Instructions for use SIMFEN

This service allows the simulation of water flow at any point on the Breton river system based on flow observations from the Hydro Bank network. The hydrological model used comes from research work in hydrological modeling described in the "Principles of Hydrological Modeling" section.

Basic Mode

In input, the service uses the following parameters :

1 – Indicate the simulation period,

- a. start date of the simulation,
- b. end date of simulation,
- c. the time step,

2 – Locate the "target" station to simulate.

3 – Launch the simulation.

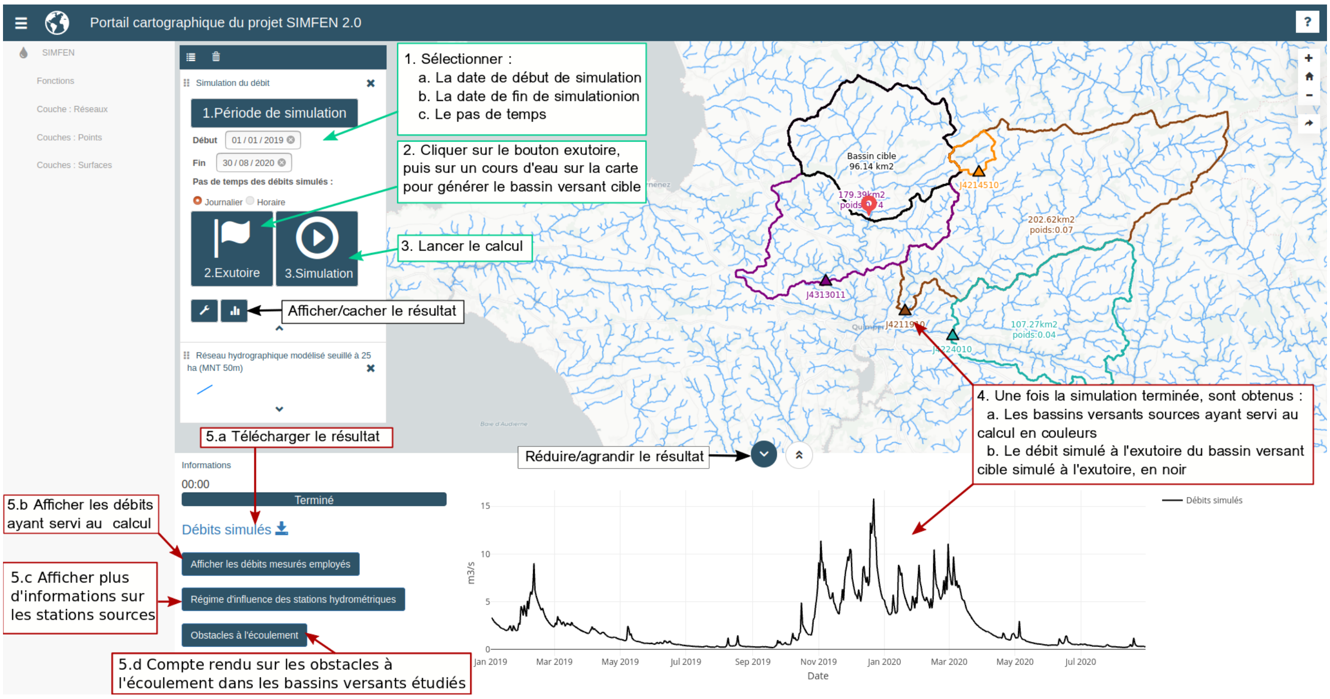
In output,

4 – Once the simulation is complete, the following will be displayed:

- a. the contours of the watersheds of the "source" stations,
- b. the streamflow of the target watershed calculated at the outlet you selected (2)

5 – Optionally, once the simulation is finished, it is possible to :

- a. download the results (calculated streamflow, hydrological code of the source stations, geographical coordinates of the outlet and the surface of its watershed)
- b. display the measured flows at the source stations



Expert mode 

For users with advanced knowledge of the environment where the flow will be simulated, it is possible to influence the operation of the model with respect to the default parameters. For the moment, here are the parameters that can be modified:

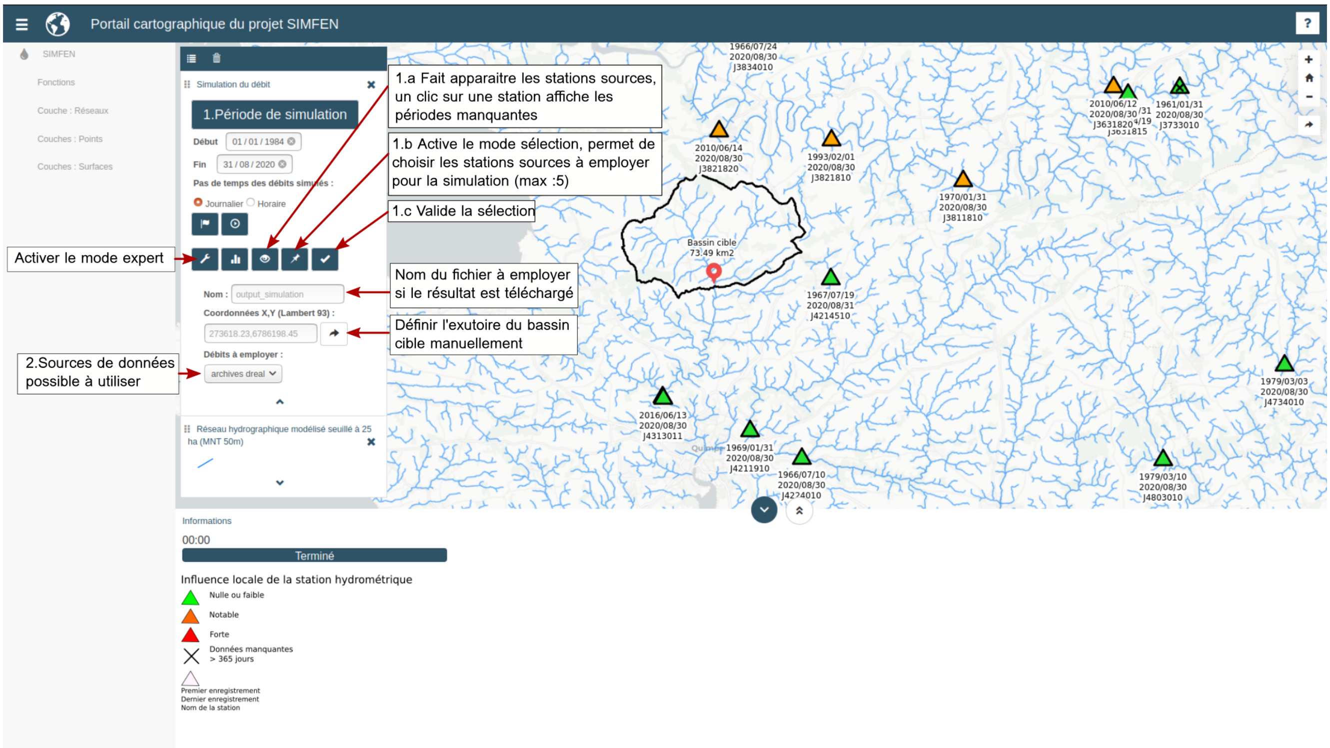
1 – The choice of sources stations :

- a. To display the availables stations, a click on a station shows the periods without recording.
- b. Select the stations by clicking (maximum 5 stations).
- c. Validate the selection.

2 – Choice of the data provider, (involving the possible simulation period and the stations available for the chosen period).

Optionally :

- Name the result files.
- Manually locate the point where to simulate the flow from its X,Y coordinates in Lambert 93 (please respect the syntax indicated).



Additional information

The source basins used by the simulation are displayed on the map. For each basin, its measurement station, its area (in km2) and its weight in the simulation are indicated. The watershed simulation is carried out by the WPS MNTSurf from a Digital Terrain Model (DTM) at 50 meters of spatial resolution. The hydrographic network displayed and used by the model was calculated by MNTSurf from the same DTM.

Recordings of BD Hydro Dreal source begin for some in the sixties, but the default date of simulation start is set to 1984 in order to have as many stations as possible.

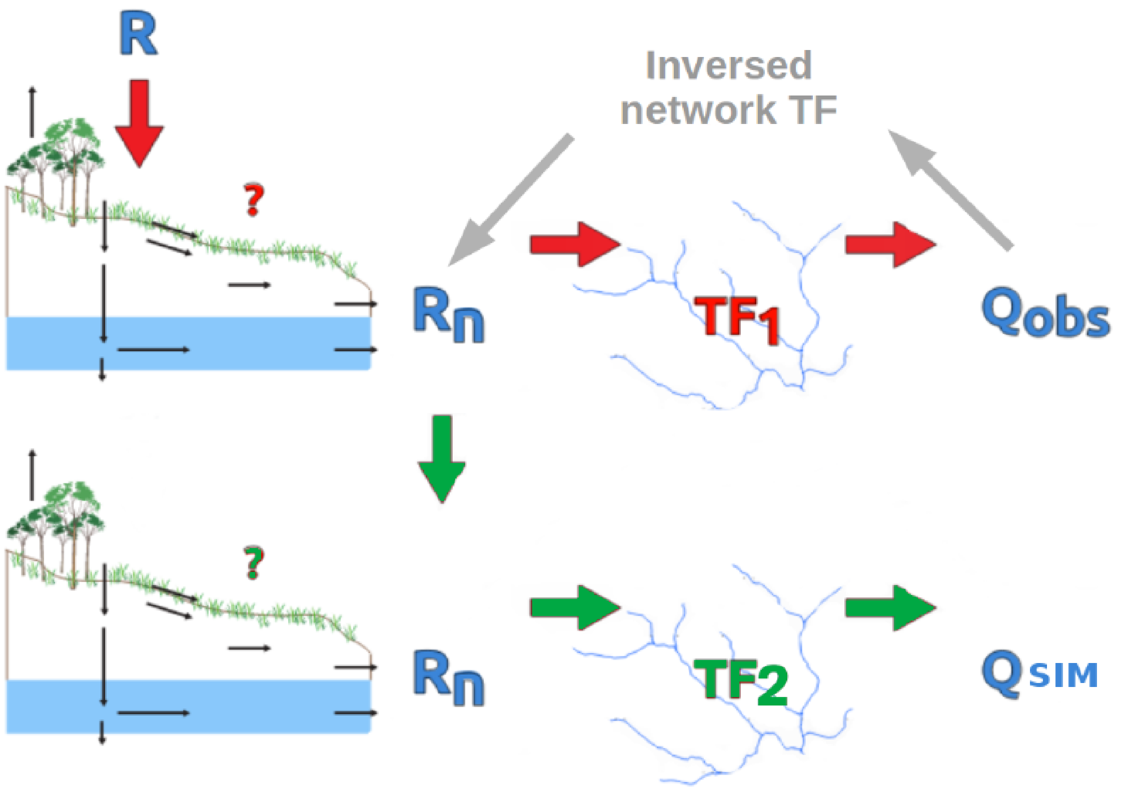
NOTE: Only one query can be executed at a time.

Principle of hydrological modeling

The SIMFEN Service allows to activate in Brittany, France, a geomorphologic-based hydrological modeling developed through research conducted since 1998 in different hydrological contexts, and which is part of the general problem of forecasting in ungauged basins (PUB - Prediction in Ungauged Basins).

Hydrological modeling based on geomorphology

A geomorphological transfer function is used to describe the transfer of water through the hydrographic network into a gauged or ungauged watershed, whatever it may be. The inversion of the transfer function of a gauged watershed allows the net rainfall to be calculated from the chronic flow observed at the outlet. The net rainfall can be transposed from one or more watersheds sources of information to a target watershed, based on similarity, if possible in a nesting or neighborhood configuration, to simulate the chronic stream flow at the target outlet.



Principle of inversion / transposition

Several nuances of the modeling approach are possible and some operational choices have been made for the basic version of the SIMFEN service. The next version will offer flexible options in an expert mode. A reference hydrographic network is provided for the entire region. For each watershed sampling point, the water path to the outlet is identified by geomatics and the hydraulic length L of the channelized portion of this path within the hydrographic network is measured. The probability density function of the hydraulic length fdp (L) is thus extracted for the watershed considered as a whole. The travel time t of the water through the hydrographic network (pdf (t)) can be deduced from the fdp (L) by applying a mean flow velocity across the hydrographic network. This average velocity was estimated by analyzing a set of flood events detected between 1990 and 2010 in gauged watersheds in the region, and quantifying a robust regional relationship expressed as a function of the average hydraulic length of the basin. slope. The fdp (t) can be considered as a transfer function FT (t) of the unit hydrograph type, which makes it possible to simulate the flow at the outlet Q [m3. s-1] thanks to the following convolution: $Q(t) = S \cdot Pn(t) * FT(t)$ where t [s] is the time, S [m^2] is the catchment area and Pn [m] is the net rainfall defined as the water level coming out of the slopes and entering the river system on average in the basin slope.

Deconvolution and hydrograph transposition

The net rainfall of a gauged watershed is estimated by deconvolution of the hydrograph observed at the outlet. This deconvolution is performed by inverting the geomorphological transfer function, which allows to estimate the chronic net rainfall from the chronic flow. The net rain is then transposed to the target catchment, based on similarity, where it can be reconverted with the transfer function specific to this watershed, to simulate the hydrograph. One or more source watersheds may be considered for a given catchment area. This approach makes it possible not to have to consider in detail the heterogeneous and strongly nonlinear processes internal to the slopes, which determine the genesis of the flows and therefore the net rain.

Transposition strategy

For a target catchment area, one or more donor watersheds are selected according to the following rules:

- Search for all stations within a radius of 50 kilometers;
- Calculates Ghosh distance from all donor watersheds relative to the target basin (article);
- Determine the 5 basins closest to the target basin based on the Ghosh distance;
- Among these basins, calculate the standard deviation between each basin, gradually, to keep only those with a small difference. Therefore, if the 5 basins have these distances: 1000, 2000, 3000, 10000, 11000, then only the first three basins will be preserved, because similar in terms of distances.

References

Aouissi J., Pouget J.C., Boudhraâ H., Storer G., Cudennec C, 2013. Joint spatial, topological and scaling analysis of river network geomorphometry. Géomorphologie–Relief Processus Environnement, 1, 7-16, https://doi.org/10.4000/geomorphologie.10082.

Béra R., Squividant H., Le Henaff G., Pichelin P., Ruiz L., Launay J., Vanhouteghem J., Aurousseau P., Cudennec C., 2015. GéoSAS : A modular and interoperable open source spatial data infrastructure for research. In ‘Remote sensing and GIS for hydrology and water resources’, Chen et al. (Ed.), PIAHS, 368, 9-14, https://doi.org/10.5194/piahs-368-9-2015.

Boudhraâ H., Cudennec C., Slimani M., Andrieu H., 2009. Hydrograph transposition between basins through a geomorphology-based deconvolution-reconvolution approach. In ‘New Approaches to Hydrological Prediction in Data Sparse Regions’, Yilmaz K. et coll. (Ed.), IAHS Publ., 333, 76-83, https://iahs.info/uploads/dms/14818.14-76-83-333-30-4175_Boudhraaetal-corr.pdf.

Boudhraâ H., Cudennec C., Andrieu H., Slimani M., 2018. Net rainfall estimation by the inversion of a geomorphology-based transfer function and discharge deconvolution. Hydrological Sciences Journal, 63, 2, 285-301, http://dx.doi.org/10.1080/02626667.2018.1425801.

Cudennec C., Fouad Y., Sumarjo Gatot I., Duchesne J., 2004. A geomorphological explanation of the unit hydrograph concept. Hydrological Processes, 18, 4, 603-621, https://doi.org/10.1002/hyp.1368.

Cudennec C., Slimani M., Le Goulven P., 2005. Accounting for sparsely observed rainfall space-time variability in a rainfall-runoff model of a semiarid Tunisian basin. Hydrological Sciences Journal, 50, 4, 617-630, https://doi.org/10.1623/hysj.2005.50.4.617.

Cudennec C., 2007. On width function-based unit hydrographs deduced from separately random self-similar river networks and rainfall variability. Hydrological Sciences Journal, 52, 1, 230-237, https://doi.org/10.1623/hysj.52.1.230.

Hrachowitz M., Savenije H.H.G., Blöschl G., McDonnell J.J., Sivapalan M., Pomeroy J.W., Arheimer B., Blume T., Clark M.P., Ehret U., Fenicia F., Freer J.E., Gelfan A., Gupta H.V., Hughes D.A. Hut R.W., Montanari A., Pande S., Tetzlaff D., Troch P.A., Uhlenbrook S., Wagener T., Winsemius H.C., Woods R.A., Zehe, E., Cudennec C., 2013. A decade of Predictions in Ungauged Basins (PUB) – a review. Hydrological Sciences Journal, 58, 6, 1198-1255, https://doi.org/10.1080/02626667.2013.803183.

Dallery D., Squividant H., de Lavenne A., Launay J.,Cudennec C., 2020. An end-user-friendly hydrological Web Service for hydrograph prediction in ungauged basins. Hydrological Sciences Journal https://doi.org/10.1080/02626667.2020.1797045

de Lavenne A., 2013. Modélisation hydrologique à base géomorphologique de bassins versants non jaugés par régionalisation et transposition d'hydrogramme. PhD thesis,. URL. Sciences de l'environnement. Rennes, Agrocampus-Ouest https://hal.archives-ouvertes.fr/tel-02810356.

de Lavenne A., Boudhraâ H., Cudennec C, 2015. Streamflow prediction in ungauged basins through geomorphology-based hydrograph transposition. Hydrology Research, 46,2, 291-302, https://doi.org/10.2166/nh.2013.099.

de Lavenne A., Skøien J.O., Cudennec C., Curie F., Moatar F., 2016. Transferring measured discharge time-series: large-scale comparison of Top-kriging to geomorphology-based inverse modeling. Water Resources Research, 52, 7, 5555-5576, http://dx.doi.org/10.1002/2016WR018716.

de Lavenne A., Cudennec C. Assessment of freshwater discharge into a coastal bay through multi-basin ensemble hydrological modelling. Science of the Total Environment, 669, 812-820, https://doi.org/10.1016/j.scitotenv.2019.02.387.Ecrepont S., Cudennec C., Anctil F., Jaffrézic A., 2019. PUB in Québec: A robust geomorphology-based deconvolution-reconvolution framework for the spatial transposition of hydrographs. Journal of Hydrology, 570, 378-392, https://doi.org/10.1016/j.jhydrol.2018.12.052.

Rodriguez F., Cudennec C., Andrieu H., 2005. Application of morphological approaches to determine unit hydrographs of urban catchments. Hydrological Processes, 19, 5, 1021-1035, https://doi.org/10.1002/hyp.5643.

Squividant H., Béra R., Aurousseau P., Cudennec C., 2015. Online watershed boundary delineation: sharing models through spatial data infrastructures. In ‘Remote sensing and GIS for hydrology and water resources’, Chen et al. (Ed.), PIAHS, 268, 144-149, https://doi.org/10.5194/piahs-368-144-2015.