

D2.2: Gap Analysis Report



EO Best Practice – Agro-Insurance

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14 April 2020

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EO Best Practice – Agro Insurance
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Acronyms and Abbreviations

ASV	Austrian Hail, Swiss Hail, Vereinigte Hagel Insurance
CCI	Climate Change Initiative
CHIME	Copernicus Hyperspectral Imaging Mission
DEM	Digital Elevation Model
DMP	Dry Matter Production
EARSC	European Association of Remote Sensing Companies
EEA	European Environment Agency
EO	Earth Observation
EO4I	Earth Observation best practices for agro-insurance
ESA	European Space Agency
FAPAR	Fraction of Absorbed Photosynthetic Active Radiation
IPCC	Intergovernmental Panel on Climate Change
LPIS	Land Parcel Identification System
LST	Land Surface Temperature
LSTM	Copernicus Land Surface Temperature Monitoring
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
R&D	Research & Development
ROSE-L	L-band Synthetic Aperture Radar
SAR	Synthetic-aperture radar
VGT	Vegetation

1 Introduction

The ESA project “Earth Observation (EO) best practices for the agro-insurance sector” or “EO4I” project provides a roadmap with guidelines for the use of EO for the agro-insurance sector. To get sector insights the consortium collaborates with a working group of three European agro-insurance companies (Austrian Hail Insurance, Swiss Hail Insurance and Vereinigte Hail Insurance), hereafter named as the “Working Group ASV”.

In support of this roadmap, two main tasks have been defined:

- Task 1: Analysis of the geoinformation needs of the sector
- Task 2: Analysis of current EO capabilities relevant to the needs, and assessment of capability gaps

In Task 1, documented in the “D1.2 Geoinformation Requirement Report”, four activities (two workshops, online user survey and dedicated interviews with the ASV group) were undertaken to obtain the most recent insights in the geoinformation needs from the sector. This report provides an insight of the identified key geo-information requirements of the sector.

The objective of Task 2 is to identify and characterize existing EO-based information products and services relevant to the agro-insurance sector, and to assess in discussion with the ASV group and other stakeholders of the sector to what extent the current capabilities fit their requirements. In order to achieve this, five activities are undertaken:

- Definition of EO-based information products
- Gap analysis
- Workshop with the industry
- Establish EARSC user platform
- User engagement
- Identification of prototype services

The first step of Task 1 was to identify and characterize existing and available EO-based products relevant for the sector. The resulting “D2.1 Current EO capabilities report” provides a portfolio of identified relevant Earth observation-based products.

This report documents the Gap Analysis, whereby the sector’s key-geoinformation requirements are matched against current Earth observation capabilities (Chapter 2). Identified gaps are described, including the situation at this moment and how this could change in coming years, considering new data sources and technologies (Chapter 3).

2 Matching agro-insurance requirements and EO capabilities

2.1 Approach

This chapter documents the matching of identified agro-insurance requirements against Earth observation capabilities. The two main inputs for this analysis are:

- The D1.2 Geoinformation Requirement Report, which provides an overview of 26 key geo-information requirements. These are considered as the thematic building blocks supporting the development of Earth observation-based products and services for the sector.
- The D2.1 Current EO Capabilities Report, which contains a portfolio of 20 currently existing Earth observation products relevant for the agro-insurance sector.

This chapter provides first an overview of the Earth observation product portfolio, and next a table whereby these EO products are matched against the key geo-information requirements with a more detail description of the gap analysis of each requirement. The objective of this work is to provide an overview at the thematic level where the sector's geo-information requirements overlap with existing Earth observation products, and to identify the gaps. In order to assess the suitability for an actual uptake of the Earth observation products in the agro-insurance's business processes, a case by case analysis is required. The project activities, which include the interaction with the ASV group and service demonstration aim to trigger discussions on how existing Earth observation products could fit into their workflow and see where adaptations and new technologies are needed.

2.2 Overview of EO product portfolio

Table 1: Overview of identified EO products

Product ID	Earth Observation Product
P01	Vegetation Indices
P02	Vegetation growth monitoring
P03	Date of Emergence
P04	Crop Type Detection
P05	Field Boundaries
P06	Early Vegetation Stress
P07	Yield Estimation
P08	Biomass production estimation
P09	Drought Indicators
P10	Soil Moisture
P11	Crop damage zones detection
P12	Crop growth zone detection
P13	Irrigation mapping
P14	Grassland Mowing Cycle
P15	Greenhouse Early Warning
P16	Near Real Time (NRT) Service
P17	Gap filled time series of High-Resolution biophysical parameters
P18	Digital Elevation Model (DEM)
P19	Water bodies detection
P20	Evapotranspiration
P21	Monitor and forecast weather events

2.3 Overview of geo-information requirements and linked EO products

Table 2: Overview of key geo-information requirements and linked EO products. For each requirement, supporting EO products are listed. If no corresponding products were found, the cell was left empty.

	Key Geo-information requirements	Linked EO products
1	Obtain uninterrupted consistent long data series (high temporal/spatial resolution)	P01, P17
2	Obtain detailed topographic characteristics	P18
3	Obtain detailed imagery of the surface	
4	Identify soil types (mineralogy, structural properties of near surface)	
5	Identify soil moisture contents	P10
6	Obtaining information on parcel location and boundaries	P05
7	Identify crop type	P04
8	Obtain historical crop production (crop, area, yields)	P04, P07
9	Crop vegetation monitoring	P01, P02, P03, P06, P16, P17

10	Monitoring stress in vegetation	P01, P02, P06, P07, P09, P11, P20
11	Identify the crop emergence and harvest date	P03
12	Crop yield monitoring	P07
13	Estimating yield losses	P07, P11
14	Identify crop damages	P01, P02, P09, P11, P12, P16
15	Identify effects of various risks (frequency, severity, area covered by each risk event)	P01, P02, P09, P10, P11
16	Obtain detailed land use information (crop production landscape, etc.)	P04, P05
17	Identifying agricultural practices (irrigation, fertilisation)	P13, P14, P20
18	Obtain detailed imagery of assets (property, machinery, other field infrastructure)	
19	Identify location and condition of infrastructure objects (irrigation, greenhouses, water wells, etc.)	P15
20	Identify water boundaries (flooded areas, etc.)	P19
21	Identify livestock movements	
22	Identify pastures biomass (yield potential)	P01, P07, P08
23	Identify waves height, currents' energy and thermal data	
24	Identify water flora/fauna (algae, etc.)	
25	Identify forests characteristics (area, boundaries, timber type, etc.)	P08
26	Monitor and forecast weather events	P21

2.4 Discussion of gap analysis per key geo-information requirement

1. Obtain uninterrupted consistent long data series (high temporal/spatial resolution)
 - There are currently already time series of vegetation indices (P01) available at different spatial and temporal resolutions. These datasets however do not combine all conditions as specified in this key geo-information requirement: uninterrupted (e.g. gap-filled), consistent (inter-sensor calibration required), long (multiple decades available) at high temporal and spatial resolution.
 - The currently available datasets each have their own specifications combining several of the conditions specified in this requirement, e.g.:
 - Sentinel-2: High spatial resolution, and 2 to 3-day revisit time, now +/- 5 years available. But in cloudy regions, data gaps of >2 weeks can occur.
 - Landsat: long historical time series, but low revisit times (2x/month).
 - Copernicus Global Land Service: Low/medium resolution vegetation indices at 10-daily timestep since 1999 derived from different satellites and sensors.
 - MODIS: 8 daily medium resolution (250m) data available since 2000.
 - AVHRR NDVI historical archive (1981-2015) of biweekly NDVI data from NOAA-AVHRR satellites at 8 km resolution.
2. Obtain detailed topographic characteristics
 - EO based Digital Elevation Models (DEM, P18) provide a digital representation of elevation, the most important characteristic of topography. Publicly available datasets have spatial accuracies from 30m-90m, which allow to assess the topography surrounding crop parcels.
3. Obtain detailed imagery of the surface
 - There are currently several satellite-based very high-resolution (<1m) true colour image layers available, which can be used for visual interpretation. For example, the Google Earth Maps ([google.com/earth](https://www.google.com/earth)) derived from DigitalGlobe Quickbird provide imagery at 65 cm resolution and is freely available. These layers are however not available in real time and thus could only be used for visual interpretation of historical imagery. This could be useful to collect ancillary information on the insured entities, such as the identification of field parcels, inspecting infrastructure etc. Commercial EO service providers such as Planet (<https://www.planet.com/products/hi-res-monitoring/>) offer sub-meter resolution imagery for insurance companies, which could be used for real time detection of crop damages etc. These data are however costly and currently not often used for agricultural insurance.
4. Identify soil types (mineralogy, structural properties of near surface)
 - There are currently no established methods to identify soil types from in space missions so hence there is no product assigned to this requirement.
 - R&D on remotely sensed soil type mapping is often focused on classification methods on near surface spectroscopy.

5. Identify soil moisture contents
 - The ESA Climate Change Initiative (CCI) provides a +40-year dataset of soil moisture at 0.25°. These data could be used to define drought indices at larger scales but do not meet the need for real time soil moisture information at field level.
 - Recently, higher resolution (e.g. 100x100m) near real time soil moisture products are being made available using the Copernicus Sentinel Constellation and offered by commercial companies such as Vandarsat (vandersat.com/soil-moisture-monitoring).
 - Products with a higher resolution of 10x10m are based on Sentinel-1 imagery combined with other sensor's time series and point based in-situ measurements. These products are commercially available through EO companies such as GeoVille (www.geoville.com).
 - The currently available products indicate the surface soil moisture of the top few centimetres soil at a high resolution. However, the desired output as identified in the different user meetings would be a product showing the root zone soil moisture.
6. Obtaining information on parcel location and boundaries
 - Recent technologies, which are being implemented on high resolution imagery such as Sentinel-2 data allow to delineate parcel boundaries (P05). These techniques are mostly operational over Europe with well-defined fields. In more challenging landscapes (heterogeneous with small fields), very high-resolution data (<5m) would be required and current methodologies need to be tested.
7. Identify crop type
 - Crop type mapping (P04) is a field of research since decades on data derived from satellites such as Landsat. Since the operational data delivery from Sentinel-1 & 2, there has been a great step forward in the accuracy and timeliness of crop type maps. Several EO service providers companies now offer crop type mapping services, mostly via on demand services for specific regions.
 - Several EO service providers offer EO in season crop type services at high accuracy and resolution
8. Obtain historical crop production (crop, area, yields)
 - In order to obtain information on historical crop production at regional level information on the crop type, crop area and historical yields are required. As mentioned above ("7. Identify crop type"), the quality of crop type maps has been drastically improved with the availability of Sentinel-1 & 2 data, which is only available since 2016 onwards. In order to generate historical crop production information over a region, one thus should rely on older EO data sources (e.g. the Landsat archive) to generate crop type maps for which the quality of the crop type maps will be lower (e.g. Johnson, D. 2019).

9. Crop vegetation monitoring
 - Since the operational data delivery of Sentinel-2, it is possible to monitor crop growth at unprecedented level and such services are being provided by several Earth Observation service providers.
 - The main drawback is that these crop monitoring services are 'blind' in cloudy weather, which could result in large gaps in the observational data produced. Hybrid approaches, where Sentinel-1 radar data, which can see through clouds is used in combination with Sentinel-2 optical data provide promising results.
10. Monitoring stress in vegetation
 - Classical crop monitoring services mostly use vegetation indices such as NDVI and FAPAR derived from optical imagery such as Sentinel-2. Such vegetation indices can reflect vegetation stress at longer terms (>1 week), e.g. persistent drought or disease outbreak, but are less suitable to capture timely (e.g. upcoming disease) and short-term vegetation stress (short term water deficit stress).
 - Land surface temperature (LST) has the potential to detect short term vegetation stress. The current in space missions however do not provide sufficient temporal (e.g. Landsat) or spatial detail (e.g. Sentinel 3) to build operational crop monitoring services for early stress detection.
11. Identify the crop emergence and harvest date
 - Deriving phenology indicators is a fairly well matured field of R&D. Established and commonly used methods (such as Timesat, <http://web.nateko.lu.se/timesat/>) are capable to detect start and end of the growing season from time series of EO based vegetation indices. Recently, such methods are being applied on Sentinel-2 data with success (Jonsson, et al. 2018), hereby focusing on detecting a general green-up and senescence of the vegetation. In order to detect more specific events related to crop growth (crop emergence & harvest) two main requirements should be met:
 - A high density of Sentinel-2 observations at the key phenological stages. This could be problematic in cloud abundant regions. Hence, also R&D is being done to develop crop phenology procedures on Sentinel-1 (e.g. Mercier et al. 2019)
 - Finding the right configuration (parameters) to translate time series of vegetation indices into crop specific events. This will often require local testing & evaluation against in-situ data.
12. Crop yield monitoring
 - Parcel level yield monitoring has been an extensive field of research for several years and is currently offered as a service by a number of EO service providers, e.g. Watchitgrow.be for Sentinel-2 based Belgian potato monitoring. The main challenge of EO based yield prediction is feeding sufficient ground truth data into the yield models. Hence mostly only reasonable accuracies can be obtained on local scale.

13. Estimating yield losses
 - Typically, Earth Observation based yield models are capable to detect reasonable variations in crop yield. They are often less suited to detect extreme yield deviations such as in the case of flooding or persistent droughts.
14. Identify crop damages
 - High resolution data such as Sentinel-2 is capable to detect crop damage and is being used by insurance companies (e.g. Austrian Hail). There are however a number of challenges, which could hamper the operational use of the data:
 - Spatial resolution might be insufficient to detect small patches of crop damage (e.g. caused by a storm).
 - It is difficult to distinguish between the sources of crop damage (e.g. hail, storm...)
 - Within field crop damage detection could be confused with natural field heterogeneity caused by e.g. soil characteristics.
 - Cloudy periods during a crop damage event (e.g. storm, hail) impacts the timeliness of the crop damage estimates.
15. Identify effects of various risks (frequency, severity, area covered by each risk event)
 - Long time series of historical earth observation data can be used to calculate anomalies in vegetation growth. These anomalies could then be used to assess the frequency and severity of less performing years. These methods have been applied on medium-low resolution imagery to assess the historical crop damage frequency at regional scale (e.g. Piccard et al. 2010). These methods however also have a number of limitations: They do not provide information at the parcel level (e.g. due to different soil conditions), don't differentiate between different types of risks.
16. Obtain detailed land use information (crop production landscape, etc.)
 - Historical dataset such as the CORINE Land Cover database, which provides high resolution land cover maps in frequent intervals since the 90's are valuable sources of information. These products focus however mostly on land cover rather than on land use. The novel CLC+ will be a major upgrade of this European LC/LU information basis. This next generation Corine Land Cover product, code-named CLC+, is being designed as a logically structured series of subsets, ranging from VHR input layers (CLC-backbone, vector) into a core LC/LU graphical database (CLC-core, grid) to instances, which become on-demand end user products (CLC+, CLC-heritage). <https://land.copernicus.eu/user-corner/technical-library/upcoming-product-clc>
17. Identifying agricultural practices (irrigation, fertilization)
 - Agricultural practices can't be observed directly with Earth observation data and can only be identified in indirect ways. For example, EO based rainfall estimates can be used in combination with EO based evapotranspiration estimates to give an indication of irrigation practices. These methods are suitable for larger scale irrigation mapping (area based) in semi-arid and arid regions (e.g. <http://www.fao.org/in-action/remote-sensing-for-water-productivity/wlpa->

- [introduction/wapor-applications/monitoring-irrigation-areas/en/](#)). There are no well-established methods yet to perform irrigation mapping at field level, in regions with abundant rainfall.
- The mapping of agricultural practices at field level is being tested in project such as SEN4CAP: <http://esa-sen4cap.org/content/agricultural-practices>.
18. Obtain detailed imagery of assets (property, machinery, other field infrastructure)
 - Earth observation data at very high resolution (<1m) resolution could be used to assess insurance assets. These layers are however costly for real time monitoring.
 19. Identify location and condition of infrastructure objects (irrigation, greenhouses, water wells, etc.)
 - Earth observation data at very high resolution (<1m) resolution could be used to assess insurance assets. These layers are however costly for real time monitoring.
 20. Identify water boundaries (flooded areas, etc.)
 - SAR data such as Sentinel-1 or TerraSAR-X provides a valuable source for flood mapping and established methods have been developed for this (e.g. <http://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-flood-mapping/step-by-step>).
 21. Identify livestock movements
 - Earth observation data is not capable to detect the actual movement of livestock.
 22. Identify pastures biomass (yield potential)
 - Earth observation data has proven useful for operational grassland monitoring since several years. For example, the medium resolution EO based Copernicus Global Land Service Dry Matter Production (DMP) product have been used to indicate pasture biomass hotspots & deficits in support of a pastoralist surveillance system in West Africa (Ham, et al. 2011).
 - EO based vegetation indices have been used to develop operational index insurance programs for grasslands (e.g. Punalekar, et al. 2018).
 23. Identify waves height, currents' energy and thermal data
 - Sentinel 3 provides operational data on sea surface temperature, which could be used for risk assessment for fisheries (e.g. <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-slstr/applications/maritime-monitoring/sea-surface-temperature>).
 24. Identify water flora/fauna (algae, etc.)
 - Sentinel-2 data has been used to monitor algae bloom extent and severity by estimating chlorophyll-a (chl-a) concentration (e.g. German et al. 2019).
 - Furthermore, Sentinel-3 is well suited for water quality monitoring.
 25. Identify forests characteristics (area, boundaries, timber type, etc.)
 - High and very high-resolution optical earth observation data can be used for visual interpretation of forest area, boundary & providing an indication on forest type.
 - Existing high-resolution land cover maps such as the European Land Cover map can provide a good indication of the forest area in a region.

26. Monitor and forecast weather events

- Earth Observation data (e.g. METOP-AVHRR) is being used operationally to support numerical weather forecasts. These forecasts typically provide information at coarse grid scale (>5 km). The agro-insurance sector could benefit from weather monitoring and forecasts at higher resolutions. R&D is being done to assess the use of EO data to downscale numerical weather forecasts (e.g. Lagasio, et al. 2019).

3 Identifying future EO capabilities

3.1 Identification of future EO capabilities

3.1.1 Planned missions

3.1.1.1 *Sentinels*

ESA’s Sentinel missions include radar and super-spectral imaging for land, ocean and atmospheric monitoring. Each Sentinel mission is based on a constellation of two satellites to fulfil and revisit the coverage requirements for each mission, providing robust datasets for all Copernicus services. Figure 1 shows an overview of the current in space missions (green) and in blue planned or tentative missions. The three missions most relevant for agro-insurance applications are Sentinel-1 (radar-based parcel level crop monitoring), Sentinel-2 (optical parcel level crop monitoring) & Sentinel 3 (large scale vegetation monitoring, data continuity of historical archive of SPOT-VGT/Proba-V time series). Each of these missions has an operational lifespan of 7-7.5 years with consumables for 12 years. The current in space constellations are expected to be operational at least until the early 2020’s. Follow-up missions are planned to guarantee data continuity for these missions until at least 2030.

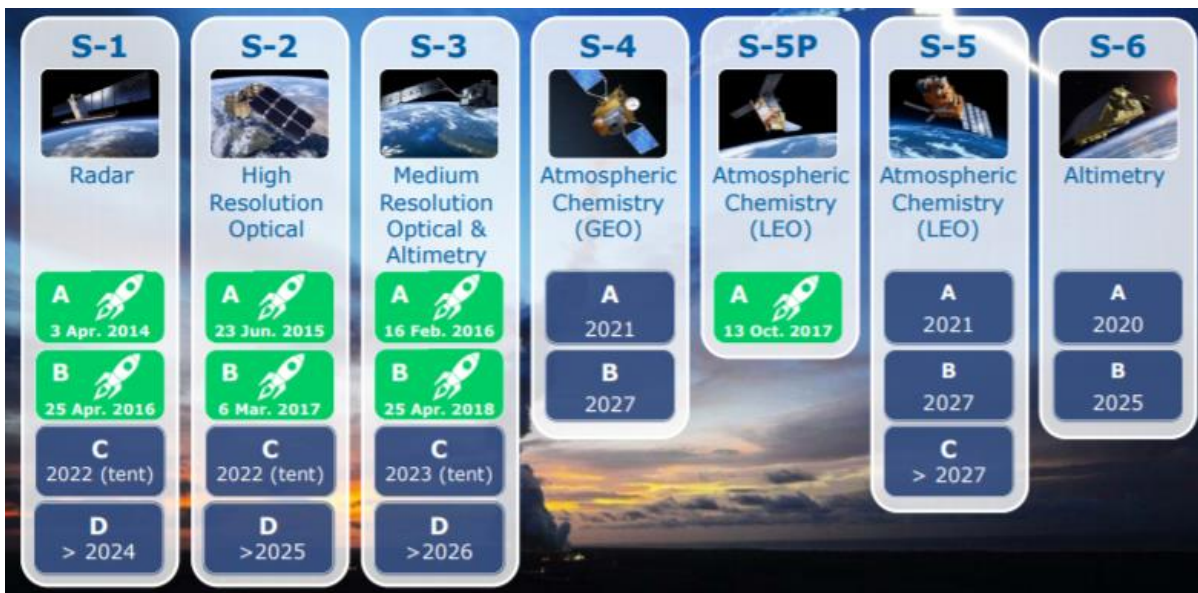


Figure 1: Overview of Sentinel Missions and Satellites: in space (green) and planned (blue). Source: <http://emits.sso.esa.int/emits-doc/ESTEC/News/ESACopernicusIndustryDaysPresentation.pdf>

3.1.1.2 *Biomass*

BIOMASS is an Earth observing satellite planned for launch by ESA 2023. The mission will provide the first comprehensive measurements of global forest biomass. The mission is meant to last for five years, monitoring at least eight growth cycles in the worlds’ forests. Its basic resolution is 50m, but the biomass maps will be 200m and be provided each 6 months. The standing biomass, biomass change & forest height maps can be used for forest characterization.

Reference:

https://www.esa.int/Applications/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Biomass

3.1.1.3 Flex

The Fluorescence Explorer (FLEX) mission has been selected as ESA's 8th Earth Explorer mission with a planned launch in 2023. The primary objectives of the mission are to provide global estimates of vegetation fluorescence, actual photosynthetic activity, and vegetation stress. The data will have a 300m resolution and a 1-month revisit time. This means it is most useful for larger scale analysis (e.g. landscape or regional scale) and to support ecosystem stress & production estimates. The data will be less suitable for operational crop growth stress monitoring at parcel level.

Reference:

<https://earth.esa.int/web/guest/missions/esa-future-missions/flex>

3.1.1.4 Landsat 9

Landsat 9 is a planned mission in the NASA Landsat series, scheduled for launch in March of 2021. It will contain four visible spectral bands, one near-infrared spectral band, three shortwave-infrared spectral bands at 30 m spatial resolution, plus one panchromatic band at 15 m spatial resolution, and two thermal bands at 100 m. It will contribute the long historical archive of the Landsat legacy and thus support historical analysis. The single mission will have a 16-day revisit time and an 8-day in combination with Landsat 8. Currently, most operational optical crop monitoring in Europe is done with Sentinel-2 as it outperforms the spatial and temporal resolution of Landsat. This is not expected to change with the launch of Landsat 9. It is however a valuable back-up mission for European crop monitoring and can be used in addition to Sentinel-2. The thermal data, which will be provided by Landsat at 100m resolution, could be of use for evapotranspiration or early stress detection.

Reference:

<https://eosps.nasa.gov/missions/landsat-9>

3.1.2 Candidate missions

3.1.2.1 CHIME: Copernicus Hyperspectral Imaging Mission

The CHIME mission would carry a visible to shortwave infrared spectrometer to provide routine hyperspectral observations to support agriculture and biodiversity monitoring, as well as soil property characterization. It will complement currently flying multi-spectral missions such as Sentinel-2. Compared to multi-spectral missions, CHIME will have an increased number of narrow spectral bands (spectral resolution of 10nm with no gaps between bands) in the visible-to-shortwave infrared range (400-2500nm), which will allow for a more accurate determination of biochemical and biophysical variables. Expected spatial resolution will be 20-30m with a revisit time of 10-12.5 days, using a synchronous overpass time of between 10.30-11.30 am. This spatial detail will allow to perform analyses at the parcel level. Given the revisit time, it is expected that downstream products could serve the agro-insurance sector mainly with geo-information for which the required timeliness or temporal detail is not within days (e.g. as in the case of crop damage assessment). There are however a number of potential applications that could provide new or enhanced services for the sector, such as:

- Improved Yield Assessment and Forecast

- Species identification (e.g. crop type (e.g. differentiate wheat & barley), invasive species)
- Crop health and damage (water and nutrient stress)
- Detection of weeds
- Crop water requirement
- Mapping soil properties: structure and texture
- Estimation of carbon storage in soils
- Soil Erosion and degradation mapping
- Detection of soil pollution and soil contamination

References:

http://esamultimedia.esa.int/docs/EarthObservation/Copernicus_CHIME_MRD_v2.1_Issued20190723.pdf

https://www.d-copernicus.de/fileadmin/Content/pdf/Forum_2018/2018_11_08_CHIME_Copernicus_Bonn_Vista.pdf

3.1.2.2 LSTM: Copernicus Land Surface Temperature Monitoring

The LSTM mission would carry a high spatial-temporal resolution thermal infrared sensor to provide observations of land-surface temperature (LST). The mission will allow enhanced agricultural monitoring at field-scale, mainly by providing information on drought stress and rates of evapotranspiration. The main characteristics are a revisit time of 1-3 days, a spatial resolution of 50 m and an early afternoon overpass. The minimum mapping unit (e.g. field size) for this spatial resolution is considered as 1 ha. Figure 2 (obtained from the Mission Requirements Document, see References) provides an overview of the percentage of fields >1ha on a 10x10km grid over Europe, as derived from the LPIS database.

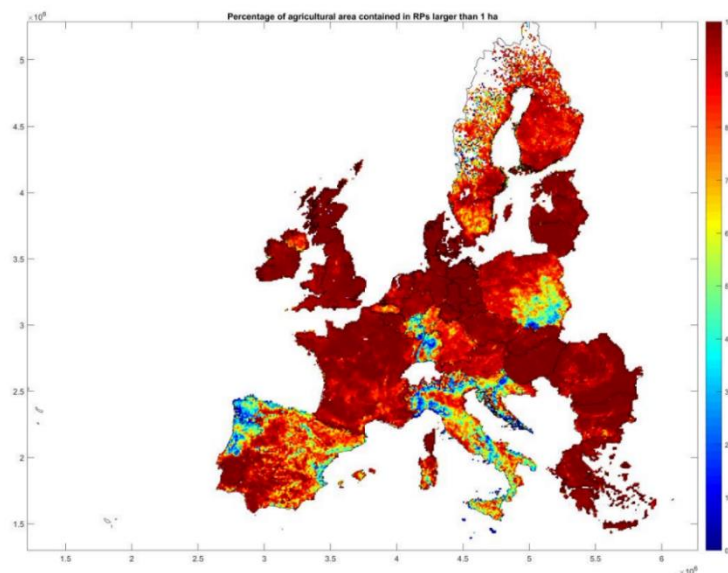


Figure 2: EU distribution of the percentage of agricultural area covered by reference parcels of more than 1 ha within a 10kmx10km grid (blue is 0% and red is 100%). Source: MRD.

Reference:

http://esamultimedia.esa.int/docs/EarthObservation/Copernicus_LSTM_MRD_v2.0_Issued20190308.pdf

3.1.2.3 ROSE-L: L-band Synthetic Aperture Radar

ROSE-L is an L-band SAR mission that will complement the current in space Sentinel-1 mission. For instance, ROSE-L's long wavelength will be able to measure surface deformation in vegetated areas currently. This will greatly extend the earthquake zones and regions at risk of landslides that can be systematically monitored from space. Information from ROSE-L will also improve the accuracy of measurements of forest biomass and changes in forest cover and condition across the globe. Other applications that benefit from the unique capabilities of ROSE-L include the mapping of soil moisture at field scale throughout the vegetation season, which will support improved agricultural crop monitoring and water use, as well as better land cover mapping. Over oceans ROSE-L will be used to monitor wave direction and wave heights. ROSE-L is currently expected to achieve complete coverage of Earth's surface every six days based on two satellites. Over Europe ROSE-L is expected to image all of Europe in 3 days or less and once per day in the Arctic. The spatial resolution is expected to be better than 50 m², or roughly 2x better than the current Sentinel-1 IWS product. ROSE-L is expected to operate in the same orbit as Sentinel-1 providing frequent and complementary SAR coverage of Europe and the world. Potential applications for agro-insurance include:

- Evapotranspiration estimates
- Irrigation mapping
- Forest height, biomass, area and disturbance
- Land cover, crop type, crop status
- Agricultural Management Practices
- Soil moisture
- Monitor wave heights

References:

https://esamultimedia.esa.int/docs/EarthObservation/Copernicus_L-band_SAR_mission_ROSE-L_MRD_v2.0_issued.pdf

<https://futureearth.org/publications/explainers/plans-for-a-new-wave-of-european-sentinel-satellites/>

3.1.3 Publicly available products

3.1.3.1 Copernicus Global Land Service

The Copernicus Global Land Service has been providing operationally global products of biophysical parameters such as NDVI, FAPAR, fcover,... from Proba-V satellite imagery. This service will switch to Sentinel 3 data (from Q2 2020 onwards) to ensure data continuity for its users. These data provide both long historical archives (1999 – today), which could be used for historical analyses and near real time monitoring at medium resolution scale.

<https://land.copernicus.eu/global/>

3.1.3.2 High resolution Pan-European Service: Phenology

Started in early 2020, the European Environment Agency (EEA) has kicked off the development of a high-resolution Pan-European Sentinel-2 based phenology layer. The resulting maps, which will be produced yearly, will contain for each 10m x 10m the start, max and end of season. These layers could be used by the agro-insurance sector to have a general idea in a region on the crop growing season. The project will also deliver near real time basic vegetation indices derived from level 2A Sentinel-2 data.

<https://land.copernicus.eu/user-corner/technical-library/phenology>

3.1.3.3 WorldCover

With the WorldCover project [2019-2021] ESA aims to deliver to the public a land cover map of the entire globe at 10m resolution based on its Sentinel-1 and 2 data. The map will include 10 predefined classes (based on IPCC Level 1) with an expected 75% overall accuracy. It will focus on the fast generation and validation (possibly less than 3 months after last data take). This map, which will be free and publicly available could serve as a valuable source of information on land cover at global scale for the agro-insurance sector.

<https://eo4society.esa.int/projects/worldcover/>

3.2 Overview of identified future capabilities per geo-information requirement

Table 3: Overview of key geo-information requirements and relevant future EO capabilities.

	Key Geo-information requirements	Future capabilities
1	Obtain uninterrupted consistent long data series (high temporal/spatial resolution)	Copernicus Global Land Service Landsat 9
2	Obtain detailed topographic characteristics	
3	Obtain detailed imagery of the surface	CHIME
4	Identify soil types (mineralogy, structural properties of near surface)	CHIME
5	Identify soil moisture contents	ROSE-L
6	Obtaining information on parcel location and boundaries	
7	Identify crop type	CHIME
8	Obtain historical crop production (crop, area, yields)	Copernicus Global Land Service WorldCover
9	Crop vegetation monitoring	LSTM
10	Monitoring stress in vegetation	FLEX LSTM
11	Identify the crop emergence and harvest date	High resolution Pan-European Service: Phenology
12	Crop yield monitoring	FLEX CHIME
13	Estimating yield losses	
14	Identify crop damages	

15	Identify effects of various risks (frequency, severity, area covered by each risk event)	
16	Obtain detailed land use information (crop production landscape, etc.)	WorldCover
17	Identifying agricultural practices (irrigation, fertilisation)	LSTM
18	Obtain detailed imagery of assets (property, machinery, other field infrastructure)	
19	Identify location and condition of infrastructure objects (irrigation, greenhouses, water wells, etc.)	
20	Identify water boundaries (flooded areas, etc.)	ROSE-L
21	Identify livestock movements	
22	Identify pastures biomass (yield potential)	BIOMASS FLEX
23	Identify waves height, currents' energy and thermal data	ROSE-L
24	Identify water flora/fauna (algae, etc.)	
25	Identify forests characteristics (area, boundaries, timber type, etc.)	BIOMASS
26	Monitor and forecast weather events	CHIME

4 Conclusion

This report summarizes the gap analysis performed in the EO4I (Earth Observation best practices for agro-insurance) project. A prior to the gap analysis, activities were performed to identify the geo-information requirements and to describe the current EO capabilities. This report first provides an overview of how EO products match the identified geo-information requirements. Next, for each geo-information requirement, a gap analysis was performed by describing in more detail how existing EO capabilities could support the agro-insurance sector, and what are current limitations. Some conclusions:

- Most of the geo-information requirements have corresponding EO products, which can be matched at a thematic level. But it often requires insights in the business processes in order to assess the actual fit. E.g. EO based “crop type mapping” matches the “Identify crop type” requirement. But the timing within the growing season defines the actual relevancy of these EO products for the sector. Crop type maps can be accurately produced from the moment there is a decent coverage of the field of the specific crop. But the sector could be most interested in this information very early in the season, even before the emergence of the crop.
- In order to assess the suitability for an actual uptake of the earth observation products in the agro-insurance business process, a case by case analysis is required. The project activities, which involve the interaction with the ASV group and service demonstration aim to trigger discussions on how existing earth observation products could fit into their workflow.

The second part of this report describes the future EO capabilities. A focus has been made on ESA planned and candidate missions. The major contribution to the current EO capabilities in coming years will be the continuation of the high-resolution Sentinel-1 & 2 mission. The BIOMASS mission can contribute to agro-insurance on forestry where the FLEX mission is mostly suited for larger scale analysis, e.g. to evaluate the impact of major droughts in a region. The candidate ESA missions CHIME, LSTM & ROSE-L could bring a contribution to the current identified gaps: CHIME by delivering information on soil, improve mapping of species, LSTM by providing parcel level information on evapotranspiration, which could be used for irrigation mapping, drought analysis, etc. and ROSE-L by supporting the current Sentinel-1 capabilities, e.g. for parcel level soil moisture estimates.

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