Supplementary material for "Surface mass balance modelling of the Juneau Icefield highlights the potential for rapid ice loss by the mid-21st century"

Ryan N. Ing[1]*, Jeremy C. Ely[2], Julie M. Jones[2] and Bethan J. Davies[3]

*Corresponding author

1. School of Geosciences, University of Edinburgh, Edinburgh, UK, EH8 9XP

2. Department of Geography, The University of Sheffield, Sheffield, UK, S10 2TN

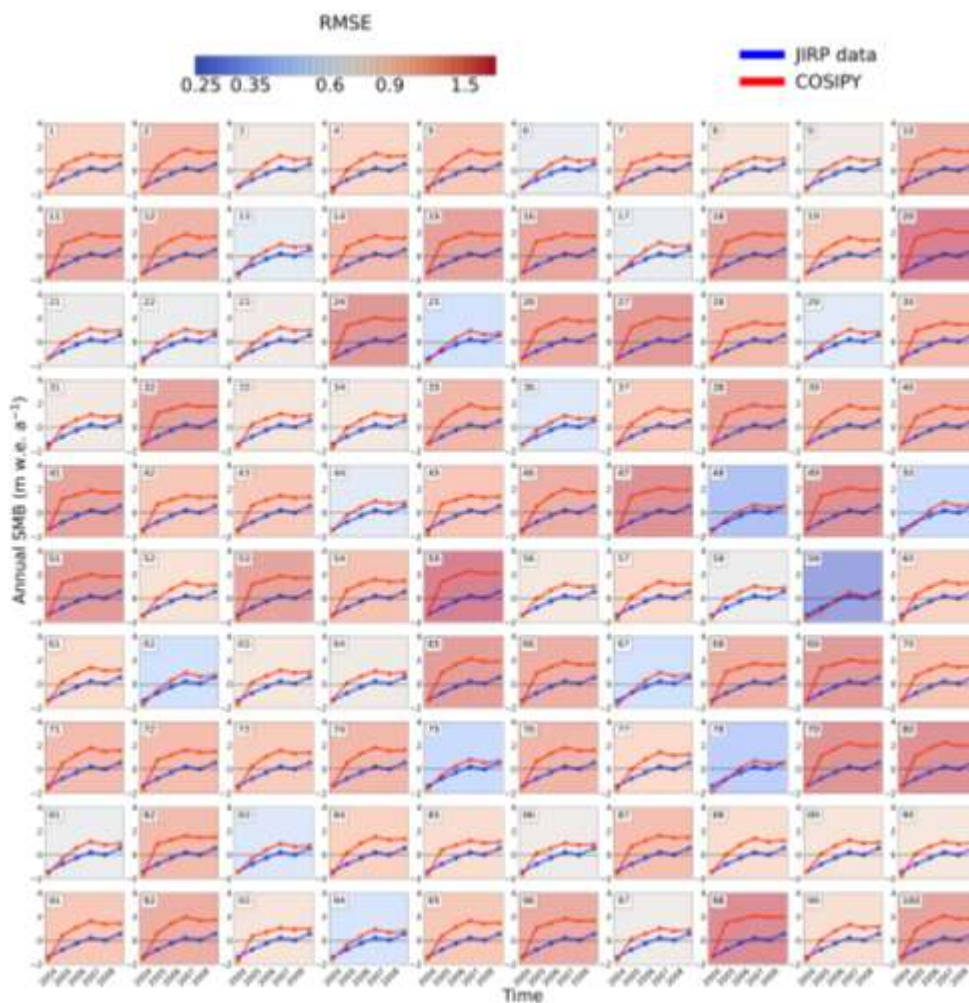3. School of Geography, Politics and Sociology, Newcastle University, Newcastle upon Tyne, UK, NE1

Fig. S1. The 100 optimisation runs for Taku Glacier, 2004 to 2008. The blue line represents glacier wide SMB from JIRP. The red line shows the simulated SMB from COSIPY. Each tile represents a model run, with the blue to red colour map displaying the normalised RMSE with a log scale between the simulated COSIPY SMB and the JIRP SMB.
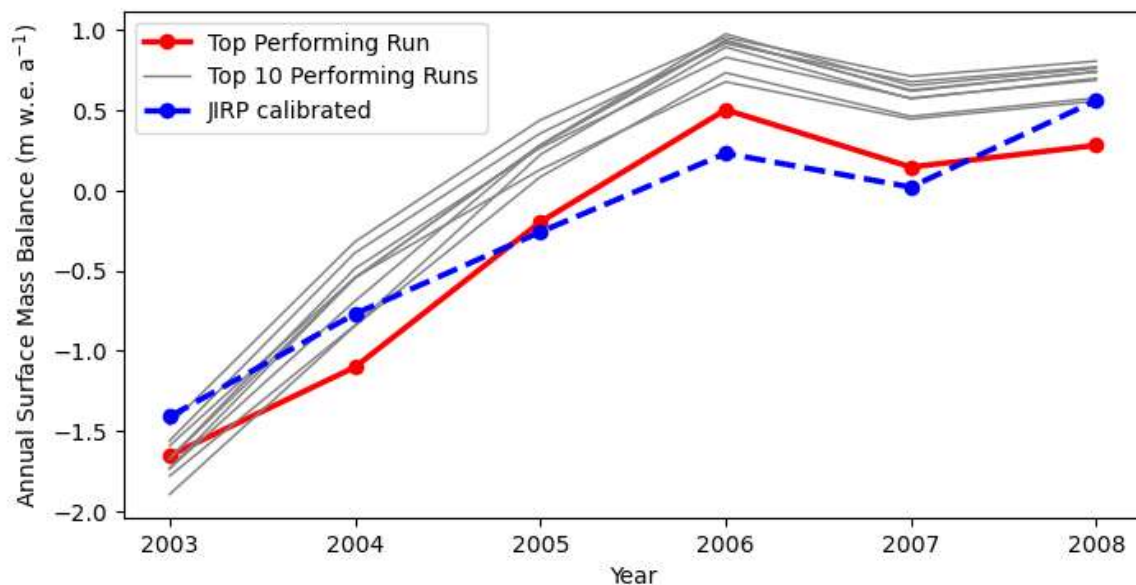
Fig. S2. Comparison between the calibrated Juneau Icefield Research Program (JIRP) SMB (blue dotted), COSIPY optimised SMB (red) and the top 10 performing optimisation runs for Taku Glacier, 2004 to 2008.
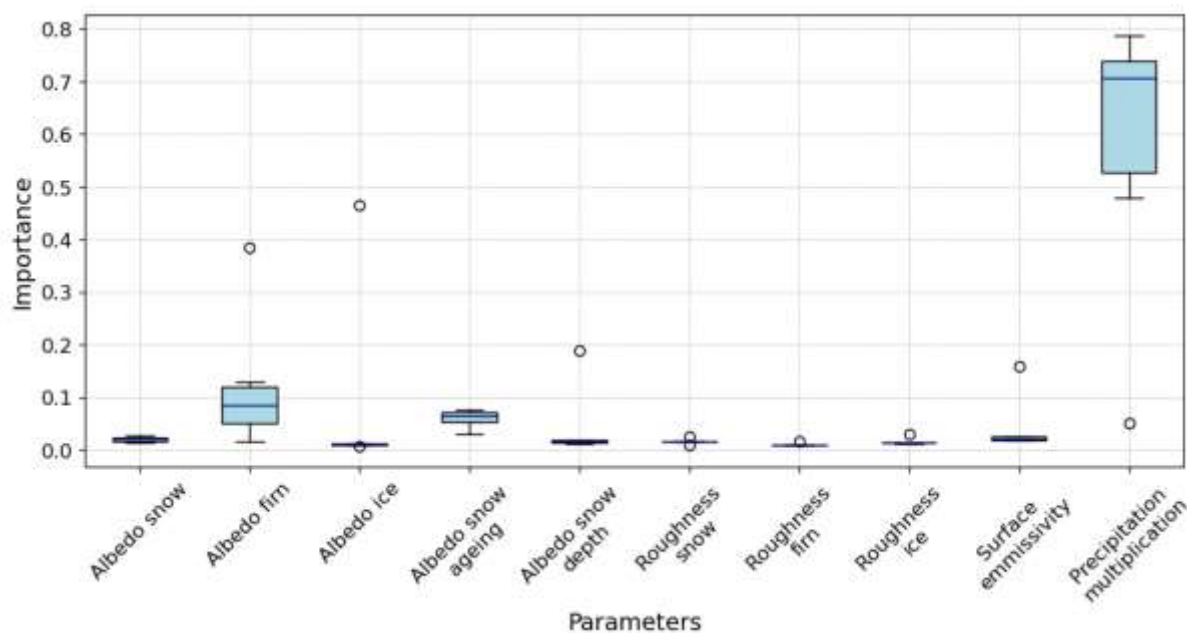

Fig. S3. Importance of Model Parameters for Taku Glacier, 2004 to 2008. Each box represents the importance of a model parameter determined by a Random Forest analysis of 100 optimistion runs. Boxes show the interquartile range (IQR) with the median depicted by the horizontal line, whiskers extending to 1.5 times the IQR, and outliers shown as individual points.
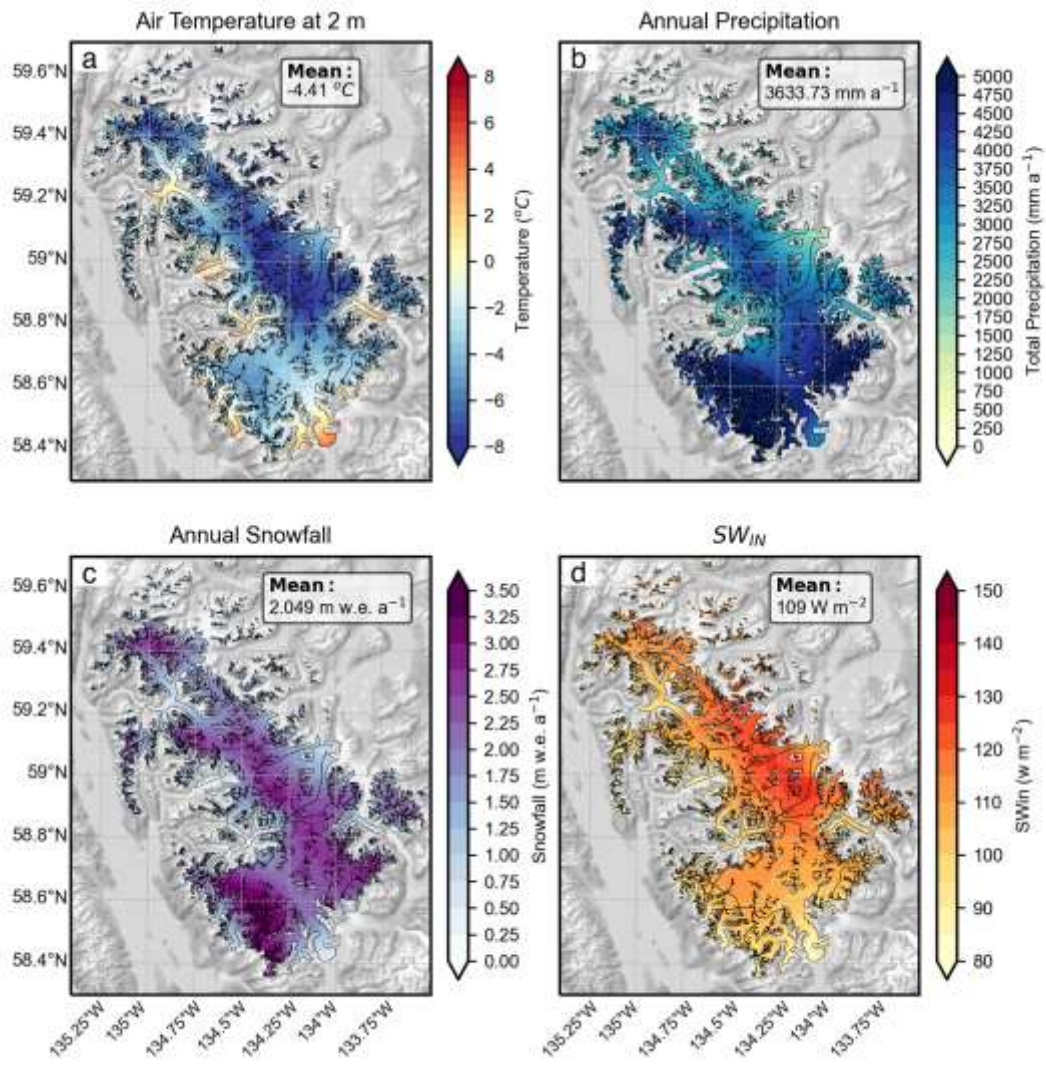
Fig. S4. Climate average for Juneau Icefield from downscaled GFDL data 1980 to 2010. a) Mean daily air temperature at 2 m, b) mean total annual precipitation, c) mean total annual snowfall, d) mean incoming shortwave radiation.
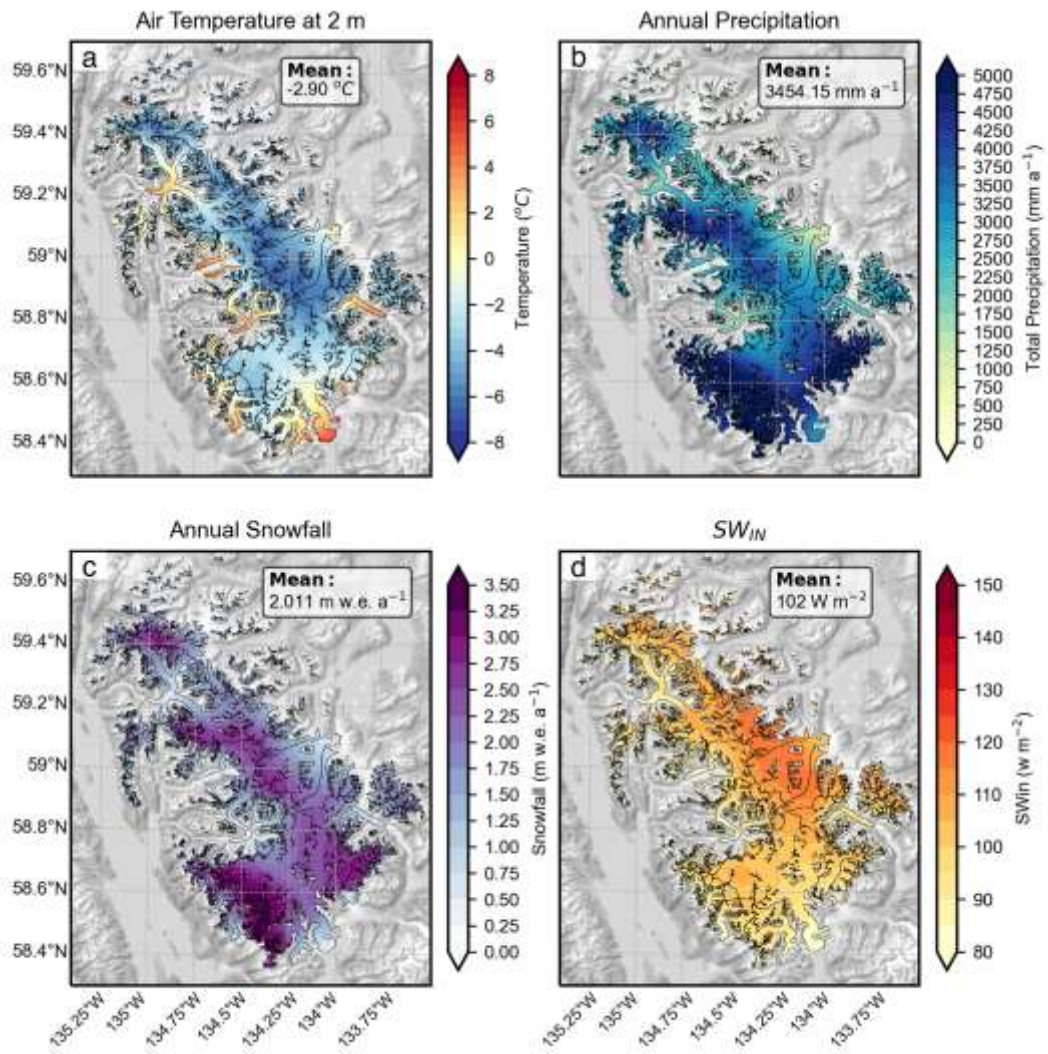
Fig. S5 As in Fig. S4 but for CCSM.

Table S1. Comparison of the annual SMB derived laser altimetry surveys and the CFSR-COSIPY simulations. The date of the first survey, and the period covered is also noted.

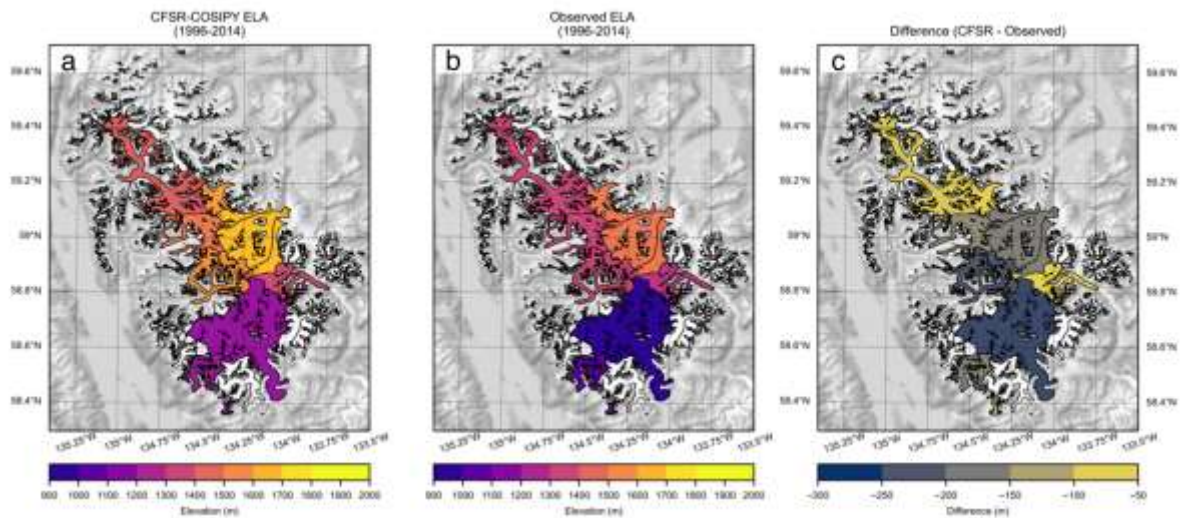| Glacier name	Survey start date	Period (years)	Annual SMB	
			Larsen and others (2015)	CFSR-COSIPY (this study)
Taku	09/03/1993	19	0.13	0.08
Lemon Creek	09/03/1993	19	-0.91	-0.51
Meade	09/03/2007	5	-1.03	-0.31
Field	09/03/2007	5	-0.94	-0.06
Gilkey	09/03/2007	5	-0.75	-0.70
Llewellyn	09/03/2007	5	-0.61	-0.08
Mendenhall	09/05/1999	13	-0.57	-0.32
Willison	09/03/2007	5	-0.51	0.01

Fig. S6. The ELA of glaciers across Juneau icefield. a) for CFSR-COSIPY past simulation (1989-2019). b) observed ELAs derived from satellite imagery in Ziemen and others (2016) for the period 1996-2014. c) The difference between observed (b) and modelled (a) ELAs.

Table S2. Climate means and decadal trends for the CFSR reanalysis simulations and the GFDL and CCSM global climate models rounded to 2 s.f.. Total precipitation and snowfall represent the annual totals for the Juneau Icefield domain; all other variables are the annual means for the Juneau Icefield domain. Bias-corrected data for the GFDL and CCSM past and future simulations are in **bold**. Decadal trends were calculated using a Theil-Sen estimator. Decadal trends that are statistically significant, as revealed by a Mann-Kendall test where p-value <= 0.05, are underlined.

| Data (raw/**bias-corrected**)	Total Annual Precipitation		Total Annual Snowfall		Annual Air Temperature		Annual Incoming Shortwave	
	Mean (mm)	Decade Trend (mm decade^{-1})	Mean (m w.e.)	Decade Trend (m w.e. decade^{-1})	Mean (°C)	Decade Trend (°C decade^{-1})	Mean (W m^{-2})	Decade Trend (W m^{-2} decade^{-1})
CFSR reanalysis (1980-2010) (Observations)	3100	-140	1.8	-0.092	-3.4	0.16	110	-0.0042
GFDL (1980-2010)	3600	<u>-350</u>	2.1	<u>-0.21</u>	-4.4	<u>0.44</u>	110	2.1
CCSM (1980-2010)	3500	-180	2.0	<u>-0.16</u>	-2.9	0.19	100	-0.35
GFDL (2030-2060)	3800 / **3300**	-210 / **-190**	1.7 / **1.4**	<u>-0.20</u> / **<u>-0.17</u>**	-2.0 / **-0.91**	<u>0.77</u> / **<u>0.85</u>**	100 / **100**	0.47 / **0.64**
CCSM (2030-2060)	3600 / **3300**	-140 / **-140**	1.9 / **1.0**	<u>-0.19</u> / **<u>-0.17</u>**	-1.2 / **-1.9**	0.39 / **0.32**	97 / **110**	-0.62 / **-0.87**
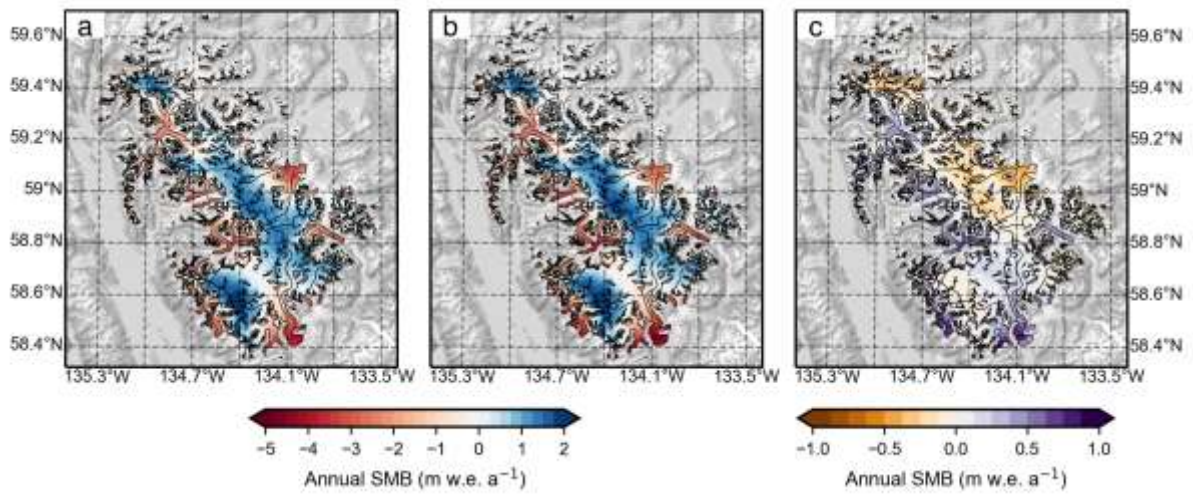
Fig. S7. Spatial distributions of mean annual SMB for the reanalysis (CFSR; 1981 to 2010) and evaluation (GFDL and CCSM; 1981 to 2010) simulations. (a) CFSR, (b) mean of GFDL and CCSM and (c) difference between the CFSR mean and the mean of GFDL and CCSM.