# AI for climate adaptation and mitigation

## AI for environmental data, Uppsala University

Olof Mogren, RISE Research Institutes of Sweden

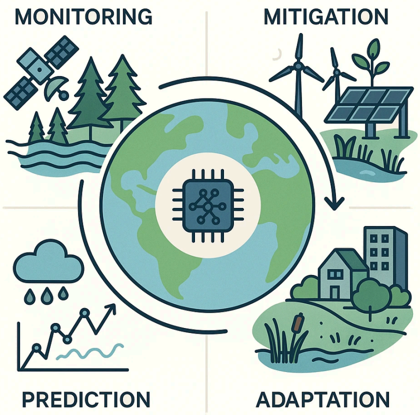


RI. SE

# Climate change

## A multifaceted challenge benefiting from AI at every level

- Monitoring
  - remote sensing, sensor networks, bioacoustics
- **Mitigation**
  - Emission reduction and carbon sequestration
- **Adaptation**
  - Resilience planning
- Prediction
  - Weather systems and extreme events

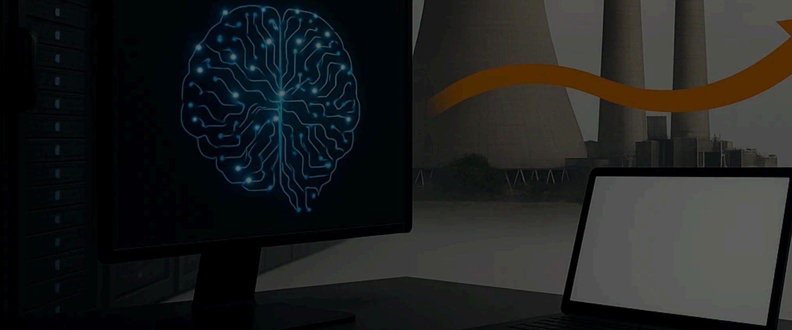


# Both mitigation & adaptation necessary

- We are heading for 2°C
- Mitigation is essential to slow warming and reduce long-term risks
- Adaptation is unavoidable, impacts are already here and will intensify
- Neither is sufficient alone

# Climate footprint of AI

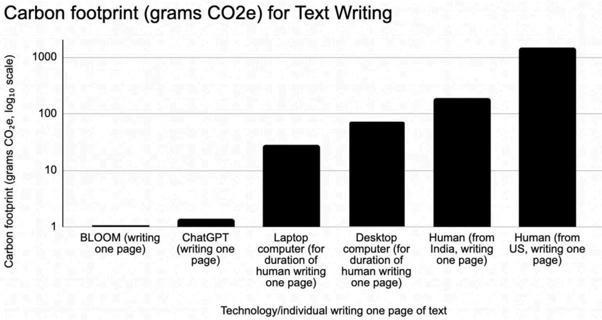
- Less than **one** percent of global GHGs*
- Likely increasing
- May lead to net increase **or** net decrease
- Depends on energy mix



* ICEF AI Climate Roadmap, November 2024

# Footprint

- Generating a page of text with AI emits less than human writing (Tomlinson, et al, 2024)
- One prompt to Chat GPT -> approximately two to five grams of $CO_2$ equivalents

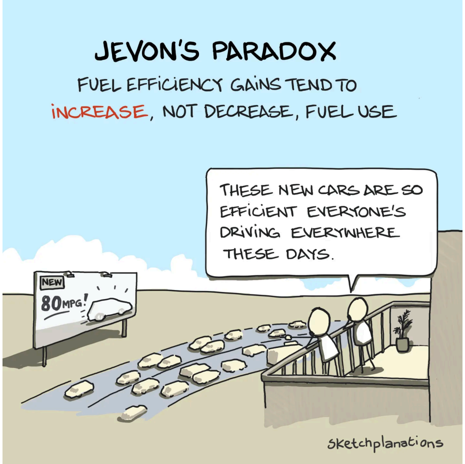




Tomlinson, B. et al. The carbon emissions of writing and illustrating are lower for AI than for humans. Nature Sci Rep (2024). https://doi.org/10.1038/s41598-024-54271-x

# Indirect environmental effects of AI

- AI can make us more efficient
- Fast-fashion is already a burden to the environment
- Jevon's paradox/rebound effects

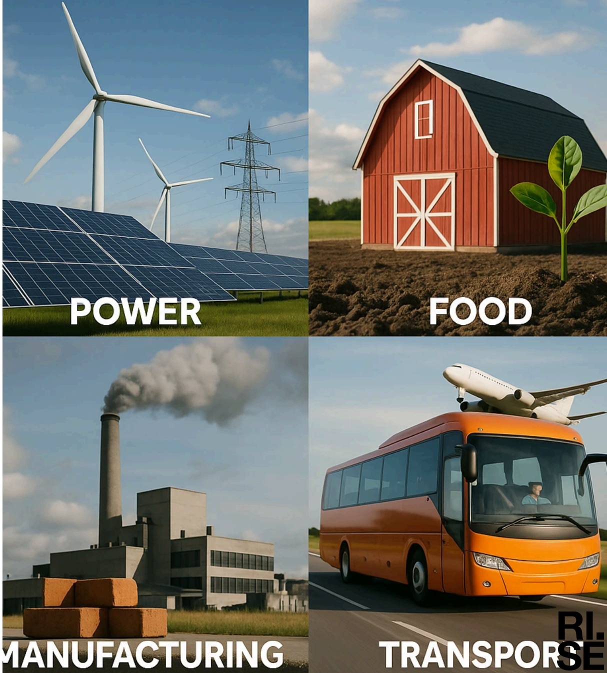




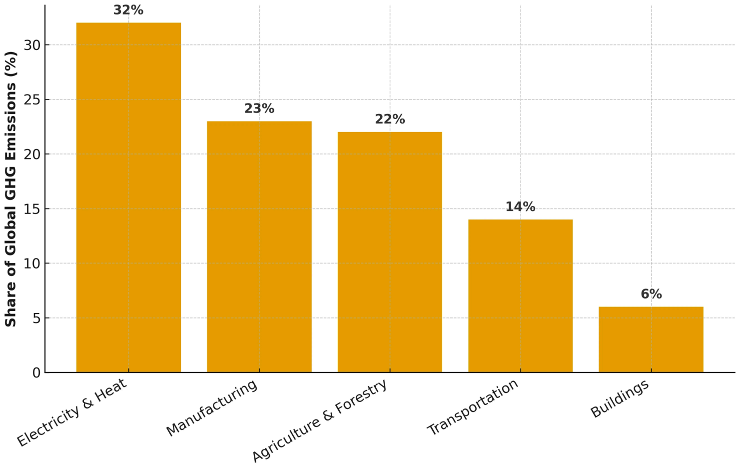

RI. SE

# The potential of AI

- Incremental gains
  - Enhancing solar energy output
  - Improving building efficiency
- Transformational gains
  - Discovering new clean energy sources, materials, etc.



# GHG emissions by sector



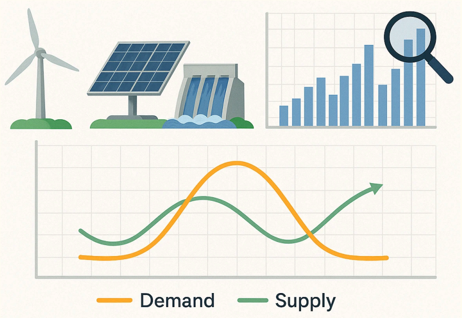
# The energy sector

# The energy sector

- Energy production = **~32% of global GHG emissions**
- Fossil fuels (coal, oil, gas) dominate electricity and heat globally

# AI for the energy sector

- Grid integration of renewables
  - Redice wasted solar/wind power
- Demand & supply forecasting
  - Reduce overproduction
- Dynamic load balancing
  - Reduce transmission loss
- Energy efficiency across sectors






RI.
SE

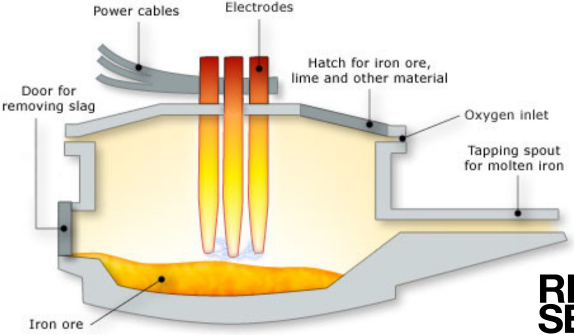

INPUT
Data
Weather 33 350
Date/Time 14.45 10,25
Load 21.25 1,08
Temperature 81.0 1,120
Humidity 8,56 1,510
Price 3.15 2,36
Price 1,99 8,80
DEEP LEARNING
FORECAST
TIME
PAST DATA
Date 10,955
Load 17.64 2,915
76,90 2,936
5,694 4,336

# Manufacturing

- **~23% of global GHG emissions**
- Largest sources:
    - Steel, cement, chemicals
- Challenges:
    - High-temperature industrial heat
    - Chemical process emissions (e.g. cement calcination)

# AI for steel production

- Optimizing steel Electric Arc Furnaces (EAF) with scrap variability
- Reducing overuse of costly additives in steel

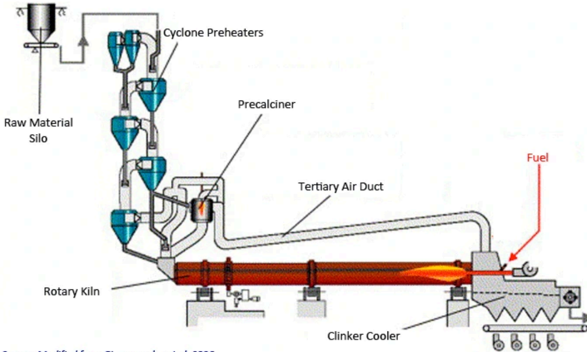


# Cement: 8% of global GHG emissions

Image: Heidelberg Materials, Slite

# AI optimizing cement production

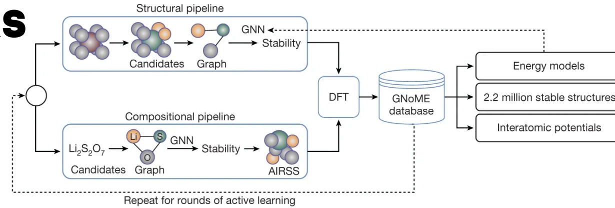
- Lessen demand of petroleum coke
- Optimize air temperature for the clinker kiln
- Less fuel is needed



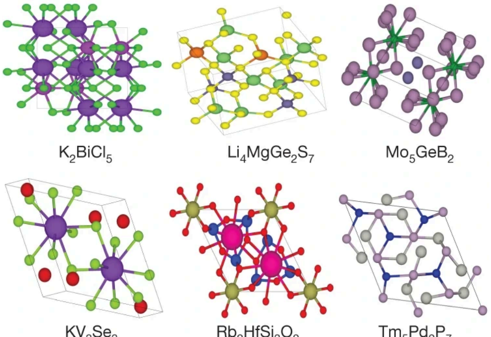

*Source: Modified from Giannopoulos et al, 2006*

 Acharyya, et al., 2019

# Graph neural networks
## for materials discovery




- Stable inorganic materials
- Batteries, superconductors, and electronics
- Active learning
- Graph neural networks





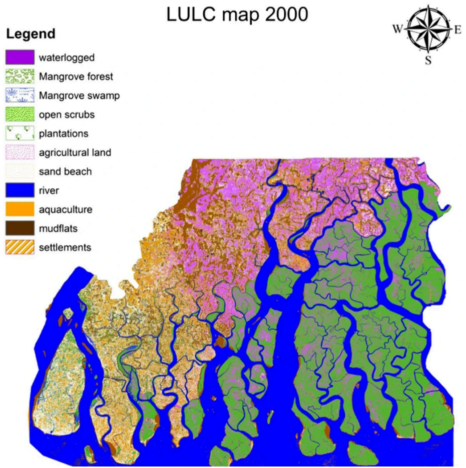
Merchant et al., 2023

# Agriculture, forestry, land use (AFOLU)

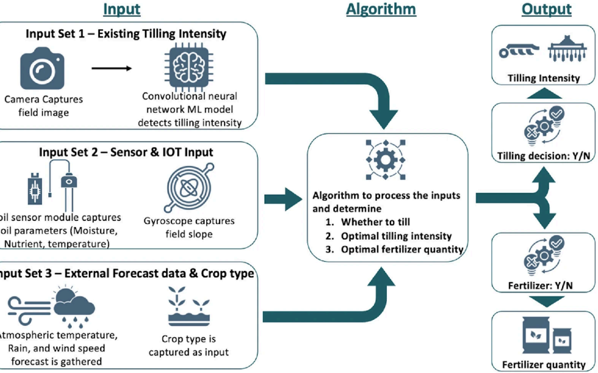
- **~22% of global GHG emissions**
- Main drivers:
  - Deforestation
  - Methane from livestock
  - Fertilizer use ($N_2O$)

# AI for agriculture and forestry

- Monitoring land use change (remote sensing)
- Optimizing fertilizer use
- Improving livestock management
- Forest management & carbon accounting



# Optimizing fertilizer use




- Suggesting N,P,K dosage, tillage, timing
- Based on environmental variables

 Malik et al., 2025, Magesh, 2025

# AI for climate-smart agriculture

- Precision irrigation and yield prediction
- Pest/disease detection under climate stress
- Example: ML-based decision support for smallholder farmers

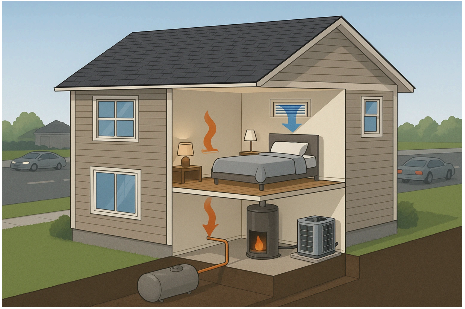
# Transportation

- **~14% of global GHG emissions**
- Fossil based fuels

# AI for transportation

- Route optimization and EV charging
- Reducing congestion and fuel use
- ML in logistics and shipping
- Smart infrastructure and modal shift

# Buildings



- ~8% direct emissions
- ~25% including electricity/remote heat



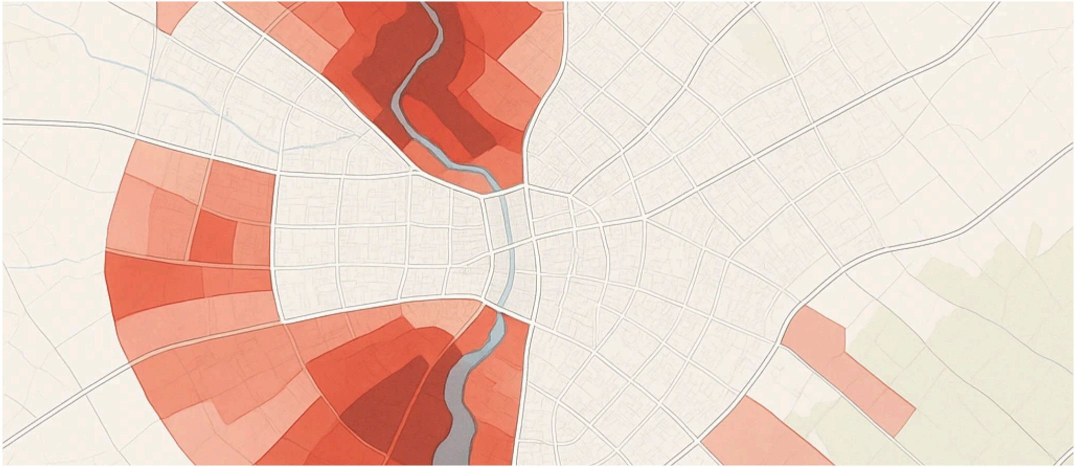
RI.
SE

# AI for building optimization

- Design and materials
  - Passive designs
  - Heating/cooling load modeling
  - Sustainable or recycled materials
- Construction and demolition
  - Reduce material waste
  - Optimize low-tech cooling/heating
- Operations
  - Smart grid coordination

# Climate adaptation

# Urban flood risk forecasting



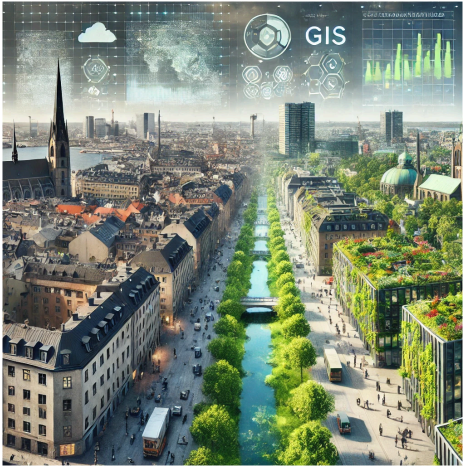


RI. SE

# Constructions

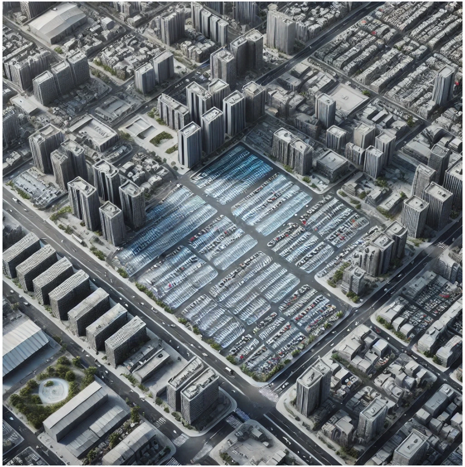
# Planning urban green areas

- Optimize conversion of grey areas to green areas
  - 3-30-300
  - Climate resilience and biodiversity
  - Cost efficiency
- Satellite data, ML, GIS
- Cooling, biodiversity, public health, and carbon benefits
- RISE, SLU, Malmö Stad, Uppsala Municipality



# Detecting potential areas
## for green transformation

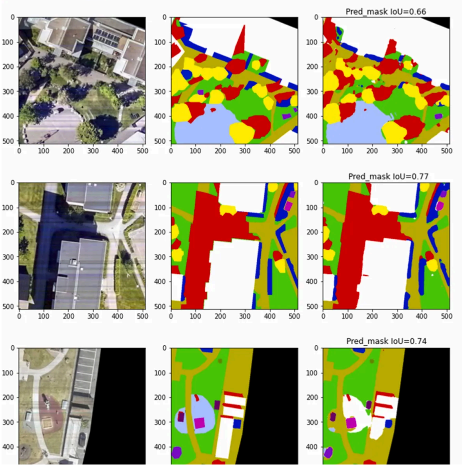
- Identify grey spaces
- Identify areas where green transformation
  - is the most useful
  - is possible





RI.
SE

# AI for urban green infrastructure

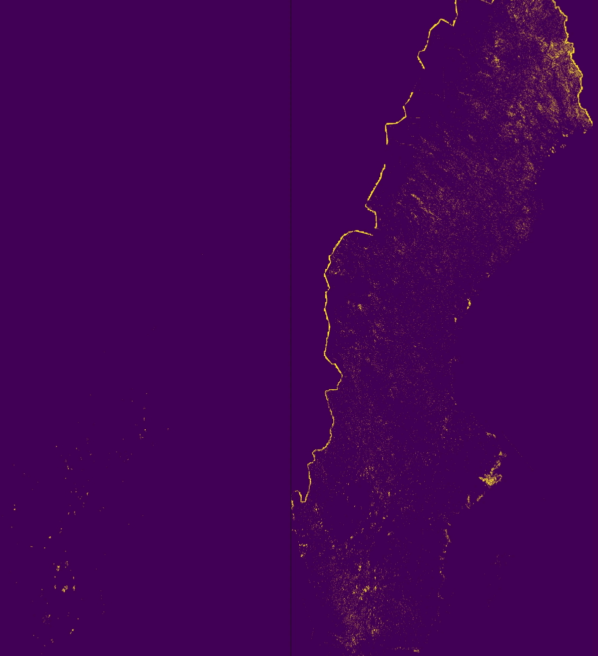



- Quantifying urban green infrastructure in Örebro (left)
- Algorithmic green infrastructure

Rahaman et.al., 2024, Shaamala et.al., 2024

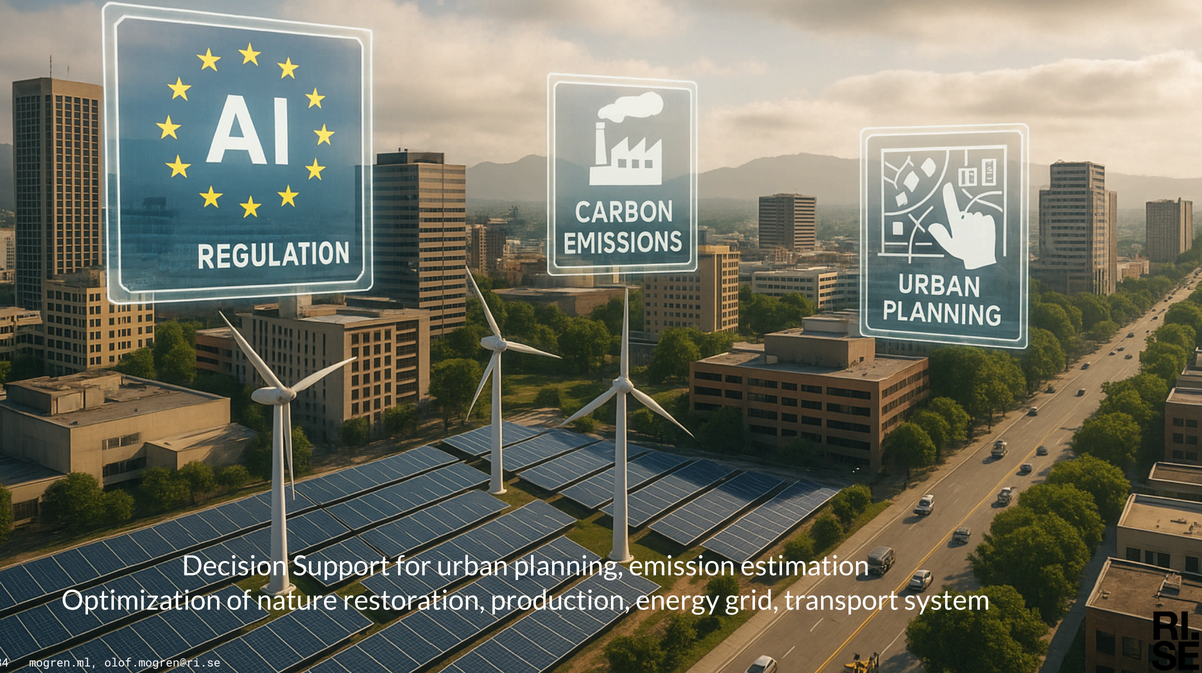
# Algorithmic green infrastructure

- Using remote sensing, geospatial data, environmental data
- Scenario planning
- Provide urban planners with AI-optimised layouts that balance multiple objectives (cooling, water, biodiversity, equity).



# Earth observation
## for wetland estimation

- Generated map, crucial for
  - Wetland restoration
  - Biodiversity
  - Climate adaptation




Decision Support for urban planning, emission estimation
Optimization of nature restoration, production, energy grid, transport system

# High tech for low tech

- Wetland restoration
- Mangrove and coastal ecosystem protection
- Urban green infrastructure
- Agroforestry
- Restoring river floodplains
- Rewilding

Dall-E 3: A computer lab with many big computer screens, showing charts, tables, and images of forests and wetlands

# Common challenges

- Data availability and bias (e.g. Global North vs Global South)
- Energy use of AI systems themselves
- Interpretability, trust, and ethics in deployment
- Improved efficiency may increase demand
- AI is not a silver bullet
    - Could divert attention from simpler solutions



RI. SE

# Workshops

## Slack workspace

Start collaborations
Share
- Positions
- Calls
- Papers

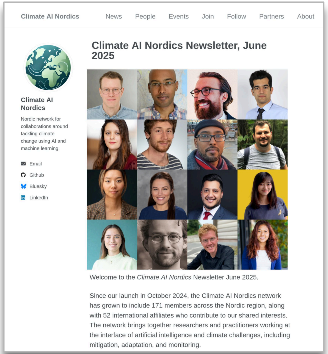
# Climate AI Nordics

## climateainordics.com

*176 Nordic members*

# Dissemination

Website, newsletter, social media


Climate AI Nordics | News | People | Events | Join | Follow | Partners | About

Climate AI Nordics

Nordic network for collaborations around tackling climate change using AI and machine learning.

Email
Github
Bluesky
LinkedIn

**Climate AI Nordics Newsletter, June 2025**

Welcome to the *Climate AI Nordics* Newsletter June 2025.

Since our launch in October 2024, the Climate AI Nordics network has grown to include 171 members across the Nordic region, along with 52 international affiliates who contribute to our shared interests. The network brings together researchers and practitioners working at the interface of artificial intelligence and climate challenges, including mitigation, adaptation, and monitoring.

climes Swedish centre for impacts of climate extremes
AfriClimate AI
RISE
ellis ML4E&C
Global Wetland Center
Klimatkollen

Climate Change AI

AfriClimate AI

# Schedule

**Today:**

- 10: Introduction to AI and Machine Learning
  - Olof Mogren
- 11: Introduction and Brief History of Natural Language Processing (NLP)
  - Murathan Kurfalı
- 13: AI for Climate Adaptation and Mitigation
  - Olof Mogren
- 14: Exercises

**Tomorrow:**

- **10: AI for Environmental Monitoring**
  - Olof Mogren
- 11: AI for Prediction and Earth System Modelling
  - Olof Mogren
- 13: Using NLP and Large Language Models: General Concepts and Climate Applications
  - Murathan Kurfalı
- 14: Exercises