Answers to comments and conclusion given by A. Frolov

To answer to the comments given by lead scientist researcher of Water Problems Institute of Russian Academy of Sciences Dr.Sci. A. Frolov the authors will follow to the order in his list.

To the comment 1 by Frolov A.:

The "linear black box" model with stochastic components is used as core equation for the hydrological model because it fit an assumption that the multi-annual runoff time series can be considered as a simple Markov chain stationary process (Kovalenko, 1993). To proof this assumption in hydrology, an autocorrelation coefficient (AC) is usually applied (Dobrovolski, 2011; Rozdestvenskiy and Chebotarev, 1974), and the AC is statistically significant on numerous observed annual runoff time series (Ratkovich, 1993; Rogdestvenskiy, 1986; Ratkovich, 1976). In our study, the "linear black box" model was chosen as physical core to describe the annual river surface runoff, while the linear model of the river basin with a stochastic input process by Klemeš (1978) is mostly applied on seasonal and short-term predictions, i.e. it considers more complicate physical processes going on a river catchments.

To clarify this issue, the text above was added to the manuscript together with the following references:

Dobrovolskiy S.: Global change on river runoff. Moscow: GEOS, 660 pp., 2011.(in Russian).

Klemeš V.: Phisically based stochastic hydrologic analysis// Adv. in Hydroscience, 11, 285-386, 1978.

Ratkovich D.: Multi-year fluctuation of river surface runoff. Regularity and regulation. Leningrad, Gidrometizdat, 225 pp., 1976. (in Russian).

Ratkovich D.: Hydrological basis of water supply. Moscow, The Water Problem Institute of Russian Academy of Science, 429 pp., 1993. (in Russian).

Rogdestvenskiy A. V.: Spatial and temporal variations of river flow in USSR, Leningrad, Gidrometeizdat, 385 pp., 1988. (in Russian).

Generally, it is important continuously expand a range of hydrological models to be apply in various situations depending on time and space scales of a processes considered withing the framework of the particular study.

To the comment 2 by Frolov A.:

In our paper, the Eq. (4) do not include the parameter k (the runoff coefficient, following Kovalenko, 1993), and the parameter a_0 (page 4, line 105,) includes the stochastic component of the Gaussian "white noise" with zero means. The Eq. (4) is written for a continue time, and the only single correlation function as well as the only single the coefficient of correlation are existed. While the time is discrete in practical calculations, there are different assumptions how the continue time can be presented discretely. In our study, the only stationary processes were considered (see page 5, line 126), thus the correlation functions and time relaxation issues do not considered. The revised manuscript includes this explanation in the section of Discussion. Since, the second comment given by A. Frolov is addressed more to Kovalenko (1993) we decided to include the critical discussion (in Russian) the AFA method used in Shevnina (2015) as a supplement to this manuscript.

To the comment 3 given by A. Frolov:

While the Eq. (4) allows the infinite values of non-central moments for combination of the parameters, the probability density function of annual runoff was assumed to be the functions of only three non-central moments in our study. This assumption is proofed by numerous studies addressed to the annual runoff distribution fitting to multi-year surface river runoff observations including time series of the annual runoff (van Gelder et al., 2006; Rogdestvenskiy, 1986; Matalas and Wallis, 1973). The distribution function of only three parameters are common in the

hydrological engineering practice (SP, 2004; Guidelines, 1986), and it was also used withing this particular study. To answer this comment the text above was added to the revised version on the manuscript in the section of Discussion. The numeration of the equation was also changed (since it was noticed that the Eq. 16 does not exist).

To the comment 4 given by A. Frolov:

In our model description paper we would like to rise the discussion on the Fokker-Plank-Kolmogorov approach in hydrology (Rosmann and Domínguez, 2017; Shevnina et al., 2017; Kovalenko et al., 2010; Domínguez and Rivera, 2010; Kovalenko, 1993) to define its place among others modeling approaches. In our manuscript we consider only the method of AFA, and we would like clarify any concrete critics, questions and comments connected to the MARCS model core version 0.2. The MARSC model is under development, and it includes many blocks (Shevnina, 2015). The results of the model validation together with details about the cross-validation procedure are previously presented by Shevnina et al. (2017) and Kovalenko (1993).

To the comment 5 given by A. Frolov:

Unfortunately, it is not directly mentioned why "the limits of integration are incorrectly indicated". We can just suppose that this comment linked to the value of Q>0, thus $\int_{-\infty}^{+\infty} p(\mathrm{Q,t})$ may be rewrite as $\int_{0}^{+\infty} p(\mathrm{Q,t})$ since Q>0. The Eq. (4) allows the $p(Q,t)>0$ for the Q<0. However, this situation can be recognized on a data preprocessing analysis (see details in lines 55-60, p. 6), thus it allows to modify the basic core (the Eq.(4) in this study) to more advanced. It could be the topic of other model description paper. The above text is now added to the section of Discussion.

To the conclusion given by A. Frolov:

It should be noted, that most comment are actually not addressed to this particular study, which is the model description paper. Thus, it is not possible to discuss the Fokker-Plank-Kolmogorov approach in hydrology withing one particular paper. However, we are going to continue our study in the future.

With the best regards
Elena Shevnina and Andrey Silaev