Coupled Hydrodynamic and Hydrologic modelling using Telemac-2D

Nitesh Godara YP[1*], Michal Pavlíček[2], Oddbjørn Bruland[3]

[1,2] PhD Scholar, [3] Professor, Norwegian University of Science and Technology, Trondheim, Norway

*Correspondence YP: nitesh.godara@ntnu.no

Hosted by Spain Water and IWHR, China

Woww Project

Abstract

Floods and other hydrological processes are difficult to estimate because of complex relationship between various meteorological and basin parameters, extreme rainfall events and complex topography such as steep slopes within the catchment. Telemac-2D model is used for rainfall- runoff modelling in a steep and small (10.5 km^2) catchment in Møre og Romsdal county in western Norway. Telemac-2D is a hydrodynamic model and the SCS curve number method can be used in the rainfall-runoff module of this model to extend it to a Hydrodynamic Rainfall-Runoff Model (HDRRM). This paper focuses on the coupling of the hydraulic model and the hydrologic model to extract the hydrograph at any point in the catchment. The implemented hydrological scheme is quite simple, and the simulation is inaccurate and quite slow from the hydrologic point of view because of coupling with the hydraulic model. The purposes of this work are to improve the hydrological scheme in Telemac-2D, increasing the accuracy of the coupled model and reducing the simulation runtime.

Keywords: Hydrology, steep catchment, floods, Telemac-2D, rainfall-runoff modelling.

Methods

Study catchment:

- Area 10.5 km^2
- Average slope 48 % (up to 100 %)

Model:

- Telemac-2D
- Shallow Water Equations
- Soil Conservation Curve Number (SCS-CN)

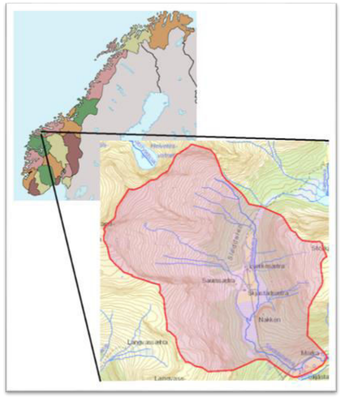

Figure 1: Study catchment

Input data for the model:

- Digital Elevation Model (DEM, red lidar)
- Curve Number (CN) raster (Jaafar et al., 2019)
- Hourly observed precipitation data

Investigated parameters and methods

- Mesh size (differ in the river and in the catchment)
- Antecedent Moisture Condition (AMC)
- Steep slope correction

The final simulation set-up (Figure 2.)

- Triangular mesh size (10 m in the river and 500 m in the catchment)
- Manning roughness coefficient 0.200
- Inflow boundary condition: hyetograph
- Outflow boundary condition: water level in the river
- CN 100 in the river and 80 in the catchment
- AMC 2
- Steep slope correction

Results

Figure 2. shows the results of the final simulation set-up. The model responds to the rainfall, but there are large discrepancies between observed and simulated.

It can be seen in Figure 3. that the effect of the steep slope correction was significant only in the beginning of the simulation time period.

Figure 4. presents the comparison between fine mesh (3 m in the river and 5 m in the catchment) and coarse mesh (10 m in the river and 500 m in the catchment).

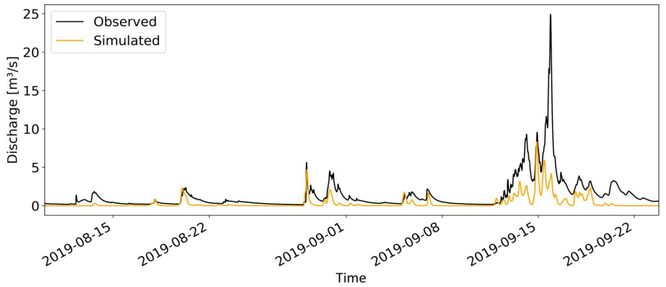

Figure 2: Observed and simulated discharge for a longer period with a coarse mesh size.

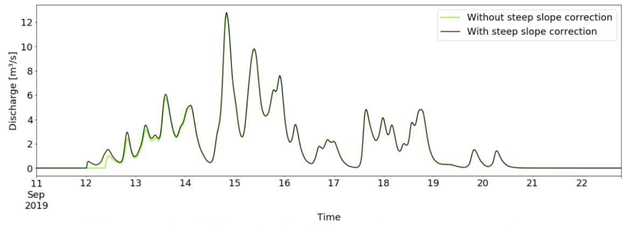

Figure 3: Effect of steep slope correction.

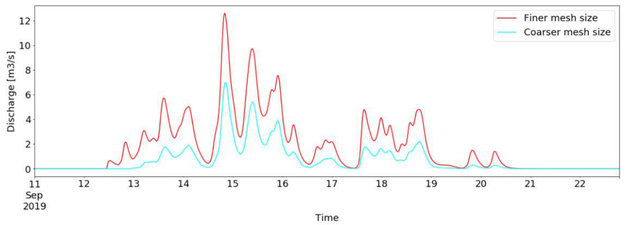

Figure 4: Effect of the mesh size.

Conclusions

Hydrologic model was coupled with the hydraulic model using the SCS-curve number rainfall-runoff module present in Telemac-2D model. The simulations were very fast in terms of hydraulic modelling but quite slow in the hydrologic point of view. Running the simulation for a longer time period (with coarse mesh size) showed that currently the results for peak discharges are not very good for the coarser mesh size, but volume of the water can be made more precise with a finer mesh size. In the future work, more sophisticated hydrologic models and methods including a snow routine will be implemented in Telemac-2D to improve the simulation results. Additionally, the effect of mesh size and definition of the boundary between the river and the catchment will be investigated with more scenarios to further reduce the simulation runtime.

Bibliography

Jaafar H. H., Ahmad F. A., El Beyrouthy N. (2019). Gcn250, new global gridded curve numbers for hydrologic modeling and design. Scientific data 6(1), 1–9.

Ligier P.-L. (2016). Implementation of a rainfall-runoff model in telemac-2d. In Proceedings of the XXIIIrd TELEMAC-MASCARET User Conference 2016, 11 to 13 October 2016, Paris, France, pp. 13–19.

Taccone F., Antoine G. (2015). Numerical modeling of sediment transfers at the catchment scale with telemac. In Proceedings of the XXII TELEMAC-MASCARET Technical User Conference October 15-16, 2044, pp. 18–27.