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Hydrology and Earth System Sciences Discussions

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Interactive Comment

Interactive comment on "Responses of snowmelt runoff to climatic change in an inland river basin, Northwestern China, over the past 50a" *by* J. Wang et al.

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Thanks for your kind suggestion. The following is our replies,

1. The hydrological response to climate change using SRM has already been assessed in numerous climatic zones all over the world. The paper is technically correct but not well written. The authors attempt to analyze the responses of snowmelt runoff to climate change over the past 50a in Northwestern China. But unfortunately they didn't put the focus on in this work, although they listed lots of work they have done, including improving snow cover mapping method through incorporating CIVCO model for DEM

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correction and an improved NDSI threshold. Specifically, CIVCO model for the terrain elimination was not one of the main works developed by authors in this work. And they didn't evaluate the CIVCO model in this study.

Reply: The response of snowmelt runoff to climate change is the topic of the manuscript. Snow cover mapping is very important in simulation of climate change scenario using SRM model. However, most of the previous similar job had paid more attention on some parameters such as recession coefficient and runoff coefficient. In Heihe river basin, snow cover is usually thin, patchy and instable. Snow Cover Area (SCA) is almost a random variable in a snow season, so its accurate acquisition is more important than other characteristic parameters of the basin. Using CIVCO model and NDSI adjustment is an effective way to more accurate results. As your kind suggestion, we thought it is necessary to analyze the deeper relationship between air temperature, precipitation, runoff and snow cover area.

2. When the authors improve NDSI threshold in this study area, the range of NDSI is set 0.3_0.4, which didn't give the explanation for the range selection. In another words, why did we try 0.4_0.5?

Reply: In different types of snowpack, a credible threshold can be established. However, the previous results also indicate that a range of NDSI threshold values between 0.20 and 0.50(Hall, 1995;2002). NDSI threshold values greater than 0.50 resulted in large changes in snow extent; visual analysis indicated that actual snow cover was eliminated at these higher thresholds. At low NDSI thresholds, that is 0.20 and lower, many non-snow pixels are identified as snow. In the paper, the MODIS snow products were compared with the Landsat-ETM+ snow cover maps (groudtruth). We found the MODIS snow products underestimate the snow cover in study area. The NDSI threshold of the MODIS snow cover products distributed by the NSIDC (National Snow and Ice Data Center) is 0.40. The NDSI values of the MODIS scenes are greater than or equal to 0.40 represent snow cover pixels. An early research (Hall, 1995) have indicated that the snow areal extent (number of snow pixels) decreases as the NDSI threshold was increased from 0 to 1.0 from MODIS image. So the NDSI is less than 0.4. Further comparison found the snow cover area was overestimated when the NDSI is equal to 0.3. So the credible NDSI threshold for MODIS snow mapping is during the range of 0.3-0.4 in the study area. In the manuscript, the NDSI threshold value was increased gradually for 0.30 to 0.40 by 0.01 intervals. A credible NDSI threshold was estimated when MODIS snow cover area was close to the Landsat-ETM+ snow cover area in the study area.

3. What's the representative of three weather stations used in the manuscript to the whole inland river basin in Northwest China? The authors should give more details here.

Reply: Heihe river basin is the second largest inland river basin over China. Heihe river basin is a typical basin in arid northwestern China because of its topography, climate, and environmental conditions. The supplies of water resources of the Heihe River in spring are snowmelt runoffs and ground water. Therefore, flow patterns of the Heihe River, which show very typical trends of snowmelt runoffs for those rivers originated from mountains with significant amounts of snow cover in northwestern China, response sensitively to climatic changes. The altitudes in the Heihe Watershed range from 1674 to 5108 m. Long-term snow cover snowlines, permafrost and alpine vegetation are above 3600 m. High Mountains zone consists of glaciers, snow cover, permafrost and alpine meadow, dotted with patches of shrubs and forests. According to the distribution rule of snow cover, they are divided to three vertical zones which can be represented by the three weather stations used in the manuscript.

4. This paper contained some ambiguity, such as "Annual average air temperature of three different weather station located in the basin has increased 2.1, 2.5 and 2.9deg, respectively", here authors should add the span time, such as from 1959a to present. Also in the conclusion part, "discharges become larger as the responses of snowmelt runoff to air temperature increasing".

Reply: Thanks, we will modify this part as your suggestion.

5. P500, line20-21, "The new snow cover algorithm considered the effect of atmospheric and topographic conditions", how to consider the atmospheric effect in estimating snow cover, the authors didn't mention here? Only a flow chart in Figure 2.

Reply: In the paper, the MODIS surface reflectance data (MOD09) were used to map the SCA. Figure 2 shows the detail flow. By applying the proposed algorithms and associated processing code, MODIS level 1B radiances are corrected for atmospheric effects to generate the MODIS surface reflectance product (MOD09). We'll add some explanation following your suggestion.

6. P501, how to calculate the Recession coefficient for QiLian station and YinLuoXia station? How many data was used for the calculation?

Reply: The recession coefficient is an important feature of SRM since (1-k) is the proportion of the daily meltwater production which immediately appears in the runoff. Analysis of historical discharge data is usually a good way to determine k. The detailed method we used follow the suggestion by Martinec(Martinec, Rango et al. 2005). Runoff observation through 2004 snow season was used to obtain the coefficient. We will add more detail description about this parameter in the further manuscript.

7. P503, in the analysis of air temperature and precipitation change, the authors used Qilian and YeNiuGou and Tuole Station, which were different from for the snowmelt runoff analysis. The difference between maximum and minimum air temperature over the past 50 year, is about 2.1 deg at Qilian Sation, 2.6 at YeNiuGou Station and 2.9 at Tuole Station", that seemed not reliable.

Reply: The three stations located at different altitudes of the basin. As the control factors, air temperature and precipitation play most important roles in runoff produces. The change trend of air temperature and precipitation is similar with each other. We will add more description in real scenarios analysis. The difference between maximum and minimum air temperature over the past 50 year, was resulted from Fig. 4. (Change of the average annual air temperatures of weather stations in the past 50 years).

8. What's the dark line in Figure 4?

Rely: It is the linear fit of the dataset.

9. Figure 9, why the maximum runoff (discharge) happened in Aug in 00s?

Reply: Snowmelt is dominant in spring discharge, however, rainfalls contribute major part of the discharge in summer, so the maximum runoff happened in Aug is reasonable.

10. A spelling error on the 9th line in Page 500, 'MODSI' should be 'MODIS'.

Reply: Yes, we will correct the error.

References: Martinec, J., A. Rango, et al. (2005). SRM ïijĹSnowmelt Runoff ModelïijĽUser's Manual. E. Gómez-Landesa. Hall D K, Riggs G A, Salomonson V V. Development of methods for mapping global snow cover using moderate resolution imaging spectroradiometer data. Remote Sensing of Environment. 1995, 54: 127–140. Hall D K, Riggs G A, Salomonson V V, et al. MODIS snow-cover products. Remote Sensing of Environment. 2002ïijŇ83: 181-194.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 493, 2010.