ThinkingEarth aims to:

1 **Research and develop Artificial Intelligence (AI) methods for a unified Earth system.** ThinkingEarth's overarching goal is to create Copernicus Foundation Models using multimodal Sentinel data, and to create a data-driven graph representation of the interactions of fundamental Earth system variables towards modelling the Earth as a Graph. Small-scale applications and large-scale Use Cases will showcase the models' capabilities.

2 **Develop the first Copernicus Foundation Models.** We will use self-supervised learning (SSL) for Sentinel-1, 2, and 3 data to improve contrastive learning and data compression. The approach aims to fuse information from diverse Sentinel data types while enhancing deep learning (DL) generalisation across time and space.

3 **Build a DL-based Earth graph representation.** Using graph neural networks (GNNs), we will link Earth events across space and time, capturing regional and global climate patterns. Self-supervised graph learning will integrate with NVIDIA's Earth-2 engine for visualisation on the Omniverse platform.

4 **Apply causal, physics-aware Machine Learning (ML), and xAI for Earth science.** Hybrid models will merge AI and physics-based constraints for consistency, using causality and explainable AI for transparency. This approach will reveal cause-effect dynamics, improving climate variability predictions and Earth system insights.

5 **Create scalable products with Copernicus and user data.** ThinkingEarth aims to develop value chains in sectors like renewable energy, biodiversity, and food security. Examples include solar energy forecasting, urban biodiversity tracking, and causal graphs for food security forecasting and World Food Programme (WFP) Anticipatory Action.

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Funded by the European Union

This project has received funding from the European Union's Horizon Europe Research and Innovation Program under Grant Agreement number 101130544.

Copernicus Foundation Models for a Thinking Earth

ThinkingEarth utilises AI to create Copernicus Foundation Models and a Graph representation of the Earth. Four Use Cases will be developed under the project.

At ThinkingEarth, the Earth is viewed as a complex, unified, and interconnected system. To harness the power of Artificial Intelligence (AI), cutting-edge techniques are used, including deep learning, causality, eXplainable AI, and physics-aware Machine Learning. The predictive abilities of Self-Supervised Learning and Graph Neural Networks are leveraged to develop task-agnostic Copernicus Foundation Models and a Graph representation model of the Earth.

The potential of these assets is demonstrated through small-scale downstream Spotlight Applications, as well as large-scale use cases that integrate distributed industrial and user non-EO datasets. These use cases address ambitious problems with high socio-environmental impact and new business growth opportunities, such as accelerating Europe's clean energy transition and independence from volatile fossil fuels, understanding Earth's processes by modelling causal Earth system teleconnections, and assessing and modelling the impact of the current and future Climate emergency on biodiversity and food security.

Find out more and follow us for updates.

thinking-earth.eu

Use Case 1

Energy communities: Distributed solar energy production forecasting & demand management

Use Case 1 focuses on forecasting solar energy production and managing demand to optimise local energy efficiency. Led by the National Observatory of Athens with EnergyFamily and StadtWerke Amstetten as core users, it addresses fluctuating solar production due to weather changes and the need for smart grid solutions. By creating 3D models of cities like Amstetten and Athens, it aims to improve solar PV forecasts and develop smart grids that align supply with demand, helping Distribution System Operators plan energy distribution and fostering energy independence at the community level.

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Use Case 2B

Forest biomass monitoring: carbon sink assessment for the carbon credit industry

Use Case 2B develop tools for forest biomass monitoring, crucial for carbon assessments. Led by GlobeEye, it models Above Ground Biomass to track carbon stocks across large forested areas, focusing on the Amazon basin. High-resolution data will provide detailed carbon estimations for conservation projects, aiding carbon offset assessments and supporting international climate goals like the Paris Agreement and the UN Sustainable Development Goals. This approach promotes sustainable forest management and contributes to global carbon reduction efforts.

GlobeEye, research@globeeye.eu

Use Case 2A

Biodiversity monitoring in urban environment

Use Case 2A aims to transform urban biodiversity monitoring through advanced satellite data, making it accessible to cities of all sizes. Developed by CERTH with AQUATEC, the project leverages deep learning to enhance Sentinel imagery for identifying plant species, assessing vegetation health, and mapping urban water bodies. Unlike traditional methods, it uses Copernicus data for frequent, comprehensive green and blue infrastructure monitoring. This scalable solution will be tested across Spanish cities, supporting new ecosystem services for municipalities.

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Use Case 3

Causal inference for food security analysis

Use Case 3 investigates the causal links between climate change and food security. This project, led by the University of Valencia in partnership with the World Food Programme, applies advanced causal machine learning to analyse the impacts of climate events, like droughts and floods, on food availability and stability in the Horn of Africa. By integrating Copernicus data, socioeconomic factors, and food security metrics, we aim to enhance risk assessment, policy effectiveness, and intervention planning for vulnerable regions.

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