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Corrigendum to "Representing moisture fluxes and phase changes in glacier debris cover using a reservoir approach" published in The Cryosphere, 8, 1429–1444, 2014

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We note that three debris properties stated to represent "whole-rock" values are inaccurately specified in the published simulations: namely, whole-rock thermal conductivity (0.94 W m^{-1} K^{-1}), specific heat capacity (948 J kg^{-1} K^{-1}), and density (1496 kg m^{-3}; cf. Table 1 in Collier et al., 2014).

The values for the first two parameters were estimated from whole-rock values of typical facies present on the Miage Glacier, corrected for observed porosity and an estimated moisture content. The thermal conductivity was computed by averaging 25 point measurements on debris at the Miage Glacier in 2005 using the "residual" approach, as explained in Brock et al. (2010). Therefore, all three values represent "effective" debris properties rather than whole-rock properties and include some influence of moisture content and porosity.

To assess the impact of these inaccurate parameter choices on our published results, we performed a Monte Carlo simulation using new ranges for the three whole-rock properties, which bracket published values for common rock types (granite, schist, gneiss, shale, granitic gneiss):

1. thermal conductivity: 1.5–2.75 W m^{-1} K^{-1} (Conway and Rasmussen, 2000; Eppelbaum et al., 2014);

2. specific heat capacity: 700–800 J kg^{-1} K^{-1} (Robertson, 1988);

3. density: 2500–2900 kg m^{-3} (Daly et al., 1966).

We sampled each of these ranges randomly to complete 5000 simulations for each year (2008 and 2011) and each case of moist or dry debris (20 000 runs in total). All other aspects of the simulations were identical to those published in Collier et al. (2014).

The resulting cumulative sub-debris ice melt is increased by a factor of $\sim$2–2.5 compared with the published simulations (Fig. 1), clearly due to the increase in whole-rock thermal conductivity (Fig. 2a; the pattern for 2011 is consistent with that of 2008). In addition, the overestimation of sensible heat (QS) is reduced using these parameter ranges (not shown). However, the main conclusions of Collier et al. (2014) are reproducible:

1. Sub-debris ice melt is reduced when moisture is considered, largely due to heat extraction by the latent heat flux and also through changes in the debris thermal properties (Fig. 3a, c).

2. When moisture is considered in the simulations for 2008, total cumulative mass balance is more negative – for lower thermal conductivity values below $\sim$2 W m^{-1} K^{-1} – since surface vapour fluxes compensate reduced sub-debris ice melt. Conversely, considering moisture in the simulations for 2011 reduces the

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mass loss due to the formation of ice near the base of the debris, which reduces heat transfer to the underlying ice regardless of the debris property specification (Fig. 4).

The analysis reveals an interesting relationship between the whole-rock thermal conductivity and the total cumulative mass balance during the 2008 ablation season, wherein conductivities greater than $\sim 2\,\mathrm{W\,m^{-1}\,K^{-1}}$ result in more efficient heat transfer from the surface and therefore a reduction in energy available for surface vapour exchange (since the surface temperature is currently used to compute this flux in the CMB model) and, as a result, reduced mass loss due to evaporation (Fig. 4). Future research should explore the relationship between uncertainties and variability in the specification of the debris properties and the associated influence in the representation of debris moisture.

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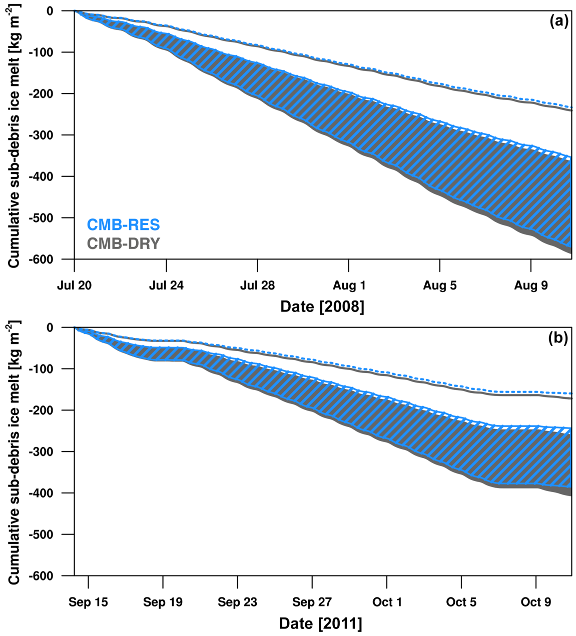

Figure 1. A time series of cumulative sub-debris ice melt ($\mathrm{kg\,m^{-2}}$) for the **(a)** 2008 and **(b)** 2011 simulations and the CMB-RES (blue curves) and CMB-DRY (grey) cases. The single lines show the results from the originally published simulations, while the filled polygons indicate the range of solutions from the Monte Carlo simulations.

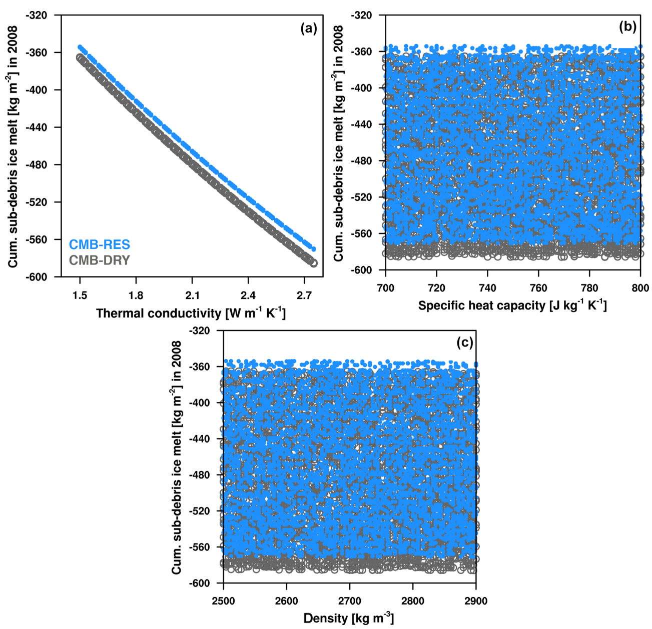

Figure 2. Cumulative sub-debris ice melt ($\mathrm{kg\,m^{-2}}$) in 2008 vs. the randomly selected whole-rock debris parameter values within the aforementioned ranges for the CMB-RES (blue markers) and CMB-DRY (grey) cases.

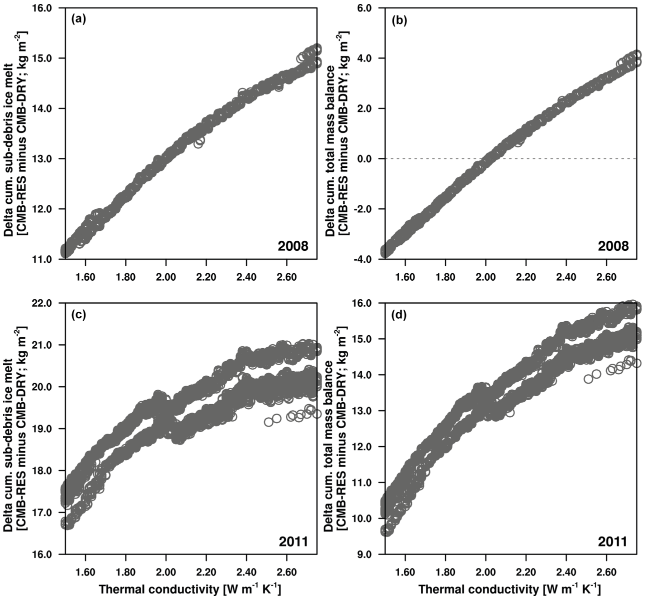

Figure 3. The difference in cumulative sub-debris ice melt (kg m^{-2}; panels **a** and **c**) and in total accumulated mass balance (kg m^{-2}; panels **b** and **d**) for CMB-RES minus CMB-DRY (note both are negative numbers) in 2008 (top row) and in 2011 (bottom row).

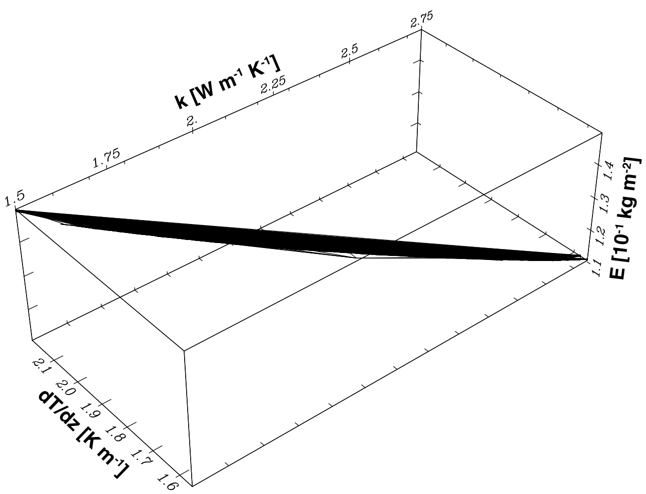

Figure 4. The relationship between the specified whole-thermal conductivity k ($W\,m^{-1}\,K^{-1}$) in the 2008 simulations, the mean vertical temperature gradient in the debris dT/dz ($K\,m^{-1}$), and the simulated evaporative mass flux E (10^{-1} kg m^{-2}) in CMB-RES.