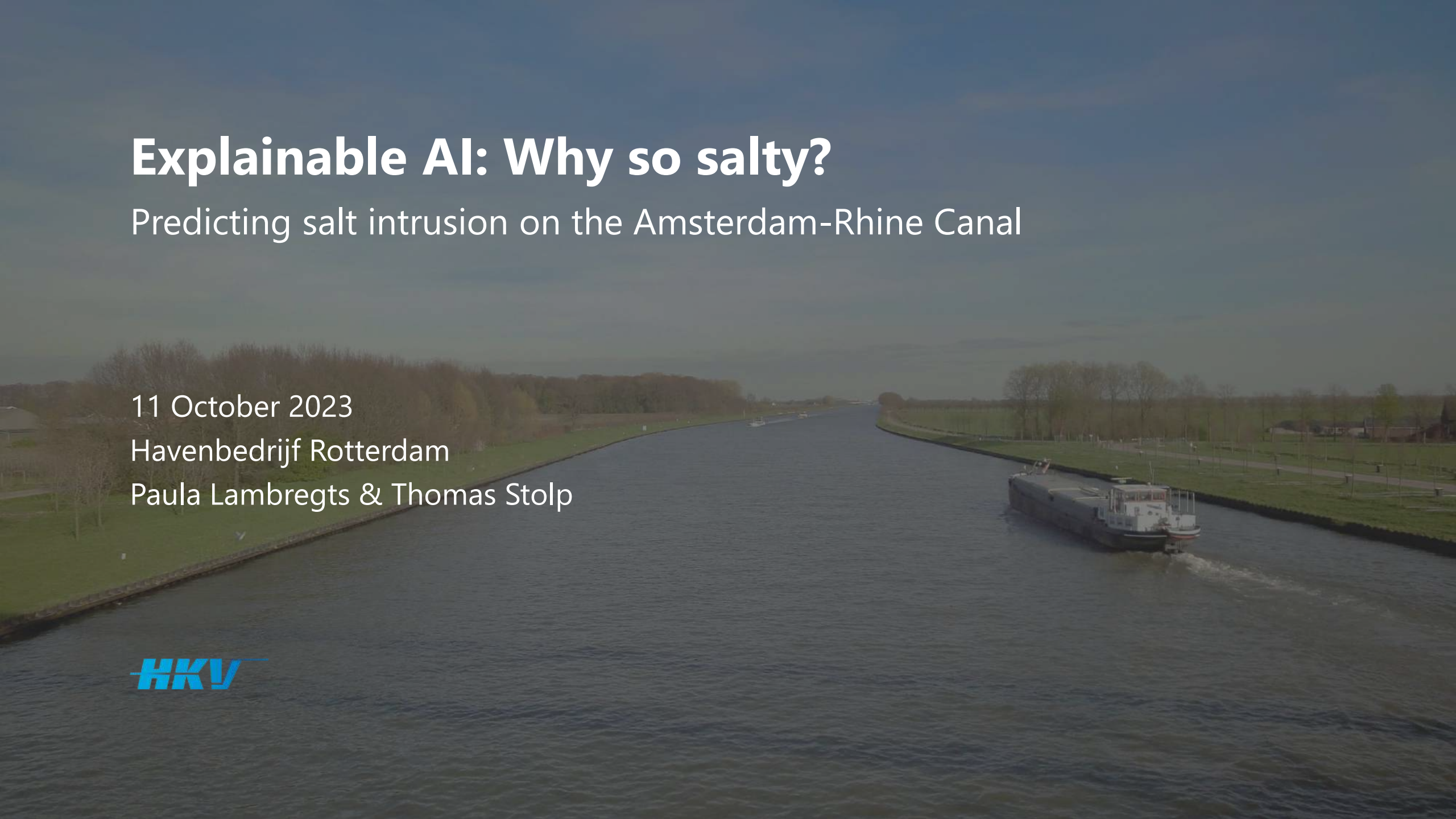
Explainable AI: Why so salty?

Predicting salt intrusion on the Amsterdam-Rhine Canal



11 October 2023

Havenbedrijf Rotterdam
Paula Lambregts & Thomas Stolp

Introduction
Agenda

- Introductions
- Context
- Get to know XAI
- Discussion
- Closure

Statement

"Within the water sector, there is a strong demand for explainability of data-driven models"

"Binnen de watersector is een sterke behoefte aan uitlegbaarheid van data-gedreven modellen"

Context

Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal

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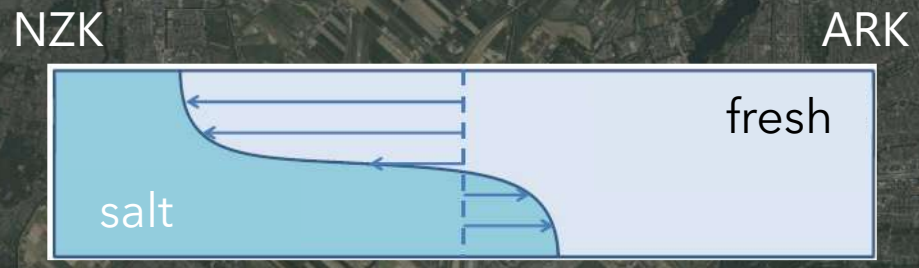
Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal

Noordzeekanaal

Intrusion **of salt wedge**



Amsterdam-Rijnkanaal

Context

Salt intrusion on the Amsterdam-Rhine Canal

Monitoring points
of salt intrusion

Context

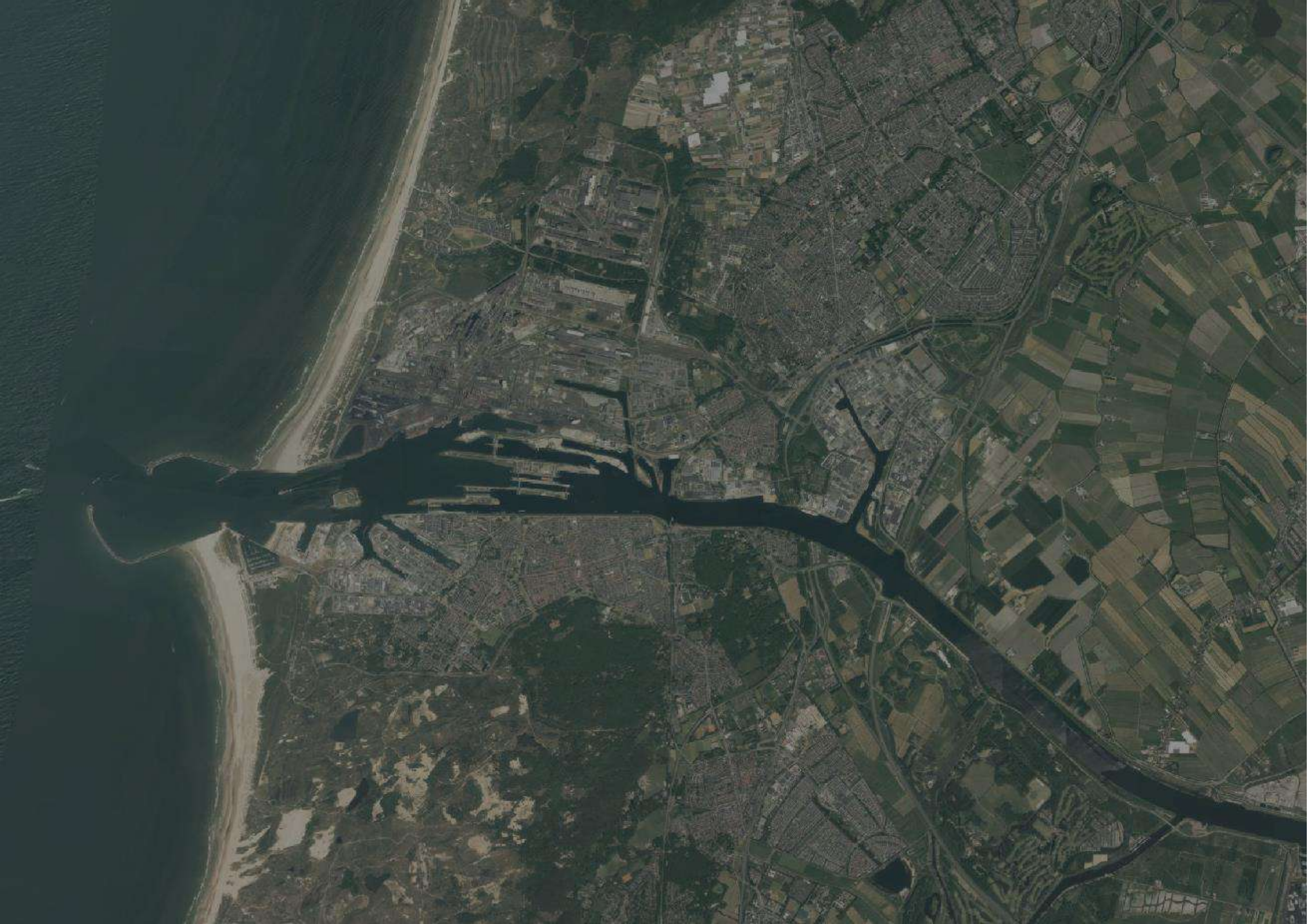
Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal



Context

Salt intrusion on the Amsterdam-Rhine Canal

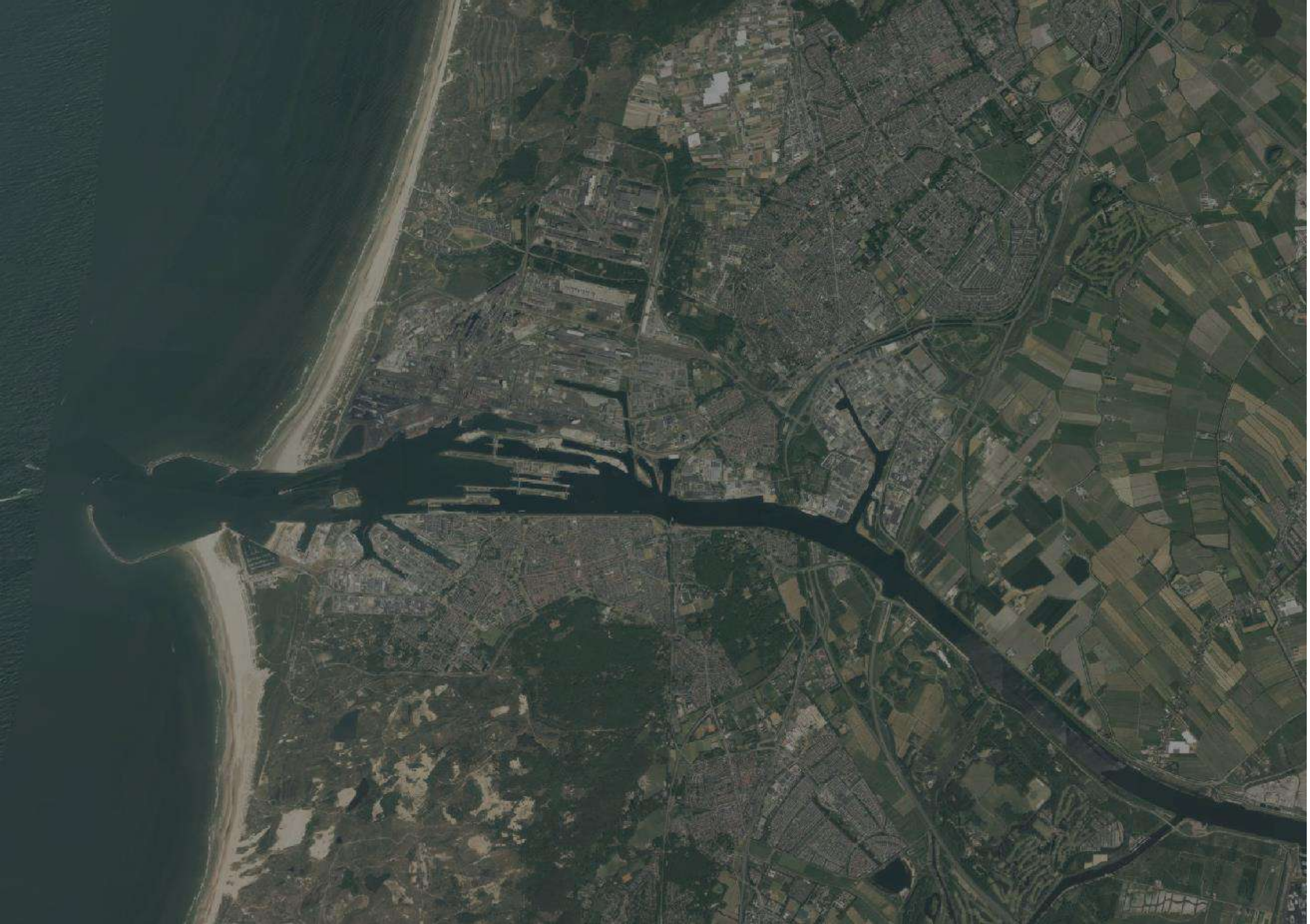
Context

Salt intrusion on the Amsterdam-Rhine Canal

Salt load, IJmuiden

Features:

- Exchange volume Sluices IJmuiden
- Exchange volume Noordersluis and Zeesluis IJmuiden
- Gravity drainage and pumping discharges IJmuiden



Context

Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal

Wind, intensity and direction

Context

Salt intrusion on the Amsterdam-Rhine Canal

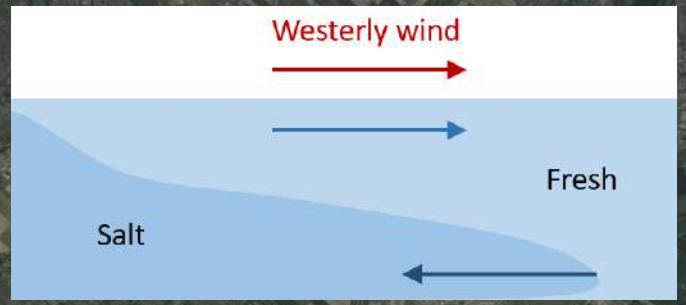
Context

Salt intrusion on the Amsterdam-Rhine Canal

Wind, intensity and direction

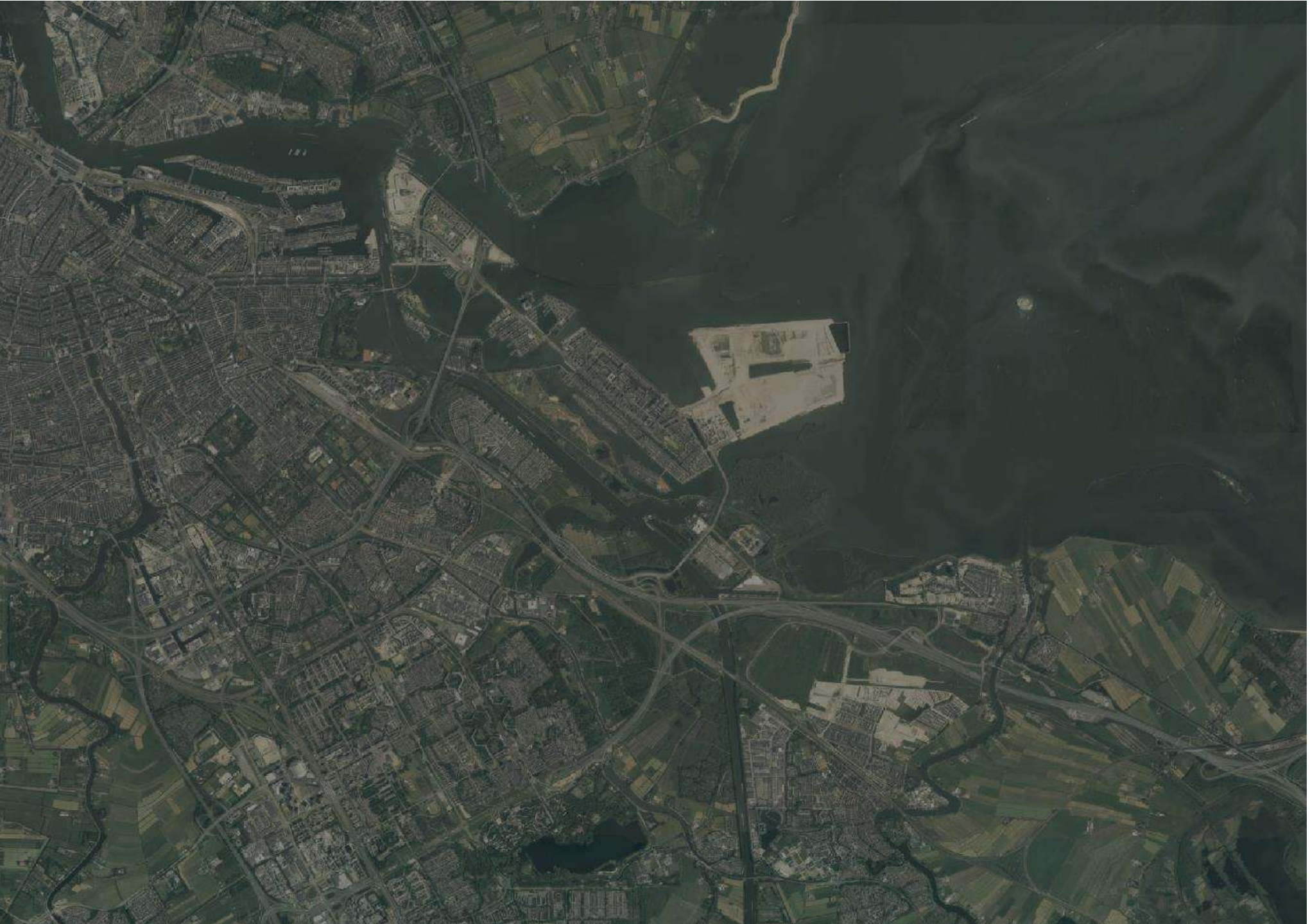
Perpendicular direction

Parallel direction



Context

Salt intrusion on the Amsterdam-Rhine Canal



Context

Salt intrusion on the Amsterdam-Rhine Canal

Context

Salt intrusion on the Amsterdam-Rhine Canal

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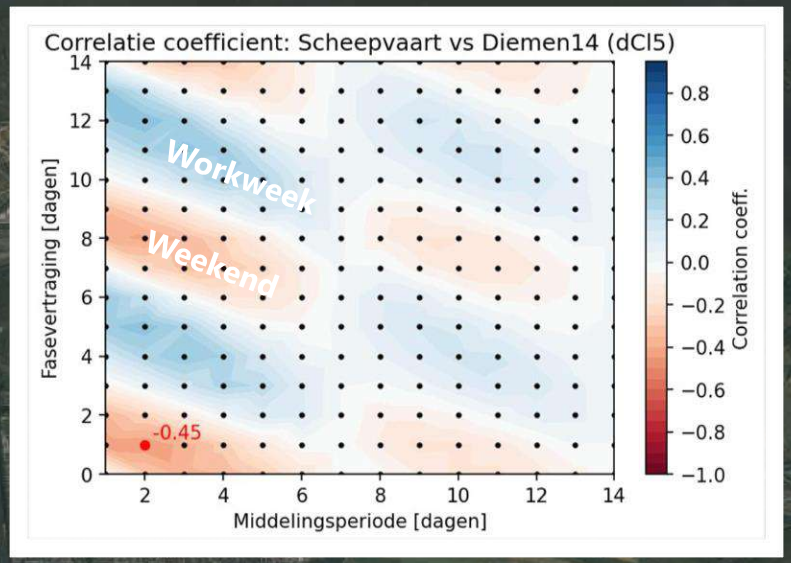
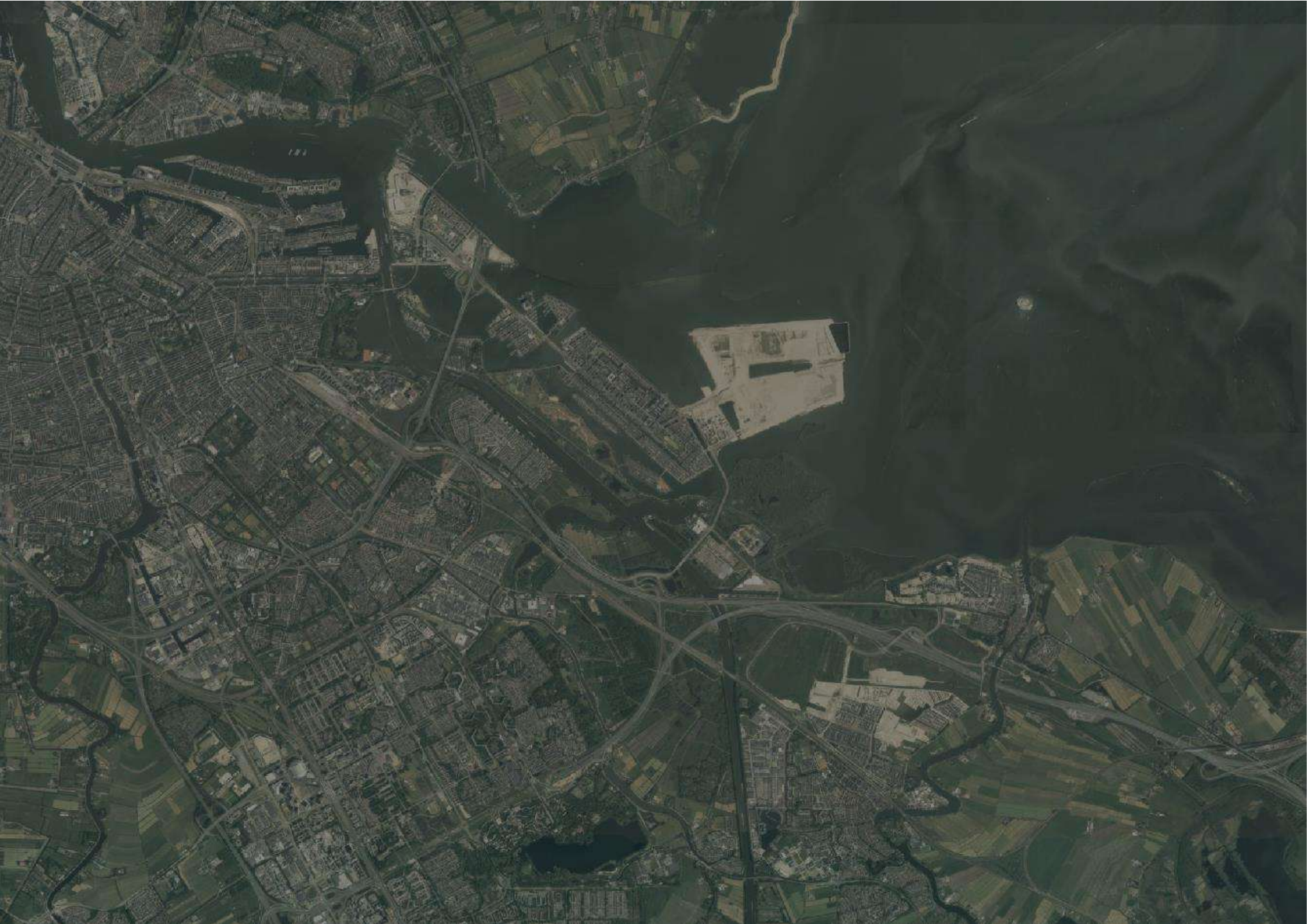
Salt intrusion on the Amsterdam-Rhine Canal

Shipping intensity at the Amsterdam-Rhine canal





Context

Salt intrusion on the Amsterdam-Rhine Canal

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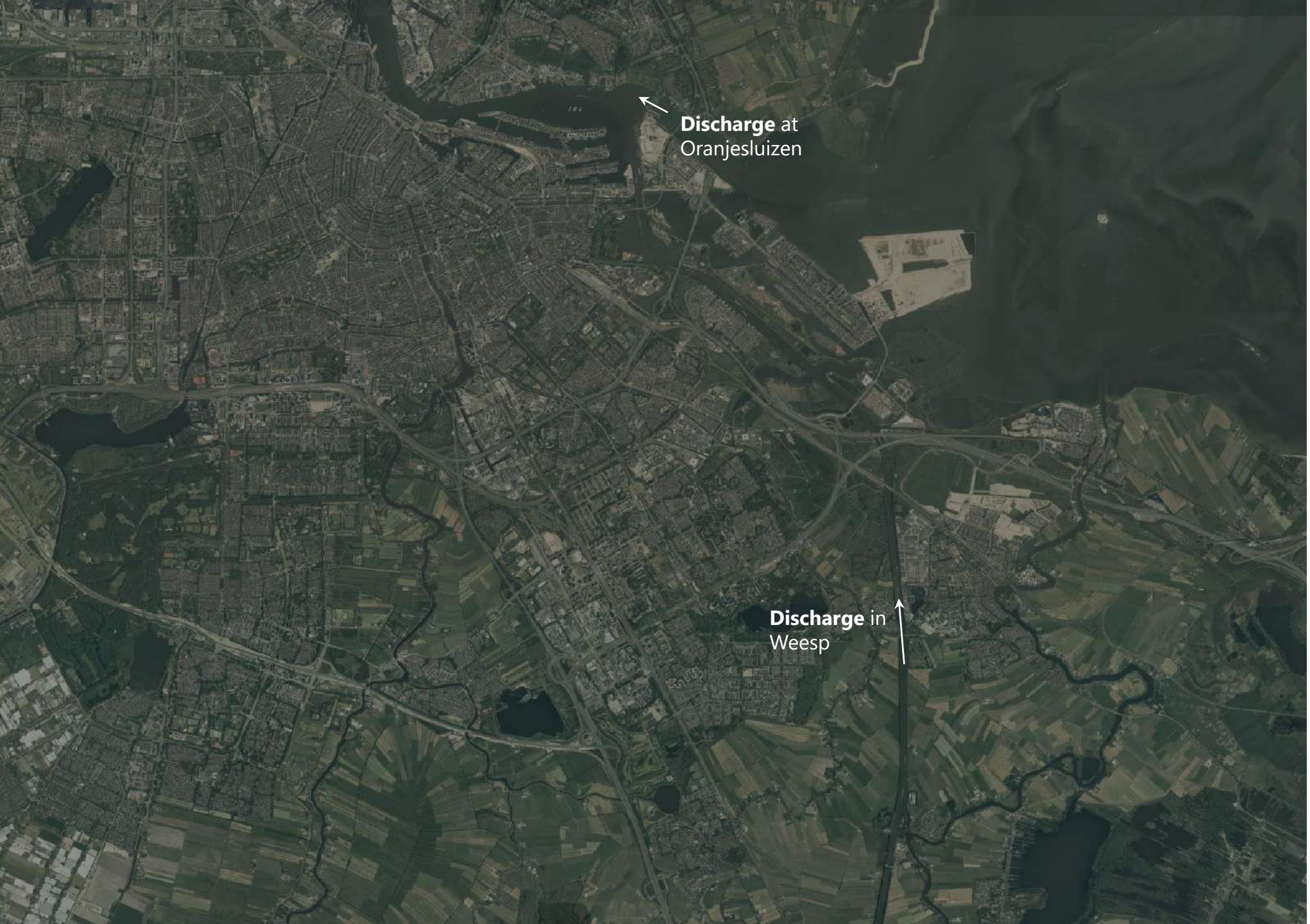
Salt intrusion on the Amsterdam-Rhine Canal



Context

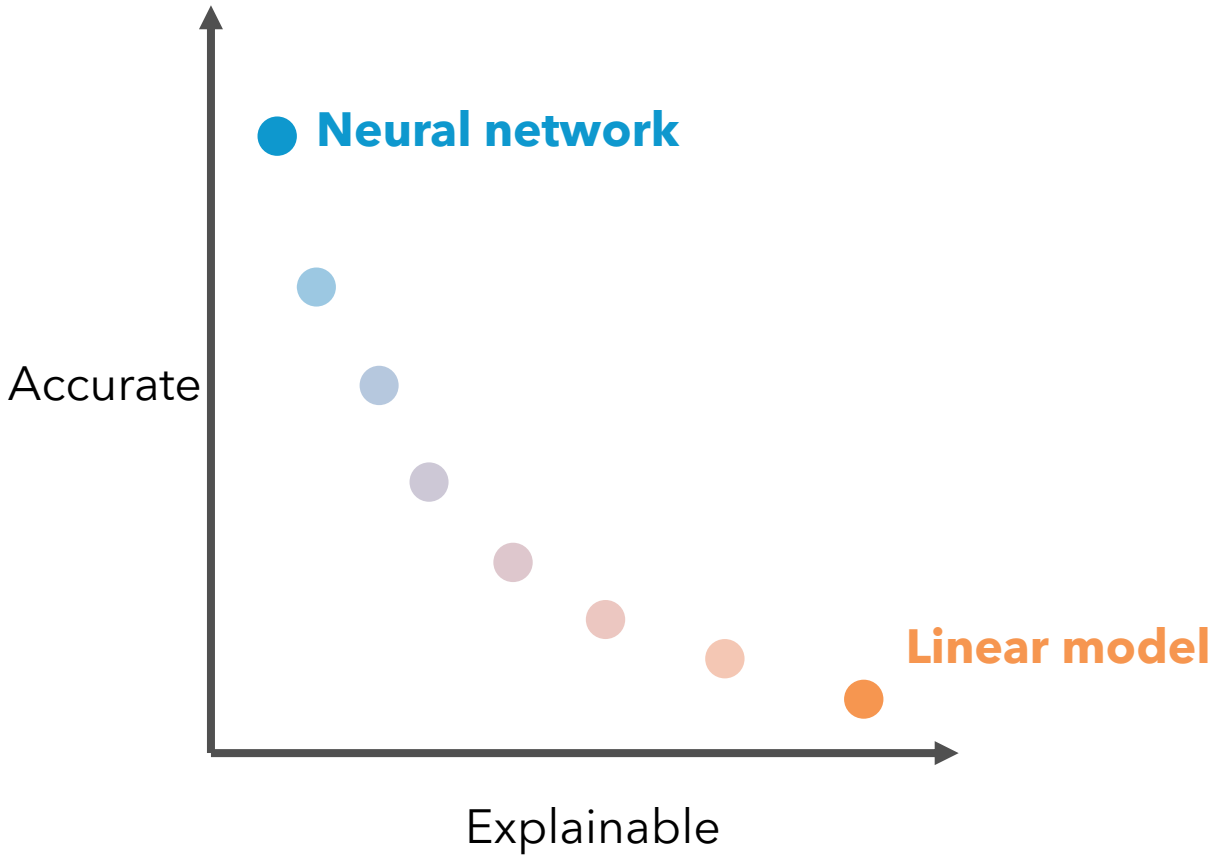
Salt intrusion on the Amsterdam-Rhine Canal

Context
Key factors

- Discharge in Weesp
- Daily discharge fluctuations
- Sum of negative discharges
- Hourly discharge fluctuations
- Absolute windspeed
- Wind component parallel to NZK
- Wind component perpendicular to NZK
- Discharge Oranjesluizen
- Exchange volume sluices IJmuiden
- Exchange volume Noordersluis and Zeesluis IJmuiden
- Salt load IJmuiden
- Gravity drainage and pumping discharges IJmuiden
- Lateral discharges NZK
- Shipping intensity ARK

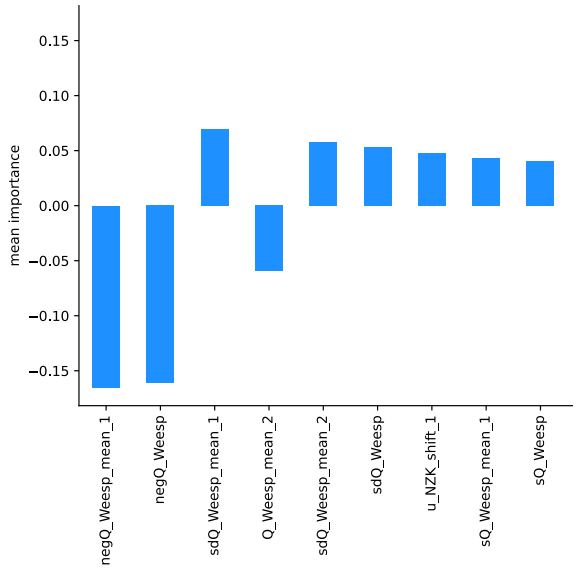
Context

AI versus conventional techniques

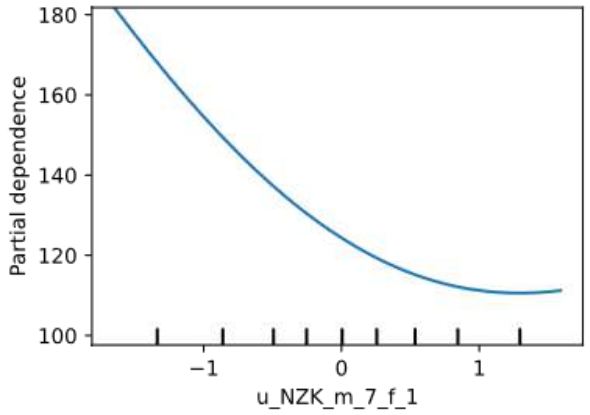


Context
Explainable AI

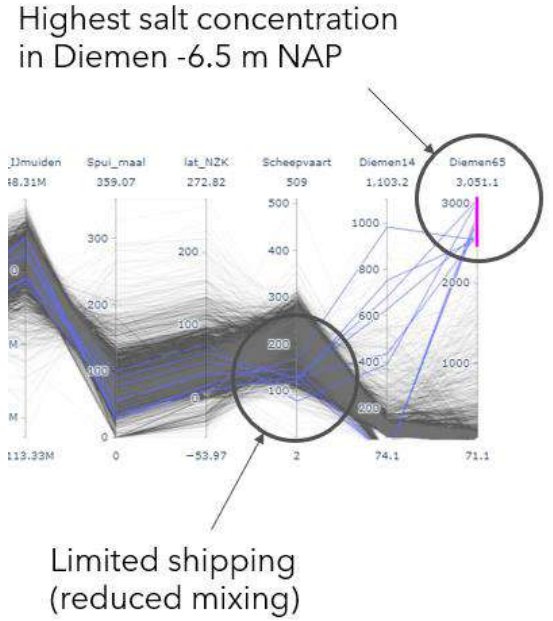
- **Ranking**



- **Dependence**

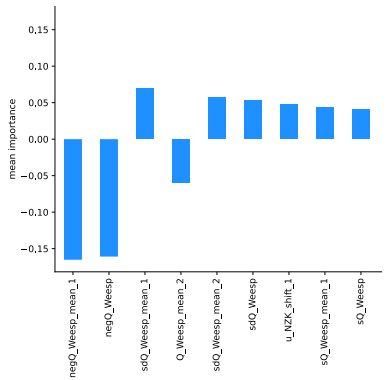


Visualisation



Context
Explainable AI

- **Ranking**

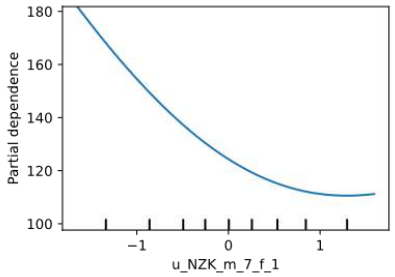


I. Permutation feature importance

II. Leave One Feature Out (LOFO)

III. SHAP mean importance

- **Dependence**

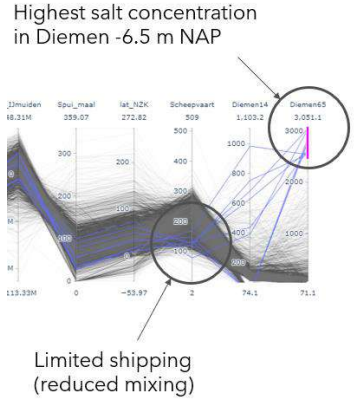


I. Partial dependence plot (PDP)

II. Accumulated local effects (ALE)

III. SHAP mean importance

- **Visualisation**

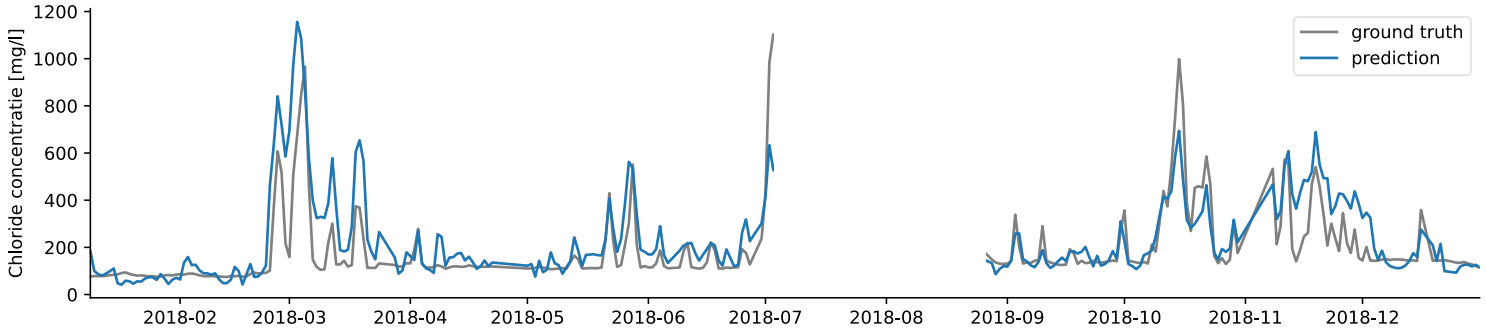


I. Parallel coordinate plot

II. Visual (interactive) interpretability

Context
Predictive modelling

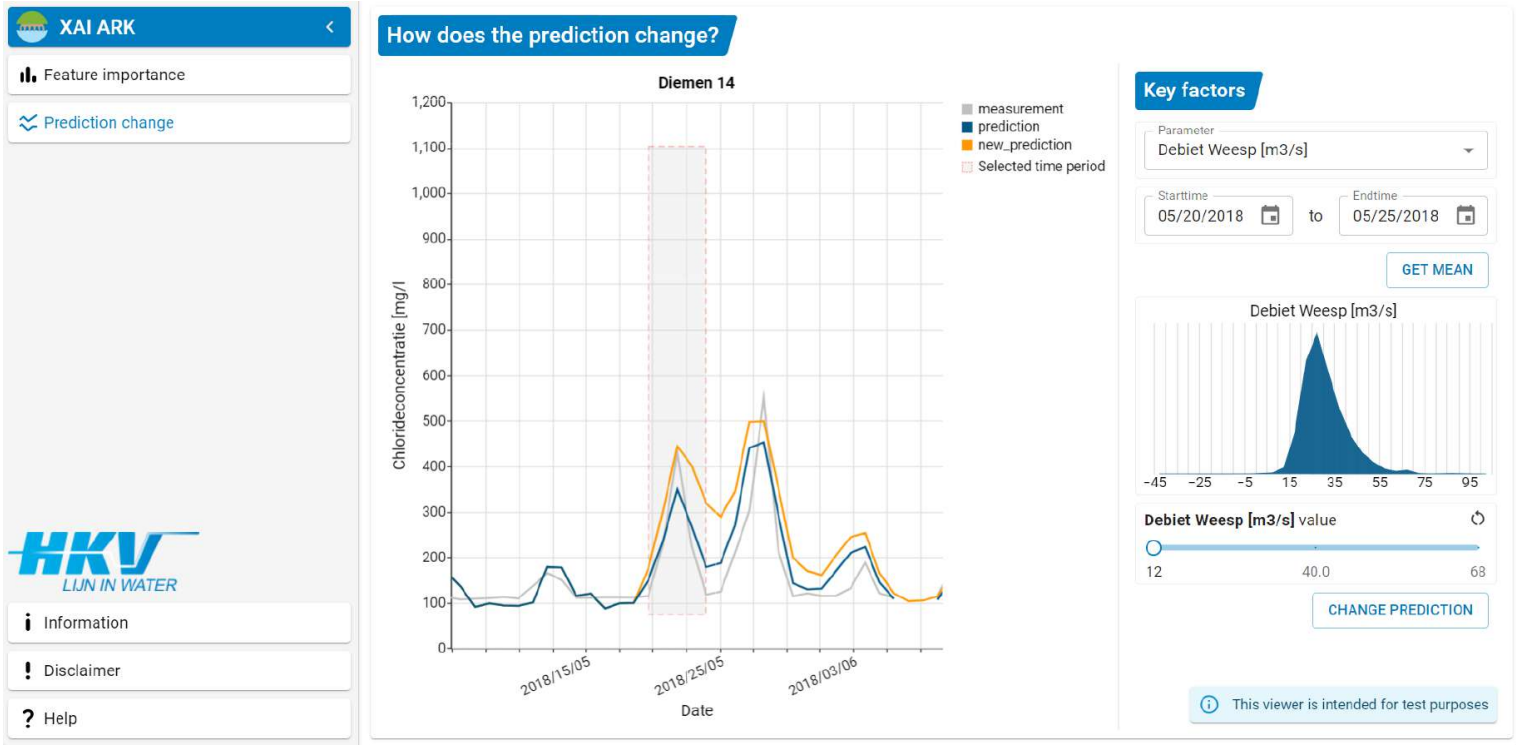
- Neural network
  - Dares to predict peaks
  - Without prior knowledge for year 2018



Prediction of salt concentrations in Diemen using a neural network.

Get to know XAI
Introducing the tool

- Goal: Increase confidence in outcome of ML-models
- Method: Increase insight in model outcome using Explainable AI techniques
- Target user: users of operational predictive models



XAI ARK

Feature importance

Prediction change

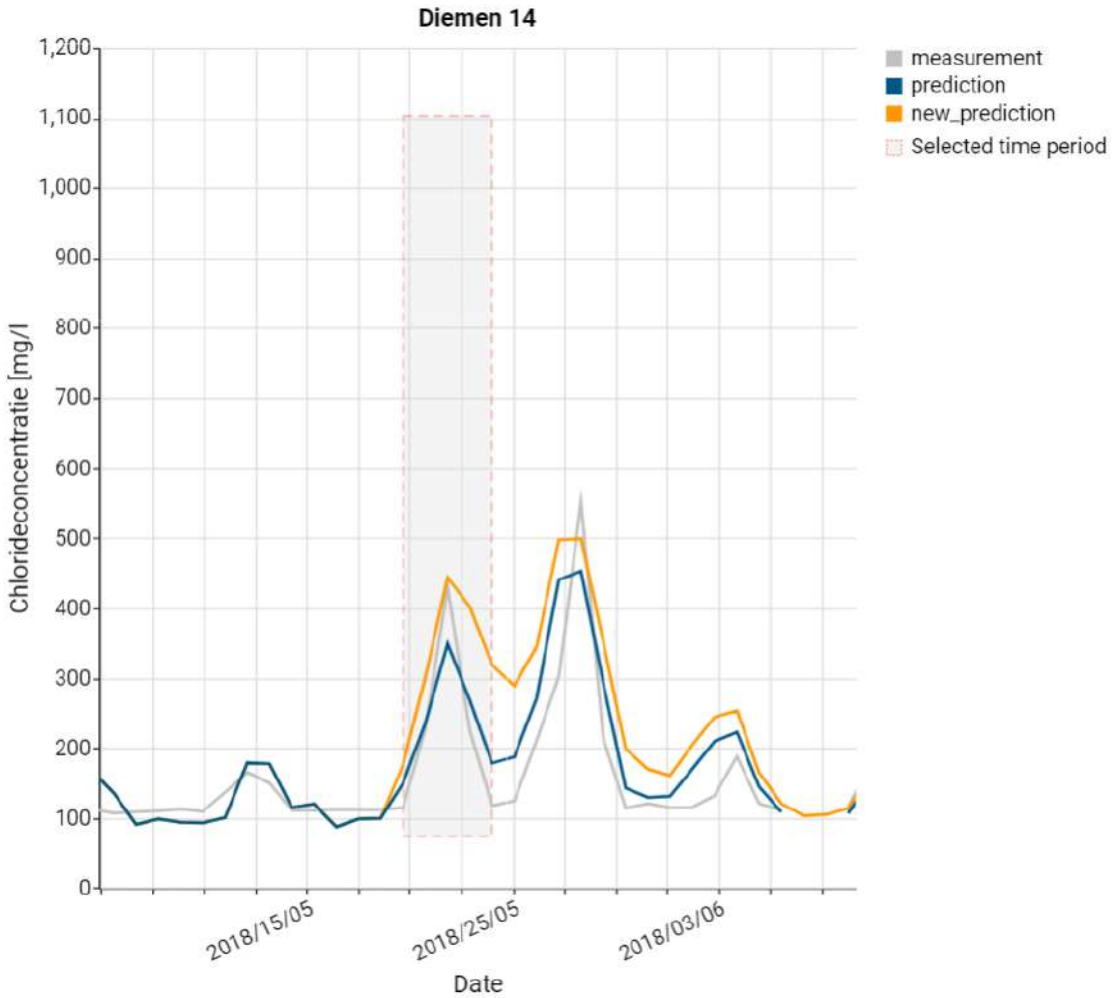
HKV LIJN IN WATER

Information

Disclaimer

Help

How does the prediction change?

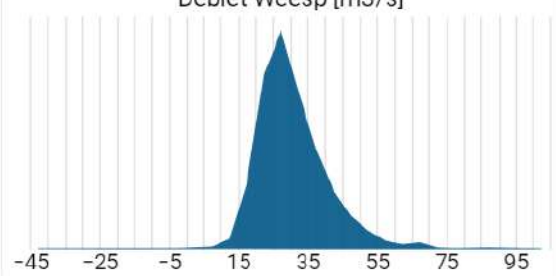


Key factors

Parameter: Debiet Weesp [m3/s]

Starttime: 05/20/2018 to Endtime: 05/25/2018

GET MEAN



Debiet Weesp [m3/s] value

12 40.0 68

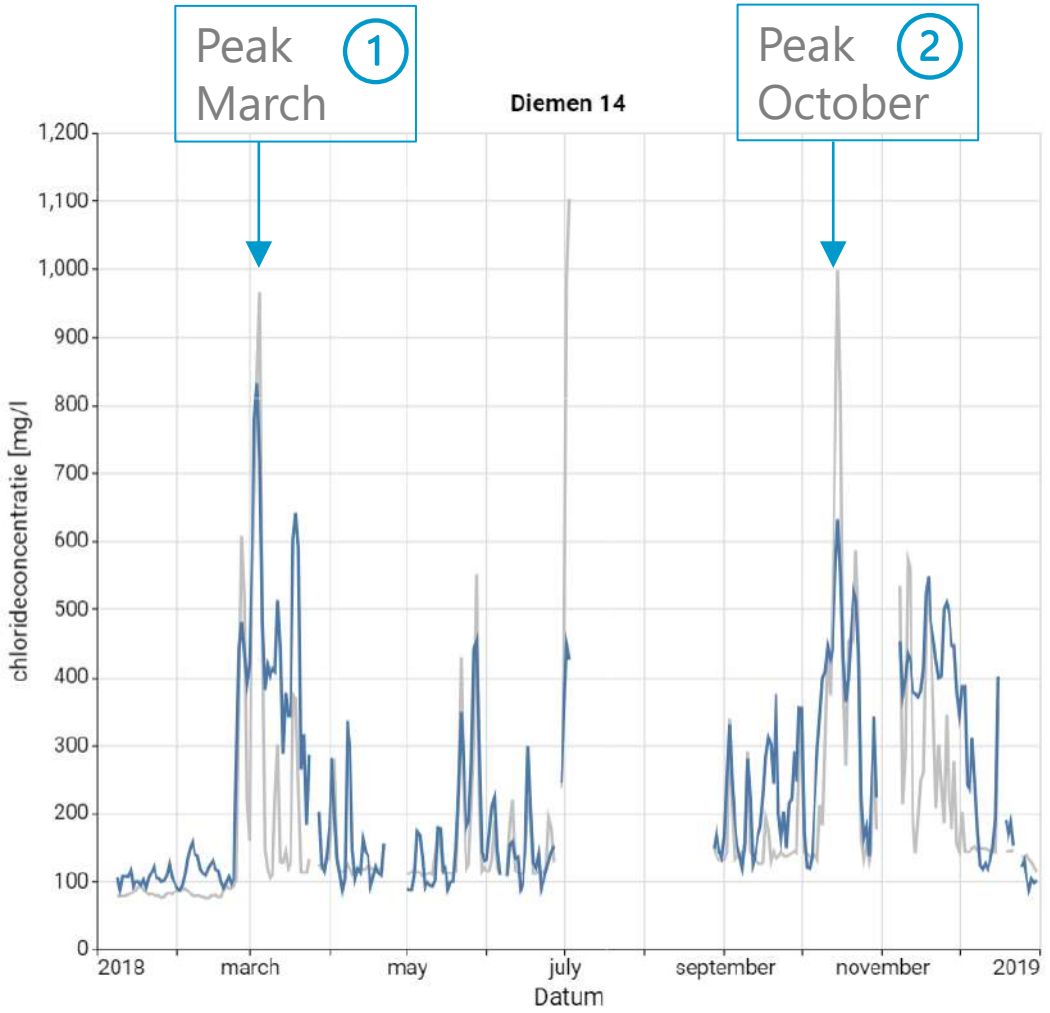
CHANGE PREDICTION

This viewer is intended for test purposes

Get to know XAI
Questions

1. Which features have **largest contribution** to the predicted salt peak in beginning of March?

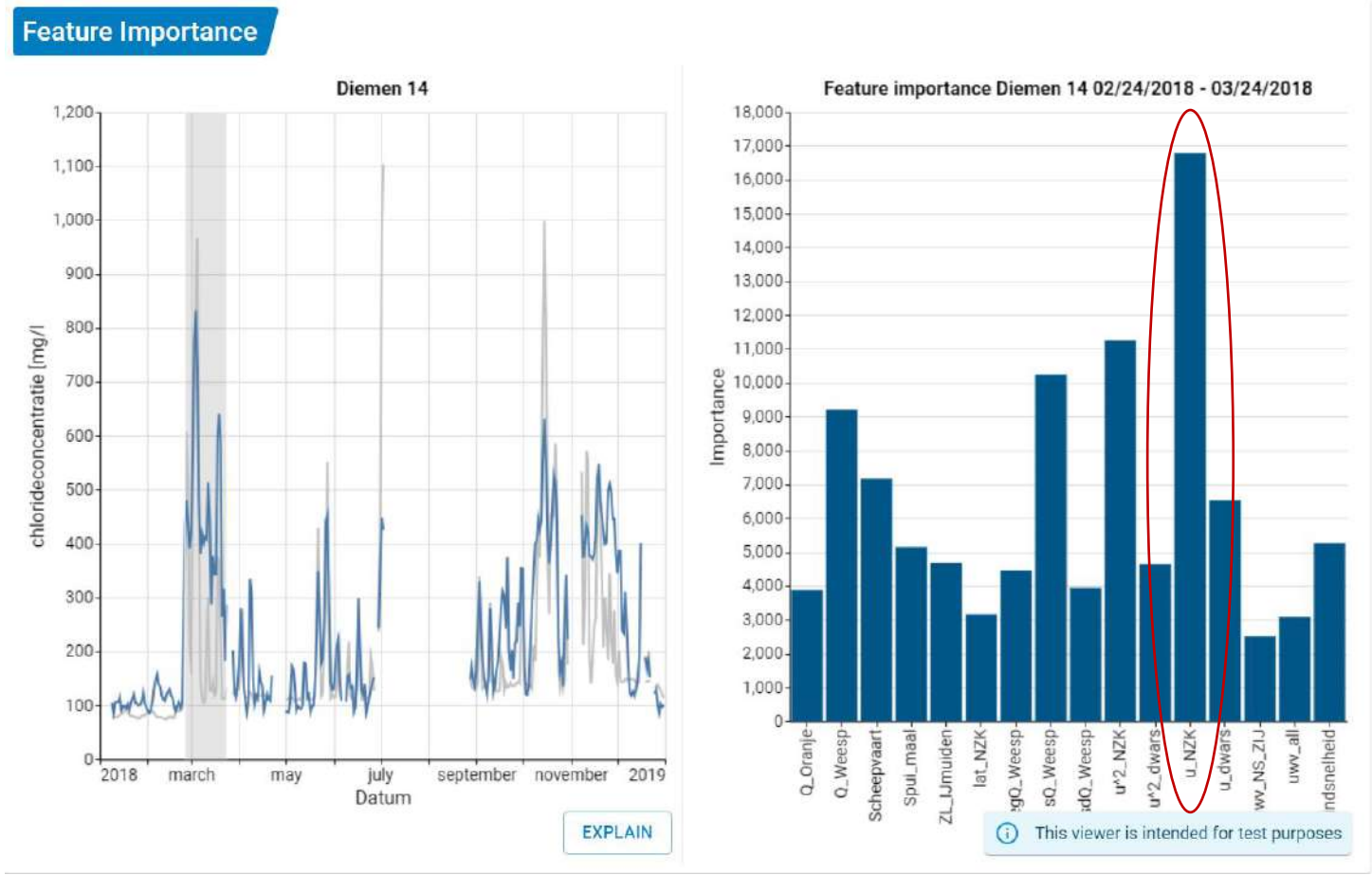
2. Can you change the conditions so that the salt peak in October does not exceed 500 mg/l?



Get to know XAI

1. What causes the salt peak in beginning of March?

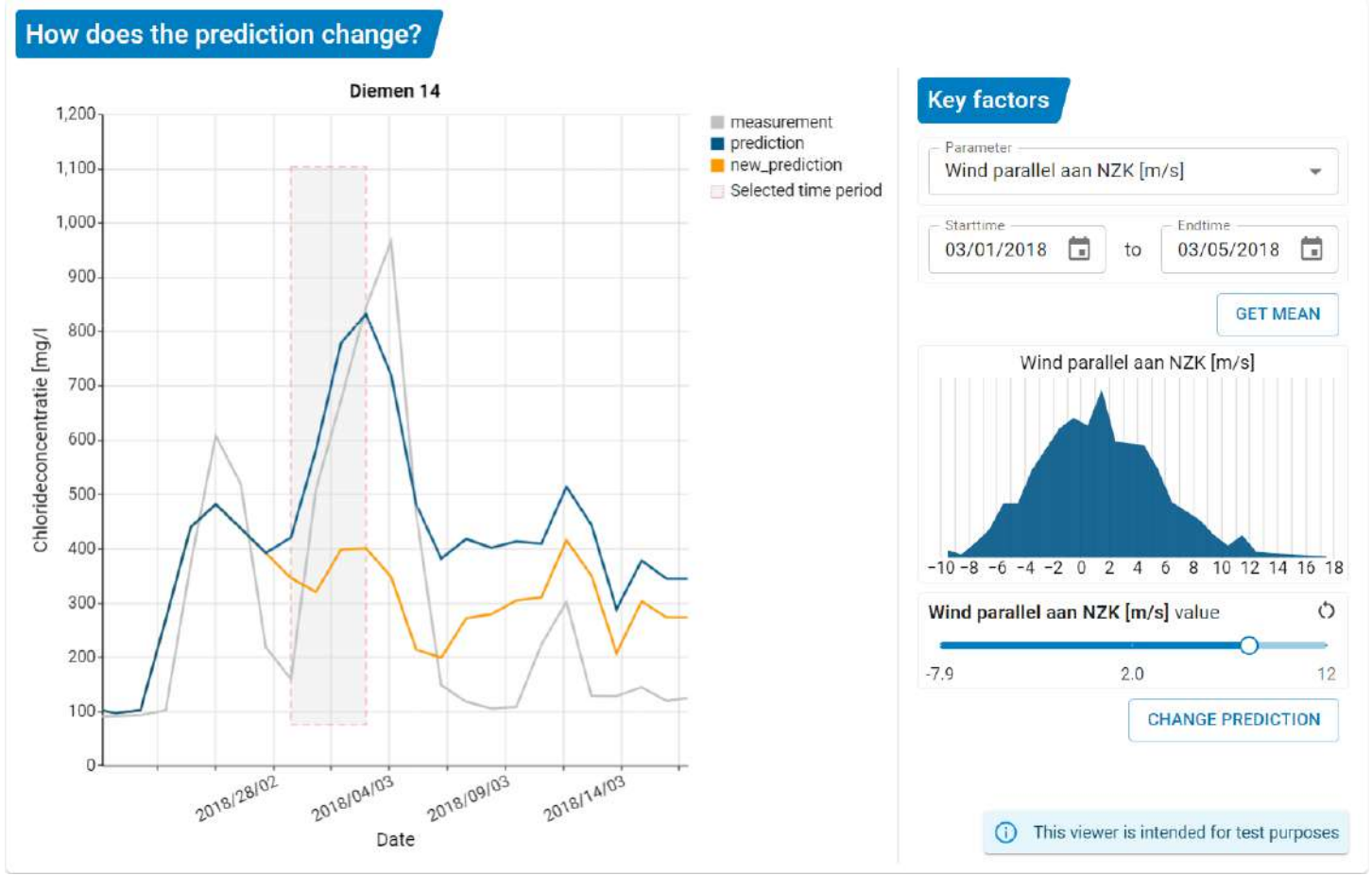
- Wind is important!



Get to know XAI

1. What causes the salt peak in beginning of March?

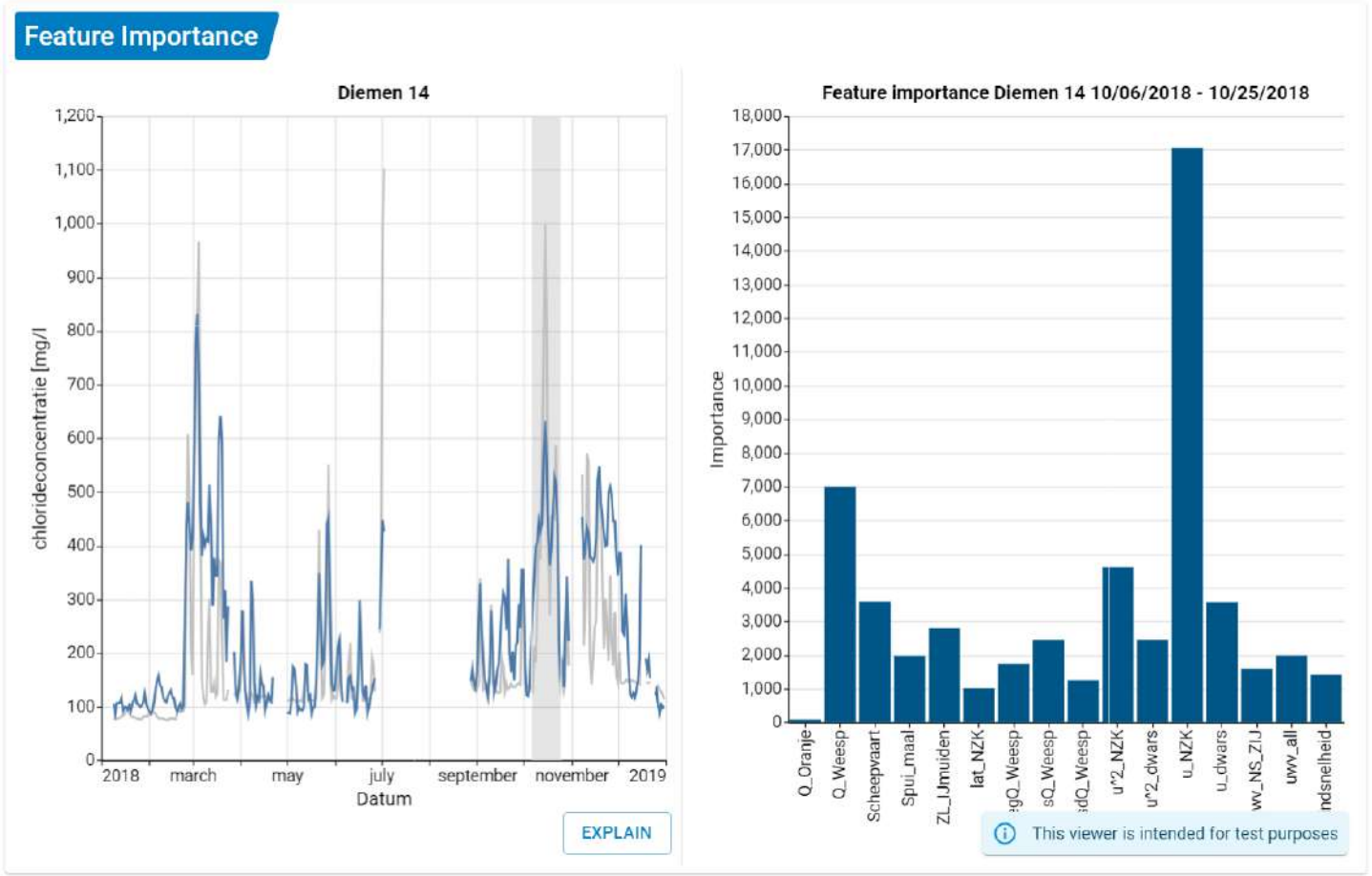
- If the wind had blown in the opposite direction, there would not have been a salt peak.



Get to know XAI

2. Can you change the conditions so that the salt peak in October does not exceed 500 mg/l?

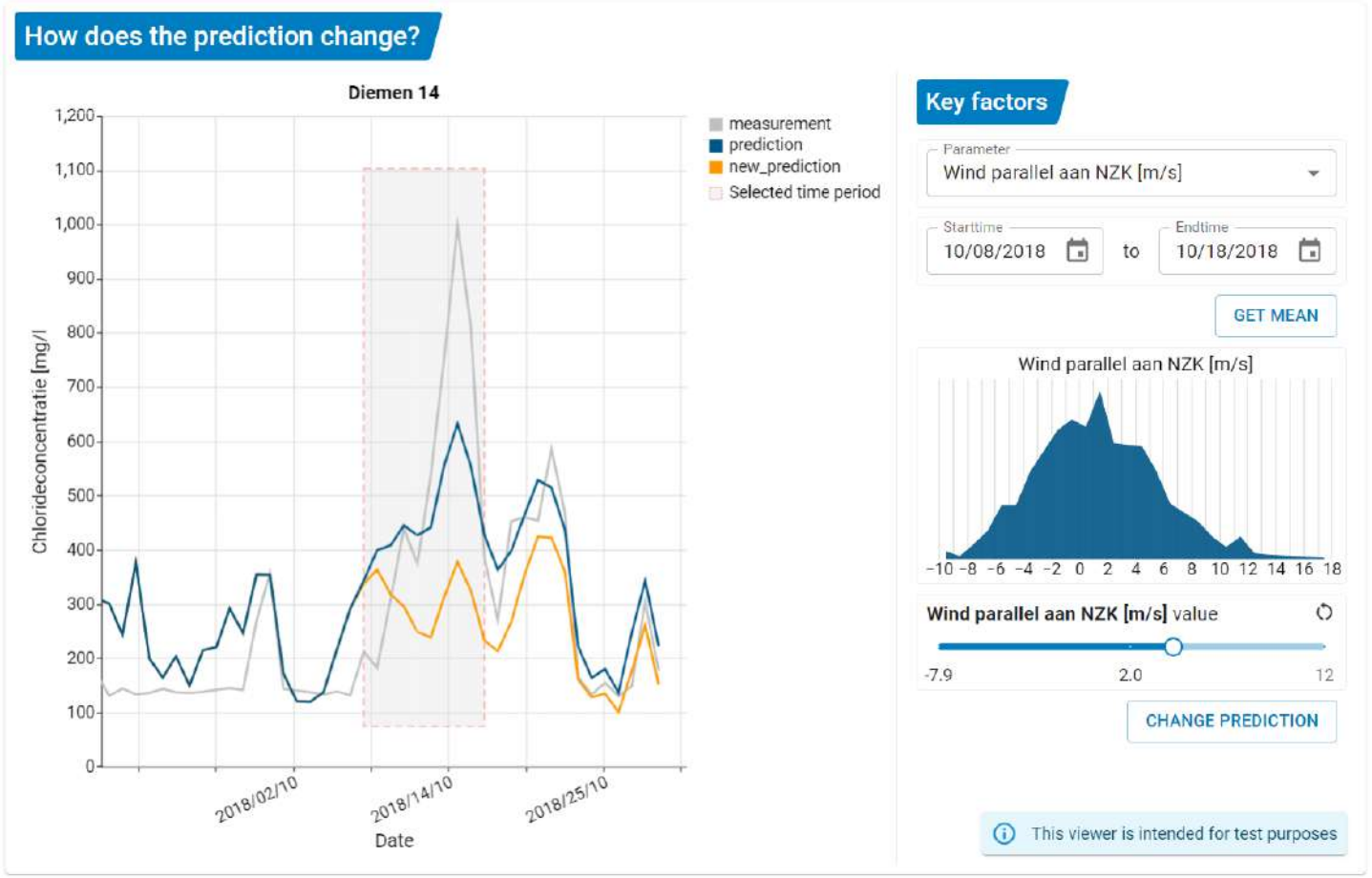
- Wind is important, followed by the discharge.



Get to know XAI

2. Can you change the conditions so that the salt peak in October does not exceed 500 mg/l?

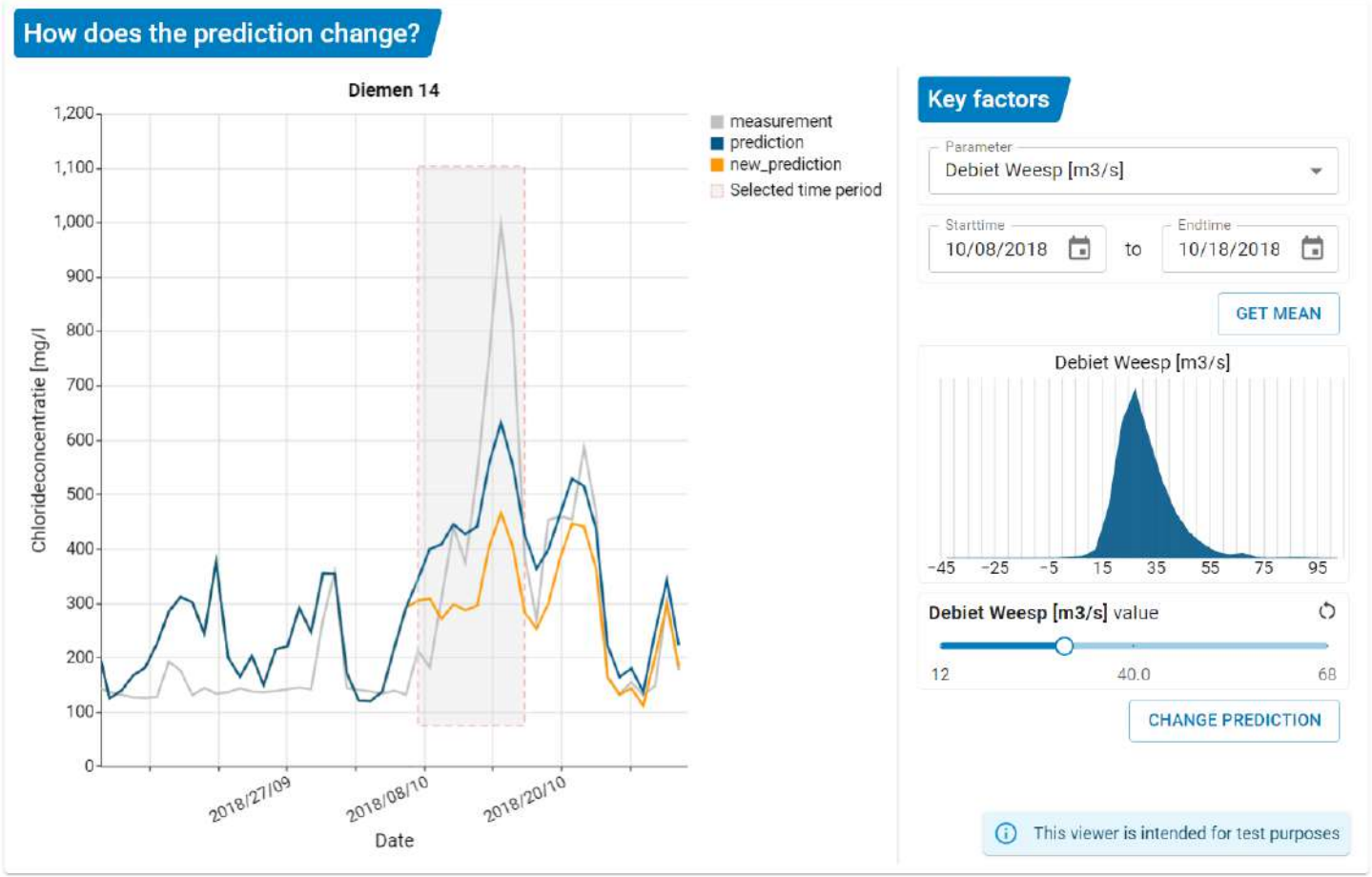
- Changing wind direction lowers the salt peak.



Get to know XAI

2. Can you change the conditions so that the salt peak in October does not exceed 500 mg/l?

- But you can also achieve this by increasing the discharge!



Discussion

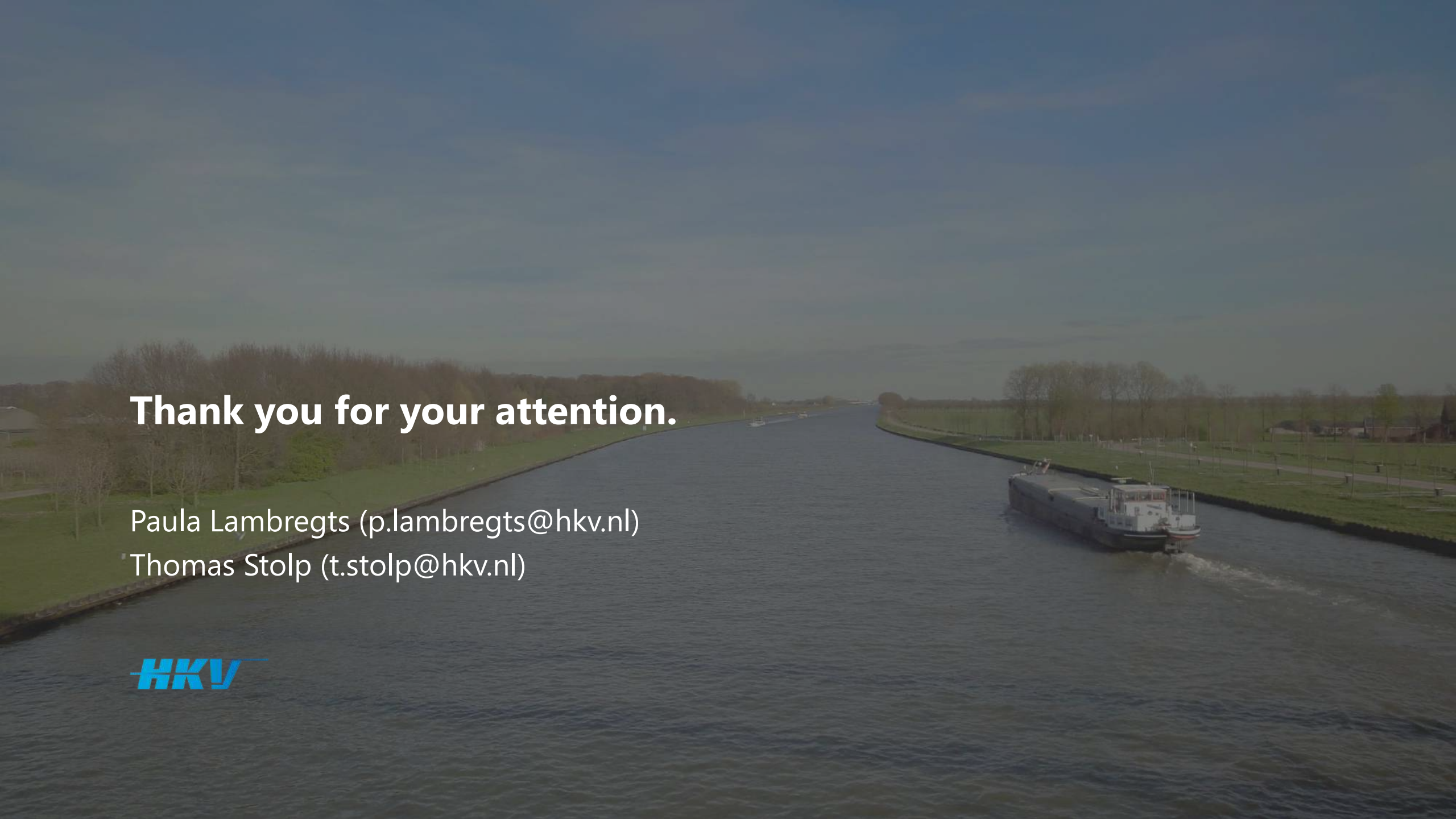
First impressions & future developments

Source: https://www.kpsol.com/benefits-using-discussion-forums-knowledge-management-environment/

Closure
What's next?

- What will we do with your input?
  - Continue development
  - Plant the seed!
- Ultimate goal: Operational along-side a predictive model

Source: https://medium.com/lightspeed-venture-partners/you-raised-seed-money-now-what-49b1ea686ea4



Thank you for your attention.

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Thomas Stolp (t.stolp@hkv.nl)