SCIENCE FOR ENVIRONMENT POLICY

To aid water-management policy, long-term drought risk modelling must couple detail with fast computation

27th October 2021
Issue 570

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Source:
Mens, M., Minnema, B., Overmars, K. and van den Hurk, B. (2021) Dilemmas in developing models for long-term drought risk management: the case of the National Water Model of the Netherlands. *Environmental Modelling & Software*: 105100.
Link: https://www.sciencedirect.com/science/article/pii/S1364815221001432

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The effects of climate change and other factors such as changes in water use on future droughts are uncertain. However, policymakers must conceive long-term strategies to mitigate the risk of water shortages. Integrated assessment models that simulate possible scenarios can support decision making. Yet, these models suffer a trade-off between timeliness and detailed output. Referring to the Netherlands' National Water Model, researchers have described this dilemma, along with suggestions for solving the problem.

Drought-risk management involves understanding likely future drought conditions and impacted sectors. Models are indispensable tools for exploring connections between the elements involved (for example, how agricultural dependency on water supply is affected by more frequent periods of low river discharge). However, representing complex system dynamics, at a range of scales and over long periods, can lead to long computing times.

In the case of the Netherlands' National Water Model, this presents a serious dilemma for model developers and project managers, say researchers. Based on in-depth analysis, including interviews with scientists and policymakers, the researchers look at the evolution of the model, and whether it is relevant for the decision-making process, acceptable to stakeholders and timely for decision making. The study's results are to be used in the country's updated Delta Programme (2022–2027), addressing the strategy to manage water shortage due to drought,[1] but can also inform developers and users of similar models elsewhere.

The National Water Model project is led by an advisory board, steering and scientific committee. It is an example of a modular assemblage approach (or a connected group of models), as opposed to a single model representing a whole system. That is, existing models[2] are reused, reducing development time, cost and effort. It incorporates four national sub-models simulating physical processes: a hydrological model; a hydrodynamic model (i.e., modelling fluids in motion) of major

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"Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

rivers and canals; a hydrodynamic model calculating salt-water intrusion in coastal waterways in the Netherlands' south-west; and a surface-water temperature model. The Delft-FEWS[3] computational framework links these sub-models.

The model has been used to forecast and explore the impacts of water shortage in 2050 and 2100, under five scenarios, including one where peat areas are wetted to reduce CO^2 emissions. The models have to deal with a great degree of uncertainty, and running a whole 100-year simulation (to reflect the wide variety of drought conditions) can take two to three months, including the time it takes to prepare scenario inputs. This makes it difficult to synchronise with the policy-making process. Due to time and cost constraints, the full model has been used to compare just three strategies.

The model fulfils the requirement to realistically represent the physical drivers and propagation of drought, including frequency and intensity of impacts — such as low waterway depths affecting inland shipping. However, it does not manage to do so in a reasonable time, limiting its usefulness. In response to the need for fast, rough explorations of policy measures, a less-detailed quick-scan tool has therefore been developed that completes simulations in a few hours. This meta-model has been used to explore a set of 30 policies but offers reduced information.

Although the integrated approach cuts development costs and fulfils multiple stakeholder requirements, policymakers told the researchers that exploring just three strategies with the full model was not sufficient to address all questions. For example, it did not address the relative impact of drinking and agricultural water abstraction on declining groundwater levels. The researchers would need to explore different levels of complexity to address the simulation time. But it is impossible to adjust sub-models when they are used for other purposes such as short-term forecasting.

To improve the national model, the researchers recommend an increase in the flexibility of the modelling framework and software. Updating the application used for groundwater modelling would facilitate this, they say. They also propose the use of a simpler and faster meta-model (intended to give an all-inclusive picture of a process or system, especially by considering data from detailed individual models) that includes all relevant processes, to quickly explore many scenario/strategy combinations. This meta-model should be consistent with the complex national model.

1. Drought is defined as a period of precipitation deficit, low river discharge or a combination of both. Impacts include soil moisture deficit, shortage of supply for irrigation, low water levels in transport waterways and warmer temperatures in rivers and canals.

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Insights from this case may be valuable for others developing and maintaining similar models for long-term policymaking for water resources management. In the light of changing requirements, a continuous conversation between policymakers and model developers is necessary and should be formalised, say the researchers. They also conclude that a standardised procedure is needed to ensure consistency between meta-models and complex, institutional models.

2. Some sub-models — describing impacts on agriculture, shipping, industry and drinking water, for example — were first developed in the 1980s, the researchers note, and have undergone numerous updates.

3. Werner, M., Gijsbers, P., Schellekens, J., van Dijk, M., van den Akker, O., Heynert, K. (2013) The Delft-FEWS flow forecasting system. *Environ. Model. Software* 40: 65–77. https://doi.org/10.1016/j.envsoft.2012.07.010