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How do we improve the reproducibility of hydrological simulation studies? A discussion of the approaches implemented in the HydPy framework based on HBV96.

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Many hydrological simulation studies are hardly reproducible. Today's state of the art in computer technology allows for approaching the goal of "open science" more closely. In the field of data and model exchange, efforts have long been made in this direction (for example, in the form of the HEPEX testbeds). Efforts in software maintenance and documentation have recently intensified. See e. g. the debate on how to achieve higher scientific standards in computational hydrology initiated by Hutton et al. (2016).

Higher standards of quality and transparency serve both a scientific and a practical purpose. Only transparent model systems enable the whole scientific community (not just advanced programmers with special source-code access) to fully understand the functioning of a hydrological model, to verify all its components, and to understand how it has actually been used in a study. Enlarged feedback on models and studies, based not only on conceptual descriptions but also on real implementations, should strengthen our skills in improving (or rejecting) our methods.

In our presentation, we will distinguish between three programming levels: the "framework level", the "model level", and the "workflow level". At the "framework level", conventions for implementing, testing, and applying models are made (by the hydrological community) and the technical prerequisites necessary to comply with these conventions are created (by programmers). At the "model level", different process equations are defined and compiled into verifiable modules (by the model developer). At the "workflow level", a simulation study is defined in the form of properly documented, easily executable source code (by the model user). We should strive for different degrees of complexity: much thought and work is required to set up a general framework that eases implementing and testing models and helps writing workflow scripts that are actually understandable and do what they promise to do.

We will describe how these different programming levels are addressed by the hydrological Python framework HydPy, which was cooperatively developed at the German Federal Institute of Hydrology and Ruhr University Bochum. An evaluation study on the "response area" option of the well-known HBV96 model serves as an example.