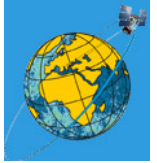BULGARIAN ACADEMY OF SCIENCES
SPACE RESEARCH AND TECHNOLOGY INSTITUTE
Remote Sensing and GIS Department

COPERNICUS Training and information session | 17 April 2018, Sofia, Bulgaria

Application of Copernicus satellite data for monitoring of agriculture in Bulgaria

Presenter: Assoc. Prof. Lachezar Filchev, SRTI-BAS
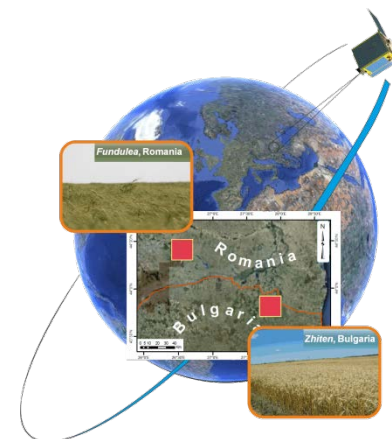
Outline

- Proba-V
  - PROAGROBURO (BELSPO)
  - PROBA-V 100 Exploration Exercise (VITO initiative)
- SPOT-5
  - Take 5 (CNES-CESBIO-ESA initiative)
- Sentinel-2
  - TS2AgroBG (ESA-PECS Project)
  - PhD project by Dessislava Ganeva

PROAGROBURO -
Testing PROBA-V and VEGETATION data for agricultural applications in Bulgaria and Romania

CONTRACT NR CB/XX/16 financed by BELSPO

Space Research and Technology Institute, Bulgarian Academy of Sciences (SRTI-BAS)

National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences (NIMH-BAS)

Romanian National Meteorological Administration (RNMA)

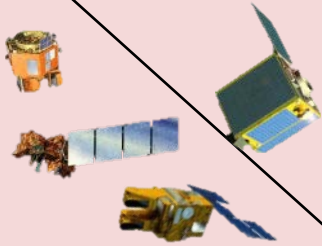**PI**: Assoc. Prof. Dr. Eugenia Roumenina, SRTI-BAS

Promoter 2: Dr. Gheorghe Stancalie, RNMA

Promoter 3: Assoc. Prof. Dr. Valentin Kazandjiev, NIMH-BAS

The main objective of the PROAGROBURO Project is to assess the quality of the PROBA-V mission as a continuity mission to VEGETATION 1 & 2 by comparison and validation of SPOT-Vegetation and PROBA-V simulated data for assessing crop condition on chosen test sites for the territory of Bulgaria and Romania.

DATA SETS

PROBA-V spectral bands and the corresponding bands of the high resolution images used for their simulation

|	PROBA-V bands (µm)			
	Blue (0.45-0.49)	Red (0.61-0.69)	NIR (0.78-0.89)	SWIR (1.57-1.65)
Corresponding EO-1/ Hyperion bands (central wavelength, µm)	B10(0.447), B11(0.457), B12(0.467), B13(0.477), B14(0.487)	B26(0.610), B28(0.630), B30(0.650), B32(0.670), B34(0.690)	B44(0.793); B46(0.813), B48(0.833), B50(0.854), B52(0.874)	B142(1.57), B144(1.59), B146(1.61), B148(1.63), B150(1.65)
Corresponding EO-1/ ALI bands (µm)	Band 3: Blue (0.45-0.52)	Band 5: Red (0.63-0.69)	Band 6: NIR (0.78-0.80), Band 7: NIR (0.84-0.89)	Band 9: SWIR (1.55-1.75)
Corresponding SPOT 5 HRG bands (µm)	Band 1: Green (0.50-0.59)*	Band 2: Red (0.61-0.68)	Band 3: NIR (0.78-0.89)	Band 4: SWIR (1.58-1.75)
Corresponding Landsat TM bands (µm)	Band 1: Blue (0.45-0.52)	Band 3: Red (0.63-0.69)	Band 4: NIR (0.76-0.90)	Band 5: SWIR (1.55-1.75)

*The green band of SPOT HRG was used for the simulation because of the lack of blue band.

The PROBA-V 100 m and 300 m daily (S1) Top of Canopy reflectance products were downloaded from the VITO's Product Distribution Portal in GeoTIFF file format. The PROBA-V satellite has three cameras aligned to each other to cover the full swath of 2250 km. The PROBA-V 300 m product combines the image stripes of the three cameras and the resulting full-width image is resampled to 300 m pixels. The 100 m product use data solely from the central camera.
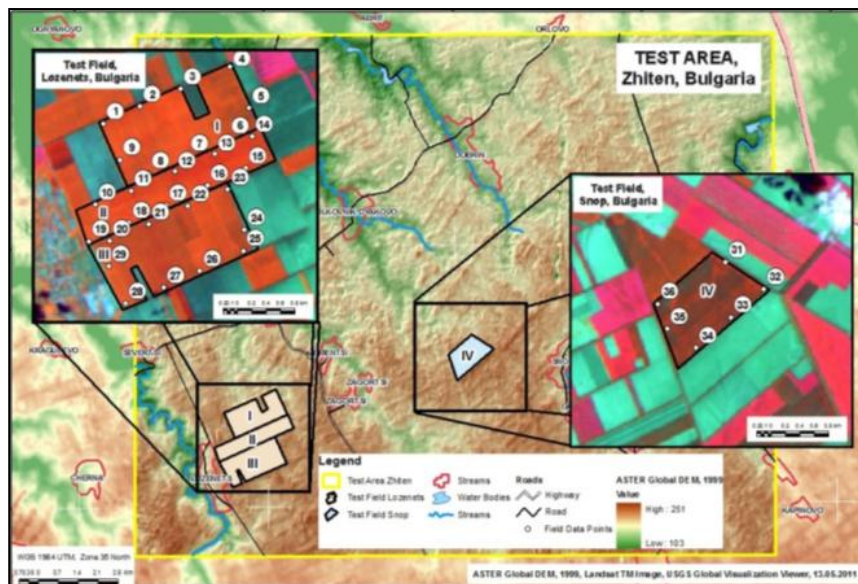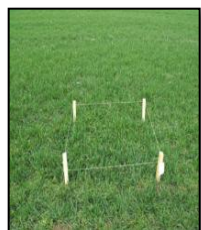
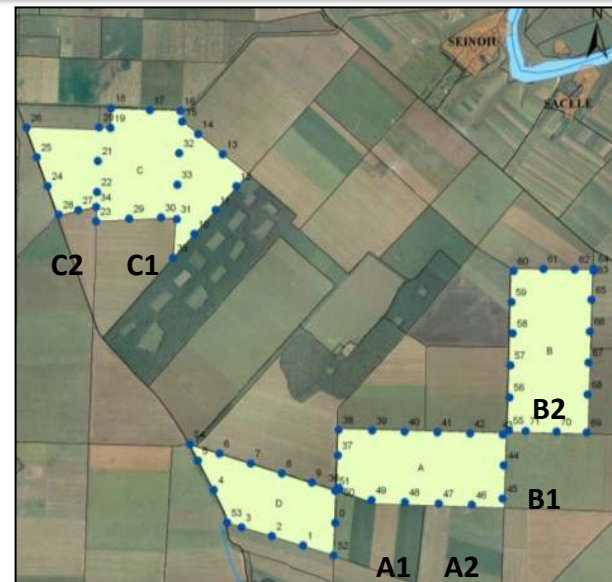Spatial distribution of the reference sites in the test fields of the *Zhiten* test area (Bulgaria)

Spatial distribution of the reference sites in the test fields of the *Fundulea* test area (Romania)

4 test fields
35 reference sites sized 1 m² and spaced at a distance of 600 m
Main crop types: winter wheat

8 test fields
71 reference sites sized 1 m² and spaced at a distance of 600 m
Main crop types: winter wheat (B2, C1, D), barley (A, B1, C2)

The dates for performing field measurements were determined in advance by WOFOST model calculation using climatic values for the meteorological elements over the period (1971–2011).

DATA SETS

- **Density and Plant height**

- **Leaf Area Index (LAI)** was measured by two methods – direct and indirect (Gower *et al*. 1999, Jonckheere *et al*. 2004). The indirect method includes measurement of the crop's LAI using AccuPAR linear PAR Ceptometer.

- **The soil moisture content** of each field was determined at the following standard depths - 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 cm by direct measurement using the gravimetric method. Two parameters are calculated Total Water Content (TWC) and available water content (AWC).

- **The weight of the aboveground fresh biomass (fAGB)** was determined directly by weighing a representative plant sample collected from 1 m^2.

- **The weight of aboveground dry biomass (AGBd)** was determined by drying the whole collected aboveground green biomass.

COPERNICUS Training and information session, Sofia, Bulgaria

DATA SETS

The amount of chlorophyll and carotene was determined by biochemical analysis in two phases – field and laboratory.

Total Projective Cover (TPC) for each phenological stage.

The yield structure was determined during the additional, fourth field experiment. This measurement aims to determine the characteristics of the stems and classes (class weight, class length, number of grains in a class, and the weight of 1000 grains) in Wax maturity.

METHODOLOGY
EXTRACTION OF INFORMATION AND SYNTHESIS OF RESULTS

PREPARATION AND COMPARATIVE ANALYSIS OF CROP CONDITION MAPS BASED ON NDVI, NDWI AND LAI INDICES FROM SPOT VEGETATION AND PROBA-V SD

For *Zhiten* teast area, three high SR satellite images were used: (**1**) Landsat 5 TM of 26.03.2011; (**2**) SPOT 5 HRG of 21.04.2011 and (**3**) Landsat 5 TM of 13.05.2011, as well as the three low SR PROBA-V L2A SD products. The acquisition dates of the two Landsat TM scenes correspond to the time of performing the field measurements.
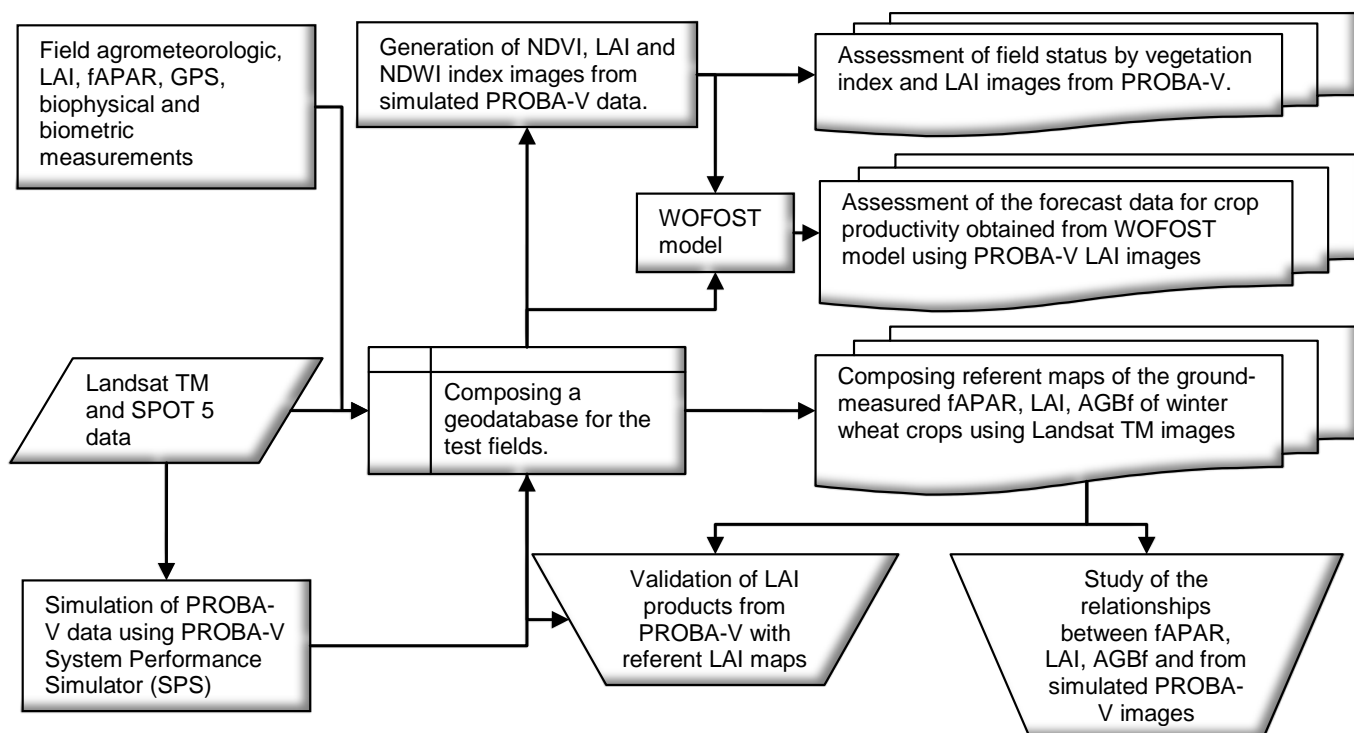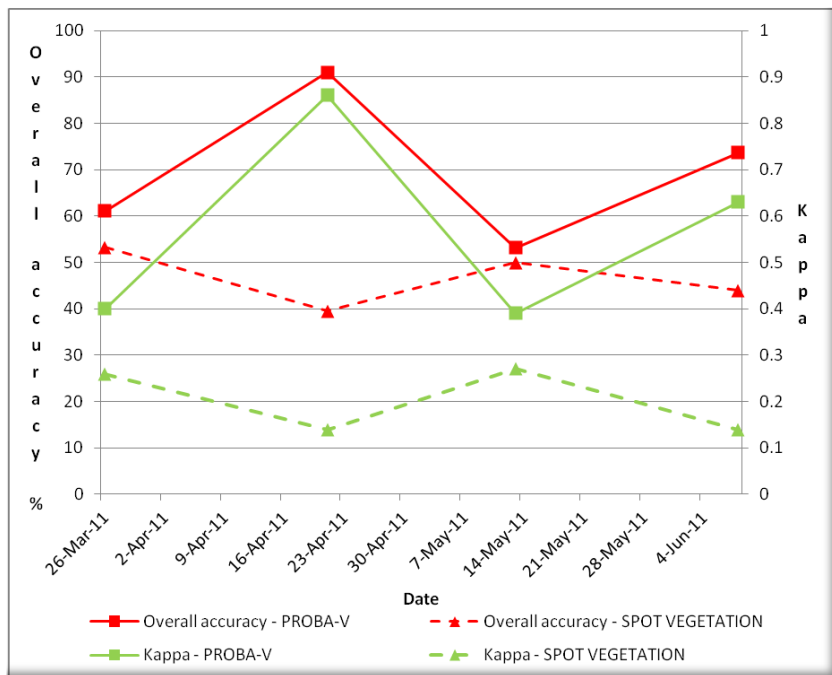

Flowchart of the study

RESULTS

Zhiten test area (Bulgaria)

Single-date supervised MLC of LU/LC for:
a) **PROBA-V SD**
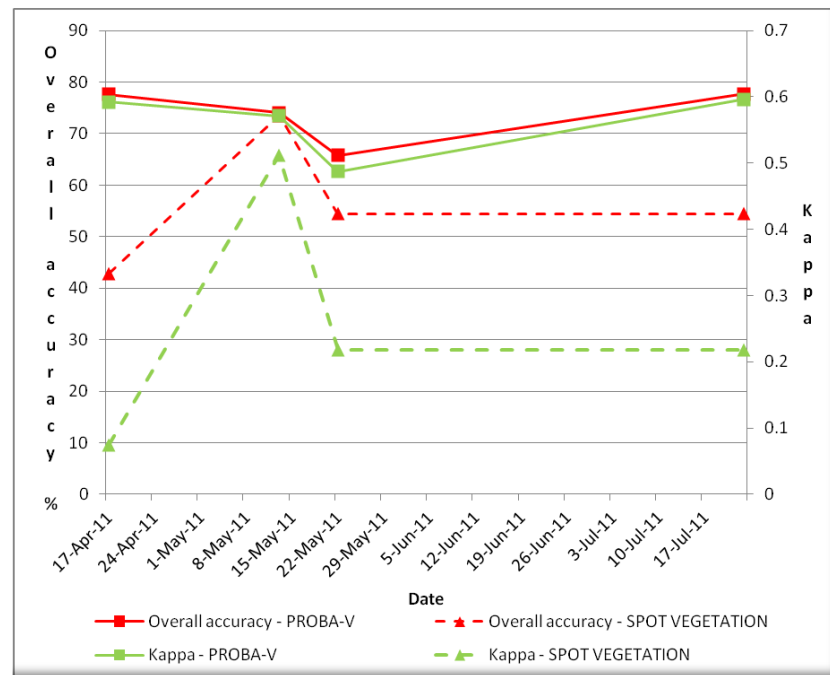b) **SPOT VEGETATION**
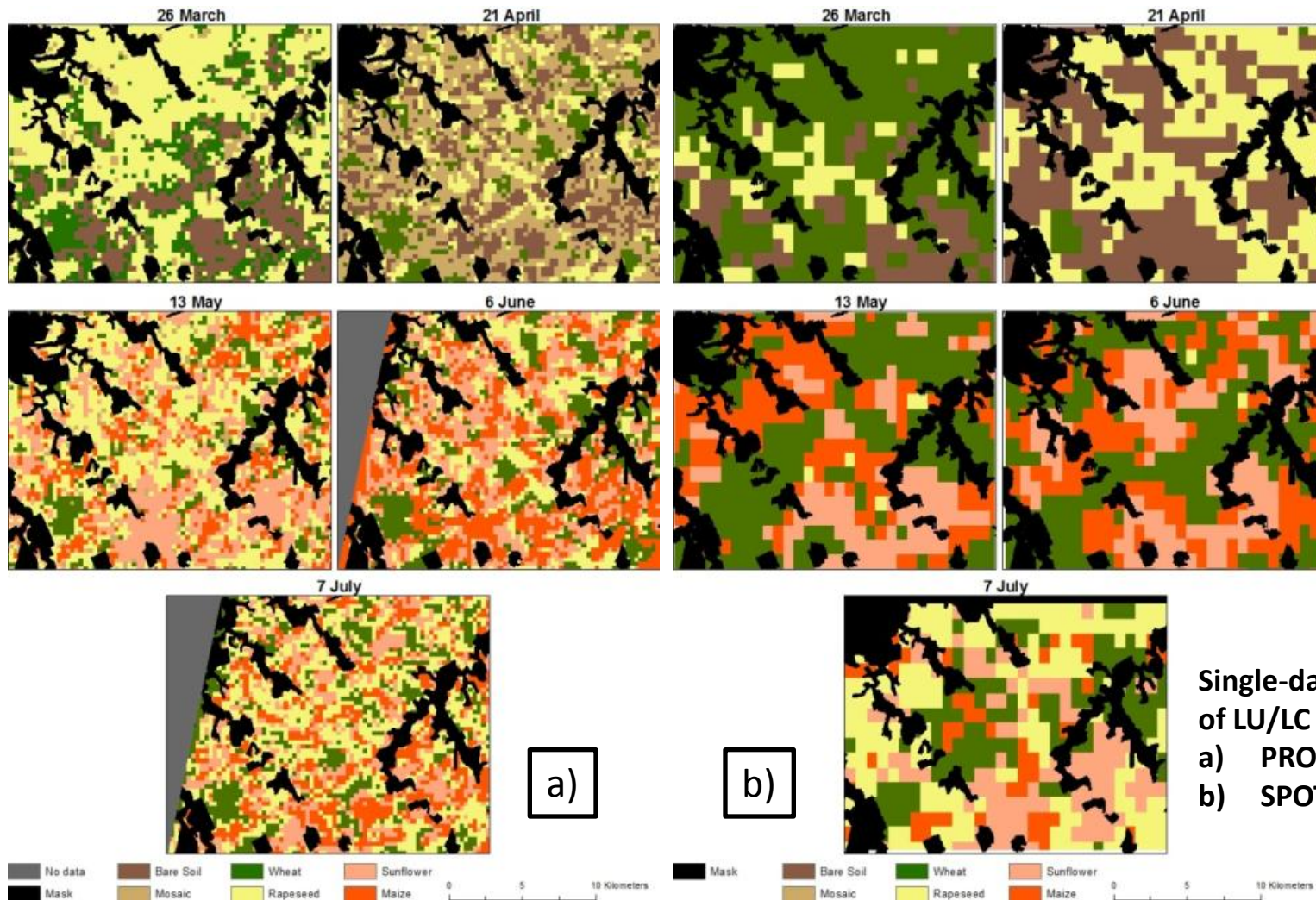
RESULTS

Zhiten test area (Bulgaria)

Overall accuracy and Kappa statistics for the supervised MLC of PROBA-V SD and SPOT VEGETATION images over the *Zhiten* test area.
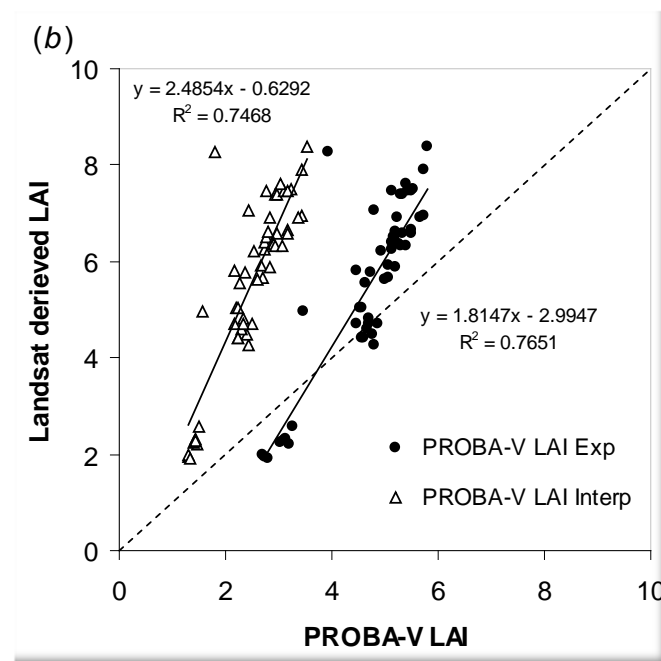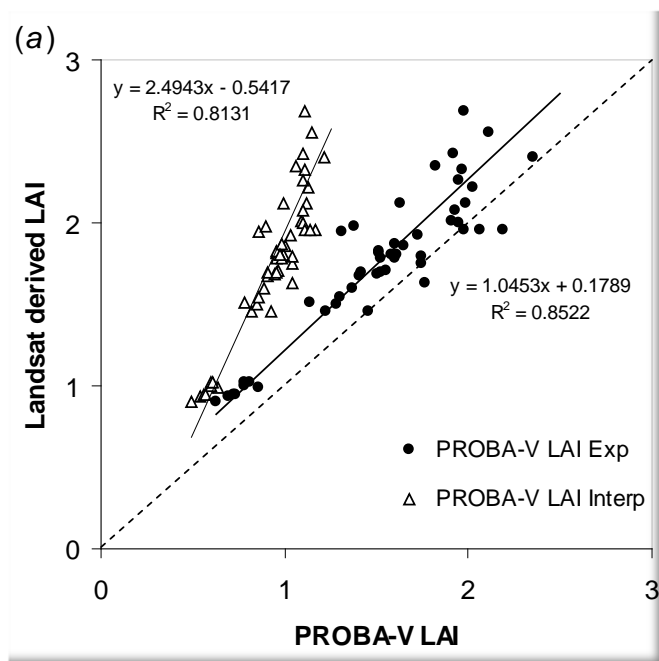
Fundulea test area (Romania)

Overall accuracy and Kappa statistics for the supervised MLC of PROBA-V SD and SPOT VEGETATION images over the *Fundulea* test area.

Validation of the LAI products from PROBA-V SD with reference LAI maps

Relationship between LAI generated from PROBA-V SD and LAI derived from the referent maps for 26.03.2011 (*a*) and 13.05.2011 (*b*).

RESULTS

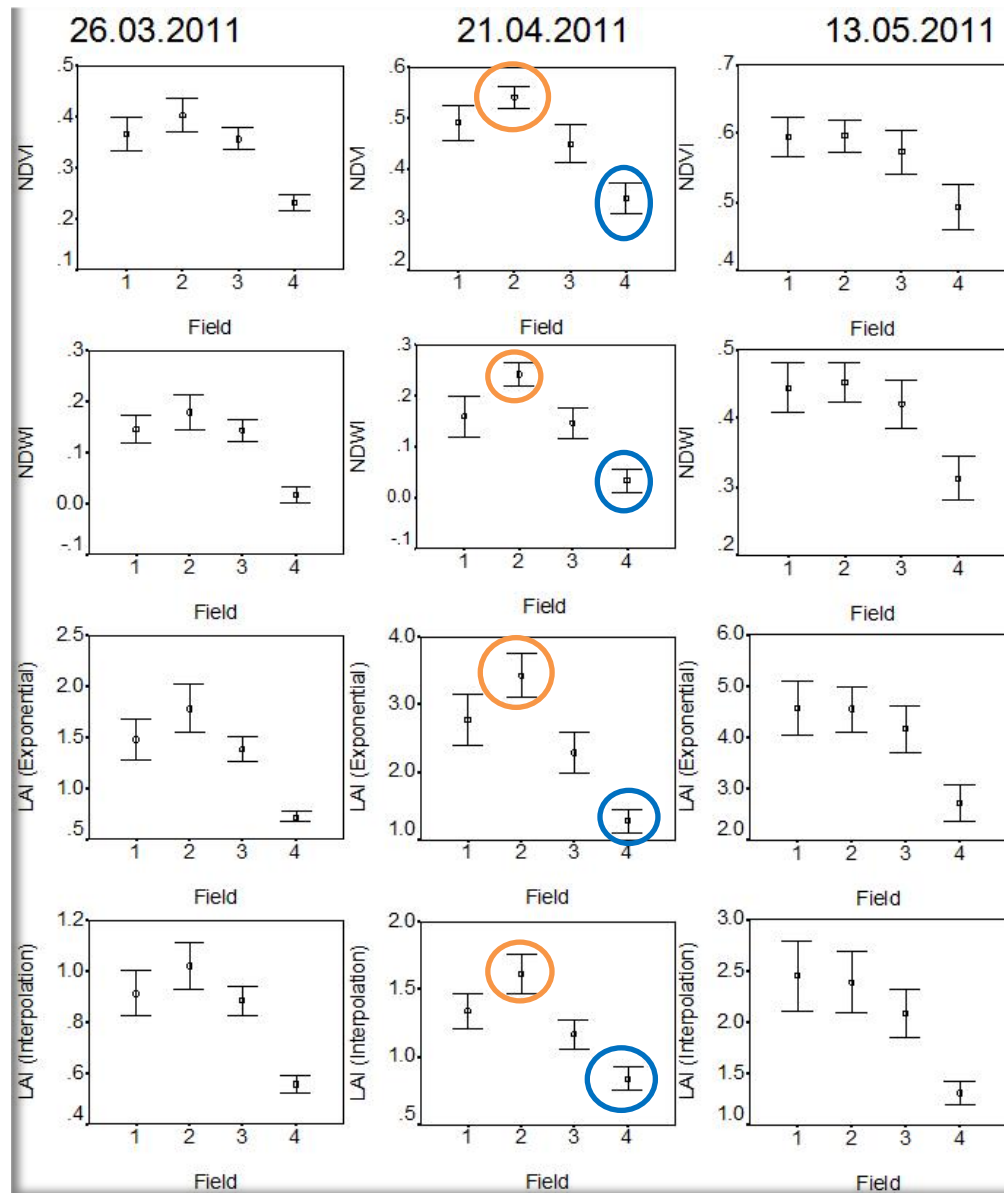**Assessment of the status of test fields by VI and LAI images from PROBA-V SD**
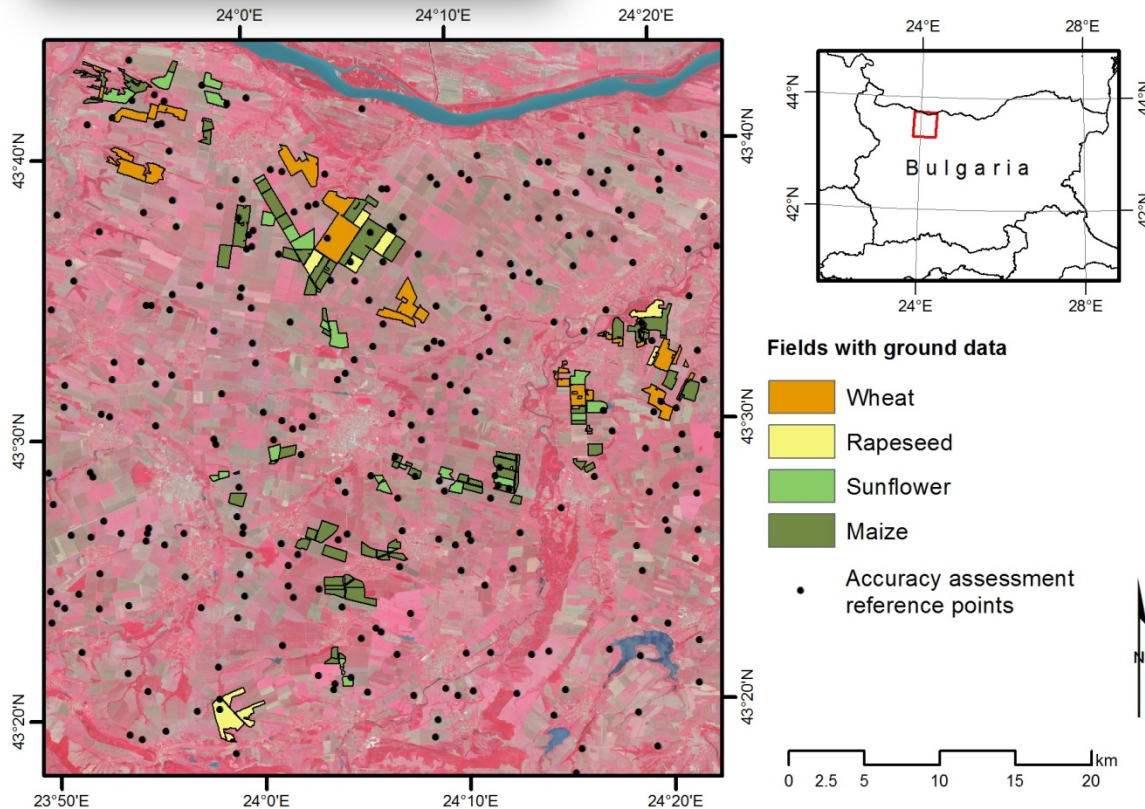
Field II – 26.03.2011

Field IV – 26.03.2011

Mean values and 95% confidence intervals of PROBA-V NDVI, NDWI, and LAI calculated by the two methods for the four test fields for 26 March, 21 April, and 13 May 2011

PROBA-V 100 Exploration Exercise

Zlatia test site in Bulgaria. Background false color (RGB) composite (bands 5-4-3) from Landsat-8 OLI acquired on 11 June 2014. The colored polygons correspond to four crop types with *in situ* (ground) data available (e.g., winter wheat, rapeseed, sunflower, and maize).

Fields with ground data

Wheat

Rapeseed

Sunflower

Maize

Accuracy assessment reference points

The study area has a size of approximately 45 × 50 km (2 250 km²) and is located in North-West Bulgaria. The test site occupies part of the drainage basin of the Bulgarian part of the *Danube* River. The *Zlatia* test site is characterized by intensive agriculture due to the favorable climatic and soil conditions.

DATA SETS — PROBA-V 100 Exploration Exercise

Two types of classification were conducted to assess the added value of 100 m data against 300 m PROBA-V data:

(1) single- and multi-date supervised maximum likelihood classification (MLC) of the multi-spectral data, and

(2) multi-date maximum likelihood classification (MLC) and Iterative Self-Organizing Data Analysis Technique (ISODATA) clustering of NDVI time series.

| Single-Date Spectral Classification Experiments		Abbreviation of Classification Experiment			
		SINGLE1	SINGLE2	SINGLE3	SINGLE4
Image used	21 March (I)	+	–	–	–
	4 April (III)	–	+	–	–
	7 June (V)	–	–	+	–
	8 July (VII)	–	–	–	+
Distinguished classes		Wheat, Rapeseed, Soil	Wheat, Rapeseed, Soil	Wheat, Rapeseed, Soil, Maize, Sunflower	Maize, Sunflower, Soil/crop residue
Multi-Date Spectral Classification Experiments		Abbreviation of Classification Experiment			
		MULT1	MULT2		MULT3
Images used	21 March (I)	+	+		–
	4 April (III)	+	+		+
	7 June (V)	+	+		+
	8 July (VII)	+	–		+
Distinguished classes		Wheat, Rapeseed, Maize, Sunflower			

PROBA-V 100 Exploration Exercise
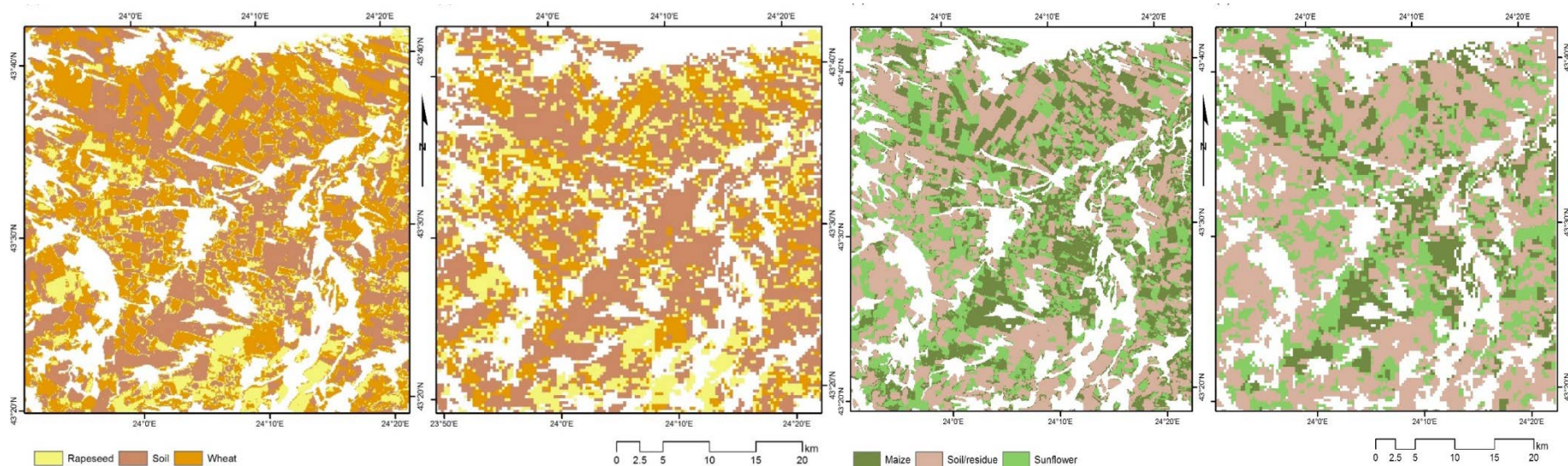
The overall accuracy for the 21 March and 7 July 2014 PROBA-V images is 86.2% and 82.5 %, respectively (100 m) and 79.3% and 70.2%, respectively (300 m). For both image acquisitions, in March and July, the 300 m classifications were less accurate than the 100 m results.

PROBA-V 100 Exploration Exercise

Crop map with four classes for PROBA-V NDVI (**a**) 100 m and (**b**) 300 m time series from unsupervised ISODATA clustering. The areas outside the CORINE class 211 (non-irrigated arable land) were left blank.
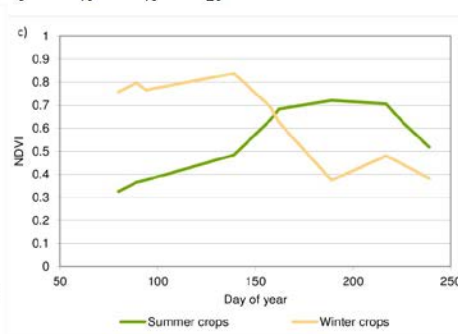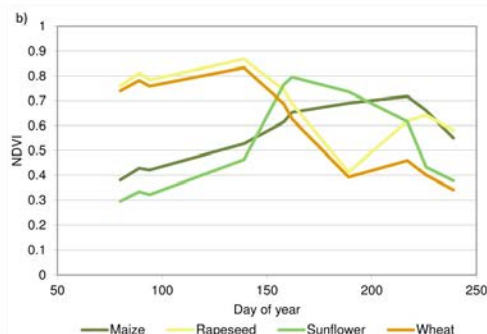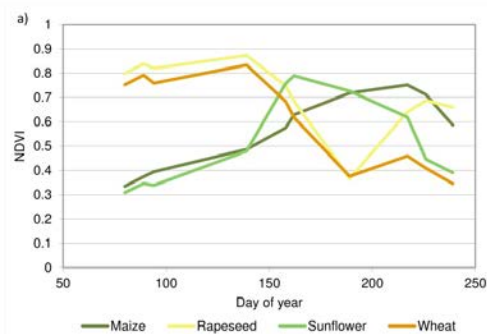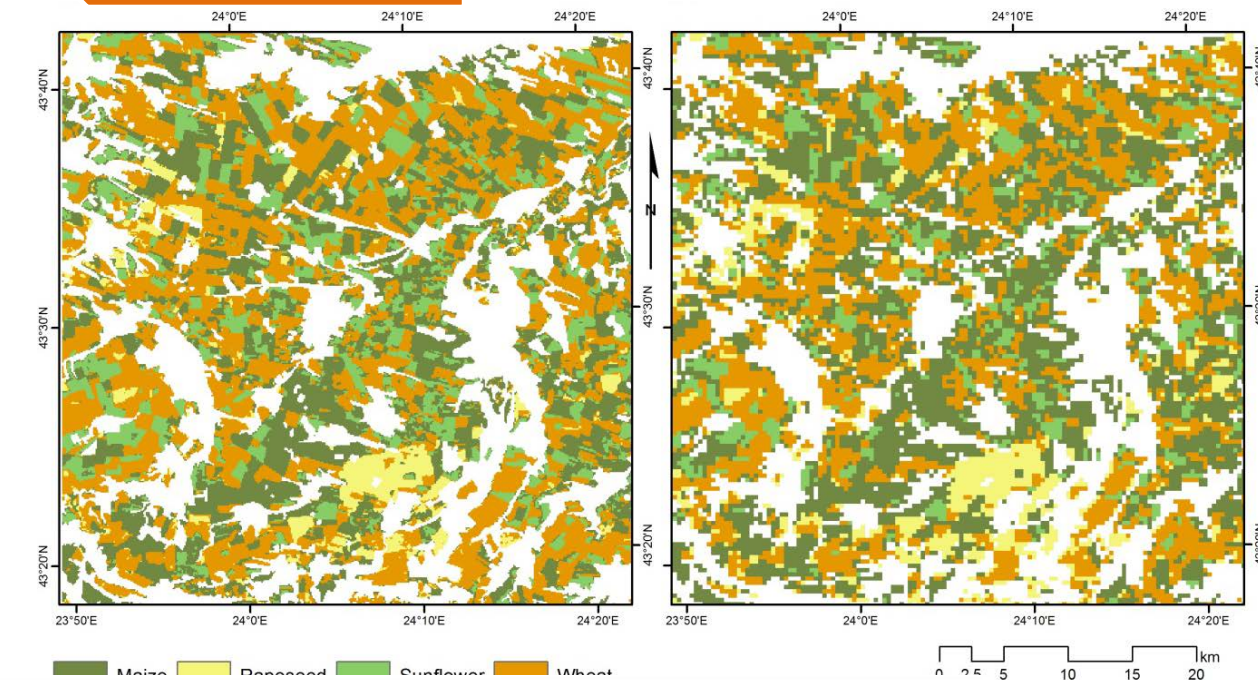
PROBA-V NDVI (**a**) 100 m and (**b**) 300 m time series profiles of four classes from ISODATA clustering and the recoded time series profiles with two classes (**c**) 100 m and (**d**) 300 m.
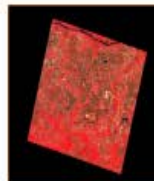
SPOT-5 Take 5

Zlatiya test area

SPOT 5/HRG2_XS
08.07.2015

DATA SETS

SPOT-5 Take 5 - field campaign equipment

Sensefly, eBee Ag with two cameras S110_RGB and S110_NIR, and a tablet for mission planning

Field spectrometer - Analytical Spectral Devices, FieldSpec 4 Hi-Res

Soil moisture - TDR 100
GNSS system Leica GS08plus

ЕВРОПЕЙСКИ СЪЮЗ
Европейски фонд
за регионално развитие
Инвестираме във вашето бъдеще

НАЦИОНАЛНА
СТРАТЕГИЧЕСКА
РЕФЕРЕ-ТНА РАМКА
2007 - 2013
www.eufunds.bg

ОПЕРАТИВНА ПРОГРАМА
Развитие на конкурентоспособността
на българската икономика 2007-2013
www.opcompetitiveness.bg

Оперативна програма
„Развитие на конкурентоспособността на българската икономика" 2007-2013

Бенефициент: Институт за космически изследвания и технологии при Българска академия на науките (ИКИТ-БАН)

Проект: „Информационен комплекс за аерокосмически мониторинг на околната среда" (ИКАМОС)

Ид. номер: BG161PO003-1.2.04-0053-C0001

Space Research and Technology Institute – Bulgarian Academy of Sciences (SRTI-BAS)
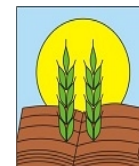
Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov" (ISSAPP)

RESULTS

Map of winter wheat crop condition *19.04.2015* (*reclassification of NDVI from SPOT 5/HRG2_XS*)

Crop condition in % of the fields area
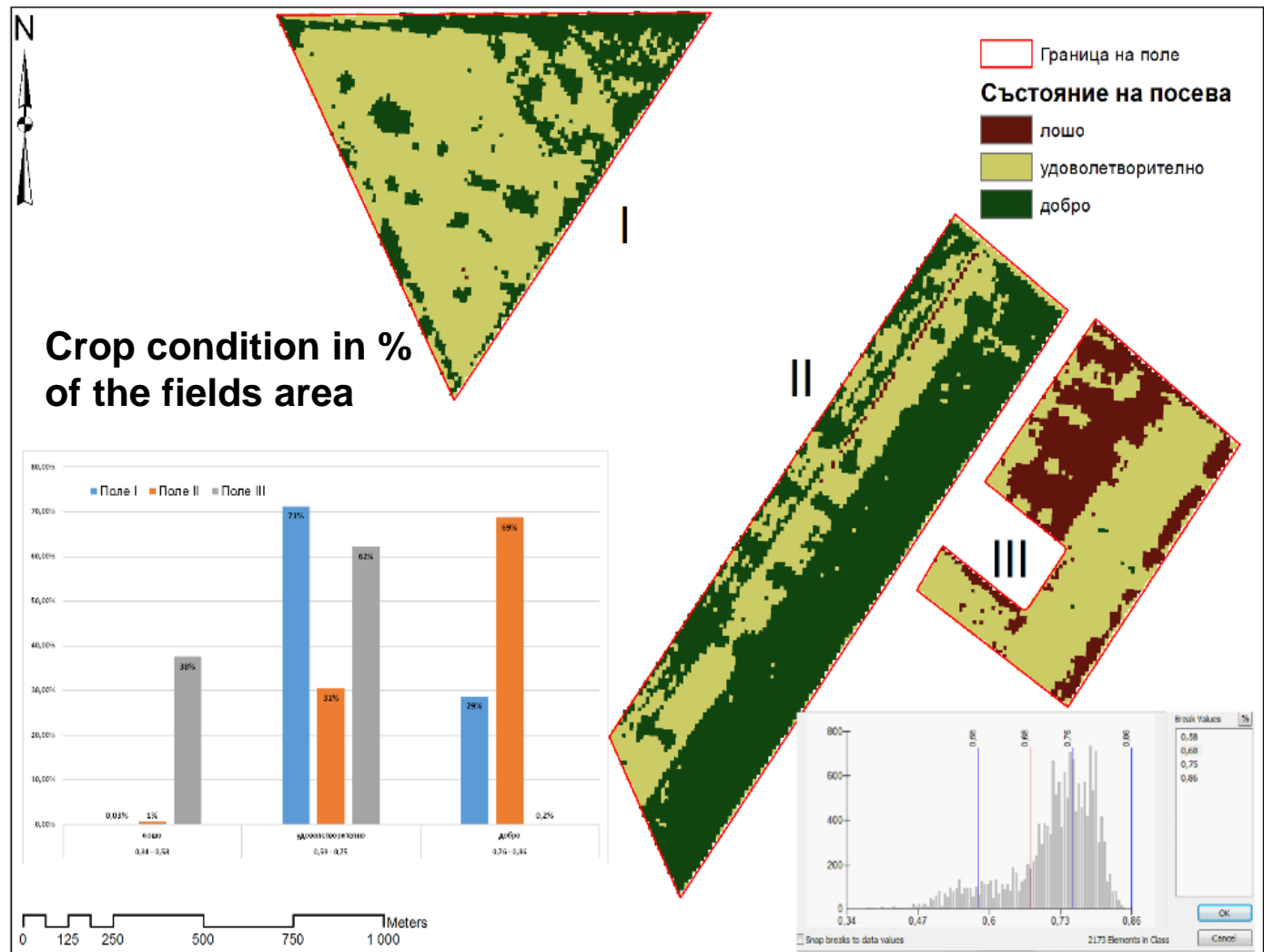
Field No. III, 17.04.2015 treatment with insecticide; Imago with density 3-8 No/m²

Map of soybean crop condition *08.07.2015* (*reclassification of NDVI from SPOT 5/HRG2_XS*)
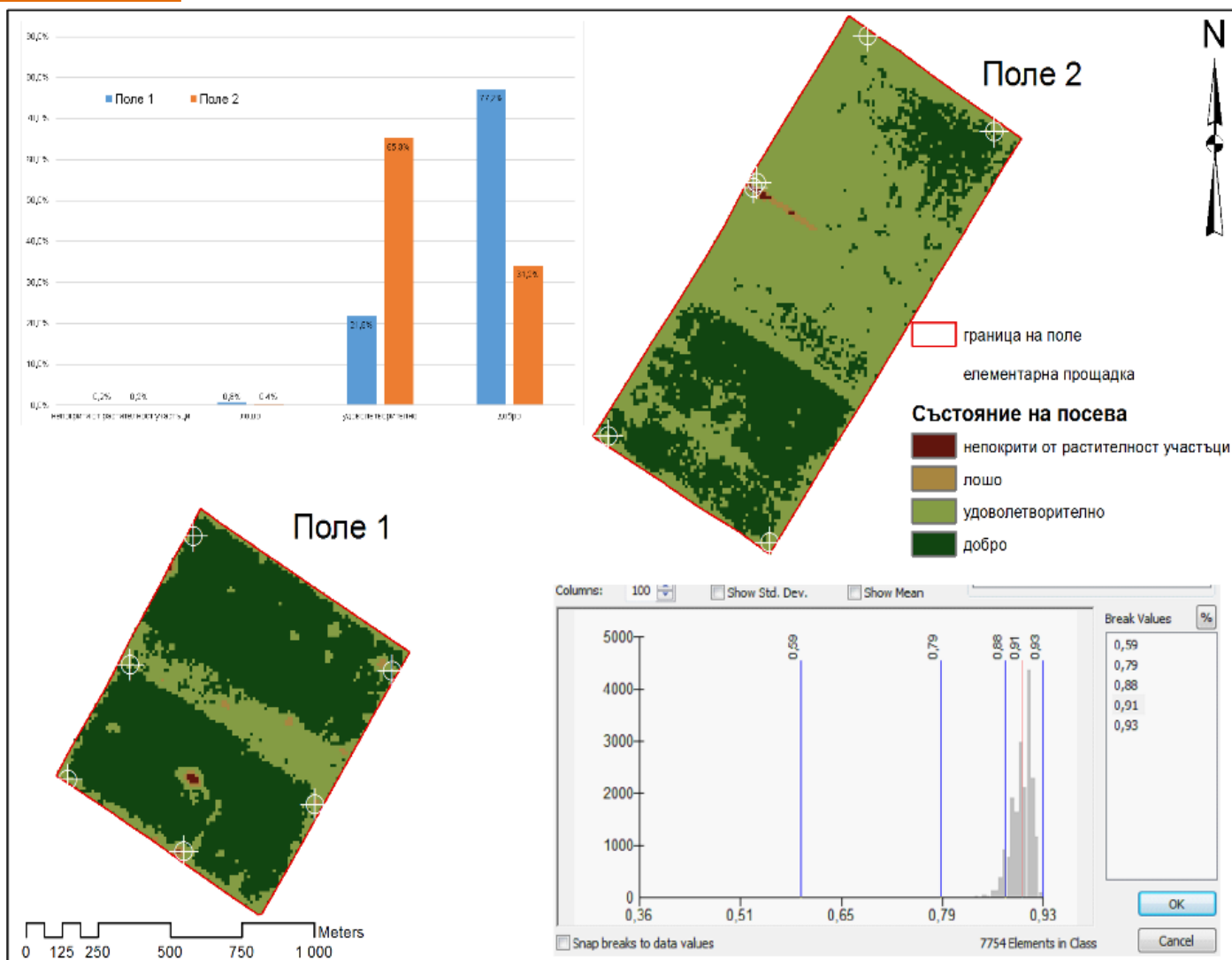
Testing Sentinel-2 vegetation indices for the assessment of the state of winter crops in Bulgaria (TS2AgroBG) - ESA PECS Project

Project start date: 1 September 2016; **Duration**: 24 months

The main **objectives** are:

1. To conduct series of **field campaigns** in a selected test site and to provide geo-database containing ground measurements of winter wheat biophysical variables;

2. To develop regression models for retrieval of different **biophysical variables of winter wheat** using Sentinel-2 vegetation indices applicable to winter wheat grown in Bulgaria;

3. To propose a methodology for generating **assessment maps of crop condition** for winter wheat grown in Bulgaria;

4. To produce **crop type map at national level** using classification of PROBA-V 100 m time series.

Space Research and Technology Institute – Bulgarian Academy of Sciences (SRTI-BAS)

Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov" (ISSAPP)

Vlaamse Instelling voor Technologisch Onderzoek NV (VITO)

DATA SETS

Field measurement of Biophysical variables:

- Above Ground Biomass
- Leaf Area Index
- Nitrogen content
- Nitrogen uptake
- Canopy Chlorophyll Content
- fCover
- fAPAR

Growth seasons 2017 and 2018

6 Field campaigns

METHODS

Sentinel-2 images

Spectral Indices

Biophysical parameters

Validation

Reclassification and Overlay

Regression analysis

Sentinel-2

Field campaigns

Ground truth data

Crop condition
Poor
Fair
Good

Validation

Assessment map of crop condition

PROBA-V 100 m

NDVI time series

Crop type classification
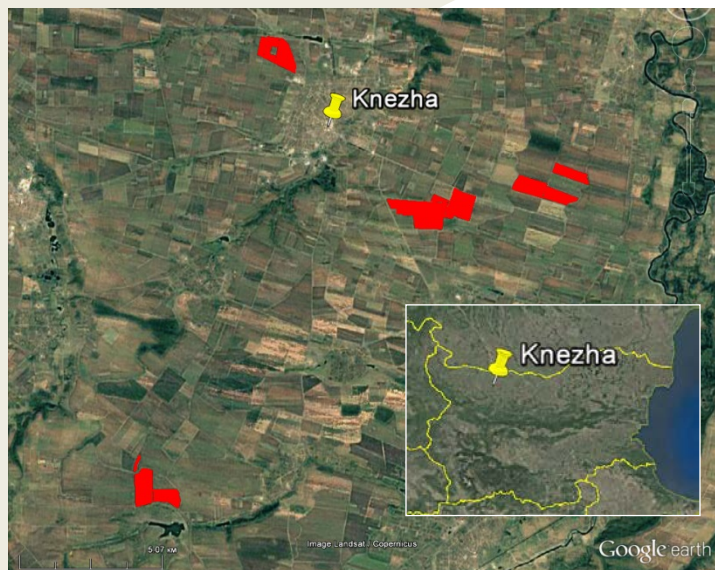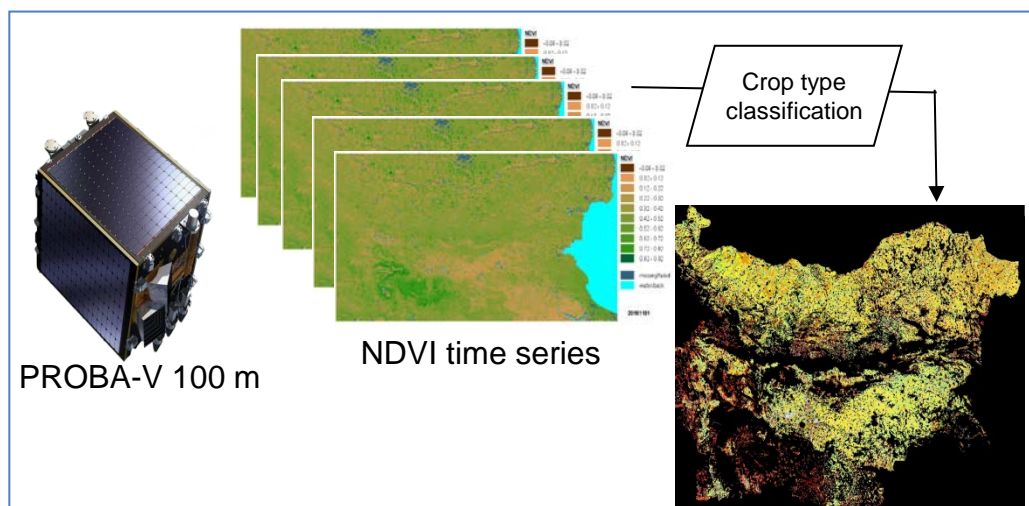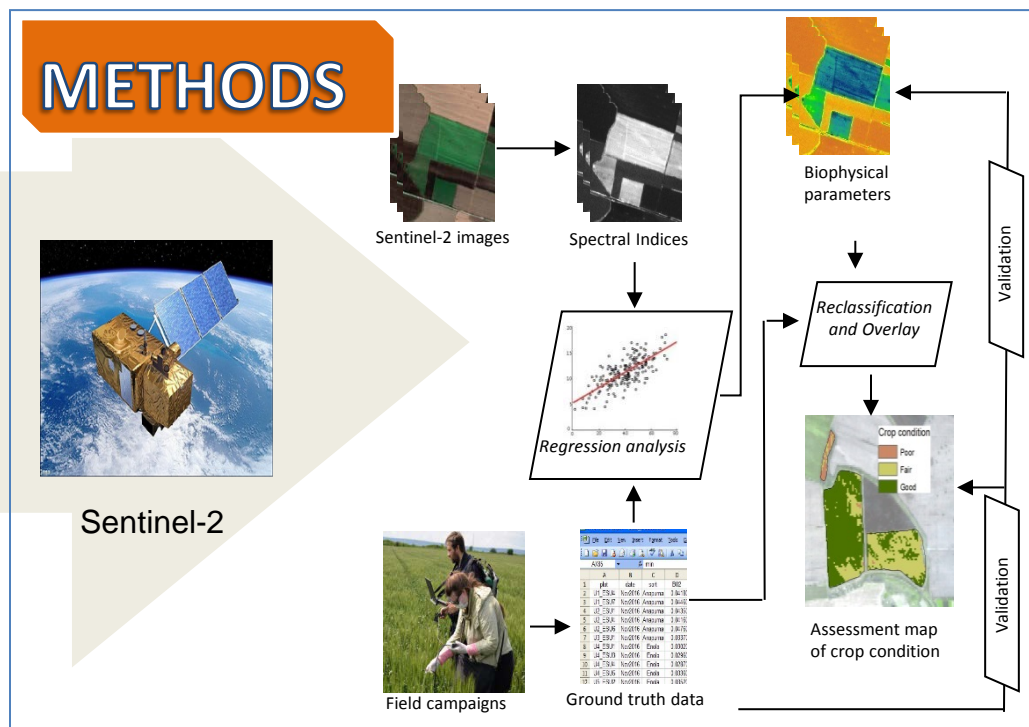
Biophysical Variables and Assessment Map of Winter Wheat Condition

dry Above Ground Biomass [g/sq.m]

1034
288

Nitrogen content [%]

1.57
0.75

Data: Sentinel-2 from 19 April 2017
(Stem elongation, Zadoks 31-33)

Assessment Map of Crop Condition

- Poor
- Fair
- Good

fAPAR

1
0.55
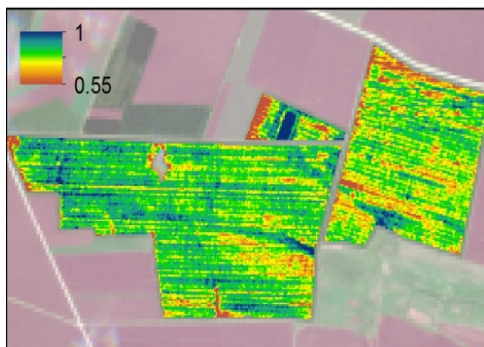
Canopy Chlorophyll Content [g/sq.m]

2.80
0.83

Leaf Area Index

5.69
1.73
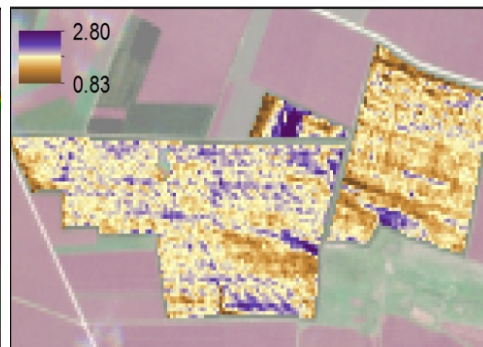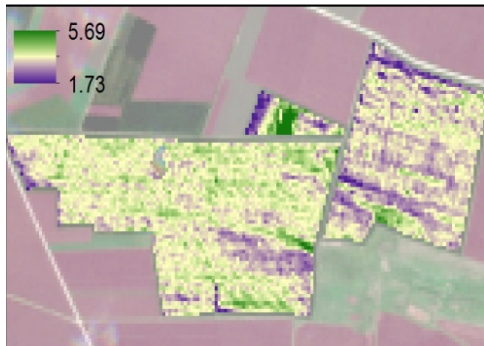
Fraction of vegetation cover

1
0.44
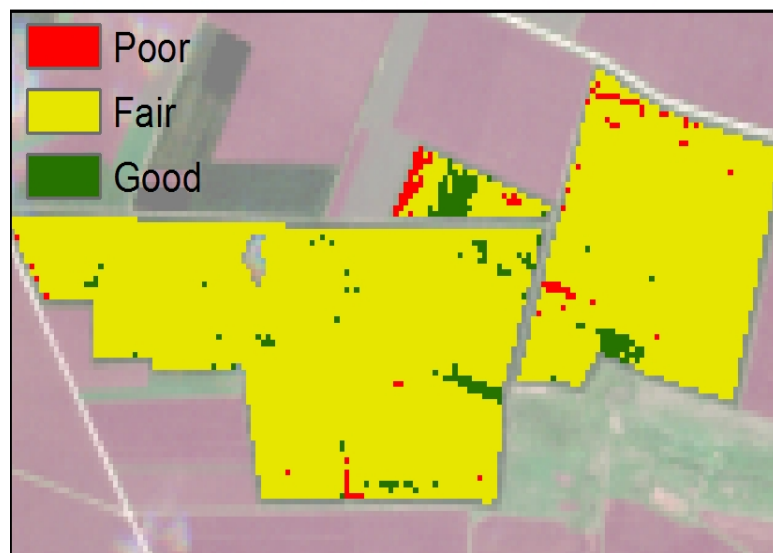
Rapeseed crops flowering duration estimation
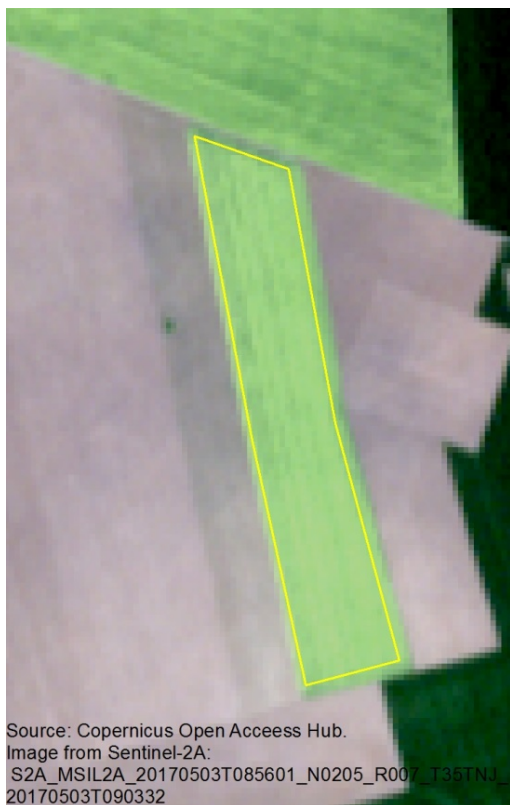
Source: Copernicus Open Acceess Hub.
Image from Sentinel-2A:
S2A_MSIL2A_20170503T085601_N0205_R007_T35TNJ_
20170503T090332

UAV RGB orthomosaic
Date: 20170430

Part of the PhD research by Dessislava Ganeva, project start date 01.07.2016 and end date 30.06.2019
This project is supported by Research Grant Award № ДФНП-17-43/26.07.2017 from the Bulgarian
Academy of Sciences and it is done with the collaboration of Prof. Rumenina E.

Special thanks to Pioneer™ for the use of their DJI Phantom 3 Advanced UAV equipped with RGB and
NIR digital camera

RESULTS

Ground-truthing with a drone

Date:30.04.2017   Date:19.05.2017   Date:26.05.2017

Test Field
NoData
Flowering
No Flowering

0   200   400 Meters
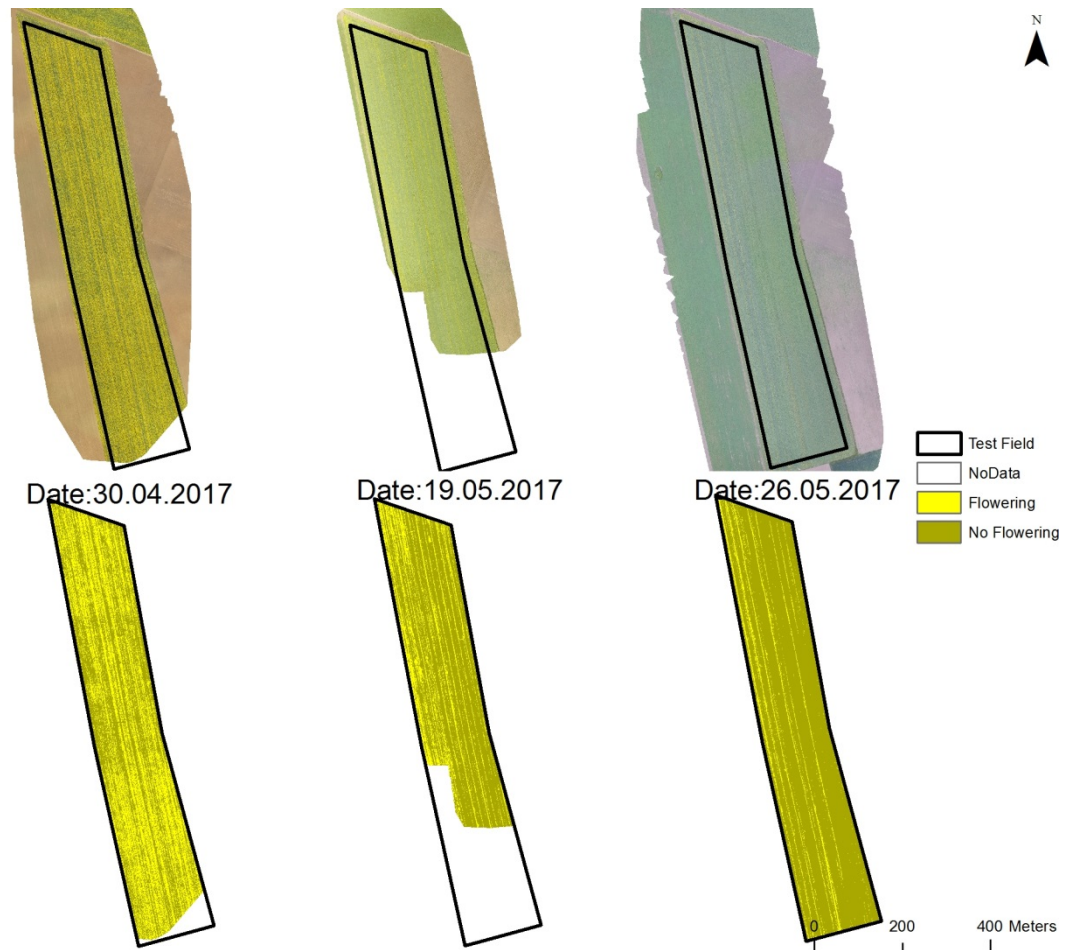
- Use RGB orthophoto images from consumer drone for ground truth
- Use the distinctive yellow color as identification for flowering
- Use transformation from RGB to another color model that decouples the intensity (or brightness) information from the color information

RESULTS

Flowering duration of the rapeseed crop with Sentinel-2 images

Date:03.05.2017   Date:13.05.2017   Date:23.05.2017

Legend:
- Test Field
- NoData
- Flowering
- No Flowering

0   200   400 Meters
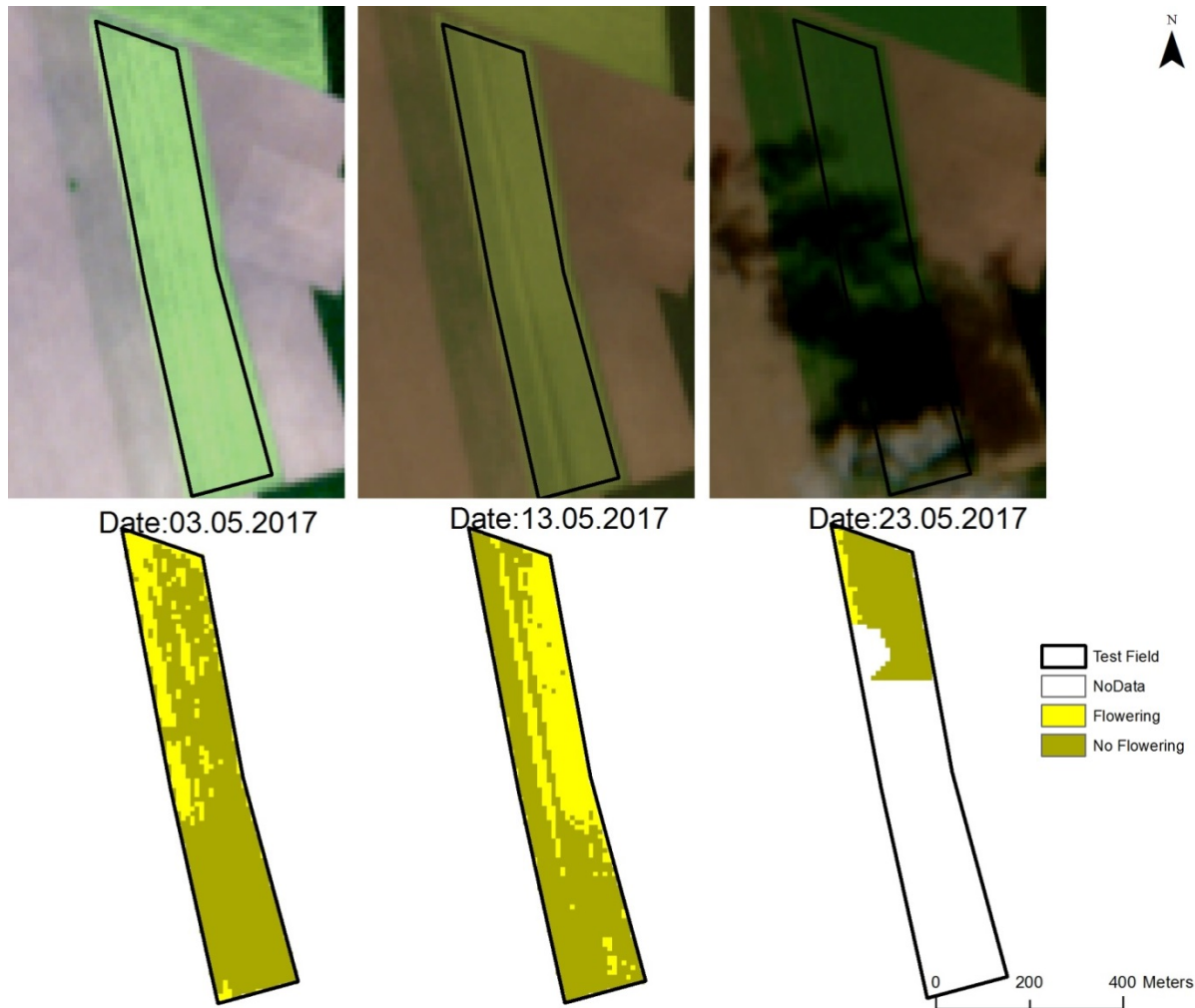
Poster presented at the 7th ESA Advanced Training Course on Land Remote Sensing, 4–9 September 2017 | Szent István University | Gödöllő, Hungary

References

1. Ganeva, D., 2017, *Remote Estimation of the Flowering Stage Duration for Winter Rapeseed Crops, Poster at the 13th International Scientific Conference*, In: Space, Ecology, Safety. SES'2017, 2–4 November 2017, Sofia, Bulgaria
2. Ganeva, D., 2018, *Rapeseed Crops Flowering Duration Estimation by RGB images acquired With Consumer Drone: a Tool For Ground-Truthing*, In: Proceedings from the 6th International Conference on Remote Sensing and Geoinformation of the Environment, 26-29 March, 2018, Paphos, Cyprus
3. Kazandjiev, V., V. Georgieva, D. Joleva, N. Tsenov, E. Roumenina, L. Filchev, P. Dimitrov, and G. Jelev. *The Changes and Fluctuations of Climate and the Production Conditions for Winter Wheat in the Dobrich District*. AID's journal *Field Crops Studies,* 2011, vol. VII–2. pp. 195-220. (in Bulgarian)
4. Roumenina, E., V. Kazandjiev, G. Stancalie. (Ed.) *Methodological Requirements for Testing PROBA-V and VEGETATION data for agricultural applications in Bulgaria and Romania (PROAGROBURO)* developed and published in bi-lingual versions (English-Bulgarian). *Prof. Marin Drinov* Academic Publishing House, Sofia, 2011, p. 148. ISBN 978-954-322-483-8
5. Roumenina, E., L. Filchev, P. Dimitrov, G. Jelev, V. Kazandjiev, Veska G., D. Joleva. *Monitoring of Winter Wheat of the Enola Variety on the Lozenets Reference Area Using Satellite and Ground-Based Data*. AID's journal *Field Crops Studies,* 2011, vol. VII–2. pp. 221-232. *ISSN 1312-3882*.
6. Roumenina, E., G. Stancalie, V. Kazandjiev, L. Filchev, P. Dimitrov, E. Savin, V. Vassilev, G. Jelev, L. Kraleva. Poster on the topic *Testing PROBA-V and VEGETATION data for agricultural applications in Bulgaria and Romania* presented at the Second Earth Observation – GMES Operational Capacity Workshop, Sofia, 17–18 March 2011.
7. Roumenina, E., Filchev, F., Vassilev, V., Dimitrov, P. Jelev, G. Stancalie,G., Savin,E., Mihailescu,D. *Comparative analysis of land-use/land-cover maps for chosen test sites on the territory of Bulgaria and Romania using low-resolution PROBA-V SD, 32nd EARSeL Symposium 2012, Mikonos Island, Greece*.

References

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THANK YOU FOR YOUR ATTENTION

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