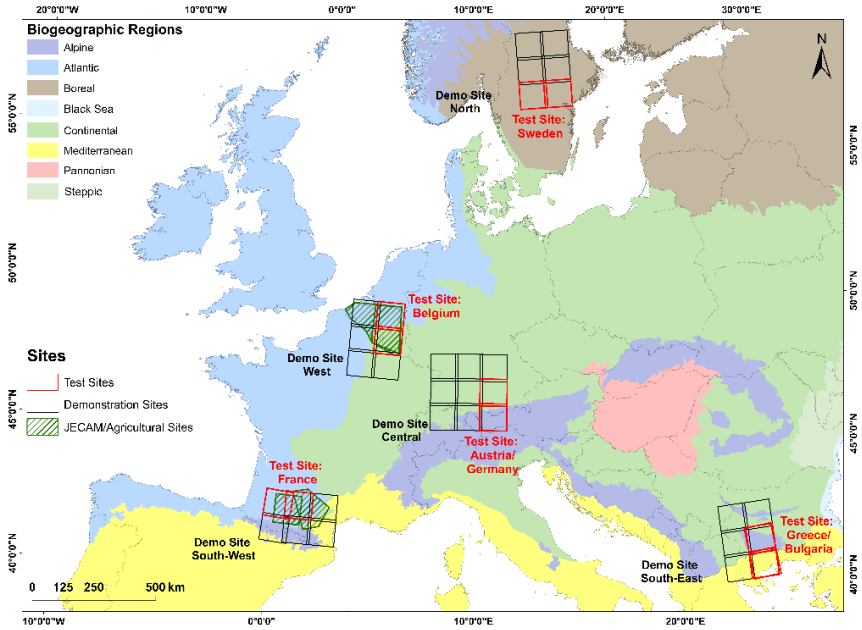
Dense optical+SAR time series classification



Example: AGRI & GRA, FOR, IMP



5 Test- and Demonstration sites in various biogeographic regions.



# Agricultural Prototype Implementation – Input data

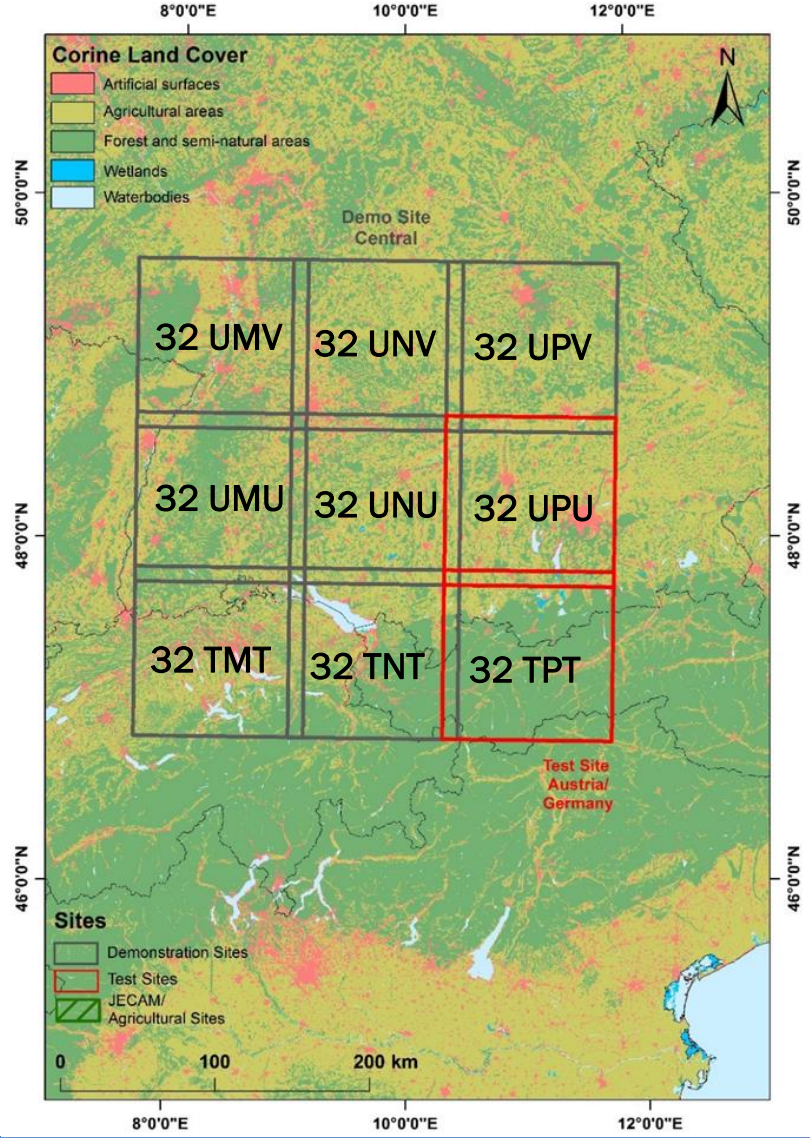
## Sentinel-1 and Sentinel-2

- time period: mid-March 2017 to mid-November 201
- S-2: cloud cover constrained to a maximum of 90%

| | 32TMT | 32TNT | 32TPT | 32UMU | 32UMV |
|---|---|---|---|---|---|
| S-1 | 38 | 105 | 66 | 54 | 37 |
| S-2 | 46 | 47 | 45 | 47 | 45 |
| SUM | **84** | **152** | **111** | **101** | **82** |

| | 32UNU | 32UNV | 32UPU | 32UPV | SUM |
|---|---|---|---|---|---|
| S-1 | 115 | 103 | 92 | 103 | **713** |
| S-2 | 49 | 44 | 42 | 44 | **409** |
| SUM | **164** | **147** | **134** | **147** | **1122** |

Central Demonstration Site



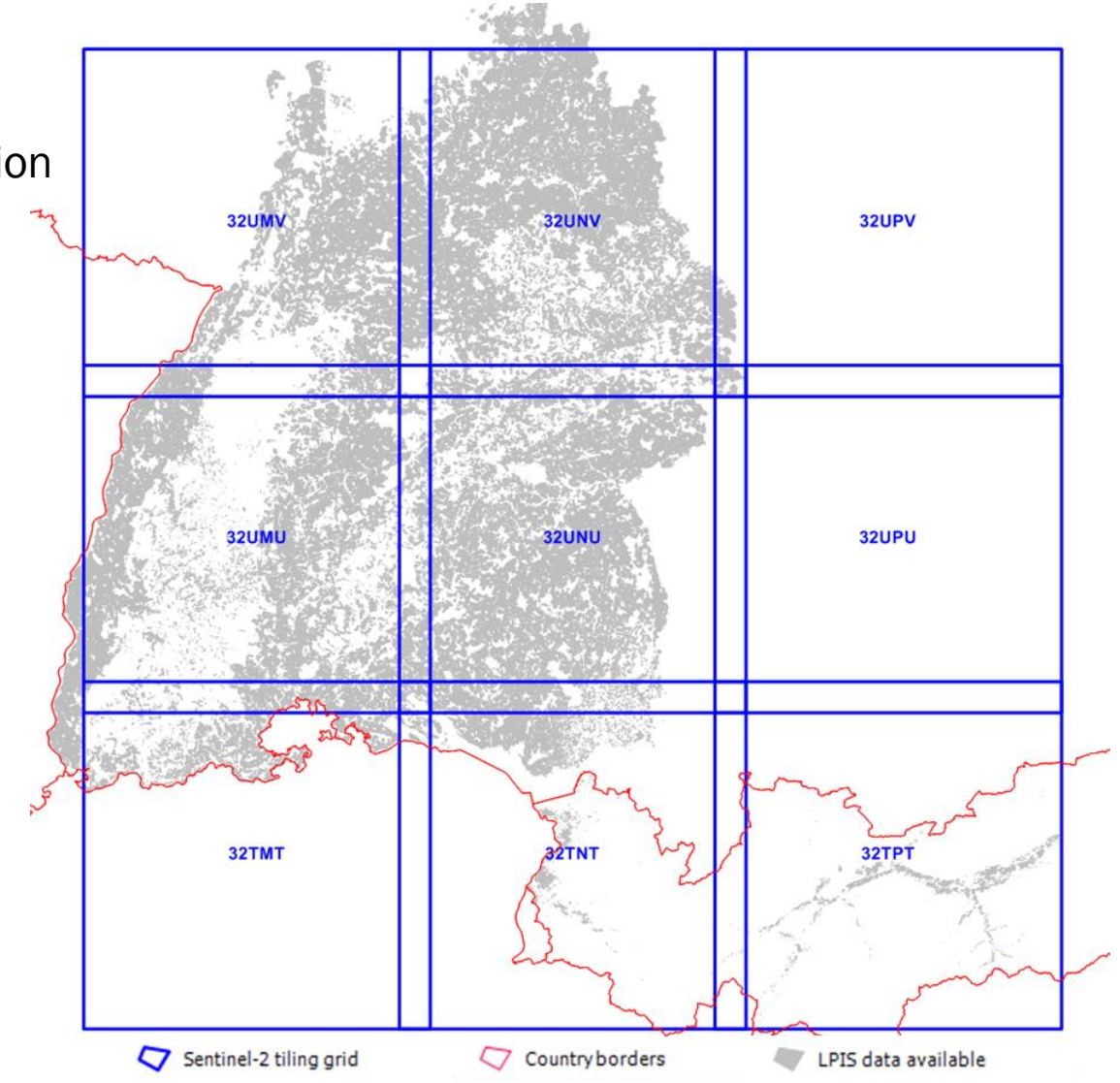
# Agricultural Prototype Implementation – Input data

## Land Parcel Identification System (LPIS) data

- Reference data for classification model and validation
- grouped in crop groups, 16 classes

| ClassID | Crop Group |
|---|---|
| 1 | Agrarian Grass |
| 2 | Fallow |
| 3 | Fruit Trees |
| 4 | Legume |
| 5 | Maize |
| 6 | Others |
| 7 | Potatoes |
| 8 | Strawberries |
| 9 | Sugar Beets |
| 10 | Summer Crop |
| 11 | Summer Rape |
| 12 | Sunflowers/Topinambour |
| 13 | Vegetables |
| 14 | Winegrowing |
| 15 | Winter Crop |
| 16 | Winter Rape |

## Central Demonstration Site



# Workflow of Crop Type Mapping

LPIS training data
for crop types


LPIS-independent samples
from the HRL 2015 production
for crop mask

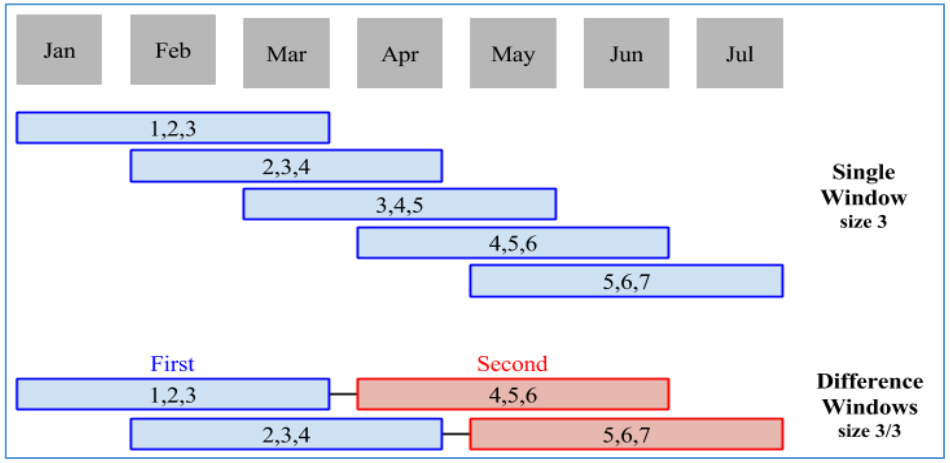
# Derived Time Features

- **Simple time features:**

  … commonly used statistical metrics, calculated over time using all valid observations

| SENSOR | BANDS/INDICES | TIME FEATURES GROUPS |
|---|---|---|
| Sentinel-1a/b | • **VV** (Gamma0)<br>• **VH** (Gamma0)<br>• Norm. Difference VV/VH (**NDVVVH**)<br>• Ratio VV/VH (**RATIOVVVH**) | activity<br>cov<br>dif<br>max<br>maxmean<br>mean<br>median<br>min<br>percentiles (p010 p025 p050 p075 p090),<br>std<br>trend |
| Sentinel-2a/b | • **Brightness** (derived through summation of the values of the bands Green, Red, NIR and SWIR1)<br>• **IRECI** (Inverted Red Edge Chlorophyll Index)<br>• **NDVI** (Normalized Difference Vegetation Index)<br>• **NDWI** (Normalized Difference Water Index, based on SWIR and NIR)<br>• **B03, B04, B08, B11, B12** | |

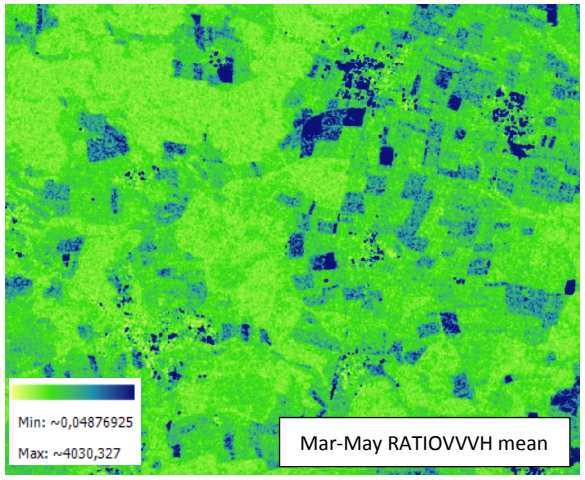
- The "**complex" time features** are calculated by the application of a temporal sliding window from the time series stack.

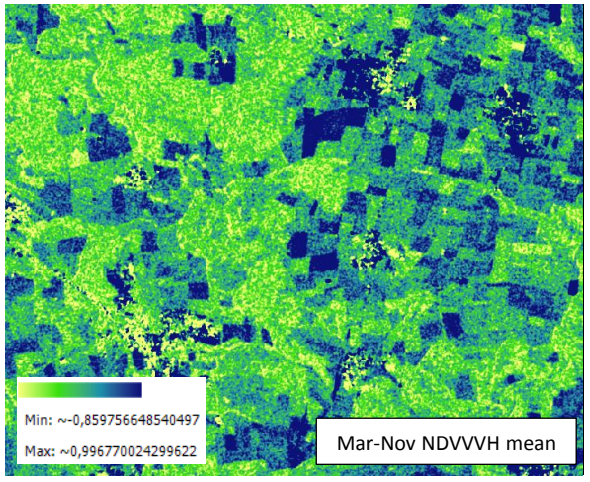


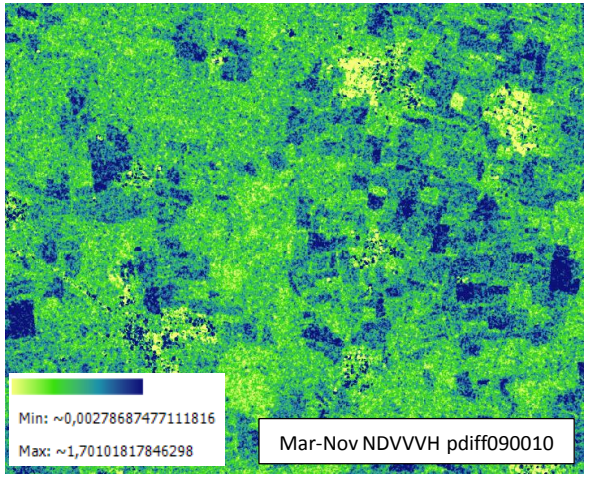

- **Input:** S-1 bands, S-1 indices (NDVVVH, RATIOVVVH), S-2 bands, S-2 indices (NDVI, NDWI, BRIGHTNESS, IRECI)
- **Time intervals:** (i) full period: Mar-Nov and (ii) 2-monthly (Mar-May, May-Jul, Jul-Sep, Sep-Nov)
- **Forward feature selection:** 28 selected time features (20 optical & 8 SAR; from ~500 input features)

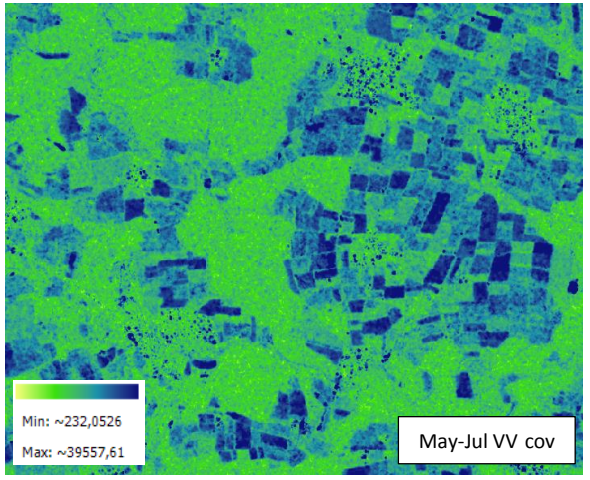
# Selected Time Features based on optical and radar data

## Sentinel-1 Time Features



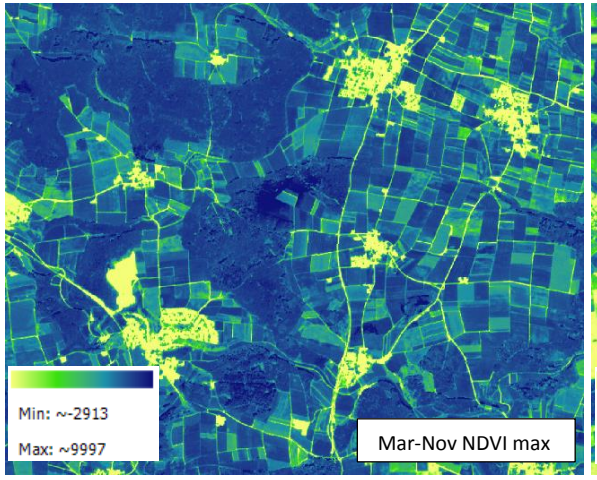



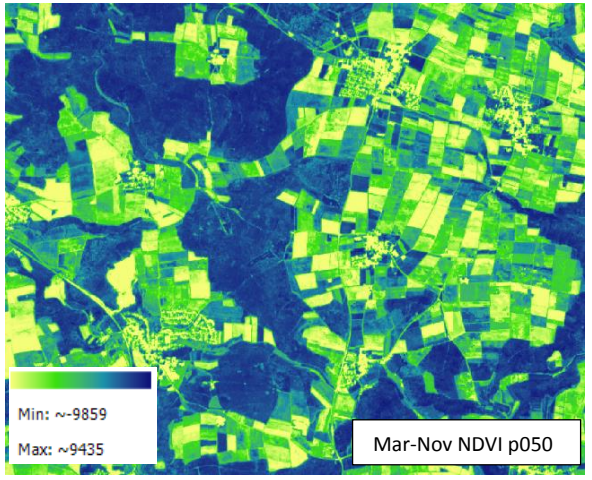



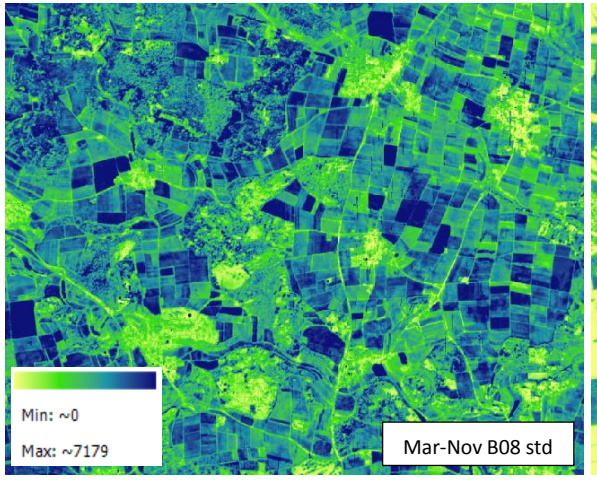



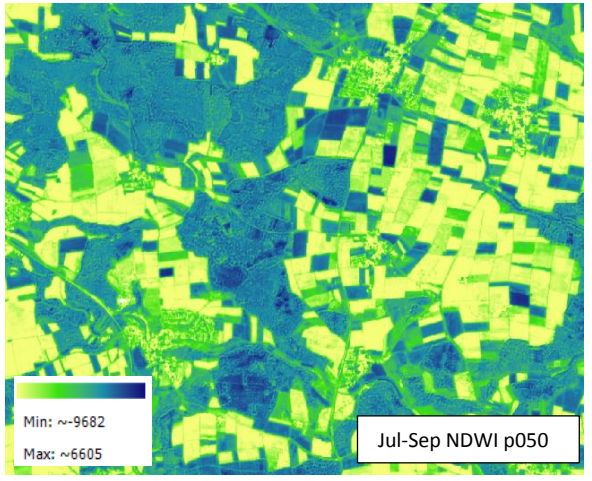

**mean, std, pdiff090010, and cov**
derived from different **Sentinel-1** based indices/bands.

## Sentinel-2 Time Features



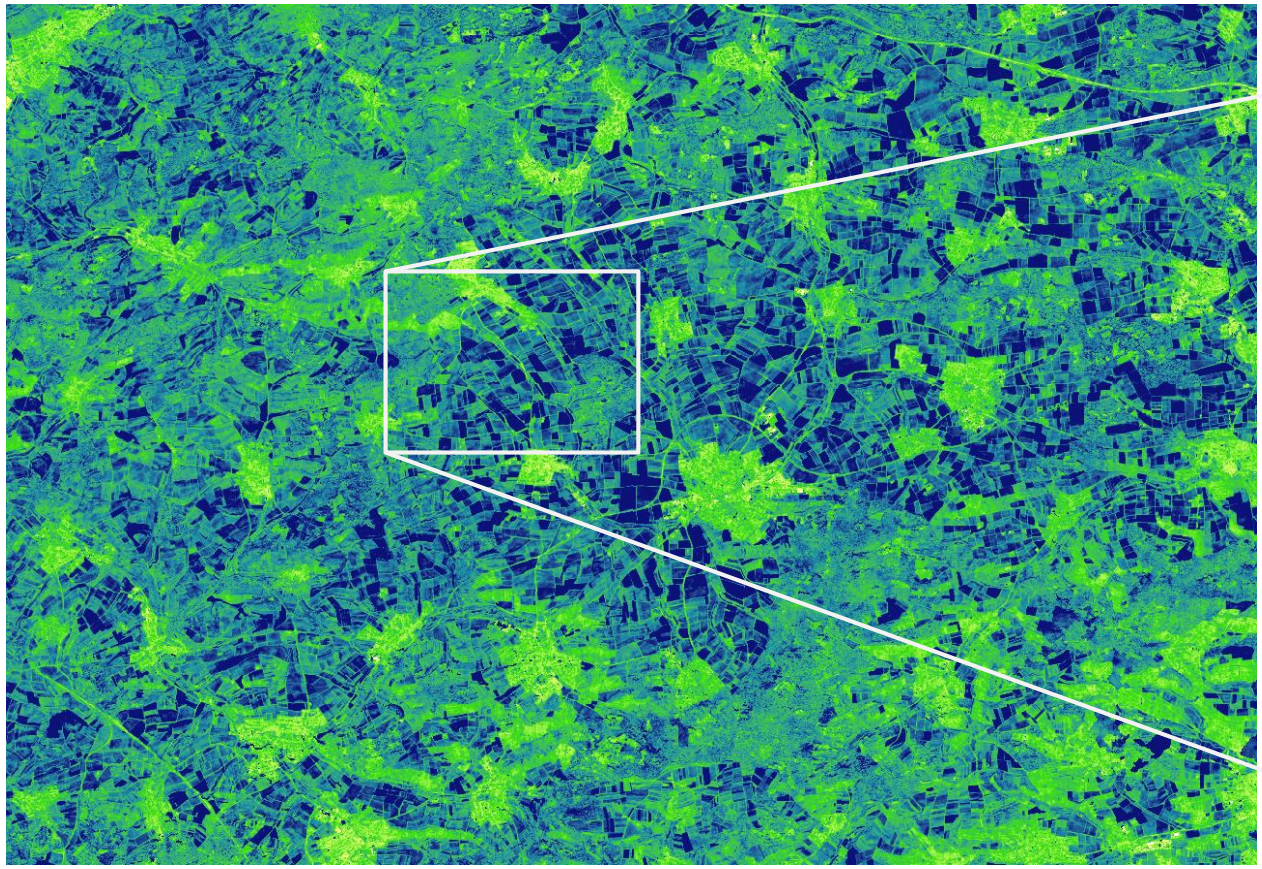




**max, p050 and std**
derived from different **Sentinel-2** based indices/bands.

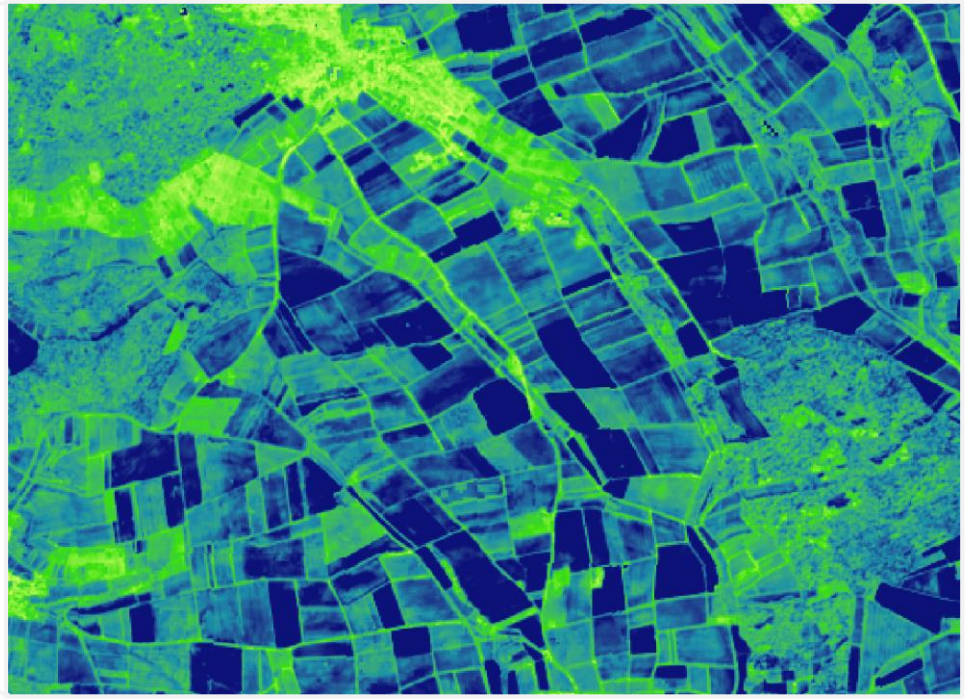
# Sentinel-1 & -2 Time Featues

Demonstration Site: Central (Subset: Baden-Württemberg, Germany)

S-2, 2017-03-15 to 2017-11-14

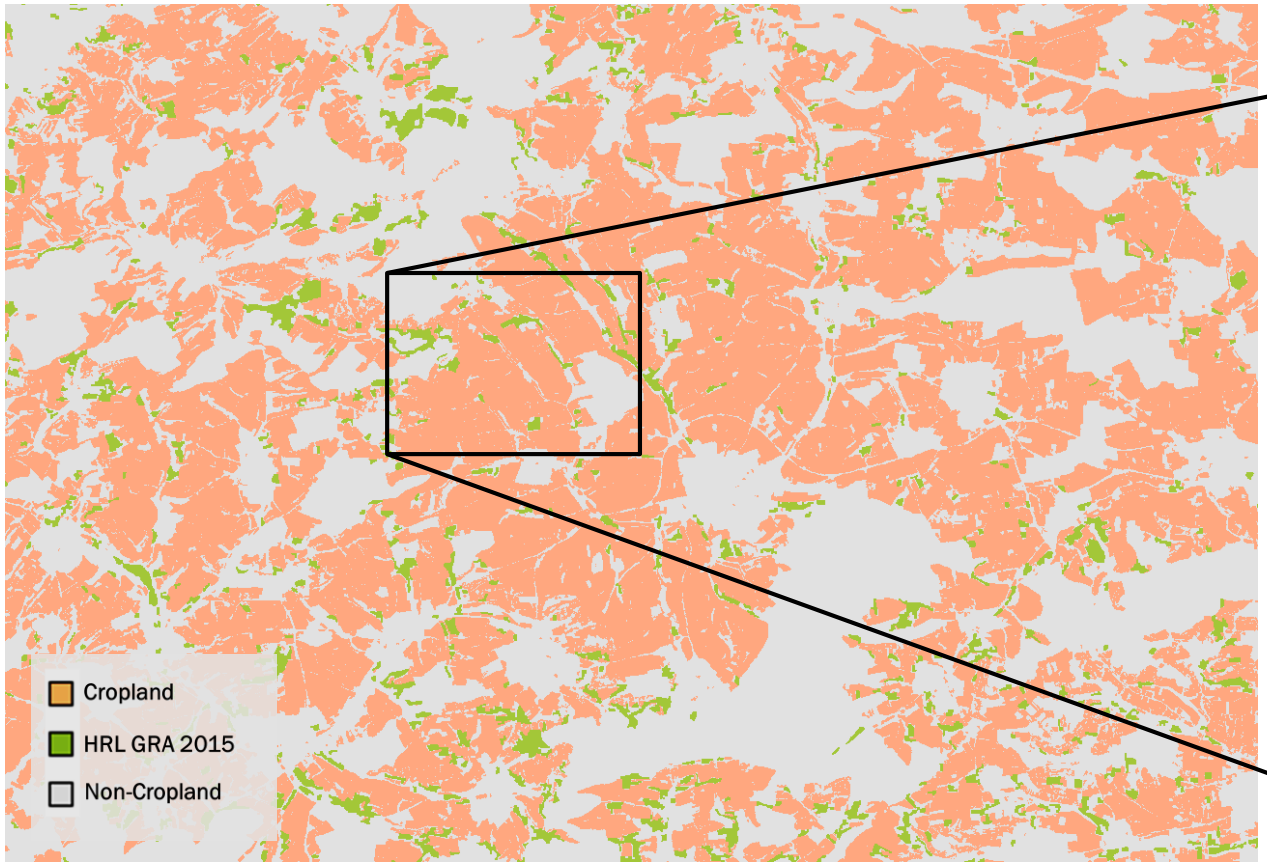
Time Feature: B08_std



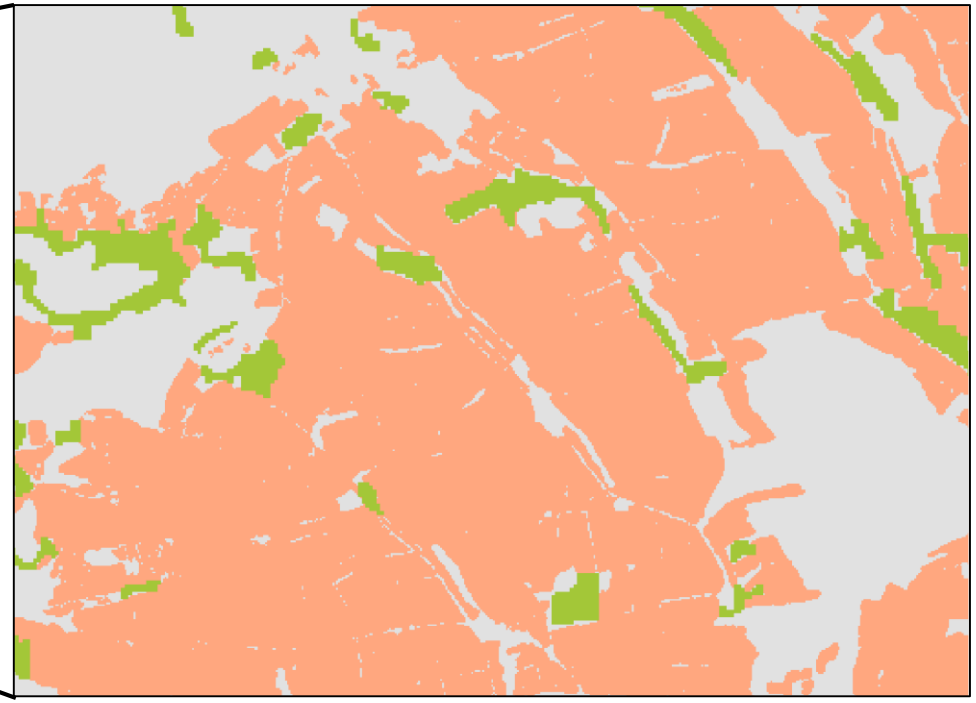
*Produced using Copernicus Sentinel data [2017]*

# Crop Mask/Type – Potential future Copernicus Agricultural Layers

## Demonstration Site: Central (Subset: Baden-Württemberg, Germany)




## Crop Type Map (16 crop types)



*Maize (PA=94%, UA=95%), SugarBeets (PA=95%, UA=91%), WinterCrop (PA=94%, UA=94%), WinterRape (PA=98, UA=93%), SummerRape (PA=46%, UA=21%), Sunfl/Topinamb (PA=64%, UA=28%)*

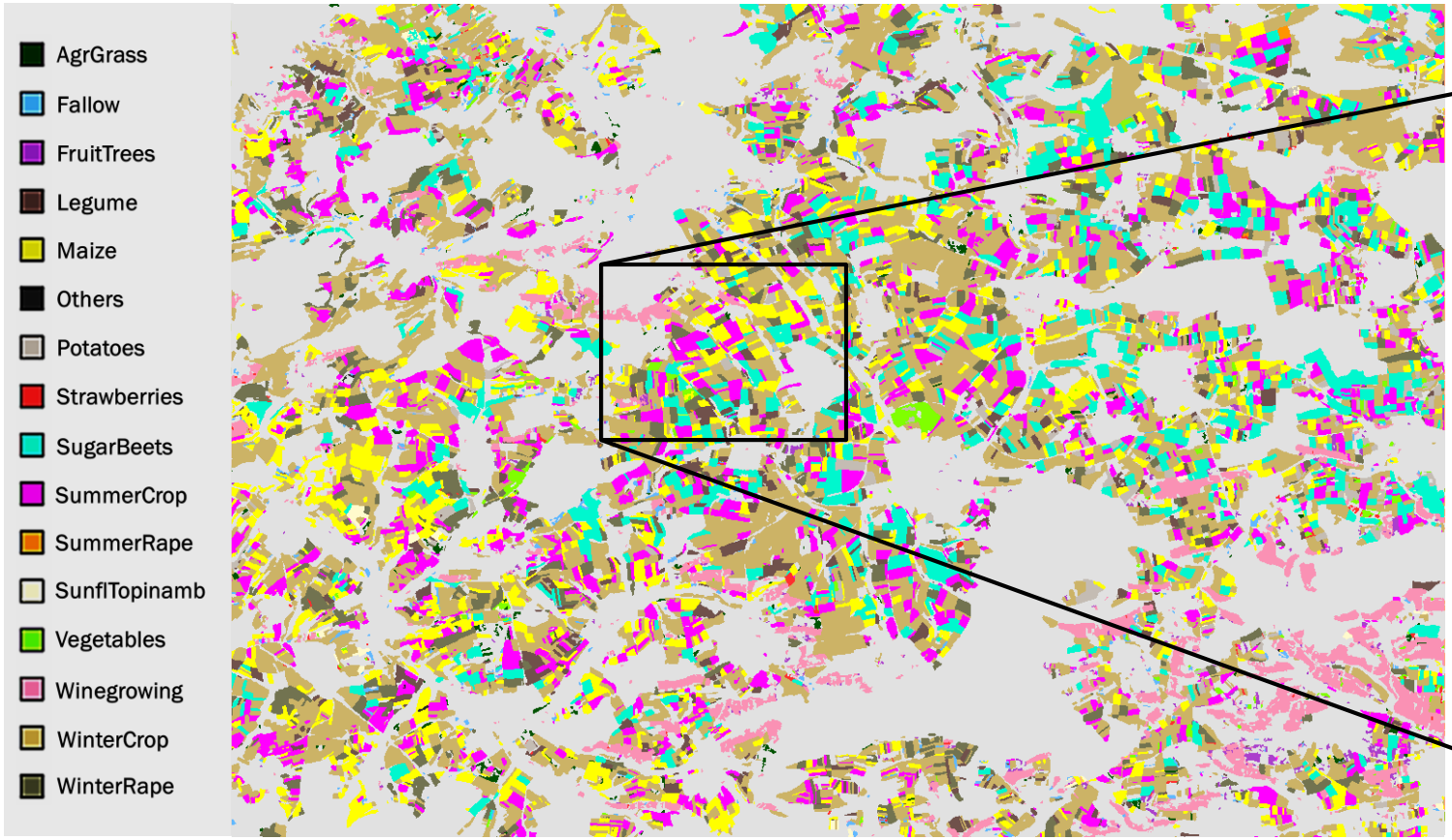
*Overall Accuracy (OA) = 89%*
*Producer's Accuracy = 46-98%*
*User's Accuracy = 21-95%*

*LPIS data © MLR BW*

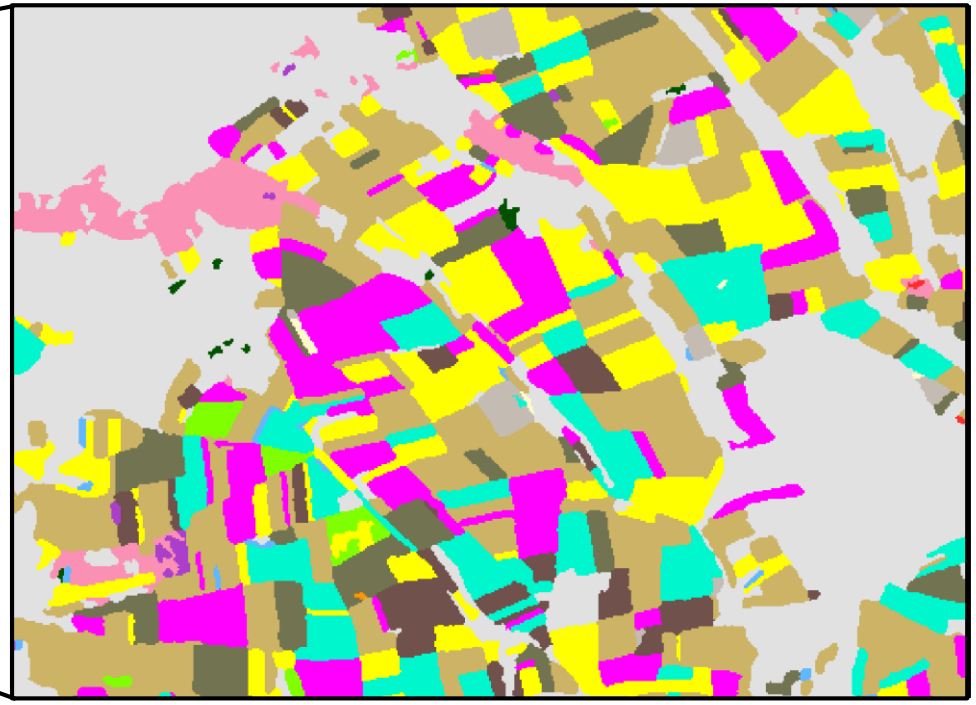
*Produced using Copernicus Sentinel data [2017]*

# Crop Mask/Type – Potential future Copernicus Agricultural Layers

## Demonstration Site: Central (Subset: Baden-Württemberg, Germany)




### Crop Type Map (16 crop types)



*LPIS data © MLR BW*

*Produced using Copernicus Sentinel data [2017]*

*© European Union, Copernicus Land Monitoring Service 2015, European Environment Agency (EEA).*

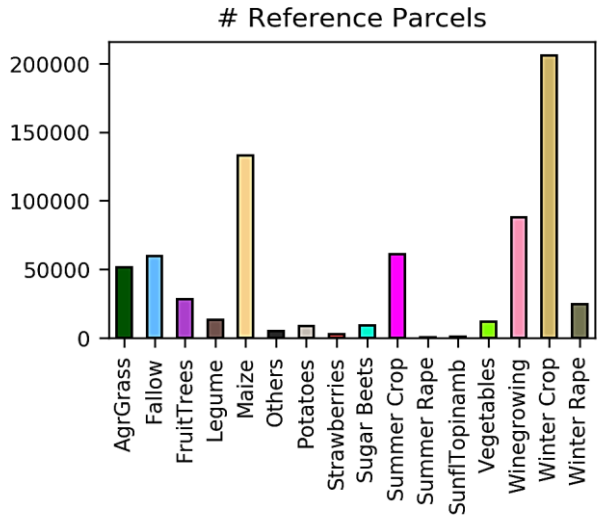
*Maize (PA=94%, UA=95%), SugarBeets (PA=95%, UA=91%), WinterCrop (PA=94%, UA=94%), WinterRape (PA=98, UA=93%), SummerRape (PA=46%, UA=21%), Sunfl/Topinamb (PA=64%, UA=28%)*

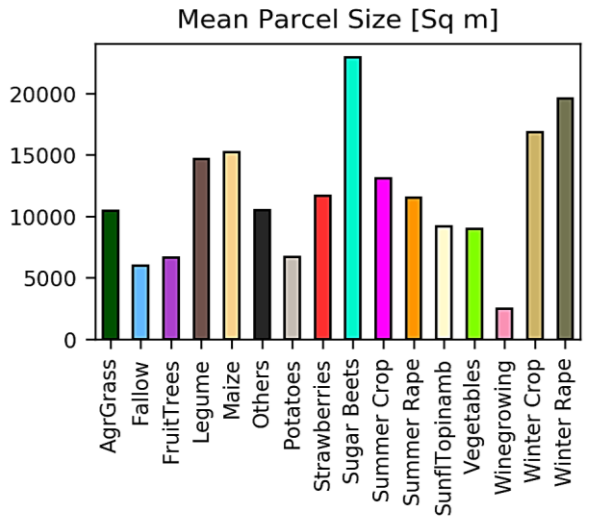
*Overall Accuracy (OA) = 89%*

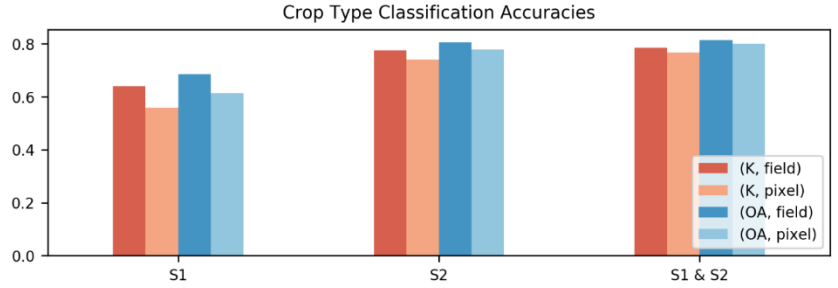
*Producer's Accuracy = 46-98%*

*User's Accuracy = 21-95%*

# Crop Type – Potential future Copernicus Agricultural Layers



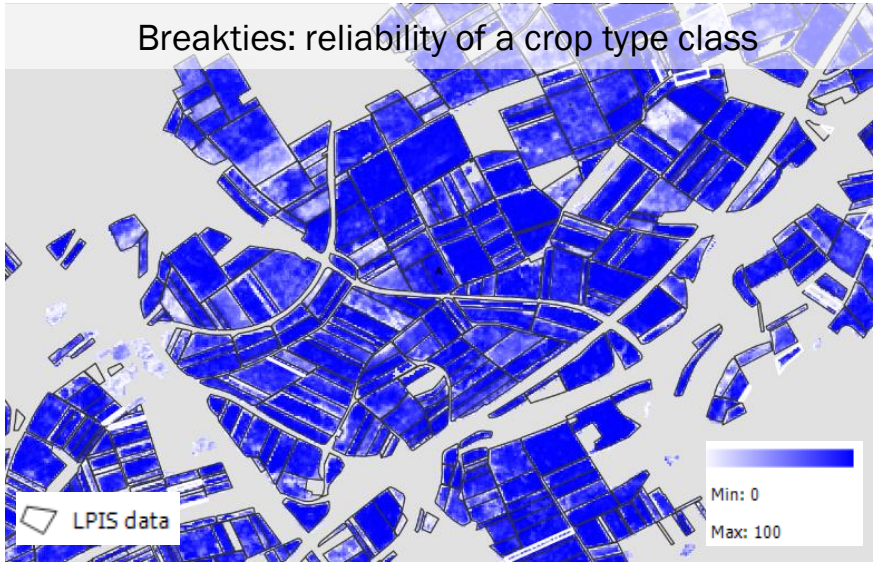



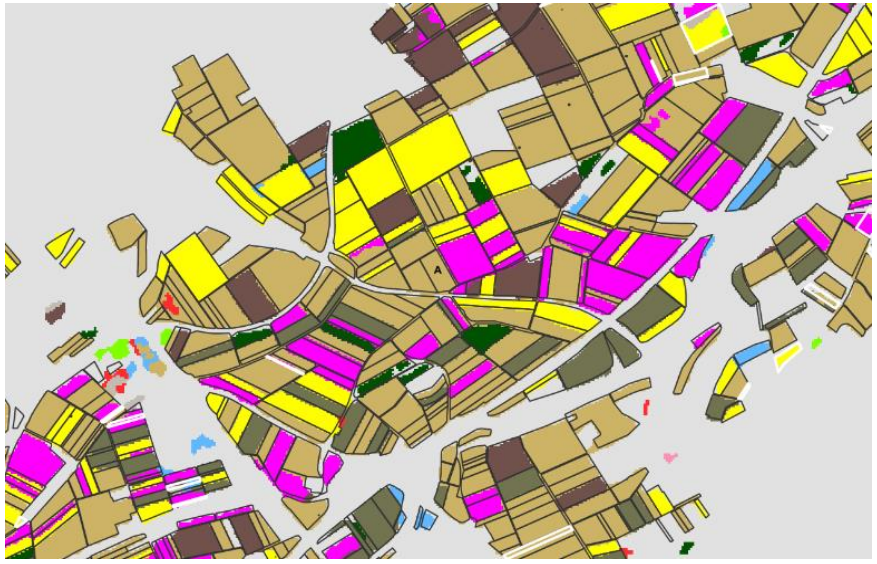




High-occurance & accuracy: **WinterCrop, WinterRape, SummerCrop and Maize**

Low-occurance & accuracy: **SummerRape, SunflTopinamb, Strawberries and Others**

| Crop Group | PA (%) | UA (%) |
|---|---|---|
| AgrGrass | 58 | 74 |
| Fallow | 49 | 71 |
| FruitTrees | 75 | 71 |
| Legume | 76 | 75 |
| Maize | 94 | 95 |
| Others | 53 | 73 |
| Potatoes | 51 | 59 |
| Strawberries | 79 | 41 |
| SugarBeets | 95 | 91 |
| SummerCrop | 86 | 82 |
| SummerRape | 46 | 21 |
| SunflTopinamb | 64 | 28 |
| Vegetables | 68 | 48 |
| Winegrowing | 96 | 95 |
| WinterCrop | 94 | 94 |
| WinterRape | 98 | 93 |


# Summary & Conclusions

## Summary - ECoLaSS:

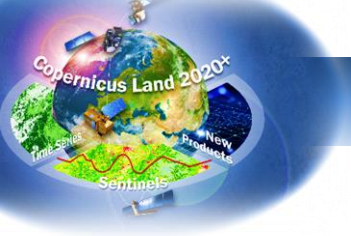
- **Methods:** High volume data processing chains: automated, flexible, customizable, scalable
- **Next-generation of existing services:** improvement of existing HRLs → 2020+
- **New Service:** new Agricultural Service for EEA-39 under conceptualization and testing

## Conclusions – Crop Mapping:

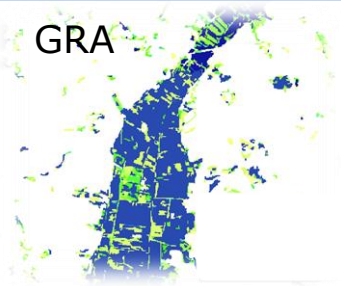
- **Results promising:** High accuracies for crop mask and type
- **Grouping classes = complex**, especially smaller classes are problematic
- **In-situ data (LPIS) not available everywhere** (thinking global, pan-European level)

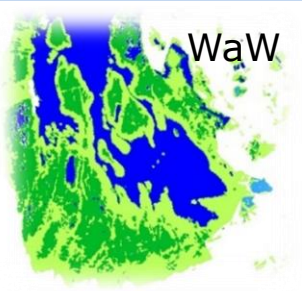
  → no LPIS data included in the crop mask classification

# Challenges for Operationalization for Future Copernicus Services






+


## Key Challenges for Operationalization:

- **Large data volumes** from different sensors (S-1, S-2 and Copernicus contributing missions)
- Automation of algorithms in **cloud environment**
- **Novel product** development, as well as **complex change** products
- Stable & **high accuracy** levels on pan-European scale

- In-situ **reference & validation data** availability
- Integration of **regional knowledge**/in-situ data while preserving **European consistency**

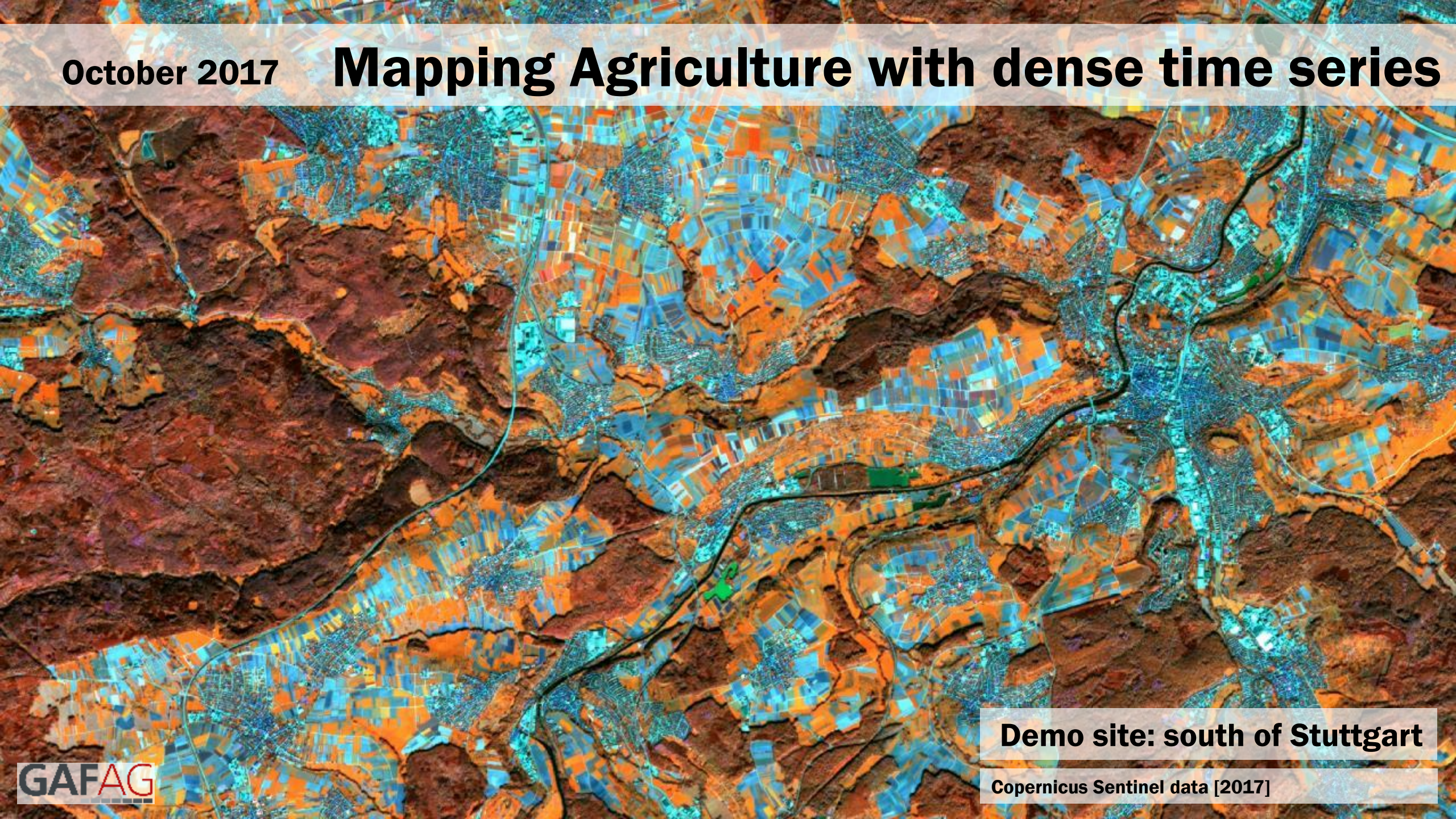
- **Timing** and **infrastructure** requirements for the inclusion in Copernicus Service
- Definition of a systematic **benchmarking** procedure for **operational roll-out**

European Commission

Horizon2020

October 2017

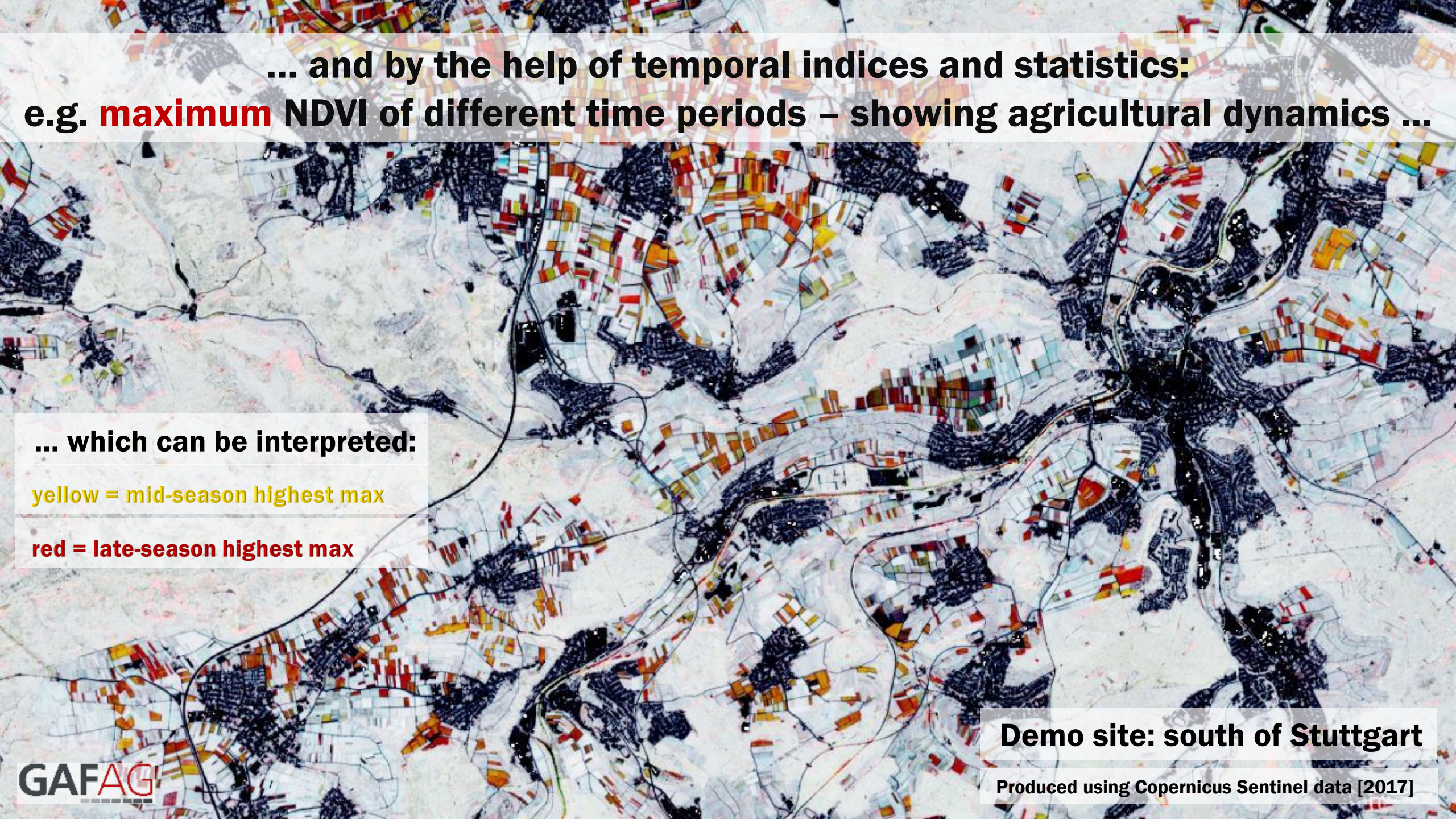
# Mapping Agriculture with dense time series

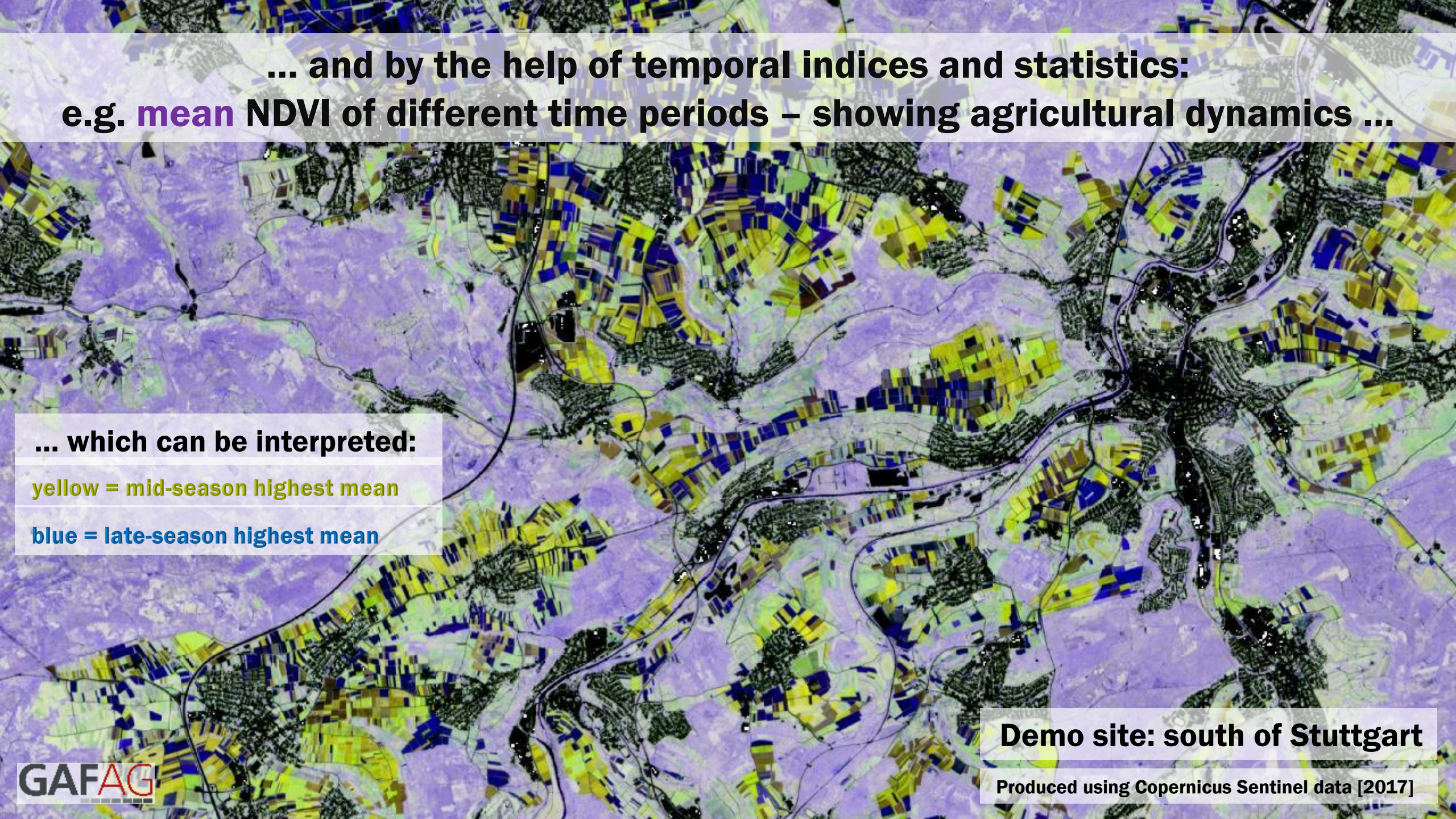


Demo site: south of Stuttgart

Copernicus Sentinel data [2017]

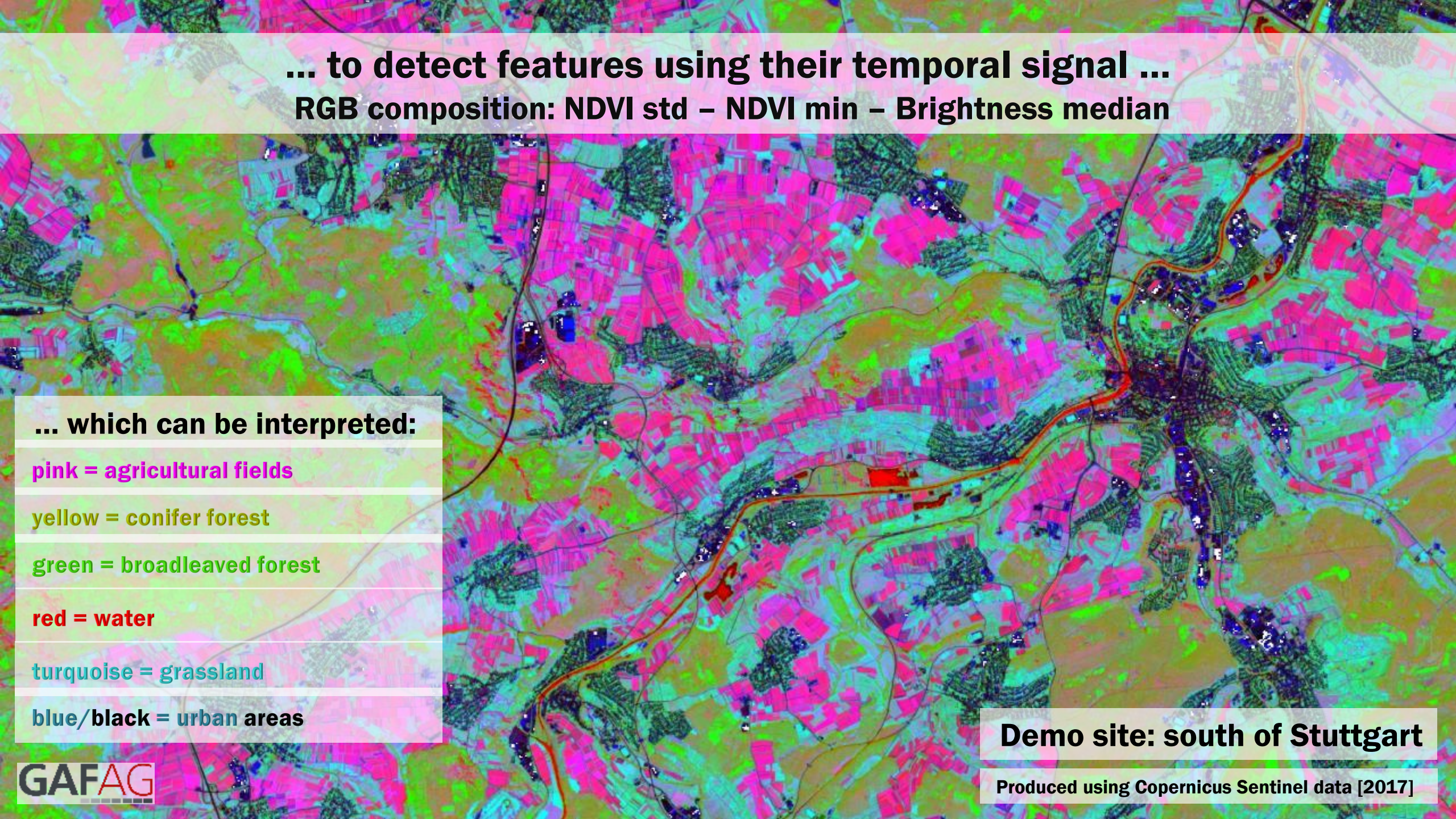
GAFAG


... and by the help of temporal indices and statistics:
e.g. maximum NDVI of different time periods – showing agricultural dynamics ...
... which can be interpreted:
yellow = mid-season highest max
red = late-season highest max
Demo site: south of Stuttgart
Produced using Copernicus Sentinel data [2017]
GAFAG


... and by the help of temporal indices and statistics:
e.g. mean NDVI of different time periods – showing agricultural dynamics ...
... which can be interpreted:
yellow = mid-season highest mean
blue = late-season highest mean
Demo site: south of Stuttgart
Produced using Copernicus Sentinel data [2017]
GAFAG

# … to detect features using their temporal signal …

## RGB composition: NDVI std – NDVI min – Brightness median



**… which can be interpreted:**

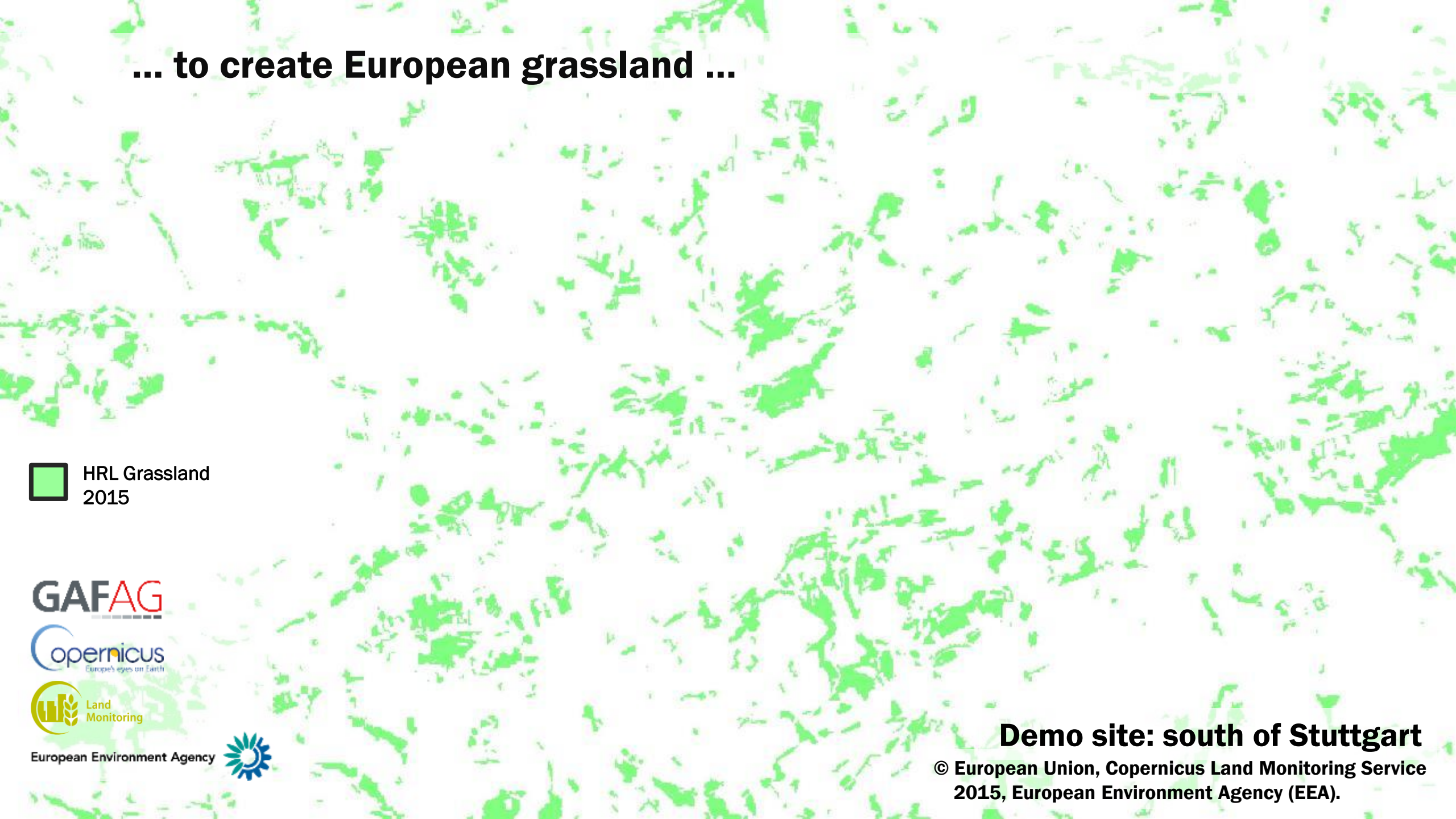
- pink = agricultural fields
- yellow = conifer forest
- green = broadleaved forest
- red = water
- turquoise = grassland
- blue/black = urban areas

**Demo site: south of Stuttgart**

Produced using Copernicus Sentinel data [2017]

GAFAG

# … to create European grassland …




GAF AG

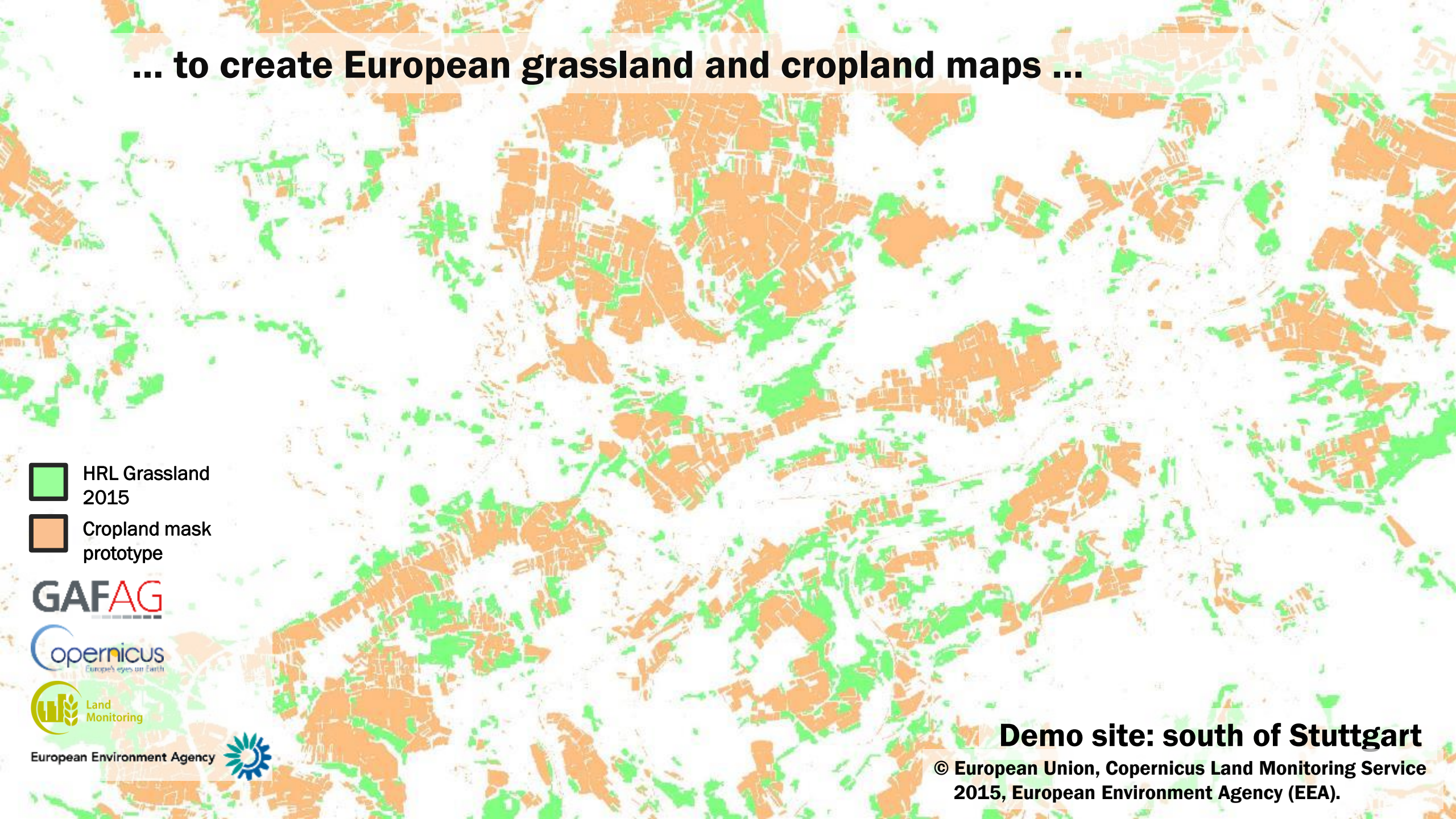
Copernicus
Europe's eyes on Earth

Land Monitoring

European Environment Agency

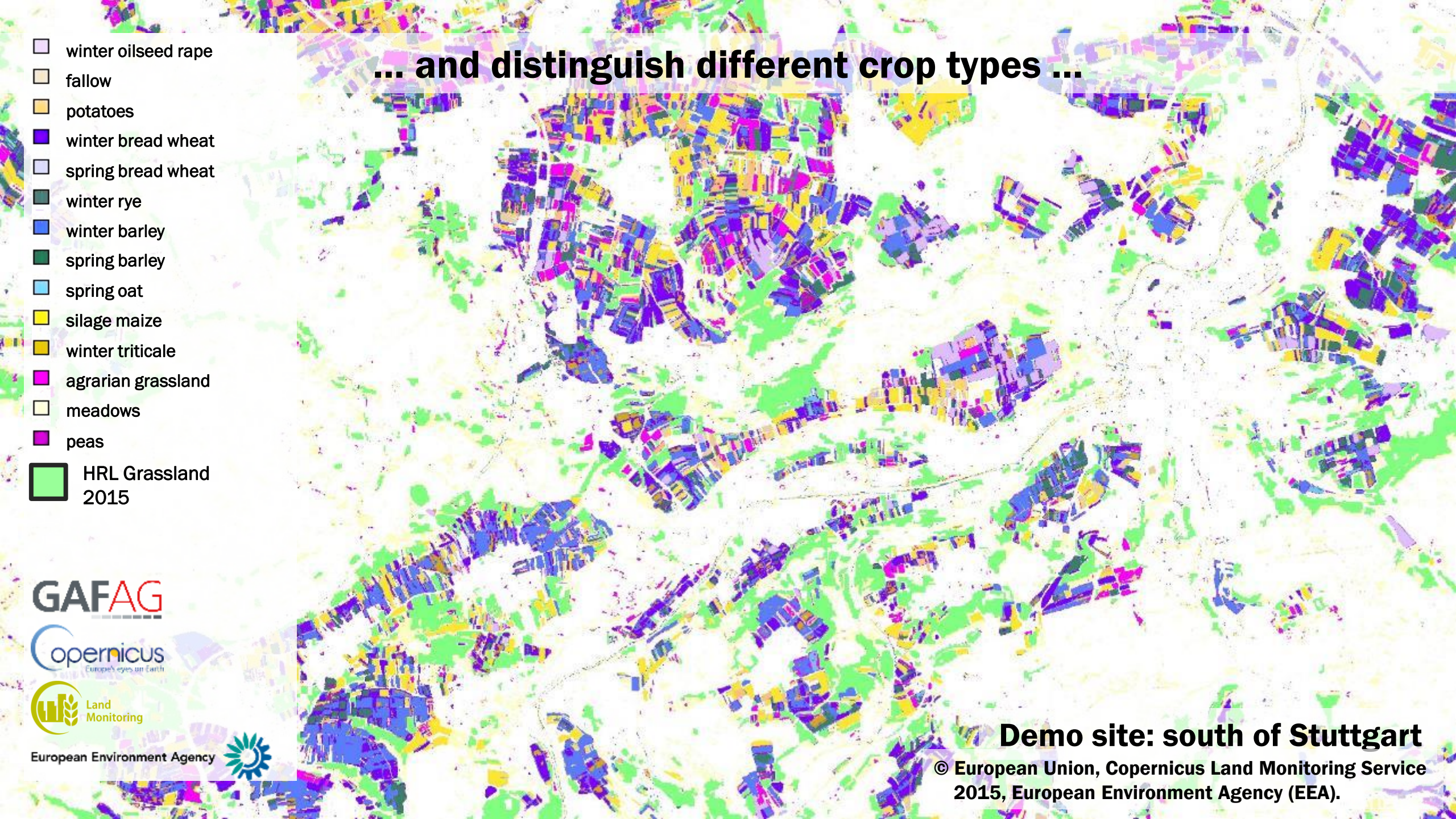
**Demo site: south of Stuttgart**

# … to create European grassland and cropland maps …




**Demo site: south of Stuttgart**

# … and distinguish different crop types …




## Demo site: south of Stuttgart

# Thank you on behalf of the ECoLaSS team !!


Contact: linda.moser@gaf.de

(Project Coordinator)


Special thanks to Benjamin Mack (GAF AG)

GAF AG L. Moser, M. Probeck, G. Ramminger, D. Herrmann, K. Schwab & Team

SIRS C. Sannier, S. Villerot, B. Desclée & Development Team

JOANNEUM RESEARCH H. Gallaun, M. Schardt, P. Miletich, J. Deutscher, K. Granica

UCL Université catholique de Louvain P. Defourny, I. Moreau, J. Wolter, O. Mohamed, X. Blaes

DLR A. Metz-Marconcini, I. Klein, A. Hirner, T. Esch

**www.ecolass.eu**

Follow us:

**@ECoLaSS2020**


***The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 730008.***

European Commission | Horizon2020

Copernicus Europe's eyes on Earth | Land Monitoring