



NVE

# FLOOD FORECASTING EVERYWHERE - PUTTING PUB TO WORK

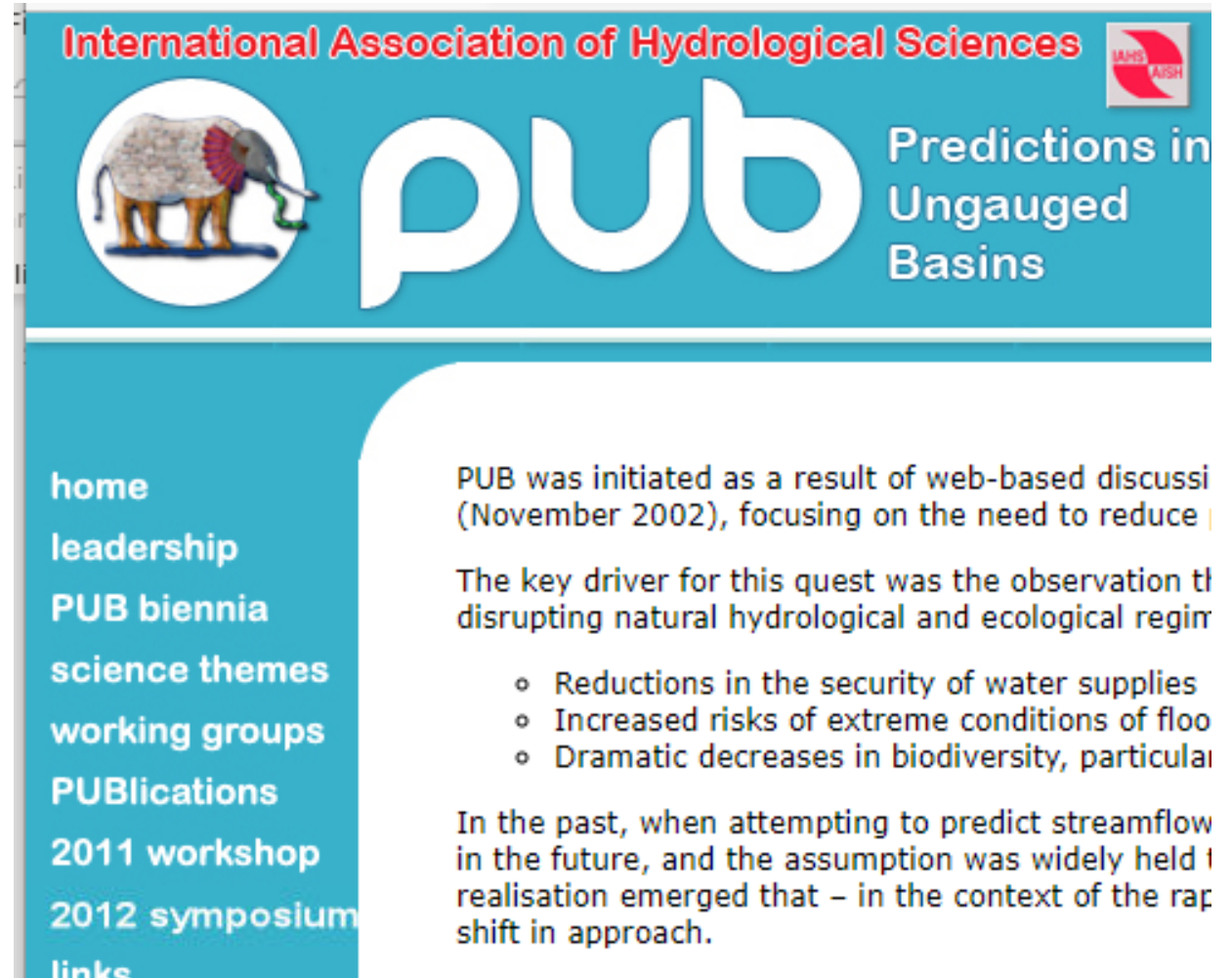
A PROJECT UNDER THE FLOMRISK UMBRELLA

Thomas Skaugen, Zelalem Mengistu, Ivar Peereboom, W.K. Wong and J. Andersen

HM, IKTI, HV

## Back in the day - 2003

- The IAHS' PUB decade 2003-2013
- A very inspiring and challenging theme: useful and with a clear objective
- There is an increasing need for hydrological information, historical and forecasts, everywhere: runoff (floods, droughts), snow (when, how much), groundwater (high-, low levels), etc.
- The potential for the use of PUB has no limits...



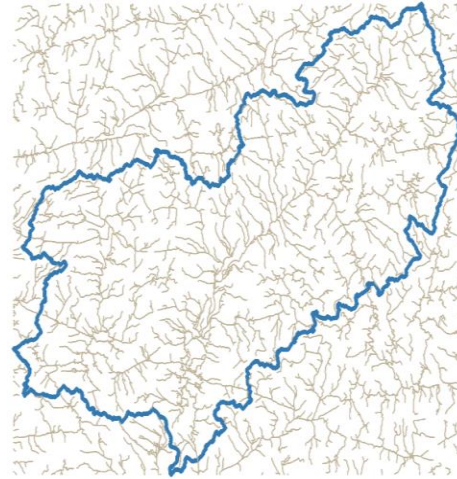
The screenshot shows the IAHS PUB website. At the top, it reads "International Association of Hydrological Sciences" in red, with the IAHS logo to the right. Below this is a circular image of a decorated elephant. The main title "pub" is in large white lowercase letters, followed by "Predictions in Ungauged Basins" in white. A vertical navigation menu on the left includes: home, leadership, PUB biennia, science themes, working groups, PUBLications, 2011 workshop, 2012 symposium, and links. The main content area has a white background with a blue border. It contains the text: "PUB was initiated as a result of web-based discussion (November 2002), focusing on the need to reduce..." followed by "The key driver for this quest was the observation that disrupting natural hydrological and ecological regimes..." and a bulleted list: "Reductions in the security of water supplies", "Increased risks of extreme conditions of flooding", and "Dramatic decreases in biodiversity, particularly...". Below the list, it says: "In the past, when attempting to predict streamflow in the future, and the assumption was widely held that... realisation emerged that - in the context of the rapid shift in approach."



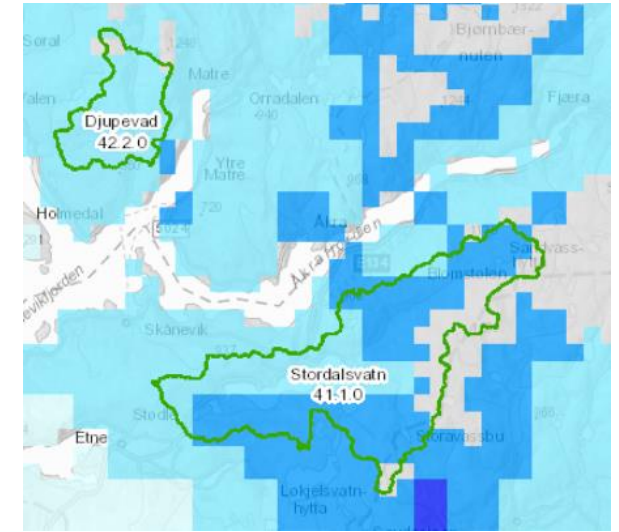
# PUB is possible because:

- Everywhere (in Norway) we have the information needed for setting up a rainfall-runoff model and simulate long time series of hydrological information -historical and forecasts

## DTM- catchments- rivernetworks

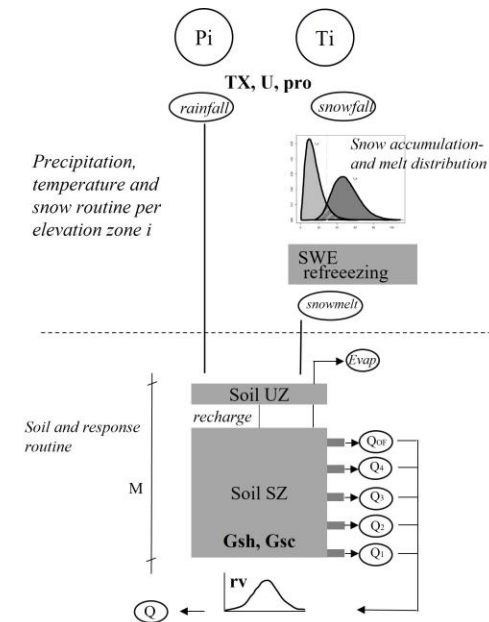
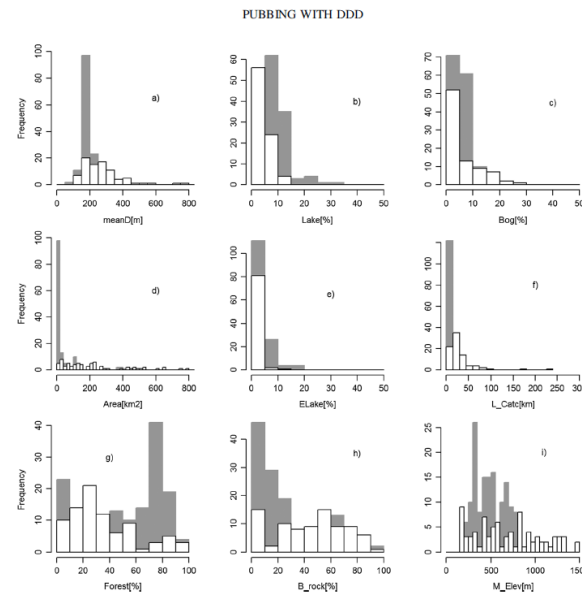


## Meteorology- precip and temperature



## Rainfall-runoff model (DDD)

## Catchment characteristics







# The DDD model has previously been used to estimate hydrology in ungauged basins - at nesting sites of Norway's national bird, Fossekalen

HYDROLOGICAL PROCESSES  
*Hydrol. Process.* 29, 1999–2013 (2015)  
Published online 22 September 2014 in Wiley Online Library  
(wileyonlinelibrary.com) DOI: 10.1002/hyp.10315

## Use of a parsimonious rainfall–run-off model for predicting hydrological response in ungauged basins

Thomas Skaugen,<sup>1\*</sup> Ivar Olaf Peerebom<sup>1</sup> and Anna Nilsson<sup>2</sup>

Received: 3 November 2017 | Revised: 26 January 2018 | Accepted: 9 February 2018  
DOI: 10.1002/ece3.3958

ORIGINAL RESEARCH

WILEY Ecology and Evolution

## The potential influence of Atlantic salmon *Salmo salar* and brown trout *Salmo trutta* on density and breeding of the white-throated dipper *Cinclus cinclus*

Anna L. K. Nilsson<sup>1</sup> | Jan Henning L'Abée-Lund<sup>2</sup> | L. Asbjørn Vøllestad<sup>1</sup> | Kurt Jerstad<sup>3</sup> | Bjørn Mejdell Larsen<sup>4</sup> | Ole Wiggo Røstad<sup>5</sup> | Thomas Skaugen<sup>2</sup> | Nils C. Stenseth<sup>1</sup> | Bjørn Walseng<sup>7</sup>

frontiers in Ecology and Evolution

ORIGINAL RESEARCH  
published: 14 October 2020  
doi: 10.3389/fevo.2020.542848

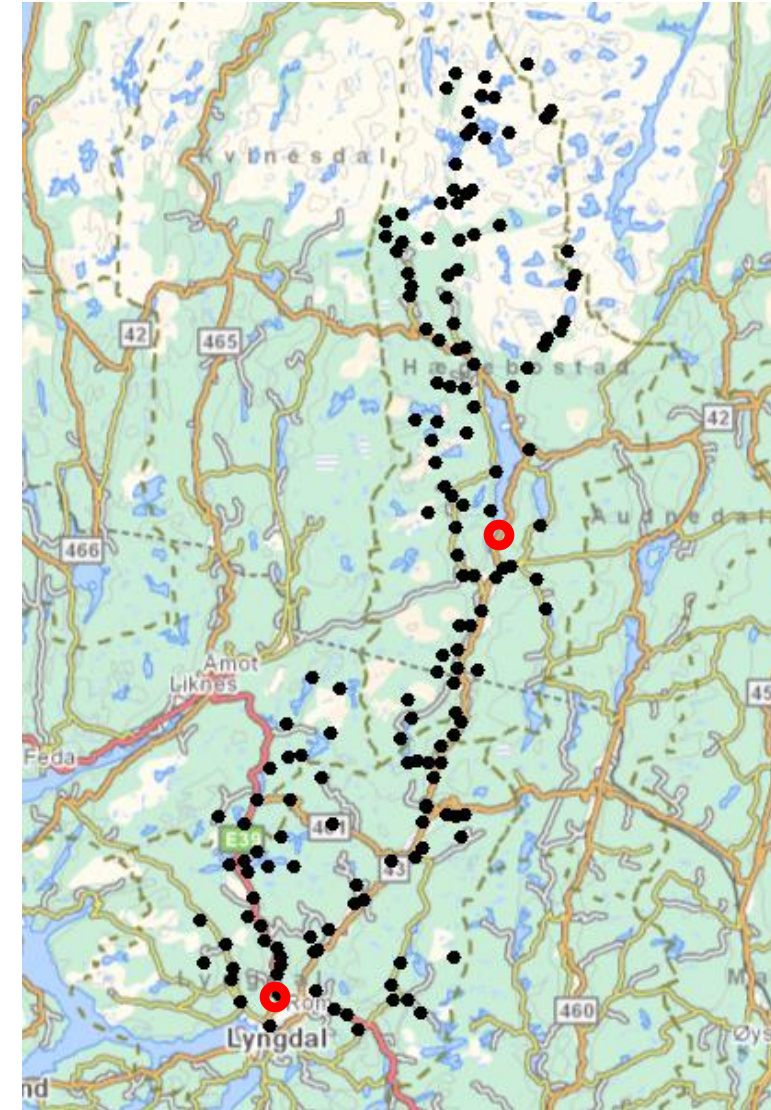
## Location Is Everything, but Climate Gets a Share: Analyzing Small-Scale Environmental Influences on Breeding Success in the White-Throated Dipper

OPEN ACCESS  
Edited by:

Anna L. K. Nilsson<sup>1,2\*</sup>, Trond Reitan<sup>1,2</sup>, Thomas Skaugen<sup>3</sup>, Jan Henning L'Abée-Lund<sup>3</sup>, Marlene Gamelon<sup>4</sup>, Kurt Jerstad<sup>5</sup>, Ole Wiggo Røstad<sup>6</sup>, Tore Slagsvold<sup>1</sup>, Nils C. Stenseth<sup>1</sup>, L. Asbjørn Vøllestad<sup>1</sup> and Bjørn Walseng<sup>7</sup>

Red circle, measured sites  
24.8 Møska (south)  
24.9 Tingvatn (north)

Black dots are known nesting sites for Fossekalen and define catchments with simulated hydrology



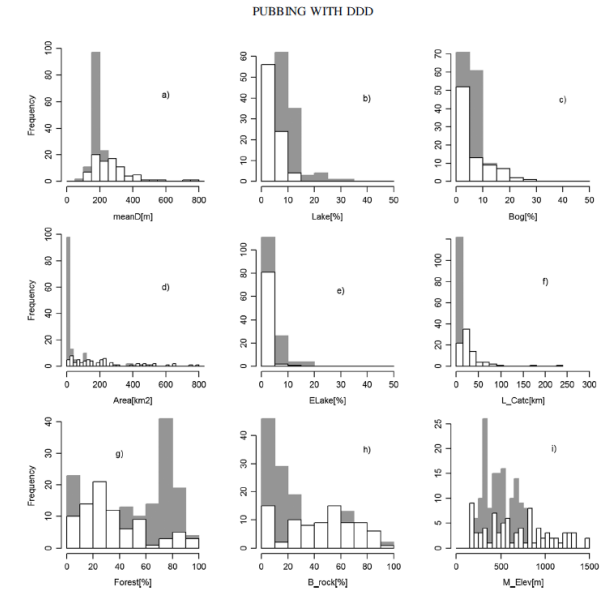
The idea behind the development of the DDD model was:

- as few as possible parameters to calibrate
- physically based model parameters –a real possibility to estimate them from CCs.

— Procedure:

- 1) Calibrate the DDD model against measured runoff for many catchments (III).
- 2) Establish regression equations for model parameters. Calibrated model parameters are explained and a function of catchment characteristics (CC) such as % of Lakes, Wetlands, Forest, Elevation, mean daily runoff etc.

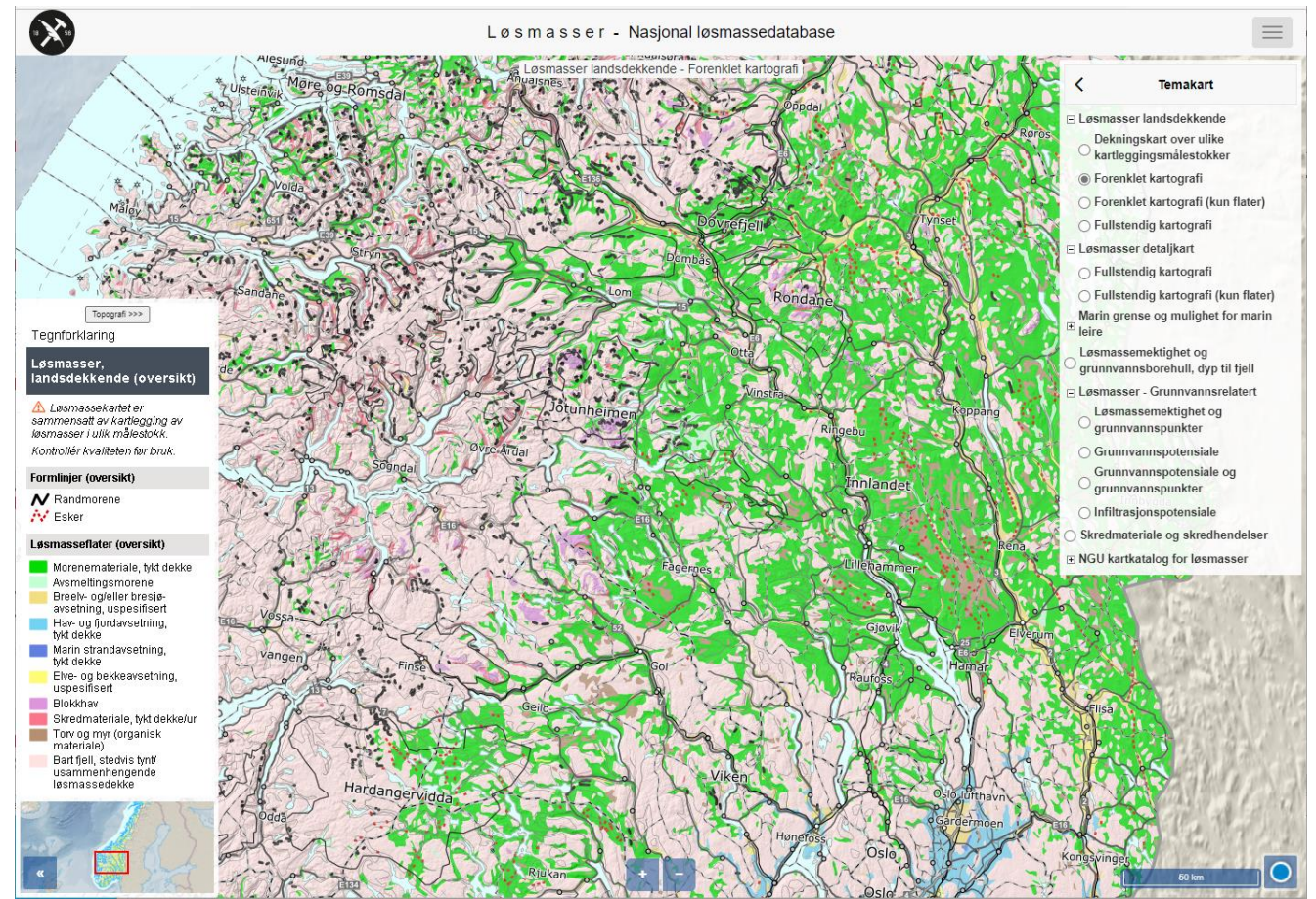
Catchment characteristics CC





# A new model parameter for describing runoff dynamics in DDD: Mean Response Time (MRT) is estimated from CCs ( $R^2 = 0.8$ ) **Personal best!**

— NGU's map of infiltration capacity significantly explains some of the variability of MRT



Skaugen, T., Stavang, A.E., Lawrence, D., Møen, K.M. 2023. Catchment response times – understanding runoff dynamics from catchment distances and celerities. *Hydrological Sciences Journal* 68/8: 1127-1138 <https://doi.org/10.1080/02626667.2023.2201449>

# The service HydSimOveralt

← ↻ 🏠 ⚠ Ikke sikret | sat-data03.nve.no:8504

✕

HydsimOveralt

**About DDD**

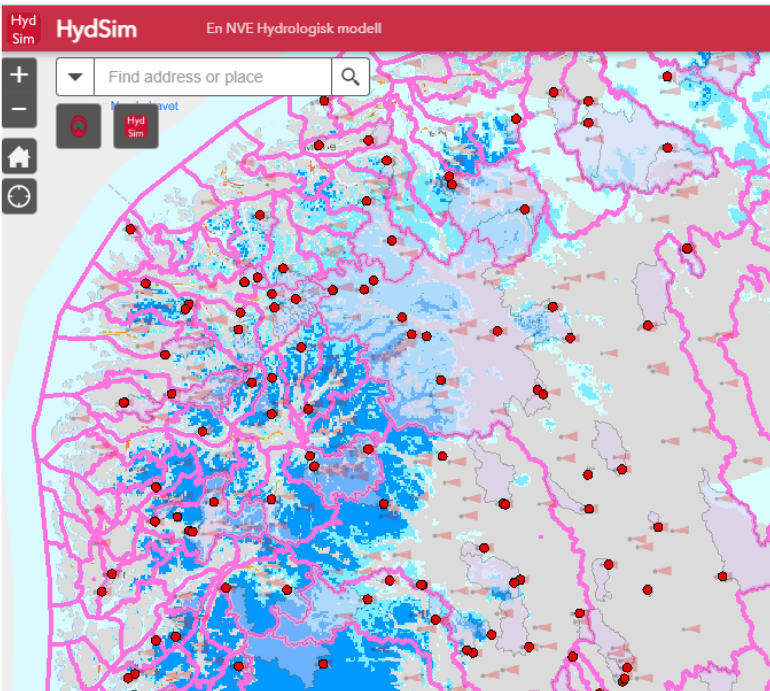
- 📅 Enter date and catchment ID
- ✓ Check or edit input files
- 📅 Run Model
- 📄 Make report
- 📄 Download files
- 👤 Contact

### DDD Model

Before running the DDD (Distance Distribution Dynamics) model, you need to generate the catchment characteristics used for estimating model parameters.

Please use the link below, or just press the Open Hydsim button. In the map tool, you need to generate the catchment and catchment parameters

<https://nve.maps.arcgis.com/apps/webappviewer/index.html?id=adeb21e3feab4cc3bf8a9e9647d315e1>

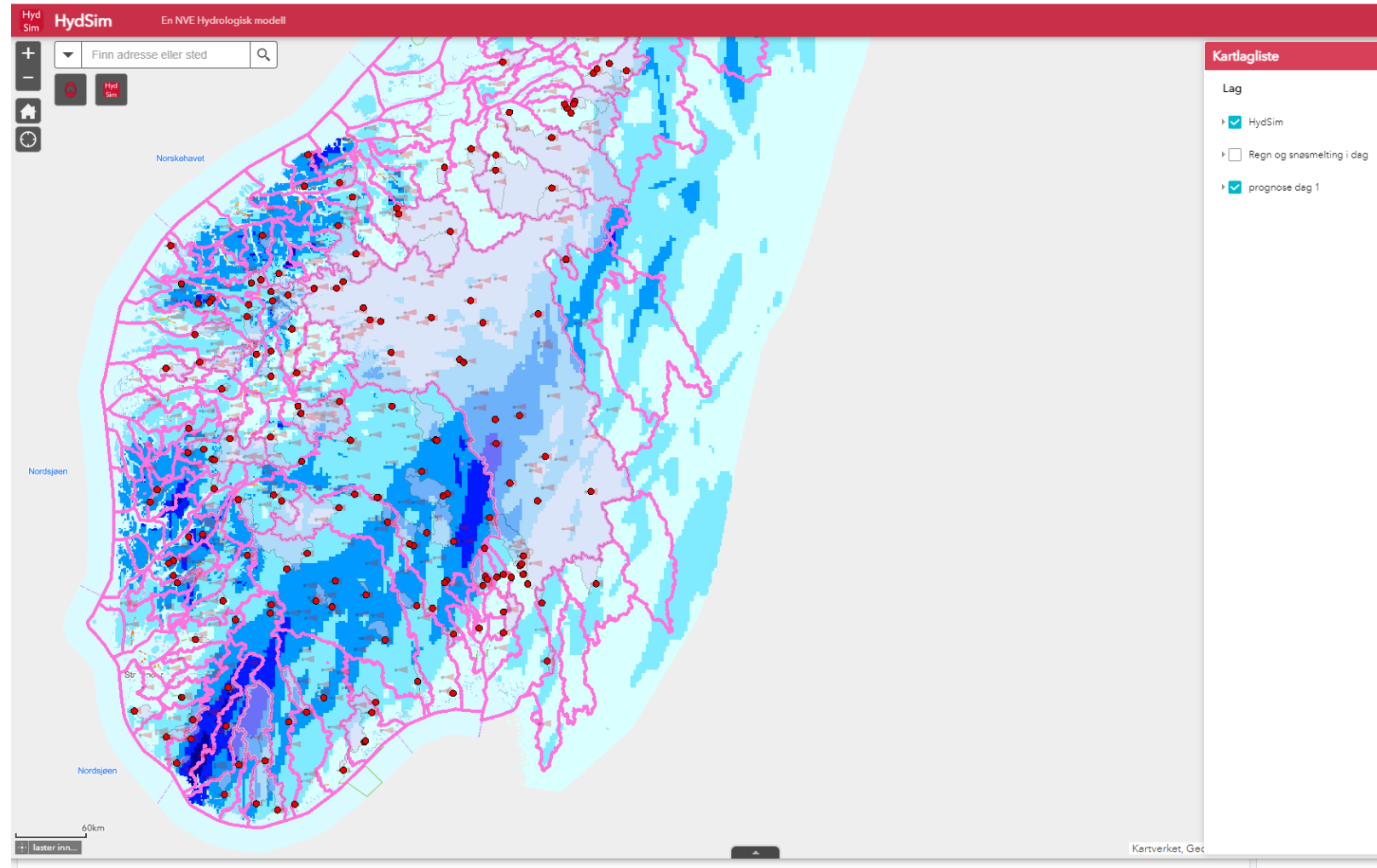
The screenshot shows the HydSim web application interface. At the top, there's a red header with "Hyd Sim" and "En NVE Hydrologisk modell". Below the header is a search bar with the text "Find address or place" and a magnifying glass icon. The main area is a map showing a catchment area with a network of pink lines representing rivers and streams. The map is overlaid with a blue and white color scheme, likely representing elevation or precipitation. There are several red dots scattered across the map, possibly representing gauging stations or specific catchment points. On the left side of the map, there are navigation controls including a plus sign, a minus sign, a home icon, and a refresh icon. At the bottom of the map, there is a button labeled "Open Hydsim".

Open Hydsim

# The service HydSimOveralt

— In the map tool, which includes gridded meteorological forecasts, you can choose to simulate for an area where you think the action will be

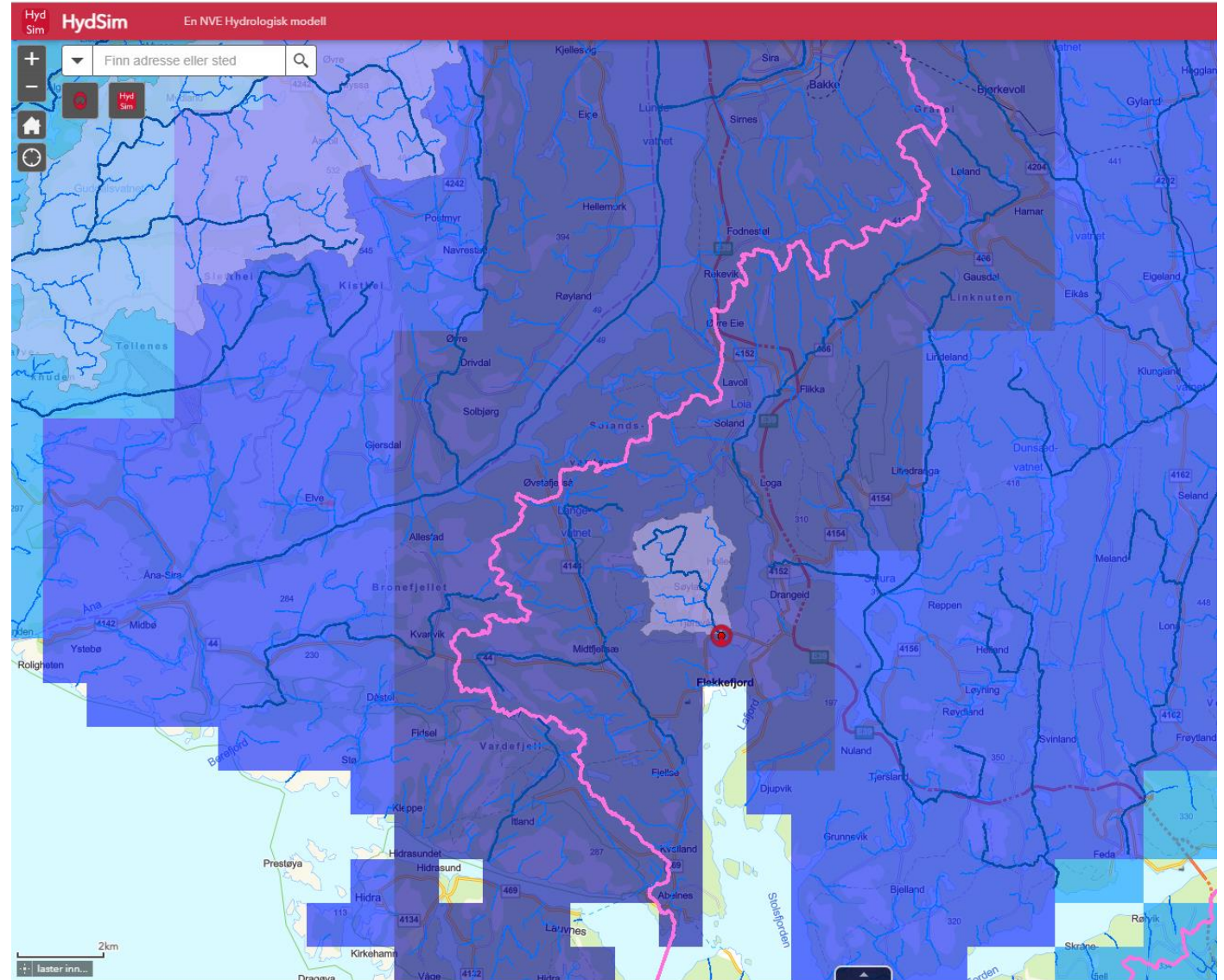
(15.08.2023)





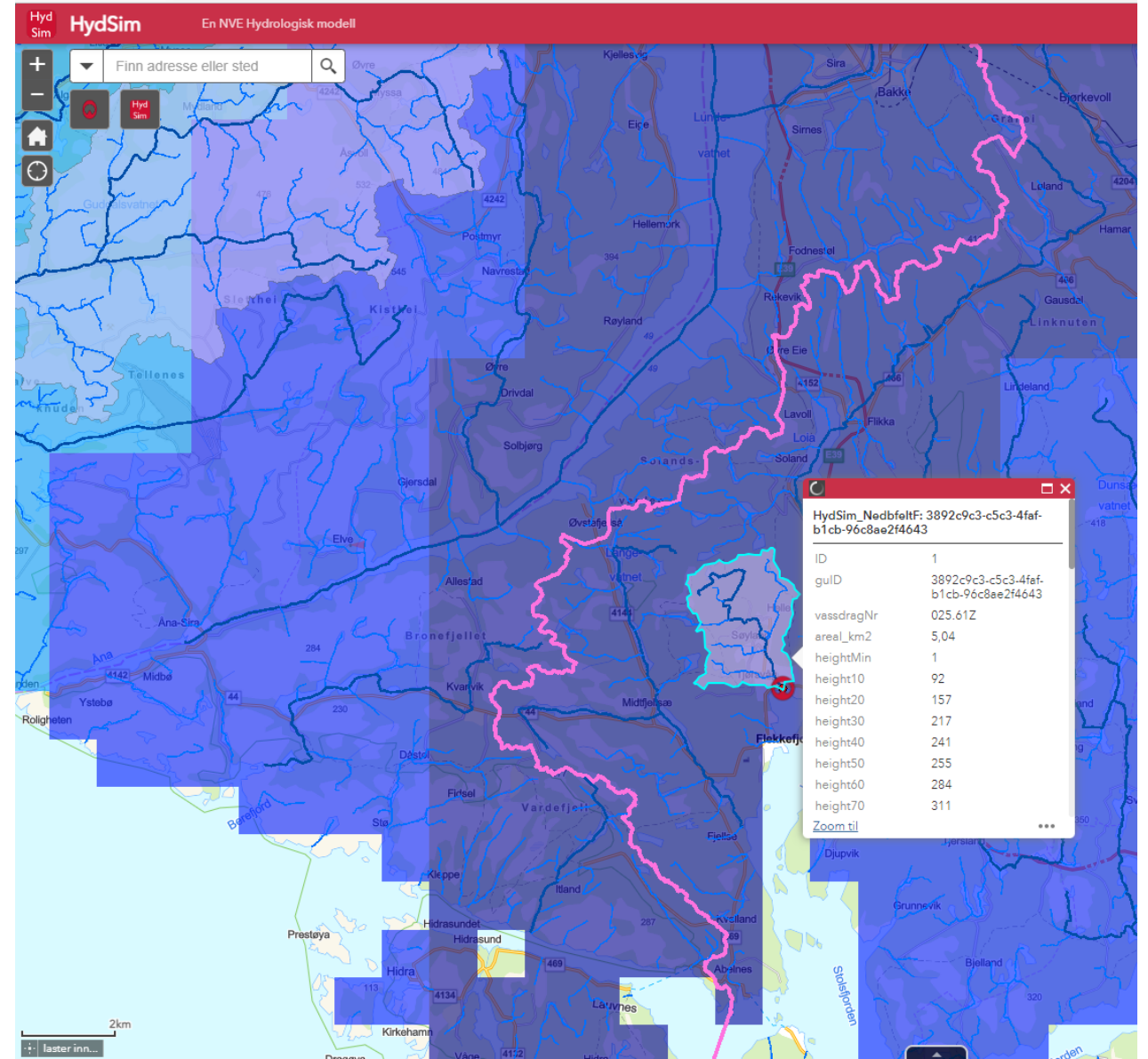
# The service HydSimOveralt

- In the map tool, which includes gridded meteorological forecasts, you can choose to simulate for an area where the action is
- Select your catchment



# The service HydSimOveralt

- In the map tool, which includes gridded meteorological forecasts, you can choose to simulate for an area where the action is
- Select your catchment
- The tool calculates the necessary information for estimating model parameters and provides a unique ID





# The service HydSimOveralt

HydsimOveralt

- About DDD
- Enter date and catchment ID

**Check or edit result**

Input parameter

Length of dataset: 56

Edit the dataframe below

Input climate data

Length of dataset: 20433

Edit the dataframe below

- HydsimOveralt
- About DDD
- Enter date and catchment ID**
- Check or edit input files
- Run Model
- Make report
- Download files
- Contact

**Enter date and catchment GUID, then by pressing submit, param file and PT file is generated...**

GUID:

Time step:

Start date:

Start time:

End date:

End time:

3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643

Input parameter

	OBJECTID	3031
0	ID	1
1	3892c9c3-c	1
2	025.61Z	1
3	heightMin	1
4	height10	92
5	height20	157
6	height30	217
7	height40	241
8	height50	255
9	height60	284

3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643 3H

Input climate data

	datetime	rr0	rr1	rr2	rr3	rr4	rr5	rr6	rr7	rr8	rr9
0	2016-09-11T00	6.2	7	6.8	6.8	6.8	6.2	6.2	6.7	6.2	6.
1	2016-09-11T03	9.7	10.3	10.25	10.25	10.25	9.7	9.7	11.2	9.7	9.
2	2016-09-11T06	12.3	10.7	11.9	11.9	11.9	12.3	12.3	11.2	12.3	12.
3	2016-09-11T09	0	0	0	0	0	0	0	0	0	0
4	2016-09-11T12	0	0	0	0	0	0	0	0	0	0
5	2016-09-11T15	0	0	0	0	0	0	0	0	0	0
6	2016-09-11T18	0	0	0	0	0	0	0	0	0	0
7	2016-09-11T21	0	0	0	0	0	0	0	0	0	0
8	2016-09-12T00	0	0	0	0	0	0	0	0	0	0
9	2016-09-12T03	0	0	0	0	0	0	0	0	0	0

Edit the dataframe below

	datetime	rr0	rr1	rr2	rr3	rr4	rr5	rr6	rr7	rr8	rr9
0	2016-09-11T00	0	0	0	0	0	0	0	0	0	0
1	2016-09-11T03	2.78	2.76	2.6	2.67	2.64	2.56	2.4	2		
2	2016-09-11T06	9.7	9.82	10	9.43	9.78	9.74	9.8			
3	2016-09-11T09	0	0	0	0	0	0	0			
4	2016-09-11T12	0	0.02	0.07	0	0.06	0.08	0.1	0.1		
5	2016-09-11T15	0	0.04	0.07	0.05	0.06	0.14	0.2	0.2		
6	2016-09-11T18	0	0	0	0	0	0	0	0		
7	2016-09-11T21	0	0	0	0	0	0	0	0		
8	2016-09-12T00	0	0	0	0	0	0	0	0		
9	2016-09-12T03	0	0	0	0	0	0	0	0		





# The service HydSimOveralt

HydsimOveralt

- About DDD
- Enter date and catchment ID**
- Check or edit input files
- Run Model
- Make report
- Download files
- Contact

Enter date and catchment ID

GUID: 3892c9c3-c5c3-4faf-b1d1-3892c9c3-c5c3-4faf-b1d1

Submit

3892c9c3-c5c3-4faf-b1d1-3892c9c3-c5c3-4faf-b1d1

Input parameter

OBJECTID	3892c9c3-c5c3-4faf-b1d1-3892c9c3-c5c3-4faf-b1d1
0	ID
1	3892c9c3-c5c3-4faf-b1d1-3892c9c3-c5c3-4faf-b1d1
2	025.61Z
3	heightMin
4	height10
5	height20
6	height30
7	height40
8	height50
9	height60

3892c9c3-c5c3-4faf-b1d1-3892c9c3-c5c3-4faf-b1d1

HydsimOveralt

- About DDD
- Enter date and catchment ID
- Check or edit input files**
- Run Model
- Make report
- Download files
- Contact

## Check or edit result

Input parameter

Length of dataset: 56

Edit the dataframe below

	OBJECTID	3034
0	ID	1
1	39f23313-f87d-4efa-941e-ffd77720da7	1
2	062.E2A	1
3	heightMin	46
4	height10	378
5	height20	476
6	height30	618
7	height40	709
8	height50	797
9	height60	892

Submit

	OBJECTID	3034
0	ID	1
1	39f23313-f87d-4	1
2	062.E2A	1
3	heightMin	46
4	height10	378

Input climate data

Length of dataset: 20433

Edit the dataframe below

	datetime	rr0	rr1	rr2	rr3	rr4	rr5	rr6	rr
0	2016-09-11T00	0	0	0	0	0	0	0	
1	2016-09-11T03	2.78	2.76	2.6	2.67	2.64	2.56	2.4	2
2	2016-09-11T06	9.7	9.82	10	9.43	9.78	9.74	9.8	1
3	2016-09-11T09	0	0	0	0	0	0	0	
4	2016-09-11T12	0	0.02	0.07	0	0.06	0.08	0.1	0.1
5	2016-09-11T15	0	0.04	0.07	0.05	0.06	0.14	0.2	0.1
6	2016-09-11T18	0	0	0	0	0	0	0	
7	2016-09-11T21	0	0	0	0	0	0	0	
8	2016-09-12T00	0	0	0	0	0	0	0	
9	2016-09-12T03	0	0	0	0	0	0	0	

Submit





# The service HydSimOveralt

### HydsimOveralt

- About DDD
- Enter date and catchment ID
- Check or edit input files**

### Check or edit result

Input parameter

Length of dataset: 56

Edit the dataframe below

	OBJECTID	3034
0	ID	1
1	3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643	

Input climate data

Length of dataset: 20433

Edit the dataframe below

	datetime	rr0	rr1	rr2	rr3	rr4	rr5	rr6	rr
0	2016-09-11T00	0	0	0	0	0	0	0	2.4
1	2016-09-11T03	0.78	0.78	0.6	0.67	0.64	0.66	0	9.8
2									0
3									0.1
4									0.2
5									0
6									0
7									0
8									0
9									0



Ikke sikret | sat-data03.nve.no:8504



- Hydsim
- About
- Enter date and catchment ID**
- Check or edit input files
- Run Model
- Make report
- Download files
- Contact

## HydsimOveralt

- About DDD
- Enter date and catchment ID
- Check or edit input files
- Run Model**
- Make report
- Download files
- Contact

### Run Model

Before running the model, make sure the input files are fine

for the catchment and time resolution shown below

3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643

3H

Run DDDOveralt

starter modell for the following GUID 3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643 and Time 3H

```
julia .\DDD\RunDDDHSOClassicPT_rev.jl 3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643 3H
```

```
C:\Users\flomtana\hydsim2\DDD\inndata\3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643_3H_pt.csv 0 bias=1.049 Time elapsed[s]= 56.312573895 3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643
```

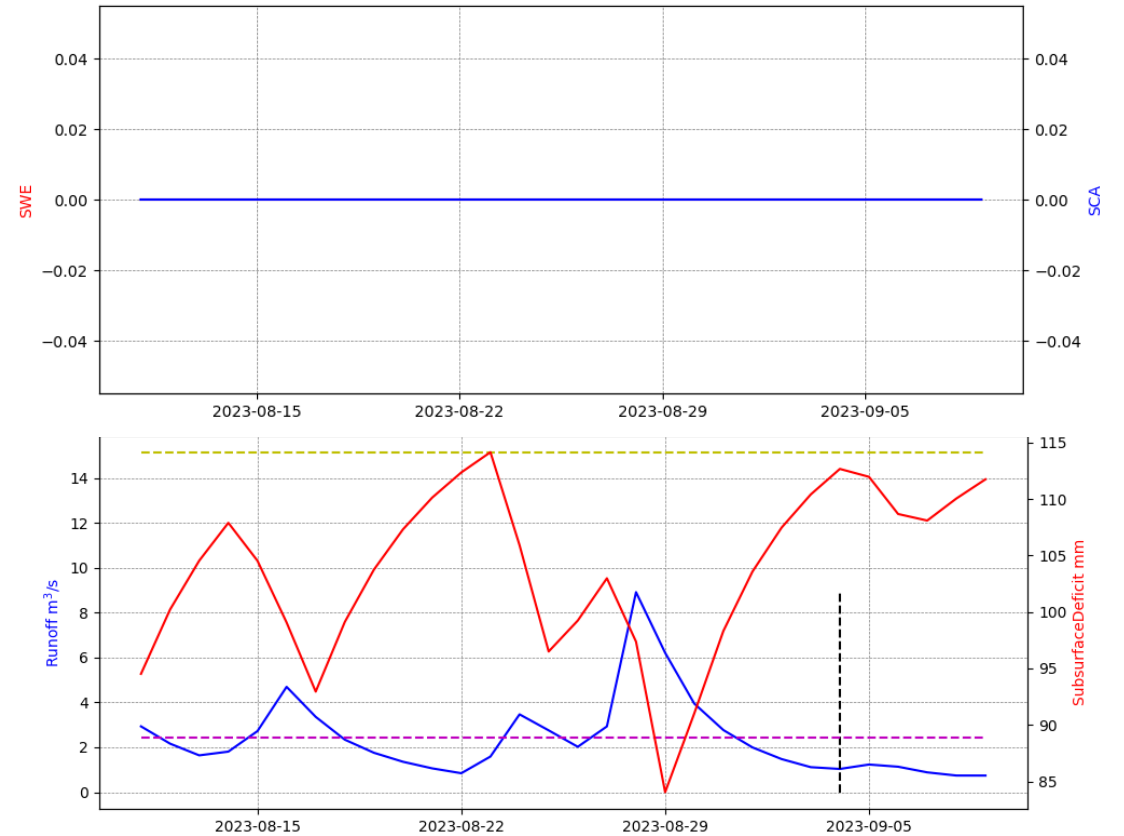
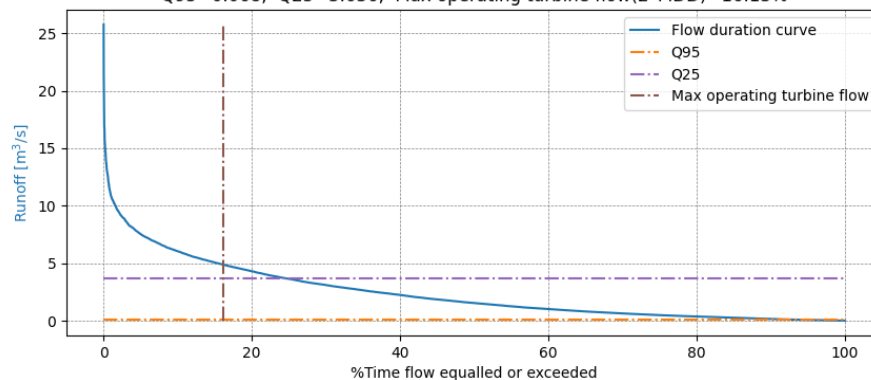
The model run is finished



# The service HydSimOveralt- the entire operation takes about 10 minutes



Q95=0.068, Q25=3.636, Max operating turbine flow(2\*MDD)=16.13%







# The service HydSimOveralt- downloading the results

← ↻ 🏠 ⚠ Ikke sikret | sat-data03.nve.no:8504

HydsimOveralt

- About DDD
- Enter date and catchment ID
- Check or edit input files
- Run Model
- Make report
- Download files**
- Contact

**Make sure that you have a model result**

39f23313-f87d-4efa-941e-ff6d77720da7

24H

Choose model resolution

3H  
 24H

Please choose model result result file

3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643\_3H\_simres.csv

Download modell result

3892c9c3-c5c3-4faf-b1cb-96c8ae2f4643 3H

Choose data type to download

Modell parameter  
 Climate data

Please choose the item to download

39f23313-f87d-4efa-941e-ff6d77720da7\_24H\_param.csv

Download file

Please choose figure type to download

precipitation  
 runoff  
 snow  
 duration curve

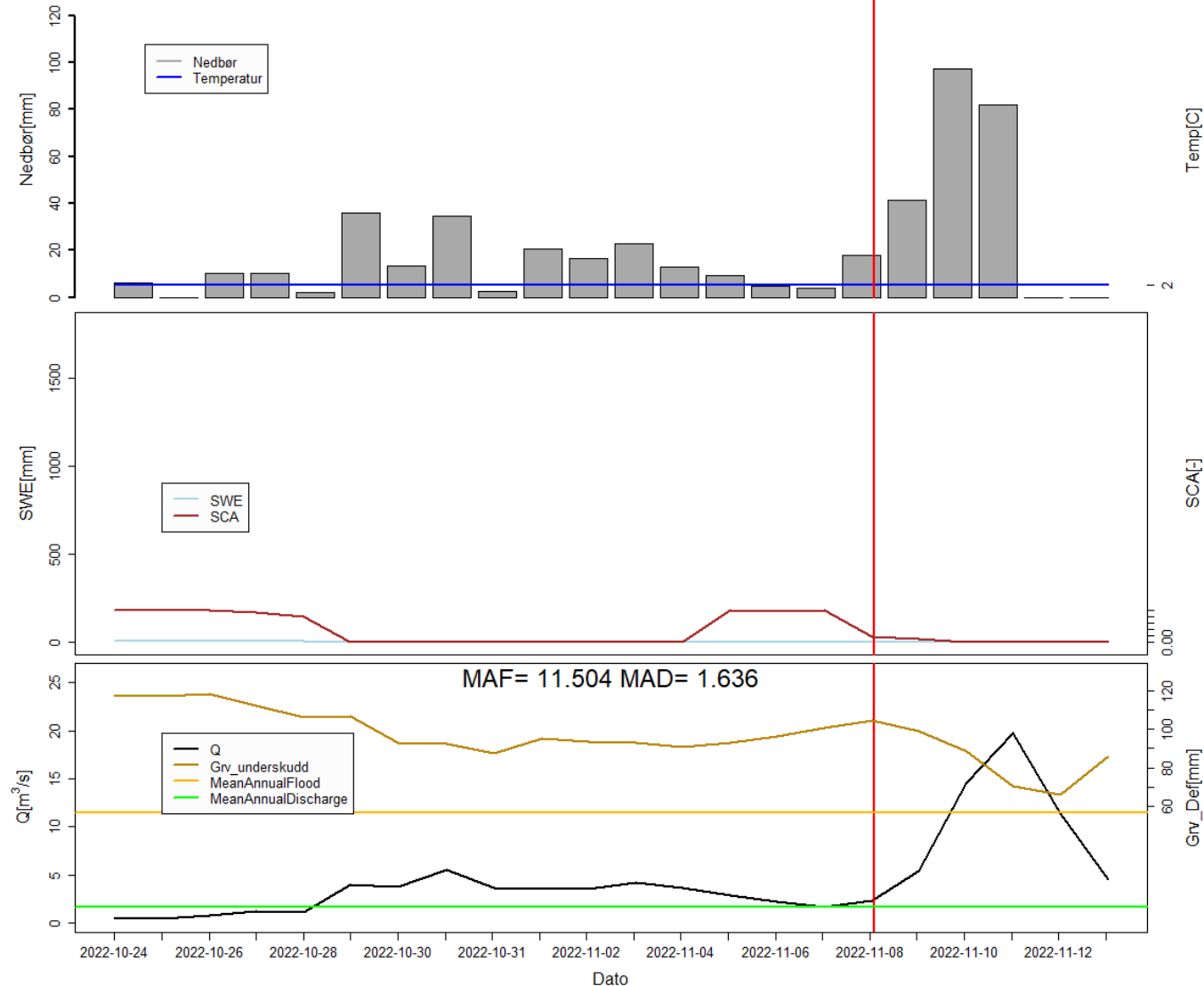
Please choose the item to download

39f23313-f87d-4efa-941e-ff6d77720da7\_24H\_ppt\_temp.png

Download file

# «On the fly» flood forecasts. Vestlandet, November 2022

a6dc7fab-46cd-44e1-92ce-a383694d3c07 Areal= 18.83 km<sup>2</sup>



Mean annual flood calculated from simulated 30 years timeseries (time lengths can be chosen)

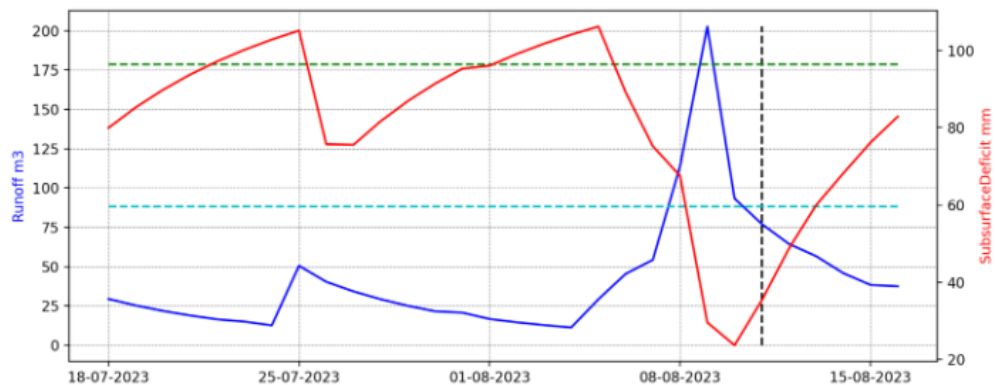
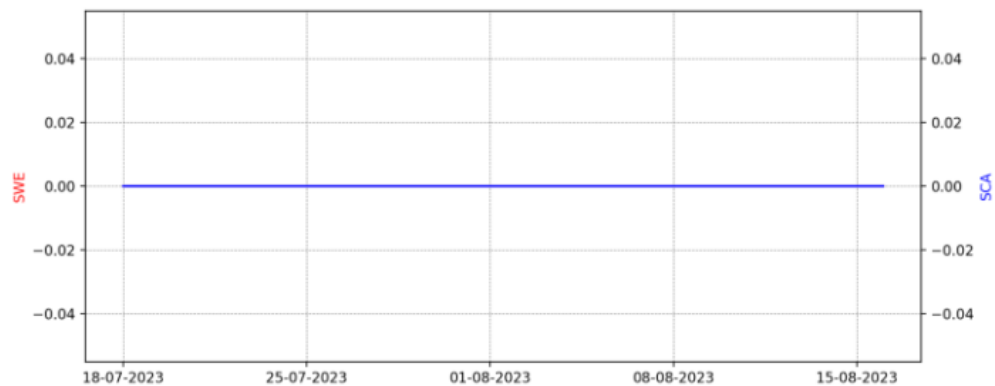
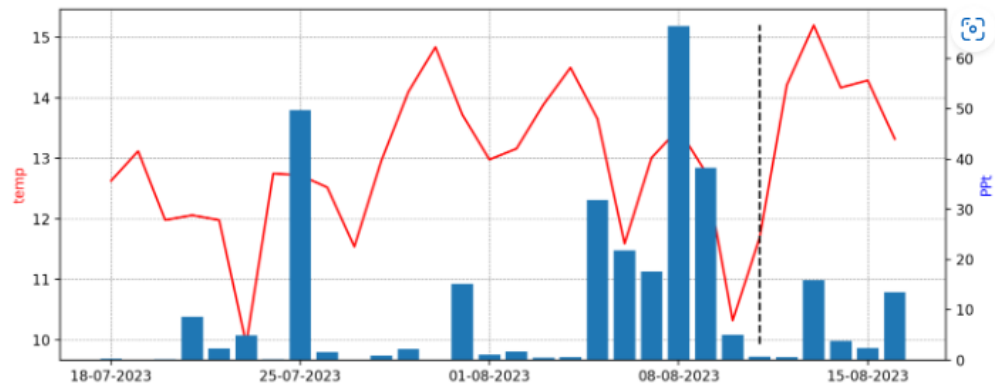
The model compares simulated forecasts against simulated mean annual flood

Each catchment has its unique ID calculated once and for all. With new meteorological data, running the model again is very speedy and simple.

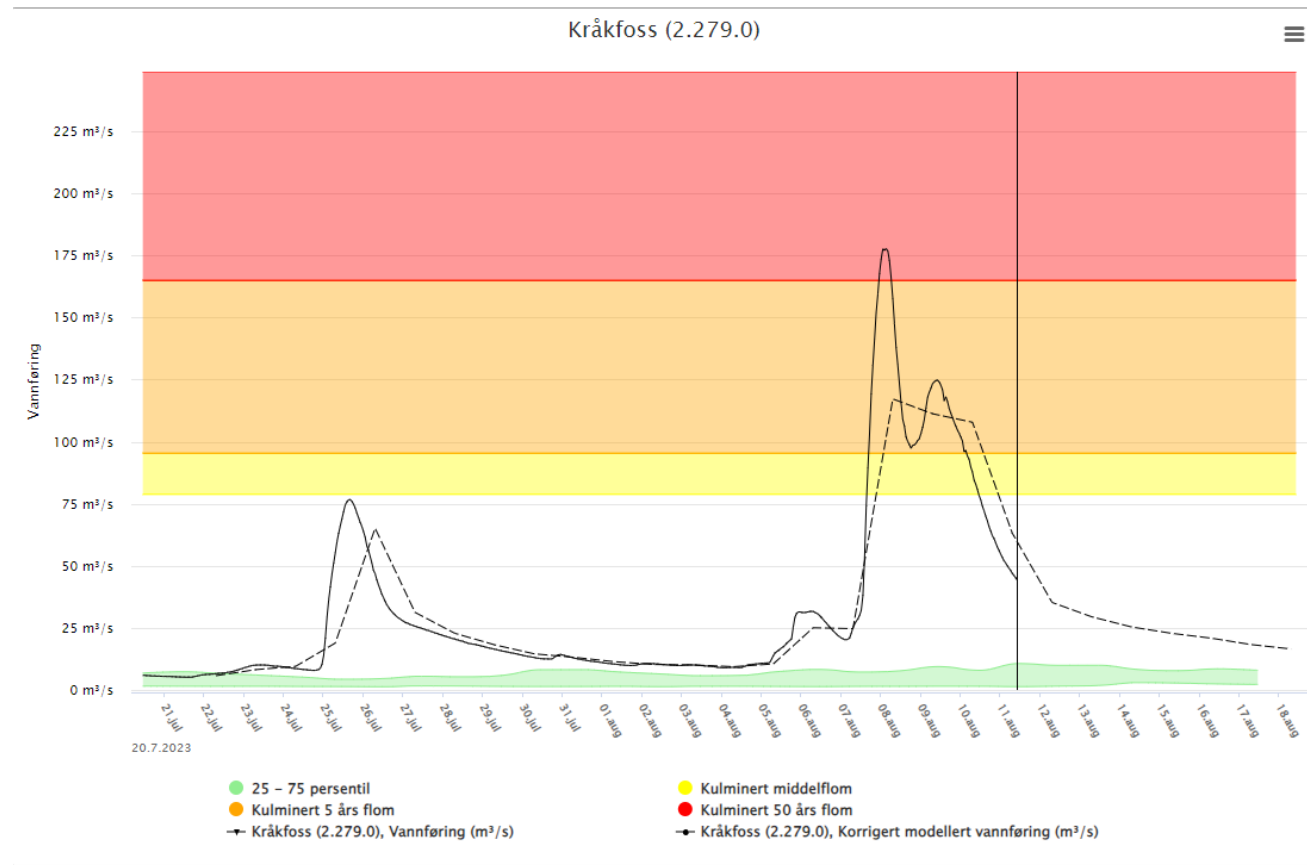


M\_200 = 283.455    M\_50 = 178.617    M\_5 = 88.327    MAF = 77.144    MAD = 10.746

Show M\_200     Show M\_50     Show M\_5     Show MAF     Show MAD

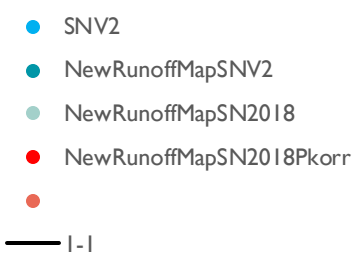
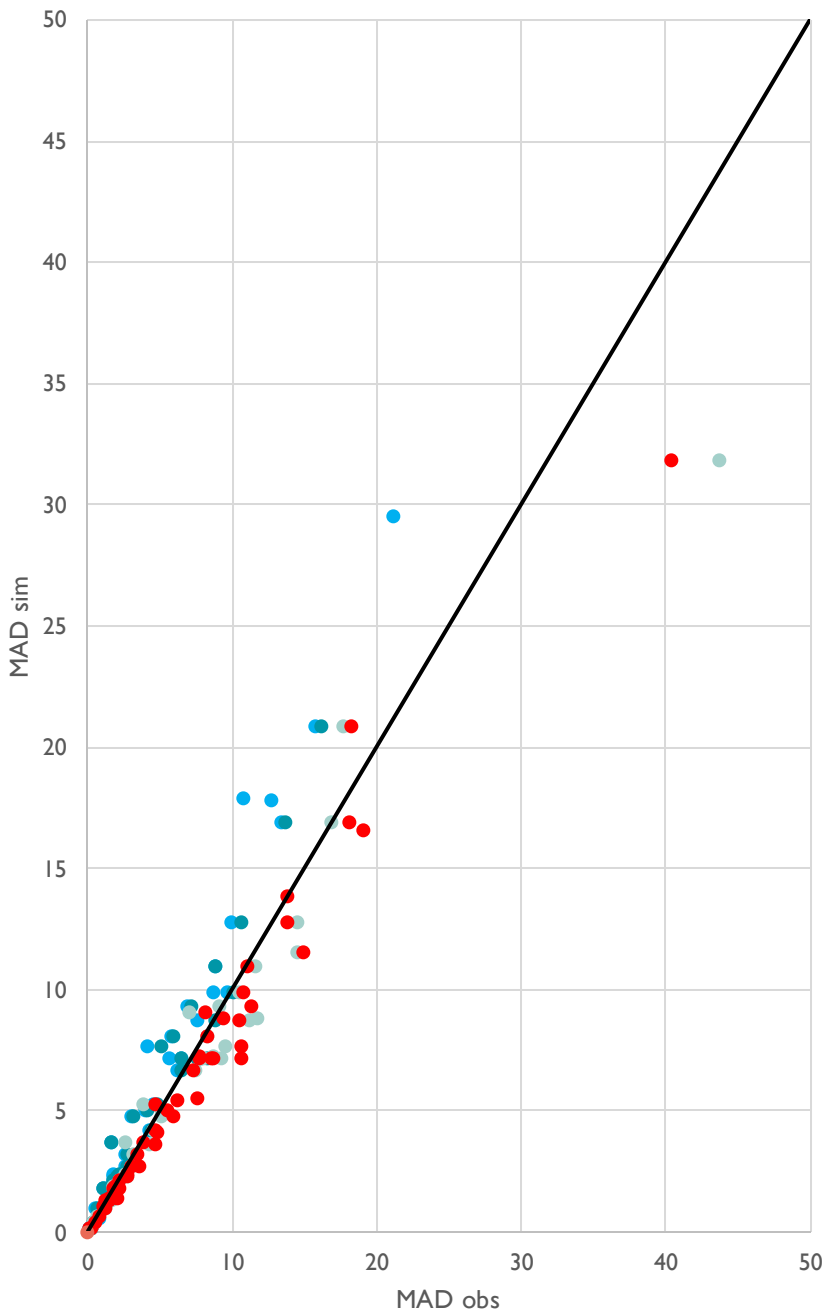


# HANS @runoff station Kråkfoss

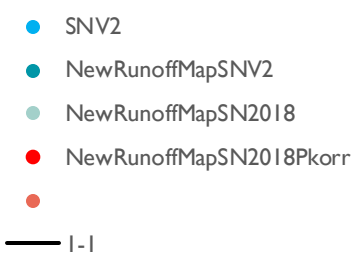
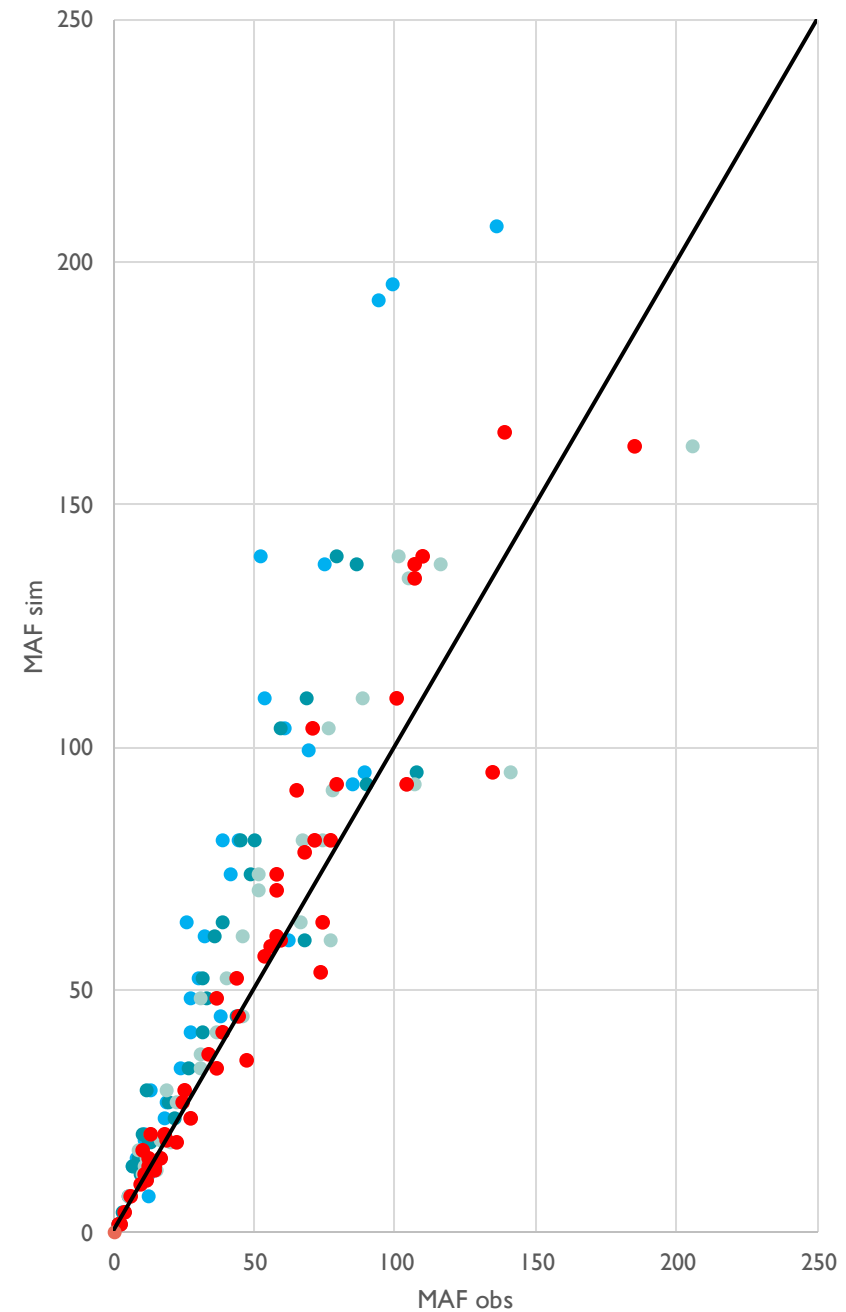




### HSO Mean Annual Discharge



### HSO Mean Annual Flood



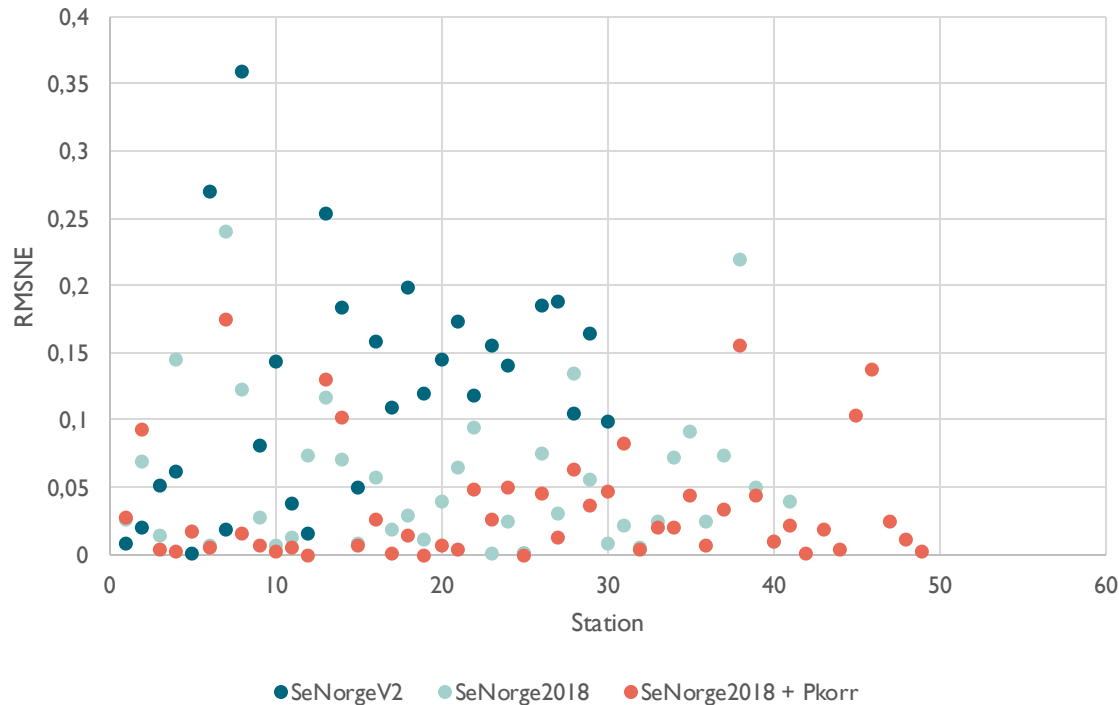
# Application: Estimate the mean annual flood,

RMSNE = 0.35 (SeNorgeV2)

RMSNE = 0.23 (SeNorge2018)

RMSNE= 0.19 (SeNorge2018 + Pkorr)

Root, mean, normalised squared error- estimating mean annual flood



RMSNE for HSO is 0.19,  
RMSNE for RFFA2018 is 0.23.

**More, and better information  
further improves the system!**

# Conclusions- HydSimOveralt

- The parts of the system are in place and works well - how to develop the ideal system (or systems) for users remains to be decided.
- Runoff forecasts can be run for everywhere in Norway
- Relevant hydrological statistics can be calculated for everywhere in Norway
- The model has no preferred temporal resolution. Current version runs for 24h som 3h. Higher resolution on temporal and spatial data will give high resolution hydrological simulations.
- Extracting meteorological data, calculating model parameters and running the model is carried out on a time scale suitable for operational flood forecasting (5-10 minutes)
- We want to make a (n even) better GUI, and make the system accessible for users outside of NVE

