CAPSTONE PROJECT

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AI for Earth’s Future

AI-powered Risk Analysis of Wild River Shifts

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AI for Earth’s Future

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EnvAIron Team

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Causes & Consequences | River Shifts

1. Erosion and sedimentation constantly reshape riverbeds.
2. Unpredictable changes increase the risk of flooding and infrastructure damage **(e.g., 2024 in Southern Germany)**:
   - Six fatalities and missing persons
   - + 2 Billion Euro

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Motivation

- Early warning system based on highly accurate prediction models
- Economical solution:
  - Alternative to costly, complex and physically-based water models in the Alpine region.
- Optimize interventions to:
  - Protect infrastructure
  - Preserve natural river dynamics

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Goal

- EnvAIron develops reliable models to predict river dynamics for specific project areas in the Alpine region.
- Predict the risk of river shift courses based on different scenarios
  → **Take measures like sediment removal**

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Data Sources

- Sentinel-2 L2A
  - Satellite Images
- Gewässerkundlicher Dienst Bayern
  - Discharge
  - Water Level
  - Precipitation

Bayerisches Landesamt für Umwelt

→ **Challenges: Limitation of satellite data due to temporal availability and weather**

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Methodology & Technology Stack

- Data Collection | Feature Engineering (i.e., Additional Factors, **G**oogle **E**arth **E**ngine and **N**ormalized **D**ifference **W**ater **I**ndex)
- Algorithm Selection : **C**onvolutional **N**eural **N**etwork, **L**ong **S**hort-**T**erm **M**emory
- Building Model
    - Training Model: Train-Generator Function
    - Evaluation Model Performance (Intersection of Union):
        - 94% of the river courses are predicted correctly.
- Local hosting with Streamlit

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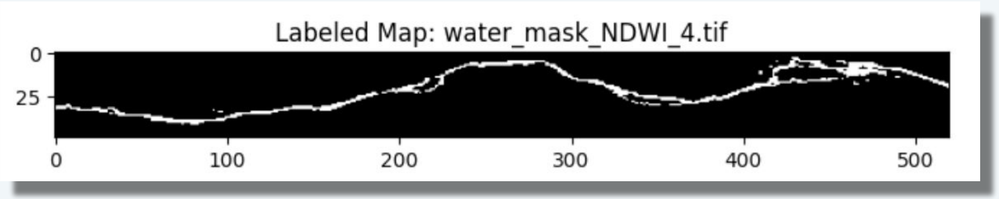
Processing of Satellite Images

⇒



Sentinel-2 L2A Image

Binary-labeled Water Mask

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Sentinel - 2 Satellite Imagery

Gewässerkundlicher Dienst

Satellite Data Processing

Filter Images
Date Range, Cloud Cover < 30%, Snow Cover < 3%

Calculate NDWI
The Normalized Difference Water Index

Create Water Mask
Individual Threshold: 93rd percentile

Additional Data Processing

Hydrological Factors
Discharge, Precipitation, Number of Extreme Events

Temporal Features
Time Differences, Month One-Hot Encoding

Deep Learning Model

CNN | Image Processing
Spatial Information

Long-Short Term Memory
Temporal Information

Model Structure
3 Input Layers: 5 Past Sequential Water Masks + 5 Past Additional Factors + 1 Future Additional Factor (e. g. weather forecast)

Evaluation Metrics
Intersection of Union, Accuracy, Visual Inspection

Output
River Shift Visualization
based on scenario

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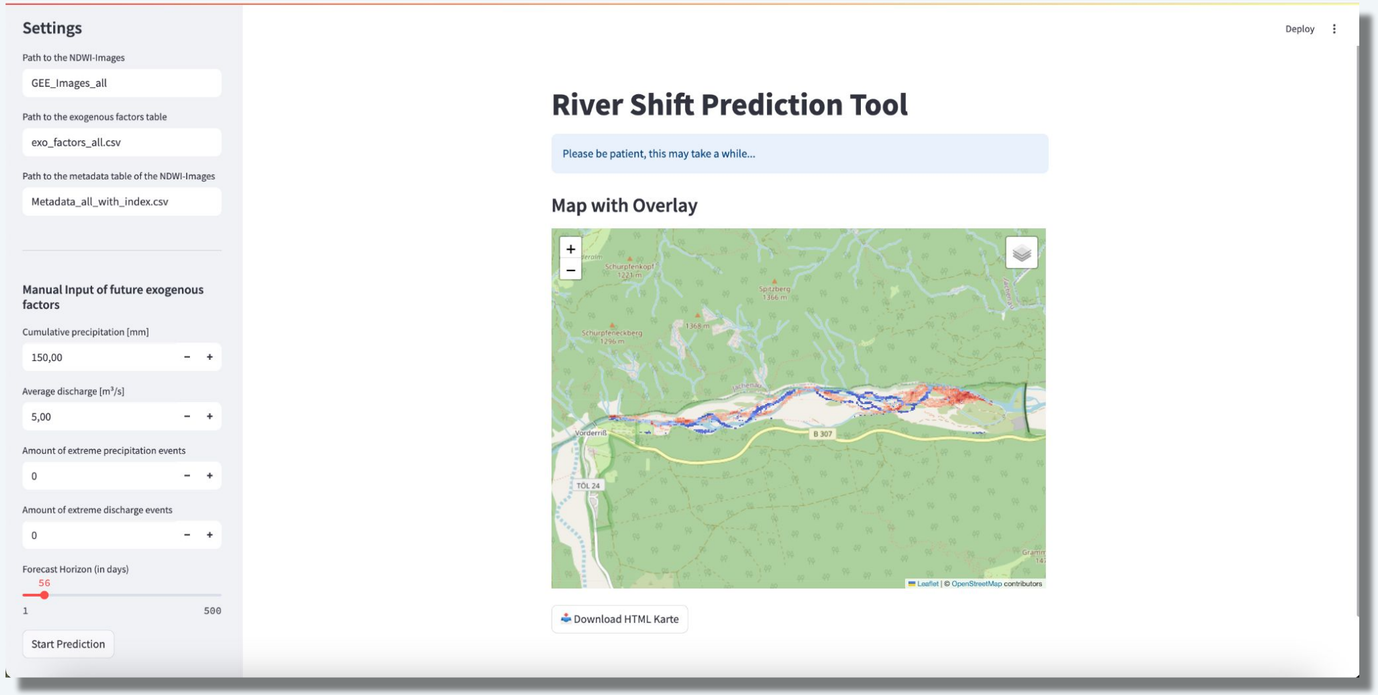
Interface of the Streamlit Application



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Challenges

- **Challenge - Limitations** of Sentinel-2 Imagery
  - Global availability ⇒ since April 2017
  - Resolution ⇒ 10 m
  - High cloud coverage
- **Web Scraping** ⇒ Digitalization of reliable sources (e.g., national authorities)
- Implement the elevation model and update it based on sedimentation and erosion processes

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Future Developments

We cannot predict the future, however we can prepare for that!

- **Autonomous Systems**
  - Deploy drones / unmanned aerial vehicles for hyperlocal imagery to fill gaps in satellite data coverage.
- **Sensor Integration & WebScraping & API Integrations on critical areas**
  - Fuse IoT data (e.g., water level, soil moisture) with satellite feeds

THANK YOU!