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The emergence of community models in hydrology

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Hydrological models (HMs) are essential tools to explore terrestrial water dynamics and to anticipate future hydrological events. Since their inception, HMs have been developed in parallel by different institutions. There is now a plethora of HMs, yet a relative absence of cross-model developments (code is almost never portable between models) and of guidance on model selection (modellers typically stick to the model they are most familiar with). Furthermore, traditional HMs, developed over the last decades by successive code additions, are rarely adapted to modern hydrological challenges, principally because they lack modularity. These HMs typically rely on a single model structure (most processes are simulated by a single set of equations), which make it difficult to i) understand differences between models, ii) run a large ensemble of models, iii) capture the spatial variability of hydrological processes and iv) develop and improve hydrological models in a coordinated fashion across the community.

These limitations can be overcome by modular modelling frameworks (MMFs), which are master templates for model generation. MMFs offer several options for each important modelling decision. They also allow users to add functionalities when they are required, by loading libraries developed and maintained by the community. This presentation uses FUSE (Framework for Understanding Structural Error) as an example of MMF for hydrology. FUSE enables the generation of a myriad of conceptual HMs by recombining elements from four commonly-used models. This presentation will summarize the development of FUSE version 2 (FUSE2), which was created with users in mind and significantly increases the usability and range of applicability of the original FUSE. In FUSE2, NetCDF output files contain a detailed description of the modelling decisions (e.g., selected modules, numerical scheme, parameter values), which improves reproducibility. FUSE2 also makes code re-usable, as modules can be used across the community and are not limited to a single model structure. After decades of siloed model development, we argue that MMFs are essential to develop and improve hydrological models in a coordinated fashion across the community.