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Interactive comment on "Using Deep Learning to Fill Spatio-Temporal Data Gaps in Hydrological Monitoring Networks" *by* H. Ren et al.

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The paper presents an interesting use of deep learning with LSTM Networks for infilling groundwater data. The article is timely and tries to make a comprehensive description and explanation of how the Deep learning technique is implemented using statistical and machine learning techniques. The paper is a welcome contribution to the field of groundwater and hydrological earth sciences. However, I cannot recommend publication in the present form due to the comments and questions raised. The paper needs major revision.

1. The paper states that long-term spatiotemporal changes in subsurface hydrological flow is usually quantified using a network of wells. However this paper does not deal

with the long-term trend or analysis. Hourly data is hardly interpreted or used for the long term. Hourly information for sure contains noise that would be advisable to remove for the long term analysis.

2. Observations are mentioned to be spatially sparse, and temporal gaps exist. Many papers have solved the same type of problem, without using the term spatiotemporal. Almost every course in hydrology deals in one chapter with the issue of using spatial correlation and temporal correlation to fill in data. So in this respect, the authors are invited to clearly indicate what innovation is brought by this work to spatiotemporal analysis.

3. Following point two, it is known that in most of the cases, aquifers with little or no human intervention have low variability. Conventional guidelines and measures in hydrogeological science are typically based on monthly data.

4. In the present paper the idea of nonlinear dynamics is mentioned almost everywhere in the introduction and justification of the work. This is somewhat surprising and needs better justification, since groundwater dynamics, in many cases, can be represented with linear models. As it is concluded in this paper results, ARIMA can approximate the system quite well.

5. The particular case study presented here shows a relative complex dynamic nature indeed, but it seems it is due to human intervention (however I could be wrong). Can you comment on this and the uncertainties associated?.

- The human intervention might affect your calculation and therefore, extractions might not be following a random but more human induced behaviour. So data understanding or replicability used in one year might not be the same in another. It would be advisable first to check how much and when extraction took place. Is this data filled in for a long term analysis, or short-term? This question arises since the hourly step is used. - If indeed human intervention influence the dynamics of the groundwater system, the logical approach would be to find a variable to represent direct or indirect measurement of extractions. - It is suggested to read the paper by Amaranto et al. (2018) “Semi-seasonal groundwater forecast using multiple data-driven models in an irrigated cropland”. J Hydroinformatics, 20 (6): 1227–1246. DOI: https://doi.org/10.2166/hydro.2018.002 and - Amaranto et al. (2019). A spatially enhanced dataâĂŘdriven multimodel to improve semiseasonal groundwater forecasts in the High Plains aquifer, USA. Water Resources Research, 55, 5941– 5961. https://doi.org/10.1029/2018WR024301

6. The regional aquifer and geology might play a more significant role in the study, since not only the river but the size and other interventions and hydrometeorological recharges might be correlated.

7. The stations are so close, and the hourly variation appears to be periodic with an amplitude of 4 or 5cm, according to Figure 1 (and on other graphs). It is intriguing, the question I would have is what happens every hour? and if this hourly variation is noise on the measurement device or data? What is the precision of the measurement device? What is the volume of water extracted to reach the variation of 1 cm? Where the recharge water comes from(has this been studied in the past)? Is this 5 cm recharge volume feasible in one hour? Could be the water from the river affecting your measurements (interflow)? It is advisable to present the time series of the river flow. It would be also useful to have a few hydrological balances (note that this is a hydrological journal). The problematic still can be questioned due to its apparent complex dynamics with the river and human intervention (not a typical, natural aquifer).

8. On the model setup, Please explain why you use Mx128.

9. Page 7, line 10, mentions the supplemental material, but I cannot find it in the paper.

10. Important: choice of (a very complex model) LSTM has to be justified, since it seems AR-type models is enough. Frankly, I don’t see the need for complex models like LSTM, but if you have arguments to defend your position, please present them to convince the readers.

11. On page 14, it states that other configurations of LSTM can be further explored; however, it is not clear why this was not done before. Not sure why the selected configuration was just tried to see if it works or not, without any analysis what is the best structure. This relates to comment 8 and 9.

12. I am a bit in confusion how to interpret the statements made in conclusion. The ARIMA is not suited or less suited for filling high frequency (hourly, or short gaps) and more suitable for a long term period (24, 48 and 74 hours). It is suggested we need deep learning for filling high-frequency gaps (of one hour)?. Maybe is good to elaborate on the simplicity of what this translates to, I am not sure if the meaning is right.

13. Not sure if there is an idea of how high is the overall error; in the figure 8, with well 1-15 it seems almost perfect representation (zero error in the validation data for many points). Also in the same well, it appears like high negative correlation up to 128 hours.

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