Title of the project: Evaluating the generalization abilities of a Graph Neural Network to predict floodings for unseen topographies.

Assignment no.: **17.24**	**Internal/external:** External
Head graduation committee: tbd	**Daily advisor:** Fedde Hop (Hydrologic) Bram Schnitzler (HydroLogic) Anouk Bomers (UT)
Name(s) of participating companies or institutes: Hydrologic	**Start of the project:** As soon as possible
Required courses: Hydraulic modelling	

Short description of the project

Floods are amongst the world's most damaging and most frequently occurring natural hazards. Forecasting the temporal and spatial flood behaviour is essential to communicate safe evacuation routes to those potentially affected. To simulate flood propagation, typically hydrodynamic models are used. Although accurate, these models cannot be used for short-term forecasting due to their long simulation times. Developing faster alternative modelling approaches has therefore become an active field of research. Artificial neural networks (ANNs) gain much attention for flood forecasting purposes because of their ability to mimic complex non-linear input–output behaviour, while having very low computational times. ANNs are typically trained using input-output of a detailed hydrodynamic model. Most ANN architectures developed so far have problems generalising to unseen landscapes. Consequently, trained ANNs can only be applied to a specific case study, making them unsuitable for quick assessments of unseen topographies.

Graph Neural Networks (GNNs), may overcome this generalisation problem. GNNs are based on graphs defining the nodes and edges of a computational grid. GNNs use the information encoded at the nodes, edges and graph structure and process these data with neural networks similar to how numerical models solve the partial differential equations using neighbouring grid cells. Bentivoglio et al. (2023) developed a GNN by implementing the Shallow Water equations in the propagation rules. As such, the GNN learned how fluxes are exchanged between cells, based on topographical slopes and water level gradients. The study showed that, by including a wide range of schematised topographies in the training data, the GNN was able to predict overland flow to unseen topographies accurately. However, the applicability of the GNN approach to realistic case studies has yet to be evaluated.

In this study, the ability of GNN architecture as developed in Bentivoglio et al. (2023) to predict flooding in realistic case studies will be tested. For more information, you can read the vacancy at: https://www.hydrologic.nl/vacature/afstudeeropdracht-overstromingen-voorspellen-ai.

References

Bentivoglio, R., Isufi, E., Jonkman, S. N., Taormina, R. (2023). Rapid Spatio-Temporal Flood modelling via Hydraulics-Based Graph Neural Networks. EGUsphere, 1–24. https://doi.org/10.5194/egusphere-2023-284