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Interactive comment on "Error reduction and representation in stages (ERRIS) in hydrological modelling for ensemble streamflow forecasting" *by* Ming Li et al.

Anonymous Referee #1

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The paper is generally well written and well structured, which deserves to be published after some minor revisions. The presented work is an interesting extension of previous published papers from the authors and could become important for hydrologist working on operational forecast systems. Nonetheless there are a few points which should be addressed and clarified in more detail. The authors propose an interesting approach for modelling the forecast errors separated into four stages. Unfortunately the application is restricted to one step ahead predictions so far, which questions a bit the effort of implementing four different stages, since operational forecasts will need methods for longer lead times anyhow. Therefore it should be mentioned already in the abstract that the proposed method will be a theoretical exercise. Furthermore it should be stressed

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Discussion paper

right from the beginning that this paper represents some further developments of previous work of the authors, where they have published already parts of this work (stage 1 and stage 3), see Li (2015)! The term “ensemble” used within the paper is somewhat divergent to its usage in hydro-meteorology and I would suggest to use probabilistic or density forecasts instead of ensemble forecast. As far as I have understood you refer to “ensemble forecasts” because of the Gaussian distributed residuals in stages one to three (four). You should clarify how you understand ensembles, since your approach is not based on meteorological ensembles (e.g. ENS from ECMWF), which are usually the driving forces for creating hydrological ensembles (see HEPEX, which you have mentioned in the introduction). I find it also a bit surprising that the work of Krzysztofowicz, R. has not been mentioned, since there are quite a lot of analogies. Although his Hydrological Uncertainty Processor relies on Bayesian Theory, the different stages of ERRIS are implemented similarly: Transformation to the normal space (normal quantile mapping), bias correction (regression between observed and simulated series) and an Autoregressive AR(1) model. It would be good to cite some papers of Krzysztofowicz (1990,2001) and maybe follow up work (Todini, 2008; Reggiani, et a., 2009) and highlight the differences. Regarding the PIT diagrams: It should be mentioned that the usual analysing tool is the rank histogram (Hammil, 2001; Gneiting, et al., 2005), which is closely related to the diagrams used in this paper, which are, however, called “predictive quantile quantile” plots (Renard, 2010). Furthermore a Kolmogorov significant band should be included in these QQ diagrams as a test of uniformity (Laio and Tamea, 2007 (which is cited within the text, however missing in the reference list)). Since you use the CRPS for verification, it would make sense to decompose the CRPS into a reliability part and a resolution/uncertainty part (Hersbach, 2000). Thus the uncertainty part could be related to the average spread within the ensemble and the behaviour of its outliers, which would be an important information complementing the results of the α–index and the AWCI and maybe confirm your interpretation of the decreased reliability of stage 3.

Some more technical comments:

Page 3, line 53: I don't agree with the statement that the aim of the ensemble is the reduction of the uncertainty! This is rather the aim of the post-processing of the ensembles.

Page 5, line 92: Since there are a lot of papers applying the Normal Quantile Transform, you should cite this paper at least: Krzysztofowicz, R. (1997)

Line 108-109: The forecast quality will more and more depend on the quality of the meteorological forecast and will dominate the uncertainty with increasing lead-time! (the same remark is valid for page 25, line 500)

Page 8, line 153: you assume a constant variance for the residuals in the normal space. In Figure 2 (a) it seems that the variance is varying depending on stream-flow. So this variability of the variance will stem from the back-transformation, I assume. Could you please clarify this.

Page 12, line 241: weights p = ω, ω-1

Page 14, line 269: Why are these parameters needed for estimation purposes only. That should be clarified.

Page 16, line 295 – 300: No references are given for sharpness, AWCI ! (E.g. Gneiting, et al., 2007)

Line 306-308: I assume that you will need a reference forecast for each day (day/month/year) and not only one per month (month/year) and that you will take the mean of the 1000 samples per day? Could you please clarify this?

Page 18: Here you mention the GR4J model, in table 4 you show 4 hydrological model parameters x1,..x4, could you please give more details about the model and explain the meaning of these four parameters

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