Summary note – June 2024

The European Commission Knowledge Centre on Earth Observation (KCEO) serves as a pivotal hub for maximizing the uptake of Earth Observation (EO) products and services, to bolster EU Policies across diverse sectors. At the heart of its mission, the KCEO employs Deep Dive (DD) assessments to scrutinize EU policy requirements within specific domains, evaluate existing EO offerings, identify potential gaps, and provide recommendations for the future trajectory of the Copernicus and Research Programmes (Camia et al., 2023). The ongoing third DD initiative is dedicated to assessing the role of EO in Compliance Assurance (CA), a domain of critical significance given the EC's central role in overseeing and enforcing EU laws[1].

Earth Observation (EO) data[2] plays a crucial role in the components of CA by offering a comprehensive and objective view of our planet and its dynamic changes. (i) EO supports promotion by providing free-and-open data, fostering awareness and transparency, and educating stakeholders about the environmental impact of their activities through visual insights. (ii) With its extensive coverage, EO enables broad-scale surveillance for detecting and monitoring areas at risk of non-compliance, ensuring prompt detection of any deviations. (iii) In case of emergencies or sudden events, EO provides a rapid response, allowing authorities to react quickly and providing essential evidence for legal interventions and enforcement.

In the DD assessment on CA, we are considering two levels of assessment:

[1] Treaty on the Functioning of the European Union (TFEU)

[2] Earth observation data refers to information collected about the Earth's surface and atmosphere using various technologies and instruments, typically from remote sensing platforms such as satellites, aircraft, drones, or ground-based sensors.

(i) State-of-the-art assessment: we evaluate the status, advancements and capabilities of EO for various policy areas where EO has previously been used or is sufficiently mature for compliance monitoring at the Member State (MS) or EC level.
(ii) Case-by-case assessments: through collaborative efforts with four policy Directorates-General (DGs), we have identified specific policy areas and legislations where EO can enhance or has the potential to support compliance efforts. For these targeted areas, we are undertaking fitness-for-purpose analyses.
At the end of both assessments, we will provide recommendations on how EO can effectively facilitate compliance assurance activities, and we will discuss some cross-cutting topics, including assessing data accuracy and veracity, traceability and reproducibility of methods, as well as the legal constraints related to the admissibility of the data in court proceedings.

STATE-OF-THE-ART ASSESSMENT

We are examining the existing maturity level, recent developments and potential of EO across various policy domains such as the Common Agricultural Policy (CAP), environmental and forest monitoring, marine surveillance and security, national greenhouse gas (GHG) inventories, and air quality monitoring.

Within the **Common Agricultural Policy (CAP)**, the Integrated Administration and Control System (IACS) plays a pivotal role, encompassing a comprehensive system of controls and administrative procedures to ensure the appropriate utilization of EU agricultural funds (some 50 billion/year). Since decades now, EO offers substantial solutions for the management of areas eligible for payment and the verification of area-based subsidies. As a result, in recent years, nearly 80% of all farm checks in the EU used EO. In 2023, the CAP has underwent a substantial reform, with a strong emphasis on results and performance to support the transition towards sustainable agriculture and forestry in the EU. In that new frame, EO through Copernicus satellite images is an essential component of the EU wall-to-wall monitoring system of land and activities defined in the national CAP Strategic Plans[3] and managed by Paying Agencies.

EO is essential in **environmental and forest monitoring**. EO-based monitoring systems are needed in the context of Natura2000 (N2K) and the implementation of key Directives such as Birds and Habitats[4,5], the Marine Strategy Framework Directive (MSFD)[6], and the Action Plan dedicated to protecting and restoring marine ecosystems for sustainable and resilient fisheries (European Commission, 2021). Copernicus Land Monitoring Service (CLMS) products were not

[3] REGULATION (EU) 2021/2116
[4] DIRECTIVE 2009/147/EC
[5] DIRECTIVE 92/43/EEC
[6] DIRECTIVE 2008/56/EC

designed to support CA. However, when the Commission receives complaints about the deterioration of protected habitats, it increasingly uses EO[7] to assess the validity complaints, to gauge risks to compliance, and to inform subsequent enforcement interventions. The Copernicus Emergency Management Service (CEMS) has contributed to the investigative process. The upcoming land cover and forest maps of CLMS will also support forest monitoring and compliance with related regulations[8,9,10].

The European Fisheries Control Agency (EFCA), the European Maritime Safety Agency (EMSA) and the European Environment Agency (EEA) have a key role in **Marine surveillance** to ensure compliance with the objectives of the MSFD to achieve good environmental status of European marine waters. EFCA organizes coordination and cooperation between national control and inspection activities so that the rules of the Common Fisheries Policy (CFP) are respected and applied effectively. In particular, the Vessel Monitoring System (VMS) is EO-based monitoring system which regularly provides data to the fisheries authorities on the location, course and speed of vessels and identifies possible illegal activities. Beyond fisheries, the Ship Recycling Regulation[11] is also crucial to prevent, reduce and minimize adverse effects on human health and the environment associated with ship recycling. To those ends, the Maritime Surveillance Service (CMS), entrusted to EMSA as one of the three Copernicus Security Services (CSS), provides key information based on EO, correlated with vessel traffic data. Information is available to authorities for all MS and is relevant also to environmental compliance: Examples include the illegal dismantling of ships violating EU directive, e.g. EU Ship Recycling (SRR) and EU Waste Shipment (WSR). CMS and EMSA also support EFCA and MS on countering illegal and unregulated fisheries, as well as clean and safe navigation at sea or combating marine pollution, through CleanSeaNet, which allows detecting oil spills and facilitating swift responses to marine pollution.

In terms of **Security**, EO aids in monitoring and securing EU borders, primarily through the Copernicus Border Surveillance Service (CBS) entrusted to FRONTEX as a second component of the CSS, ensuring compliance with security and immigration regulations. Additionally, EU Satellite Centre (SatCen) provides fast and reliable analysis of satellite data to face current security challenges and supports EU decision-making and action in the context of Europe's Common Foreign and Security Policy. SatCen is also entrusted with the implementation of the third component of the CSS, Support to EU External and Security actions (SESA) service, and environmental compliance over land is in part of portfolio of services.

[7] COM(2022) 518 final
[8] EU Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan
[9] REGULATION (EU) No 995/2010
[10] REGULATION (EU) 2023/1115
[11] REGULATION (EU) No 1257/2013

Within the framework of the Zero **Pollution** Action Plan[12], the EU has a comprehensive clean air policy based on three pillars: (i) ambient air quality standards, (ii) reducing air pollution emissions, and (iii) emissions standards for key sources of pollution. Under this Plan, there are a few directives such as the AAQD, the Industrial Emissions Directive (IED)[13], the Regulation on Vehicle Emission Standards[14], the Nitrate Directive[15] and the Sulphur Directive[16] which establish limit and target values for various pollutants and emissions. EO is crucial in monitoring air pollution and the industrial impacts on the environment. The Copernicus Atmosphere Monitoring Service (CAMS) is used in reporting and analysis, providing products and services describing past, current, and future air pollution fields, with the European Air Quality Index [17] as an example hosted by the EEA. Satellite data assess natural contributions to air pollution and forecast peak pollution events. Copernicus offers a web platform to MS to check flexibility options under the National Emission Reduction Commitments Directive[18] during extreme weather events possibly leading to increased air pollutant emissions.

The EU Emissions Trading System (ETS) stands out as a primary and prominent measure introduced by the EU to combat climate change and reduce its **GHG emissions**. It sets a yearly cap from stationary installations, covering power and carbon-intense industries, flights within the European Economic Area and, from 2026, international navigation. The comprehensive process for monitoring, reporting, and verifying (MRV), along with all associated procedures, constitutes the ETS compliance cycle. The EEA supports the EC to compile the EU GHG inventory, which serves as the official submission to the United Nations Framework Convention on Climate Change (UNFCCC). Additionally, the EEA has the mandate to implement quality assurance and quality control checks on the GHG inventories submitted EU MS. To support the GHG MRV capacity, modelling, and observations from both surface-based and a new generation of satellite sensors, including the CAMS, are combined to provide reliable, high-resolution information on anthropogenic emissions and natural fluxes of carbon dioxide and methane. This will be further extended in the next years through the flagship CAMS CO2 and CH4 emissions monitoring capacity (CO2MVS), taking advantage of the dedicated CO2M Sentinel constellation, to provide detailed monitoring of anthropogenic emissions. The Emissions Database for Global Atmospheric Research (Commission et al., 2023) offers independent emission estimates, distinct from those reported by EU MS or by Parties under the UNFCCC, using international statistics and a consistent IPCC methodology.

[12] EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'
[13] DIRECTIVE 2010/75/EU
[14] REGULATION (EU) 2019/631
[15] Council Directive 91/676/EEC
[16] DIRECTIVE (EU) 2016/802
[17] https://airindex.eea.europa.eu/AQI/index.html
[18] Directive (EU) 2016/2284

CASE-BY-CASE ASSESSMENTS

Through collaborative efforts with DEFIS and four policy Directorates-General (DGs), the KCEO has identified a range of policy areas where EO data and services can enhance or support compliance efforts. For these targeted areas, we are currently undertaking fitness-for-purpose assessments to analyse gaps and provide specific recommendations.

Monitoring GHG emissions at the city level (DG ENER)

Climate change is shaping the political and scientific debate at the global level with increasing urgency. This challenge requires the contribution of all actors in different fields, guises, and levels of governance (Betsill & Bulkeley, 2006),(Kern, 2008),(IPCC, 2022),(Romero-Lankao et al., 2018). Along with international and national commitments, local governments are involved in implementing specific actions to tackle climate change (CC), as cities are widely recognized as responsible for GHG emissions while being affected by CC. The potential of cities to contribute to the CC has been recognized and supported within Europe by the Covenant of Mayors (CoM)[19] initiative. Aligned with many EU priorities and efforts, particularly the EU energy and climate targets for 2020 and 2030, the CoM is the first pan-European initiative involving local authorities enabling different levels of government to work together and complement their actions in their policy areas to contribute to a low carbon transition (Melica et al., 2018).

The Baseline Emission Inventory (BEI) is not meant to be exhaustive and therefore has potentially significant issues associated with it especially linked to urban areas of different sizes and (bio)geographical regions. Some of the main limitations include the following: (i) the inventories are not related to a spatial unit, but linked to sector type, and excludes the private sector; (ii) the quality of the published inventory data is variable; (iii) the setting-up of the inventory requires significant investment of time and resources; (iv) the required reporting frequency is low and variable. Based on the issues identified, the dynamic nature of the atmosphere, and the ambitious European goals, there is an urgent need for standardised products and services that provide municipalities with the necessary information to develop strategies and achieve their goals. A systematic, scientific grounded approach is required for quantifying and monitoring GHG and air quality at relevant urban scales for reporting purposes.

The objective of this use case is to describe how EO data, services and derived products can be used to support local European city administrations in their roles to achieve urban sustainability goals linked to GHG emission reductions and air quality improvements specifically focusing on CO2 (carbon dioxide) and CH4 (methane) to deliver the goals of the CoM.

The development and integration of sophisticated EO products and services may complement and progressively evolve the current bottom-up methodology for creating and updating emission

[19] https://eu-mayors.ec.europa.eu/en/home

inventories, alleviate the reporting burden, and provide an independent estimation of GHG emissions to assess the progress toward climate targets.

Monitoring energy efficiency of buildings (DG ENER)

There is the need for planning tools for municipalities, providing explicit information on thermal transfer at the local scale (building or neighbourhood) for a better planification of the mitigation actions. Those tools should also consider the monitoring of adopted measures the framework of the Energy Performance of Buildings Directive (EPBD)[20] and integrate parameters related to various processes (e.g. energy resources, waste management, water management), and produce quantitative measures needed for reporting activities.

The objective of this use case is to describe how EO data, services and derived products can be used to support energy consumption reduction, particularly through the assessment of thermal transfer, the mapping of photovoltaic (PV) panels and PV potential in the EU cities of the CoM.

- Thermal Transfer Analysis: Utilizes thermal infrared sensor data from satellites or airborne platforms to evaluate building heat signatures, identifying inefficient insulation or ventilation through analysis of heat loss or gain.
- Mapping Rooftop PV Panels: Employing high-resolution satellite imagery to pinpoint the presence and coverage of solar panels on rooftops, offering insights into urban renewable energy generation capacities.
- Mapping PV Potential: Combining EO data with solar radiation databases to quantify the potential for solar installations, aiding in strategic urban energy planning and expansion of renewable energy infrastructure.

Monitoring GHG emissions from fossil fuels facilities (DG ENER)

As a contribution to the achievement of the Paris Agreement goal[21], the EU committed to reduce its GHG emissions by at least 55% below 1990 levels by 2030 and to reach zero-net emissions (climate neutrality) by 2050 as defined in the EU Green Deal and established in the Climate Law Regulation[22]. The EU's methane strategy[23], published in October 2020, aims to curb temperature increases, improve air quality, and reinforce the EU's global leadership in the fight against climate change. The EC adopted a proposal[24] on 15 December 2021, aimed at reducing methane emissions in the energy sector. A provisional agreement was reached between the European Parliament and the Council on 15 November 2023. The Commission proposals on measurement, monitoring, reporting and verification (MMRV) of methane emissions, which build on the Oil and

[20] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en
[21] https://unfccc.int/most-requested/key-aspects-of-the-paris-agreement
[22] REGULATION (EU) 2021/1119
[23] COM/2020/663 final
[24] COM/2021/805 final

Gas Methane Partnership 2.0 (OGMP 2.0) framework, will help identify the exact locations and volumes of methane emitted, shifting from estimates to direct measurements verified independently. The urgency to tackle methane emissions is reflected in the mitigation proposals aiming to deliver reductions soon after the legislation enters into force.

The objective of this use case is to describe how EO data, services, and derived products can be used to provide GHG monitoring services (CO2 and CH4) associated with EU oil, gas, and coal in the production and delivery phase, which represents 15% of global GHG emissions.

Inventory and monitoring of fossil fuels facilities (DG ENER)

In the context of the upcoming Communication on Fossil fuel phase-out (scheduled for Q3 2024), there is an urgent need to map and monitor hydrocarbon investments worldwide. This is crucial to identify potential free riders, track the gradual reduction of fossil fuels use and production, and ensure progress towards achieving carbon neutrality by 2050, as mandated by the Climate Law regulation[25].

The objective of this use case is to leverage EO data, services, and derived products to establish a comprehensive global inventory of fossil fuel (oil and gas) facilities and infrastructure. This inventory would serve as a baseline for monitoring changes (expansion activities, abandoned sites) and new investments in the fossil fuel sector over time.

Support the Carbon Removal Certification Framework (CRCF) process (DG CLIMA)

On November 21, 2023, the European Parliament adopted the initial draft legislation for the EU Carbon Removal Certification Framework (CRCF)[26], which aims to define and formulate methodologies for certifying carbon removals within the EU. The proposal aims to develop a voluntary certification framework to complement emission reductions through high-quality carbon removals and soil emission reductions. Three carbon removal categories are differentiated: carbon farming (including af-/re-forestation, improved forest management, agroforestry, soil carbon sequestration, and peatland restoration), permanent carbon storage (such as Bioenergy with Carbon Capture and Storage and Direct Air Carbon Capture and Storage), and carbon storage in long-lasting products (like wood-based construction materials). Carbon removals seeking certification must adhere to the "QU.A.L.ITY" criteria, outlined in the Legal Act. Carbon removals and soil emission reductions need to be certified through independent, accredited third-party auditing carried out by certification bodies to ensure credibility and reliability.

[25] Regulation (EU) 2021/1119
[26] Proposal for a REGULATION on carbon removals

This use case aims to explore how EO data, services, and derived products can help in the certification process under new CRCF, focusing on Nature-based solutions, i.e. peatlands restoration, reforestation and agro-forestry.

Mapping and monitoring Critical mining sites (DG GROW)

On 16 March 2023, the EC proposed a set of actions to ensure the EU's secure and sustainable access to Critical Raw Materials (CRM), which is essential for the EU to succeed in its green and digital transitions. The Proposed CRM Act[27] envisages a framework for selecting and implementing strategic CRM projects in the MS and develops a mechanism for the coordinated monitoring of CRM supply chains and adopting measures for mitigating supply risks. Key objectives of the Proposed Regulation are achieving the circularity of CRM markets and lowering the environmental footprint of CRM. The Proposed Regulation sets out criteria for recognizing projects that contribute to the security of the EU's supply of strategic raw materials as Strategic Projects. The latter will be eligible for streamlined permit-granting processes in the MS and coordinated support by the EC and the MS in securing financing.

The objective of this use case is to assess how EO data, services, and derived products can benefit sustainable mining efforts and support the regulation proposal on CRM, particularly through two strongly related steps:

- Mapping and monitoring the extent and development of critical mining sites and their contextual environmental conditions.
- Monitoring the evolution of strategic CRM sites, including environmental impacts following the rules defined in existing directives, i.e. The Extractive Waste Directive[28], (ii) The Water Framework Directive (WFD)[29], and (iii) The Industrial Emissions Directive[30].

Monitoring water quality (ENV)

The EU WFD of 2020 commits MS to achieving good qualitative and quantitative status of all water bodies. Citizens, environmental organisations, nature, water-using sectors in the economy all need cleaner seawater, rivers and lakes, groundwater and bathing waters. Water quality is essential to fostering sustainable development in the blue economy and to protect the marine environment and the health of citizens.

The objective of this assessment is to describe how EO data, services, and derived products can be used to support water quality monitoring and control, through the 3 following use cases:

[27] Regulation (EU) 2024/1252
[28] Directive 2006/21/EC
[29] Directive 2000/60/EC
[30] Directive 2010/75/EU

1. Controlling and enforcing compliance in water quality in the context of the WFD, the Urban Waste Water Treatment Directive (UWWT)[31], the Nitrate Directive[32], and the Drinking Water Directive (DWD)[33], and providing support to MS when assessing compliance with environmental permits for water discharge.
2. Monitoring water bodies at risk for ecological status deterioration and allow for early warning of threat situations at the pan-European scale, in the context of the WFD.
3. Harmonizing indicators for marine quality monitoring in the context of the MSFD.

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