CITY OF
BERGEN

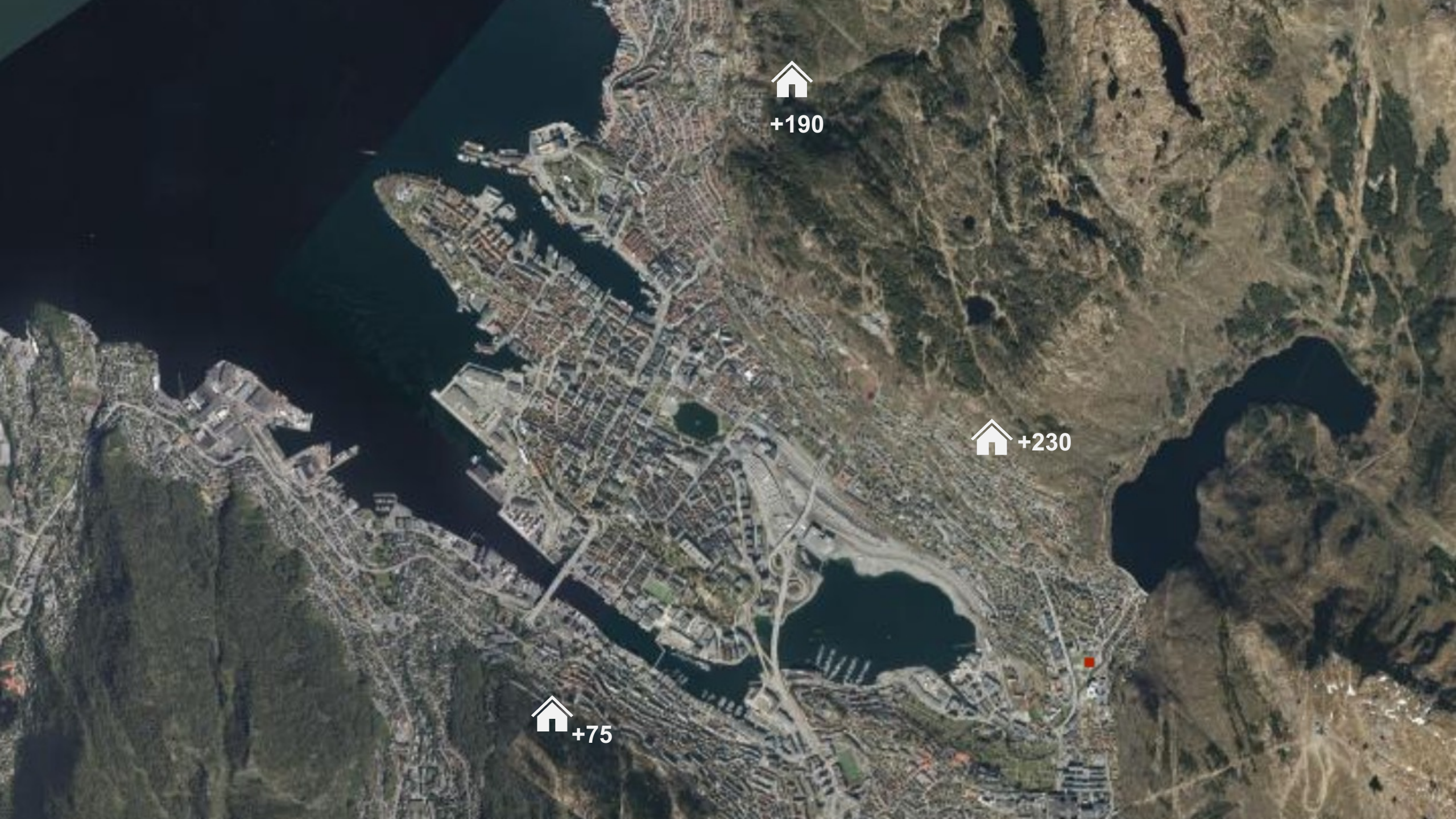
# Flood risk and coastal protection in Bergen
ADAPATALAB 11/03/2025

## Climatic- and topographic conditions for the City of Bergen

- Mild coastal climate with low pressure systems coming in from the west and southwest
- “The city surrounded by the 7 mountains”

## This gives us

- Yearly precipitation: 2000 – 4000mm
- 200 rainfall days

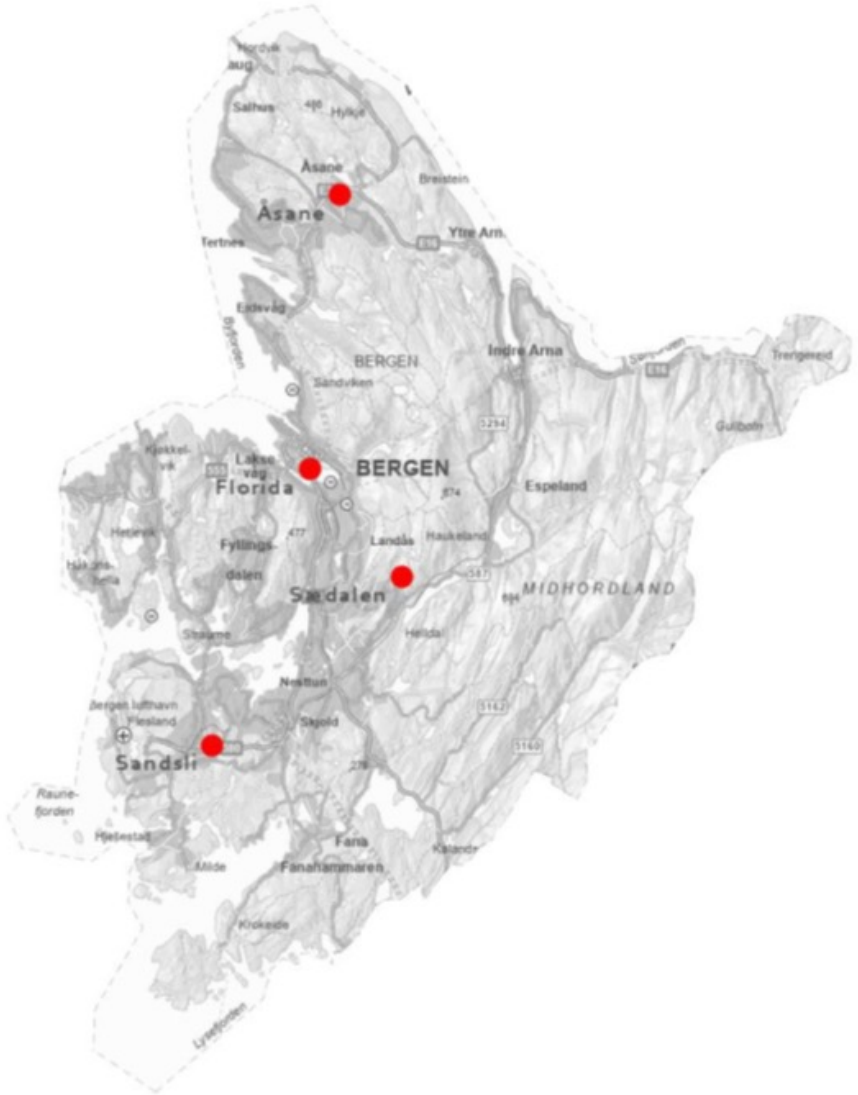

+190
+230
+75

## Cloudburst: What should we plan for?

- The flood path for stormwater: Designed for climate-adjusted 100-year rainfall
- We use IDF-curves + 30-50% (Climate change factor)

## The cloudburst “never” hits the gauge

- August 2023: 50-60 mm/1h
- IDF-value (200 retur period) + 50% Climate change factor: 58,5mm/1h




CITY OF BERGEN

BERGEN
KOMMUNE

# Cloudburst plans Bergen Municipality

Nazia Zia
Bergen Water Authority
***(nazia.zia@bergen.kommune.no)***

I4C ADAPTLAB - 11.03.2025

# Cloudburst Plans

Cloudburst plans" or "extreme rainfall plans" are developed by municipalities to address vulnerabilities associated with intense and heavy rainfall events.

Bergen  Municipality initiated to develop cloudburst plans in 2024. These plans provide tools and processes to manage cloudbursts and heavy rainfall, helping the municipality to **identify risks** and implement effective stormwater management strategies.

BERGEN
KOMMUNE

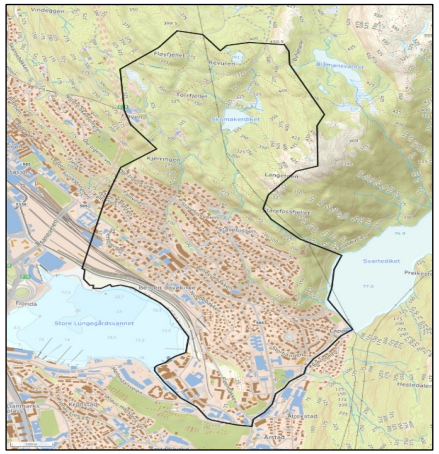

Extreme rainfall event  26.08.2023

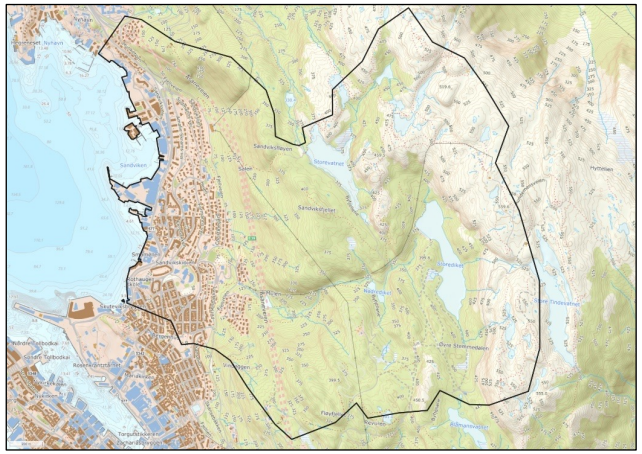
BERGEN
KOMMUNE

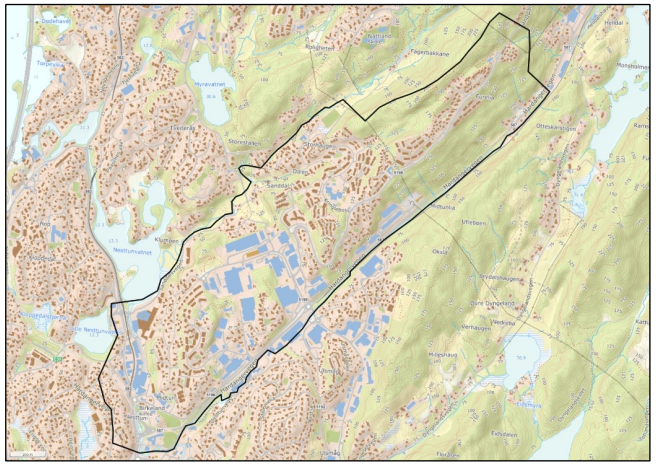
# Cloudburst plans in Bergen Municipality

The goal of the cloudburst plan is to identify risks, but also highlight opportunities to gradually improve stormwater management, both in the short and long term.

Initially, three watersheds were selected in Bergen city, where the stormwater system was combined with the sewerage system, which had insufficient capacity. Based on hydrodynamic modelling for extreme rainfall events (100 years return period + 40 % CF), these plans were developed.

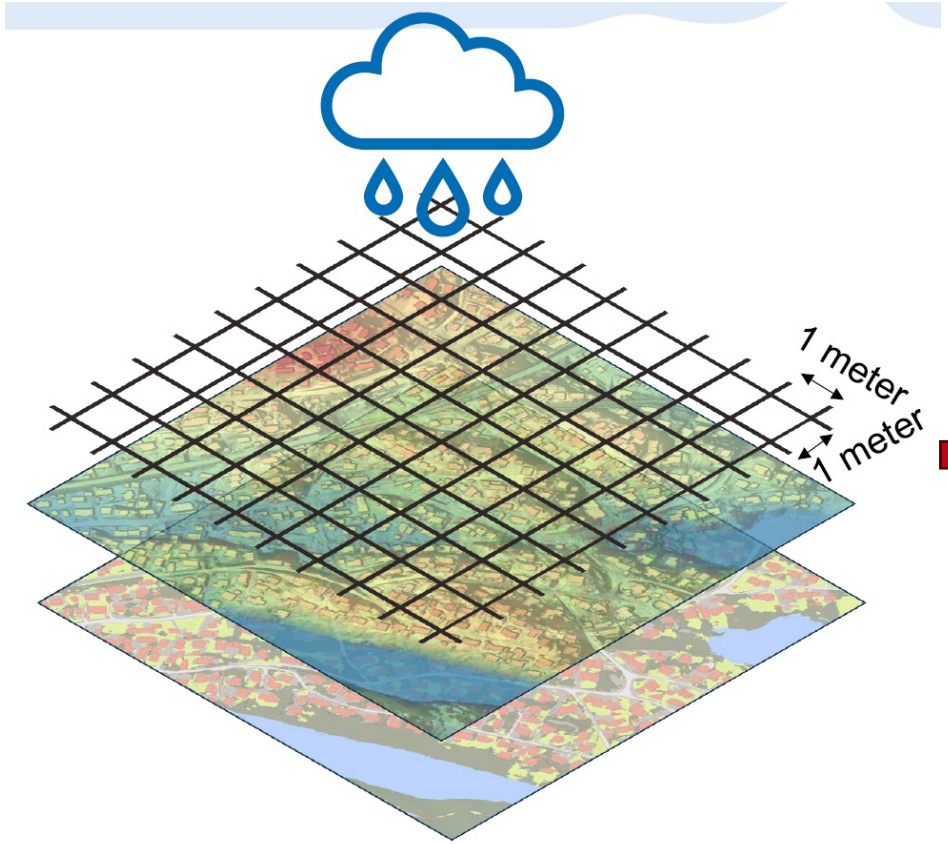






BERGEN
KOMMUNE

# Hydrodynamic Modelling



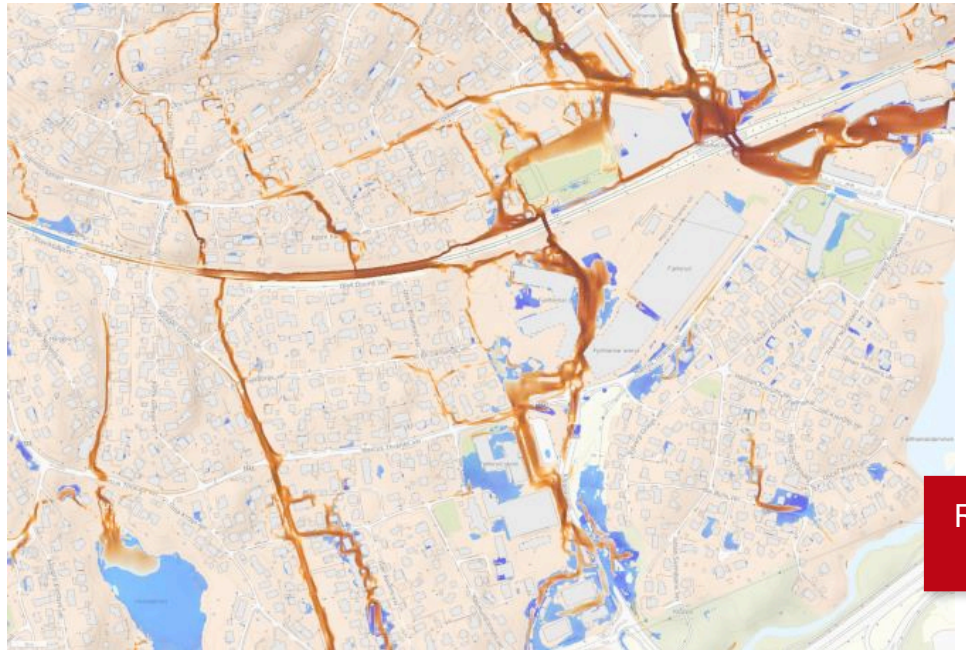

SCALGO

TUFLOW

**Input til modellen (workspace)**
Terreng, Overflate mm.

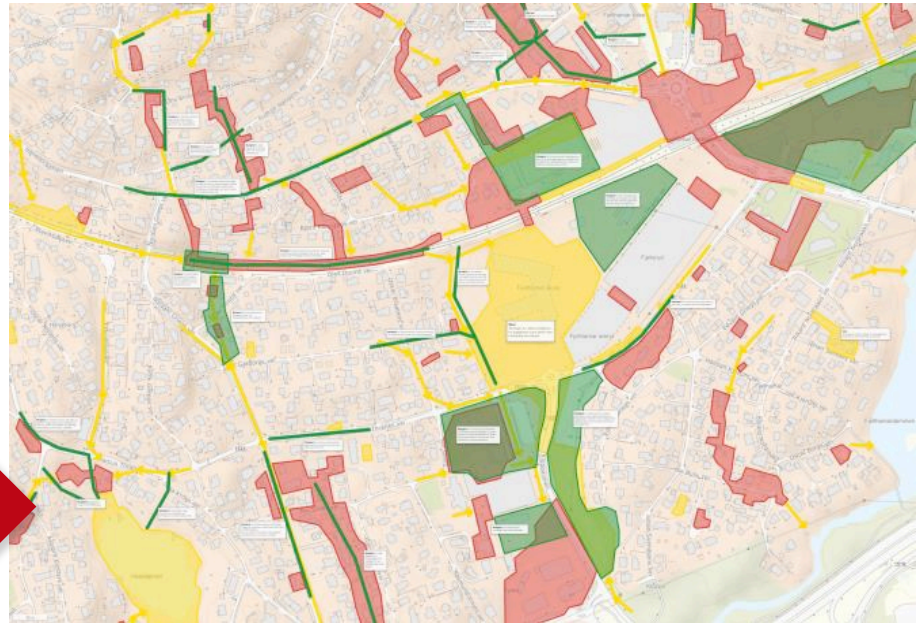
**Modellresultater (Modelspace)**
Vanndybde, hastighet, flux

## Model results




Recommendations from **NVE guidelines 4/2022**

## Cloudburst plans



BERGEN
KOMMUNE

# Elements of Cloudburst plans

**Problem Zones**
Flooding that can cause damage, or inappropriate flood pathways

**Attention Zones**
Areas with a lot of stormwater, but not in the risk zone category

**Opportunity Zones**
Areas with a special potential to incorporate climate adaptation into the project

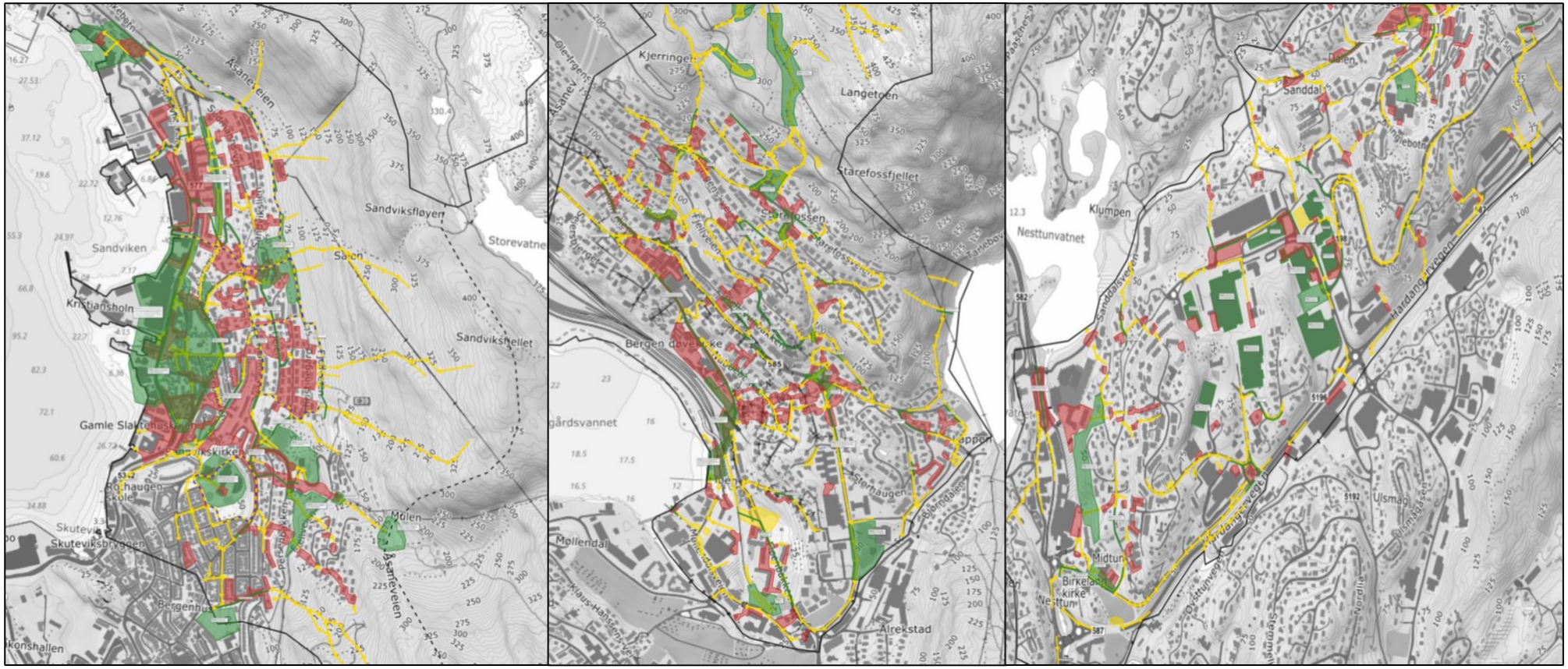
BERGEN KOMMUNE

# Dynamic Cloudburst Plans in Bergen

## Sandviken

## Starefossen

## Nesttun




The dynamic cloudburst plan defines problem areas as red, attention areas as yellow and opportunities as green.

BERGEN KOMMUNE

# From plans to climate resilience solutions

BERGEN
KOMMUNE

CITY OF
BERGEN

# Measures against sea level rise in Bergen

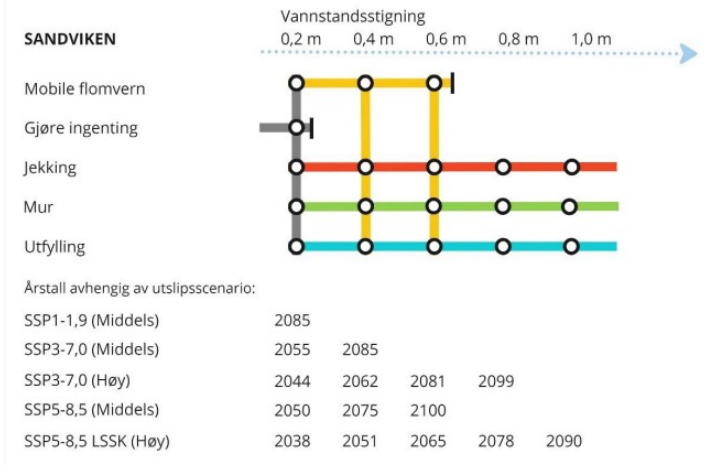
Jakob Grandin
Senior advisor, Climate Unit
Agency for the Urban Environment

11 March 2025


Assessment of measures against sea level rise, done by consultancy firm Cowi in close collaboration with the Climate Unit and the Bergen Water Authority.

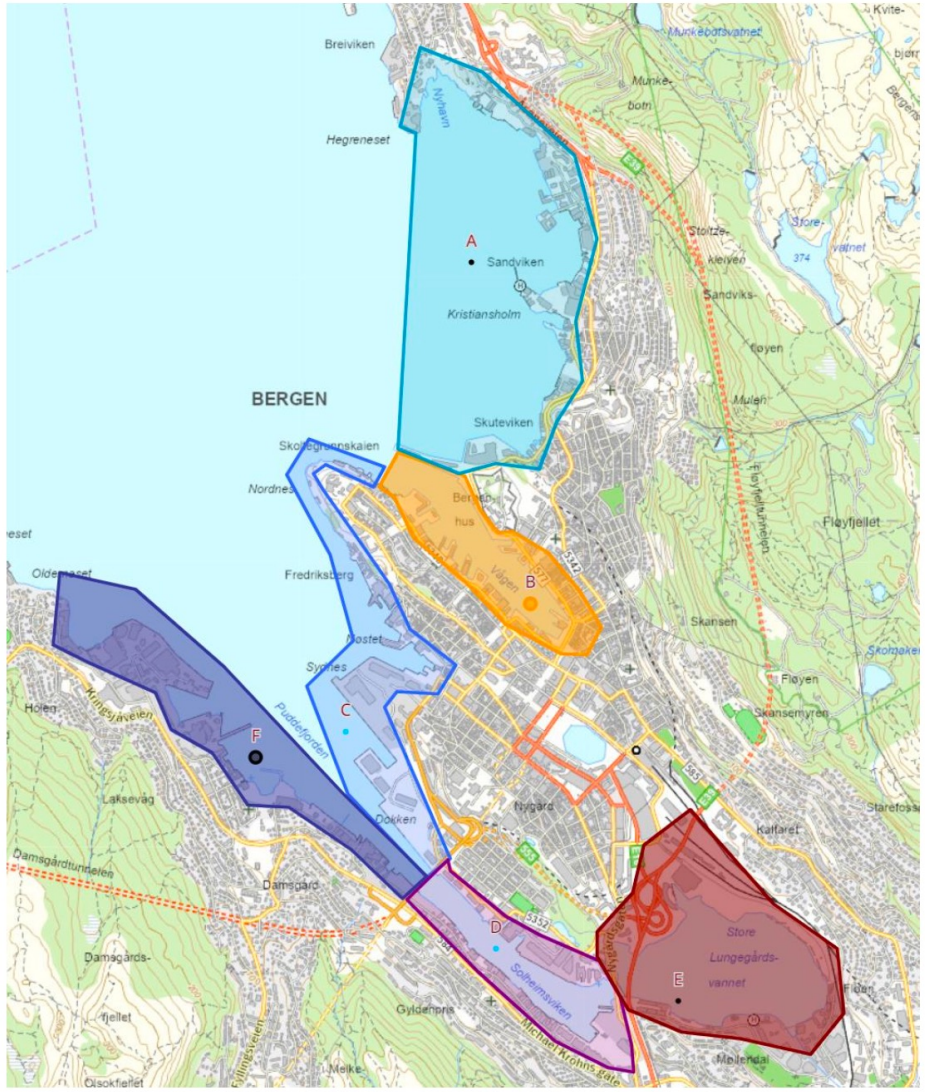
Guiding question: Which measures are most appropriate to reduce the consequences of sea level rise in combination with storm surges for buildings and infrastructure in central Bergen by 2100?

Use of DAPP (Dynamic Adaptive Policy Pathways)-methodology.




*Figur 7-9 DAPP analyse*

BERGEN KOMMUNE

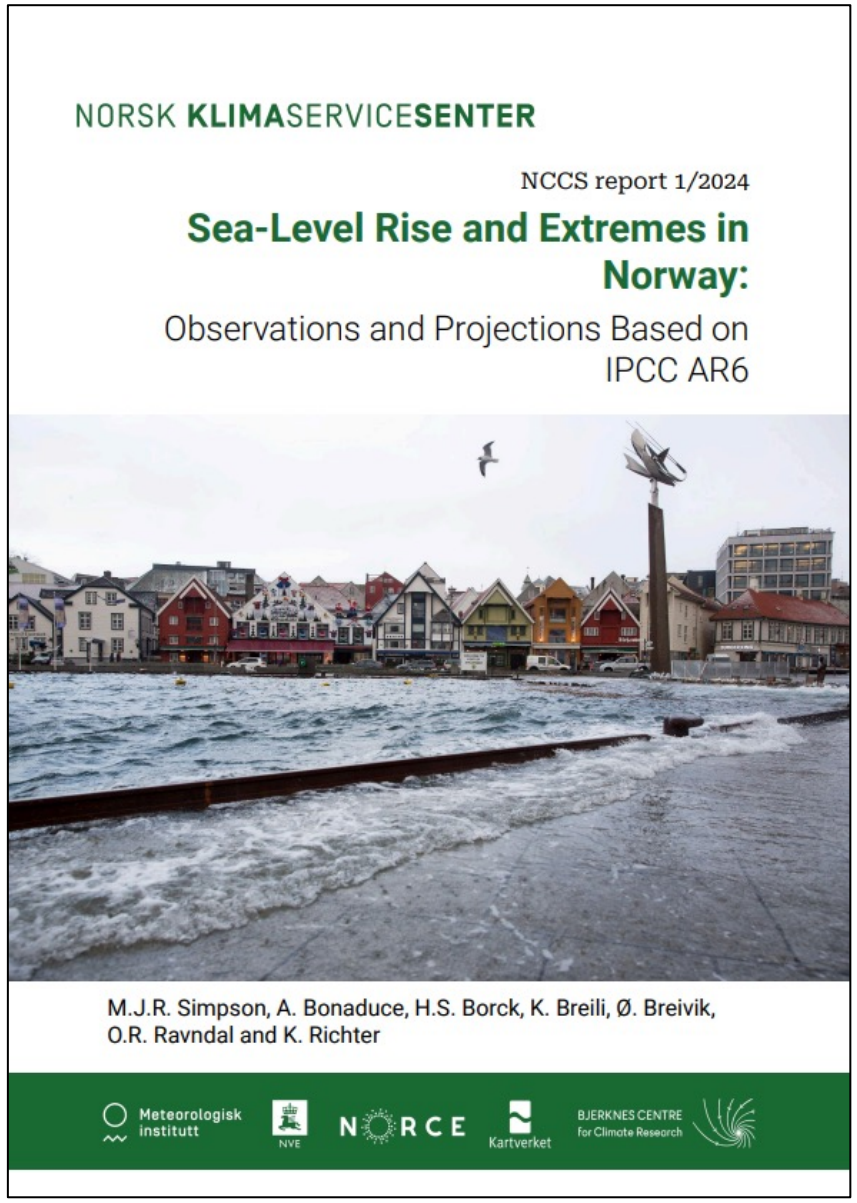


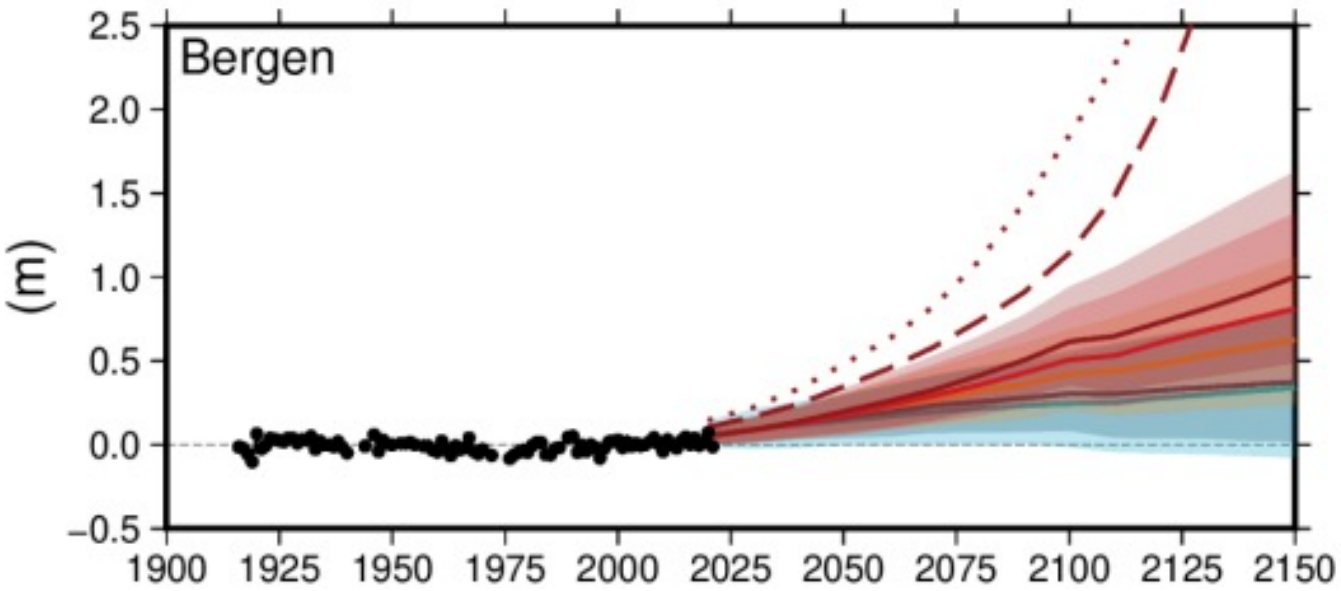

**Division into sub areas:**

A) Sandviken
B) Vågen
C) Dokken
D) Damsgårdssundet
E) Store Lungegårdsvannet
F) Laksevåg

# The area of interest

BERGEN KOMMUNE




The Norwegian Directorate for Civil Protection recommends the use of the high emissions SSP3-7.0-scenario (83 percentile) as the new basis for planning for high water levels, in line with the precautionary principle.

For Bergen, this means that we need to account for a sea level rise of **81 cm** by 2100

BERGEN KOMMUNE

# Scenarios for sea level rise (IPCC's SSPs)

*Tabell 2-1: Ekstremverdier vannstand i Bergen med returperioder (NCCS, 2024) i dag uten og med havnivåstigning*

| Returperioder | Vannstand i dagens situasjon (cm NN2000) | Vannstand i fremtiden med 81 cm havnivåstigning (SSP3-7-0, øvre 83% intervall, cm NN2000) |
|---|---|---|
| Årlig høyvann (stormflo) | 102 cm | 183 cm |
| 5-års høyvann (stormflo) | 114 cm | 195 cm |
| 10-års høyvann (stormflo) | 119 cm | 200 cm |
| 20-års høyvann (stormflo) | 124 cm (F1) | 205 cm |
| 50-års høyvann (stormflo) | 129 cm | 210 cm |
| 100-års høyvann (stormflo) | 133 cm | 214 cm |
| 200-års høyvann (stormflo) | 137 cm | 218 cm (F2) |
| 1000-års høyvann (stormflo) | 144 cm | 225 cm (F3) |

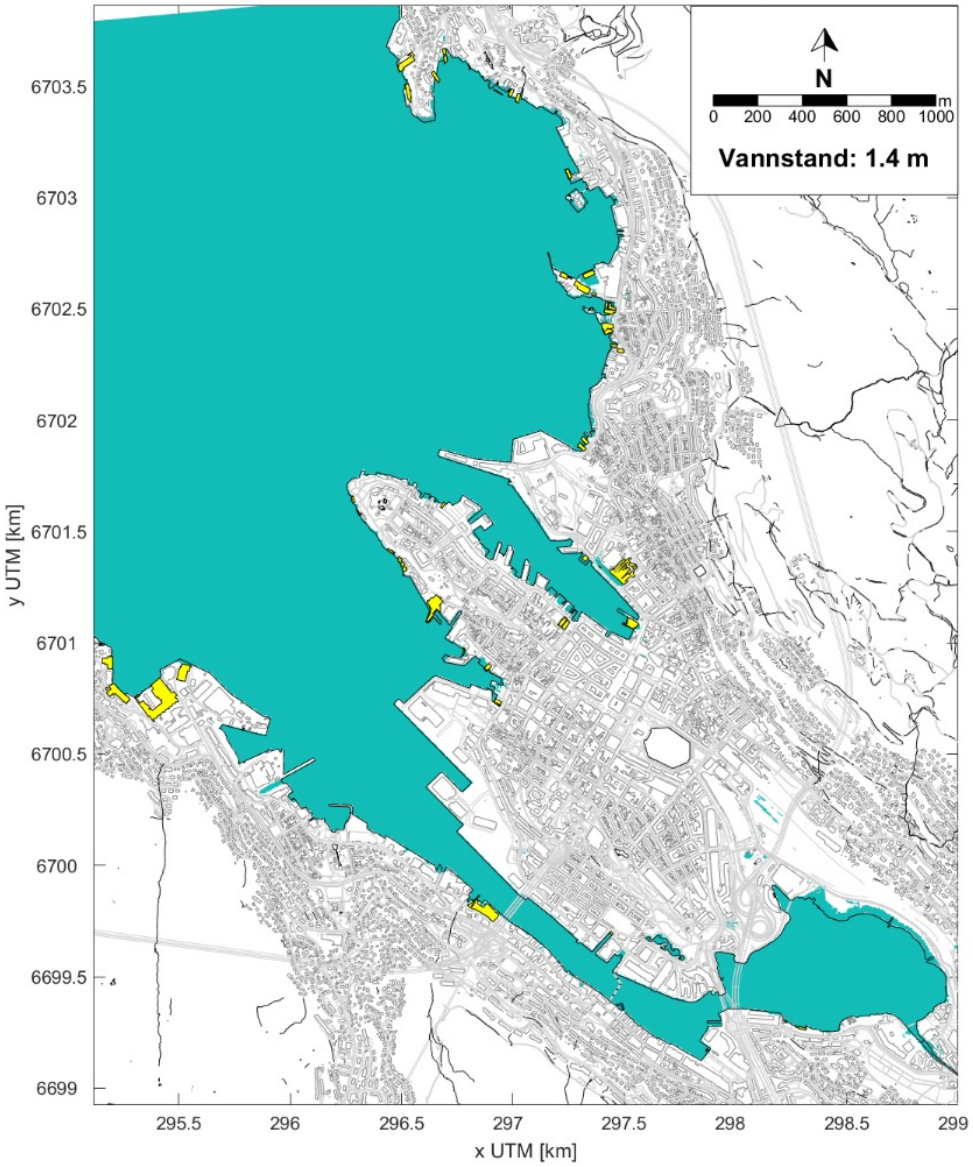
A 10 year storm surge level today equals the daily high tide in 2100.

BERGEN KOMMUNE

# Storm surge levels

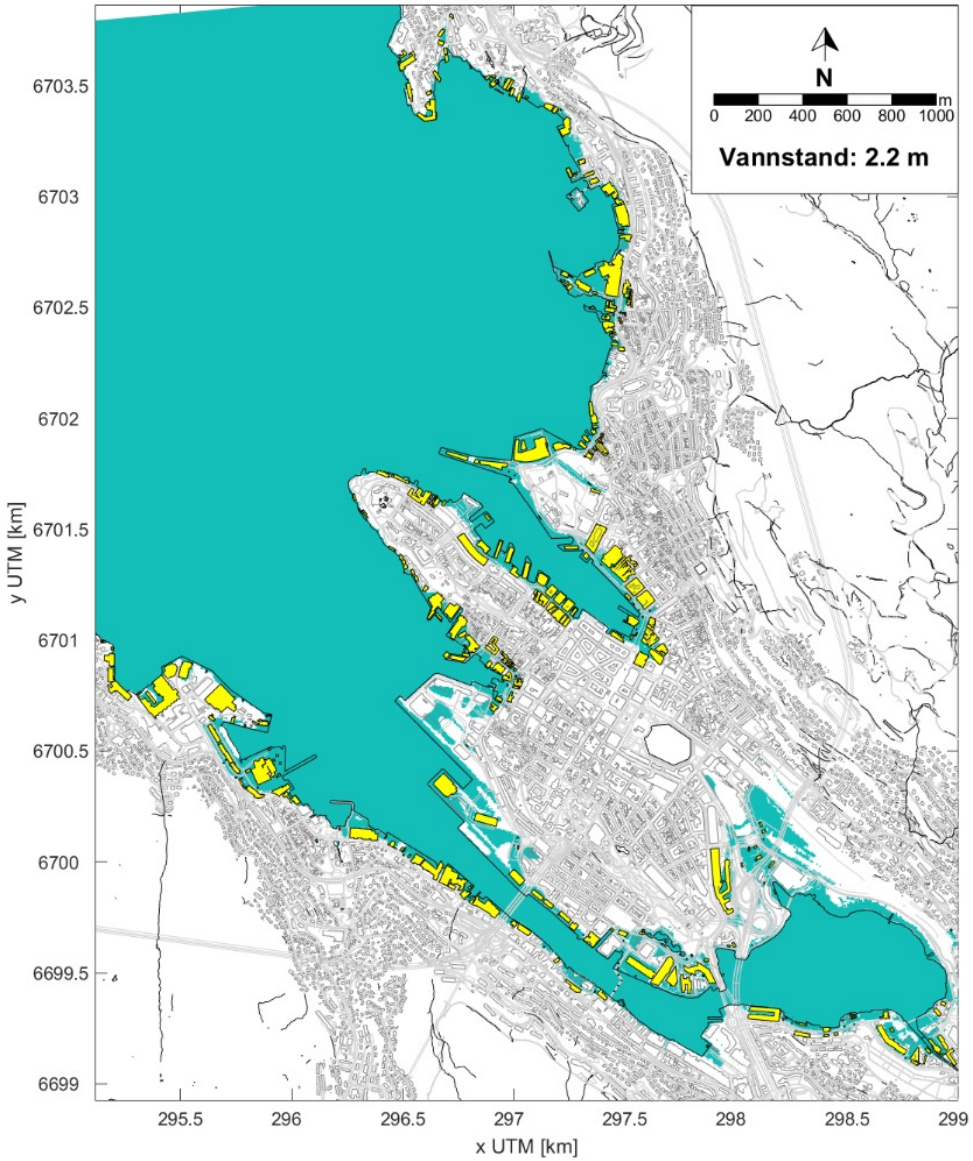
# 1.4m water level

Highest historical storm surge in Bergen.

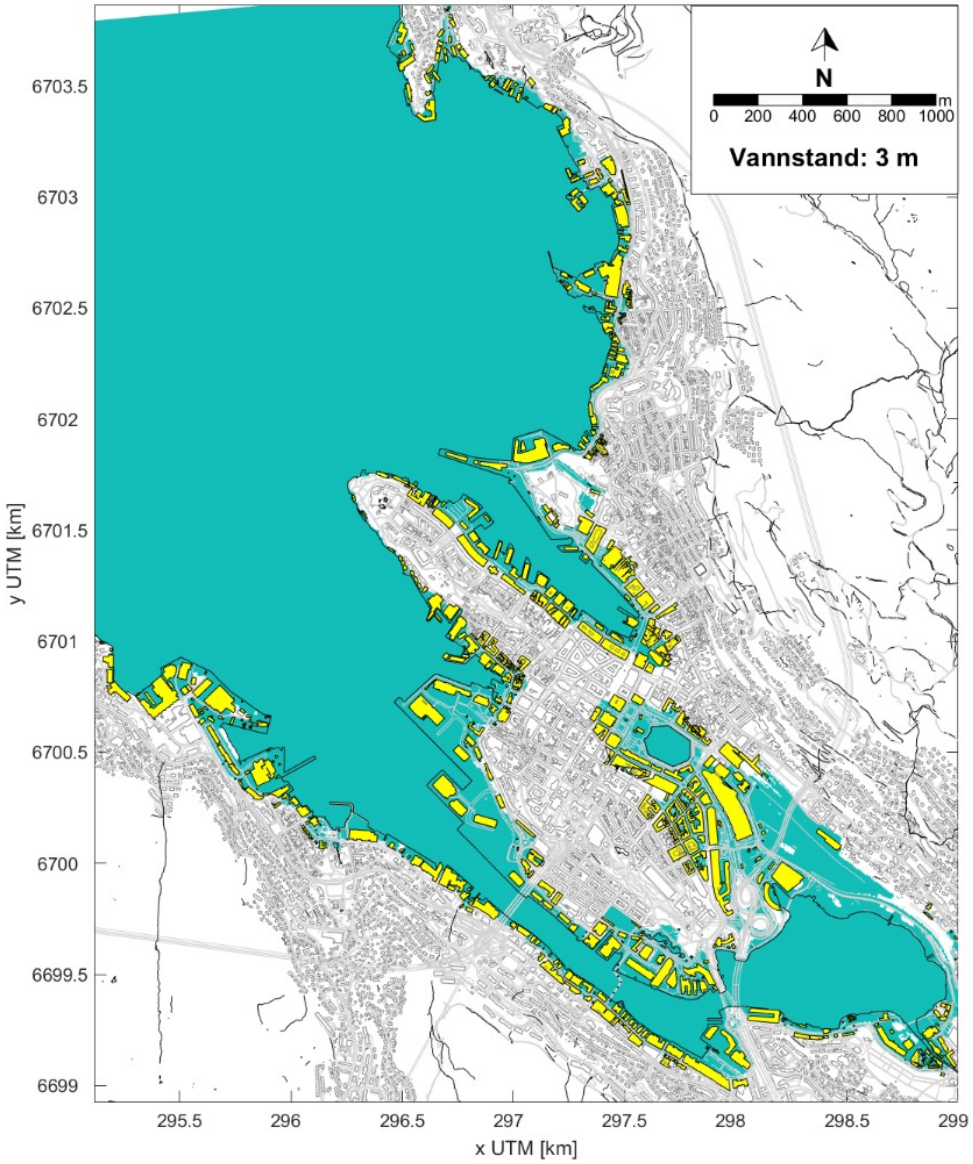


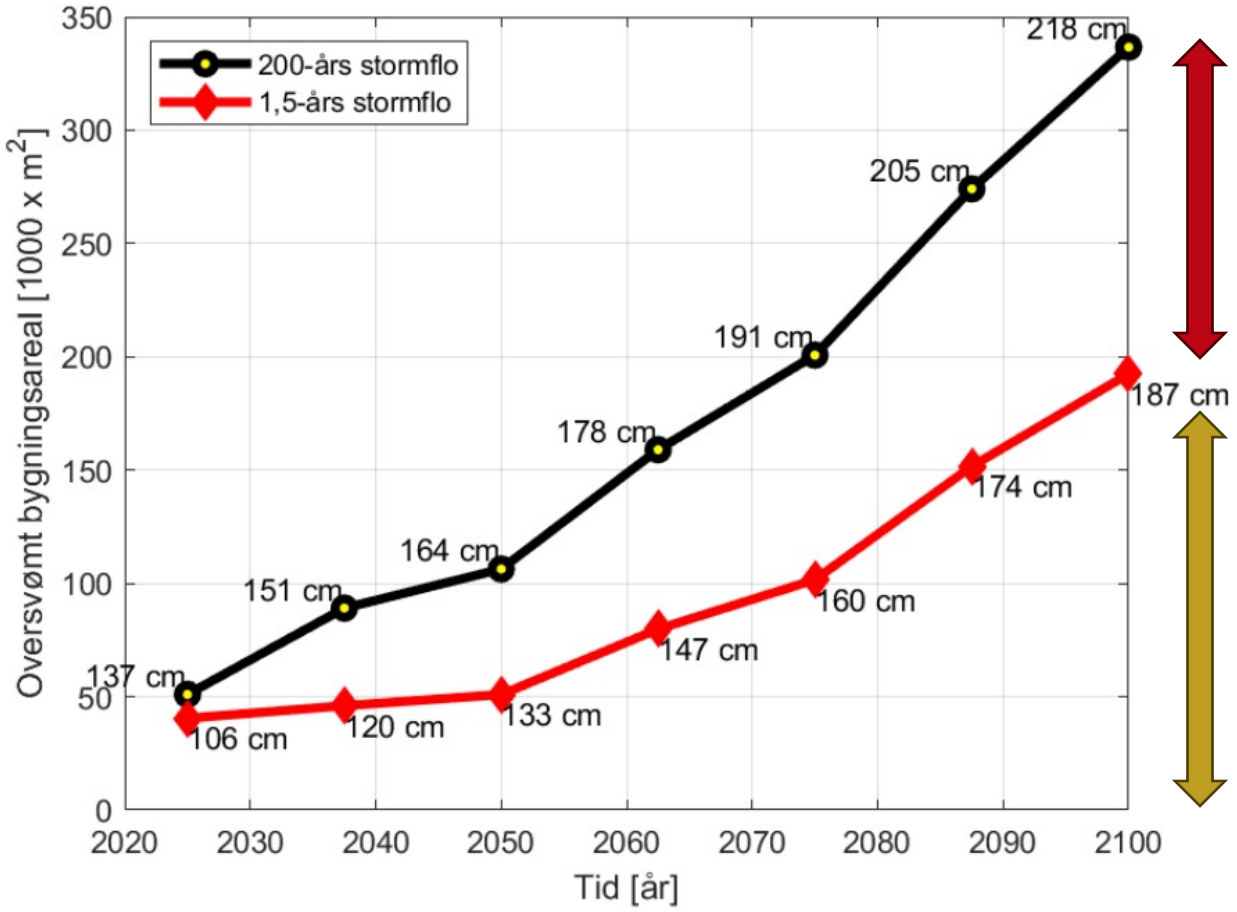
# 2.2 m water level

A 200 year storm surge in 2100 (SSP 3-7.0, 83 percentile)



# 3.0 m water level






*Figur 5-4 Total oversvømt bygningsareal i Bergen sentrum over tid. Rød linje indikerer 1,5-års stormflo og svart linje indikerer 200-års stormflo. Klimautslippsscenario SSP 3-7.0 med 83% utfallsscenario. Vannstander indikert med tall.*

About 50% of the vulnerable building area will be flooded more often than 1 time per 1.5 years.

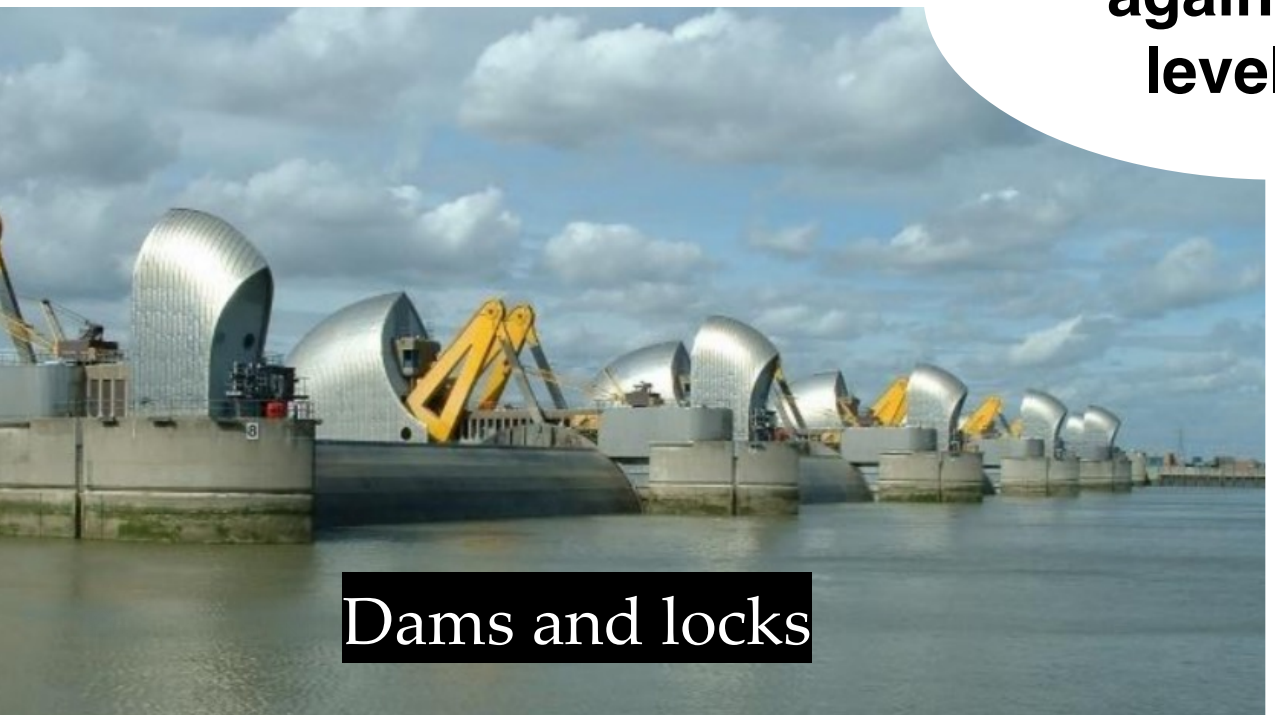
BERGEN KOMMUNE

# Total flooded building area in Bergen over time

Mobile flood protection

Permanent flood protection

# Measures against sea level rise



Dams and locks


Integrate flood protection in planned urban development

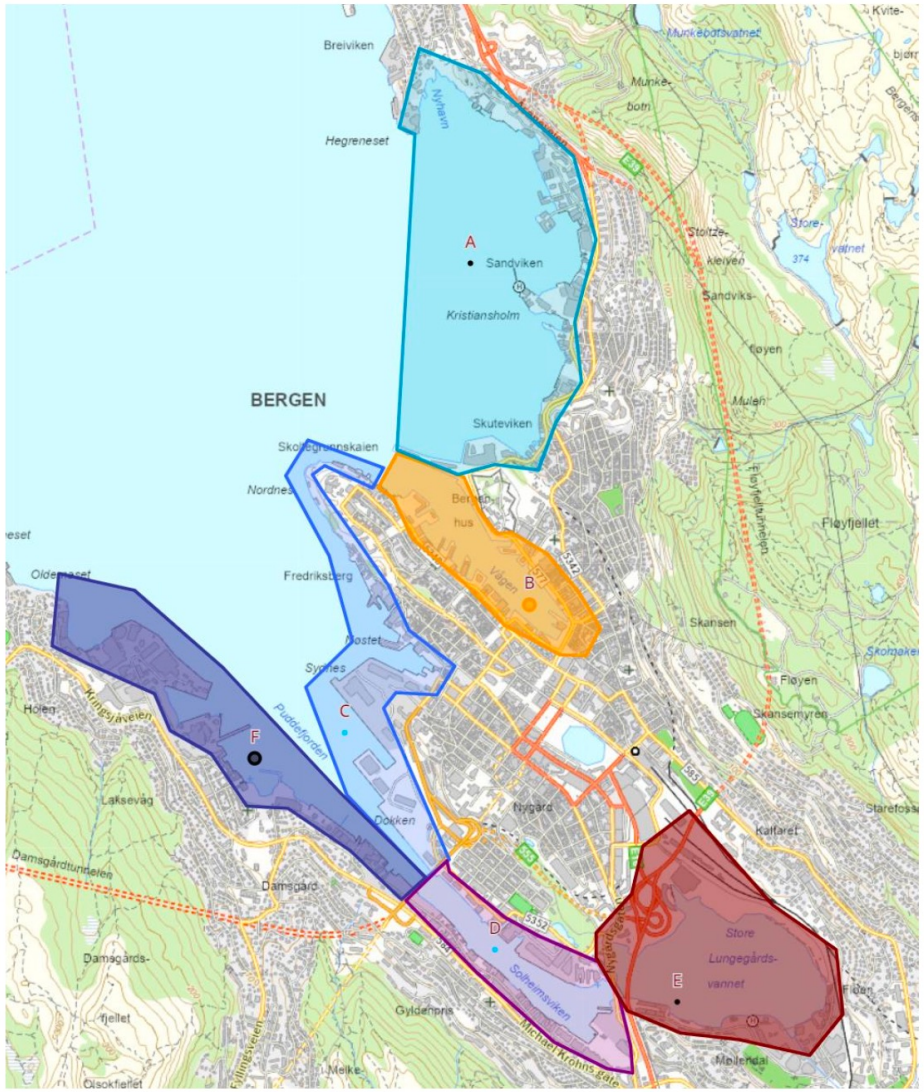




- Use of mobile flood protection.
- Permanent flood protection not assessed due to landscape and cultural heritage reasons.
- A flood barrier in the mouth of Vågen
- Possible to raise (jack) some of the old buildings on Bryggen

BERGEN KOMMUNE

# Proposed measures for Vågen




**Sandviken**: tailored flood protection for individual buildings, jacking of old buildings, use of walls and mobile flood protection.

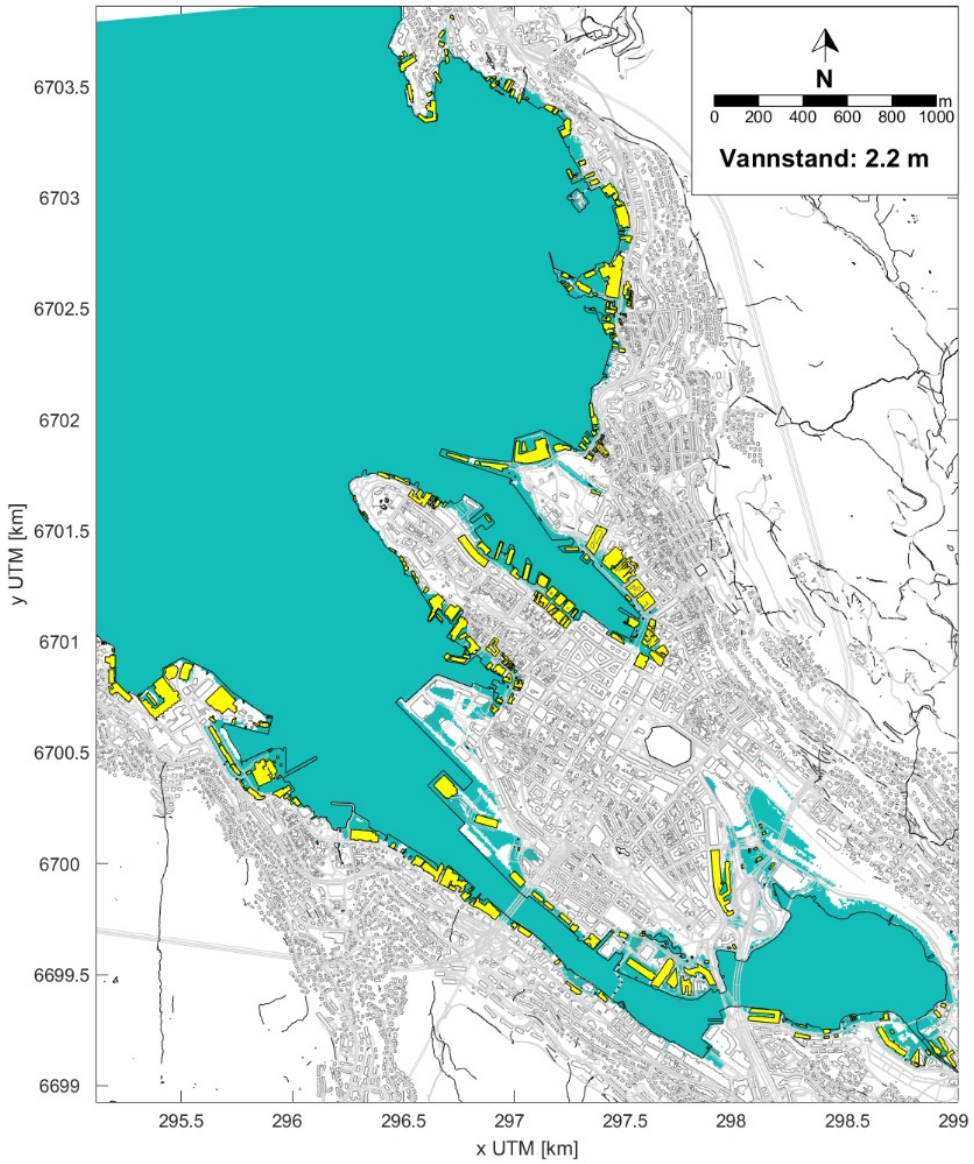
**Dokken**: combination of walls and mobile flood protection, new construction in the area can be used to protect the existing coast line.

**Store lungegårdsvannet**: Walls to protect Northern and Southern parts, a lock can be useful in the long run.

**Laksevåg**: Integration of flood protection in planned urban development combined with walls and mobile flood protection.

BERGEN KOMMUNE

# Proposed measures per subarea




Integrate resilience to sea level rise in municipal plans and practices

Climate-proofing of new investments and existing buildings, infrastructure and social services for the entire service life

Integrate climate adaptation into maintenance and operations.

Climate-robust urban planning

Withdrawal from vulnerable areas?

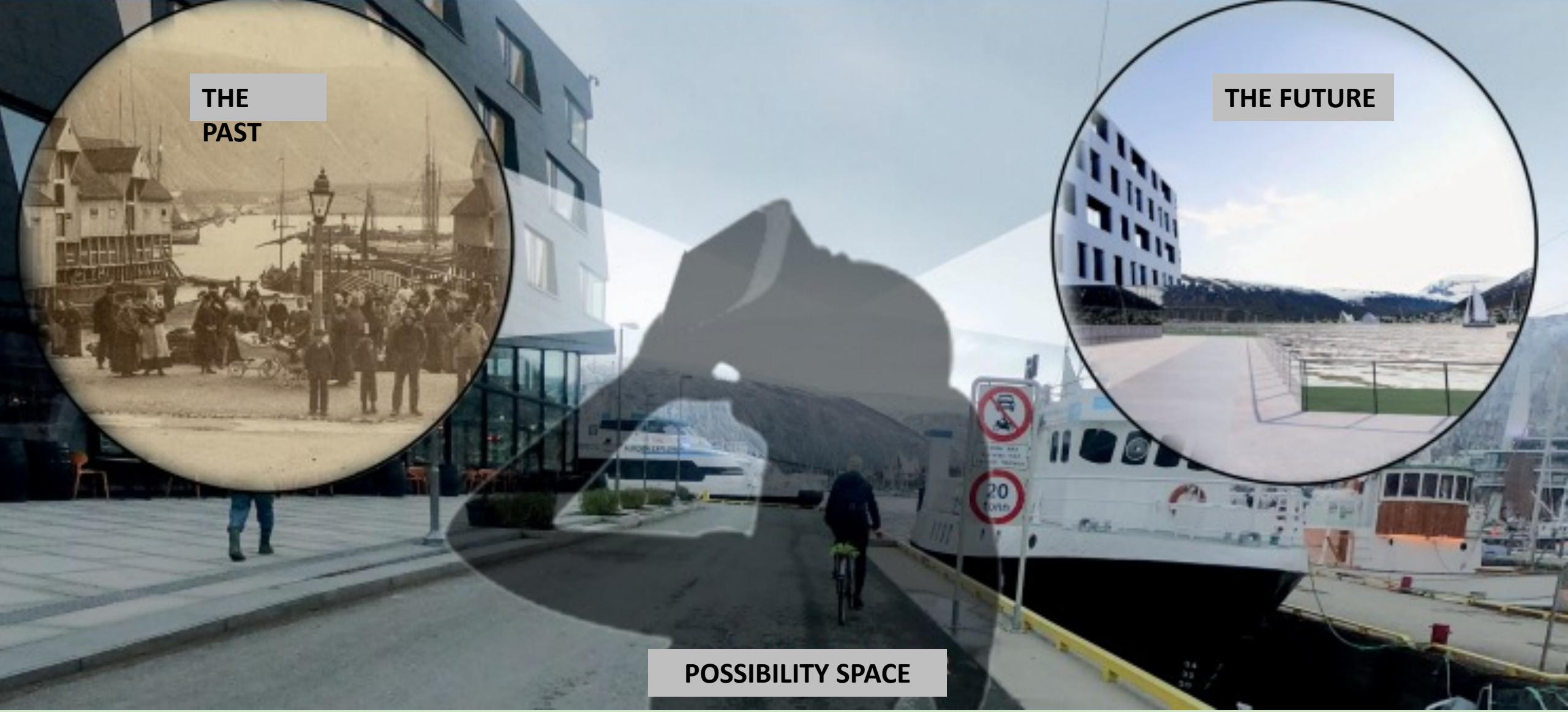
Large-scale climate adaptation measures

Preparation vs. permanent solutions

Responsibility, financing and priorities

BERGEN KOMMUNE

# Preparing for a new normal




# Climate Change in VR!

# Climate Glasses (klimabriller)

**Silje Lund Sørland, Senior Climate Advisor & Climate Risk specialist**
Group Green Transition, Sweco Bergen

SWECO

Big thanks to Øystein Rapp and Erle Kristvik for support with the VR-Glasses

# Understanding of future challenges

Climate change is about the environment

Climate adaptation is about the people

# Understanding of future challenges

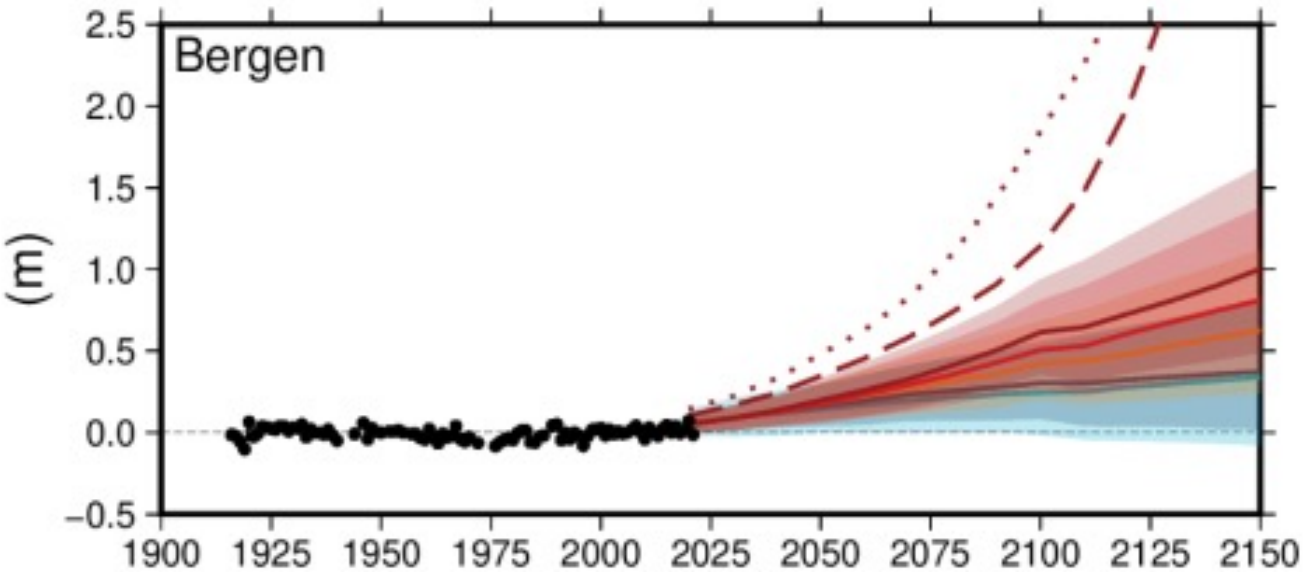
Climate change is about the environment

Climate adaptation is about the people

**Climate adaptation involves understanding the consequences of climate change and implementing measures to, on one hand, prevent or reduce harm, and on the other hand, seize the opportunities that the changes may bring.**

**If the people don't understand the consequences of climate change it is difficult to know how to adapt.**

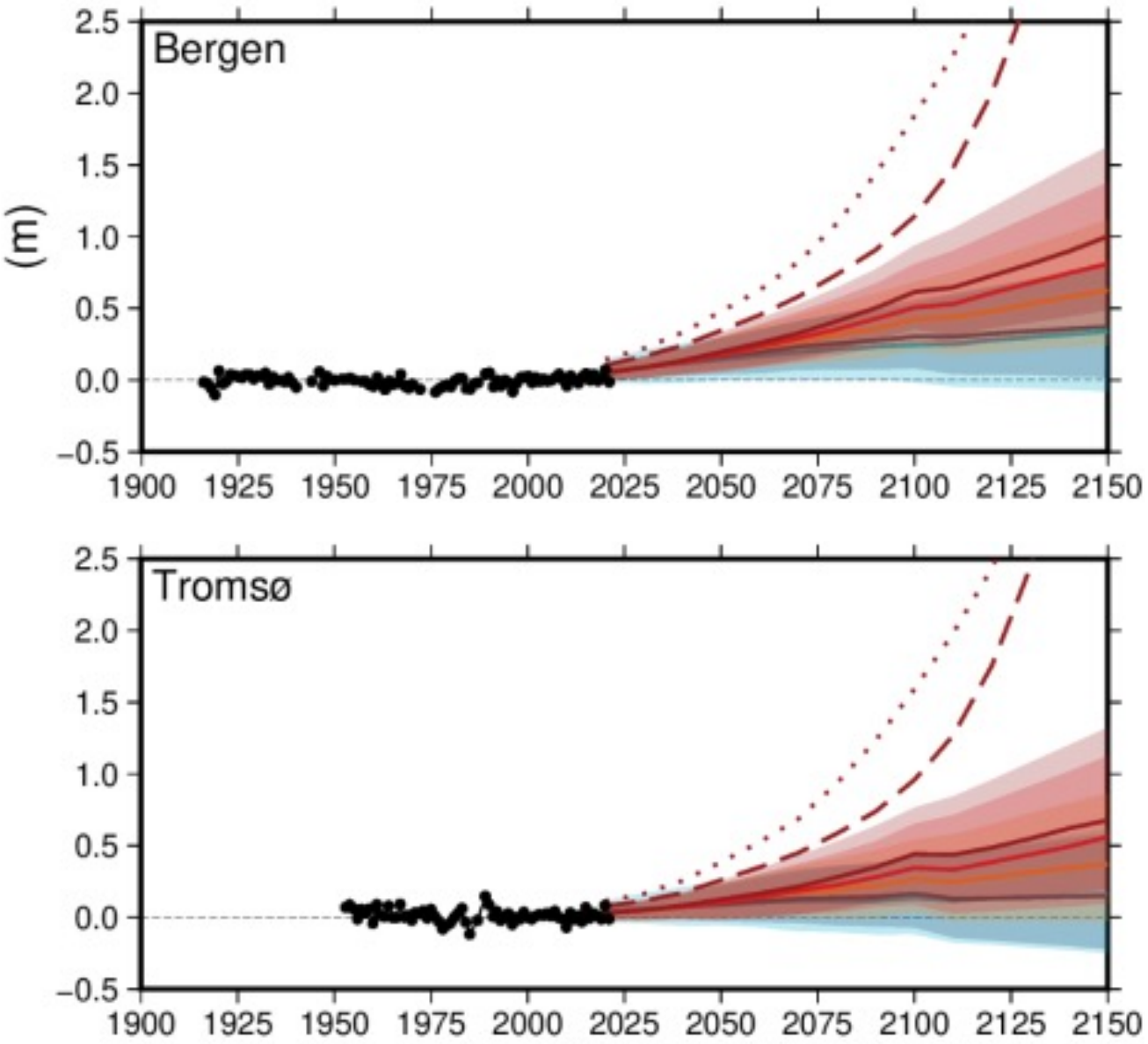
# Scenarios for Sea-level rise




| | | *Medium confidence* | | | | | *Low confidence* | |
|---|---|---|---|---|---|---|---|---|
| | % | SSP1-1.9 | SSP1-2.6 | SSP2-4.5 | SSP3-7.0 | SSP5-8.5 | SSP1-2.6 | SSP5-8.5 |
| Oslo | 95 | 0.45 | 0.43 | 0.57 | 0.74 | 0.91 | 0.46 | 1.56 |
| | 83 | 0.23 | 0.25 | 0.37 | 0.5 | 0.64 | 0.25 | 0.84 |
| | 50 | -0.05 | 0.01 | 0.13 | 0.21 | 0.32 | 0 | 0.39 |
| | 17 | -0.3 | -0.19 | -0.07 | -0.02 | 0.07 | -0.23 | 0.06 |
| | 5 | -0.48 | -0.31 | -0.18 | -0.15 | -0.07 | -0.37 | -0.12 |
| Stavanger | 95 | 0.8 | 0.8 | 0.94 | 1.09 | 1.26 | 0.82 | 1.92 |
| | 83 | 0.57 | 0.6 | 0.73 | 0.85 | 0.99 | 0.6 | 1.19 |
| | 50 | 0.28 | 0.33 | 0.45 | 0.55 | 0.65 | 0.33 | 0.75 |
| | 17 | 0.02 | 0.1 | 0.23 | 0.3 | 0.38 | 0.06 | 0.38 |
| | 5 | -0.17 | -0.04 | 0.1 | 0.16 | 0.24 | -0.1 | 0.18 |
| Bergen | 95 | 0.75 | 0.76 | 0.89 | 1.05 | 1.21 | 0.78 | 1.85 |
| | 83 | 0.53 | 0.56 | 0.68 | 0.81 | 0.94 | 0.56 | 1.14 |
| | 50 | 0.25 | 0.3 | 0.42 | 0.51 | 0.61 | 0.29 | 0.68 |
| | 17 | -0.02 | 0.08 | 0.21 | 0.26 | 0.35 | 0.03 | 0.33 |
| | 5 | -0.2 | -0.05 | 0.09 | 0.12 | 0.21 | -0.12 | 0.13 |
| Heimsjø | 95 | 0.57 | 0.57 | 0.7 | 0.84 | 1 | 0.58 | 1.6 |
| | 83 | 0.35 | 0.37 | 0.49 | 0.6 | 0.73 | 0.37 | 0.93 |
| | 50 | 0.07 | 0.12 | 0.23 | 0.3 | 0.41 | 0.1 | 0.51 |
| | 17 | -0.17 | -0.11 | 0.01 | 0.06 | 0.15 | -0.16 | 0.12 |
| | 5 | -0.34 | -0.23 | -0.11 | -0.08 | 0.01 | -0.32 | -0.1 |
| Tromsø | 95 | 0.63 | 0.62 | 0.75 | 0.89 | 1.04 | 0.63 | 1.59 |
| | 83 | 0.42 | 0.43 | 0.54 | 0.65 | 0.77 | 0.43 | 0.96 |
| | 50 | 0.14 | 0.16 | 0.27 | 0.34 | 0.44 | 0.13 | 0.53 |
| | 17 | -0.12 | -0.07 | 0.04 | 0.09 | 0.18 | -0.16 | 0.1 |
| | 5 | -0.29 | -0.21 | -0.09 | -0.06 | 0.04 | -0.33 | -0.13 |
| Honningsvåg | 95 | 0.64 | 0.66 | 0.81 | 0.92 | 1.08 | 0.67 | 1.65 |
| | 83 | 0.45 | 0.47 | 0.59 | 0.69 | 0.81 | 0.47 | 1.01 |
| | 50 | 0.19 | 0.2 | 0.32 | 0.39 | 0.49 | 0.18 | 0.56 |
| | 17 | -0.04 | -0.03 | 0.09 | 0.15 | 0.24 | -0.11 | 0.18 |
| | 5 | -0.19 | -0.17 | -0.04 | 0.01 | 0.11 | -0.28 | -0.04 |

SWECO

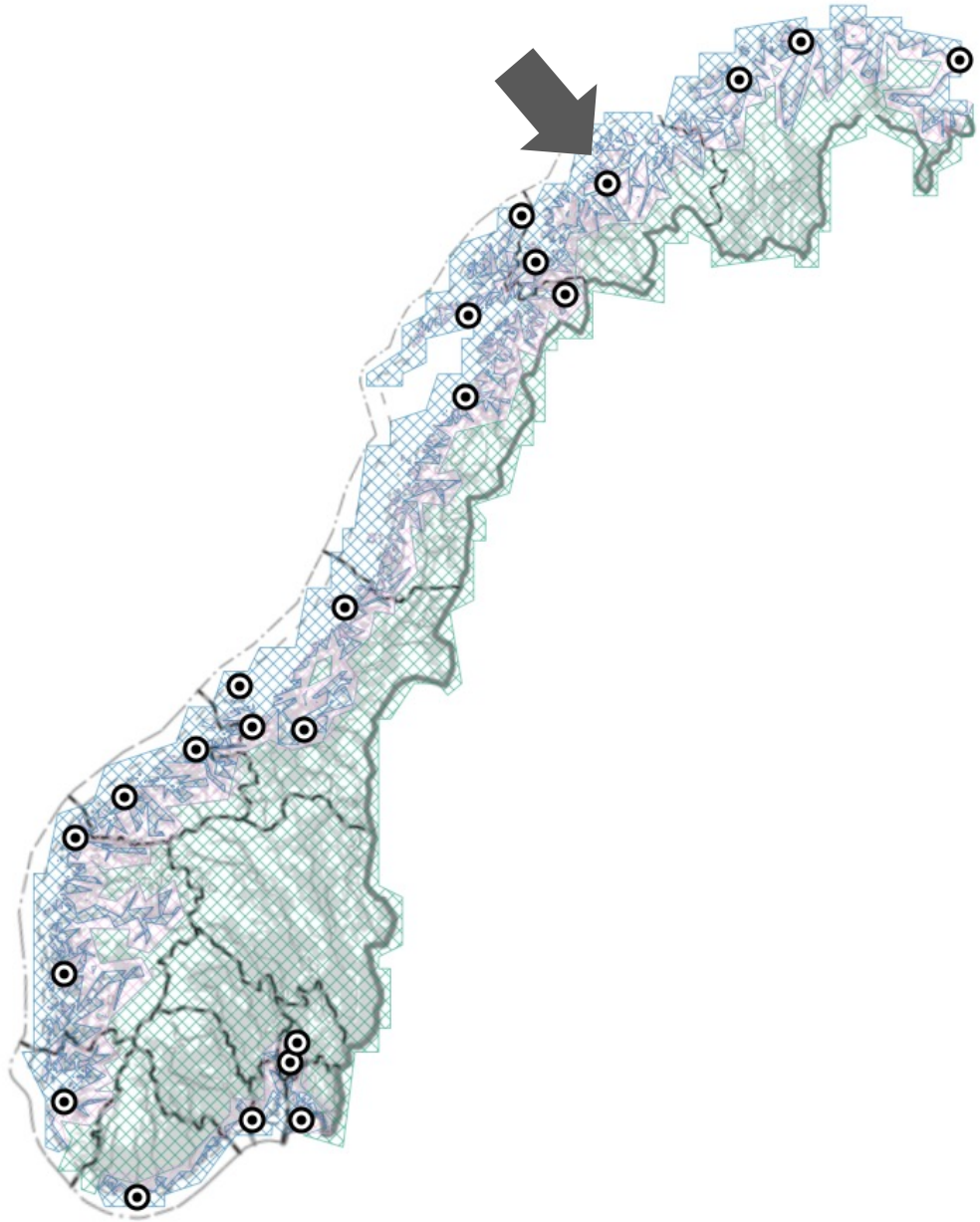
# Scenarios for Sea-level rise




| | | *Medium confidence* | | | | | *Low confidence* | |
|---|---|---|---|---|---|---|---|---|
| | % | SSP1-1.9 | SSP1-2.6 | SSP2-4.5 | SSP3-7.0 | SSP5-8.5 | SSP1-2.6 | SSP5-8.5 |
| Oslo | 95 | 0.45 | 0.43 | 0.57 | 0.74 | 0.91 | 0.46 | 1.56 |
| | 83 | 0.23 | 0.25 | 0.37 | 0.5 | 0.64 | 0.25 | 0.84 |
| | 50 | -0.05 | 0.01 | 0.13 | 0.21 | 0.32 | 0 | 0.39 |
| | 17 | -0.3 | -0.19 | -0.07 | -0.02 | 0.07 | -0.23 | 0.06 |
| | 5 | -0.48 | -0.31 | -0.18 | -0.15 | -0.07 | -0.37 | -0.12 |
| Stavanger | 95 | 0.8 | 0.8 | 0.94 | 1.09 | 1.26 | 0.82 | 1.92 |
| | 83 | 0.57 | 0.6 | 0.73 | 0.85 | 0.99 | 0.6 | 1.19 |
| | 50 | 0.28 | 0.33 | 0.45 | 0.55 | 0.65 | 0.33 | 0.75 |
| | 17 | 0.02 | 0.1 | 0.23 | 0.3 | 0.38 | 0.06 | 0.38 |
| | 5 | -0.17 | -0.04 | 0.1 | 0.16 | 0.24 | -0.1 | 0.18 |
| Bergen | 95 | 0.75 | 0.76 | 0.89 | 1.05 | 1.21 | 0.78 | 1.85 |
| | 83 | 0.53 | 0.56 | 0.68 | 0.81 | 0.94 | 0.56 | 1.14 |
| | 50 | 0.25 | 0.3 | 0.42 | 0.51 | 0.61 | 0.29 | 0.68 |
| | 17 | -0.02 | 0.08 | 0.21 | 0.26 | 0.35 | 0.03 | 0.33 |
| | 5 | -0.2 | -0.05 | 0.09 | 0.12 | 0.21 | -0.12 | 0.13 |
| Heimsjø | 95 | 0.57 | 0.57 | 0.7 | 0.84 | 1 | 0.58 | 1.6 |
| | 83 | 0.35 | 0.37 | 0.49 | 0.6 | 0.73 | 0.37 | 0.93 |
| | 50 | 0.07 | 0.12 | 0.23 | 0.3 | 0.41 | 0.1 | 0.51 |
| | 17 | -0.17 | -0.11 | 0.01 | 0.06 | 0.15 | -0.16 | 0.12 |
| | 5 | -0.34 | -0.23 | -0.11 | -0.08 | 0.01 | -0.32 | -0.1 |
| Tromsø | 95 | 0.63 | 0.62 | 0.75 | 0.89 | 1.04 | 0.63 | 1.59 |
| | 83 | 0.42 | 0.43 | 0.54 | 0.65 | 0.77 | 0.43 | 0.96 |
| | 50 | 0.14 | 0.16 | 0.27 | 0.34 | 0.44 | 0.13 | 0.53 |
| | 17 | -0.12 | -0.07 | 0.04 | 0.09 | 0.18 | -0.16 | 0.1 |
| | 5 | -0.29 | -0.21 | -0.09 | -0.06 | 0.04 | -0.33 | -0.13 |
| Honningsvåg | 95 | 0.64 | 0.66 | 0.81 | 0.92 | 1.08 | 0.67 | 1.65 |
| | 83 | 0.45 | 0.47 | 0.59 | 0.69 | 0.81 | 0.47 | 1.01 |
| | 50 | 0.19 | 0.2 | 0.32 | 0.39 | 0.49 | 0.18 | 0.56 |
| | 17 | -0.04 | -0.03 | 0.09 | 0.15 | 0.24 | -0.11 | 0.18 |
| | 5 | -0.19 | -0.17 | -0.04 | 0.01 | 0.11 | -0.28 | -0.04 |

SWECO

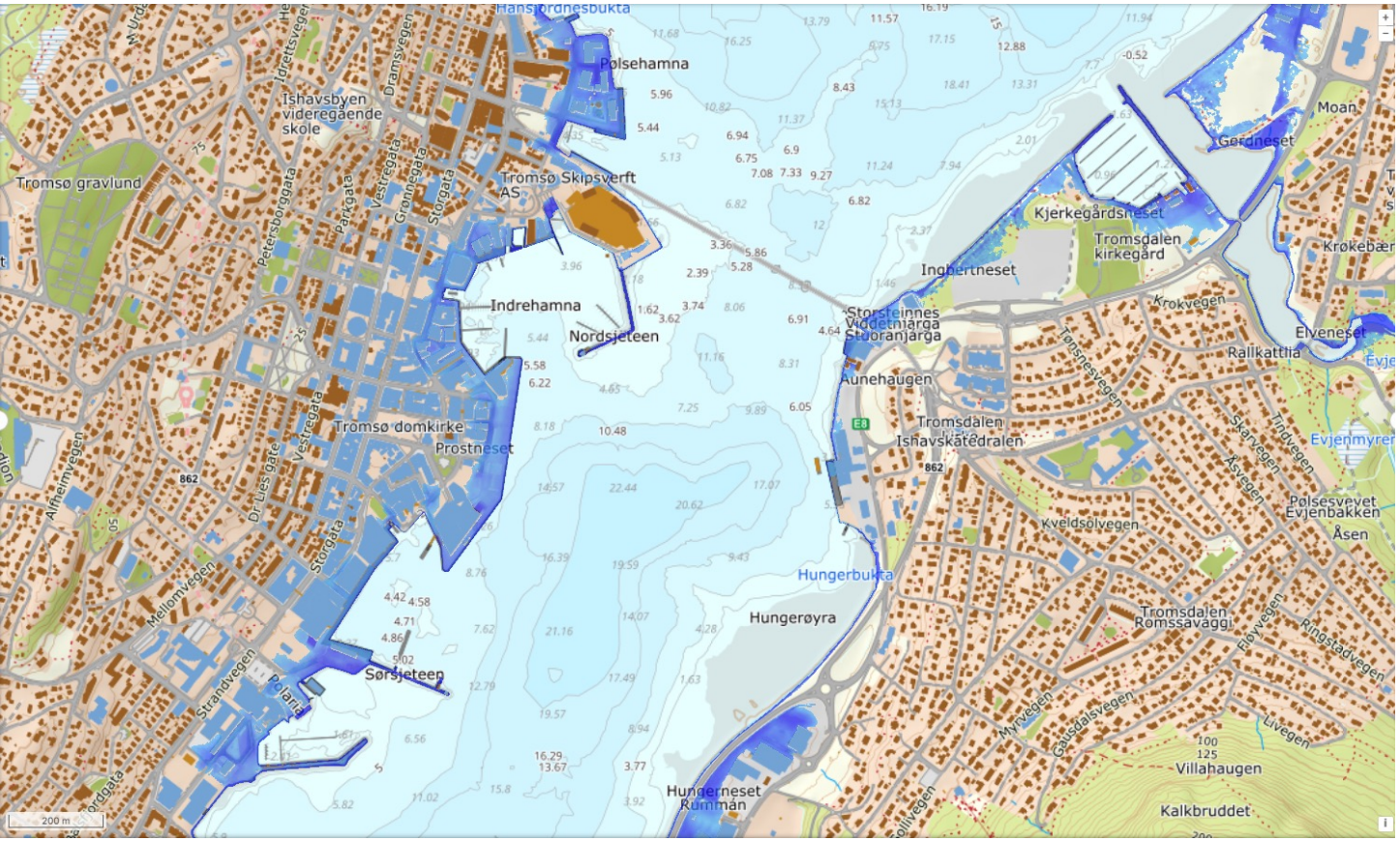
# Example from Tromsø

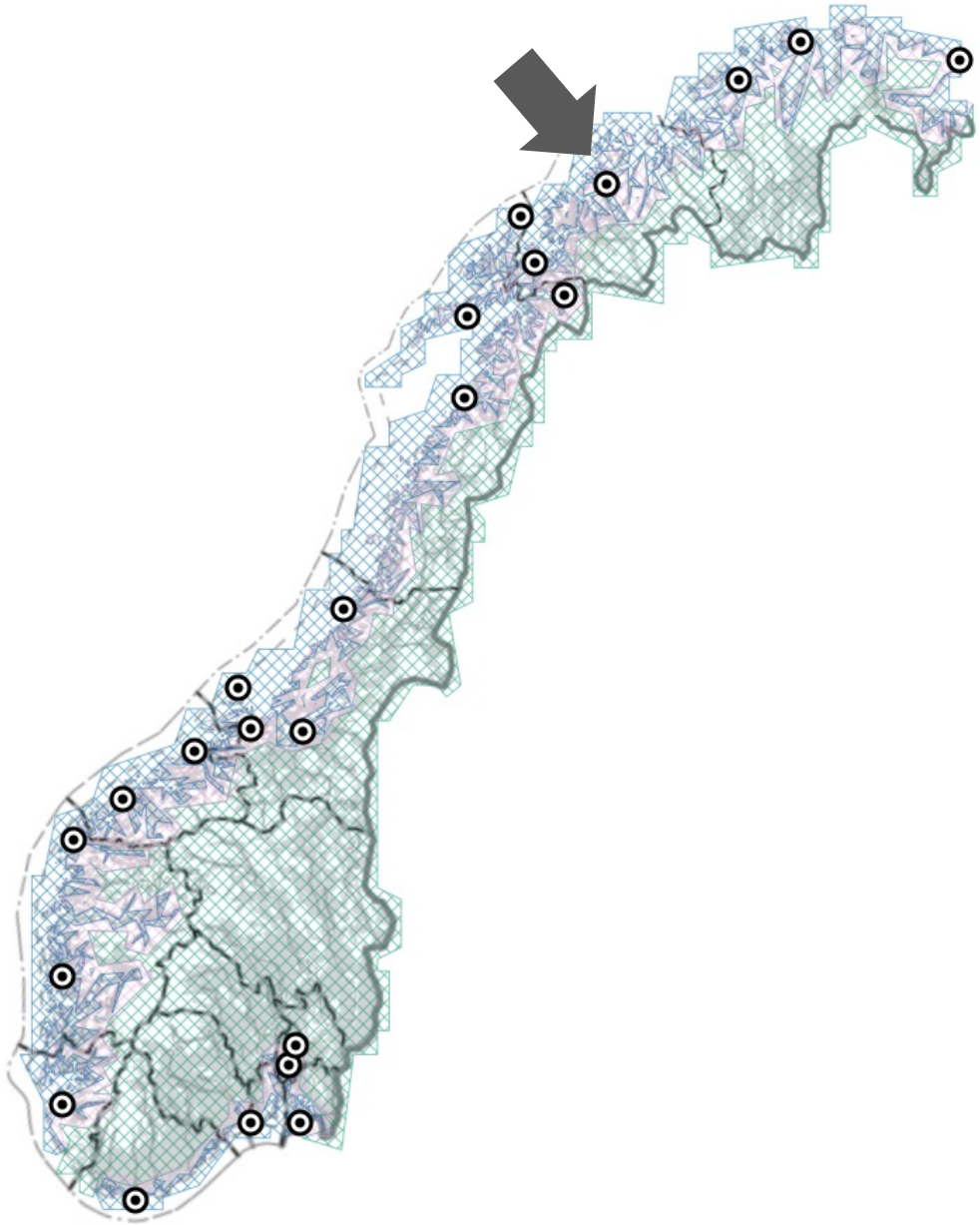



SWECO

# Example from Tromsø

Sea level rise and 200-year storm surge events in Tromsø: 270 cm

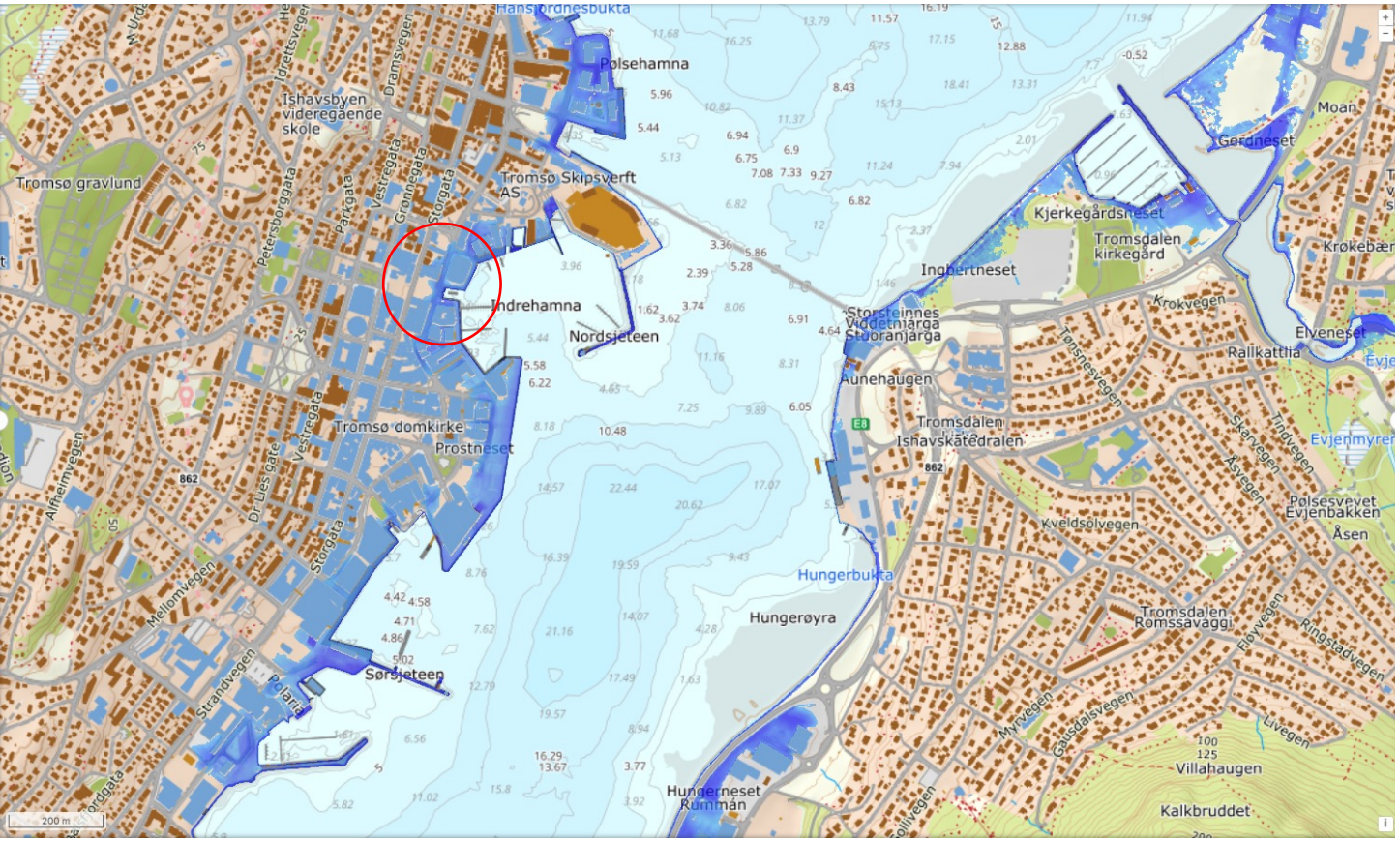


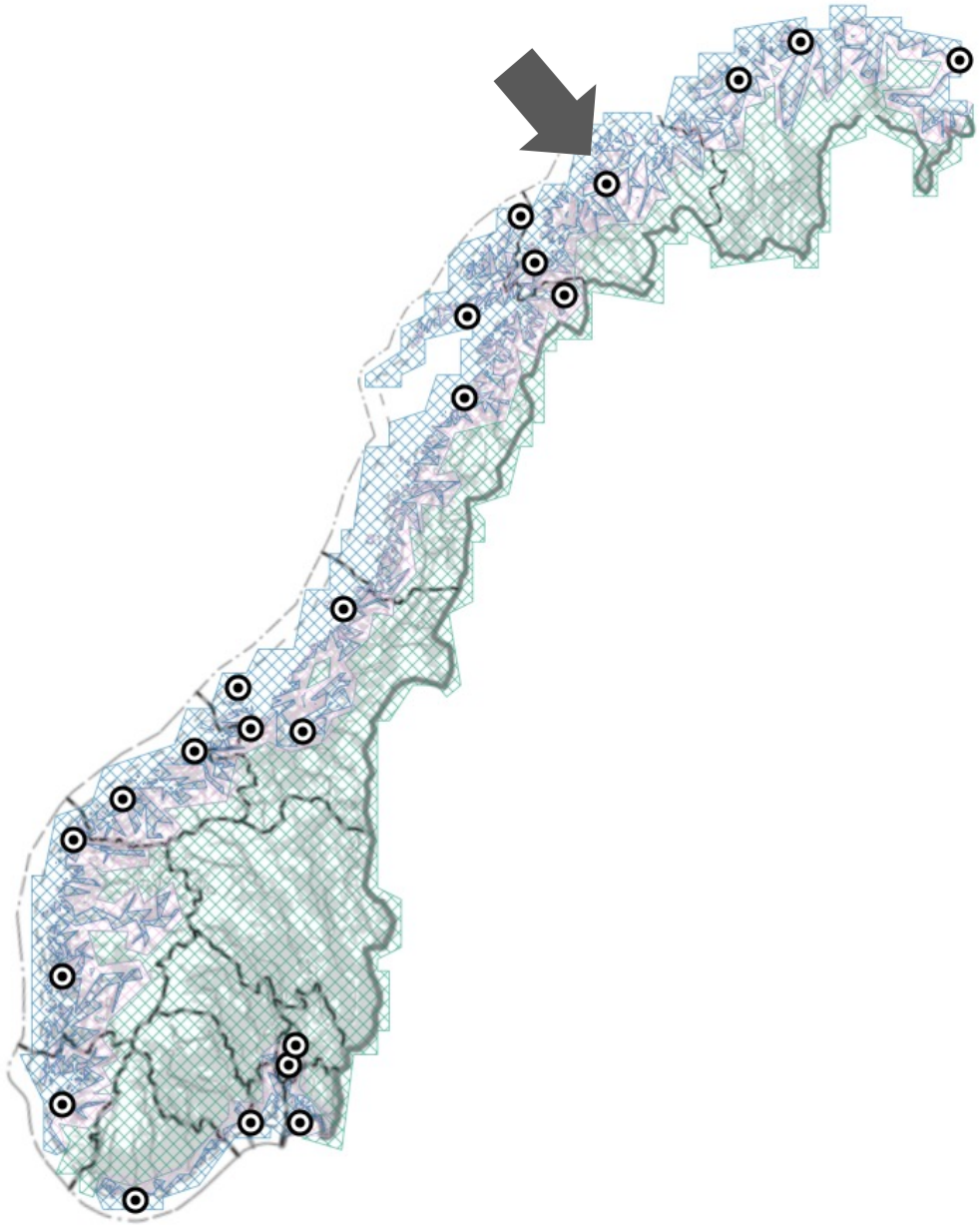



SWECO

# Example from Tromsø

Sea level rise and 200-year storm surge events in Tromsø: 270 cm



SWECO


Taxi
Norconsult
Arbeidstilsynet
Nord-Norge
Norconsult
Kaia

# Tromsø in year 2100 with sea level rise and a 200-year storm surge event

# New tools for better understanding

Part of the project IMPETUS: Turing climate commitments into action, Sweco together with UiT and Tromsø Municipality tested how VR-glasses can be used to communicate climate risk.

**Climate glasses/VR - glasses:**

- Sea level at year 2100 with a storm surge (200 year even)with and without  flood protection
- Used Revit to make the model
- 360 pictures from different positions in Tromsø, with and without flood protection.

**The Reactions:**

'Have you shown this to municipal planners?’

'Have you shown this to politicians?’

'Have you shown this to developers, planners, and architects?'

4 NYHETER

NYHETER

Tipstelefon: 77 61 05 00 E-post: tips@nordlys.no

Se video av oversvømmelse, scann QR-kode med din mobil

Virtuelt bilde av Tromsø sentrum i 2100:

Gater lagt under vann

TESTET: Anne-Berit Figenschau hadde aldri prøvd VR-briller før, men synes det var en gøy opplevelse.

Gunnar Wilhelmsen (Ap) og Anne-Berit Figenschau (H) fikk se et Tromsø sentrum lagt under vann.

Tekst: Robin Andersen
robin.andersen@nordlys.no
Foto: Torgrim Rath Olsen
torgrim.ratholsen@nordlys.no

HAVNIVÅ

Onsdag formiddag fikk ordfører Gunnar Wilhelmsen (Ap) og ordførerkandidat Anne-Berit Figenschau (H) et innblikk i

OVERRASKET: Gunnar Wilhelmsen ble skremt av det han fikk se av Tromsø i år 2100.

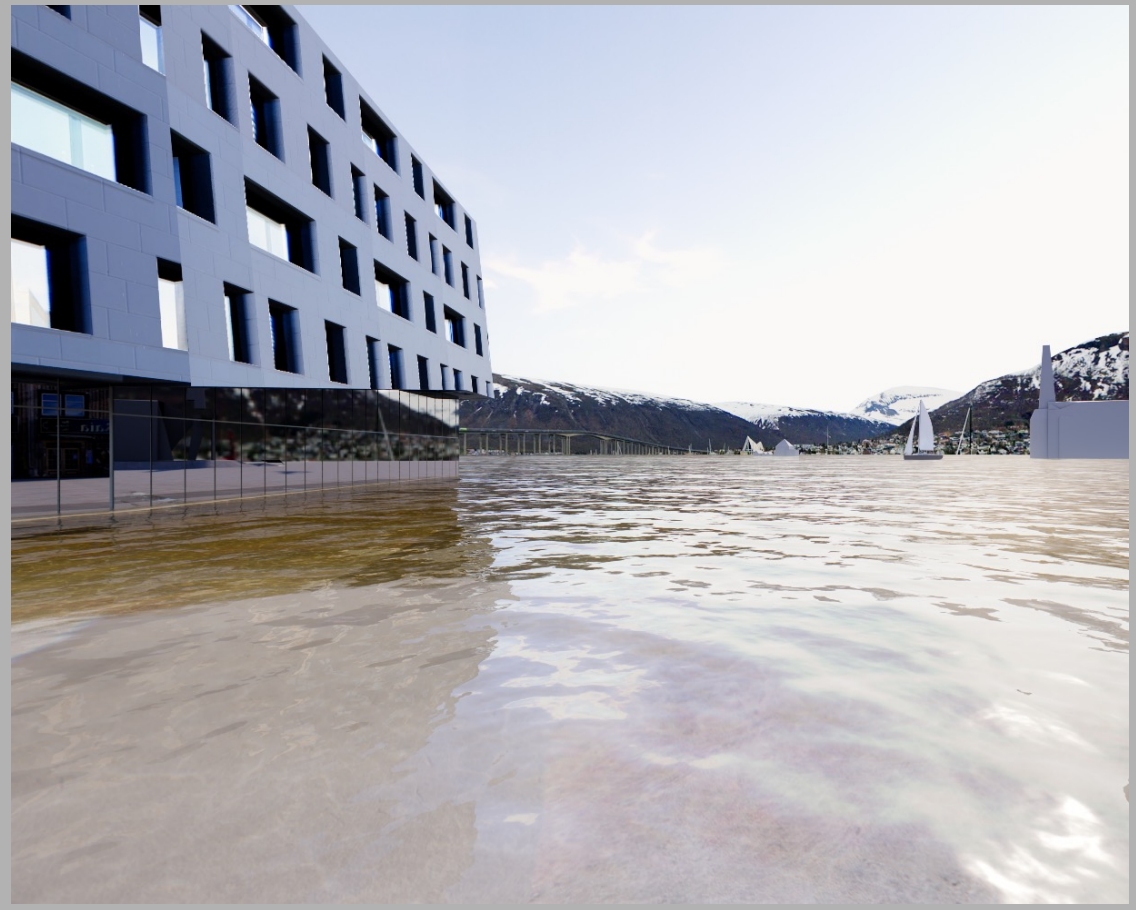

Søk i Google Maps
10 Havnegata
Tromsø, Troms
Google Street View
juli 2022 Se flere datoer
Del
SKIRRI
Storetorget
Google

SWECO

With flood protection

Without flood protection

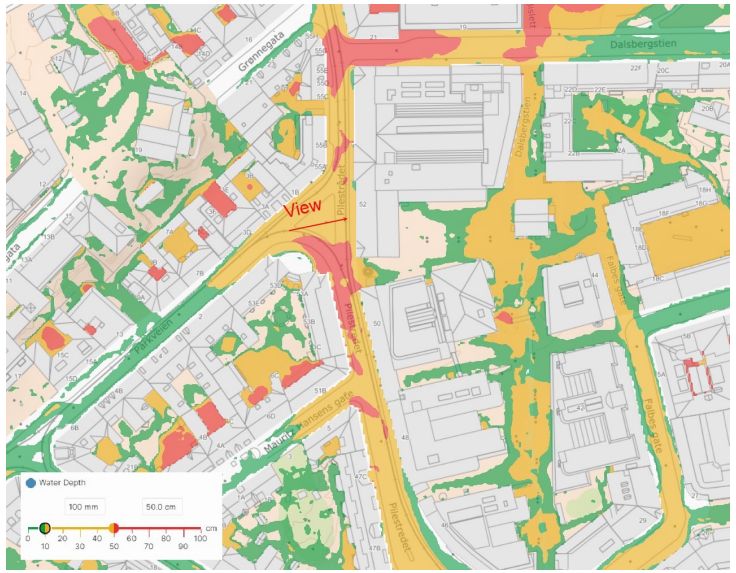
With flood protection



Without flood protection

# Stormwater event in Oslo

- Rain event: 2011-07-02 Copenhagen Cloudburst (135 mm/ 2 hours)
- Scalgo Core+ Dynamic Flood  surface flood calculation.





<u>Viewpoint:</u>
Pilestredet/
Parkveien (200 m
downstream of
Bislett Stadium)

HAVNIVÅSTIGNING TROMSØ SENTRUM OVERVANNSHÅNDTERING

# Her sjokkeres Anne-Berit og Gunnar: – Skremmende å se



SWECO

## Goal with the Climate Glasses

- To transform numbers into something visual  (understand the consequences of climate change)
- To generate awareness
- To start the discussions about climate adaptation measures

https://www.nordlys.no/her-sjokkeres-anne-berit-og-gunnar-skremmende-a-se/s/5-34-1776585

**Contact**
Silje Lund Sørland
Fagspesialist klimarisiko, Sweco
silje.lundsorland@sweco.no