Sentinel-2 Agriculture project

Preparing Sentinel-2 exploitation for agriculture monitoring

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Koetz Benjamin

due
data user element
European Space Agency

Copernicus Sentinel-2

Multispectral High Resolution Optical Imager

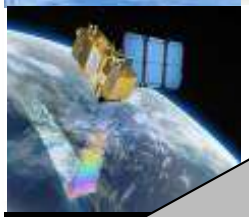
- Launch: 2014/15, 2016, ...
- 13 bands (VIS, NIR & SWIR)
- 290 km swath at 10, 20 and 60 m
- Systematic acq. of all land and coasts
- 5 days repeat cycle with 2 satellites
- 7 years design lifetime (max. 12 yrs)

Sentinel Missions
Joint EU-ESA Copernicus Space Programme

Long-term Continuity and Access to suitable EO data

- Free, full and open data policy*

Sentinel 1 – SAR imaging
All weather, day/night applicati



Sentinel 2 –
Land a
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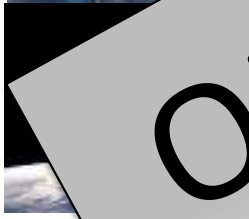
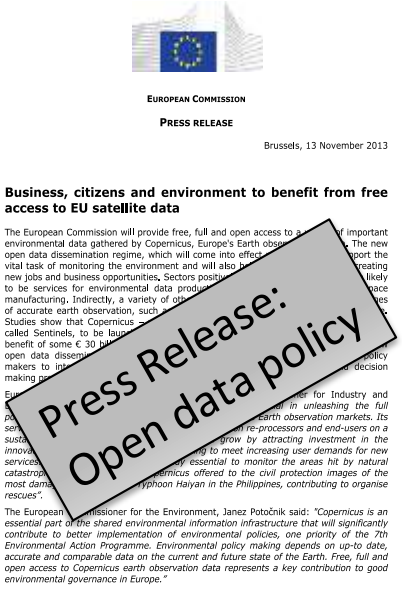


bal land monitoring
, **global vegetation**, sea/land
re, altimetry

2014/15 & 2016

OPERATIONAL



European Commission

Press release

Brussels, 13 November 2013

Business, citizens and environment to benefit from free access to EU satellite data

The European Commission will provide free, full and open access to a of important environmental data gathered by Copernicus, Europe's Earth obse . The new open data dissemination regime, which will come into effec port the vital task of monitoring the environment and will also h reating new jobs and business opportunities. Sectors positi likely to be services for environmental data produ pace manufacturing. Indirectly, a variety of ot es of accurate earth observation, such Studies show that Copernicus called Sentinels, to be laun benefit of some € 30 bil open data dissemi policy makers to in d decision making p

Eu er for Industry and *in unleashing the full* p *earth observation markets. Its* ser re-processors and end-users on a *sust grow by attracting investment in the* innova g to meet increasing user demands for new *services* y essential to monitor the areas hit by natural *catastrop pernicus offered to the civil protection images of the most dam typhoon Haiyan in the Philippines, contributing to organise rescues".*

The European missioner for the Environment, Janez Potočnik said: *"Copernicus is an essential part of the shared environmental information infrastructure that will significantly contribute to better implementation of environmental policies, one priority of the 7th Environmental Action Programme. Environmental policy making depends on up-to date, accurate and comparable data on the current and future state of the Earth. Free, full and open access to Copernicus earth observation data represents a key contribution to good environmental governance in Europe."*

IP/13/1067

Press Release:
Open data policy

* Joint EU/ESA Data Policy Principles adopted by ESA member states in Sep '09, EU announced for Nov. 2013

Sentinel contribution to JECAM & GEOGLAM Primary missions for all targets Products

Req#	Spatial Resolution	Spectral Range	Effective observ. frequency (cloud free)*	Sample Type	Field Size	Target Products: Crop Mask	Crop Type Area and Growing Calendar	Crop Condition Indicators	Crop Yield	Crop Biophysical Variables	Environ. Variables	Ag Practices / Cropping Systems
	Coarse Resolution Sampling (>100m)											
1	500 - 2000 m	thermal IR + optical						X	X			
2	100-500 m	optical + SWIR				X	X	X	L	L		L
3	5-50 km	microwave	Daily	Cropland Extent	All			X	X	X	X	
	Moderate Resolution Sampling (10 to 100m)											
4	10-70m	optical + SWIR + TIR	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	Cropland Extent	All	X	L/M					X
5	10-70m	optical + SWIR + TIR	Weekly (min. 1 per 16 days)	Sample	All	X	X	X	X	X	X	X
6	10-100m	SAR	Weekly (min. 1 per 2 weeks)	Cropland Extent of persistant cloudy areas/Rice	All	X	X	X	X	X	X	X

Copernicus Global Land Programme

Sentinel-3

SMOS

Sentinel-2

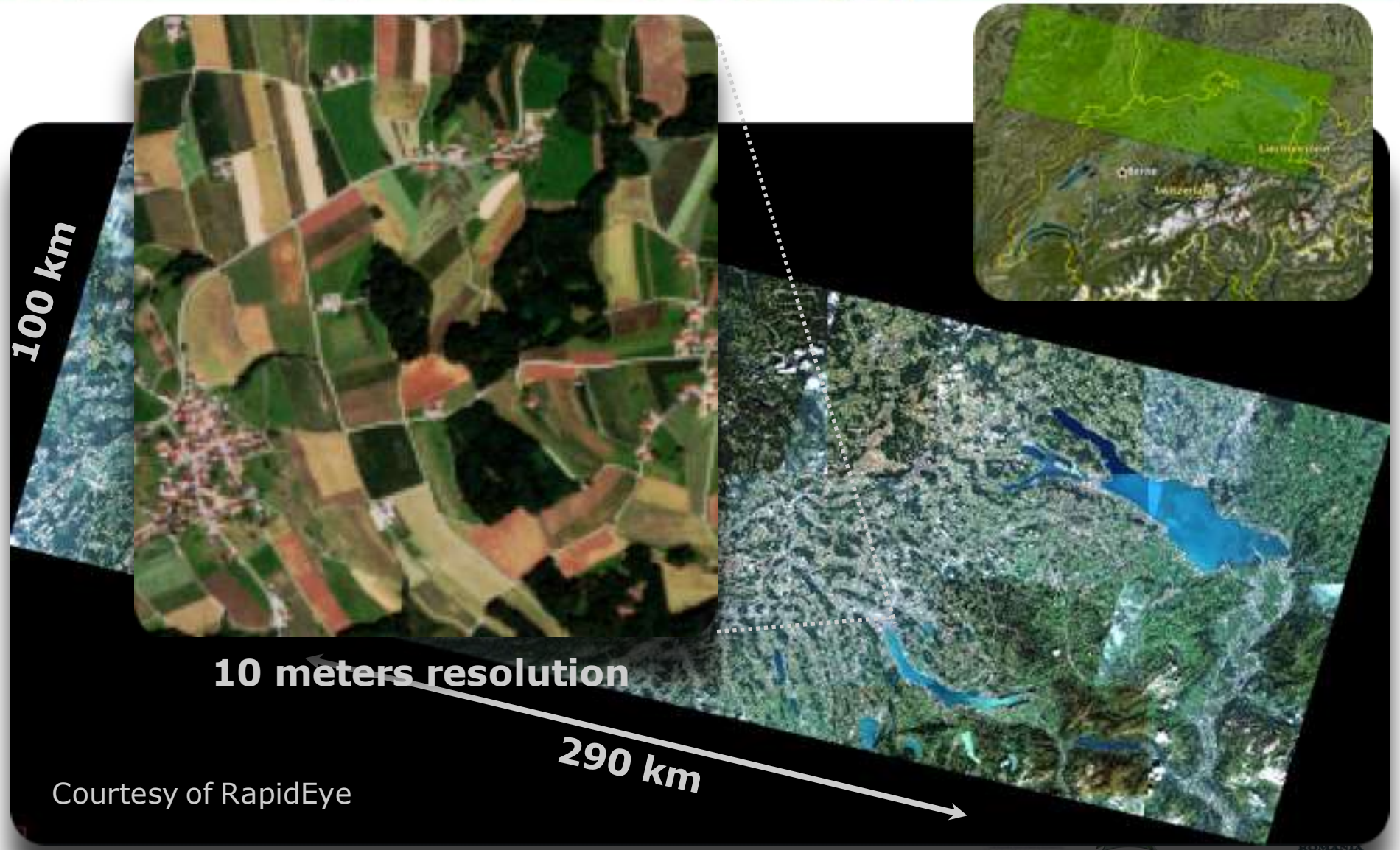
Sentinel-2

Sentinel-1

Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM PHASE 1

Sentinel-2: Coverage & Resolution

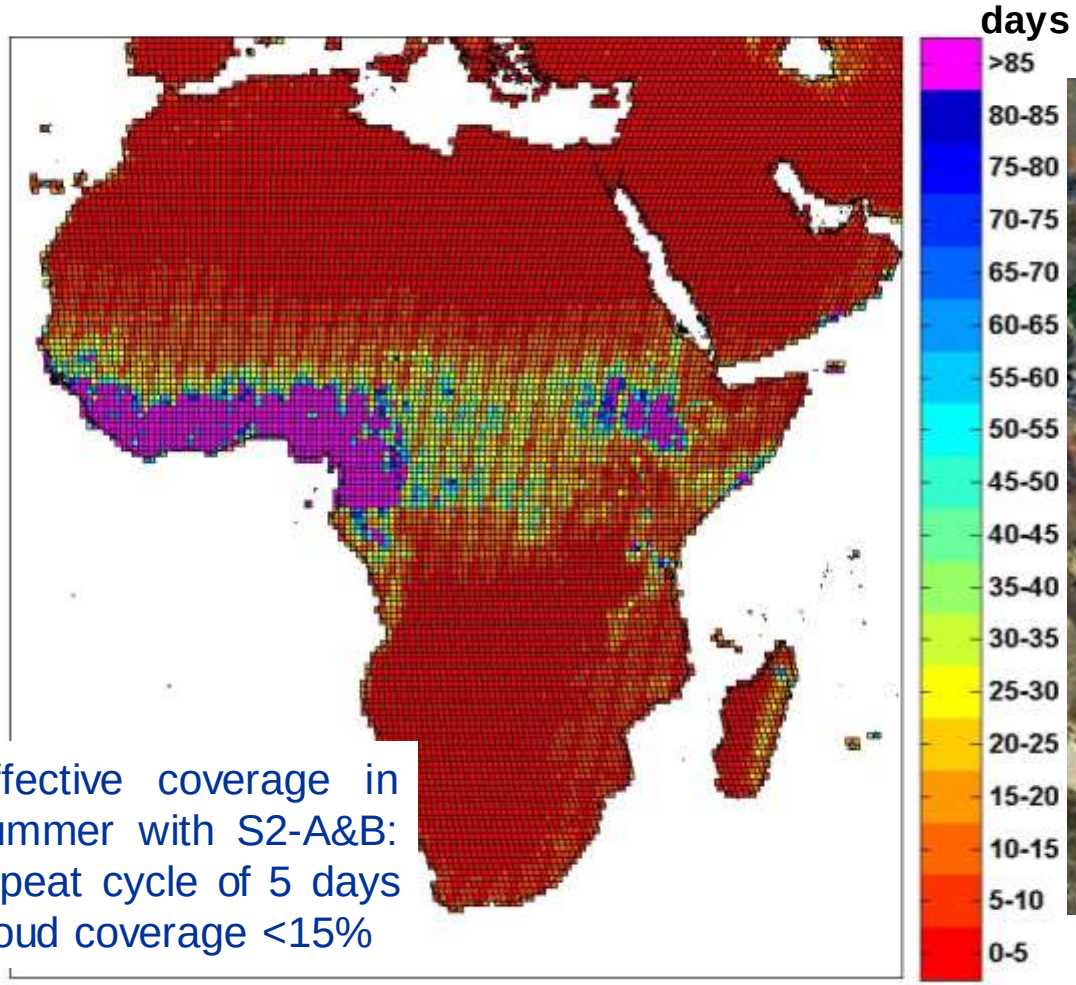
10 m resolution for field scale mapping



Courtesy of RapidEye

Sentinel-2 Revisit Time Capability

5 days revisit for crop dynamics



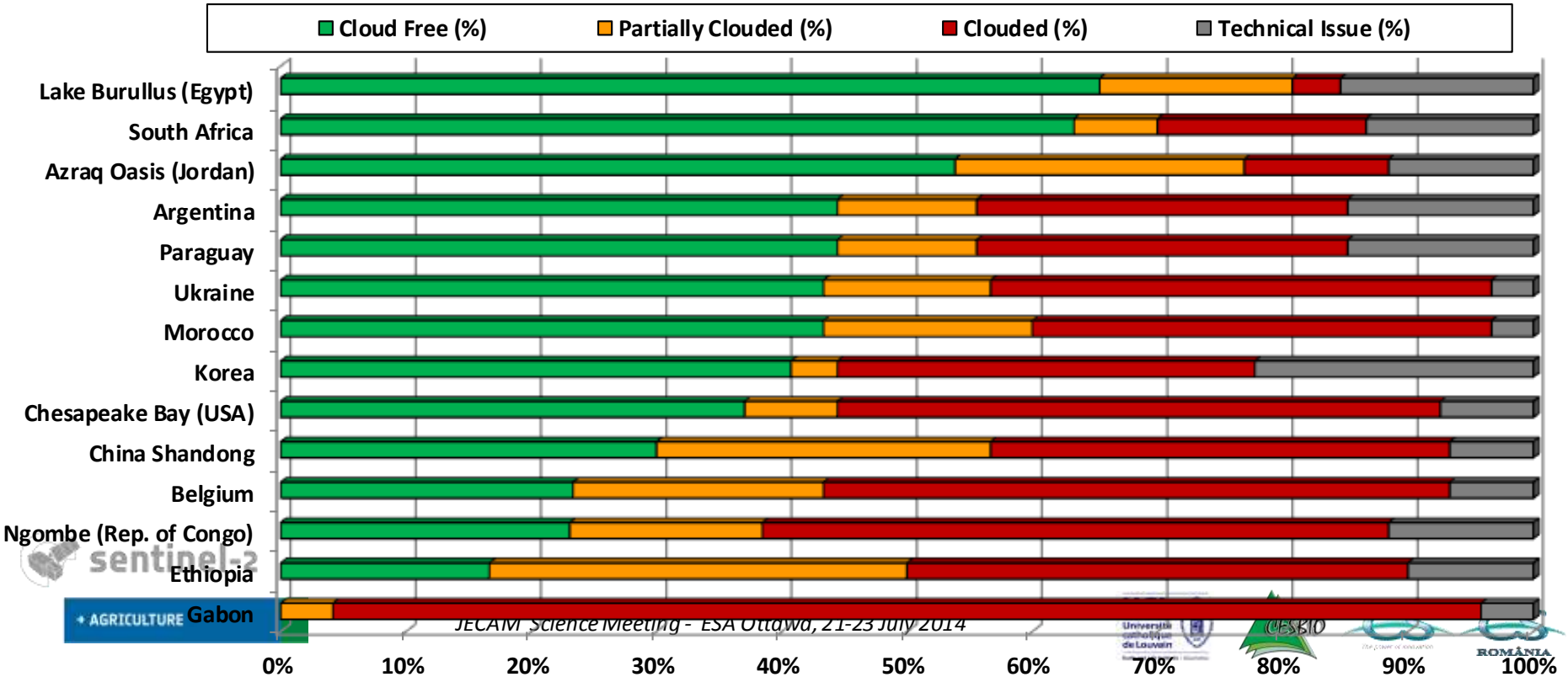
Effective coverage in summer with S2-A&B: repeat cycle of 5 days cloud coverage <15%

South Africa JECAM site: 5 days revisit, February-June 2013 - RapidEye

Monthly cloud free composites possible for most areas

Overview of S2 Time Series: RapidEye

- Total of 390 acquisitions, 24-30 per site
- 38% cloud free of total acquisitions (0-65% at site level)
- Even with 5 days repeat, low coverage over Europe during growing season



Sen2-Agri – a timely project for a very hot topic

EO response to operational agricultural applications :

- **Sentinel-2 mission to finally reach ag. expectations** (jointly with Landsat-8 and Sentinel-1)
- Emerging collaborative initiatives endorsed by G20 in the context of GEO (AMIS, GEOGLAM)
- CEOS support to global agriculture users requirements
- US and Chinese efforts on 30-m global croplands mapping
- JECAM and SPOT4-Take 5 initiatives opening the door to move from local experiments to global solutions

=> unique momentum for satellite remote sensing in agriculture

Sen2-Agri partnership

Consortium

UCL Université catholique de Louvain
CESBIO
CS
CS ROMÂNIA

Support & data provider

esa

Champion Users

Agriculture and Agri-Food Canada
RADI
FAO
IFAD
European Commission
cirad
RCMRD
جامعة شعيب الدكالي
Université Chouaïb Doukkali
ولاية الخرطوم
KHARTOUM STATE
WFP
NEOSS
USGS
INTA
ATIC
ARVALIS
Fenareg

Site managers & JECAM network

cirad
CSIR
INRA SCIENCE & IMPACT
ARC • LNR
FAO
ISTC
RADI
USDA
INTA
CESBIO
UCL

sentinel-2
+ AGRICULTURE

Sen2–Agri Objectives

- **Preparation for national to regional agricultural monitoring based on Sentinel-2**
  - R&D for full exploitation of temporal & spatial resolution of S2
- **Consolidate Best Practices for EO agricultural monitoring**
  - Benchmarking & validation of algorithms for 4 EO products
  - Testing products over a wide range of conditions (JECAM network)
- **Strengthening National Capacity for Agricultural Monitoring**
  - Open source system supporting **national reporting & food security**
  - Transfer to users including local system installation & training
  - Demonstration of validated agricultural EO products at national scale

User oriented approach

- Initial user's requirements survey in April 2012 by ESA with about 50 members of the agricultural communities
  => more than **15 organizations - our "Champion Users"** - agreed to remain actively involved in the Sen2-Agri project
- Consolidation of user's requirements by additional survey and interviews by the project team

- **1st User Workshop** hosted by FAO on 19 May 2014

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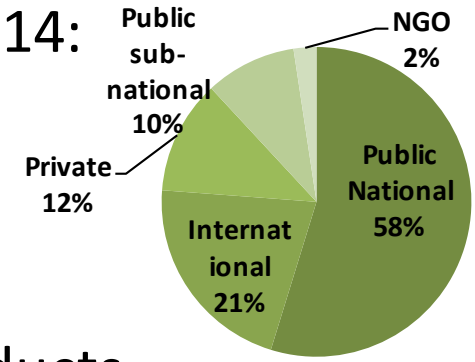
  12 sites managers
  30 representatives of the Champion Users



=> very successful interactions

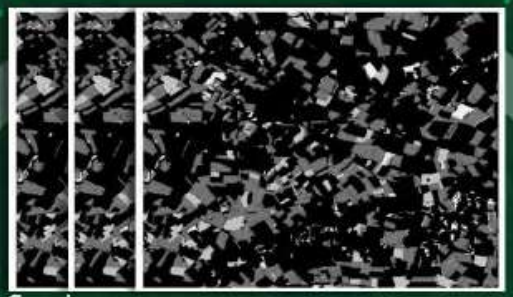
=> very important outcomes for Sen2-Agri products

Ag. products from users requirements

Monthly cloud free surface reflectance composite at 10 m

CLOUD FREE SURFACE REFLECTANCE COMPOSITES

DYNAMIC CROPLAND MASK

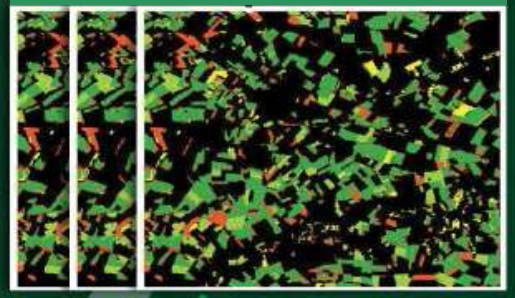


Binary map identifying annually cultivated land at 10m updated every month

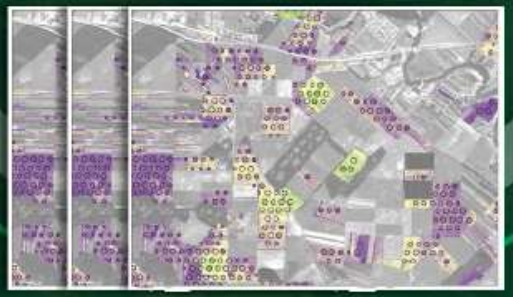
Open source toolbox
Capacity building and training

CULTIVATED CROP TYPE MAP

EARLY AREA INDICATOR



VEGETATION STATUS



Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index)

Crop type map at 10m for the main regional crops including irrigated/rainfed discrimination

Main expected deliverables

1. **A core of processing strategies** (ATBD) combining advanced algorithms to produce 4 types of EO agri. products and able to deal with the large range of agricultural systems (JECAM collaboration)

2. **An open source and portable software** developed from the OTB to convert the S2 L1c data into cloud free multispectral surface reflectance mosaic and to produce relevant EO products

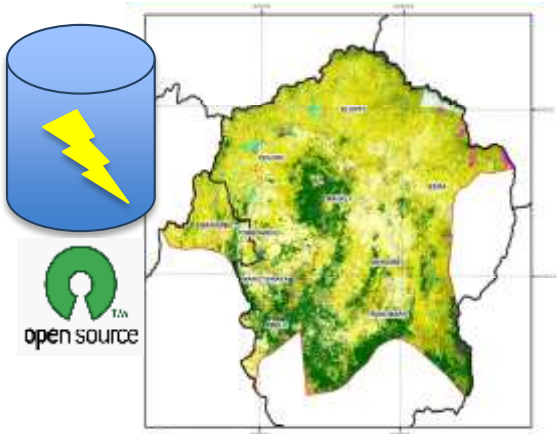
3. A set of **4 validated S2-derived products** for each of the 8 demonstration cases

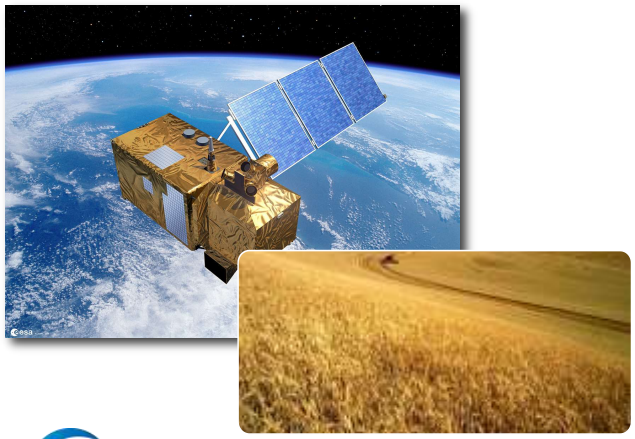
4. A **key users community** trained and ready for S2 exploitation

Sentinel-2 for Agri overview

Algorithm Development → Prototypes of EO products → Demonstration & Validation

JECAM
Joint Experiment for Crop Assessment and Monitoring





GEOGLAM
Global Agricultural Monitoring

Main Design Activities:
- User Requirements
- EO product specification
- Algorithm Development

Processing System:
- 4 agricultural EO products
- Open source system
- Testing & validating of EO prototypes (12 sites)

Use cases:
- 3 national cases & 5 local cases(290x290 km)
- Validation of EO products
- Transfer to national users

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+ AGRICULTURE

Test sites for algo. benchmarking

12 test sites for the benchmarking and algorithm selection based on existing data set :

Spot 4 Take 5
South Africa

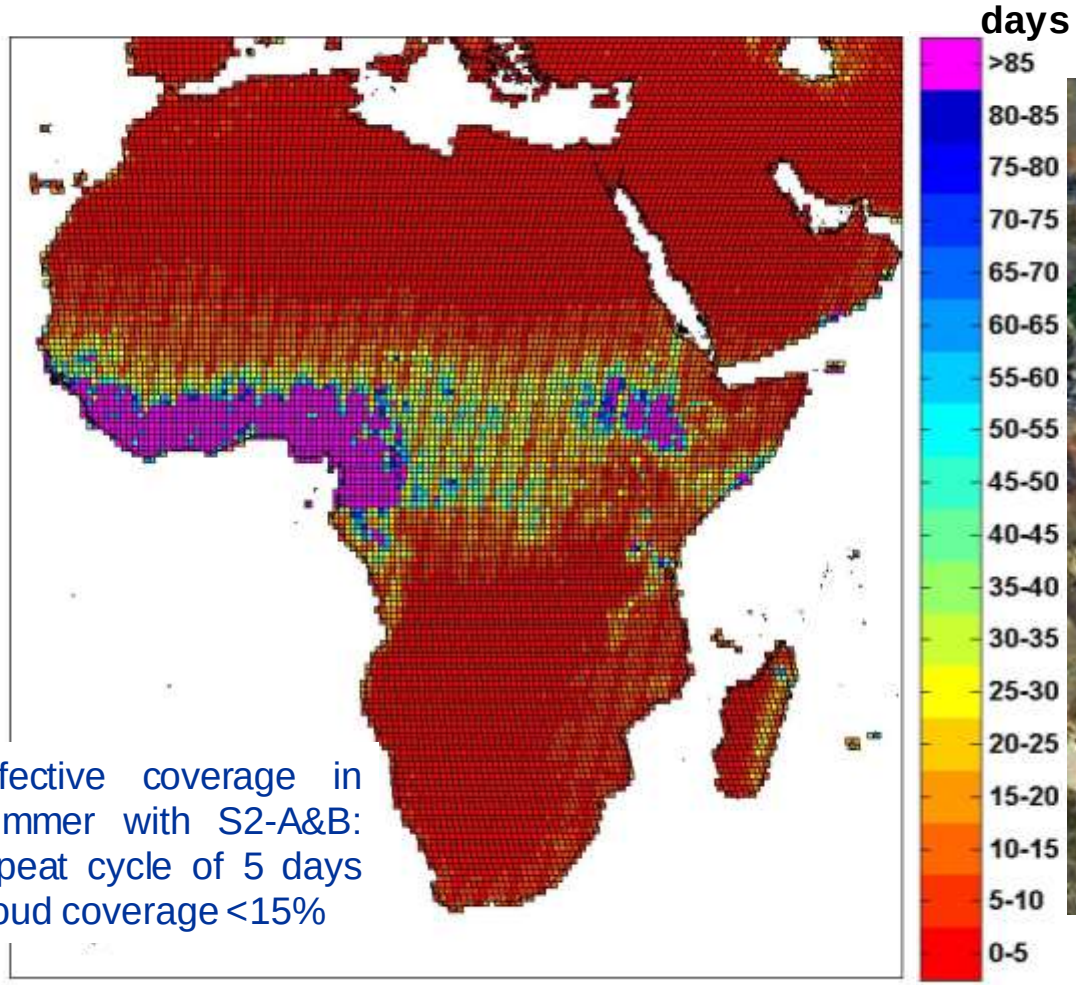
- Already existing field data (+ possible field completion) based on 8 JECAM sites and SPOT-4 Take 5 TS

- Satellite time series
  - SPOT4-Take 5
  - Landsat-7 & 8
  - RapidEye (Take 5 + TPM)

Sentinel-2 Revisit Time Capability

5 days revisit simulated by SPOT 4 Take 5

courtesy of B. Koetz - ESA



Effective coverage in summer with S2-A&B: repeat cycle of 5 days cloud coverage <15%

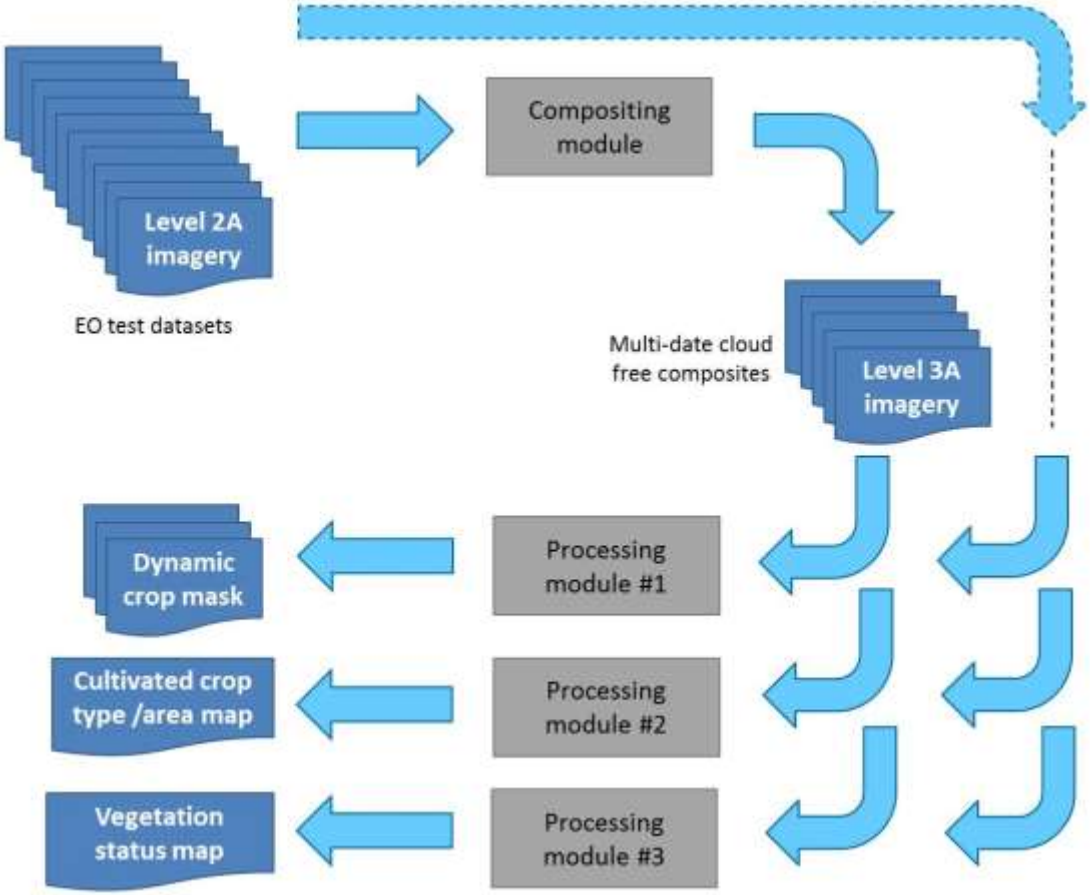
South Africa JECAM site: 5 days revisit, February-June 2013 - RapidEye

Monthly cloud free composites possible for most areas

see SPOT4T5 presentation by Olivier Hagolle – Th. 10:10

Algo. benchmarking and method development

Close collaboration with the JECAM sites network and associated teams to assess results across sites to tackle the ag. diversity



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Vegetation status

- Map of vegetation status at 20 m (NDVI, LAI, phenology index) to be delivered every 10 days

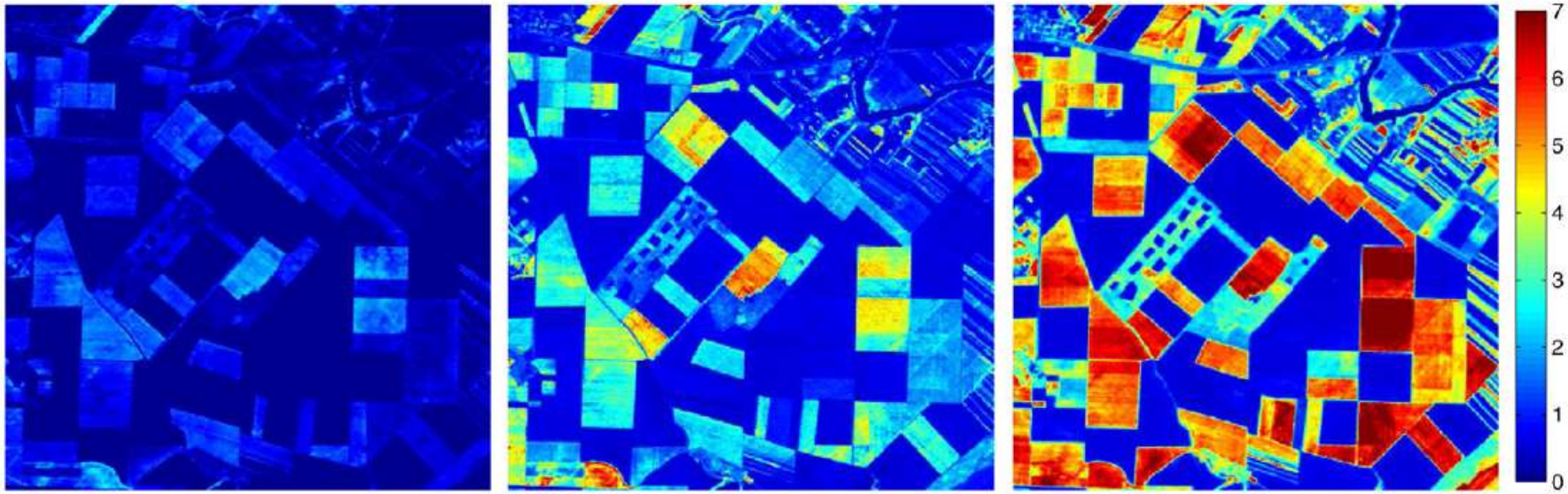


Fig. 3. Spatialized GAI obtained from images acquired (from left to right) on March 3rd, on April 4th and May 5th, 2001. All images have been corrected with the linearisation operation (described in the text) and all depict GAI values using the same colour scale (far right). Most of the fields which are orange or red over the right-most image are winter wheat fields.

Duveiller et al., RSE 2011

Test sites for demonstration

5 local use cases (290 x 290 km) for the system demonstration

- using actual Sentinel-2 time series
- validated by synchroneous in situ data collection

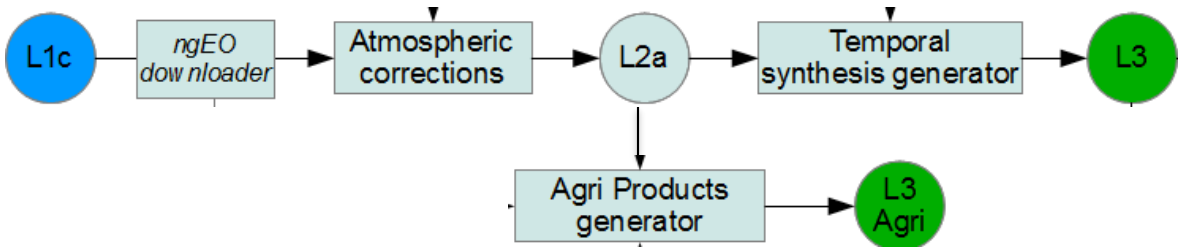
3 national use cases for demonstration of Sen2-Agri system from

- using actual Sentinel-2 time series
- validated by synchroneous in situ data collection

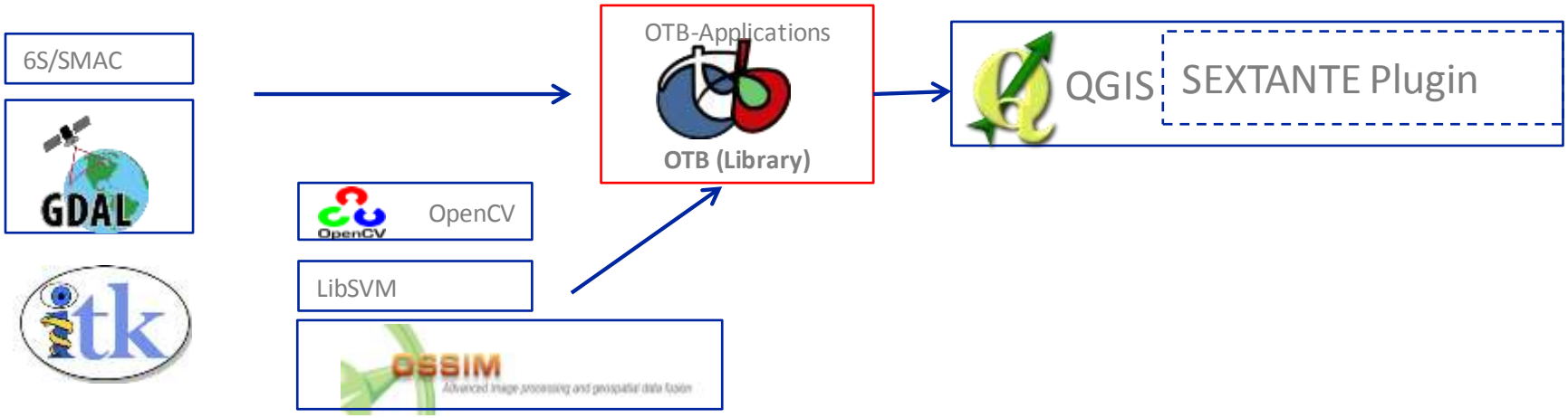
Local and national demonstration cases to be selected before the end of Sen2-Agri phase 2 (around Sentinel-2 launch)

Sen2-Agri system : a stand alone open source toolbox

From **Sentinel-2 L1c** data to 4 end-user products



based on existing open source software (Orfeo Tool Box, QGIS)

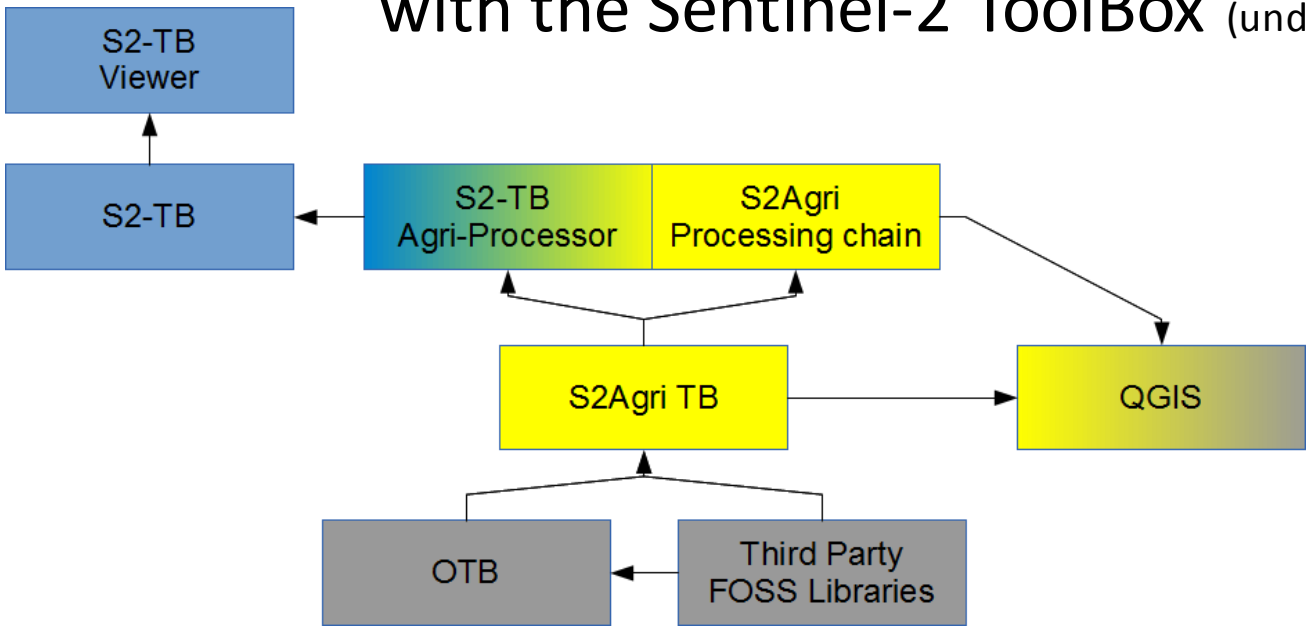


using an iterative development process (internal validation + users feedback)

S2Agri ToolBox processing plan

Strong interaction with existing tools and

with the Sentinel-2 ToolBox (under development)



Production of 4 Sen2-Agri products from Sentinel-2 time series for the demonstration cases

Data volume estimation for demonstration cases

Preliminary estimation of **Sentinel-2 data**	**Local Case (290x290 km)**	**National Case (500 000 km²)**
Single observation (level 1C)	≈ 3,5 GBytes	≈ 21 GBytes
6 months time series with 5 days cycle	≈ **128 GBytes**	≈ **762 GBytes**
Monthly surface reflectance composite	≈ 56 GBytes	≈ 335 GBytes
10-d vegetation status product (6 months)	**≈ 76 GBytes**	≈ 455 GBytes
Monthly dynamic cropland masks	≈ 5 GBytes	≈ 30 GBytes
Cultivated crop type and area indicator	**≈ 0,8 GBytes**	**≈ 5 GBytes**

=> Data volume reduction from L2 to L3 but mainly from L3 to L4

=> Need a large bandwidth to retrieve S2 product and disseminate output

=> Users tool and computers not necessary ready to open these big files as usual

5 main Sen2-Agri Challenges

- Addressing the **large diversity** of agricultural systems
- Algorithms selection and system development **before S2**
- **Portable open-source solution** for operational production
- **Timeliness** of EO products from Sentinel2 large volume
- **EO products validation** by users and external partners

Sen2-Agri communication to stay tuned and updated

3 User Workshops

Newsletter

Joint JECAM Meetings

www.esa-sen2agri.org

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Thank you for your attention
Niger - UCL 2006

sentinel-2

→ AGRICULTURE

Sentinel-2 for Agriculture: Test sites & demonstration

esa

ID	Site name	InSitu data	
1	Argentina	JECAM	L8 (RE)
2	Belgium	JECAM	Take5, L8, RE
3	China (Shandong)	JECAM	Take5, L8, RE
4	Ukraine	JECAM	Take5, L8, RE
5	South Africa	JECAM	Take5, L8, RE
6	Madagascar	JECAM	Take5, L8, RE
7	Tunisia	CESBIO	Take5, L8, RE
8	CSudmipyO	JECAM	Take5, L8, RE
9	CMaroc	JECAM	Take5, L8, RE
10	Russia (Tula or Stavropol)	JECAM	L8 or RE
11	Malawi	From users	L8 or RE
12	Pakistan	From users	L8 or RE
13	Maricopa	USDA	L8 or RE
14	Provence	INRA	Take5

JECAM
Joint Experiment for Crop Assessment and Monitoring

GEOGLAM
Global Agricultural Monitoring

Potential National Demonstration:

- Sudan
- Morocco
- Malawi
- Pakistan
- Russia
- UCL Université catholique de Louvain, CESBIO, CS, CS ROMÂNIA

S2 Products / Overview

Name	High-level Description	Production	Preservation Strategy	Volume
Level-1B	Top-of-atmosphere radiances in sensor geometry	Systematic	Long-term	~27 MB (each 25x23km^2)
Level-1C	Top-of-atmosphere reflectance in cartographic geometry (UTM/WGS84)	Systematic	Long-term	~500 MB (each 100x100km^2)
Level-2A	Bottom-of-atmosphere reflectance in cartographic geometry	On user side (using Sentinel-2 Toolbox)	-	~600 MB (each 100x100km^2)

Sentinel contribution to GEOGLAM Products

Req#	Spatial Resolution	Spectral Range	Effective observ. frequency (cloud free)*	Sample Type	Field Size	Target Products: Crop Mask	Crop Type Area and Growing Calendar	Crop Condition Indicators	Crop Yield	Crop Biophysical Variables	Environ. Variables	Ag Practices / Cropping Systems
	Coarse Resolution Sampling (>100m)											
1	500 - 2000 m	thermal IR + optical	Daily	Wall-to-Wall	All			X		L		
2	100-500 m	optical + SWIR	2 to 5 per week	Cropland Extent	All	X	X	X	L	L		L
3	5-50 km	microwave	Daily	Cropland Extent	All			X	X	X	X	
	Moderate Resolution Sampling (10 to 100m)											
4	10-70m	optical + SWIR + TIR	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	Cropland Extent	All	X	L/M	Sentinel-2				X
5	10-70m	optical + SWIR + TIR	Weekly (min. 1 per 16 days)	Sample	All	X	X	X	X	X	X	X
6	10-100m	SAR	Weekly (min. 1 per 2 weeks)	Cropland Extent of persistant cloudy areas/Rice	All	X	X	X	X	X	X	X

Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM PHASE 1