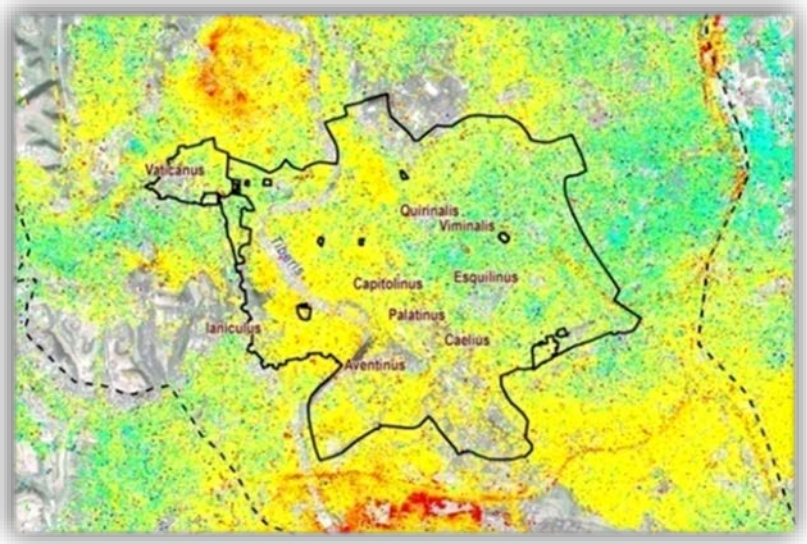
INTERNATIONAL CONFERENCE

Cultural heritage challenges Climate change, Interreg central Europe Project ProteCHt2save



Copernicus in support of the safeguarding of Cultural and Natural Heritage at risk

Daniele Spizzichino

ISPRA - Italian National Institute for Environmental Protection and Research
Dep. for the Geological Survey of Italy – Support to National Space policy Area

COPERNICUS IN BRIEF

No1 in the world in environmental monitoring and terrestrial ecosystems

It is a tool for economic development, a key to the digital economy

Free, total and free data access

3rd largest data provider

Ca 300,000 registered users

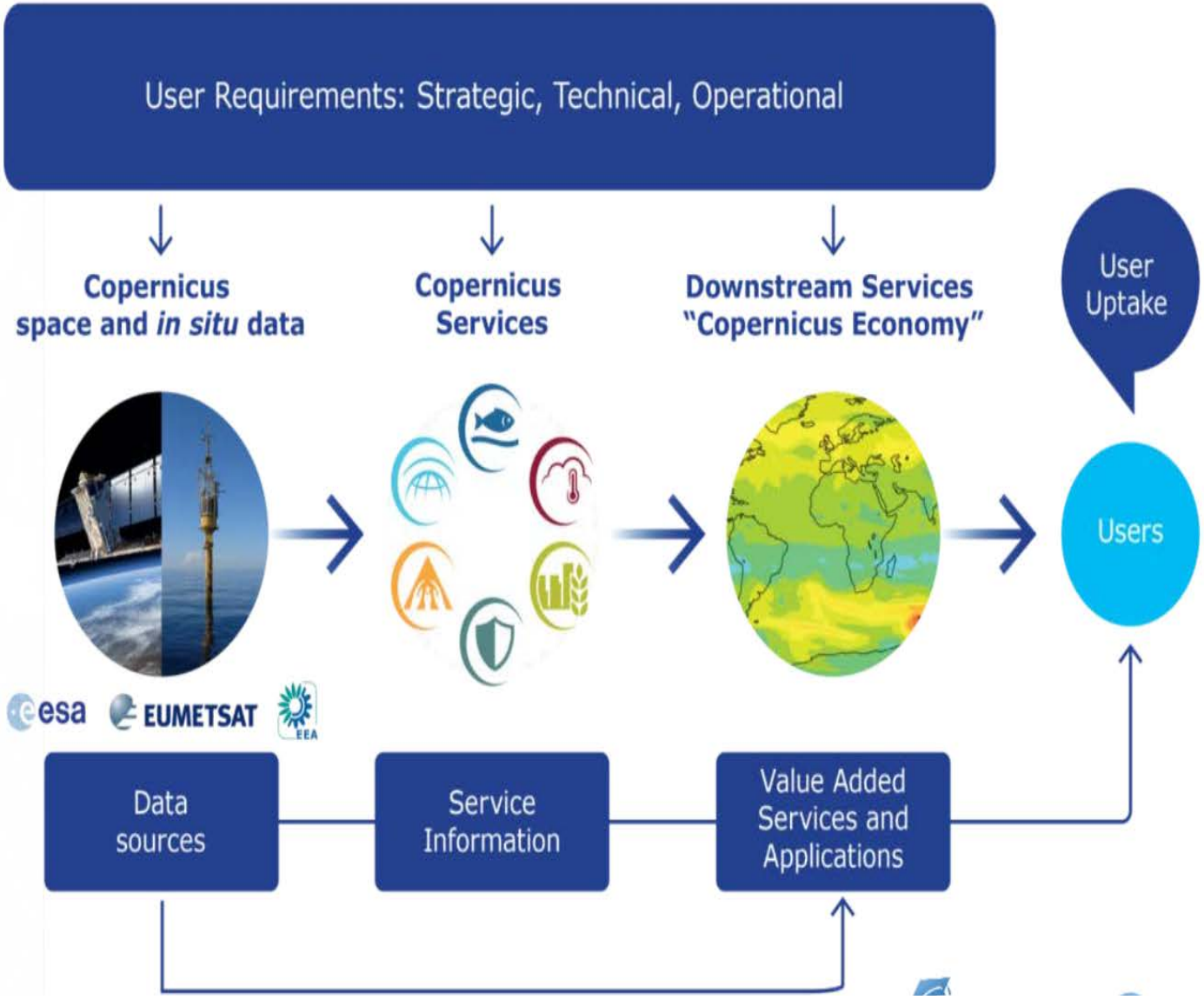
COPERNICUS COMPONENT

FROM GLOBAL TERRESTRIAL OBSERVATION DATA TO LOCAL INFORMATION AND APPLICATIONS

SENTINEL SATELLITE & CONTRIBUTING MISSION

IN SITU SENSORS DATA | SERVICES | INFORMATION | CUSTOM PROCESSES | PRODUCTS

COPERNICUS IS DRIVEN BY THE USERS



Interreg CENTRAL EUROPE
ProteCHt2save

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

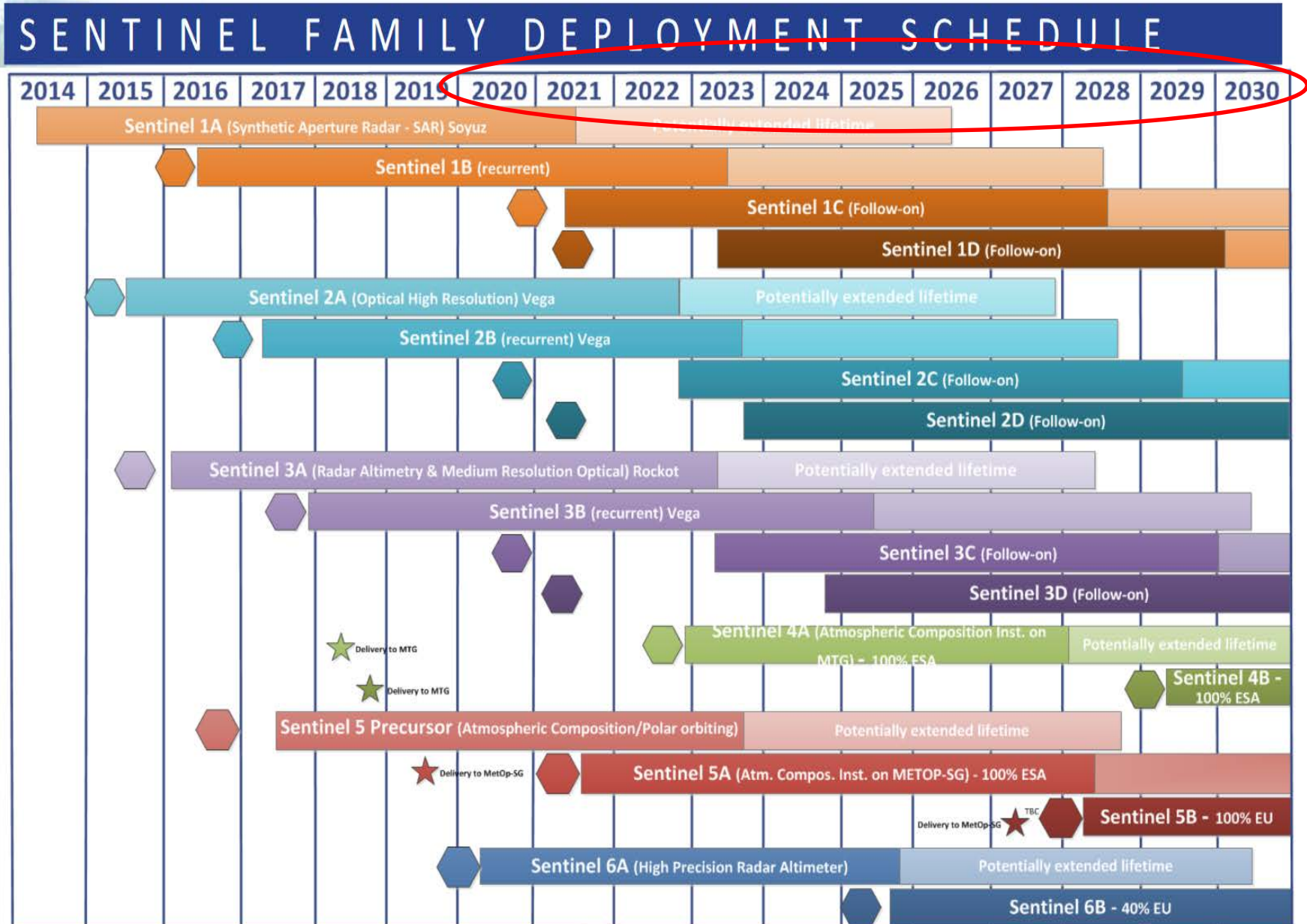
Copernicus

THE SENTINELS

FULL, FREE AND OPEN

	Sentinel Mission and Status		Key Features
	SENTINEL-1: 9-40m resolution, 6 days revisit at equator	*S1-A and B in orbit*	Polar-orbiting, all-weather, day-and-night radar imaging
	SENTINEL-2: 10-60m resolution, 5 days revisit time	*S2-A in Orbit S2-B in Orbit*	Polar-orbiting, multispectral optical, high-res imaging
	SENTINEL-3: 300-1200m resolution, <2 days revisit	*S3-A in Orbit S3-B Launch Q4 2017*	Optical and altimeter mission monitoring sea and land parameters
	SENTINEL-4: 8km resolution, 60 min revisit time	*1st Launch Q4 2022*	Payload for atmosphere chemistry monitoring on MTG-S
	SENTINEL-5p: 7-68km resolution, 1 day revisit	*Launch in Q2 2017*	Mission to reduce data gaps between Envisat, and S-5
	SENTINEL-5: 7.5-50km resolution, 1 day revisit	*1st Launch in 2021*	Payload for atmosphere chemistry monitoring on MetOp 2nd Gen
	SENTINEL-6: 10 days revisit time	*July 2020*	Radar altimeter to measure sea-surface height globally

Copernicus


SENTINEL FAMILY DEPLOYMENT SCHEDULE
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Sentinel 1A (Synthetic Aperture Radar - SAR) Soyuz
Sentinel 1B (recurrent)
Sentinel 1C (Follow-on)
Sentinel 1D (Follow-on)
Sentinel 2A (Optical High Resolution) Vega
Potentially extended lifetime
Sentinel 2B (recurrent) Vega
Sentinel 2C (Follow-on)
Sentinel 2D (Follow-on)
Sentinel 3A (Radar Altimetry & Medium Resolution Optical) Rockot
Potentially extended lifetime
Sentinel 3B (recurrent) Vega
Sentinel 3C (Follow-on)
Sentinel 3D (Follow-on)
Delivery to MTG
Delivery to MTG
Sentinel 4A (Atmospheric Composition Inst. on MTG) - 100% ESA
Potentially extended lifetime
Sentinel 4B - 100% ESA
Sentinel 5 Precursor (Atmospheric Composition/Polar orbiting)
Potentially extended lifetime
Delivery to MetOp-SG
Sentinel 5A (Atm. Compos. Inst. on METOP-SG) - 100% ESA
Delivery to MetOp-SG
TBC
Sentinel 5B - 100% EU
Sentinel 6A (High Precision Radar Altimeter)
Potentially extended lifetime
Sentinel 6B - 40% EU

THE CONTRIBUTING MISSIONS

Subject to Data Owner's Data Policy

IN-SITU: OVERVIEW

- *In situ* data = observation data from ground-, sea-, or air-borne sensors, reference and ancillary data licensed for use in Copernicus
- Use of *In situ* data:
  - Validate & calibrate Copernicus products
  - Reliable information services
- Implementation in two tiers:
  - Tailored *in situ* data for each Copernicus service level
  - Cross-cutting coordination across services by the EEA





6 operational Services

Monitoring the State of the Earth System Environment …

… cross-cutting Thematic Services

CSC operations status: Data Access Statistics

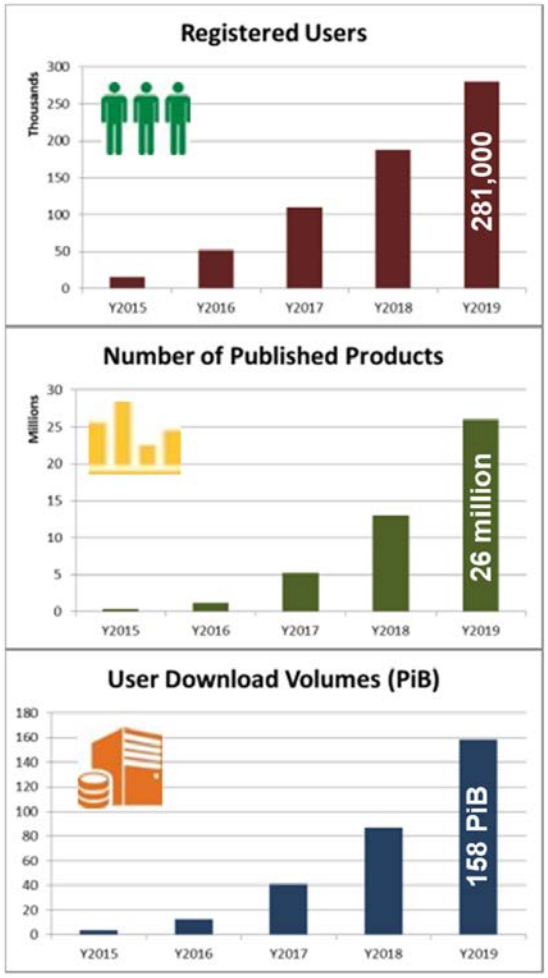
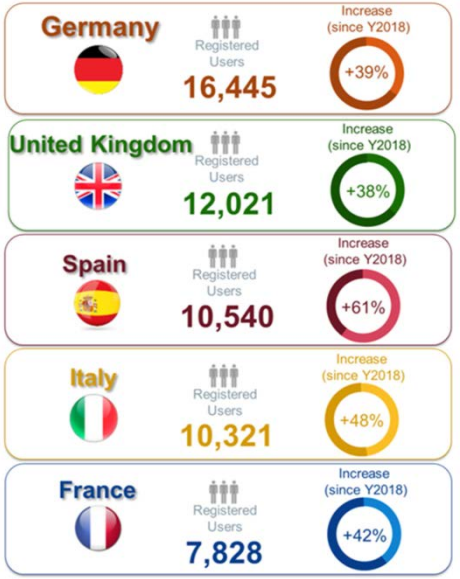


Figure 15: Open Hub registered users in Europe



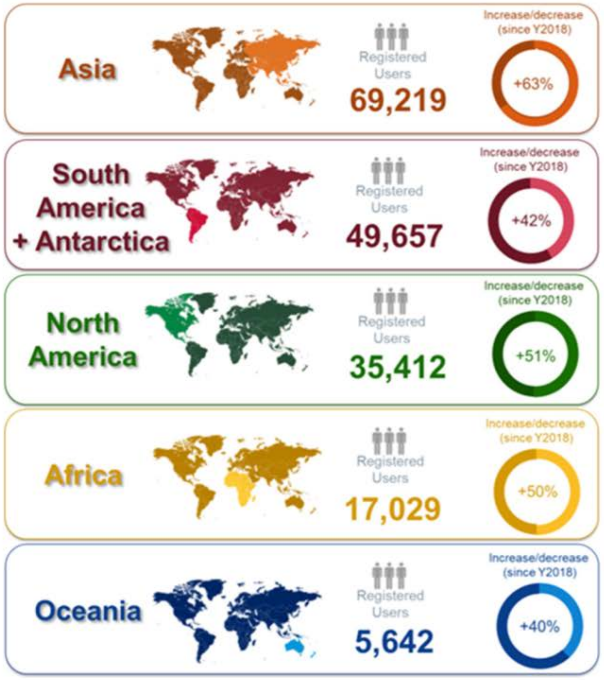


Figure 16: Number of registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during Y2019

(http://www.copernicus.eu)

Copernicus for Cultural Heritage Workshop

2018-2019

www.pwc.fr

Ref. Ares(2018)5305294 - 16/10/2018

Copernicus services in support to Cultural Heritage

DG GROW

Final report

Prepared for EC DG GROW

2nd October 2018

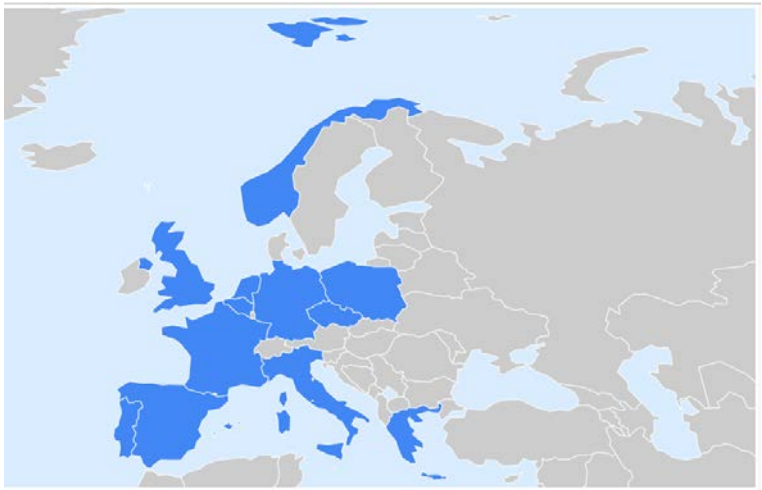
Prepared by: PwC France

N° ENTR/341/PP/2013/FC - Framework Contract for Expert advisory support to the European Space Policy and Programmes

By the end of 2018 the Copernicus User Forum propose the institution of the "Copernicus Cultural Heritage Task Force". Formalised by the Copernicus Committee.

The CCHTF was mainly composed by Member States (MS's) national experts, from both the Cultural Heritage and Earth observation domains, and is officially coordinated by Italy and chaired by the Italian Ministry of Cultural Heritage and Activities and for Tourism (MiBACT).

The activity of the Copernicus Cultural Heritage Task Force, based on the outcomes of the study "Copernicus services in support to Cultural Heritage" (PwC, 2018) was aimed at identifying the best option(s), to facilitate Cultural Heritage community access to Copernicus products.



Country
BE
CY
CZ
DE
ES
FR
GR
IT
MT
NL
NO
PL
PT
UK

Acknowledgments an credits to the all Member and participants to the CCHTF activities

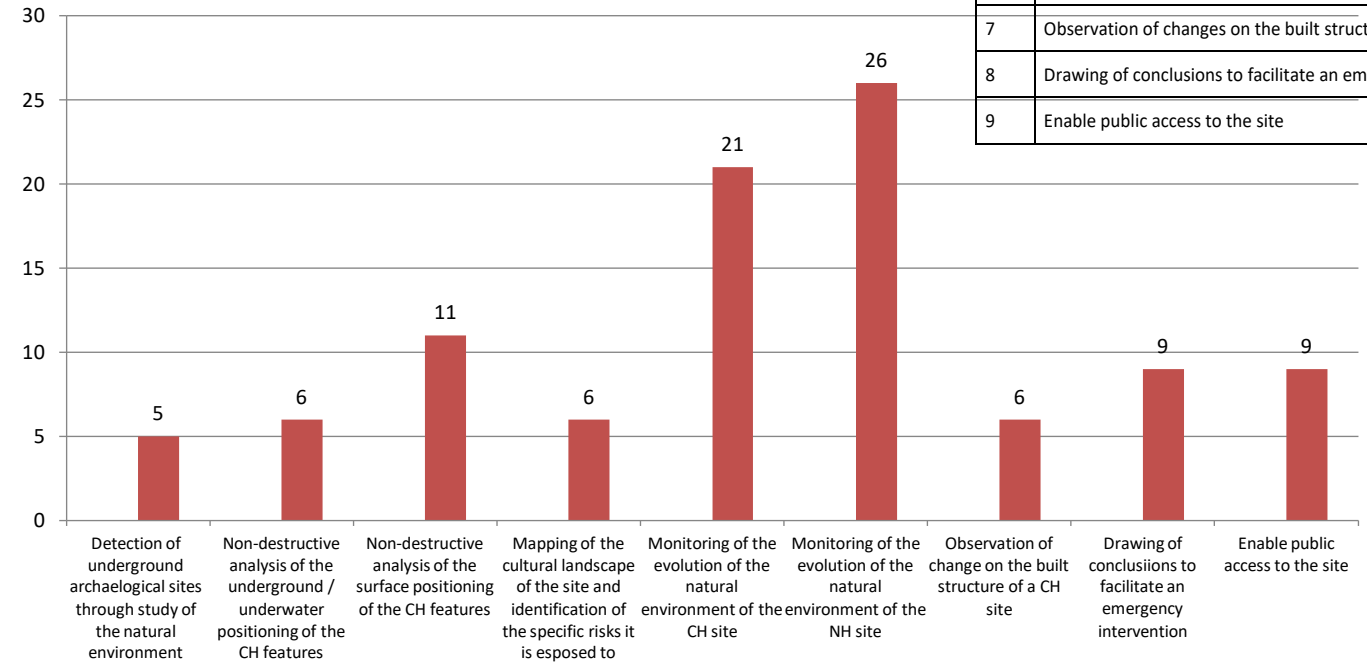
Activities conducted by the Copernicus Cultural Heritage Task Force - 2019

To reach its objective, the Copernicus Cultural Heritage Task Force implemented the following roadmap:

1) Map the Member States' users' needs for Cultural Heritage in the Earth observation domain, beyond those identified in the "Copernicus services in support to Cultural Heritage" study.
2) Complement, filter, aggregate and codify the user needs into specific requirements.
3) Analyse how existing Copernicus data, services and products could satisfy those requirements,
4) Identify possible enhancement and customization of Copernicus products within already operational Core Services.
5) Analyse possible synergies with National, European or International space related solutions to fill the gaps.

nine - High level users needs

1	Detection of underground archaeological sites through the study of the natural environment
2	Non-destructive analysis of the underground / underwater positioning of the CH features
3	Non-destructive analysis of the surface positioning of the CH features
4	Mapping of the cultural landscape of the site and identification of the specific risks it is exposed to
5	Monitoring of the evolution of the natural environment of the CH site
6	Monitoring of the evolution of the natural environment of the NH site
7	Observation of changes on the built structure of a CH site
8	Drawing of conclusions to facilitate an emergency intervention
9	Enable public access to the site



Matrix analysis description

To reach its objective, the Copernicus Cultural Heritage Task Force implemented the following roadmap:

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High level users need 1	**Detection of underground archaeological sites through the study of the natural environment**	
Users' needs	**1 - Normalized difference vegetation index (NDVI)** (More indexes will be included in the Copernicus WP2019 for service improvement)	**2- Thermal anomaly**
Weight (From 0 to 5)	**5**	**4**
Spatial Resolution (m)	**5 - 10m**	**10-30m**
temporal resolution (dd / M)	**2weeks late winter/early summer** **3M the rest of the year**	**1 M**
Requirements	**NDVI map**	**Map of Thermal anomalies**

1) Map the Member States' users' needs for Cultural Heritage in the Earth observation domain, beyond those identified in the "Copernicus services in support to Cultural Heritage" study.
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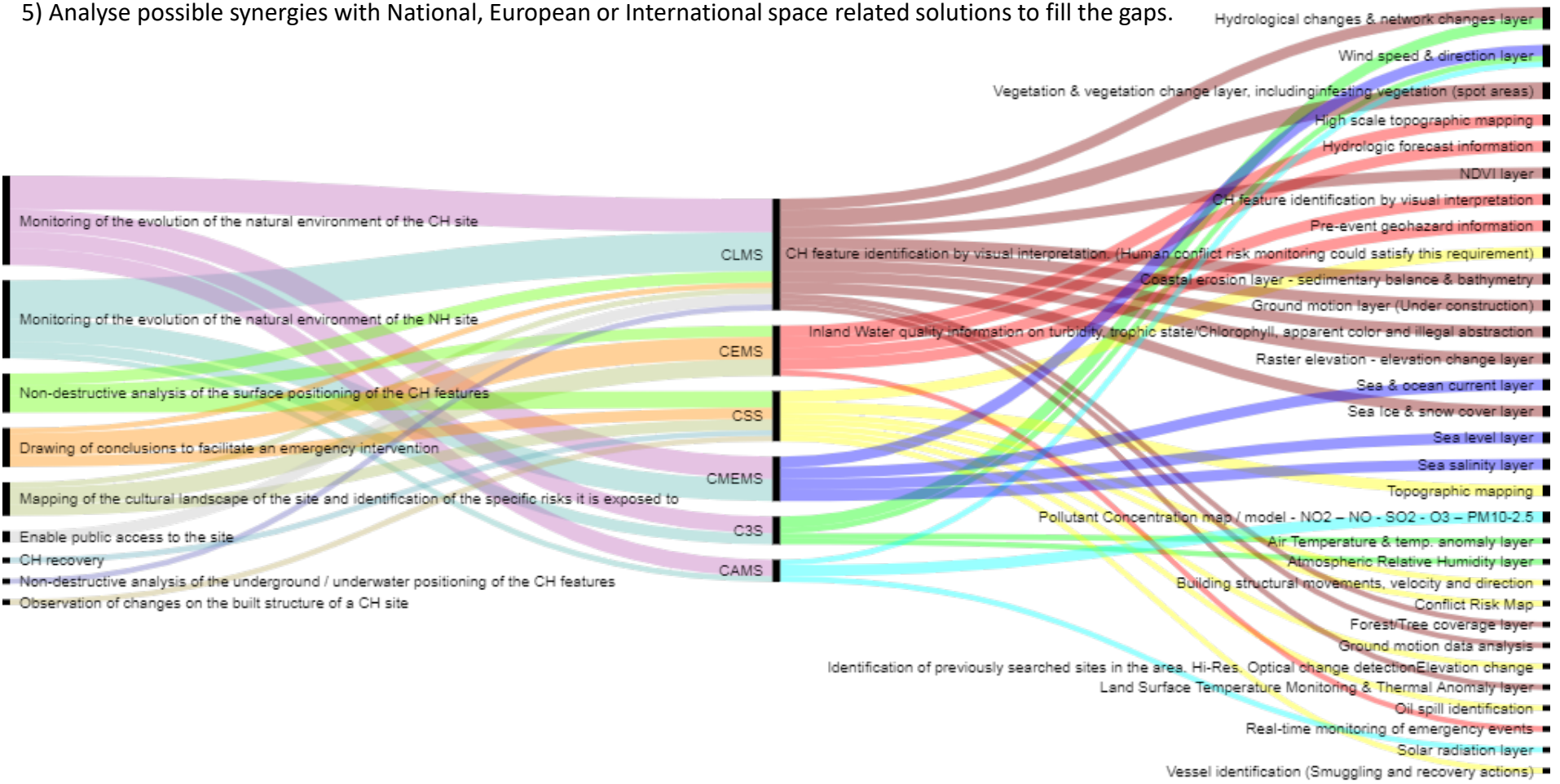

Link between high level user needs (Monitoring domains), Copernicus Core services and user requirements

1) Map the Member States' users' needs for Cultural Heritage in the Earth observation domain, beyond those identified in the "Copernicus services in support to Cultural Heritage" study.
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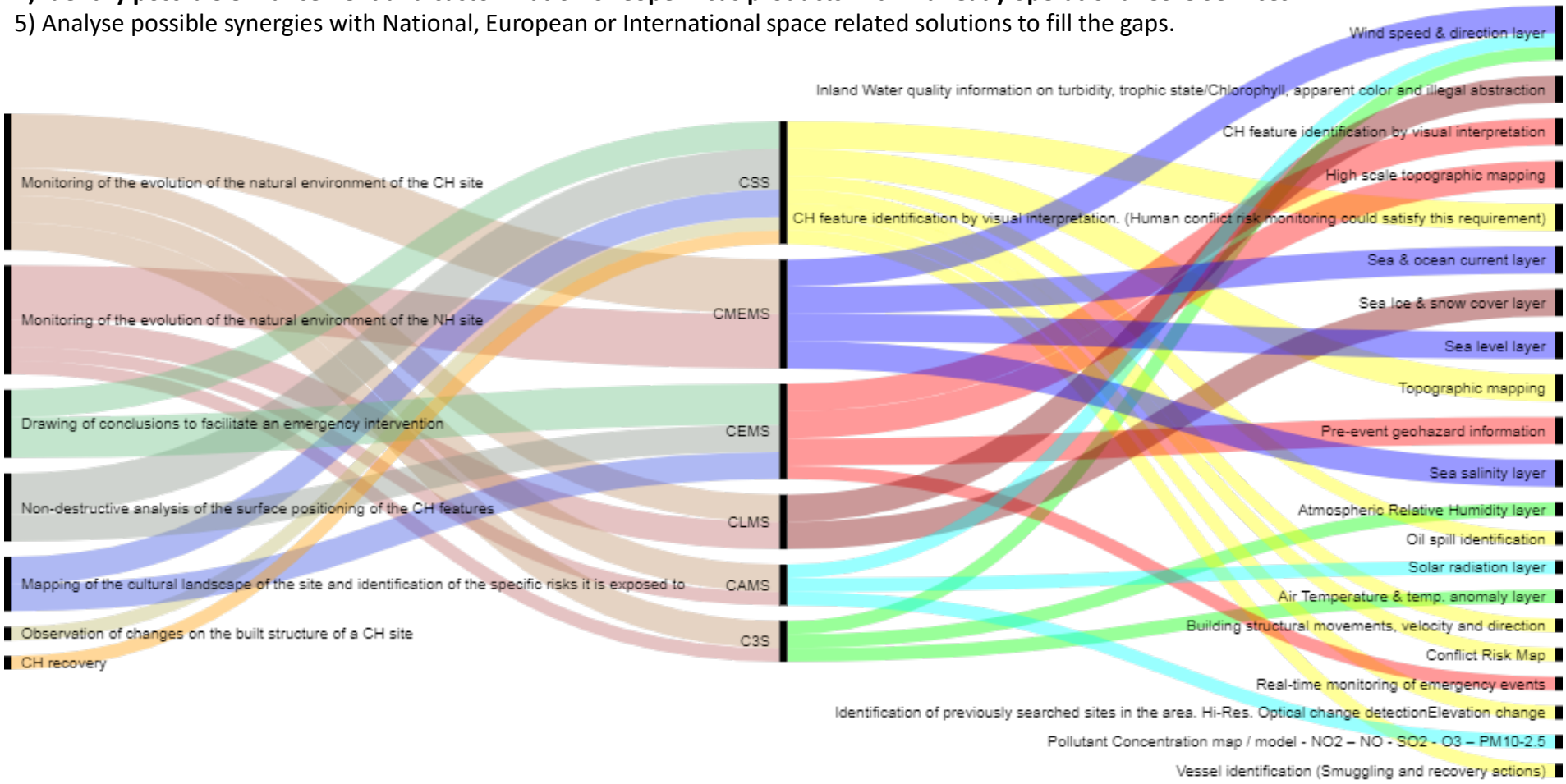

Link between high level user needs (monitoring domains), Copernicus Core services and user requirements already compliant

GAP analysis Copernicus Land Monitoring Service - CLMS

1) Map the Member States' users' needs for Cultural Heritage in the Earth observation domain, beyond those identified in the "Copernicus services in support to Cultural Heritage" study.
2) Complement, filter, aggregate and codify the user needs into specific requirements.
3) Analyse how existing Copernicus data, services and products could satisfy those requirements,
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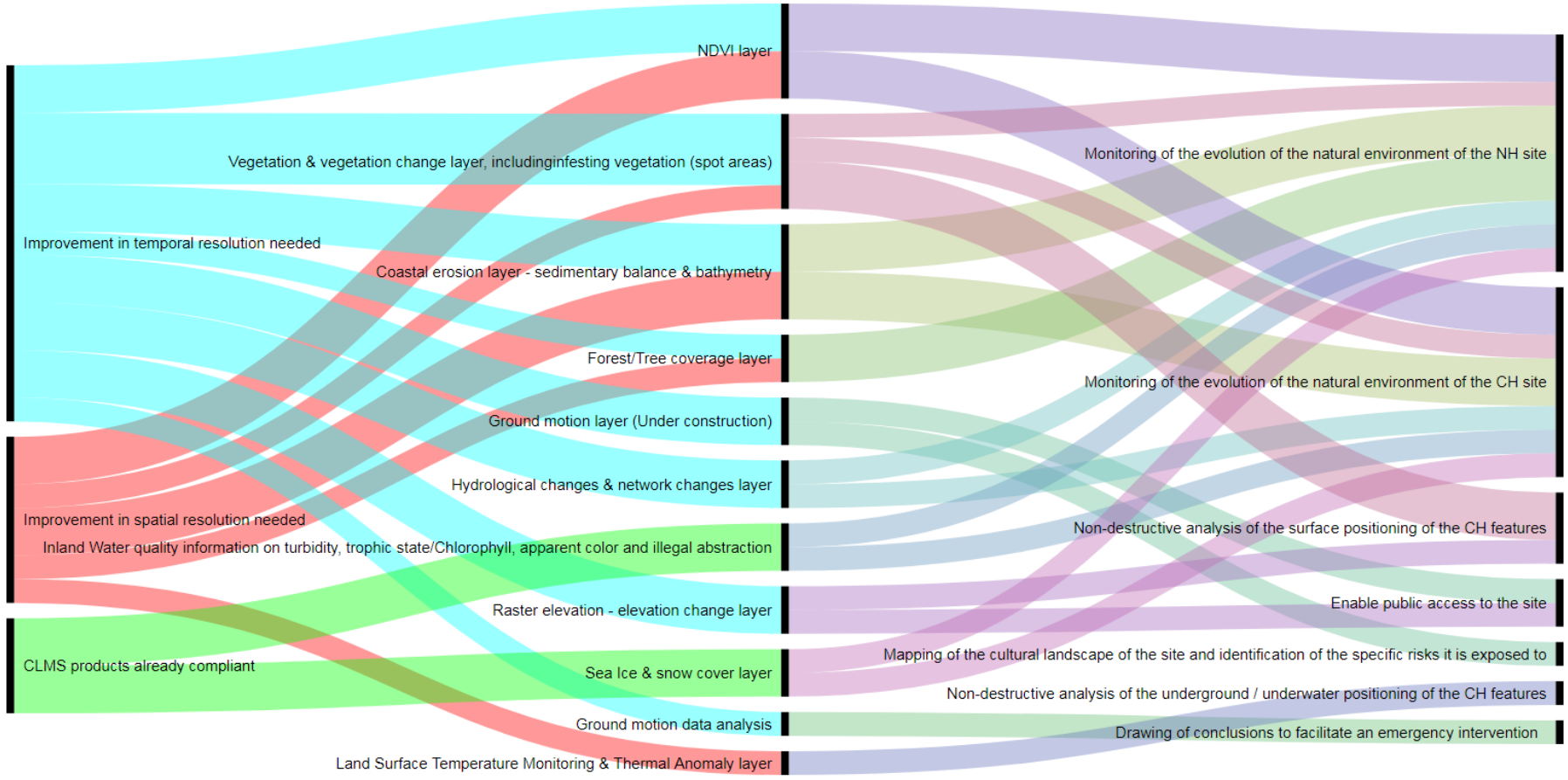
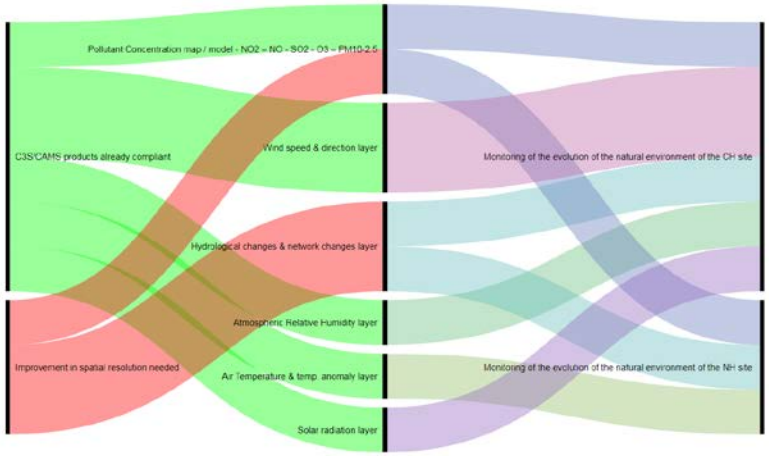


Link between the requirements (central column), CLMS and monitoring domain (right column) (green: requirement fully satisfied - Cyan: requirement with temporal resolution not satisfied - red: requirement with spatial resolution not satisfied).

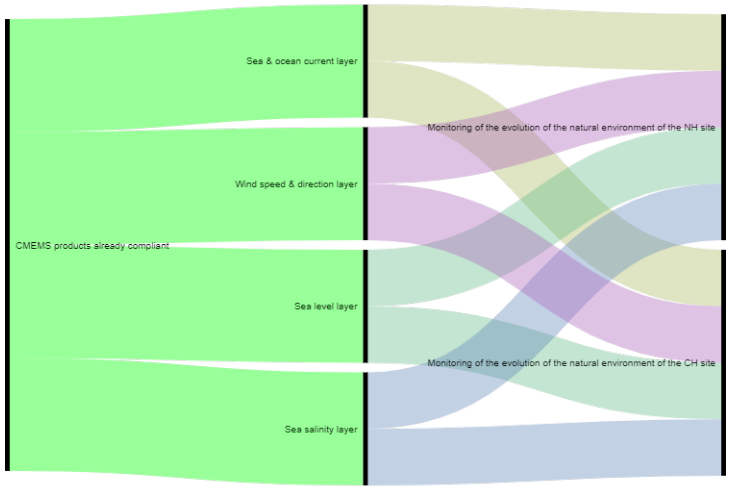
GAP analysis Copernicus Land Monitoring Service - CLMS

GAP analysis C3S/CAMS



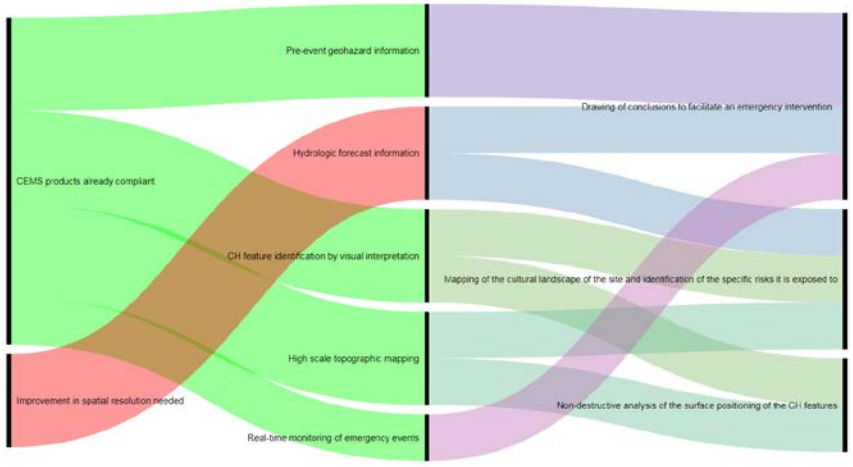
Link between requirements (central column), CAMS and C3S (left column) and monitoring domain (right column) in relation to the requested spatial resolution (green: compliant - red: to be improved).

Gap analysis CMEMS



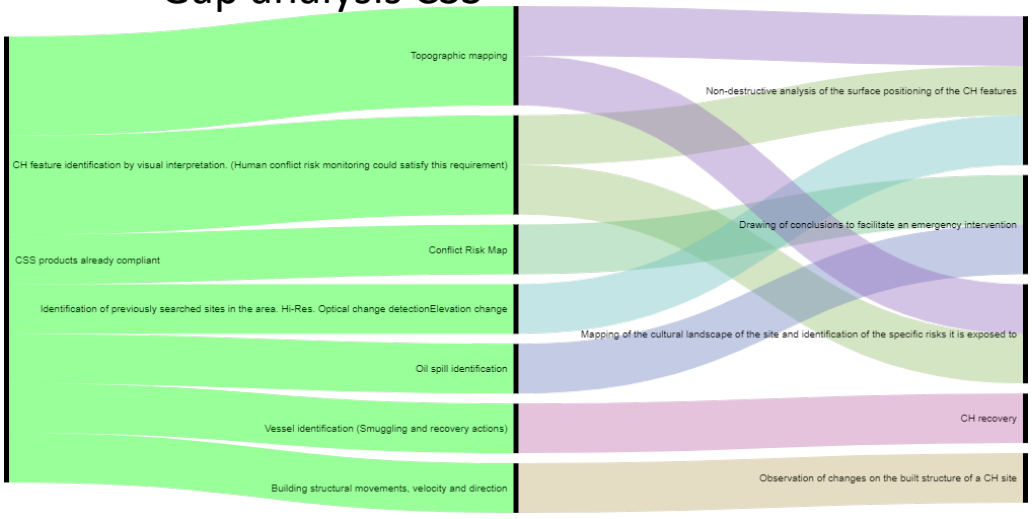
Link between requirements (central column), CMEMS (left column) and monitoring domain (wright column). All the requirements are satisfied.

Gap analysis CEMS



Link between requirements (central column), CEMS and monitoring domains (right column) in relation to the requested spatial resolution (green: complaint - red: to be improved in spatial resolution).

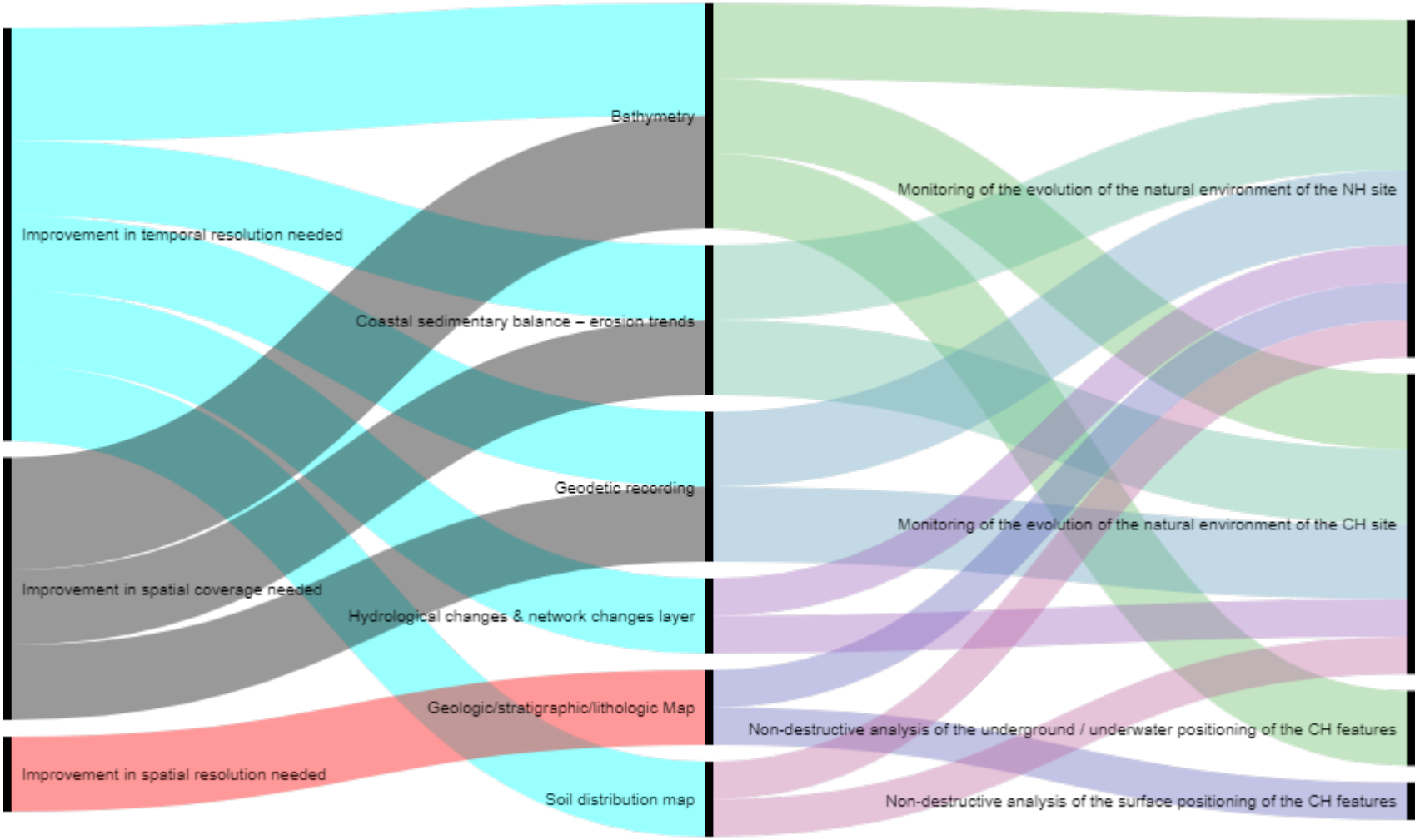
Gap analysis CSS



Gap analysis Link between requirements (central column), CSS (left column) and monitoring domain (right column). All the requirements are satisfied

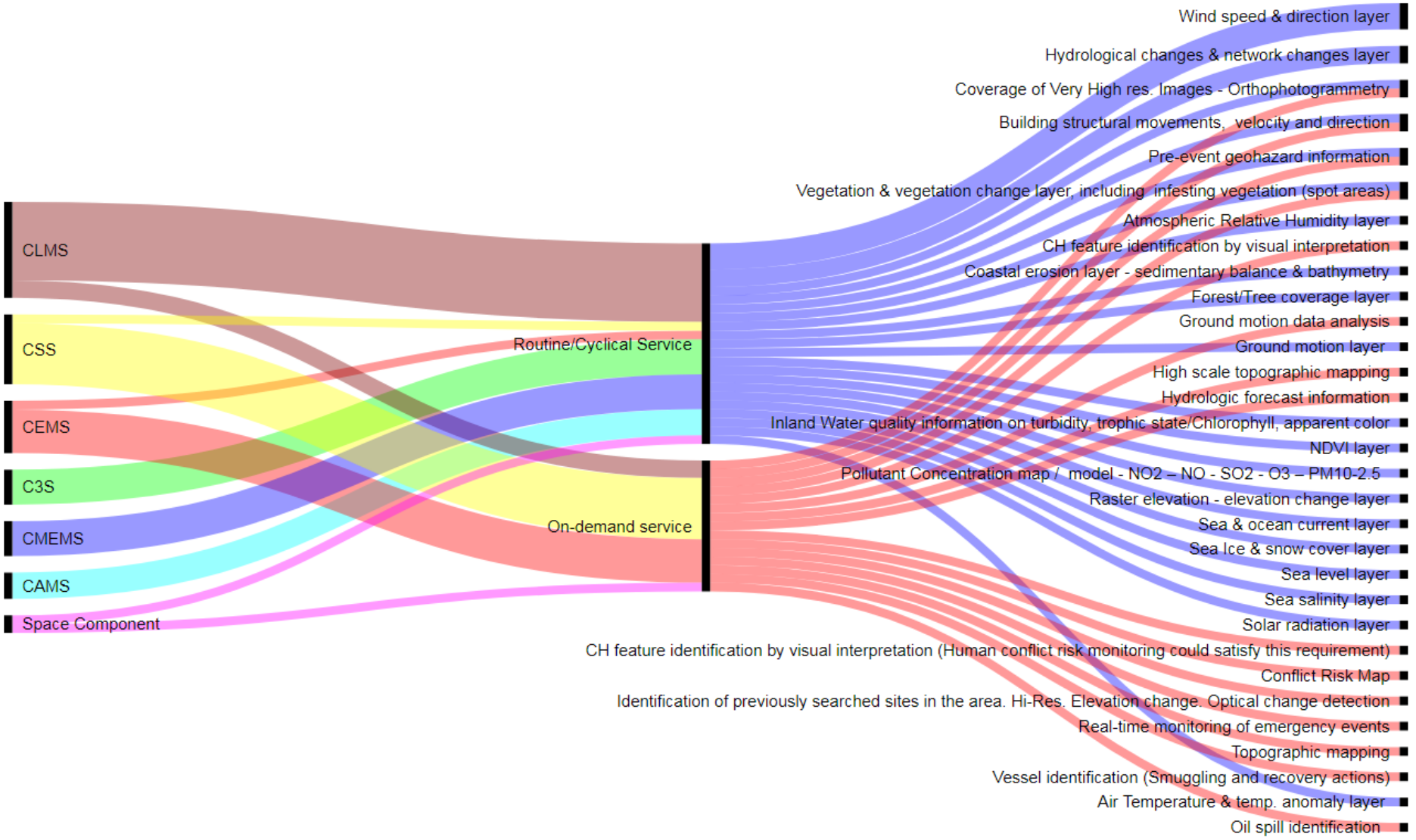
GAP analysis Copernicus Land Monitoring Service - CLMS

In situ gap Analysis



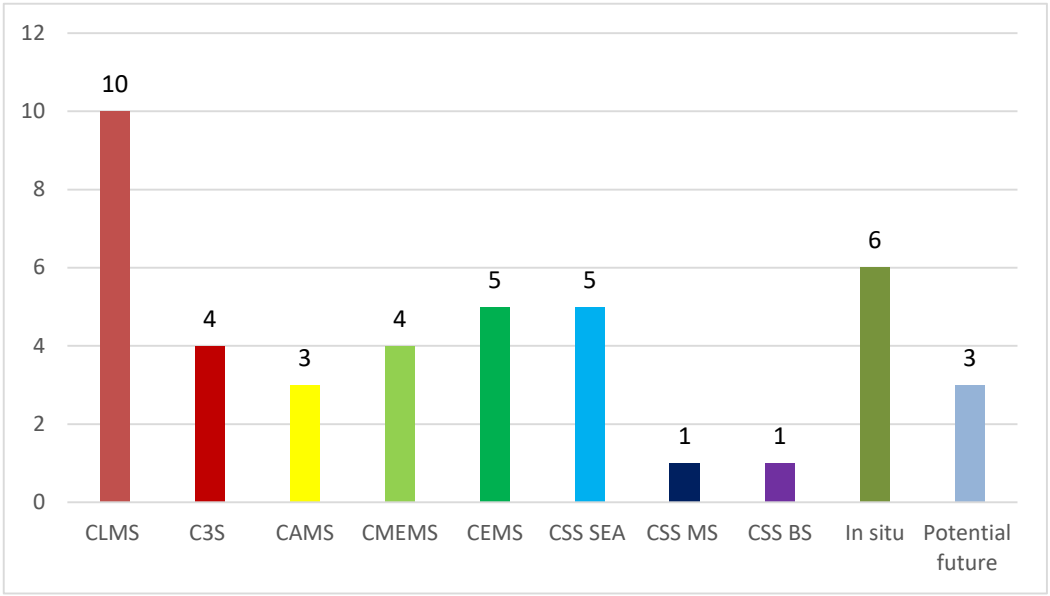
Link between in situ requirements (left column) and monitoring domain (right column), sorted by their frequency of request

Identification of routine and on-demand service delivery



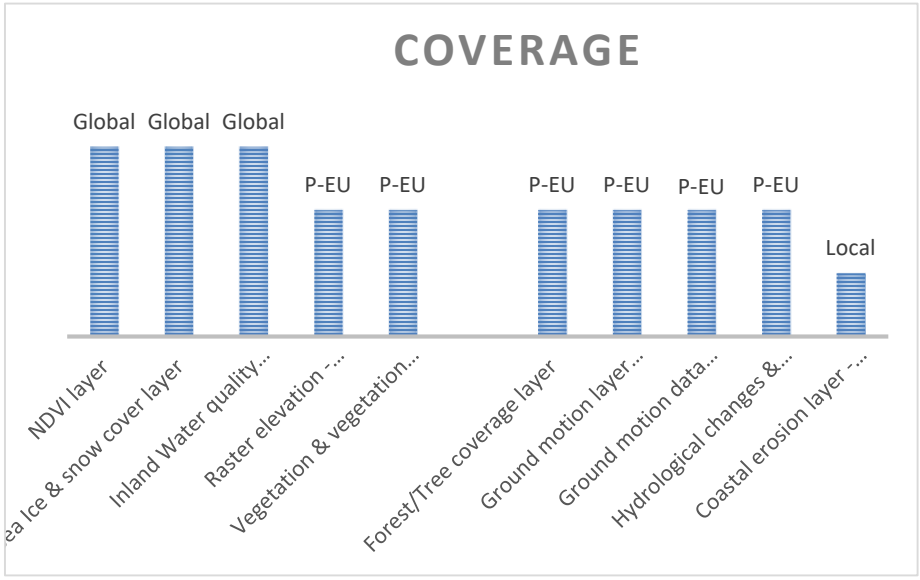
Link between regularly delivered service and on-demand service (central column), Copernicus relative Services (left column) and user requirements (right column).

Gap analysis main outcome and results

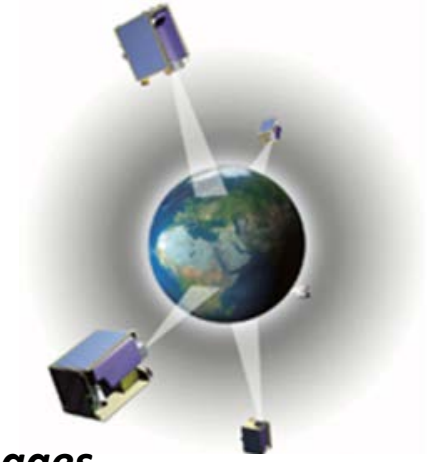


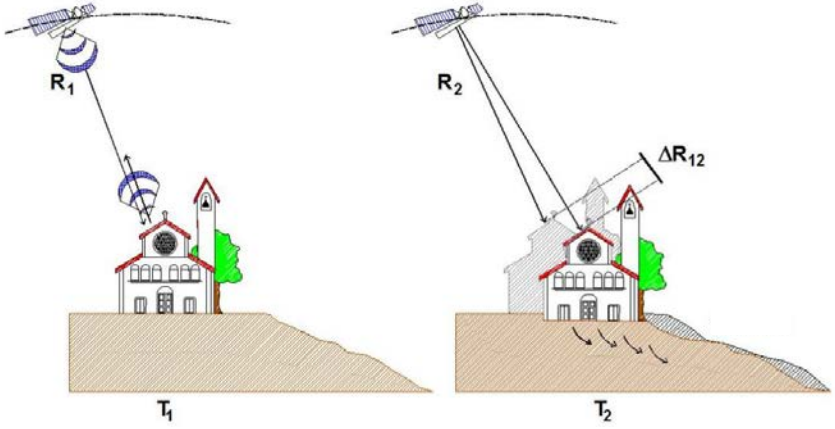
Copernicus Services or Component	Number of identified requirements
CLMS	10
C3S	4
CAMS	3
CMEMS	4
CEMS	5
CSS – SEA	5
CSS – BS	1
CSS - MS	1
In situ	6
Potential future development	3

Through the involvement of the Entrusted Entities, it emerges that most of the Copernicus products have the potential to satisfy the requirements.

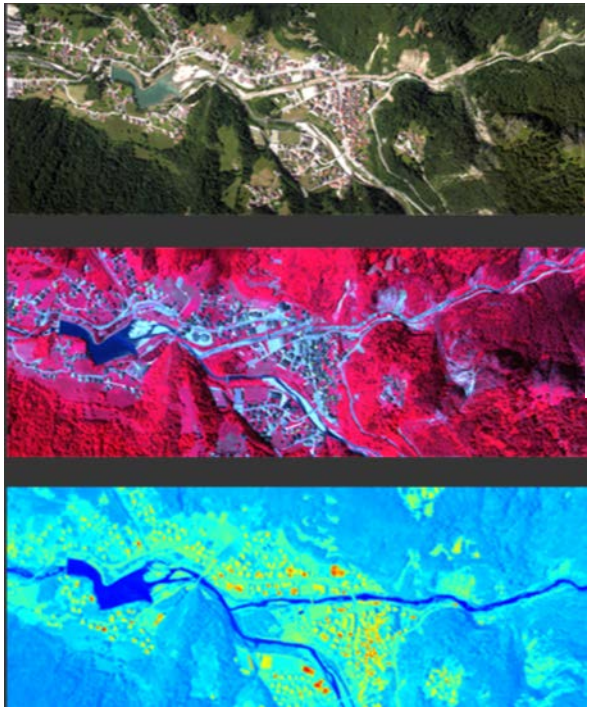


Data Warehouse Phase 2 Copernicus Contributing Missions





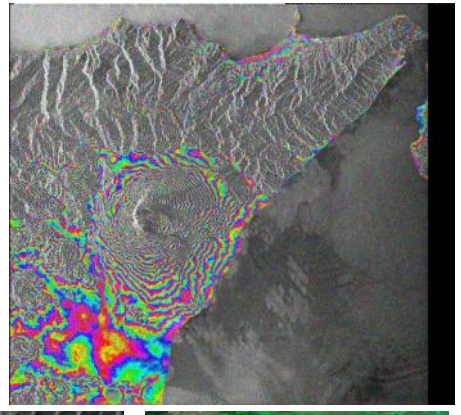
Optical images
MULTI E IPER SPECTRAL

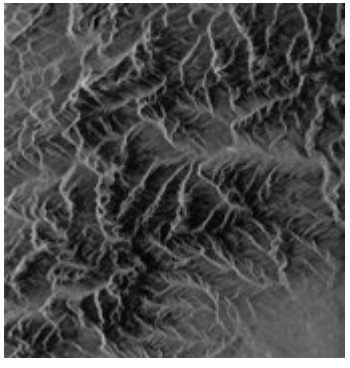


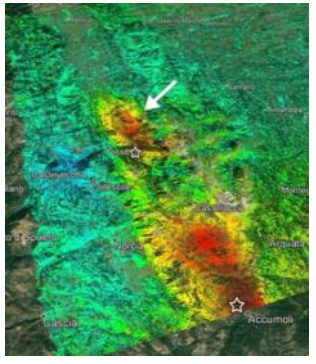
Mission Group 1 - SAR VHR1-MR2	Mission Group 2b Optical VHR1/2	Mission Group 2 Optical HR1/2	Mission Group 3 Optical MR1/2	Mission Group 4/5 Atmospheric missions	Others
ALOS-PALSAR	Deimos-2	ALOS-AVNIR-2	Proba-V	ERS-1/2	CryoSat
COSMO-SkyMed Constellation	Dubaisat-2	Deimos-1	Resourcesat-1, Resourcesat-2	Envisat	SMOS
Envisat	GeoEye-1	Landsat-5 Landsat-7 Landsat-8	Oceansat-2	GOSAT	ERS-1/2
ERS-1/2	IRS-P5 CartoSat	Proba	Sentinel-3	ODIN	Sentinel-3
Kompsat-5	Ikonos-2	RapidEye Constellation			
PAZ	Kompsat-2, Kompsat-3	ResourceSat-1, ResourceSat-2			

RADARSAT-2	Pleiades-1A/1B	Sentinel-2			
RISAT-1	QuickBird-2	SPOT-4, SPOT-5, SPOT-6-7			
Sentinel-1	SPOT-5, SPOT-6/7	TH constellation			
TerraSAR-X, TanDEM-X	TH constellation	UK-DMC2			
	WorldView-1, WorldView-2				
	WorldView-3				
	Worldview-4				

Radar Images







DInSAR analysis for geohazard assessment at the Roman city of Carsulae (Central Italy)

[1] ISPRA
Geological Survey of Italy

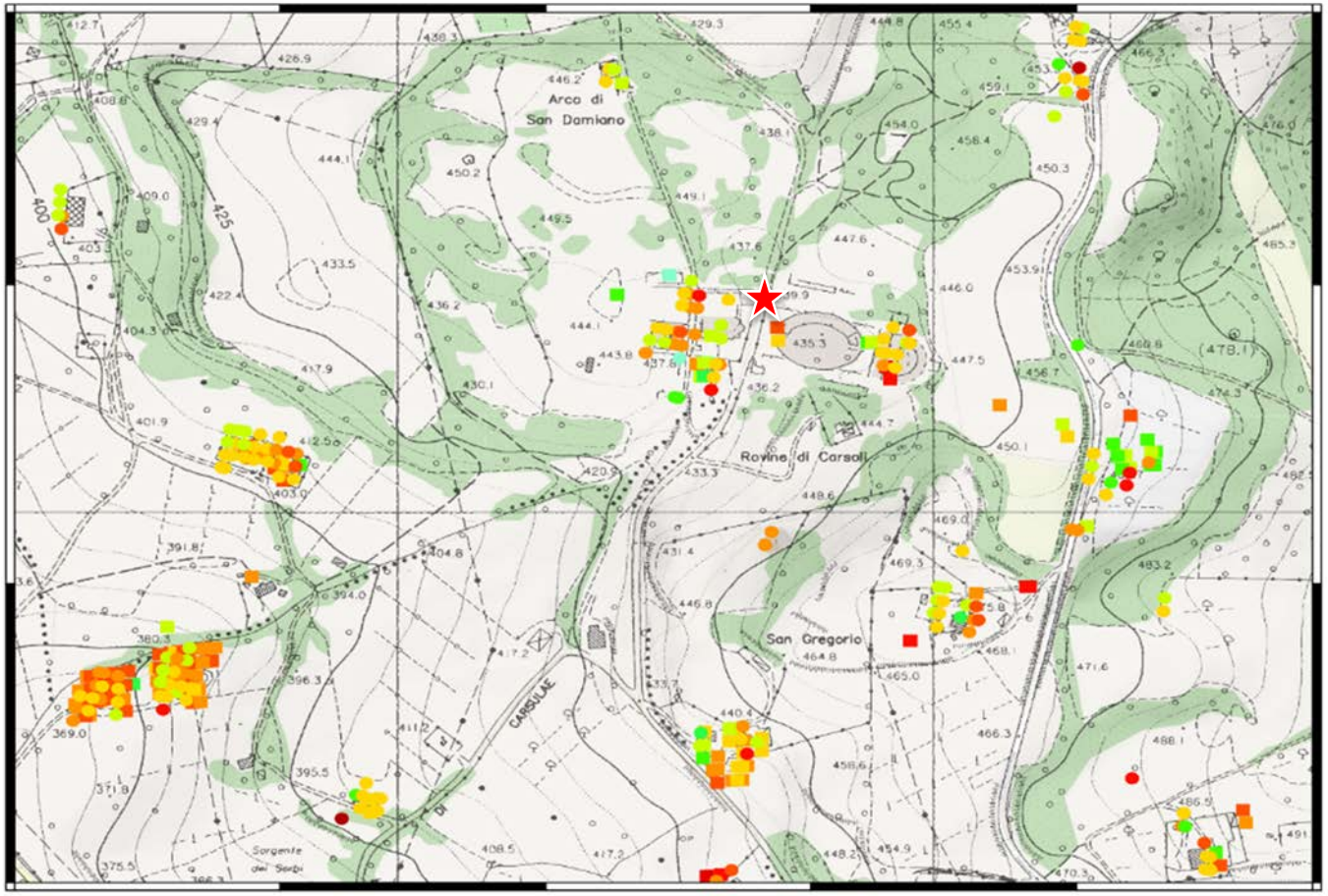
[2] MIBACT
Polo Museale dell'Umbria

[3] MIBACT, Parco Archeologico dei Campi Flegrei

EGU2020-6652 EGU General Assembly 2020

DInSAR analysis

PS ground displacements, period August 2018 – July 2019



- **Ascendent**
- **Descendent**

LOS 75°

LOS 285°

Velocity along LOS (mm/year)

−30 −20 −10 0 10 20 30

DInSAR analysis has been conducted using SAR data from Sentinel-1 to run the SBAS technique.

This good combination of wavelength band, data resolution and revisit time optimizes the results in rural areas.

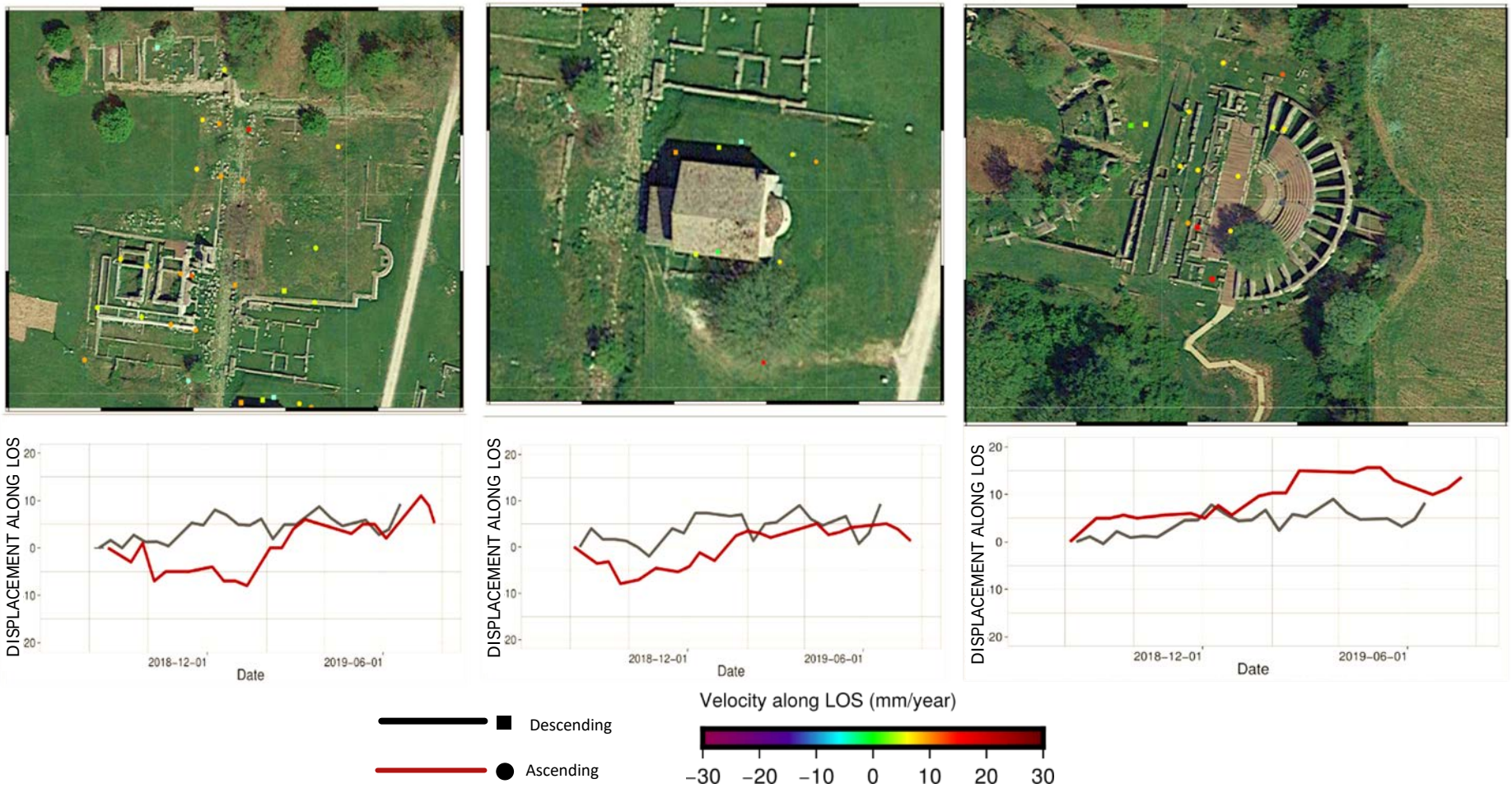
Particular attention was paid to the selection of the Ground Reference Area as a geologically stable site.

DInSAR analysis

Forum – Twin Temples

San Damiano church

Theater



At the Forum-Temples-Church area, the PS highlights a weak movement upward and westward, by 5-10 mm during the fall period (Nov 2018 – Jan 2019), then stable until the end. At the Theater the PS show a continuous trend downward.

Direct survey

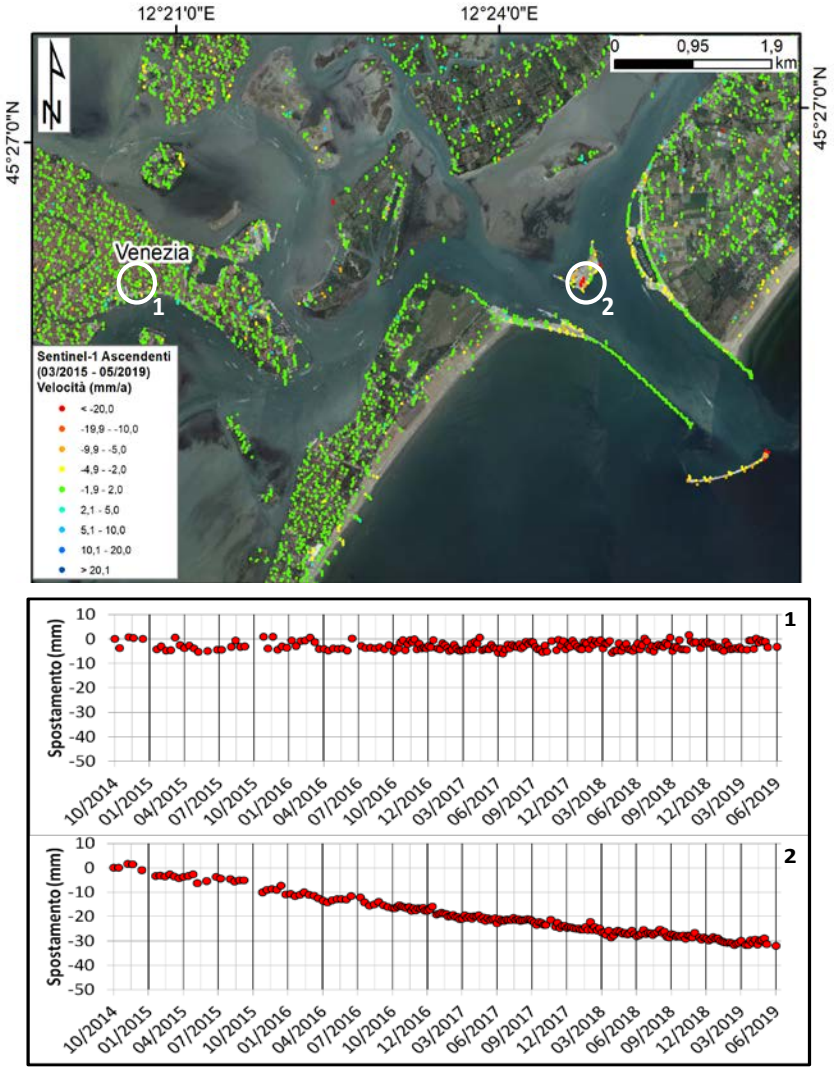
A field survey has been carried out on the archaeological remains to validate EO analysis, highlighting the absence of important damages, according with the overall ground stability of the site. Although some useful results were obtained, it is worth noting that the lack of coherence due to the rare natural or manmade reflectors and the availability of images limited to last year did not allow the complete exploitation of the technique.

VENICE AND ITS LAGOON (ITALY)

Silvia Bianchini, Nicola Casagli, Earth Sciences Department, University of Firenze, Via La Pira 4, Florence (Italy). nicola.casagli@unifi.it

Venice, is built on more than 100 small islands in a lagoon in the Adriatic Sea. It has no roads, just canals, lined with Renaissance and Gothic palaces. The central square, Piazza San Marco, contains St. Mark's Basilica, which is tiled with Byzantine mosaics, and the Campanile bell tower offering views of the city's red roofs.

Sentinel-1 satellite SAR (Synthetic Aperture Radar) data processed by means of multi-temporal interferometric techniques, i.e. Persistent Scatterers Interferometry (PSI), are operationally exploited to analyse terrain deformations motions across time with a frequent update (6-12 days following the Sentinel-1 short revisiting).



PSI Sentinel-1 satellite data on Venice city: spatial distribution of mean yearly velocities (up) and time series of two selected measure points

FLORENCE CITY CENTRE AND SURROUNDING METROPOLITAN TERRITORY (ITALY)

Silvia Bianchini, Nicola Casagli, Earth Sciences Department, University of Firenze,
Via La Pira 4, Florence (Italy). nicola.casagli@unifi.it

Some recent events like the Lungarno Torrigiani collapse in 2016 and the Lungarno Diaz sinkhole in 2019 as well as the historical slope instability problems of San Miniato hill demonstrate that phenomena of hydrogeological instability could be a real risk to the integrity of the historic centre of Florence city and surrounding metropolitan territory .

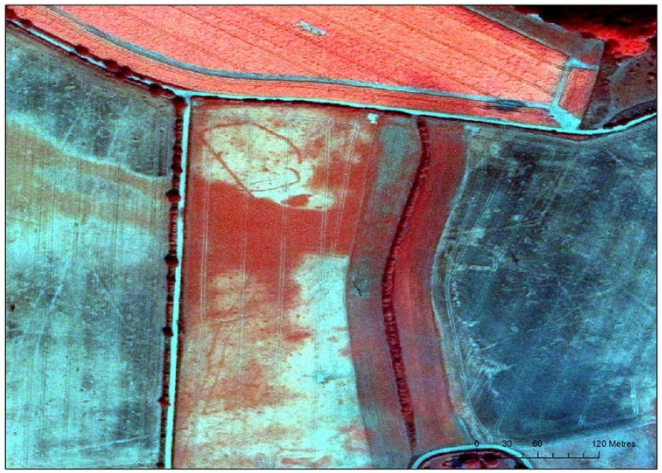
remote sensing techniques are an efficient tool to this aim, given the need to adopt non-invasive techniques without direct contact with the objects of investigation in order not to damage them

At the moment, Sentinel-1 satellite SAR (Synthetic Aperture Radar) data processed by means of multitemporal interferometric techniques, i.e. Persistent Scatterers Interferometry (PSI), are operationally exploited to analyse terrain deformations on the area with millimetric accuracy and frequent update (6-12 days following the Sentinel-1 short revisiting), allowing to dynamically and continuously

Monitoring of the Florence city center by means of radar satellite interferometric techniques exploiting Copernicus Sentinel-1 constellation.

Assessing the Utility of High-Resolution Satellite Remote Sensing for Archaeological Prospection and Mapping

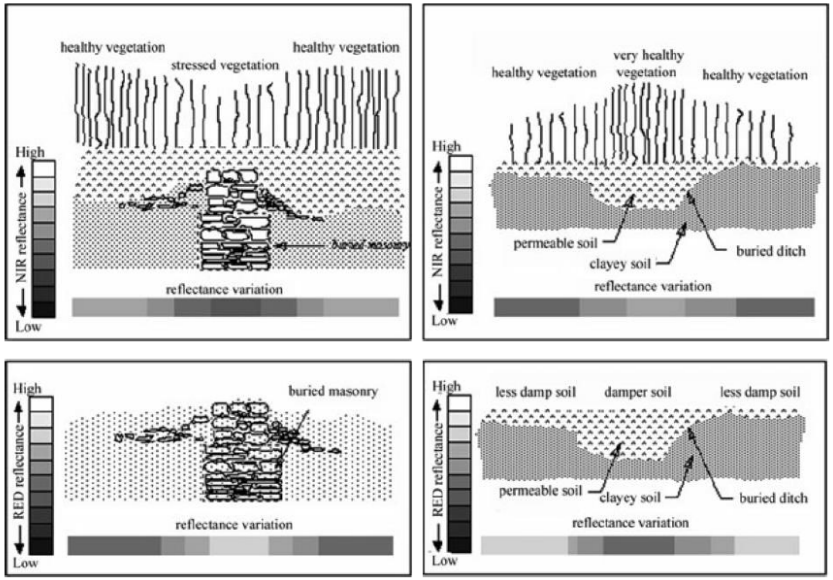
Keith Challis, and Simon Crutchley
Remote Sensing Coordinator , National Trust, Heelis, Kemble Drive, Swindon, Wiltshire, SN2 2NA UK



Cropmarks near Harkstead, Suffolk, UK. WorldView2 False Colour Composite

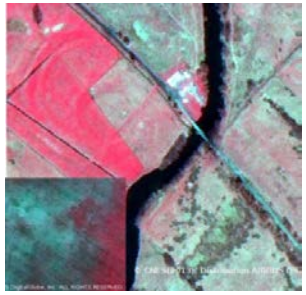
Cropmark enclosure near Ladcock, Cornwall, UK. WorldView 2 False Colour Composite.

When funding for archaeological prospection is challenging, single satellite images covering a large area, offer a cost-effective contribution to campaigns of archaeological prospection.



Chris Stewart & Philippe Martimort, Workshop Copernicus 24/04/2017
Lasaponara&Masini 2012,

Marker :
Vegetation = **NIR**
Soil = **Red**
humidity= **SWIR**



In general, digital multispectral imagery was found to be most suited to detection and mapping of archaeological cropmarks. Soil marks and illumination dependent features are less well evidenced on such imagery due to the less pronounced spectral variations in soil properties and the fact that most imagery is captured in periods of relatively even illumination where shadow features are minimised

Sub metre resolution imagery from the WorldView 1 and 2 and Quickbirld sensor platforms were found to provide consistently good imaging of cropmarks on images captured at appropriate seasons.

MONITORING CULTURAL-HISTORICAL LANDSCAPES IN NORWAY

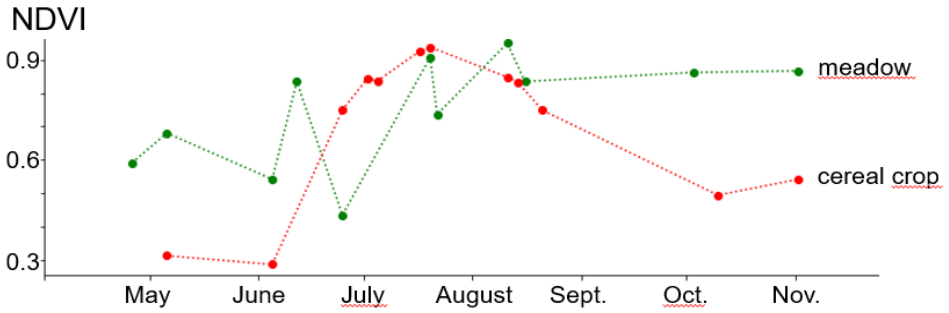
Wendy Fjellstad, Research Scientist, Norwegian Institute of Bioeconomy Research NIBIO

Land cover greatly influences our experiences of cultural heritage in the landscape. Photo from Oldtidsveien-Skjebergsletta, W. Dramstad, NIBIO

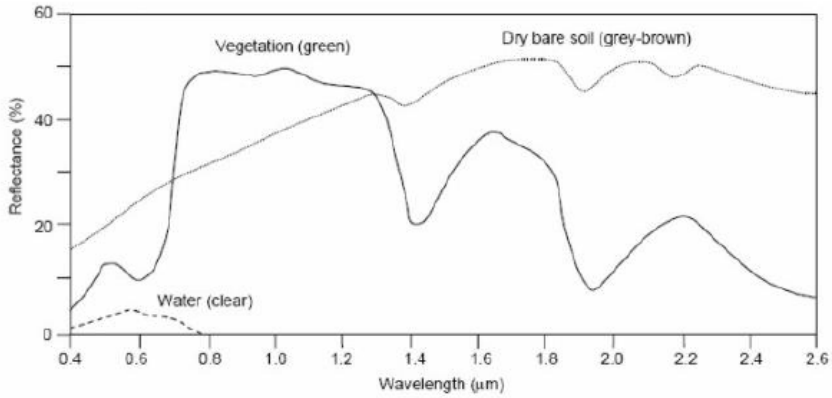
By combining the detailed maps with digital terrain models, we are also able to assess the degree of visibility of different changes in the landscape and assess their importance in relation to the cultural heritage values in the area.

Relevant changes are clear-cutting of forest, afforestation, re-growth of forest on former agricultural land, changes from cereal production to permanent grassland, and building and infrastructure construction.

Sentinel-2 therefore significantly improves data availability for Norway. By analysing how pixels change during a growing season, is possible to determine how land cover and, by inference, land use change.



Changes in normalized difference vegetation index (NDVI) throughout the year. The meadow has green cover at the end of the year, the cereal crop does not



Typical spectral reflectance curves of common earth surface materials in the visible and near to mid-infrared range. Credits: Department of Geology, Aligarh Muslim University, India

Conclusion and follow up

•Cultural Heritage represents a priceless resource for the sustainable development in Europe and worldwide;

• Current remote sensing technology, accessible to EU citizens via the Copernicus program, offers an incomparable possibility for fostering its protection and valorisation by delivering tools to diverse target stakeholders, including managers and professionals;

•the current Copernicus Programme capacities cover a considerable portion of the requirements of the Cultural Heritage community nevertheless efforts are still required to customize current Copernicus products on the basis of the identified requirements;

•a unique *service-access point* would be of benefit, to permit users to exploit a single infrastructure where Copernicus Products and related information are collected and made accessible e.g. via network-services, being the access to information a still critical issue to be solved;

•the access to Very High-Resolution imagery to test innovative applications aimed at improving monitoring capacity and novel applications is required by the Cultural Heritage research community, having high and specific thematic and geomatic skills