Answers to the potential review of the Anonymous Referee #1
by Elena Shevnina and Andrey Silaev

The Referee #1 concluded that the manuscript "still needs further improvement as described below prior to acceptance".

General comments:

Comment: At a first glance, the paper show how competent the authors are in probabilistic hydrological models. Reviewer thinks that key aspects of this research are to provide the theoretical background of Markov Chain System. The manuscript is well written and logically structured. The extensive literature review is much appreciated as well.

Answer: One formulates more precisely, the manuscript provides the basics of the statistical theory of automatic system (Pugachev et al., 1974), the simplifications behind to the Advance of Frequency Analysis (Kovalenko, 1993) as well as the equations used on the core version 0.2 of the probabilistic hydrological model MARCS (MARkov Chain System). In this manuscript, the authors not only translate the parts of two books with theoretical basis from Russian, but also try to formulate material logically and to provide the equations for the new core of the hydrological model. The theory of Markov Chain System is outside of the manuscript content, even it gives the name for the hydrological model with simple Markov Chain core (see the Eq. 2 in the manuscript). Only a couple of months ago, the authors realized that the model with name MARCS is already exists (http://marcs.astro.uu.se/index.php), however the official name is the MARCS – atmospheres. We would need to change the name of our probabilistic hydrological model (MARCS) or becomes to be involved to the MARCS model community with the probabilistic hydrological model MARCS – hydrosphere. It would probably needs to change the version of the core, status and content of the code during revision process.

These comments are incorporated to the revision of the manuscript.
Pugachev, V.S., Kazakov, I.E. and Evlanov, L.G.: Basics of statistical theory of automatic system, Mashinostroenie, Moscow, USSR, 1974. (In Russian).
Kovalenko, V. V.: Modelling of hydrological processes, Gidrometeizdat, St. Petersburg, Russia, 1993. (In Russian).

Comment: Even though the goal of the paper relies on the scope of GMD, the intuition of the approach is not clearly stated. Since the approach uses Markov chain system, for the recent scientific community, it may not be new. So, the reviewer suggests laying the objective of the paper in different way. Indeed, the authors showed much effort on the topic but there is not much about the model use and its description. The manuscript mentions the version of model is 2. Reviewer does not see properly how they are different. The assumptions of the model are not clearly stated. The paper is mathematically enriched. Sometimes, reader may lose the concentration due to inappropriate description of the technical jargons.

Answer: We agree that the Markov Chain System approach is known by the recent scientific community and it is not a new. However, in this manuscript we attempted to explain the method used in the math "language", not on the intuition "language". On both "languages" it is not easy if the topic is on a boundary of two scientific disciplines (Hydrology and Statistical Radiophysics in our case). On the boundary, the therms may come from both sides to add or to complement each others, and it results to a specific jargon, which is noticed by the Referee 1. The back ground of the authors comes from the Hydrology (the frequency analysis and physical modeling) and the Radiophysics (the statistical theory of automatic system), and the explanations in the manuscript were given on the "language" in common. In our manuscript, we try to use the math equations as

much as possible to prevent non-correct description of the method due to the difference in the therms. It results to the "mathematically enriched text". In this manuscript, the core version 0.2 was presented in details. The previous model version 0.1 is shortly described in the Annex to Shevnina et al. (2017) without any theoretical details, which we have promised to present in our next manuscript. To follow our promises, this manuscript fills the gap and provides the theoretical basis of the probabilistic hydrological model MARCS. In the revised manuscript we stressed these two circumstances.
Shevnina, E., Kourzeneva, E., Kovalenko, V., and Vihma, T., 2017: Assessment of extreme flood events in a changing climate for a long-term planning of socio-economic infrastructure in the Russian Arctic, Hydrol. Earth Syst. Sci., 21, 2559-2578, doi:10.5194/hess-21-2559-2017.

Comment: The conclusion made in this manuscript seems to be the summary of the whole content. It may need revision posing future research and recommendation of this research. Right now the direction of this research is not clear. The reviewer suggests including some potential application beyond the water engineering even though the method is similar to Pearson type distribution. The extension of the paper will be better if the idea of posing such approach in space. Such statement shall be made clearly.
Answer: We agree, that it is important to place the probabilistic approach amount others hydrological modeling approaches. The general view on this place is done in Shevnina et al., 2017 (Fig. 1), and the details are provided in Shevnina et al. (2018). In the revised version of the manuscript we add one figure to show how different scientific disciplines are overlap in the AFA approach. It should be noted, that the statistical theory of automatic system is adopted to be used for a seasonal prediction of water inflow to hydropower reservoirs by Domínguez and Rivera (2010) and Shevnina (2001). There are also more studies published in Russian whose not included to the list of References since it is already long. It does not include a number of oral and poster presentations and lectures. However, in revised version of the manuscript we extend the section of discussion. It helps to clarify the place of the approach among others as well as to suggest the direction of the MARCS model development.
Domínguez, E., and Rivera, H.: A Fokker–Planck–Kolmogorov equation approach for the monthly affluence forecast of Betania hydropower reservoir, J. Hydroinform., 12(4), 486–501, doi: 10.2166/hydro.2010.083, 2010.
Shevnina, E.: Deterministic and stochastic models for seasonal forecasting of inflow to reservoirs of hydropower stations, PhD thesis, Russian State Hydrometeorological University, Russia, 188 pp., 2001. (in Russian).

Constructive suggestions

• Author mentioned three statistical moments in line 79. But these are not listed here. For general audience, reviewer suggests to list them.
Answer: we added the list of the moments in the revised text.
• Section 1.1 is very rich in mathematical expression. Only audience or practitioner with sound mathematical background easily understands. But for general audience, this section shall be revised in a simpler way…
Answer: We would like to keep the math "language" of the section, however we arranged the equations on other way: the revised text of the section 1.1 now included only the equations behind the model core, and the Annex provides the theoretical basis for the readers wanted to the details.
•Please briefly mention what kind of parameters are lumped one and why such is called.
Answer: we clarify the situation in the revised version of the manuscript.
• The reviewer wants to have implicit explanation of the secondary parameters like a, b, c and c, Gs. It is not clear how such empirical equations are related with either data or physics.
Answer: we try to clarify the situation in the revised version of the manuscript.
• Are the time-series data are daily or monthly or yearly as mentioned in line 227? It would be better to define the time scale.

Answer: the time series of runoff consists of yearly discharges, thus the time scale of the process considered is multi-year, long term. It was was stressed in the revised version.

• In order to make the paper strong, reviewer suggests having some key statistics pictorially. This means how the observed set and models are correlated. What is the degree of performance?

Answer: In this manuscript we presented only the core, not the validation procedure for the probabilistic hydrological model. The validation procedure is described in Shevnina et al. (2017) and includes also figures and tables to show the degree of the model performance under two characterization schemes. Since the text is already long we refrained to add discussion of the model validation block (Shevnina and Gaidukova, 2017).

•Reviewer feels the paper is somewhat incomplete as in the several statements; the authors did not mention how future works will be proceed. They just envisioned about the future paper.

Answer: We agree, that steps of the future work were not described in the manuscript, and only the main directions were mentioned. However, now it is still difficult to outline a circle of potential stockholders for a probabilistic form of forecasts of river runoff. This form of forecast allows evaluation of extremes, which is important for risks assessment, in particularly in a design of building construction (Shevnina et al. 2017). In our opinion, it needs to find a common "language" with an Economic, and we have tried to do it in Shevnina et al., 2018. Recently, the direction of the development for the probabilistic hydrological model depends on the Academy of Finland.

Specific comments

• In line 90, comma is needed between features and which.

Answer: We revised the text.

• The authors mentioned in parenthesis ("the reference"). What does it mean? It seems the authors forgot to have proper citation. In line 158.

Answer: We added the explanation.

• There are three graphs in the paper however, they are not proper captions. In line 273 has Figure 2, but where is Figure 2?

Answer: We improved the quality of the figure .