Response to referee #1's comments

(1) Abstract P6896, L15. Change "DY station" to "cold regions catchment". Make the statement more general.

Answer: Revised (Line 29 in the revised manuscript).

(2) Introduction

For the mini-review, cold region hydrology modeling in Siberia is suggested to be mentioned, for example, Ye et al., 2009. Ye, B. S., Yang, D. Q., Zhang, Z. L. and Kane, D.: Variation of hydrological regime with permafrost coverage over Lena Basin in Siberia, Journal of Geophysical Research, 114(D07102), doi:10.1029/2008JD010537, 2009. A special issue on frozen soil parameterization on JGR also provides up-to-date knowledge in this field. Zhang, T., F. Nelson, and S. Gruber. 2007. Introduction to special section: permafrost and seasonally frozen ground under a changing climate. Journal of Geophysical Research 112, F02S01, doi:10.1029/2007JF000821.

Answer: Two references (Stocker-Mittaz et al., 2002; Ye et al., 2009) (Lines 49-50 in the revised manuscript) have been added in the review of cold region hydrology modeling.

Stocker-Mittaz, C., Hoelzle, M., and Haeberli, W.: Permafrost distribution modeling based on energy-balance data: a first step, Permafrost Periglacial Processes, 13, 271–282, 2002.

Ye, B. S., Yang, D. Q., Zhang, Z. L. and Kane, D.: Variation of hydrological regime with permafrost coverage over Lena Basin in Siberia, J. Geophys. Res., 114, D07102, doi:10.1029/2008JD010537, 2009.

(3) Model description

P6898, L21. The radiation budget is calculated by the WEB-DHM or the model uses all (or part of) the radiation components as input (forcing) needs to be clarified.

Answer: The radiation budget is calculated by the WEB-DHM; while only the downward shortwave and longwave radiations are used as the model inputs. Due to

the 3rd referee's comments, the description of radiation budget has been removed in the revised manuscript.

(4) P6899, L8, define the unit of Ta. L9, define the unit of P. L12, How is the Eq 4 derived? A reference is needed. L12, The Mgs needs to be defined.

Answer: In the old manuscript, P6899, L8, the Eq. 3 should be $T_W = 0.584 * (T_a - 273.15) + 0.875 * e - 5.32$. The unit of T_a and P are (K) and (m), respectively; the Eq. 4 follows the Eq. 31 of Sellers et al. (1996a). M_{gs} is the snow-ice stored on the ground (m).

Sellers, P. J., Randall, D. A., Collatz, G. J., Berry, J. A., Field, C. B., Dazlich, D. A., Zhang, C., Collelo, G. D., Bounoua, L.: A revised land surface parameterization (SiB2) for atmospheric GCMs, Part I: Model Formulation, J. Climate, 9, 676-705, 1996a.

In the revised manuscript, the method by Yamazaki (2001) has been removed, which is found having little influence on the simulated results; while the review of the treatments of snow is also removed. Alternatively, the generally processes and the soil model of WEB-DHM are briefly reviewed, according to the 2nd referee's comments.

Yamazaki, T.: A one-dimensional land surface model adaptable to intensely cold regions and its applications in eastern Siberia, J. Meteorol. Soc. Jpn., 79(6), 1107-1118, 2001.

(5) Datasets for the study area

P6904, L3-4, change "with the air temperature increase, snowmelt occurred from the lower regions to the mountain areas" to "with the increase of air temperature, snowmelt occurs from the lower regions to the mountain areas".

L7. Change "was rather small" to "is rather small".

P6905, L9. Change "and can be obtained. . ." to "can be obtained. . .".

L 13. Change "hourly time steps" to "hourly time step".

Answer: Thanks.

In the revised manuscript, all of them have been revised except that "and can be obtained" (Line 264) is kept:

Lines 279-280: "with the increase of air temperature, snowmelt occurs from the lower regions to the mountain areas";

Lines 283-284: "is small (around 15% of annual runoff; Zhang and Yang, 1991)"

Zhang, X., and Yang, Z.: The primary analysis of water balance in in Binggou Basin of Qilian Mountains, Journal of Glaciology and Geocryology, 13(1), 35-42, 1991. [In Chinese with English Abstract]

(6) Model evaluations at the Binggou watershed

P6905, L19. change "and then the optimized soil hydraulic parameters were obtained by the calibrations of . . ." to "and then the soil hydraulic parameters were optimally obtained by the calibrations of . . .".

Answer: Revised (see Lines 303-304 in the revised manuscript).

(7) P6906, L5. "top soil depth" should be "total soil depth"?

Answer: The WEB-DHM includes a lumped unconfined aquifer to describe the groundwater dynamics, and the "top soil" represents the soil column above the unconfined aquifer (see Fig 2 in the revised manuscript). Therefore, it is called as "top soil depth" (D_s).
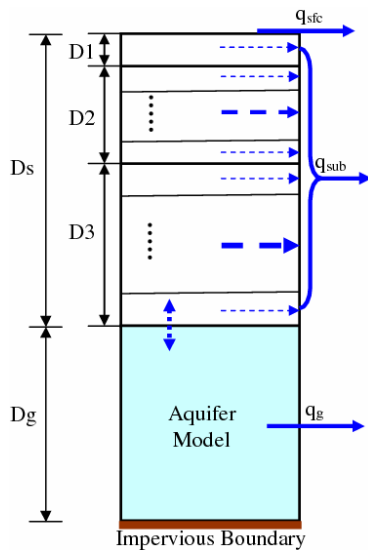

Figure 2. Soil model of the WEB-DHM.

(8) Figure 8-g. The overestimation of soil moisture at the deepest layer may due to the large gravels distributed in deep soil layers.

Answer: Good comments. We have added the sentence (Lines 427-431) in the revised manuscript: "The overestimation of soil moisture at deep soil layer (25-125 cm), from May to July 2008 by the WEB-DHM with the frozen scheme is possibly attributed to the large gravels distributed in deep soil layers. Without considering the large gravels, the excessive recharges to the deep soil layer from the unconfined aquifer may have been simulated with the WEB-DHM with the frozen scheme."

(9) Tables

Table 2. The canopy cover fraction is set as 0.3. But in the main text, it is 0.9 (P6906, L1). Please check the consistence. Table 2. As,v is 0.12 but in the main text it is 0.15. Please check the consistence.

Answer: Sorry for my unclear description.

The parameters within the main text refers to the SiB2 biome 9 (Agriculture/C3 grassland); while the Table 2 gives the area-averaged values from all the 3 SiB2 biomes in the basin.

Furthermore, in the revised manuscript, the canopy cover fraction has been changed into "0.2" for the land use of "Agriculture/C3 grassland", according to the field observations.

Further discussion with the authors (not an obligation for the authors to answer):

(10)

Will the frozen soil process have an impact on lateral flow? How can this be modeled and validated?

Answer: Yes, the frozen soil process has a great impact on lateral flows, since the freezing/thawing significantly modulates the soil hydraulic conductivity in both vertical and lateral directions. Lateral flows can be modeled using Darcy's law, and validated using the observed streamflows.

(11)

The authors mentioned that "The much larger diurnal changes of soil temperature than the observed ones (measured with heat flux transducer) from 20 January to March

2008, simulated by the WEB-DHM with the frozen scheme, was possibly caused by the underestimation of snow accumulation on the ground.". Do the authors have future plan to add a snow melt runoff module in the WEB-DHM?

Answer: In the revised manuscript, the WEB-DHM can reproduce the snow depth with an acceptable accuracy, with the improvements of frozen soil physics and careful parameter optimizations.

For further improvements on the snow melt runoff in WEB-DHM, a PhD candidate in our group is now developing a three-layer physically-based snow scheme for WEB-DHM.