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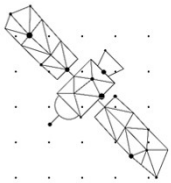
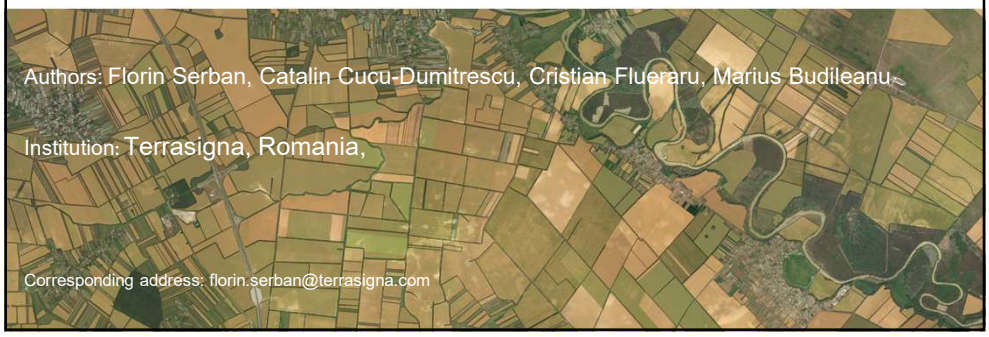


Using Copernicus multi-temporal data: implementation challenges and short-term perspectives



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Institution: Terrasigna, Romania,

Corresponding address: florin.serban@terrasigna.com

Structure of presentation

1. The Romanian agricultural landscape
2. DataBio project
3. Copernicus data for agriculture monitoring in Romania
4. Validation and results
5. Conclusions and perspectives

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Romania, CAP support monitoring - distribution of arable land

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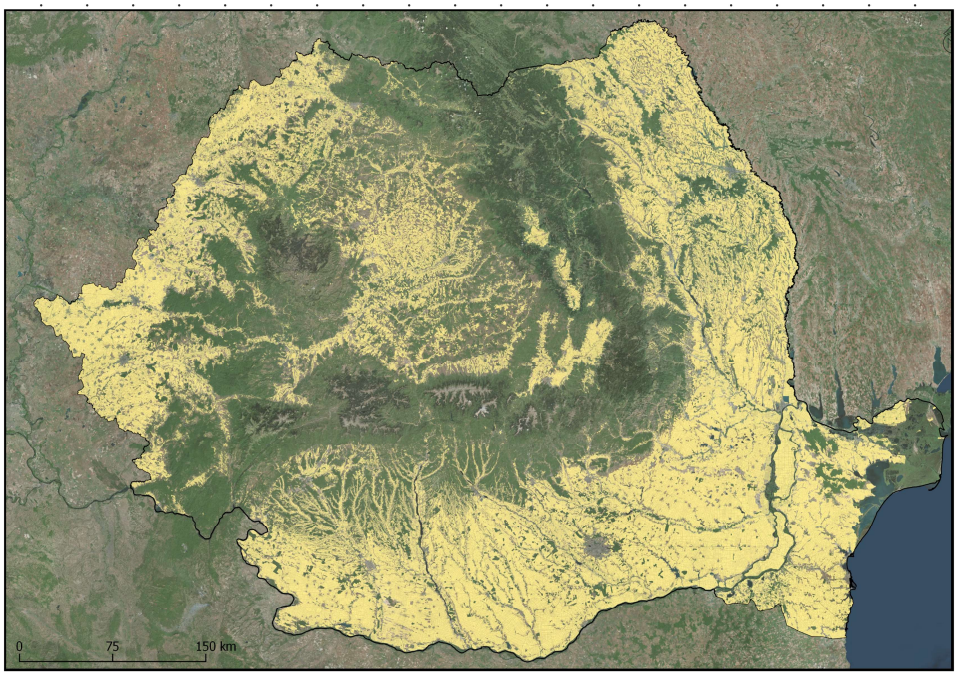
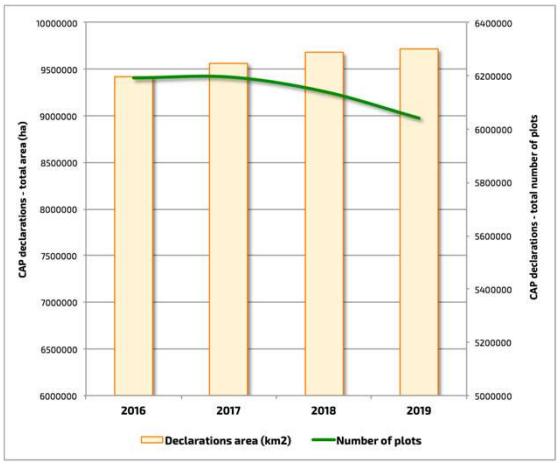


The Romanian Agricultural Landscape

- Between 2016 and 2019 the total declared area **increased** with 2924 km^2.
- Between 2016 and 2019 the total number of plots eligible for CAP support decreased with 149.457 (2.41%).
- Currently (2019) 9.678.170 hectares corresponding to 6.041.346 plots are registered for CAP support



Romania - total declared area and number of plots registered for CAP support (2016-2019) Data Source: Agency for Payments and Intervention in Agriculture (APIA), Romania

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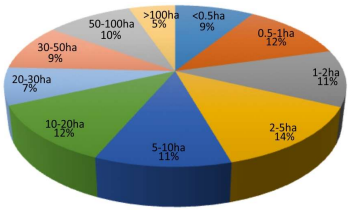
The Romanian Agricultural Landscape

The current structure of the agricultural holdings (2019) reveals that the **small plots (< 5 ha)** represent close to 95% out of the total number of plots registered for CAP support while accounting for only 46% of the total area.

Medium-size plots (5 - 30 ha) represent **4.28%** of the total number of registered plots and **30%** of total area.

Large plots (> 30 ha) represent **< 1%** of the total number of registered plots and **24%** of total area.



Plot area	Count-%of total	Area-%of total	Average area(ha)
<0.5ha	47.47	8.95	0.30
0.5-1ha	27.07	11.74	0.70
1-2ha	13.31	11.33	1.37
2-5ha	7.12	13.55	3.06
5-10ha	2.49	10.88	7.01
10-20ha	1.37	11.83	13.93
20-30ha	0.49	7.46	24.32
30-50ha	0.39	9.29	38.23
50-100ha	0.23	9.73	67.60
>100ha	0.06	5.24	143.41

Romania - total declared area and number of plots registered for CAP support (2016-2019) Data Source: Agency for Payments and Intervention in Agriculture (APIA), Romania

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Romania, CAP support monitoring - test sites

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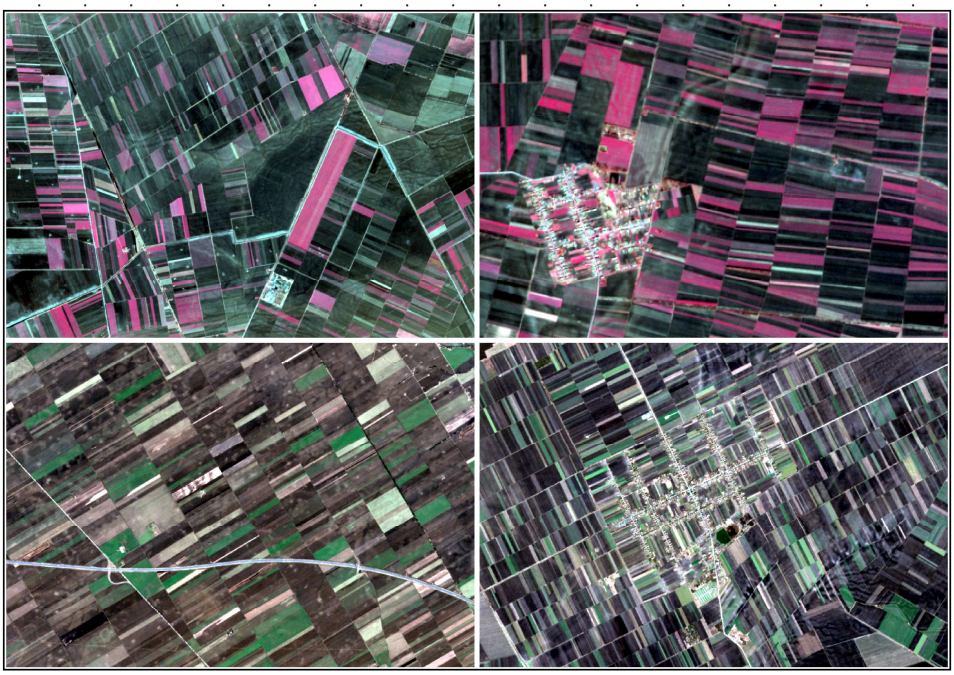


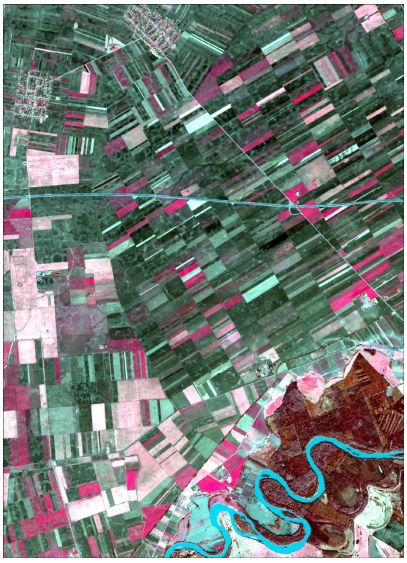
The Romanian Agricultural Landscape

The **Agency for Payments and Intervention in Agriculture** (APIA) performs annual verifications of the farmers that applied for subsidies using multiple approaches. Among them:

- classical OTSC - on-site verifications;
- compliance verifications;
- verifications using remote sensing techniques.

In 2019, **83.464** farmers might be included for CwRS verifications, summarising 506.570 plots that correspond to 738.593 ha.

This represents a significant increase comparing to 2015 when 75.599 farmers were selected for CwRS verifications.



https://agrointel.ro/115772/plati-fermieri-esantionul-de-control-pentru-subventiile-apia-din-acest-an/
https://www.agroinfo.ro/vegetal/veste-uriasa-pentru-fermierii-blocati-la-plata-subventiilor-sef-apia-anunta-vineri-incep-platile

Copernicus data for agriculture monitoring in Romania

Challenges

large area to be surveyed
geographical variability
small / narrow plots
crops diversity
clouds

Copernicus Sentinel-2

10 m spatial resolution
5 days revisiting time
superior radiometric resolution
archive since 2015
sustainability (no data costs)
continuity

A service for agriculture monitoring in Romania should be able to

- address small / narrow plots distributed over diverse location
- provide results for a broad variety of crops
- make use of the Copernicus Sentinel temporal resolution
- provide early warnings to the decision makers

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DATABio
Data-driven Bioeconomy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 732064

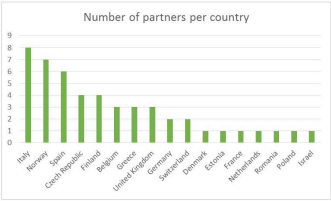
BIG DATA VALUE PUBLIC-PRIVATE PARTNERSHIP
This project is part of BDV PPP

DATABIO – DATA-DRIVEN BIOECONOMY

terrasigna.com

DataBio Consortium

- 48 Partners
- 17 states (14 member states)
- 70+ associated partners
- 3 pilots focused on forestry, agriculture & fishery



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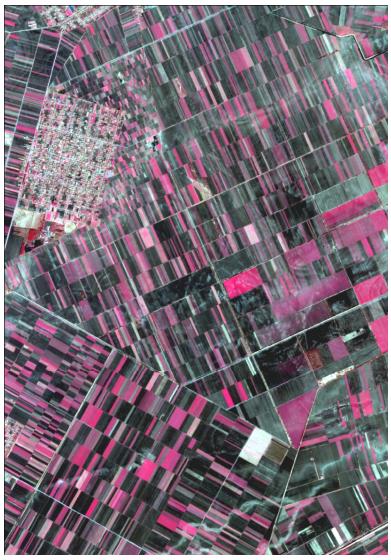
Romania, CAP support monitoring

Under the framework of DataBio project Terrasigna ran CAP support monitoring service trials during 2017, 2018 & 2019

- Input **EO data**: Copernicus Sentinel-2 (>35 granules, 2 UTM zones) and LANDSAT
- automatic workflows for data download and pre-processing
- Romanian National Projection System - Stereo 70 (EPSG 3844)
- 2018 & 2019: **national coverage**
- **results for 32 crops**
- solid validation results (>95%) gathered throughout 5 validation campaigns that included both reference and OTSC data
- all the processing is done on local servers.
- availability of additional information layers (e.g. water masks, fire occurrences)
- *harmonisation of the workflows towards the traffic lights approach*



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Romania, CAP support monitoring

New innovative approach developed by Terrasigna.

Input data:

- Earth Observation data ingested as satellite images time series (SITS): Copernicus Sentinel-2 & LANDSAT
- declared crop types - geometry + crop code (following APIA classification index)

The classes of pixels with similar evolution are extracted from the SITS through a fuzzy-statistic approach. Each pixel receives a confusion matrix, expressing the probability of belonging to a specific crop type in every individual scene (i.e. at every observed moment).

The final results are observed crops maps and compliance maps of discrete levels of trust. The level of trust can be expressed at pixel or parcel level. Low level of trust means that, from the algorithm's point of view, the current location (pixel or parcel) was cultivated with a different crop then the one declared. A high level of trust means that the observed crop matches the declared one.

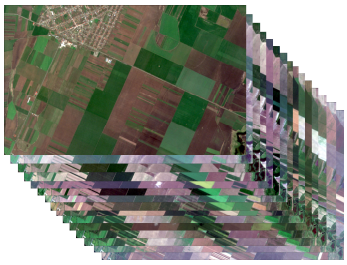
v.06 of the algorithm **uses the phenology calendar for the crop classification optimisation,** not in the sense of restricting the time domain, because one can never say where a particular crop will be found, but for getting early conclusions, in particular for the winter crops (wheat, barley etc.).

Once a winter crop is confirmed (e.g. the beginning of June), the system will acknowledge the crop label as final and will stop monitoring the plot.

For summer crops, the acknowledgement arrives later (e.g. August), so early conclusions are usually not possible.

Continuous **developments** and **improvements** over the last **5 years**

Version v.06 of the algorithm



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Copernicus data for agriculture monitoring in Romania

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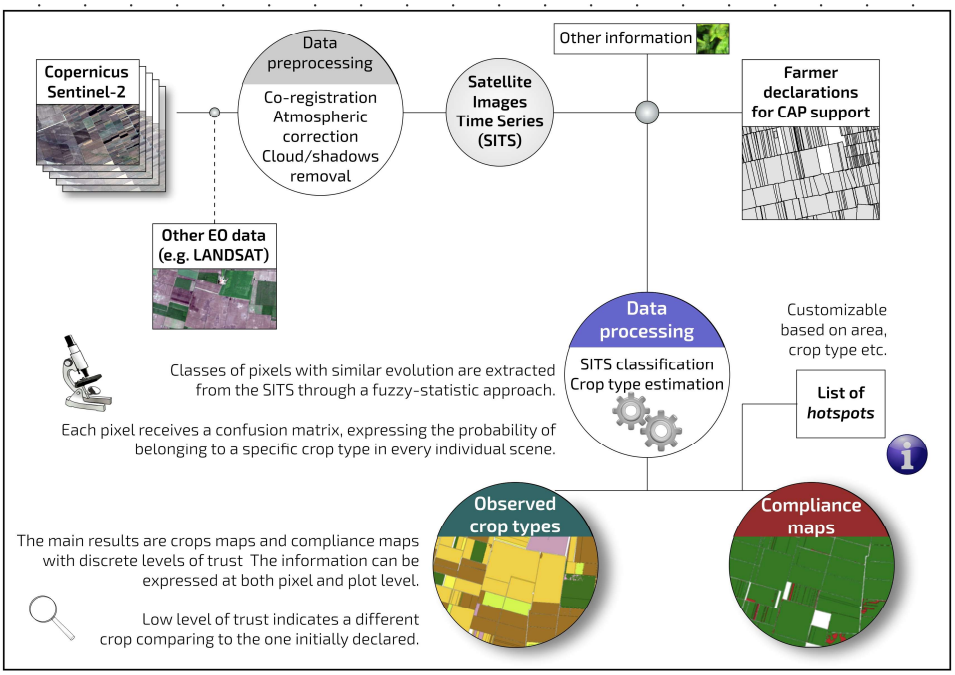

Geometry adjustment

- The scenes' geometry represents a powerful tool for correcting the co-registration of the satellite images.
- The latent objects that can be observed in the scenes allow the calculation of an edge probability map (bottom).
- The geographical position of the pixels is adjusted while trying to find the best match between the probabilistic edges observed in the scenes.

S2 -T34TDR
01.06.2018

RGB

Image probability map
(calculated)

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Romania, CAP support monitoring

List of products

1. **32 classes crop maps covering an entire agricultural cycle** (available Oct - Nov);
2. **Intermediate crop maps** available during the agri. season (they can serve as early alarms/support for prophylactic actions);
3. **Degree of confidence** for # 1 and 2 above;
4. **Compliance maps** between the declared and observed crops;
5. **Individual list of non-compliant plots** in accordance with #4;
6. **Sentinel-2 mosaics at national scale** (clouds- and shadows-free) for various time intervals;
7. **Sentinel-2 NDVI mosaics at national scale** (clouds- and shadows-free) for various time intervals;
8. **Winter and summer crops maps**, available since end of May;
9. **Burned areas**, deliverable 3 times during an agricultural season
10. **Water ponding / flooding** occurrences, deliverable at customer's request for certain AOIs

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Romania, CAP support monitoring - Sentinel-2 (February - March 2019)

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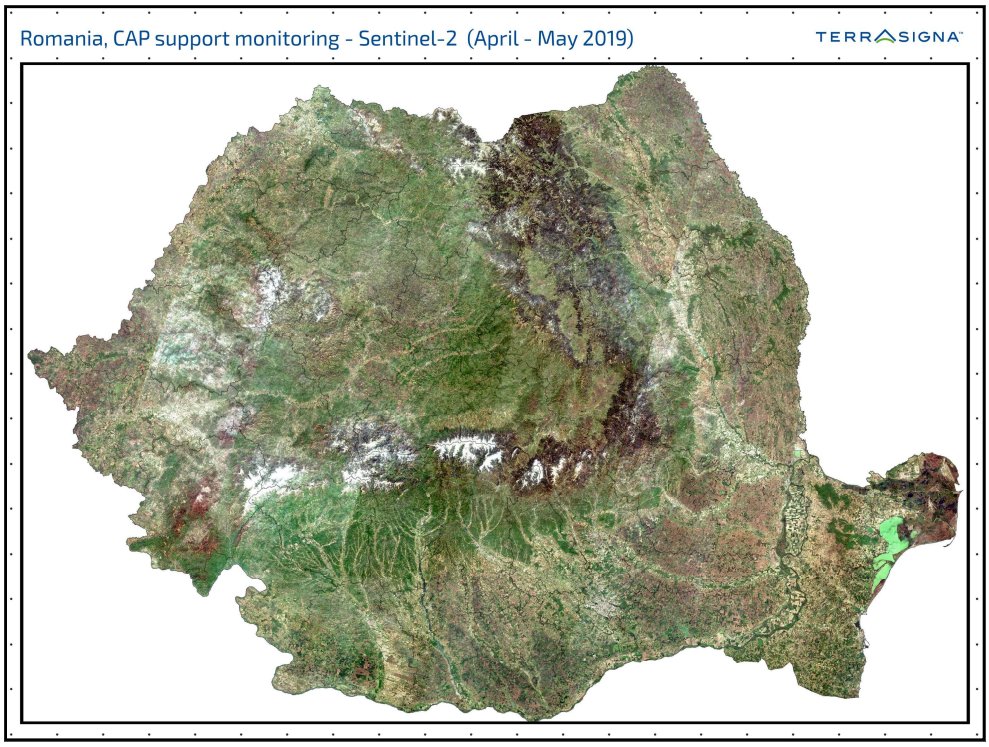
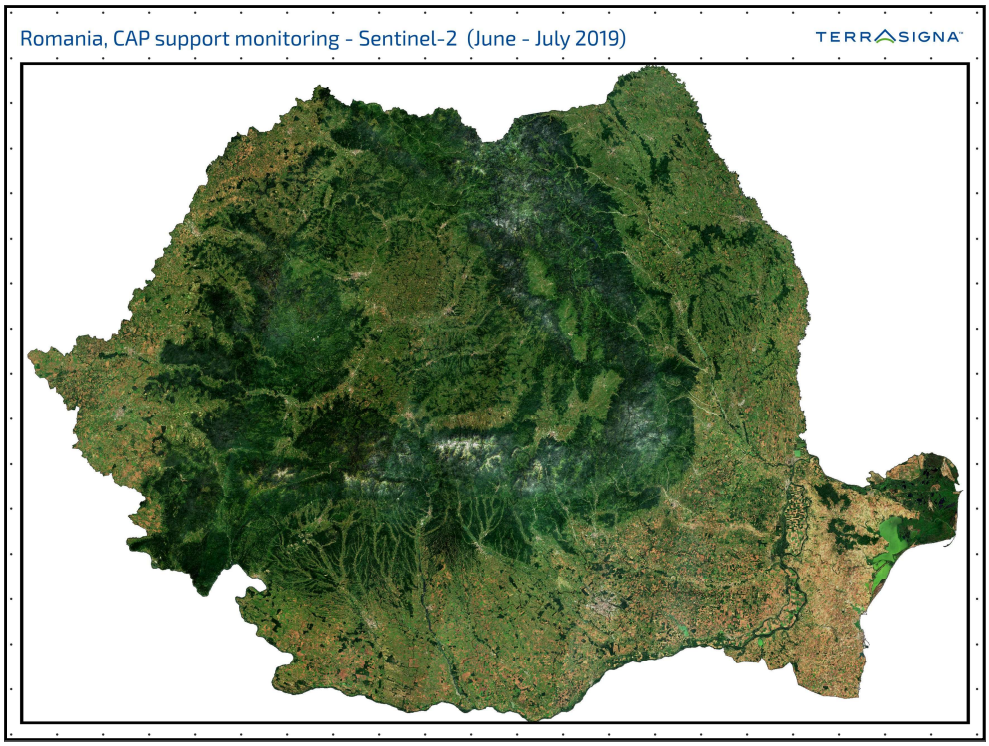
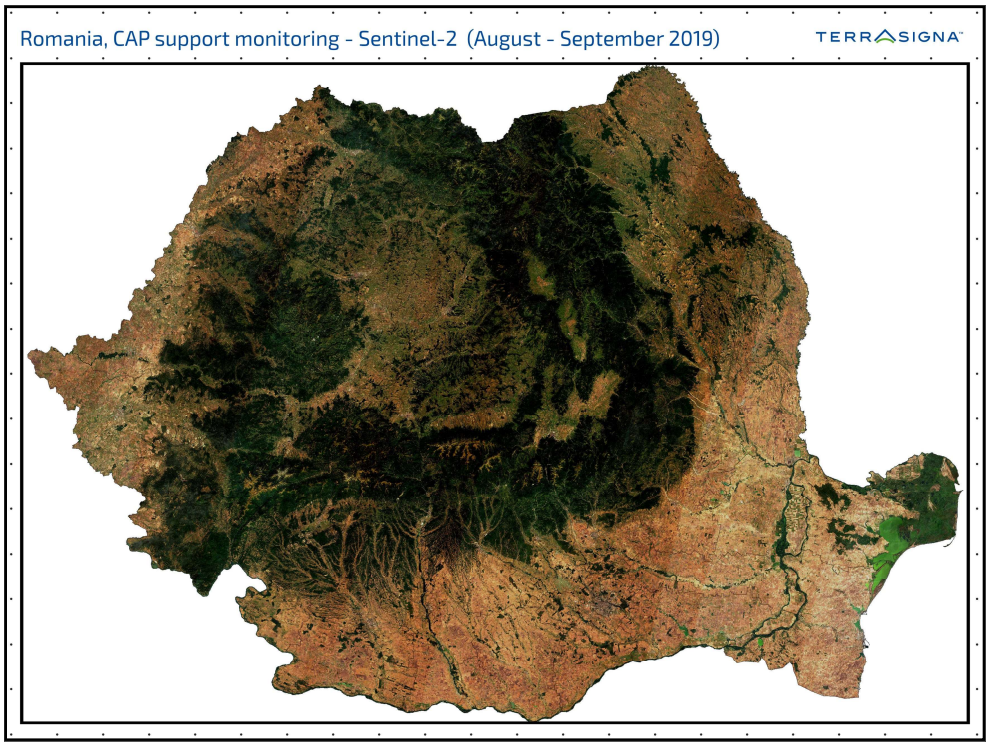
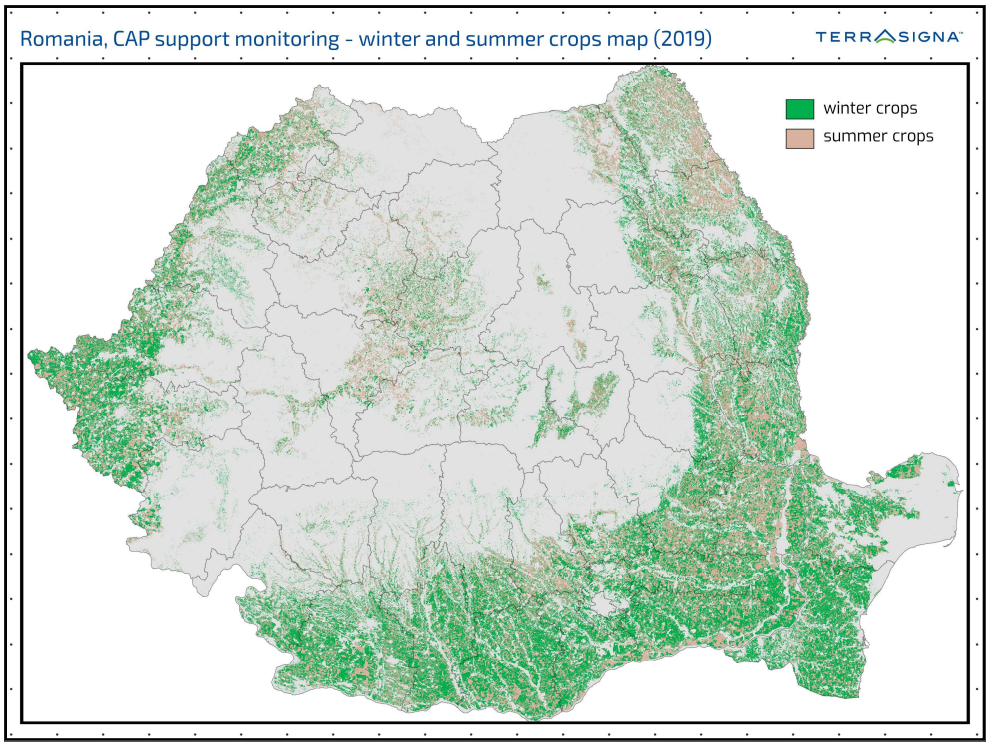

Romania, CAP support monitoring - Sentinel-2 (April - May 2019)
TERRASIGNA

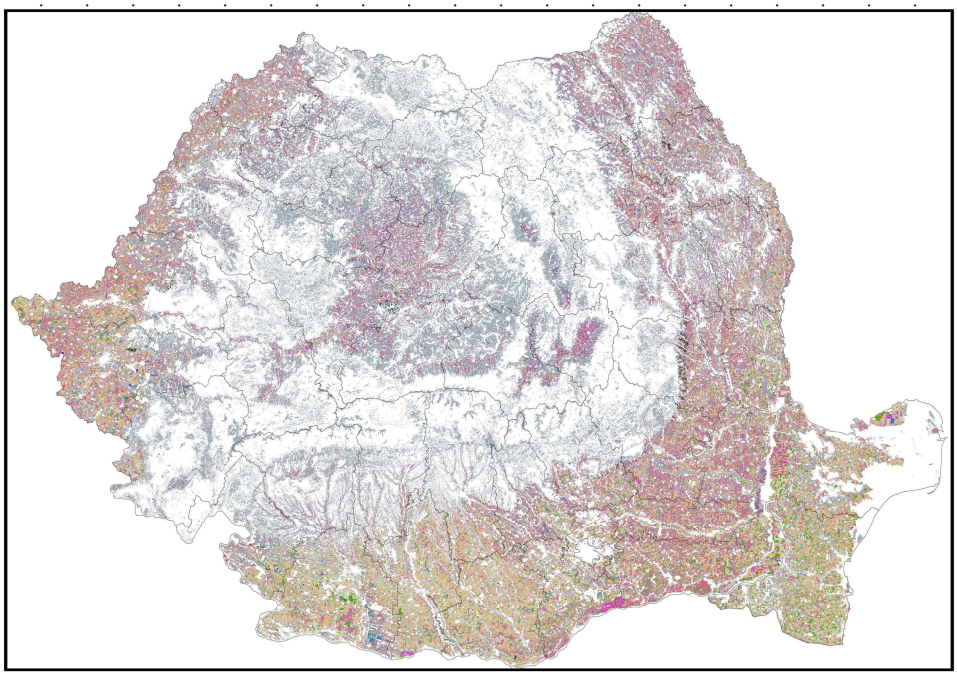

Romania, CAP support monitoring - Sentinel-2 (June - July 2019)
TERRASIGNA


Romania, CAP support monitoring - Sentinel-2 (August - September 2019)
TERRASIGNA


Romania, CAP support monitoring - winter and summer crops map (2019)
TERRASIGNA
winter crops
summer crops

Romania, CAP support monitoring - crop map, 32 crops (2019)

TERRASIGNA



Towards the “Traffic lights” implementation

- The delivery of crop maps towards the end of the agricultural season prevents the dialogue with the farms and/or other prophylactic measures
- For a certain number of crops it is possible to deliver reliable results earlier, as soon as the observed crop is confirmed
- Early results will enable the decision makers to take the appropriate measures
  - clear the payment for the “green” plots
  - assessment of “red” plots (e.g. type of crop, financial, total area of the holding)
  - open the dialogue with the farmer,
  - gather additional evidence in case of the “yellow” plots,

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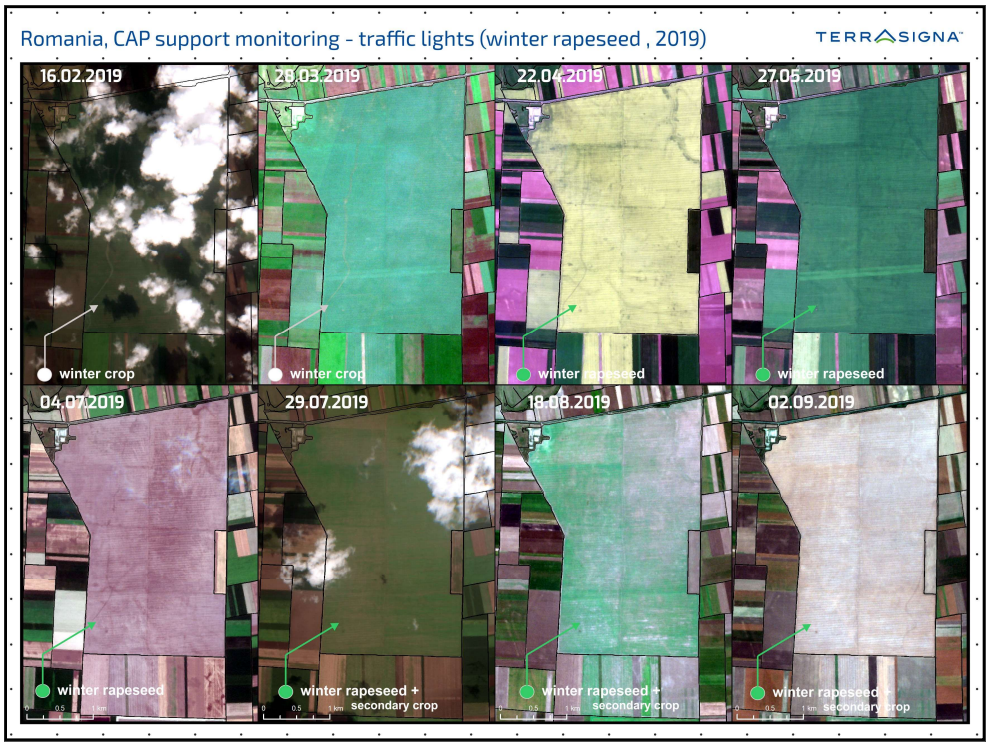
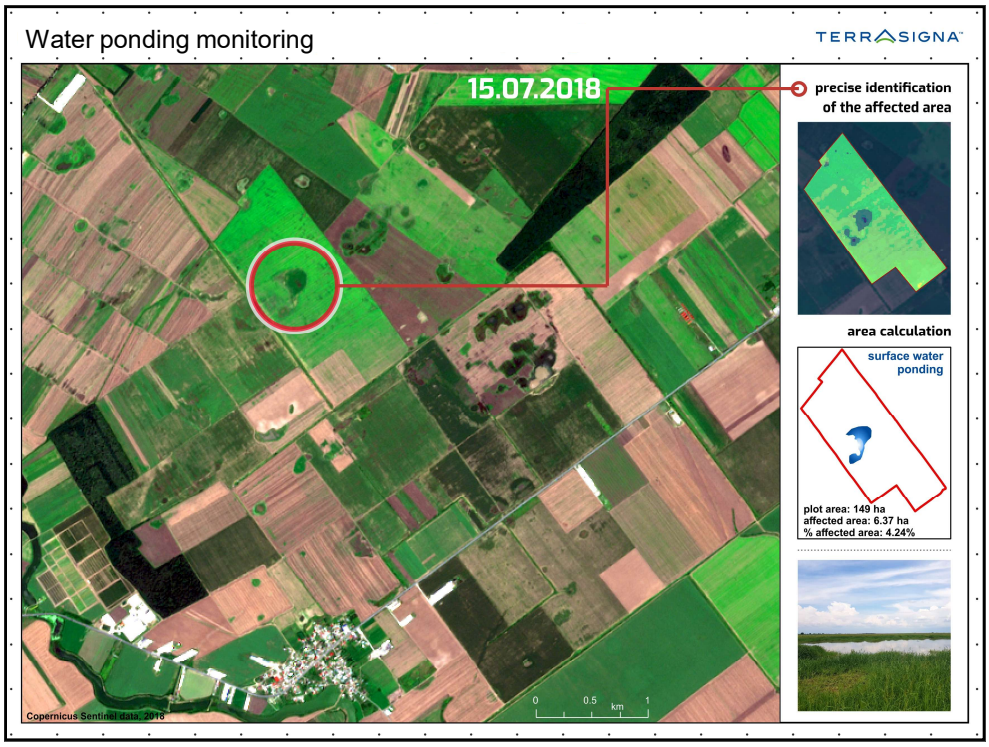
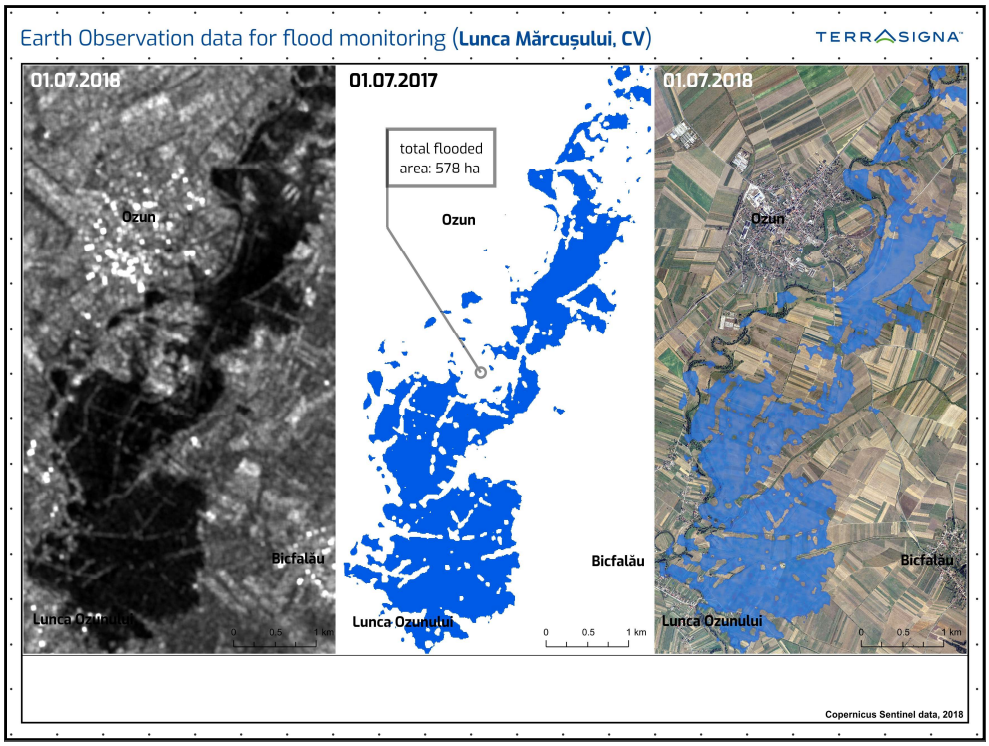

Romania, CAP support monitoring - traffic lights (winter rapeseed , 2019)
TERRASIGNA
16.02.2019
28.03.2019
22.04.2019
27.05.2019
winter crop
winter crop
winter rapeseed
winter rapeseed
04.07.2019
29.07.2019
18.08.2019
02.09.2019
winter rapeseed
winter rapeseed + secondary crop
winter rapeseed + secondary crop
winter rapeseed + secondary crop

Romania, CAP support monitoring - traffic lights (maize , 2019)
TERRASIGNA
16.02.2019
22.04.2019
07.05.2019
27.05.2019
21.06.2019
16.07.2019
25.08.2019
04.10.2019
summer crop
summer crop
maize
maize + no secondary crop


Water ponding monitoring
TERRASIGNA
15.07.2018
precise identification of the affected area
area calculation
surface water ponding
plot area: 149 ha
affected area: 6.37 ha
% affected area: 4.24%
0
0.5
km
1
Copernicus Sentinel data, 2018


Earth Observation data for flood monitoring (Lunca Mărcușului, CV)
TERRASIGNA
01.07.2018
Ozun
Bicfalău
Lunca Ozunului
01.07.2017
total flooded area: 578 ha
Ozun
Bicfalău
Lunca Ozunului
0
0.5
1 km
01.07.2018
Ozun
Bicfalău
Lunca Ozunului
Copernicus Sentinel data, 2018

Validation using APIA - OTSC data (2018)

- **Coverage:** the entire area of Romania eligible for CAP support
- **Data sources:** official OTSC data: remote sensing - CwRS - and ground controls). APIA data was considered as reference data.
- **Approach**: pixel based approach. For each plot a dominant crop code was assigned, provided it covers >40% of plot's area
- **Methodology:** data intersection (Terrasigna crop maps vs. OTSC) was done by APIA. The results were delivered as .csv files and joined with the initial set of declarations
- The validation focused on the **32 most predominant crops.** The samples vary in terms of area and number of plots.
- The results are broken down for 7 *plots classes*:
  - very small plots <0.5ha, 0.5-1 ha,
  - small plots: 1-2ha, 2-5ha,
  - medium plots: 5-10ha, 10-20ha,
  - large plots: >20ha

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Validation - comparison of Terrasigna results against OTSC 2018 (pixel based)

Overall pixel based performance: 97.28% for 32 crops, 16.000+ plots, 60.000+ ha

Plot class	number of plots	number of plots - % of total	% of total OTSC area	Accuracy (%)
< 0.5 ha	4864	30.61%	2.59%	90.77%
0.5 - 1 ha	3892	24.49%	4.57%	92.67%
1 - 2 ha	2717	17.1%	6.21%	93.64%
2 - 5 ha	2046	12.88%	10.51%	94.61%
5 - 10 ha	978	6.15%	11.61%	97%
10 - 20 ha	699	4.39%	16.04%	97.69%
> 20 ha	693	4.36%	48.46%	99.03%

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Validation - comparison of Terrasigna results against OTSC 2018 (pixel based)

Crop type	% of agreement between Terrasigna & OTSC Ground checks
Winter wheat	97.07%
Maize	94.7%
Sun flower	89.12%
Rapeseed	87.91%
Soybean	78.25%
Beetroot	89.35%
Summer wheat	90.18%
Orchards	83.33%
Wineyards	88.49%
Pastures	99.08%

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Validation - comparison of Terrasigna results against OTSC 2018 per crop type (pixel level)

Plot class	Winter wheat	Maize	Sunflower	Rapeseed	Soybean	Summer wheat	Pasture	Wineyards
< 0.5 ha	70.93	77.69	66.25	58.43	41.84	96.08	99.53	91.97
0.5 - 1 ha	83.49	85.61	76.61	37.82	42.08	74.4	99.56	87.97
1 - 2 ha	91.25	85.87	79.35	70.81	60.76	78.14	99.62	69.14
2 - 5 ha	92.92	91.33	79.85	81.17	70.04	95.59	98.73	92.74
5 - 10 ha	94.44	95.52	85.65	83.87	66.24	83.9	98.97	91.4
10 - 20 ha	96.54	98.52	90.23	77.1	58.31	99.02	98.93	99.58
> 20 ha	99.65	98.8	93.75	94.95	87.81	n.a.	99.11	n.a.

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Conclusions and perspectives

- **Full implementation of the *traffic lights* approach** for the continuation of the **national level** implementation (definition of the crop workflows, algorithm adjustments)
- **Reporting at parcel level**
- **Standardised solutions for particular cases** (e.g. plots with multiple crops)
- Increasing the spatial & temporal resolution for fire occurrences / burned areas using Sentinel-2
- **Harmonisation** with the official workflows
- Iterations of traffic lights approach for 2017 - 2019
- **Trials in other countries / geographical areas**

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