

Sentinels for Agricultural Monitoring Sen4CAP – Concept & Goals

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Sentinels Looking after Agriculture





Copernicus Space Component

Long term continuity space observations



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Sentinels for Agricultural Dynamics



Majority of Europe >2 day revisit

Majority of Europe >3 day revisit



European Collaboration – Technology meets Policy







common agricultural policy



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Sen4CAP: R&D for Common Agricultural Policy



Sen4CAP Objectives:

- Provide evidence how Sentinel derived information can support the modernization and simplification of the CAP in the post 2020 timeframe
- Provide validated algorithms, products, workflows and best practices for agriculture monitoring relevant for the management of the CAP

Sen4CAP Implementation: (2017-2019)

- Collaboration with DG-AGRI, DG-GROW, DG-JRC, and national Paying Agencies
- Responding to the request from DG-AGRI & DG-GROW



Sen4CAP: R&D for Common Agricultural Policy

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ect:	Cooperation between the European Commission and the Europea Space Agency (ESA) on the follow-up of the CzechAgri study

57	and	the	European	Commission	have	an int	erest	in j	
sk	ome	nt of	Earth Obs	ervation (EO) use a	nd re	loted.	can	i

DG-GROW,

Fallowing frees promising results, is would be extremely useful to further explore-inthe cooperation with the Baregues Commission. Be capabilized on the Copencius of the Copencius of the Copencius of the Copencius of the Copencius CAP and the exponentiates of EOD from space for anyopering, the Isagerand Mathematical Copencius of Copencius of the Copencius of the Copencius properties and the Copencius of the Copencius of the Copencius of the Isagerand Structure (CAS), the Isagerand Structure of the Copencius of the Structure of the Copencius of the Copencius of the Copencius of the structure of the Copencius of the Isagerand Structure of the Copencius of the structure of the Copencius of the Isagerand Structure of the Copencius of the structure of the Copencius of the Isagerand Structure of the Copencius of the structure of the Isagerand Structure of the Isagerand Structure of the Copencius of the structure of the Isagerand Structure of the Isagerand

Vith this letter, we acknowledge and welcome ESA's readiness to continue this effort by onducting two or three follow-up pilot studies to the CzechAgri project in preparation of the CAP 2020 reform together with the main stukeholders (DG AGRI, DG GROW and G JRC) and the national Paying Agencies.

Mr. Josef Aschbacher Macrotor of Earth Observation Programmes imopean Space Agency fra Galiko Galikei Saella postale 64 00044 Frascati - Italy

We have taken great interest in the results of the CzechAgri study that was jointly initiated in December 2015 by ESA, DG JRC and SZIF (Czech Paying Agency) and successfully implemented thanks to ESA funding and a technical steering involving DG AGRI.

Endorsement of Copernicus for Use within the CAP



Commissioner P. Hogan: "...already Paying Agencies using data of the Sentinels ... ESA has launched a tender Sen4CAP which will provide us useful knowledge and further possibilities on how we use Sentinel data in the context of the CAP "

Sen4CAP – Expertise, Technology & Collaboration Cesa





Sen4CAP Pilot Countries – EU Agricultural Landscape CSA



From Satellites to Compliance Decision



Sentinel-1 & -2





Sen4CAP - 1st Evidence for CAP Monitoring Approach CSA

Benefits:

- Continuous and timely allowing for monitoring & preventive approach
- Wall-to-wall coverage 100% sample at national scale
- Physical temporal markers objective & transparent monitoring
- Global & open EO data EU wide consistent & comparable approach

Performance:

- EU Heterogeneity: tested for 6 countries landscape, field size, LPIS
- Reliability: validated over representative test sites
- Compliancy: Demonstration based on IACS use cases
- Efficiency: automation & cloud computing allows for economies of scale

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Sen4CAP: An European Effort to prepare for CAP2020 CSA

- Open & operational Sentinel time series enable CAP monitoring approach
- Integration in PA operations for IACS implementation essential
- Sen4CAP tools support automated, E2E monitoring at large scale
- Cloud computing on DIAS will allow for national to European up-scaling
- Open source approach for direct and customizable uptake & sharing



Sen4CAP – Time Planning & Status



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User Requirements collection

1. Analysis existing **recommendations** coming from the **CzechAgri pilot study** and the different **PA workshops** from the last months

2. Design of a **questionnaire** dedicated to the PAs formally involved in the project + **interview** of these PAs

3. Organize a **User Requirement Workshop** in which the user requirements will be discussed actively with all bodies involved



IACS Use Cases Definition

- User workshop, Brussels, 2017 July 20th
- Interactions with PAs and 3 EC-DGs
- User Requirements in terms of IACS use cases
 - Emphasis on the usefulness of the products to support decision about farmers' compliance
 - o Defined at the level of concrete use cases
 - o Traffic Light Approach



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Use case	Pilot country interested
Crop diversification	All
Permanent grassland identification / Comparison with permanent grassland reference	All
EFA-Land lying fallow	Czech Republic, Italy, Lithuania, Spain
EFA-Catch crops	Czech Republic, Lithuania, Netherlands, Romania
EFA-Nitrogen-fixing crops	Czech Republic , Italy, Lithuania, Romania, Spain
Land abandonment	All
Interactive visualization	All (national scale)
LPIS update	All
Claimless system	All

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Workplan for use case demonstration

Proof of concept

- ✓ Deliver a proof of concept through
 - Fast track prototypes
 - $\circ\,$ Iteration with PAs for final prototypes
- ✓ Pilot Review to provide early evidence of Sentinels benefit
- ✓ 2016 & 2017
- ✓ 10.000 km² test site + national coverage

Full scale demonstration

- ✓ Demonstration products and use case implementation
- ✓ 2018 & 2019
- ✓ National coverages for all six countries
- \checkmark Near-real time processing (2019) and timely delivery
- ✓ Operational environment of pilot PAs
- ✓ Capacity building and training

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Workplan for use case demonstration



Proof of concept

Full scale demonstration

- 1) Multi-national framework
- 2) Laboratory, up to national scale, in close collaboration with Paying Agencies
- 3) Open source deliveries for easy sharing & up-take of algorithms and know-how



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Proof of concept - 1st evidence of Sentinels benefits

- 1) Identify **use cases** (i.e. payment schemes) to test the use of Sentinels data in a monitoring approach
- 2) Identify Sentinel-based markers that could be relevant for these use cases
- 3) **Produce** these Sentinel-based markers over the 6 pilot sites
- 4) **Implement** these markers in use cases, going to the compliance decision



Sentinel-based markers for CAP Monitoring



6 National Pilots: Data collection and pre-processing

- Earth Observation data National coverages:
 - Sentinel-1 (SAR, 20m, 6-day revisit)
 - Sentinel-2 (optical, 10 & 20m, 5-day revisit)
 - Landsat 8 (optical, 30m, 16-day revisit)
- Access to IACS data sets (LPIS, GSAA, OTSC) data through Collaboration Agreements with Paying Agencies:
 - Used for methods development and products assessment
 - Close collaboration with Paying Agencies to ensure correct understanding
- Very High Resolution EO imagery provided from DG-JRC (assessment purpose)
- Internal project activities to collect ground data

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Sen4CAP System – Automated Processing



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Crop type mapping for crop diversification monitoring - Netherlands

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Crop type mapping for crop diversification monitoring - Netherlands

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Sentinels supporting crop diversification



Crop type mapping for crop diversification monitoring - Lithuania



Sentinel-based vegetation indicator as auxiliary data – Czech Republic

4 indicators





ID	NKOP_DPB	AREA	CONF_IDX	CT_DECL	CT_PRED_1	CT_CONF_1	C_INDIC
5482	681104301/1	23275	0	Maize	Winter rapeseed	0,56	Additional info required
6581	665114804/1	18086	1	Winter Wheat	Grassland	0,25	Additional info required



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EFA Catch crop assessment – Czech Republic

RULE: Winter Catch Crop must be sown before 20 Sept. and must not be harvested before 31 Oct. During this period, crop coverage must not be mechanically or chemically removed or limited in growth.



Harvest - Visual check







20.06.2017 52A20170620T33UWB 03.06.2017 S2A20170603T33UWR

21.06.2017 LE720170621T190025







07.07.2017 LE720170707T190025

22.07.2017 LC820170722T191025 30.07.2017 S2A20170730T33UWR











08.09.2017



*



18.09.2017 01.10.2017 11.11.2017 S2A20170918T33UWR S2A20171001T33UWR LC820171111T191025



EFA Fallow land assessment – Italy

RULE: Fallow land parcel must be represented by: bare land without vegetation; land with natural vegetation; seeded only for "green manure" (sporadic). Any cutting or other agronomic work remains forbidden. Must be in field from Jan to June (6 months).



Fallow land – Visual check



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EFA Nitrogen fixing crop assessment – Spain

RULE: Crops must reach at least blooming state. Sowing density and the rest of tilling tasks have to be suitable and according to local agricultural habits.



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Grassland mowing detection – Czech Republic





Not assessed Compliant No compliant (no mowing) Compliant (mowing in the period + other mowing) No compliant (mowing outside the period)

asa



Summary – Sen4CAP Use Cases

- Sentinels benefits for CAP monitoring demonstrated with *prototype* products
 - For IACS use cases: crop diversification, permanent grassland and EFA
 - Under specific assumptions in terms of parcels size, parcels geometry, etc.
 - Several ways identified to increase relevance of Sentinels markers:
 - Algorithms improvement
 - Interactions with PAs to better understand national cropping systems and regulations, and go to the holding-level
- Demonstration that Sentinel-based markers can be useful for CAP monitoring
 - Using S1 and S2 data (cloud computing)
 - Over 6 countries with diverse cropping systems, LPIS, landscape, etc.
 - Wall-to-wall coverage, from test sites up to national scale

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Towards PA's uptake of EO at National Scale

- Integration of Level 2, 3 and 4 Sen4CAP
 EO products & markers in PA's environment
- Visualization of data in Web interface
- National scale monitoring Assessment of cloud capabilities & requirements



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National Agricultural Monitoring: Processing resources

Czech Italy Republic Czech Republic Input EO data (2016-2019) Italy Output L2 data (2016-2019) 26 TB 128 TB Output L3 data (2016-2019) 31 TB 137 TB 50 TB Pre-processing resources (ongoing) 14 TB Products & distribution resources 16 cores, 90 GB 48 cores, 230 GB (ongoing)

*Average LPIS database volume: 0.1-10 GB

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OGC compliant web mapping service providing RGB imagery and simple indicators

URL - http://services.eocloud.sentinel-hub.com/v1/wms/c8d740dd-f9c0-4f6c-9a05-f2dabcfac982?

- Sentinel-2 L2A
 - True color, False color, Individual bands
- Landsat 8 L2A
 - True color, False color, Individual bands
- Vegetation Indeces
 - NDVI, LAI, Fcover, FAPAR

🚀 Create a new WMS connection ? 🗙									
Connection details									
	Name	Sen4CAP							
	URL	http://10.242.0.8:18080/v1/wms/c8d740)dd-f9	c0-4f6c-9a05-f2dabcfac982					
		 [-						
ID		Name	V	Title					
Ξ	··· 0			Sentinel Hub WMS					
	⊞ 1502	SEN4CAP_S2L3B.TIME		Sentinel 2 L3B - Tile time texts					
	⊡ 1488	SEN4CAP_S2L3B.OUTLINE		Sentinel 2 L3B - Tile outlines					
	🗄 1049	SEN4CAP_S2L3B.NDVI		Sentinel 2 L3B - NDVI					
	⊞ 1041	SEN4CAP_S2L3B.LAI		Sentinel 2 L3B - LAI					
	± 1509	SEN4CAP_S2L3B.ID		Sentinel 2 L3B - Tile ID texts					
	⊞ 1481	SEN4CAP_S2L3B.FILL		Sentinel 2 L3B - Tile fills					
	⊞ 1025	SEN4CAP_S2L3B.FAPAR		Sentinel 2 L3B - FAPAR					
	i⊞… 1495	SEN4CAP_S2L3B.DATE		Sentinel 2 L3B - Tile date texts	;				
	⊞ 1033	SEN4CAP_S2L3B.COVER		Sentinel 2 L3B - COVER					
	⊞ 927	SEN4CAP_S2L2A.TRUE_COLOR		Sentinel 2 L2A - True color					
	⊞ 1467	SEN4CAP_S2L2A.TIME		Sentinel 2 L2A - Tile time texts					
	i∰… 1453	SEN4CAP_S2L2A.OUTLINE		Sentinel 2 L2A - Tile outlines					
	⊞ 1474	SEN4CAP_S2L2A.ID		Sentinel 2 L2A - Tile ID texts					
	⊞ … 1446	SEN4CAP_S2L2A.FILL		Sentinel 2 L2A - Tile fills					
	⊞ 932	SEN4CAP_S2L2A.FALSE_COLOR		Sentinel 2 L2A - False color					
	⊞ … 1460	SEN4CAP_S2L2A.DATE		Sentinel 2 L2A - Tile date texts	5				
	⊞ 1017	SEN4CAP_S2L2A.CLD		Sentinel 2 L2A - Cloud Mask					
	⊞ 993	SEN4CAP_S2L2A.B8A		Sentinel 2 L2A - Band B8A					
	⊞ 1009	SEN4CAP_S2L2A.B12		Sentinel 2 L2A - Band B12					
	⊡ … 1001	SEN4CAP_S2L2A.B11		Sentinel 2 L2A - Band B11					
	🕀 <mark>985</mark>	SEN4CAP_S2L2A.B08		Sentinel 2 L2A - Band B08					
	🕀 ··· 977	SEN4CAP_S2L2A.B07		Sentinel 2 L2A - Band B07					

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WMS Service integrated in PAs environment

- Time filtering
- Configurable visualization
- Reprojection to local coordinate systems
- Customizable by country





Visualisation tool – Implementation by country



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Visualisation tool - Datasets

Input datasets generated by Sen4CAP

- Cultivated crop type map
- Grassland mowing detection product
- Vegetation status indicators
- Agricultural practices monitoring
- Sentinel-2
- Landsat 8
- Sentinel-1
- Input datasets from PAs
- LPIS data
- Declarations data

INFO	CONTENT	LAYER	PERSONAL		
Sen4C/	AP_Lithuania			ø	Ð
Cult	tivated crop typ	e map (Ul	R1)		Í
	Crop type map	LT		14	0
10	LT_LUT_Crop(Code		E 4	0
10	Crop_Category	1		4	0
	CropType_Cor	fIndic		E,	0
10	CropType_Cor	npIndic		E.	0
Gra	ssland mowing	product (UR2)		
	Grassland mov	ving LT		14	0
1	Satellite_Missi	on		E.	0
1	GrMow_Comp	liancy		E.	0
Agr	icultural practic	es monito	ring (UR4)		
	Agricultural pra	ctices LT		14	0
10	Agr_Practice			E4	0
1	Catch_Crop_T	ype		E 4	0
10	AgPr_Comp_Ir	ndicator		E.	0
10	AgPr_Ind_Con	d_Indicato	or	E.	0
10	AgPr_Flag			E.	0
In-S	itu data				
Tes	t site				

Vegetation status indicator (UR3)	
🗌 🚴 Sentinel-2 L3A - NDVI	0
🗌 🚴 Sentinel-2 L3A - LAI	0
🗌 🚴 Sentinel-2 L3A - FCover	0
🗌 🚴 Sentinel-2 L3A - FAPAR	0
Sentinel-2	
🗌 🚴 Sentinel-2 L2A - True Color	0
🗌 🚴 Sentinel-2 L2A - False Color	0
Landsat 8	
🗌 🚴 Landsat 8 L2A - True Color	0
🔲 🚴 Landsat 8 L2A - False Color	0

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Visualisation tool – products metadata

Product description

- Year
- Type of agricultural practice
- Regulation
- Interpretation of
 regulation
- Description of fields

Legends

Codelists with descriptions



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Visualisation tool – view attributes of the parcel related to the selected layer



Visualisation tool – Queries over multiple fields



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Visualisation tool – viewing results at farm level for Cesa compliance assessments

1003892612_1003892612_3 1003892612_1003892612_1 1003892612_1003892612_1 Advanced filter Use all fields (AND)* * * 75 m											
E N: 2588037.775	5 7448846.171 55°	26'44.41" N 23°14'5	5.46" E				1 973292610	© 2018 Sinergi	ise d.o.o. Data: terres	tris GmbH, OpenS	treetMap contributors
Table of records for	or layer: Crop type	e map LT (Filtered)						S Refresh	Add selection set	🛃 Export layer	🗹 🍸 Filter 🗙
VALDA (Holding no.)	KZS (Block no.)	LAUKO_NR (Field no.)	Area	Conformity	CT_decl	CT_pred_1	CT_conf_1	CT_pred_2	CT_conf_2	Status	C_Indic
1003892612	146452-5589	2	6,398	1.0	MNŠ	MNŠ	0.161	DOB	0.092	Yes	Compliant
1003892612	145452-6380	1	11,004	1.0	MNŠ	MNŠ	0.332	DOB	0.163	Yes	Compliant
1003892612	145451-5152	ī	8,550	1.0	NMI	AVI	0.227	KVV	0.117	Yes	Insufficient evidence
1003892612	145451-5768	1	15,131	1.0	KRŽ	KVŽ	0.434	KRŽ	0.19	Yes	Expert-judgement required
1003892612	146452-0763	3	19,083	0.0	MNŠ	MNŠ	0.355	DOB	0.129	Yes	Compliant
1003892612	145452-8265	2	18,000	0.0	MNŠ	MNŠ	0.318	DOB	0.138	Yes	Compliant
= •• •		± 10.9	- 😑 🗖						I+I	Europ	ean Space Agency

Visualisation tool – Visualize S2 and L8 data on chosen time = timely decisions



Visualisation tool – Time animation following crop dynamics



Visualisation tool – NDVI/LAI/FCover/FAPAR indicator value averaged at the parcel-level





From National to European scale



	Czech Republic	Italy	Europe
Input EO data (2016-2019)	26 TB	128 TB	3 PB
Output L2 data (2016- 2019)	31 TB	137 TB	4 PB
Output L3 data (2016- 2019)	14 TB	50 TB	1.5 PB
Pre-processing resources (ongoing)	16 cores, 90 GB	48 cores, 230 GB	1000 cores, 6 TB
Products & distribution resources (ongoing)	28 cores, 72 GB	62 cores, 144 GB	1000 cores, 3 TB

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Cloud Computing Approach

- DIAS environment
 - Sentinel (and Landsat) data are there
 - No need to copy data
 - Infrastructure resources available (economy of scale)
 - PA's data inputs (security, privacy)
- Transparent selection of DIAS provider
 - Sentinel-1, Sentinel-2, Landsat 8
 - Europe
 - Long-term archive
 - Pre-processing ?
- Adaptation of EO tools required

• SNAP, Orfeo Toolbox ESA UNCLASSIFIED - For Official Use

Cloud Computing Recommendations

- Raster data streamed over OGC WMS/WCS
 - Avoiding large downloads
 - Compute intensive tasks
 - Weekly of more frequent
 - Can be run by a 3rd party (DIAS?)
- Vector data downloaded as SHP and integrated in PA's environment
 - Alternative option WFS
 - weekly/monthly
 - can be run by a 3rd party or by PAs (in the cloud)

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Perspectives – Sentinels for CAP

- First experiment of Sentinels contribution to CAP use cases tested across 6 countries directly assessed by the corresponding Paying Agencies
 - For crop diversification, EFA and permanent grassland using Sentinels-based markers
 - Using S1 and S2 data, based on cloud processing
 - Improvements expected from tuned algorithms and interactions with PAs based on concrete use cases
- Forthcoming experiment to run prototype using Sentinels and LPIS/GSAA at national scale in 6 different countries for the current CAP use cases and forthcoming CAP monitoring
- Open source tools tested, documented and demonstrated on cloud infrastructure (DIAS) available to the Member States and the CAP application
 - Generic approaches tunable to national/local cropping systems
 - Cloud-computing solution compatible for nationwide production
- Go one step forward to also provide relevant information supporting farmers during the season ESA UNCLASSIFIED - For Official Use