

# Urban Climate Risks in Northern Cities

Research and Education at NERSC



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Winter inversion over Bergen, Norway



# NERSC - Nansen Environmental and Remote Sensing Center



Independent research institute

**Bergen, Norway**

~70 researchers | 20+ nationalities

## Research strengths

- Climate and environmental modelling
- Remote sensing of Arctic and urban environments
- Climate information for society

## Collaboration

- Norwegian climate research network
- European programs (Copernicus, EU projects)
- International Nansen Centers (China, India, Bangladesh and etc)



# Urban Growth in a Rapidly Warming Arctic



## Rapid change

- The Arctic is the **fastest-warming region on Earth**
- **Northern cities are expanding**

## Urban climate risks

- Urban heat islands
- Winter air pollution
- Infrastructure stress (permafrost thaw)
- Extreme weather events

## Key question

How does **urbanization interact with climate and society in cold regions?**



Construction in an Arctic coastal town



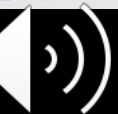
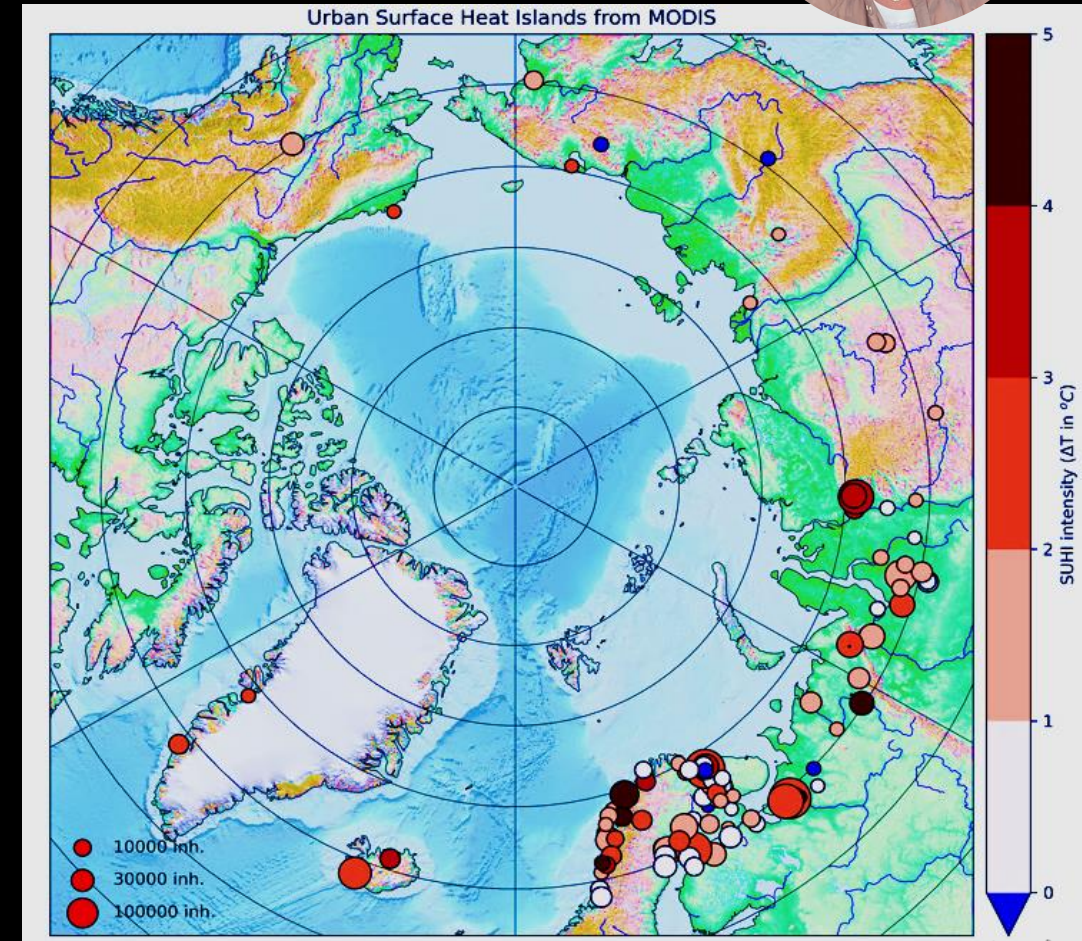
# Cold Climate Urban Heat Island: A Pan-Arctic Phenomenon

## Cold Climate Urban Heat Island: A Pan-Arctic Phenomenon

Evidence from **119 Arctic cities**

- Urban surface temperatures show **consistent warm anomalies**
- Typical SUHI intensity: **+2–3°C**
- Maximum values **>5°C**

Urban areas in high-latitude regions are consistently warmer than surrounding landscapes.



# Hot Hot and Cool Urban Islands in Northern Cities



## Urban temperature patterns

- **Hot islands:** dense built areas
- **Cool islands** :parks, forests, water

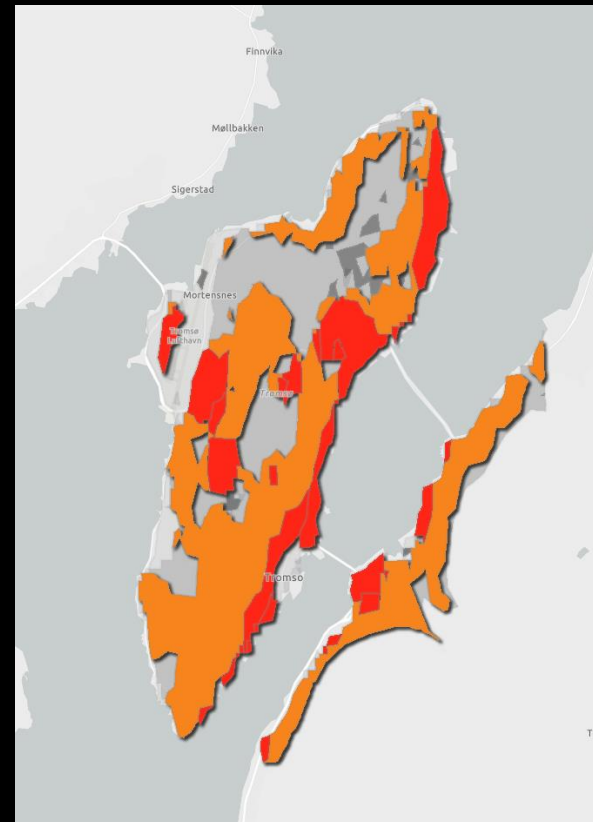
## Key finding

- In Tromsø, hot areas are **2.5× larger than cool areas**

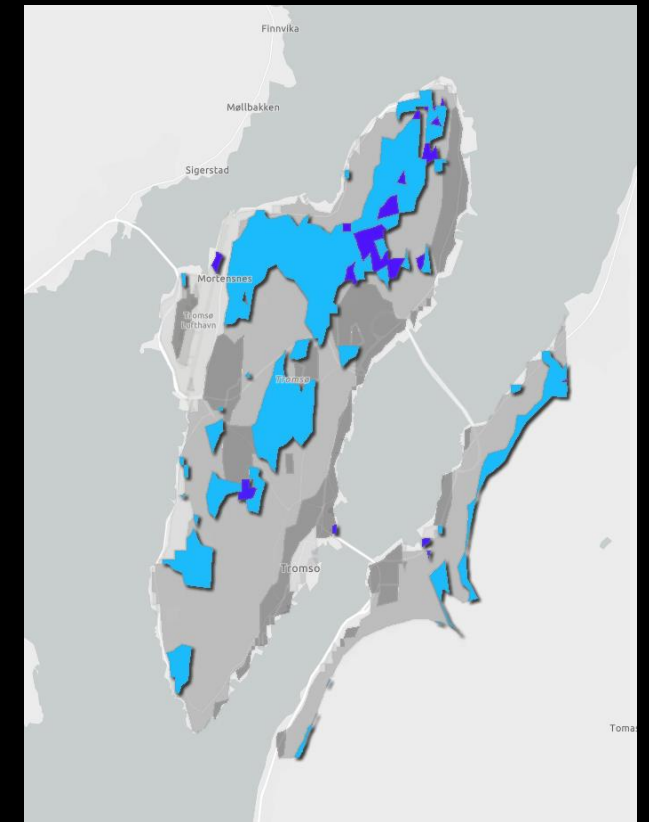
## Implication

- Preserving **urban green and blue spaces** supports climate resilience

Hot Islands (Dense Urban Areas)



Cool Islands (Green / Blue)



Tromsø, Norway (69.65° N, 18.96° E)

This imbalance threatens both climate resilience and the cultural landscape of the city.



# Urban Climate: Interactions Across Scales

## Large-scale climate

- Arctic amplification
- Atmospheric circulation and blocking

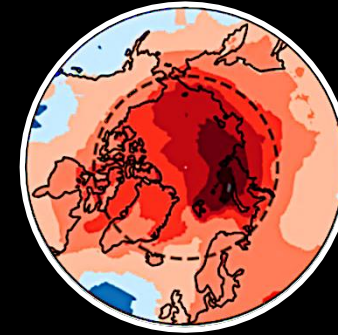
## Urban environment

- Built surfaces and density

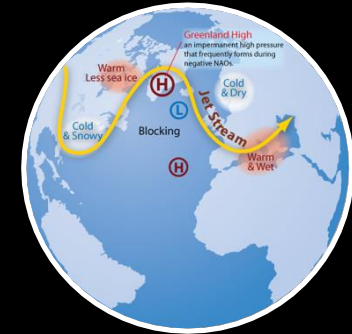
## Local processes

- Heat storage and release
- Pollution accumulation
- Vegetation cooling

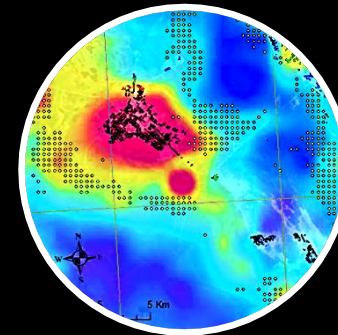
Urban climate emerges from **interactions between global climate and local urban form.**



Arctic Amplification

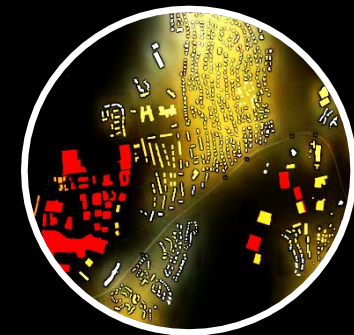


Atmospheric circulation and blocking



Upscaling Climate Effects

Urban Climate Diversity



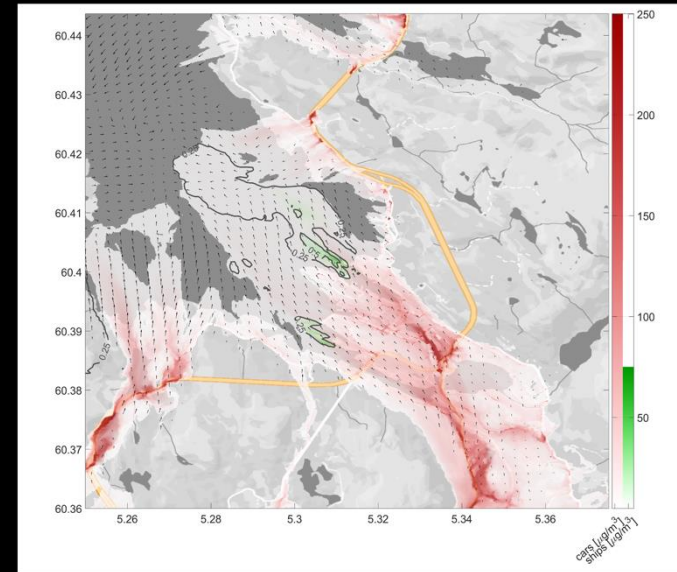
# Street-Scale Urban Air Quality Modelling



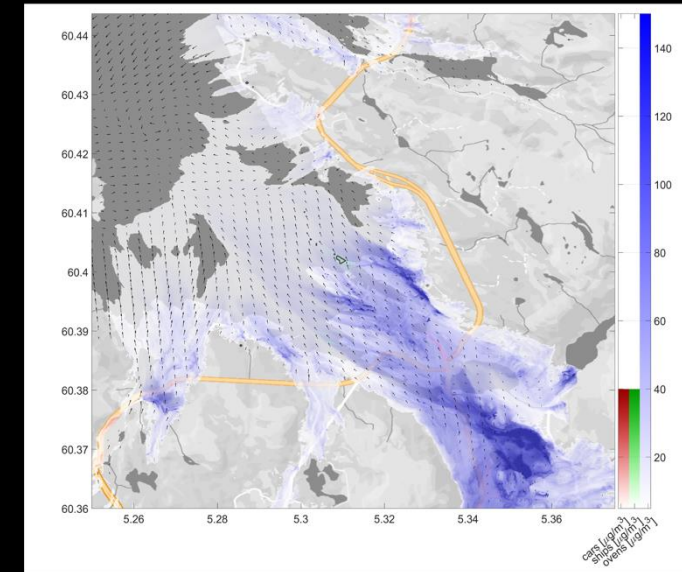
## Street-scale modelling using **PALM Large-Eddy Simulation (LES)**

- Airflow and pollution (**2–10 m resolution**)
- Dispersion of  $\text{NO}_2$  and  $\text{PM}_{2.5}$
- Contribution from traffic, shipping, and heating

$\text{NO}_2$  – traffic dominated



$\text{PM}_{2.5}$  – mixed sources



Emission sources: **cars** **ships** **ovens**

*Wolf & Esau, 2012, 2014, 2017*

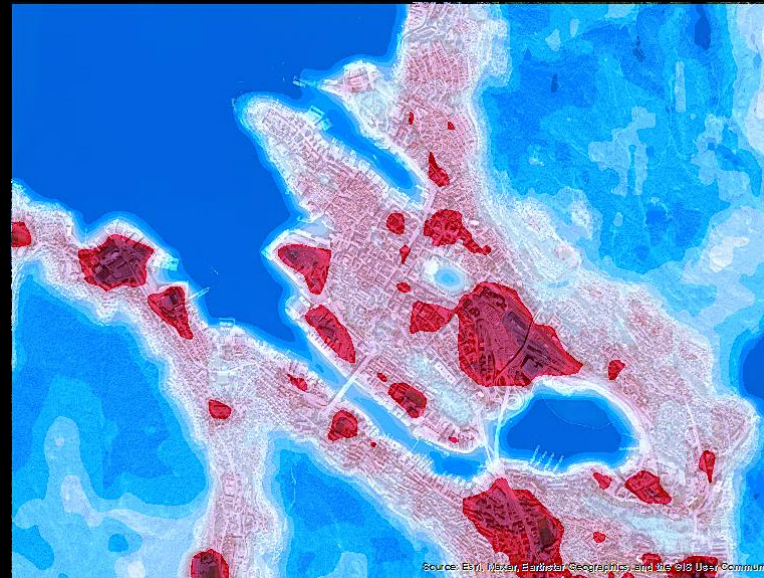
Identify urban pollution hotspots and quantify how weather, urban form, and emissions interact.



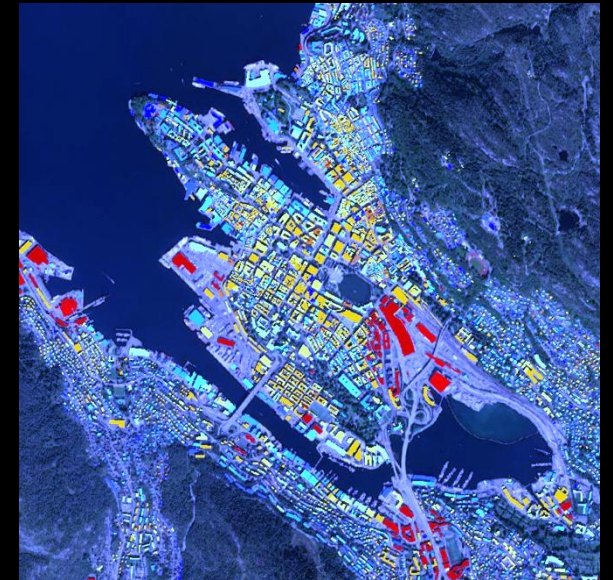
# High-Resolution Remote Sensing for Urban Climate

Mapping urban heat-stress hotspots at neighborhood and street scale

- Identify **heat-accumulating surfaces**
- Detect **urban heat-stress hotspots**
- Assess **cooling potential of green and blue infrastructure**



Surface temperature / heat-stress hotspots



Urban structure and thermal patterns

Supports spatial planning and urban climate adaptation.



# From Urban Climate Science to Decisions



## 1. Understanding impacts

Heat waves, air pollution, climate extremes

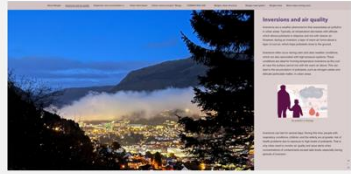
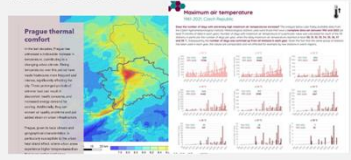


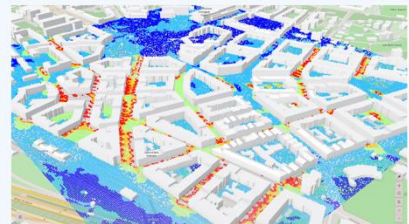
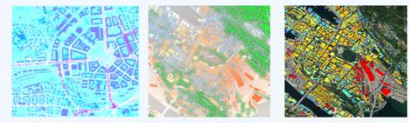

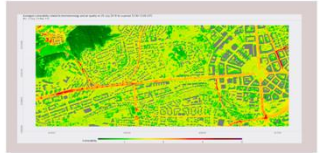
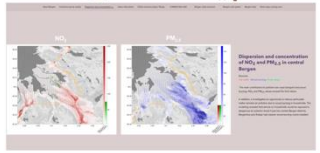
## 2. Risk assessment

GIS + modelling identify vulnerable areas

## 3. Exploring solutions

Nature-based strategies and urban planning

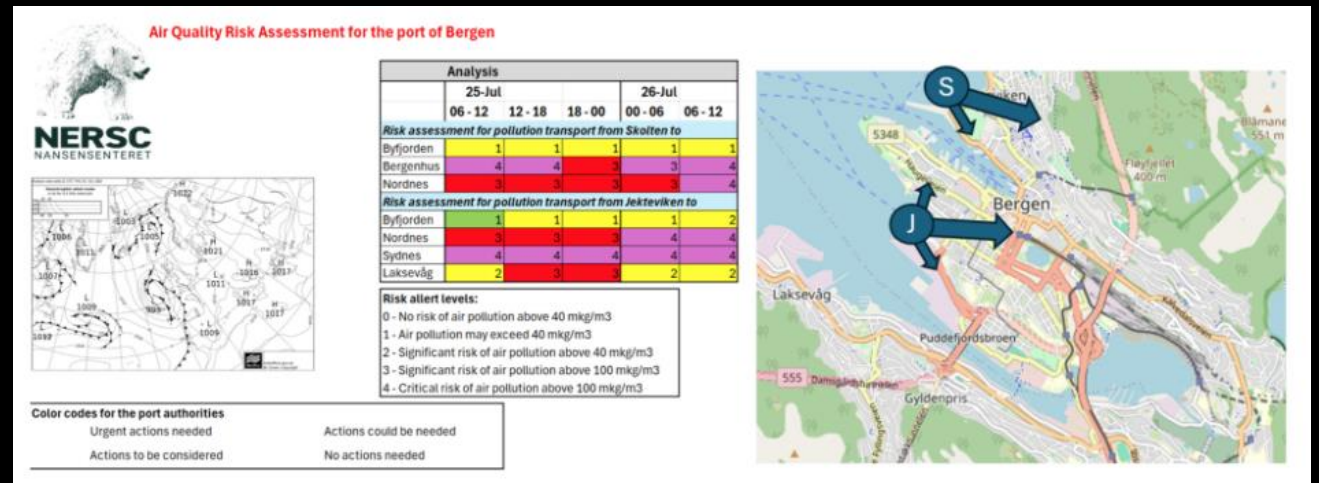
Goal: **science** → **actionable strategies for resilient cities**

Understanding impact	Risk assessment	Exploring options
<p>Inversion and air quality</p>  <p>Maximum air temperature and heat waves</p>  <p>Forest fires and local extremes</p> 	<p>Basic GIS layers of urban structure</p>  <p>Translating LES to GIS</p>  <p>Air quality and microclimate mapping</p> 	<p>Nature based solutions</p>  <p>Vulnerability mapping</p>  <p>Scenarios assessments</p> 



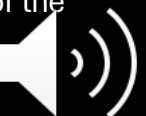
# Bergen Port: Air-Quality Decision Support

- LES simulations (~10–15 m resolution)
- Assess pollution plumes from ship emissions
- Evaluate risk under different wind scenarios
- Provide color-coded risk indicators for port authorities



This example illustrates how scientific modelling can inform operational decision-support in urban environments.

Example of a PALM-aided IUS service table used within the decision-support system of the Bergen Port Authority.



# International Education & Collaboration



Urban Sustainability in Action **URSA MAJOR**

International research and education project  
Funded by the **Research Council of Norway (INTPART)**

Focus:

- Interdisciplinary urban climate education
- Global collaboration **North–South**
- Engagement with cities and stakeholders

Learning network:

**Trondheim – Tromsø – Kochin – Fairbanks**



URSA MAJOR community



# Learning Through Real Urban Case Studies



Field-based learning across **contrasting climates**

- **Trondheim (2022)** – stakeholder urban studies
- **Tromsø (2023)** – modelling and remote sensing
- **Kochin (2024)** – urban hackathon and scenarios
- **Fairbanks (2026)** – Arctic sustainability field course

Students apply urban climate tools to **real city challenges**.



## Urban Sustainability in Alaska

Insects, flowers and concrete: urban growth and climate resilience

Pravin Punde, Lihong Zhou, Leanne Bulger, Mary Torok, Adele Birkenes, Cooper Moen  
May 26, 2025



# Urban Climate Research at NERSC: From Science to Collaboration



## Urban climate science

- High-resolution modelling and remote sensing
- Urban heat, air quality, and climate hazards

## Applications

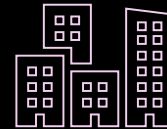
- Decision-support tools for cities
- Integrated urban services

## Education and global collaboration

- URSA MAJOR network (Trondheim – Tromsø – Kochin – Fairbanks)

## New partnerships

- **NERSC-PEEX MoU**
- Joint research, education & urban climate services



*Thank you  
for your time!*

NERSC welcomes collaboration in urban climate research and services.

