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Interactive comment

Interactive comment on "Scenario approach for the seasonal forecast of Kharif flows from Upper Indus Basin" *by* Muhammad Fraz Ismail and Wolfgang Bogacki

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Dear Referee No. 2

Thank you for your specific comments and suggestion, we have tried to address your concerns on the points you have mentioned below. We appreciate your precise comments and detailed suggestion for the improvement of our paper.

COMMENT: Section 2.2 (Line 11-14). You should provide enough quantitative evidences to explain how to divide the Upper and Lower parts within UIB.

RESPONSE: The main reason for splitting the model into two parts is that the Modified

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Discussion paper

Depletion Curve approach for predicting the available snow-water equivalent, which strongly depends on a representative behavior of the elevation zones that are already melting at the time when the forecast is to be issued. In this respect, the snow cover at the Tibetan Plateau behaves very different from the remaining parts which leads to a severe underestimation of the actual snow-water equivalent. These differences in snow cover depletion are given in our comparison in Table 01 of the research paper. We will explain this in more detail also giving some figures which will exhibit this effect. Ideally the split between Upper and Lower UIB model should be done downstream of the Tibetan Plateau. Due to the lack of discharge data in this part of the UIB, Kharmong as the closest gauging station where daily discharge data is available was selected.

COMMENT: Section 2.2 (Line 15-16). There are little details about the Kirpich travel-time equation that is used to determine the 3-day time lag between Kharmong and Tarbela. Please add the relevant information in the revised version.

RESPONSE: We will give a short paragraph on the Kirpich formula as well as on the determination of the input values, i.e. channel flow length and main channel slope.

COMMENT: Section 3 (Line 1-5). This part (forecast skill metrics) belongs to method description. Please move it to Section 2.

RESPONSE: You are right. We shall move this to the methods section in the revised version.

COMMENT: The authors only focused on the forecast performance of median (50%) volume values. Actually, the extreme volumes, like “dry” (20%) and “wet” (80%) conditions, may be of greater importance for the downstream regions. It should add a few additional skill assessments in terms of predicting extreme conditions.

RESPONSE: We have confine ourselves to a comparison of the forecasted “most likely” (median) values, as only these are in hand for the IRSA and UBCWM forecasts. We shall add a figure giving the 20%, 50%, and 80% flows forecasted by SRM+G for all years in comparison with the observed volumes, on which the forecast skill for extreme conditions will be discussed.

COMMENT: This study assessed the forecast skill only by examining the volume difference of determined values. In the revised version, a few probabilistic quantitative metrics, like anomaly correlation (AC), Brier Score (BS), the false alarm rate (FAR), hit rate (HR), and Equitable Threat Score (ETS), should be employed to assess its skill in probabilistic forecasting.

RESPONSE: We have focussed on the error in predicted flow volume, as this is the common metric in discussions with the involved authorities. We will discuss additional probabilistic metrics like the ACC in the revised version. We also may visualise these in a Tailor diagram etc. However it has to be considered, that forecasts by all of the three models are primarily based on estimates of the snow-water equivalent at the beginning of the Kharif season while the climatic conditions during the forecast period, including precipitation during monsoon, are basically averaged. Thus all models tend to predict near to average conditions.

COMMENT: Section 3. Please add 1-2 figures to illustrate the comparison of SRM+G model-based scenario approach with other forecast models.

RESPONSE: There are only two operational forecast models currently working in Pakistan. One is IRSA's statistical model and the other is the University of British Columbia Watershed Model (UBCWM) which is operated by the Glacier Monitoring and Research Centre (GMRC) of Water and Power Development Authority (WAPDA). In Table 04 of the research paper we have given a summarised comparison with these two models. Table 04 will be substituted by a more detailed comparison of yearly forecast results with all three models for the study period as given in the attached Table 01.

COMMENT: You are suggested to add a comparison between SRM+G and SRM, to highlight the superiority of SRM+G in terms of incorporating glacier component.

RESPONSE: We very much appreciate this suggestion as well as the one below, as this will more clearly point out the improvements obtained in the study. We have added a comparison of SRM (without Glaciers) and SRM+G (with Glaciers). In the attached Figure 01 one can see the impact of glaciers on the hydrograph while using the same set of parameters for both the models. The impact of glacier in the Lower UIB is much more prominent than in the Upper UIB. The reason is that in the Lower UIB the glaciated area is about 10.5% of the catchment area while in the Upper UIB the glaciated area is only 1.7%.

COMMENT: Adding a comparison of SRM+G estimates between with and without consideration of divisions (Upper and Lower parts) should be inserted and discussed in the revision.

RESPONSE: We will give a comparison of forecast results and a more detailed discussion on this. Please see also our response to the 1st comment.

COMMENT: Section 2.3 (Line 30). If I understand correctly, R indicates the daily runoff depth, not precipitation depth.

RESPONSE: Yes, you are right, precipitation depth relates to the original SRM notation. We shall re-write this in the revised version.

COMMENT: Section 2.5 (Line 33). "TRMM 3B34 product" should be "TRMM 3B34 product". Please correct it.

RESPONSE: We have written "TRMM 3B34 product" in our paper. So please let us know what your point is.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/hess-2017-182/hess-2017-182-AC1-supplement.pdf

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Table 01: Yearly comparison of forecasted Kharif flows [$10^6 m^3$] for the three operational forecast models

		[illegible]				SRM+G			UBCWM		
Year	**Observed**	**Most Likely**	**Error**	**|Error|**	**Most Likely**	**Error**	**|Error|**	**Most Likely**	**Error**	**|Error|**
2003	67773.7	63960.6	-5.6%	5.6%	63099.6	-7.0%	7.0%	63468.6	-6.0%	6.0%
2004	51783.5	60516.6	16.9%	16.9%	60762.6	17.0%	17.0%	63591.6	23.0%	23.0%
2005	68880.7	69003.7	0.2%	0.2%	60885.6	-12.0%	12.0%	73308.7	6.0%	6.0%
2006	67773.7	68388.7	0.9%	0.9%	61623.6	-9.0%	9.0%	73308.7	8.0%	8.0%
2007	60516.6	74907.7	23.8%	23.8%	61008.6	1.0%	1.0%	70110.7	16.0%	16.0%
2008	57687.6	68511.7	18.8%	18.8%	53874.5	-7.0%	7.0%	59163.6	3.0%	3.0%
2009	57564.6	63714.6	10.7%	10.7%	62361.6	8.0%	8.0%	67158.7	17.0%	17.0%
2010	76629.8	63345.6	-17.3%	17.3%	61377.6	-20.0%	20.0%	68388.7	-11.0%	11.0%
2011	60024.6	67158.7	11.9%	11.9%	59901.6	0.0%	0.0%	70848.7	18.0%	18.0%
2012	55350.6	61254.6	10.7%	10.7%	60393.6	9.0%	9.0%	61746.6	12.0%	12.0%
2013	65559.7	64944.6	-0.9%	0.9%	59778.6	-9.0%	9.0%	58794.6	-10.0%	10.0%
2014	52890.5	64575.6	22.1%	22.1%	61377.6	16.0%	16.0%	64206.6	21.0%	21.0%
2015	67158.7	63345.6	-5.7%	5.7%	58917.6	-12.0%	12.0%	61254.6	-9.0%	9.0%
2016	66420.7	62361.6	-6.1%	6.1%	63062.7	-5.0%	5.0%	66420.7	0.0%	0.0%
Bias / Mean Absolute Error			**5.7%**	**10.8%**		**-2.1%**	**9.4%**		**6.3%**	**11.4%**

Fig. 1.

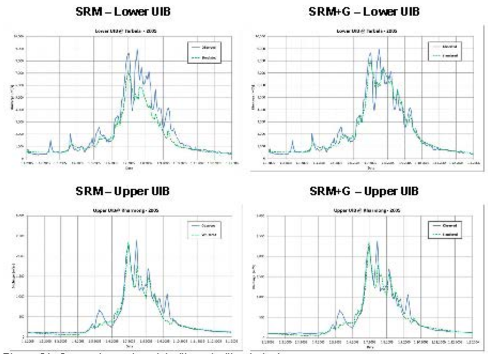

Figure 01: Comparison of model with and without glaciers

Fig. 2.