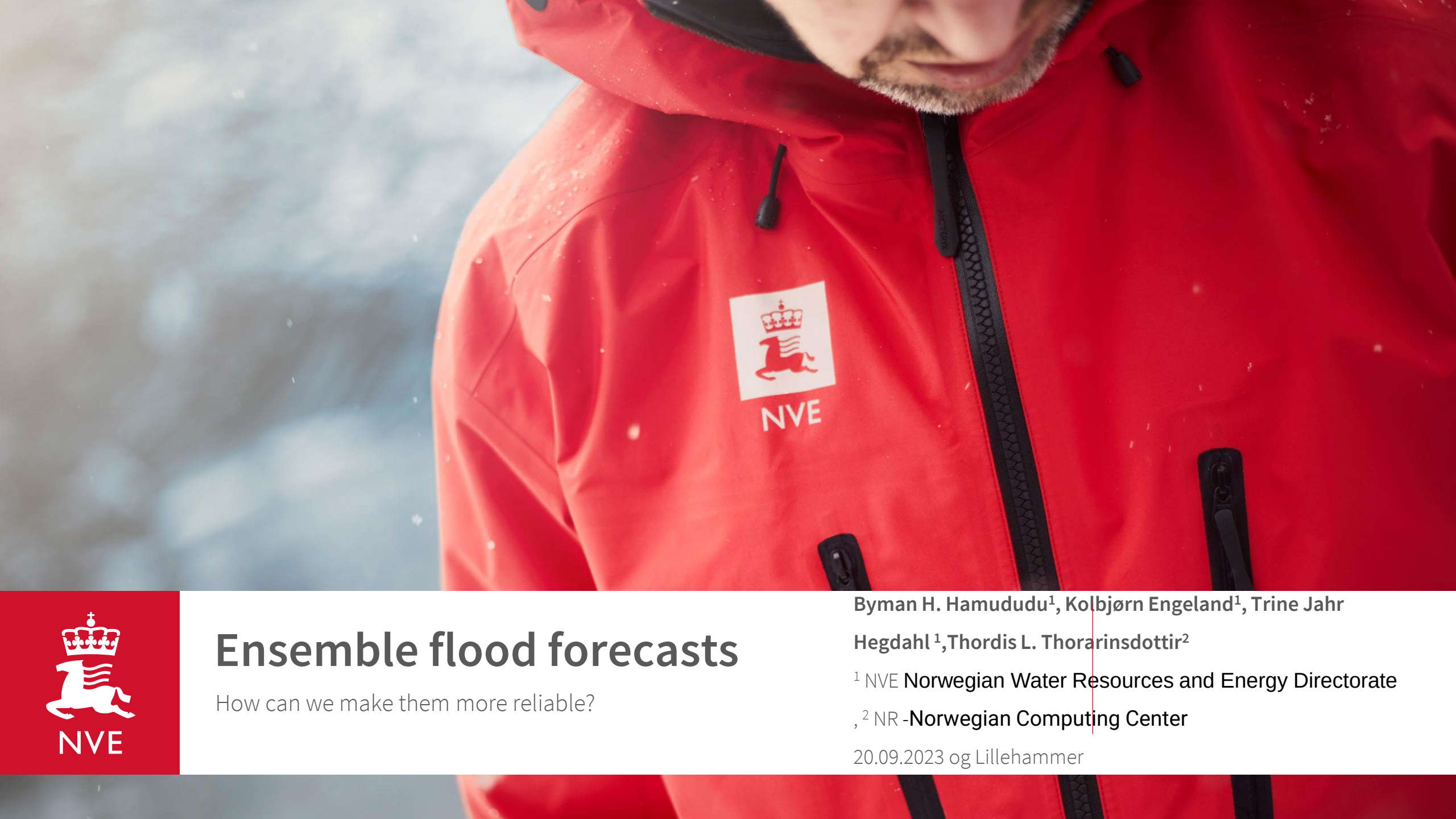


# Ensemble flood forecasts

How can we make them more reliable?

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[1] NVE Norwegian Water Resources and Energy Directorate

, [2] NR -Norwegian Computing Center

20.09.2023 og Lillehammer

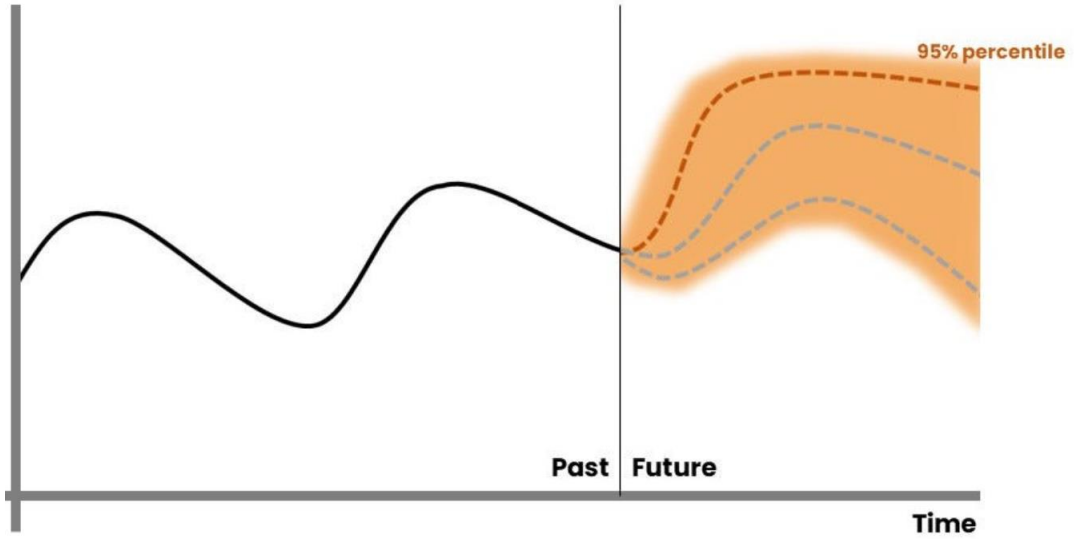
# Agenda

- Introduction
- Techniques
- Evaluation measures
- Further work
- Shiny App demo

# Forecasting

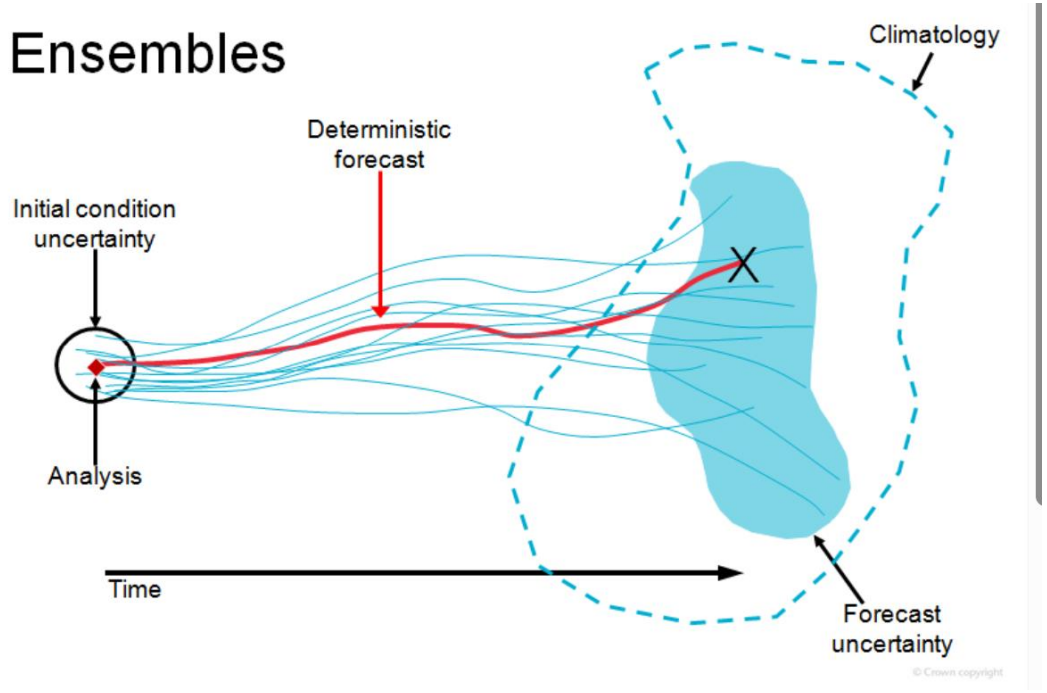
## Deterministic forecast

- Forecast – estimate of future state
- Current state (obs) – evolve into the future
- Small errors (obs) – large errors in future time
- Never a perfect forecast…

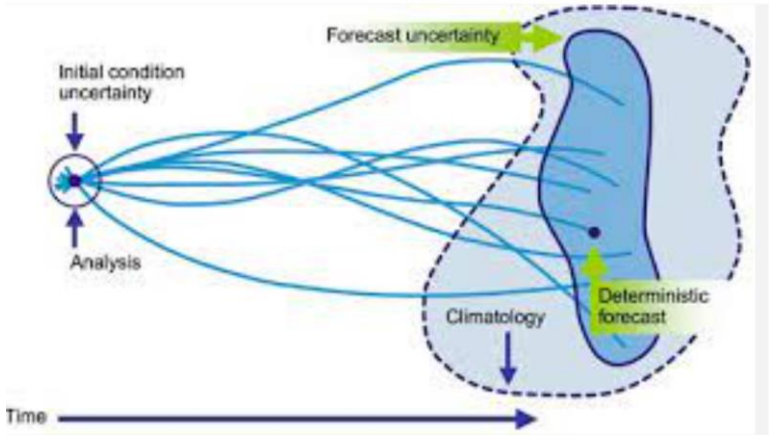



## Ensemble forecast

- Compliments - deterministic
- Represents / quantify uncertainty



# Postprocessing techniques and evaluations




- Techniques
  - Bayesian Model Averaging (BMA)
  - Ensemble Model Output Statistics (EMOS)
  - Quantile regression Forest (QrF)
  - Etc…
- Evaluation
  - Cont. Rank Prob. Score CRPS
  - Reliability
  - Sharpness
  - Uncertainty
  - BIAS
  - Brier Score

# Data available

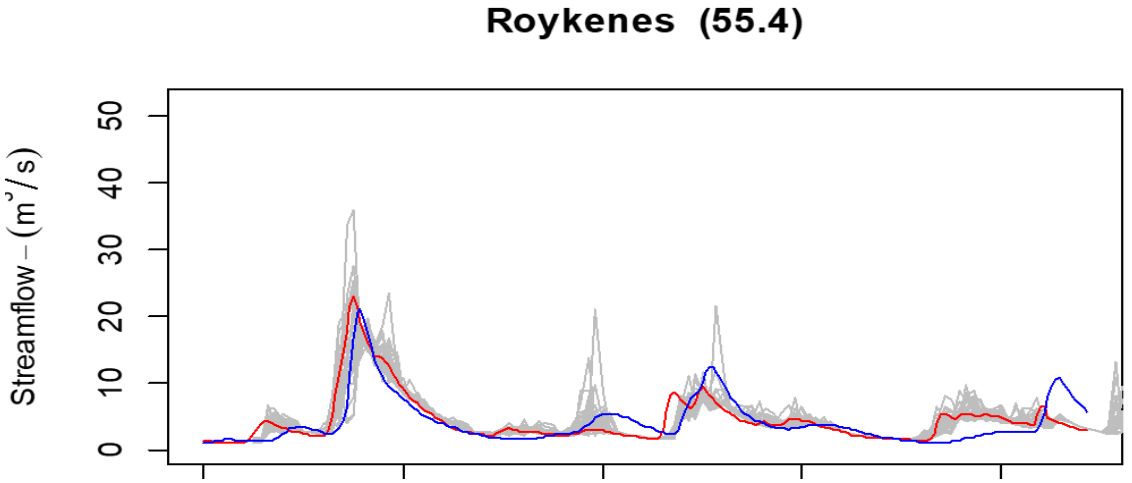
NetCDF

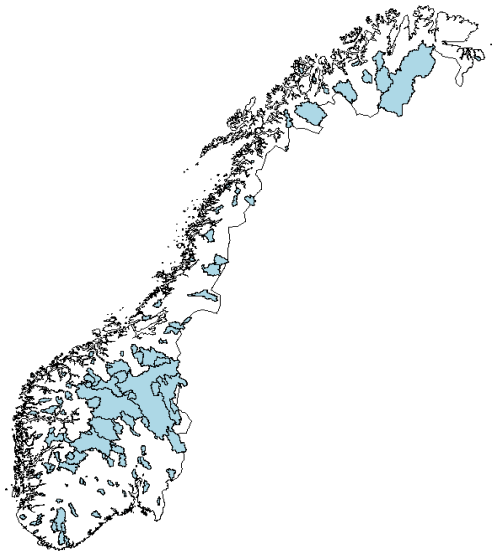
All 145 (HBV) catchments (Norway)

5 years with 3-hourly

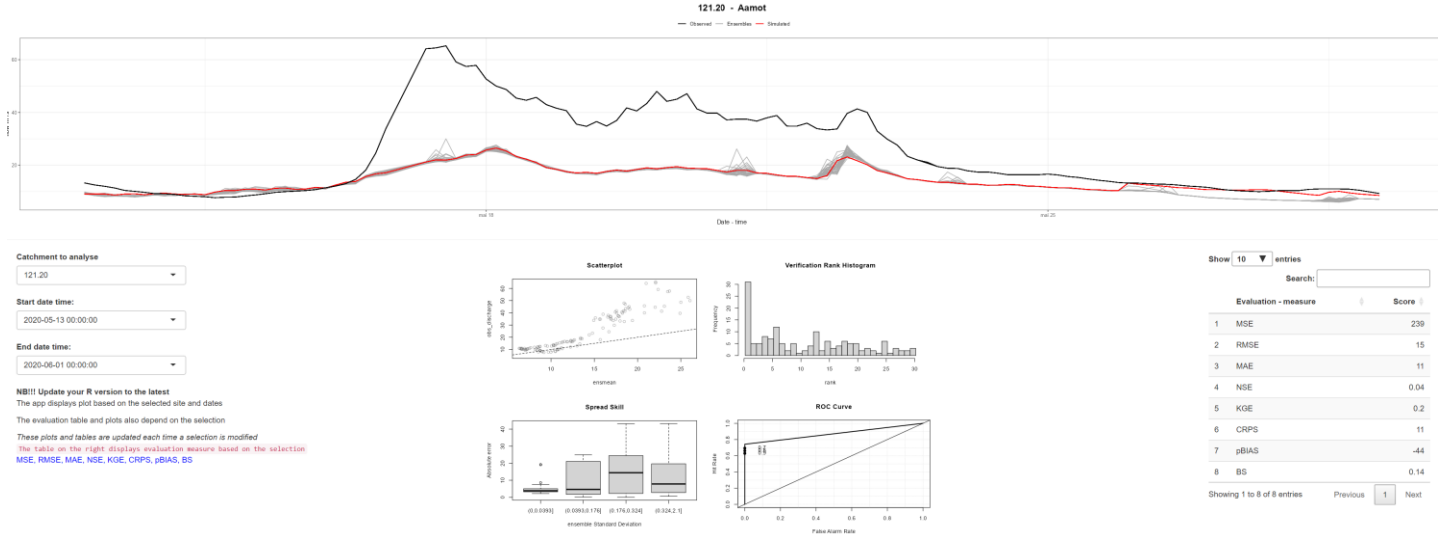
Flow ensembles – 30

Obs – Rainfall
Temp
Discharge



# Methodology




NetCDF → R
Save rds format

Shiny App

Evaluation measures –

MSE, RMSE, MAE,NSE, KGE,
CRPS, pBIAS, BS.

Reliability
Sharpness
ROC

QrF - postprocessing

# QrF

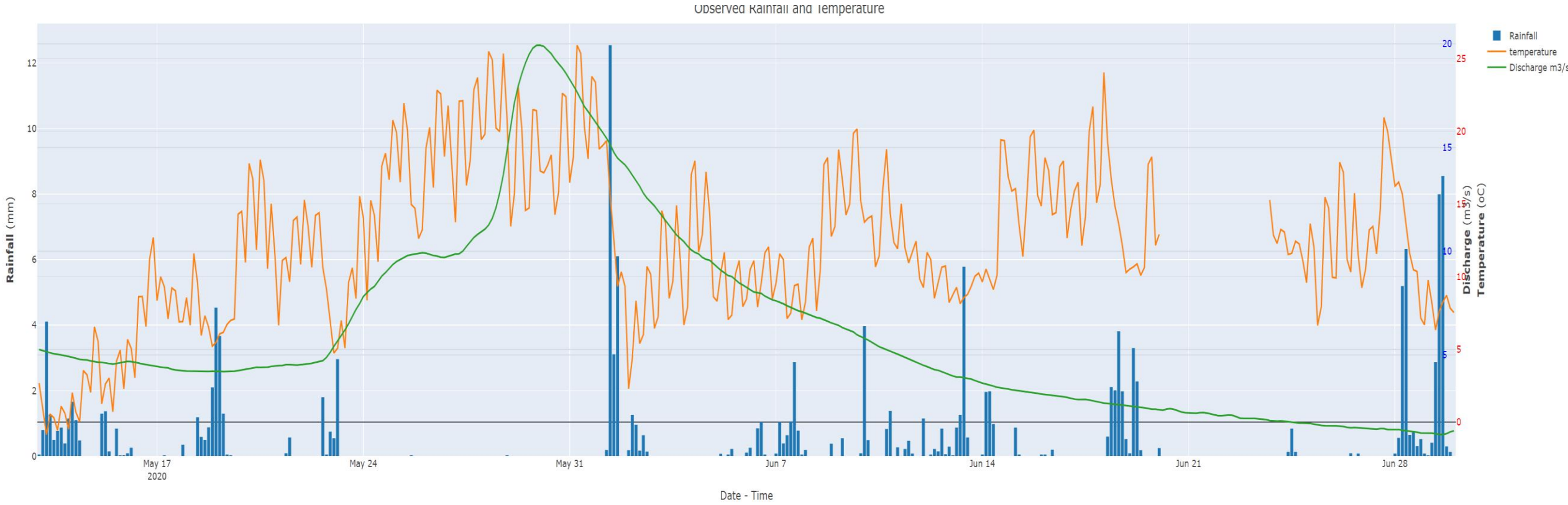
Quantile Regression Forest - way of estimating conditional quantiles

non parametric
non linear
Robust

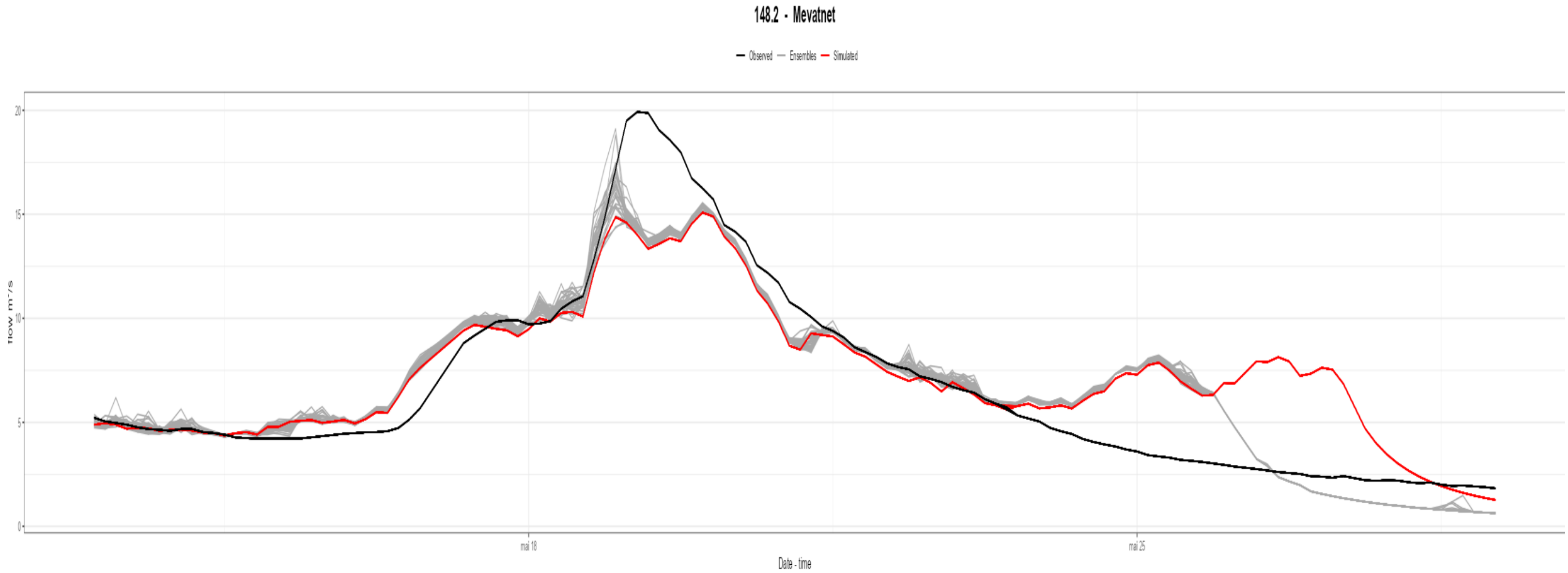
Vector of predictions

Averaging CDF from trees

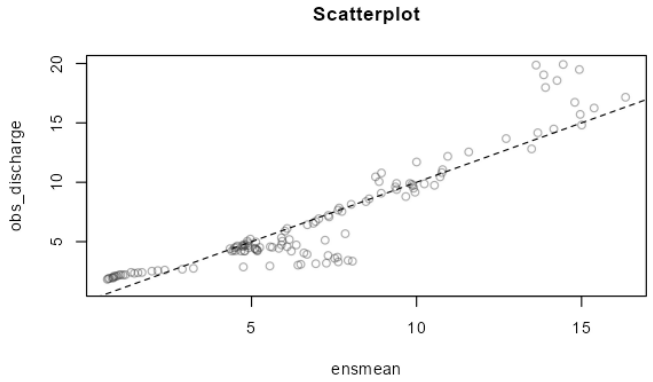
# Observations

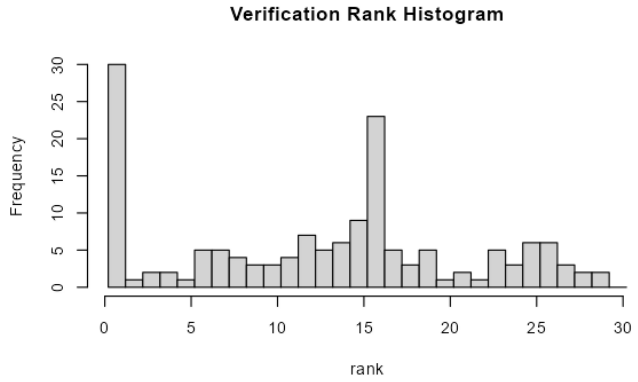


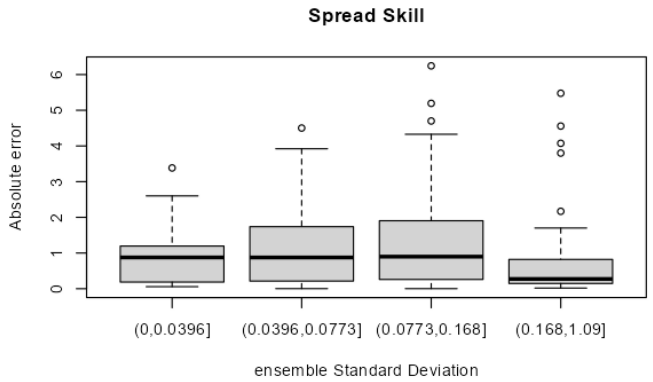
# Flows – Observed, simulated & ensembles

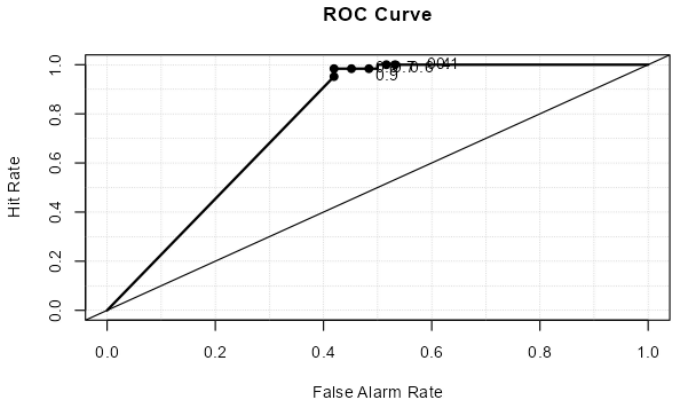


# Evaluation


Scatterplot
obs_discharge
ensmean
5
10
15
20


Verification Rank Histogram
Frequency
rank
0
5
10
15
20
25
30

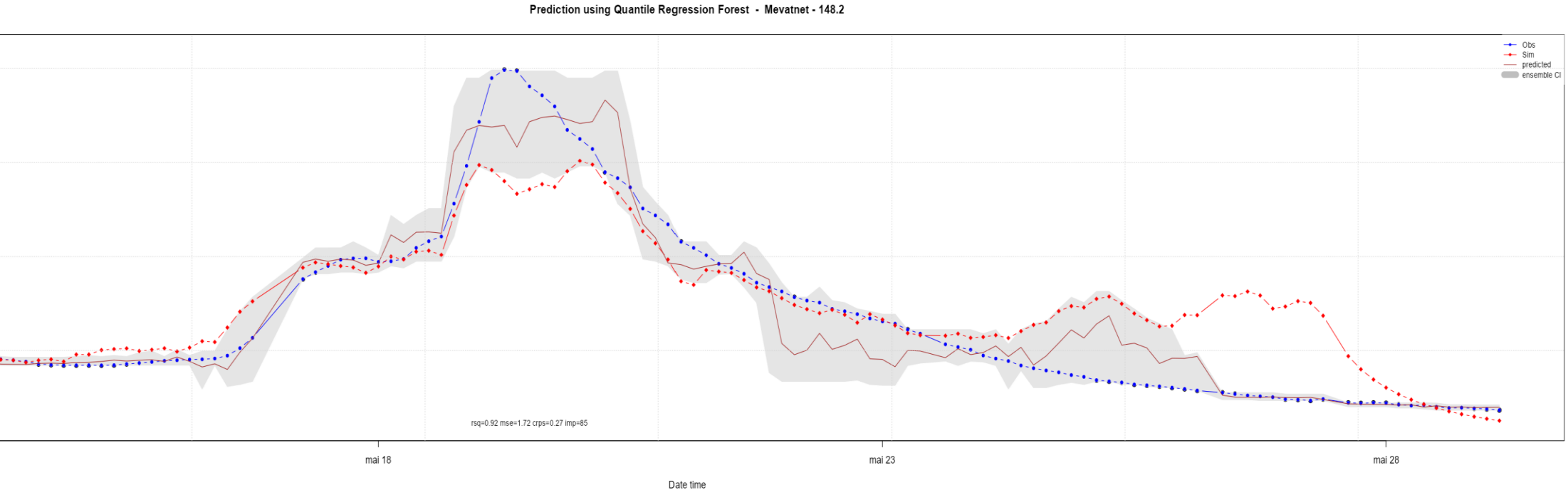

Spread Skill
Absolute error
ensemble Standard Deviation
(0,0.0396]
(0.0396,0.0773]
(0.0773,0.168]
(0.168,1.09]


ROC Curve
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0

# Evaluation

| | Evaluation - measure | Score |
|---|---|---|
| 1 | MSE | 3 |
| 2 | RMSE | 2 |
| 3 | MAE | 1 |
| 4 | NSE | 0.84 |
| 5 | KGE | 0.83 |
| 6 | CRPS | 1 |
| 7 | pBIAS | 2 |
| 8 | BS | 0.21 |

# Prediction?


Prediction using Quantile Regression Forest - Mevatnet - 148.2
Obs
Sim
predicted
ensemble CI
rsq=0.92 mse=1.72 crps=0.27 imp=85
mai 18
mai 23
mai 28
Date time

# Further work - ongoing

- Statistical post processing
  - corrections
  - Interpreting probability
- Errors  -- Lead time
- Comparison of different methods – evaluation criteria