Artificial Intelligence applied to enviromental monitoring

Technical challenges and limitations of environmental AI

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Module 4: Governance and AI Act

How does the digital revolution transform our views on values, good behaviors, and the kind of sustainable and equitable innovation?

Cabinet Office

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Data Science Ethical Framework

Data science carries both huge opportunities and a duty of care. Technology is changing so rapidly; as are the public's views. In this new and changing landscape, this document is not about creating additional hurdles, but rather about making innovation easier. It does this by bringing together the relevant law in the context of new technology, and prompting consideration of public reaction so that government data scientists and policymakers can be confident to innovate appropriately with data.

Developing the ethics around data science can't be done by government alone. This framework is a first iteration - a beta, if you like - of a set of principles wider than the legal framework, to help stimulate innovative and responsible action.

I look forward to listening to, and participating in that debate.

The Rt Hon Matt Hancock MP
Minister for the Cabinet Office and
Paymaster General

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Why data science ethics are important

Who is this guidance for?
This guidance gives those analysing or making policy or operational decisions with data the confidence to innovate. It balances the use of new data and techniques with respect for privacy and makes sure no-one suffers *unintended* negative consequences. An introduction to data science can be found here.

Why is guidance needed for data science?
Data science is a new practice for government which provides opportunities to create insight and improve public services. Digital advances are producing huge amounts of new forms of data, allowing computers to more quickly process this data and makes decisions without human oversight. This creates new opportunities and many new challenges we have not had to consider before.

The law (e.g. the Data Protection and Intellectual Property Acts) sets out some important principles about how you can use data. And analytical, health and other professions have high standards for the quality and integrity of data processes. Those working with data should be aware of these and always act within them. But these are often in different places and not written with data science in mind. This guidance gives people the confidence to innovate by bringing together these laws and standards in the context of the rapidly evolving data landscape.

Public attitudes to data are changing. Working with data in a way which makes the public feel uneasy, without adequate transparency or engagement, could put your project at risk and also jeopardise other projects across government. Consideration of public attitudes and communication with them is key: most people are data pragmatists if told how society will benefit and how risks are managed.

Rather than creating additional hurdles this guidance makes it easier to innovate by helping you both navigate the legal aspects applicable to data science and think through some of the ethical issues which sit outside the law.

How to use the guidance
Data science projects have a number of stages; discovery work to explore what it is possible to do with the data; the actual delivery; refining the accuracy of the insight; and the ongoing use of that insight by policymakers or operational staff. This guidance will help you think through the methodology and ask appropriate questions about how the project is conducted at each stage.

The guidance gives six principles which are based on existing law. **Fundamentally, the public benefit of doing the project needs to be balanced against the risks of doing so.**

1 Start with clear user need and public benefit
2 Use data and tools which have the minimum intrusion necessary
3 Create robust data science models
4 Be alert to public perceptions
5 Be as open and accountable as possible
6 Keep data secure

The guidance starts with a summary and checklist against the six principles and then goes on to explain each principle in more detail with real examples of where data science has been used well and less well, and practical suggestions of what you can do to act ethically. The Information Commissioner's Office has confirmed that the checklist can form the basis of a Privacy Impact Assessment.

This guidance is based on existing law. The exemptions within the Data Protection Act around crime, fraud and national security still apply.

The guidance will be iterated and developed with feedback from departments and external stakeholders. It is designed to be iterated as it is used, and is shared in the expectation that it will encourage feedback and further improvement. It also complements other ethical frameworks for analysis such as those relating to health data and from the National Statistician.

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Data Science Ethical Framework

- A document that aims to make innovation easier to understand.
- To achieve this, it attempts to bring together relevant regulations and user feedback so that policymakers and scientists can work effectively on data management.
- It is a guide that balances the use of new data and techniques with respect for privacy, ensuring that no one faces unintended consequences.
- Data science is a practice used by governments to improve public services.

Data Science Ethical Framework

The guide establishes six principles based on existing laws:
- Start with a clear user need and a public benefit
- Use data and tools that are minimally intrusive
- Build robust models
- Stay vigilant regarding public perceptions
- Be open and accountable
- Take data security into consideration

Digital ethics

- Understanding which of these moves are the best is the task of **digital ethics**.
- It is the branch of knowledge that deals with moral issues related to data and information, aiming to support morally good actions.
- It shapes both digital governance and regulation.

Digital ethics

SOFT ETHICS

- Post-compliance ethics of established legal norms.
- Considers what should or should not be done beyond existing regulations.

HARD ETHICS

- Precedes and helps shape legal regulation.
- Analyzes what is generally right or wrong.

The real challenge is to anticipate ethical development, and to do so, we must be able to assess what is truly feasible, prioritizing what is sustainable from both an environmental and social perspective.

ADOPTING AN ETHICAL APPROACH OFFERS A DOUBLE ADVANTAGE:

- **Soft ethics** can provide an opportunity-driven strategy
- **Ethics** offers a solution for effective risk management
- This is possible when there is **adequate legislation**, **public trust**, and **clear accountability**.

WHY IS IT SO URGENT?

Because ethical evaluation shapes public opinion

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which determines what is politically possible

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and thus what is legally enforceable

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Debate on the Ethics of algorithms

- **Algorithms** = mathematical constructs that can be developed into a program or a configuration.
- Algorithms underpin the services and infrastructures of society (e.g., recommendation systems).
- They are used in schools, hospitals, financial institutions, courts, local government bodies, and national governments.
- Their growing use prompts us to reflect on their ethical implications.

Are algorithms neutral?

Mapping the ethical issues related to algorithms

Machine learning algorithms ("automata" or "semi-automata" because their results are induced by data and are not deterministic) can be used to:

- Transform data into evidence for another outcome
- Trigger or motivate an action that may have ethical consequences
- Assign responsibility for the effects of actions that an algorithm may trigger

Six ethical issues

1. **Inconclusive evidence**
2. **Inscrutable evidence**
3. **Misleading evidence**
4. **Unfair outcomes**
5. **Transformative effects**
6. **Traceability**

Inconclusive evidence

They refer to the way in which machine learning algorithms identify associations and correlations between data variables, but not causal connections → thus generating **probabilistic outputs**

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Apophenia
The tendency to perceive meaningful patterns where none actually exist.

Inconclusive evidence

PROBLEM:

They generate ethical problems because non-causal indicators divert attention from the underlying cause of the problem — the problem is not solved by simply having more data.

SOLUTION:

Through independent validation of algorithms and practices that ensure data preservation and reproducibility.

Inscrutable evidence

They refer to issues of non-transparency, lack of control, and accountability

1. Cognitive impossibility for humans to interpret algorithmic models and data systems
2. Lack of tools to keep track of large volumes of code and data
3. Poor structuring of data and code causing unreadability
4. Continuous updates (malleability of algorithms)
5. Human influence on the model

Inscrutable evidence

Transparency is not an ethical principle in itself, but a tool for ethical purposes

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Solution:

Highlight the causes that lead to non-transparency

1.The AI Now Institute (New York University) has produced a guide for algorithmic impact assessment which includes an interpretable explanation of internal processes (such as Explainable AI made available by Google and IBM).

2.Implementation of public education

Misleading evidence

Unintended *biases* are of concern

Caused by algorithmic formalism

Adherence to prescribed rules that ignore the complexity of the world

1. Inability to model the entire system to which the social criterion will be applied
2. Inability to understand how replicating a solution in one context can be misleading or inaccurate in another
3. Inability to account for fairness
4. Inability to understand that the introduction of a new technology may change the behaviors and/or values of a system
5. Inability to understand that the best solution may be dissociated from the technology

Misleading evidence

Biases derive from the data used

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Solution:
Remove certain specific data variables (e.g., gender, race — prohibited by anti-discrimination law and data protection regulations)
And what about invisible biases?
Through external auditing and public disclosure of a model along with the data and metadata used.

Unfair outcomes

Related to the need for algorithmic fairness

DEFINED BY 4 PRINCIPLES

- **Anti-classification:** refers to protected categories (race, gender)
- **Classification parity:** a model is fair if common measurements are equal across protected groups
- **Calibration:** measures how well an algorithm is calibrated
- **Statistical parity:** views fairness as an equal estimate of the average probability across protected groups

Unfair outcomes

Removing protected variables does not mean eliminating the discrimination rate because invisible variables exist.

Solution:
Introduce a third party that attempts to eliminate possible discrimination.
A collaborative model focused on the data resource.

Transformative effects

They are intertwined with issues concerning autonomy.

1. Pervasive and proactive distribution of algorithms in shaping user choices
2. Limited understanding of algorithms by users
3. Lack of power over algorithmic outcomes

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Solution:
Autonomy must be constrained and reversible

Traceability

It concerns the issue of responsibility

On one hand, it seems impossible to define moral responsibility due to the human-machine hybridization /
On the other hand, it is unthinkable to trace data back to its source.

Lack of transparency + lack of explainability =

NEED FOR NEW APPROACHES

The European Commission regulation

In April **2021**, the European Commission published a proposal for **a regulation on the European approach to artificial intelligence.**

It includes transparency rules and more specific provisions regarding high-risk systems (such as personnel selection systems and systems assessing the reliability of statements made by individuals to prevent or investigate crimes).

It prohibits:

- **The use of systems employing subliminal techniques on unaware individuals**
- **The deployment by public authorities of systems to assess individuals' reliability based on their social behavior or personality traits**
- **The use of real-time remote biometric identification systems**

Bad Practices of AI

Five Criminal Areas Affecting AI Crimes (Artificial Intelligence Crimes):

1. Trade and Financial Markets
2. Harmful and Dangerous Drugs
3. Crimes Against the Person
4. Sexual Crimes
5. Theft, Fraud, Counterfeiting, and Identity Theft

Concerns Related to AI Crimes (CIA)

- Emergency
- Responsibility
- Monitoring
- Psychology

Emergency

It refers to the possibility that artificial agents may act in ways that go beyond our expectations

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Responsability

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It would undermine legal certainty → No law would be recognized that could acknowledge the crime itself

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Monitoring

1. It refers to three types of problems: 1. Attribution of non-compliance with regulations 2. Feasibility: concerns cases where artificial agents operate at speeds or levels of complexity beyond the capacity to monitor the rules (e.g., bots on social media) 3. Intersystem actions: refer to experiments showing how to automatically reproduce a user's identity (e.g., on Twitter)

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Psychology

It refers to the concern that AI could negatively influence and manipulate a user's mental state to the point of facilitating a crime → Among the effects, gaining users' trust is noted

AI Act

- **Entered into force**: August 1, 2024
- Some provisions are **already applicable**
- Others require a **transitional period** due to complexity and implementation needs
- Promoted by the **European Commission** to:

•Support early adoption of the AI Act

•Encourage developers to comply **before official deadlines**

Pillar 1: Knowledge Sharing through the AI Pact Network

•Access point to the AI Pact community

•Exchange of **best practices**, experiences, and expertise

•Updates and guidance on **AI Act implementation**

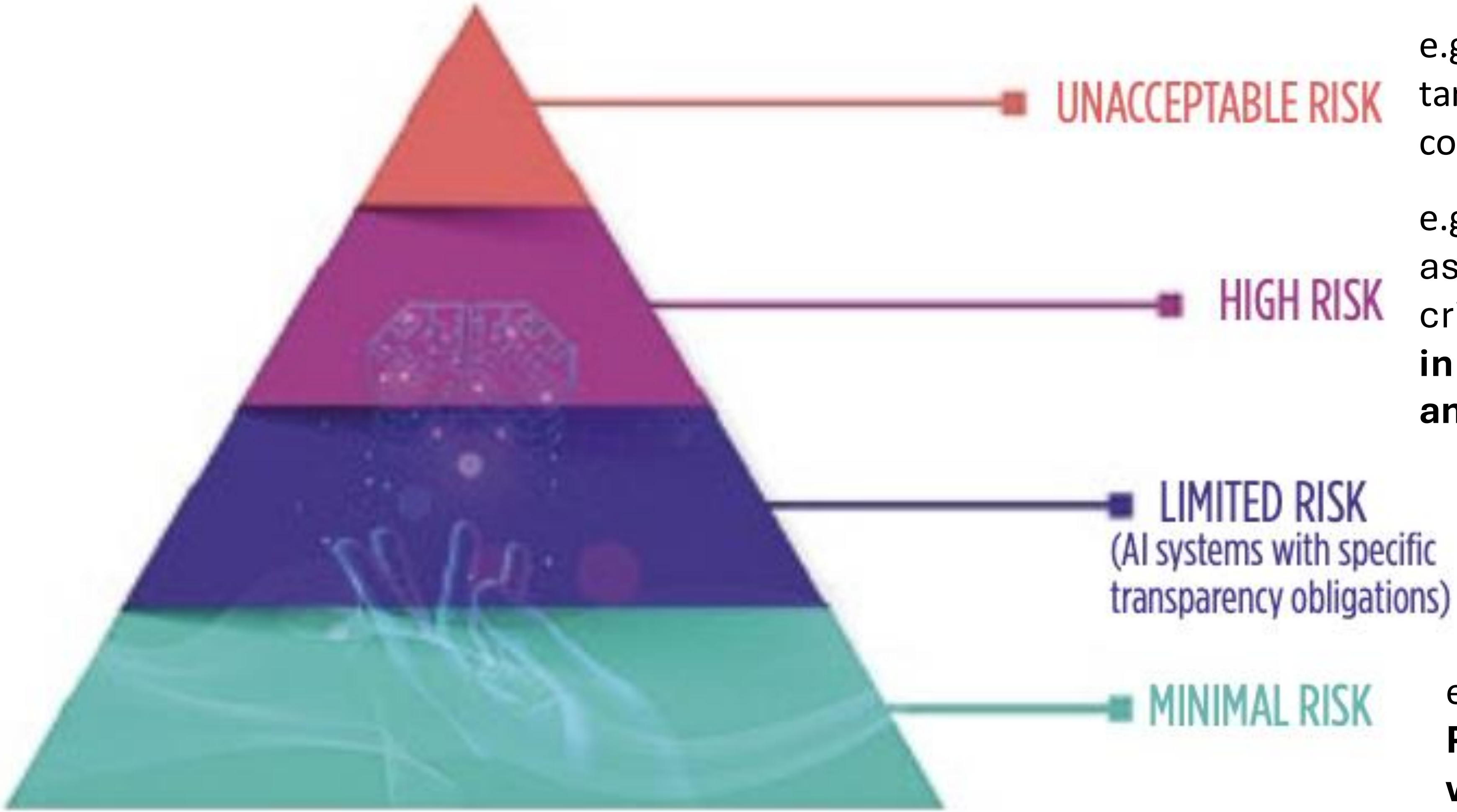
Pillar 2: Facilitating Business Commitments

•Framework to **accelerate adoption** of AI Act measures

•Encourages AI providers/operators to:

- Prepare in advance
- Adopt compliance strategies early

AI Risk Classification in the AI Act



e.g. Social scaring, advertising messages targeted at children, psychological conditioning → **forbidden**

e.g. credit scoring, personnel selection, assisted surgery, police operations, critical infrastructures → **Permission in compliance with AI requirements and prior conformity assessment**

e.g. chatbot → **Permission in compliance with transparency and information obligations**

e.g. videogames, anti-spam systems → **Permission without obligations but with a recommended code of conduct**

AI Act and enviromental monitoring

Currently, the AI Act does not contain specific articles on environmental monitoring through artificial intelligence. The existing provisions address environmental impact in a limited and non-binding manner.

BREAK

Module 5: Advanced technologies for environmental management

The Φ-lab Innovation Hub

•**Part of ESA's Climate Action, Sustainability and Science Department**
Focused on integrating AI, deep learning, and machine learning for real-time environmental monitoring → ESA's mission is to explore and protect the earth
•**Efficient analysis of massive satellite data**
Utilizes data from missions like **Copernicus** with unprecedented speed and precision
Key monitoring areas:
•Climate change
•Deforestation
•Sea level rise
•Air quality
•Rapid urbanization

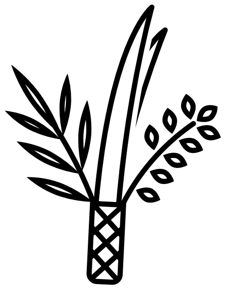
The Φ-lab Innovation Hub

Advanced capabilities:
•AI detects and analyzes land cover changes to protect forests and biodiversity.
•Edge computing & AI onboard satellites reduce data processing time, enabling faster crisis response (wildfires, floods, disasters).

Deep learning applications:
•Improve land cover classification and global forest mapping.
•Support continuous deforestation monitoring and ecosystem impact analysis.

Beyond environment:
•Combines satellite data with epidemiological models to predict vector-borne diseases (e.g., dengue).
•Enables rapid, targeted public health interventions to reduce risks and boost community resilience.

Precision agriculture & air quality monitoring

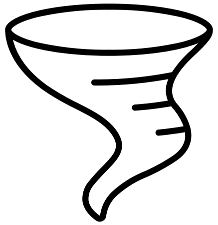


Precision agriculture:

•AI algorithms analyze satellite images to monitor crop health, predict yields, and optimize natural resource use (water, fertilizers).

•Enhances production efficiency and reduces waste.

•Supports sustainable, profitable farming and addresses global food challenges amid climate change.



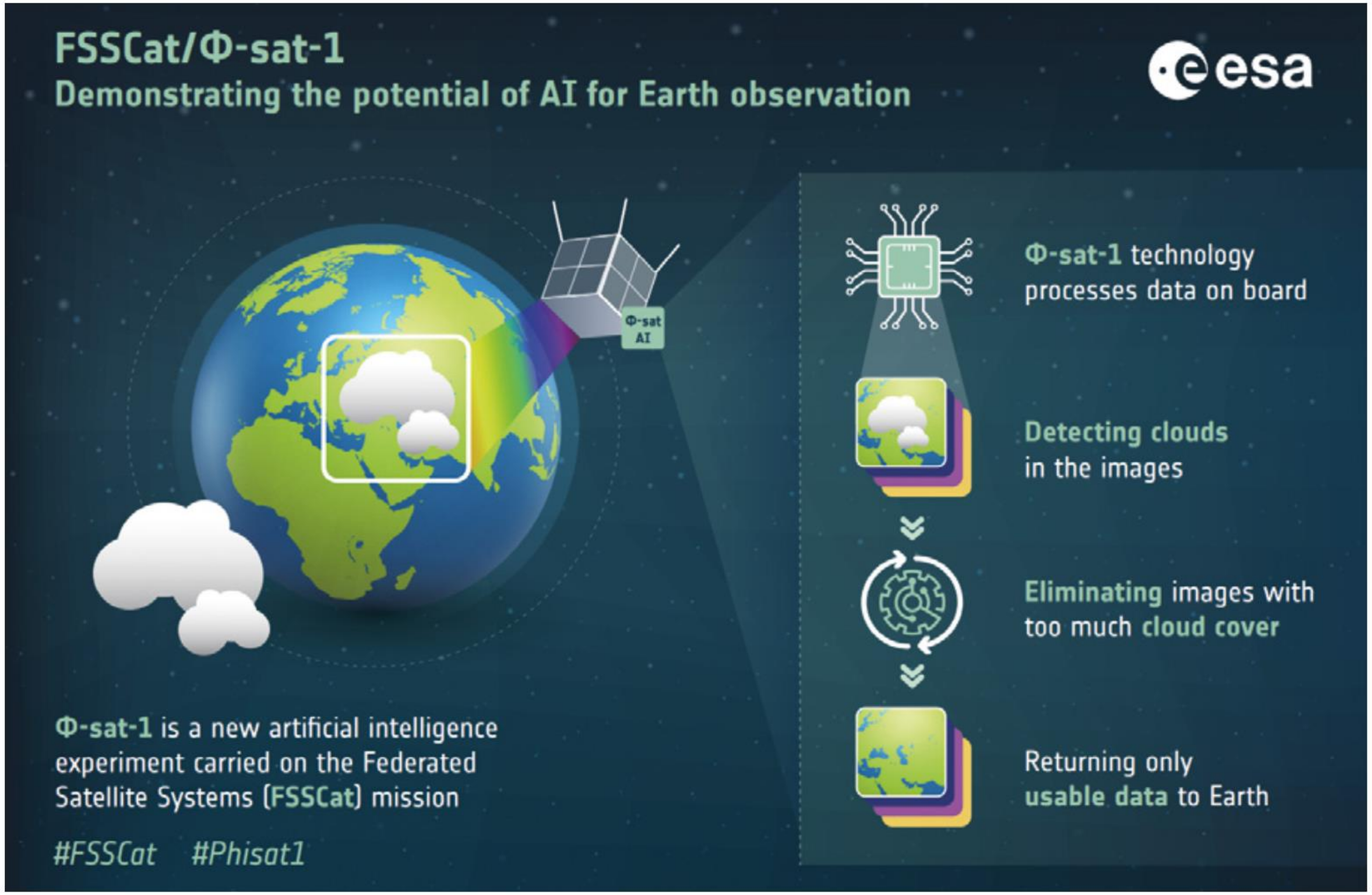
Air quality management:

•Φ-lab leverages satellite data (e.g., Sentinel-5P) to monitor pollutants like nitrogen dioxide (NO_2) and carbon monoxide (CO).

•Provides essential data for air quality policies.

•Supports new economic models to reduce emissions and improve public health.

Open platforms and democratization



CREDIT: ESA (2017)

Example: *Sentinel Hub*

Democratizes access to satellite data

Enables:
- Development of new applications
- Commercial solutions
- Competition between startups and large companies

- Dynamic ecosystem for innovation
- Maximizing technology potential for environmental sustainability

Enviromental data more accessible to everyone

CONVERSATIONAL ARTIFICIAL INTELLIGENCE HAS ENORMOUS POTENTIAL TO MAKE ENVIRONMENTAL DATA MORE ACCESSIBLE BY ALLOWING USERS TO ASK QUESTIONS IN NATURAL LANGUAGE.
WHAT TOOLS ARE AVAILABLE AND NEED TO BE DEVELOPED? WHAT ARE THE CHALLENGES TO ACHIEVE EFFECTIVE SOLUTIONS AND RELIABLE ANSWERS?

Enviromental data more accessible to everyone

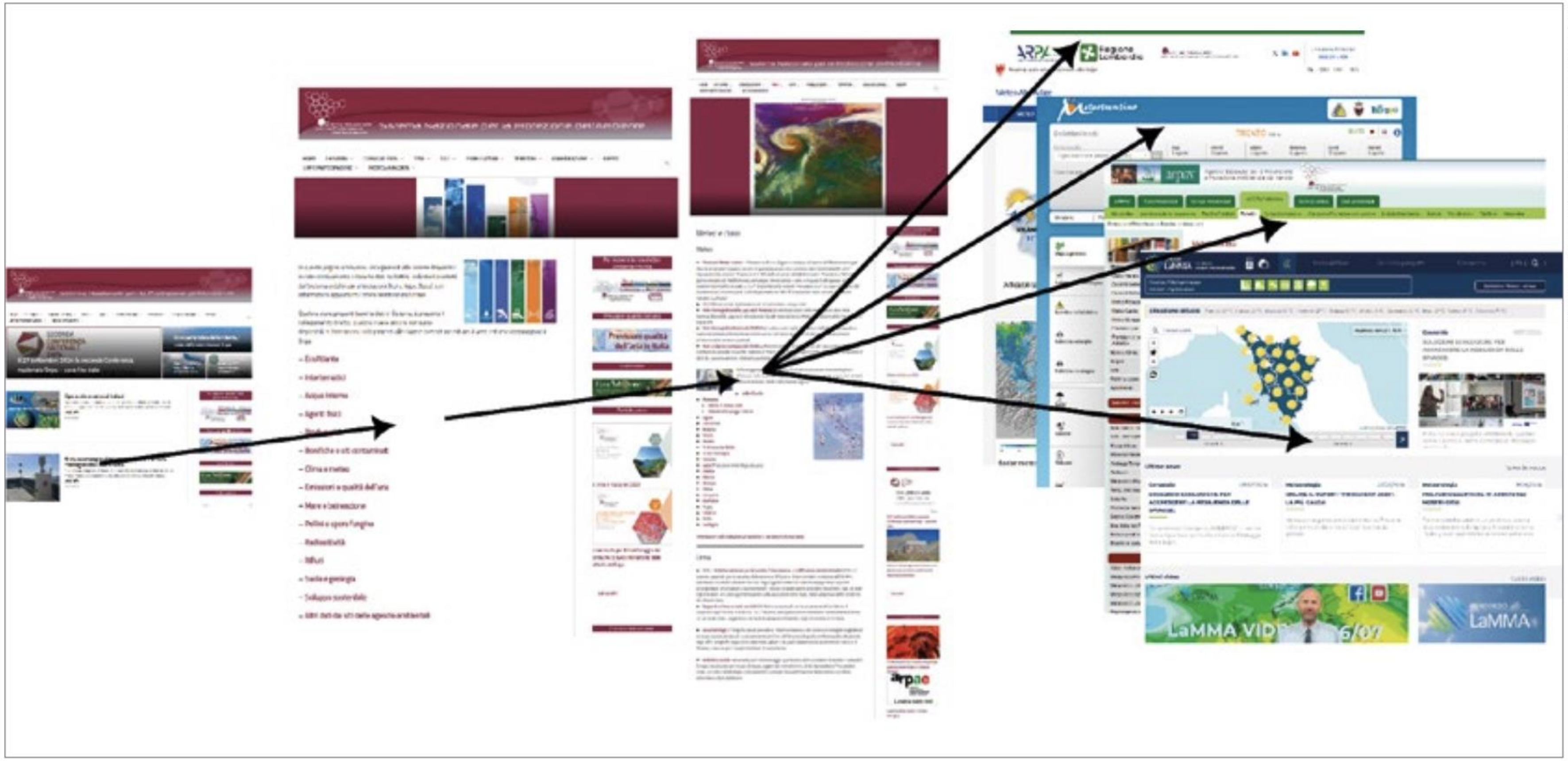


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FIG. 1 RICERCA DATI CLIMATICI
Rappresentazione del percorso di un utente alla ricerca di dati climatici per un confronto tra dati di regioni diverse.

AI tools enabling natural language access to data

- LLMs (Large Language Models) and RAG (Retrieval-Augmented Generation)

Limitations of LLMs
•May produce:
- Inaccurate or outdated information
- Confusion between similar terms in different contexts

•Challenges in specialized or rapidly evolving domains

Introducing the RAG Framework
•Combines LLMs with external knowledge sources
•Two main components:
- **Retriever**: finds relevant info from databases/docs
- **Generator**: produces natural language responses using retrieved info

Benefits of LLM + RAG
•More **accurate** and **context-aware** answers
•**Always grounded** in updated, authoritative sources
•No need to retrain the entire model
•Ideal for complex, dynamic domains like environmental data

- Transform how we interact with complex environmental data

Challenges of applying LLMs and RAG to environmental data

- Data often **fragmented** and from **heterogeneous sources**
- **Non-standard formats and schemas** complicate integration
- **Complex, context-specific causal relationships**
- **Technical language** difficult for general-purpose models
- **Unstructured and inconsistent** data further complicate processing

What's needed for effective AI solutions?

> **Domain-adapted retrievers**, using:

•**Embedding-based approaches**:

- Understand unstructured textual data

•**Graph-based approaches**:

- Represent spatial/temporal relationships and complex entity links

Challenges of applying LLMs and RAG to environmental data

Improving data quality and acessibility

- **Unify and centralize** data and documents
- Ensure:
  - **Well-structured, complete datasets**
  - **Comprehensive, gap-free document corpora**
- Result:
  - Enhanced retriever performance
  - **More accurate and faster responses**

Case study

FIG. 2 QUIVR
Un esempio di creazione di un sistema con Quivr: una volta aggiunta la conoscenza (a) è possibile interrogarla in linguaggio naturale in modo conversazionale (b).

Case study

FIG. 3 RAGFLOW

Esempio di interazione con RagFlow: l'agente, a cui è stata creata una base di conoscenza costituita unicamente da fogli di calcolo, comprende la domanda, seleziona e cita la fonte dati pertinente, restituisce il valore desiderato estraendola da essa, spiegandone il significato ed elaborando una valutazione contestuale.

BREAK

Module 6: AI for environmental and land monitoring

Artificial Intelligence and environmental monitoring

- In recent years, **AI has transformed** how we collect, analyze, and use data.
- It processes **large, complex datasets** quickly and effectively.
- AI is emerging as a **key tool** for studying environmental dynamics and **safeguarding the planet**.

Artificial Intelligence and environmental monitoring

Examining biodiversity

AI can link data from various sources to provide a clear view of biodiversity loss and potential response actions.

Energy sector

AI can improve the transparency and verification of carbon credits + optimize energy management by enhancing grid efficiency and reducing waste.

Water resource management

minimize losses and improve the efficiency of water use

Case studies

Applications in land monitoring

- **Land change monitoring**
  - Detects changes in land use/cover
  - Updates maps to track deforestation, urbanization
  - Supports spatial planning
- **Degraded area detection**
  - Identifies erosion and desertification
  - Enables timely land management interventions
- **Biodiversity mapping**
  - Combines satellite and field data
  - Predicts and supports species conservation
- **Detection of unauthorized infrastructure**
  - Analyzes urban imagery
  - Helps enforce building regulations

Artificial Intelligence for Land use and land cover (LULC)

- AI has significantly impacted the **mapping of land use and land cover (LULC)**.
- Uses **satellite and aerial imagery** to track environmental change.
- **Accurate LULC data** is vital for:
  - Assessing human impact on ecosystems
  - Supporting **sustainable land management**
  - Reaching **UN Sustainable Development Goals** (2015)

Current data and limitations

Copernicus Land Monitoring Service (Europe)

- Provides a **wide range of LULC datasets**
- Limitations include:
  - **Low update frequency**
  - **Inconsistent classification systems**

Challenges in LULC mapping

- Large volume and variety of satellite imagery
- Different **detection scales**
- Requires **specialized software and tech**
- Particularly complex in **urban and peri-urban areas** due to:
  - Rapid changes (e.g., construction)
  - Mixed **natural and human-made features**

Why AI is essential?

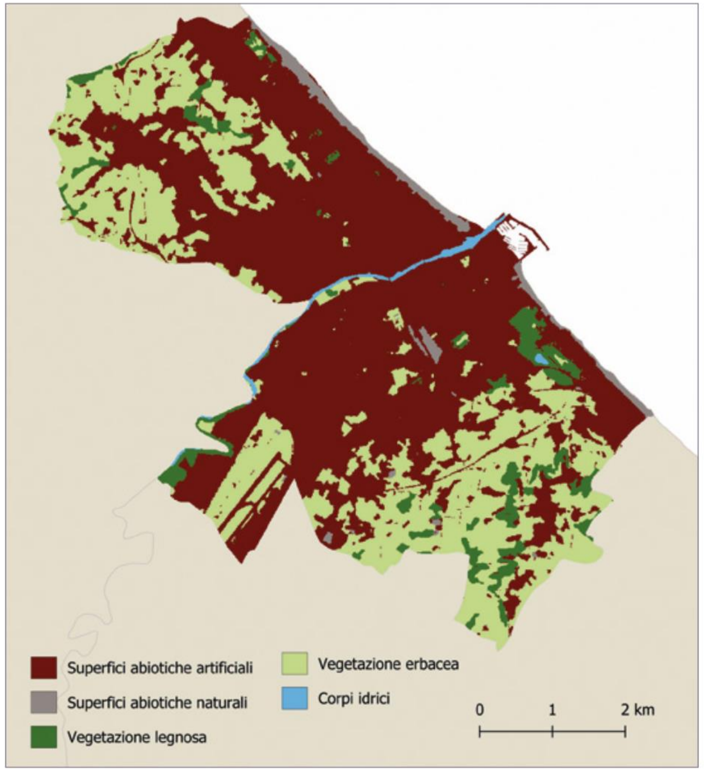
- AI manages and structures **huge data flows**
- Offers **scalable, advanced solutions**
- Supports **real-time, continuous monitoring**

ISPRA case study

- ISPRA applies deep learning (DL) on Sentinel-2 multispectral images for automatic land cover classification in Rome and Pescara.
- Two CNN models tested in Rome:
- **VGG16**: highest accuracy (~87%), excels in urban areas
- **DenseNet121**: slightly lower accuracy (~72%)
- Pescara study used 2018-2021 images + spectral indices (NDVI, NDWI).
- Temporal analysis shows better results using same period across years (75% accuracy), highlighting the importance of temporal generalization.
- Challenges: need for high-quality datasets and better model generalization.

FIG. 3
COPERTURA DEL SUOLO A PESCARA

Classificazione al 2021 ottenuta tramite deep learning.



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Perspective of AI in meterology

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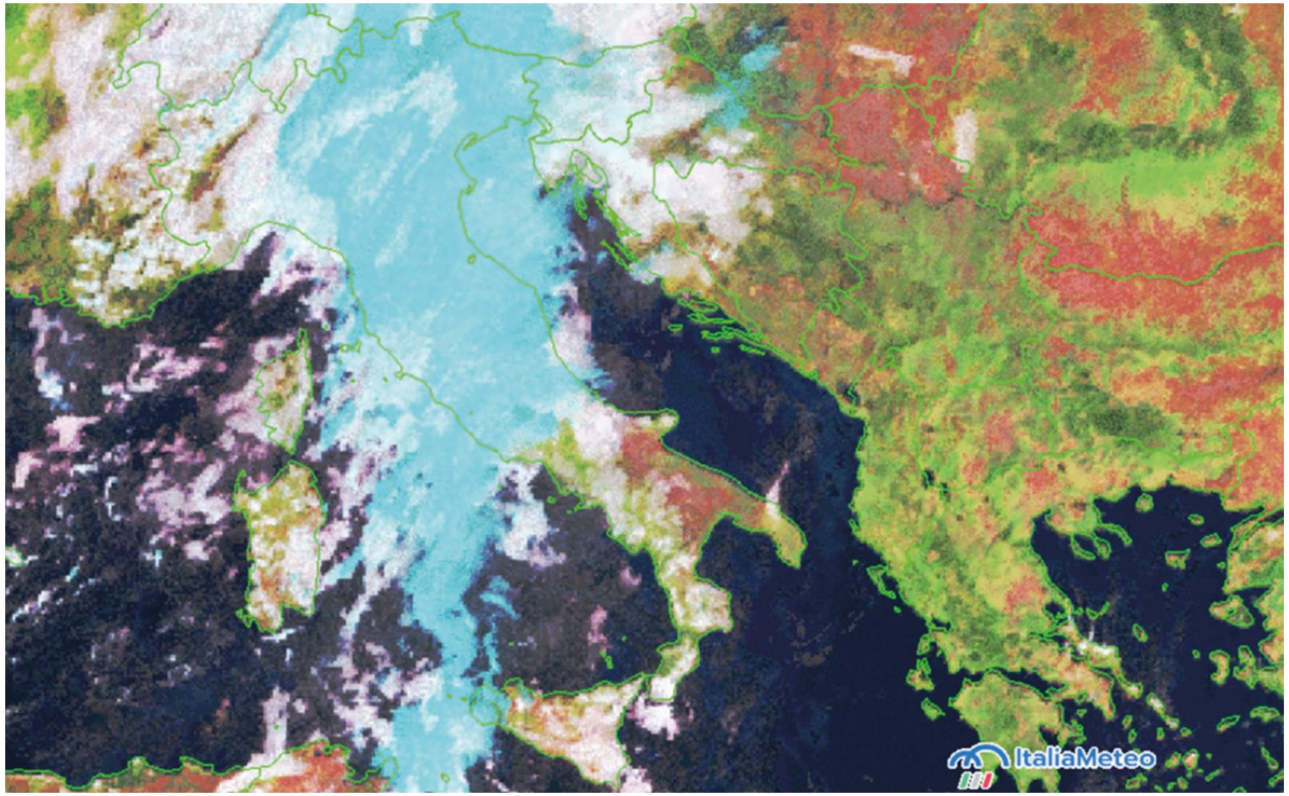
- Huge and growing volumes of meteorological data
- AI (Machine Learning) handles big data and complex relationships
- Improves accuracy and reduces computation time



Perspective of AI in meterology

Nowcasting (3-6 hours forecast)

- Traditionally based on radar data extrapolation
- AI analyzes satellite, radar, and sensor data to predict complex weather patterns
- Example: Google DeepMind improves precipitation forecasts beyond traditional methods
- Mia-Rad project: Deep learning with radar and lightning data

Short & Medium-Long Term Forecasts (2-15 days)

- AI accelerates models by emulating costly components with ML
- Parameterization of physical processes (radiation, turbulence, cloud microphysics) is key
- AI reduces forecast computation time
- Savings enable: higher model resolution, complex parametrizations, more ensemble runs
- Result: better overall forecast quality

Dependence on training data

- AI models rely heavily on training data.
- Except for nowcasting, data mostly come from reanalyses based on traditional physical models (e.g., ERA5).
- AI improvements are linked to advances in numerical models and data assimilation techniques.

Limitations of AI models

- AI excels at pattern recognition and optimizing complex processes.
- However, it lacks explicit physical understanding.
- This may reduce reliability in unusual or never-before-seen atmospheric conditions.

Balancing AI and numerical models

- Combining AI and traditional numerical models is essential.
- Goal: build forecasting systems that are more robust and efficient.

The future of meteorological modeling

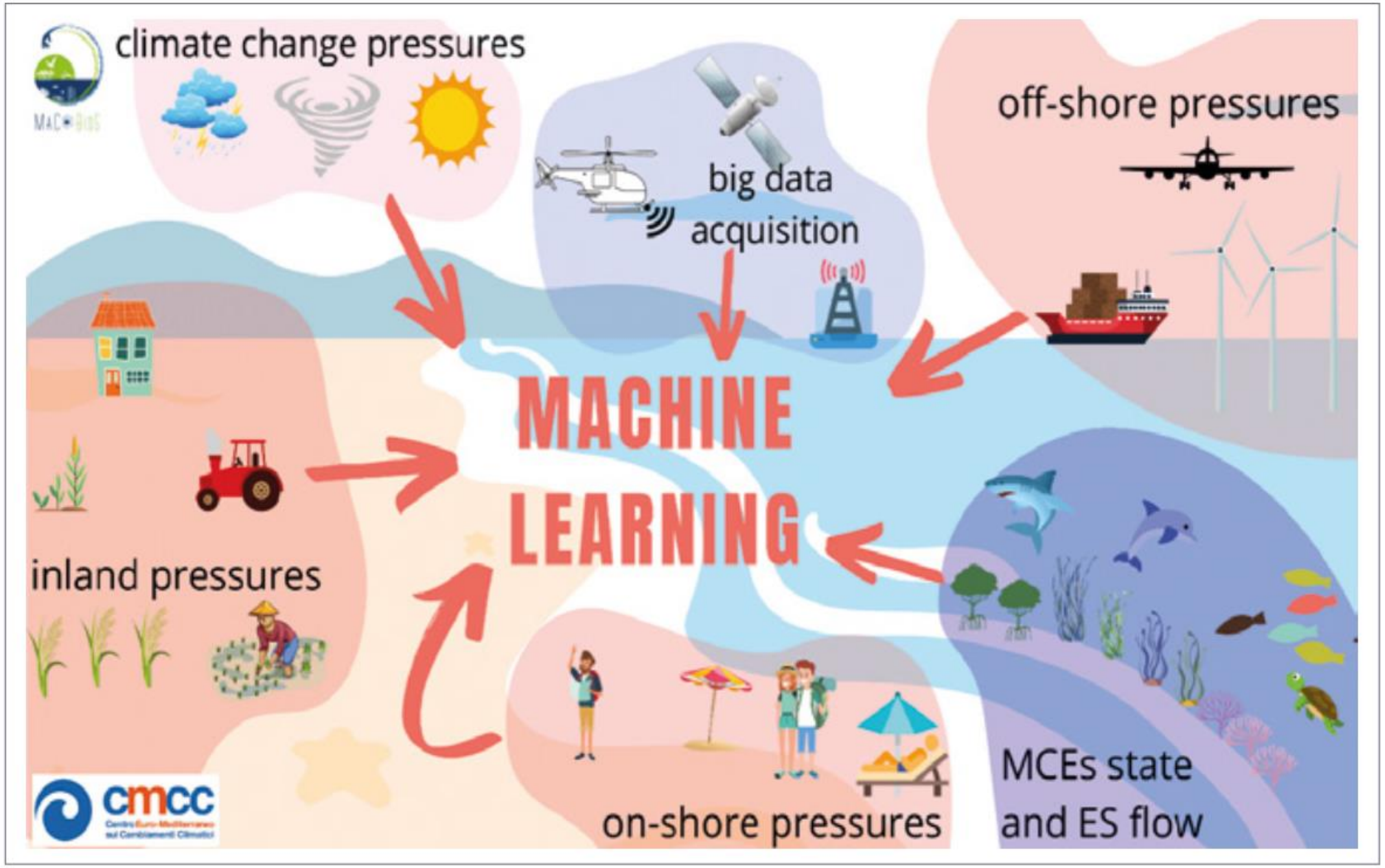
- Increasing use of hybrid systems (data fusion) combining AI and traditional models.
- ItalyMeteo Agency aims to:
- Develop AI models in collaboration with Italian stakeholders.
- Network available data and information.
- Improve forecasts of extreme, intense, and frequent weather events.
- Better meet stakeholder needs.

3

Blue Intelligence for marine and coastal areas

- The production and development of information are growing exponentially every day
- This transformation impact **environmental management** and the use of **marine-coastal ecosystems.**
- Data are continuously collected via satellites, aerial remote sensing, monitoring stations, ships, and buoys.
- These environmental data are essential for effective marine resource management and coastal protection efforts.
- Beyond environmental conservation, these data support economic activities such as fishing and tourism, promoting sustainable growth in coastal economies.

Interreg AdriaClim Project



Myriad-Eu Project

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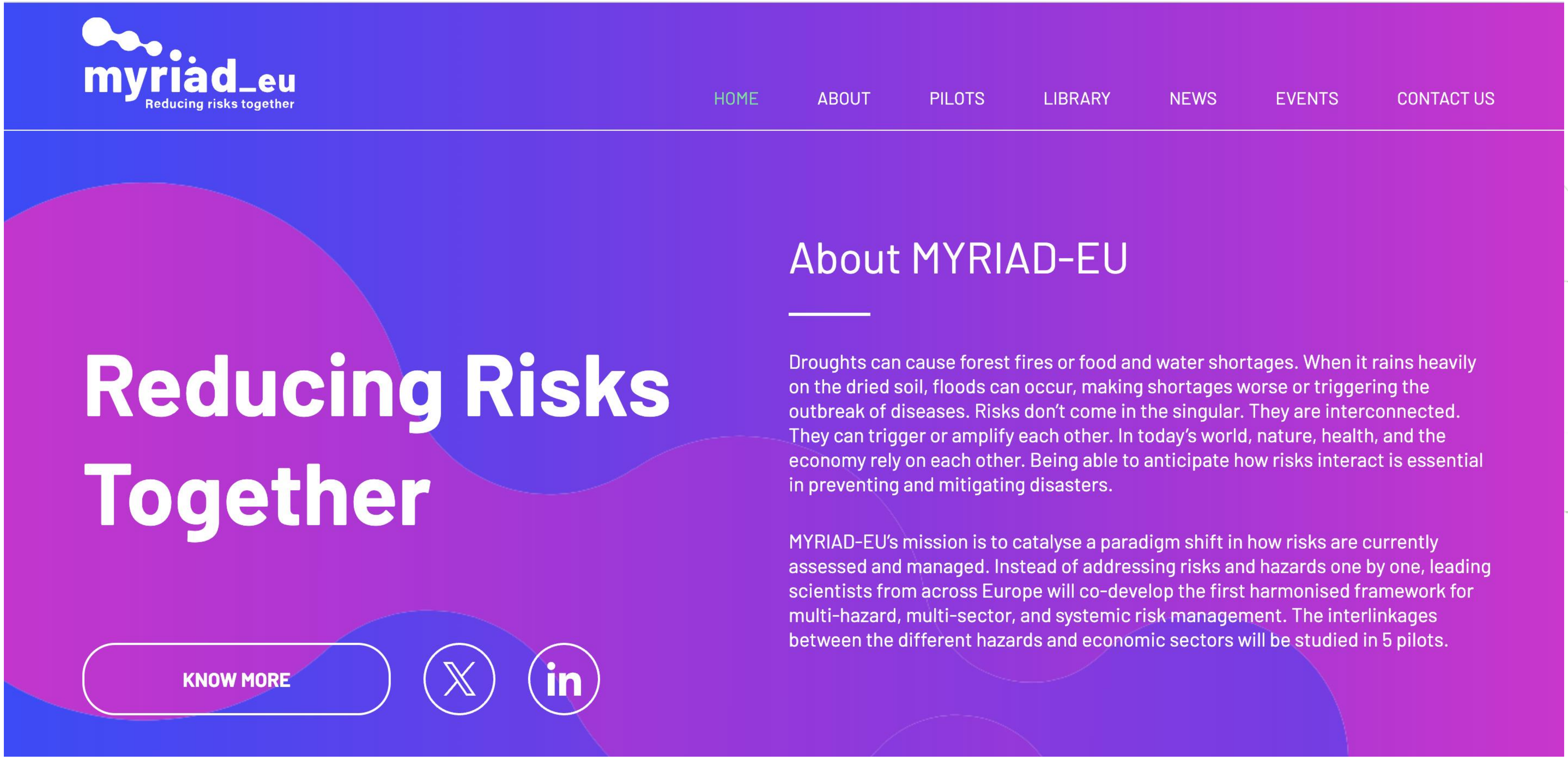

Myriad-Eu Project

- **Goal:**
  Enhance ML models to estimate risks from extreme weather under various climate change scenarios.
- **Focus:**
  Coastal risk factors in Veneto region, including:
  - Sea level rise
  - Precipitation
  - Wind
- **Approach:**
  Annual frequency and impact projections based on future scenarios.
- **Key Insight:**
  Multi-risk analysis considering combined factors amplified by climate change offers deeper understanding of worsening impacts along Veneto’s coastlines, aligned with IPCC Sixth Assessment Report guidelines.

BREAK

Project

Design a (even hypothetical) idea for using artificial intelligence to address a real environmental issue, considering both the potential benefits and the ethical and technical challenges.

- **Total time: 40–60 minutes**
  1. Choose an environmental problem (5 min)
- Each group selects an area, for example: Air pollution, deforestation, coastal degradation, biodiversity monitoring, urban energy consumption, flood or wildfire prediction
- **2. Design an AI application**

For the chosen problem, answer the following questions:

- What data is needed? (satellite images, sensors, open data, etc.)
- What type of AI would you use? (e.g. computer vision, NLP, predictive models, etc.)
- Who benefits from it? (public administrations, citizens, NGOs, researchers...)
- What are the ethical limitations?
- How can they be mitigated? (transparency, audits, participatory governance...)

- **3. Prepare a brief presentation:** each group prepares a quick presentation (2–3 minutes) of their project.

Source

1. Luciano Floridi, *Etica dell'intelligenza artificiale*, 2022, Raffaello Cortina Editore
2. *Ecoscienza – sostenibilità e controllo ambientale,* rivista di Arpae, n.4 – Ottobre 2024
3. https://www.isprambiente.gov.it/contentfiles/00003800/3874-rapporti-02-27.pdf/
4. https://www.ecmwf.int/sites/default/files/elibrary/2006/9299-bias-correction-environmental-monitoring.pdf
5. David B. Olawade a,b,c,* , Ojima Z. Wada d , Abimbola O. Ige e , Bamise I. Egbewole f , Adedayo Olojo g , Bankole I. Oladapo, *Artificial intelligence in environmental monitoring: Advancements, challenges, and future directions,* 2024
6. https://www.ecmwf.int/sites/default/files/elibrary/2006/9299-bias-correction-environmental-monitoring.pdf

THANKS!

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