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CLIMATE-RESILIENT REGIONS THROUGH SYSTEMIC SOLUTIONS AND INNOVATIONS

Lessons learned from synergizing CCA/DRM in Esbjerg (ARSINOE Case Study 7)
Resilient Futures: Practical Approaches to Disaster Risk Management and Climate Adaptation

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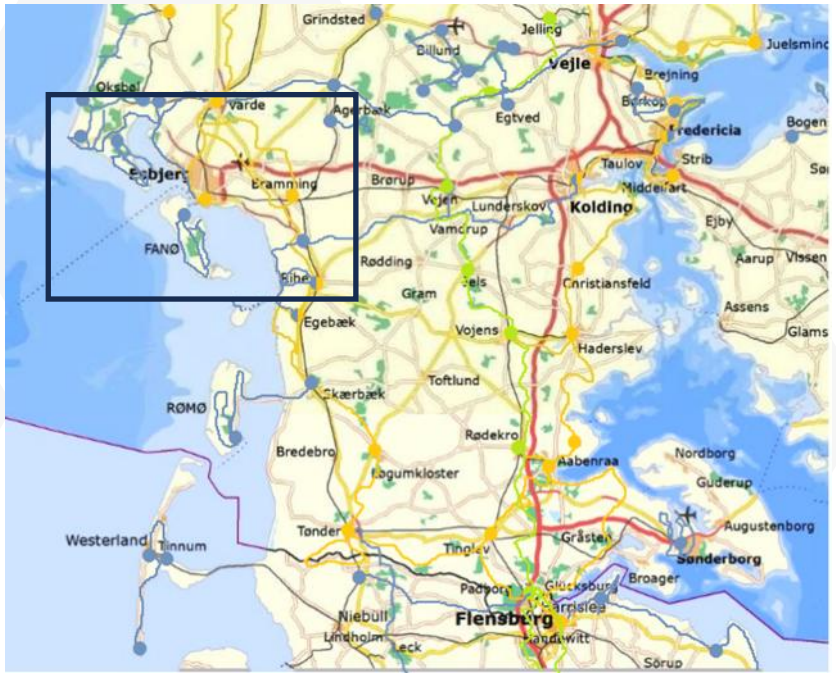
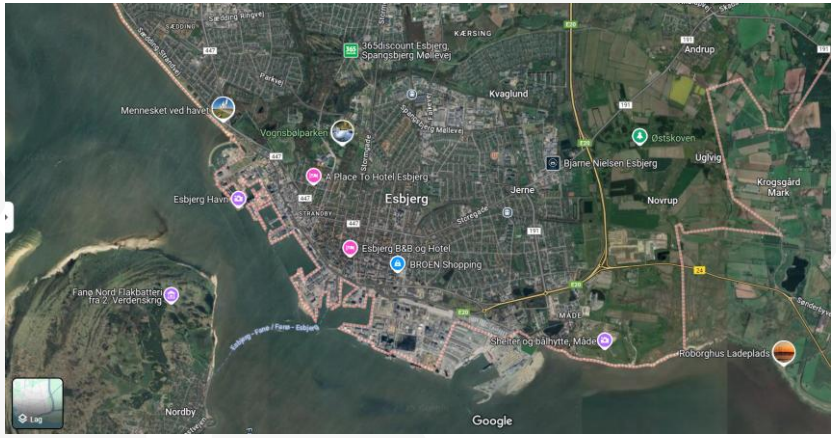
Challenges

- Water pressures from all sides: **storm surges**, **heavy rain and cloudbursts**, rivers/back water, rising groundwater
- Increasing summer droughts
- Land use/land use change: agriculture, **urban development**, protection of cultural and natural heritage
- Emergency services cover three municipalities: Esbjerg, Fanø (island) and Varde
- **Raising awareness and empowering civil society**
- **Adaptation solutions**





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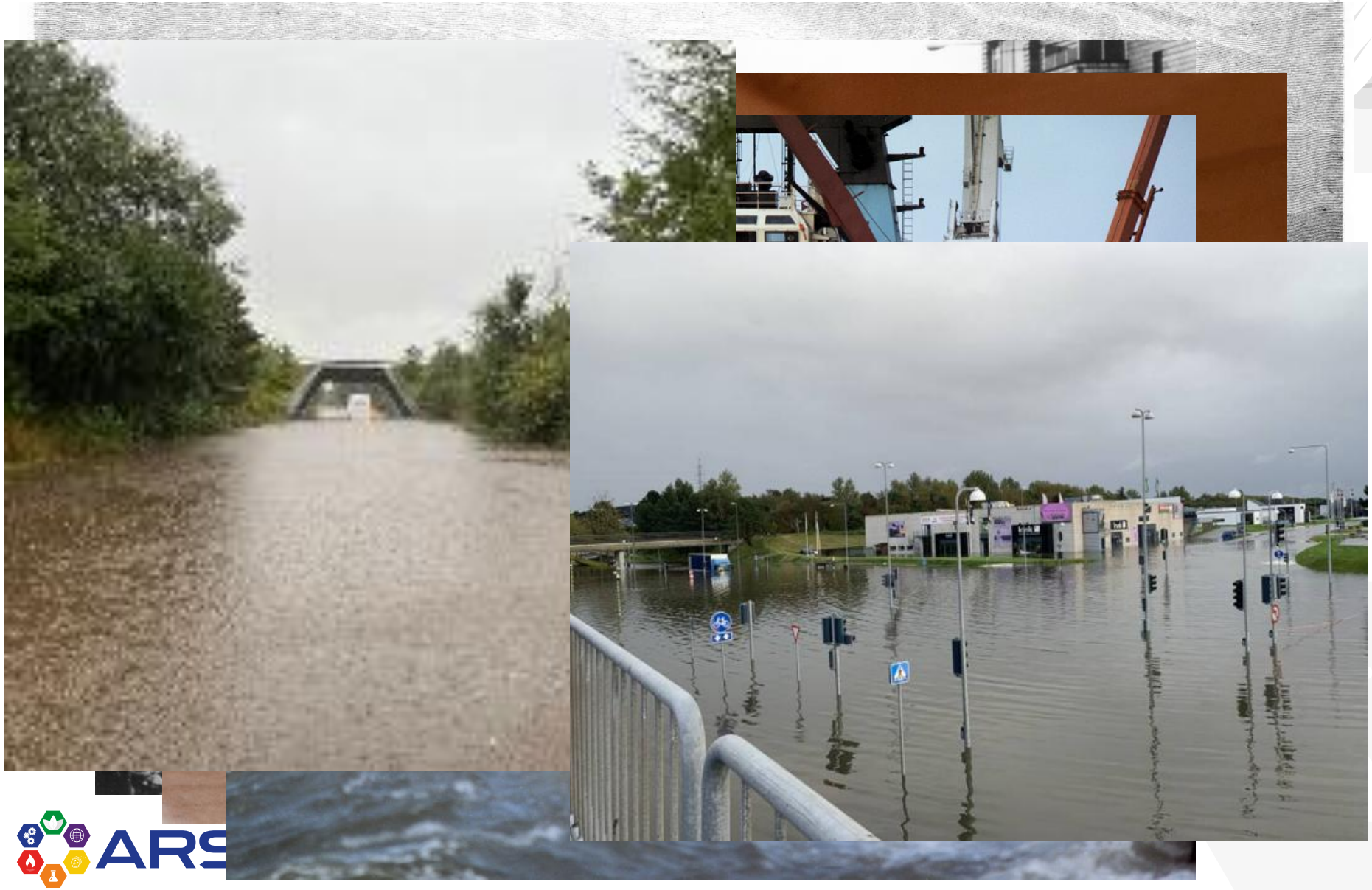
Historical events



1362

1634 (6,3 m)

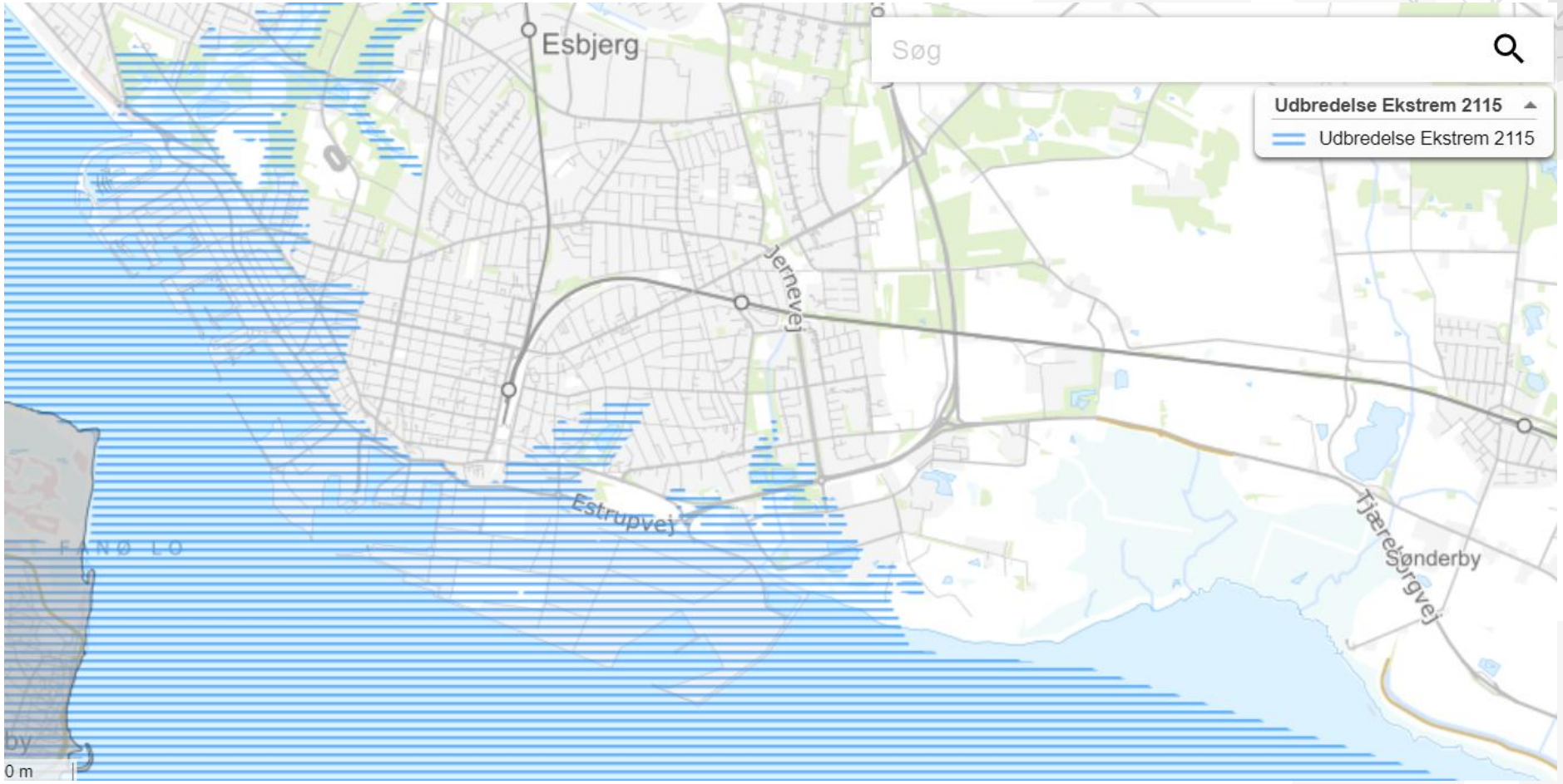
1981 (4,3 m)

1985

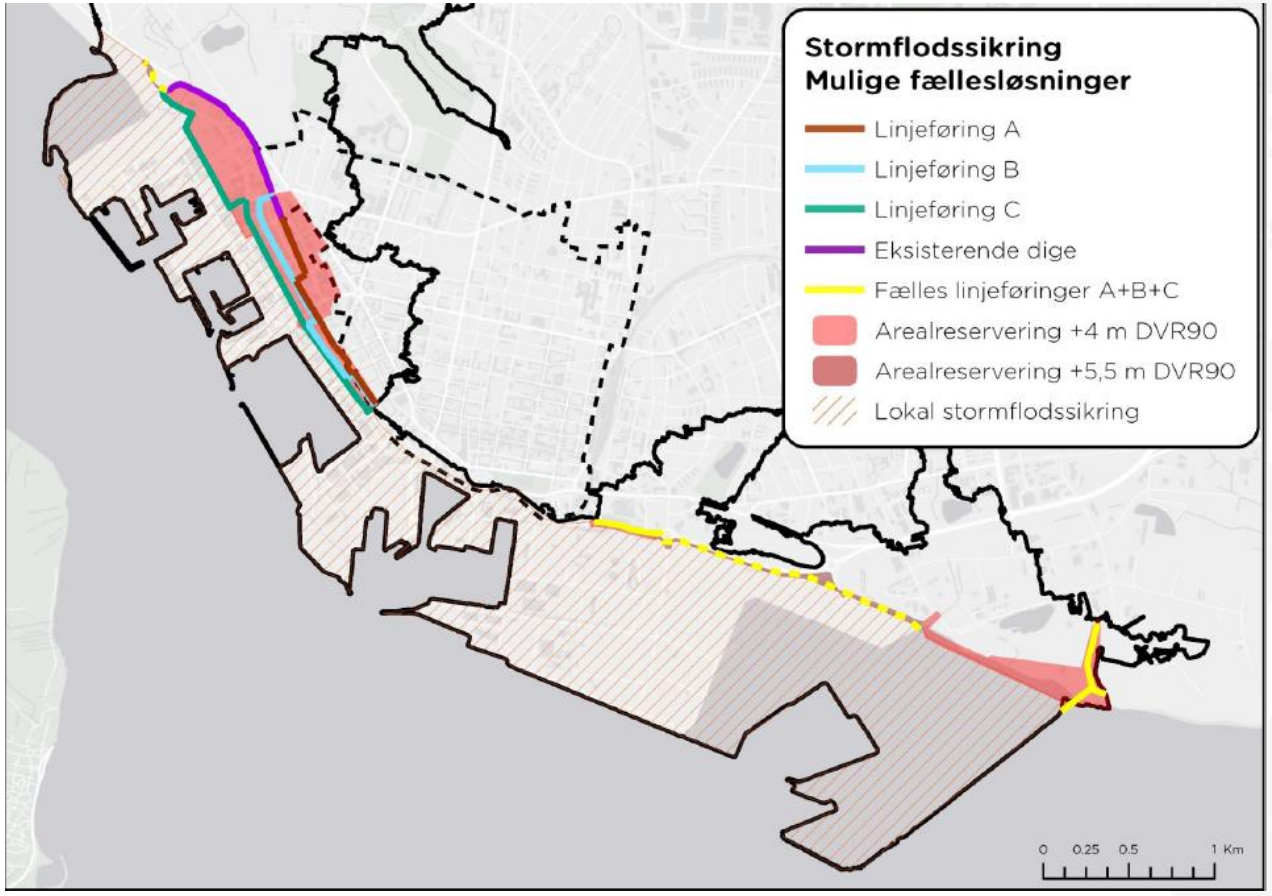
1999

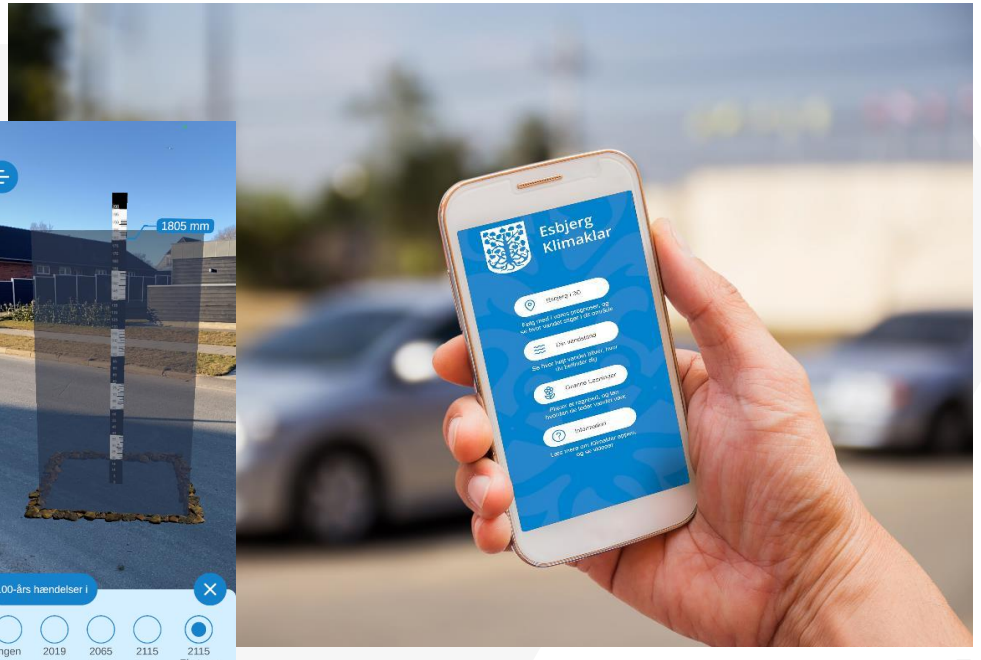
2024 (144,6 mm)

Esbjerg (and part of Fanø): European Floods Directive



Coastal protection (planned)





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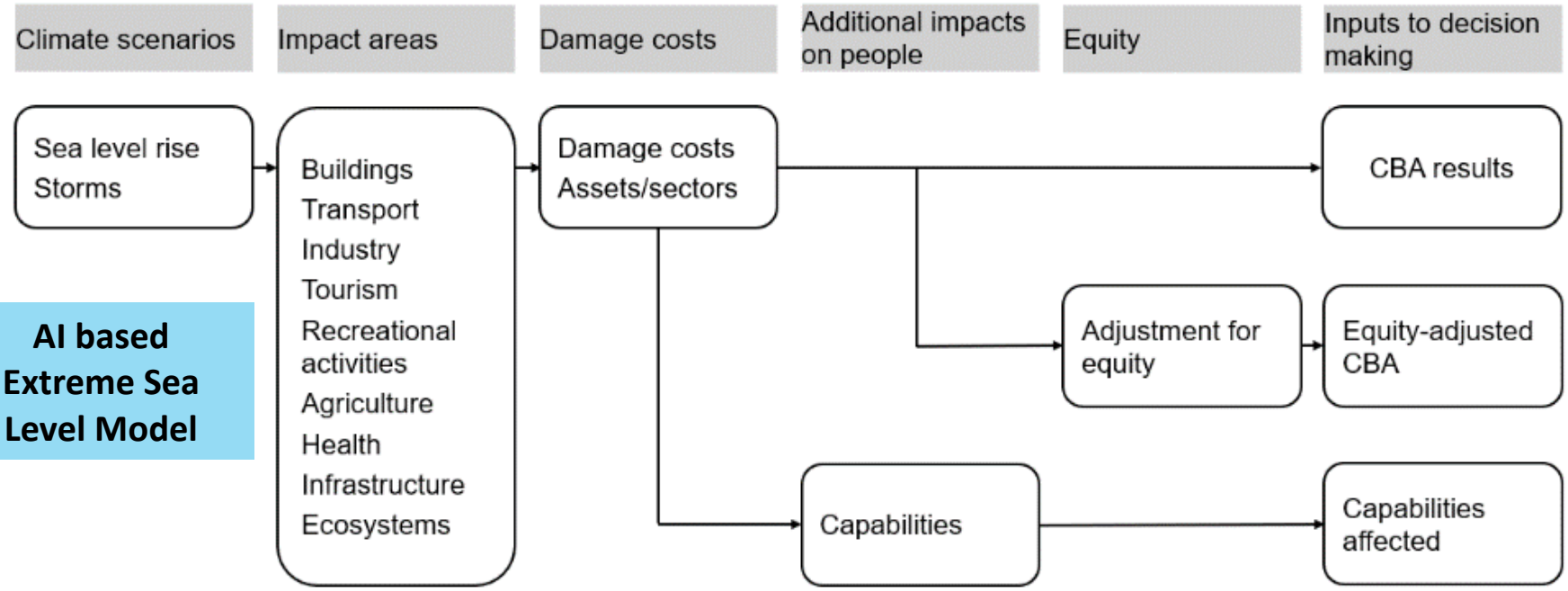
About the Case Study: Climate adaptation & Disaster risk management

- ARSINOE Living Lab (local government, emergency services, port, industry, investors and citizens)
- Several models refined or developed (OS/2 DamageCost, AI-based storm surge models, assessment framework)
- Ongoing activities: cascading failures model, transport impact model
- 3 external innovations tested (2 social innovations, 1 technical)
- Integrated resilience assessment
- Technical University of Denmark (DTU), Esbjerg municipality, LNH Water (SME), Danish Coastal Authority (DCA), LMU Munich

Water Smart Strategies and Climate Adaptation

CMIP6 ESMs

Regional downscaling



Economy
Environment

Social

AI based Extreme Sea Level Model

Flood model suite

Integrated ”DamageCost” assessment tool

Systemic and sustainable solutions for water resilience
Climate adaptation
Disaster risk management

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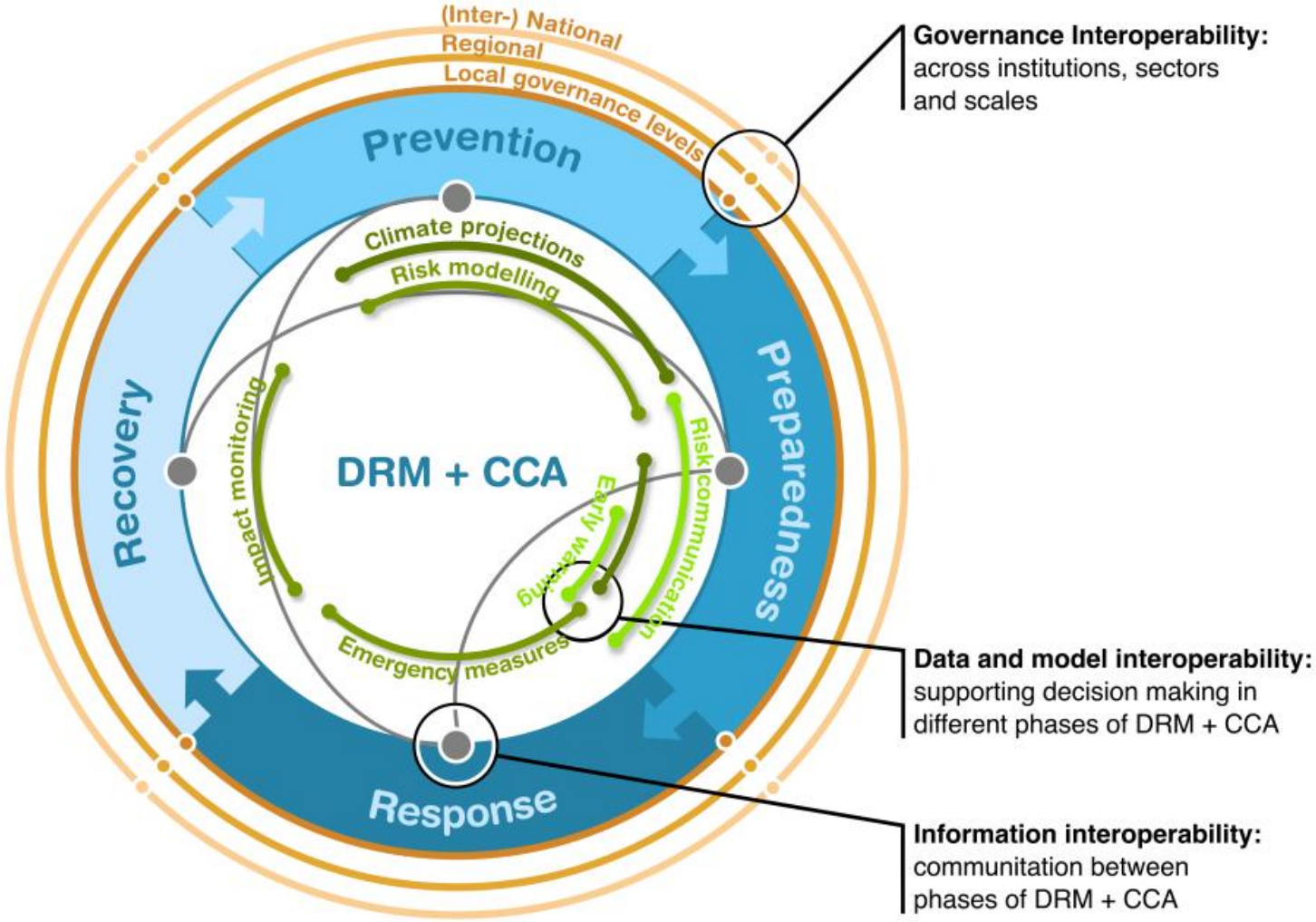
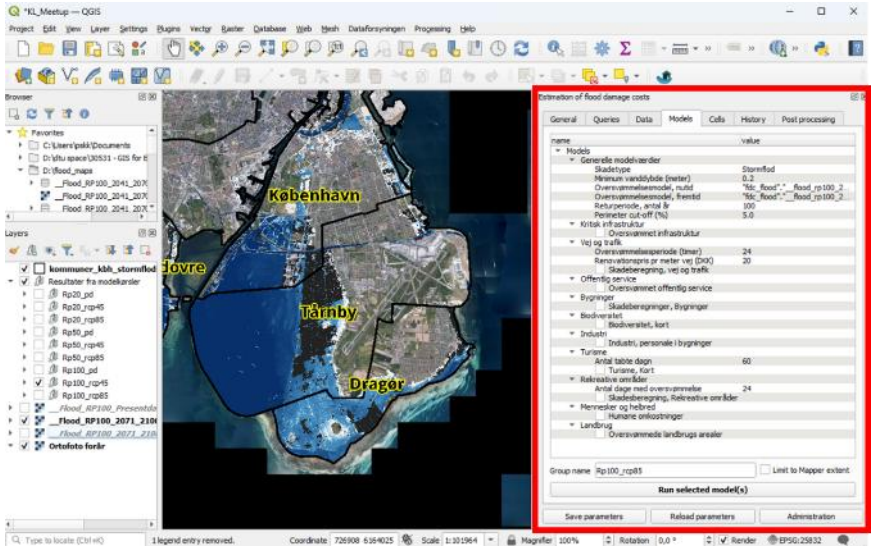


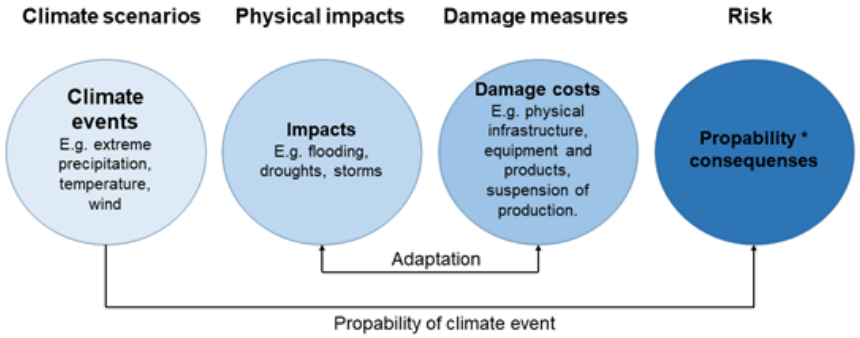
Schröter et al. 2025, Nat. Hazards Earth Syst. Sci. Discuss. [preprint], https://doi.org/10.5194/nhess-2024-135, in review, 2024.

Integrated OS/2 DamageCost assessment tool

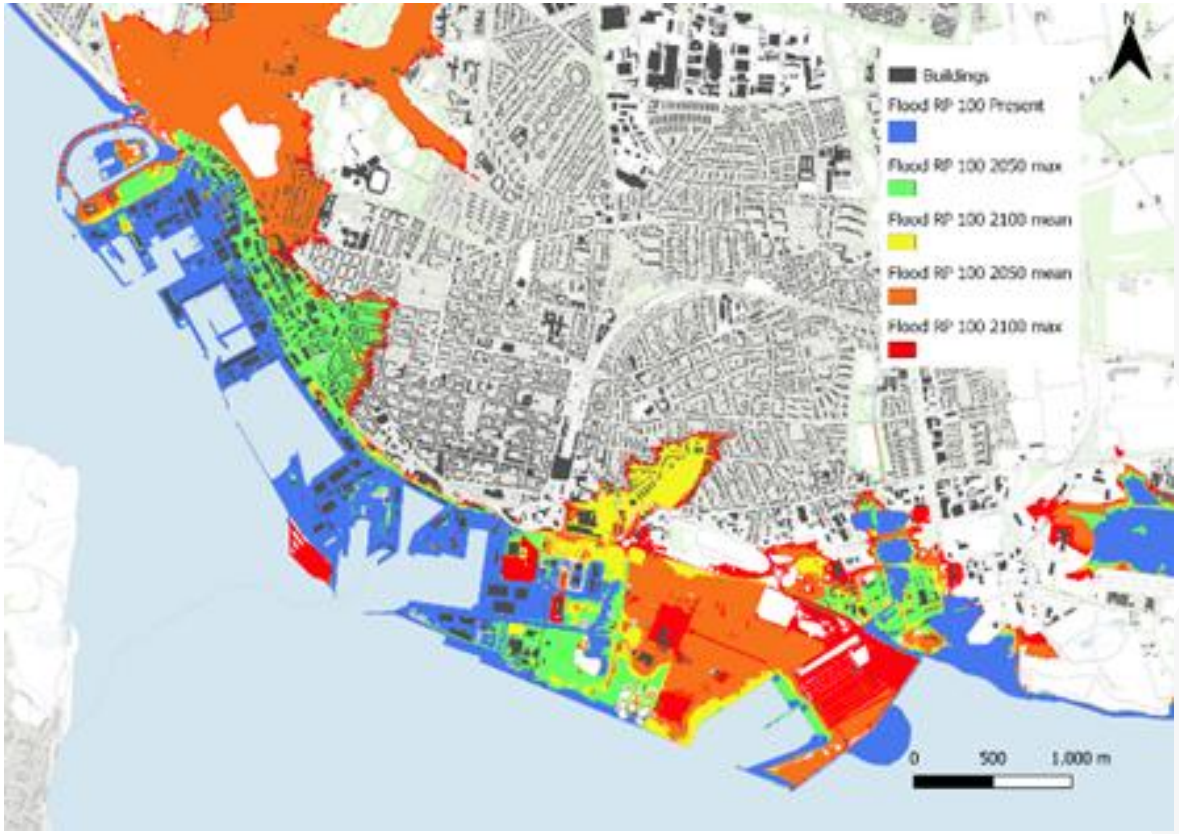


Buildings	€	Agriculture	€
Roads and traffic	€	Critical infrastructure	⚑
Humans and health	€	Industry	⚑
Tourism	€	Public service	⚑
Recreational areas	€	Ecosystems	⚑

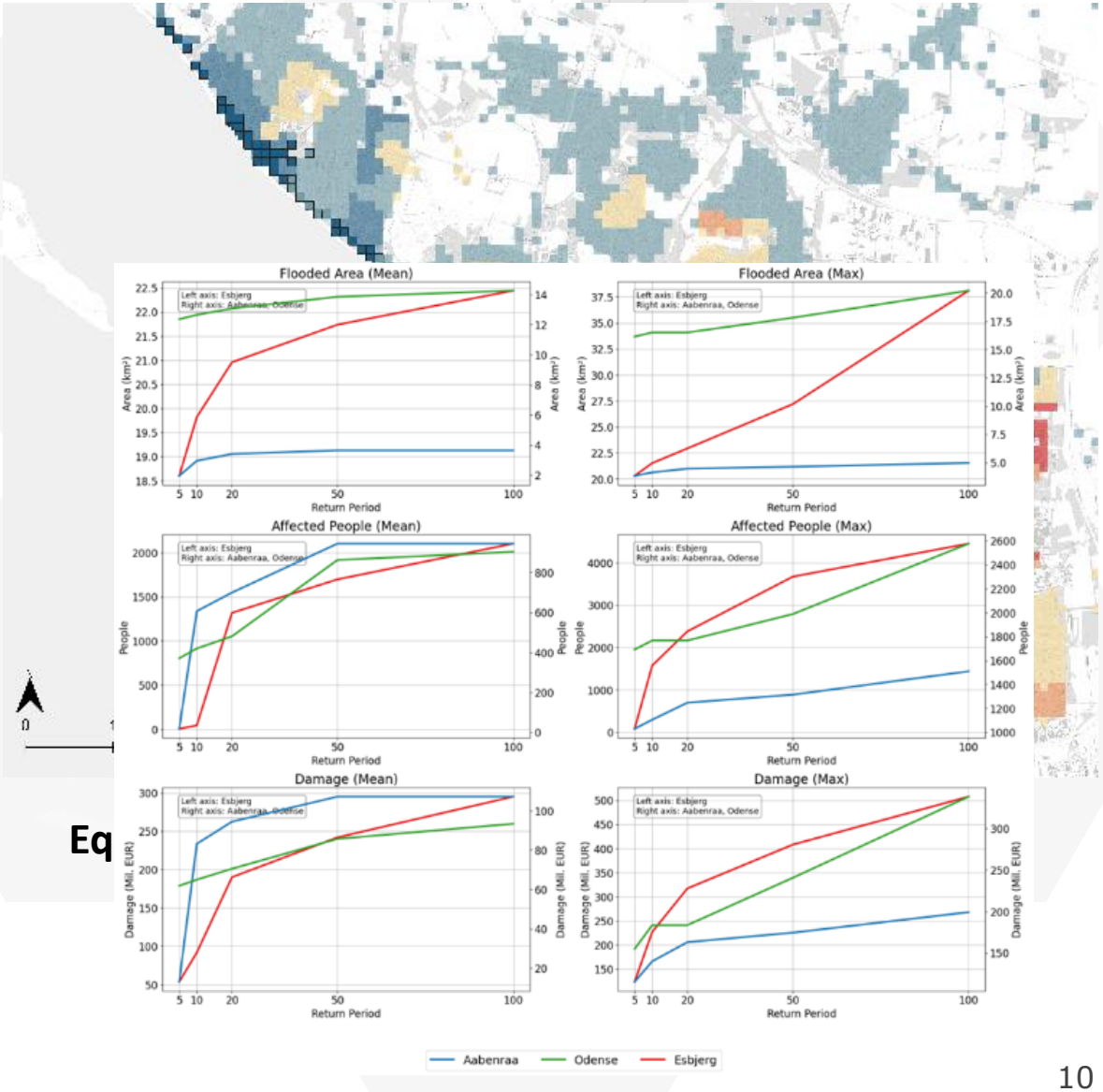
€ An economic loss is calculated ⚑ Priorities can be assigned



Results

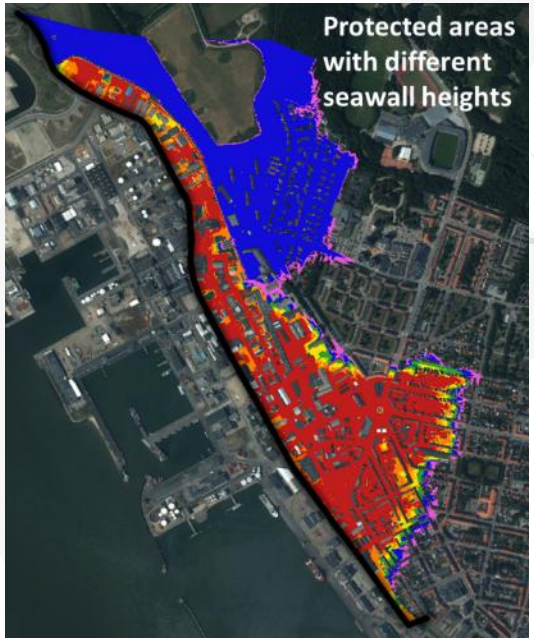


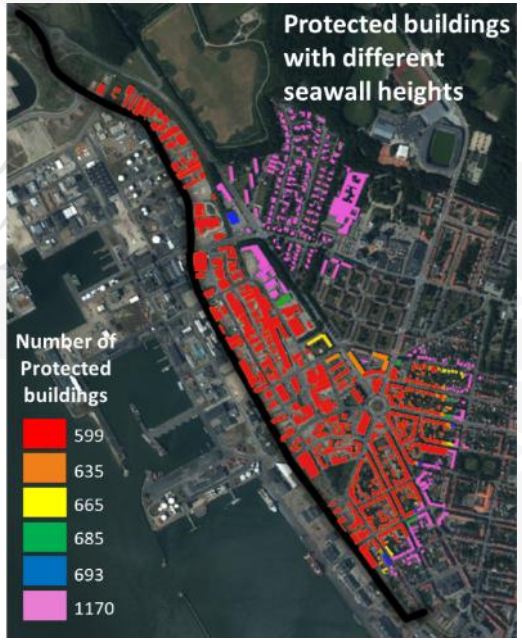
Flood risk

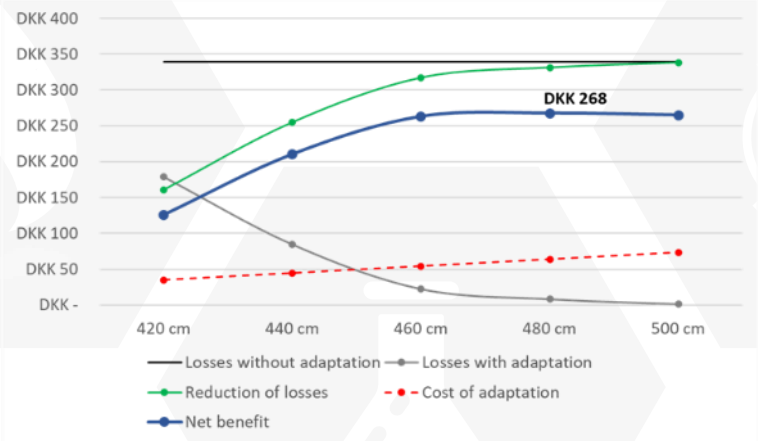


Eq

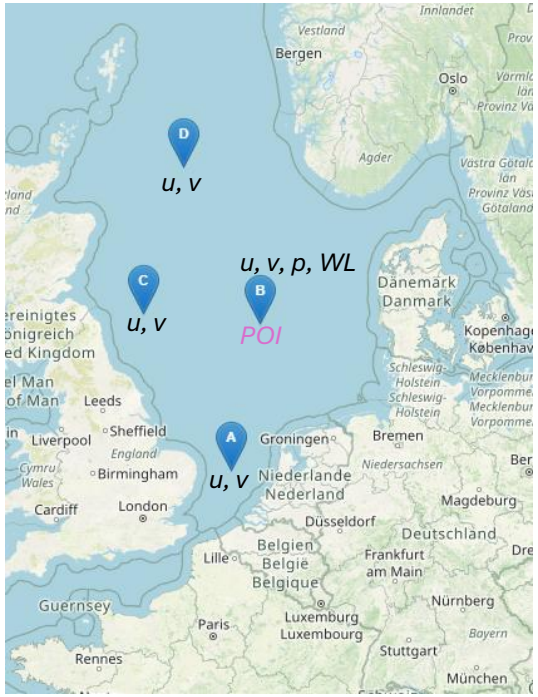
Results – Climate adaptation







Multiple points



58 years of wind speed In east/west (u) and north/south (v) direction with 1 hour resolution

Train/Validation/Test: 0.7 / 0.1 / 0.2

Shuffle = True

Input data

Hindcasted Water level

UTIDE

Residual water level

Target

Wind (E/W)

u_i
u_{i-1}
...
u_{i-47}
u_{i-48}

v_i
v_{i-1}
...
v_{i-47}
v_{i-48}

Wind (N/S)

Input data used to Predict water level in time step i

p_i
p_{i-1}
...
p_{i-47}
p_{i-48}

Atm. Pres.

Model

LSTM

sequence = 48
Hidden size = 32
layers = 4
epochs = 20
batch = 240

Last fully connected layer

Output

Water level (WL) residual at time *i*

WL_i

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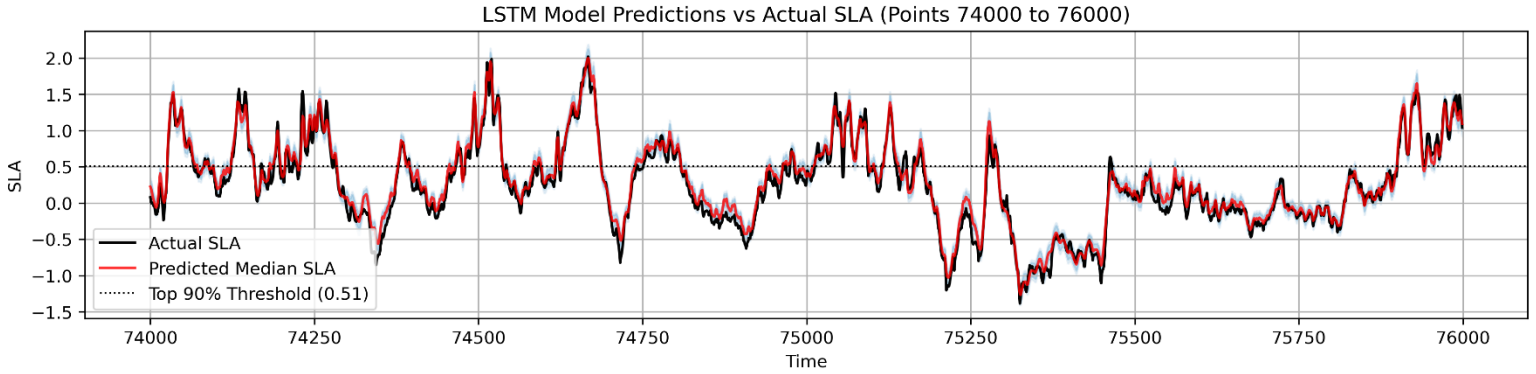
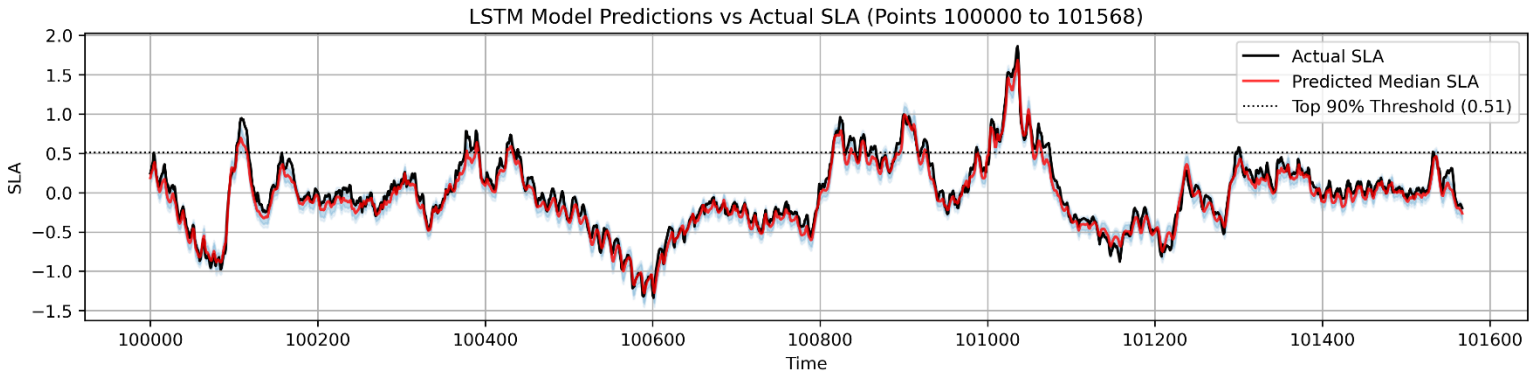
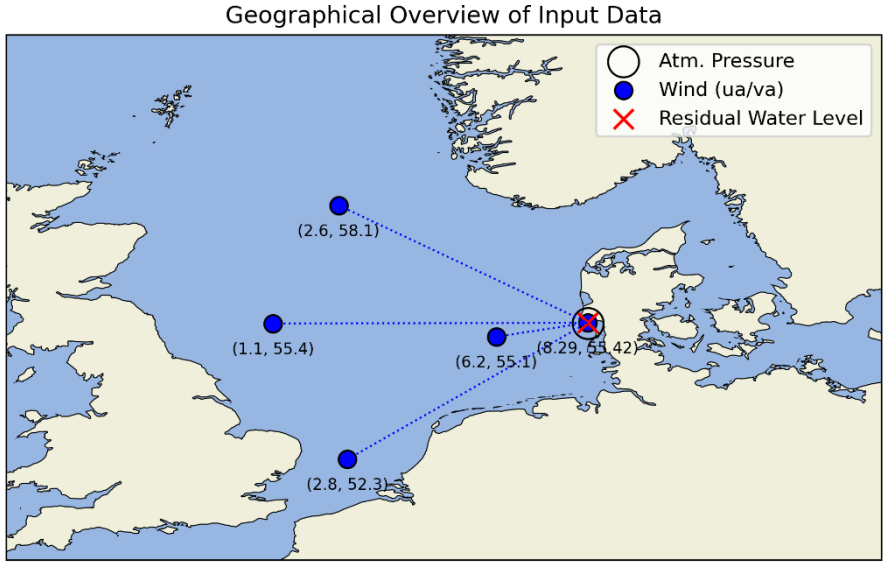
Esbjerg





Model Evaluation Metrics:
MSE: 0.009
RMSE: 0.095
MAE: 0.075
KGE: 0.92
R: 0.94

Evaluation Metrics by Quantiles:
90% Lows - MAE: 0.1057, RMSE: 0.1263, Bias: 0.0891
Median - MAE: 0.0690, RMSE: 0.0863, Bias: 0.0179
90% Peaks - MAE: 0.0935, RMSE: 0.1232, **Bias: -0.0359**



Courtesy of Villy Mik-Meyer

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Lessons learned

- Interoperability in data and methods have a high potential
- We introduced a seamless approach to DRM and CCA across time and space in Esbjerg
- Next steps: integrate compound events, cascading effects (including transport)
- Mutual learning is needed - CCA and DRM generally happen in different spaces
- Adaptative planning

THANK YOU

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