26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Comparing the performances of a physically based hydrologic model and machine learning model in the Ashburton catchment, New Zealand

Jing Yang [a], Yosuke Miura [b], Yohei Sawada [c], Qing He [c], Channa Rajanayaka [a], Doug Booker [a], Taikan Oki [c], Pan Liu [d], Barry Croke [e]

[a] Earth Sciences New Zealand, Christchurch 8011, New Zealand
Email: jing.yang@niwa.co.nz
[b] Ritsumeikan University, Kyoto, Japan
[c] The University of Tokyo, Tokyo, Japan
[c] Wuhan University, Wuhan 430072, China
[e] Australian National University, Canberra ACT 2601, Australia

Abstract: Although New Zealand has abundant water resources, their spatial and temporal distribution is highly uneven for both surface and groundwater systems. With many rivers and aquifers fully or over-allocated, there is an urgent need for water resource management that safeguards ecosystem requirements while meeting increasing demands from agriculture, industry, cultural and recreational activities, and domestic use. These pressures are further exacerbated by extreme events such as droughts and floods, alongside climate variability and population growth. Addressing these challenges requires a robust understanding of hydrologic responses to weather systems and anthropogenic activity and improved forecasting methods to support decision-making across multiple spatial and temporal scales while ensuring environmental sustainability.

The Ashburton catchment, located in New Zealand's South Island, exemplifies these issues, facing both flood and drought risks, alongside increasing water demands. Its rivers originate from snow-covered headwaters and drain eastward to the sea, while the groundwater system extends north to the Rakaia River and south to the Rangitata River. Understanding the interactions between streamflow, groundwater, climate, and human activity is therefore critical. To support flood forecasting and water management, we developed both a physically based hydrologic model which integrates an irrigation model (IrriSET, Srinivasan et al. 2021) and Three-Dimensional Variably Saturated Flow Model (Miura and Yoshimura 2022), and a machine learning model capable of simulating both streamflow and groundwater levels. Their performance is compared, and the advantages of each are evaluated, providing insights into the development of a hybrid physically based–machine learning hydrologic model. This approach aims to enhance decision-making for flood and drought mitigation and sustainable water resource management.

REFERENCES

Miura, Y., & Yoshimura, K. (2022). Development and validation of a three-dimensional variably saturated flow model for future water resource assessment at a global scale—Targeting saturated groundwater flow in plains. Journal of Advances in Modeling Earth Systems, 14, e2022MS003017.

Srinivasan, M.S., R. Measures, C. Muller, M. Neal, C. Rajanayaka, U. Shankar, G. Elley. 2021. Comparing the water use metrics of just-in-case, just-in-time and justified irrigation strategies using a scenario-based tool. Agricultural Water Management 258 (2021) 107221. DOI: 10.1016/j.agwat.2021.107221.

Keywords: *streamflow, groundwater, hydrologic modelling, machine learning*