Review of manuscript doi:10.5194/tcd-7-4015-2013

Modeling energy and mass balance of Shallap Glacier, Peru

Authors: W. Gurgiser, B. Marzeion, L. Nicholson, G. Kaser, and M. Ortner

The Cryosphere Discuss., 7, 4015-4064, 2013

The paper investigates the 2006-2008 surface mass and energy balance of Shallap Glacier, in the Cordillera Blanca of Peru. The analysis is carried out using a mass balance model accounting for accumulation and ablation processes. The ablation components are simulated using an energy balance model. A Monte Carlo technique is used to optimize the model parameters. The spatial and temporal uncertainty is assessed using a leave-one-out cross validation approach.

The main difference between the two mass balance years occurs on the lower part of the glacier, and it is caused by a lower amount of solid precipitation. While the mass balance in the upper part is similar in both years, the ice exposed for a longer period during the 2006-2007 mass balance year – due to the fact that the net shortwave radiation is the dominant source of energy for ablation in the outer tropical Andes – explains larger ablation and negative annual mass balance.

The paper is well written, clear and interesting. The analysis carried out in the paper is consistent with the objectives proposed in the title. It contains results, applications and theoretical developments of interest to warrant publication in *The Cryophere*. My recommendation is to accept the manuscript for publication with minor revisions.

GENERAL COMMENTS

Section 2.1.1. Model design – Please indicate which SWE values were used to initialize the model runs. The 2006-2007 surface mass balance above 4850 m - where no information about the surface condition is available - is certainly influenced by the amount of snow assumed in the modelling. Although three months of spin-up are included in the modelling, they are "located" in the dry period (when

precipitation is low, Fig. A2). The mass loss due to sublimation occurring in these three months could anticipate the ice exposure and lead to the negative mass balance on most of the glacier area. Did you investigate the effect of different initial SWE maps? You can eventually discuss it briefly in Section 4.3 (Uncertainties).

Section 2.1.1. Model design – Please indicate how relative humidity and wind speed are extrapolated to the DEM grid points. In a data scarce context such as that of the outer tropical Andes, not many extrapolation techniques can be obviously derived from the measurements. Meteorological data (relative humidity and wind speed) are generally assumed invariant in space. However, recently attention has been paid on the correct characterization of meteorological variables, and the comparison between on- and off-glacier input data has been generally conducted to assess the influence of forcing observed at not-glacierized locations (in your case an AWS installed on a steep moraine). How is the correlation between on- and off-glacier relative humidity and wind speed? Gurgiser et al. (2013) describe carefully only the local transfer function for air temperature and its effect on the glacier vapor pressure using RH_M. In this paper the comparison is conducted only in terms of wind speed values averaged over 184 days.
I would suggest to mention and to describe these assumptions in the discussion section of the paper.

Section 2.1.1. Model design – Is QL entirely converted into mass fluxes of sublimation or, when surface conditions allow the process, is partly used for the evaporation of surface meltwater?

SPECIFIC COMMENTS

Page 4017 Line 12 - Although it has gained acceptability as singular word, data is plural (plural form of datum). Please replace "is" with "are".

Page 4017 Line 16 - I would replace "degree day" with "empirical temperature-index".

Page 4019 Line 24 - Data as plural word. Please replace "was" with "were".

Page 4019 Line 24 – Wrong unit. Please remove "°".

Page 4022 Line 10 – Wrong unit. Please add "°C" or replace "°" with "K".

Page 4022 Line 18 – Wrong unit. Please remove "°".

Page 4027 Line 18 – Consistency, you always use the B.E. Please replace "modelled" with "modeled".

Page 4031 Line 28 – For clarity, I would remove "net shortwave energy fluxes and".

Page 4034 Lines 14-15 – The net shortwave radiation and the surplus of energy for melting should be positive. Please replace "-" with "+".

Page 4034 Line 14 – Please replace "mean" with "means".

Page 4036 Line 22 – Please replace "horizzontal" with "horizontal".

Page 4036 Line 25 – Please replace "likley" with "likely".

Page 4047 Table A1 – Wrong unit. Please remove "°" in the fixed bottom temperature.

Page 4056 Fig 9 – Please specify which accumulation value corresponds to white in (b). I guess it corresponds to no accumulation, but no white color is included in the colorbar.

Sincerely,
Marco Carenzo