

# Using AI to develop early warning systems for flooding

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In the future, summer houses and agricultural land in Jammerbugt Municipality will be even more exposed to flooding following heavy and continuous rain.  
Credit: Jammerbugt Municipality

Susanne Nielsen realizes that it is probably only a matter of time before her parents' summer house at Slettestrand in North Jutland is affected by flooding. Because under the house, which is just 400 meters from the bay of Jammerbugt in the municipality of the same name, the

groundwater level is now often so high that there is a risk that large amounts of rain will not be able to seep away, but rather enter the house.

"It's a concern we have if we get a lot of rain," she admits.

To give residents and [decision-makers](#) the best chance to protect themselves against flooding in the area, researchers from DTU have helped Jammerbugt Municipality develop an early warning tool. It can provide 48 hours' notice of local flooding along rivers, streams, and coastal areas in the municipality. It is the first of its kind to provide local flood warnings.

"It will give us time to react if necessary, so it will be a huge help," says Susanne Nielsen from her home in Aalborg—some 40 kilometers away from the summer house which she looks after for her parents, who live in Norway.

## **Complex nature, complex calculations**

The tool—a so-called "wet index"—is based on [artificial intelligence](#) trained on freely available data on dynamics that influence the risk of flooding. Data comes from [satellite imagery](#) and weather forecasts, as well as information on ground and seawater levels and the topography of the landscape.

However, the movement and accumulation of water in open landscapes are difficult to calculate because many parameters affect how water moves and accumulates. To handle this complexity, artificial intelligence was used in the development of the model behind the wet index.

By utilizing specific design principles in the construction of the model and feeding it with carefully selected data, the researchers have incorporated an understanding of water movement, distribution, and

interaction with the surrounding environment, according to Roland Löwe. He is one of the developers of the wet index and an Associate Professor at DTU specializing in how water behaves.

## **Both ups and downs**

Jammerbugt Municipality tested the tool in 2023. The results show better than expected predictions for the wet spring months. However, during the summer period, when Denmark was almost drought-stricken, the tool incorrectly predicted flooding in the same areas that had been flooded during the rainy spring.

The incorrect predictions were due to the tool being trained with too little data from the summer months. This is because satellites cannot register water beneath vegetation and given that fields are covered by plants during the summer, the data set at that time of the year is smaller.

"An early warning needs to be relatively accurate for citizens to trust the system. This is why we chose to do a trial run, where only selected citizens have checked it regularly—and where we as a municipality had drones in the air to validate predictions," explains Project Manager Heidi Egeberg Johansen from Jammerbugt Municipality.

However, she emphasizes that the overall experience is that the project partners have created a tool with great potential. Therefore, the municipality is seeking funding to re-train and possibly adjust the model, which will be offline until that work has taken place, says Heidi Egeberg Johansen.

## **Faster calculations and decisions**

Accurate calculations are crucial—not only when citizens and emergency

services need to get water tubes and sandbags ready, but also when, for example, municipalities need to decide how best to expand their drainage systems to handle the wetter climate of the future. Traditional simulations can easily produce rock-solid calculations of systems' ability to divert water under different scenarios—but according to Roland Löwe, they take forever to complete.

"In practice, this means that every time planners need to analyze something, they have to hire consultants who disappear into a box for two months before they can come back with results. And that's just too inconvenient," he explains.

To shorten the computation time while maintaining the physical accuracy, the researchers rely on scientific machine learning, a branch of artificial intelligence that combines two different approaches.

## **Two approaches in one**

One is machine learning, where a computer figures out how to analyze a large amount of data and makes predictions without having a theoretical understanding of the phenomena it is analyzing. The spam filter in your email or the facial recognition feature in your phone are examples of machine learning.

The other approach is [scientific computing](#), which can, for example, simulate physical processes, which in this case is how water moves through a given space under the influence of several factors.

"The advantage of combining the two approaches is that you get machine learning models that have a built-in understanding of how the system is expected to behave. This helps to ensure that the models generate fast predictions that make sense physically and aren't all over the place, which can be a problem with machine learning models," says Roland

Löwe.

In a project where the professor, along with startup WaterZerv and Associate Professor at DTU Allan Peter Engsig-Karup, used scientific machine learning to predict the movement of water through [drainage systems](#), they managed to perform calculations 100 times faster than with traditional models.

"So instead of outsourcing a project, you can gather the relevant decision-makers in a room to run the models live and get the results more or less immediately. You can then sit down and try out different options to find the best solution for a given situation," he explains.

Provided by Technical University of Denmark

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