HYPERstreamHS: A DUAL LAYER MPI CONTINUOUS LARGE SCALE HYDROLOGICAL MODEL FOR HUMAN SYSTEM

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The contest of climate change and water scarcity scenarios forces the developement of proper hydrological models able to deal both with large scale and long term simulations where a key role is played by the interaction between the hydrological cycle and artificial human infrastructures.
In this framework, hydrological models are characterized by high computational demands where large scale and long time simulations imply dealing with a large amount of data while predictions and uncertainty analyzes require fast run-time. However, only recently the High Performance Computing (HPC) with parallel computing began to have a key role in hydrological modeling. In particular, parallelization standard such as Message Passing Interface (MPI) and Open Multi-Processing (openMP) have been applied to serial hydrological models in order to reduce computational time of hydrological simulation and uncertainty analyses.
Despite the unquestionable advantages in parallel computing, it presents some limits: the speedup, which is the improvement in run time execution due to parallelization, does not increase once the number of processors exceeds a certain threshold. This issue is particularly evident in hydrological models where streamflow routing along the river network has to be executed serially, thus not allowing full parallelization of the code.
Motivated by above, in this work we present a new version of the hydrological model HYPERstream, named HYPERstreamHS, which has been parallelized with a double-layer approach based on the MPI standard. Specifically, the first layer represents the parallelization of the hydrological model itself: parallel simulation of hillslope hydrological fluxes and routing along the river network. Afterward, the second level of parallelization is embedded over the first. This second layer deals with model calibration and uncertainty analyses by subdividing the available processors in sub-sets, each one managing an independent simulation of the hydrological model adopting a given set of parameters.
The scalability and efficiency of the dual-layer approach applied to HYPERstreamHS have been tested on the Adige river basin. The results show that the scalability of the first layer, as expected, drops rapidly while the second layer of parallelization is able to restore performances to an almost ideal speed-up.