Modelling runoff from green roofs using machine learning

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Introduction

- Climate change and rapid urbanization will increase stormwater runoff in future cities. Green roofs can reduce stormwater runoff from building.
- There is a need for a proper modelling tools that can predict runoff reduction for green roofs.
- This study investigated the potential of using Machine Learning (ML) to simulate runoff from green roofs.

Methods and Data

- Artificial Neural Network (ANN), M5 Model tree, Long Short-Term Memory (LSTM) and k-Nearest Neighbor (kNN) were applied to simulate hourly stormwater runoff from sixteen extensive green roofs located in four Norwegian (Figure 1).
- Uncalibrated SWMM (Physically-based model) models were used in this study as 'measure of information' of the ML models. That means, if ML models could yield better results than SWMM models with arbitrary choice of model parameters, then they carry useful information about the system.
- The study investigated the potential of using ML models as a design tool that predict the performance of new roofs. This was done by testing transferability performance of ML models between the different roofs, i.e. predicting the runoff of a green roof using a model of another green roof

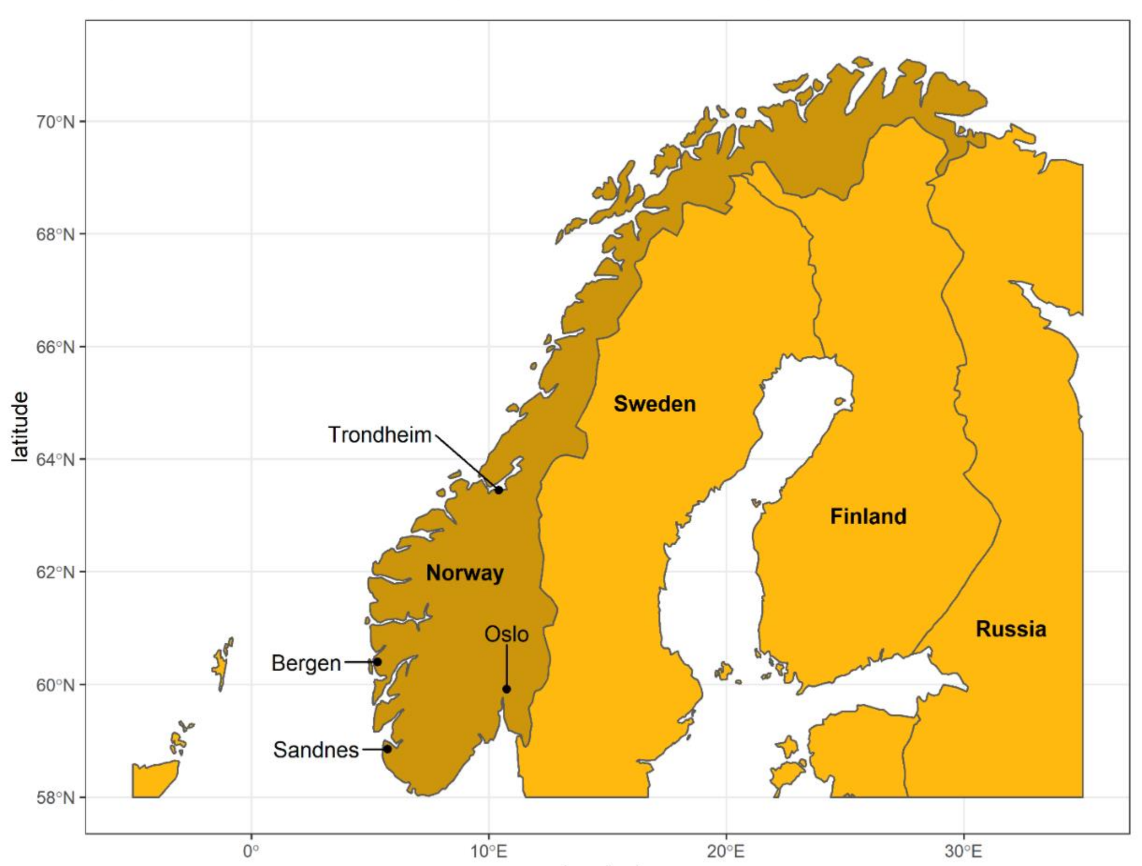

Figure 1: Locations of the four Norwegian cities

Results

Table 1: Overall modelling performance (NSE)

Green Roof	ANN		M5 model tree		kNN		LSTM		SWMM
	Training	Validation	Training	Validation	Training	Validation	Training	Validation	
BERG1	0.85	0.83	0.94	0.93	-	0.88	0.81	0.82	0.64
BERG2	0.76	0.82	0.85	0.93	-	0.86	0.7	0.79	0.68
BERG3	0.73	0.77	0.83	0.87	-	0.79	0.66	0.75	0.58
BERG4	0.88	0.82	0.95	0.92	-	0.87	0.84	0.8	0.59
BERG5	0.84	0.77	0.94	0.89	-	0.78	0.79	0.75	0.64
OSL1	0.88	0.52	0.92	0.67	-	0.57	0.73	0.58	0.63
OSL2	0.89	0.52	0.97	0.72	-	0.58	0.65	0.59	0.59
OSL3	0.88	0.54	0.96	0.63	-	0.57	0.72	0.59	0.65
SAN1	0.94	0.77	0.95	0.82	-	0.69	0.88	0.74	0.48
SAN2	0.92	0.58	0.93	0.69	-	0.56	0.83	0.62	0.5
SAN3	0.9	0.67	0.94	0.61	-	0.48	0.84	0.74	0.47
SAN4	0.9	0.67	0.94	0.61	-	0.48	0.84	0.74	0.45
TRD1	0.88	0.66	0.89	0.56	-	0.55	0.79	0.7	0.44
TRD2	0.89	0.65	0.83	0.56	-	0.47	0.85	0.73	0.44
TRD3	0.84	0.51	0.8	0.57	-	0.51	0.61	0.58	0.45
TRD4	0.9	0.54	0.75	0.59	-	0.51	0.6	0.52	0.55

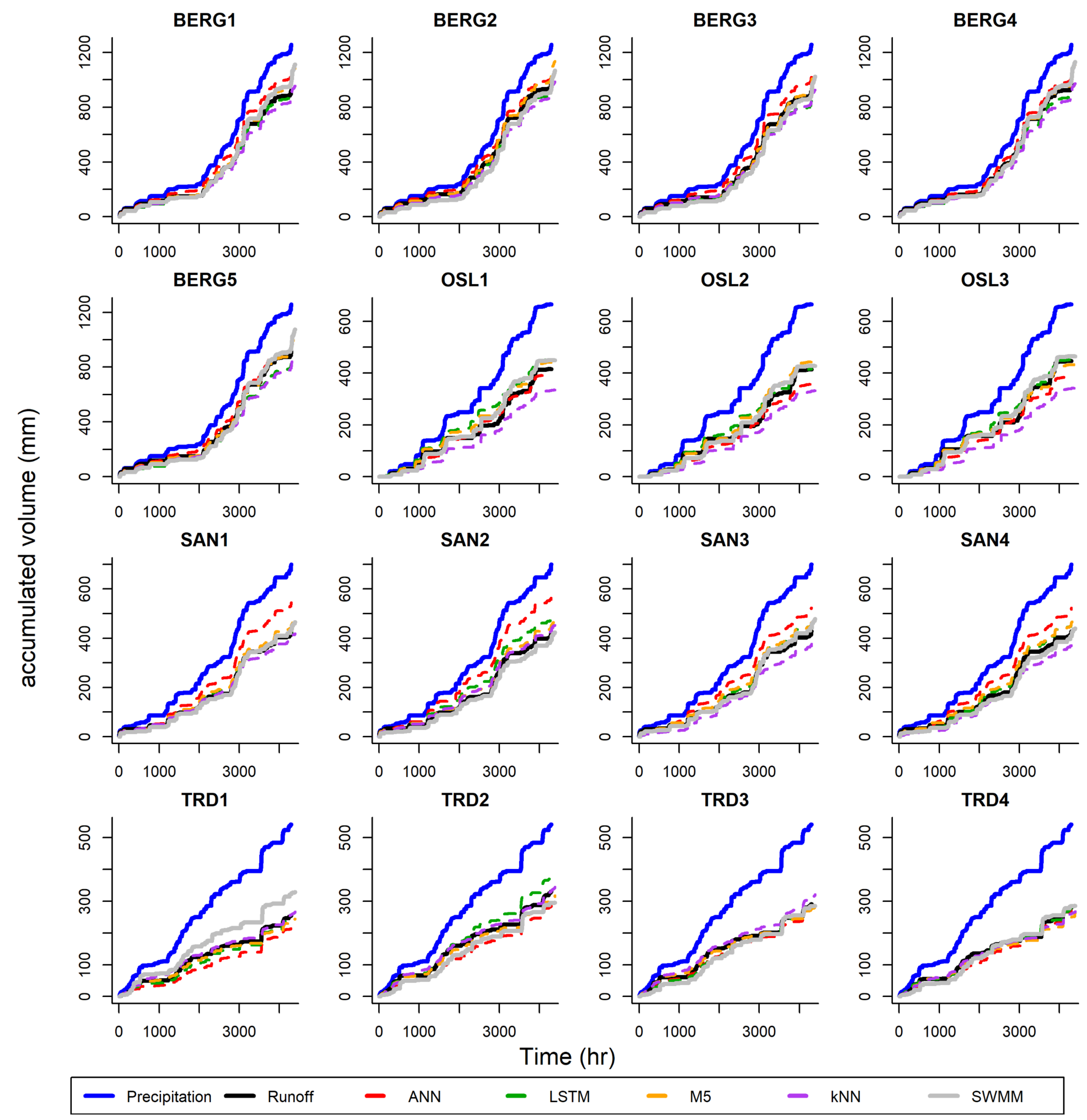

Figure 2: Cumulative precipitation, observed and simulated runoff of the green roofs

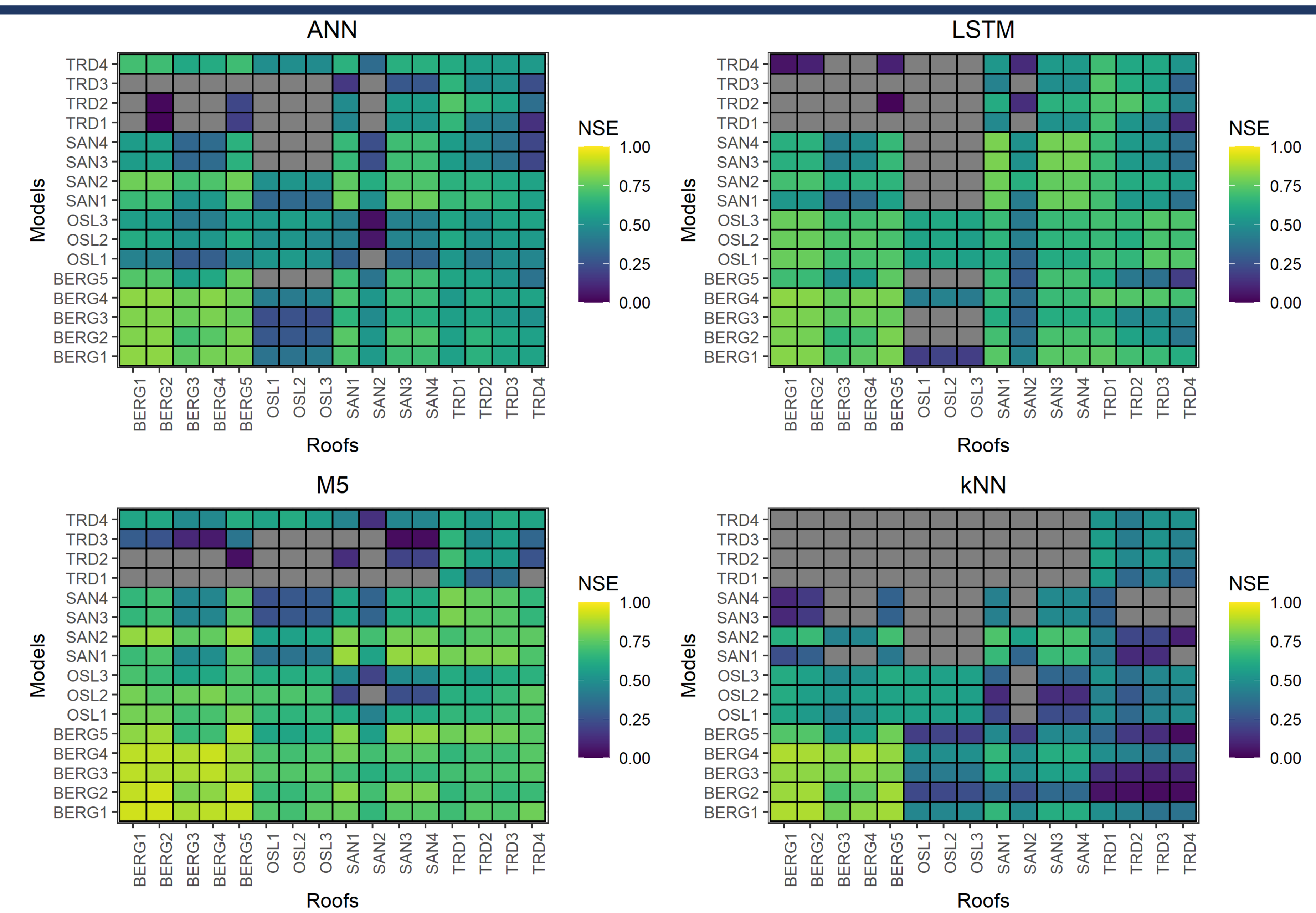

Figure 3: Transferability between the different roofs (NSE). Models in the y-axis are used to simulate the roofs in the x-axis. Grey-coloured boxes are values with NSE that is less than 0

Main findings

- **Machine Learning models could produce better modelling results than the uncalibrated SWMM models in most cases (see Table 1)**
- **M5 model tree and LSTM performed better than ANN and kNN (see Table 1 and Figure 2)**
- **LSTM, M5 and uncalibrated SWMM can be used to estimate runoff reduction from green roofs (see Figure 2).**
- **Transferability of LSTM and M5 model tree between roofs located in different places was found possible in most cases, especially within the same city (see Figure 3).**
- **The transferred models can be used to predict runoff reduction for unmonitored and new roofs (as a design tool).**

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