



Deep learning-based runoff forecasting

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Project team

Researchers

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Reference Group

- Beatriz Quesada Montano, Uniper
- Susanne Nyström & Mikael Sundby, Vattenfall
- Imenne Ahlen, Fortum
- Magnus Rylander, Holmen Energi
- Björn Norell, Vattenregleringsföretagen-VRF

Background

Significance of runoff forecasting

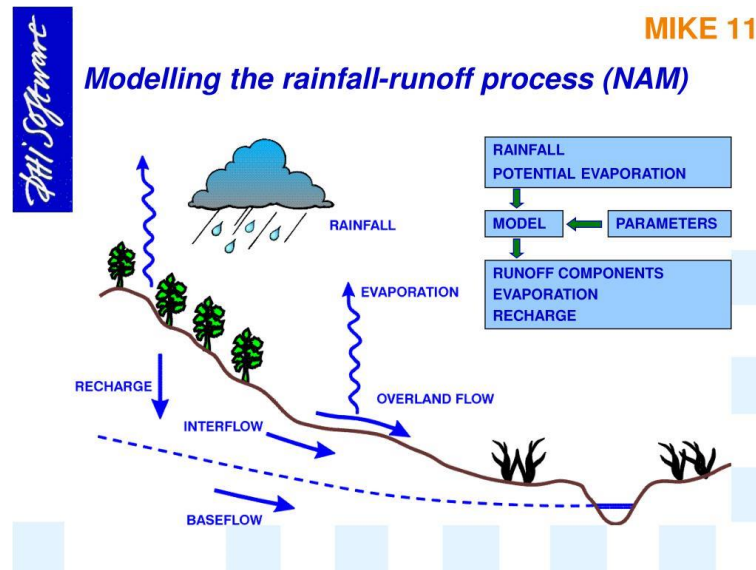
- Flood prediction
- Water resource management
- Agricultural planning
- Environmental protection
- Power generation
- ...



Background

Forecasting approaches

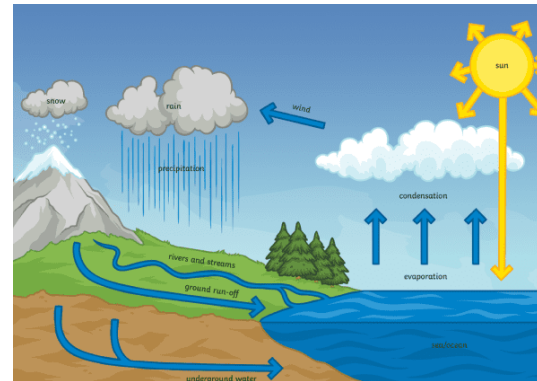
- Empirical models (e.g., rainfall, catchment area, runoff coefficient, etc.)
- Conceptual models (simplified hydrological processes: infiltration, evaporation, baseflow)
- Physically based models (physical laws: conservation of mass, energy, and momentum)
- **Data-driven models** (handling complex, nonlinear interactions in large datasets)
- ...



Background

Current state

- Digitalization
- DL: Data-driven + High dimensionality + Adaptability
- Lag in Swedish hydropower industry [ref. HUVA]





Project goals

- Design and implement DL for runoff forecasting
- Adaptability, uncertainty quantification, interpretability
- Compression with existing approaches, i.e., HBV
- Best-practice recommendations

Project implementation

Data

- Precipitation
- Temperature
- Streamflow
- Snow cover
- ...

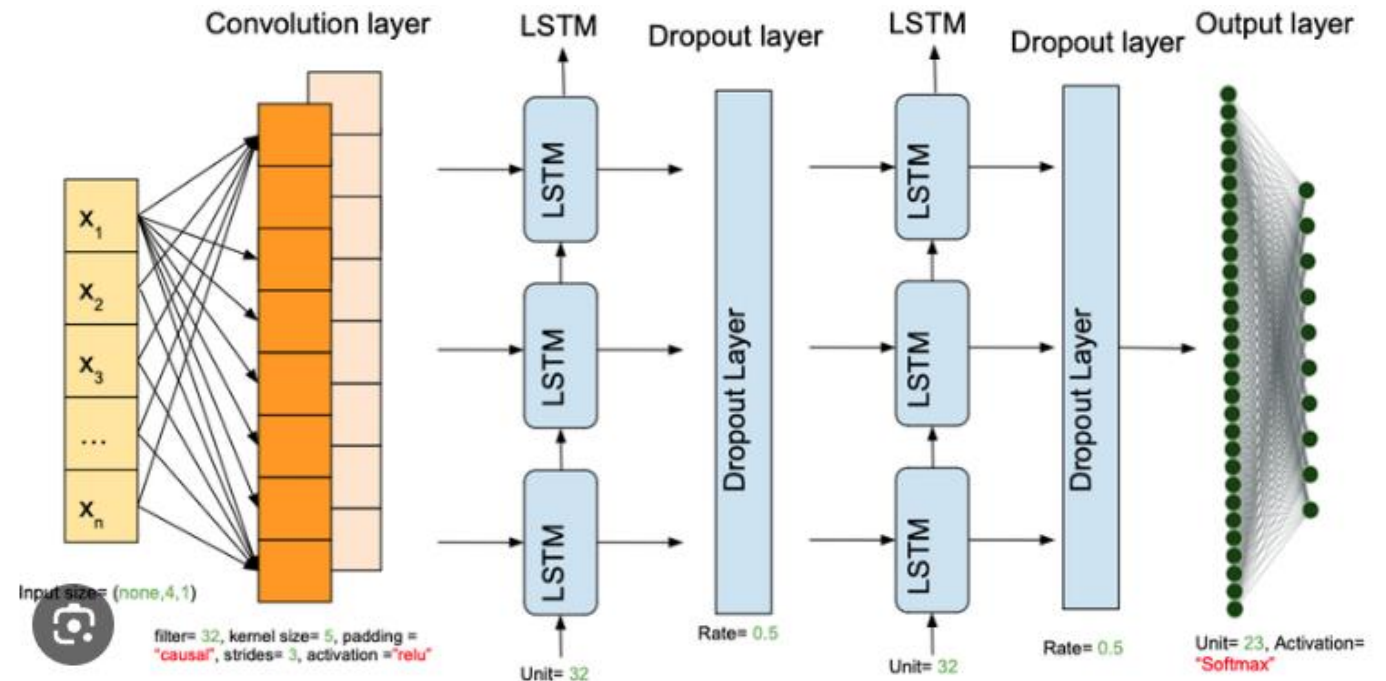
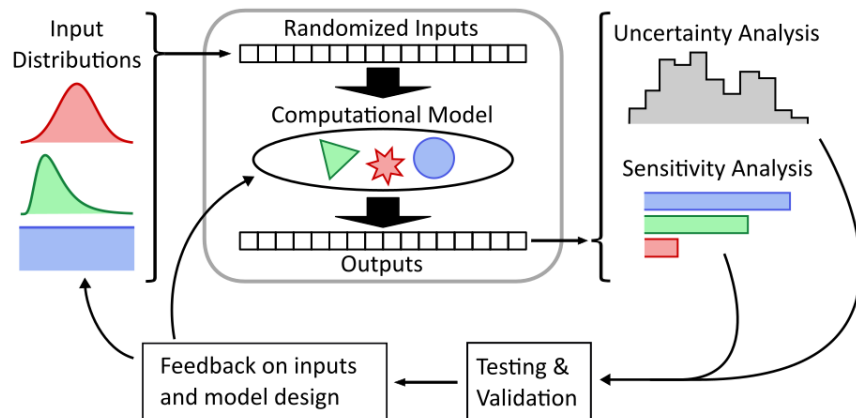
HBV modeling?



Project implementation

Methods

- CNN+LSTM
- CNN: feature extraction + dimensionality reduction
- LSTM: Temporal modeling
- Uncertainty quantification (Monte Carlo)
- Interpretability (SHAP)



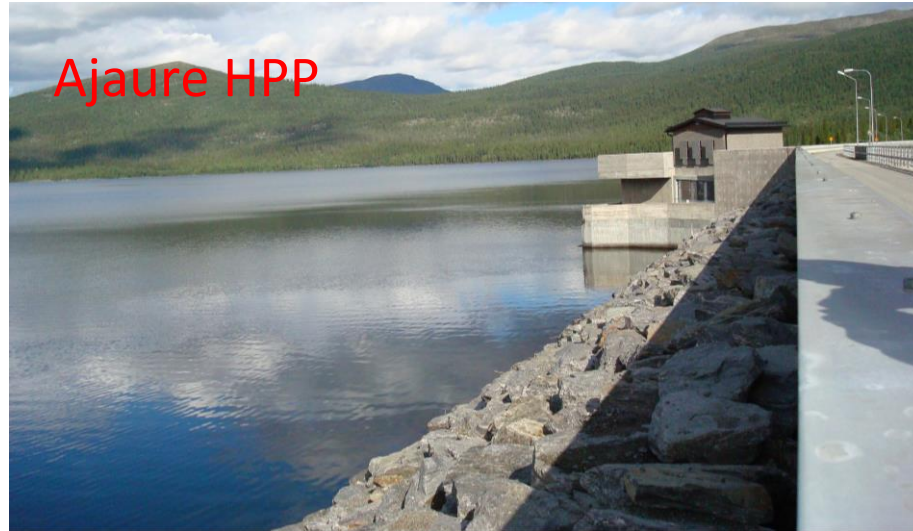
Expected deliverables

- An DL framework (forecasting, uncertainty, interpretability)
- Best-practice experiences (via report, paper, seminar)

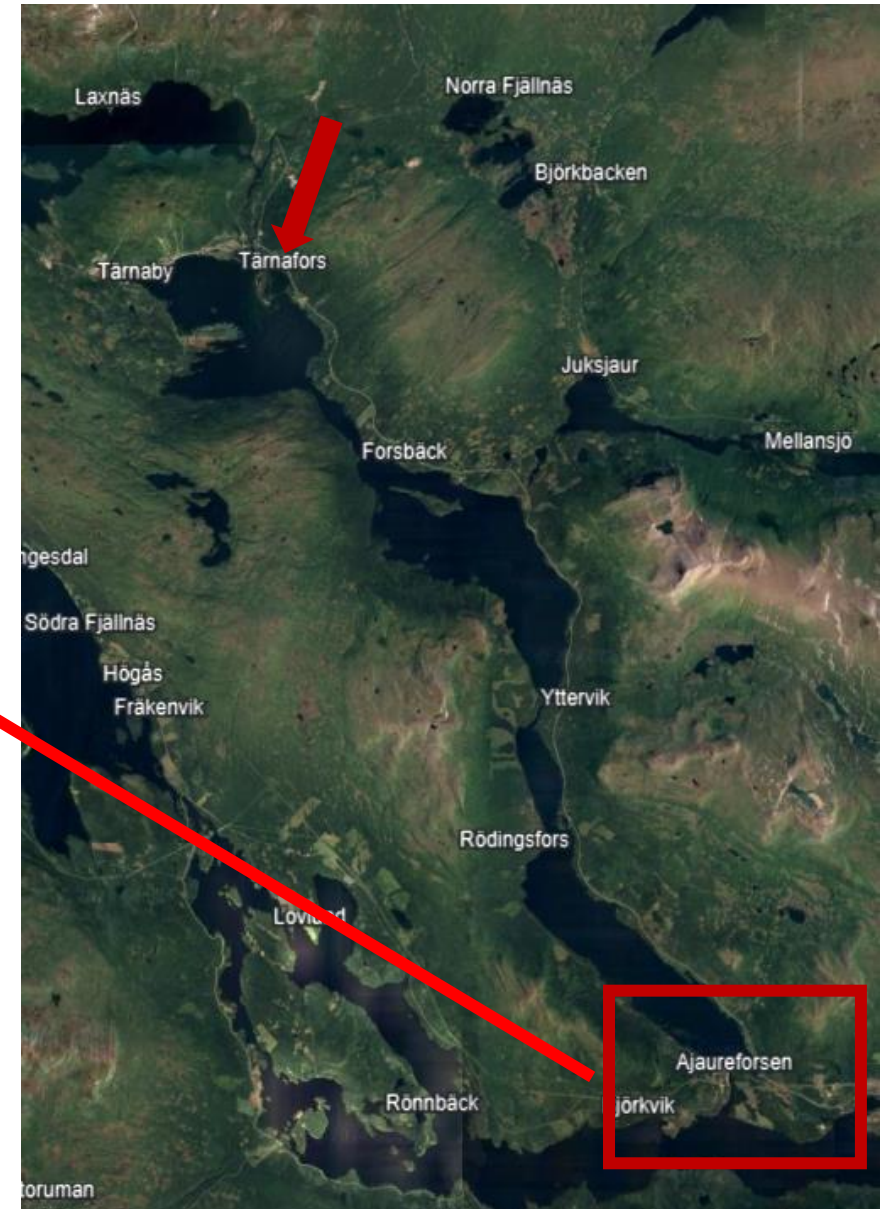


Preliminary results

- Study area

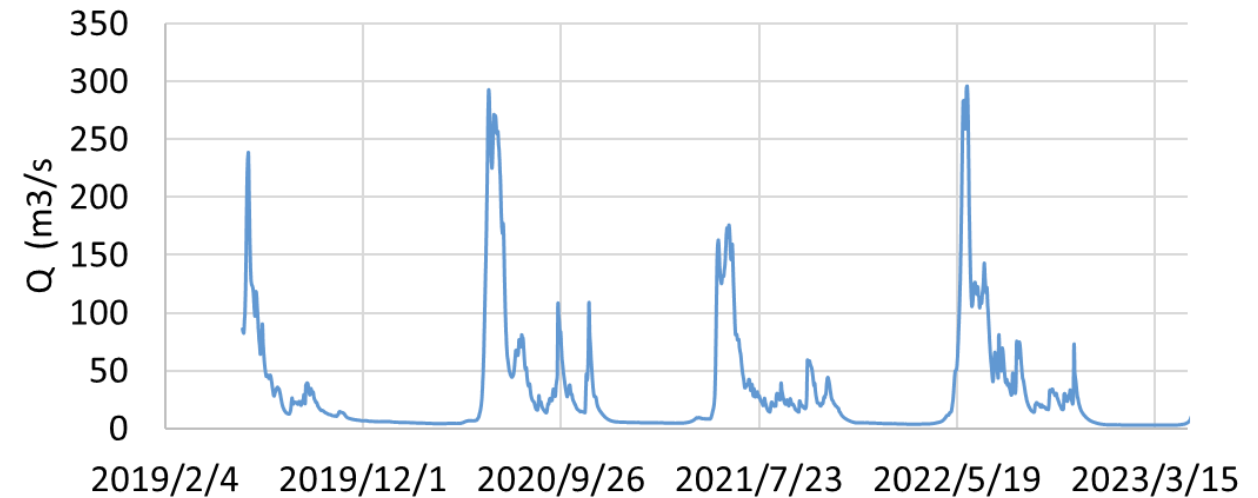
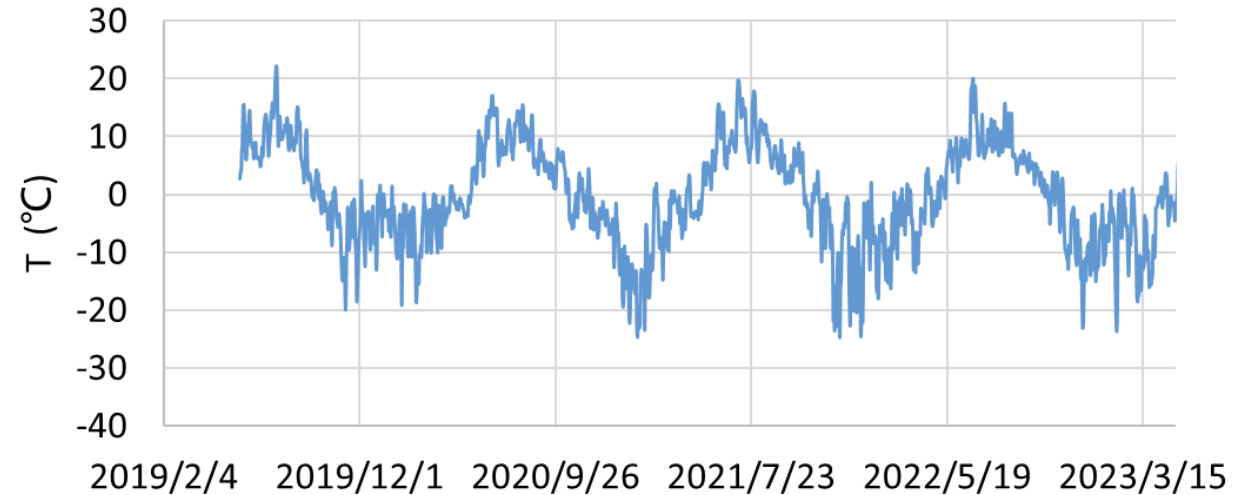
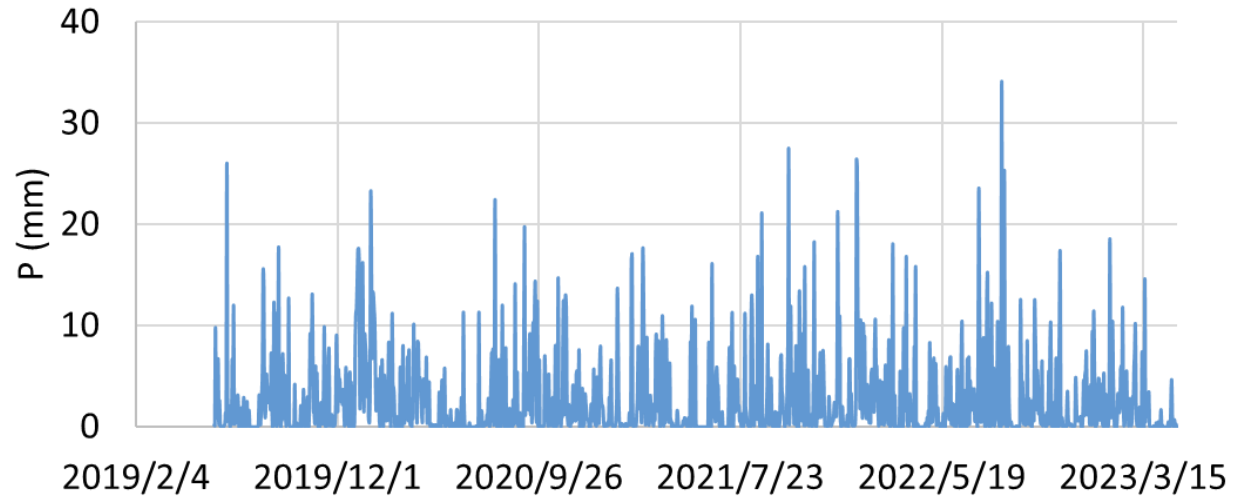


Electricity Capacity	80 MWe
Stream	Ume älv
Head	46 m
Water discharge	170 m³/s
Turbine type	Diagonal
Vattenfall ownership share	100 %
Status	In Operation



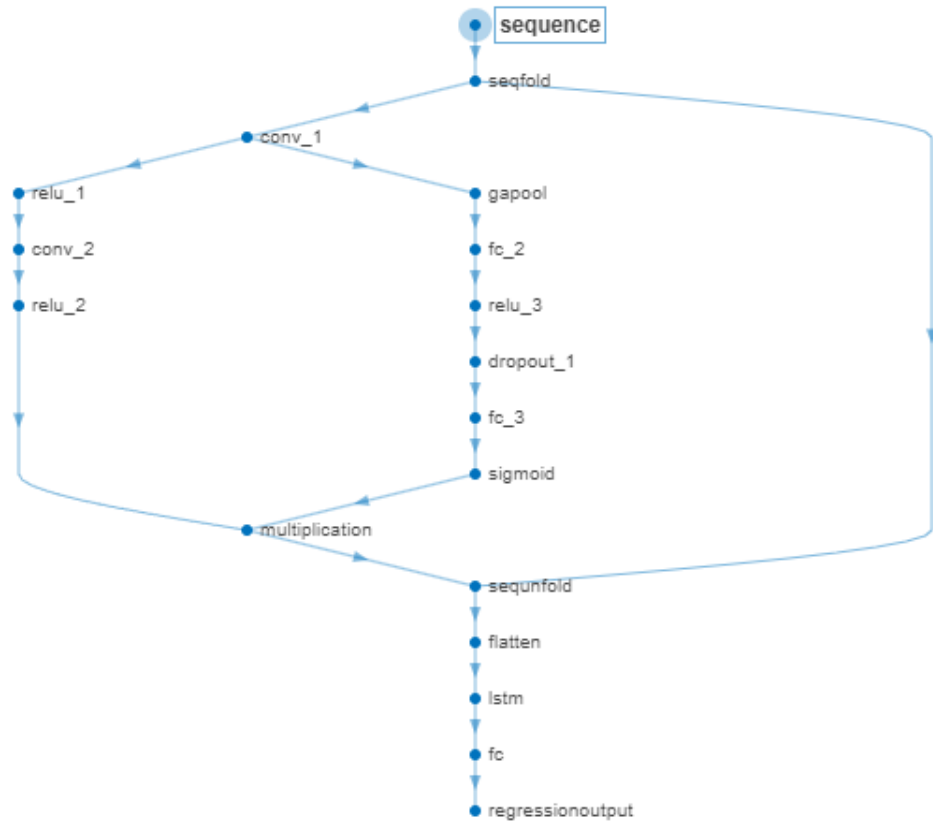
Preliminary results

- Data collection: 5yrs, June 2019 - May 2024

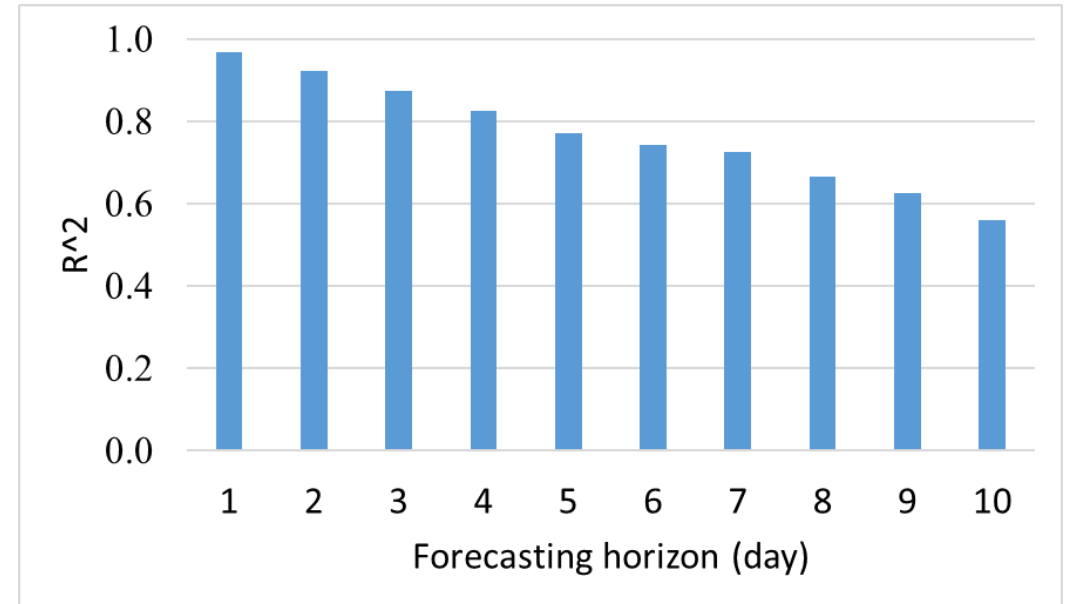


Preliminary results

- Model: CNN-LSTM with attention

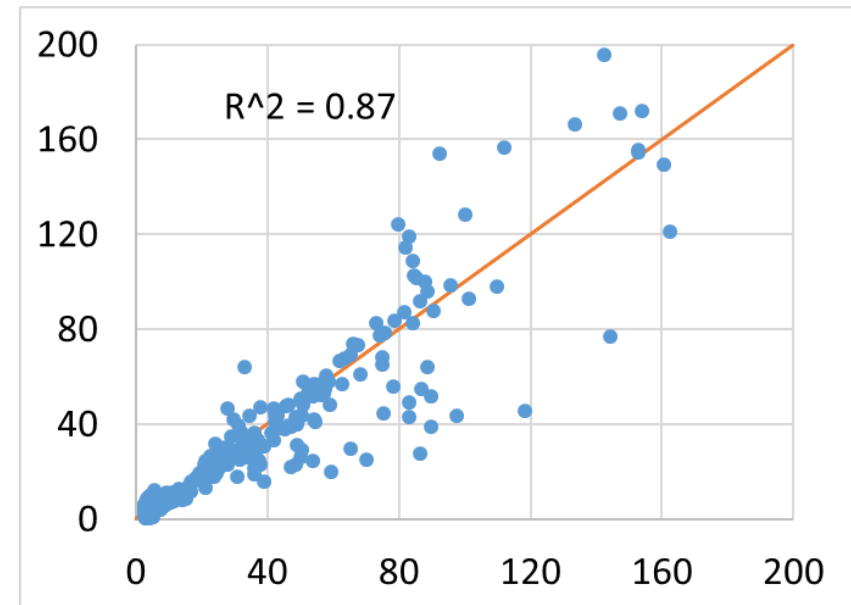
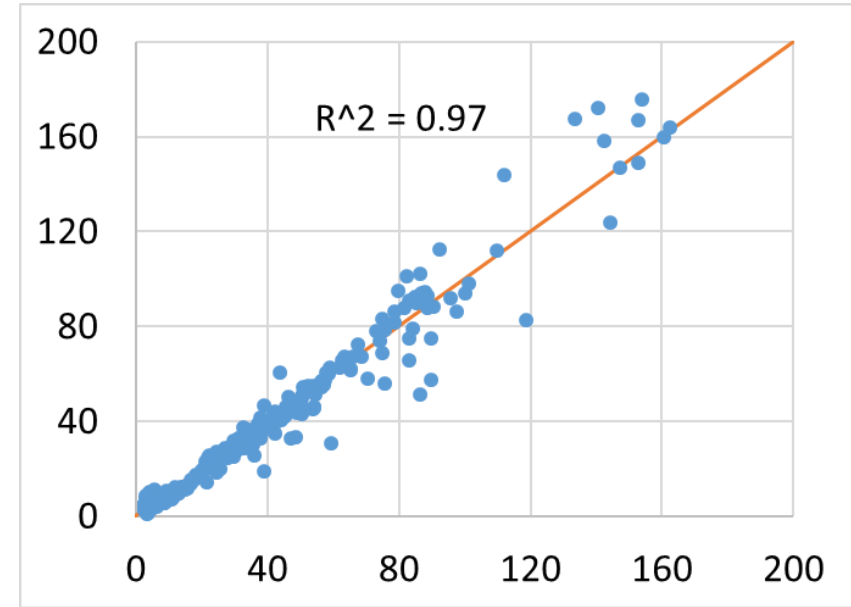
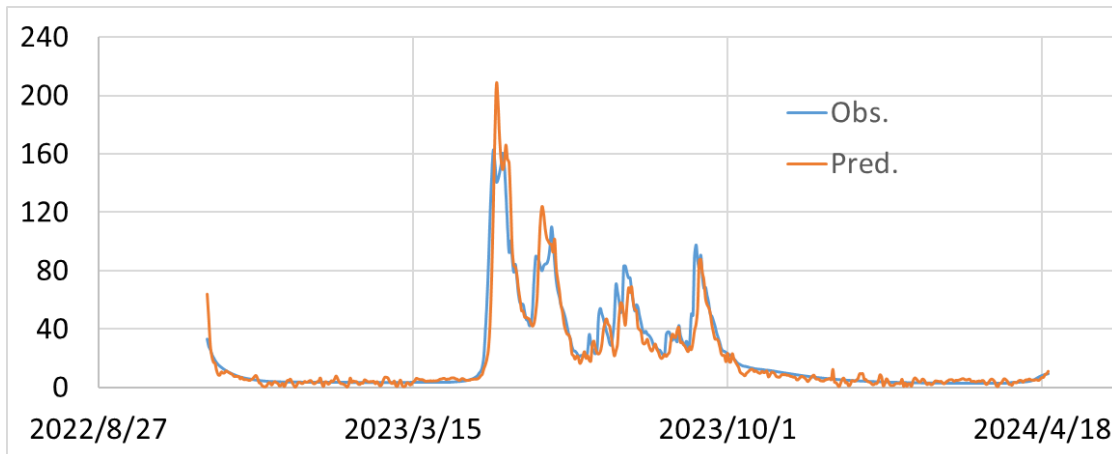
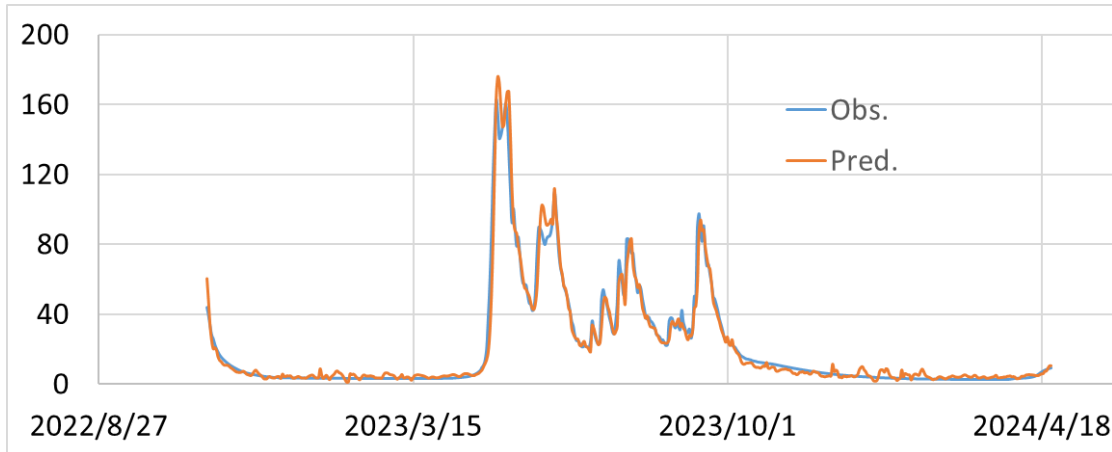


FH (day)	R ²	RMSE (m ³ /s)	MAE (m ³ /s)
1	0.97	5.34	2.71
2	0.92	8.44	3.97
3	0.87	11.06	4.86
4	0.82	14.15	6.48
5	0.77	15.42	7.11
6	0.74	18.64	8.72
7	0.73	18.91	10.31
8	0.66	20.15	10.15
9	0.63	22.98	12.50
10	0.56	22.66	12.55



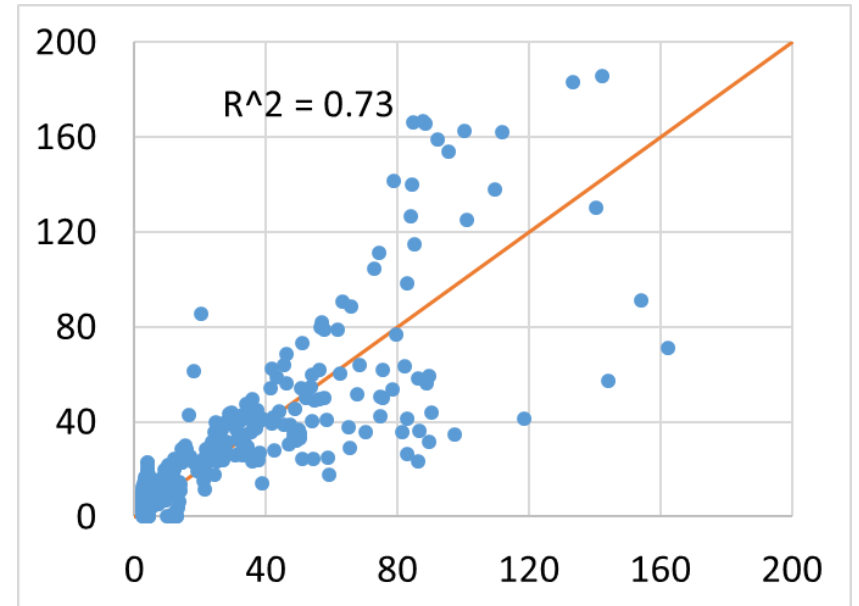
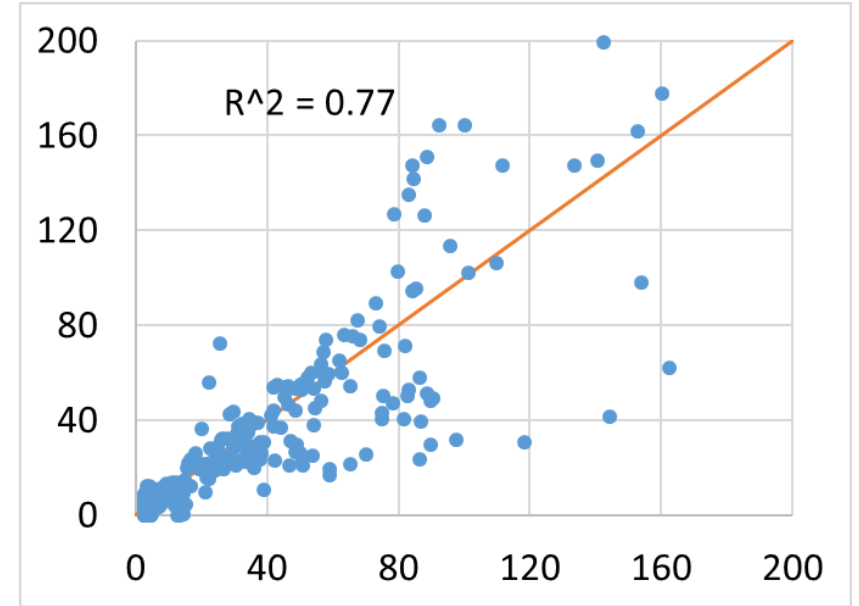
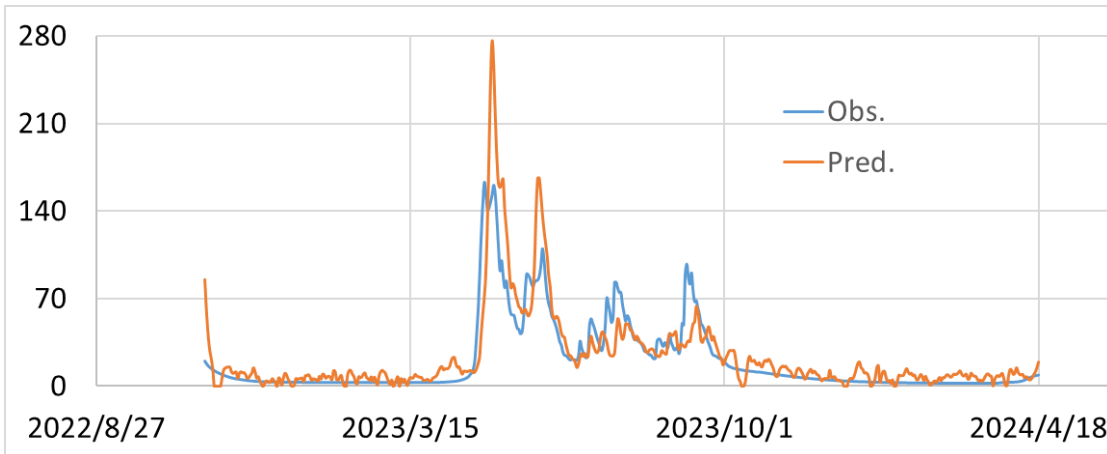
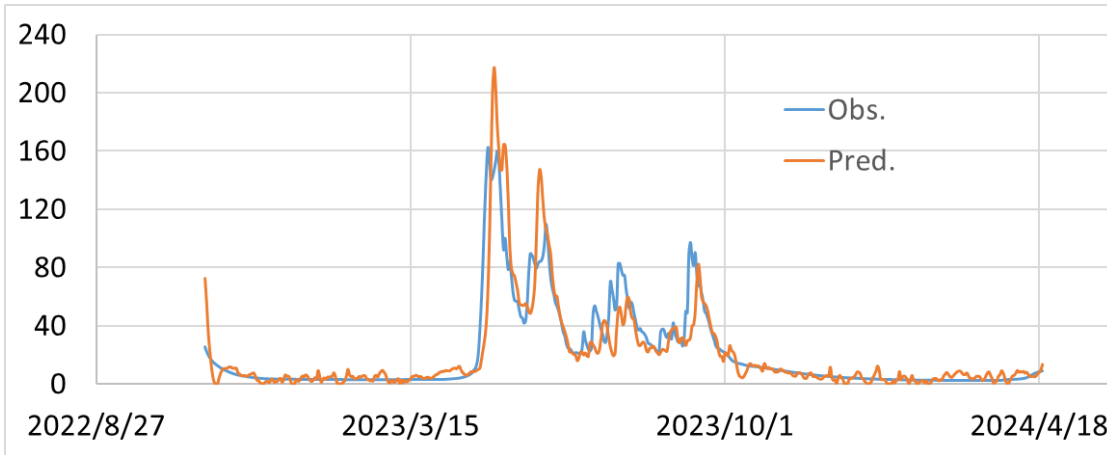
Preliminary results

- FH = 1, 3d



Preliminary results

- FH = 5, 7d. Calibration + validation < 5 min





What's next?

- Model optimization
- Data quality
- Uncertainty quantification
- Interpretability