**Supplementary Information**

**Nine model runs *MODA*to *MODI***

**Table S1** The nine model inputs used for model evaluation.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model run | Precipitation perturbation (%) | Roughness lengths (m) | Snow/rain threshold (° C) | Temperature Lapse rate  (° C m-1) | *afrsnow* | *afirn* | *aice* | t\* (days) | D (cm) | Rank |
| MODA | 0 | z0m = 3.6e-3  z0h = 5.5e-55 | 0, 2 | -0.005 | 0.95 | 0.65 | 0.42 | 10 | 1.5 | 9 |
| MODB | 0 | z0m = 3.6e-3  z0h = 5.5e-5 | 0, 2 | -0.005 | 0.95 | 0.53 | 0.34 | 21.9 | 3.2 | 8 |
| MODC | 0 | z0m = 3.6e-3  z0h = 5.5e-5 | 0, 2 | -0.004 | 0.95 | 0.53 | 0.34 | 21.9 | 3.2 | 7 |
| MODD | -15 | z0m = 3.6e-3  z0h = 5.5e-5 | 0, 2 | -0.005 | 0.95 | 0.53 | 0.34 | 21.9 | 3.2 | 2 |
| MODE | -15 | z0m = 3.6e-3  z0h = 5.5e-5 | 0, 2 | -0.004 | 0.95 | 0.53 | 0.34 | 21.9 | 3.2 | 4 |
| MODF | -15 | z0m = 3.6e-3  z0h = 5.5e-5 | 0, 2 | -0.005 | 0.95 | 0.65 | 0.42 | 10 | 1.5 | 4 |
| MODG | 0 | z0m = 1.0e-3  z0h = 1.0e-3 | 0, 2 | -0.005 | 0.95 | 0.65 | 0.42 | 10 | 1.5 | 6 |
| MODH | -15 | z0m = 1.0e-3  z0h = 1.0e-3 | 0, 2 | -0.005 | 0.95 | 0.65 | 0.42 | 10 | 1.5 | 1 |
| MODI | -15 | z0m = 3.6e-3  z0h = 5.5e-5 | -1, 1 | -0.005 | 0.95 | 0.65 | 0.42 | 10 | 1.5 | 3 |

z0m is the roughness length for momentum and z0h is the roughness length for temperature



**Fig. S1** Scatter plots of the observed (*ObsMB*) and modelled (*MODobserved-like dates*) winter balances of (a) *MODA*; (b) *MODB*; (c) *MODC*; (d) *MODD*; (e) *MODE*; (f) *MODF*; (g) *MODG*; (h) *MODH* and; (i) *MODI*. The black line represents the one-to-one line. The RMSE and MBE are shown for modelled mass balance for each model run with *ObsMB*.



**Fig. S2** Scatter plots of the observed (*ObsMB*) and modelled (*MODobserved-like dates*) summer balances of (a) *MODA*; (b) *MODB*; (c) *MODC*; (d) *MODD*; (e) *MODE*; (f) *MODF*; (g) *MODG*; (h) *MODH* and; (i) *MODI*. The black line represents the one-to-one line. The RMSE and MBE are shown for modelled mass balance for each model run with *ObsMB*.



**Fig. S3** Scatter plots of the observed (*ObsMB*) and modelled (*MODobserved-like dates*) annual balances of (a) *MODA*; (b) *MODB*; (c) *MODC*; (d) *MODD*; (e) *MODE*; (f) *MODF*; (g) *MODG*; (h) *MODH* and; (i) *MODI*. The black line represents the one-to-one line. The RMSE and MBE are shown for modelled mass balance for each model run with *ObsMB*.



**Fig. S4** Altitudinal profiles of the mean annual observed (*ObsMB*) and modelled mass balance of the nine model runs (A-I) during the observed-like dates.



**Fig. S5** Scatter plots of the observed (*ObsMB, calibrated*) and modelled (*MODfull period*) annual balances of (a) winter *MODD*; (b) winter *MODH*; (c) winter *MODI*; (d) summer *MODD*; (e) summer *MODH*; (f) summer *MODI*; (g) annual *MODD*; (h) annual *MODH* and; (i)annual *MODI*. The black line represents the one-to-one line. The RMSE and MBE are shown for modelled mass balance for each model run with *ObsMB, calibrated*.



**Fig. S6** The modelled mass balance for each model run (mass balance year is defined as 01 Apr-31 Mar). The black dotted vertical lines indicate the range of dates for the end of the ablation period (summer balance) and the end of the accumulation period (winter balance) for each of the model runs.