

# 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

## Introduction Statement

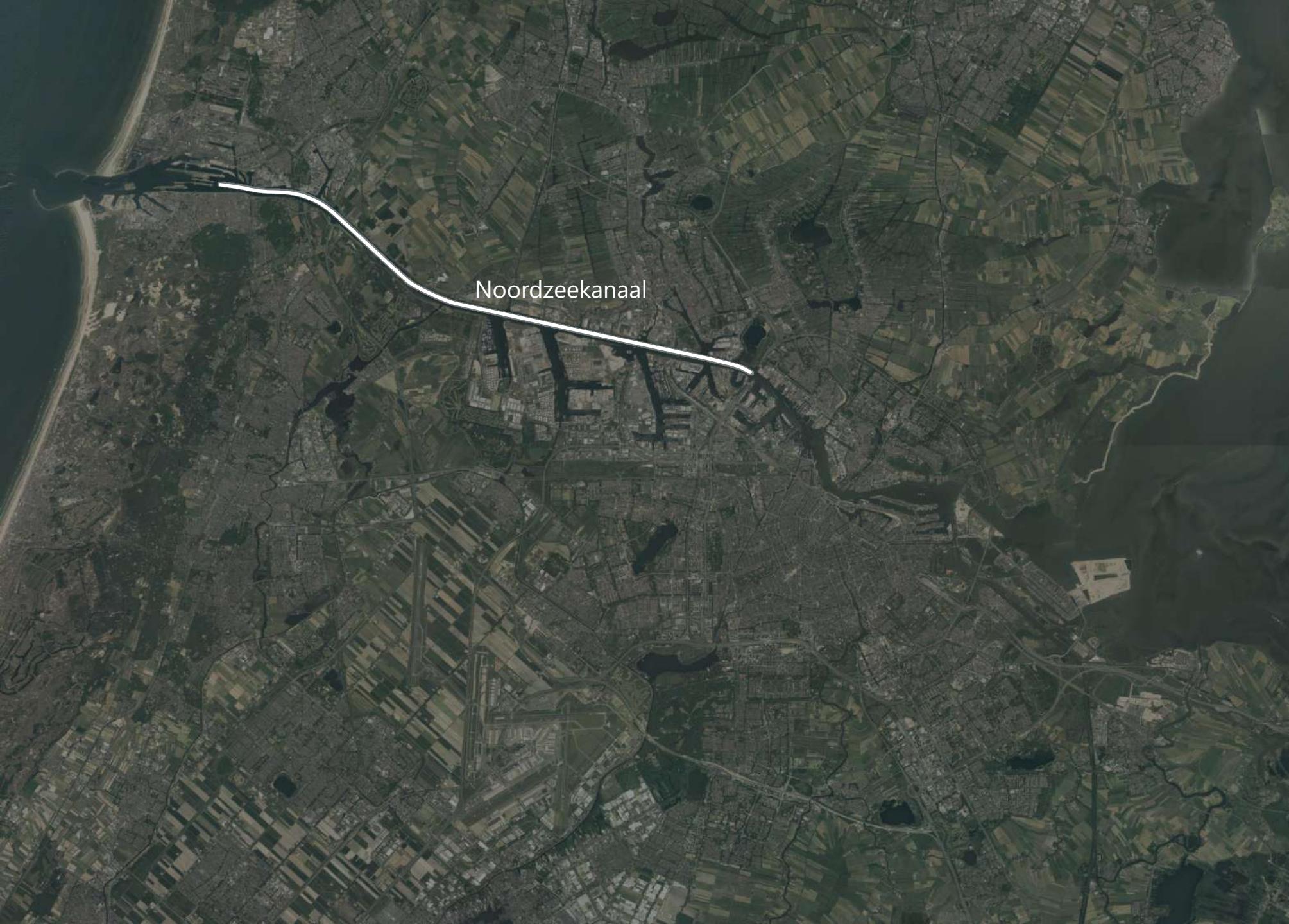
*"Within the water sector, there is a strong demand for explainability of data-driven models"*

*"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

Noordzeekanaal

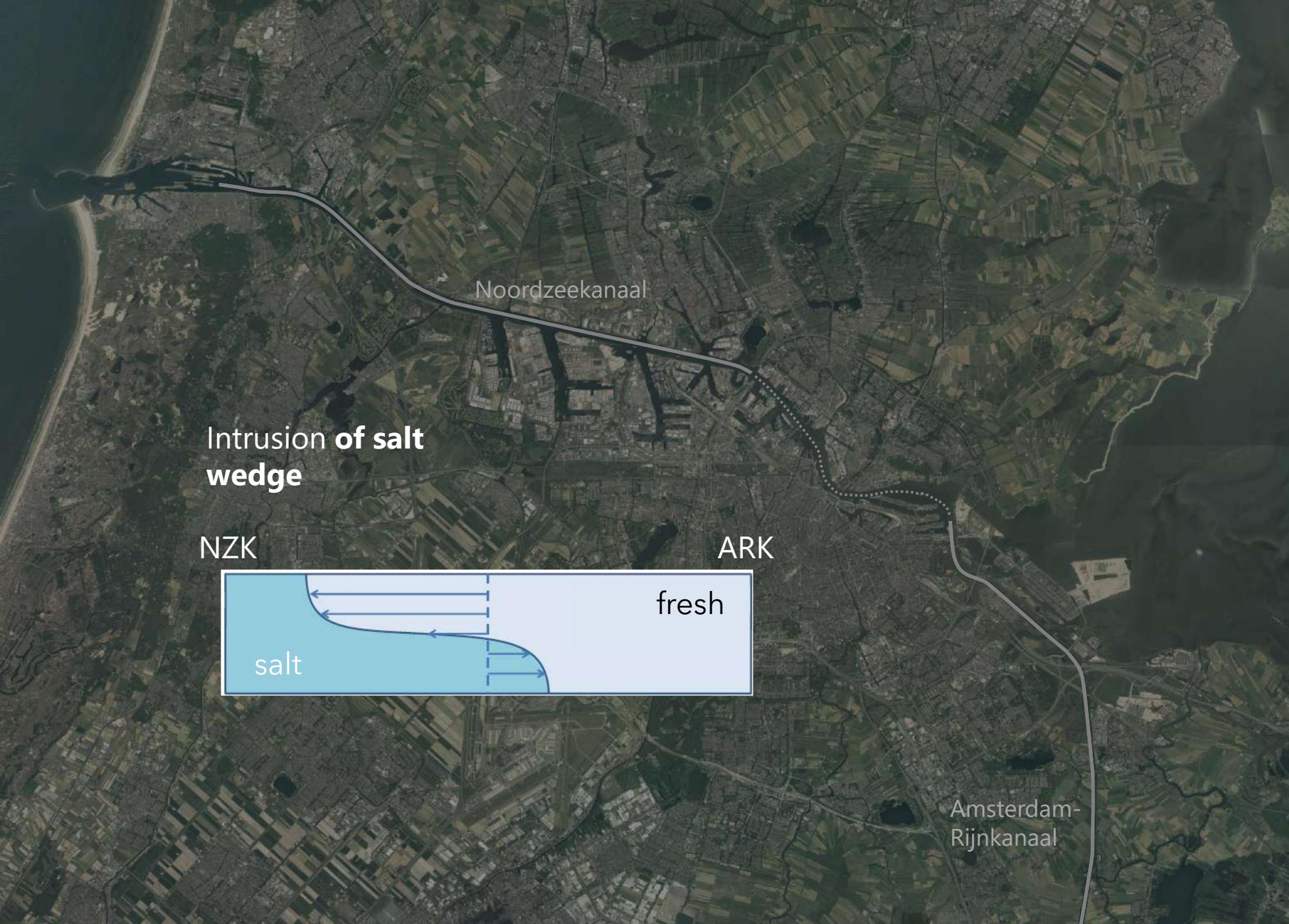


## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal





**Context**

Salt intrusion on  
the Amsterdam-  
Rhine Canal

Noordzeekanaal

**Critical points for salt  
intrusion**

Driemond

Vecht

Nigtevecht

Drinking water ↓

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal





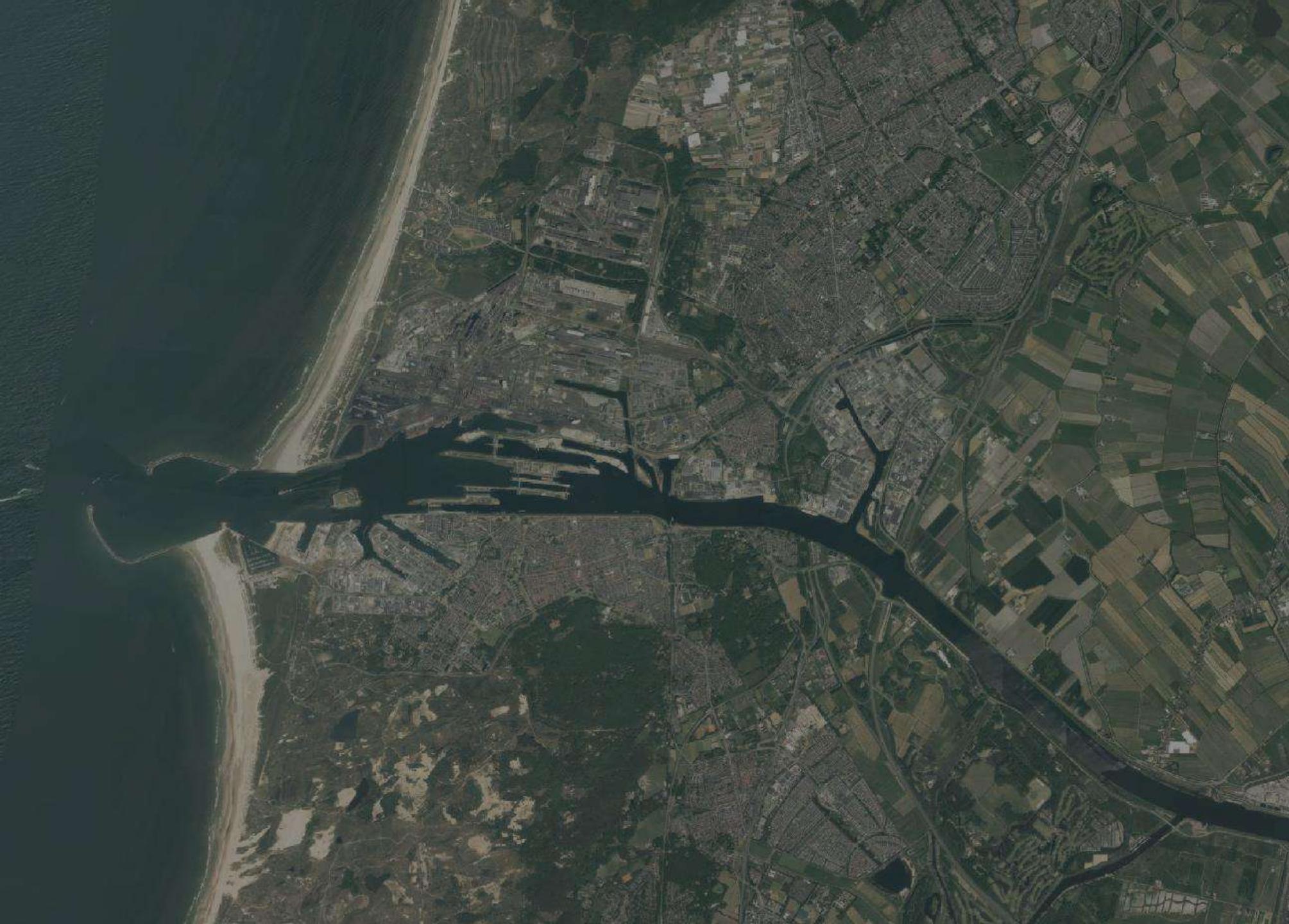
## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal



## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

A satellite photograph showing the urban sprawl of the Netherlands, specifically the area around the Amsterdam-Rhine Canal. The image captures a dense network of canals, roads, and agricultural fields. The city of Rotterdam is visible in the background, with its characteristic industrial port facilities. The foreground shows the intricate patterns of farmland and water management systems.

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

## Context

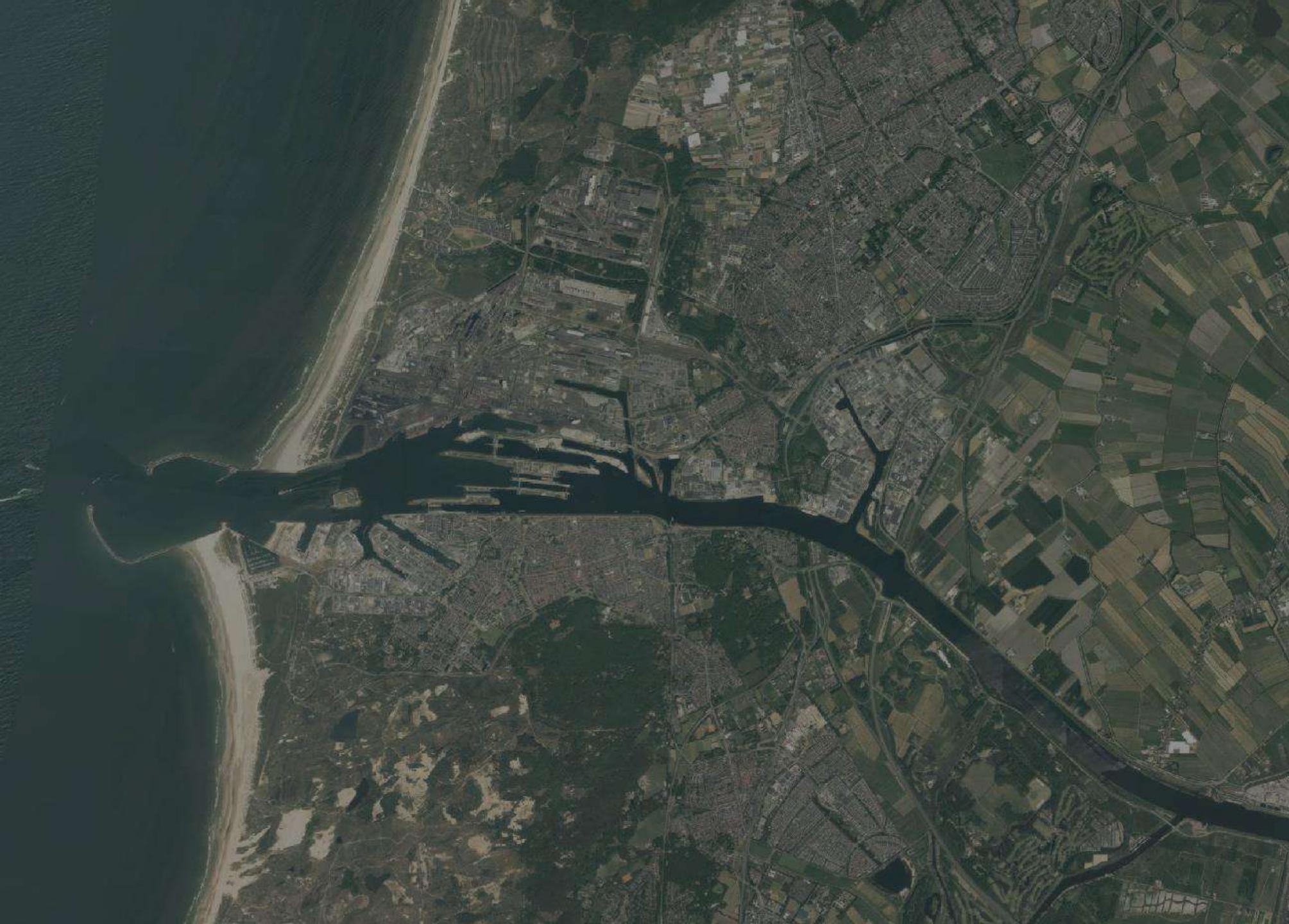
Salt intrusion on  
the Amsterdam-  
Rhine Canal

### Salt load, IJmuiden

Middensluis → Noordersluis  
Zeesluis IJmuiden

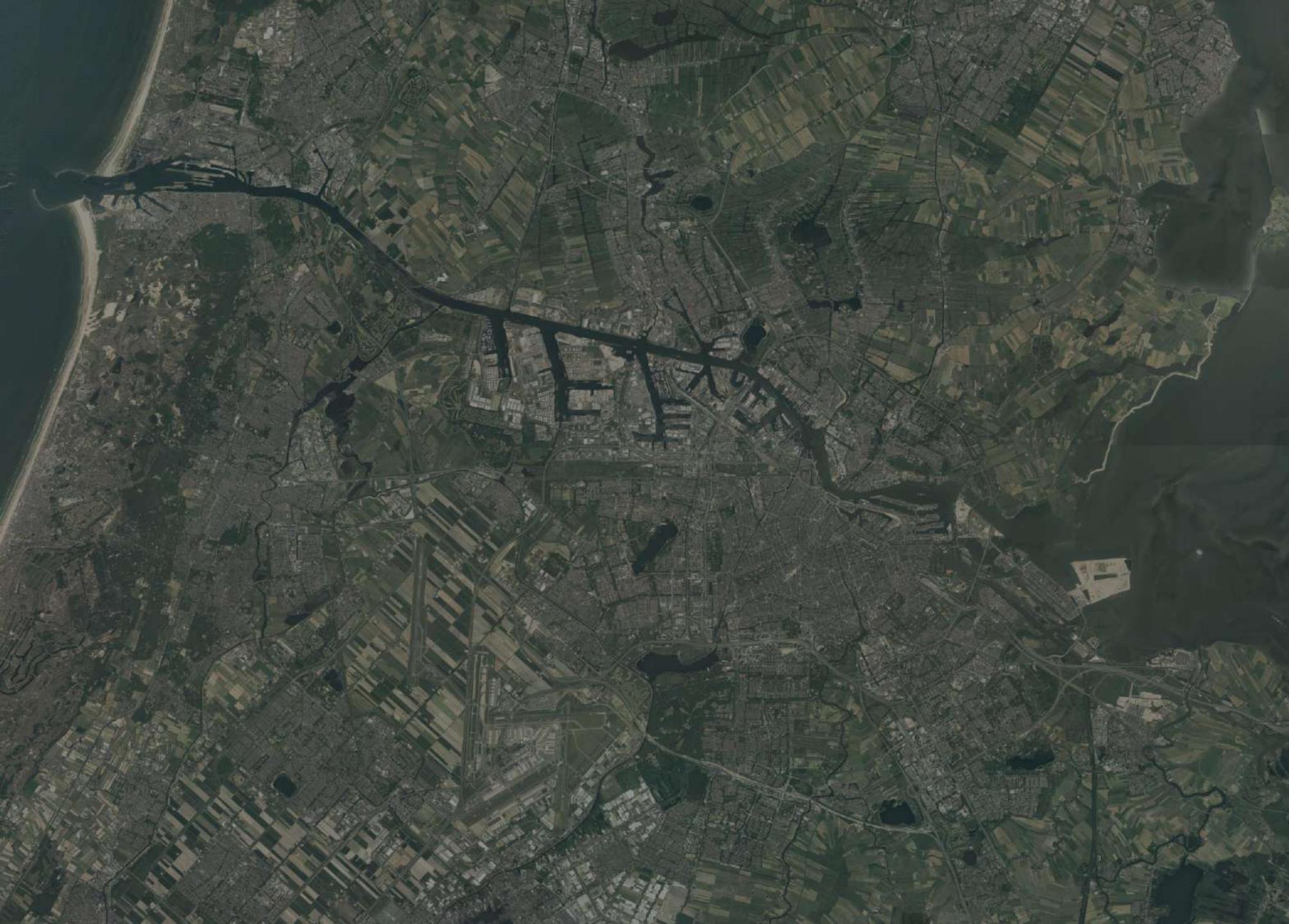
#### Features:

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

A satellite photograph showing the urban sprawl of the Netherlands, specifically the area around the Amsterdam-Rhine Canal. The image captures a dense network of canals, roads, and agricultural fields. The city of Rotterdam is visible in the background, with its characteristic industrial port facilities. The foreground shows the intricate patterns of farmland and water management systems.

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal



## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

An aerial photograph of the Amsterdam-Rhine Canal area. The map shows a dense network of canals and rivers, with agricultural fields and urban areas. Numerous white arrows are overlaid on the map, representing wind direction and intensity. A large cluster of arrows points generally towards the northeast. A specific vector is highlighted with a larger arrowhead and labeled with text.

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

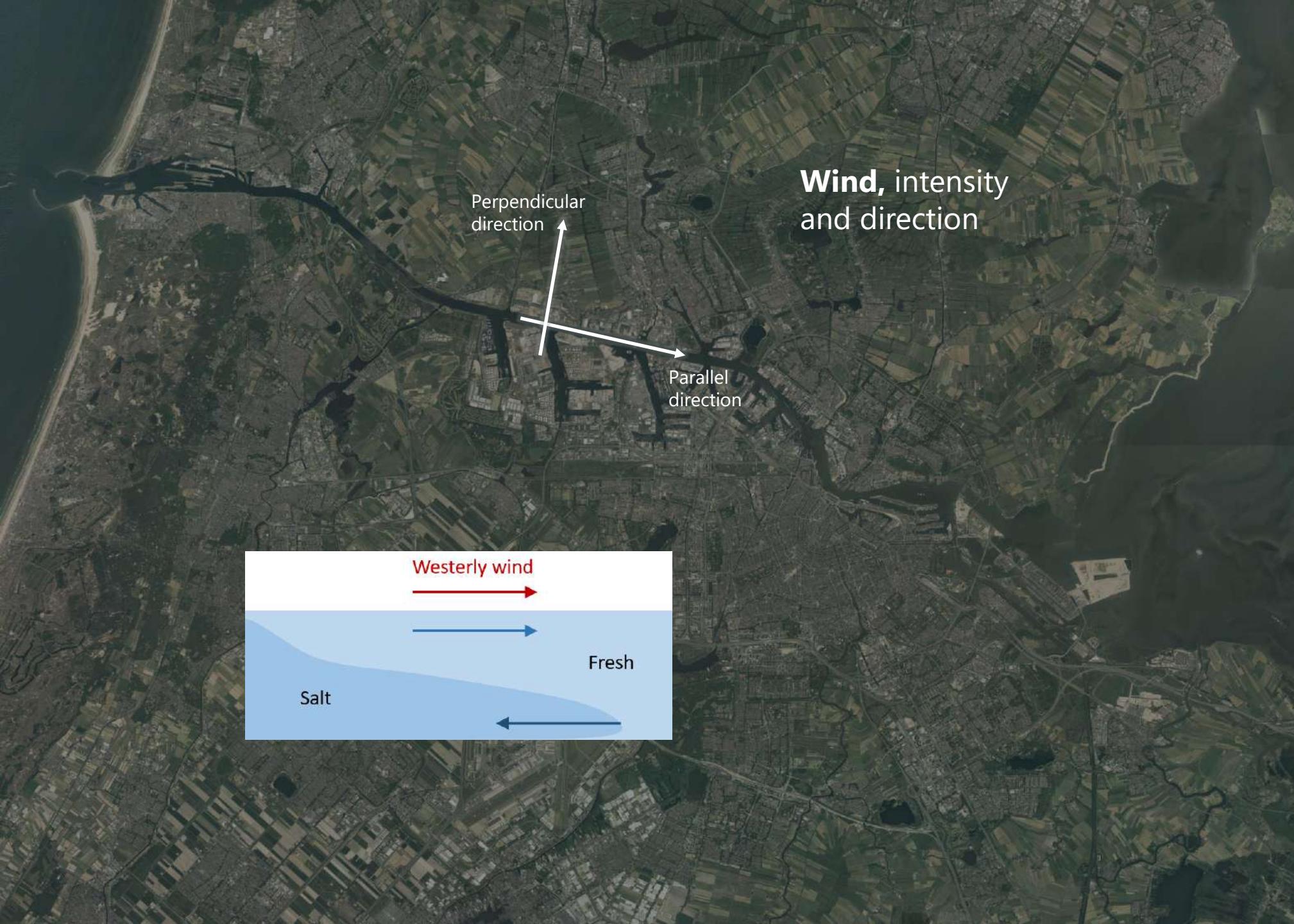
**Wind, intensity  
and direction**

Perpendicular  
direction

Parallel  
direction

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal





## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

A satellite map showing the Amsterdam-Rhine Canal (ARC) in the Netherlands. The map includes the city of Rotterdam on the left, industrial areas along the canal, and agricultural fields to the west. The water body of the canal is dark blue, contrasting with the green land. A large white rectangular area, likely a salt evaporation pond, is visible near the center-right.

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

A satellite map showing the Amsterdam-Rhine Canal area. The map includes a dense urban area in the northwest, agricultural fields, and a large body of water. Five white arrows point from the text "Shipping intensity at the Amsterdam-Rhine canal" to various points along the canal's course.

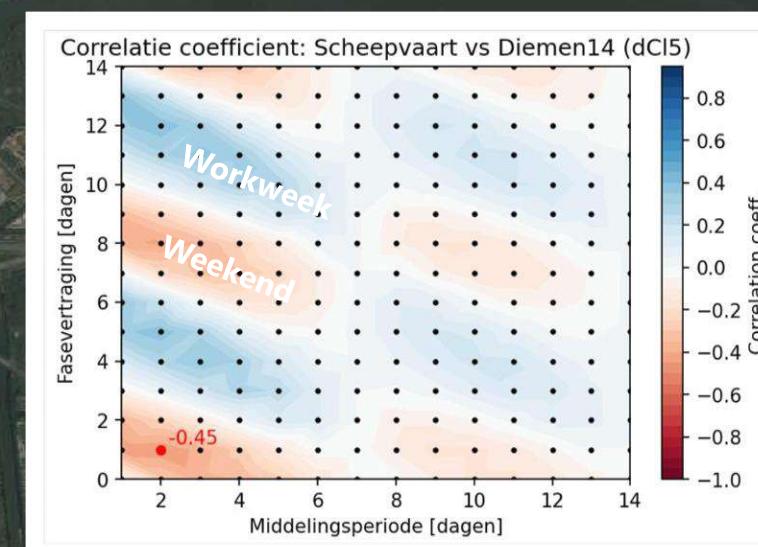
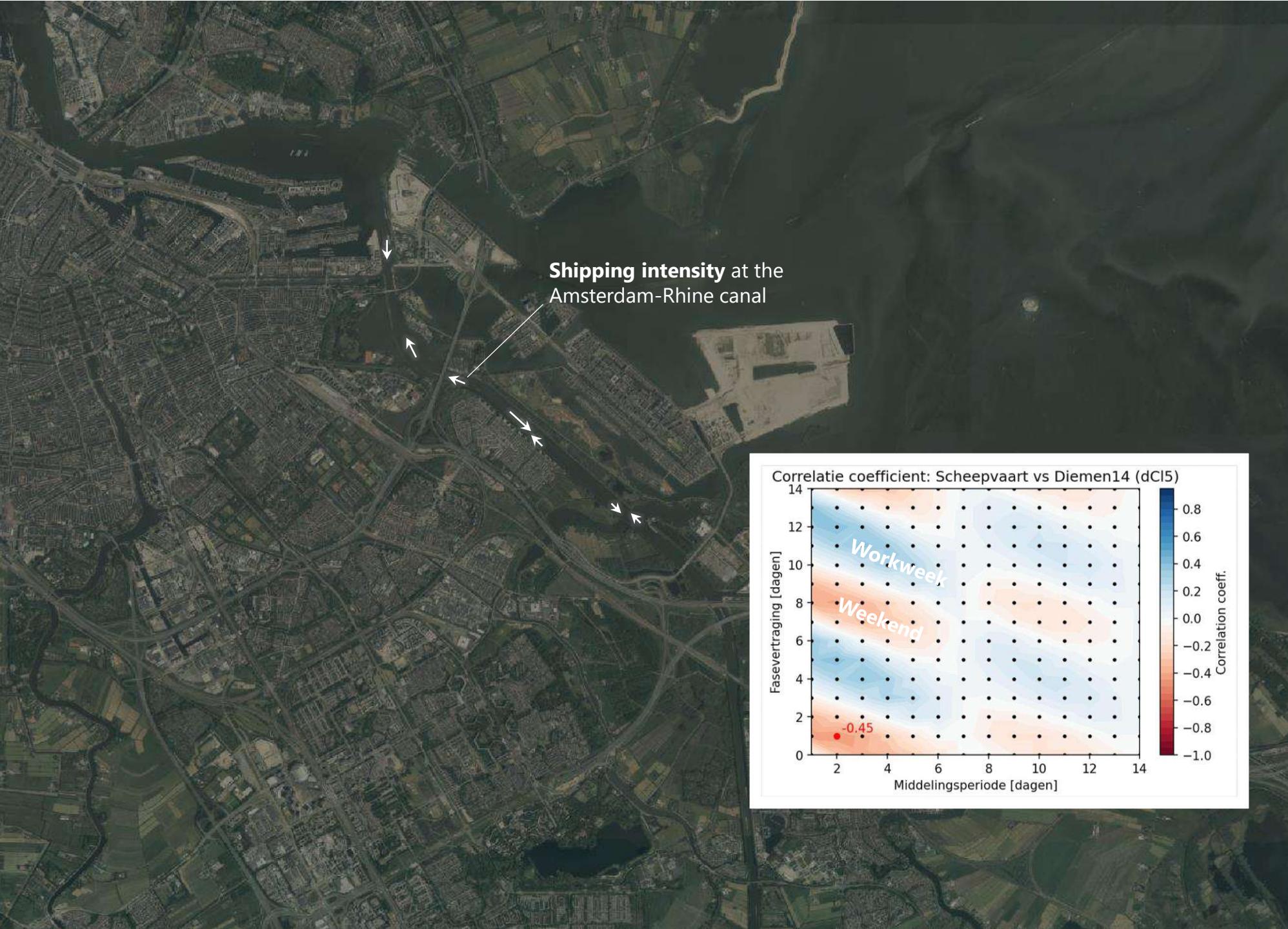
## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

**Shipping intensity** at the  
Amsterdam-Rhine canal

## Context

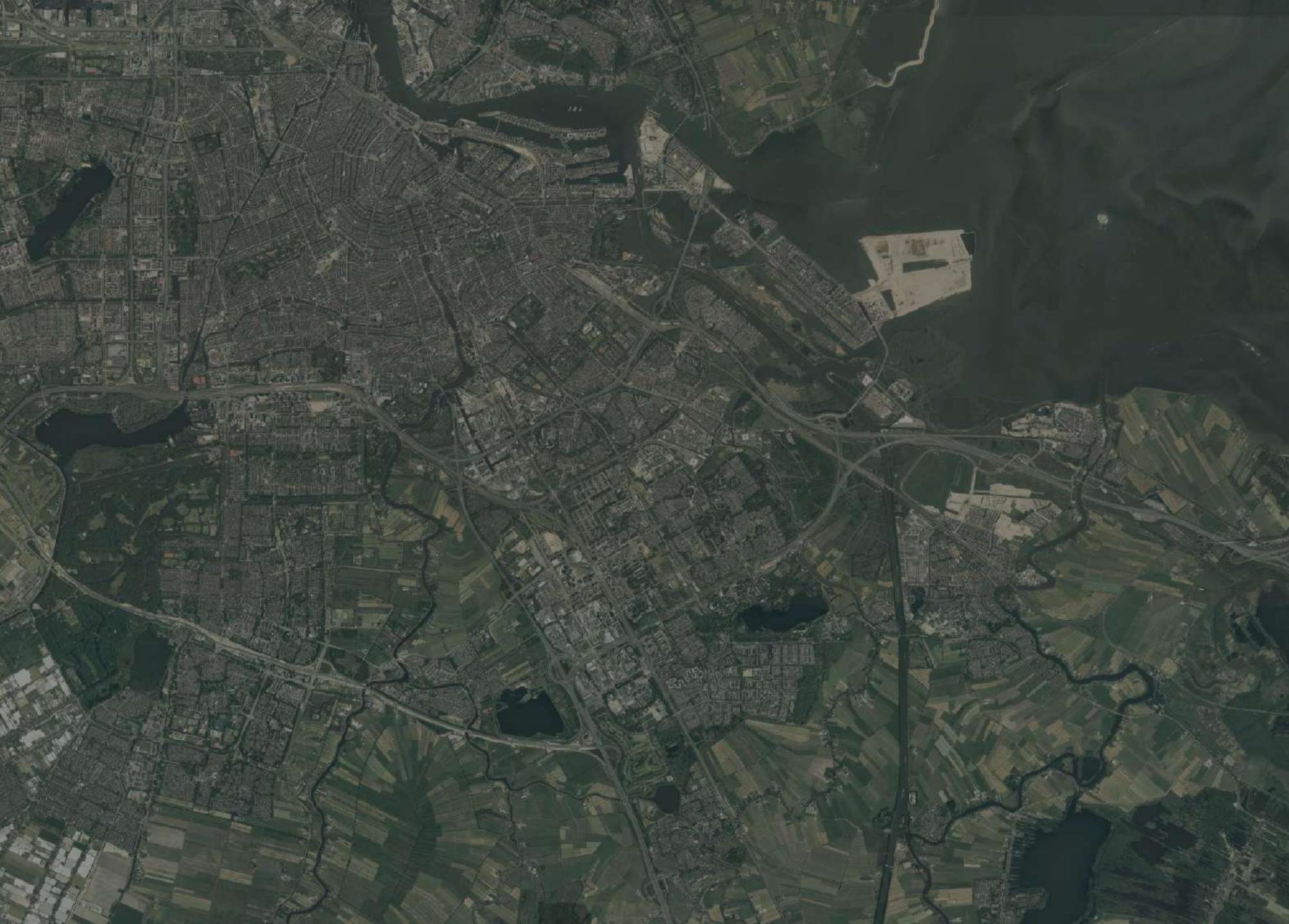
Salt intrusion on  
the Amsterdam-  
Rhine Canal



A satellite map showing the Amsterdam-Rhine Canal (ARC) in the Netherlands. The map includes the city of Rotterdam on the left, industrial areas along the canal, and agricultural fields to the west. The water body of the canal is dark blue, contrasting with the green land. A large white rectangular area, likely a salt evaporation pond, is visible near the center-right.

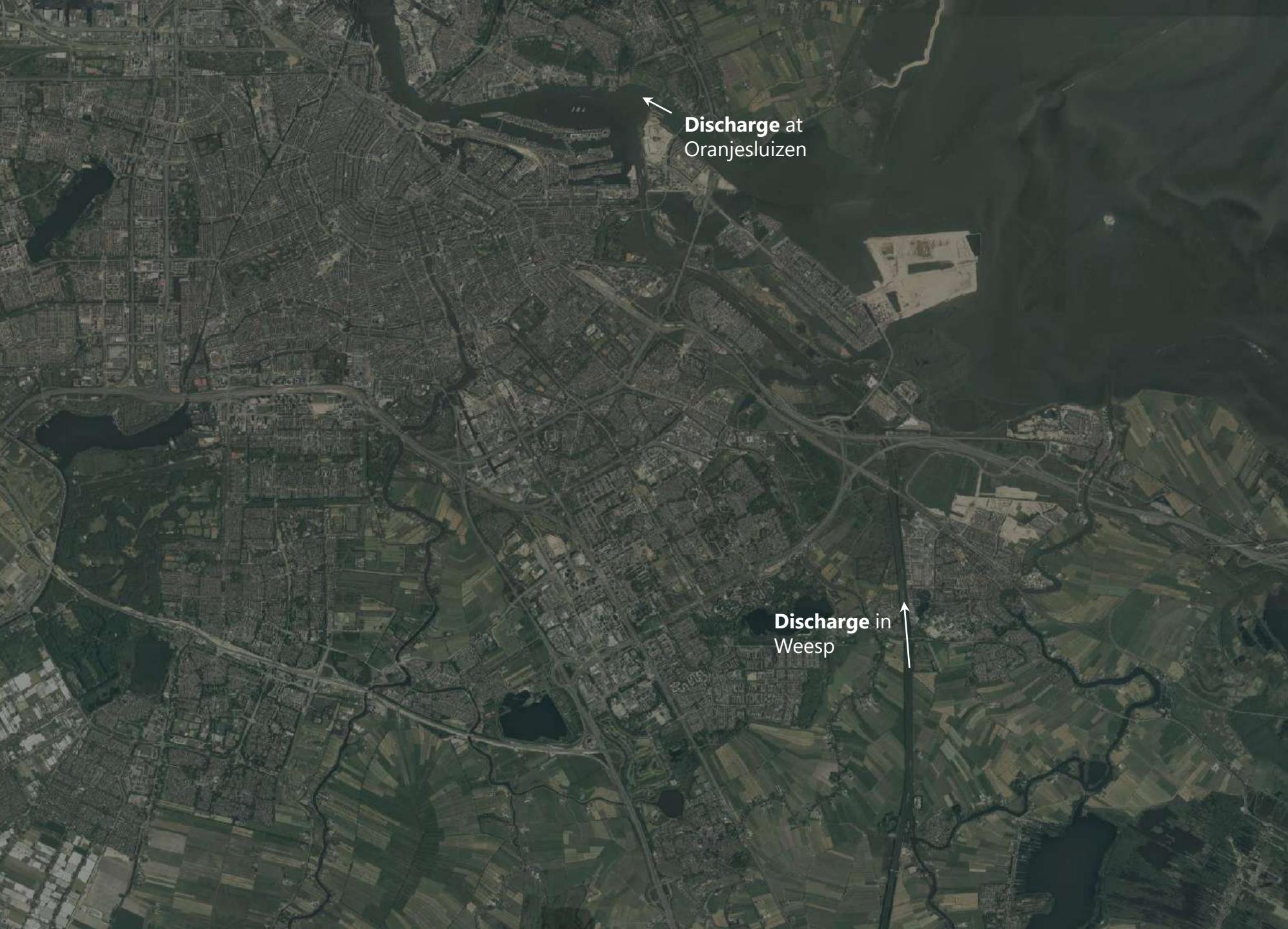
## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

An aerial photograph of a large urban area, likely Amsterdam, showing a dense grid of buildings and roads. A major waterway, the Amsterdam-Rhine Canal, cuts through the city. The surrounding land is divided into various agricultural fields and green spaces. The image is taken from a high vantage point, providing a comprehensive view of the urban sprawl and its natural surroundings.

## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal



## Context

Salt intrusion on  
the Amsterdam-  
Rhine Canal

Discharge at  
Oranjesluizen

Discharge in  
Weesp

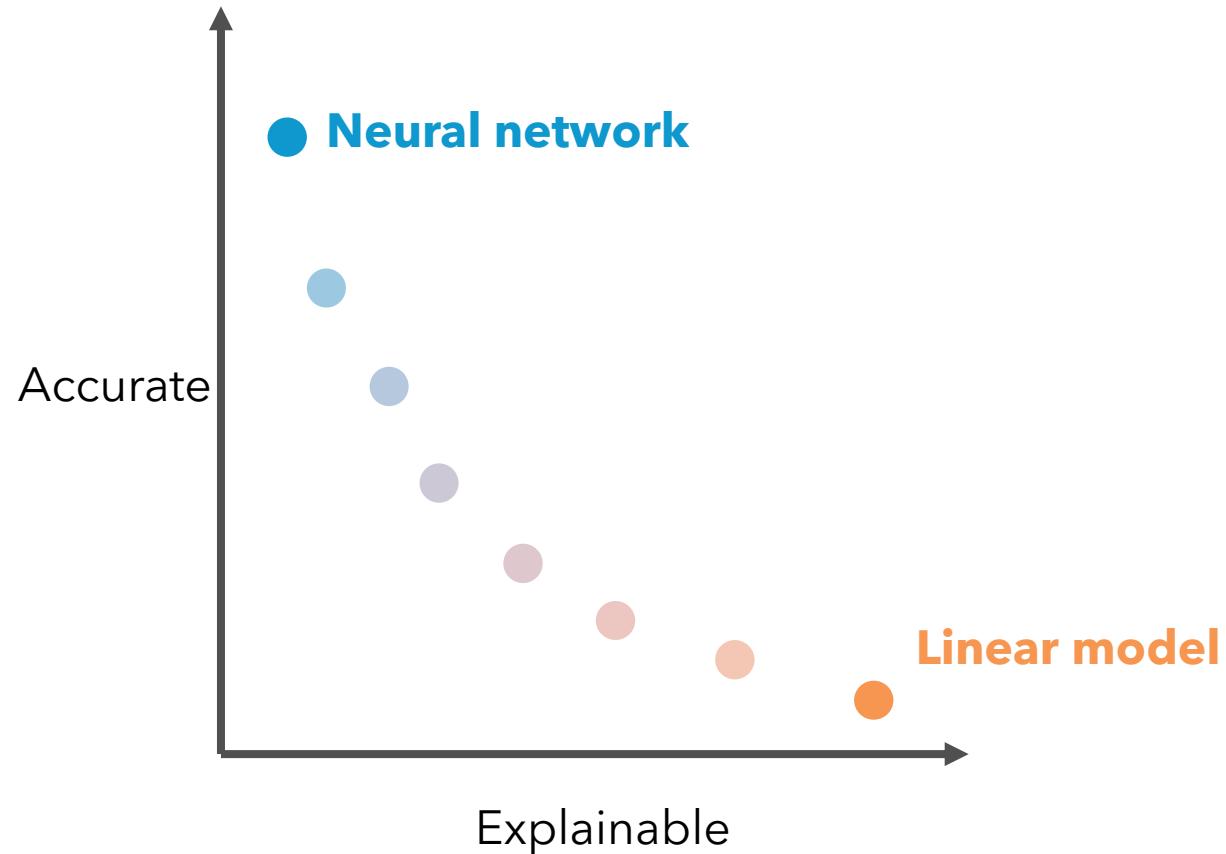
## Context

### 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

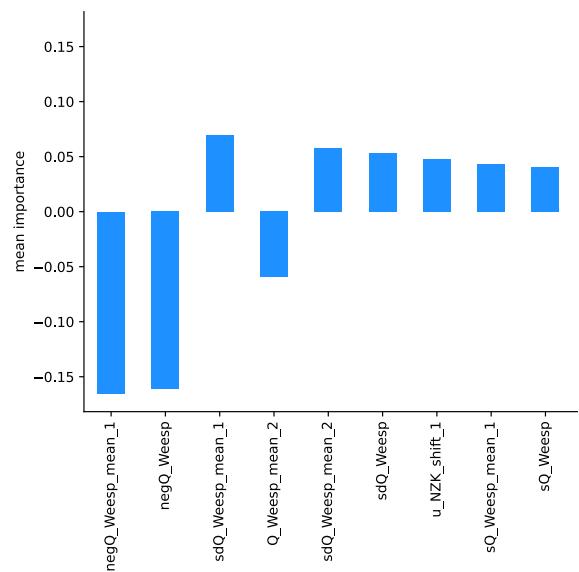
### AI versus conventional techniques



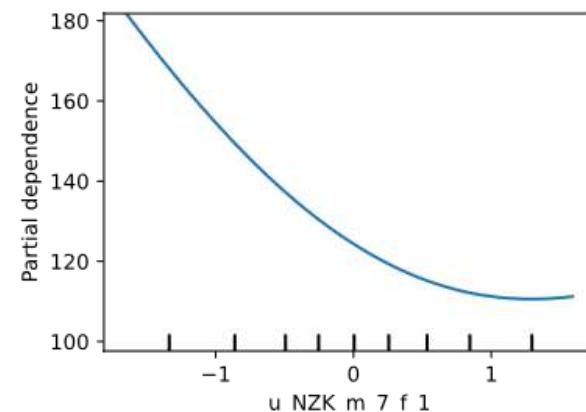
## Context

## Explainable AI

- **Ranking**

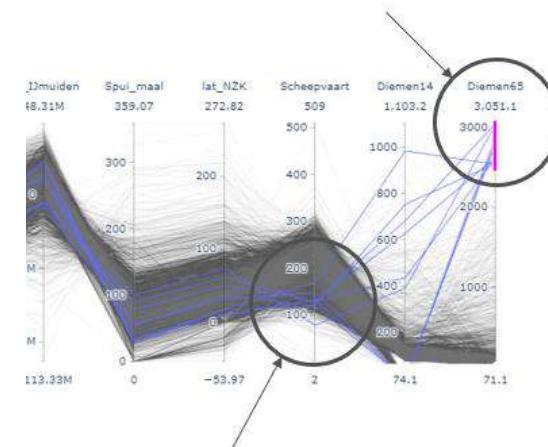


- **Dependence**



- **Visualisation**

Highest salt concentration  
in Diemen -6.5 m NAP

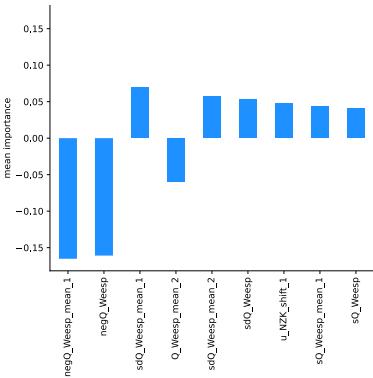


Limited shipping  
(reduced mixing)

## Context

## Explainable AI

### Ranking

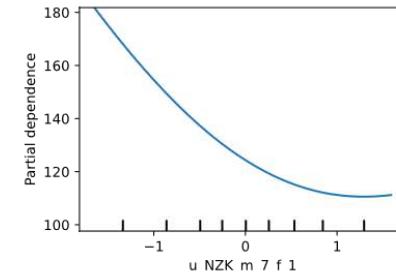


I. Permutation feature importance

II. Leave One Feature Out (LOFO)

III. SHAP mean importance

### Dependence

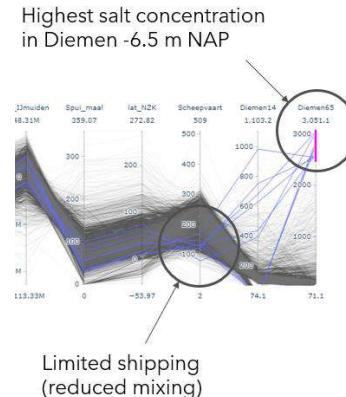


I. Partial dependence plot (PDP)

II. Accumulated local effects (ALE)

III. SHAP mean importance

### Visualisation



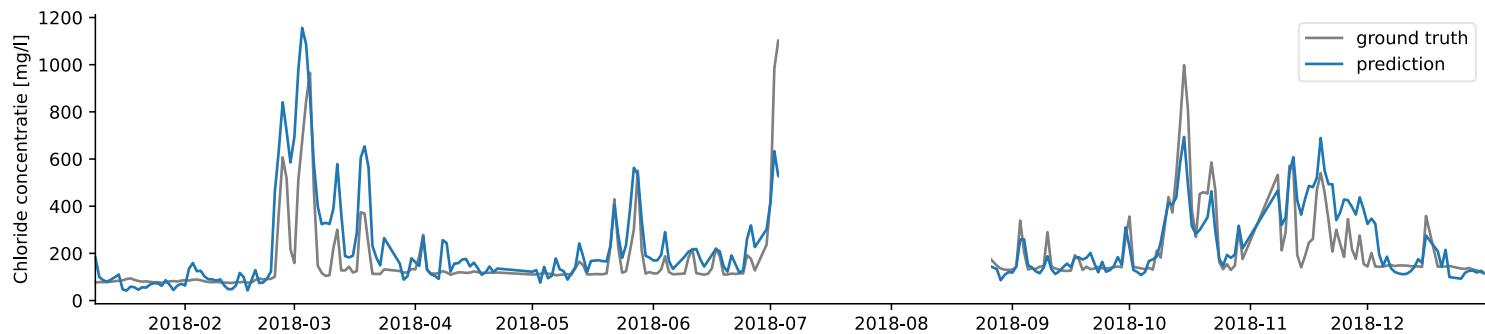
I. Parallel coordinate plot

II. Visual (interactive) interpretability

## Context

### Predictive modelling

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

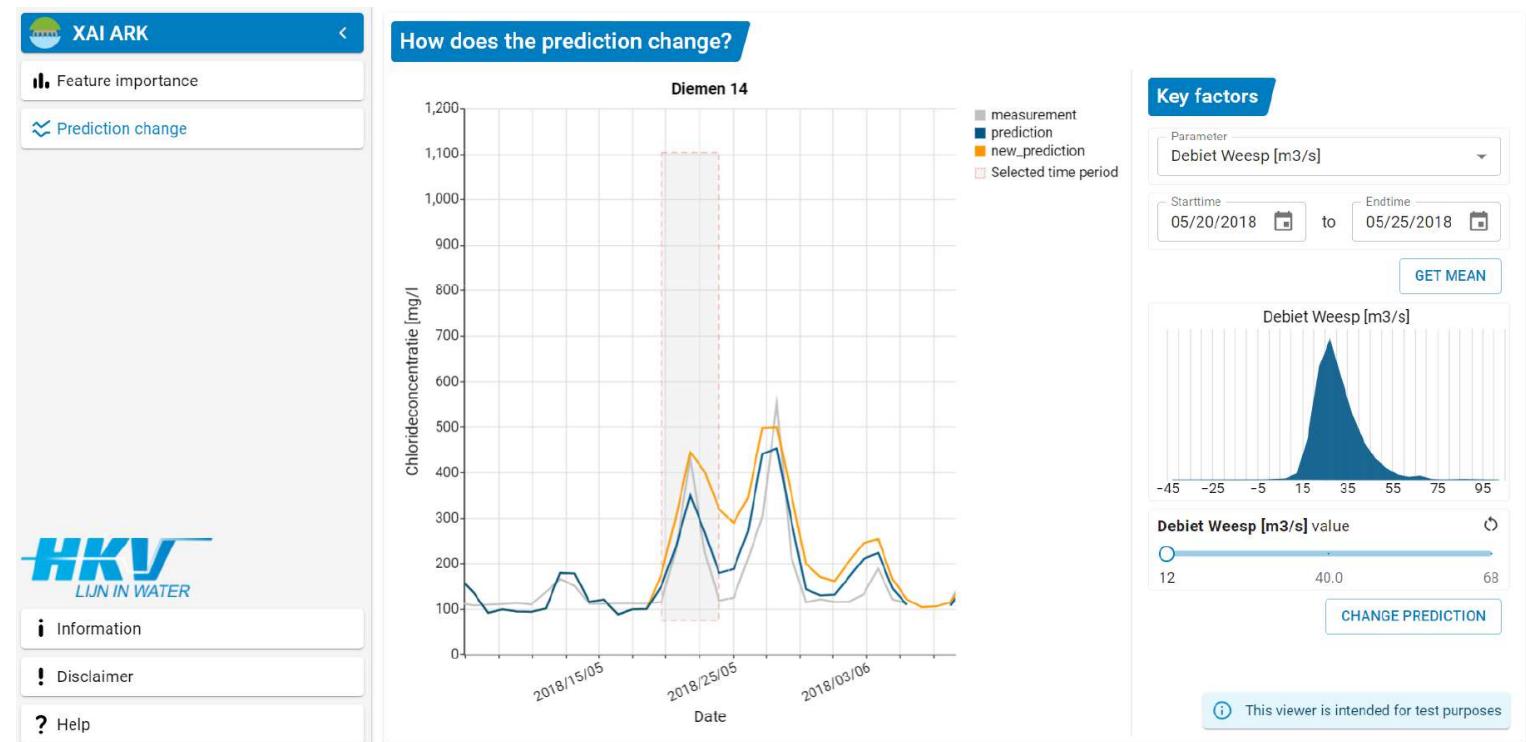


Prediction of salt concentrations in Diemen using a neural network.

# 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



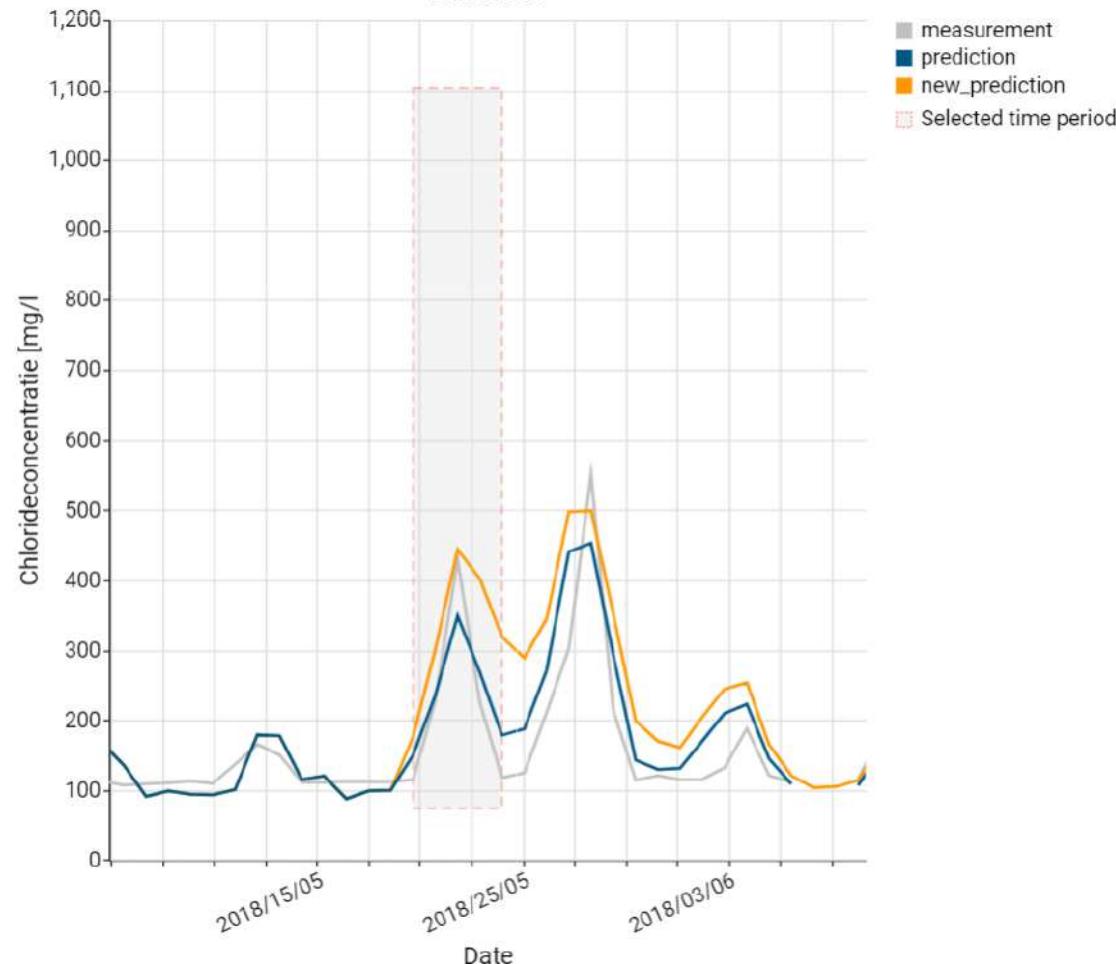
Information

Disclaimer

Help

## How does the prediction change?

Diemen 14



## Key factors

Parameter

Debiet Weesp [m3/s]

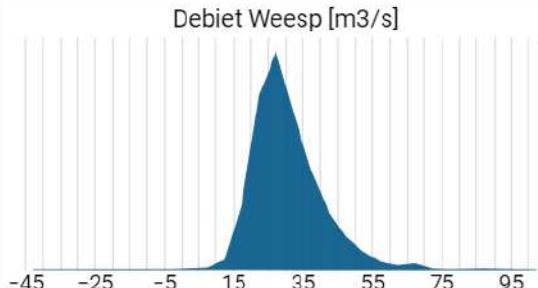
Starttime

05/20/2018

Endtime

05/25/2018

GET MEAN



Debiet Weesp [m3/s] value



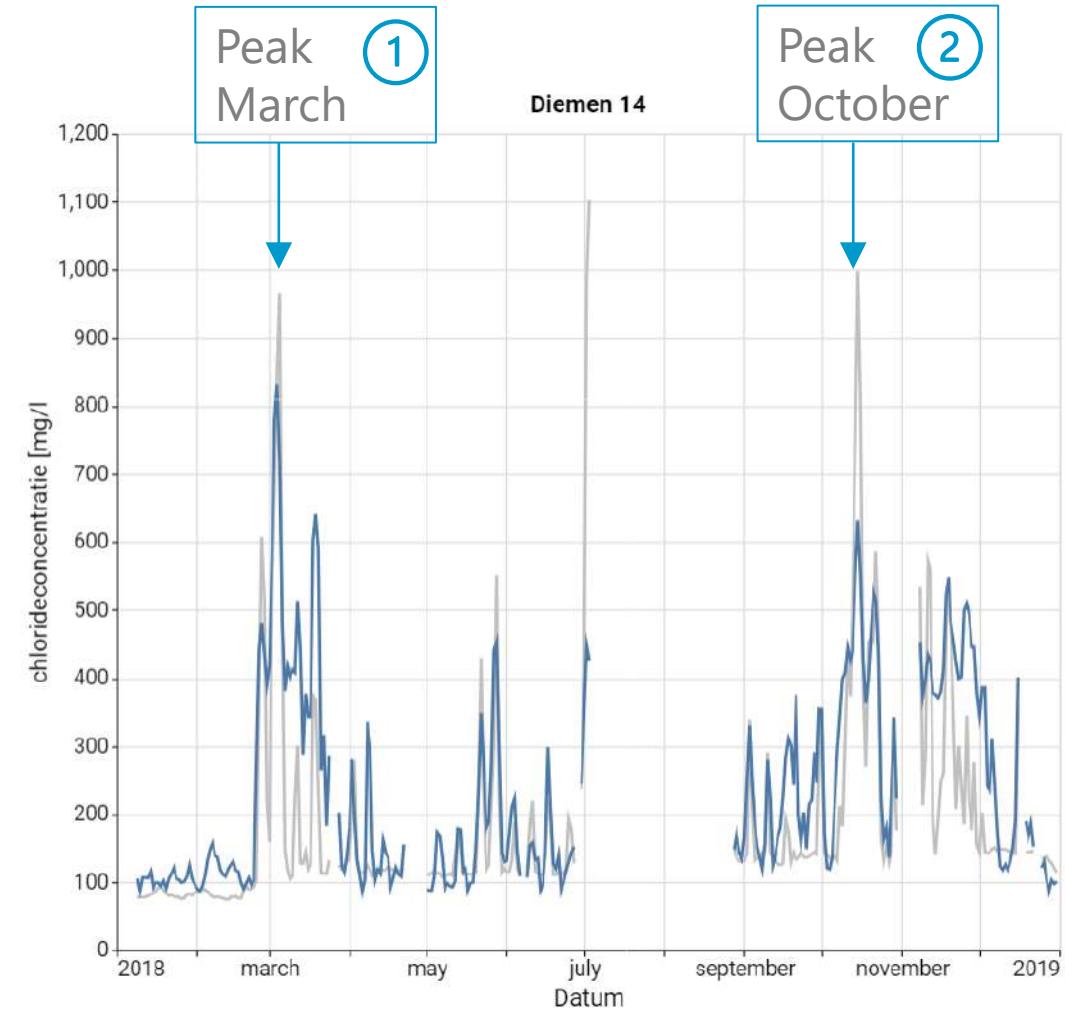
CHANGE PREDICTION

This viewer is intended for test purposes

# Get to know XAI

## Questions

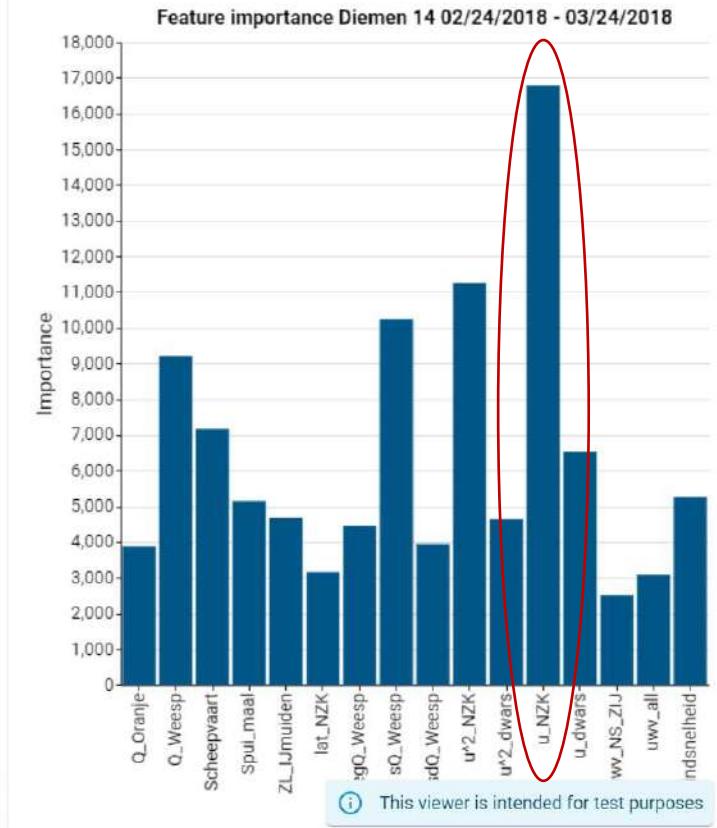
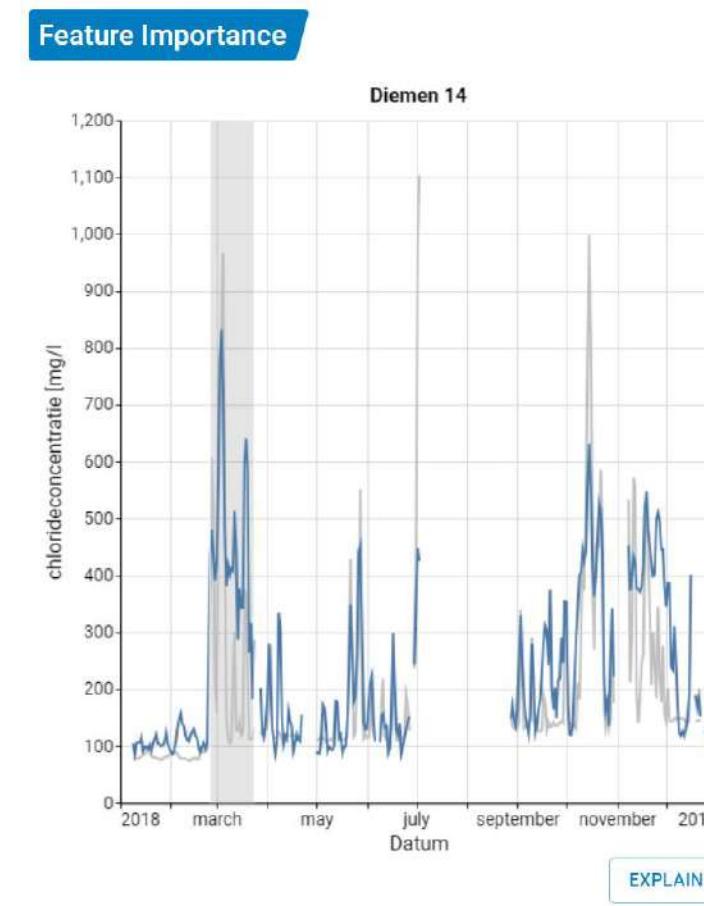
- ① Which features have **largest contribution** to the predicted salt peak in beginning of March?
- ② Can you change the conditions so that the salt peak in October does not exceed 500 mg/l?



# Get to know XAI

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

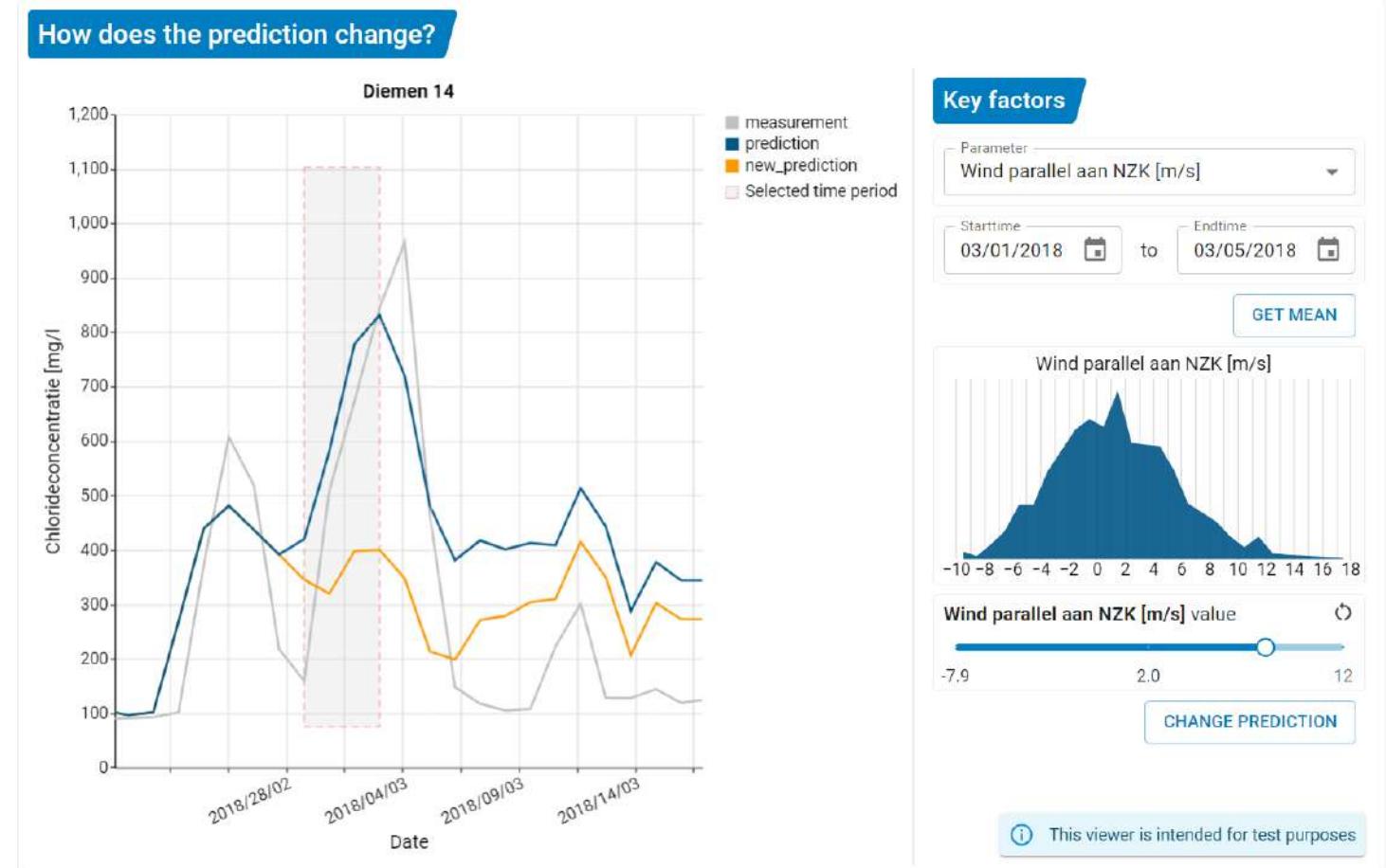
- Wind is important!



## Get to know XAI

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

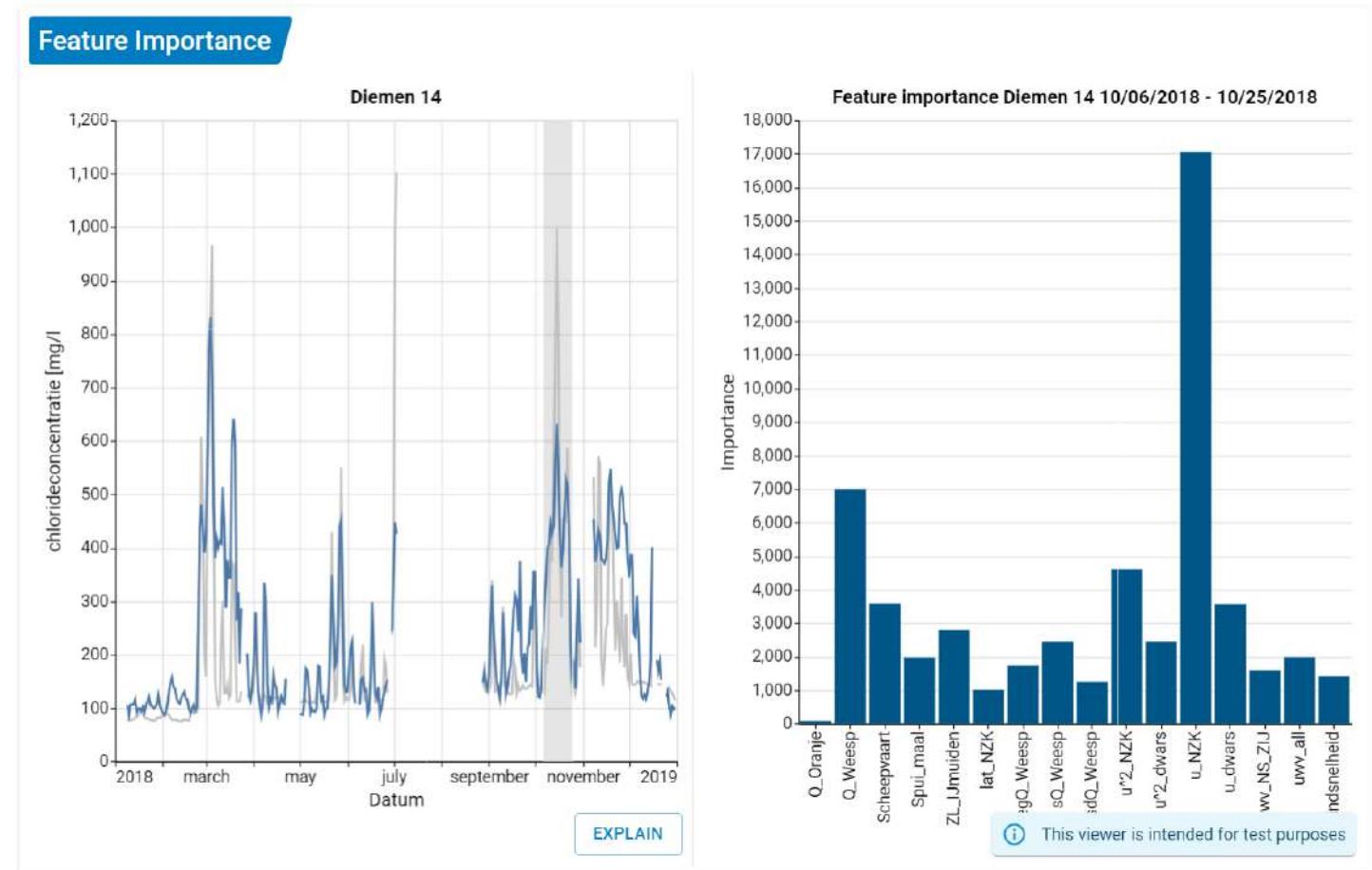
- If the wind had blown in the opposite direction, there would not have been a salt peak.



## Get to know XAI

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

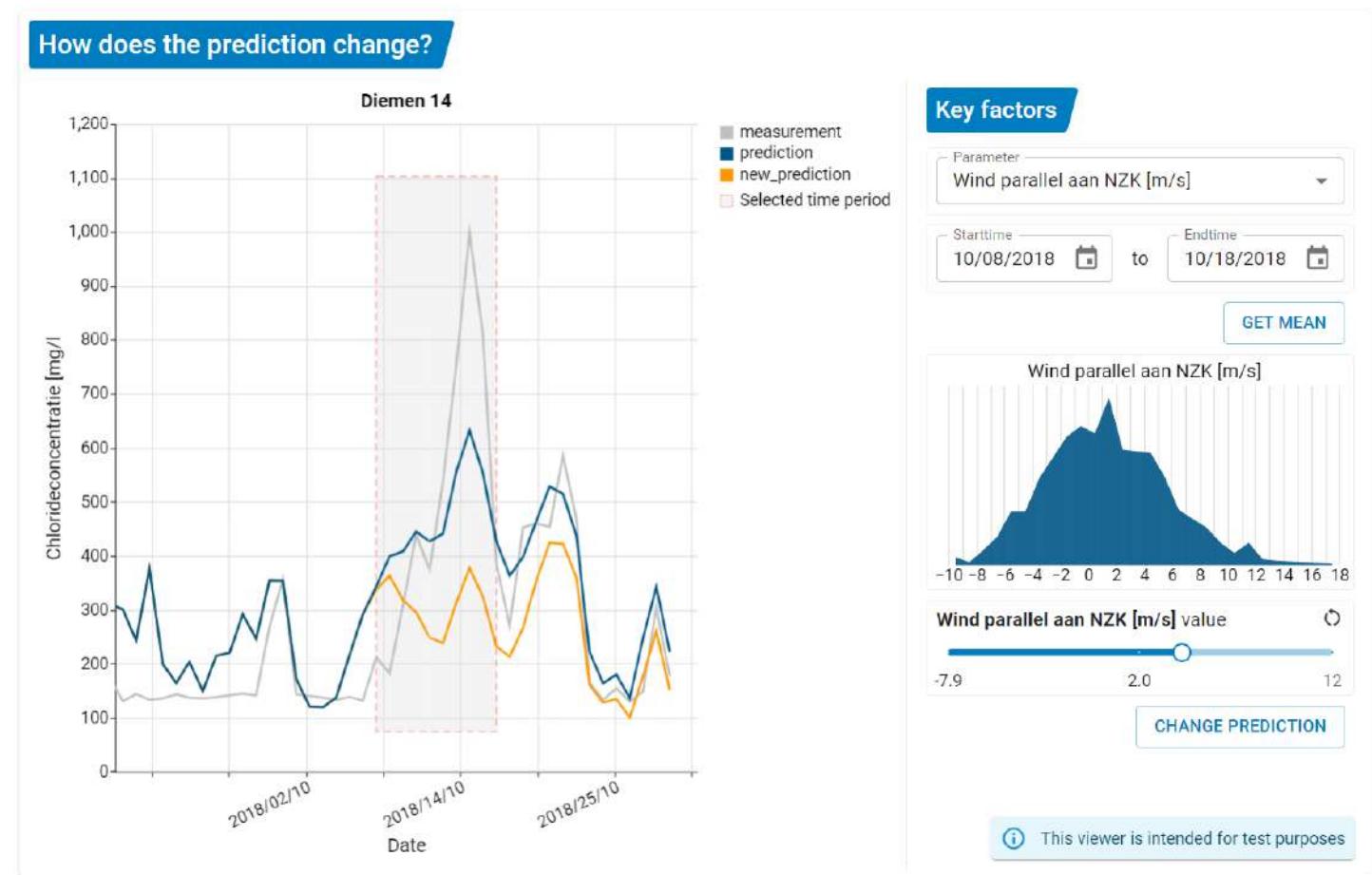
- Wind is important, followed by the discharge.



## Get to know XAI

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

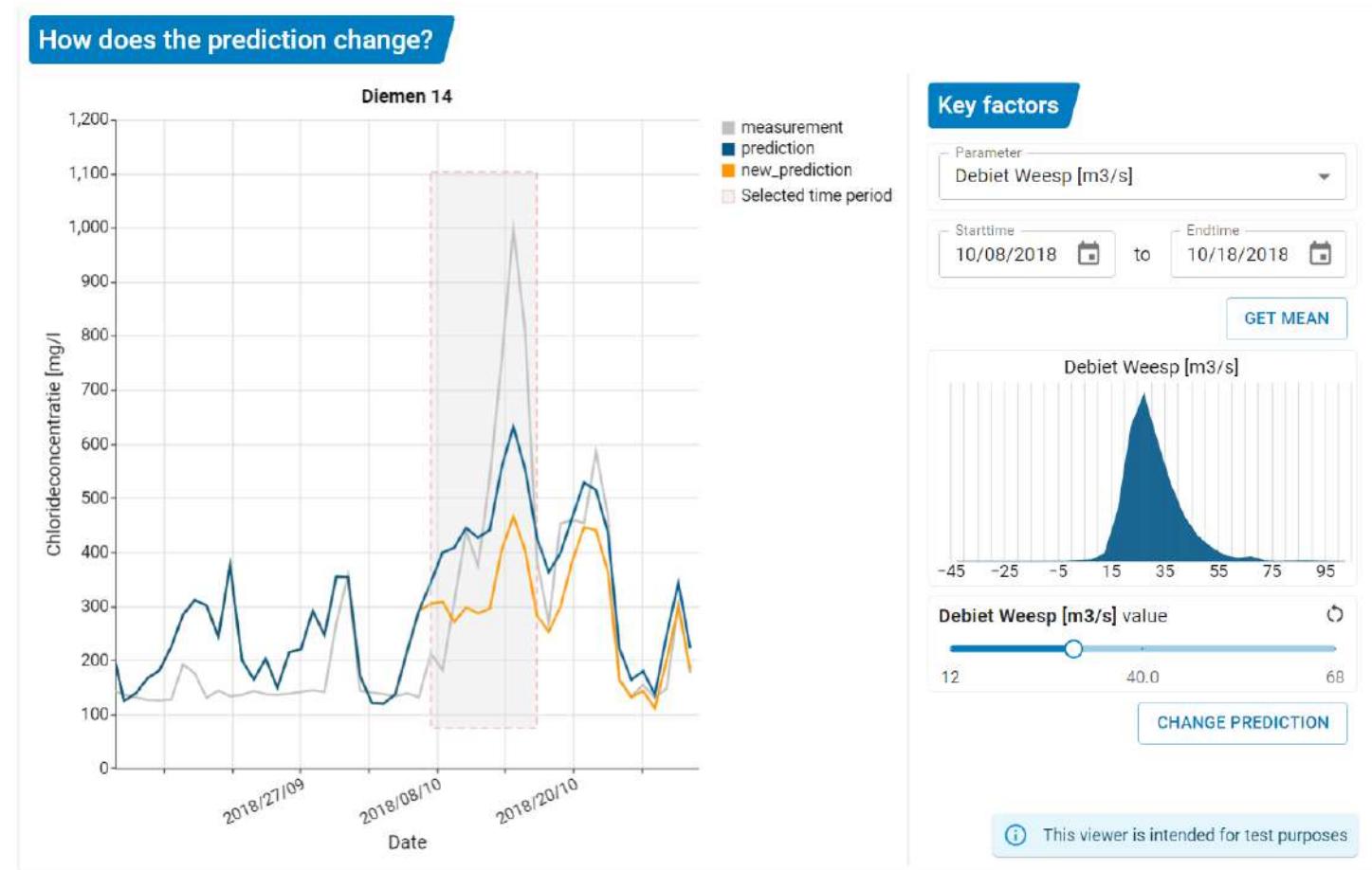
- Changing wind direction lowers the salt peak.



## 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/>

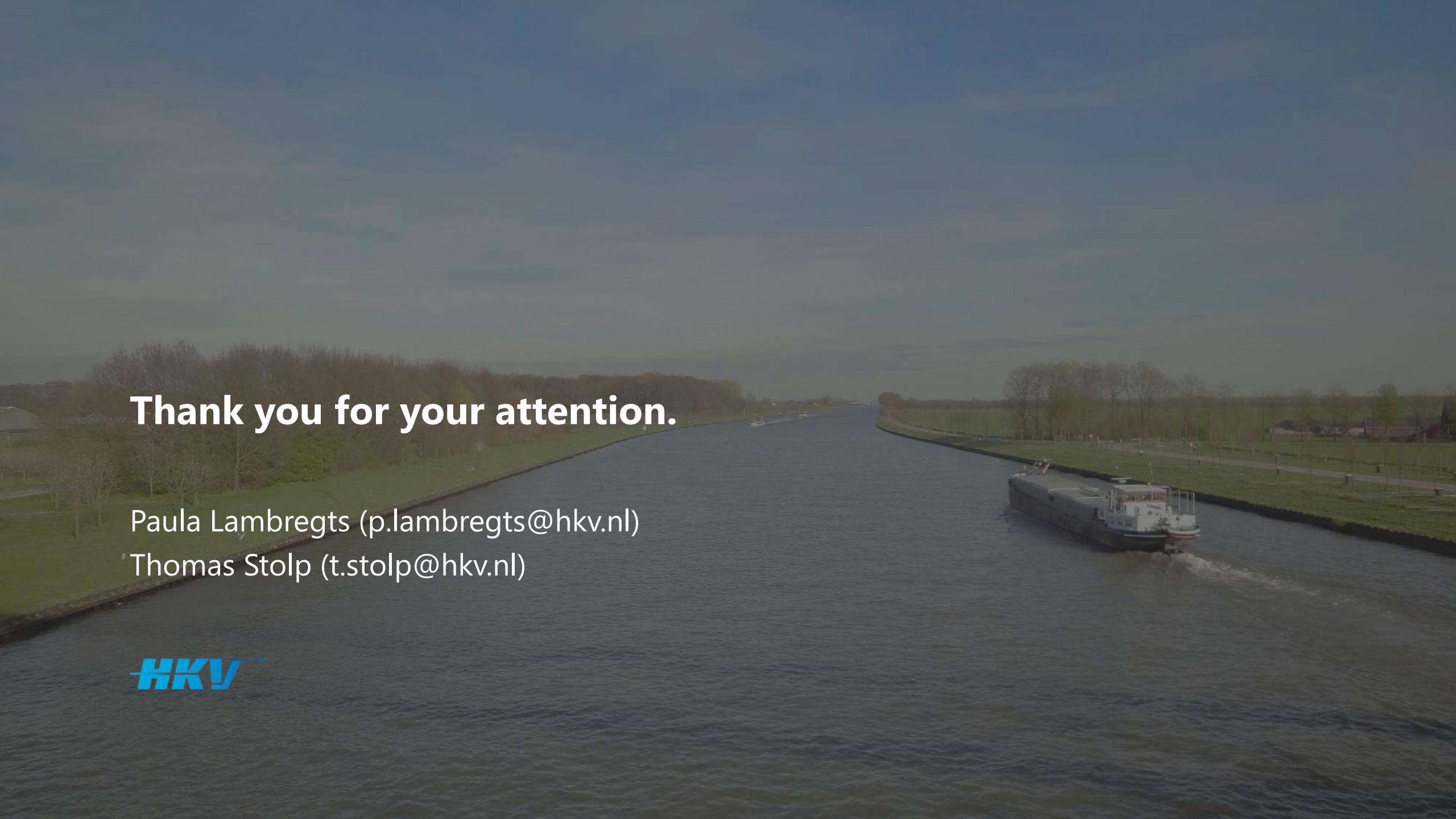
## Closure

### 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.**

Paula Lambregts (p.lambregts@hkv.nl)

Thomas Stolp (t.stolp@hkv.nl)

