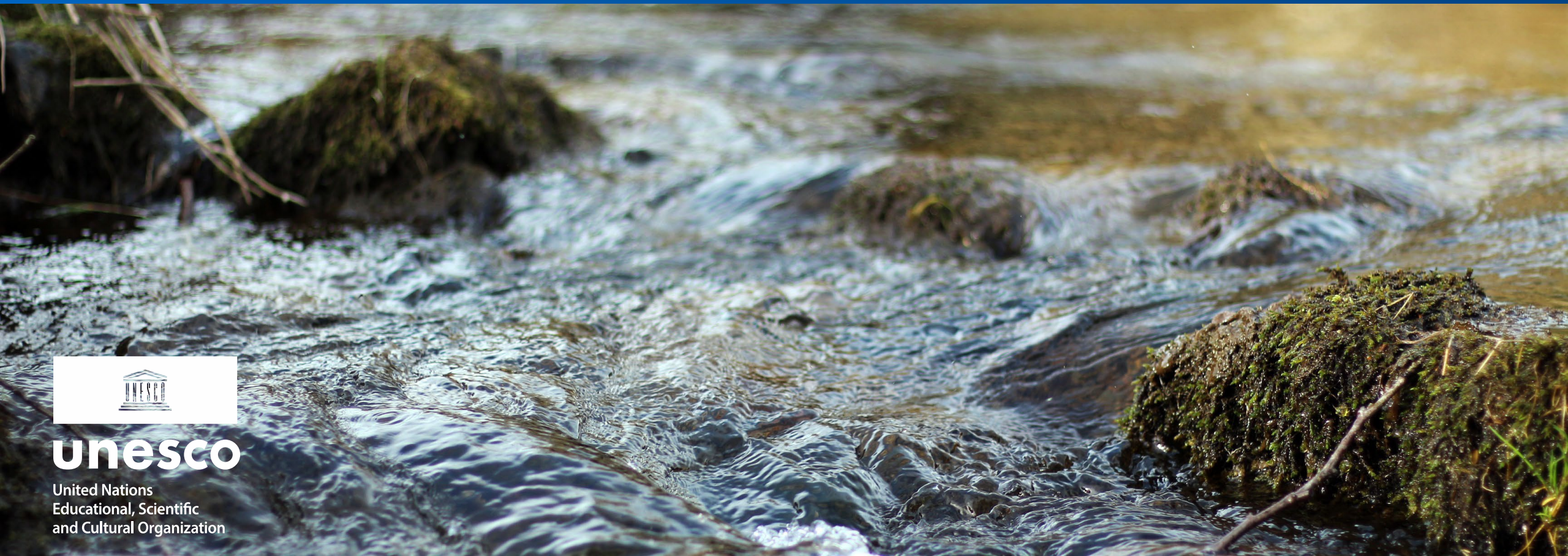
# AI/ML Applications for Water Resources Management

Dr. Koen Verbist, Programme Specialist, Intergovernmental Hydrological Programme, UNESCO



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# Brief introduction of UNESCO's Natural Sciences Sector Work on AI

# AI for the Planet Alliance

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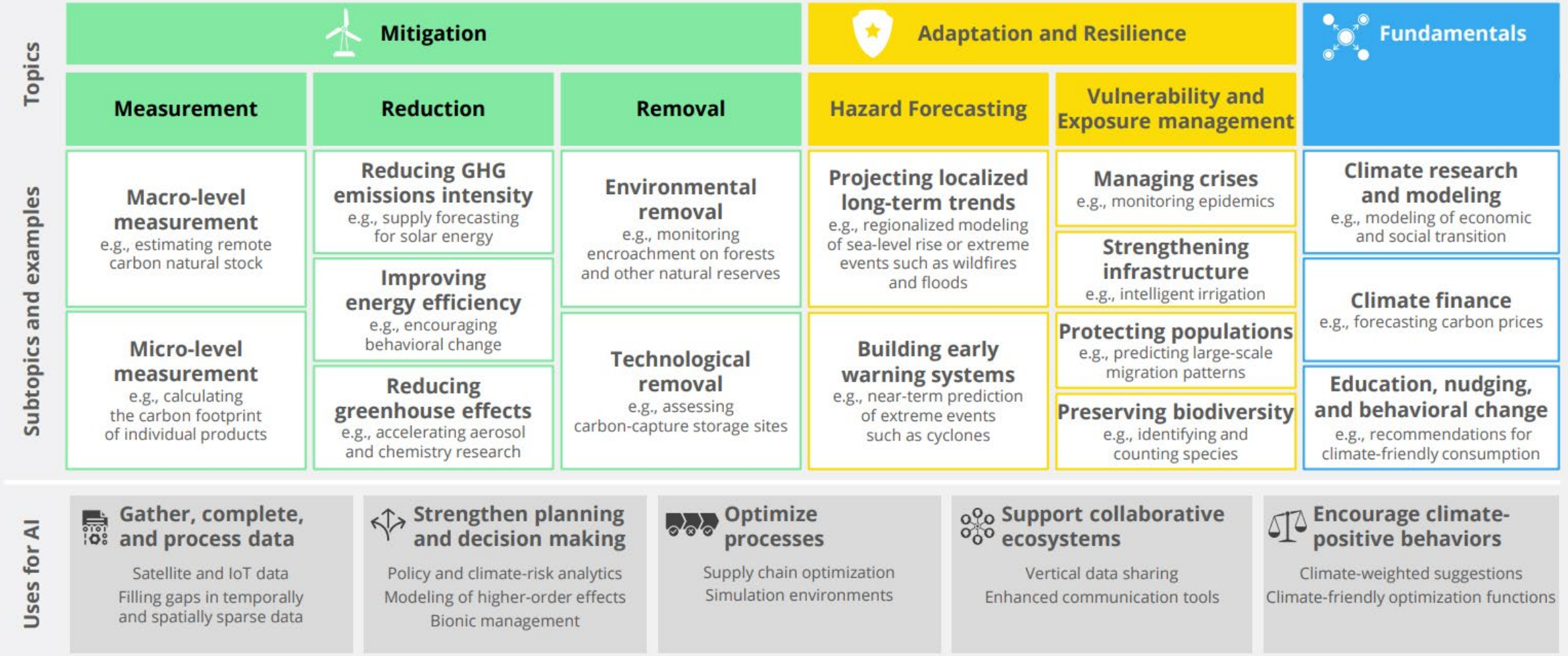
# Framework for Using AI in Combating Climate Change




**Sources:** BCG project experience; Climate Change AI, "Tackling Climate Change with Machine Learning"; Global Partnership on AI, "Climate Change and AI: Recommendations for Government Action."
**Note:** GHG = greenhouse gas; IoT = Internet of Things.

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# Activities of AI for the the Planet Alliance

AI for the Planet Alliance is a newly formed neutral and international alliance to drive AI solutions for climate change at scale, seeks to catalyze global efforts in this domain through research and advocacy.

**Promote innovation**

in applying advanced analytics and artificial intelligence (AI) to climate challenges, supported by global experts from academia, startups, and the public and private sectors.

**Act as a global platform**

for identifying and prioritizing the leading tools and uses for AI in addressing the climate crisis.

**Identify and champion the most promising solutions**

to address climate change mitigation, as well as adaptation and resilience, especially in the Global South, giving the solutions visibility and recognition.

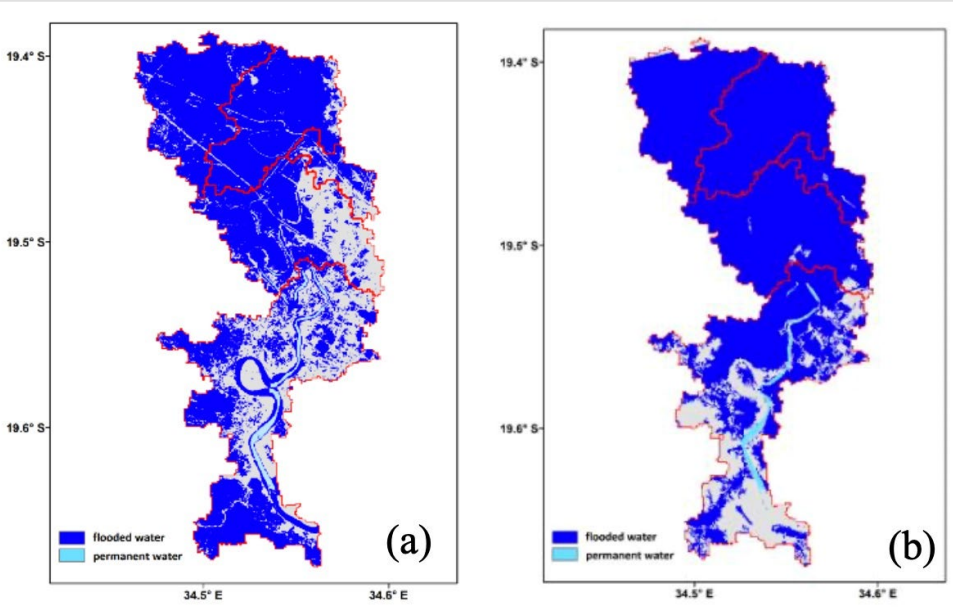
**Ensure impact at scale**

through concrete and measurable actions such as building access to funding and to practitioners on the ground.

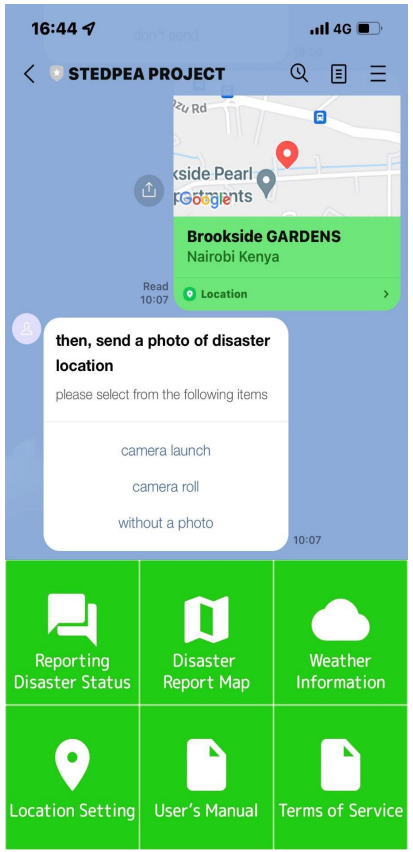
**Facilitate the development of networks**

among project teams, investors, and experts in the field— including startups, corporations, and the public sector.

# Other AI pilot activities



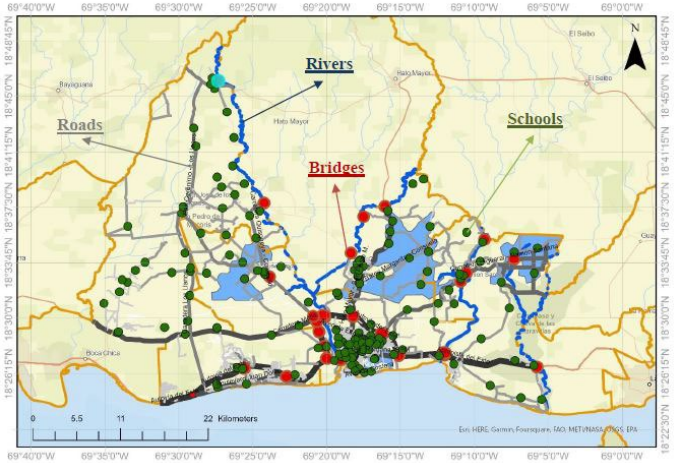

**24-hour forecast of inundated areas at 30-m resolution for the five sub-catchments of the lower Pungwe Basin, and b) effectively inundated areas during Cyclone Idai**




**AI Chatbot to improve the communication of disaster risk reduction**

**Publication on AI for Hydrology (end of 2024)**

## Applications of AI/ML in water management




**By tracking the functionality of the integrated School-Road Networks, the AI algorithm calculates an optimized solution to minimize the disruption of education during flood and earthquake hazards**

# AI/ML applications for water resource management

# AI: Artificial or synthetic Intelligence

Definitions (source: Chat-GPT):

- **Artificial Intelligence** (AI) is the theory en development of computer systems that can perform tasks that normally require *human intelligence*,
  such as visual perception, speech recognition, decision-making and translation between languages.
  … and can repeatedly improve itself based on gathered information.
- **Machine learning**: a subset of AI where algorithms can improve their performance over time as they are exposed to more data.
- **Deep learning**: a subset of machine learning where multilayer neural networks learn from vast amounts of data.
- **Neural Network**: series of algorithms used in machine learning that can recognize patterns and relationships in large amounts of data. Neural networks use a logical structure inspired by the human brain and form the basis for deep learning algorithms.

# Artificial Intelligence as a part of ‘Data Science’

AI ’Fields of Work’:

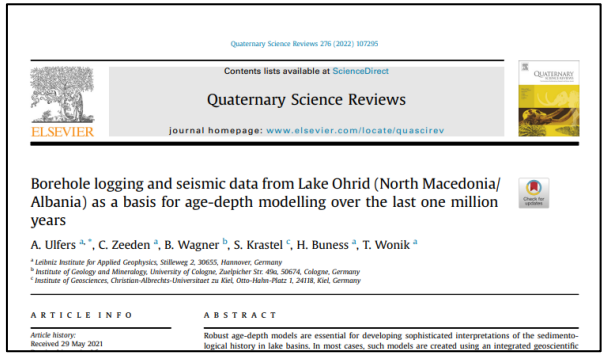
1. Generative AI
   - Large Language Models (LLM’s)
   - e.g. ChatGPT by OpenAI: advanced chatbot
2. AI-based processing and analysis of large datasets
   - Photo’s, video's, remote sensing data
3. 'Data-driven’ model building
   - Classification
   - Regression
   - Clustering
4. Emulators or 'Surrogate Models’
   - Simulating existing numerical models

# 1. Generative AI

## Extractie of grondwater data from ‘grey literature’

**Data mining based on OpenAI API (ChatGPT)**

Document with text/images (e.g. reports, engineering files, scientific articles)


Quaternary Science Reviews 276 (2022) 107295

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Borehole logging and seismic data from Lake Ohrid (North Macedonia/Albania) as a basis for age-depth modelling over the last one million years

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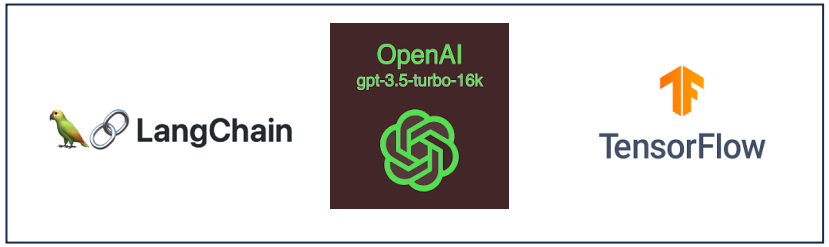
ARTICLE INFO

*Article history:*
Received 29 May 2021

ABSTRACT

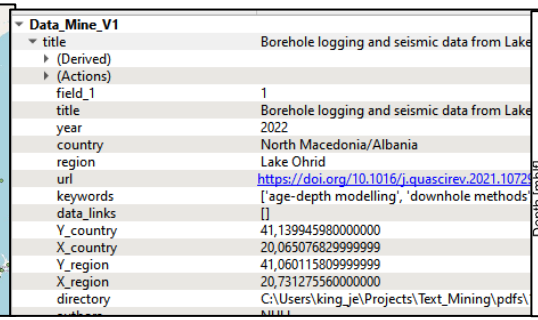
Robust age-depth models are essential for developing sophisticated interpretations of the sedimento-logical history in lake basins. In most cases, such models are created using an integrated geoscientific

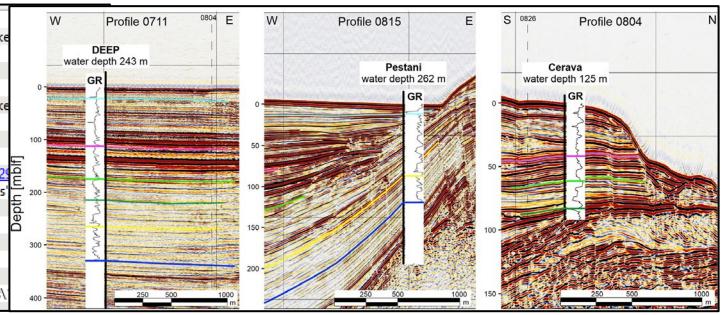
Python script with APIs




Contextual query:
(e.g. give me all borehole and seismic essays in Albania)

Catalogued and georeferenced data




1. Select georeferenced data 2. Check information 3. Extract automatically classified images

# 1. Generative AI

## Better and faster coding of software

Easier coding of (tooling)software:

- GitHub Copilot: developed by GitHub in collaboration with OpenAI, works like a virtual co-coder that helps developers write better codes faster.

Recent (januari 2024):

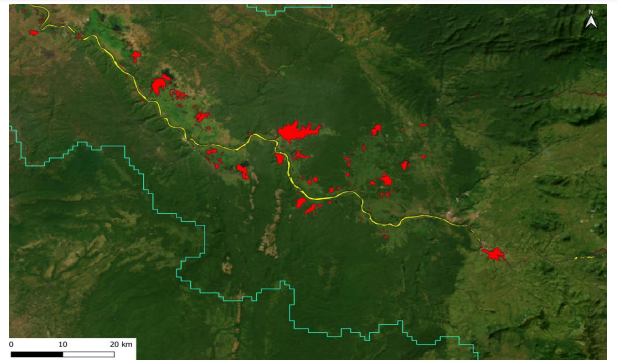
- OpenAI:
  *"We're launching the GPT Store to help you find useful and popular custom versions of ChatGPT"*

# 2. AI-based processing and analysis of large datasets

## Computer Vision CNN

**Automated detection of infrastructure from remote sensing (Dams detection)**

- Missing infrastructure (dams) in public/government records. Knowing the location, type and characteristics of dams is essential for quantifying and managing risk.
    1. Automated detection/classification of reservoirs
    2. Detection and segmentation of dam bodies and dam type (relevant for failure probability)
    3. Early Warning Systems for floating Vegetation Events

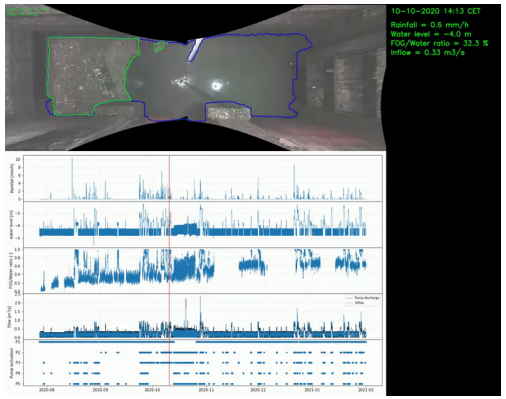


**Laboratory setups**

- Hydraulic Laboratory – Automated plastics detection and 3D path reconstruction. Image processing for targeted object detection and time-space tracking.

## FATracker

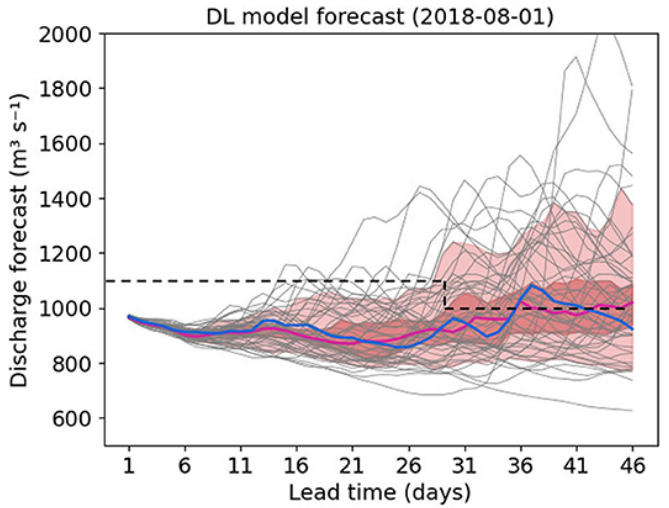
- Pumping station fat-oil-grease detection

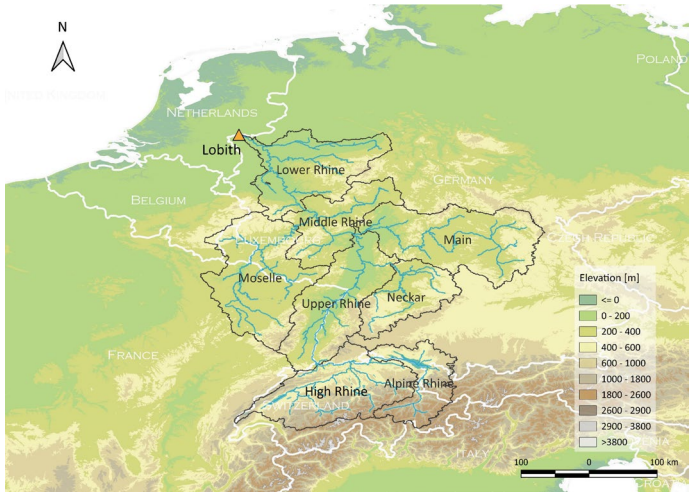


# 3. 'Data-driven' model building

## Operational low-flow forecasting model near Lobith

- Long-Short-Term-Memory-based model architecture has been designed to use both historical observations and predicted meteorological data to perform low water level forecasting for the Rhine at Lobith on a daily basis, with lead times of up to 46 days in advance.
- Long-Short-Term-Memory (LSTM) neural networks have outperformed traditional Rainfall-Runoff (RR) models in quality for several years:
- An RR model is a 'black box model'; it contains no deterministic concepts, precipitation and downstream discharge are 'fitted'.
- A neural network is a form of 'multi-dimensional regression' and 'discovers' patterns that are not in the fitted 'black-box' model.




Recent HESS-artikelen, by Kratzert et al. :

- Towards learning universal, regional, and local hydrological behaviors via machine learning applied to large-sample datasets
- Toward Improved Predictions in Ungauged Basins: Exploiting the Power of Machine Learning

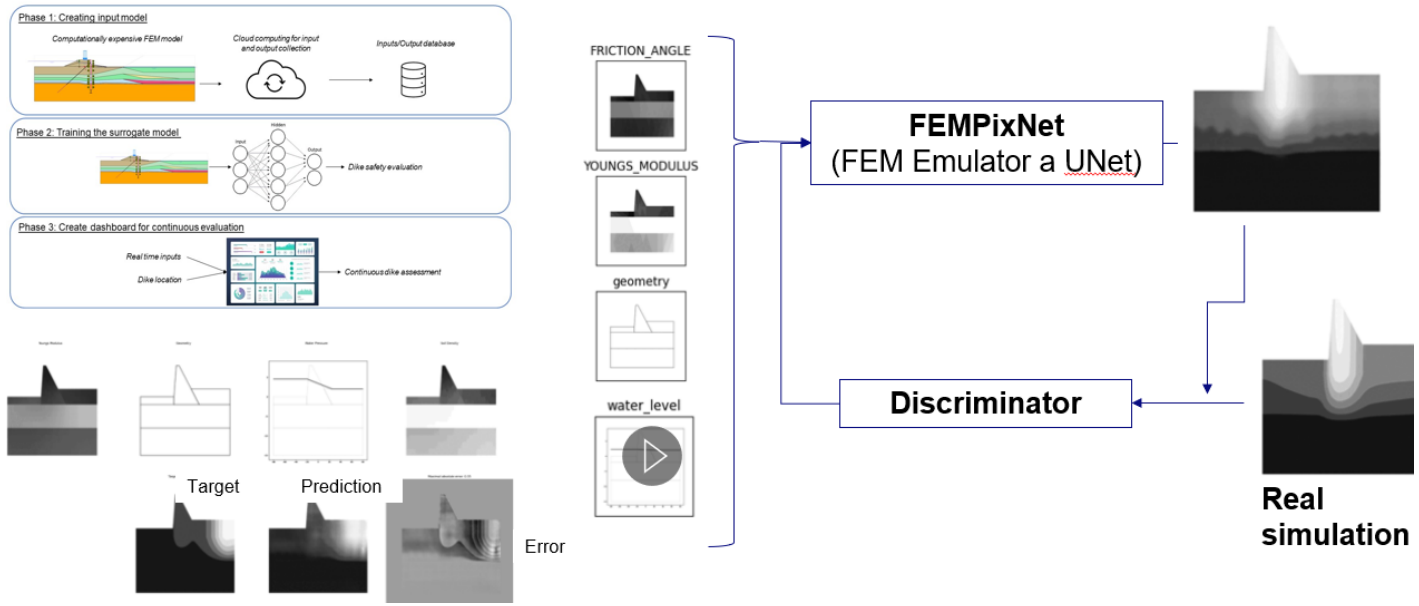
# 4. Emulators or 'Surrogate Models'

## 2D flood modeling:

- D-Flow FM, 3Di, HEC-RAS, TUFLOW, etc. contain physical deterministic concepts, for example, 'flooding over land surface'; however, they have long computation times.

## Model Emulation: GAN based emulator of a sheet pile installation (FEMPixNET)

- Computationally expensive FEM model of a sheet pile (Kratos + STEM)
- 5000 simulations (cloud-based as training set)



# Thank you

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