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The Cryosphere Discussions

Interactive comment on "Ideal climatic variables for the present-day geometry of the Gregoriev Glacier, Inner Tien Shan, Kyrgyzstan, derived from GPS data and energy-mass balance measurements" *by* K. Fujita et al.

K. Fujita et al.

cozy@nagoya-u.jp

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Replies to general comments:

1) "In a first step": As the referee #1 pointed out, this manuscript deals a by-product from our ice-core drilling campaign. However, I don't understand why this fact is "severe deficiency".

2) "In a second step": Unmeasured area (< 4225 m) only accounts for 4% of the total area. I will add some explanation about the error but I don't think that this is important.

3) "Another problem": I agree that geodetic mass balance can only be applied to entire glacier and not to altitude profile. I will remove the description about comparison of surveyed and calculated profiles, and will just describe the profile of elevation change (Fig. 4a) to obtain the specific mass balance (Table 4).

4) "One results of the study": The referee #1 misunderstands our approach. We calculated the "ideal" precipitation to maintain the glacier surface in the current state from vertical flow of a stake, mass balance, surface snow density, and modeled evaporation. We only use meteorological variables to estimate evaporation. This is possible at the summit of flat-top glacier where the horizontal movement is small enough. In addition, our calculation results in few cases of meltwater discharge at the summit of the glacier (4600 m a.s.l.) for the last eight decades. We described the consistency among the ideal precipitation and the long-term precipitation. Because glacier wouldn't respond immediately to the deficit of precipitation in the 1990s, we believe that it is reasonable speculation. However, we NEITHER compare NOR justify the consistency among precipitation for the recent three decades (1979-2007) and the long-term precipitation (1930-2003). I will add some more explanation to avoid misunderstanding but will not change the story.

5) "The climate to preserve": Assumption of the constant glacier area is mentioned at 858/9. I suppose that the description here is early enough. Unfortunately the referee #1 does not understand how we evaluated the uncertainty from the different seasonal patterns of meteorological variables. We have 29 seasonal patterns (1979 to 2007) of meteorological datasets in this study. We regulate daily precipitation to obtain a given annual precipitation as:

PRcal=(PRyr/APyr)APgv

Here PRcal is daily precipitation used in the model, PRyr and APyr area daily and annual precipitation in a given year (yr), APgv is a given annual precipitation. To obtain the ideal temperature and mass balance profile, for instance, APgv is set as 289 $\pm$ 35 mm. We change air temperature step by step (0.1 degree C), calculate specific mass balance, and then determine the ideal air temperature and mass balance profile when specific mass balance is zero (See 866/18-26). We get 29 sets of ideal air temperature and mass balance profile, and then obtain the averages and standard deviations. APgv is set as the observed values (modified from the Tien Shan station to the summit of the glacier) when we obtain the uncertainty due to different precipitation seasonality. I will add some more explanation above mentioned.

6) "proof-reading": This manuscript was edited by Stallard Scientific Editing (http://www.stallardediting.com/index.php) before submission.

7) "Is it really necessary to provide": If the readers believe that our GPS measurement and analysis are precise, I will omit the details. However, I have been commented so many times about instruments and software in the other review processes (not this study). Actually, the referee #1 required "more details about mass balance model" even this model has been described in several papers. About differential GPS measurement, some studies described that they surveyed their target by differential GPS. But in some cases I know, some measurements were analyzed only using code-phase (without using carrier-phase, I mean). If we declare which instrument and software we used, the readers are able to judge how precise our data is. Therefore, I think it is necessary to show these details.

Replies to specific comments:

856/20: I provide Chapter 4 of IPCC-AR4. Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas and T. Zhang 2007. Observations: changes in snow, ice and frozen ground. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, etc., Cambridge University Press., 338-383.

856/26: I will add "due to collapse of Soviet Union".

857/20: I will add climatic conditions from the Tien Shan station in the chapter 2 not in Introduction.

858/6 & 7-8: Two DEMs are used to obtain Fig. 4a (See also reply to 881 Fig. 4). I don't change here because it is too early to show Fig. 4 here.

858/11-16: I will merge this paragraph and the sub-chapters "Automatic weather station, Mass balance and DGPS survey" into "observations".

589/4: But we measured location "of" one stake.

859/8: I replaced it by "obtained".

860/25 & 860/26: Detailed calculation schemes were described in the previous papers. We determine the surface, snow and ice temperatures by iterative calculations to satisfy all heat balance equations.

861/2: This is latent heat for melt. See 861/5.

861/7-17: Only 4 papers cited here. Fujita et al. (1996) dealt meltwater refreezing. Fujita and Ageta (2000) established the basis of this model. Fujita et al. (2007) applied the model to runoff (but here this is cited for the person who wants to know more details). Fujita (2007) described details of albedo scheme. I think that the basic feature of model is described enough. It is enough if the readers know that this study uses not temperature-index model but energy-mass balance model. The referee #1 comments "more details" (here) and "too much details" (GPS measurement) at the same time. We describe the minimum information about published works whereas we show details about unpublished works.

862/15-21: I will add the explanation above mentioned (5).

863/9: Values to alter a mass balance of Tibetan glacier by 100 mm w.e. were listed in Table 2 of Fujita and Ageta (2000). But I think it is too much detail to list here again.

863/19-21 & 864/4: The surrounding stakes (Stake 1 to 4) are situated 1.3 to 2.4 m lower than the AWS and obviously in the slope so that we deal only AWS site to obtain vertical flow velocity. I will add this explanation.

865/9: This is simply because of the difference between records of precipitation (Fig. 2) and surface level (Fig. 5b). I will briefly describe this discrepancy but I don't think it is severe shortcoming of the model validation.

865/21-26: I will delete this part according to the comment above pointed out (3).

866/27-28: This appears at 858/9-10. I suppose that the description here is early enough. See also reply (5).

867/14: Comparison of observed and calculated mass balance for the whole period is possible only at the summit. The calculated results show good consistency with observation as below. I will add this explanation and data in a new table. 2005-2006 Observation: 166 mm w.e. Calculation: 197 mm w.e. 2006-2007 Observation: 325 mm w.e. Calculation: 276 mm w.e.

868/4: In case of negative correlation, greater correlation means worse one. I will simply mention "are worse than -0.675 (July)" in the revised manuscript.

868/7: The other "single" monthly means show smaller values. The latter higher numbers are of multi-monthly or annual ones. I will simply mention "are worse than 0.498 (June)".

868/3-11: We don't assert like the referee #1 commented. See reply (4).

868/24: I am happy to know that this issue seems to catch the referee #1's interest. However, I am unable to accept the referee #1's encouragement. In addition, an establishment of relationship between dust concentration and the albedo when the dust was deposited at the glacier surface is a scientific challenge. This is completely different story from the present study.

874 Table 1: As we described in the chapter 2.6, we estimated daily values of air temperature and precipitation at the Tien Shan station from reanalysis datasets. In Table 1, we show the parameters of linear regressions between estimated variables for the Tien Shan station and the summit of Gregoriev Glacier. I will simply add here "(See chapter 2.6)".

881 Fig. 4: SRTM DEM is obtained in 2000 and ASTER GDEM is an average between 2001 and 2009, and glacier extent has obviously shrunk for this period. We obtain the area-altitude distribution as average of all combinations among them. I will remove the GPS derived profile from (b) and indicate the periods and runs in the panel. The method to obtain the ideal mass balance profile (c) is described in the main text (866/18-26). But I will add more explanation as replied above (5).

882 Fig. 5: I will replace "Calculation" by "Dusted-run".

883: Here we show the ideal air temperature, precipitation and ELA but don't show the present-day glacier geometry. So I don't catch what the referee #1 means by this correction.

Title: I want to keep the terms "ideal climatic variables" though I don't think that this is a common term. I will remove "Kyrgyzstan" and will add "and" between "energy-" and "mass".

856/4: I will replace "depletion" by "lowering".

856/7: I will replace "modern" by "current".

864/12: Although I don't define clearly, I use the term "elevation" for changing glacier surface and the term "altitude" for the geographical height.

869/20: I will correct this typo.

878 Fig. 1: I will indicate the dates of the glacier outlines and SRTM, and will correct "were".

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880 Fig. 2: These are gap-filled variables so that we don't show here the estimated variables if observed ones are available (precipitation as well). It is able to judge the match between observed and calculated variables in Table 1.

Interactive comment on The Cryosphere Discuss., 5, 855, 2011.