Natural Hazards
and Earth System
Sciences

Open Access

EGU

Supplement of

Evaluating the impact of model complexity on flood wave propagation and inundation extent with a hydrologic–hydrodynamic model coupling framework

Jannis M. Hoch et al.

Correspondence to: Jannis M. Hoch (j.m.hoch@uu.nl)

Supplement: GLOFRIM 2.0 and description of the supported models

GLOFRIM execution

In contrast to GLOFRIM v1.0, we streamlined the execution of the models and limited the amount of information supplied by the user to the necessary minimum. Users only need to reference the model's initialization files in a separate GLOFRIM-specific ini-file, which is enough for GLOFRIM 2.0 to interpret all model specifications including spatial domain, and to define the exchange of variables between models as well as the exchange interval. Also, we implemented a two-step model initialization in which all model-specific configuration files are first aligned to user-specified settings, such as the start and end times for simulation, and subsequently models are initialized based on the altered configuration.

GLOFRIM can then be executed from command line specifying the path to the required ini-file as well as the optional environment file (env-file) and start and end time (both as YYYY-MM-DD):

python glofrim_runner.py run /path/to/glofrim.ini --env /path/to/glofrim.env -s startdate -e enddate

By means of the environment file, where local paths to the model executables are provided, applying GLOFRIM in shared data environments is facilitated. To give users additional freedom, it is furthermore possible to not only execute coupled runs, but also run the models in stand-alone mode.

An example of the ini-file and further instructions how to execute a coupled model run using GLOFRIM can be found on the GLOFRIM online documentation at https://glofrim.readthedocs.io/en/latest/.

PCR-GLOBWB

PCR-GLOBWB (PCR; Sutanudjaja et al., 2018) is a global hydrologic model solving the water balance for the terrestrial part of the earth surface. PCR is entirely coded in PCRaster Python (Karssenberg et al., 2010) and distinguishes between two vertically stacked soil layers, an underlying groundwater layer, and a surface canopy layer. While in the default version it is possible to replace the groundwater layer with a fully-fledged groundwater model, this is not yet tested within GLOFRIM.

Water can be exchanged vertically, and excess surface water can be routed horizontally along a local drainage direction network employing the kinematic wave approximation. Currently, PCR is available at 30 arc-min spatial resolution as applied in the study and 5 arc-min spatial resolution. The latter, however, was not yet tested within GLOFRIM.

PCR requires precipitation and temperature as meteorological forcing and facultatively pre-processed potential evapotranspiration. If no data is provided, evapotranspiration is computed using the Hamon-approach.

Besides, PCR can account for domestic and industrial water consumption by accounting for water demand data. This also includes the explicit inclusion of dams and their management from their date of construction.

The default version of PCR can be found at https://doi.org/10.5281/zenodo.595656 while the BMI-compatible version is downloadable from https://doi.org/10.5281/zenodo.1472346. PCR with its DynRout extension is only available upon request.

Please note that PCR within GLOFRIM was only tested on Linux platforms. Please also read carefully any further instructions provided on the GLOFRIM online documentation as well as the Readme-files of the different repositories.

wflow

wflow (WFL; (Schellekens et al., 2018) is a distributed hydrological modelling platform and part of Deltares' OpenStreams project. Within WFL, a range of hydrologic models can be run, for example HBV (Lindström et al., 1997), SBM (based on the TOPOG SBM model; Silberstein et al., 2007) or WR3A (van Dijk et al., 2013). Depending on objective in mind, WFL therefore allows to select the appropriate model from the available options. We tested GLOFRIM so far, however, only for the HBV model as well as the W3RA model.

WFL was applied for different study objectives, such as assimilation of streamflow and soil moisture data (Lopez et al., 2016) or model intercomparison with other hydrologic models (Boer-Euser et al., 2017).

Similar as PCR, the kinematic wave approximation is used to route runoff along a drainage network. What is different is that WFL can be discretized at any spatial resolution. Also, model discretizations can be automatically obtained by using the built-in modelbuilder tool which makes use of the Google Earth Engine and global input data sets. To make WFL integrative with other models, it has a BMI adapter natively implemented.

It is important to note that WFL was recently upgraded to Python 3. GLOFRIM, however, has not yet been migrated to Python 3 but is based upon Python 2. We therefore recommend to carefully check whether the correct WFL model is in use if envisioning to employ it within GLOFRIM. For more information about WFL and its latest developments, we refer to the online documentation at https://wflow.readthedocs.io/en/latest/.

CaMa-Flood

CaMa-Flood (CMF; Yamazaki et al., 2011) simulates the floodplain hydrodynamics of continental-scale rivers globally. Since it solves the 1D local inertial equation (Bates et al., 2010; Yamazaki et al., 2013) and only changes in water storage are prognosticated, simulations are computationally efficient. Another advantage is that CMF is a global model and therefore model data exists for the entire terrestrial surface, reducing the need to manually set up the model. Yet, also this possibility is provided in case more accurate local data is available.

The river network of CMF is derived from 18 arc-seconds (approximately 500 m at the Equator) elevation data using the FLOW method (Flexible Location of Waterways; Yamazaki et al. 2009). It also containing river bifurcation which improves inundation representation in delta areas (Ikeuchi et al., 2015; Mateo et al., 2017; Yamazaki et al., 2014b). River channel width is based on the Global Width Database for Large Rivers (GWD-LR; Yamazaki et al., 2014a). The model domain is discretized by unit catchments corresponding with each model calculation grid. Model output is provided at 0.25 degree spatial resolution (approximately 25 km at the Equator), but inundation depth can be downscaled to a resolution of 18 arc-seconds in a post-processing step (see supplementary material of Ikeuchi et al., 2015).

For additional information about CMF, we refer to the above-mentioned articles as well as the to the manual (http://hydro.iis.u-tokyo.ac.jp/~yamadai/cama-flood/Manual_CaMa-Flood_v362.pdf).

Currently, the default non-bmi'ed version of CMF can be downloaded online. Unfortunately, the BMI-compatible version of the model is only accessible upon request at the GLOFRIM developers from https://github.com/hii600/cama-flood_bmi_v3.6.2/releases/tag/v3.6.2-bmi.

LISFLOOD-FP

LFP is a raster-based hydrodynamic model to compute floodplain inundation in a computationally efficient way. Since its first version (Bates and De Roo, 2000), it has regularly been adapted and improved, for instance by adding the local inertia equations (Bates et al., 2010) or by adding a sub-gridding scheme to account for channel flow within cells (Neal et al., 2012). It is possible to run LFP with different set-ups: a 2D only, a1D, a 1D/2D or a sub-grid model, with the latter being the most accurate for large-scale inundation modelling approaches as it greatly increases floodplain connectivity (Neal et al., 2012).

LFP can be discretized at any spatial resolution but is typically employed for fine-resolution assessment of inundation dynamics. Applying it over larger areas at a fine spatial resolution will otherwise result in greatly increased computational load. The required input data can be produced using common GIS programmes and do not require extensive pre-processing. What is typically needed are elevation, river width, and river depth data.

The default non-bmi'ed and most up-to-date version of LFP can only be obtained upon request at the University of Bristol, School of Geographical Sciences. To apply LFP within GLOFRIM, version 5.9 was made BMI-compliant and is openly available at https://doi.org/10.5281/zenodo.1478677. It should be noted that version 5.9 contains, although not being the most up-to-date version, all relevant core functionalities of the model.

Delft3D Flexible Mesh

Delft3D Flexible Mesh (DFM; Kernkamp et al., 2011) allows the user to schematize the model domain not only as a regular grid but also as a flexible mesh in 1D/2D/3D, supporting the computationally efficient schematization of topographically challenging areas such as river bends or irregular slopes. Depending on model schematization, the requirements with respect to input data change. If a flexible mesh is designed, certain geometrical requirements must be satisfied to guarantee mass conservation.

It solves the full shallow equations for surface flow, but settings allow for also switching to simpler forms of hydrodynamic routing if run times may have to be reduced.

DFM is developed with a BMI natively implemented. While DFM can be executed on both Windows and Linux platforms, it was only tested on Linux environments as part of GLOFRIM. The model and source code are not yet available openly but have to be requested from the developers' team.

For a comprehensive overview over the technical details of the model, we refer to its technical manual at https://content.oss.deltares.nl/delft3d/manuals/D-Flow_FM_Technical_Reference_Manual.pdf. Concerning an outline how to apply the model, please see the user manual to be found at https://content.oss.deltares.nl/delft3d/manuals/D-Flow_FM_User_Manual.pdf.

Additional important information how to run DFM within GLOFRIM can be found at the GLOFRIM online documentation.