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Towards scalable and reproducible hydrological modelling with HydroMT: A proof of concept for Australia

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Abstract: Reproducibility of model building and analysis is becoming increasingly important in times where scientific work is being questioned in debates about our planet's future. As a scientific community, but also more and more as governmental institutes, showing our work and promote feedback is required to move forward and further improve our work.

Next to that, there is an increasing trend in data availability. Recent advances in earth observations have opened vast amounts of good quality data that is invaluable for hydrological applications, especially in data scarce areas or over large geospatial domains. To access and operate on these datasets requires a new set of skills. Tools that can help hydrologist unlocking these datasets are needed to advance science and make more impact with our models.

HydroMT (Hydro Model Tools) is an open-source Python package that aims to make the process of building and connecting models and analysing model results automated and reproducible. The package provides a common interface to data and models, includes workflows to transform data into models based on (hydrological) GIS and statistical methods and comes with various methods to analyse model results.

HydroMT is built on top of commonly used Python libraries such as *pandas*, *rasterio* and *xarray*. This Python ecosystem allows for scalability, making HydroMT suitable for applications at global, regional, and local scale. The architecture of HydroMT ensures that data from various sources can easily be used together.

HydroMT has been applied in Australia for the setup of Flood Impact Forecasting System (FliFS) for the Bureau of Meteorology. For this system, hydrological (*wflow,* Van Verseveld et al., 2023) and flood models (*SFINCS,* Leijnse et al., 2022) were setup for the entire North-East, East, and South-East coast of Australia, using HydroMT. The region is split into 13 sub-domains, for which individual models were setup. The method was designed and tested for 1 region first and reproduced for all other regions. The fact that the whole modelling process was setup using HydroMT, made that upscaling from 1 region to 13 regions easily achievable and reproducible. All models are then integrated in an operational system for flood early warning (*Delft-FEWS*).

The workflows in HydroMT also include steps to derive model parameters on the fly, based on spatial characteristics of the region such as land cover or soil properties. The derivation of model parameters using Pedo Transfer Functions (PTFs) is implemented directly in the workflows of HydroMT. The same is true for the derivation of hydrographic properties of the river network. The direct link between earth observation data and model parameters makes that the models that are build using HydroMT generally give reasonable to good results "straight out of the box". The models can, and have been, further improved by including better (local) data and calibration of specific model parameters using data for historical events in the Brisbane river basin.

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