Reinforcing the AI4EU Platform by Advancing Earth Observation Intelligence, Innovation and Adoption

D3.2: AI4Copernicus and the European AI and Copernicus ecosystems report I

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Executive Summary

In this deliverable we present the activities we carried out to position AI4Copernicus in the two relevant European ecosystems: the Artificial Intelligence ecosystem and the Copernicus programme ecosystem. We monitored activities in these two ecosystems and collaborated closely with some of them, especially with the other ICT-49 projects.

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List of Terms & Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
ML	Machine Learning
EO	Earth Observation
ESA	European Space Agency
RS	Remote Sensing
NN	Neural Networks
DL	Deep Learning

1 Introduction

The use of Artificial Intelligence (AI) technologies in Earth Observation (EO) goes back to the 1990s. For example, see early papers on neural network (NN) techniques for EO [Benediktsson et. al, 1991, Serpico et al. 1996, Bruzzone et al., 1997] (the last two papers were co-authored by our colleague Prof. Lorenzo Bruzzone, leader of the University of Trento node in AI4Copernicus). By 2000, there was a small community of Remote Sensing (RS) researchers working on applying NN to EO problems. Then, around 2004/2005, there was the first strong push with Support Vector Machines (SVM) and kernel methods (Prof. Bruzzone and colleagues introduced this to the RS community with the papers [Melgani and Bruzzone, 2004] and [Camp-Valls and Bruzzone, 2005]). For many years there was a large interest in kernel methods with many more researchers using these techniques. The final big push came around 2016 when Computer Vision started having a lot of successes using Deep Learning (DL) techniques on very large datasets like ImageNet. Since then, ML has become pervasive in RS.

Another set of AI technologies that have been used in EO for quite some time are semantic technologies (mainly ontologies and linked data). The European Space Agency (ESA) funded various projects initially in the context of the Global Monitoring for Environment and Security (GMES) Programme (the precursor to Copernicus). One of the most important of these projects was Heterogeneous Missions Accessibility (HMA) which concentrated on standardization and interoperability [Usländer, et al., 2012]. More recent projects include RARE and Prod-Trees; partner UoA participated in the latter [Karpathiotaki et al. 2014]. Around the same time, the European Commission funded projects TELEIOS (2010-2013) [Koubarakis et al., 2016], LEO (2013-2015) [Burgstaller et al., 2017] and MELODIES (2013-2016) [Blower et al., 2014]. The first two projects were coordinated by the partner UoA which leads this deliverable and the third one by the University of Reading. Various other projects funded by ESA or the European Commission followed.

With respect to the Copernicus programme, an important milestone has been the creation in 2018 of the five Data and Information Access Services (DIAS). These are CREODIAS[1], WEkEO[2], ONDA[3], SOBLOO[4] and Mundi[5]. They are cloud platforms that bring computing power close to Copernicus data to enable the development of EO applications.

Another important milestone, this time in the area of European AI, has been the funding of the H2020 project AI4EU (2019-2021) which developed the AI-on-demand (AIoD) platform[6]. The platform is a one-stop-shop for anyone looking for AI knowledge, technology, tools, services and experts.

AI4Copernicus capitalizes on the results of the above activities. Its main objective is to make the AIoD platform the platform of choice for users of Copernicus data, and in this way, give rise to a new wave of commercial activities involving AI technologies and Copernicus data.

[1] https://creodias.eu/
[2] https://www.wekeo.eu/
[3] https://www.onda-dias.eu/
[4] https://sobloo.eu/
[5] https://mundiwebservices.com/
[6] https://www.ai4europe.eu/

1.1 Purpose and Scope

The purpose of this deliverable is to present the activities that we carried out in the first 18 months of the project in order to position technically AI4Copernicus in the changing landscapes of AI and Copernicus.

1.2 Approach for Work Package and Relation to other Work Packages and Deliverables

Work package WP3 (Technical positioning and architecture) started at M1 and ends at M30 of the project. It is led by partner UoA with the collaboration of partners NCSR-D, TAS, CF and UNITN. WP3 positions technically AI4Copernicus in the European AI and Copernicus ecosystems. In addition, it develops the software architecture of the project.

WP3 has the following three tasks:

- Task 3.1 Architecture specification, tools and components (M1-M18, lead: UoA, contributors: NCSR-D, TAS, CF, UNITN). The technical contribution of this task is the development of the software architecture of the project with a specific emphasis to interfacing with the AIoD platform, CREODIAS and WEkEO.
- Task 3.2 Design of the semantic catalogue and the semantic search and discovery functionality (M1-M9, lead: UoA, contributor: NCSR-D). The technical contributions of this task are the development of a question answering engine for discovering Copernicus data, and the development of the Copernicus ontology.
- Task 3.3 Positioning of AI4Copernicus in the European AI and Copernicus ecosystems (M7-M30, lead: UoA, contributors: TAS, UNITN). This task monitors the AI and Copernicus landscape in Europe and positions technically AI4Copernicus in this landscape.

The present deliverable D3.2 is the second deliverable of WP3 and contains the contributions of the project to Task 3.3. WP3 has one more deliverable that targets Task 3.3 too:

- D3.3 AI4Copernicus and the European AI and Copernicus ecosystems - report II - final, (M30, R, PU, UoA)

1.3 Organization of the Deliverable

The rest of the deliverable is organised as follows. Section 2 positions AI4Copernicus in the European AI ecosystem. Section 3 positions AI4Copernicus in the Copernicus ecosystem. Section 4 concludes the deliverable.

2 AI4Copernicus in the European AI Ecosystem

The AI landscape in Europe is currently been shaped by the European AI strategy[7] partly guided by the High-Level Expert Group on Artificial Intelligence[8]. In addition, there is the current proposal for a "Regulation of the European Parliament and of the Council laying down harmonised rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain Union legislative acts.[9] From a technical

[7] https://digital-strategy.ec.europa.eu/en/library/communication-artificial-intelligence-europe

[8] https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

[9] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206

point of view, the European approach to AI focuses on two areas: excellence in AI and trustworthy AI. Both areas are served by the AIoD platform to which AI4Copernicus contributes.

The first contribution of AI4Copernicus to the European AI ecosystem is to bring Copernicus data to the AIoD platform.

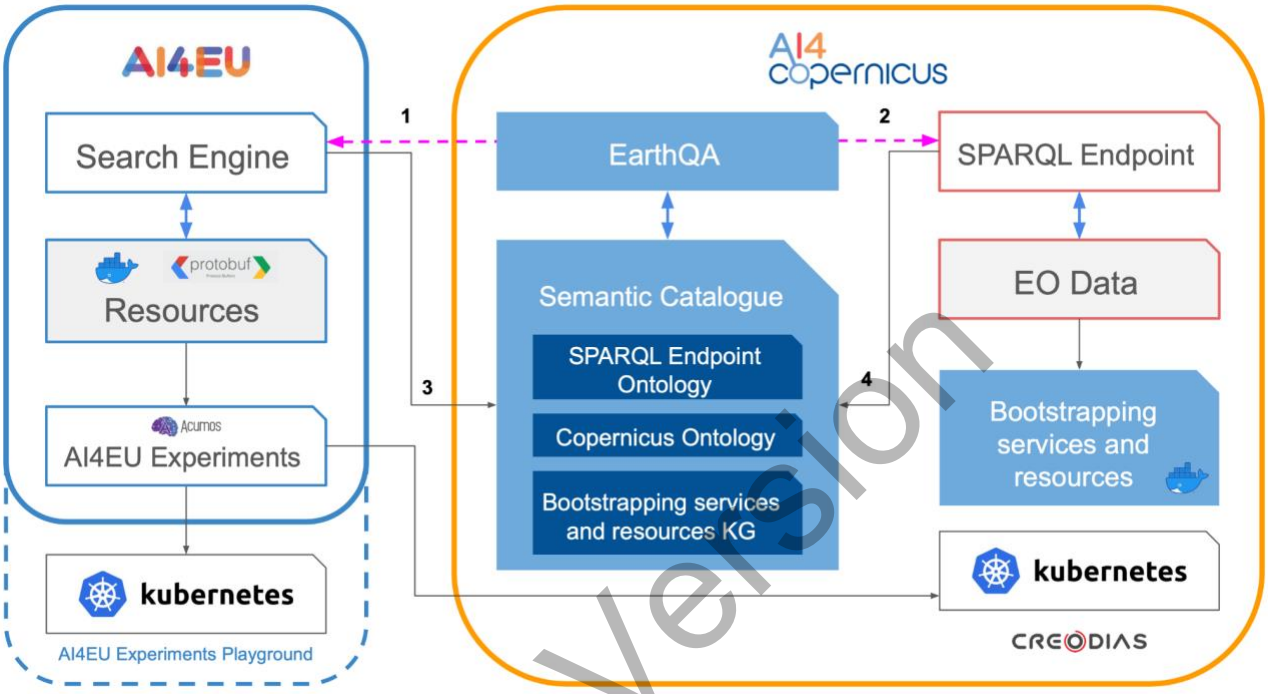

Figure 2.1: The AI4Copernicus architecture

The above figure shows the software architecture of AI4Copernicus and its interoperation with the AIoD platform. The main technical contributions of our work are:

- The provision of bootstrapping services and resources (e.g., ML algorithms for EO data).
- The availability of CREODIAS, where the above services and resources can be deployed using Kubernetes dockers.
- The option to use the AI4EU Experiments Playground component to create deployable Kubernetes dockers, which users can deploy on CREODIAS.
- The definition of the Copernicus ontology for annotating services and resources.
- The development of the EarthQA question answering engine for discovering Copernicus data and its interfacing with the search engine of the AIoD platform.

Deliverable D3.1 (Architecture, semantics and discovery report) and other deliverables of WP4 and WP5 present in detail the above contributions to the AIoD platform. The interested reader is referred to those deliverables for more details.

The second contribution of AI4Copernicus to the AI4EU project has been the participation of our Technical Manager Prof. Manolis Koubarakis from UoA to the Technical Governance Board of the AIoD platform. The Technical Governance Board facilitates contributions to the AIoD platform by

presenting and discussing new contributions and releases, connecting experts for collaboration and advice, voting on critical additions or changes to the architecture, creating new concepts for technical integrations, and accepting requests for presentations. The voting members of the Technical Governance Board have been the WP leaders of the AI4EU project; this will soon be changed to take into account the new project AI4Europe and other developments.

The third contribution of AI4Copernicus to the AI4EU project has been the participation of project members to the AI Asset Ontology Working Group. This Working Group aims to define the directions and coverage of the ontological specifications produced by the participating projects, in order to ensure that all ontologies are aligned to the central conceptual model of the AIoD platform, while also contributing to its enrichment with generally required constructs.

The members of AI4Copernicus that are participating in this working group are:

- Antonis Koukourikos (NCSR-D). Antonis was the main designer and developer of the AIoD conceptual model and coordinates the alignment efforts of the different projects, while specifying foreseen extensions of the conceptual model itself as new requirements emerge from the discussions.
- Eleni Tsalapati (UoA). Eleni has been working on the Copernicus ontology which is presented in Deliverable D3.1; this ontology is connected to the AI Assets ontology.

Another important contribution of AI4Copernicus to the AI ecosystem in Europe is the joint work with the other projects funded under the ICT-49 call, which are the following:

- AIPlan4EU: Bringing AI Planning to the European AI On-Demand Platform.[10]
- BonsAPPs: AI-as-a-Service for the Deep Edge[11]
- DIH4AI: AI on-demand platform for regional interoperable Digital Innovation Hubs Network[12]
- I-NERGY: Artificial Intelligence for Next Generation Energy[13]
- StairwAI: Ease the Engagement of Low-Tech users to the AI-on-Demand platform through AI[14]

The six projects have recently organised their collaboration around the following six working groups: Coordinators, Trustworthy AI, Financial Support for Third Parties, Communication, Technical Integration and Exploitation. AI4Copernicus participates actively in these working groups.

The Technical Working Group is led by our colleague Dr Iraklis Klampanos from the coordinating node NCSR-Demokritos. The goal of this working group is twofold: (a) to coordinate potentially common technical directions across ICT-49 projects and (b) to facilitate the elicitation of common technical requirements against the AIoD platform. More specifically, directions covered by the Technical Working Group include:

[10] https://www.aiplan4eu-project.eu/
[11] https://bonsapps.eu/
[12] https://www.dih4ai.eu/
[13] https://i-nergy.eu/
[14] https://stairwai.nws.cs.unibo.it/

(1) The organisation of user-stories and requirements in a format usable across the ICT-49 projects, therefore providing opportunities for developing common vocabularies and synergies

(2) The integration of common architectural and integration elements, e.g. common tools for deploying workflows onto 3rd party clouds from within AI4EU Experiments

(3) Standardisation of descriptive semantics for products developed across all projects in order to achieve a common presentation on Catalogues

(4) Common approach towards technical support, especially after the completion of the ICT-49 projects.

It is expected that some of these directions will require coordination across WGs, therefore widening the collaboration amongst projects even further.

At the same time, AI4Copernicus is positioning itself in sync with the aforementioned ICT-49 projects in order to result in a cohesive offering under the AIoD platform umbrella. We can distinguish two directions of platform evolution through ICT-49 actions: evolution through the simultaneous development in different *verticals*, and evolution of horizontal services and knowledge assets.

Horizontal services are already being taken into account for the implementation of AI4Copernicus. Collaboration pathways are built firstly over the sharing and alignment of representation frameworks used by the different projects. Distinct ontologies are designed for the Energy and Planning domains, both mapping to the AI4EU conceptual model as the AI4Copernicus Ontology. Furthermore, higher-level ontologies such as the ones used by StairwAI and BonsApps respect the standards set by AI4EU on the descriptive and resource deployment level, as they have been set by the AI4EU ontology and the AI4EU Experiments platform respectively. In this regard, all actions are positioned to provide a uniform means of discoverability and integration through the solutions built by AI4Europe and StairwAI, while streamlining and obscuring the testing and deployment process via the platforms and frameworks built e.g., by BonsApps.

The full exploitation of developments in verticals is a more complex endeavour that will likely bear fruits at the mid-term. Nevertheless, the alignment at the technical level is important beforehand, as the focal applications domains of AI4Copernicus, I-NERGY and AIPlan4EU call for combined solutions that, for example, seamlessly integrate planning and energy optimization in EO analytics. To this end, the technical working group will ensure a deeper knowledge of services brought on the table and the means to collaboratively exploit them in larger-scale solutions.

Another contribution of AI4Copernicus to the European AI ecosystem has been the active monitoring of the following Networks of Excellence funded under the ICT-48 call:

- TAILOR: A Network for Trustworthy Artificial Intelligence.[15] Partner UoA participates in TAILOR and monitors the work on Trustworthy AI in case any of it can be transferred to AI4Copernicus. So far, there has been no techniques or technology that we could use from that project.

[15] https://tailor-network.eu/

- Humane AI-Net: European Network of Human Centered Artificial Intelligence.[16] No partners of AI4Copernicus participate in this network but we are monitoring their work through their website and social networks. So far, there has been no techniques or technology that we could use from that project.
- AI4Media: A Centre of Excellence delivering next generation AI Research and Training at the service of Media, Society and Democracy.[17] No partners of AI4Copernicus participate in this network but we are monitoring their work through their website and social networks. So far, there has been no techniques or technology that we could use from that project.

The final contribution of the AI4Copernicus to the European AI ecosystem has been the dissemination of the project in events of the Big Data Value Association (BDVA) and the AI, Data and Robotics Public Private Partnership. AI4Copernicus was presented at the online BDVA Data Week 2021 conference in the session "Artificial Intelligence and Big Data Technologies for Earth Observation" organized by Prof. Manolis Koubarakis of UoA. More specifically, on 25 May 2021, project coordinator Dr. Vangelis Karkaletsis from NCSR Demokritos presented the project's objectives and drew the audience's attention to the forthcoming open calls. In the same session, the projects ExtremeEarth, DEEPCUBE and CALLISTO[18] that are also applying AI techniques to EO were presented.

In the near future, AI4Copernicus will also collaborate with the recently funded project AI4Europe (An AI-on-demand platform to support research excellence in Europe) which is a continuation of AI4EU and is coordinated by University College - Cork, Ireland. From the partners of AI4Copernicus, the coordinating partner NCSR-D participates in AI4Europe. The main goal of this new project is to extend the AI-on-demand platform with new functionalities so that it becomes the platform of choice for AI researchers in Europe for doing their excellent research.

3 AI4Copernicus in the Copernicus Ecosystem

In addition to positioning our project in the European AI ecosystem, we have been working hard to position AI4Copernicus in the Copernicus ecosystem. This ecosystem is currently shaped by the various activities of ESA (Φ Lab, DIASes, AI4EO, Big Data from Space Conference etc.) and other stakeholders such as the European Association for Remote Sensing Companies (EARSC). Pierre-Philippe Matthieu, head of the Φ Lab explore office, is part of the AI4Copernicus Advisory Board.

One of the goals of AI4Copernicus is to connect two of the DIASes (CREODIAS and WEkEO) to the AIoD platform. More details about this are given in Deliverable D3.1 where the architecture of AI4Copernicus is presented.

In the context of AI4Copernicus dissemination activities, the project was presented in various events organised by Copernicus stakeholders:

[16] https://www.humane-ai.eu/

[17] https://www.ai4media.eu/

[18] https://callisto-h2020.eu/

1. Big Data from Space Conference (BiDS 2021). AI4Copernicus was introduced with presentations "Exploring the climate-security nexus with spaceborne data" on 18 May by S. Albani and "Digital Twin Earth for Security: from data to information" on 20 May 2021 by P. Saameno, both from partner SatCen.
2. Michele Lazzarini from partner SatCen presented AI4Copernicus in the AI4EO side event of ESA Φ-week (11-15 October 2021), under the title "AI and Earth Observation: Efforts to build an ecosystem" on Thursday 14 October. The AI4EO side event presented the main objectives and goals of the AI4EO initiative, as well as unveiled details of the first AI4EO challenge.
3. Sergio Albani from partner SatCen gave a presentation in the same side event titled "New Space Actors contribution to EO for Security" on Friday 15 October. Sergio introduced the outcomes of SatCen RTDI activities, highlighting the importance of cooperation and R&I initiatives, as AI4Copernicus, to address the current challenges in the space and security domain. The session featured presentations from institutions assisting intergovernmental, governmental and non-governmental organisations in the fields of security and law enforcement, by providing services, training and capacity building, as well as from Industries on the latest innovation, with a high focus on developing analytics and AI tailored for EO data.
4. Dr. Vangelis Karkaletsis (Project Coordinator) and Dr. Xenia Ziouvelou (Open Calls lead) from NCSR-Demokritos participated in an Earth Observation Cafe webinar dedicated to the project organized by the EARSC. The event took place virtually on Thursday 15 April 2021, while more than 100 people attended. The series of EO Cafes offer timely, relevant and practical information on a broad variety of topics related to the Earth Observation domain. During this webinar, Dr. Karkaletsis and Dr. Ziouvelou elaborated on the goals and objectives of AI4Copernicus and provided details regarding the Open Calls with their talk titled: Enabling Artificial Intelligence & Earth Observation Innovation.
5. AI4Copernicus was introduced during the annual event of EARSC, namely EXPANDEO, which took place virtually on 16 and 17 June 2021. On the second day, in the session Artificial Intelligence for Data in Europe, Dr. Xenia Ziouvelou of coordinating partner NCSR Demokritos and Mr. Michele Lazzarini of partner SatCen presented the project and its open calls, which will open at the end of June.
6. AI4Copernicus participated in another EOcafe on 7 April 2022, with a talk titled "Funding Opportunities & Offered Services in AI & EO, AI4Copernicus, a Year on!". During the talk, colleagues Iraklis Klampanos (NCSR Demokritos) and Michele Lazzarini (SatCen) discussed with host Geoff Sawyer (EARSC) the funding opportunities and offered services through the AI4Copernicus project.

More recently, the European Commission funded the Destination Earth Initiative (DestinE)[19] which is also related to AI4Copernicus due to the importance of Copernicus data in its activities. DestinE will develop a high precision digital model of the Earth to monitor and simulate natural and human activity. The first two digital twins to be developed by DestinE will focus on weather-induced and geophysical extremes, and on climate change adaptation. They will be very high precision digital replicas of our planet which will help monitor, visualise, and forecast natural and human activity on

[19] https://digital-strategy.ec.europa.eu/en/policies/destination-earth

the planet in view of weather-induced and geophysical extremes and climate change. The digital twins will be able to monitor the health of the planet, perform simulations of Earth's interconnected system with human behaviour, and support sustainable development. As a result, they will reinforce Europe's efforts for a better environment to respond to the urgent challenges and targets addressed by the Green Deal. By opening up access to public datasets across Europe, DestinE will also represent a key component of the European Strategy for Data.

The DestinE system will comprise the following functional components: the Core DestinE Platform, the Data Lake and the Digital Twin Engine. These will be developed as part of the Commission's Digital Europe programme by the ESA which will develop the Core Platform, the European Centre for Medium-Range Weather Forecasts (ECMWF, a partner of AI4Copernicus) which will develop the Digital Twin Engine and the first two digital twins, and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) which will develop the Data Lake. Horizon Europe will provide research and innovation opportunities that will support the further development of DestinE.

Partner ECMWF is keeping us up-to-date with respect to DestinE activities so that ideas and technology from this project could be used in AI4Copernicus if it is deemed useful.

4 Conclusions

In this deliverable, we presented the activities we carried out in M1-M18 of AI4Copernicus in order to position the project in the European AI ecosystem and the Copernicus ecosystem. We monitored the most important activities taking place in these ecosystems and collaborated closely with some of them, especially with the other ICT-49 projects.

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