Conference Paper, Published Version

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A flood forecasting model on river Oise with the plugin mascaret

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***Abstract* — The flood forecasting service Oise-Aisne commissioned Cerema to adapt an existing model for flood forecasting under the plugin mascaret, because it is easier for them to control the data on the mascaret model. The choosen river is a branch of Oise located between Origny-Saint-Benoite upstream to Sempigny downstream. The distance between these two stations is around 85 kilometers.**

I. INTRODUCTION

On the rivers Oise and Aisne catchments, there are seven propagation sub-models used by the flood forecasting service for predicting flood connected with rain-flow models where necessary. One sub-model was chosen to the experiment of the transposition of the existing model to a new model under the Mascaret plugin. All the available data were used to construct the model, calibrate and verify its validity. One of the most difficult tasks was to geolocate the cross sections and to integrate the bathymetry with the topography extracted from the digital terrain model. Finally we have succeeded in developing a propagation model that responds quite well to the observed data in situ.

The figure 1 hereunder shows the general map of the model location.

Figure 1 – General map of the model location

II. DATA AVAILABLE FOR THE PROJECT

A. Bathymetry

We had on one side the traces of the georeferenced profiles and on the other the bathymetric points with the name of the profiles and the location of the profiles with their name in a pdf file. With this information, we managed to fill in the georeferenced bathymetric points table of the Mascaret plugin to connect to the cross profiles table.

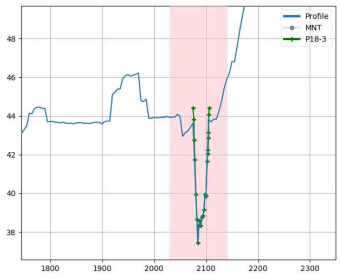

Figure 2 – Bathymetric points in green

B. Topography

The Oise-Aisne flood forecasting service has made available the digital terrain model available on the study area at a distance of 1 meter.

From these data we were able to extract the topographic points of the flood plain for each of the cross sections constituting the model.

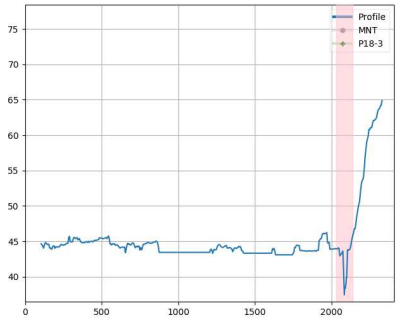

Figure 3 – Final profile in blue

With the topographic and bathymetric points of each cross section, we were able to build the final profile that is shown in Figure 3 above. The part in pink corresponds to the minor bed of the river.

C. Hydrology

In the study area, we have three hydrometric stations on the Oise river (Origny-Sainte-Benoite, Condren and Sempigny) and three hydrometric stations on tributaries (Serre, Ailette and Verse).

We have data for several floods : 1993, 1995, 2011, 2003, 2011, 2013 and 2016.

We have calibrated the model on the 2011 flood, which has the advantage of presenting fairly simple characteristics, then we will check the calibration on the more complex floods of 1993 and 1995. Finally we exploited the model on the other floods to test its reaction.

One of the main difficulties of this hydrological component is to estimate the diffuse inputs, because the flows of the tributaries do not always cover the inflows of flows observed at Sempigny.

D. Hydraulic

We do not have a lot of hydraulic data, like flood markers, to calibrate or validate the model. However, we have water level data recorded at the Origny-Sainte-Benoite, Condren and Sempigny stations. This makes it possible to compare the calculated limnigraphs or hydrographs with those observed at the stations.

The figure 4.1 hereunder gives an example of these comparisons at Sempigny station for Mascaret model.

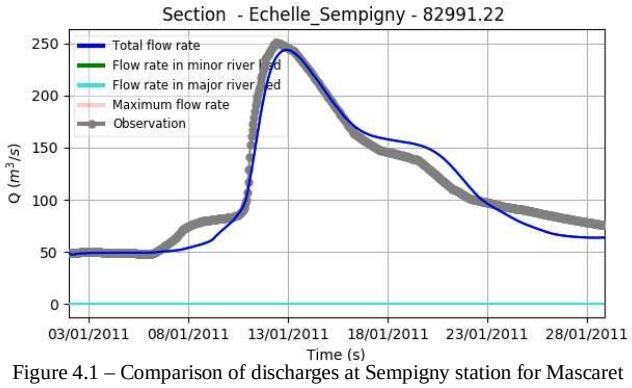

Figure 4.1 – Comparison of discharges at Sempigny station for Mascaret model (flood 2011)

The figure 4.2 hereunder gives an example of these comparisons at Sempigny station for previous model.

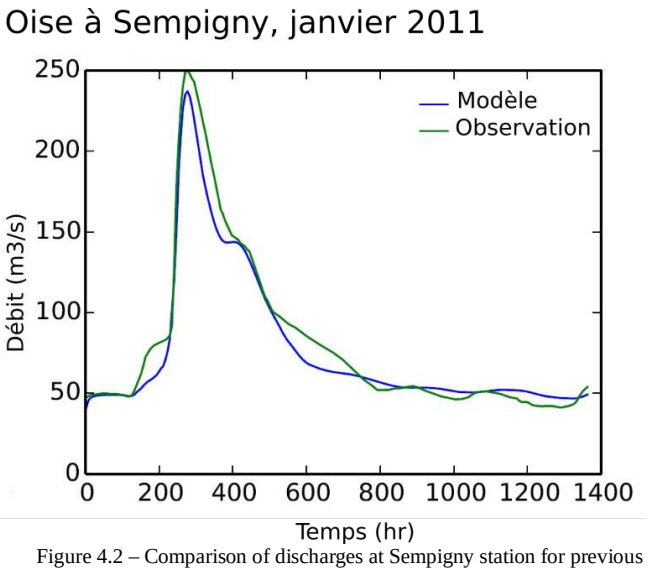

Figure 4.2 – Comparison of discharges at Sempigny station for previous model (flood 2011)

III. PRESENTATION OF THE MODEL

As indicated above, the model extends from Origny-Sainte-Benoite upstream to Sempigny downstream, about 85 km in length. In the upstream part, about 30 kilometers, the river Oise is separated into two branches by the Sambre canal. The two branches then meet at the Fère town to form a single reach.

Between the upstream and the town of la Fère, there is a connection between the two reaches of the river Oise, with a structure consisting of 7 pipes that pass under the Sambre canal (see photo in Figure 5).

Figure 5 – Hydraulic structure under the Sambre canal

The final model consists of 175 cross sections, a basin and two links to represent the connection between the two branches of the river Oise mentioned above.

The model was calibrated on the flood of 2011 which has the advantage of being a simple flood with a single peak.

The result of the calibration leads to Strickler coefficients similar to those retained by the Hydratec consultant, namely 18 for the minor bed and 8 for the floodplain.

In addition, it was necessary to add diffuse inputs, in addition to tributary flows, to obtain a flow rate comparable to that observed at Sempigny. The equivalent of the hydrograph of the Serre river for the 2011 flood has been added in linear form.

Tributary flows are derived from the nearest hydrometric stations at the confluence.

At the upstream boundary condition, there are two branches of the river Oise at Origny-Saint-Benoite, where we inject 2/3 of the flow on the right ranch and 1/3 of the flow on the left branch. The imposed flows at the boundary conditions are deduced of the observed hydrographs at the Origny-Sainte-Benoite station.

At the downstream boundary condition, we impose the Sempigny rating curve, deduced from measurements and gauges made at the hydrometric station (see figure 6 hereunder).

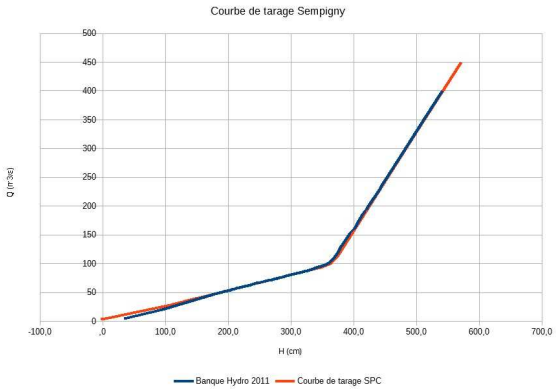

Figure 6 - Rating curve at Sempigny station

The results of the 2011 flood at Origny-Sainte-Benoite, Condren and Sempigny stations are shown in Figures 7, 8 and 9 below (these are calculated and observed water level results).

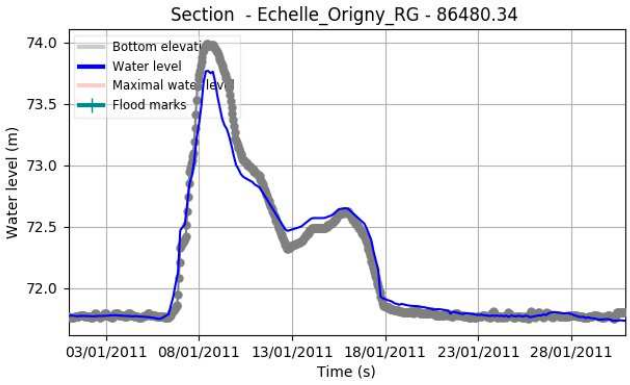

Figure 7 – 2011 flood – Results at Origny-Sainte-Benoite (left branch)

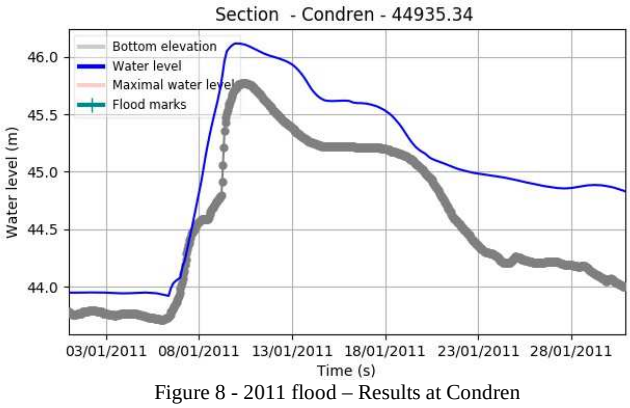

Figure 8 - 2011 flood – Results at Condren

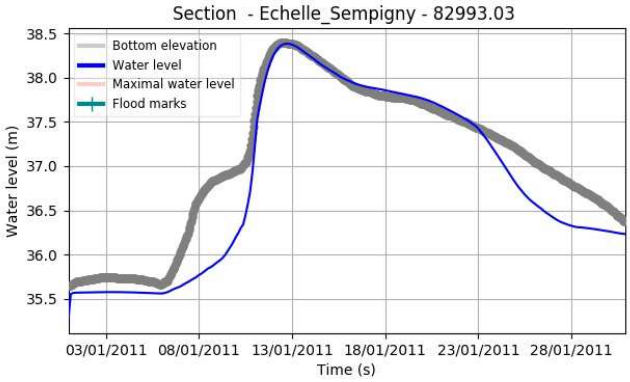

Figure 9 - 2011 flood – Result at Sempigny

The results for the 2011 flood are quite good, even if they are not perfect. The predictions at Origny-Sainte-Benoite station are very closed to the observed water levels, that confirm the discharge ratio used between the right and left branches. The predictions at Condren station are not so good, they are overestimated which can be due to the diffuse discharges injected in the upstream branch. Finally, the predictions at Sempigny station are quite good, specially for the peak water level.

IV. ASSESSMENT OF CALIBRATION

We used the floods of 1993 and 1995 to evaluate the quality of the rigging of the model. The highest flood recorded in recent years is that of 1993. It is for this flood that we will present the results obtained with the propagation model.

The maximum flow recorded at the Origny-Sainte-Benoite station is 272 m^3/s on December 21, 1993 at 15:00.

The figure 10 hereunder shows the flow discharge registered at Origny-Sainte-Benoite station.

The flood of 1993 is more complex than those of 2011 because there are high discharges during about 20 days before the peak of discharge.

This hydrograph was imposed at the upstream boundary condition, with the same ratio as 2011 flood between the right and left branches.

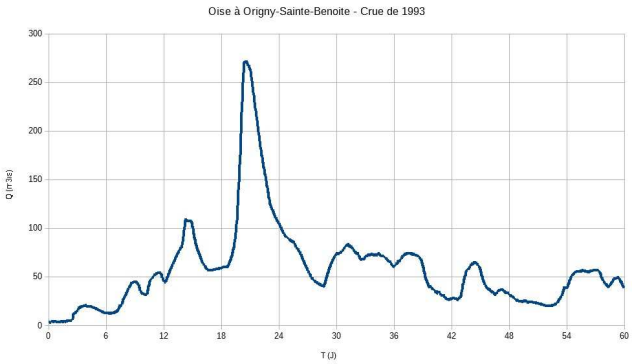

Figure 10 – Flow discharge at Origny-Sainte-Benoite station during the 1993 flood

The downstream boundary condition is always the rating curve at the Sempigny station. The tributary flows are taken into account and the intermediate inputs have this time been limited to 40% of the Serre river hydrograph.

The results obtained at the Sempigny station for the discharge and the water level are shown respectively on figures 11 and 12 hereunder.

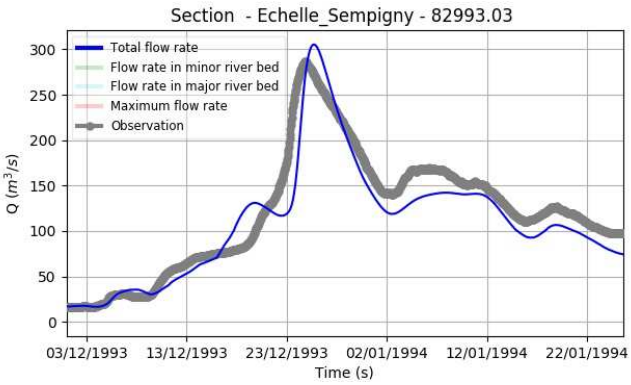

Figure 11 – 1993 flood – Results at Sempigny station for discharge

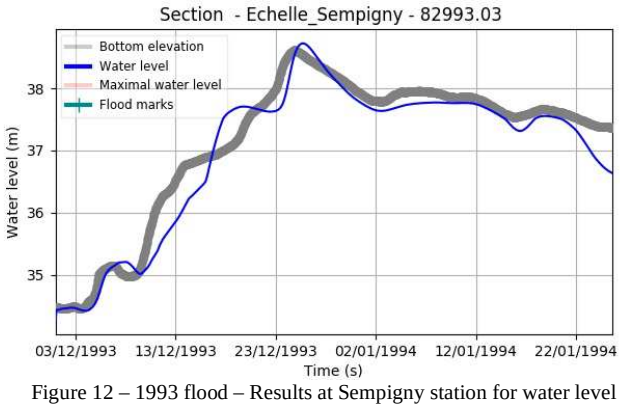

Figure 12 – 1993 flood – Results at Sempigny station for water level

The results are quite good even if they are not perfect. So the propagation model can be considered as validated, but the remained difficulties is to calibrate the intermediate discharges.

V. IMPLEMENTATION OF THE MODEL ON RECENT FLOODS

The most recent flood of medium importance is that of February 2016. The maximum flow in Origny-Sainte-Benoite would be 87 m^3/s. As we will see in the analysis of the results, it seems that the flows recorded at Origny-Sainte-Benoite are over-estimated except for the peak of discharge.

The boundary conditions imposed for the calculation are the same as for the previous floods, namely the hydrograph of the 2016 flood in Origny-Sainte-Benoite, with the distribution 1/3 in the right branch and 2/3 in the left branch, and the rating curve at Sempigny. The flows of the tributaries are taken into account in the form of hydrographs, but there are no additional diffuse intermediate discharges.

The results obtained at the Sempigny station for the discharge and the water level are shown respectively on figures 13 and 14 hereunder.

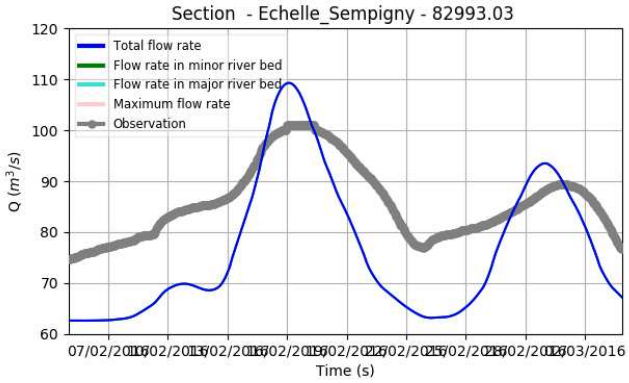

Figure 13 – 2016 flood – Results at Sempigny station for discharge

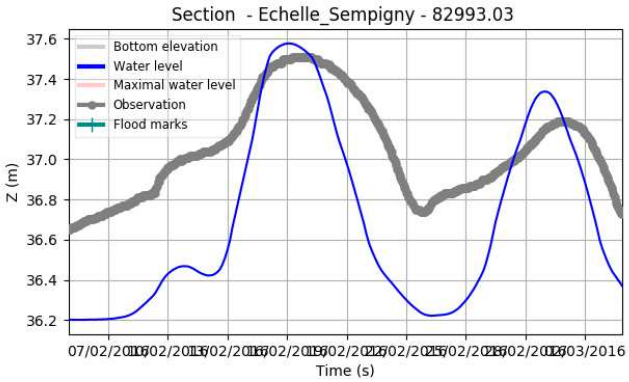

Figure 14 – 2016 flood – Results at Sempigny station for water level

Peak flows and water levels are fairly well represented, however there is an underestimation of the calculated flow or overestimation of the observed flow for the rest of the hydrograph at Sempigny. Taking into account intermediate inputs could improve this situation, but the result would be degraded for peaks.

The results obtained at the Condren station for the discharge and the water level are shown respectively on figures 15 and 16 hereunder.

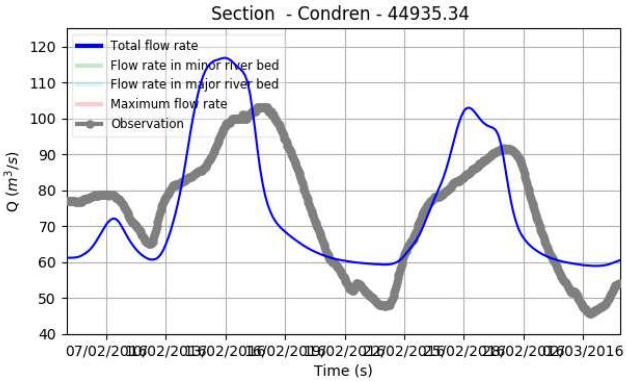

Figure 15 – 2016 flood – Results at Condren station for discharge

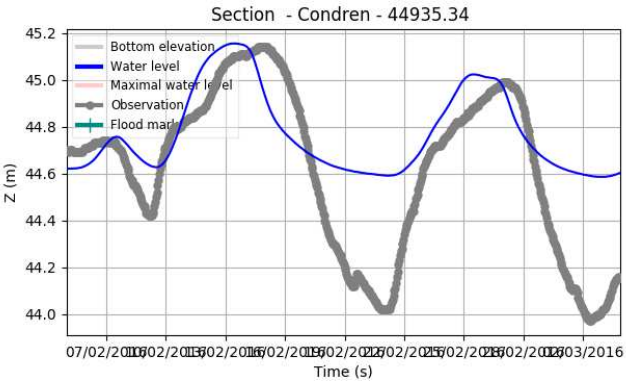

Figure 16 – 2016 flood – Results at Condren station for water level

The results obtained at the Condren station are not too bad. However, there is an overestimate of the water level of 60 cm between the two flood peaks which is relatively large. This can come from the model, but also from the measuring station.

The results obtained at the Origny-Sainte-Benoite station for the water level in the left branch are shown on figure 17 hereunder.

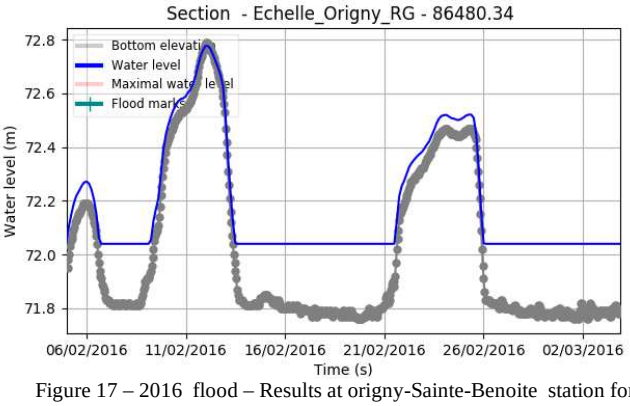

Figure 17 – 2016 flood – Results at origny-Sainte-Benoite station for water level

The water levels calculated in Origny-Sainte-Benoite are rather good. However, there is a difference of 1 m during low flow, which is normal, because there is a weir of 1 m height

downstream of the station, which is lying during the floods, while it is not in the calculation.

VI. CONCLUSION

The construction of the propagation model on the Oise river between Origny-Sainte-Benoite and Sempigny made it possible to test the Mascaret plugin under Qgis. It was also an opportunity to contribute to the debug of several modules with the consultant Artélia.

The final result allows the flood forecasting service to have an operational flood forecasting model, all of whose data is accessible and can be corrected or modified.

The model is not perfect, but its behavior on observed floods, even those like 2016 that were not used for calibration or validation, is rather satisfactory.

ACKNOWLEDGEMENT

We first thank the Oise-Aisne flood forecasting service, which allowed us to do this work and provided us with its data.

We also thank the consultant Artélia for his responsiveness in the debugging of the plugin.

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