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Interactive Comment

Interactive comment on "Combining semi-distributed process-based and data-driven models in flow simulation: a case study of the Meuse river basin" *by* G. Corzo et al.

E. Toth (Editor)

elena.toth@mail.ing.unibo.it

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General comments

The paper describes an application of artificial neural networks for improving the performances of a semi-distributed rainfall-runoff model with two separate schemes, where ANN models are used for: 1) the replacement of the conceptual lumped models for some of the sub-basins or 2) the replacement of the traditional routing scheme for integrating the output of the different watersheds. Both ideas are very interesting and, as confirmed by the results, are capable to overcome some of the drawbacks of the traditional implementation of the semi-distributed model. The application is re-

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ferred to a large, important watershed (the Meuse river catchment), whose hydrological behaviour has been accurately analysed by the Authors, as evident from the comments/interpretations in the paper, that highlight a deep knowledge of the catchment dynamics.

As far as the main concern of Referee #2 is concerned, on the fairness of the comparison of conceptual and data-driven model, I do agree that the use of recent streamflow observations gives an important advantage to the DDMs, especially since the sub-basins have large drainage areas and there is certainly a strong correlation between past and future streamflow values. Indeed, the forecasting ability of the conceptual sub-basins model may be substantially improved by an updating technique, for example by coupling it with a parallel simulation error forecasting model, based on the latest error observations as done in many real-time flood forecasting studies (e.g. Kachroo et al., 1992; Schreider et al., 1997; Toth et al., 1999; Toth and Brath, 2007). This important issue must certainly be mentioned in the paper: I warmly invite the Authors to test, if possible, the performances of the sub-basins in updating mode, since it would contribute to the value of the paper, but, on the other hand, I understand that this would require a complete revision of all the analyses carried out in Scheme 1 (and also in Scheme 2, in view of the below suggestion of coupling the two schemes) and maybe the actual implementation of the updating procedure for the HBV-M may be postponed to a future development of the Authors' work.

Concerning the matter of time, I do not believe, instead, that it should prevent the Authors from testing an integration of the two schemes, as suggested also by Referee # 1 (comment 11): this would not require a complete revision of all the work but only an addition to what obtained in Scheme 2. The integration would in fact be based on the application of the results already obtained in Scheme 1, choosing the best performing replacing scenarios and substituting in Eq. 4, for the chosen replaced sub-basins, the (lagged) outputs of the conceptual model with those of the DDMs. Such integration would certainly give more unity to the paper (the applications of the two schemes are now completely separated and there is no reason for describing them together if there is not a final merging, aimed at an even further improvement of the model performances) and more value to the paper.

Scientific methods and assumptions are valid and clearly outlined but the presentation may be improved, as suggested in the comments below.

Specific comments

1) From l. 21 p. 730 to l. 9 p. 731: this paragraphs shows a confusion in the classification of the models, that is in the distinctions of conceptual vs physically-based vs data-driven and the distinction of lumped vs semi-distributed vs fully distributed.

2) ll. 14-18 p 733: the function of the integrator and of the routing function in the MBV-M should have been introduced and briefly explained before this phrase.

3) l. 15 p 734: a description of the HBV routing function (Muskingum Cunge) should be placed here, before section 2.1.

4) p. 736, section 2.2: please add a detailed description of calibration and validation data; in particular, it seems that data 1968-1998 are used for validation only and there is no reference to the calibration period.

5) l. 27 p. 739: this phrase is misleading: the optimal lags were not chosen on the basis of average mutual information?

6) l. 23 p. 740: add a figure with the overall scheme of the HBV-M and its routing, showing the connections of each sub-basin with the other sub-basins and with the river reaches were routing is carried out.

7) p. 741 Section 4.1: as underlijed also by Referee #1, a description of calibration and validation data for all sub-basins should be added at the beginning of the session, maybe moving here also ll. 18-19 of p. 741.

8) ll. 14-16 p. 744 and ll. 7-8 p. 744: the role of weather forecast information in this

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work is not clear and these phrase may be removed.

9) ll. 18-20 p. 743: it is not true that previous simulation discharges are needed for forecasting with DDMs model over lead-times longer that 1 time-step: a DDM model may be built so to forecast directly the future discharge at any given lead-time, like, for example, in Toth and Brath (2007).

10) l. 9 p. 745: the two parts of Figure 4 (showing respectively the annual and the seasonal errors) should be separated and, especially for the graphs relative to the seasonal errors, a more detailed caption (and a corresponding description in the text) is needed to describe what it shows (what is on the y-axis?).

11) l. 16 p. 748: add a description of the calibration/validation data and of the final ANN model used for routing/integrating (that is a figure or table with the actual values of the various M in Eq. 4).

Technical suggestions

12) ll. 9-13, p. 730: the results of the two proposed schemes should be described more clearly and separately: points (1) and (2) refer to Scheme 1, and it is not clearly stated that point (3) refers to scheme 2.

13) Move ll. 16-29 p. 731 to Section 2.

14) Move ll. 19-22 p. 733 to p. 732, before l. 24.

15) Move ll. 1-14 p. 737 to section 2.2.

16) ll. 8-9 p. 739: replace with '.. data-driven models (DDM) can be built for each of the sub-basins under consideration'.

17) ll. 11-13 p. 739: this information is redundant, since it is said again, with the relevant references, in ll. 1-4 of p. 740.

18) l. 19 p. 739: replace with '... were compared for 8 of the 15 sub-basins'.

19) p. 741: Check notations and definitions of Eq. 4 and ll. 3-5 (lower and upper indexes are not consistent).

20) ll. 18-19 p. 741: in the list there are 9 and not 8 sub-basins: Vesdre should be removed?

21) There should be consistency in the denomination of Lorraine Sud and Meuse source: choose one denomination to be used throughout all the text and the tables/figures.

22) l. 3 p. 743: replace MLP with ANN, as in the rest of the paper.

23) l. 22 p. 743: replace 'thirs' with 'third'.

24) l. 29 p. 747: delete the parenthesis embracing 'under 600 m3/s'.

25) l. 17 p. 748: rather than correlation graphs I would say scatterplots.

26) p. 757, Table 2: add the units of RMSE.

27) Figure 4: add the unit of the y-axis of the first graph and the y-axis of the second and third graph. Replace the numbered basins in the first graph with their names.

28) Figure 6 and 7 should be in reversed order, that is in the order in which they are cited in the text.

29) Caption of Figure 7: specify to which ANN model the figure is referred (routing function, scheme 2); also the caption of Fig. 8 may cite the scheme 2.

The meaning of this phrases and paragraphs are not clear to me and should be rephrased or deleted:

- ll. 18-21 p. 732

- from l. 23 p. 738 to l. 6 p. 739

- ll. 5-6 p. 740

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- ll. 27-28 p. 744

- ll. 20-22 p 749

- from l. 23 p. 749 to l. 1 of p. 750

- from l. 26 p. 751 to l. 1 of p. 752

References

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Schreider, S.Yu.; A. J. Jakeman, B. G. Dyer and R. I. Francis (1997), A combined deterministic and self-adaptive stochastic algorithm for streamflow forecasting with application to catchments of the Upper Murray Basin, Australia, Environ. Model. Software, 12 (1), 93-104.

Toth, E., Brath, A. and Montanari A. (1999), Real-time flood forecasting via combined use of conceptual and stochastic models, Physics and Chemistry of the Earth, B, 24(7), 793-798.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 729, 2009.