Open Research Day

9 April 2025

10:50-11:30

Parallel Sessions- *lightning talks followed by breakout session*

A108: AI for Environment

Chair: Professor Yifang Ban, KTH

A123: 6G – Communication, Sensing, Computing, Biology, Digitalized Medicine

Chair: Professor Emil Björnson, KTH

A108: AI for Environment

- Lightning talk: Session chair: Professor Yifang Ban, KTH

1. EO-AI4Global Change (CI)
2. DeepFlood: Enhancing large scale Flood Detection and Mapping using PolSAR, Metaheuristic, and Deep Learning Algorithms (RP)
3. DeepAqua: Revolutionizing the quantification of Swedish surface water changes with deep learning (RP)
4. iHorse+ Improving air pollution and health risk forecasts by emerging IoT sensors
5. Beyond 2030: Achieving the SDGs within the Planetary Boundaries, an AI-based approach (Demo)*

   Embedding AI in an innovative geospatial tool to support policy for clean cooking adoption in low- and middle-income countries (Demo)*
6. Combining Advanced Systems for Climate Adaptation and Disaster Enhancement in Stockholm – CASCADE (SI)

**In the Breakout session both projects will be presented one after the other at Screen #5*

EO-AI4Global Change (CI)

Name
Title, Affiliation

EO-AI4GlobalChange:
Earth Observation Big Data & AI for Global Environmental Change Monitoring

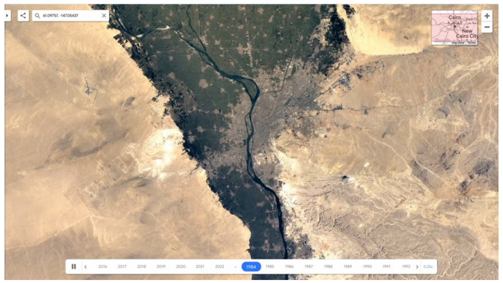
Yifang Ban, KTH ABE (yifang@kth.se)
Andrea Nascetti, KTH ABE
Hossein Azizpour, KTH EECS
Josephine Sullivan, KTH EECS

Objectives

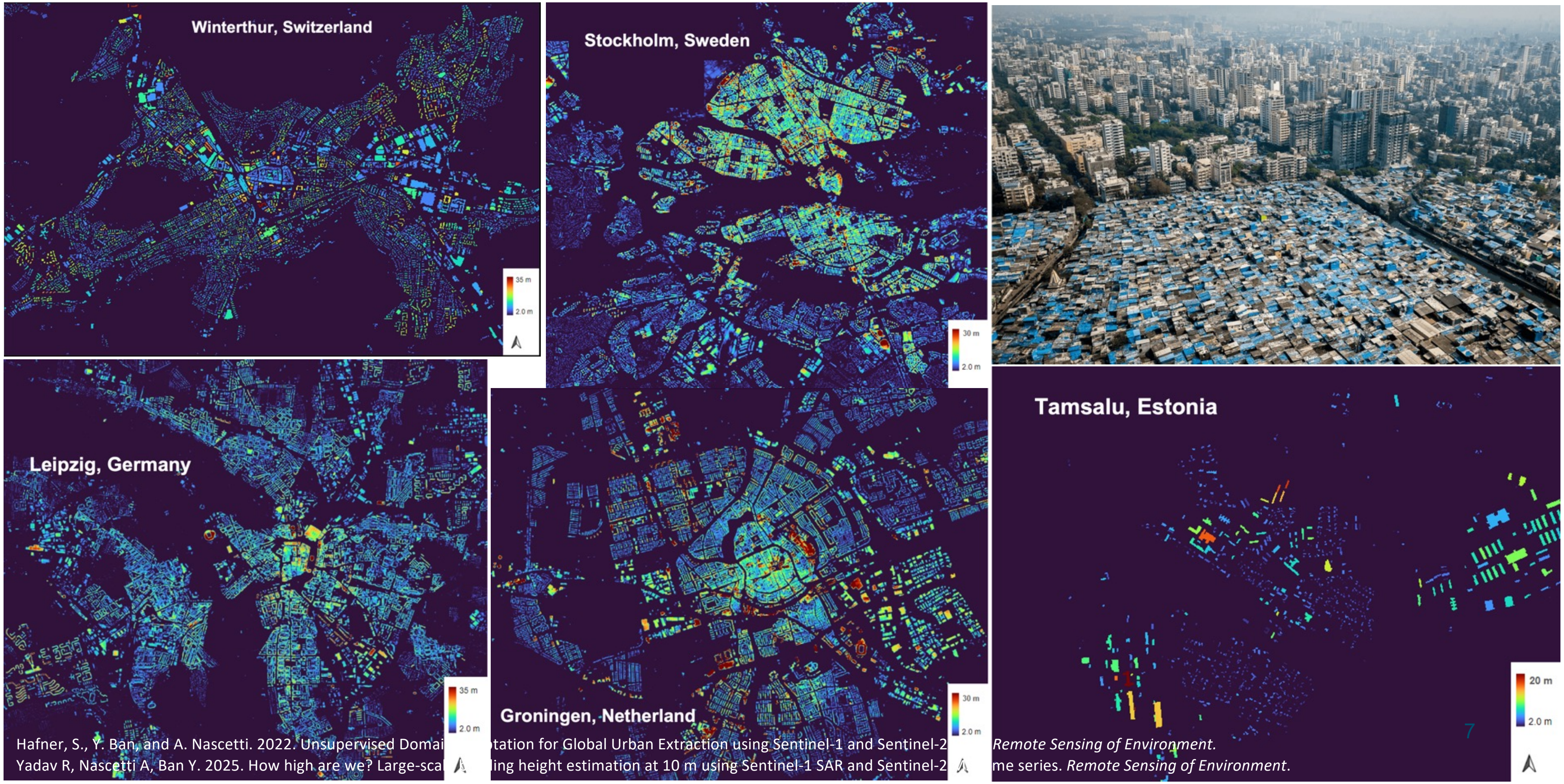
Advancing **Societal Impact** by transforming the novel algorithms and methods developed within **EO-AI4GlobalChange** into operational tools

- Transforming **Urban Mapping and Change Detection** Algorithms into Operational Tools
- Transforming **Wildfire Detection and Monitoring** Algorithms into Operational Tools
- Transforming **Flood Mapping** Algorithms into Operational Tools





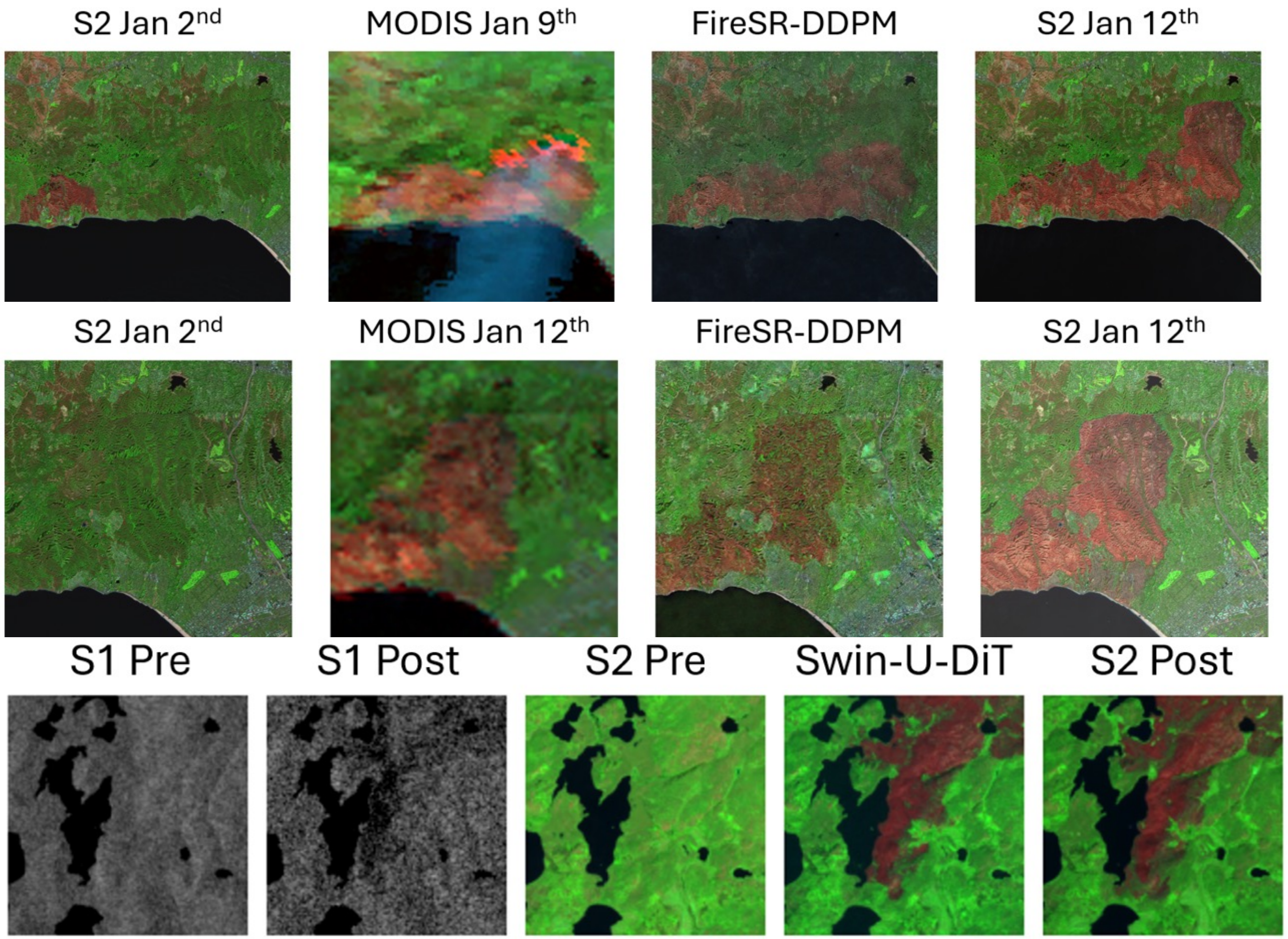
EO-AI for 2D & 3D Urban Mapping



Hafner, S., Y. Ban, and A. Nascetti. 2022. Unsupervised Domai… tation for Global Urban Extraction using Sentinel-1 and Sentinel-2 … *Remote Sensing of Environment.*

Yadav R, Nascetti A, Ban Y. 2025. How high are we? Large-sca… ing height estimation at 10 m using Sentinel-1 SAR and Sentinel-2 … me series. *Remote Sensing of Environment*.

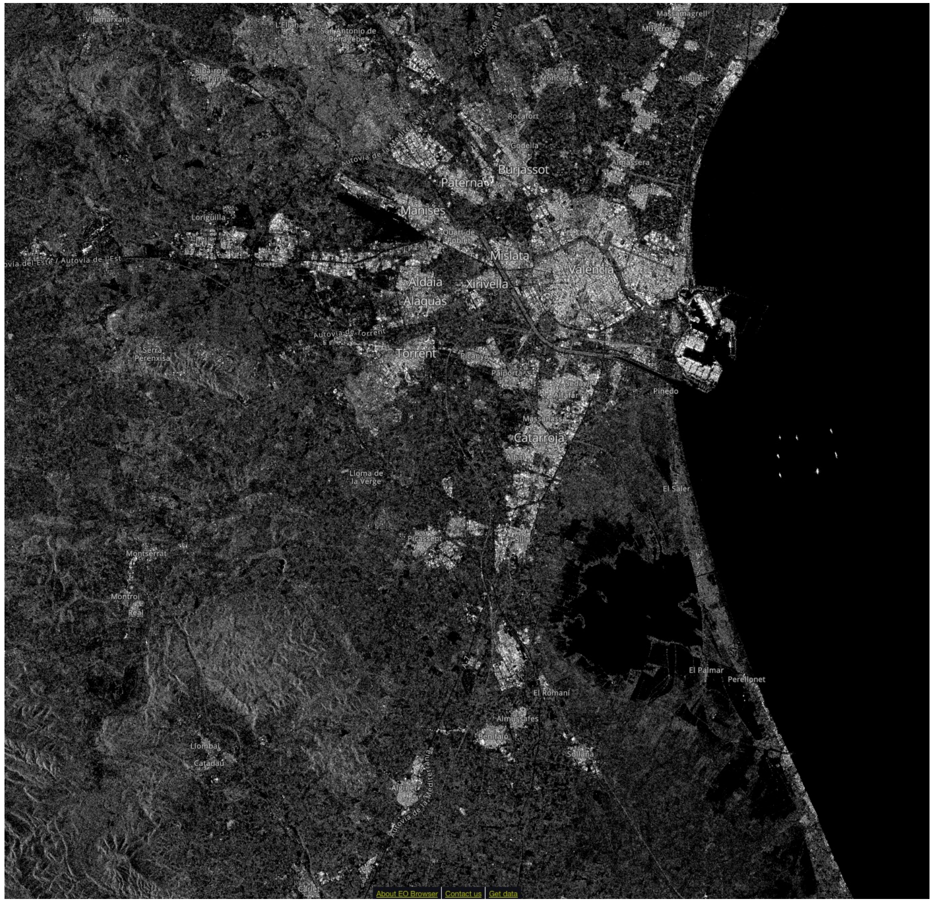
EO-AI for Daily HR Wildfire Monitoring

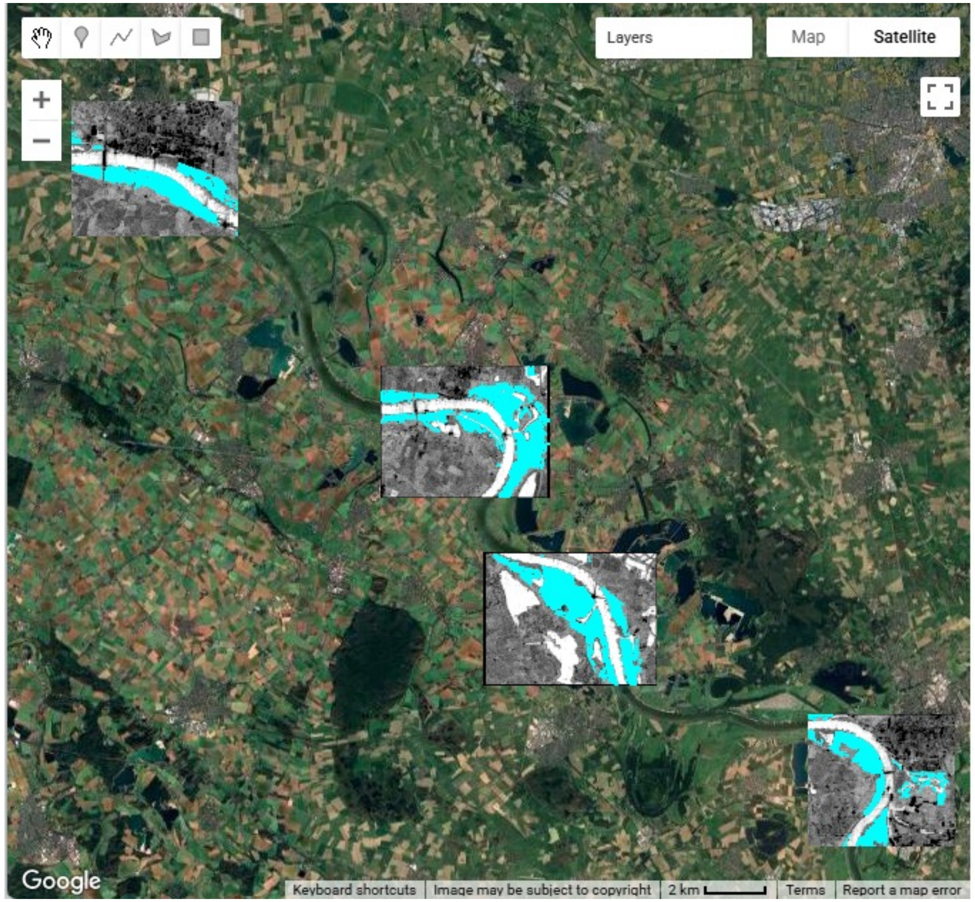


Brune, E., and Y. Ban. 2024. SAR-to-Optical Translation using Conditional Diffusion Models for Wildfire-Burned Area Segmentation. *Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS*).
Brune, E., and Y. Ban. 2025. Daily High-Resolution Wildfire Monitoring Using Context-AwareMulti-Task Diffusion Models. . *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (under review)

Zhao, Y. and Y. Ban. 2025. Near Real-Time Wildfire Progression Mapping with VIIRS Time-Series and Autoregressive SwinUNETR. *International Journal of Applied Earth Observation and Geoinformation.*
Zhang, P., X. Hu, Y. Ban, A. Nascetti, M. Gong. 2024. Assessing Sentinel-2, Sentinel-1, and ALOS-2 PALSAR-2 Data for Large-Scale Wildfire-Burned Area Mapping: Insights from the 2017–2019 Canada Wildfires. Remote Sensing
Zhao, Y., Y. Ban, Sullivan, J. 2023. Tokenized Time-Series Satellite Image Segmentation with Transformer Network for Active Wildfire Detection. *IEEE Transaction on Geoscience and Remote Sensing.*

EO-AI for Flood Mapping






Thank you

DeepFlood: Enhancing large scale Flood Detection and Mapping

Solmaz Khazaei, KTH Royal Institute of Technology

Liangchao Zou, KTH Royal Institute of Technology

Fernando Jaramillo, Stockholm University

Carla Ferreira, Polytechnic Institute of Coimbra in Portugal, prev. at SU

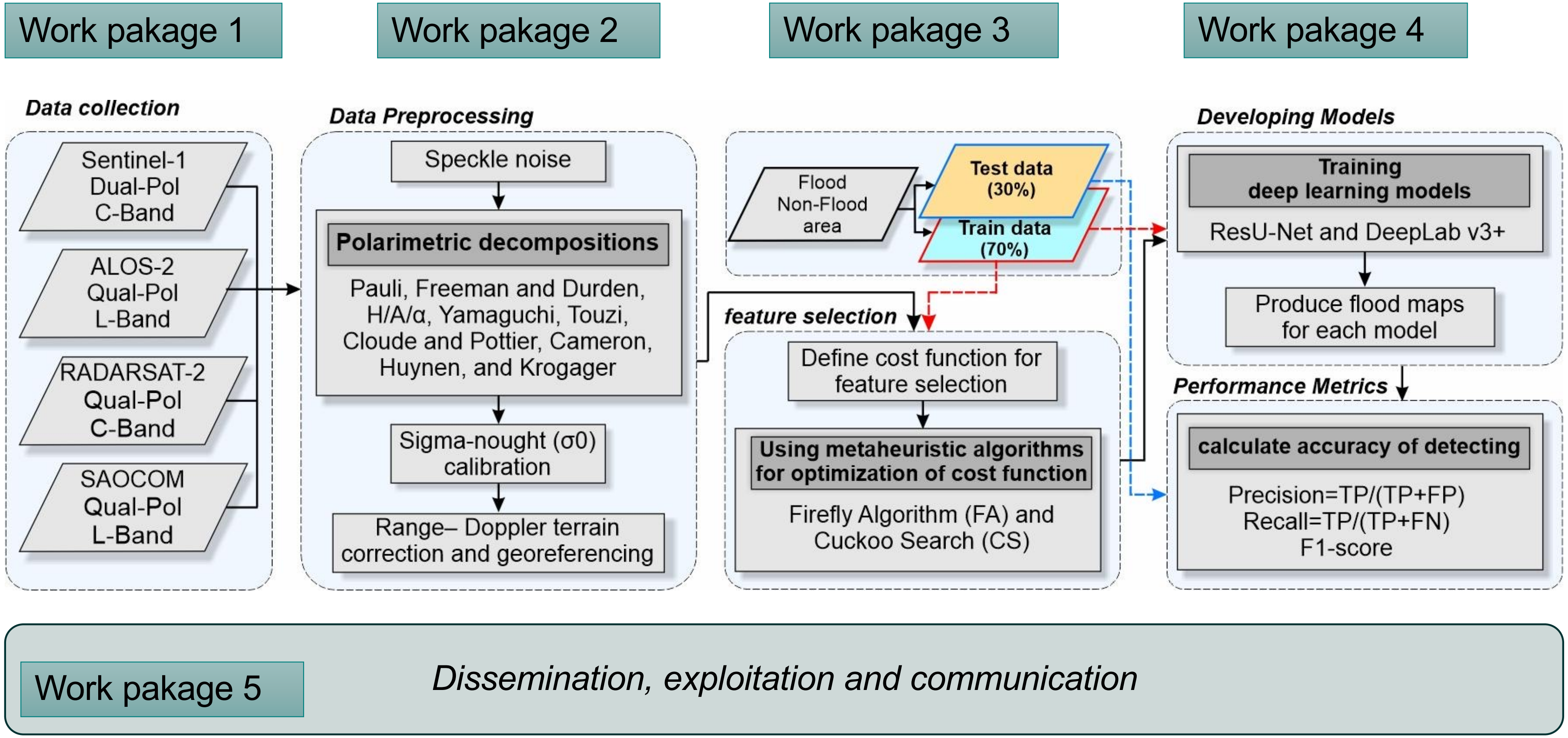
Zahra Kalantari, KTH Royal Institute of Technology

Background & Motivation

Floods can have devastating impacts to human societies

Precise and fast flood mapping will help water resources managers, stakeholders, and decision-makers in mitigating the impact of floods.

Project plan



Expected outcomes and impacts

Outcomes:

- This project will provide precise and fast flood mapping with rapid detection of flooded areas and information about water depth.

Impacts:

- Support flood risk mitigation and planning
- Support successful disaster response
- Support implementation of floods directive in Sweden
- Improve water and land management

Thank you

DeepAqua: Revolutionizing the quantification of Swedish surface water changes with deep learning (RP) - Remote monitoring of wetland surface area through radar satellite images

Ioannis Iakovidis
KTH

Wetlands

Wetlands are land areas that are seasonally or permanently saturated with water.

They are hubs of biodiversity and store enormous amounts of greenhouse gasses.

They are threatened by human developments and climate change.

Remote monitoring of wetland surface area

Optical satellite images

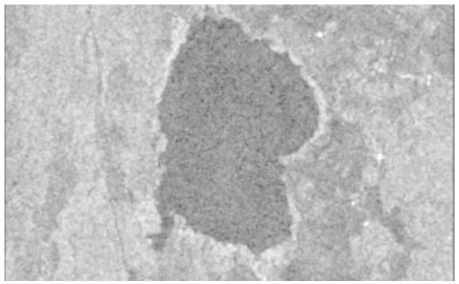
- Pros: Clear images, can easily separate water using combinations of spectral bands such as NDWI (Normalized Difference Water Index) and simple thresholding rules.
- Cons: Can’t penetrate vegetation or clouds.

Optical image

Water detected

• Radar satellite images

- Pros: Can penetrate vegetation and clouds to detect the water hidden underneath.
- Cons: Noise makes water separation hard, requiring complex methods such as machine learning (ML) models.



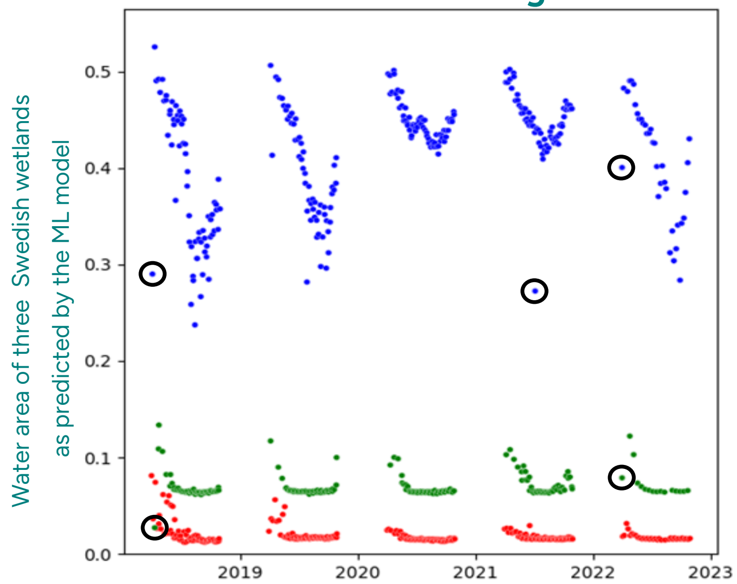
Radar image

Water detected

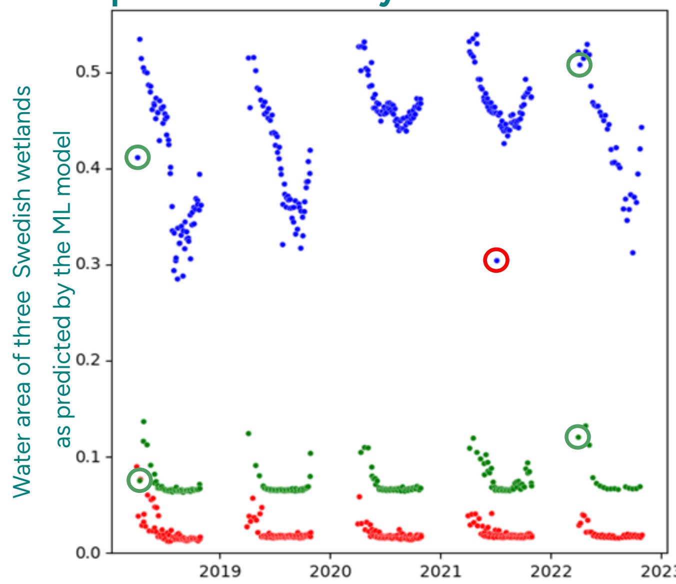
Incorporating temporal consistency

- We expect images of a wetland taken a few days apart to not be radically different.
- During training, we ask the model to detect the water area for each wetland from three different satellite images, each taken a week after the previous one.
- Temporal consistency is incorporated by penalizing the model for predictions that differ too much between these dates.
- Results in improved accuracy and reduction in outlier predictions.

Standard training



Temporal-consistency-enhanced training



Thank you

iHorse+ Improving air pollution forecasts by emerging IoT sensors

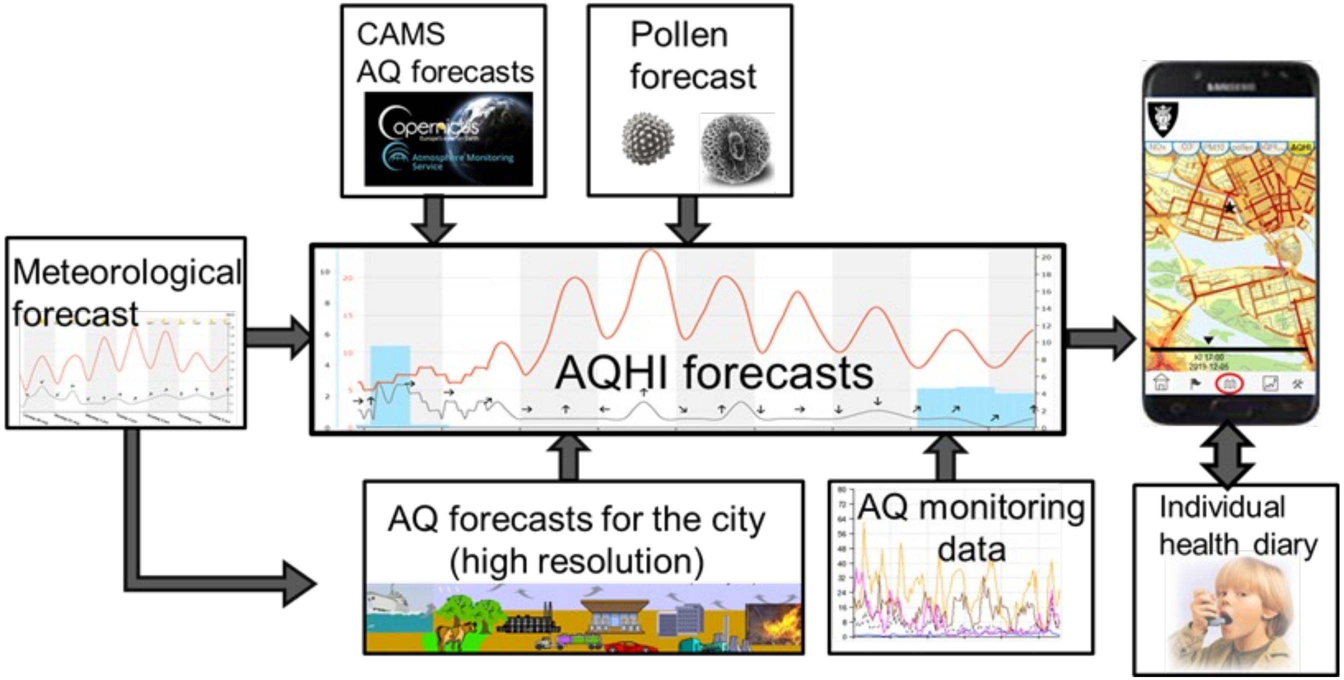
presented by

Zhiguo Zhang, PhD student

ABE, KTH

Stockholm AQHI System

Deterministic models provide hourly air quality (AQ) forecasts down to street level for the next 4 days.



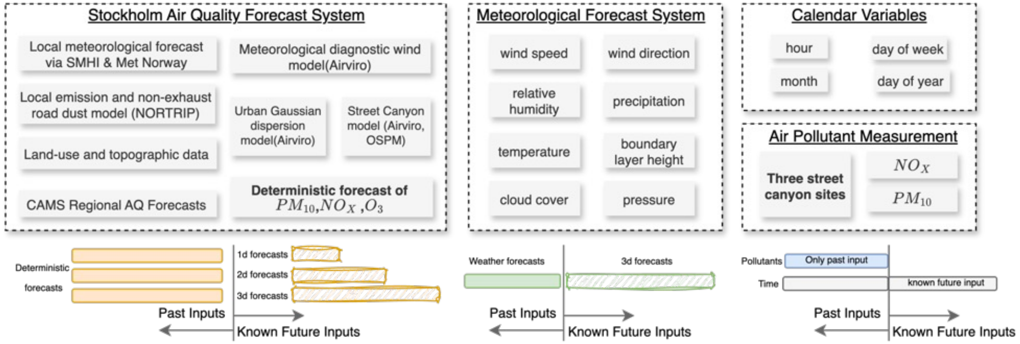
Moderate prediction accuracy

Limited prediction lengths

Framework

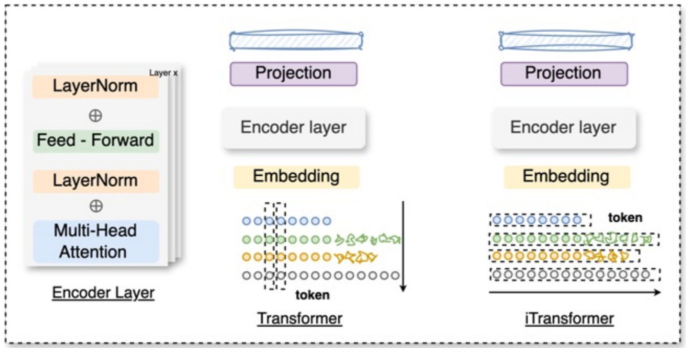
Multi-Source Data

install IoT sensors
to enrich AQ data



IoT Sensor Deployment

Modeling



Integrate multi-source data

More accurate long-term prediction

More transparent modelling

Summary

❑Machine learning improves AQ's deterministic forecasts

- Multi-source data: existing + **small IoT sensors**;
- Multiple prediction horizon: **1 hour to 7 days**;
- Multiple **interpretable analyses**: instance to global.

❑Implement partial model in current forecast system in Stockholm.


Thank you

Beyond 2030: Achieving the SDGs within the Planetary Boundaries, an AI-based approach

Francesco Fuso Nerini
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Ricardo Vinuesa
Associate Professor, Lead Faculty at the KTH Climate Action Centre.
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The rationale

We propose, with leading sustainability scientists to extend and increase in ambition the SDGs

However, environmental goals have lagged behind, compared to economic and social ones

There is a need for metrics and work to make sure the SDGs are achieved within planetary boundaries

Comment

Workers plant straw barriers in desert areas in northwest China's Gansu province to stop sand from spreading, aiding afforestation.

Extending the Sustainable Development Goals to 2050 – a road map

Francesco Fuso Nerini, Mariana Mazzucato, Johan Rockström, Harro van Asselt, Jim W. Hall, Stelvia Matos, Åsa Persson, Benjamin Sovacool, Ricardo Vinuesa & Jeffrey Sachs

Comment in Nature on the need for new strategies and goals beyond 2030

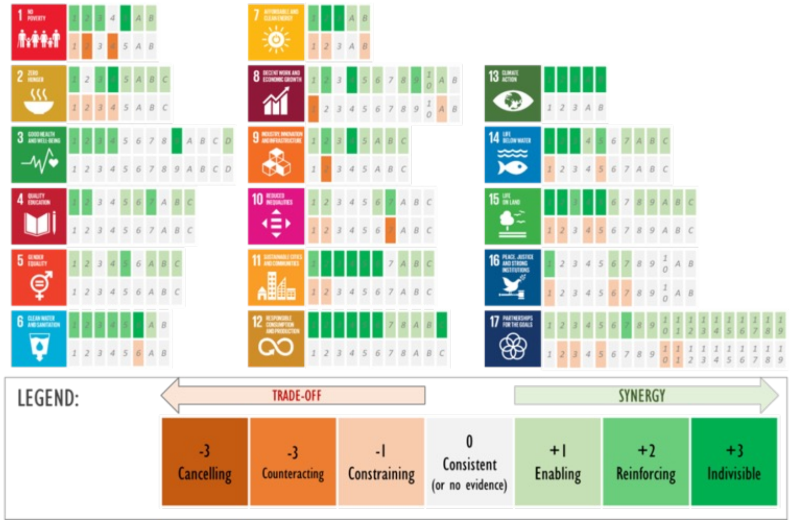
Interactions among SDGs, Why?

Hypothesis: AI-methods can be used to study non-obvious SDG interactions.

Aim: We aim at finding hidden and unexpected connections among SDG targets to avoid unintended consequences.

How: We have developed new tools to automatically identify synergies and trade-offs among the SDGs with through natural-language processing (NLP).

Final goal: Help decision makers and funding agencies to create more effective public policies and funding schemes and to design more effective sustainability agendas.



Synergies and trade-offs between climate action and the SDGs (Fuso Nerini et al 2019). Obtained by manualy reviewing thousands of papers.

Methods AND PROJECT STRUCTURE

WP1: Fine tune Gemini and family of LLMs (with Google Research)

Provide additional sustainability datasets (articles, projects, policy, etc.) to **improve LLM performance on sustainability.**

WP2: Establish connections between the 231 SDG indicators and the 9 Planetary Boundaries

We will identify **hidden connections** in terms of **synergies and tradeoffs** between the **231 indicators of the SDG agenda and the 9 PBs** taking advantage of the enhanced LLM capabilities.

WP3: Use of optimization methods to develop a <u>CONSOLIDATED Agenda beyond 2030</u>

We will consider optimization both through gradient-based methods and DRL to **streamline redundancies** and aim at a global Agenda. **Stakeholder Engagement with workshops** on 3 levels:

- **World leaders** (Tegmark, Dignum).
- **Agencies** (NSF, ERC, OECD).
- **Tool for policy development** (UN, EU).


Thank you

Embedding AI in an innovative geospatial tool to support policy for clean cooking adoption in low- and middle-income countries

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Camilo Ramirez – *camilorg@kth.se*
PhD candidate
Division of Energy Systems, Energy Technology Department, KTH Royal Institute of Technology

Current state of clean cooking access

"Ensure access to affordable, reliable, sustainable and modern energy for all"

- Target 7.1: Universal access to energy services by 2030
- As of 2021, 2.3 billion people without access to clean cooking
- 1.9 billion projected to remain without access in 2030

HEALTH

Up to **3.7 million** people die prematurely every year from HAP related illnesses (IEA, 2023)

CLIMATE & ENVIRONMENT

Traditional cooking produces over **25% of global black carbon emissions** (CCA, 2022)

GENDER & LIVELIHOODS

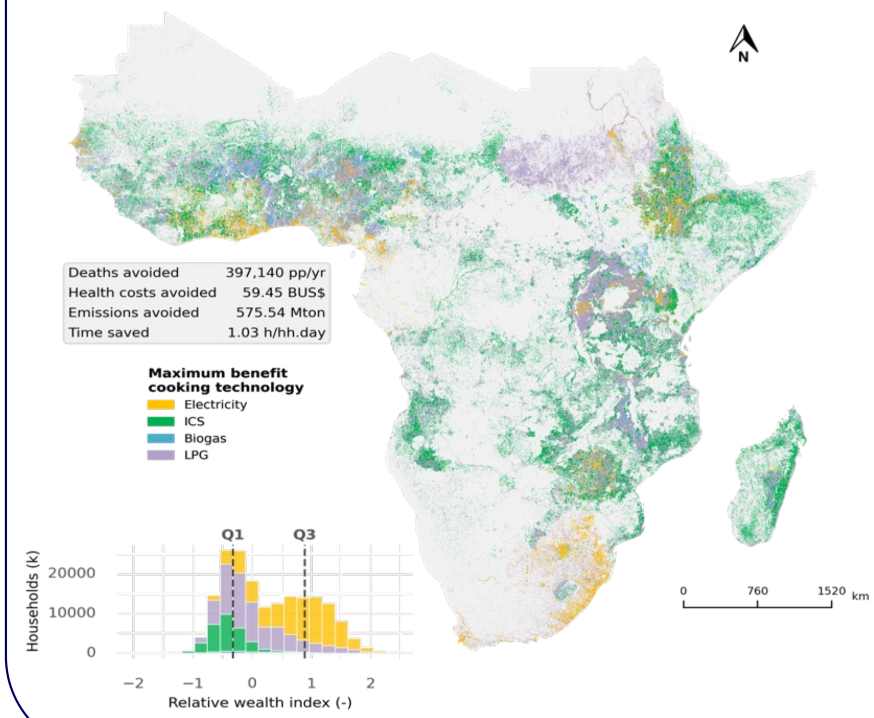
Women and children spend in average **1.3 hours per day** collecting traditional fuels (ESMAP, 2022)

The first spatial clean cooking tool - OnStove

A geospatial clean cooking tool, determining the net-benefit of cooking with different stoves across an area

- Estimates costs regarding **capital**, **fuel** and **operation and maintenance**
- Estimates benefits regarding **reduced morbidity**, **reduced mortality**, **time saved** and **emissions avoided**
- Target groups **policy makers**, **international community** and **actors** of the clean cooking **market**

Khavari, B., Ramirez, C., Jeuland, M. & Fuso Nerini, F. A geospatial approach to understanding clean cooking challenges in sub-Saharan Africa. Nat Sustain (2023) doi:10.1038/s41893-022-01039-8.



Methods and project structure

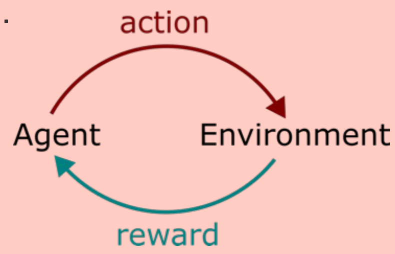
WP1: Improving the spatial representation of current cooking practices.

Use geospatial information, country surveys and **AI-based learning models** to determine the spatial distribution of current cooking practices used across given geographical areas. Different models will be explored such as:

- Spatial Bayesian Networks, or
- Convolutional Neural Networks (CNN)

WP2: Improving the maximization of net-benefits in a clean cooking transition.

Use **Deep Reinforcement Learning** through a **Markov Decision Process**, to optimize the multi-objective problem of clean cooking transitions, under the cost-benefit context of the OnStove model.



WP 3: Developing a user-friendly interface for the improved OnStove tool.

The interface should allow the user to run an analysis from beginning to end without requiring any programing knowledge.

- Developed using the Python programming language
- Completely **open-source**, to allow widespread use and adoption by users from low- and middle-income countries


Thank you

CASCADE: Combining Advanced Systems for Climate Adaptation and Disaster Enhancement in Stockholm

Amir Rezvani, *rezvani@kth.se*

Department of Sustainable Development, Environmental Science and Engineering (SEED)
KTH Royal Institute of Technology
Stockholm, Sweden

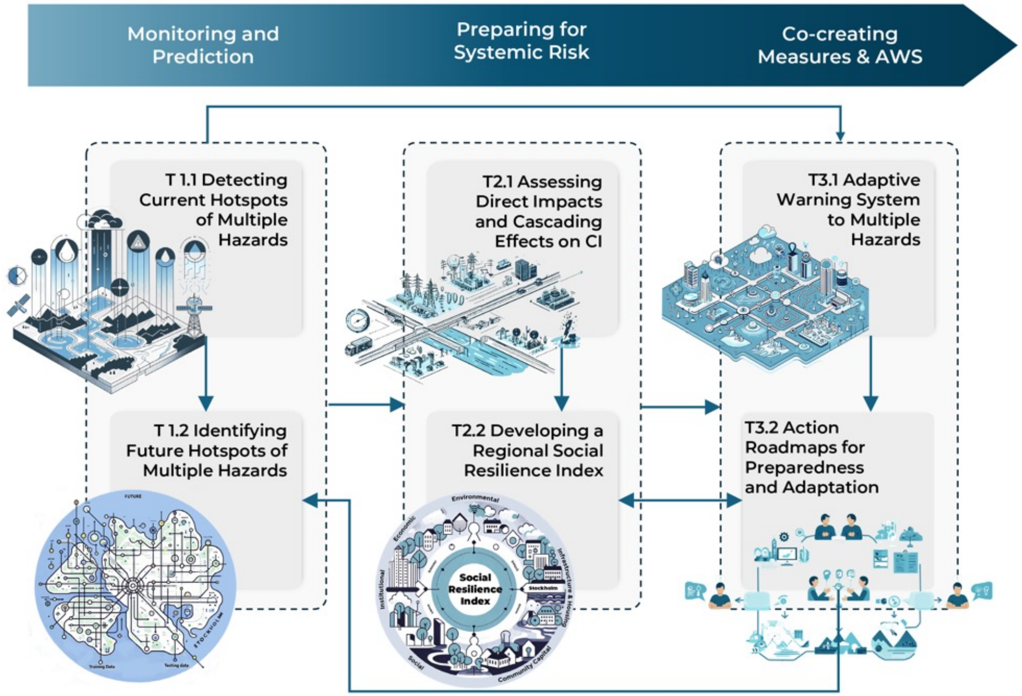
digital futures

Open Research Day, 9 April 2025

CASCADE Project Plan

The CASCADE project aims to enhance urban resilience and preparedness against multiple hydrometeorological hazards in Stockholm, particularly various types of flooding:

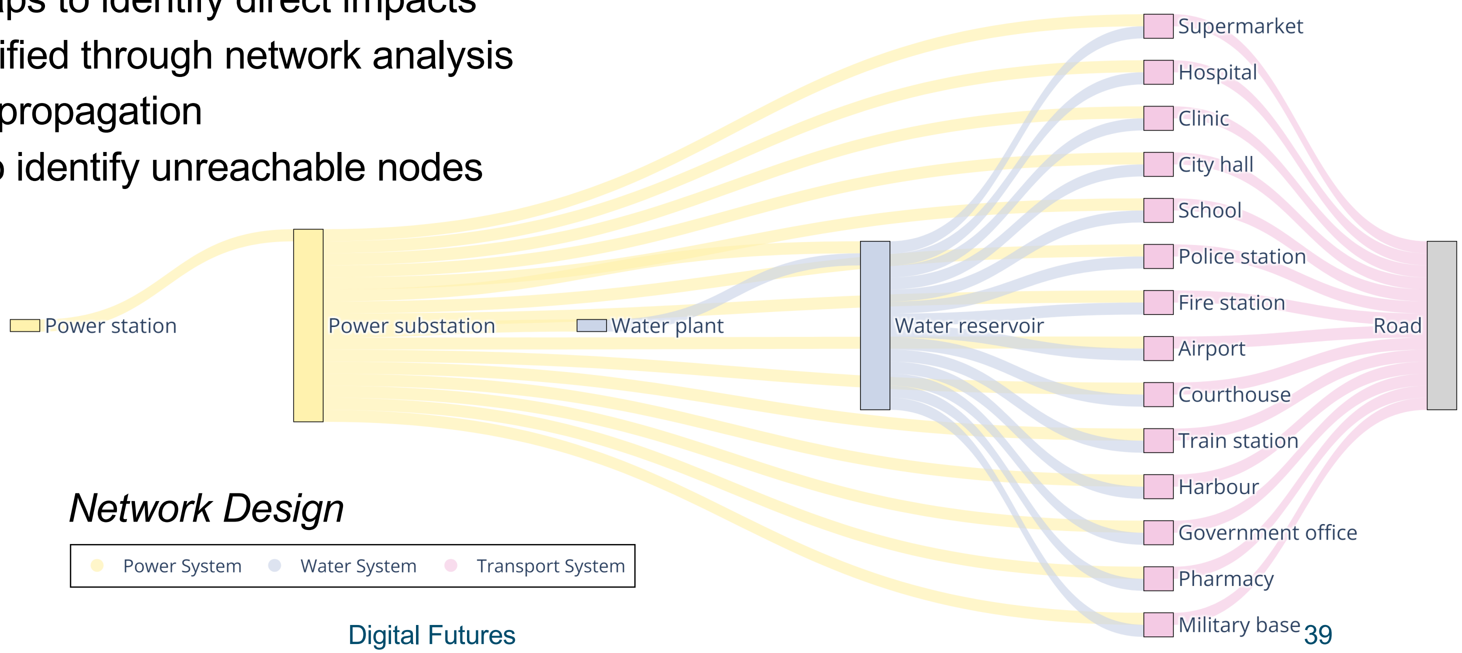
1. _Monitoring and Prediction:_ Detecting current and future hotspots of hydrometeorological hazards using deep learning models and multivariate copula analysis (MvCAT).
2. _Preparing for Systemic Risk:_ Evaluating cascading effects on infrastructure through network analysis, resilience metrics, and probabilistic methods.
3. _Co-creating Solutions:_ Developing an adaptive warning system and strategic roadmaps to strengthen disaster preparedness and societal resilience.



Understanding Systemic Risk

Flood Resilience Assessment of Interconnected Critical Infrastructures:

- Network-based model of critical infrastructure interdependencies at municipality scales
- Transport, electricity, and water supply systems
- Flows of goods and services based on population demand
- Overlay flood hazard maps to identify direct impacts
- Cascading effects quantified through network analysis
- Simulation of disruption propagation
- Serviceability analysis to identify unreachable nodes



Network Design

Understanding the Network Flow Constraints

Supply nodes: Power and water plants, social service infrastructure

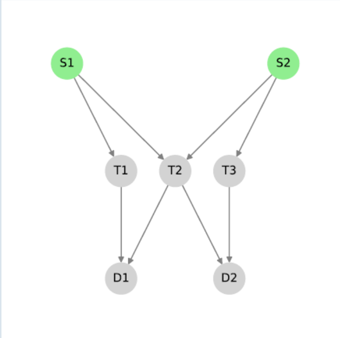
Transit nodes: Power substations, water reservoirs

Demand nodes: Residential areas along road intersections

The goal: Minimize total cost while satisfying demand. Cost is defined as the distance between nodes

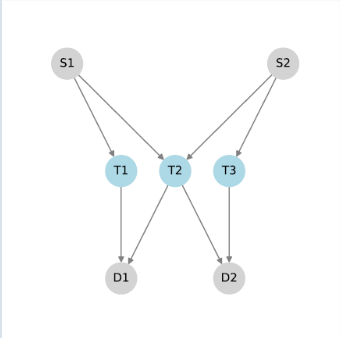
Application for resilience planning: Quantification of cascading effects due to disruptions on estimated flows

Supply nodes



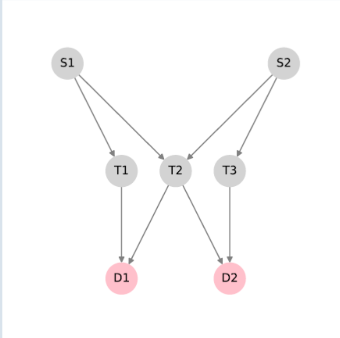
Example: power station in the electrical system

Transit nodes



Example: power substation in electrical system

Demand nodes



Example: costumers in the electrical system


Thank you

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