EUROPEAN
COMMISSION

Brussels, 25.10.2019
SWD(2019) 394 final

COMMISSION STAFF WORKING DOCUMENT

Expression of User Needs for the Copernicus Programme

TABLE OF CONTENTS

Contents

1. INTRODUCTION AND OBJECTIVES OF THE DOCUMENT

Copernicus is the European Union's Earth Observation and monitoring programme launched in 2014 (building on its predecessor programme Global Monitoring for Environment and Security - GMES) in order to establish an operational European capacity to deliver Earth Observation data and related value-added services in the fields of environment, emergency management and security according to Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010[1] (Copernicus Regulation).

Copernicus is a user-driven programme and requires the continuous, effective involvement of users - Union institutions and bodies, European, national, regional or local authorities, research entities, the private sector, particularly regarding the definition and validation of service requirements.

Following the adoption of the Copernicus Regulation, the Commission services have engaged in a continuous collection of user needs to gather evidence in view of the implementation of the programme, including feedback from users but also considering emerging needs fostered by changes in society, policies and technologies. This document builds on various consultation sources, including questionnaires, interviews, desk studies and analysis of published reports.

The aim of this document is to provide an overview synthesising all collected needs for Copernicus data and information services, expressed in different policy areas and stemming from various users.

This document responds to the necessity in the Copernicus Regulation to maintain a continuous dialogue with the users to keep the Copernicus programme relevant and to make it an effective tool for policymaking and policy implementation. It has been elaborated following recommendations published in the Copernicus mid-term evaluation report[2] to improve the process to gather user needs for the evolution of the Copernicus programme.

Disclaimer:

This document is a working document of the Commission services. It does not have legal effect and does not commit the Commission. The present document serves to outline collected user needs. The enlisting of user needs does not mean that the Copernicus programme will evolve according to them or that they would necessarily be translated into technical

[1] Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010, OJ L 122, 24.4.2014, p. 44.

[2] European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, *Interim evaluation of Copernicus, final report*, ISBN-978-92-79-71618-8, doi: 10.2873/666679, EU publications office, November 2017.

specifications under the future Space Programme Regulation for the next multiannual financial framework[3]. This document is intended to serve as a source of information and evidence as regards the evolution of Copernicus and its implementation.

1. PRINCIPLES OF THE PROGRAMME

The Copernicus programme is user-driven and policy-driven.

According to the Copernicus Regulation , '*The objective of Copernicus should be to provide accurate and reliable information in the field of the environment and security, tailored to the needs of users and supporting other Union policies, in particular relating to the internal market, transport, environment, energy, civil protection and civil security, cooperation with third countries and humanitarian aid*' and '*Copernicus should be user-driven, thus requiring the continuous, effective involvement of users, particularly regarding the definition and validation of service requirements*'[4].

Copernicus is a civil programme building on the existing national and European capacities, as well as ensuring continuity with the activities achieved under the predecessor programme Global Monitoring for Environment and Security.

Copernicus is broken down into three components (space, service and in-situ) with specifically a service component ensuring delivery of information in six areas: atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency management and security. Data and information products delivered by the Copernicus programme are subject to a free, full and open data and information policy[5].

The programme targets four groups of users[6]:

(a) Copernicus core users: Union institutions and bodies, European, national, regional or local authorities entrusted with the definition, implementation, enforcement or monitoring of a public service or policy;

(b) research users: universities or any other research and education organisations;

(c) commercial and private users;

(d) charities, non-governmental organisations and international organisations.'

---

3 Proposal for a Regulation of the European Parliament and of the Council establishing the space programme of the Union and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013, (EU) No 377/2014 and Decision 541/2014/EU, COM/2018/447 final.

4 See recitals (7) and (18) of the Copernicus Regulation, respectively.

5 Commission Delegated Regulation (EU) No 1159/2013 of 12 July 2013 supplementing Regulation (EU) No 911/2010 of the European Parliament and of the Council on the European Earth monitoring programme (GMES) by establishing registration and licensing conditions for GMES users and defining criteria for restricting access to GMES dedicated data and GMES service information, OJ L 309, 19.11.2013, p. 1–6.

6 Article 3(9) of the Copernicus Regulation.

The Copernicus programme is policy-driven. According to the Copernicus Regulation, the Commission should support the appropriate development of Copernicus services and ensure the complementarity, consistency and links between Copernicus and other relevant Union policies, instruments, programmes and actions in order to ensure that those policies, instruments, programmes and actions benefit from Copernicus services[7].

2. IMPLEMENTATION OF THE PROGRAMME

The implementation of the programme from capturing the user's needs to the implementation of relevant space infrastructures and services (land monitoring, marine environment monitoring, atmosphere monitoring, climate change, emergency management and security) is defined by the Copernicus Regulation.

The Commission has concluded Delegation Agreements with entities, including the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)[8], to develop and operate space capacities and the service components for the purpose of the programme.

In accordance with the Copernicus Regulation, the Commission has adopted two implementing Decisions setting out the Technical Specifications for the Copernicus service component[9] and the Technical Specifications for the Copernicus space component[10]. The technical specifications are largely based on the preparatory work of the implementation groups (involving the key stakeholders for each service) which were organised by the Commission in 2007-2010. The technical specifications identify the portfolio of data and information services to develop within the Copernicus programme in order to satisfy a subset of user needs that is considered of high priority and relevant for the Copernicus objectives. Based on the technical specifications and the data and information collected and identified therein, the user needs are then developed in more technical detail. They are transformed into user requirements to drive the implementation of the components of the Copernicus programme.

User interaction and user feedback play a significant role for improving the data and services' products and gaining further insight on the user needs and their possible evolution. In order to ensure the continuous and effective involvement of users, particularly regarding the definition and validation of service requirements[11], as well as to provide ESA with needs for space observations derived from these service requirements, the Commission services carried out a major study to collect user needs. This allowed to process for the first time user needs in a

---

7 Article 9(4) of the Copernicus Regulation.

8 Articles 10 and 11 of the Copernicus Regulation concern the entrustment of implementation tasks.

9 Commission Implementing Decision (EU) 2018/620 of 20 April 2018 on the technical specifications for the Copernicus service component pursuant to Regulation (EU) No 377/2014 of the European Parliament and of the Council, OJ L 102, 23.4.2018, p. 23–55.

10 Commission Implementing Decision (EU) 2018/621 of 20 April 2018 on the technical specifications for the Copernicus space component pursuant to Regulation (EU) No 377/2014 of the European Parliament and of the Council, OJ L 102, 23.4.2018, p. 56–79.

11 Recital 43 of the Copernicus Regulation.

more systematic manner across all application areas and to understand their evolution since the GMES implementation groups set up during the preparation of the GMES initial operations (2010-2013) and the Copernicus programme (2014-2020).

The implementation of Copernicus in the long-term will then take into account evolving user needs benefiting also of latest technological developments. As regards the next multiannual financial framework, the implementation of Copernicus will take place in accordance with the rules to be set out by the EU legislator in the future Space Programme Regulation.

3. CONSULTATION OF USERS

The consultation of users carried out in order to identify user needs has been threefold, considering the existing Copernicus service portfolio as the starting point:

- **user consultations** made through questionnaires, interviews and workshops, Copernicus service feedback mechanisms, access to core user expert groups, consultation with ESA, EUMETSAT, Member States, participating states;
- **desk studies** comprising the review of existing policies (i.e. as set out in EU legislation, communications published during the current multiannual financial framework timeframe);
- **analysis of published reports** from expert groups in space technologies, review of ESA, Framework Programme 7 for Research, Horizon 2020 project outcomes and market reports.

During this process, the four groups of Copernicus users (as outlined in section 1) have been consulted with a priority to identify the needs of core users in most of the policy areas.

In this context, the need of the Commission services have also been collected to consolidate the policy context and include needs from the public or the private sector at European or national level to comply with policies.

All needs have been recorded 'as expressed' by users or as given in source documents. They have been stored in a database with full traceability of the information in order to identify which categories of users were consulted and which meetings or source documents were reviewed.

User needs have been categorised whenever possible according to areas of benefits under three referentials: the societal benefit areas of the Group on Earth Observation[12] (GEO), the

[12] The Group on Earth Observations (GEO) is an intergovernmental organisation working to improve the availability, access and use of Earth observations for the benefit of society with 105 participating Member Countries and 129 Participating Organisations, information available at https://www.earthobservations.org/index.php.

market segment taxonomy defined by the European association of remote sensing companies (EARSC)[13] and EU policy areas.

User needs have been categorised whenever possible into observation requirements, product/service requirements or generic functional needs to support the formal user requirement exercise.

For the purpose of transparency, the list of consultations and sources are provided in annex (cf. 7.2) and minutes of workshops are published online on the Copernicus web site[14]. The database with user needs and observation needs is also available on the Copernicus website[15]. Its structure is described in annex (cf. 7.3).

4. ASSUMPTIONS

This document results from activities performed up to May 2019. Several assumptions are important to recall as regards the form and content of the document.

User base: the consultation mainly targeted core users. EU policies were analysed to identify needs of EU agencies and national public actors to monitor, control and plan policies implementation, or the needs of the private sector that has to comply with policies. However, national or regional policies have not been reviewed extensively unless being addressed during interviews.

Expressions of needs by the private sector, research users or governmental and international organisations have been included only if directly linked to the implementation of European policies or the international commitments of the EU, and accessible through consultation or desk studies.

Heterogeneity: the knowledge about expected and effective use of Copernicus varies considerably in form, content and maturity from one user community to another that means that the expressed user needs vary in detail.

The scope of the document addresses a wide range of potential applications, policies, markets sectors, and societal benefit areas from a very large and quite diverse community of users ranging from different countries or European organisations, international organisms, from research entities to public bodies, industries, small and medium enterprises, non-governmental organisations or associations.

Feasibility: needs have been captured from a user perspective with no restriction nor hypothesis if and how they could be technically feasible or fulfilled in the future by Copernicus.

---

13 EARSC, *A Taxonomy for the EO Services Market: enhancing the perception and performance of the EO service industry,* 2015.

14 https://www.copernicus.eu/en/events/events

15 https://www.copernicus.eu/en/documentation/technical-documents/technical-documents
https://www.copernicus.eu/sites/default/files/2018-10/Nextspace_FullUserReqs_20180228.xlsx

5. USER NEEDS

5.1. Monitoring of the Land environment

5.1.1. Land cover, land use and changes

State of play

Copernicus provides geographical information on land cover, land use and its changes at European scale and global scale. On the European scale, land cover and land use mapping classifications are based on the Corine Land Cover classification (CLC[16]). This is refined into detailed high-resolution layers (HRL) on land cover characteristics, such as imperviousness, forests, grassland, water and wetness, and small woody features. Copernicus provides in addition 3D dimensional information based on digital elevation model and reference hydrological networks reference mapping. At global level, the land cover mapping follows the modular-hierarchical Land Cover Classification System of the Food and Agriculture Organization of the United Nations (FAO)[17] and delivers mainly information on vegetation, soil energy, water and cryosphere.

Policy context

Knowledge on land use and land use change is of primary importance to support many regulations for which the use of land has to be known, reported and even planned. As an example, building on the outcome of the Reporting Fitness Check[18], the Commission has adopted ten actions that will improve environmental reporting, described in the Commission Report '*Actions to Streamline Environmental Reporting*'[19]. Another important policy application is the land use monitoring especially in the context of climate change. The Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry (LULUCF)[20] into the 2030 climate and energy framework was adopted in May 2018, and requires that estimates of emissions and removals from land should be based on spatially explicit datasets.

---

16 The Corine Land Cover (Coordination of Information on the Environment Land Cover, CLC) is a European programme establishing a computerised inventory on land cover of the EC Member States and other European countries, at an original scale of 1: 100 000, using 44 classes of the 3-level Corine nomenclature, information available at https://www.eea.europa.eu/publications/COR0-landcover.

17 FAO, *Land cover classification system (LCCS): Classification concepts and user manual*, v1.0, ISBN-92-5-104216-0, 2000.

18 Commission Staff Working Document *Fitness Check of Reporting and Monitoring of EU Environment Policy* Accompanying the document Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Actions to Streamline Environmental Reporting SWD/2017/0230 final.

19 Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Actions to Streamline Environmental Reporting* COM/2017/0312 final.

20 Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU, OJ L 156, 19.6.2018, p. 1–25.

A reference mapping of the land use is thus necessary to support many policies as described in following chapters and the Corine Land Cover programme was created in 1985 and implemented by the European Environmental Agency for this multi-purpose use. Some of the policies like the Common Agriculture Policy (CAP) and policies related to the urban agenda evolve in terms of minimal mapping unit (MMU) that needs the evolution of Copernicus land use reference mapping.

User community

Many Commission services are performing their tasks based on numerous statistical information such as regional and urban statistics, EU-wide harmonised land use/land cover statistics provided by Eurostat and geospatial statistics created from geo-coded data and displayed on maps of different scales. Similarly, national and local agencies such as planning services, geographical survey agencies, greenhouse gas inventory compilers, regions and departments need similar information for the management of their territory.

Evolving needs

For reference mapping and based on the work performed by the EAGLE[21] group under the European Environmental Agency authority, the current time series of the reference Corine Land Cover (CLC) programme[22] could evolve in spatial and temporal resolution to CLC+ by 2023 to go for 1 ha minimum mapping unit. Update intervals could be shortened compared to the current 6 years update cycle (e.g. 2 years) in Europe and synchronised with other existing information published on land-use and land-cover such as the Eurostat's LUCAS survey. The timeliness of the dissemination of the information could be improved to less than t+1 year.

Additional high-resolution layers (HRL) of information have been identified such as: the coastal geomorphology, forest, EAGLE agricultural information, soil features, imperviousness matching needs for natural capital accounting[23], Natura 2000 habitats, air quality reporting and management, energy siting, green infrastructure development and planning, climate vulnerability, urban mapping and planning, and SDG monitoring. These HRL could become available with higher frequency and better timeliness than today. This has been highlighted specifically in the following paragraphs.

---

21 EAGLE is a working group of the European Environment Information and Observation Network from the European Environmental Agency (EIONET) on land mapping composed from the National Reference Centres for EEA, information available at https://rod.eionet.europa.eu/contacts?roleId=eionet-group-eagle.

22 European Environment Agency, *Corine Land Cover*, 01 January 1995, information available at https://www.eea.europa.eu/publications/COR0-landcover.

23 European Commission, Directorate-General for Environment, *Natural Capital Accounting*, *'Natural Capital accounting is a tool to measure the changes in the stock of natural capital at a variety of scales and to integrate the value of ecosystem services into accounting and reporting systems at Union and national level. An integrated natural accounting system for ecosystems and their services and associated data sets is being developed by the Knowledge Innovation Project (KIP INCA). KIP INCA involves: DG ENV, ESTAT, EEA, JRC, RTD, and links with MS activities and MAES'* available at http://ec.europa.eu/environment/nature/capital_accounting/index_en.htm.

Eurostat needs more high-resolution data to monitor inland waters at national scale but also across boundaries and to keep up-to-date indicators at city scale.

To implement the Directive on renewable energy[24], there is a need to assess the developments in the agricultural sector, including the status of global expansion of agricultural areas into land with high carbon stock, based on latest scientific outcomes. This needs to be based on the production and availability of generic, standardised and harmonised information on land cover, land use and land use changes, available across all EU countries and indeed across the globe.

In combination with high-resolution layers, users need that the reference digital elevation model (EU-DEM) and the hydrological networks mapping (EU-hydro datasets) remain consistent in resolution with CLC+ performances (e.g. for canals, water bodies, drainage lines). Their full consistency, harmonisation and continuity across borders and all European territories (including northern areas above 60°N, islands and outermost regions of the EU Member States) could provide for a consistent reporting and implementation at European scale.

In addition to mapping products, observation of dynamic changes of variables defined for reference mapping is a new need to support systematic monitoring of land use and land use changes on a short-term basis. The monitoring of bio-geophysical variables (e.g. normalised difference vegetation index, fraction of absorbed photo synthetically active radiation, fraction of green vegetation cover, leaf area index, and land surface temperature) is needed every 10 days or less with the possibility to assemble long-time series for:

- assessing vegetation state and development dynamics for natural vegetation and agriculture;
- long-term studies related to the impact of climate change and policies on land use;
- environmental monitoring related to wetlands, surface water occurrences, grassland, forest (e.g. related to Greenhouse gas emissions cf. 5.1.7 or international initiatives cf. 5.1.11);
- monitoring of urban areas, rural areas, human settlements and population dynamics for correlation of land use change with dynamics of people, urban sprawl, vehicles-and transport flows;
- climate change impacts assessment considering acute (e.g. heatwaves, flood, etc.) and chronic (e.g. declining precipitation, sea level rise, etc.) hazards;
- extractions of resources monitoring.

A 5-20 m resolution land cover change alert system could be of value for users involved in operational land use/land status monitoring services such as protected park areas managers,

[24] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, OJ L 328, 21.12.2018, p. 82–209.

national statistical institutes and non-governmental organisations (nature preservation). This system could work at European and global scale. Individual or combined products merging multiple layers (including status, changes, derived statistics on inter and intra-annual variability) at 5-20m resolution could be produced typically on a 'occur' basis (when something happens) or on a sub-decade timeframe.

For monitoring the effects of climate change, it is also needed to be able to combine multiple layers of information into products to detect changes and trends (including status, changes, derived statistics on inter and intra-annual variability). Such products could be based on the exploitation of large datasets available in Copernicus with time series of images and images available in various spatial resolution. This could also be relevant to support new agriculture practices.

Statistical institutes need statistical products derived from HRL and other Copernicus data that are validated in terms of statistical errors by applying methods for quantification of errors due to commission and omission in pixel classification and taking into account the quality of the original validation data.

Given the importance of sound statistical information, statistical products derived from Copernicus information – adequately validated and documented – could be distributed on a regular basis together with the map products.

Users finally ask that existing and future products be standardised with automated methodologies for the computation and analysis of desired variables using the full potential of the Copernicus Data and Information Access Services (DIAS).

5.1.2. Regional and urban policies

State of play

Copernicus addresses partially the needs related to regional and urban development since Copernicus services proposes data and information for pan-European purposes to the extent that it respects the principles of subsidiarity and national sovereignty. Several products are however available at local scale to address the regional and local/urban issues such as the urban atlas, riparian zones, Natura2000 sites or the European Settlement Map specially developed in cooperation with the Directorate-General for Regional and Urban policy and the European Environment Agency.

Policy context

The Regional Policy[25] targets all regions and cities in the European Union to support job creation, business competitiveness, economic growth, sustainable and low-carbon and climate resilient development, and improve citizens' quality of life. In order to reach these goals and

[25] https://ec.europa.eu/regional_policy/en/

address the diverse development needs in all EU regions, several funding mechanisms such as the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Social Fund (ESF) budget have been set aside for cohesion policy for 2014-2020. The regional policy is mainly an investment policy, to help implementing and complementing many EU policy objectives such as those dealing with education, employment, energy, agriculture, the environment, climate change, the single market, research and innovation that are each individually addressed in the document.

The *Report on Economic, Social and Territorial Cohesion*[26]*, The State of European Cities Report*'[27] and the *European urban agenda report*[28] are all documents demonstrating the need and the use of remote sensing.

In these three reports, there has been a growing use of remote sensing derived data. Together with other geospatial data (provided by Eurostat, the European Environment Agency, Member States or other institutions such as the Organisation for Economic Co-operation and Development - OECD), these data enhance the analytical possibilities, especially by providing opportunities for the production of local and/or urban indicators and typologies.

The EU urban agenda launched in May 2016 with the Pact of Amsterdam[29] is an important component of regional policy. It represents a new multi-level working method promoting cooperation between Member States, cities, the Commission and other stakeholders to stimulate growth, liveability and innovation in the cities of Europe and to identify and successfully tackle social challenges. Major objectives are:

- sustainable urban development;
- smart cities and communities;
- actions to tackle climate adaptation and energy transition;
- the Habitat III new urban agenda[30];

---

26 European Commission, Directorate-General for Regional and Urban Policy*, My Region, My Europe, Our Future, Seventh report on economic, social and territorial cohesion*, September 2017, available at http://ec.europa.eu/regional_policy/en/information/cohesion-report/.

27 European Commission, United Nations Human Settlements Programme (UN-Habitat), *The State of European Cities 201, Cities leading the way to a better future*, 2016, available at http://ec.europa.eu/regional_policy/en/policy/themes/urban-development/cities-report/.

28 Report from the Commission to the Council on the Urban Agenda for the EU, *Urban Agenda for the EU*, COM/2017/0657 final, available at https://ec.europa.eu/futurium/en/urban-agenda-eu/what-urban-agenda-eu.

29 *Urban Agenda for the EU, Pact of Amsterdam, Establishing the Urban Agenda for the EU 'Pact of Amsterdam', agreed at the Informal Meeting of EU Ministers Responsible for Urban Matters on 30 May 2016 in Amsterdam, the Netherlands*, 30 May 2016, available at https://ec.europa.eu/regional_policy/sources/policy/themes/urban-development/agenda/pact-of-amsterdam.pdf.

30 UN-Habitat for a better urban future, Habitat III is the United Nations Conference on Housing and Sustainable Urban Development from 2016. In resolution 66/207 and in line with the bi-decennial cycle (1976, 1996 and 2016), the United Nations General Assembly decided to convene the Habitat III Conference to reinvigorate the global commitment to sustainable urbanization, to ratify the "New Urban

- air quality and health;
- circular economy;
- urban mobility;
- sustainable use of land and nature-based solutions;
- transition to a low-carbon/climate-neutrality and climate-resilient economy and society.

For each of them, three pillars are considered: better regulation, better funding and lastly better knowledge to which Copernicus can directly contribute in terms of monitoring environmental situations and efficiency of policy actions.

User community

The Copernicus programme could adapt its offer to the regional dimension of Europe, providing relevant information for European regions but also for regions as defined by Member States, for needs expressed for instance by the Committee of the Regions. Target communities are regional planners, urban planners, city councils, the Covenant of Mayors' signatories, public utilities operators, and any agency or operator in charge of territorial management.

Evolving needs

With an increasing percentage of the population living in an urban environment, the spatial planning of large cities requires an in-depth understanding of land use / land change spatial patterns to ensure and preserve good quality living conditions. This becomes even more important as more cities grow towards megacities (> 10 M inhabitants) and megalopolis (e.g. Randstad, Rhine-Ruhr, Upper Silesia, Flemish diamond). With 72% of the European Union's population living in cities and urban areas[31], these are places where environmental problems, such as air, water and land pollution (e.g. illegal waste dumping) and excessive noise, are central. Cities are also particularly vulnerable to increasing climate change impacts and risks, such as cloudbursts, floods, heat waves, drought, forest fires and coastal erosion. Urban areas also account for about 80% of energy use, about the same share of greenhouse gas emissions, and generate up to 85% of Europe's Gross Domestic Product (GDP).

Therefore, reliable data, in land cover change mapping, with a resolution that is fit for purpose is necessary (e.g., land cover maps and HRL less than 20 m). From observing the land cover change, land use change can be modelled and understood. The identification of generic layers matching all activities and problems to track at urban scale is needed portraying the diversity of structures and tasks of urban authorities, for evidence/fact-based urban policy making, as

---

Agenda", building on the Habitat Agenda of Istanbul in 1996, information available at https://unhabitat.org/habitat-iii/, new urban agenda, available at http://nua.unhabitat.org/.

[31] Eurostat, *Urban Europe Statistics on cities, towns and suburbs 2016 edition*, ISBN 978-92-79-60140-8, 2016.

well as for providing tailor-made solutions to major challenges, for instance through the implementation of nature-based solutions. This includes appropriately downscaled, user-friendly and easy-to-download sets of past, current and future climate data at the various levels of the nomenclature of territorial units for statistics (NUTS) – suitable for climate change adaptation planning and decision-making.

Copernicus information could help monitoring the following areas and/or topics:

- green corridors, ecological corridors, urban forests/vegetation cover;
- urban sprawl, imperviousness, flood-prone areas, ground motion of major civil works in the event of subsidence/seismic risks;
- real-time transport and urban traffic for optimisation of public transport and traffic lights, bike and car sharing;
- urban heat island effect, heat waves and related surfaces albedo;
- air quality and temperature, industry and airport emissions;
- infrastructures, utilities networks, mapping of buried optic fibre, gas and electric lines;
- buildings (roof) thermal losses, critical infrastructures;
- changes in characteristics of the environment due to natural disasters, soil morphology and moisture, inland and sea water quality and temperature;
- sustainable urban agriculture, solar energy, winds for wind power stations;
- detection of illegal dumpsites.

Additional new layers of information are needed: building height, 3D mapping of buildings for energy consumption, building footprints and road width. In addition, the information could be maintained up-to-date being synchronised with the recommendations of the United Nations committee of experts on global geospatial information management for updating Europe core data (e.g. for cadastral parcels) and with other pan-European data release calendars (e.g. LUCAS). It is important that they are refreshed every two years, taking special care to shorten the time between observation and products release.

Regional development also includes the support to outermost regions that are mostly of small size, isolated and remote, while being part of the European Union. Same level of data and information services for these remote territories are crucial with priority given to providing information on the marine environment and marine pollution, land cover/land use including agricultural and soil pollution aspects, biodiversity and plant health, climate change risks and adaptation, atmosphere and air pollution.

5.1.3. Soils

State of play

Copernicus delivers information on soil mainly as part of the high-resolution layers of the Corine Land Cover (CLC) classification products (e.g. imperviousness). Additional products have been added in 2017 and 2018 to the Copernicus portfolio related to water and soil such as surface soil moisture and soil water index. However, at this stage the portfolio related to soil characteristics, soil mapping and soil changes remains limited.

Policy context

Soil protection is not regulated at European level and Member States can individually develop specific policies for the sustainable exploitation and conservation of their soil. However, the Commission proposal for a post-2020 CAP (cf. 5.1.5) devoted special attention to the contribution of agriculture to the conservation of the soil fertility and 5 of the 10 GAECs proposed (Standards for Good Agricultural and Environmental Condition of land) focus on soil conservation.

European guidelines have been set up under the Seventh Environment Action Programme[32], which entered into force in 2014 and recognises that soil degradation is a serious challenge. It defines that, by 2020, land is managed sustainably in the Union, soil is appropriately protected and the remediation of contaminated sites is well underway. It also commits the EU and its Member States to increasing efforts to reduce soil erosion and increase soil organic matter and to remediate contaminated sites.

User community

The community concerned by soil ranges from regional planners, to environmental agencies, agricultural departments, researchers in charge of climate change analysis or emergency services facing possible risks of droughts, landslides, floods or fires. It also includes the community exploiting land and soil e.g. stone carry, mining industry, water extraction.

Evolving needs

The needs in this sector of policy are for harmonised methodologies for the continuous monitoring of the soil properties described below and the activities with potential impact on soil (soil sealing, maintenance of the canopy cover, plodding intensity etc.).

Information like soil properties (texture, structure and composition) is needed for the dynamic monitoring of soil changes, land degradation and desertification processes. Surface and root zone soil moisture are needed for activities such as mapping agricultural practices minimizing the soil erosion. Burned areas and soil chemical content are also needed.

---

[32] Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 '*Living well, within the limits of our planet'*, OJ L 354, 28.12.2013, p. 171–200.

Information needs to be refreshed regularly but also delivered as long-time series of data for climate change monitoring purposes and assessment of agricultural and environmental policies. The needed time and spatial resolutions are yearly or seasonal maps based on daily to weekly information and 5-20 m pixel to go for 0.5 to 1 ha minimum mapping unit although more ambitious temporal and spatial resolutions could also allow addressing specific issues at lower scale.

Added to a regular mapping of land use/land change (cf. 5.1.1) and inland waters (cf. 5.1.4), the monitoring of ground motion is important for many local public administrations or operators of civil works. Geotechnical communities but also civil protection or seismic institutes ask for ground deformation maps, detection of aboveground and underground infrastructures deformations updated regularly at high-resolution and millimetre accuracy. This is to monitor phenomenon such as erosion, organic matter decline, salinization, compaction and landslides for dynamic land management, for groundwater extraction or building permissions, town planning or civil engineering.

The scientific communities and non-governmental organisations interested in acidification and eutrophication of vegetation and soils need soil chemical content affected by atmospheric deposition fluxes of nitrogen oxides, ammonia and ammonium salts, sulphur oxides, particle matter and ozone.

Building long-time series of data on soils is at stake for climate change monitoring purposes and assessment of environmental policies.

5.1.4. Inland Water

State of Play

Water products from Copernicus are new. They include inland water, wetness, snow and land ice products.

Water levels are computed for 1000 lakes larger than 50 ha and intersections of major river networks. Lake water quality products and lake surface water temperature are produced according to the Global Lakes and Wetlands Database[33] (GLWD) and the Water Framework Directive[34]. At pan-European level, Copernicus produces water and wetness products (permanent water, temporary water, permanent wetness and temporary wetness), a water and wetness probability index and water bodies' areas covered by inland water along the year.

Snow cover has a strong influence on the Earth's radiation and energy balance. Changes in snow extent tend to amplify climate fluctuations. This phenomenon need to be well identified for the prediction of water balance, streamflow and river runoff in hydrological models used for water resource management, climate modelling and arctic/sub-arctic area monitoring. The

[33] https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database

[34] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000, p. 1-73.

key cryosphere parameters monitored within Copernicus are the area snow extent, snow water equivalent and lake ice extent.

At global level, water Essential Climate Variables are produced to report to the International Global Climate Observing System program[35] (GCOS). For climate change monitoring purposes, precipitation, relative humidity and soil moisture are monthly reported.

Copernicus at this stage does not provide regular information on rivers dynamics and especially on river runoff and overall hydrological dynamics, nor on under water systems.

Policy context

The implementation of the Water Framework Directive from 2000 in an integrated way (integrating all pressures from all activities) but also the dynamic monitoring and management of water (drinking, bathing and fresh waters) are major priorities for the next decades. As such, the legal framework was completed by the Bathing Waters Directive[36], the Ground Water Directive[37] and the Directive about Discharge of Dangerous Substances[38]. In February 2019, the Commission issued a report of the implementation of the Water Framework Directive[39] that highlights achievements and remaining challenges versus the objectives established in 2000. The report shows significant improvements in knowledge and reporting on the Water Framework Directive compared to the last reporting cycle. Problems remain however as regards chemical pollution, over-abstraction of water, in particular for agriculture, and obstacles to the natural flow for rivers. In concordance, the Commission proposals for a post-2020 Common Agriculture Policy[40] (cf. 5.1.5) promote the monitoring of

---

35 The Global Climate Observing System (GCOS) is an international programme that regularly assesses the status of global climate observations and produces guidance for its improvement co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the United Nations Environment Programme (UN Environment), and the International Science Council (ISC). GCOS supports the monitoring as requested by the Paris Agreement (COP21).

36 Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330, 5.12.1998, p. 32–54.
Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC, OJ L 64, 4.3.2006, p. 37–51.

37 Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration, OJ L 372, 27.12.2006, p. 19–31.

38 Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community, OJ L 64, 4.3.2006, p. 52–59.

39 Report from the Commission to the European Parliament and the Council on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Second River Basin Management Plans First Flood Risk Management Plans COM/2019/95 final.

40 Proposal for a regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulation (EU) No 1305/2013 of the European Parliament and of the Council and Regulation (EU) No 1307/2013 of the European Parliament and of the Council, COM/2018/392 final.

water resources through the implementation of specific indicators about water quality and quantity.

NB: The Floods Directive is addressed in the chapter related to disasters (cf. 5.12.1).

User community

The portfolio of Copernicus for hydrology and water is new and the user community is not yet fully identified. Major recognised users are the river basin authorities and agencies, regional and local authorities in charge of drinkable water, wastewaters, agencies in charge of agriculture, emergency services and hydro-meteorological administrations. It also includes private actors of the hydro-energy sector or the water transport (cf. 5.4.3). Communities working along the coastline where inland waters connect with the seas are also relevant.

Evolving needs

Following interviews from the community and a dedicated workshop on Copernicus for water held in 2018 (cf. 7.2) more products are needed for the implementation of the Water Framework Directive on natural water retention measures, detection of illegal water abstraction, implementation and control of river basin management plans:

- water quality and water levels (quantity) not only on major lakes, but also in smaller reservoirs and rivers at much finer scale (catchment scale);
- water dynamic monitoring and fluxes such as river runoff, interfaces with seas and oceans to understand interactions between inland waters, seas and land component (e.g. to be used for nutrient pollution alert systems, flood prevention and flood risk management);
- information to monitor additional sources of water such as ground water and aquifers.

The understanding of the hydrological cycle, including the evapotranspiration process and the soil moisture/soil water balance, monitored through timely observations and eventually forecasts, is needed for many applications from agriculture to disaster mitigation or food security and climate. Hydrological models to calculate hydrological fluxes for small streams or entire river basins in connection with sea could be a significant progress that could benefit several Copernicus data and information services requiring hydrological dynamics (climate, ocean, emergency, land) and many users from different sectors of applications.

More information on the hydrological processes could ensure best water use practices related to irrigation monitoring and forecasting, hydrological planning and modelling for river basin governance, risk management including in urban areas, development of inland fisheries and aquaculture, monitoring of the quality of bathing waters and drinking water, evaluation of hydro morphological alterations and pressures in European rivers, lakes, transitional and coastal waters.

Proposal for a regulation of the European Parliament and of the Council on the financing, management and monitoring of the Common Agricultural Policy and repealing Regulation (EU) No 1306/2013 COM/2018/393 final.

For agricultural policy applications, key variables will be evapotranspiration estimates and relevant information for irrigation monitoring. The expected time and spatial resolutions needed are yearly and seasonal maps based on daily to weekly information and a 5-20 m pixel resolution to go for 1 ha minimum mapping unit. These applications could provide data related to the use of water in agriculture for the production of indicators required by the CAP proposal. The requirements for downstream applications like irrigation management advice are more demanding in terms of frequency and faster delivery time.

For all potential snow/iced areas, new accurate and timely information on the cryosphere like snow depth, wet snow, snow melt timeline including past and future variations, ice sheet topography and elevation changes, permafrost and seasonally frozen ground monitoring are also needed especially in the frame of arctic monitoring (cf. 5.3).

In order to better address water use and especially changes in water and cryosphere resources, (e.g. for agriculture, inland aquaculture, disaster mitigation and climate risks like prevalence of pluvial floods due to climate change), water-related forecasts and water-related climate records need to be produced in addition to Copernicus existing observed products.

The inclusion of this information in the Water Information System for Europe[41] (WISE) is also needed.

5.1.5. Agriculture

State of play

The Copernicus programme supports the agriculture sector e.g. for farm management, irrigation, seasonal mapping of yields and cultures or subsidy controls (both for farmers and for policy objectives) through the existing land use / land change products portfolio. Indeed, Copernicus helps assessing agricultural land use and trends, crop conditions and yield forecasts with high-resolution layers of information on grassland, wetness or small woody features. Many products are also proposed for vegetation monitoring such as but not only fraction of green vegetation cover, vegetation productivity, leaf area index, land dry matter and climate indicators on e.g. soil moisture, temperature, humidity and precipitation.

Earth Observation is of high importance for the agriculture sector. However, still many of the public needs are not addressed in particular in the context of efforts addressing correct spending of EU agricultural funds. Member States possess since 2018 the possibility to use Copernicus (or other equivalent data sources) to monitor the fulfilment of eligibility

[41] The Water Information System for Europe (WISE) is a partnership between the European Commission (Directorate-General for Environment, Joint Research Centre and Eurostat) and the European Environment Agency providing a web-portal entry to water related information ranging from inland waters to marine providing input to thematic assessments in the context of EU water related policies for water professionals and scientists with access to reference documents and thematic data.

conditions for area-related aid schemes/measures at the level of farm holdings and/or individual agricultural parcels[42].

This requires, on the one hand knowing the exact area of all parcels eligible for area-related support in a given holding[43] and, on the other hand, whether agricultural activities take place on these parcels and adhere to the eligibility criteria defined by law for those schemes/measures that the beneficiary applied for. Eligibility criteria relate to the presence or absence of specific agricultural activities (e.g. ploughing, mowing, harvesting, grubbing, etc.) and practices within predefined periods or until/from a given cut-off date, as well as to the share of land(s) with specific characteristics in a holding (e.g. crop diversification, ecological focus areas).

One of the main benefits in using Copernicus Sentinel data lies in the timely provision of evidence to beneficiaries about possible inconsistencies between the declared and monitored agricultural reality – in view of avoiding penalties for farmers and costly on the spot controls (as well as financial correction procedures) for administrations.

As these control and payment processes operate along a strict regulatory timeline and are subject to a high accuracy requirement, the current Copernicus products (apart from the update of Sentinel images) are not directly suitable for current control purposes because of their too low spatial resolution (around 12% of the parcels in the EU measure less than 0.5 ha).

Policy context

The Common Agricultural Policy Regulation (CAP)[44] has five major objectives:

- to increase agricultural productivity;
- to ensure a fair standard of living for the agricultural community;
- to stabilise markets;
- to assure the availability of supplies;
- to ensure that supplies reach consumers at reasonable prices.

---

42 Commission Implementing Regulation (EU) 2019/936 of 6 June 2019 amending Implementing Regulations (EU) No 808/2014, (EU) No 809/2014 and (EU) No 908/2014 as regards financial instruments set up under the programmes for rural development OJ L 149, 7.6.2019, p. 58–60.
Commission Implementing Regulation (EU) No 809/2014 of 17 July 2014 laying down rules for the application of Regulation (EU) No 1306/2013 of the European Parliament and of the Council with regard to the integrated administration and control system, rural development measures and cross compliance OJ L 227, 31.7.2014, p. 69–124.

43 Article 10 of Regulation (EU) 1307/2014 stipulates that the eligible area of a holding for which direct payments can be claimed should not be less than 1 hectare. Annex IV of the same regulation indicates that the limit for the adjustment of that area threshold may become 0.3 hectare (or less) for some MS.

44 Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the common agricultural policy and repealing Council Regulations (EEC) No 352/78, (EC) No 165/94, (EC) No 2799/98, (EC) No 814/2000, (EC) No 1290/2005 and (EC) No 485/2008, OJ L 347, 20.12.2013, p. 549–607.

The following future challenges should be noted:

- ensure viable food production that will contribute to feeding the world's population, which is expected to rise considerably in the future;
- climate change adaptation and mitigation as well as the sustainable management of natural resources;
- look after the countryside across the EU and keeping the rural economy alive.

The Commission's vision for the future of the CAP has been subject to two proposals for regulations[45]. They reinforce the importance of using the CAP budget to foster the environmental protection and climate action. In addition, one of the main objectives of the future CAP post-2020 is the development and application of digitalisation in the agricultural and forestry sectors.

Member States would have to pay particular attention to environmental and climatic specific objectives, to generational renewal, and the modernisation of the policy implementation by focusing on a better use of knowledge and advice on new technologies. As such, Member States are for example required to set up an Area Monitoring System (AMS) to support farmers in fulfilling their eligibility and conditionality requirements, simplify the CAP management and contribute to the development of area-based indicators.

The CAP is also a partnership between Europe, its Member States and its farmers with aims to improve agricultural productivity, so that consumers have a stable supply of affordable food and to ensure that EU farmers can make a reasonable living.

User community

The community includes the European institutions, the bodies in charge of agriculture planning and control, regional/national/local actors in ministries of agriculture and paying agencies. Needs from farmers and cooperatives are also collected as long as they need data and information to simplify their compliance with the legislation. However, all needs related to smart farming or precision farming for improving agriculture productivity for the sake of profitability/business are out of the scope if this is not directly linked to compliance to policy.

Evolving needs

- Monitoring of European farm economics

[45] Proposal for a regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulation (EU) No 1305/2013 of the European Parliament and of the Council and Regulation (EU) No 1307/2013 of the European Parliament and of the Council, COM/2018/392 final.
Proposal for a regulation of the European Parliament and of the Council on the financing, management and monitoring of the Common Agricultural Policy and repealing Regulation (EU) No 1306/2013 COM/2018/393 final.

The Commission monitors farm economics based on the production and publication of 45 context indicators made of geographic aggregated data also illustrating trends in time and space, data registered and maintained in the farm accountancy data network.

To do so, users need timely and reliable quantitative (e.g. area) and qualitative (e.g. crop phenology) information[46] on agricultural production but also crop yield forecasts to anticipate the possible effects of meteorological conditions used on crop balance sheets forecasts and short-term outlooks.

Major needs are continuous and consistent long-term archives of vegetation biophysical parameters coupled with land cover information for the qualitative assessment of crop development and growth monitoring. Both large coverage, at regional or sub-regional scale, and high-spatial resolution appropriate to observe smallest parcels size (less than 0.5 ha) are needed together with short revisit time, for a reliable monitoring of crop biomass and the qualitative assessment of crop phenological development. Additionally improvements are needed in weather forecast capacity to better assess the impact on crops.

Building long-term archives of products is needed to develop statistical predictors of growth anomalies and improving vegetation information to better monitor plant health and pests spread (cf. 5.1.9). For the publication of 45 context indicators, Copernicus could be a key source of data if observation could be updated annually rather than every 6 years (as of today with land cover products) and information could be produced according to the three levels of nomenclature of territorial units for statistics (NUTS).

- To support farmers and the environment

The use of digital technologies such as satellites, combined with drones, robots and in-situ sensors for monitoring crops have been identified as one possible means to support farm-level decision making that could benefit productivity purposes while saving natural resources and protecting the environment. On the industry side, farmers need additional information layers with more refined and dynamic information on the vegetation status, phenology and layers related to cultures, shrubs, bare soils, monitoring of crop area, type, condition, yield health and rotation of cultures, risk and management. Information on surface soils (cf. 5.1.3), but also water availability and soil moisture (cf. 5.1.4) could be combined with yield production information. Information on evapotranspiration is also needed for irrigation planning, optimisation of water resources in compliance with the CAP and the WFD. Update of the information is needed on a weekly basis, possibly scheduled daily depending on planting and growing seasons (specific to each species cultivated). Information about exceptional weather events could also be necessary (excessive rain, drought, frost, flooding) for operational management but also for payment derogation.

[46] European Commission, Directorate-General for Agriculture and Rural Development, *Technical handbook on the monitoring and evaluation framework of the common agricultural policy 2014 – 2020*, October 2015 - technical guidelines for monitoring agricultural resources given by Regulation (EU) No 1306/2013 available at http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=21095&no=3.

In the frame of the use of modern technologies in agriculture, the farms sustainability tool (FaST) laid down in the CAP is potentially linked to the downstream applications of Copernicus. The FaST will be a digital application in the hands of the farmers providing advice in the use of nutrients. This initiative will provide the necessary ground for integrating Copernicus data and information products and for downstream Copernicus-based services to develop, in support of more modern and efficient agriculture. Additional potential services like precision agriculture could be included as downstream applications of Copernicus for agriculture.

Imagery with improved performances is thus needed with increased spatial resolution (currently from 5-10m to 1-2m), increased temporal resolution (revisit ideally daily, seasonal cycle), and possibly new forms of space technologies to better distinguish vegetation types, pigments, stress, water stress (including frozen grounds) or soil properties (nutrition, fertilisation, content in pesticides).

- Member States prerogatives and duties

In the proposed new CAP context, financial mechanisms would be set up between Europe and Member States built on agriculture area-based schemes for which targets are set in terms of land cover classes (arable, permanent grassland or permanent crop), greening (e.g. ploughing, mowing, residue management, grazing, stubble burning and also the retention and improvement of landscape features) and rural developments measures. Member States would report annually of their compliance using, where relevant, information contained in integrated administrative and control system databases (IACS) aggregated to national level. As far as area-related output indicators are concerned, the area monitoring system (AMS) will assure that declarations are coherent with the agricultural reality.

In this way the AMS would help Member States to use Copernicus data and information to support a reliable reporting of relevant indicators within the performance monitoring and evaluation framework (PMEF) of the future CAP, and optionally also allow for:

- helping farmers in fulfilling their CAP obligations, both regarding eligibility for interventions and for conditionality, i.e. with respect to the good agricultural and environmental conditions (GAEC) standards and the statutory management requirements (SMRs);

- paying agencies to carry out systematic checks and make decisions on payments to beneficiaries;

- the generation of statistics from time-stamped and geo-referenced agricultural event information improving environment/ climate related impact studies, the provision of services to farmers such as the management of agricultural resources whether at parcel/farm level or at regional/EU level.

The needs in this area are the development of harmonised methodologies and relevant information for the identification of the activities and measured in the statutory management

requirements (SMR) and the good agricultural and environmental conditions (GAEC), the identification of the agricultural activity (land uses) and the acquisition of data for the indicators related to water, agriculture and forestry. Therefore, Member States need access to very high-resolution information for systematic accounting and quality assurance sampling.

They also need information to assess agricultural processes such as land abandonments, crop diversification, crop specific practices, grassland management, ecological features, crop rotation, tilling, environmental policing (use of pesticides and herbicides) and information to support future environmental impact assessment of agriculture practices over areas that represent an aggregation of farm holdings (e.g. watershed, protected area).

The Commission services have expressed detailed needs on high-resolution layers for agriculture including type of crops, crop rotation, green cover, and vegetation buffer strips, specific landscape features fitted to agriculture, irrigation features, burning of burn crop residues and all relevant in-situ information that can be accessible (cf. 7.2).

- New technologies for the modernisation of CAP implementation

In view of defining capabilities for next generation Sentinel satellites that could stimulate the modernisation of the CAP and in particular the continued uptake of new technologies by the agricultural sector, the user community need much higher spatial resolution data with spatial resolutions comparable or better than what the private sector currently offers (i.e. better than 0.5m). Such level of resolution is needed particularly for expanding the scope of services enabling the fully automated monitoring of agricultural activities/conditions and for the future claimless system that will provide correct payments on the basis of the monitored agricultural reality and the legal requirements in force. The spatial resolution characteristics of existing Sentinel satellites currently limit the capabilities of these schemes. Additional elements that could become feasible with such high spatial resolution data and that would contribute significantly to the modernisation and digitalisation of the CAP implementation include:

- measuring the area of individual agricultural parcels with the required precision: the land parcel identification system (LPIS) contains the reference area that forms together with the farmer's declaration the basis for area-related aid payments. Most Member States currently use aerial imagery, with a 25 cm ground sampling distance and a 3-year or less update cycle, for mapping agricultural area into the LPIS. The availability of area measurements from Copernicus could allow to revolutionise the manner in which CAP payments are distributed;

- identifying fine spatial features (e.g. hedges, ditches, buffer strips, etc.) relevant among others in the context of the good agricultural and environmental condition (GAEC) standards, of for the extraction/ identification of agricultural practices/activities in small and very narrow parcels (including on urban roof tops), the detection of tree pruning efforts, the harvesting of permanent crops, the density of shrubs/trees, the state of rivulets and streams, and even the presence of animals/machinery on agricultural land.

The development of new agro-environmental practices and monitoring need information in the future to identify/inventory agricultural practices/conditions related to mixed crops, plant diseases, soil erosion types, abandoned lands, scattered rocky outcrops, small water bodies or unproductive shrubs in otherwise eligible agricultural land, the presence of animals/machinery/manure or - in a rural development context - the degree of insulation of urban infrastructures, the type of roofing, the width and surface-type of roads, etc.

5.1.6. Forestry

State of play

Even though the Copernicus programme has no dedicated services related to forest management many products related to vegetation supports the forestry sector as also illustrated for agriculture (cf. 5.1.5).

Policy context

There is a long history of EU measures supporting forest-related activities, coordinated with Member States including the resource efficiency roadmap[47], the rural development policy (cf. 5.1.2), the EU climate and energy package/framework with its 2020 and 2030 targets[48], the forest law enforcement, governance and trade facility[49] (FLEGT), the plant health strategy (cf. 5.1.9) and the biodiversity[50] and bio-economy strategies[51].

The 2013 Commission Communication[52] on *'A new EU Forest Strategy: for forests and the forest sector'* sets two key objectives for 2020:

- ensuring that all forests in the EU are managed according to sustainable forest management (SFM) principles;
- strengthening the EU's contribution to promoting sustainable forest management principles.

The strategy aims at strengthening the knowledge base to address the challenges for forests and the forest-based sector, by enhancing cooperation, coordination in the development of the

47 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Roadmap to a Resource Efficient Europe*, COM/2011/0571 final.

48 https://ec.europa.eu/clima/policies/strategies/2020_en

49 Communication from the Commission to the Council and the European Parliament - *Forest Law Enforcement, Governance and Trade (FLEGT) - Proposal for an EU Action Plan*, COM/2003/0251 final.

50 Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the committee of the Regions *our life insurance, our natural capital: an EU biodiversity strategy to 2020*, COM/2011/0244 final.

51 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment*, SWD(2018) 431 final.

52 Communication from the Commission *A new EU Forest Strategy: for forests and the forest-based sector*, COM/2013/0659 final.

forest information system for Europe (FISE) by the Directorate-General Joint Research Centre as a reference for data and information on forests and forestry in Europe, in close connection with other data and information systems and harmonising data at EU level.

The communication encouraged Member States to:

- increase their forests' mitigation potential through increased removals and reduced emissions, including by cascading use of wood;
- adapt their forests to ensure they can withstand the impacts of climate change;
- develop ecosystem services building on mapping and assessment of ecosystems;
- maintain and enhance forest cover to ensure soil protection, water quality and quantity regulation by integrating sustainable forestry practices in coherence with the Water Framework Directive and river basin management plans;
- achieve a measurable improvement in the conservation status of forest species and habitats by fully implementing EU nature legislation.

The implementation of the forest strategy was reviewed in 2018. Recommendations have been made and a report published[53]. The Council conclusions[54] encourage to identify additional elements that would benefit from further collaborative work, research and knowledge sharing on forest-related databases and statistics, methodologies for payments for forest ecosystem services and forests' contribution to society through land use planning, including their role in urban and peri-urban areas.

User community

Management of forest at European level is part of the mandate of Member States representatives such as forest guards and ministries of resources or environment. The forest industry is diverse ranging from timber, to furniture and paper industries and has been addressed in case they have to comply with the forest strategy in terms of sustainable exploitation, but also biodiversity conservation and management of forests as CO_2 carbon sinks.

Evolving needs

In order to monitor progress on the EU forest strategy needs particularly for public purposes have been recorded in many dedicated areas according the use of forests:

- in terms of land use / land change (cf. 5.1.1);
- for plant health (cf. 5.1.9);

[53] Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Progress in the implementation of the EU Forest Strategy *'A new EU Forest Strategy: for forests and the forest sector'*, COM/2018/811 final.

[54] Council Conclusions on the progress on the implementation of the EU Forest Strategy and on a new strategic framework for forests, 7709/19, 15 April 2019.

- for the contribution of forest management to the monitoring of greenhouse gases in a context of climate change (cf. 5.1.7);
- for reporting to the United Nations Conventions for combat desertification and international commitment for forest management in the frame of the REDD+ programme (cf. 5.1.11).

The Commission monitors Member States progress and reports relevant information and data to the United Nations Conventions for combat desertification. The Commission is also setting an EU forest information system for which Copernicus could provide relevant pan-European data and information production.

In concordance with the forest strategy, the Commission proposal for a post-2020 CAP included the monitoring of forest status and management interventions by means of specific indicators in relationship with the objectives of climate change mitigation, adaptation and sustainable energy, sustainable development and efficient management of natural resources and protection of biodiversity, enhanced ecosystem services and preserved habitats and landscapes. As indicated in previous areas like soil (cf. 5.1.3) and agriculture (cf. 5.1.5), the forest community needs information services based on more automated and standardised methodologies as well as imagery of higher temporal and spatial resolution.

The needs of policy makers and the industrial forestry sector include information for the monitoring of forest area: distribution species, height and canopy structure or individual trees, volume, biomass estimates, indicators of health and damages (degradation, deforestation, fragmentation, loss of connectivity between forest patches), capacity ground bearing for both forest areas as well as forest roads. Both timely information and detailed time series of information are needed for short-term and long-term monitoring. These needs are expressed for:

- the exploitation of the forest such as allocation of forest areas, afforestation, deforestation;
- the ecological monitoring of forests in connection with biodiversity, with natural and climate risks mitigation (storm damage assessment, fire forecast and management);
- land cover change management for future climate and carbon accounting monitoring purposes;
- adaptation to climate change;
- impact assessment on habitats and species migration due to climate change.

5.1.7. Greenhouse gas emissions from land in the frame of Climate Change

State of Play

Copernicus delivers regular observation, forecasts and climate records on the atmospheric composition for air pollution, health purposes but also for some greenhouse gases monitoring in a context of climate change. As previously presented, land cover/ land use products are

available that can support the recording and reporting on GHG emissions from land (cf. 5.1.1). Geographical position of emissions and source of gases are not yet identified.

Policy context

Forests and agricultural lands currently cover more than three-quarters of the EU's territory and naturally hold large stocks of carbon. In May 2018, the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry[55] (LULUCF) into the 2030 climate and energy framework was adopted to ensure that all sectors contribute to the EU's 2030 emission reduction target[56].

In line with the Paris Agreement, this regulation defines at Member State level the critical needs to ensure that accounted greenhouse gas emissions from land use, land use change or forestry are offset by at least an equivalent removal of CO_2 from the atmosphere in the period 2021 to 2025 and 2026 to 2030, reaching long-term climate mitigation objectives.

The LULUCF Regulation has simplified and upgraded the current accounting methodology under Decision n° 529/2013/EU[57] and the Kyoto Protocol and established a new EU governance process for monitoring how Member States calculate emissions and removals from actions on their forests[58]. The scope of accounting covers all managed land within the EU (afforested land, deforested land, managed forestland, managed cropland, grassland and wetland). Another important objective of the regulation is to improve the quality of the inventories. To this end, the monitoring of agriculture and forestry practices will have to be improved to cope with the requirement to base the inventories on spatially explicit data. To support this objective, the public administrations need remote sensing information on land use and land use change.

User communities

The Regulation does not impose any particular management practice on individual farmers and foresters. Rather, it provides a framework for Member States to account for emissions and removals in the sector encouraging them to incentivise climate-smart practices. Inventory compilers and policy-makers in the land use domain will need decision-support data and information to which Copernicus can contribute.

---

55 Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU, PE/68/2017/REV/1, OJ L 156, 19.6.2018, p. 1–25.

56 https://ec.europa.eu/clima/policies/strategies/2030_en

57 Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities, OJ L 165, 18.6.2013, p. 80–97.

58 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council, OJ L 328, 21.12.2018, p. 1–77.

Evolving needs

To reach the objectives above, Copernicus services could be used to monitor lands managements and land use changes with potential impacts in the land emissions (cf. 5.1.1). It could be useful that Copernicus upgrades its high-resolution layers to each type of LULUCF categories. Information to further stratify the land use, forest, crops, wetness surfaces, trees categories, characteristics and the changes or disturbances that might affect the emission of GHG would also be needed.

The performances of observations could be enhanced with a geographic resolution corresponding to parcel sizes below 1 ha, an annual update frequency and the capacity to map, at least, IPCC top-level land use categories. It could also capitalise on long-term archives of time series to ensure the analysis of biomass changes consistently with land conversion periods imposed by policy implementation plans (20 to 30 years).

The LULUCF Regulation will also encourage national policies that incentivise farmers to develop new agriculture practices which contribute to resilience to climate change (cf. 5.1.5) and that support foresters (cf. 5.1.6) giving greater visibility of the climate benefits of using wood products. Emissions of biomass used in energy (cf. 5.5.2) will also be recorded and accounted towards each Member State's 2030 climate commitments, through the correct application of accounting in LULUCF and check of compliance (cf. 5.6).

The Commission proposal for the evolution of the common agriculture policy (cf. 5.1.5) promotes the monitoring of specific indicators in relationship with the objectives of climate change mitigation, adaptation and sustainable energy. As indicated in previous areas like soil and agriculture, the community in charge of the LULUCF implementation for GHG emissions reduction needs information services that provide automated and standardised methodologies as well as imagery of higher temporal and spatial resolution.

5.1.8. Biodiversity

State of Play

The Copernicus portfolio does not yet address biodiversity with direct information products or data on live ecosystems. However, products are available to describe and monitor the environmental conditions and landscapes related to biotopes. This is provided through land use and land change mapping in Natura 2000 sites and information on ocean conditions in marine ecosystems habitats.

Policy context

In the 2011 Communication on *'A Biodiversity Strategy to 2020'*[59], the Commission laid down the framework for EU action to support biodiversity. The EU 2020 targets are to:

[59] Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions *Our life insurance, our natural capital: an EU biodiversity strategy to 2020*, COM/2011/0244 final.

- fully implement the Birds and Habitats Directives[60];
- maintain and restore ecosystems and their services and promote the deployment of green infrastructures;
- increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity;
- ensure the sustainable use of fisheries;
- combat invasive alien species[61];
- help avert global biodiversity loss.

In 2015 a mid-term review of the EU biodiversity strategy to 2020 was performed to assess the progress made towards the 2011 commitments, reported in *'The Mid-Term Review of the EU Biodiversity Strategy to 2020'*[62] and the more detailed Commission Staff Working Document '*EU assessment of progress in implementing the EU Biodiversity Strategy to 2020'*[63]. While significant progress has been made in a number of important policy areas like the revised common fisheries policy (Target 4), the control and management of invasive alien species (Target 5) and timber regulations as well as the introduction of biodiversity provisions in bilateral trade agreements (Target 6), the mid-term review shows that the biodiversity targets will only be reached if efforts in relation to implementation and enforcement are accelerated and strengthened. At the current rate of implementation, biodiversity loss and the degradation of ecosystem services will continue throughout the EU and globally, eroding natural capital and compromising efforts to achieve sustainable development.

User Community

Monitoring biodiversity status and taking actions are mostly addressed at national and regional level by public administrations and agencies in charge of protected areas such as forest guards, park managers but also marine protected areas agencies. At the international level, the Group of Earth Observation (GEO) addresses strategically biodiversity status monitoring to develop a common methodology for assessment.

Evolving needs

---

60 European Commission, Directorate-General for Environment, *The EU Birds and Habitats Directives For nature and people in Europe,* March 2018, available at https://publications.europa.eu/en/publication-detail/-/publication/7230759d-f136-44ae-9715-1eacc26a11af.

61 Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species, OJ L 317, 4.11.2014, p. 35.

62 Report from the Commission to the European Parliament and the Council, *The mid-term review of the EU biodiversity strategy to 2020*, COM/2015/0478 final.

63 Commission Staff Working Document *EU assessment of progress in implementing the EU biodiversity strategy to 2020 accompanying the document report from the Commission to the European Parliament and the Council the Mid-Term Review of the EU Biodiversity Strategy to 2020*, SWD/2015/0187 final.

Data needs for monitoring and protecting the biodiversity as proposed in the future of the common agriculture policy[64], implemented by Natura 2000 sites, or included in the monitoring of descriptors established by the report[65] on the Marine Strategy Framework Directive[66] or the EU biodiversity strategy to 2020[67] are very similar to needs that have been elaborated at generic level or for specific land use practices in the above chapters.

Following the mid-term review of the EU biodiversity strategy to 2020, the Coordination Group for Biodiversity and Nature (CGBN) assisting the Commission and Member States in the implementation of the EU biodiversity strategy issued a roadmap[68] to facilitate the achievements of objectives. Knowledge gaps have been identified under Target 1 (fully implement nature legislation), Target 2 (protect and restore ecosystems and their services), Target 3B (sustainable forestry), Target 4 (sustainable fisheries) and under horizontal aspects (knowledge target) where Copernicus could contribute in providing long-time series of data and information products to assess trends and progress.

EU provides methodological guidance to Member States to map their biodiversity. Needs for geospatial information include time series of plant and animal species populations annually updated, main habitat types and information on pressures, mapped per protected area. Climate change should be given due consideration wherever relevant.

Existing Copernicus products such as normalised difference vegetation index, leaf area index and land use data could be improved at a geographical scale representative of the areas and species to monitor and reference land-use should be up-to-date (annually instead of every 6 years).

In the frame of the international Group on Earth Observation (GEO), the GEOBON working group co-chaired by the Commission is active to establish the notion of essential biodiversity variables (EBVs) to monitor the biodiversity health based on space data. Some products are proposed such as proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type, red list index of natural habitats, biodiversity and threatened species, protection of wetland systems[69]. Information could be based on emerging EU or international standards and scientific knowledge. Information could support reporting on the sustainable development goals from the landscape management

---

64 European Commission, Directorate-General for Agriculture and Rural Development, *Modernising and simplifying the CAP, Background Document, Climate and Environmental challenges facing EU agriculture and rural areas,* 11 December 2017.

65 Report from the Commission to the European Parliament and the Council *Assessing Member States' monitoring programmes under the Marine Strategy Framework Directive*, COM/2017/03 final.

66 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), OJ L 164, 25.6.2008, p. 19–40.

67 European Commission, *The EU biodiversity Strategy to 2020*, ISBN 978-92-79-20762-4, 2011.

68 European Commission, *EU Roadmap for enhanced implementation of the EU Biodiversity strategy to 2020*, 18 October 2016, available at https://www.eurosite.org/wp-content/uploads/EURoadmapNDM_clean_October.pdf.

69 United Nations Educational, Scientific and Cultural organization (UNESCO), *Convention on wetlands of International Importance especially as waterfowl habitat, Ramsar 2.2.1971, as amended by the protocol of 3.12.1982 and the Amendments of 28.5.1987*, 1987.

practices and their impact of ecosystem health. Some new indicators are proposed such as abundance and distribution of selected species, area of forest under sustainable management, extent of deadwood in forests, land abandonment, coverage of nationally designated protected areas, intensification/extensification within agriculture, landscape context maps indicating overall landscape configuration or fragmentation, maps of habitat patches and vegetation types, net primary productivity, green linear elements / small woody features.

The need for an early warning monitoring system based on biodiversity conservation/degradation change detection has also been expressed by the working group as a potential way forward to point out quickly the deterioration of sites. Therefore, daily high-resolution and very high-resolution snapshots could be needed.

Biodiversity conservation is a global challenge. Data and knowledge from Copernicus services are needed at global scale for efficient monitoring and protection of biodiversity in the European outermost regions, which represent a substantial part of the European Union's biodiversity.

According to the 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) global assessment report, climate change is a main driver of global biodiversity loss and its relative influence is expected to increase over the coming decades, in some cases surpassing the impact of land and sea use change and other drivers. Copernicus data could help monitor and evaluate this worrying trend, and could inform biodiversity policy development and policy evaluation in response to climate change.

5.1.9. Plant health

State of play

A few products are relevant to monitor plant health in Copernicus such as indexes on vegetation and information on water stress (cf. 5.1.6). However, the portfolio is still scarce compared to what is needed for policy objectives.

Policy Context

The increasing threat of plant pests is a worldwide phenomenon mainly driven by globalisation of plant trade and the effects of climate change. Reinforced and harmonised provisions for better prevention, detection, and control are the key elements of the recently adopted EU Plant Health Regulation[70] that will become applicable on 14 December 2019[71].

Experience shows that early detection of pests is crucial for their successful eradication and limit their spread within the Union territory. Therefore implementing article 19 and 22 of the

[70] Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC, OJ L 317, 23.11.2016, p. 4–104.

[71] Except for certain provisions, see Article 113 of the Regulation.

regulation, annual survey programmes will become compulsory for the Union quarantine pests that qualify as priority pests based on their economic, environmental, and social impact on the European Union.

User community

This user community encompasses plant health experts, national to local health and food services, ministries of agriculture, agriculture and horticultural actors.

Evolving needs

Member States currently test or use several emerging observation technologies, e.g. with drones and helicopters, for targeted small-scale plant health monitoring campaigns concerning quarantine pests. Parallel work is showing the possibility of tracking the disease severity at the landscape scale using Sentinel-2 satellite data.

Information extracted from Copernicus can support multiple stages of the pest management cycle. To better understand the risk of pest outbreaks, Earth Observation data can be used to map the distribution of host plant species that are vulnerable to a particular pest. It can serve to map outbreaks of particular disturbance agents and while an epidemic is unfolding, it can help track how a pest spreads and the damage it causes. For plant health measures, in particular to be efficient, the early detection of pests is critical.

To comply with the regulation, the professional operators (in charge of pest detection and control) would need information on vegetation mapping, vegetation status, such as leaf area and chlorophyll content over large areas in tree-dominated landscapes. The main issue is to choose proxies to detect possible pathogen and vectors at tree-level. Ultra-high-resolution with flexible acquisition time and frequencies could be needed to collect observations that would be then combined with diagnosis tools or visual inspections data. At least plant health policies development could benefit from next-generation of vegetation type and status maps derived from Earth Observation. It could depict in near real-time vegetation composition, phenology and major disturbances, all of which that may influence the dynamics of plant disease epidemics. Climate change and its impact on species migration (bringing potential diseases) should be given due consideration wherever relevant.

5.1.10. Cultural heritage

State of play

The Copernicus programme has conducted a dedicated consultation about space and cultural heritage at the European level and eventually in the frame of the United Nations action for world heritage. In 2017, a workshop was held to address how Copernicus and space technologies could support cultural heritage activities (cf. 7.2).

Policy context

Cultural heritage, a shared source of identity, remembrance, understanding, dialogue, and creativity, represents an irreplaceable source of historical data and inspiration while contributing to social cohesion and economic growth.

In 2014, both the Council adopted the Conclusions on '*cultural heritage as a strategic resource for a sustainable Europe*'[72] and the Commission issued the Communication *'Towards an integrated approach to cultural heritage for Europe*[73]*'* which examines what the EU can do to enhance heritage's intrinsic value and take advantage of its economic and societal potential. The '*Mapping of Cultural Heritage actions in European Union policies, programmes and activities*[74]*'* was updated in 2017.

2018 was the European year of cultural heritage to celebrate the diversity of cultural heritage across Europe and reinforce a sense of belonging to a common European space. Cultural heritage is recognised as a strategic asset for a sustainable and peaceful Europe, stimulating the interest of the European Union and its Member States in the development of data and information to support cultural heritage conservation, monitoring and management.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has a world heritage mission aimed at management and preservation of cultural heritage sites – to date, 1,073 sites are registered and monitored by UNESCO[75].

Cultural heritage when combining European and international definitions embrace both man-made heritage and natural landscape heritage.

User community

The user community is diverse ranging from national institutes for environmental protection or natural science, ministries of education, weather and climate services, archaeological institutes, cultural foundations to regional organisations acting on the field, civil protection in charge of natural disaster management, or private companies involved in the maintenance or conservation of civil works.

Evolving needs

---

72 Council conclusions of 21 May 2014 on cultural heritage as a strategic resource for a sustainable Europe, OJ C 183, 14.6.2014, p. 36–38.

73 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Towards an integrated approach to cultural heritage for Europe*, COM/2014/0477.

74 European Commission, *Mapping of Cultural Heritage actions in European Union policies, programmes and activities,* August 2017, available at https://ec.europa.eu/culture/sites/culture/files/2014-heritage-mapping-version-2017_en.pdf.

75 UNESCO, The World Heritage Convention recognises some World Heritage properties specifically for their outstanding biodiversity values, protecting many of the most important ecosystems and areas of high biodiversity on the planet, as follows: being 'outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals' (criteria ix) or containing 'the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation' (criteria x), information available at https://whc.unesco.org/en/biodiversity/.

Workshop outcomes and a dedicated study performed in 2018 (cf. 7.2) indicate that the existing Copernicus portfolio can contribute to tangible and natural cultural heritage preservation and management. Copernicus could support preventive conservation, geo-mapping of cultural heritage sites and the assessment of their vulnerability against environmental risk and climate change. Copernicus can support emergency intervention in historical and protected areas. Preventive actions should be privileged with respect to reactive ones e.g. with high frequency of observations (constant monitoring) and high and very-high-resolution imagery. Needs for space-based information have been highlighted for the following:

- imagery to develop non-invasive prospective methods and less-in-situ invasive methods to detect possible tracers of cultural sites through geology and geo-structure mapping, thermal analysis, geochemistry (metal detection, salinity), geomorphology and geo-botanical data;

- high-resolution mapping and monitoring of work during archaeological excavation given the geomorphological and geochemical conditions combined with e.g. thermal anomaly, geodetic recording and bathymetry;

- historical information to support the production of international indicators to justify and enforce the recognition of a site as a cultural heritage based on the site characteristics and its evolution in time;

- land cover / land use / land change maps on identified cultural hotspots to monitor the evolution of the site possibly in conjunction with site management when open to the public;

- dynamic monitoring of sites to detect and prevent possible natural or man-made risks that could endanger structures through subsidence, ground motions, air pollution, coastal erosion, or sites which are in risk-prone areas;

- medium to long-term climate change projections combined with the identification of potential future threats;

- systematic monitoring of some hotspots or sites to deter possible illegal activities.

More than new types of space-based observations, the key challenge of the use of Earth Observation data and information for cultural heritage is the development of tailored products, with appropriate geospatial and temporal resolution to be able to monitor such heritage at local to regional scale, both on the European territory and worldwide.

Climate change should also be given due consideration wherever relevant notably as regards the potential impacts and risks for the sites of cultural heritage to support e.g. climate vulnerability and risks assessments. Climate records and climate projections of the environmental conditions around sites would be needed at a fit-for-purpose resolution.

5.1.11. International and global dimension

State of play

Copernicus has a dedicated portfolio for land services outside the European territory and for the purpose of international policies with reference products in the domain of water, cryosphere, vegetation, soil energy budgets and land temperature that can help in handling droughts. In support to international cooperation, Copernicus is able to provide on demand services for hot spot monitoring in terms of land change, land degradation for example in African or developing countries.

Policy context

Many of the needs for land products described at pan-EU level are also relevant for the actions of the European Union in favour of developing countries[76], regions of the world or internationally at global level.

This includes, to name few, activities of the Union in the frame of the United Nations environment programme (UNEP), the Agenda 21, the RAMSAR convention (on wetlands), the habitat programme, the Rio declaration, the high-level political forum on sustainable development (HLPF), the United Nations UN-REDD programme[77] and the support of the Union to United Nations Institutions such as Food and Agriculture Organization, the World Food Programme, the international fund for agricultural development, and the World Bank.

User needs expressed at European level are also relevant in the frame of the contribution of Europe to the Group on Earth Observation (GEO) and the development of the European component of the GEOSS (Group on Earth Observation System of Systems). In addition, the Agenda 2030 and the Paris Agreement are recently fostering sustainable development globally as well as the sustainable development goals (cf. 5.13.4).

User communities

The Copernicus programme develops a full, free and open policy so that data and information can be used largely beyond the European territory to tackle international major challenges in the frame of environment and sustainable development. User communities can be extremely diverse and Copernicus in the international frame (accessible through GEOSS) does not target specific communities but specific conventions as described above.

Some dedicated programs are also in place such as ‘GMES and Africa’ to support these developments at international level with mechanisms to collect needs from third countries and foster the integration of the Copernicus portfolio abroad.

Evolving needs

---

[76] List of international activities related to environment available at http://ec.europa.eu/environment/international_issues/index_en.htm.

[77] https://www.un-redd.org/, https://ec.europa.eu/europeaid/sectors/environment/sustainable-forestry/reducing-emissions-deforestation-and-forest-degradation_en

Copernicus services have been demonstrated at global, pan-European and local levels, addressing the different purposes with different ranges of performances. Some international bodies and administrations need same types of products both for pan-EU purposes and for international global ones. However, their need is to reach better resolution for Copernicus products related to agriculture, forestry, water, human settlements monitoring and rural development, food security and environment, meaning:

- existing land products with global coverage transitioning to higher spatial and temporal resolution globally with a full suite of 10-20m Sentinel resolution products and bio-geophysical products related to vegetation cover, water, cryosphere, climate at 300m;
- providing basic variables (fAPAR, Land Surface Temperature, etc.), key generic products like analysis-ready-data (e.g. phenology) or composite products (e.g. water, urban, land cover) at global scale to foster the integration into downstream services;
- maintaining a refreshing rate of products every at least 5 years;
- evolving from generating and storing static products (e.g. with fixed resolution, coverage, temporal frequency) to the possible provision of quality-controlled algorithms for generating on-demand products, either by Copernicus services or by the final international users, with ad-hoc flexible coverage and temporal extension;
- providing timely and high-resolution information for dynamic monitoring of land features on pre-identified hot spots to identify the inter and intra-annual variability of specific environments like for example wetlands, grassland, forests, surface waters, urban areas;
- providing information supporting the development of accounting mechanisms of LULUCF and monitoring, reporting and verifying systems for REDD+, as proposed for the European coverage is needed at global scale especially in developing countries.

International organisations, Member States public authorities and some non-governmental organisations need information mostly for situation assessment (including illegal activities), policies development and monitoring of implementing measures. As such, they need long-time series to identify and monitor changes possibly achieved thanks to policies implementation complemented with regular short-term monitoring. Regular observations, short-term forecasts are less relevant for such targets. For monitoring of some illegal activities, they could need on ad-hoc basis real-time observation (e.g. illegal fishing, forest illegal logging).

The first need could be to start implementing transparent, reliable and repeatable methods for national forest inventories, forest reference levels (for national or regional forest monitoring systems). It might possibly need at Copernicus level the development of local topographic and digital elevation model products, specific classification and mapping fit to tropical vegetation or marine life cycles and characteristics (bushlands, mangroves, tropical peatlands, coral reefs, etc.) but also disturbances (road networks developments, drainages channelling,

logging, conversion into plantations, climate change impacts and risks, fires, insects defoliation, etc.).

5.2. Marine environment, Maritime affairs and fisheries

Policy context

As summarised in a recent publication of the European Parliament, '*Ocean governance and blue growth Challenges, opportunities and policy responses*[78]', from March 2019, it is widely recognised that oceans offer new opportunities for sustainable economic growth while being seriously at threat because of climate change and biodiversity loss.

In 2018, the Marine Strategy Framework Directive[79](MSFD) will start its second 6-year cycle with a need to further enhance the actions to be taken to achieve the good environmental status of oceans, and strengthen cross linkages to other policies that help protect marine ecosystems and manage the anthropogenic pressures affecting them. Indicators and data sources used for the implementation of the Marine Strategy Framework Directive at regional, national and EU level could also be considered to shape the contribution of Europe to the ongoing UN world ocean assessment started in 2016.

Reducing plastics, the loss of fishing gears and marine litter is also high on the maritime affairs agenda. On top of the Marine Strategy Framework Directive, this topic has been introduced in several legislations: the plastics strategy[80], the waste legislation[81], and recently in the circular economy action plan.[82]

Building on a widely shared understanding that the ocean governance framework needs to be reinforced, the European Commission and the EU's High Representative published on 10

---

78 European Parliament, EPRS | European Parliamentary Research Service, Frederik Scholaert, Members' Research Service, *Ocean governance and blue growth Challenges, opportunities and policy responses*, PE 635.557, March 2019. Available at http://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635557/EPRS_BRI(2019)635557_EN.pdf.

79 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), OJ L 164, 25.6.2008, p. 19–40.

80 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *A European Strategy for Plastics in a Circular Economy*, COM/2018/028 final.

81 2014/955/EU: Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council. OJ L 370, 30.12.2014, p. 44–86.
Commission Regulation (EU) No 1357/2014 of 18 December 2014 replacing Annex III to Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives, OJ L 365, 19.12.2014, p. 89–96.

.82 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Closing the loop - An EU action plan for the Circular Economy*, COM/2015/0614 final.
Commission Staff Working Document Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *A European Strategy for Plastics in a Circular Economy*, SWD/2018/016 final.

November 2016 a joint Communication related to the '*International Ocean Governance*'[83] proposing 50 actions for safe, secure, clean and sustainably managed oceans in Europe and around the world, also stressing that a better understanding about the oceans is necessary to achieve these objectives. This is an integral part of the EU's response to the United Nations' 2030 agenda for sustainable development, for the implementation of the sustainable development goal 14 'Life below water'.

Under the G7 umbrella science working group in the 2016 Tsukuba communiqué, the Commission, together with France, Germany, Italy and other major countries, agreed to the development of an international initiative called the '*Future of Seas and Oceans*[84]'. This initiative aims at enhancing global sea and ocean observation to better monitor inter alia climate change and marine biodiversity.

5.2.1. Marine environmental monitoring

State of play

Copernicus delivers daily real-time observation of the oceans, 10 days ocean forecasts and climate records describing the ocean physics (like currents, sea level, sea temperature, sea ice parameters) and the ocean biogeochemistry (like water quality, optical properties, content in chlorophyll and planktons per functional type). The products are delivered globally for all oceans and for each EU regional sea basin: Atlantic, North West Shelves, Arctic, Mediterranean Sea, Black Sea, and Baltic Sea.

Environmental Policy context

As described above, Copernicus contributes to the monitoring of the state and dynamics of oceans needed under the Marine Strategy Framework Directive, the Maritime Spatial Planning Directive[85] and other European and international environmental legislations, as well as to the understanding of the oceans' role in accentuating or mitigating climate changes.

The sustainable development goal 14[86] dedicated to ocean health 'Life below Water', is part of the 2030 agenda of the United Nations with 10 targets and indicators on which to report. The Intergovernmental Panel on Climate Change special report '*Climate Change, the Oceans and Cryosphere*[87]' is expected to confirm the crucial significance of future changes in the

---

83 Joint Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions I*nternational Ocean Governance: an agenda for the future of our oceans*, SWD/2016/352 final.

84 G7 science ministers meeting | Annex to the Declaration, *G7 future of the Seas and Oceans working group: progress since May 2016, Executive Summary*, September 2017 https://www8.cao.go.jp/cstp/kokusaiteki/g7_2017/20170928annex1.pdf.

85 Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning, OJ L 257, 28.8.2014, p. 135–145.

86 United Nations, Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development, information available at https://sustainabledevelopment.un.org/sdg14.

87 IPCC Panel, joint scientific leadership of Working Groups I and II, '*The Ocean and Cryosphere in a Changing Climate'*, IPCC special report, IPCC, September 2019, available at https://www.ipcc.ch/report/srocc/.

ocean to ecosystem health and human well-being in COP25 in September 2019. 19 (over 54 in total) essential climate variables[88] have been established by the global climate observing system programme (GCOS) to monitor the ocean climate.

User communities

Ocean products are used by a significant large community of public bodies (e.g. national hydrological, weather or marine services, environmental agencies, ministries of transport, fisheries, operational maritime authorities for ports, coastguards), but also a significant research community involved in oceans, climate, Earth science or biology. The user base is equally balanced with the private sector acting in blue economy especially interested in ocean physics: energy, shipping, tourism, fisheries and aquaculture.

Evolving needs

The Copernicus marine portfolio is in a continuous process of improvement to extend forecast periods, increase the resolution of observations based on satellite data and modelling. The higher the resolution is, better decision-making for example for ship routing is reliable. Public authorities need that the ocean features are better described in resolution and dynamics and the performances of the portfolio is improved to implement maritime spatial planning by 2021, report on the 11 descriptors for good environmental status by 2020 and address coastal challenges (cf. 5.2.2). Therefore, the following improvements are needed:

- improving the description of ocean physics by (1) improving horizontal resolution to at least 1/36° for the global ocean and at least double this resolution in regional seas (2) improving in treatment of closed or marginal seas with high dynamics at sub-mesoscale, linked to interactions with the atmosphere, ice, waves and winds (3) better addressing coastal areas and hydrological systems especially in areas of greatest human activity and hence pressure on the marine environment or European economic zones of interest including for overseas territories (4) better addressing uncertainties to ensure high-quality datasets;

- understanding the dynamics of the biological component of the ocean in terms of 'fauna and flora' (because of the marine species being either exploited or to be protected) and how this marine living component behaves in relation to the ocean state, climate change and the man-made pressures (e.g. transport, pollution, fisheries, etc.) and in particular the plankton-to-fish links;

- better understanding environmental changes over the poles with a refined monitoring of sea-ice conditions and changes in continental ice, glaciers or permafrost, land-ice/snow and sea-ice interface improving real-time observation and short-term forecasts, but also long-term projections to best predict impacts of climate change;

[88] https://gcos.wmo.int/en/essential-climate-variables/ecv-factsheets

- in addition, integrating these various components into a full consistent overview of the ocean dynamics both at short term (with real-time observations and forecasts) to support daily applications but also in time to contribute to the analysis of climate change at global and regional scale and its impacts, and constituting a reference system.

5.2.2. Coastal management

State of play

In 2017 and 2018, as requested by the Copernicus User Forum and Committee, the Copernicus run dedicated consultations with experts and user workshops to discuss the evolution of Copernicus services to address coastal zones (cf. 7.2).

Copernicus already delivers a full suite of real time observation, forecasts and climate records scaled for the EU regional sea basins specific ocean features. However, the performances of such products are not representative enough of coastal phenomena heavily influenced by land and rivers (area of the continental shelf and up to 24 nautical miles from coastline in terms of territorial waters and contiguous zone).

Policy context

Coastal areas are key places of significant human activities such as tourism, economic activities, fisheries, offshore operations, industrial port areas, cities growth. These are also areas potentially vulnerable to many risks such as storm surges, flooding, erosion or climate change impacts such as sea level rise. Coastal development can be at the expense of natural systems (e.g. wetlands, beaches and dunes) that normally act as buffer between the sea and the land, leading to a conflict between protecting socio-economic activity and sustaining the ecological functioning of coastal zones in Europe.

Integrated coastal zone management have been subject to policy making in 2002 but then have been further developed through the existing directives in force: the Marine Strategy Framework Directive, Maritime Spatial Planning Directive, the Water Framework Directive[89], and the common fisheries policy (addressing specifically territorial coastal fishing within 12 Nautical miles). The description of the coastal environmental status is made through the quality elements established by the Water Framework Directive and the 11 descriptors (Annex 1 of Marine Strategy Framework Directive) for assessing the good environmental status.

User community

The coastal community is dominated by local public actors - regions, department, town councils, community of communes - in charge of their coastline, bathing waters, drinkable waters and utilities such as ports, dams but also local mobility, urban planning, tourism

[89] See also the report from the Commission to the European Parliament and the Council on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC, Second River Basin Management Plans, First Flood Risk Management Plans and recommendations in Annex, COM/2019/95 final.

development and nature protection. The private sector is also important, operating at coast for civil works, water operations, sanitation, energy, short sea shipping and tourism. Most of these actors, when searching for information at sea, rely on national institutes in charge of hydrology and oceanography, most of them operating coastal ocean modelling capacities to monitor the shore for coastal erosion or marine ecosystems and fish exploitation.

Evolving needs

The needs for coastal environmental monitoring is mainly to monitor and understand the trends in spatial extent of vulnerable coastal ecosystems including to climate change, to understand anthropogenic pressures on the condition of such systems, as well as the interactions with shallow coastal waters. Pressures could be identified/characterised along four geographical areas that need different approaches: land (terrestrial part of coast e.g. up to 10 km inland from shoreline), transitional waters (according to the nomenclature of Water Framework Directive), coastal waters (according to the nomenclature of Water Framework Directive) up to marine waters.

Coastal land pressures on ecosystems, as defined by the 2018 report on '*the Mapping and Assessment of Ecosystems and their Services Report*[90]' are characterised by five main drivers to be considered in land use and land change: habitat change, climate change, invasive species, over-exploration, and pollution and nutrient enrichment.

Users need information that is representative of the dynamics of the coasts. This requires that the information is complementary and consistent from the land to the sea and vice-versa, being also tuned to much higher resolution to observe and predict coastal sub-mesoscale dynamics including surges, tides and fine resolution water quality phenomenon (e.g. blooms, sediment transport, turbidity) that could affect, for example, fisheries, aquaculture, coastal erosion, dam resistance to surges.

Coastal communities mainly develop their own coastal ocean models to describe at best specifics of their areas of interest, given that their capacities can be well initialised or forced with accurate upstream information. As such, they need boundary conditions compatible of their high-resolution (1 km) description of the ocean behaviour (coming from the open ocean or regional seas) and the hydrological inputs coming from the land (like rivers, estuaries or ice melt).

To better link with the land, they also need an improved access and better accuracy of the digital elevation model. The coastal topography and bathymetry are unanimously being asked by national coastal services. Land-sea interactions could be dynamically observed with respect to erosion or accumulation, sediment transport, concentration of pollutants at high-resolution (less than 1km) like chemicals but also floating plastic debris (Marine Directive for

[90] Fifth MAES report, *an analytical framework for mapping and assessment of ecosystem condition in EU Discussion paper,* final, January 2018. MAES is the Biodiversity information system for Europe led by Directorate-General for Environment for the Mapping and Assessment of Ecosystem and their services.

Litter[91]). In order to develop solutions for resilience to climate change effects like coastal floods, storm surges, sea level rise, climate records of coastal products should be given due consideration.

5.2.3. Fisheries and aquaculture

State of play

Copernicus operates a significant suite of real-time ocean observations and biogeochemical ocean forecasts to support activities related to fisheries, support to sustainable best practising, fisheries control and fish stock planning. Such products are used regularly and from recent statistics of use of the program, this user demand is growing significantly. A dedicated study was carried out in 2018 to address this sector of activity in cooperation with Directorate-General for Maritime Affairs and Fisheries (cf. 7.2).

Policy context

To provide for the sustainability of fisheries in EU waters and the EU fleet worldwide, the Common Fisheries Policy Regulation (CFP)[92] has defined a set of harmonised provisions[93] to manage the EU fleet and their fishing activities to keep fish stocks at healthy levels, for managing European fishing fleets and for conserving fish stocks. To ensure the sustainability of fisheries and aquaculture in the waters around our continent, the EU CFP set fishing quotas per exploited species and regional limitations of fishing effort. Similar mechanisms are also negotiated internationally, in particular within Regional Fisheries Management Organisations (RFMO) to which the EU is a contracting party[94].

Access to accurate and verified data and parameters is of upmost importance to provide for a proper management and control of fishing and aquaculture activities.

User Community

The fishery industry is for most of it living near the coastline, where about half of the world population resides. The artisanal and coastal fisheries industry is a major source of revenue for the local markets, tourism and population. At larger scale, the industrial fisheries and fish processing industry generate important value when dealing with some major pelagic species like tuna, herrings or mackerels or anchovy.

In parallel, fisheries control is managed at national level, at sea or when landing, by public authorities and controlled at European level by the European Fisheries Control Agency (EFCA).

---

91 Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment, OJ L 155, 12.6.2019, p. 1–19.

92 Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC, OJ L 354, 28.12.2013, p. 22–61.

93 European Commission, *The new Common Fisheries Policy: Sustainability in depth*, Factsheet, 2015, available at https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/2015-cfp-management_en.pdf.

94 European Commission, *The international dimension of the EU Common Fisheries Policy*, Factsheet, 2015, available at https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/2015-cfp-international_en.pdf.

Evolution of the needs

EU public authorities and Regional Fisheries Management Organisations (RFMOs) need mainly information and tools for the following:

- identify favourable ocean conditions at sea (e.g. planktons, temperature) to best plan annual or seasonal fishing activities;
- perform fish / marine ecosystem stock assessment to support the definition of time-area closure schemes to fishing based on habitats particularly centred on fish reproduction, and multi-annual plans, the definition of quotas and effort limitation helping ensuring the sustainability of fish populations and the fishery profitability;
- tools to monitor and control the fishing activity and production at sea including detecting and deterring unregulated and illegal fishing, mapping and control of aquaculture sites;
- tools to better anticipate or understand the impacts of fisheries on the environment and the man-made pressures on fisheries and marine ecosystems especially incidental bycatch and physical disturbance to the sea-floor;
- long-time series of information to monitor at long-term the impact of climate change on fish stocks and especially on recruitment and support food security related policies.

The fisheries and aquaculture industry need:

- information of low-pressure grounds for fishing and suitable aquaculture farm sites while remaining within the protective limits and regulations;
- monitoring information of the ocean health and ocean conditions influencing the stocks and the production, water quality and possible pollution at sea (e.g. harmful algae blooms, plankton-to-fish links, oil, land chemical pollutants, atmospheric inputs of nutrients, etc.);
- information to optimise fisheries activities while steaming and fishing and securing operations at sea.

In particular, this requires more dynamic and fine scale information of physical and biogeochemical ocean variables such as temperature, thermocline, oceanic thermal and productivity fronts, content in chlorophyll, nutrients or first stage of the food web elements (like nektons), and the implications of climate change. Near real-time information is needed to guide fishermen outside of active nurseries or habitat of protected species. However, time series and forecasts are also particularly relevant for planning activities and developing environmental scenarios of fish stocks assessment based on modelling.

The list of expected water quality and biogeochemistry variables is significant with new products linked to pollutants, eutrophication, productivity of oceanic fronts and algae species differentiation with toxicity information, distribution of nutrients and functional types of plankton, plankton biomass, phenology, suspended sediments but also environmental parameters such as bathymetry, seabed habitats, river discharges, winds and waves.

While the current list of ocean products available in Copernicus is satisfactory and fit for purpose for offshore aquaculture and fisheries (mostly industrial), users consulted during workshops ask for more 'closer-to-shore products' in real-time and at finer scale for small-scale fisheries and aquaculture activities taking place in the near shore and coastal areas but also in lakes and inland waters. The area of interest is pan-European but also global given the extensive coverage of exclusive economic zones from European Member States and areas managed by RFMOs.

Needs for fisheries control specially in terms of combating illegal, unreported and unregulated fishing practices by the European Fisheries Control Agency (EFCA) and its stakeholders fall under the Maritime Surveillance area (cf. 5.15.2).

5.2.4. Pollution at sea

State of Play

Under Copernicus, significant efforts have been made and implemented by the European Maritime Safety Agency (EMSA) to fight against intentional or accidental oil pollution. The Copernicus portfolio is one of the best examples of what can be achieved worldwide in terms of space-based solutions for oil detection and pollution management. Oil pollution is fully integrated operationally with maritime surveillance (cf. 5.15.2).

Fighting against plastics or chemical pollution is much more complex and this is not yet developed in Copernicus with the available satellite resolutions and services capacities. Preliminary water quality products are available daily however to detect some chemical content and organic matters at sea (e.g. nitrates, iron, phosphates).

Policy context

The number of policies related to pollution at sea is quite substantial both at international and European level with:

- the United Nations Convention on the Law of the Sea (UNCLOS), Safety Of Life At Sea (SOLAS)[95] and MARPOL[96] conventions;
- the EU strategy for plastics[97];
- the Waste Directive[98];

---

95 International Maritime Organization, International Convention for the Safety of Life at Sea, 1974, (SOLAS), available at http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx.

96 International Maritime Organization, International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, available at http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx.

97 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *A European Strategy for Plastics in a Circular Economy*, COM/2018/028 final.

- the circular economy package[99];

- the '*International Ocean Governance'* Communication from November 2016;

- the Erika III package[100];

- the Port Reception Facilities Directive[101] (and its proposal for revision[102]);

- the Sulphur Directive[103];

- the Regulation[104] on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport;

Working documents on marine litter are also important to consider such as the guidance on monitoring of marine litter in the European seas[105], and thematic reports on sources of litter[106] and on riverine litter[107] monitoring.

Pollutants to be tracked are:

- oil and gas pollution from offshore activities including heavy fuel;

- pollutions due to the maritime transport (bilge and ballast waters, oil pollution and leakages, black carbon, CO_2 and sulphur pollution from vessels and possible pollution from hazmat transports of goods);

---

98 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008, p. 3–30.

99 European Commission, Directorate-General for Environment, *Presentation of the package* available at http://ec.europa.eu/environment/circular-economy/index_en.htm.

100 Communication from the Commission - *Third package of legislative measures on maritime safety in the European Union*, COM/2005/0585 final.

101 Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues - Commission declaration; OJ L 332, 28.12.2000, p. 81–90.

102 Commission Staff Working Document *Impact Assessment Accompanying the document Proposal for a Directive of the European Parliament and of the Council on port reception facilities for the delivery of waste from ships*, repealing Directive 2000/59/EC and amending Directive 2009/16/EC and Directive 2010/65/EU, SWD/2018/21 final.

103 Directive (EU) 2016/802 of the European Parliament and of the Council of 11 May 2016 relating to a reduction in the sulphur content of certain liquid fuels, OJ L 132, 21.5.2016, p. 58–78.

104 Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC, OJ L 123, 19.5.2015, p. 55–76.

105 Directorate-General Joint Research Centre MSFD Technical Subgroup on Marine Litter, *Guidance on Monitoring of Marine Litter in European Seas*, JRC scientific and policy reports, 2013, available at http://publications.jrc.ec.europa.eu/repository/bitstream/JRC83985/lb-na-26113-en-n.pdf.

106 Directorate-General Joint Research Centre MSFD GES Technical Subgroup on Marine Litter, *Identifying Sources of Marine Litter*, JRC scientific and policy reports, 2016, available at http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/MSFD_identifying_sources_of_marine_litter.pdf.

107 Directorate-General Joint Research Centre MSFD GES Technical Subgroup on Marine Litter, *Riverine Litter Monitoring - Options and Recommendations*, JRC scientific and policy reports, 2016, available at http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/MSFD_riverine_litter_monitoring.pdf.

- chemical pollution (e.g. nitrates, black carbon, methane, ammonium, nitrates, heavy metals) coming from land and possibly affecting aquaculture, tourist areas or marine protected areas;

- persistent-organic pollutants;

- radioactivity, invasive species (e.g. from ballast water), heat (e.g. from cooling water), dumped ammunitions, waste dumping;

- major pollution caused by floating plastics, micro plastics and debris from ships accidents or mining activities.

User communities

Actors dealing with ocean pollution are mainly public institutions in charge of the ocean good environmental status of their coasts and territorial waters, but also foundations and associations specially invested in fighting against plastics. To some extent land tenants such as farmers, cities identified as sources of pollution can also be potential users. The research institutes play an active role to support public knowledge-based decision-making.

Evolving needs

From the above list of pollutants to be tracked for regulation purposes, still a lot are not addressed: gas pollution, bilge and ballast waters, black carbon, sulphur, hazmat pollution, methane, heavy metals, waste dumping, most of micro plastics, or invasive species. Since they cannot be simply observed, they need to be deduced and modelled from proxy information provided by observations. When they diffuse or drift quickly in the oceans, diluting making them difficult to catch, their spread has to be modelled.

To help, more systematic real-time observation of pollution at finer scale is needed especially in the case of coastal pollution or in areas of high traffic. Building upon the EU CleanSeaNet system[108], operated in EMSA for oil pollution detection and alert mechanism to coastal states, it is also important to integrate and coordinate all sources of information for decision-making:

- near real-time detection of pollution by satellite;

- ship position from traffic monitoring systems at least for ship-based pollution (the union maritime information and exchange system - SafeSeaNet);

- alerting system and;

- manned or unmanned aerial means from coastal states for verification, identification of polluters and prosecution (cf. 5.6).

Pollution control also needs the implementation of pollution drift forecasts for each type of sources and components, to establish if pollution will be dispersed in the air over the surface

[108] CleanSeaNet portal, information available at http://www.emsa.europa.eu/csn-menu.html.

or at sea, to identify possibly the origin and the possible polluter (vessel at the source, chemicals from the coast, beached oil, etc.).

Monitoring EU flagged vessels for pollution control with regular random sampling over areas where EU flagged vessels are present could be performed to detect slicks, identify refuelling at sea and identify polluters subject to a port state control inspection.

In the event of emergencies at sea or potential pollution that threat the maritime environment, EMSA and national services need environmental information in real-time and forecasted, such as high-resolution wind, waves, temperature, salinity and currents ocean products, to be complemented with other sources of information (like automated identification systems and vessel monitoring systems), with a large systematic coverage of waters to be monitored.

An emergency support service including early warning alert of pollution and support during response operations is already in place based on satellite services and correlation with these other data sources, through the CleanSeaNet service, for EU and neighbourhood countries, and it is extensively based on Sentinel data that is central for its continuity. Consulted users have suggested that the extension of such service for third countries that shown interest could be considered.

For most of chemical pollutions listed in the regulations, significant improvements are needed to better assess water quality, chemical content, optical properties monitoring, land-sea and rivers-sea interactions, combined with currents modelling (surface, in-depth and vertical transport) to tackle the issue of marine litter identification and concentration forecasts.

Chemical pollutions of CO_2, NOx ($NO+NO_2$), SO_2 and particulate matter (PM2.5) in the air emitted by vessels are also part of gases to monitor and need the monitoring eventually of the troposphere for all major shipping routes, including possibly at vessel scale. Atmospheric composition, aerosols, dust concentration will need to be observed or assessed at finer scale than current atmospheric composition monitored in Copernicus, to be also linked to the potential pollutant source (cf. 5.8). For some types of pollution (e.g. radioactive), needs are not mature yet and would probably need significant model developments and validation before operational use and official reporting. Promising experiences have already taken place in some Member States in monitoring sulphur emissions along major shipping routes through remotely piloted aircrafts (RPAS) which could complement the satellite imagery and provide this additional evidence ship by ship, to be shared with responsible authorities (e.g. port state control).

5.2.5. Maritime Spatial Planning

State of play

Information needed for maritime spatial planning ranges from environmental information (e.g. habitats, seabed, sediments, bathymetry, and coastline) to datasets mapping human activities (e.g. fishing, aquaculture, shipping, energy, cables and pipelines). Copernicus delivers already part of the environmental information especially through long-time series of

ocean products necessary to produce atlas. However, such data are mainly at regional sea basin scale and not enough detailed at coastal level. Man-made activities are not directly mapped and monitored in Copernicus even though satellite observation can be useful to identify shipping lanes, fisheries and aquaculture grounds.

Policy context

Competition for maritime space – for renewable energy equipment, aquaculture and other uses – has highlighted the need to manage waters more consistently. Maritime spatial planning (MSP) works across borders and sectors to ensure human activities at sea take place in an efficient, safe and sustainable way. In 2014, the Directive for Maritime Spatial Planning in Europe[109] was adopted to reduce conflicts, encourage investment (blue economy), increase cross-border cooperation and protect the environment.

The Directive lists the 11 relevant mandatory areas of intervention[110] and data to be collected and mapped, that should be addressed by Member States and updated at least every 4 years.

User community

Member States have to implement maritime spatial planning. If regional local authorities, cities, environmental agencies are most of the time in charge of it, its implementation requires the contribution of many institutes specialised in marine science, biology or water management. The private sector, association of industries and foundations are also part of the elaboration of plans.

Evolving needs

The Commission set up a platform[111] to support all EU Member States in the implementation of the directive by 2021. In this framework, studies have been performed to identify data gaps[112]. Copernicus and EMODNET[113] (the marine knowledge information system from the Directorate-General for Maritime Affairs and Fisheries) provide many data sources for maritime spatial planning especially for human activities. On the Copernicus side, progress is needed to fit with expected resolution for coastal mapping (cf. 5.2.2).

---

109 Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning, OJ L 257, 28.8.2014, p. 135–145.

110 Article 8 of the Directive enlists the following areas: '*aquaculture areas, fishing areas, installations and infrastructures for the exploration, exploitation and extraction of oil, of gas and other energy resources, of minerals and aggregates, and for the production of energy from renewable sources, maritime transport routes and traffic flows, military training areas, nature and species conservation sites and protected areas, raw material extraction areas, scientific research, submarine cable and pipeline routes, tourism, underwater cultural heritage'*.

111 The European MSP platform, information available at https://www.msp-platform.eu/.

112 European Commission, Directorate-General for Maritime Affairs and Fisheries, *SIMWESTMED, Analysis of data needs and existing gaps, Supporting Implementation of Maritime Spatial Planning in the Western Mediterranean region*, December 2018, EASME/EMFF/2015/1.2.1.3/02/SI2.742101.

113 http://www.emodnet.eu/human-activities

Needs related to siting human activities such as aquaculture farms or marine renewable energies plants are described in each sector of interest: energy (cf. 5.5), maritime transport (cf. 5.4), marine environmental monitoring (cf. 5.2.1) and fisheries and aquaculture (cf. 5.2.3).

One important need lies in the obligation to consider land-sea interactions for which it would be useful if Copernicus delivers land-sea consistent data and information products as indicated for coastal management (cf. 5.2.2).

5.3. Arctic policy and polar areas

State of play

Copernicus addresses the poles with:

- a dedicated Arctic ocean monitoring and forecasting centre in charge of observing, forecasting sea ice conditions and maintain related long-time series of arctic changes;
- cryosphere monitoring on land for lake ice extent, snow cover and snow parameters;
- climate records and climate projections delivered for international reporting on seven essential climate variables related to sea-ice and glaciers;
- maritime surveillance services monitoring shipping and fishing in the Arctic for maritime safety purposes.

Policy context

The joint Communication by the European Commission and the High Representative of the Union for Foreign Affairs and Security Policy to the European Parliament and the Council, issued on 27 April 2016 '*An integrated European Union policy for the Arctic*[114]', highlights the strategic, environmental and socio-economic importance of the Arctic region including the Arctic Ocean and adjacent seas.

The Arctic's fragile environment is also a direct and key indicator of climate change, which requires specific mitigation and adaptation actions as agreed with the global agreement reached during the COP-21 held in Paris in December 2015. To this end, the integrated EU Arctic policy has identified three priority areas:

- climate change and safeguarding the Arctic environment (livelihoods of indigenous peoples, Arctic environment);
- sustainable development in and around the Arctic (exploitation of natural resources e.g. fish, minerals, oil and gas), blue economy, safe and reliable navigation (e.g. North East Passage);

[114] Joint Communication to the European Parliament and the Council *An integrated European Union policy for the Arctic*, JOIN/2016/021 final.

- international cooperation on arctic issues (scientific research, EU and bilateral cooperation projects, fisheries management / ecosystems protection, commercial fishing).

User community

All categories of users from the public to the private sector are considered in the frame of the Arctic policy up to the citizen and indigenous population.

Evolving needs

In the frame of Copernicus, a polar expert group has been set up to assess the interest and define high-level mission requirements[115] for future space missions dedicated to the monitoring of the poles in a context of climate change and aligning with the Arctic policy. The experts held several workshops, collated and analysed documents to establish the users' needs synthesised hereunder (cf. 7.2).

Domains of interest expressed by users range from meteorology, climatology, hydrology, oceanography, ecology, natural and industrial hazards, emergency response, energy, transport, infrastructure management to security and climate change adaptation and mitigation. Therefore, data and information products are needed related to the atmosphere, ocean, fresh waters, land surface and vegetation but also specific products linked to the poles such as permafrost and soils, sea ice including icebergs and ice shelves, ice sheets, glaciers and ice caps, plus seasonal snow.

The expert group established a summary list of variables to support as many needs as possible ordered by priority of interest:

- floating ice variables including sea ice extent / concentration / thickness / type / ridge / drift velocity, thin sea ice distribution, iceberg detection / volume change and drift, ice shelves thickness and extent. These parameters are necessary for operational services (navigation, marine operations) as well as to climate modelling;

- glaciers, caps and ice sheets parameters including extent / calving front / grounding line / surface elevation and surface elevation change / surface velocity / mass balance and mass change / melt extent to monitor climate change and sea level rise;

- sea level / sea level anomaly parameters to have a better description of oceanic large scale and mesoscale circulation/variability and currents for marine forecasting;

- all weather sea surface temperature (SST) for climate modelling, mesoscale analysis, oceanic predictions and as climate change indicator;

[115] European Commission, *User Requirements for a Copernicus Polar Mission - Phase 1 Report*, ISBN 978-92-79-80961-3, doi:10.2760/22832, JRC111067, Publications Office of the European Union, 2018. European Commission, *User Requirements for a Copernicus Polar Mission - Phase 2 Report*, ISBN 978-92-79-80960-6, doi:10.2760/44170, JRC111068, Publications Office of the European Union, 2018.

- surface albedo as major determinant for the energy balance between atmosphere and surface, crucial for many application domains including climate, meteorology, numerical weather modelling, hydrology and more;

- surface fresh water (river run-off and discharge, river and lake ice thickness) as an important resource for the supply of water to populations as well as for transport activities and impact on ocean changes / climate modelling;

- snow (extent/fraction and snow equivalent water, melt extent both on land and sea-ice) important for many applications in hydrology, meteorology, water management and climate modelling;

- permafrost (extent/fraction and topography/deformation monitoring) important for operational activities (transport, construction / ground movement) as well as indicator of climate change. Permafrost observation is also a strong need since permafrost includes 24% of the land in the northern hemisphere and stores massive amounts of carbon and methane that need to be accounted for greenhouse gases monitoring according to the Paris Agreement.

According to the polar expert group, most of the products already available need to be improved in terms of resolution and time availability expecting sub-daily resolution under 5kms specially to support safe navigation. Detection of small icebergs including growlers is needed when opening new routes. Monitoring of glaciers with surface elevation changes is a good indicator to assess the effects of climate change that impact directly sea level rise but also possible hydropower generation or irrigation.

Needs identified for the Arctic are partly applicable also to monitor the Antarctic precisely in the purpose of monitoring the effects of climate change, sea ice and ice caps interactions with the oceans and sea level rise.

5.4. Transport

State of play

Except for maritime transport significantly addressed by Copernicus, other forms of transport (air, rail, inland) are currently less addressed by Copernicus products.

5.4.1. Terrestrial transports

Policy context

Directive 2010/40/EU[116] establishes the framework for the deployment of intelligent transport systems (ITS) in the field of road transport and for interfaces with other modes of transport.

User community

[116] Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport, OJ L 207, 6.8.2010, p. 1–13.

The community is mainly divided in regional, local authorities and state in charge of the deployment of transport infrastructures and the private sector in charge of deploying and maintaining these civil works.

Evolving needs

Most of the needs for the transport sector are linked to the best knowledge of land use and land cover, especially identifying networks of transports and infrastructures: transport mapping (including networks and infrastructures) related to airports, ports, railways multimodal connections like railroad, information to be delivered in digital format (by regulation). While mapping is already provided by Copernicus inside EU, extending the mapping to EU neighbouring countries is needed by agencies in charge of infrastructures and in view of the existing regulation[117].

The sector also needs data on topography (digital elevation models), geophysical and soil characteristics for civil engineering related to networks deployment, real-time monitoring and long-time records of known sites affected by ground motion or natural risks and to help in setting up clearing circuits.

Climate records describing frequency and intensity of seasonal weather events (e.g. like storm or ice periods) - both in terms of real-time observation and short-term forecasts, but also long-term projections - are also of relevance for transport network deployment and management to best predict impacts of climate change and ensure the resilience of transport infrastructure. Data on the past, current and future climate are the basis for climate vulnerability and risk assessments at network level for the different modes of terrestrial transport.

5.4.2. Air transport

State of Play

Copernicus already delivers a few air quality products to support air traffic management and air safety. The contribution of the programme is relatively limited for aviation and air transport in general.

Policy context

The functioning of the European aviation safety system was subjected to a review as part of the 2015 EU aviation strategy[118] and the Commission presented a revised European aviation safety programme[119], which describes how aviation safety is managed in the EU. In 2018, the

[117] Commission Delegated Regulation (EU) No 473/2014 of 17 January 2014 amending Regulation (EU) No 1315/2013 of the European Parliament and of the Council as regards supplementing Annex III thereto with new indicative maps, OJ L 136, 9.5.2014, p. 10–18.

[118] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *An Aviation Strategy for Europe*, COM/2015/0598 final.

[119] Report from the Commission to the European Parliament and the Council, *the European Aviation Safety Programme*, COM/2015/0599 final.

the Aviation Safety Regulation[120] was adopted to prepare the EU aviation safety system for the challenges of the future, including a new era of innovation and digital technologies.

User Community

Weather information given to pilots is managed as key information for air operations. The European Aviation Safety Agency has a dedicated project team for '*Weather information to Pilots'*[121].

Evolving needs

As an outcome of the '*All Weather Operations Project'*, the agency issued the *'Weather Information to Pilots Strategy Paper'*[122] developing nine recommendations for better information and decision-making. In terms of air transport and air traffic control, few needs have been expressed to provide complementary information to the ones delivered by the World Meteorological Organisation, volcanic ash advisory centres and regional specialised meteorological centres. Few needs are identified by this community to better detect and eventually anticipate the displacements of ashes due to volcanic eruptions with early warning information on the ash cloud profiles, mass loading, aerosol layer height, aerosol size of particles. Long-range pollutant identification and forecasts should also be relevant to best anticipate air traffic operations and risks.

Similarly, to terrestrial transport, the sector needs data on topography (digital elevation models), geophysical and soil characteristics for civil engineering. National aviation authorities have expressed a need for data on the past, current and future climate as the basis for climate vulnerability and risk assessments at airport level with particular attention to airport hubs.

The air transport sector is also active in managing its impact on the environment. The European Aviation Safety Agency develops as such tools for environmental impact assessments and has published '*The European Aviation Environmental Report'*[123]. At this stage, no needs have been identified as regards how Copernicus could help in evaluating this impact i.e. on air quality.

5.4.3. Inland water transport

State of play

120 Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91, OJ L 212, 22.8.2018, p. 1–122.

121 https://www.easa.europa.eu/easa-and-you/air-operations/weather-information-pilots

122 European Aviation Safety Agency, Flight Standards - Air Traffic Management/Air Navigation Services (ATM/ANS) Development, *Weather Information to Pilots Strategy Paper, an Outcome of the All Weather Operations Project*, 19 January 2018.

123 European Environment Agency, European Aviation Safety Agency, Eurocontrol, *European Aviation Environmental Report*, ISBN: 978-92-9210-214-2, 2019.

Copernicus does not address inland water transport neither in terms of river environments nor in terms of ship traffic management. The hydrographic network is one of the Copernicus land cover high-resolution layers as well as riparian zones.

Policy context

Inland water transport is regulated differently from maritime transport under the Directive for Inland Waterway Vessels[124] that identifies technical needs for vessels operating inland and advocating for harmonised practices in Europe. River information services are also regulated under the Directive on River Information Services[125] to support safety, efficiency and environmental friendliness of inland navigation.

User community

The user community involved is mainly related to inland shipping for transport of goods and passengers including tourism. The local public sector is also concerned due to public safety obligations along rivers, channels and tail locks, tide gates management.

Evolving needs

The properties, distribution and circulation of water plan, information on the availability of navigable channels through oceans, rivers, lakes and shallow waters play an important role in the inland transport industry. Hydrography is part of the land management activities. Hydrology and hydro-dynamics of rivers down to estuaries or connection to lakes is at the same time necessary to know for transport operations.

Climate records related to seasonal weather or hydrology, as well as short-term forecasts, but also long-term projections taking into account climate change, are also of relevance for inland traffic management and risk mitigation, climate vulnerability and risk assessments. Main data and information needs are related to water bodies' characterisation and status management including water level monitoring, shallow water bathymetry, water quality indicators such as turbidity or transparency used as a proxy for detecting possible banks or sand, ice conditions, navigability. Information is of interest both as long-time series (e.g. for civil engineering purposes), real-time observation (e.g. for safety, ice appearance[126]) and forecasts (traffic management).

5.4.4. Maritime transport, navigation and safety

State of Play

[124] Directive (EU) 2016/1629 of the European Parliament and of the Council of 14 September 2016 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC, OJ L 252, 16.9.2016, p. 118–176.

[125] Directive 2005/44/EC of the European Parliament and of the Council of 7 September 2005 on harmonised river information services (RIS) on inland waterways in the Community, OJ L 255, 30.9.2005, p. 152–159.

[126] European Space Agency, Rartel S.A., S*afer Danube satellite assistance for Danube navigation*, 2018, available at https://business.esa.int/projects/saferdanube.

Copernicus operates a comprehensive maritime surveillance service (cf. 5.15.2). In parallel, ocean information is produced to describe the marine environmental conditions for safe sea shipping: 10 days forecasts up to seasonal forecasts or climate records for long-term planning (cf. 5.2.1).

Policy context

Safety at sea is regulated by the international Convention for the Safety of Life at Sea[127]. Many EU regulations (on passenger ship safety, port reception facilities, safe loading and unloading of bulk carriers, safety of offshore oil and gas operations, EU arctic policy, hazardous and noxious substances carried by ships) reinforce its application in the EU. The European Maritime Safety Agency has been created[128] to implement and control compliance with these regulations.

User community

Copernicus data and information products are both used by the maritime authorities: coast guards, maritime rescue coordination centre, citizen sailors but also routing services operated by the private sector.

Evolving needs

For the community, the continuity of current meteorological and ocean information services is necessary to support maritime navigation and safety. This contributes to search and rescue and safer route planning or route optimisation (e.g. for. time-to-arrival estimate, fuel consumption, comfort of cruise).

Ship operators need increased geospatial resolution with sub-mesoscale ocean dynamics to keep improving transport operations. It is combined with met-ocean conditions (meteorological conditions over the oceans and ocean state).

Maritime emergency operations need fastest response information and met-ocean information when either a vessel or its crew are in serious distress. In terms of maritime safety and security, Copernicus is integrated in the operations of the European Maritime Safety Agency (EMSA). EMSA needs real-time identification of the vessels, debris and / or potential pollution around the area of the emergency to provide for fast, safe and appropriate response to incidents at sea where the picture may be changing by the hour.

The maritime rescue coordination centres in the EU and EMSA expect more data and information from Copernicus for detection of a missing target, oil spills, local dangers and their drift forecast (e.g. life raft or person, lost container, small vessels or their wakes, icebergs, debris of diverse nature) including to support distress in third countries .

---

127 International Maritime Organisation, International Convention for the Safety of Life at Sea (SOLAS), 1974.

128 Regulation (EU) 2016/1625 of the European Parliament and of the Council of 14 September 2016 amending Regulation (EC) No 1406/2002 establishing a European Maritime Safety Agency, OJ L 251, 16.9.2016, p. 77–79.

Maritime surveillance becomes also significantly important in the Arctic (e.g. northern east passage) with the ship traffic, fishing, and transport increasing in this area because of the climate change impacts and reduced ice. Safety services need more sea-ice and met-ocean information and forecasts with a resolved resolution compatible of small icebergs detection (including leads and polynyas), iceberg drift forecast, merged with small vessel tracking.

To act quickly, fast access to satellite resources (minutes to hours before the acquisition) and quasi real time delivery of information, is needed with routine monitoring of prioritised areas chosen with operational actors.

Maintaining an up-to-date map of all activities and vessels at sea is important for sea operations and safety. To improve this mapping, additional radiofrequency detection capabilities using space capacities (e.g. VHF, satellite phone, GSM or maritime radar) could greatly improve the maritime situation awareness to better detect vessels at sea (including sailing boats and small boats) that are not subject to equipment by regulation with certified mandatory reporting systems. Moreover, EMSA and rescue centres need correlation of the satellite-based information detecting effective vessels at sea and their position with information gathered from the vessel reporting systems (provided by certified systems such as automated identification systems[129] and managed by EMSA through the SafeSeaNet information system across the EU Member States) to establish the baseline of monitoring safety at sea.

Finally, assets that allow very high-resolution observation (such as high-altitude platforms or Remote-Piloted Aircraft Systems), in combination with satellite monitoring, could greatly improve maritime domain awareness both for safety and security purposes.

5.5. Energy

5.5.1. Energy transition and Public action

State of Play

Energy is a promising sector of Copernicus uptake. Many products from Copernicus such as fire radiative power, aerosols, ocean winds and waves, currents, are used for the development of solar and marine renewable energies solutions. SAR Sentinel data and marine products are used by the oil and gas industry for exploration, safety of operations and pollution detection. Both climate records are used for site siting and daily forecasts for optimizing the operations and production of plants. While the energy private sector is very active in using Copernicus, the uptake of Copernicus products by Member States to implement the energy policy, is still low.

Policy context

[129] International Maritime Organisation, Regulation 19 of SOLAS, *Chapter V - Carriage requirements for shipborne navigational systems and equipment*, International Convention for the Safety of Life at Sea (SOLAS), 1974.

On 25 February 2015, the Commission adopted '*A Framework Strategy for a Resilient Energy Union with a forward-looking climate change policy*[130]', creating a new momentum to bring about the transition to a low-carbon, secure and competitive economy. The overall framework for energy transition has been adopted in the Governance of the Energy Union and Climate Action[131] and revised in 2018.

Based on the Commission's proposals published in 2016, EU countries have agreed on a new 2030 framework for climate and energy – the *'Clean Energy for all Europeans'* package, consisting of eight legislative acts[132].

The three main goals of the package are putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers. The legislative acts thus focus on energy efficiency, decarbonisation and renewable energy, design of the internal electricity market, security of electricity supply and governance rules for the Energy Union. This framework will help the EU achieve a more competitive, secure and sustainable energy system and meet its long-term 2050 greenhouse gas reductions target. One of the main goals of the Clean Energy Package is to ensure that the EU takes an ambitious path to a more energy efficient economy ("energy efficiency first" principle). This key role of energy

130 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank *A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy*, COM/2015/080 final.

131 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council, OJ L 328, 21.12.2018, p. 1–77.

132 Directive 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, OJ L 156, 19.6.2018, p. 75–91.
Directive 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency, OJ L 328, 21.12.2018, p. 210–230.
Directive 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, OJ L 328, 21.12.2018, p. 82–209.
Regulation 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council, OJ L 328, 21.12.2018, p. 1–77.
Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity, OJ L 158, 14.6.2019, p. 54–124.
Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU, OJ L 158, 14.6.2019, p. 125–199.
Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC, OJ L 158, 14.6.2019, p. 1–21.
Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators, OJ L 158, 14.6.2019, p. 22–53.

efficiency in achieving ambitious 2050 climate objectives is also emphasised in the European Commission's 2050 long-term strategy[133].

The Renewable Energy Directive amended in 2018 establishes an overall policy for the production and promotion of energy from renewable sources in the EU with targets such as: 20% of EU total energy needs produced from renewables by 2020, 10% of EU national transport fuels coming from renewable sources by 2020, at least 27% renewables in the final energy consumption met by the EU in 2030.

The Energy Efficiency Directive revised in 2018 establishes a common framework of measures to ensure that the Union's 2020 headline targets on energy efficiency of 20% and its 2030 headline targets on energy efficiency of at least 32,5% are met.

The Energy Performance of Buildings Directive promotes the improvement of the energy performance of buildings within the Union, taking into account outdoor climatic and local conditions. This is a key area as buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the EU.

In 2019, the Risk-Preparedness Regulation in the electricity sector sets out a common framework of rules on how to prevent, prepare for and manage electricity crises, bringing more transparency in the preparation phase and during an electricity crisis and ensuring that measures are taken in a coordinated and effective manner. The proposed methodology should identify possible crisis scenarios on which to react potentially being linked either to environmental conditions such as rare and extreme natural hazards, or to consequences of possible fuel shortages.

User community

The ongoing transformation is a multi-disciplinary process with many stakeholders, users, providers requiring understanding and inputs from a variety of disciplines to come to collaborative solutions. Users are:

- the public sector at European and national level in charge of energy regulation but also involved in transitioning to low-carbon facilities like smart cities;
- the traditional network utilities sector that need to implement energy efficiency best practices, including also the traditional electricity and oil and gas sector contributing to the energy security strategy[134] (EU self-sustainability in terms of energy resources);

133 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the regions and the European Investment Bank *A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy,* COM/2018/773 final.

134 Communication from the Commission to the European Parliament and the Council *European Energy Security Strategy*, COM/2014/0330 final.

- all potential end-users from the industrial renewable energies sector that should bring innovation and competitiveness into the EU energy transition contributing to a low-carbon economy and to energy security in Europe;

- the climate and research actors contributing to the understanding and measurements of the impact of the energy sector on the climate change and the effectiveness of policies in terms of mitigation and decarbonisation.

In the public sector, the Commission services are already using Earth Observation and Copernicus to monitor and understand energy markets drivers like weather forecasts (temperatures, winds, snowfall and rainfall) for anticipating energy supply disruptions and/or demand.

Evolving needs

With the reinforcement in 2018 of regulations on transformation, reporting and metering obligations, the development of products for energy transition could be pro-actively pursued proposing ad-hoc products for the energy sector (climatology, resource assessment for renewables energy supply forecasting). Long-term forecasts are necessary to perform the necessary studies and verify that renewable energy choices taken are robust in the face of possible climatic changes (e.g. hydropower, water for cooling purposes, changes in wind speed).

In the context of the Risk-Preparedness Regulation implemented by Member States, Copernicus information could play a significant role to develop scenarios:

- to support the design of crisis scenarios and climate vulnerability and risk assessments, in particular those linked to extreme weather scenarios at regional level (e.g. a 1 every 20 year event of temperature / wind / solar radiation, flooding, ice storms, flood, wildfires) but not only (volcanic events, earthquake);

- to monitor actual situation in the EU electricity transmission systems at different timescales (intra-day, day-ahead, week ahead, month ahead etc.);

- to set up early warning and preventive measures to cope with natural hazards which can cause physical damage to transmission and distribution lines;

- to support also the specific regular gas crisis simulations with land-use structure information, high-resolution mapping of areas (both SAR and multispectral images), high-temporal frequency images, or data sets related to natural hazards and threats;

- to help defining critical natural gas demand related to extreme weather or ‘cold waves’;

- to support emerging dynamic line rating mechanisms to optimise at best the use of transmission and distribution networks (depending on orography, temperature, precipitation and wind conditions).

Energy supply and distribution are also matter of international balancing mechanism and provision between countries in and outside Europe. An increase in the development of intercontinental energy grids (electricity, gas) is foreseen in the next decades, for instance connecting Europe with North Africa, Middle East, Central Asia, and North America. Copernicus derived geospatial derived information could be useful for getting data mainly for areas outside the EU: land cover / land use, topographic / elevation / bathymetry data, climatic data, natural hazards and risks.

At the international scale, the Commission would import bio-energy from third countries. The Commission services and public actors could be interested in regularly monitoring of global biomass changes in these relevant countries to prevent possible adverse environmental impacts on EU biofuels procurement, and to assess the impact of the EU energy policies on these third countries.

The Energy Efficiency Directive also encourages the Commission and Member States to improve the energy efficiency of existing infrastructures and equipment. It regulates the energy performance of buildings and energy related products, as well as the energy labelling of appliances and products, office equipment and tyres. Buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the EU. The Energy Performance of Buildings Directive[135] promotes the improvement of the energy performance of buildings within the Union, taking into account outdoor climatic and local conditions.

A detailed evaluation of the energy performance of buildings at local level requires knowledge of a number of parameters:

- use of the building (residential, industrial, commercial or other);
- building/dwelling and household characteristics (size, age, typology, energy class, household structure);
- characteristics of envelope and systems (construction materials, type of heating / cooling system, renovation measures implemented, etc.);
- additional energy-related technological features (e.g. production of renewable energy);
- information on climatic conditions, direct environment and geographical location.

The availability of accurate and precise information on buildings along the different parameters highlighted above, e.g. on building energy performance, on the presence of solar thermal and / or photovoltaic panels, is therefore of great importance and would be relevant as far as the resolution is sufficient. It would also be beneficial that the collection of such

[135] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, OJ L 156, 19.6.2018, p. 75–91.

information is informed by, and consistent with the framework for building data collection given by the Commission's Building Stock Observatory[136] (BSO).

The directives strengthen the EU sustainability framework for bioenergy, extending its scope to include also biomass and biogas for heat and power generation and introducing specific criteria for forest-based biomass and for agricultural residues and wastes. In addition, the directive includes a gradual phase-out of conventional biofuels associated to high and low indirect land-use change risks (e.g. resulting in significant land expansion in high carbon rich areas). In this context, Copernicus could support the monitoring of the EU bioenergy sustainability criteria as follows:

- the status of global expansion of agricultural areas into land with high carbon stock, based on latest scientific evidence;
- land use change associated to bioenergy feedstock production;
- soil quality and soil carbon of extraction of agricultural residues at project level;
- soil/biodiversity impacts of wood fuel harvesting at regional level;
- forest carbon impacts of wood fuel harvesting at regional level.

5.5.2. The energy markets

State of play

The energy private sector is active in using Copernicus products to develop renewable energies and for oil and gas operations. Specific products have been developed of high interest such as solar radiation, aerosols, wave forecasts, sea surface temperature for thermal energy plants or tide observations. Climate records are extremely useful already for plant siting and exploration at sea.

In the private sector, the full potential of the Copernicus programme is not yet fully explored. However, the range of needs is vast and addresses different areas of expertise such as air composition, atmosphere, the marine and land environment. The area of expertise depends on which source of energy and type of operations (exploration, production) are targeted or policies' implementation and control.

User community

The user community is diverse since the value chain in these market sectors is complex with lots of intermediate providers. Needs have been expressed per sectors given their own specificity.

Evolving needs for oil and gas

[136] European Commission, Directorate-General for Energy, *EU Building Stock Observatory,* available at https://ec.europa.eu/energy/en/eubuildings.

The oil and gas land industry needs real-time and forecasted information to support exploration and exploitation of its aboveground and underground infrastructures. The transition from Corine Land Cover (CLC) to CLC+ (high-resolution cf. 5.1.1) and the high and even very high-resolution satellite data of the Copernicus programme could provide the needed. It could also include geological and soil characteristics up to dynamic information like ground motion to monitor changes in the terrestrial environment and build-up, including of utility networks (e.g. pipelines) and terrestrial transport networks. For example, operators of transmission pipelines have a need to protect their infrastructure against problems like corrosion, unauthorised digging, floods or geo-hazards (gradual ground movement of slopes, subsidence and landslides). Atmospheric information could be relevant to detect possible gas leakages ($13CH_4$, $14CH_4$).

At sea, the oil and gas industry is mainly interested in oil slicks detection and met-ocean conditions. Higher resolution solving sub mesoscale dynamics and vertical mixing / diffusivity, could lead to improved forecasting capacity of the production. Future deep-sea exploration and exploitation need deeper ocean modelling down to 5000 or 7000 meters with improved global modelling and relevant in-situ measurements. Inland/coastal water information: density, salinity, plumes, seabed mapping and bathymetry with coastal resolution including interferences with watersheds, estuaries, tides and waves, intrusion of unsalted waters at sea (for oil and gas on continental shelves and in large estuaries), information on sea ice and continental ice are needed for most oil and gas extraction areas on the continental shelf. This industry is also accountable for possible pollution impacts on the marine environment and marine life. They need products that could enable them to detect and fight against possible accidental oil pollution, but also simulate biogeochemical impacts that could affect the living environment (e.g. plankton, fish stocks, marine mammals, corals).

Evolving needs for marine renewable energies

The oceans represent also a vast and largely untapped source of marine energy in the form of surface waves, fluid flow, salinity gradients, and thermal. Main forms of emerging marine renewable energy systems are thermal energy converters, tidal turbines, wave energy plants or ocean current turbines. Needs of this sector mainly highlight improvements in the accuracy of forecasts in terms of geographical resolution (<1km), daily update and best representation of sub-mesoscale phenomenon like interferences between plant and waves, best representation of tides into models, improved local wind and wave information, vertical and horizontal gradients in salinity/temperature, improved boundary conditions for local ocean or hydrodynamic models, including modelling of potential changes due to climate change.

Evolving needs for land renewable energies

On land, alternative sources of energy include biomass and biofuels (also known as bioenergy), hydropower and solar and wind energy. They all use land cover-use land change information for site siting and for environmental impact assessment. Their needs are similar to the ones highlighted already for improved land planning (cf. 5.1.1 and 5.1.2) with

improvements in geospatial resolution, updates that are more frequent on land changes and additional high-resolution layers classification to serve their specific needs.

Evolving needs for biofuels

The biomass and biofuel industry needs similar information as the one provided for agriculture and forest industry (cf. 5.1.5 and 5.1.6) on land classification, growth extent, forest type, woody biomass, vegetation indexes, biophysical parameter on vegetation conditions and biomass at fine resolution. The resolution of these products has to fit sub-national scale both for exploitation and for estimate of energy production through woody biomass.

Evolving needs for hydropower

Hydropower is a traditional industry used to operate its own in-situ systems to best forecast and anticipate water levels, water discharges and optimise its production and retention strategies. Plant operators need water information on runoffs, water level, water quality for their hydrological and hydrodynamics modelling. New needs concern information about snow cover, snow storage, snow water equivalent, ground water assessment and possible impacts of climate change on water availability and seasonality.

Evolving needs for solar energy

In the solar sector, applications are already developed based on climate data records provided by Copernicus and additional short-term forecasts of the atmosphere composition and solar radiation. Main products (e.g. aerosols, particulate matters, water vapour concentrations) provided at surface are now needed as vertical profiles along the air column. Operators need aerosols and particulate matters with resolution less than 1 km. New needs are related to 3D high-resolution imagery to assess solar irradiation over building roofs, 'irradiance forecasts' for electric production of a solar plant. Both historical databases and forecasts are necessary to force and validate models, support long-term planning as well as daily production.

Urban planning agencies, real estate agencies and local authorities are also keen in using more systematic information products that could help them to calculate possible energy production within cities or regionally, with products like local solar atlas.

Evolving needs for wind energy

The wind energy sector (land, sea) is mainly interested in surface wind speed and direction that can be complementary to weather forecasts, to be combined with maritime spatial information or land use / land cover. Seasonal forecasts are extremely important for site siting, energy production estimates and storage management together with short-term forecasts. Siting will also increasingly need to take into account changes in wind speed (in particular extreme) that may increase with climate change.

In addition to environmental information, there is a strong interest to better integrate Copernicus with location and messaging services based on timecoding (for metering services) and space surveillance technologies that are proven solutions to prevent and forecast possible disruption of electricity productions due to bad synchronisation, or magnetic/solar disturbances.

5.6. Environmental compliance and impact assessment

State of play

The Copernicus programme already delivers a significant portfolio of products that can be used to support environmental compliance in terms of land use (detecting also land changes), ocean state, water quality, air, land or sea pollution. The emergency or maritime surveillance services have been already used to support detection and deterrence of non-environmental compliant activities. Fighting against oil pollution or illegal fishing are two significant cases of Copernicus contribution to the policies.

Dedicated workshops and consultations (cf. 7.2) have been made with the Commission services and Member States authorities in charge of environmental compliance to refine their expectations in terms of data and information.

Policy context

At the global, EU, national and even local levels many rules have been agreed and put in place to provide society with environmental benefits that include clean water, breathable air and a healthy nature.

Environmental monitoring and assessments however show that the ambient conditions these rules envisage are not being fully realised. In Europe, for example:

- people in many European cities are exposed to unsafe levels of particulate matter and nitrogen dioxide to name just two air pollutants [137];
- many water bodies suffer from excessive levels of nutrients and pesticides, because of run-off from the land or untreated wastewater[138];
- over 80% of protected habitat types have an unfavourable conservation status, while the situation with protected species is not much better[139];
- an estimated 15% of waste within the EU is placed on sites that do not meet EU standards[140]. Waste crime and the illegal dumping and movements of waste is a growing

137 European Environment Agency, Air quality in Europe, issue N° 12/2018, 2018.

138 See Commission Staff Working Document accompanying the document Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused from agricultural sources based on Member State reports for the period 2012-2015, SWD/2018/246 final and the European Environment Agency, *European waters – assessment of status and pressures,* Report, No 7/2018, 2018.

139 European Environment Agency, Biodiversity — protected areas – *SOER 2015*, 2015, updated 2018.

problem with high societal impacts, economically as well as on health and the environment.

Non-compliance with these rules come with financial costs[141] estimated around EUR 50 billion per year while an overwhelming majority of Europeans want the EU to make sure that these rules are applied across Europe.

In response to these issues, the Commission issued a Communication on 18 January 2018 on '*EU actions to improve environmental compliance and governance'*[142]. This Communication presents the concept of 'Environmental Compliance Assurance' to mitigate the risk of some duty-holders not respecting their obligations and therefore negatively impacting the state of water, air, biodiversity, human health and the economy.

It does so by assessing the causes and impacts of non-compliance and by using an adaptable combination of the following three broad classes of interventions involving the Member States to influence duty-holder conduct for securing compliance:

- promotion means helping duty-holders like businesses and others to comply through awareness raising, guidance and advice;

- monitoring means using inspections and other checks to collect information about levels of compliance and provide solid evidence for enforcement. This covers routine environmental inspections, police investigations, environmental audits by public audit bodies and the examination of complaints from the public;

- enforcing means stopping those who disregard the rules, sanctioning them and obliging them to rectify the damage. This covers audit recommendations, official warnings, cease-and-desist orders, administrative fines, criminal prosecutions and demands to take remedial action. Such interventions may vary according to what works best.

The 9-point action plan accompanying the communication includes a strategic set of concrete actions to support Member States in assuring environmental compliance and a strong demand for Copernicus to support the delivery of geospatial intelligence for compliance promotion, monitoring, inspections and enforcement actions.

In addition, environmental compliance monitoring has to be developed to conform to the United Nations Convention on Biological Diversity[143] and EU legislation such as the Council Decision 93/626/EEC[144], the Council Directive on wild fauna and flora[145] and the Wild Bird

---

140 Ecologic, Institute European Environmental Policy, *A Report on the Implementation of Directive 1999/31/EC on the landfill of waste*, May 2009.

141 European Commission, Directorate-General for Environment, *the* costs of not implementing the environmental acquis, Final report, ENV.G.1/FRA/2006/0073, 2011.

142 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *EU actions to improve environmental compliance and governance*, COM/2018/010 final.

143 https://www.cbd.int/convention/text/

144 93/626/EEC: Council Decision of 25 October 1993 concerning the conclusion of the Convention on Biological Diversity, OJ L 309, 13.12.1993, p. 1–2.

Directive[146]. It is also reinforced by the Directive related to environmental impact assessment[147] amended in 2014, the Strategic Environmental Assessment Directive[148], the Espoo convention[149] and the Strategic Environmental Assessment Protocol[150] from the United Nations Economic Commission for Europe.

User community

The user community comprises mainly public authorities from national to local scale, operators of protected areas that need to be monitored, ministries, administration in charge of planning and services in charge of law enforcement. The community ranges from the fisheries or maritime authorities to land managers, foresters and park managers, environmental agencies but also administration of cultural site or universities. It also includes many of the actors that have to comply with environmental rules from the business sector.

Evolving needs

Timely information on levels of compliance and even an alert system at local, regional and even global scale could support environmental compliance assurance as it is already now provided for hazards and disasters in Copernicus. The information can be used to inform duty holders and to raise their level of awareness but also timely identify areas where there are growing risks of non-compliance, real-time infringements (e.g. pollution, illegal fishing activities) and to guide more efficient inspections on the ground.

In addition to raising awareness and providing decision-making information through environmental monitoring services, Copernicus could support actions to enforce environmental compliance and trigger if necessary Copernicus services with a mechanism of authorised users. Where non-compliance results from criminal actions, Copernicus could help to deter such illegal activities or assist with their detection and management: e.g. illegal disposal of waste, inland and marine water pollution, illegal land use and land use change, illegal water pumping, illegal use of pesticides, hunting and other breaches.

Spatial resolution, capacity to task and access real-time satellite capacities and the production of maps and real-time alerting mechanisms, including identification of potential polluter or criminal to the authorities in charge, are needed to support detection and support enforcement.

---

145 Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7–50.

146 Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds, OJ L 20, 26.1.2010, p. 7–25.

147 Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, OJ L 124, 25.4.2014, p. 1–18.

148 Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, OJ L 197, 21.7.2001, p. 30–37.

149 United Nations Economic Commission for Europe*, Convention on Environmental Impact Assessment in a transboundary context*, 1991.

150 UNECE Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context (Kyiv, 2003), the text of the Protocol, as published in 2017 (ECE/MP.EIA/SEA/8).

Copernicus already demonstrated it in the frame of fighting against marine oil pollution or illegal, unregulated and unreported fishing (IUU). Access to very high-resolution and persistent capabilities for verification including satellite, remote piloted aircrafts, high altitude platforms and manned aircrafts could be important to support pursuing cases of non-respect of the existing obligations.

Information products are also needed to check compliance to the additional regulations such as the United Nations Convention on Biological Diversity to protect species and habitats, the thematic strategy for soil protection and the roadmap to a resource-efficient Europe related to sustainable use of soil (cf. 5.1.3) and sustainable management of land take (cf. 5.1.1), including all new actions in favour of climate change mitigation and adaptation (cf. 5.11.2 and 5.11.3) and protection of cultural and natural heritage sites (cf. 5.1.10).

For environmental impact assessment, data and information are both necessary for developers that want to deploy activities and infrastructures (like transport, real estate or energy industries) but also for Member States that are due to monitor and control the effect of activities on the environment in compliance with European and international legislation.

The information needed to support impact assessments are e.g. land cover / land cover change information based on CLC and CLC+, emission databases such as the European Pollutant Release and Transfer Register[151] and the monitored gas emissions in the atmosphere (cf. 5.1.7), or oil spills or other pollution into water (cf. 5.2.4). For all monitoring information to detect non-compliance and act, products need to be based on high-resolution Sentinel data or very-high additional data with high revisit time and fast delivered. Whatever the environmental place at stake, land, air, sea, long-time series of information are necessary to assess the ex-ante situation and then simulate possible environmental impacts, such as climate data records in the past and possible forecasts or long-term projections. Spatial resolution needs to match sizes of areas to be protected in compliance also with recommendations from Member States in charge of regulating environmental compliance such as protected areas but also river corridors or industrial sites.

5.7. Raw materials

State of play

Two workshops have been conducted (cf. 7.2) to assess the interest of Copernicus products for the community acting in raw materials. This subject was also addressed in the frame of the expert group for a space hyperspectral mission since hyperspectral technologies are well fitted to detect soil chemical content in particular. At the time being, Copernicus does not deliver many products for raw material identification yet. However, environmental conditions of soils (cf. 5.1.3 - water, wetness etc.) and land use (cf. 5.1.1) are already available.

Policy context

[151] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC, OJ L 33, 4.2.2006, p. 1–17.

In 2011, the Commission issued a Communication *'Tackling the challenges in commodity markets and on raw materials'*[152] which sets out a strategy for tackling the issue of access to raw materials in the EU. Its implementation was described in 2014 by a Communication[153] and supported by relevant policies from trade, environment, research and innovation and development. The policy objectives are to:

- provide for access to raw materials from international markets under the same conditions as other industrial competitors;
- set the right framework conditions within the European Union in order to foster sustainable supply of raw materials from European sources;
- boost overall resource efficiency and promote recycling to reduce the EU's consumption of primary raw materials and decrease the relative import dependence.

The Commission also updated in 2017 a list of critical raw materials[154] of high importance to the EU economy and of high risk associated with their supply that is subject to regular review and update.

User community

The target user community is mainly composed of mining companies, waste management companies, manufacturers in the sector energy, electricity, composites and battery, and in the public domain: geological survey institutes, geologists, geographical institutes, environmental agencies, marine and water management administrations.

Evolving needs

State-of-the-art remote sensing information and Copernicus information can be used for the monitoring of a variety of complex environmental processes in surface water, soils and vegetation, related to different aspects and stages of mining activities like assessment and monitoring of mining and waste management, non-invasive exploration, support to impact and opportunity assessment activities.

Geological institutes and environmental agencies need mainly data and information to support the assessment and revision of existing geological mapping, the identification of minerals / alteration zones related to mineralisation, a rapid appraisal and geological interpretation of large geographic areas with difficult field access, site-specific field-based observations to be

152 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Tackling the challenges in commodity markets and on raw materials*, COM/2011/0025 final.

153 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the review of the list of critical raw materials for the EU and the implementation of the Raw Materials Initiative, COM/2014/0297.

154 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the 2017 list of Critical Raw Materials for the EU, COM/2017/0490 final.

viewed in a wider context, identification of target areas for fieldwork / mineral sampling / geophysical data acquisition.

Data and information could integrate the land use and land cover characteristics like surface conditions (cf. 5.1.1 - dense vegetation, subtle topographic relief or no exposure).

Mining exploration and exploitation operators need data and information for mineral analysis to support specific tasks such as delineation of lineaments and small geological features, detection of host rocks, increased distinction of minerals indicating alteration, separation between alteration and weathering. To tackle minerals in detail and raw material individually, the most important need is to better detect/assess chemical soils composition (e.g. materials identification such as Cu, Au, Ag, Pb, Zn, Fe, Li, Salt, LREE, HREE, Nb, and Ta). Soil composition cannot be analysed in isolation and conditions of soil moisture, soil reflectance, soil water index, water and wetness probability index (cf. 5.1.3, 5.1.4) groundwater content need to be known to perform the analysis.

The monitoring of dynamics of land surface is necessary to support operational planning but also safety of infrastructures, and includes soil water content variations, ground motion and displacements of infrastructures. Access to high-resolution topography and the understanding of ground motion processes could be relevant to support exploitation and deep exploration (10 km sub-surface, 100 km sub-surface in the future) like deep ground motions, natural ground instability, natural ground movement, and manmade ground instability with mm-level accuracy.

Since there is an intrinsic limitation to measure parameters below ground, use of Earth Observation could be used as a proxy to make estimates complemented by other in-situ geo-information (including data from navigation and location systems but also very high-resolution sensing and fast-deployable from drones) as well as indirect geophysical methods, like gravity, magnetic/electromagnetic methods, radiometry, gamma spectrometry and seismic measurements.

Both for prospection and then exploitation, data and information could be provided as long-time series first, but also through regular observations on same hotspots. Spatial resolution should be high to support local operations but with a possible global coverage since the raw material industry is targeting large export opportunities (e.g. in Africa) to feed the market demand.

Mining companies are also subject to environmental impact assessment before exploiting some land territories and after closing mines, to assess alteration zones relating to mineralisation and the environmental recovery after closure. They need environmental products related to land use / land change, vegetation productivity indexes, environmental and biodiversity monitoring with an expected resolution of 5 to 10 m (cf. 5.1.1). Monitoring of the atmospheric composition on sites can be necessary to identify potential air pollution (cf. 5.8) and possible contribution to greenhouse gas emissions (cf. 5.1.7) that would account for reporting under the UNFCCC transparency framework.

Environmental compliance (cf. 5.6) applies to the raw material industry. Land use / land change detection at very high-resolution and on a regular basis could be relevant to detect possible illegal mining activities versus awarded licences including in remote or wild areas, law enforcement conducted by public authorities.

5.8. Air quality

State of play

Air quality is one product portfolio of Copernicus mainly to support health management and support directives related to air pollution or greenhouse gas monitoring. Copernicus provides hourly air pollution forecast bulletins with content in aerosols and dust, pollens, fine particle matters, ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and other gases or pollutants. This also includes the monitoring of the ozone layer and solar radiations. Data are also available as daily means and climate records to support trend analysis and planning.

Policy context

At the Earth's surface, particulate matter (aerosols), ozone, ultraviolet radiation reaching the surface and other reactive gases such as nitrogen dioxide, carbon monoxide, non-methane volatile organic compounds and ammonia determine the quality of the air around us, affecting human health and life expectancy. Every year, more than 400 000 people in the EU die prematurely due to the consequences of air pollution. Another 6.5 million people fall sick as air pollution causes diseases such as strokes, asthma and bronchitis.

The Communication *'Clean Air for all'*[155] has reconfirmed the objective to achieve full compliance with existing air quality standards across the EU as soon as possible and set objectives for 2020 and 2030. A Directive on the Reduction of National Emissions of Certain Atmospheric Pollutants[156] was adopted in 2016.

EU policy efforts rest on three main pillars.

The first pillar comprises the ambient air quality standards set out in the Ambient Air Quality Directive[157] for ground level ozone, particulate matter, nitrogen oxides, dangerous heavy metals (such as mercury, arsenic, lead, cadmium and nickel) and a number of other pollutants. These air quality standards were attained by all Member States across their territories from - depending on the pollutant - 2005 or 2010 onwards.

---

155 Communication from the Commission to the European Parliament, the Council, the European Economic and Social, Committee and the Committee of the Regions, *A Europe that protects: Clean air for all,* COM/2018)/330 final.

156 Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, OJ L 344, 17.12.2016, p. 1–31.

157 Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, OJ L 152, 11.6.2008, p. 1–44.

The second pillar about national emission reduction targets was revised by the Effort Sharing Regulation[158] in 2018 to include new limits that need to be met from 2021 to 2030, and an additional pollutant – fine particulate matter (PM2.5). Member States have to develop national air pollution control programmes by 2019 with a view to complying with their emission reduction commitments.

The third pillar comprises emissions standards for key sources of pollution, from vehicle and ship emissions to energy and industry. These standards are set out at EU level in legislation targeting industrial emissions[159], emissions from power plants[160], vehicles[161] and transport fuels[162], as well as the energy performance of products[163]. The control of emissions from both point sources and mobile sources, improving fuel quality, promoting, and integrating environmental protection needs into the transport, energy, industry and agriculture sectors are central to these aims.

User community

Air quality is controlled at national to local level by public authorities such as institutes in charge of environment and industrial risk, agencies for sanitary security, universities or cities. The private sector is beneficiary of air quality data to develop information services for citizen and health services. Industry is interested in air quality monitoring to develop industrial practices compliant of air quality standards, to monitor risk of pollution but also in the event of air pollution could affect their production.

Evolving needs

To comply at national and European level on pollutant emission, Member States need to have information to monitor particle matters, black carbon, organic carbon, sulphates and dust is

158 Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013, OJ L 156, 19.6.2018, p. 26–42.

159 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), OJ L 334, 17.12.2010, p. 17–119 .

160 Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants, OJ L 313, 28.11.2015, p. 1–19.

161 Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO 2 emissions from light-duty vehicles , OJ L 140, 5.6.2009, p. 1–15.
Regulation (EU) No 510/2011 of the European Parliament and of the Council of 11 May 2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO 2 emissions from light-duty vehicles, OJ L 145, 31.5.2011, p. 1–18.

162 Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC, OJ L 140, 5.6.2009, p. 88–113.

163 Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, OJ L 285, 31.10.2009, p. 10–35 .

needed, ideally with seasonal forecasts at fine scale for local risk prevention. The detection and forecasts of different types of pollen seasonally at fine scale is also particularly important to fight against allergies and asthma.

Both air quality value as such as well as contributions from the different sources of air pollution (e.g. electricity and heat production, petroleum refining and storage, fire smokes, agriculture) and the transport of the pollution need to be monitored to implement policy at national level. Air quality monitoring is needed at hourly and at sub-national scale. In addition to established parameters (SO_2, PM2.5, PM10, NO_2, O_3, and others), additional parameters could become increasingly relevant (such ultrafine particles, black carbon and methane).

At the same time, air pollution needs to be understood in terms of geographical distribution of concentration, with identification of sources, origin of pollution and total quantity of emission per source. Local authorities have to make available public information to citizen in terms of observed exceedances but also short-term forecasts to support early warning. This requires therefore being able to observe and forecast different gases, aerosols or pollutants at fine scale, both in total column and all along the vertical profile, at sampling points and also covering larger geographically regions. Additionally, institutes need long-time series of data in the past and the future for reporting and long-term monitoring of the benefits of policies implementation and for the development of scenarios for risk prevention planning.

Existing Copernicus ozone and UVs monitoring could be improved with a deep understanding of emission and surface fluxes but also the ozone layer, clouds and aerosols along the profile for trend analysis, decision-making and impact assessment.

Public institutes or the private sector need information fit for the local scale to develop forecasts. Significant improvements are still expected in terms of reaching higher spatial resolution. Inventories and warning will likely necessarily remain mostly based on in-situ networks. Real-time observation and short-term forecast (eventually hourly) at local scale with a full European coverage to support early warning functions could however be beneficial to consolidate modelling and derive geographical distribution where in-situ networks remain weak. Mapping of polluting emission plumes could be valuable at pan-EU scale to verify the evolution in time of pollutants and the possible effect of the implementation of emission reduction measures.

The UN 2030 Agenda also identifies the link between air quality and health (cf. 5.9). Sustainable development goals 3 and 11 address population exposure to air pollution by particulate matter and reporting on greenhouse gas emissions per capita. In the frame of the sustainable development goals objectives, projections of information in the future is necessary to develop scenarios for risk prevention planning. To report from greenhouse gas emissions (anthropogenic and natural), high-spatial resolution and accuracy column measurements are needed, in addition to the need for continuity of high-resolution space-time measurements of air quality parameters, with a special look at those which are currently impossible to measure from space, e.g. particulate matter (very important EU policy-wise).

5.9. Health

State of play

Copernicus delivers products directly of benefit for health only in the area of air quality and pollens forecasts. Copernicus also supports the development of safe and healthy agriculture activities by providing information on land cover, land use, information on vegetation and water.

Policy context

Health policy is not simply a case of keeping people healthy. It is keeping them living, working and ageing in good health, actively engaged in society and actively contributing to the economy. Therefore, health is now an integral part of most major EU initiatives. Most Commission initiatives are obliged to examine potential impacts on health and health systems in the policy design process.

As indicated above, successful implementation of a number of the policies can have a positive impact on the health of European citizens and contribute to the achievement of some the specific objectives laid out in the health and food safety strategic plan 2016-2020[164]. The plan includes two objectives for which Copernicus could contribute:

- specific objective 1.1 *'Better preparedness, prevention and response to human, animal and plant health threats';*
- specific objective 1.2 s *'Safe and sustainable food and food production systems'.*

User community

The strategic plan embraces all sectors that can contribute to the development of conditions for citizen health and well-being. Beyond reaching directly the citizen, the user community is more about actors that can favour the development of healthy environmental conditions like cities, environmental agencies, urban planners, transport authorities, rather than the pharmaceutical or medical sector.

Evolving needs

The Copernicus programme could contribute to the goals of the health strategy plan by providing information and analysis on environmental factors affecting health, including but not limited to:

- monitoring, analysis and prediction of poor air-quality events (cf. 5.8), including chemical incidents, and their geographic and temporal extent;
- monitoring, analysis and modelling of water quality (cf. 5.1.4), including pollution events (cf. 5.2.4);

[164] European Commission, Directorate-General for Health and Food Safety, *Strategic Plan 2016-2020,* 20/12/2017.

- monitoring, analysis and modelling of heat and cold waves with potential to cause significant health issues;

- monitoring and mapping of vector-borne disease susceptibility (e.g. mosquito distribution and density, soil moisture, land coverage, surface water presence and temperature);

- monitoring and modelling of sea surface temperature and currents in coastal areas (cf. 5.2.2) have been used to predict cholera propagation.

Several products are needed with different update frequencies, some being almost real-time notably where the aim is threat detection, risk assessment and response in a crisis, other being daily, weekly, seasonal or annual.

For example, at urban scale, the Environmental Noise Directive[165] relating to the assessment and management of environmental noise is also linked to public health concerns. To support it, complex algorithms are implemented at EU and Member State level that need environmental data: digital terrain model, information on land use, buildings, transport networks associated to socio-economic or population data. Providing homogeneous data among Member States is necessary with a high frequency of update.

Information on temperature in particular in urban setting (heat/cold waves, urban island effects) is relevant for the health sector and something Copernicus could usefully provide. Climate change should be given due consideration where relevant.

Land, air and water information are relevant to fight against specific diseases for which proxies have been understood. This is the case for example of disease vectors spread by mosquitos that develop in both humid and warm conditions and for which future spread may be affected by climate change. Information combining both soil moisture, presence of waters, land surface and water surface temperature are relevant as proxies (cf. 5.1.3, 5.1.4). Information related to sea surface temperature, currents in coastal areas (cf. 5.2.2) are used for evaluating cholera propagation. Such information could support also progress in implementing solutions to end with the epidemics of AIDS, tuberculosis, malaria, neglected tropical diseases and combat hepatitis, water-borne and other communicable diseases closely related to poverty.

Information related to human activities and location of population such as demographic trends, human settlement patterns and migration flows are also relevant to build resilient health system. The footprint of human activities can be partly monitored by Copernicus thanks to land use and land use change products (cf. 5.1.1 and 5.1.2). Such information could support progress in implementing solutions to the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases as well as combat hepatitis, water-borne and other communicable diseases closely related to poverty.

---

[165] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, OJ L 189, 18.7.2002, p. 12–25.

Before moving to continuous monitoring of diseases, these relevant information products could be produced during long-timeframes: climate data records and trends of information in the future to support decision-making, prevention and early warning by international bodies (World Health Organization) and national public authorities.

5.10. Tourism

State of play

Copernicus does not target this sector of activity in particular but it can provide some environmental information that can be used such as land use / land use change (cf. 5.1.1), urban information (cf. 5.1.2). Coastal information is not detailed enough in resolution yet because Copernicus does not deliver products along the coastline (cf. 5.2.2). Some business cases have been however successfully developed for surfing based on ocean and wind forecast information.

Policy context

The Communication from the Commission *'Europe, the world's No 1 tourist destination*[166]*'* sets the political framework for tourism in Europe with a multiannual rolling action plan including indicators of best practices supporting the development of sustainable tourism taking care of environmental impacts, social development and climate change in particular for coastal and marine tourism.

In 2016, the Commission adopted a Decision on the Implementation of Best Environmental Management Practices, Sector Environmental Performance Indicators[167], establishing for each actor of the sector which environmental performance indicator to report of.

User community

The actors impacted by the tourism legislation are broken down into three groups: the supply chain (agriculture, civil engineering etc.), the tourism service providers (food and drink, accommodation, travel agents, transport and logistics) and the support services (energy, waste, water supply). Local administrations are also relevant especially for the provision of some of the support services and control of best environmental practices.

Evolving needs

Local administrations, cities, regions may need some qualitative information in the future to support tourism planning policies versus environmental or climate change conditions. It could

166 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - *Europe, the world's No 1 tourist destination – a new political framework for tourism in Europe*, COM/2010/0352 final.

167 Commission Decision (EU) 2016/611 of 15 April 2016 on the reference document on best environmental management practice, sector environmental performance indicators and benchmarks of excellence for the tourism sector under Regulation (EC) No 1221/2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), C/2016/2137, OJ L 104, 20.4.2016, p. 27–69.

enable the sector to become more resilient to the impact of climate change and able to mitigate the effects of the possible structural changes caused by tourism. It could also support development of sustainable and environmental (eco) tourism.

Climate change in Europe could determine a restructuring of travel models and affect certain destinations in aspects like holiday's patterns, seasonality, tourism quality, health implications, sustainability and wellbeing of local economies and communities (e.g. due to declining snow cover in Europe's mountainous regions, sea level rises in coastal areas). Administrations in charge of European and national tourism policies implementation will need to take account of all these structural changes. Several topics could be concretely proposed based on yearly monitoring of evolutions that could affect competitiveness and sustainability of tourist destinations including Earth Observation data and information products such as:

- monitoring and analysis of evolution of beaches based on specific information on chlorophyll concentration at global or regional scale, turbidity, water transparency, and algal blooms;
- monitoring and analysis of snowy surfaces in winter, in relation with winter sports (e.g. downhill skiing, cross-country skiing, and others), including evolution due to climate change;
- identification and monitoring of potential hazard such as cloudbursts, flooding, drought, forest fires, storms, heatwaves including in combination with elevated levels of relative humidity;
- monitoring of the impact of tourism on environment like the evolution of build-up areas in zones of mass tourism and around, evolution of vegetation in zones of mass tourism;
- monitoring of the air quality in general and specifically in zones of mass tourism and around;
- monitoring and analysis of evolution of average time of sunshine;
- monitoring of climate changes in relation with potential impact on fauna and flora as touristic attraction.

5.11. Climate change

5.11.1. CO_2 and other long-lived GHG anthropogenic emissions monitoring

State of play

Copernicus already monitors some greenhouse gases with observation, daily and hourly forecasts but also climate records and long-term projections. Gases are monitored in total along the column at pan-European and global scale. Features are not yet refined enough to identify local sources of emissions and information along the atmosphere column is not available. In order to fulfil the objectives of the Paris Agreement, an expert group established

by Copernicus issued two reports (cf. 7.2) to identify which are the necessary measurements and which space mission could be developed therefore in the frame of Copernicus.

Policy context

The European Union has long been committed to international efforts to tackle climate change and felt the duty to set an example through robust policy-making at home. At European level, a comprehensive package of policy measures to reduce greenhouse gas emissions has been initiated since 1991. The EU targets for reducing its greenhouse gas emissions transitioning to a low-carbon society in 2050 are identified in the 2020 climate and energy package[168], the 2030 climate and energy framework[169] and the latest long-term strategy for 2050[170] '*A clean planet for all*'[171]. In addition, the Regulation on the Governance of the Energy Union and Climate Action[172], which entered into force on 24 December 2018, aims among other to integrate strategic planning and reporting on climate and energy measures in order to ensure the achievement of the objectives of the energy union, in particular the EU's 2030 energy and climate targets, and the long-term EU greenhouse gas emissions commitments, consistently with the Paris Agreement.

With ambitious climate policy efforts undertaken at European level, the European Union provided a substantial contribution to the international climate negotiations for the post-2020 period, following the signature of the Paris Agreement on 12 December 2015, position spelled out in the Communication *'The Paris Protocol – a blueprint for tackling global climate change beyond 2020*[173]*'*.

In October 2016, the Paris Agreement entered into force, with amongst other actions to:

- reduce global emissions of greenhouse gases;
- enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change;

168 European Commission, *Climate action, 2020 climate & energy package,* available at https://ec.europa.eu/clima/policies/strategies/2020_en.

169 European Commission, *Climate action,* 2030 *climate & energy framework,* available at https://ec.europa.eu/clima/policies/strategies/2030_en.

170 European Commission, *Climate action, 2050 long-term strategy*, available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN.

171 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank - *A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*, COM/2018/773 final.

172 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council, OJ L 328, 21.12.2018, p. 1–77.

173 Communication from the Commission to the European Parliament and the Council *The Paris Protocol – A blueprint for tackling global climate change beyond 2020*, COM/2015/081 final.

- implement a transparency framework for monitoring the impact of the nationally determined contributions (NDCs);

- undertake a global stock take of collective progress every 5 years starting from year 2023.

In the five yearly global stock take, governments agreed to track their progress towards the long-term goal using a robust transparent and accountable system of stock takes, to be implemented bottom-up by individual countries through national reports.

User community

While nationally determined contributions should be the primary input to the global stock takes and be implemented by the Member States administration, the need for a global CO_2 monitoring, reporting and verification (MRV) support capacity providing independent, observation-based atmospheric data should be considered to complement this bottom-up transparency framework and contribute to increase the reliability and accuracy of the national reports. Commission services could develop this MRV capacity.

Evolving needs

Following the first global stock take, planned for 2023 at the COP 29, the Parties will be asked to revise and strengthen their nationally determined contributions. A crucial global stock take will subsequently take place in 2028 based on inventories collected during 2026-2027.

To achieve the global stock take Member States could benefit from support capacity in the form of space-borne total column CO_2 measurements, which, combined with an ensemble of models, will provide in the end observation-based evidence of the anthropogenic emissions. The model results could enable:

- the detection of emitting hot spots such as megacities or power plants but detecting also future hot spots e.g. from new oil new industrial facilities burning fossil fuel or from growing urban areas;

- monitoring the hot spot emissions to assess total emission reductions of the activities;

- assessing emission changes against local reduction targets to track progress of the NDCs implementation;

- verifying the trends of the emissions from hot spots at high-resolution over the globe;

- assessing whether the global emission reductions promised by the NDCs are actually observable in the atmosphere;

- assessing the national emissions and changes in 5-year time steps to estimate the global stock take.

Datasets should be global, uniform, homogeneous and indisputable to monitor anthropogenic CO_2 emissions at the relevant regional, European or global spatial resolution, updated at least every 5 years and quantifying the uncertainties.

The monitoring of anthropogenic CO_2 emissions could also implicitly include the monitoring of the natural components of the carbon cycle to discriminate from possible anthropogenic sources, and to detect feedbacks of the climate system on emissions. Possible natural sources of emission or sinks could be specifically the soil, forests and ocean components of the Earth system. Anthropogenic sources could be segregated per source sector to match EU policies segmentation and better report their effectiveness and efficiency. Hotspots could be monitored either at point level or at spatial level for distributed sources:

- anthropogenic emissions for the global and European domains and global emissions from wildfires and biomass burning;
- greenhouse gas surface flux inversions allowing the monitoring of the evolution in time of these fluxes.

The European Union's EU emissions trading system (EU ETS) is a key to comply with the European international commitments to fight against climate change. It is a cap and trade system whereby a cap is set on the overall amount of emissions and companies can trade emission allowances between them to ensure cost-effectiveness. The cap is reduced over time so that overall emissions fall. For those sectors of the economy that fall outside the scope of the EU ETS, EU Member States have binding annual greenhouse gas emission reduction targets defined by regulation[174]. These sectors, including transport, buildings, agriculture, non-ETS industry and waste, account for almost 60% of total domestic EU emissions. Finally, the land use sector is also part of the EU 2030 climate objective, after the introduction of a new LULUCF Regulation in 2018 (cf. 5.1.7). Copernicus could support the improvement of the European monitoring, reporting and verification system (MRV) which requires Member States to report their annual emissions to the EU and to the UNFCCC across all the sectors of the economy.

Complementing the focus on CO_2 emissions reduction, it is necessary to act in parallel on short-lived climate pollutants, such as methane. Methane has more warming potential than CO_2, although it stays in the atmosphere for a shorter period of about 12 years. Maintaining the credibility of gas as an environmentally sound option for a transition to a carbon-neutral economy also requires the issue of methane leakage and venting in the energy sector to be urgently addressed. Monitoring of anthropogenic CH_4 emissions would also implicitly include being able to monitor CH_4 from natural sources.

Europe imports most of its gas and oil, so information on the 'methane footprint' of the whole gas supply chain to the EU could also be covered and provide input to potential future policy

[174] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013, OJ L 156, 19.6.2018, p. 26–42.

measures and ad-hoc actions (e.g. detection of a major methane emission followed up by diplomatic contact and cooperation). There is a need for a global monitoring, detection, reporting and verification support capacity that Copernicus could provide, such as:

- continuous monitoring of CH_4 emissions;
- identification of emission hotspots and alert of major 'accidents';
- complementing bottom-up measurement and quantifying and improving the reliability and accuracy of national inventory reports;
- assessing whether global and national (EU) emissions are reduced;
- verifying trends of emissions;
- supporting research into methane emissions on the ground by providing additional (top-down) data and verification capability.

5.11.2. Adaptation to Climate Change, Member States needs and local level

State of play

Copernicus delivers relevant information on land use and land use change that can support the development of climate mitigation and climate adaptation strategies at European, national, regional level. At local level, some information is also available but could deserve additional developments either at Copernicus level or at national level.

To support planning and long-term decision-making, climate records of the past and seasonal forecasts are available for the atmosphere and the marine areas. Access to historical data and information on land use is less developed. However, archives of historical Earth Observation data become accessible. Climate projections are available mainly for describing the behaviour of the Earth system (air land, water) for decades to come to help developing scenarios.

Policy context

Adaptation to climate change is increasingly important to protect lives and assets, e.g. anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise. Adaptation strategies are needed at all levels of administration and across populations, economic sectors and regions within Europe, but due to the varying severity and nature of climate impacts between regions in Europe, most adaptation initiatives and strategies have to be developed at regional or local levels.

Following the adoption of the European Union’s climate and energy package in 2008, the European Commission launched the Covenant of Mayors, to endorse and support the efforts deployed by local authorities in the implementation of sustainable energy policies. In 2014, the European Commission launched the Mayors Adapt initiative. Based on the same principles as the Covenant of Mayors, this sister initiative was focusing on adaptation to

climate change. In 2015, the Covenant of Mayors and Mayors Adapt initiatives officially merged into the EU Covenant of Mayors for Climate and Energy. The signatories of the EU Covenant of Mayors for Climate and Energy commit to reduce their CO_2 emissions (and possibly other GHG) and to adopt a joint approach to tackling mitigation and adaptation to climate change. They commit to prepare and implement a sustainable energy and climate action plan[175] (SECAP) with the target year of 2030 for emission reduction. SECAPs include an assessment of the geographical, demographical and energy local context, a baseline CO_2 emission inventory (BEI) referring to a specific base year, a climate risks and vulnerability assessment, a clear identification of the emissions reduction target, a climate change adaptation goal and the actions planned together with periods, assigned responsibilities and estimated impacts and costs. In 2016, the European Commission supported the creation of the Global Covenant of Mayors for Climate and Energy at international scale.

User community

Copernicus could provide the necessary data for local authorities to fill in the SECAP template [176], in accordance with the accompanying reporting guidelines [177] and notably for the fields related to assessing risks and vulnerabilities to climate change, monitoring and evaluating implemented adaptation measures, with the help of the adaptation indicators proposed in the template[178]. The data provided by Copernicus could also support local authorities in their reporting to the European Commission (every two years after having submitted the SECAP or a similar relevant strategy or plan for local authorities not being part of the Covenant of Mayors).

Evolving needs

Climate reanalyses, seasonal or decadal forecasts and long-term projections could be thus provided at global, continental level so that national and regional authorities in charge of climate assessment at national and regional and/or local scales can develop relevant information to their adaptation and mitigation strategies with multi-scale consistencies.

Copernicus climate data could also support the climate vulnerability and risk assessments of new investment projects, existing assets in the built environment, networks (e.g. transport, communication, energy), and nature-based solutions. Furthermore, Copernicus could provide

175 Actions presented at https://www.covenantofmayors.eu/en/.

176 https://www.covenantofmayors.eu/support/library.html

177 Covenant of mayors for Climate and Energy, European commission, *The Covenant of Mayors for Climate and Energy Reporting Guidelines*, June 2016, available at https://www.covenantofmayors.eu/support/library.html (the 2016 version of the Reporting Guidelines are foreseen to be aligned in 2020 to the 2019 revised SECAP template).

178 In more detail, Copernicus could support local authorities in replying to the following questions of the Urban Adaptation Support Tool (http://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast) for developing a local climate change adaptation strategy and/or action plan: 1.5 What initial information do I need to collect? (Section 'Identifying current and future climate change impacts'), 2. Assessing risks and vulnerabilities to climate change and all of its sub-questions, possibly 4. Assessing and selecting adaptation options and all of its sub-questions, and 6. Monitoring and evaluation and all of its sub-questions in relation to indicators.

climate data corresponding to the climate and weather variables that are relevant vis-à-vis the Eurocodes used for structural engineering (including the national annexes to the Eurocodes).

Adapting to climate change requires data and information from all Earth system components: the atmosphere, the land and the cryosphere and oceans. Both reference time series (data demonstrating of changes and trends) and climate change indicators are thus necessary either composite or covering the specific economic sectors impacted by European and national policies for economic and ecological sectors and services such as water, energy, agriculture, insurance, health, infrastructure, tourism, biodiversity, land use (e.g. soil sealing, imperviousness, erosion, carbon uptake, etc.). While expectations for long-term climate data records and long-term projections are similar for global international purposes and local adaptation strategies, the geospatial resolution can significantly vary to fit regional and local actions. In order to support local authorities, products need to be downscaled in resolution to cover around 80% of the local authorities' needs. Methodologies, core data, and information ready-to-use to build data at the city level for cities to undertake climate risks and vulnerability assessments and monitor changes could be most useful.

Copernicus could help geo-locate people vulnerable to climate change consequences (e.g. heatwaves, floods), notably concentrated in specific hotspots (e.g. districts, nurseries / educational establishments / elderly residences). It could be useful to understand, monitor and reduce the foreseen increasing impacts on vulnerable groups (e.g. low-income, elderly, young, foreigners not understanding the national language, people with poor health, etc.).

Relevant Copernicus data and information services could be made available as already initiated to users through the Climate-ADAPT platform in all areas of the current and future EU adaptation strategy. Climate-ADAPT is the strategies' main channel to disseminate information on adaptation to national and local actors. Complementarity with other EU knowledge platforms (such as the Disaster Risk Management Knowledge Centre or the european forest fire information system) and with the growing number of national adaptation platforms will be important in this context.

5.11.3. Adaptation to Climate Change and the private sector

Policy context

The Commission has issued for the period 2014-2020 an outline of the climate change related needs and guidance for major projects to support resilience to the adverse impacts of climate change and reducing the emission of greenhouse gases[179].

Climate proofing (for infrastructure investments larger than €5 m) ensures the resilience of infrastructure investments to climate change impacts - this is done through a climate

[179] European Commission, Directorate-General for Climate Action, *Climate Change and Major Projects, Outline of the climate change related requirements and guidance for major projects in the 2014-2020 programming period, Ensuring resilience to the adverse impacts of climate change and reducing the emission of greenhouse gases,* 2016, available at https://ec.europa.eu/clima/sites/clima/files/docs/major_projects_en.pdf.

vulnerability and risk assessment followed by the identification, assessment and selection of relevant adaptation options.

User community

Adaptation to climate change requires many of the actors of the private sector to adapt their solutions and their infrastructures to comply with climate law and regulations from the 2030 and 2050 European respective agendas. This applies specifically for the building, energy, transport, agriculture and forestry sectors or cities planning. Their needs are reflected in each of the relevant chapters of the documents for:

- more efficient use of less polluting energy;
- cleaner and more balanced multi-modal transport options;
- more environmentally-friendly land-use and climate-smart agriculture;
- more sustainable cities;
- more climate-resilient communities and ecosystems;
- fewer emissions from all sectors of our economy.

Evolving needs

The current portfolio of Copernicus covers seasonal as well as centennial time scales. However, the surveys of user needs and recent recommendations on European climate services[180] clearly indicate the need for information at decadal timescales to predict natural variability as well as human influences of the climate system so that planners and policy makers can take informed decision about future investment, resource allocation e.g. 20 years ahead. The resolution of existing climate reanalyses, projections and seasonal or decadal forecasts has to improve to fit regional scales to support national and local relevant actions to adaptation and mitigation strategies.

Copernicus could support the climate proofing of infrastructure, notably by providing data and climate projections for the climate vulnerability and risk assessment, as well as software tools for the related data analysis.

Access to spatial and topographic data in addition to climate data and projections could help for climate vulnerability and risk assessments.

[180] European Commission, Directorate-General for Research and Innovation, *A European research and innovation Roadmap for Climate Services*, ISBN 978-92-79-44342-8, doi: 10.2777/750202, 2015.
Marta Bruno Soares, Meghan Alexander, Suraje Dessai, *Sectoral use of climate information in Europe: A synoptic overview*, Climate Services, Elsevier, Volume 9, January 2018 available at https://doi.org/10.1016/j.cliser.2017.06.001.

The following needs have been identified specifically for the purposes of making available climate data to address resilience to climate change in the design and application of industry standards for infrastructures:

- gathering available data and developing robust and transparent reference datasets with similar formats;
- sharing these datasets with the different communities for testing implementation in practice, experimenting with these datasets for checking their relevance;
- sharing feedbacks from these test implementation, the coproduction/refinement of the datasets between scientists and engineers/standardization experts to enhance the robustness and transparency, and trust in the data;
- implementing communication and training to bridge the gap between the communities (scientists, engineers and other stakeholders) and cross training/education (scientists-engineers-standardization experts).

5.11.4. Climate science and International cooperation

State of play

Copernicus provides a significant contribution to the international reporting in terms of climate change by developing and operating the CMIP5 experimental protocol endorsed by the 12th Session of the World Climate Research Programme (WCRP) working group on coupled modelling. Copernicus publishes for the global climate observing system (GCOS) 30 of the 54 essential climate variables decided at international level.

For oceans, the *Ocean State Report*[181] (dealing with effects of climate on the oceans at global and regional scale, and analysis of trends) is published annually and data are available monthly as ocean monitoring indicators (e.g. ocean heat content, sea level trend, sea ice extent).

Copernicus also contributes to the CEOS/CGMS[182] working group for climate[183] and the development of the CEOS atmospheric composition virtual constellation to tackle observation of CO_2 emissions at global scale combining all available space capacities.

Policy context

As previously described, the EU contributes also to fighting climate change at global level based on international cooperation and contributing to several international major initiatives

181 European Commission, Mercator-Ocean International, Copernicus Marine Service Ocean State Report, Journal of Operational Oceanography, 11:sup1, S1-S142, DOI: 10.1080/1755876X.2018.1489208, 2018.

182 Committee on Earth Observation Satellites / Coordination group for Meteorological Satellites

183 Committee on Earth Observation Satellites, *Working group Climate,* information available at http://ceos.org/ourwork/workinggroups/climate/,
Committee on Earth Observation Satellites, *Atmospheric Composition,* information available at http://ceos.org/ourwork/virtual-constellations/acc/.

and programmes. These efforts contribute to stepping up international climate action before 2020 and towards the objectives of the Paris Agreement.

At the international level, the importance of high quality, reliable and timely climate services has been demonstrated by the establishment of the global framework for climate services (GFCS), a United Nations-led initiative instigated at the World Climate Conference[184]. In its high-level plan[185], a climate service is defined as 'climate information prepared and delivered to meet a user's needs and includes the timely production and delivery of science-based trustworthy climate data, information and knowledge to support policy and other decision-making processes'. Resolution 39 of seventeenth world meteorological congress (2015) recognised the 'fundamental importance of the global climate observing system (GCOS) to the global framework for climate services'.

User community

Reporting on Climate change at international level to support major political agendas like the Conference Of the Parties, is performed by research institutes, national meteorological and climate services organised in working groups and acting for the United Nations Framework Convention on Climate Change[186].

Evolving needs

At international level and with contribution of both European Commission and Member States, data and information have to be produced for:

- the International Panel for Climate Change reporting (IPCC) with latest reporting such as *The 2019 Refinement to the 2006 guidelines for national greenhouse gas inventories*[187], *The IPCC special report on global warming of 1.5 degrees*[188], and the three upcoming special reports that will focus on land, ocean and cryosphere (IPCC special reports on land, ocean and cryosphere to be issued in 2019);

- the World Climate Research Programme (WCRP) grand science challenges (with products related to cloud circulation, water cycle, cryosphere, ocean circulation, extreme events, and regional climate);

- the research and systematic observation (RSO) negotiations usually held twice a year under the Subsidiary Body for Scientific and Technological Advice[189] (SBSTA);

---

184 World Meteorological Organization, Global Framework for Climate Services, *World Climate Conference-3 (WCC-3),* information available at http://www.wmo.int/gfcs/wwc_3.

185 World Meteorological Organization, *Climate knowledge for action: a global framework for climate services – empowering the most vulnerable*. WMO-No. 1065, 2011.

186 https://unfccc.int/

187 The Intergovernmental Panel on Climate Change, *2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories*, IPCC, May 2019, see https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/.

188 https://www.ipcc.ch/sr15/

189 https://unfccc.int/process/bodies/subsidiary-bodies/sbsta

- the SBSTA 47 agenda item 8[190] or the state of the global climate of the World Meteorological Organisation (WMO);
- the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services[191] (IPBES).

The GCOS implementation plan updated with the 2016 GCOS-200 publication[192] drives the major needs for climate data at global scale and at European level to produce and maintain relevant climate data records and essential climate variables (ECVs).

The list of essential climate variables published by GCOS is significant. Copernicus produces 30. Some of them are not yet produced or need still significant research and validation to be released operationally and sustainably in time, such as e.g. carbon dioxide partial pressure, ocean acidity, permafrost, above-ground biomass or CO_2, CH_4, and O_3 column and profile measurements.

To produce the datasets for ECVs, the research community is a key player. They have specific needs to develop Earth system models that are representative of the effects observed at all scale, globally, at regional scale and eventually at national scale (to support climate policies). The development of global and regional models at various spatial and temporal resolutions describing the ocean, the atmosphere and the land are needed, partially similar to the ones needed for the sectors addressing the land environment or the ocean environment. Related to the atmosphere, the needs for information are partly addressed by the meteorology community. Nevertheless, some of the constituents of the atmosphere need to be further developed such as the aerosol optical depth (at multiple wavelengths for the aerosol size, aerosol composition, aerosol stratification and aerosol polarization and shape), cloud products or long-term aerosol chemical climatology.

Accurate representation of clouds in climate models is important to reduce the uncertainties in cloud calculations and the direct and indirect effect of clouds on climate projections, meteorological physics and dynamics and gas and aerosol chemistry. Needs from the European Space Agency Climate Modelling User Group[193] focus on horizontal and vertical resolution, temporal sampling (horizontal resolution 10 km, vertical resolution between 100 m – 500 m, observation cycle from 1 hour up to maximum 3 hours), and accuracy and errors of the products.

---

190 United Nations Framework Convention on Climate Change, World Meteorological Organization, *Subsidiary Body for Scientific and Technological Advice, Forty-seventh session, Bonn*, 6-15 November 2017, available at http://unfccc.int/resource/docs/2017/sbsta/eng/l21.pdf.

191 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, '*Global assessment report on biodiversity and ecosystem services',* IPBES secretariat, 6 May 2019 available at https://www.ipbes.net/global-assessment-report-biodiversity-ecosystem-services.

192 World Meteorological Organization, *GCOS, The Global Observing System for Climate: Implementation needs, GCOS-200*, 2016.

193 European Space Agency, *Climate Modelling User Group (CMUG)*.

5.12. Humanitarian aid and civil protection in Europe

5.12.1. Support to natural and man-made disasters

State of play

The warming trend in the global climate is causing more intense extreme weather events, such as floods, droughts or wildfires. Climate change predictions also foresee an increase in the frequency of the strongest tropical cyclones. Similar projections are made for flooding events. Overall, the warming trends become more tangible: Years 2015-2018 were the four warmest years in the global record. Both long-term empirical datasets and recent atypical disasters related to extreme weather events provide strong evidence that natural disasters will become if not more frequent, but definitely more damaging and unpredictable in the years and decades to come.

In this context, Copernicus operates a dedicated service to provide fast response to major disasters with two services: rapid mapping of the situation adapted to the type of disaster, in the following hours of occurrence, and recovery mapping after the event, to monitor in time how the situation is recovered by the local authorities and the population. The service can be activated worldwide by authorised public users in charge of crisis operations and is connected with the Emergency Response Coordination Centre from the Commission.

Policy context

The European Union has set up different mechanisms to help Member States to prevent, prepare and better fight against natural risks with the Council decision on emergency support[194], the EU civil protection mechanism updated in 2019[195], the humanitarian aid legislation and the creation of a dedicated corps[196] in 2014, the Floods Directive[197], the EU forest strategy (cf. 5.1.6), the EU action on water scarcity and droughts and the creation of the European drought observatory[198], the EU solidarity fund for major disasters, and the Commission action plan[199] on the Sendai framework for disaster risk reduction 2015-2030.

The Disaster Risk Management Knowledge Centre, launched in 2015, provides EU Member States and the disaster management community with an online repository of disaster related research results and access to a range of networks and partnerships.

---

194 Council Regulation (EU) 2016/369 of 15 March 2016 on the provision of emergency support within the Union OJ L 70, 16.3.2016.

195 Decision (EU) 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism, OJ L 77I, 20.3.2019, p. 1–15.

196 Regulation (EU) No 375/2014 of the European Parliament and of the Council of 3 April 2014 establishing the European Voluntary Humanitarian Aid Corps ('EU Aid Volunteers initiative'), OJ L 122, 24.4.2014, p. 1–17.

197 Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, OJ L 288, 6.11.2007, p. 27–34.

198 http://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000

199 Commission Staff Working Document Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030 a disaster risk-informed approach for all EU policies, SWD/2016/205 final/2.

In 2019, as a consequence of the increased impact of natural disasters in Europe and at global level, the Commission adopted a Decision[200] to increase the EU mandate in civil protection strengthening EU disaster management. This new legislative framework establishes an additional reserve of capacities (rescEU) including:

- firefighting planes and helicopters to be ready to help Member States when needed, i.e. to complement national capacities when overwhelmed;
- a stronger action in prevention and training[201] ;
- enhanced need for scientific knowledge related to disasters.

It is thus envisaged that the support from Copernicus will grow.

User community

Authorised users are the civil protection, local authorities and national administrations.

Evolving needs

While civil protection agencies and countries from the extended European region (participating states in the EU civil protection mechanism) and international agencies are first beneficiaries of Copernicus, the service could be further promoted through the Commission's disaster risk management knowledge centre, the Covenant of Mayors and UN resilient cities initiatives to better support local authorities to address disasters risk prevention and response more efficiently.

In addition to existing services, local, regional and national authorities in charge of land development need information for a more integrated management of risks addressing prevention, preparedness, operations and then recovery with a more holistic approach of disaster management. They also need for accessing information to simulate integrated climate change scenarios - both in prevention and recovery - to support decision-making and long-term planning.

Therefore, the product portfolio could include, per type of risks and causalities hazard:

- specific products such as impact map, heat map;
- specific products for risk prevention related to most frequent disasters such as exposure of built-up, critical infrastructure, basic European asset maps (BEAM) and mitigation infrastructure (green and grey infrastructure);

200 Decision (EU) 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism, OJ L 77I , 20.3.2019, p. 1–15.

201 European Commission, *Questions and answers – EU that protects: The EU's plan to strengthen civil protection has entered into force*, 21 May 2019, available at http://europa.eu/rapid/press-release_QANDA-19-2590_en.pdf.

- specific services for early warning like continuous monitoring of risk-prone areas with automated change detection mechanisms, up-to-date maps and digital elevation model, dynamic products (risk event timeline) allowing fast delivery of warnings and 24/7 monitoring.

About early warning and preparedness, Copernicus covers early warning systems for floods, fires and droughts. The users also need information for the management of additional types of disasters such as volcanic eruptions, storms and cyclones, earthquakes or subsidence in urban areas (linked to ground motion). Management of industrial risks could also be targeted with detection of possible pollutants in atmosphere (cf. 5.8), oil at sea (cf. 5.2.4) as necessary. When it comes to maritime disasters, the full portfolio of information, expertise on marine environmental information or ship-related information and actions tools could be activated to address the emergency in the most efficient manner. This could be done in coordination with services already entrusted with maritime safety (cf. 5.4.4 and 5.15.2).

The importance of having up-to-date and additional environmental information is also important to best anticipate and detect multiple types of natural risks such as total water storage, saturation, precipitation, runoff, weather conditions to anticipate floods. Short-term ground deformation, monitoring of soil surface emissivity and temperature, plume detection, chemical pollutant concentration in soil or atmosphere and SO_2 and CO_2 concentrations in the event of eruption can help detect precursor signs of volcanic activities and strength. Coastal ocean waves, winds and currents (cf. 5.2.1) can inform on storm surges and possible risk of coastal floods.

Access to several climate indicators (temperature increase, sea level rise, ice sheet melting, ocean warming) and climate indices (based on records of temperature, precipitation, drought event) could be more integrated. Coordination between climate and emergency or security services in particular could also provide an alternative source of information and help include a longer-term perspective in humanitarian aid and civil protection operations.

In terms of emergency and support to operations, civil protection need information as fast as possible and so Copernicus needs to improve the quality and timeliness of the information delivered in terms of geographical resolution (5 m and 1 m in urban areas) and fast response with:

- when possible, risk forecasts to anticipate the occurrence of risk to support preparedness and possibly pre-tasking of Earth observation mapping;

- early warning and 24/7 monitoring during crisis (e.g. fire outbreaks detection in less than 15 minutes/real-time);

- real-time observation of damages and extent and fastest delivery of relevant information benefiting from latest state of the art space technologies therefore;

- fast delivery of web services with crisis information layer processed by in less than one hour after satellite imagery;

- situation update, and delineation map delivered every few hours (e.g. every 4 hours in the event of flood);

- larger area coverage for floods and earthquake.

For improved quality and timeliness, the uptake of new sources of data including new technologies such as in-situ, drones, high-altitude platforms, social media and crowd sourcing, a better integration with services providing environmental information (e.g. ocean conditions, land use, hydrological forecasts, soil characteristics) and improved coordination with other international services using satellite data for emergency management[202] could be beneficial to users.

The capitalisation of the information ante and post risk could be made systematic as part of the recovery activities to support land use planning and better risk prevention at national or city scale.

5.12.2. Resilience to climate risks

State of play

Combined with climate projections and seasonal forecasts of the environmental parameters on land, air and sea, the use of the land product portfolio can support the development of land planning policies more resilient to risk.

The climate products are all global, some of the land products are global (some remain pan-European only) and can support international development related to disaster risk reduction.

Policy context

Building resilience is about helping communities withstand and recover from disasters, with the focus on tackling the root causes rather than dealing with the consequences. In April 2013, the Commission adopted an EU strategy[203] on adaptation to climate change that aims to ensure Member States are prepared for current and future climate impacts with three objectives:

- promoting action by Member States to adopt comprehensive adaptation strategies nationally and e.g. in cities, by launching a voluntary commitment based on the Covenant of Mayors initiative[204];

- promoting better informed decision developing the European climate adaptation platform[205] (Climate-ADAPT) as the one-stop shop for adaptation information in Europe;

---

202 Coordination with the International Charter 'Space and Major Disasters' and, with The United Nations Office for Outer Space Affairs (UNOOSA), Report *Satellite Aspect, Emergency Management Service*, 25/07/2017.

203 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions an EU Strategy on adaptation to climate change, COM/2013/0216 final.

204 Covenant of mayors for Climate and Energy, *Covenant initiative*, information available at https://www.covenantofmayors.eu/about/covenant-initiative/origins-and-development.html.

- promoting adaptation in key vulnerable sectors through agriculture, fisheries and cohesion policies and the use of insurances against disasters.

The 2014 Council conclusions on '*the post 2015 Hyogo Framework for Action: managing risks to achieve resilience*'[206], the related Commission Communication[207] at the world conference for disaster risk reduction stressed the need for a joint approach between adaptation and disaster risk reduction policies that can be applied at EU level.

User community

The beneficiaries of EU commitments in favour of disaster risk reduction are mostly developing countries to which the European Union can provide support for environmental development and mitigation of risks related to climate change. Actors are public at European level and international level with the potential support of consulting agencies, non-governmental organisations, foundations or the private sector to implement the recommended adaptation or mitigation measures.

Evolving needs

In this frame, and complementary to disaster prevention and early warning solutions already deployed worldwide, Copernicus could provide climate data records of relevance, climate projections, climate indicators and climate indices (based on records of extreme events) that could help developing prevention scenarios for decadal or centennial risks. This would help preparedness of the public actors (e.g. land planners, civil protection, mayors, water agencies, health sector) but also of the private sector involved (e.g. in networks and critical infrastructures, land management, public utilities operations, civil engineering or insurance). Climate resilient urban environments are aimed at increasing prevention towards the risks. Needs could be similar to what is needed at European level (cf. 5.11.2 and 5.11.3).

5.13. International development and cooperation

State of play

Copernicus already supports developing countries in cooperation with Commission services by providing regular land products on vegetation, cryosphere, water on pre-identified hotspots identified with the European public partners. An example of such cooperation is the GMES and Africa programme led by the Commission's Directorate-General for International Cooperation and Development. In addition, all global products on atmosphere, the marine environment (observation, forecasts, and climate records) and climate projections or seasonal forecasts can be used internationally.

---

205 European Commission, European Environment Agency, Climate Adapt, *Sharing adaptation information across Europe*, available at http://climate-adapt.eea.europa.eu/.

206 Council conclusions on the post 2015 Hyogo Framework for Action: Managing risks to achieve resilience, Justice and Home Affairs Council meeting, Luxembourg, 5 and 6 June 2014.

207 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions The post 2015 Hyogo Framework for Action: Managing risks to achieve resilience, COM/2014/0216 final.

Overall policy context

The Directorate-General for International Cooperation and Development is responsible for designing European international cooperation and development policy and delivering aid throughout the world to reduce poverty in the world, to provide for sustainable economic, social and environmental development and to promote democracy, the rule of law, good governance and the respect of human rights, notably through external aid.

The 2010 EU policy framework on food security[208] establishes food security, nutrition and sustainable agriculture firmly among the EU's key priorities for development cooperation in the years ahead. In 2011, the Commission set out a strategic EU approach to reducing poverty, including a more targeted and concentrated allocation of funding: *The agenda for change*[209].

Since the adoption of the 2030 agenda for sustainable development by the international, the Commission issued a Communication in 2016 for '*a new European Consensus on Development*[210] as a new common vision for development policy for the EU and its Member States where the planet, protecting the environment, managing natural resources and tackling climate change are main priorities. The new agenda outlines the EU's development framework, acknowledges that EU development policy should focus its support for inclusive and sustainable growth on sectors that have a strong multiplier impact on developing countries' economies. Agriculture is one such sector. Rural development and improved food and nutrition security contribute to poverty eradication, which remains the primary objective of development policy.

5.13.1. International cooperation with developing countries

Policy context

The Africa - EU Dialogue[211], the Pan-African Programme[212] and the African Peace Facility[213] are examples of major instruments for the implementation of the Joint Africa-EU Strategy[214]

---

208 Communication from the Commission to the Council and the European Parliament An EU policy framework to assist developing countries in addressing food security challenges SEC(2010)379, COM/2010/0127 final.

209 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Increasing the impact of EU Development Policy: an Agenda for Change* , COM/2011/637 final.

210 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Proposal for a new European Consensus on Development Our World, our Dignity, our Future*, COM/2016/740.
The new European Consensus on Development '*Our World, Our Dignity, Our Future*' joint statement by the Council and the representatives of the Governments of the Member States meeting within the Council, the European Parliament and the European Commission, June 2017.

211 https://ec.europa.eu/europeaid/regions/africa/continental-cooperation/africa-eu-dialogue_en

212 Commission Implementing Decision of 22.5.2018 adopting a Multiannual Indicative Programme for the Pan-African Programme for the period 2018-2020 to be financed from the general budget of the Union, C(2018) 3225 final.

213 https://ec.europa.eu/europeaid/regions/africa/continental-cooperation/african-peace-facility_en.

focusing on five key areas of cooperation between Africa and the EU: peace and security, democracy, good governance and human rights, human development, sustainable and inclusive development and growth, continental integration, global and crosscutting issues. In 2018, the Commission issued a Communication to further continue such investment and European assistance for sustainable investment and jobs[215].

Evolving needs

Sustainable economic development, environment development, protection of the population and food security are the main fields where Copernicus can contribute. The current Copernicus services could be continued and enlarged in the future with:

- monitoring of hotspots for economic and rural development and biodiversity conservation;
- a new food and water security service;
- information supporting national disaster risk reduction strategies and risk prevention (e.g. by building the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters);
- ad-hoc support to external action;
- relevant Earth Observation inputs to support the development on SDG indicators by third countries (cf. 5.13.4).

Developing countries are mainly interested in products that can help to improve land planning, land use cover and natural resources exploitation, regional development, fisheries management, agriculture and forest products, water management, access to energy as well as disaster risk prevention, management and response.

As an example, the African Union[216] has expressed interest in developing services related to coastal monitoring, maritime security, fisheries management, wetland and conventions monitoring, forest management, flood management, water services, agriculture and disaster management.

They need better resolution of land products: 300m resolution and even better for all global land products could be provided, instead of at 1km resolution. The concept of hotspot monitoring could be further continued possibly also provided as-a-software so that developing countries and possible facilitators (non-governmental organisations, downstream providers,

---

214 European Commission, African Union, *The Africa-EU Strategic Partnership - A Joint Africa-EU Strategy,* April 2006, information available at http://www.africa-eu-partnership.org/sites/default/files/documents/eas2007_joint_strategy_en.pdf.

215 Communication from the Commission to the European Parliament, the European Council and the Council *Communication on a new Africa – Europe Alliance for Sustainable Investment and Jobs: Taking our partnership for investment and jobs to the next level,* COM/2018/643 final.

216 GMES & Africa support programme under the Pan-African Programme | International .Cooperation and Development instrument.

and external action agencies) can produce and update Copernicus-like products on demand and independently.

In the frame of the Africa-EU Energy Partnership[217] (AEEP), the EU Energy Initiative Partnership (EUEI), the dialogue facility for the access to energy[218] and following resolution of the European parliament in 2016[219], Copernicus could propose products for the identification of access to energy like mapping of rural electrification, urban access and network infrastructure detection, renewable energy siting parameters, hydrological information (including long-term climate change scenarios) or land surface temperatures.

5.13.2. Rural development, Food and Water Security

Evolving needs

Agriculture is one sector having a strong multiplier impact on developing countries' economies. Rural development and improved food and nutrition security contribute to poverty eradication, which remains the primary objective of development policy under the European consensus for development.

In that context, Copernicus could provide policy relevant information in the following sectors:

- land use and rural development mapping in the field of agriculture, forest management, water management;
- early warning systems and prevention of food crises;
- land governance and tenure to understand land related dynamics, monitoring of large investments in remote areas, compliance to voluntary guidelines on the responsible governance of tenure[220] (VGGT);
- support to rural development;
- support to water resources monitoring;
- monitoring of water quality and occurrence;
- climate change and related shocks (droughts, floods, soil fertility changes that impact food availability);

---

217 https://www.africa-eu-partnership.org/en/projects/africa-eu-energy-partnership-aeep

218 Secretariat of the African, Caribbean and Pacific Group of States (ACP), European Commission, European Union Energy Initiative (EUEI), ACP-EU Energy Facility, *The ACP-EU Energy Facility Improving access to energy services for the poor in rural and peri-urban areas*, 2012, available at https://ec.europa.eu/europeaid/acp-eu-energy-facility-improving-access-energy-services-poor-rural-and-peri-urban-areas_en.

219 European Parliament resolution of 1 December 2016 on access to energy in developing countries (2016/2885(RSP)), OJ C 224, 27.6.2018, p. 167–172.

220 The VGGT were endorsed by the Committee on World Food Security (CFS) in 2012 and constitute today an internationally recognised reference for actions aiming to improve land governance, information available at http://www.fao.org/tenure/voluntary-guidelines/en/.

- support to disaster prevention (incl. natural disasters but also pest invasion);
- support to natural resources sustainable management (abundance, healthy ecosystems with less pollution, illegal logging, and protection of endangered species, sustainable energy and water);

In addition, evolutions expected in the field of agriculture as practised in Europe (cf. 5.1.5) could be particularly supportive of best practices for developing countries as long as they remain compatible to their soils and practices. The resolution and frequency of update could be adapted to developing countries scales.

Water products (water levels, water quality), are also important to support irrigation, access to water for cities and villages, share of water resources between countries in case of cross-border basins where hydropower infrastructures can possibly induce water risks and flood risks in adjacent countries, inland water navigation. For example, farmers and pastoralists need water short-term forecast of key parameters, as it can be very effective in reducing losses of cattle/crops.

The extension of the drought observatory operated for some EU countries to a global coverage for monitoring specific hotspot or countries could be relevant as long as it remains complementary or supportive to local, national or international drought observatory initiatives.

5.13.3. Humanitarian aid and emergency management beyond EU

State of play and beneficiaries

Emergency management as operated for the EU countries (cf. 5.12.1) is accessible at global scale to authorised users in the event of major disasters that request international assistance.

Policy context

The EU has consistently supported prevention and preparedness for crises in the most vulnerable countries, for example by identifying the need to integrate disaster risk reduction and adaptation to climate change into both development cooperation and humanitarian response.

In 2014, under the umbrella of the Hyogo framework for action endorsed by the United Nations General Assembly in the Resolution A/RES/60/195[221], the Commission Communication[222] setting '*the EU position on the post-Hyogo framework for disaster risk*

[221] United Nations, *International Strategy for Disaster Reduction,* General Assembly, Sixtieth session, Agenda item 52 (c), 05-49930, Resolution adopted by the General Assembly on 22 December 2005 [on the report of the Second Committee (A/60/488/Add.3)] 60/195, 2 March 2006, see https://undocs.org/A/RES/60/195.

[222] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions The post 2015 Hyogo Framework for Action: Managing risks to achieve resilience, COM/2014/0216 final.

reduction' strongly recommended a joint approach between climate change adaptation and disaster risk management in coherence with UNFCCC developments.

At international level, the European Union contributes to the international initiatives related to risk prevention and management under the Sendai Framework for Disaster Risk Reduction 2015-2030[223] that moves away from a disaster response culture towards comprehensive disaster risk management building on more prevention from disasters. This is a major shift, with responsibilities moving from the civil protection ministry to an all-government approach, with emphasis on long-term regional planning and investments.

User community

Beneficiaries are the same as in Europe: civil protections, operators on the field, local to national administrations from countries in distress. Copernicus is also collaborating with a wide range of international groups and activities such as:

- the international charter on space and major disasters[224];
- the International Working Group on Satellite-Based Emergency Mapping (IWG-SEM);
- the global partnership using space-based technology applications for disaster risk reduction (GP-STAR);
- numerous United Nations institutions, such as UNISDR, UN-OCHA, UNOSAT, UN-SPIDER ;
- the World Meteorological Organization or the World Food Program.

Copernicus is also part of the Group on Earth Observation and contributes to the global wildfire information system and the global drought information system from GEO Global initiatives and the Copernicus global flood awareness system is a GEO Community Activity.

Evolving needs

Beneficiaries need that Copernicus continues to serve these international initiatives and institutions. Copernicus could also support new initiatives such as the GEO Global Human Planet[225] and the Global Human Settlement Layer initiative[226] by providing reference products (e.g. CLC+) similar to the ones developed for emergency and crisis management within Europe.

---

223 The Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted by UN Member States on 18 March 2015 at the World Conference for Disaster Risk Reduction. The Sendai Framework is the first major agreement of the Post-2015 development agenda, with seven targets and four priorities for action. Information available at https://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf.

224 ttps://disasterscharter.org

225 GEO Global Human Planet Initiative, cooperation of scientists with strong implication of Directorate-General Joint Research Centre, information available at https://ghsl.jrc.ec.europa.eu/HPI.php.

226 https://ghsl.jrc.ec.europa.eu/

Emergency management at international scale could be maintained and benefit from the overall improvements planned for the European service (cf. 5.12.1) in terms of risk prevention mapping, timely disaster response and recovery mapping.

Services supporting the development of climate resilience policies and actions similar to the European example (cf. 5.12.2) could be provided in fragile states such as island states, developing countries affected by cyclones, sea level rise, major floods and desertification.

Additionally, Copernicus products and statistics of use could also support global reporting in terms of risks mitigation at global scales converting observed damages into Sendai-compliant loss indicators.

5.13.4. The Sustainable Development Goals

As different SDG indicator sets exist for SDG monitoring at global, regional and national level, it is important to distinguish between the contribution from Copernicus to the global SDG indicators and to the EU SDG indicator set.

State of play

- Member States and UN level

Copernicus provides core information that can be used to support the production of many SDGs indicators. A dedicated international and European workshop was held in 2019 to establish the contribution of Copernicus (cf. 7.2) to the SDG indicators framework. Copernicus information directly of use are all time series delivered to monitor the atmosphere and air quality, the ocean health, all climate records on the various components of land, air and seas, regular mapping of land use that give information of human settlements for example or sources of energy, water quality information.

- EU level

Copernicus services today provide data for indicators on ocean acidity (goal 14 'Life below water') and soil sealing (goal 15 'Life on land'). The latter is also used as a parameter in the model that produces the indicator on soil erosion by water (goal 15).

Policy context

- Member States and UN level

The 2030 agenda for sustainable development and its 17 sustainable development goals (SDGs), 169 associated targets adopted by the United Nations in September 2015, have given a new impetus to global and European efforts for achieving sustainable development.

In March 2016, the report of the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) to the United Nations Statistical Commission noted that the integration of statistical data and geo-spatial information would be key for the production of a number of indicators. As a means to address these issues, and to address specific areas relevant to SDG indicator

implementation, the IAEG-SDGs created a specific working group on geospatial information in 2016. Six European Member States and the Commission are members of this working group, co-chaired by Sweden, to integrate the use of space data in the development of SDG indicators and associated targets.

- EU level

Sustainable development objectives have been at the heart of European policy for a long-time, firmly anchored in the treaties[227] and mainstreamed in key crosscutting projects, sectoral policies and initiatives.

As a result, the EU, in coordination with its Member States, is committed to support the implementation of the 2030 Agenda as outlined in the 22 November 2016 Communication on '*Next steps for a sustainable European future - European action for sustainability*'[228] and in the 2019 reflection paper '*Towards a Sustainable Europe*'[229].

Eurostat is in charge to report on the progress of the EU towards the SDGs for all 17 SDGs. Eurostat, together with all Directorates General, has defined and now coordinates the publication of 100 EU SDG indicators[230] with a statistical assessment during the past five years ('short-term') and, whenever data availability allows, during the past 15 years ('long-term').

User community

Member States and UN level: Member States are required to produce and report data on global SDG indicators to the UN agencies.

EU level: Eurostat monitors the progress towards the SDGs in an EU context, based on the EU SDG indicators mentioned above which have strong links with key EU policies.

Evolving needs

- Member States and UN level

Copernicus could cooperate with the UN organisations responsible for the global indicators. At this stage, Copernicus can be a significant contributor to several global SDG indicators since it provides in Europe and over the globe regular information with sometimes decadal consistent time series of data, quality-controlled data. Copernicus could be considered a valuable source for measuring progress towards SDG2 (Zero hunger), SDG 3 (Good health and well-being), SDG6 (Clean water and sanitation), SDG 7 (Affordable and clean energy),

227 Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union, 2012/C 326/01.

228 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Next steps for a sustainable European future European action for sustainability*, COM/2016/0739 final.

229 https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf

230 Eurostat, *SDG indicators: goal by goal,* information available at http://ec.europa.eu/eurostat/web/sdi/indicators.

SDG9 (Industry innovation and infrastructure), SDG11 (Sustainable cities and communities), SDG13 (Climate action), SDG14 (Life below water) and SDG15 (Life on land). Examples of use have been published in 2018[231].

- EU level

To produce indicators, Eurostat needs timely and frequently produced data with long-time series to calculate trends and compare these against targets on an annual basis. Time series are expected to cover the two time scales of reporting: 5 years and 15 years and data should be comparable over these time spans in terms of methodology of production and quality control. Data have to be compatible to other sources of data from statistics provided by Eurostat or Member States. Quality assurance and documentation on products need to respect statistical quality principles and documentation practices including the management of classification errors of the original Copernicus raw data.

For the future, the EU indicator set could benefit from Copernicus data meeting statistical quality requirements to produce high quality and fit for purpose EU SDG indicators such as for goals 6 (Clean water and sanitations), 11 (Sustainable cities and communities), 14 (Life below water), and 15 (Life on land). Moreover, high-resolution geospatial information from Copernicus may contribute to the territorial disaggregation of EU SDG indicators where relevant.

In the future, Copernicus could be invited to prepare the ad-hoc data records to support the data reporting for both EU and UN SDG monitoring together with other Commission services and the EEA.

5.14. Migration and Home affairs

State of play

The Copernicus programme already runs some services related to policies under migration and home affairs, which are identifiable under ‘security services’.

Needs have been structured according to the current organisation of the Copernicus security service but it does not pre-empt any future possible organisation of this service. In recognition of the cross-service needs of law enforcement, needs of police forces are included in an additional dedicated section even though such services are not yet developed in particular in Copernicus.

User community

Security services are accessible only to authorised users in accordance with the Copernicus Regulation.

[231] Copernicus in support of Sustainable Development Goals, July 2018, available at https://www.copernicus.eu/sites/default/files/2018-10/Copernicus_SDG_Report_July2018pdf.pdf.

5.14.1. EU border surveillance

Policy context

Border surveillance is regulated through the EUROSUR Regulation[232] and the Regulation on the European Border and Coast Guard[233] that is under discussion for an amendment subject to a Proposal for the new European Border and Coast Guard Regulation[234].

User community

National and European coastguards and maritime authorities (depending on national organisation) are the beneficiaries of Copernicus data and information. Copernicus security services are fully integrated in the operations of the European Border and Coast Guard Agency. Copernicus services form part of the EUROSUR component on 'common application of surveillance tools' defined in Article 4 of the EUROSUR Regulation also named EUROSUR Fusion Services.

Evolving needs

With the evolution of the European coast guard function, Copernicus services could be further exploited. If the proposed regulation is adopted, it could generate more demand from the European Border and Coast Guard Agency in particular to support the operations of the standing corps of 10000 border guards envisaged by the proposed regulation.

The European Border and Coast Guard Agency should provide any national coordination centre, at its request or on its own initiative in particular for its own border operations, with information on the external borders of the requesting Member State and on the pre-frontier area. This could be derived from Copernicus information products and combined with other information sources. This includes information for:

- selective monitoring of designated third-country ports and coasts which have been identified through risk analysis and information, as being embarkation or transit points for vessels or other craft used for illegal immigration or cross-border crime;

- tracking of vessels or other craft over high seas that are suspected of, or have been identified as, being used for illegal immigration or cross-border crime;

---

232 Regulation (EU) No 1052/2013 of the European Parliament and of the Council of 22 October 2013 establishing the European Border Surveillance System (Eurosur), OJ L 295, 6.11.2013, p 11-26.

233 Regulation (EU) 2016/1624 of the European Parliament and of the Council of 14 September 2016 on the European Border and Coast Guard and amending Regulation (EU) 2016/399 of the European Parliament and of the Council and repealing Regulation (EC) No 863/2007 of the European Parliament and of the Council, Council Regulation (EC) No 2007/2004 and Council Decision 2005/267/EC, OJ L 251, 16.9.2016, p. 1–76.

234 Proposal for a regulation of the European Parliament and of the Council on the European Border and Coast Guard and repealing Council Joint Action n°98/700/JHA, Regulation (EU) n° 1052/2013 of the European Parliament and of the Council and Regulation (EU) n° 2016/1624 of the European Parliament and of the Council A contribution from the European Commission to the Leaders' meeting in Salzburg on 19-20 September 2018, COM/2018/631 final.

- monitoring of designated areas in the maritime domain in order to detect, identify and track vessels and other craft being used for, or suspected of being used for illegal immigration or cross-border crime;

- environmental assessment of designated areas in the maritime domain and at the external land border in order to optimise monitoring and patrolling activities;

- selective monitoring of designated pre-frontier areas at the external borders which have been identified through risk analysis and information, as being potential departure or transit areas for illegal immigration or cross-border crime.

EU Agencies and Member States always combine Copernicus information products with other information sources to build situational awareness and perform risk analysis. In order to deliver the EUROSUR fusion services, the agency could cooperate with other agencies and benefit from other services for maritime surveillance, support to external action or monitoring of environment that can be provided by existing Copernicus services and their possible evolution (cf. 5.15.2 and 5.2.1).

The main operational expectations from the users of the Copernicus border surveillance are:

- to increase the sources of data and have a guarantee of service;

- to increase the reactivity of the system: automation of ordering of several satellites over critical areas and/or during critical periods, priority of ordering ensured, increased revisit time of 2 hours with constellation of satellites and close to near real-time access to the relevant data;

- to increase the geographic coverage including in areas subject to issue of shutter control;

- to increase the content of the information possibly thanks to increased spatial and spectral resolution.

Whatever the information, users of security services will need that their mission order and delivery of Copernicus data and information products remain preserved when necessary. Copernicus will thus keep on complying with the security needs of EUROSUR (including on EU classified information 'Restreint UE' up to 'Confidential UE' in the future).

5.14.2. Police investigations

Policy context

The Commission and the EU law enforcement agencies, such as Europol, do not have autonomous investigative capabilities and are not in charge of operational law enforcement activities. This remains the responsibility of EU Member States.

Effective cooperation between the law enforcement authorities of EU Member States is required in order to prevent and combat cross-border serious crimes and terrorism in the EU and have traditionally been done on an ad-hoc basis, bilaterally or multilaterally.

The EU seeks to facilitate cooperation between Member States, with the aim to achieve a quicker, safer, and more structured cooperation. The Commission and the EU agencies contribute to the enhancement of law enforcement cooperation within the EU by proposing a common EU multi-annual strategic framework as outlined in the European agenda on security 2015-2020[235] by:

- improving information exchange[236] ;
- promoting operational cooperation through a proposal for new EU legislation[237] organising cross-border cooperation between EU Member States such as joint investigations against cross-border crime, joint-patrols, cross-border hot pursuits or surveillances;
- and through operational support to Member States provided by EU agencies Europol and the European Union Agency for Law Enforcement Training (CEPOL).

Evolving needs

Police investigations are characterised by cross-sectional needs for Earth Observation data. In addition to the applications for law enforcement listed already in the previous sections, Copernicus products can be used to support operational and investigative police tasks. Wherever the enforcement of treaties or legislation benefits from observable illicit activities, the information is relevant for police work and in the frame of EUROPOL operations.

Copernicus for example, provides products on land environment that could be used to prosecute a variety of criminal offences:

- drug-related crimes, such as cultivation and manufacturing of illicit drugs;
- environmental crime, such as illegal deforestation, mining activities, waste dumping or ivory poaching;

---

235 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions The European Agenda on Security, COM/2015/0185 final.

236 Communication from the Commission to the European Parliament, the European Council and the Council, Enhancing security in a world of mobility: improved information exchange in the fight against terrorism and stronger external borders, COM/2016/0602 final.

237 Proposal for a Council Decision on the position to be taken, on behalf of the European Union, in the 83rd Plenary Meeting of the Group of States against Corruption (GRECO) as regards the participation of the European Union as observer in GRECO, COM/2019/273.
Proposal for a Regulation of the European Parliament and of the Council on preventing the dissemination of terrorist content online. A contribution from the European Commission to the Leaders' meeting in Salzburg on 19-20 September 2018, COM/2018/640.
Proposal for a Regulation of the European Parliament and of the Council on establishing a framework for interoperability between EU information systems (borders and visa) and amending Council Decision 2004/512/EC, Regulation (EC) No 767/2008, Council Decision 2008/633/JHA, Regulation (EU) 2016/399 and Regulation (EU) 2017/2226, COM/2018/478.
Proposal for a Regulation of the European Parliament and of the Council on establishing a framework for interoperability between EU information systems (police and judicial cooperation, asylum and migration), COM/2018/480.

- related crimes, like smuggling;
- homicide;
- crimes against humanity;
- trafficking of human beings;
- violation of regulations on fishing or marine oil pollution;
- breaching of agreements for the preservation of cultural heritage sites.

Enforcing e.g. environmental compliance, which means 'stopping those who disregard the rules, sanctioning them and obliging them to rectify the damage' (cf. 5.6) can only be achieved via the means of constitutionally governed prosecution. In this case, the police inevitably act as executive authority.

Additionally, Earth Observation data is of interest for supporting international aspects of police work. Uses encompass personal protection of police officers and protected persons, international police missions and international police training assistance in under-governed territories.

Core needs for the development of tailored products for the police are spatial very high-resolution data, high temporal resolution and easy access to long-term data storage. Furthermore, IT-security aspects are key prerequisite to secure evidential value of Copernicus data and products. Protection of Copernicus infrastructure and data against attacks and permanent safety from data manipulation must be ensured at all times.

5.14.3. Critical infrastructures

Policy context

The European Programme for critical infrastructure protection (EPCIP)[238] together with the ECI European Critical Infrastructures Directive 2008/114/EC[239] on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, have the objective to improve the protection of critical infrastructures against all hazards with a particular focus on terrorism and risk assessments of those critical infrastructures.

238 Communication from the Commission on a European Programme for Critical Infrastructure Protection, COM/2006/786 final.

239 Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, OJ L 127, 16.5.2019, p. 34–79.

This programme has been reviewed in 2013 with a proposal for a new approach to protection[240]. It moved the centre of gravity from protection to resilience and to more practical measures at European, national and local levels.

Finally, the joint Communication on *'Countering Hybrid Threats'*[241] published in 2016 is inviting Member States, owners/operators to identity key vulnerabilities including specific hybrid related indicators that could affect either national or pan-European infrastructures. This could open a new window of opportunity for space-based information.

User community

The protection of critical infrastructures is by definition a national competence and in principle is in the core of national security. It concerns national and regional authorities in charge of territories hosting critical infrastructures but owners/operators of designated critical infrastructures to prepare their operator security plans (advanced business continuity plans) and appoint security liaison officers (linking the owner/operator with the national authority responsible for critical infrastructure protection). The community is exchanging through the European reference network for critical infrastructure protection (ERN-CIP) for capacity building, science and knowledge exchange.

Evolving needs

Copernicus data and information could serve the prevention and preparedness phases of the risk management process of critical infrastructures, although the crisis response phase should not be underestimated. If currently Copernicus covers already the monitoring of transport critical infrastructures, types of possible infrastructures to be monitored could be extended to energy, water, health, information and communication technologies networks, communications, etc. In addition to standard geospatially related information (topologies of assets), users need additional layers of metadata on the functional connections between infrastructures, if available.

They would also need Copernicus data and information products and maps to be continuously updated on a monthly basis for a predefined set of natural hazards and man-made threats that could occur and used for prevention and preparedness purposes. Due consideration should be given to consequences of climate change where relevant, including as regards the need to access climate data for the climate vulnerability and risk assessment of new and existing critical infrastructure.

Operational actors on the field need also high-resolution products for real- time monitoring and response involving crowded areas to obtain meaningful information and coordinate emergency response. High-spatial resolution could allow collecting information on the use of infrastructures during normal operating conditions but also during disruptive events.

---

240 Commission Staff Working Document, on a new approach to the European Programme for Critical Infrastructure Protection Making European Critical Infrastructures more secure, SWD/2013/318 final

241 Joint Communication to the European Parliament and the Council Joint Framework on countering hybrid threats a European Union response, JOIN/2016/018 final.

Higher frequency update of maps and products could also be necessary on a case-by-case basis to better understand of the dynamics during disruptive events and design in a more efficient manner preparedness and prevention measures as well as response interventions.

5.15. Security policies

State of play

The Copernicus programme currently supports the development of products and services in two areas related to the common foreign and security policy: maritime security, support to external action that can be also linked to Migration and Home Affairs needs (cf. 5.14) and services and serve similar activities. Copernicus data and information are integrated in services provided by the European Union Satellite Centre (SatCen) and the European Maritime Safety Agency (EMSA) on the basis of dedicated arrangements. The development of products is performed ad-hoc depending on the needs of agencies and evolution of their roles vis-a-vis the EU and the Member States.

5.15.1. Support to EU external action

Policy context

As a global actor, the EU has the responsibility to promote stable conditions for human and economic development, human rights, democracy and fundamental freedoms. In this context, a key objective of the EU is to assist third countries in crises or emerging crises and to prevent global and trans-regional threats having destabilising effects.

The need for such operations remain similar compared to the initial Copernicus security service started in 2016. Nevertheless, considering the evolving nature of these activities, Copernicus could adapt its response to the upcoming applicable policies, in particular those policies governing the EU External Action such as the EU global strategy for the European Union's foreign and security policy[242] issued in 2016, and deriving strategies, for instance in the field of connectivity[243].

User community

The communities that cooperate with the SatCen and use Copernicus data and information for security are mainly customs, law enforcement agencies to fight against illegal trafficking, crime and illicit crops. It can also be agencies in charge of narcotics, anti-fraud, etc.

Evolving needs

---

242 European Union, *European Union Global Strategy, Shared Vision, Common Action: A Stronger Europe, A Global Strategy for the European Union's Foreign And Security Policy*, June 2016, available at http://europa.eu/globalstrategy/en
European Commission, *Foreign affairs and security policy*, ISBN 978-92-79-83011-2, June 2018.

243 Joint Communication to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank *Connecting Europe and Asia - Building blocks for an EU Strategy*, JOIN(2018) 31 final.

Additionally to needs described in previous chapters related to development and cooperation, support to external action can take forms of support related to security that Copernicus could facilitate, such as monitoring of critical infrastructures (cf. 5.14.3), monitoring of areas under treaties (protected, legal crops), monitoring of illegal activities related to food and water security, support to humanitarian actions (cf. 5.13.3).

Similarly, to border surveillance, improvements are needed by the external action services and law enforcement authorities mainly in terms of adding flexibility to the existing Copernicus service, improving the content and the quality of the information provided.

Each actor (Member States civil security and defence users, military operations and civil missions for the common security and defence policy, EU security and defence agencies) need to order more ad-hoc information considering that crisis situations and, in a broader spectrum, EU external actions need tailored solutions due to their changing and evolving nature.

Therefore, accessing more sources of data to enrich its content, more fine-tuned product based on intelligence and analysis benefiting from big data and data analytics technologies could be of interest for external operations.

In the event of crisis, the users need to get data as fast as possible. Copernicus could improve in fast response, providing access to all possible information, space or non-space, immediately available at shortest delays including from non-space sensors like drones or high-altitude platforms, relayed efficiently when programmed through space capacities.

In routine mode, users need also systematic monitoring of areas of interest to detect breach to treaties or possible incidents. Wide area monitoring combined with machine learning techniques could speed up and allow systematic automated monitoring and analysis, allowing detecting activity and changes in infrastructures and generate possible semi-automated early warning.

The coverage of the data and information should remain global with access to very high-resolution imagery both night and day. Data and information could be delivered under secured infrastructures depending on the user beneficiary.

Users of the existing service need to have some products improved with higher resolution, automated change detection, use of both optical and synthetic aperture radar interferometry for activity analysis, road network status assessment, critical infrastructure analysis and conflict damage assessment.

Authorities ask to get in parallel of situational information, more environmental information such as land surface temperature, heat, soil characteristics and indirect indicators like building temperatures and water discharge temperature indicating the operational status of some industry. Environmental data on land use, land change, soil use and vegetation could be necessary to identify possible illegal activities like deforestation, illegal crops but also the health of legal crops to assess food security.

Automated monitoring and detection of changes including at very high-resolution (either along wide area or at focal points) could also be important to monitor and control critical infrastructures such as harbours, nuclear plants, pipelines and energy networks, in terms of status and possible vulnerability or local areas subject to important mass events (e.g. Olympic games).

5.15.2. Maritime Security

Policy context

Maritime security helps maintaining the rule of law in areas beyond national jurisdiction and protect the EU strategic maritime interests that include overall security and peace, rule of law and freedom of navigation, external border control, maritime infrastructures, common natural resources and environmental health and preparedness to climate change.

Adopted in 2014, the European Union Maritime Security Strategy (EUMSS) is implemented through the EUMMSS action plan revised in 2018 to contribute to the implementation of the EU global strategy for resilience[244], the renewed EU internal security strategy 2015-2020[245], the Council conclusions on global maritime security[246], and the joint Communication on '*International Ocean Governance*'[247].

While the strategy is global, it also addresses specificities at regional scale as regard to each of the European sea and subsea basins, namely the Baltic Sea, the Black Sea, the Mediterranean and the North Sea, as well as of the Arctic waters, the Atlantic Ocean and the outermost regions.

User community

The strategy principles to which Copernicus could contribute encourages a cross-sectoral approach between all partners from civilian and military authorities and actors:

- law enforcement, border control, customs and fisheries inspection, environmental authorities, maritime administration, research and innovation, navies or other maritime forces, coast guards, intelligence agencies;
- EU agencies;
- all relevant international partners and organisations, in particular the United Nations and the North Atlantic Treaty Organisation (NATO).

Evolving needs

244 Joint Communication to the European Parliament and the Council *A Strategic Approach to Resilience in the EU's external action* JOIN/2017/021 final.

245 Council Conclusions on the Renewed European Union Internal Security Strategy 2015-2020 9798/15, June 2015.

246 Council conclusions on Global Maritime Security, 10238/17, June 2017.

247 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *International ocean governance: an agenda for the future of our oceans*, JOIN/2016/049 final.

The strategy promotes enhanced common situational awareness and better sharing of information, operational concepts, *modi operandi* and experiences, considering not only the need to know but also the need to share. Access to timely and accurate information and intelligence is important for the sake of operations. The more information is aggregated and integrated, the more complete is the maritime picture created and more value is delivered to the operational end-users. In Europe, synergies could be found between Copernicus and CISE (common information sharing environment) for the delivery of Copernicus data and information products.

In terms of Copernicus contribution, maritime authorities, coastguards need the following improvements:

- improved detection for debris at sea, missing vessels, containers, contaminated and hazardous items, non-metallic targets (e.g. to monitor migrants route at sea);
- integration of space data with multiple sources of non-space data (e.g. vessel and voyage information, ship operators, shipping companies, intelligence, risk profiling) to improve the content of the information and better characterise suspicious behaviour, detection and monitoring of non-cooperative targets including in sensitive zones (possibly with high traffic) and at local scale like ports, critical infrastructures at sea and along coast;
- development of more activity-based intelligence like identification and monitoring of patterns of life, flagging of vessels based on behavioural analysis, machine learning techniques to extract information from massive data sets;
- full exploitation of environmental and ancillary information to characterise situation and support operations preparations;
- use of new very high-resolution sensors including non-space or video to extract information on dynamic processes and information at local scale with possible geo-location from messaging systems, radio-frequencies, data collection and telecom systems for faster interception;
- 24/7 service capability;
- better rapid mapping, fast identification and real-time services to anticipate and react to crisis with a worldwide coverage;
- more automated processes like automatic anomaly detection (automatic behaviour algorithms);
- systematic monitoring of areas of interest thanks to data analytics, machine learning, cloud computing to detect abnormal behaviours or possible incidents (e.g. wide area monitoring combined with machine learning techniques to speed up and allow systematic automated monitoring, allowing detecting activity and possible semi-automated early warning, automated analysis and monitoring of those areas);

- use of machine learning / deep learning algorithms to enable predictive analytics for vessel traffic and specific vessel behaviour.

For each of these, users ask for (ultra) fast response, reliable and secured information, global coverage of local high-resolution observations. Based on current achievements, the major need is in the scalability of the system and its capability to expand in terms of volume of data to increase the surveillance around the global with possibly prioritised areas, all coordinated into a shared capability supporting pre-defined agreements between operational public actors.

5.16. Research and Innovation

State of play

The Copernicus programme is already supporting a wide community of public and private research organisations directly contributing to the current European research agenda and preparing Horizon Europe. Copernicus is also a significant beneficiary of the research, innovation and competitiveness achieved by such European public and private actors.

Space data are considered as of strategic importance also opening business opportunities especially in combination with digital technologies and other sources of data.

Policy context

To prepare the ground for Horizon Europe and the new research agenda[248], the Directorate-General for Research and Innovation performed a synthesis of stakeholder priorities[249] as an input to Horizon Europe. Stakeholders expressed the need to improve synergies between the research and innovation programme and other EU programmes such as Copernicus.

The Commission proposal for Horizon Europe[250] identifies Climate Change and achieving the sustainable development goals as top priorities challenges on which the research community should work. The new research programme would be divided in 3 pillars, pillar II being the development of research to address 'global challenges together with industrial competitiveness'. Five clusters have been identified: health - inclusive and secure society - Digital and industry - climate, energy and mobility and - food and natural resources. Copernicus could contribute to all of these clusters as demonstrated in the past chapters.

---

248 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions *A renewed European Agenda for Research and Innovation - Europe's chance to shape its future*, COM/2018/306 final.

249 European Commission, Directorate-General for Research and Innovation, *Synthesis of stakeholder input for Horizon Europe*, ISBN: 978-92-79-93472-8, October 2018.
Commission Staff Working Document *Horizon Europe Stakeholder Consultation Synopsis Report*, SWD/2018/309 final.

250 Proposal for a Regulation of the European Parliament and of the Council establishing *Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination,* COM/2018/435 final,

Digitising Europe is also a high priority. A Communication on the European Commission digital strategy[251], '*A digitally transformed, user-focused and data-driven Commission'*, was published in November 2018. A proposal for the digital Europe programme[252] has been published to which Copernicus could contribute and benefit from with: future high performance computing (HPC), development of data spaces for artificial intelligence to stimulate the development of a data-driven AI economy, disposal of testing and experimentation facilities.

User community

The research community contributes significantly to the development of Copernicus but is also interested to use Earth Observation data to develop new areas of research in the non-space sector which is a priority identified in the space strategy[253]. The proposal for a new research agenda includes also cooperation with the international research community especially under the cluster 'global challenges'.

Evolving needs

Needs from the research community are tremendous. While their description might lead to an endless wish list, the priorities given by the research community and reported by the NextSpace study (cf. 7.2) includes:

- keep supporting an easy, full, free and open data policy benefiting from latest digital technology to enable data-driven research and innovation activities including in the frame of the European research infrastructures and the European open science cloud;
- comply to the new mission-oriented approach and the global challenges pillar organised per cluster, supporting the innovation and economic growth rate and direction, solving complex challenges through openness, collaboration and competitiveness, using dynamic co-investment along the entire innovation chain;
- support mission projects derived from the political agenda and implementation of European targeted missions, ambitious, cross-disciplinary, cross-sectoral and cross-actor, flexible, fostering bottom-up solutions and engaging with diverse national and regional stakeholders;
- provide for that future research activities better integrate space research with other policy areas addressing global and societal challenges, encouraging horizontal synergies and multidisciplinary approaches that allow the cross-fertilisation of ideas and spinning-in/off

[251] Communication to the Commission*, European Commission digital strategy, A digitally transformed, user-focused and data-driven Commission*, COM/2018/7118 final.

[252] Proposal for a Regulation of the European Parliament and of the Council establishing the Digital Europe programme for the period 2021-2027, COM/2018/434 final.

[253] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *Space Strategy for Europe*, COM/2016/0705 final

of space and non-space technologies, in collaboration with existing initiatives, such as the European technology platforms and joint technology initiatives;

- support activities that help to develop and implement policies for the relevant areas covered, at EU level as well as complementing policy approaches in the Member States and in particular with clusters of initiatives set up under pillar II to tackle the global challenges and industrial competitiveness, climate change, energy and mobility, food and natural resources (e.g. in particular environmental observation on land, sea and atmosphere);
- create the right ecosystem and a favourable environment for the private sector to develop innovative products and services supporting research close to the end-users and the market;
- facilitate the update and access to data and knowledge to facilitate the work of researchers;
- support also the European Union willingness to develop a stronger role at international level contributing with Copernicus data and information available at global scale, to international programmes and global societal challenges.

In the frame of the digital transformation, the Copernicus data and information products could support and benefit from the development of new digital technologies such as big data, data analytics latest technologies (deep learning, massive computing), key-enabling technologies, sensing technologies, new computing architectures, integration with the other space programs (Galileo, EGNOS, space situational awareness, secured satellite communications). Copernicus could cooperate to the development of advanced digital skills and the digital transformation through enhanced interoperability, deployment and use of digital capacities, contribution to the deployment of digital innovation hubs[254] part of the digitising European industry initiative ensuring all businesses, notably from small and medium enterprises, and the public sector to access to state-of-the-art digital technologies.

6. CROSS-CUTTING FUNCTIONAL NEEDS

State of play

Among the user needs collected, some were identified that are not linked to the content of the Copernicus data and information products or to policies implementation but concern the overall performances of Copernicus services. They are:

- cross-cutting needs relevant for several services;
- generic services that could be provided by the Copernicus system to enhance the overall quality and continuity of services of the programme;

254 https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs

- generic services that could support the creation of value based on Copernicus data and information products.

These needs apply to existing infrastructures operating the space segment, access to external sources of data (in-situ data, reference or contributing missions), infrastructures for the production and delivery of the Copernicus services, emerging infrastructures such as the data and information access service (DIAS) or possible new ones that could be needed for the evolution of the Copernicus programme including new satellites or services.

These needs have been recorded since their consideration could significantly improve the quality of service of the Copernicus programme to answer to user expectations and better implement policies. They are summarised below under a functional breakdown to remain independent of their future implementation by the programme.

Policy context

These needs are also particularly relevant to support the digital agenda of Europe expressed in two documents: the Communication on the European Commission digital strategy[255], '*A digitally transformed, user-focused and data-driven Commission'*, published in November 2018 and the proposal for the digital Europe programme[256].

6.1. Data acquisition

These needs address acquisition or access to all space-based and in-situ data (including reference data) and meta-data needed for the proper functioning of Copernicus whatever the source of data or product, the use, the service or the system component involved.

Access to quasi-real-time data functionalities has been identified already for the current emergency and security services to provide access to specific data to well-identified users in support of time-critical applications. This type of access could be available possibly to a limited user group only and should follow the delineation made under the current programme implementation, left to Member States prerogatives.

Additional needs are expressed for the evolution of the quality of service mainly related to the operations and performances of the current Copernicus land, emergency and security management service portfolio. More flexibility and predictability in the acquisition of the Copernicus satellite data is expected:

- the capability to provide data (and therefore to acquire data) in near-real-time (from 1 to 3 hours) even if it implies prioritizing the speed of Earth Observation data acquisition over image quality in some cases specifically for security;

---

255 Communication to the Commission*, European Commission digital strategy, A digitally transformed, user-focused and data-driven Commission*, COM/2018/7118 final.

256 Proposal for a Regulation of the European Parliament and of the Council establishing the Digital Europe programme for the period 2021-2027, COM/2018/434 final.

- improved coordination with user and national authorities for Earth Observation data acquisition and along the workflow of service operations;
- combining information from service forecasts and early warning (e.g. weather, flood, fire) to anticipate emergency procedures for imagery tasking;
- flexibility, automation or parallel activities in selecting and planning acquisition of data in case of rapid mapping;
- considering a super rush mode (e.g. less than 2 hours cut-off time) with the possibility to programme new acquisition of images at any site and time or to order an acquisition at a certain point in time in the future;
- access to compatible satellite imagery so that different satellite sources can be combined considering the quickest data available.

Related to the contributing missions, a guarantee of acquisition and access is expressed by the security users:

- access conditions to Copernicus contributing mission data should be more transparent in the future and access more user-friendly;
- certainty in data acquisition plans from third-party missions should be increased;
- combination with increased variety of data sources is also welcome including from in-situ, aerial or crowd-sourced data.

According to many Member States and the outcome of a workshop on in-situ data for Copernicus (cf. 7.2), acquiring more in-situ data is needed. The sustainability of in-situ measurements are mandatory for the validation of the satellite data, the production and/or the validation of the information products produced by services (through processing or modelling) like the production of ocean, flood and atmosphere forecasts and climate projections. The need for reference data has been also recalled many times by some member States of the Copernicus User Forum to ensure the validation of land products and their compatibility with national datasets.

Improved exchanges of data (space or in-situ) with the third countries in which we are in agreement could also be pursued to access more data for the purpose of better quality of services.

6.2. Data processing and quality control

Processing is the step transforming the data acquired through the data acquisition function into products suited for a further exploitation by intermediate or end-users.

- Processing

Needs related to processing are applicable in general to all ground segment or services processing/modelling facilities.

The need for an improved responsiveness between the data acquisition and the data delivery to the end-users – already mentioned in the *Data Acquisition* section –naturally impacts the *Data Processing* functions, as the processing of the data occurs in the middle of the production chain.

Users would like some improvements to take place regarding a new generation of processing capabilities that could foster the exploitation of Copernicus data and information products to create value without the burden of IT performances linked to big volumes of data and complex algorithms to run, improvements being:

- remote big data processing and cloud processing capabilities;
- possible on-board processing always with the objective to reduce final product delivery time;
- improved processing through generic and standardised algorithms proposed as toolboxes (as-a-software);
- automation of processing.

New concept of development and processing is also expected specially by Member States to support a better, faster and safer integration of Copernicus data and information products in the downstream applications at institutional level (national legacy systems) or by the private sector especially for local, national, regional or thematic specific developments (e.g. coastal developments, ground motion services).

Processing tools and environments could be welcome for co-creation and co-development between the Copernicus services and final or intermediate users that could be supported by the development of cloud-based infrastructures and specially the integration into geographical information systems environments. This could be accompanied by the necessary user support services.

The access to analysis-ready-data (ARD) is needed for the land services because it could simplify the ingestion of data into processing algorithms or geographical information systems and fasten the exploitation of information. In the security service, systematic automatic feature processing in rush mode is needed to fasten, operations and process more data.

The combination of many layers of data could enable to make more sense of the satellite measurements, allowing for better understanding of the changes observed.

The richness of information services is also addressed. Some users from the agriculture sector for example need to move from the delivery of information that describes environmental state to products than better describe trends and changes in the environmental situation.

- Quality assurance

Inherent to processing, the quality of the data and product content is also key (cf. 5.1.1, 5.1.5, 5.1.11, 5.2.1, 5.1.11, 5.11.4, 5.13.4 and 5.15.1). Quality control procedures are in place and reported in each of the Copernicus data and information services.

Some improvements are expected in the land domain to get consistent, well-calibrated and quality-documented products on which the industry can build. For example, further improvements in the quality documentation of statistics derived from Copernicus information is needed to avoid the bias introduced by simple pixel counting (cf. 5.13.4).

Concepts of quality indicators and quality controls could be generalised to all services and specially for forecast and projection products and be reported to the users, including possible quality confidence level registered in the meta-data of the product, jointly with quality reports established for each product type.

While some users would like to avoid data duplication some others need more concurrent reference/validation data to support accuracy assessment as well as more methods and model validation across sites, sensors and years.

In the climate, atmosphere and marine sectors, these areas need also usually pre-processing, assimilation, modelling and post-processing of data that are CPU and memory consuming calling for innovative data processing techniques. Routine, real-time and delayed validation and quality control mechanisms are inherent also to these technologies, including the characterisation of uncertainties and the definition of error confidence level indicators. Precedent concerns are thus common to all Copernicus services.

Whatever Copernicus data and information services, considering the changes in resolution and technologies used from one sentinel generation to the following, the processing capacities need to be developed with methodologies that ensure the continuity and the consistency of time series and products in time.

6.3. Data ordering and delivery

The Copernicus distribution services enable the distribution of all Copernicus data and information products and the Copernicus services catalogues.

To establish the Copernicus identity and provide for transparency to the Copernicus users, the following is needed to facilitate the user-friendliness of service portals and the uptake of services:

- ensuring commonalities between user interfaces to capitalise on user familiarity with any Copernicus distribution service;

- ensuring transparency to the user of the metadata-catalogue of Copernicus data and information and their access mechanisms;

- apply common open standards, in terms of catalogues, metadata, terminology, semantics and interoperability.

Catalogue with search and view, INSPIRE compliant promoting semantic search, download service functions, broadcast service functions are part of basic functions to be continued and enhanced benefiting from latest innovative digital technologies.

The following needs address specifically improved delivery of data and information products once they have been processed, to the users. They have been expressed specifically in the case of land, security and emergency data and information products:

- improve the overall data delivery time. This is strongly linked to needs for fast response specifically in case of emergency and crisis where all the production chain components should be improved to save time;

- improve accessibility as well as the delivery formats, with users asking for data in an appropriate and usable form or analysis-ready-data. Meanwhile such needs are not refined enough to ask for specific delivery technical mechanisms or formats;

- improve the way to order data (incl. for contributing missions), select data and information products before download to make it more user-friendly and efficient including a fast data ordering process in case of security (e.g. Copernicus security services should have a standard timeliness in the delivery). Standards could include: pre-defined templates for service ordering, a suite of product templates, a geodatabase of agreed features for inclusion in the map products, some pre-defined symbols to provide for consistency in the representation of the features, pre-defined QC checks to ensure consistency in both production and coordination tasks.

6.4. Data archiving

Access to archives from which users can select and order Copernicus data and information of any size and time period regardless of where and when the data and information were generated, is highly needed to create value by exploiting archives, to derive trends or exploit scenarios of change.

Archiving is indirectly needed since several services require access to long-time series in a consistent manner for modelling and change detection that requires the setting up of a strategy for archive management.

E.g., the security users as well as agriculture users responsible for the subsidies under the CAP would like to better exploit the value of long-term space data archives for pattern recognition or features automated detection and exploitation of big data technologies.

In particular in the context of transitioning the Copernicus data and information services to the cloud, the users need that data archives extending to several years are available as ‘hot‘ storage with data accessible in a matter of seconds to remain suitable of performances needed for large scale processing.

6.5. Discovery, interoperability and standards

Seamless discovery of relevant data and information products from data providers around the world is achieved through open standard and metadata. As interoperability is necessary for seamless information systems, so too are open standards necessary in order to achieve interoperability of information system implementations.

Organisations like the Open Geospatial Consortium[257], the World-Wide-Web Consortium[258] (W3C), the Internet Engineering Task Force[259], and others are open organisations in the sense that any individual or organisation can participate, the topics of debate are largely public, decisions are democratic (usually by consensus), and specifications are free and readily available. An 'open' process is necessary to arrive at an 'open' standard. These open standards enable easier access to and use of geospatial information and improved interoperability of geospatial technologies (across any device, platform, system, network, or enterprise) to meet the needs of the global community.

Data and information products or functionalities covered by Copernicus, including metadata content, could be compliant with the implementing rules and technical guidelines of the INSPIRE Directive. If conformance with technical guidelines is shown to be incompatible with the quality of the services/functionalities required, the data or information providers and relevant stakeholders (including the INSPIRE community) could come to an agreement of open standards or good implementation practices that can guarantee interoperability between the different services/platforms.

This would enable Copernicus data and information product compliant with INSPIRE to be discoverable by major open data portals like the European open data portal, the future European open science cloud or GEO portals.

Data and information products could be identified unequivocally, authenticated and checked in terms of integrity.

6.6. Integration

Seamless discovery, access and use of services is also expressed to improve the user friendliness of the services, asking that all services are integrated into a single framework or a set of tools so that users can access the content of Copernicus data and information whatever the service in charge of and how it is produced.

Integration of service's information products discovery and use is also encouraged by many users and Member States of the user Forum to avoid duplication between services and fragmentation of the offer. Integration of the portfolio could for example enable the access to the products per sectors of activities consistently or per type of user communities or geographical areas of interest.

---

257 http://www.opengeospatial.org/

258 https://www.w3.org/

259 https://www.ietf.org/

Application programming interfaces (APIs), open standards favouring the integration of Copernicus data and information products into user legacy systems could be pursued to favour user end-to-end decision support system, to be more effective.

Layers of data could be interchangeable in a reversible way without problems on the geolocation and consistent over time with archived datasets to ensure correct detection of changes.

6.7. User management

All users and Member States need user support functions. It supports Copernicus uptake to ease the transition to Copernicus in their practices and built-in environments and legacy systems. It should support the users in obtaining an appropriate usage of the desired data or information.

To improve, user support functions could include an alert system to inform users on the status of products and anomalies, a helpdesk, training and extensive documentation on the data or information technical specifications and usage.

Three specific needs have been expressed on top of existing support services proposed at each level: the Sentinels ground segments, the Copernicus services and the Copernicus user uptake program:

- to provide for a continuous consultation process to capture users' needs and improve continuously the quality of the service;
- to improve user portals to better guide the users in which product to access for which purpose;
- to maintain a users' network (with training, scientific seminars etc.).

7. ANNEXES

7.1. Annex A – definitions and glossary

Concepts and terms used in this document and needing a definition are included in the following table:

Table 7-1: Definitions

Concept/Term	Definition
End Users	Current and potential new users of the Copernicus Sentinels and in-situ data users, downstream companies using Copernicus data and information, direct users of the Copernicus services information.
User Communities	Copernicus services users federated either in networks or individually as institutions.
User Requirements UR	A requirement is a need expressed by users in either a specific thematic domain or cross-domain, to be met through space-based and/or in-situ measurements and/or Copernicus information service.
Observation Requirement OR	A requirement roughly corresponding to ESA L0, L1 and L2 products. These requirements refer to parameters/variables directly observable from space.
Service Specifications	These include items such as frequency of observation, service latency from image acquisition, advance image request, size of smallest item to be recognised, field usage scale of products, formats for ingestion in local devices, file storage, etc. Often, users need specialised help to determine such specifications.
Higher-level Product Requirement	A requirement corresponding to higher level (3-4) geophysical products. A product requirement specifies attributes (such as spatial resolution, temporal resolution, etc.) for a product.
Generic need	A generic need does not refer to any specific observation and/or any product requirement. For example, this definition includes data dissemination, content and time span of archives, access to data.
Copernicus Space Component	The Copernicus space component includes two types of satellite missions: ESA's families of dedicated Sentinels, and missions from other public or private institutions, called contributing missions.
Next Generation Copernicus Space	It refers to the second generation of the Copernicus space component after the Sentinels 1, 2, 3, 4, 5P, 5, 6 series A, B, C and

Concept/Term	Definition
Component	D.
Copernicus data	Observation product delivered by the Copernicus ground segment or by the ground segment of a Copernicus contributing mission, and related to a L0 to L2 level of product under CEOS classification.
Copernicus information	'High-level' product which has been produced and delivered by a Copernicus information service (land, climate, atmosphere, emergency, security, marine) and corresponds to a L3, L4 level of product under the CEOS classification or a product obtained from modelling techniques (reanalysis, forecast, projection).
Copernicus in-situ data	Data (from raw to L3) which has been collected by a non-space capacity (ground stations, buoys, aerial data, and drones).

Acronyms used in this document and needing a definition are included in the following table:

Table 7-2: Acronyms

Acronym	Definition
AEEP	Africa-EU Energy Partnership
AIDS	Acquired Immune Deficiency Syndrome
AIS	Automated Identification System
AMS	Area Monitoring System
API	Application Programming Interface
ARD	Analysis-Ready-Data
BEAM	Basic European Asset Maps
BEI	Baseline CO_2 Emission Inventory
BSO	Building Stock Observatory
C3S	Copernicus Climate Change Service
CAMS	Copernicus Atmosphere Monitoring Service
CAP	Common Agriculture Policy

Acronym	Definition
CCI	Climate Change Initiative from ESA
CCN	Contract Change Notice
CEF	Connecting Europe Facility
CEOS	Committee on Earth Observation Satellites
CEPOL	European Union Agency for Law Enforcement Training
CFS	Committee on World Food Security
CFSP	Common Foreign and Security Policy
CGBN	Group for Biodiversity and Nature
CGMS	Coordination group for Meteorological Satellites
CLC	CORINE Land Cover
CLMS	Copernicus Land Monitoring Service
CMEMS	Copernicus Marine Environment Monitoring Service
CMMI	Standard for Capability Maturity Model Integration
CMUG	Climate Modelling User Group (ESA CCI initiative)
COP	Conference Of the Parties
CP	Civil Protection
CSC	Copernicus Space Component
CSCDA	Copernicus Space Component Data Access
CSS	Copernicus Service Specifications
DA	Delegation Agreement
DCI	Development Cooperation Instrument (Directorate-General for International Cooperation and Development)
DEM	Digital Elevation Model
DEVCO	Directorate-General for International Cooperation and Development
DG	Directorate-General

Acronym	Definition
DIAS	Data and Information Access Service
DOORS	Dynamic Object-Oriented Requirements System
DR	Data Requirements
DRR	Disaster Risk Reduction
DTM	Digital terrain Model
EASO	European Asylum Support office
EBV	Essential Biophysical Variables
EBCGA	European Border and Coast Guard Agency
EC	European Commission
ECCP	European Climate Change Programme (Directorate-general for Climate Action)
ECHO	Directorate-General for Civil protection and Humanitarian aid Operations
ECI	European Critical Infrastructures
ECMWF	The European Centre for Medium-Range Weather Forecasts
ECSS	European Cooperation for Space Standardization
ECVs	Essential Climate Variables
EE	Entrusted Entity
EEA	European Environmental Agency
EEAS	European External Action Service
EEZ	Exclusive Economic Zone
EFCA	European Fisheries Control Agency
EFFAS	European Flood Forecast Awareness System
EFFIS	European Forest Fire Information System
EGNOS	European Geostationary Navigation Overlay Service

Acronym	Definition
EIA	Environmental Impact Assessment
EIONET	European Environment Information and Observation Network
EMS	Copernicus Emergency Management Service
EMSA	European Maritime Safety Agency
EO	Earth Observation
EOV	Essential Ocean Variable
EPCIP	European Programme for Critical Infrastructure Protection
EPRTR	European Pollutant Release and Transfer Register
ERCC	Emergency Response Coordination Centre
ERDF	European Regional Development Fund
ERN-CIP	European Reference Network for Critical Infrastructure Protection
ESA	European Space Agency
ESTAT	EuroSTAT
ETCs	Expert groups
ETS	EU Emissions Trading System
EU	European Union
EUEI	European Union Energy Initiative
EUMSS	European Union Maritime Security Strategy
EUROSUR	EUROpean border SURveillance system
FAO	Food and Agriculture Organisation of the United Nations
fAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FaST	Farms Sustainability Tool
fCOVER	Fraction of green vegetation COVER
FLEGT	Forest Law Enforcement, Governance and Trade Facility
FISE	Forest Information System for Europe

Acronym	Definition
GAEC	Good Agricultural and Environmental Condition
GCOS	Global Climate Observing System
GDIS	Global Drought Information System (from GEO)
GDP	Gross Domestic Product
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GFCS	Global Framework for Climate Services
GHG	GreenHouse Gas
GHSL	Global Human Settlement Layer initiative from JRC
GIS	Geographical Information System
GloFAS	Global Flood Awareness System
GMES	Global Monitoring for Environment and Security
GP-STAR	Global Partnership Using Space-based Technology Applications
GRECO	Group of States against Corruption
GROW	Directorate-General for GROWth, internal market, industry, entrepreneurship and SMEs
GSE	GMES Service Element
GSM	Global System for Mobile communications
GWIS	Global Wildfire Information System (from GEO)
HAPS	High Altitude Platform System
HAZMAT	HAZardous MATerials
HELM	Harmonised European Land Monitoring
High-resolution	Imagery with a spatial resolution of 1 to 5m, typically 2.5 m. Mainly used in mapping. No international standard definition exists. Not applicable to Earth system variables (as defined by GCOS).
HLPF	High Level Political Forum on Sustainable Development

Acronym	Definition
HREE	Heavy Rare Earth Elements
HNS	Hazardous and Noxious Substances
HPC	High-Performance Computing
HRLs	High Resolution Layers
IACS	Integrated Administrative and Control System
IAEG-SDGs	Inter-Agency and Expert Group on SDG Indicators
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	International Panel for Climate Change
IETF	Internet Engineering Task Force
IFAD	International Fund for Agricultural Development
INCA	Integrated system for Natural CApital and ecosystem services
ITS	Intelligent Transport Systems
IWG-SEM	International Working Group on Satellite Based Emergency Mapping
IUU	Illegal, Unreported and Unregulated
JRC	European Commission Directorate-General Joint Research Centre
KIP	Knowledge Innovation Project
LAI	Leaf Area index
LC/LU	Land Cover / Land Use
LPIS	Land Parcel Information System
Low resolution	Imagery with a spatial resolution above 50-100 m. Mainly used in mapping. No international standard definition exists. Not applicable to Earth system variables (as defined by GCOS).
LREE	Light Rare Earth Elements
LRIT	Long Range Identification and Tracking
LST	Land Surface Temperature

Acronym	Definition
LULUCF	Land Use, Land use Change and Forestry
MAES	Mapping and Assessment of Ecosystems and their Services
MARPOL	Marine Pollution (convention)
Medium resolution	Imagery with a spatial resolution between 5 and 30-50 m. Mainly used in mapping. No international standard definition exists. Not applicable to Earth system variables (as defined by GCOS)
MMU	Minimum Mapping Unit
MPA	Marine Protected Area
MRCC	Maritime Rescue Coordination Centre
MRD	Mission Requirements Document
MRV	Measuring, reporting and Verification (linked to Paris Agreement)
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
N/A	Not Applicable
NB	Nota Bene
NATO	North Atlantic Treaty Organisation
NDC	Nationally Determined Contribution (linked to Paris Agreement, anthropogenic CO_2 emission)
NDVI	Normalised Difference Vegetation Index
Next-Gen CSC	Next Generation Copernicus Space Component
NGO	Non-Governmental Organisation
NRCs	National Research Council's
NUTS	Nomenclature of Territorial Units for Statistics
OCHA	United Nations Office for Coordination of Humanitarian Affairs
OGC	Open Geospatial Consortium
PANAF	PAN-AFrican programme

Acronym	Definition
PESCO	Permanent Structure COoperation
PM	Particulate Matter
PMEF	Performance Monitoring and Evaluation Framework
PURE	Partnership for User Requirements Evaluation
QC	Quality Control
RD	Reference Document
REDD	Reducing Emissions from Deforestation and Forest Degradation (UN programme)
RF	Radio-Frequency
RFMO	Regional Fisheries Management Organisation
RIS	River Information Services
RPAS	Remote-Piloted Aircraft System
RSO	Regional Security Officer
RTD	Research technology and Development
S1	Sentinel 1
S2	Sentinel 2
S3	Sentinel 3
SAR	Synthetic Aperture Radar
SatCen	EU Satellite Centre
SBSTA	Subsidiary Body for Scientific and Technological Advice (climate, UN)
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SECAP	Sustainable Energy and Climate Action Plan
SFM	Sustainable Forest Management

Acronym	Definition
SME	Small and Medium Enterprise
SMR	Statutory Management Requirements
SOER	State Of Environment Report (published by European Environment Agency)
SOLAS	Safety Of Life At Sea
SST	Sea Surface Temperature
SW	Software
SWD	Staff Working Document
TBC	To Be Confirmed
TBD	To Be Defined
TFEU	Treaty on the Functioning of the European Union
TS	Technical Specifications
UAV	Unmanned Aerial Vehicle
UN	United Nations
Ultra High-resolution	Imagery with a spatial resolution of less than 50 cm, typically 20 cm. Mainly used in mapping. No international standard definition exists. Not applicable to Earth system variables (as defined by GCOS).
UN-OCHA	United Nations office for the coordination of Humanitarian Affairs
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
UNISDR	United Nations Office for Disaster Risk reduction
UNGA	United Nations General Assembly
UNITAR	United Nations Institute for Training and Research

Acronym	Definition
UNOOSA	United Nations Office for Outer Space Affairs
UNOSAT	UNITAR's Operational Satellite Applications Programme
UR	User Requirements
URD	User Requirements Definition
Very High-resolution	Imagery with a spatial resolution from 1 m to a few decimetres. Mainly used in mapping. No international standard definition exists. Not applicable to Earth system variables (as defined by GCOS).
VGGT	Voluntary Guidelines on the responsible Governance of Tenure of land, fisheries and forests, committee on World Food Security
VMS	Vessel Monitoring System
VOC	Volatile Organic Compounds
W3C	World-Wide-Web Consortium
W/S	Workshop
WCRP	World Climate Research Programme
WFD	Water Framework Directive
WFP	World Food Programme
WHO	World Health Organisation
WISE	Water Information System
WMO	World Meteorological Organisation
WWW	World Wide Web

7.2. Annex B: Sources

The user needs expressed so far have been collected and analysed from different sources that include:

- dedicated studies conducted from 2015 to 2018, under framework service contract 386/PP/2014/FC and referred as 'NextSpace'*;*
- the requirements expressed by users during task forces and expert groups[260] led jointly by the Commission and the European Space Agency to specify the scope and purpose of possible Sentinel expansion missions related to:
    - the surveillance of the polar zones with a focus over the Arctic area[261];
    - the monitoring of anthropogenic sources of CO_2[262];
    - the improved monitoring of water for agriculture with a land surface temperature mission;
    - the assessment of opportunity for a hyperspectral mission[263];
- the review of the rapid mapping component of the emergency service focusing on timeliness of satellite data provision[264];
- the concept note '*Towards future Copernicus service components in support to agriculture'*[265] published in 2016 by Directorate-General Joint Research Centre;
- the outcomes of several users' requirement workshops and industry workshops organised from 2016 to 2018 on various thematic[266] areas (cf. 7.2);
- the 2018 study *'Copernicus services in support to Cultural heritage'* under framework service contract 341/PP/2013/FC, ISBN 978-92-76-01370-9;

---

260 List and reports of task forces available on http://copernicus.eu/library under « study reports » folder.

261 *User Requirements for a Copernicus Polar Mission - Phase 1 Report*, ISBN 978-92-79-80961-3, doi:10.2760/22832, JRC111067, EUR, Publications Office of the European Union, 29144 Luxembourg, 2018,

- *User Requirements for a Copernicus Polar Mission - Phase 2 Report*, , ISBN 978-92-79-80960-6, doi: 10.2760/44170, EUR, Publications Office of 29144 Menthe European Union, Luxembourg, 2018JRC111068.

262 copernicus.eu/sites/default/files/library/Report_Copernicus_CO2_Monitoring_TaskForce_Nov2017.pdf, http://copernicus.eu/sites/default/files/library/CO2_Report_22Oct2015.pdf

263 OHB consortium, *User Requirements Document for a Future Operational Hyper spectral Mission,* HYP-SYS-GAF-RQ-0001, issue 2,
Survey on current hyperspectral applications and identification of novel applications, e-GEOS-HYP-TN-0006_Survey_Hyperspectral_Applications_i1r4.pdf, *Consolidation of user requirements and derivation of product/service requirements and high level observational requirements*, e-GEOS-HYP-TN-0008_Consolidation_User_Requirements_i1r2.pdfs.

264 Directorate-General Joint Research Centre, Emergency Management Service, *Satellite aspect, Review of the Rapid Mapping Component focusing on timeliness of satellite data provision*, 25 July 2017.

265 http://copernicus.eu/sites/default/files/library/AGRI_Conceptnote.pdf

266 List and reports of workshops available on http://copernicus.eu/events.

- the Joint Research Centre study *Copernicus4EC* on the use of Earth Observation geospatial data for policy development and implementation[267];

- *'Detailed user requirements on the use of Copernicus to support Agriculture'*, Note to the file - ARES grow.ddg3.i.2(2019)1906959;

- report of the expert group on the *'Future of the Copernicus Security Service'*, November 2017[268];

- recommendations from the Directorate-General for Environment workshop held 04 April 2019, *'Fostering the Uptake of COPERNICUS as a source of Geospatial Intelligence for Environmental Compliance Assurance, ECA'*[269],

- *'The ever growing use of Copernicus across Europe's Regions – A selection of 99 user stories by local and regional authorities'*, from NEREUS/ESA/GROW (2018)[270].

The following workshops have been organised in the last two years to support the collection of needs:

Workshop title	Date
Climate Change User Requirements	11/03/2016
Polar regions User Requirements	23/06/2016
Land User Requirements	30/06/2016
Raw Materials User Requirements	05/09/2016
Coastal Expert workshop	13-14/12/2016
User Workshop - Copernicus Security - SEA and other applications relevant to EEAS	05/04/2017
Cultural Heritage	24/04/2017

267 Directorate-General Joint Research Centre, Kucera, J., Janssens-Maenhout, G., Brink, A., Greidanus, H., Roggeri, P., Strobl, P.,–Tartaglia, G., Belward A. (ed.), *Copernicus Uptake in the European Commission*, JRC report 115133, 2019, with public summary in finalisation. The study focuses on consultations made with policy Directorate-Generals for their knowledge, interest and use of Earth Observation and Copernicus, and review of JRC activities or research projects in relation to, from their internal knowledge database. Activities from Directorate-Generals performed by additional contractors or European Agencies (e.g. EEA, EMSA), additional FP7 and H2020 research projects have not been comprehensively analysed.

268 Lucio Bianchi, João Borges de Sousa, Antonio Ciccolella, Denis Moura, Richard Olsen, Gunter Schreier, *Report of the Expert Group on the future of the Copernicus Security Service, strengthening European capabilities & autonomy*, Version 2, November 2017 (restricted access).

269 https://circabc.europa.eu/ui/group/cafdbfbb-a3b9-42d8-b3c9-05e8f2c6a6fe/library/8563b994-f531-4e52-a0da-491b12f4861f?p=1&n=10&sort=modified_DESC

270 https://www.copernicus.eu/sites/default/files/PUBLICATION_Copernicus4regions_2018.pdf

Workshop title	Date
Coastal Zone Monitoring	29/06/2017
Copernicus EMS Mapping User workshop	20-21/07/2017
Using the Copernicus marine data stream for ocean applications - Europe	21/08/2017
Copernicus marine week	25/09/2017
Copernicus4Energy	12/10/2017
CLC+ workshop on technical specifications	16/11/2017
User Uptake Workshop: Earth Observation for Inland and Transitional Water Quality and Aquatic Vegetation Monitoring	16-17/11/2017
Agriculture	05/02/2018
Copernicus in situ component evolution	20/06/2018
Drones	13/09/2018
Copernicus4regions success stories from local and regional authorities using Copernicus	26/09/2018
Fisheries User Requirements	02/10/2018
Copernicus land monitoring service, pan-EU component, opportunities and challenges	8-9/10/2018
Copernicus Global Land User conference	23-24/10/2018
Polar user workshop	07/11/2018
Smart cities User Requirements	09/11/2018
Copernicus for future cities	09/11/2018
Copernicus for raw materials: making the potential fully operational	12/11/2018
Copernicus4regions	22/11/2018
SEA user workshop: the Copernicus security service for Member States and the European Union	11/12/2018
Copernicus' support to sustainable development goals and International Agreements' Industry workshop	21/01/2019
Copernicus Data Access	02/04/2019

Workshop title	Date
CMEMS champion user group, CMEMS general assembly	24/05/2019
User Uptake	19/06/2019

7.3. Annex C: Descriptors of the User Requirement database

The content of the database is available on:

https://www.copernicus.eu/en/documentation/technical-documents/technical-documents
'*Work performed by the NextSpace consortium - Full User Requirements (May 2019)'*

This file contains the full description of the user requirements collected from project kick off up to May 2019. They contain needs from DGs, public administrations such as core users and research, education, international players and downstream sector. This file only includes needs that can be converted into product requirements or observation requirements, not filtered nor prioritised. Performances presented are related to the final Copernicus product delivered to the user.

NOTA BENE attached to the database contents and files:

- needs and their expected performances have been recorded without restriction and include all kind of expectations from a user perspective without taking any hypothesis on how, if and by whom such needs might be fulfilled in the future;
- they mainly address expectations for improvements of existing services and new needs. All requirements that led to the current implementation of the Copernicus services have also been exhaustively tracked back from the origin of GMES;
- the need gathering exercise is a continuous process that cannot reflect any comprehensive analysis of each market sector, policy sector or GEOSS societal benefit areas;
- the content is based on the work performed by a contractor and do not represent the Commission or entrusted entities position nor bind the Commission for any Copernicus scenario, or full/partial implementation in the future.

Table 7-3 Definitions of terms in the user requirements database and in the Observation requirement database

Term	Definition
Accuracy for the OR	Closeness of a measurement to the actual quantity being measured (Space agencies ECSS standard).

Term	Definition
Archive length / duration	Length of the time series (time interval) to be recorded for a given product in the archive. Can also be called archive duration (time interval for which the measurements are available continuously or discontinuously).
Copernicus product	A product corresponds to a bio-geo chemical or physical variable usually produced through higher level of processing or modelling (L4 mostly, L3 in some cases, output of assimilation/modelling). Product requirements correspond to the outputs of Copernicus services, but not only. They may also refer to products offered by the downstream sector and other actors.
Horizontal coverage	Geographical horizontal extent of the required product/service. E.g. local, regional, national, continental, global (or 180°W – 180°E).
Horizontal resolution	Horizontal resolution is defined as the minimum spatial resolution of an image (pixel size of an image representing the size of the surface area being measured on the ground) or in the case of a gridded product produced by modelling/interpolation techniques the minimum horizontal distance between two points of the grid.
Latency	Time difference between the satellite measurement and the moment the final product is made available to users. Also called timeliness in different studies.
Minimum mapping unit	The MMU is the area of the smallest unit that needs to be identified and mapped. Polygons below this MMU can be disregarded. This field does not apply to non-areal products (e.g. point data).
Observation requirement (variable, parameter)	Definition adopted for the purpose of Copernicus studies and not to prevent from technical solutions and remote sensing technology: An observation corresponds mostly to CEOS L0, L1 and L2 products. In the case of L2 product, these requirements refer to a biogeochemical or geophysical parameter or variable that can be observable from space. It does not mean that there is a strict matching between the physical measurement made by the space instrument and this variable processed at L2 level.

Term	Definition
Stability	Variation over a defined time period during which the gyro channel is continuously submitted to specific operating conditions (ECSS).
Tasking time	Time passed between the data order and the satellite observation. Also named lead-time is other studies.
Temporal coverage	Time difference between the first and last element in a data set / time series of a particular product or bio-geo-chemical or physical variable. Also named range in other studies.
Temporal resolution (Lead time)	Amount of time (e.g. hours, days) that passes between data collection periods for a given surface location. Time elapsed between observations of the same point or between individual elements within a model. Applicable for: - space-based observations; - models (analysis, forecast, reanalysis, modelling).
Thematic resolution (range)	Number of classes in a thematic classification. It informs about how much thematic detail the user requires.
Update frequency (interval)	Time difference between the recurrent provisions of the product or dataset to the user. Applicable for: - gridded observations; - thematic image interpretation; - models (analysis, forecast, reanalysis, modelling). Also named update interval in other studies.
Ur-id	Identification number in the NextSpace DOORS internal database.
User requirement description	A User requirement is a need expressed by users in either a specific thematic domain or cross-domain. This requirement has been recorded as expressed. It can be highly technically detailed, correspond to a specific observation need, product need, service need or be generic. More than 4500 individual requirements have been recorded. Those that are similar have been grouped. The database result of the consolidation of all individual user requirements is called the 'reduced database'. Each consolidated user requirement from this base is called a 'parent user requirement'.
Vertical coverage	Vertical coverage for an observation in the air or in the ocean

Term	Definition
	(min and max).
Vertical resolution	Vertical resolution is defined as the minimum distance between two vertical spatial measurements or in the case of a gridded product produced by modelling/interpolation techniques as the minimum distance between two vertical layers of the product.

CLOSEST EXISTING COPERNICUS DOMAIN
List of existing Copernicus services domains
Land monitoring service
Atmosphere monitoring service
Marine environment monitoring service
Climate change service
Emergency management service
Services for security applications
NO SERVICE - this requirement cannot be linked to an existing service
CROSS SERVICE - this requirement can be fulfilled by several existing Copernicus services

GEOSS -SOCIETAL BENEFIT AREAS
Disaster resilience
Public health surveillance
Energy and mineral resource management
Water resources management
Sustainable urban development
Infrastructure and transportation management
Food security and sustainable agriculture

GEOSS -SOCIETAL BENEFIT AREAS
Biodiversity and ecosystem sustainability

BENEFICIARY USER AREA
This taxonomy is based on market segments usually used for Copernicus market reports and proposed by the EARSC taxonomy
Agriculture
Forestry
Fisheries
Oil and gas
Alternative energy
Minerals and mining
Utilities (water, electricity, waste)
Construction
Transportation
Maritime
Communications
Insurance and finance
Real-estate management
Retail and geo-marketing
News and media
Travel tourism and leisure
Public local and regional planners
Emergency services
Education, training and research
Security, defence and military

BENEFICIARY USER AREA
International bodies - environmental, pollution and climate
International bodies - humanitarian operations and health