Response to review comments by Dr. Paul Smith on the manuscript "Alternative configurations of Quantile Regression for estimating predictive uncertainty in water level forecasts for the Upper Severn River" By Lopez, Verkade, Weerts and Solomatine, 2014

The authors would like to thank Dr. Paul Smith for his time and constructive and valuable comments on the manuscript. His suggestions will help us to improve the quality of our manuscript. We have included detailed responses to his comments and suggestions.

General comments:

Comment 1:

This paper applies 4 different Quantile Regression (QR) techniques to an operational flood forecasting model from the UK. It uses well regarded performance assessment criteria to try to quantify the performance of the models, particularly at high water levels. In attempting this latter aim the authors are to be commended, particularly for the honesty in their conclusions regarding the more complex QR representations.
This however raises a question. Given the visual differences between the quantile fits seen in the figures why can they not be differentiated by the performance summaries (particularly at high water levels)? Is this down to interpretation or is it suggestive of something that is missing from the assessment of the forecast (both in this paper and elsewhere)?

Answer:

These differences are largely suggestive. It is quite difficult to visually distinguish the top, say, 10% of observations due to the plotting points lying on top of one another. Furthermore, the figures include a selection of quantiles. The selection was chosen as to include many both relatively low and relatively high quantiles (.01, .05, .10, .90, .95 and .99). It is these quantiles that differ most between the scenarios. However, these have a relatively small impact on metrics and skills. For the benefit of the reader, we will add a note to this extend in section 3.1.

Comment 2:

As well as commenting on the above I suggest the authors comment more fully on the visual properties of the plots. For example The NQT QR plots in Fig 4 show an increases level of "wigglyness" and a marked difference to the other methods at the higher water with the quantiles becoming almost constant. Are these features a result of the difficulties in back transforming through the NQT (as mentioned in the paper, is a comparison of the different method possible?) or the QR methodology? Are they believable? In the case of the latter feature is the river has gone out of bank it may be a reason to prefer this methodology but if it hasn't. . .

Answer:

The visual properties of Figures 2-4 are currently described in section 3.1 (p3826, lines 11-25):

“The figures show how the uncertainty models, each based on a different configuration of Quantile Regression, differ from one another. Configurations 0 and 1 appear to be very similar. They differ only in those instances where the former configuration would lead to quantile crossing but are identical otherwise, which was indeed anticipated. Configurations 2 (derived using NQT transform) and 3 (piecewise linear approach) are quite different from the first two configurations, but not dissimilar to one another. In these configurations, the quantiles are not a linear function of the water level forecast, that is, not along the full domain. Note that this non-linearity constituted the very reason why these configurations were included in the analysis. Both models often -- but not always -- show a very small spread at lowest water level forecasts, followed by an increasing spread. At high water level forecasts however, spread no longer increases and sometimes decreases. This means that sharpness of the resulting probability forecasts then no longer reduces with increasing values of the water level prediction; sometimes it even increases.”

The reviewer highlights a property that is currently not yet included in this description, namely the behaviour of the behaviour of the Scenario 2 quantile regression models at high forecast levels. This behaviour is markedly different from the behaviour in other scenarios as well as the behaviour on less extreme domains of the predictor (the forecast). We note the following:

- The behaviour of the models derived in NQT space is best understood if the joint distributions as well as the derived quantiles – all in NQT space – are shown also.

- The behaviour shows at the tails of the marginal distributions of both observations and forecasts but not beyond the last available forecast and/or observation. While in this domain, some assumptions have to be made as to the shape of the marginal distributions, these assumptions concern interpolation and are ‘milder’ than the assumptions that would have to be made outside of the available record.

Accordingly, we shall include a note in the manuscript.

Comment 3:

Moreover some further comments as to the use of quantile regression in prediction when the magnitude of the observed or forecast value is out of the calibration sample range would be beneficial to the paper.

Answer:

If there is a forecast outside of the range of what we have seen before, then any estimate of predictive uncertainty is not supported by data in that range. We shall include a note to this effect in the manuscript in section 4.

In an operational setting, it is important for the forecaster to be aware that this issue may surface. We suggest to “flag” the uncertainty estimate if it is based on extrapolation outside of the calibration range. Possibly, in those cases the uncertainty estimate can be replaced by an assumed estimate that the forecasters are comfortable with. A note to this effect will be added also.

Comment 4:

Beyond the above and the presentational comments below I should express slight disappointment that none of the other quantile regression techniques based on local smoothing (see Smith et al. HSJ 2014 and the references within, or the R package referenced in the paper) have been compared.

Answer:

In Section 4. Summary, conclusions and discussion, we will include a recommendation for future research related with the comparison of other Quantile Regression techniques based on local smoothing, as follows:

“… regression models.

All the configurations inter-compared in the present work are parametric Quantile Regression estimations. Non-parametric or semi-parametric Quantile Regression approaches, based on local smoothing could also be considered in future studies. For example, a comparison between here presented parametric QR configurations and the non-parametric estimation of the water level or discharge conditional distribution with copulas proposed by Smith et al. (2014), would be of interest.”

Specific comments:

Comment 5:

Abstract is misleading in that it reads to suggest that the use of NQT is new, whereas the paper (correctly) indicates it was used in Weerts et al 2011.

Answer:

We will modify the abstract to clarify that NQT was previously used in Weerts et al., 2011, as it is indicated in the rest of the manuscript:

“… . Thus, four configurations were built: (i) “classical” Quantile Regression, (ii) a configuration that implemements a non-crossing quantile technique , (iii) a configuration where quantile models are built in Normal space after application of the Normal Quantile Transform (similar to the implementation used by wwv2011), and (iv) a configuration that builds quantile model separately on separate domains of the predictor. Using…”

Comment 6:

There is multiple repetition of information within the introduction. This renders some of the later sections potentially redundant, for example the material in Section 2.3.2 is a repetition of information in the proceeding text. I suggest the introduction is reviewed and some of the details left to the later sections.

Answer:

We will modify Section 2.3.2. "QR1: non-crossing Quantile Regression" to avoid repetition of information in the introduction, as follows:

"In the present research study, the problem of crossing quantiles was addressed using the relatively recent emerged technique proposed by Bondell et al. (2010). This technique imposes a non-crossing restriction on the solution of Eq. (4). Without this restriction, the solution to the proposed optimization problem is identical to that of classical quantile regression, i. e. to the models derived using QR0. For a more detailed description of the non-crossing quantiles methodology, the reader is referred to Bondell et al. (2010). The technique is freely available online …"

These modifications in section 2.3.2., together with the changes in the introduction based on Dr. Julie Demargne review suggestions allow improving the manuscript readability (particularly the sections of introduction and uncertainty models) without repetitions.

Comment 7:

In general I would prefer greater detail in the description of the methods. In particular, define ρ *in equation 4. Also expand the description of the piece wise methodology. It is apparent from the plots that there is enforce continuity in the quantiles across the breaks but this is not mentioned in the text.*

Answer:

As per the reviewer's suggestions, a definition of the quantile regression function ρ shall be added to the manuscript.

There is no enforced continuity in the quantiles across the breaks. We will avoid to suggest the contrary by adding dashed vertical lines at water levels splits in Figures 2-4.

Comment 8:

3825 approx Line 20 Please explain why these are for plotting purposes only – do they differ markedly?

Answer:

The quantile models shown in Figures 2-4 are for plotting purposes only for the following reasons: (1) the analysis uses many more quantiles; (2) analysis bases quantiles on leave-one-year-out analysis; these plots do not. The derived models, however, do not differ markedly. A note to this extend will be added to the manuscript.

Comment 9:

Figure 6 is too small to be useful. I cannot sensibly comment on the forecasts.

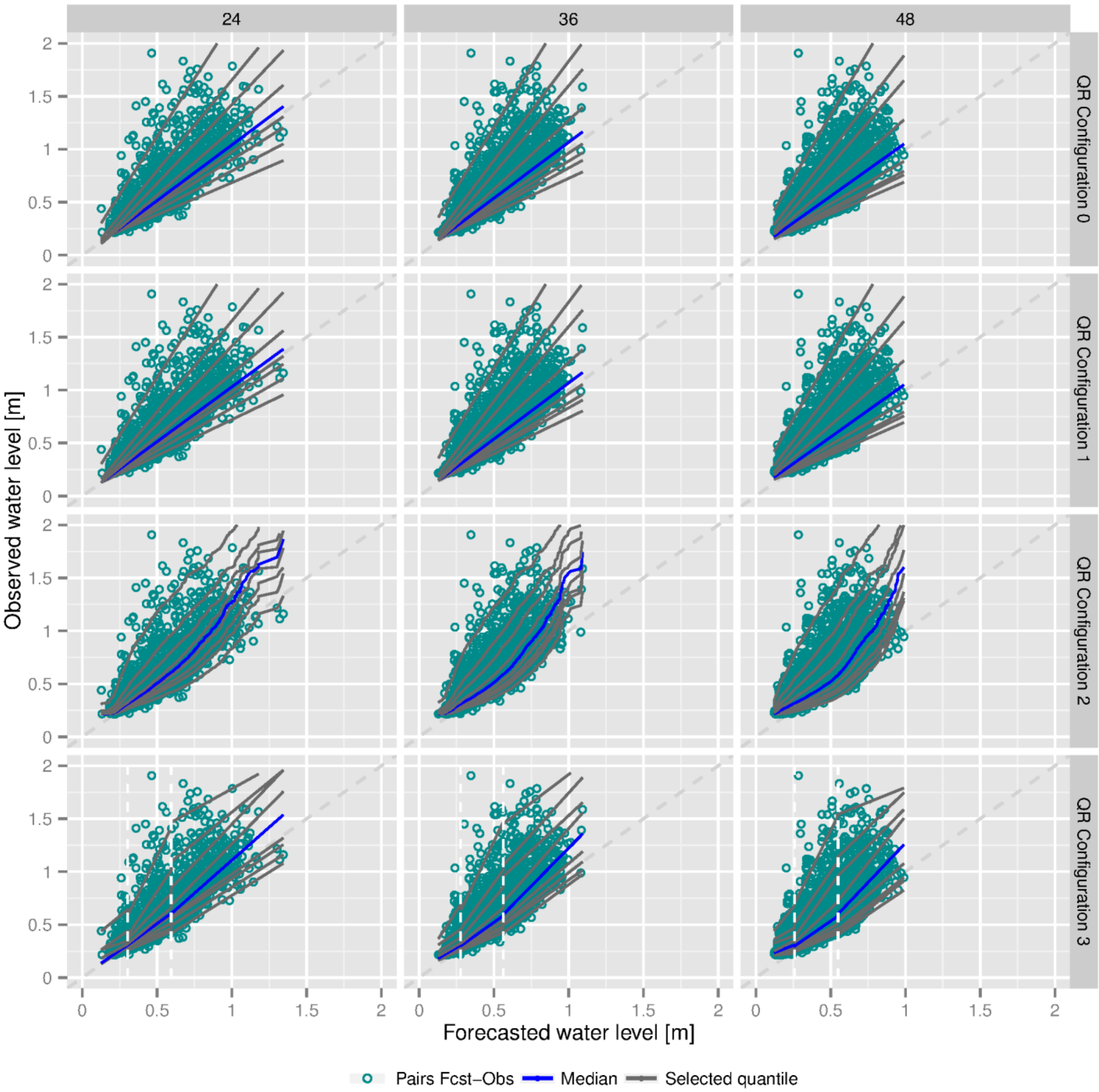
Answer:

We introduce Figure 6 as an example of the hydrographs at one of the analysed locations, Welshbridge, for a particular extreme event. The main purpose of these plots is to present anecdotal evidence of some representative characteristics of the different Quantile Regression configurations, as the uncertainty increase with lead time. For a more extensive discussion on them, it would be necessary to add and compare hydrographs at all locations and lead times.

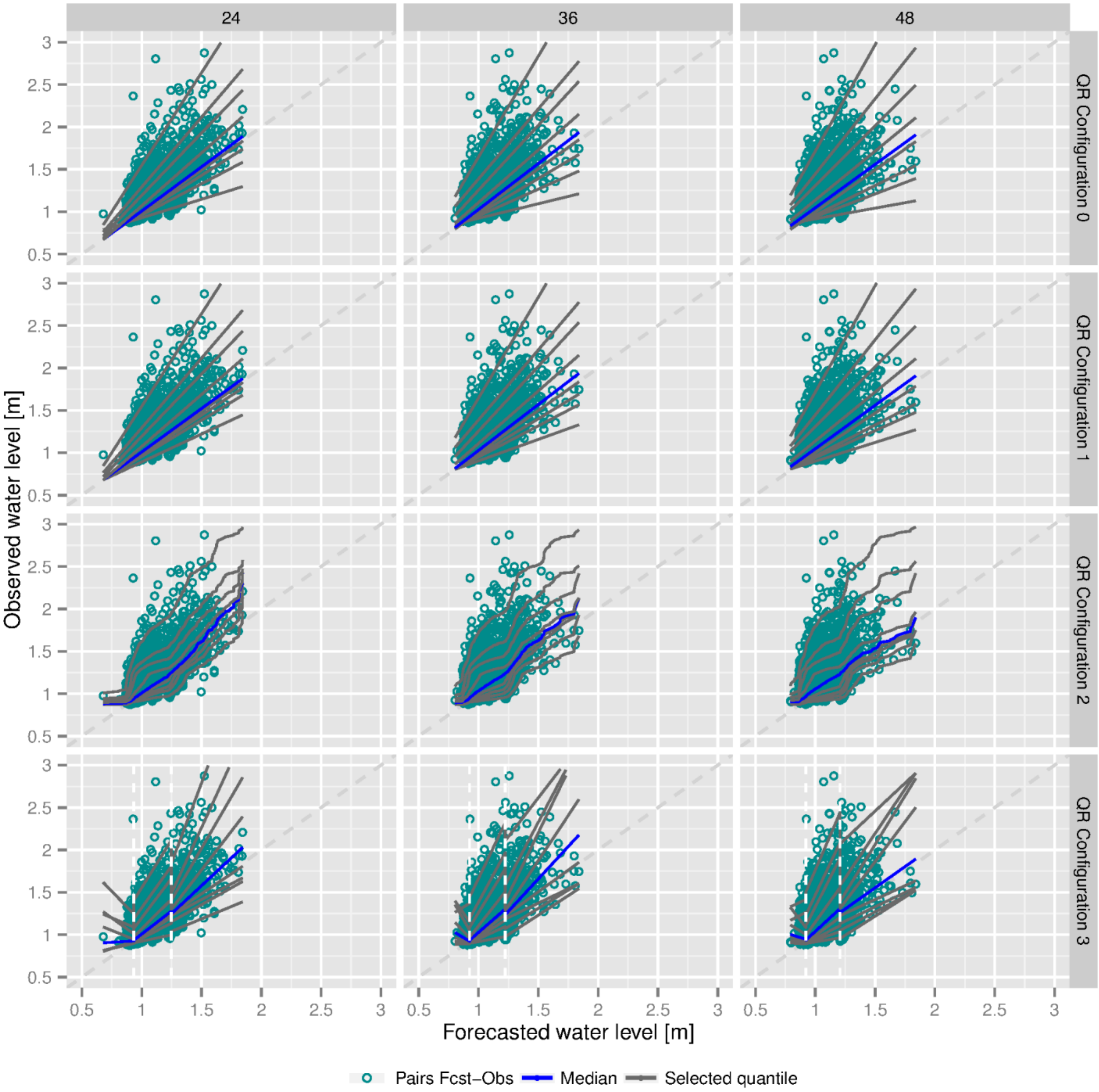
Additional references to be included

Smith, P. J., Panziera, L., & Beven, K. J. (2014). Forecasting flash floods using data-based mechanistic models and NORA radar rainfall forecasts. Hydrological Sciences Journal, (ahead-of-print), 1-15.

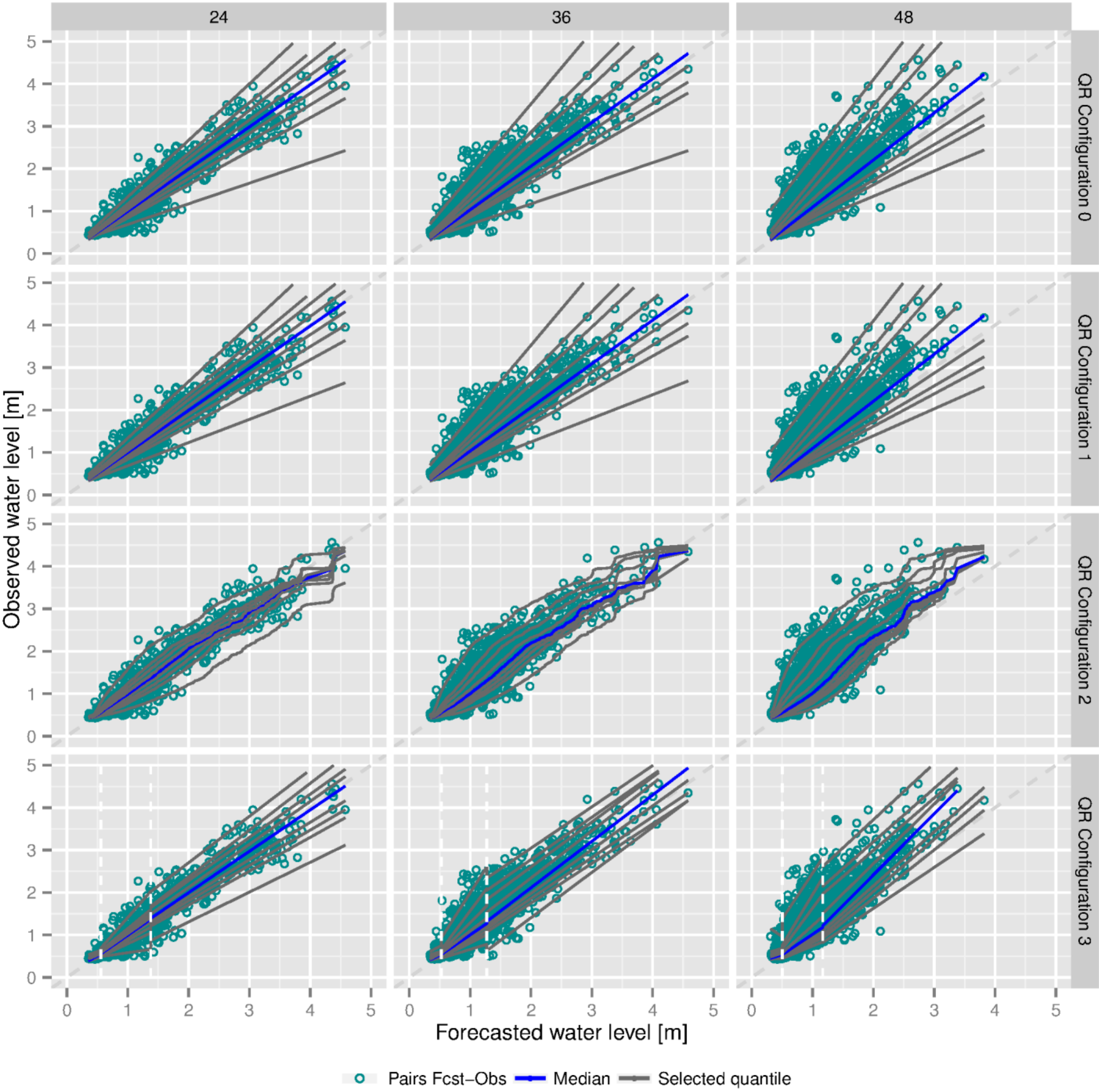
Additional modifications in figures and figures to be included



Figures 2. Quantile Regression models for Llanyblodwel. Rows show the four different configurations; columns show different lead times.



Figures 3. Quantile Regression models for Pont Robert. Rows show the four different configurations; columns show different lead times.



Figures 4. Quantile Regression models for Welshbridge. Rows show the four different configurations; columns show different lead times.

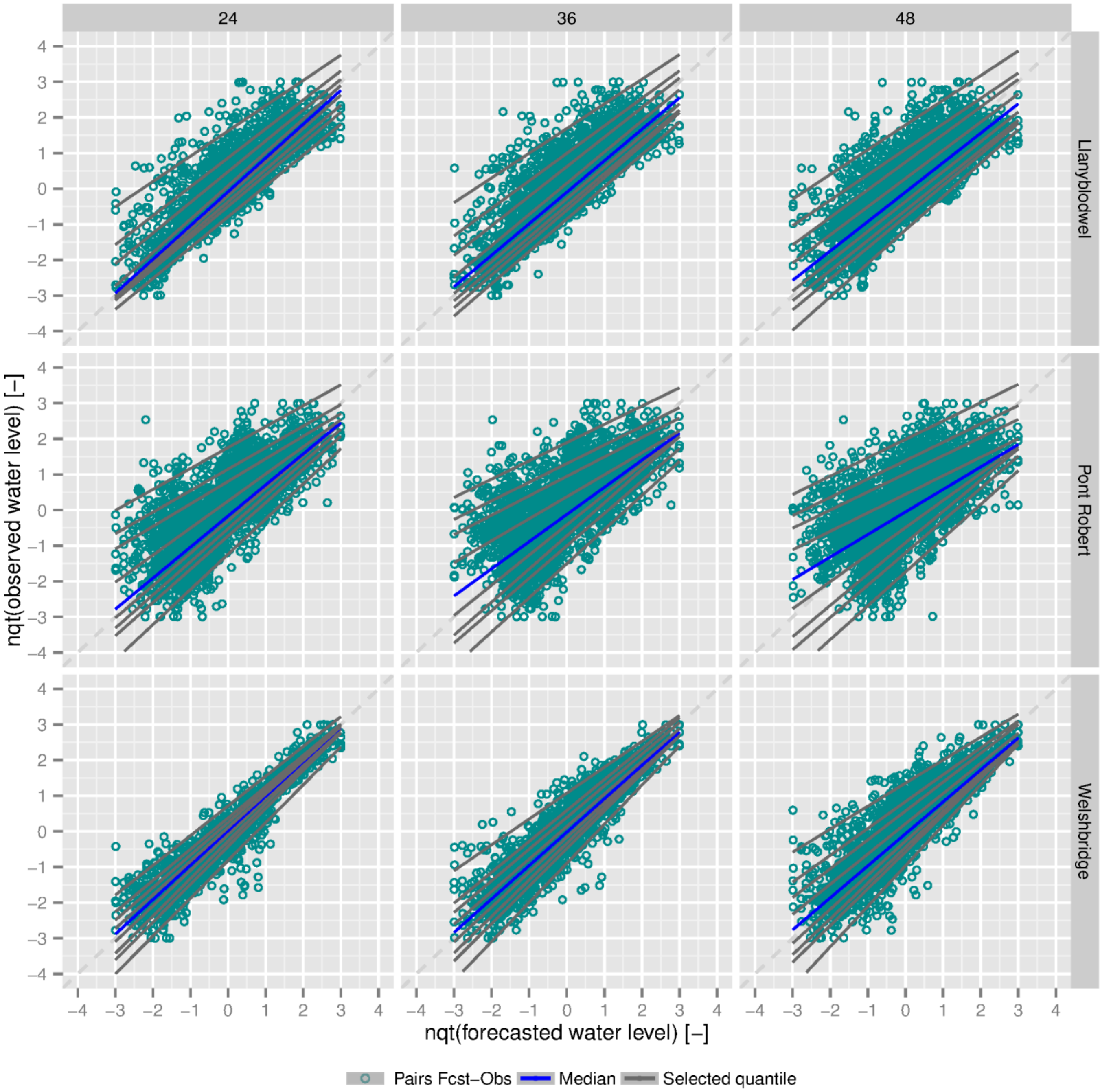


Figure 5. Quantile Regression models for Llanyblodwel, Pont Robert and Welshbridge in normal space (QR2).Rows show the three different locations; columns show different lead times.