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The Cryosphere Discussions

Interactive comment on "A model study of the energy and mass balance of Chhota Shigri glacier in the Western Himalaya, India" *by* F. Pithan

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This is an interesting approach to resolve the full energy balance from a minimum of direct field data. The result of the agreement between measurements and model output, incorporating reanalysis data as forcing, is indeed a significant one. Therefore I would ask the author to explain the methodology more clearly, which could increase the paper's impact. To me there are several unclear points, so it is hard to assess how sound the approach taken really is. While Mauri Pelto commented more on the regional aspect, my comment refers primarily to the technical aspects. I hope the comments are helpful.

(A) Is the employed radiation parameterization based on observed cloud cover or on a "cloud factor" (which relates measured radiation to theoretical clear-sky radiation)?

This might have consequences for using reanalysis cloud cover later.

(B) Subsurface model (section 2.2): For someone not deeply into energy balance modeling, I think this is hard to comprehend - as there is no reference up to item 7. Your description reminds me very much of the work of Greuell and Konzelmann (1994, Global Planet. Change 9). Is their framework your template? If so, please cite this paper. Also, which constant temperature is prescribed at the bottom layer?

(C) Tied to item (B), I can't really see how you compute surface temperature. "Surface temperatures are calculated from heat fluxes" is too vague. Which heat fluxes? Or do you refer to the assumption that the entire energy balance = 0 for each time step? Or is surface temperature obtained by extrapolation from the subsurface temperature profile (I think the Greuell model does this)? Please explain surf. temp. treatment clearly in section 2.1 or 2.2.

(D) section 2.3: (a) which constant air temp. gradient is used? (b) how is precipitation tuned? Simply by one constant scaling factor, or by a time-varying procedure? Is the tuning made before, or in conjunction with a model run?

(E) Most confusing to me is which input data are used. There are two sources: reanalysis (REA) and station data. Some of the six forcing variables (temp., RH, wind speed, cloud cover, air pressure, precip) are available at both sources. For instance cloud cover and precip are measured at the station, but a few lines further it is stated that "Precipitation and cloud cover are provided on a slightly different grid in the NCEP/NCAR datasets". Please explain more clearly which variables are used from what data source. If it is a mix of both, how do the differing time steps (section 2.4) affect the modeling procedure?

(F) Your future sensitivity experiment: (a) It implies that your simulation period (2002-2006) is representative of the 1961-1990 climate. Is this justified? (b) In section 4.4.7 it sounds as if you are considering mean changes only, but as I understood earlier in the paper you are considering time-varying changes through daily anomalies, right?

Please clarify how anomalies are imposed on the reference run eventually.

(G) I agree to Mauri Pelto's comment that there could be more illustrations for the results. (a) E.g., a number of interesting statements are made for model sensitivity (section 4.2), but no table is presented. Also, there are not many physically-based distributed mass balance models around, so it would be interesting to compare the sensitivities to those from other models (e.g., Klok and Oerlemans, 2002, J GLAC 48; Reijmer and Hock, 2008, J GLAC 54; Mölg et al., 2009, J CLIM 22). I'm a bit surprised that the threshold solid vs. liquid precip has no large impact, especially since the albedo effect for the monsoon season is repeatedly stressed. (b) Illustrating vertical profiles of the mass and energy balance components would help a lot for understanding the glacier regime and the sensitivities.

Minor ones:

Abstract: monsoon precip. lowers the surface albedo?

99, line 10: "climate sensitivity of Western Himalayan glaciers" - I guess you mean "mass balance sensitivity" (as in section 4.4 title). I know the term climate sensitivity has often been used previously in connection with glaciers (maybe even by myself several years ago...), but in the meantime I think it is more precise to use "mass balance sensitivity" to some forcing. "Climate sensitivity" refers to the sensitivity of the climate system to forcings like greenhouse gases or volcanism, etc. (typically examined with GCMs).

100, line 1: Please note that the profile of tropical glaciers shows a large difference between accumulation and ablation zone; I suspect you are comparing a max value with a mean value here.

section 2.1: q_s calculated by the assumption of saturation at the surface?

103, line 5: "RH, cloud cover and wind are assumed to be constant with elevation (or "altitude")."

103, line 29: "weaknesses in the ablation model" - Or weaknesses due to the lack of direct field data for model input. I think both sides need to be appreciated (model and measurements).

104, line 9: Abbreviation IMD appears before it is explained.

section 4.3.7: I think "evaporation" should be "sublimation" (or does all the mass loss by QL occur for surface temperatures at melting point?).

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