



This project is part of the PRIMA programme supported by the European Union

# AI Methods & Proposals

AI4Water Project



Università  
di Brescia



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# Machine & Deep Learning Methods

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# Traditional Approaches

- **Physical & Conceptual Models:** Hydrological models based on strict physical equations (e.g., MODFLOW, SWAT).
- **Statistical Methods:** Historical averaging and linear regression for forecasting
- **Limitations:**
  - Highly reliant on extensive, hard-to-calibrate parameters.
  - Computationally heavy for high-resolution or real-time simulation.
  - Struggle to capture complex, non-linear environmental dynamics.

# Main Concepts: Machine & Deep Learning

- **Machine Learning (ML):** Algorithms that ingest data, learn from it, and make decisions based on the patterns seen in the data, without being explicitly programmed for every step.
- **Deep Learning (DL):** A subset of ML using artificial neural networks (**ANN**) with multiple layers to extract complex features and patterns.
- **Data is the Fuel:** AI models are inherently data-driven. Their accuracy and reliability scale directly with the quality, quantity, and diversity of historical data.

# Candidates for forecasting/estimation

Precipitation

Water quality

Water level

Water demand

Crop Type

Evapotranspiration

# Prediction requirements

- **The Importance of Scale:**
  - **Temporal Resolution:** Different problems require different time steps availability (e.g., daily data for monitoring water quality vs. monthly/annual data for aquifer depletion).
  - **Historical Depth:** Long continuous records are necessary. Models need to "see" past events and extremes (severe droughts, 100-year floods) during training to predict them in the future.
- When using **Remote Sensing Data** its important to validate it with local information

# Combining AI with Traditional Methods

- **Bias Correction:** Refining coarse or biased forecasts (e.g., ECMWF seasonal precipitation forecasts) using local historical data to ensure regional accuracy.
- **Downscaling:** Converting low-resolution global climate data into high-resolution, localized datasets.
- **Output Refinement:** Using ML to correct the residual errors of traditional physical models.

# Surrogate Models

- **What is a Surrogate Model?** An AI model trained directly on the inputs and outputs of a complex physical model to mimic its behavior and predictions.
- **Advantages:**
  - **Speedup:** Executes in fractions of a second instead of hours or days. These models can predict hydraulic heads, storage changes, and flow patterns significantly faster.
  - **Scenario Testing:** Ideal for real-time decision making, rapid "what-if" scenario testing, and multi-objective optimization.

# Transfer Learning

- **Concept:** Training a model on a data-rich region or domain (e.g. Euro), and fine-tuning it for a data-scarce region.
- **Value for AI4WATER:**
  - Could help us solve the lack of local data
  - Leverages global structural similarities and uses the limited local data to calibrate

# Unsupervised Learning

- **Clustering Techniques:** Grouping unlabeled data to find hidden patterns.
- **Application in Hydrology:**
  - Analyzing well-water level fluctuations and water quality (e.g., salinity measurements) across different sites.
  - Identifying which geographically distinct wells are actually linked to the same underlying aquifer system.

# Crop Type Classification

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The NASA PRESTO model



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## Harmonised Reference Data

Reference Data Collections

Public Collections available as input for processing

Collection	Country	Year
140	97745040	2018

<https://rdm.esa-worldcereal.org/>



Free and easy access to public datasets

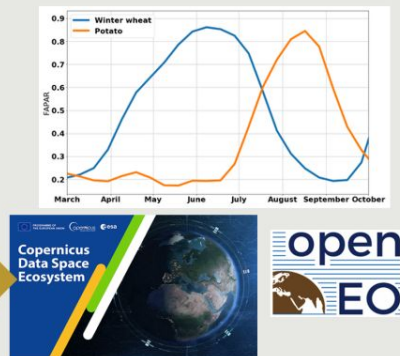


Large Language Models for automated harmonisation



Keep your data private or share with community

## Pre-Processed Inputs



Sentinel-2  
Sentinel-1  
AgERA5 meteo  
Copernicus DEM

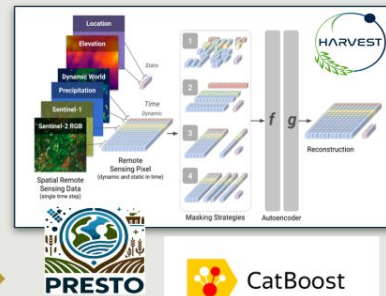


Standardised processing



Easily scalable

## Generic and Flexible Models

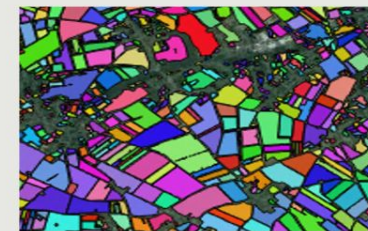


Use of AI Foundation Model to extract relevant features



Custom pixel-based crop identification model

## Season-Specific Crop Maps



Use our pre-trained global models or train and deploy custom models for your area, season and crop types



Intuitive web interfaces to generate your maps

# Custom Crop Mapping Made Easy

Powered by Cloud Computing and AI



WorldCereal

# What is missing?

- Validation on our case studies
- No classification for permanent crops
  - Possible extension by custom training and using transfer learning



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Thank you for your attention!



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