# Tilløbsprognoser til renseanlæg

## *- driftsfordel med Machine Learning ?*

**Sten Lindberg, DHI**
**Barbara Greenhill og Dines Thornberg, BIOFOS**

# Agenda

- Hvorfor?
- Metode og resultater
- Virker det?

- Afrunding, QA

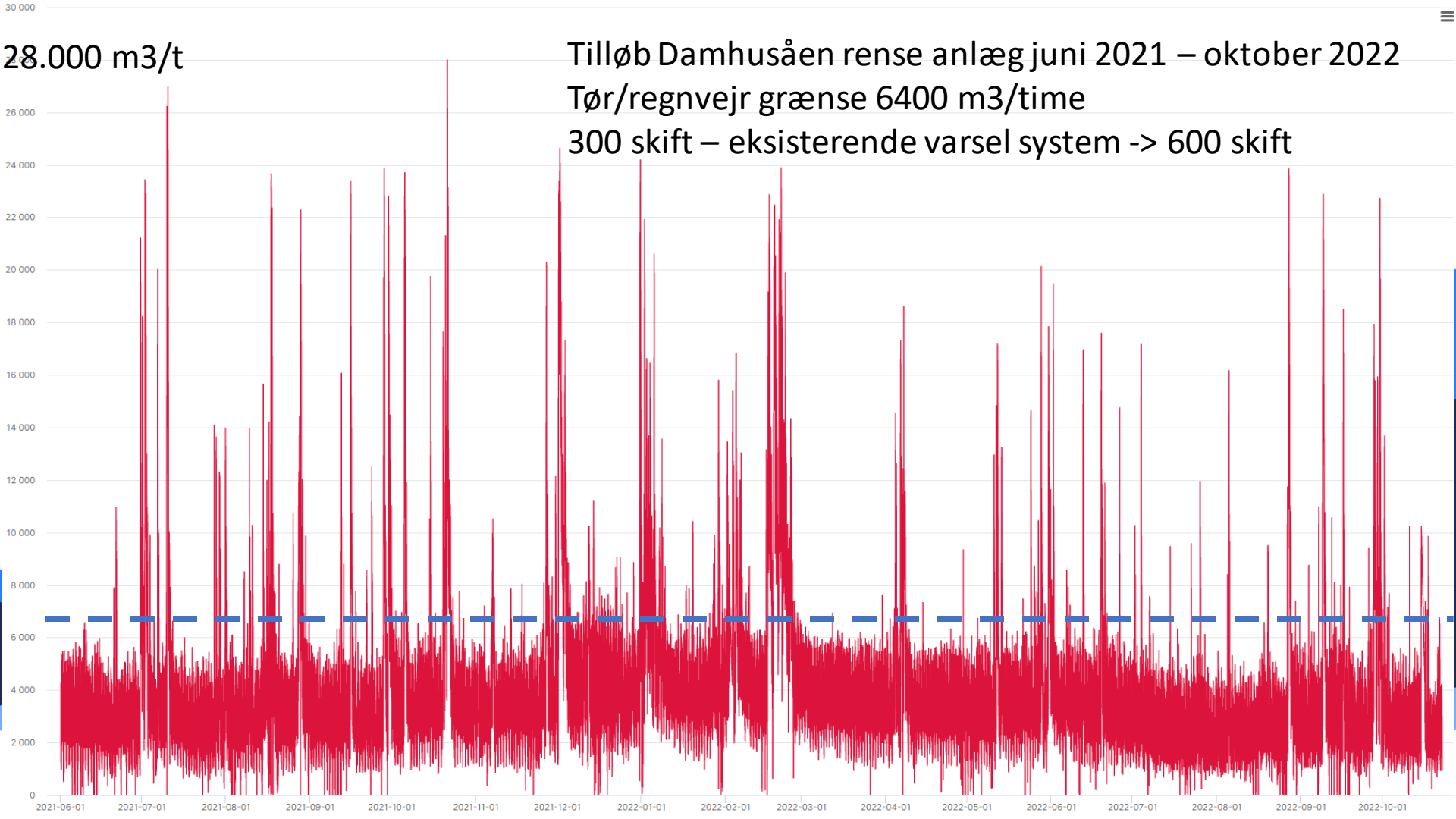
# BIOFOS catchment area

## 15 municipal owners

- 9 shareholders
- 7 utility companies (clients)
- 1.2 million inhabitants
- 3 wastewater treatment plants
- 60 km sewer system, 5 basins and 2 pumping stations
- Mostly combined sewer system
- Dry and wet weather operations at the WWTP

28.000 m3/t

Tilløb Damhusåen rense anlæg juni 2021 – oktober 2022
Tør/regnvejr grænse 6400 m3/time
300 skift – eksisterende varsel system -> 600 skift

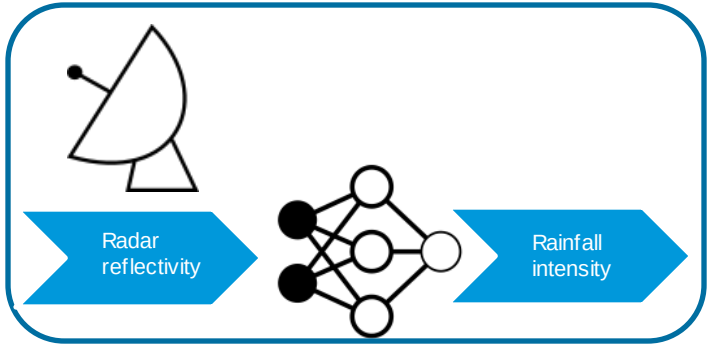


# Metode og resultater

# Inflow prediction – Machine Learning

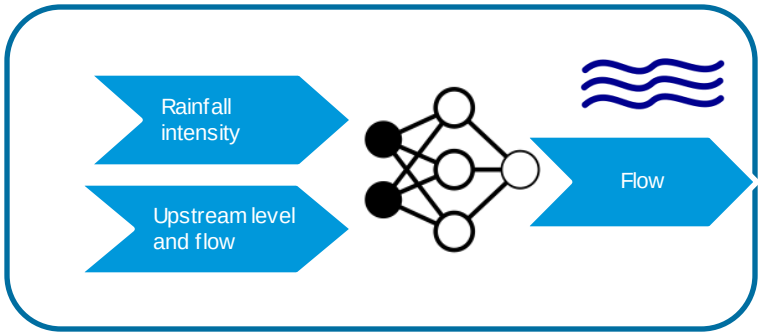
Training

- Training data, 4 different data sources (BIOFOS, Novafos, HOFOR, DMI)
- Training period min. 12 months
- Different ML variants, End-points




Real time

- DMI radar data, 25 level, flow and rain sensors
- 14% of time all data available
- 35% of time Novafos data



# Inflow prediction – MIKE+ and STAR

MIKE+ Hydrodynamic model

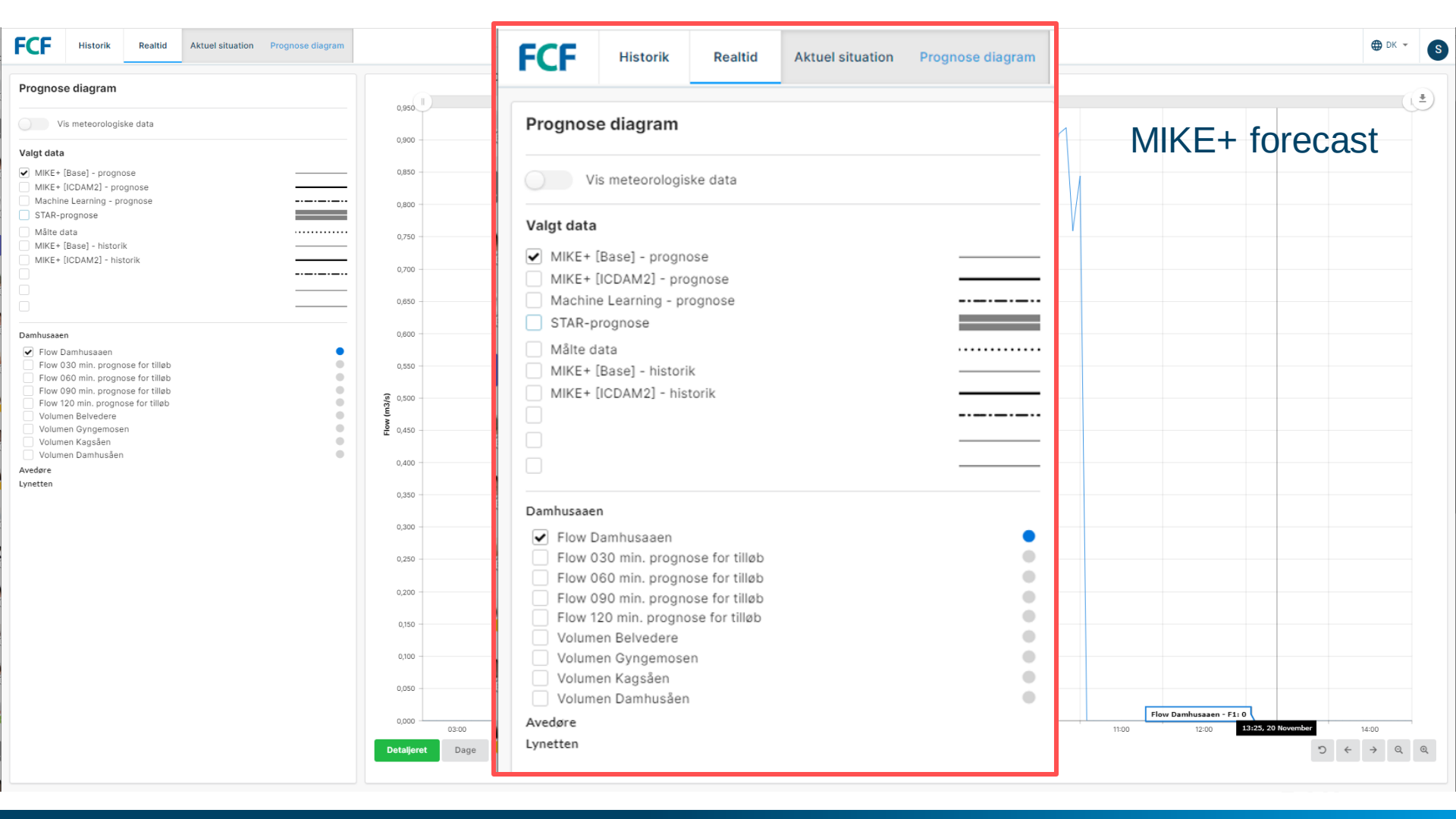
MIKE+

1 h hindcast, 3 h forecast, 10 min resolution

STAR – linear reservoir model

STAR

2 h forecast, 30 min resolution


FCF
Historik
Realtid
Aktuel situation
Prognose diagram
DK
S
Prognose diagram
Vis meteorologiske data
Valgt data
MIKE+ [Base] - prognose
MIKE+ [ICDAM2] - prognose
Machine Learning - prognose
STAR-prognose
Målte data
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Damhusaaen
Flow Damhusaaen
Flow 030 min. prognose for tilløb
Flow 060 min. prognose for tilløb
Flow 090 min. prognose for tilløb
Flow 120 min. prognose for tilløb
Volumen Belvedere
Volumen Gyngemosen
Volumen Kagsåen
Volumen Damhusåen
Avedøre
Lynetten
Flow (m3/s)
0,950
0,900
0,850
0,800
0,750
0,700
0,650
0,600
0,550
0,500
0,450
0,400
0,350
0,300
0,250
0,200
0,150
0,100
0,050
0,000
03:00
Detaljeret
Dage
MIKE+ forecast
11:00
12:00
13:25, 20 November
14:00
Flow Damhusaaen - F1: 0

## Prognose diagram

Vis meteorologiske data

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**Avedøre**

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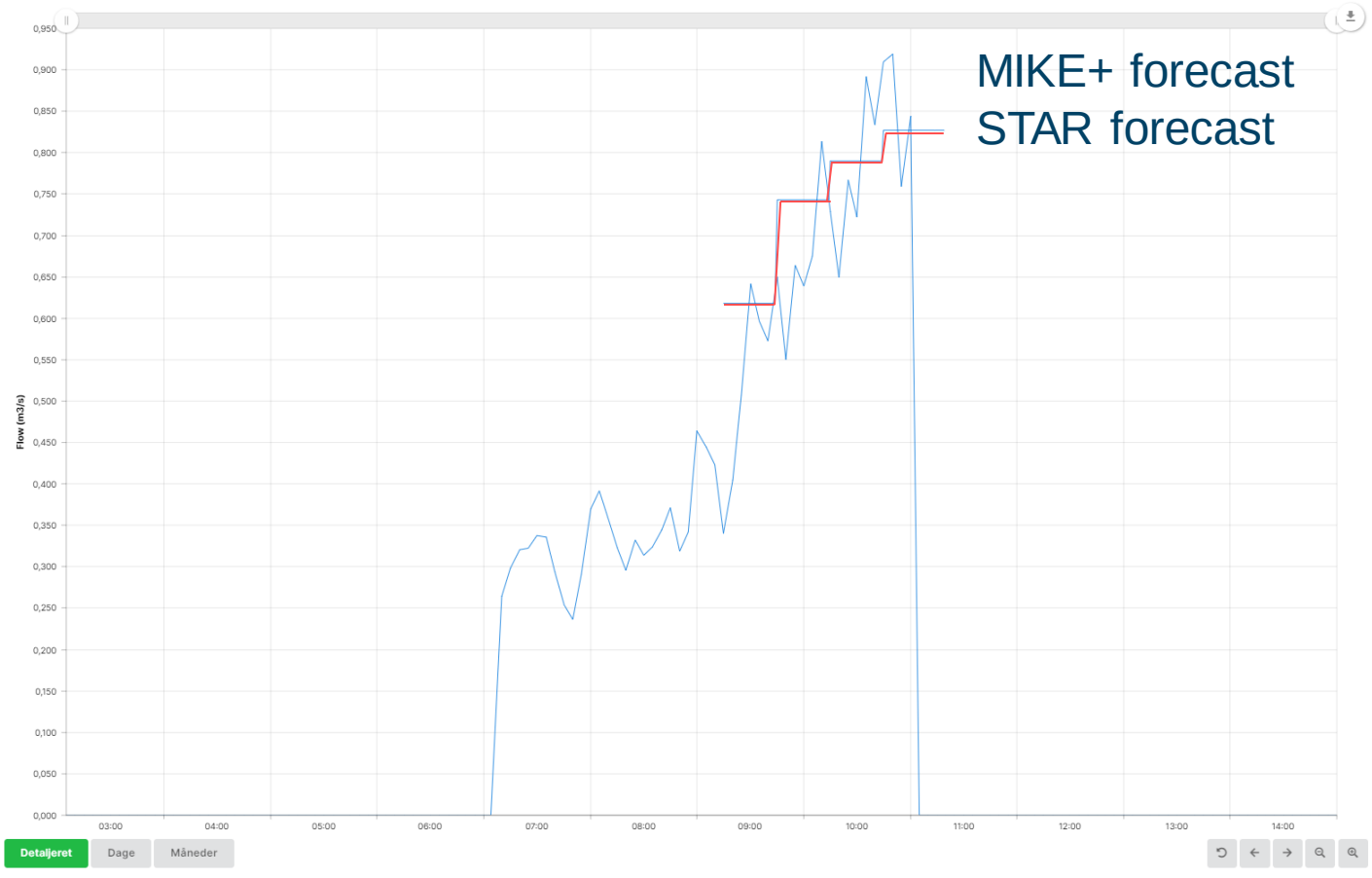

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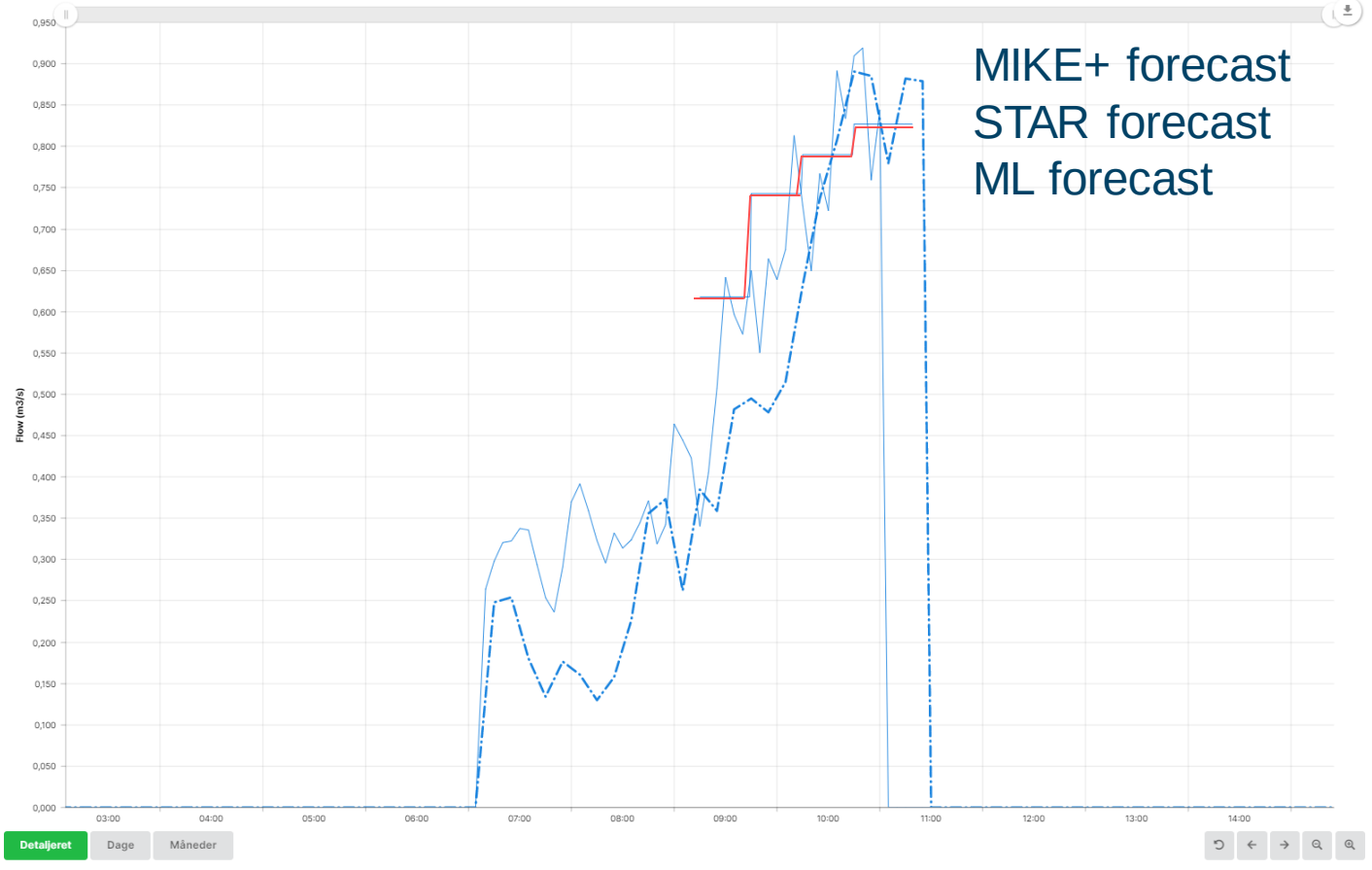

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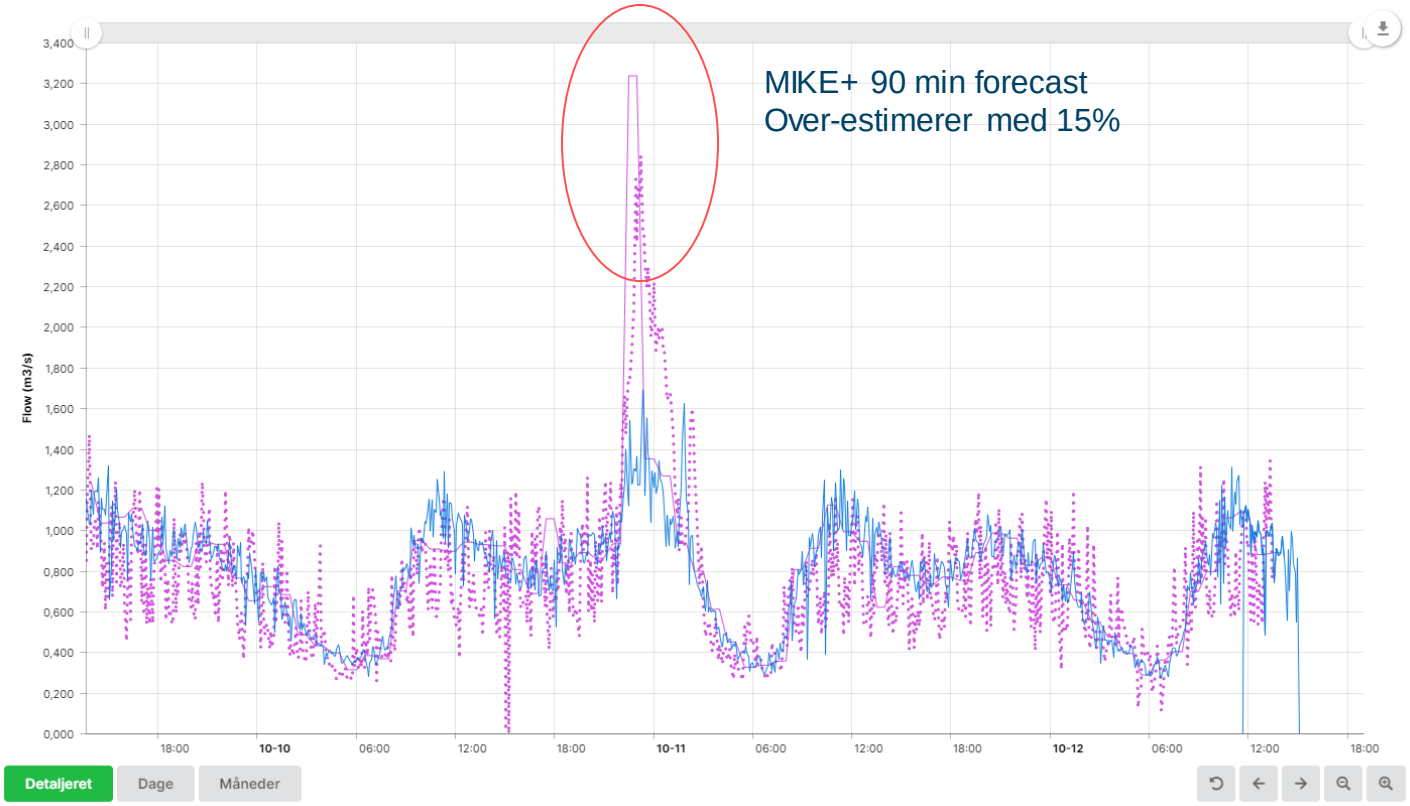

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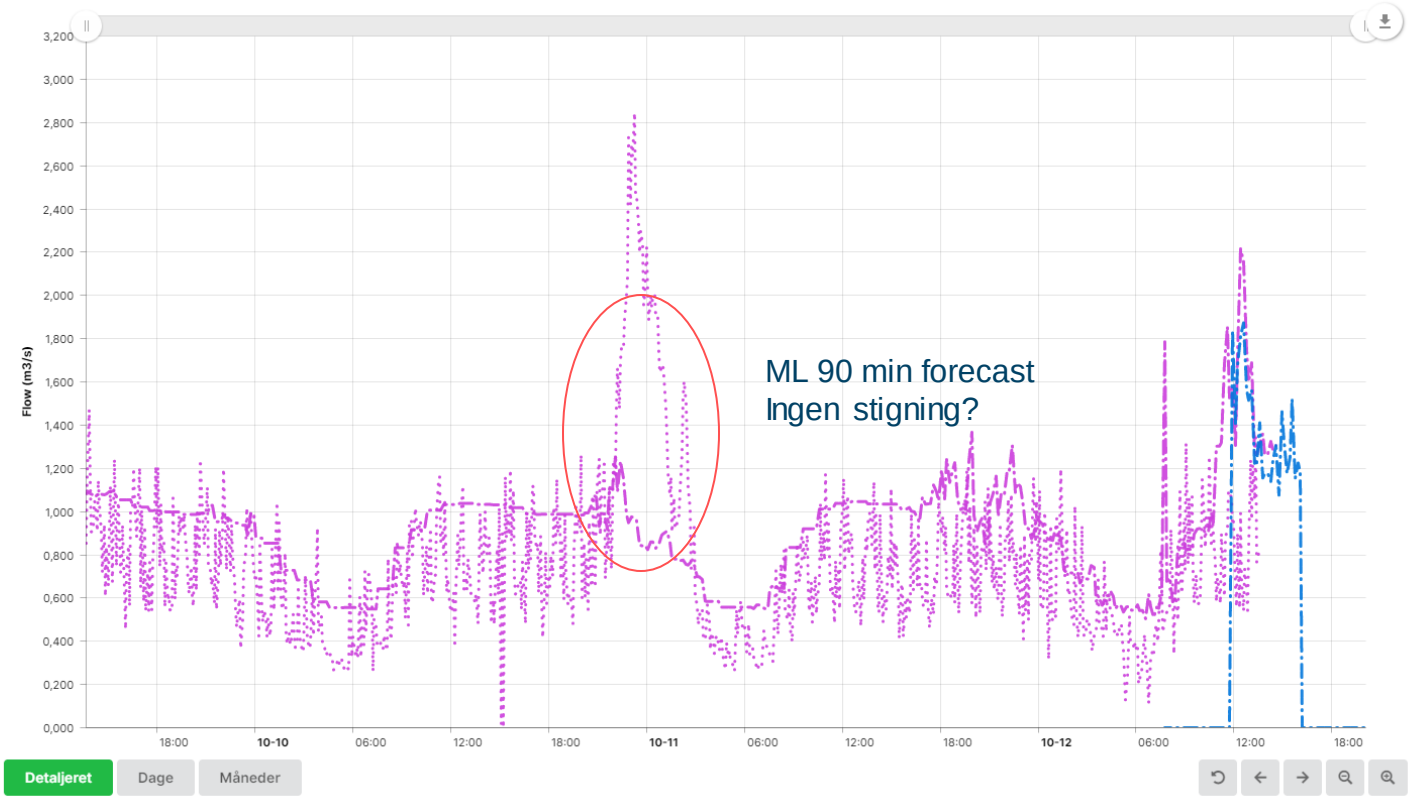

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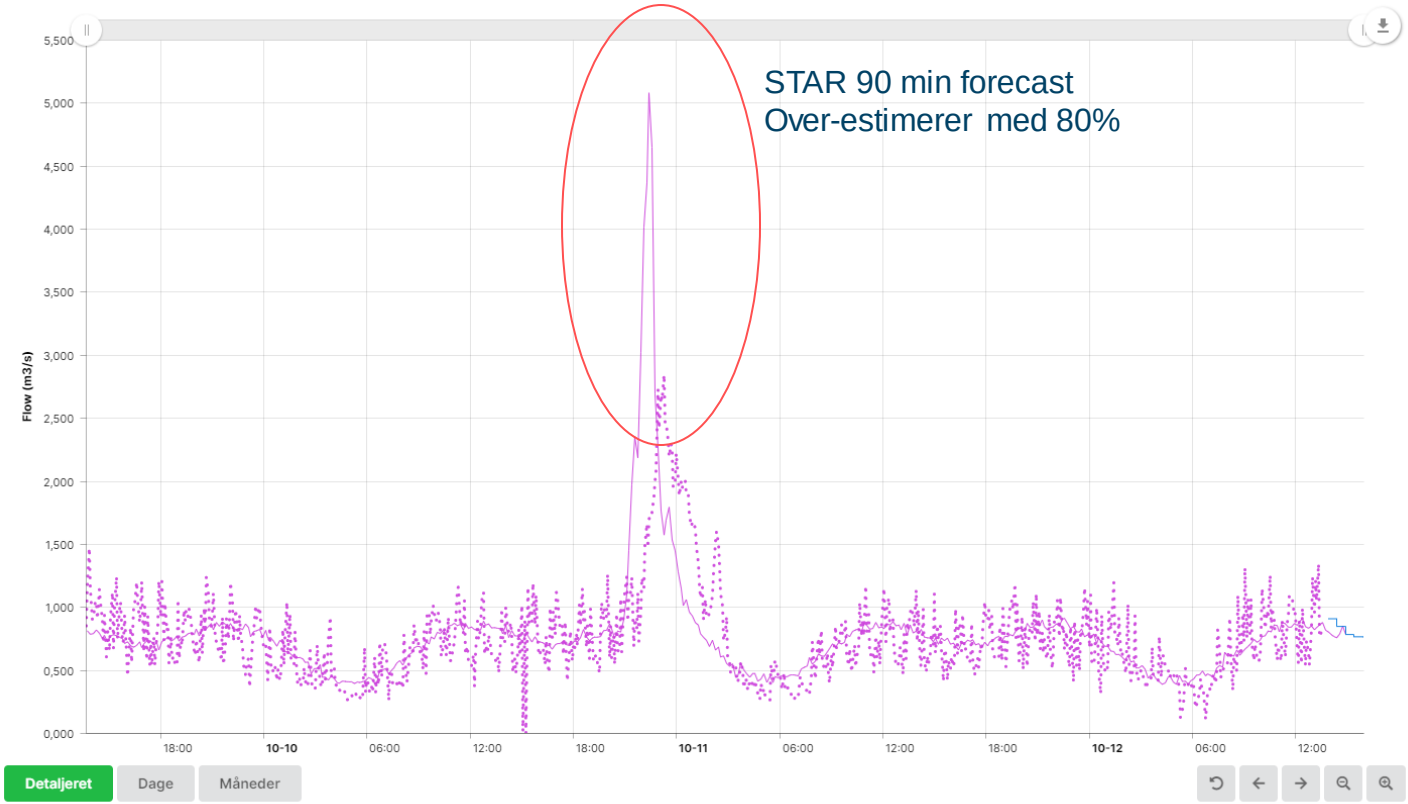

FCF | Historik | Realtid | DK | S

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Flow 120 min.

**Avedøre**

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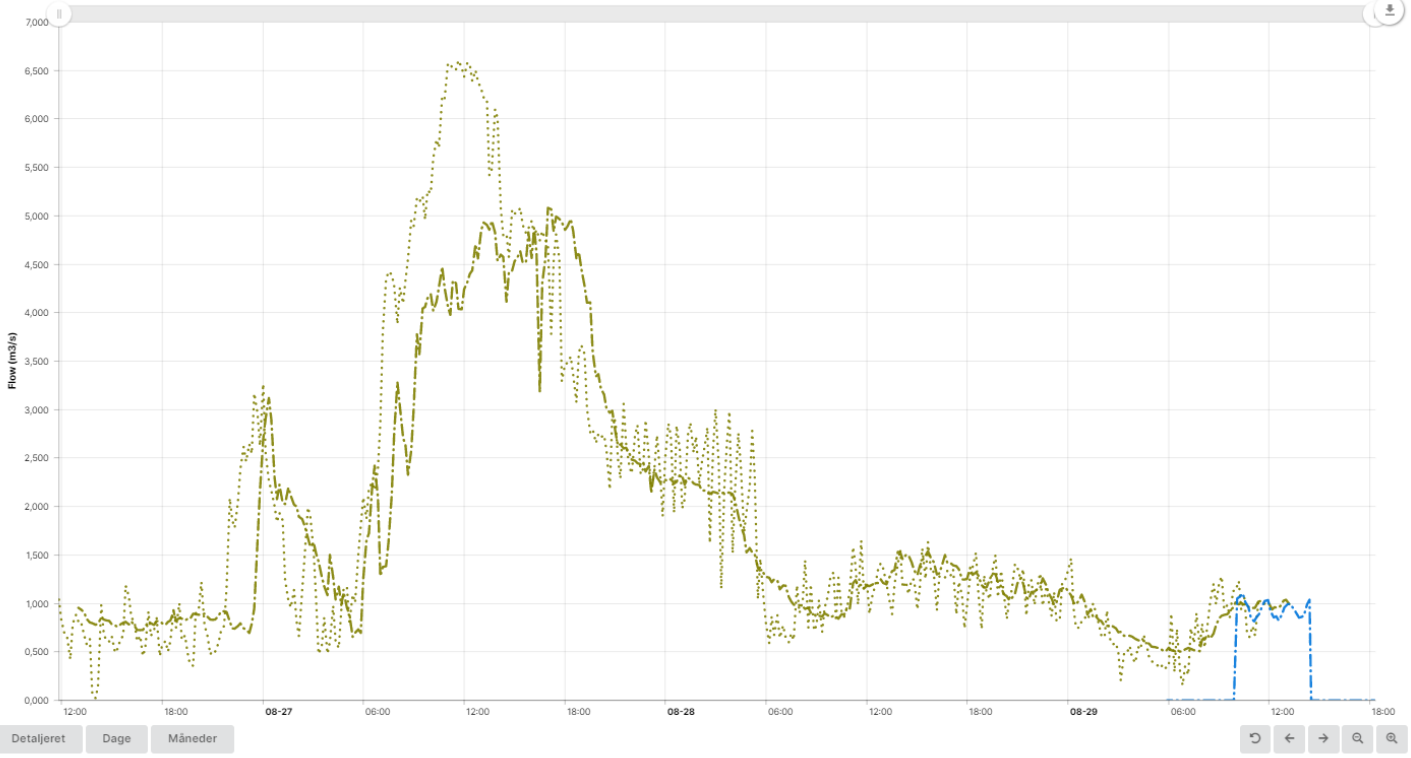


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Flow 90 min.

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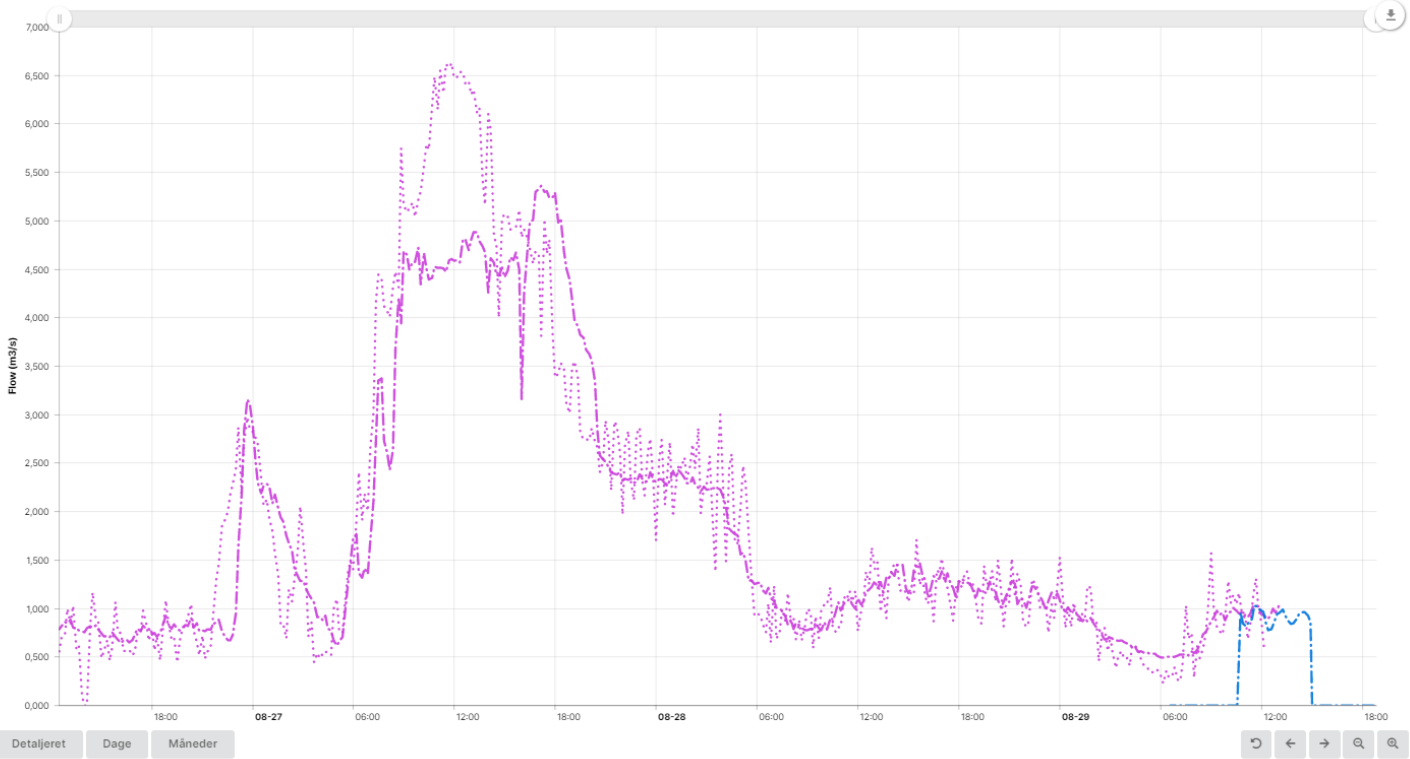


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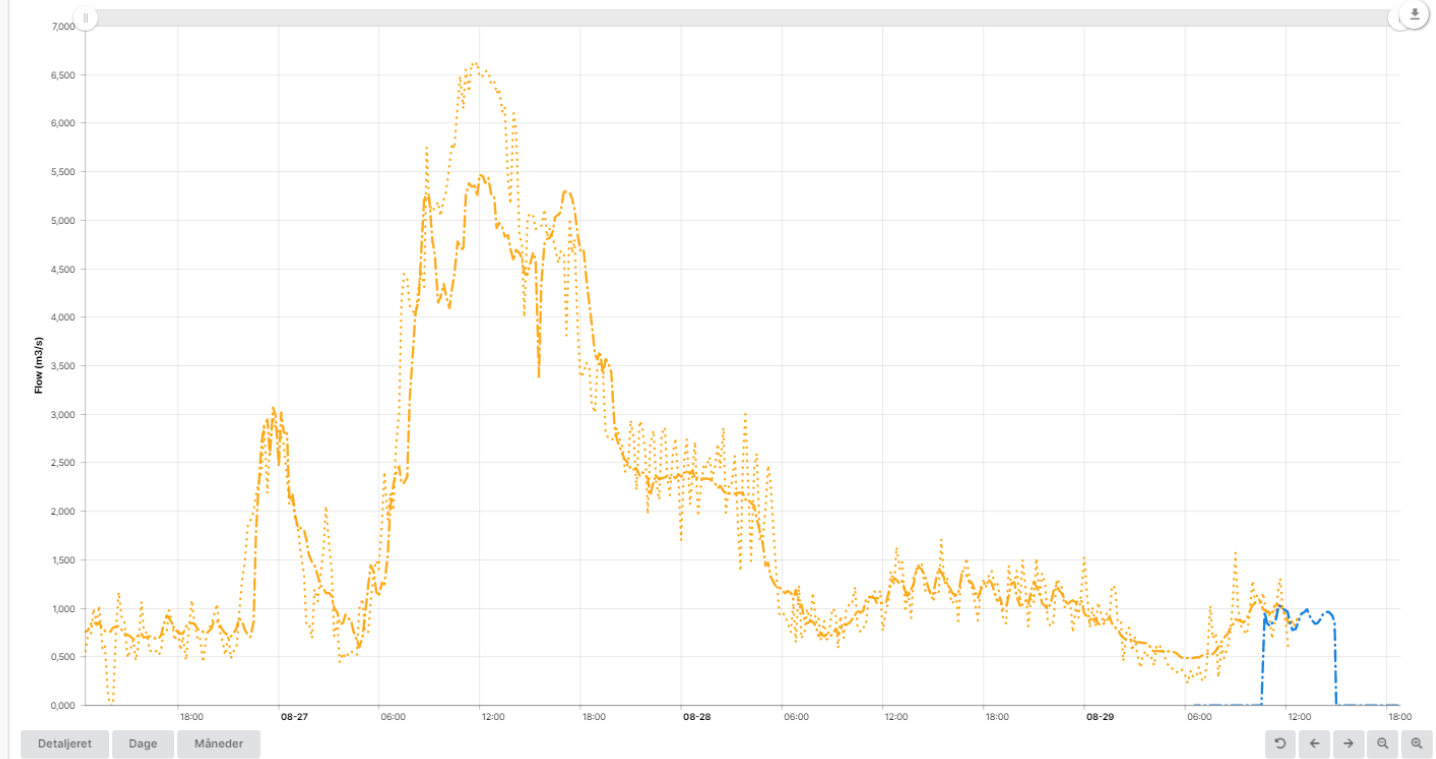


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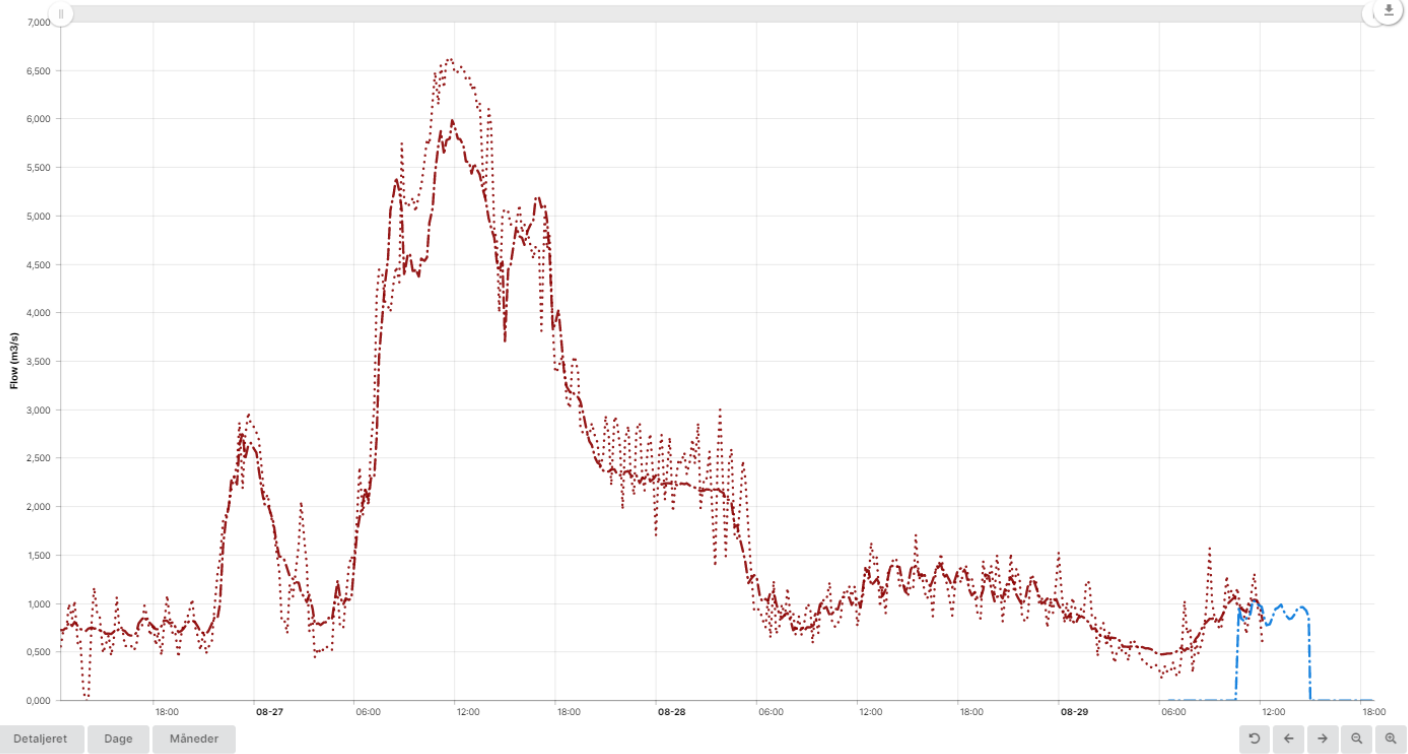


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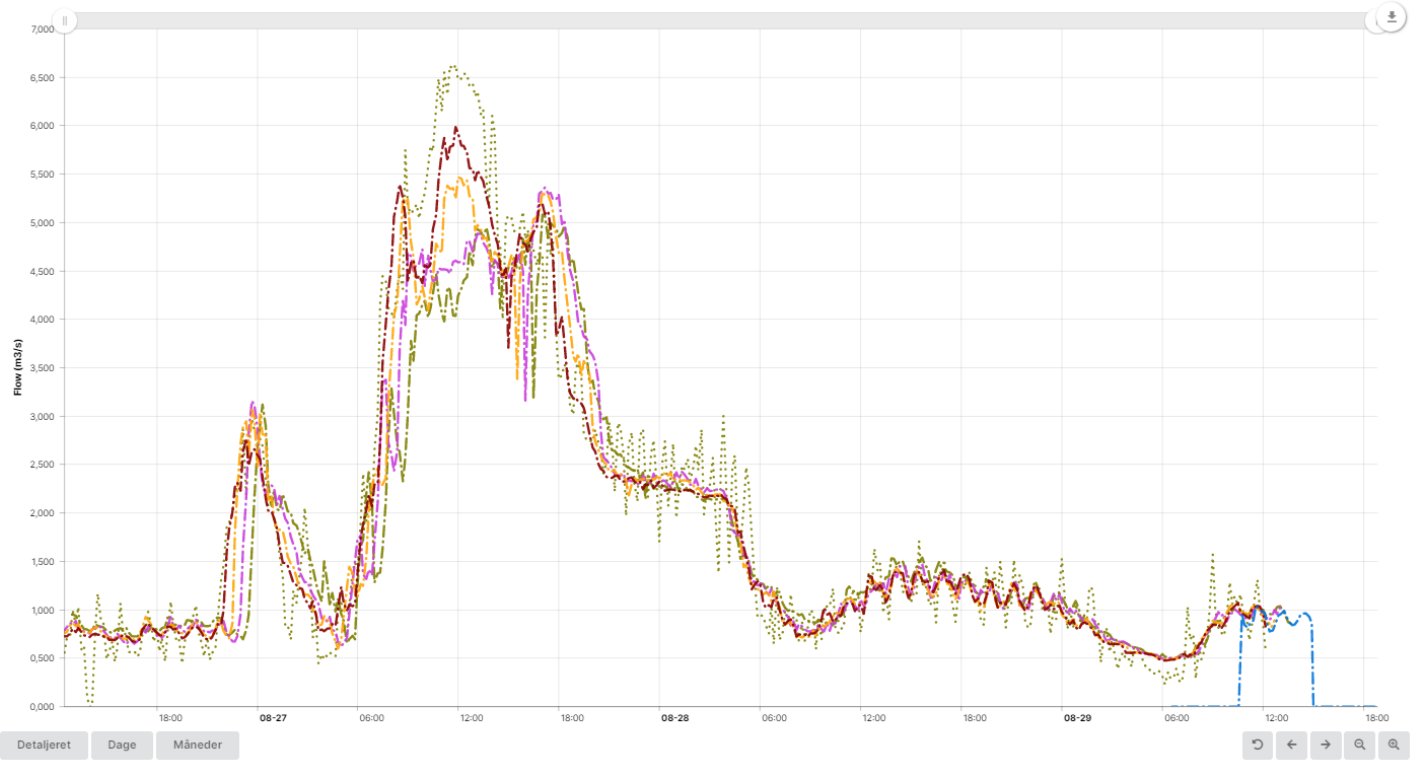
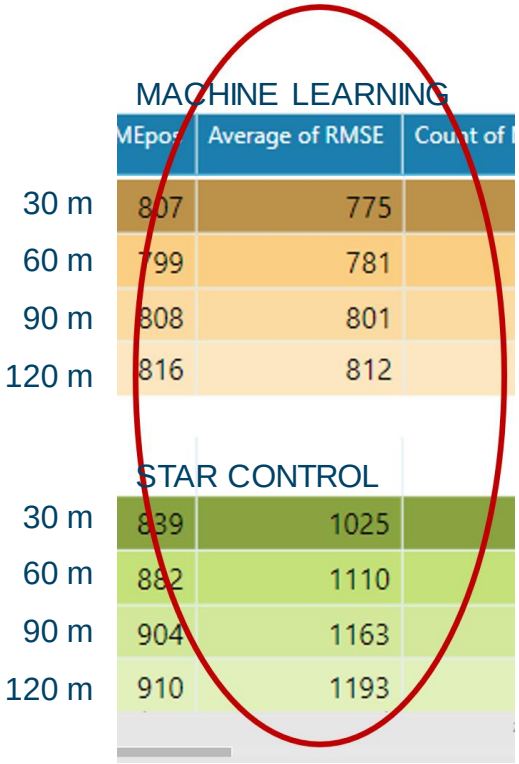



DHI

# KPI reports

| Styring | Average of ME | Average of MEneg | Average of MEpos | Average of RMSE | Count of MEneg | Count of MEpos | Count of RMSE |
|---|---|---|---|---|---|---|---|
| ML 030 | 325 | -676 | 807 | 775 | 2145 | 5450 | 9192 |
| ML 060 | 325 | -697 | 799 | 781 | 2124 | 5596 | 9192 |
| ML 090 | 321 | -742 | 808 | 801 | 2123 | 5597 | 9192 |
| ML 120 | 333 | -784 | 816 | 812 | 2025 | 5695 | 9192 |
| | | | | | | | |
| STAR 030 | 142 | -1052 | 839 | 1025 | 3757 | 6735 | 12000 |
| STAR 060 | 80 | -1375 | 882 | 1110 | 3688 | 6837 | 11997 |
| STAR 090 | 51 | -1516 | 904 | 1163 | 3679 | 6847 | 11998 |
| STAR 120 | 33 | -1598 | 910 | 1193 | 3661 | 6862 | 11995 |

# 3 Main KPI




The inflow predictions of the ML forecasts, expressed as RMSE, is around 30% better than the existing STAR and the hydrodynamic model results

The ML routine provides a significant improvement in the number of wrong switches, in the order of a 90% reduction

The prediction of the dry weather for 12-24-36 h ahead, has an accuracy score of around 75-80%

# Virker det?

# Values and next

- ML reduces the number of false dry- to wet weather shifts
- ML is fast and robust

ML reduces the number of false start by 90%

ML predicts correct high flows for 60% of all occurancies, existing STAR predicts 30%

- Stabilize the data flow
- Continue to evaluate performance until June 2023

From December 2022 to June 2023

Continued evaluation and updated performance numbers

# Acknowledgement

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Duration: 01/06/19 - 30/11/22

## Contact details

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# Recap

- Hvorfor?
- Metode og resultater
- Virker det?

- Afrunding, QA