Hydrology and Earth System Sciences Discussions

Interactive comment on "On selection of the optimal data time interval for real-time hydrological forecasting" *by* J. Liu and D. Han

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Many thanks for the constructive comments from Referee #2 which would help us improve the manuscript. Our replies are as follows:

Comment 1): 'This paper discusses the importance of the use of a suitable time step for real-time hydrological forecasting, and the selection of the optimal time step to use. This is an important point, but not one that is new. As the authors state in the abstract, this is known in the control engineering community. The authors claim however that this is ignored in operational applications of hydrological forecasting. While this may be correct in some locations, I do not think that it is generally the case. The authors do not give references or evidence to support their position, so it is difficult to assess the

accuracy of their statement.'

Reply: This is a useful comment. A research using Google scholar with the keywords 'hydrological forecasting' reveals 84,500 articles (covering scientific publications on hydrological forecasting in the last 30 years and beyond) and there is seldom mention of 'time interval' in those papers. Not only 'model time interval' is rarely mentioned, 'data time interval' and 'Nyquist Frequency' are also rarely mentioned. This indicates that model and data time intervals are largely ignored in hydrological forecasting publications. It is interesting to note that in a hydrological workshop a few years ago, we met Prof Peter Young (a renowned control engineer and hydrologist, also known to the reviewer) and he told us that he was amazed that so many hydrologists were not aware of the Nyquist Frequency, especially among the younger generation. Therefore, this paper is topical and timely for the hydrological community to realise the importance of this issue. We will add the Google search results in the paper to highlight the questions addressed in the study, and will further strengthen the literature review in this aspect (as also suggested by Reviewer #1).

Comment 2): 'The idea that the model time step should be a little less than the time of concentration is well know in the hydrological community (which includes a number of control engineers), however it is generally ignored due to the limitations of the resolution of the available data.'

Reply: This disregard was acceptable in the old days. However, with the modern telemetry system and remote sensing technology, 'the limitations of the resolution of the available data' as pointed out by the reviewer is not an issue anymore. The comment shows that this study is very relevant to the current and future situations in hydrological forecasting.

Comment 3): 'The problem of having a model time step that is too short is also well know for discrete models. It should be noted that continuous time models (see for example papers by Peter Young) avoid this issue and do not suffer from the numerical

issues of having a time step that is too fine.'

Reply: The detrimental effect of too short time interval is well known in the control engineering community (it is included in the text of discrete systems), but not in the hydrological forecasting community (as pointed in the reply to Comment 1). There are no hydrological text books addressing the model time interval issues. Although continuous time models avoid the time interval issue, they are not used in operational hydrological forecasting since modern hydrological forecasting is carried out by discrete digital computers. Nevertheless, it is useful to add this in the manuscript to clarify that not all models suffer from time interval problems as mentioned by the reviewer.

Comment 4): 'As it stands, the paper doesn't contribute a new result to the field of hydrology, rather reinforces an existing well know result. I am not working in the field of operational hydrological forecasting so I cannot comment from experience, I find it hard to accept that this idea is not generally known by people working in this area.'

Reply: This has addressed in the Reply to Comment 1.

Comment 5): 'page 10830, line 25: I would suggest saying "the future is that higher sampling rates will become more widespread".'

Reply: Agreed.

Comment 6): 'page 10833, line 5-7: For highly non-linear systems, then the model time step required may be even smaller due to the problem of solving a non-linear ODE numerically (see Kavetski and Clark papers). The requirement that the model time step is slightly less than the time of concentration really applies to all models, even linear ones.'

Reply: The reviewer has raised a very interesting point for future research. More studies on different hydrological models with different nonlinearities should be explored to find if there is a general pattern between model nonlinearity and model time interval. The reviewer's comment and the mentioned papers will be added in the manuscript.

Comment 7): 'page 10836, line 23: f_s>2B is a sufficient condition for a perfect reconstruction of the original signal only if there is no noise added in the sampling. If the signal has already been sampled at a higher frequency and is being rebinned to have f_s only just greater tha 2B, then yes. But if the analogue signal is being sampled at such a frequency, then the ability to reconstruct the original analogue signal depends on the noise added in the observations. Suggest adding "in the absence of observational noise" on line 26.

Reply: This is an excellent suggestion which will be added in the manuscript.

Comment 8): 'page 10853, line 19: "attention of hydrologists". Note that most hydrologists should already be aware of this, so in reality you are reminding them of this issue.'

Reply: Because of the general disregard on this issue by the hydrological forecasting community, 'reminding' is very necessary. In addition, the paper serves to stimulate further studies to find general patterns of model time intervals linked with different model types, catchment conditions and forecasting lead times so that the valuable knowledge gaps could be filled by the community effort.