Utrecht University
Faculty of Geosciences
Department of Physical Geography

A multi-resolution deep-learning surrogate framework for global hydrological models

Bram Droppers[1], Myrthe Leijnse[1], Marc F.P. Bierkens[1,2] and Niko Wanders[1]

[1]Department of Physical Geography, Utrecht University, Utrecht, The Netherland [2] Deltares, Utrecht, The Netherlands

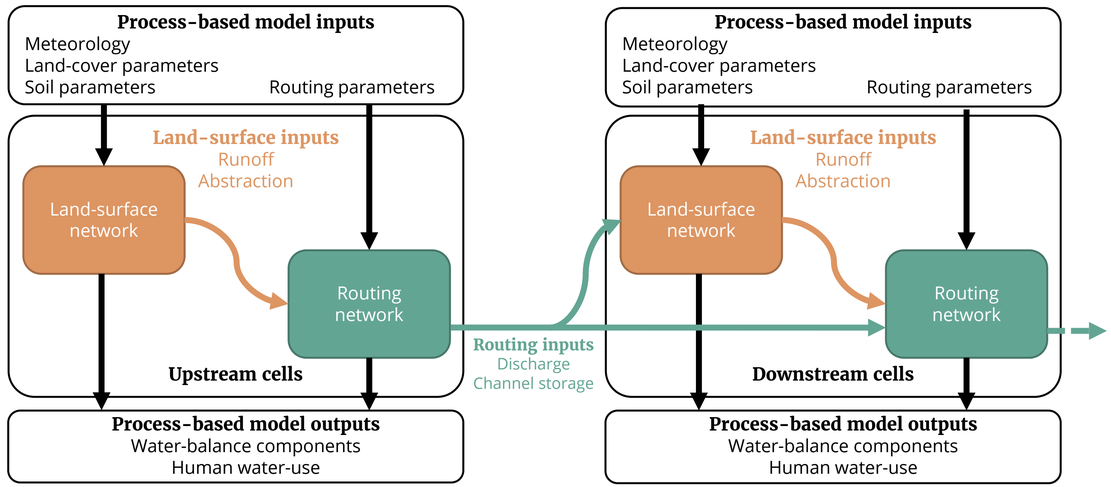

Figure 1

Deep-learning surrogate framework for global hydrological models. To incorporate human water-use, spatially explicit routing is required. Therefore, the framework consists of two different networks, a land-surface network and a routing network, that are processed sequentially from upstream to downstream.

Why develop deep-learning global hydrological model surrogates?

Global hydrological models (GHMs) are an important tool for sustainable development making in today's water-scarce world. However, the need for better, higher resolution and larger ensemble simulations is reaching the limit of what is computationally feasible.

Deep-learning model surrogates that use neural networks to emulate process-based hydrological simulations can provide computationally cheap hydrological predictions. However, most surrogates only focus on the land-surface water fluxes on a single spatial resolution, thereby limiting their application for global hydrological models.

Multi-resolution deep-learning surrogate framework

We present a novel framework to create deep-learning global hydrological surrogates, with two salient features. First, our surrogate framework integrates spatially-distributed runoff routing that is essential to simulate human water withdrawals. Second, our surrogate framework is scalable across different spatial resolutions and can match the wide variety of resolutions at which global hydrological models are applied.

Testing with the PCRaster Global Water Balance model

- In general, all models performed well for their target resolutions and captured the spatial and temporal patterns of the outputs.
- However, The single-resolution models perform poorly outside their target resolutions, indicating limited understanding of underlaying processes.
- Conversely, the multi-resolution model performs well on both resolutions and, surprisingly, often outperforms the single-resolution models on their target resolution.

Future of deep-learning surrogates

Deep-learning surrogates are a useful tool for the global hydrological modeling community, as they can aid in calibration (through parameter learning and flux matching) and more detailed model simulations. Our framework provides an excellent foundation for the community to create their own multi-scale deep-learning model surrogates.

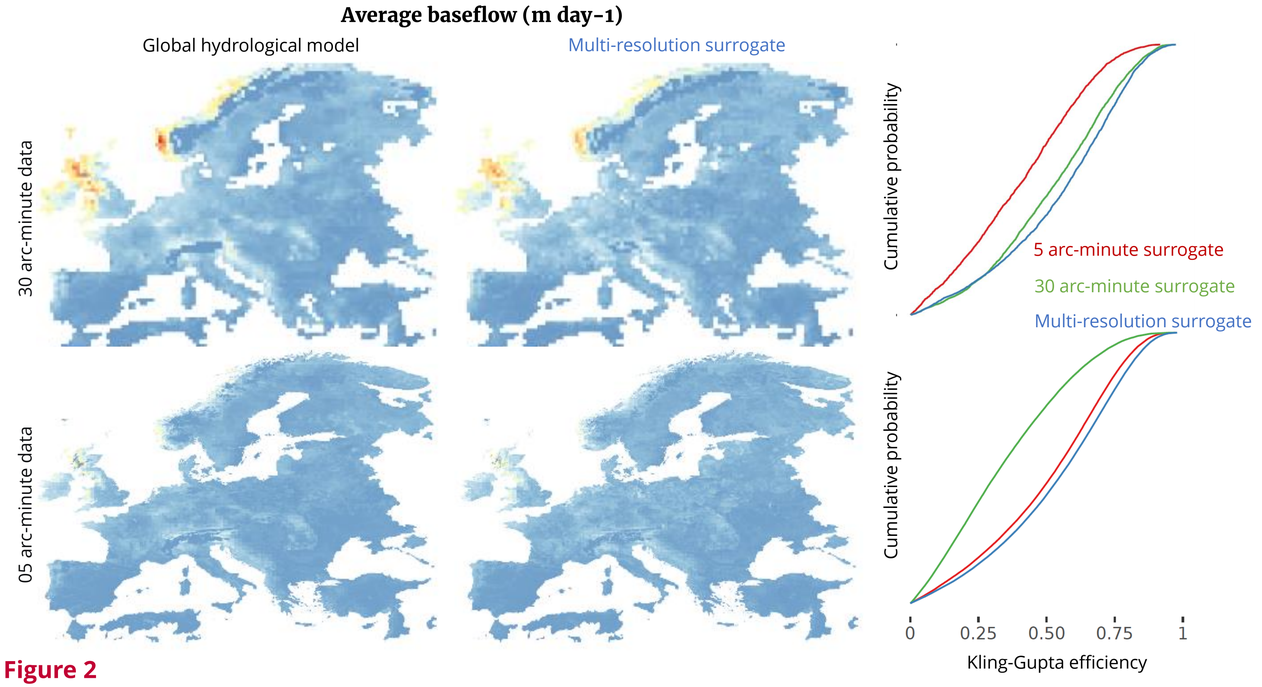

Figure 2

(left) Comparison between global hydrological model simulated and multi-resolution surrogate predicted average baseflow (m day-1) at 30 arc-minutes and 5 arc-minutes. (right) Multi-resolution and two single-resolution (one trained at 5 arc-minutes and one trained at 30 arc-minutes) performance. Note that the multi-resolution out-performs the single resolution models, even at their target resolution.

uu.nl/staff/Bdroppers twitter.com/DroppersBram b.droppers@uu.nl