

CAPSTONE PROJECT



AI for Earth's Future



AI-powered Risk Analysis of Wild River Shifts



EnvAlron

AI for Earth's Future



EnvAlron 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

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



Goal

- EnvAlron 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**

Data Sources

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

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



Bayerisches Landesamt für
Umwelt



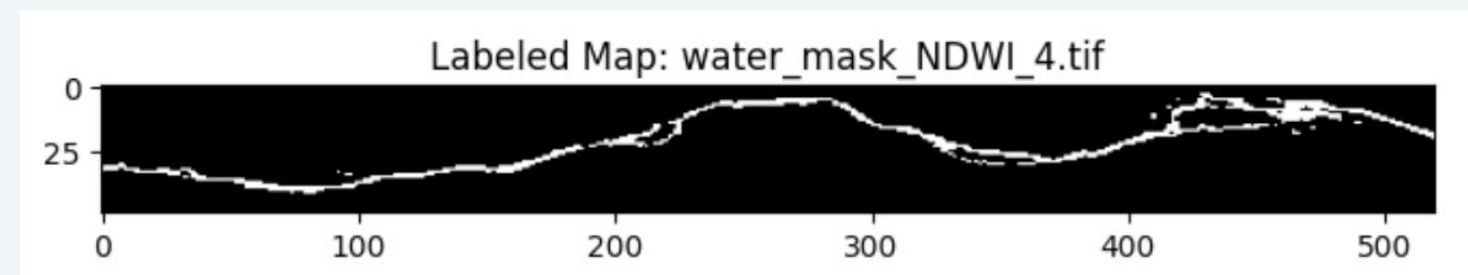
Methodology & Technology Stack

- Data Collection | Feature Engineering (i.e., Additional Factors, **Google Earth Engine** and **Normalized Difference Water Index**)
- Algorithm Selection : **Convolutional Neural Network**, **Long Short-Term Memory**
- 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

Processing of Satellite Images



Sentinel-2 L2A Image




Binary-labeled Water Mask

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

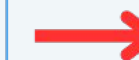
Long-Short Term Memory
Temporal Information

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



Interface of the Streamlit Application

Settings

Path to the NDWI-Images
GEE_Images_all

Path to the exogenous factors table
exo_factors_all.csv

Path to the metadata table of the NDWI-Images
Metadata_all_with_index.csv

Manual Input of future exogenous factors

Cumulative precipitation [mm]
150,00 - +

Average discharge [m³/s]
5,00 - +

Amount of extreme precipitation events
0 - +

Amount of extreme discharge events
0 - +

Forecast Horizon (in days)
56
1 500

Start Prediction

Deploy

River Shift Prediction Tool

Please be patient, this may take a while...

Map with Overlay

A map showing a river network with a red overlay indicating predicted shifts. The map includes labels for various locations like Schurpfenköpf, Spitzberg, and Vorderritt. A yellow line represents the river's path. The map is sourced from Leaflet and OpenStreetMap contributors.

Download HTML Karte

Challenges

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



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

The background is a dark navy blue field filled with various abstract geometric shapes. These include circles of different sizes, some solid and some white with dark outlines. There are also elongated, pill-shaped forms and sharp, angular shapes in shades of light blue and white. Some elements are layered, creating a sense of depth. The overall aesthetic is modern and minimalist.

THANK YOU!