Transferability of data-driven models to map urban pluvial flooding

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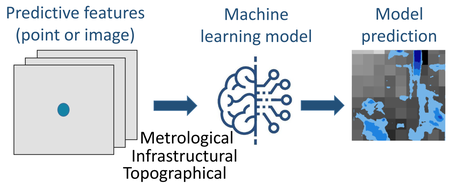
1- Introduction

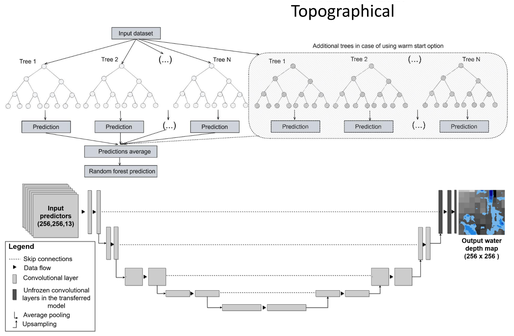
Urban pluvial flooding can occur anywhere in an urbanized watershed, even in areas without previous flooding. Traditional 2D hydrodynamic models are costly and limited in their scope. Data-driven models are emerging as a more cost-effective alternative but face challenges in generalizing beyond the training domain. **Hence, we want to know:**

1. Do traditional machine learning algorithms outperform convolutional neural networks (CNNs)?
2. Can transfer learning techniques improve the model performance outside the training domain ?

2- Methods and study area

1. Train a model and evaluate its ability to generalize to new areas.





→ Random forest (RF) model. (point-based model)

→ Convolutional neural networks (CNNs) model – U-Net architecture. (image-based model)

2. Use transfer learning techniques to boost the model performance outside the training area.

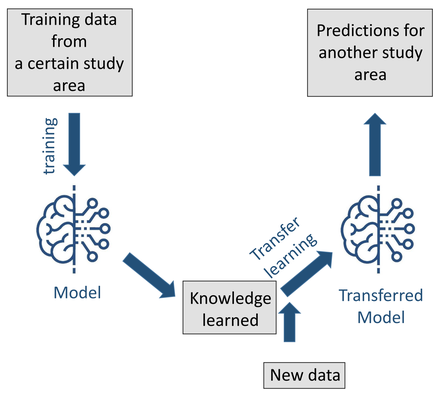
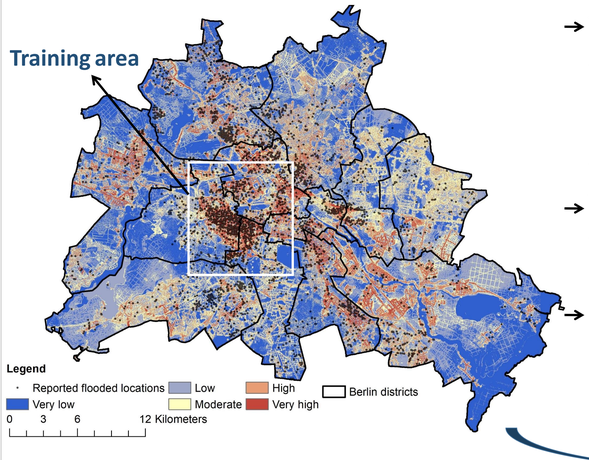


Fig. shows the study areas. Berlin has a flood inventory (gathered from 2005). The NRW has online available urban pluvial flood maps and damage data from Spekkers et al. 2017 .

3- Models transferability to map flood susceptibility



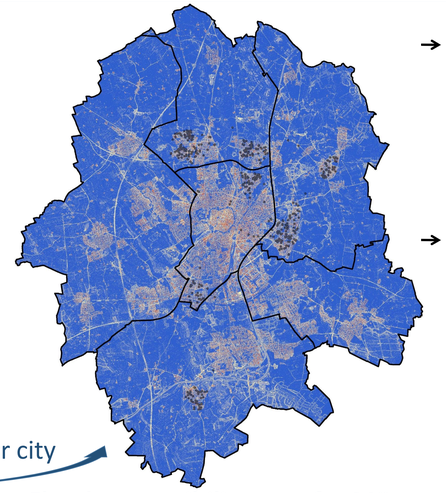
Flood susceptibility map for Berlin

→ The predicted flood susceptibility map for Berlin using random forest model (RF) at a 2 m spatial resolution.

→ The random forest models outperformed the CNNs models.

→ The models could identify flood susceptible areas outside the training area.

Model transferability to another city



Flood susceptibility map for Münster

→ The predicted flood susceptibility map for Münster by a random forest model that had been trained for Berlin.

→ The reported flood damage locations from July 2014 rainfall event agree with the predicted map.

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4- Models transferability to predict flood water depth

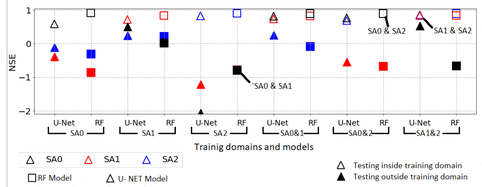
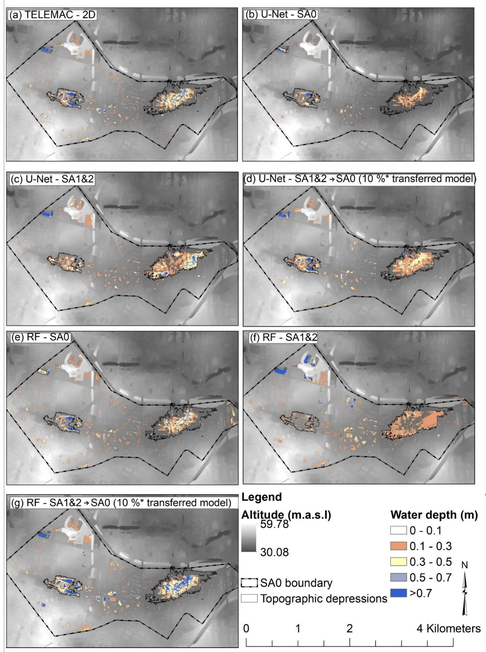


Fig. Computed performance indices for different combinations of training datasets for both the U-Net and RF models. The x axis shows the model used and the training domain, while the y axis shows the performance indices.

→ The **CNNs models** had significantly higher potential than the **RF models** to generalize beyond the training domain

→ The **RF models** outperformed the **CNNs models** for predictions within the training domain, presumable at the cost of overfitting



→ Comparison of water depths from different models and TELEMAC-2D model for a 100 mm precipitation event for study area SA0. The figure highlights the boundary of two topographic depressions within study area SA0 where runoff accumulates.

→ The transferred **U-Net-SA1&2 → SA0** model outperformed other models. It predicted the most identical inundation extent as the TELEMAC-2D model.

→ The **RF-SA0** model memorized the training data and thus predicted the water depth accurately.

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Take Home Message

1. Random forest models are superior to mapping urban pluvial flood susceptibility.
2. CNNs models have a significantly high potential than the random forest models to generalize beyond the training domain.
3. CNNs models could better benefit from transfer learning techniques to boost their performance outside training domains.

Future research requires testing transferability further in environments with different characteristics (cities in more mountainous environments).

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